OMA'S MILSTEIN HALL

A CASE STUDY OF ARCHITECTURAL FAILURE

JONATHAN OCHSHORN

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For Susan

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INTRODUCTION

This is a book about architectural failure. In addition to some general observations and an occasional digression, the heart of the book is a rather detailed examination of dysfunction, inflexibility, fire hazard, non-structural failure, and unsustainable design in Milstein Hall at Cornell University, the flagship building designed by the Office for Metropolitan Architecture (OMA) for Cornell's College of Architecture, Art and Planning.

The choice of Milstein Hall is both arbitrary and pragmatic: arbitrary because many other buildings might have served as case studies for the particular problems I enumerate; pragmatic because, as a member of Cornell's faculty since 1988, I have had special access to the building's planning, design, construction, and occupancy.

In fact, I have been thinking and writing about Milstein Hall since 2009, when the college dean sent out an email requesting feedback about the proposed building—whose fate was potentially in limbo at the time due to fallout from the financial crisis of 2008. The dean argued that "it is essential that the faculty weigh in on the project" since "there is apparently an impression that AAP faculty, and the architecture faculty in particular, are divided or even apathetic about the need for the project."[1] Well, I did weigh in at that time, and continued to criticize the building plans as they developed, as the building was being constructed, and after the building was occupied.

In spite of my obvious antipathy to the building design, the dean approved my proposal to create a series of Milstein Hall construction videos: my intention was to shadow the contractors, ask lots of questions, and videotape the work in progress with a low-resolution Flip Video camera. It is likely that my proposal was approved because—and here I'm speculating—an "educational" component that was included as part of the contractor's contractual obligations in constructing Milstein

Hall elicited no other competing faculty proposals. So I made a series of ten informal videos,[2] and learned quite a lot about the building in the process.

I also eventually, and with great effort on my part, got hold of a set of Milstein Hall working drawings. In fact, I wrote a screenplay in two acts, describing the painful ordeal of gaining access from the college, called "Half-Life of a Working Drawing"—a cautionary tale concerning academic freedom compiled verbatim from emails exchanged between 2012 and 2013—but I haven't yet had the courage to make it public. In any event, having access to a working drawing set, especially when combined with my numerous Milstein Hall site visits to document the construction process, proved to be quite valuable in understanding how this building was put together and why it has had so many problems.

Although my questions to Cornell facilities staff about Milstein Hall were, and remain, often unanswered, I was able to obtain additional information about interactions among Cornell's project managers, Milstein Hall's architects and consultants, and City of Ithaca code enforcement officials—based on minutes of meetings and email correspondence—by submitting freedom of information law (FOIL) requests to the City of Ithaca.

Finally, writing and researching my monograph from 2021, *Building Bad: How Architectural Utility is Constrained by Politics and Damaged by Expression*,[3] provided a useful theoretical base for the present work, which is, in effect, a case study in building bad. The competition driving dysfunctional modes of expression and the political/economic calculations that effectively constrain durability and safety—both of which increase the probability of building failure—are theorized in *Building Bad*. And this theory applies to most avant-garde architecture, including the architecture of Milstein Hall. The present book does not rehash the underlying theoretical arguments for nonstructural failure that appeared in *Building Bad*; instead, it examines what such failure looks like in a single building—as a case study.

Similarly, there is no attempt in the present book to *systematically* link each instance of architectural failure in Milstein Hall to the theorizing of Rem Koolhaas and OMA-AMO (AMO being the "research, branding and publication studio of the architectural practice"[4]). In a few instances, connections between the design of Milstein Hall and the architects' design philosophy are briefly noted: Bill Millard's explanation of inflexibility in the work of OMA is discussed in chapter two. Contradictory attitudes toward large, interconnected spaces and atriums in Milstein

Hall—based on Koolhaas's essay on "Junkspace"—are analyzed in chapter six. Finally, Koolhaas's embrace of fiction and false facts in *Delirious New York* provides some context for the various "fictions" that show up in published commentary on Milstein Hall, enumerated in chapter seven. But all these observations are incidental; this book is not intended as a comprehensive analysis of Koolhaas or his writing. Rather, my hope is that this book helps reorient architectural criticism away from subjective responses to form and expression, and toward more objective analyses of utilitarian functionality in buildings.

There are 26 chapters in the book organized into four parts—with each part corresponding to one category of architectural failure:

- Part I (Dysfunction and Inflexibility) includes detailed discussions of function, flexibility, privacy, lighting, acoustics, circulation, orientation, and access.

- Part II (Nonstructural Failure) offers a theoretical analysis of peculiarity and redundancy as parameters affecting nonstructural failure, as well as an examination of thermal control, rainwater control, and sloppy, dysfunctional, and dangerous details in Milstein Hall.

- Part III (Fire Hazard) discusses the many ways in which Milstein Hall contravenes normative fire safety standards, focusing on its excessive floor area; inadequate or nonexistent fire walls and fire barriers; and unsatisfactory egress from assembly spaces.

- Part IV (Unsustainable Design) is in equal part a critique of Milstein Hall's sustainability and the cynical use of the LEED Reference Guide as validation for Milstein Hall's "green" credentials—structured around LEED's sustainability categories: site, water, energy, materials, indoor environmental quality, and innovation.

Some topics have confounded my effort at systematic organization—discussion of egress, for example, can be found not only in Part III on fire hazard, but also in Part I (e.g., chapter five on circulation) and Part II (e.g., chapter 12 on dangerous details). And certain chapters could well have been moved—thermal control, for example, ends up in Part II (on nonstructural failure) but would have worked just as well in Part IV (on unsustainable design).

As to why someone might be interested in reading such a detailed examination of architectural failure in a single building, the primary reason is this: failure, as Henry Petroski has demonstrated in numerous books and articles on engineered structures, is a necessary prerequisite for success. Designers, clients, and users of architecture, having confronted the errors in this building, may be less inclined to repeat them. A second reason, also quite important, is that language used to explain architecture can be deceptive and dangerous—worse than mere puffery in that it is often taken seriously—so being exposed to such deceptions, even in a single building, might serve as a kind of inoculation against the disease.

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Milstein Hall—on Cornell University's Ithaca, New York, campus—is sited just south of Fall Creek Gorge, the largest of many spectacular tributary streams that feed into Cayuga Lake, as shown in figure 0.1. A closer look at the Cornell campus, with Milstein Hall visible just north of Cornell's Arts Quad, appears in figure 0.2. Finally, looking closer still, schematic building plans for Milstein Hall (and adjacent Sibley and Rand Halls) are assembled in figure 0.3 with rooms and spaces inside and outside of the building identified for future reference.

Figure 0.1 (facing page). Topographic map of Ithaca, New York, with Milstein Hall at Cornell University in the center.


Cayuga Lake
Fall Creek Gorge
Milstein Hall
Cornell Arts Quad
Cascadilla Gorge
ITHACA
Cayuga Heights
Northeast Ithaca
East Ithaca
Lansing
Renwick
Forest Home
Pleasant Grove Brook
0
0.5
1.0
1.5 miles
0
1
2 km
North

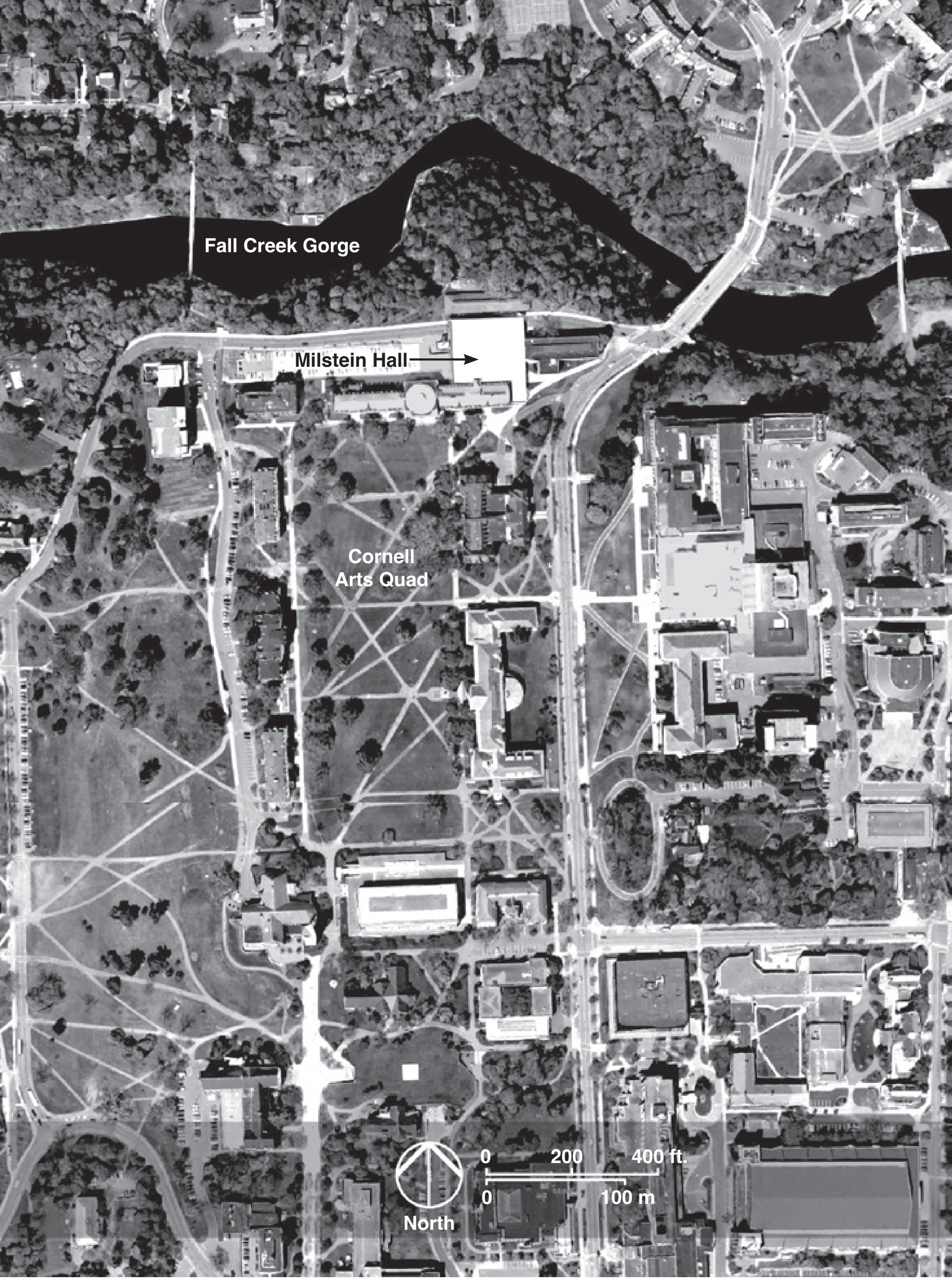


Figure 0.2. Milstein Hall and the Cornell campus.

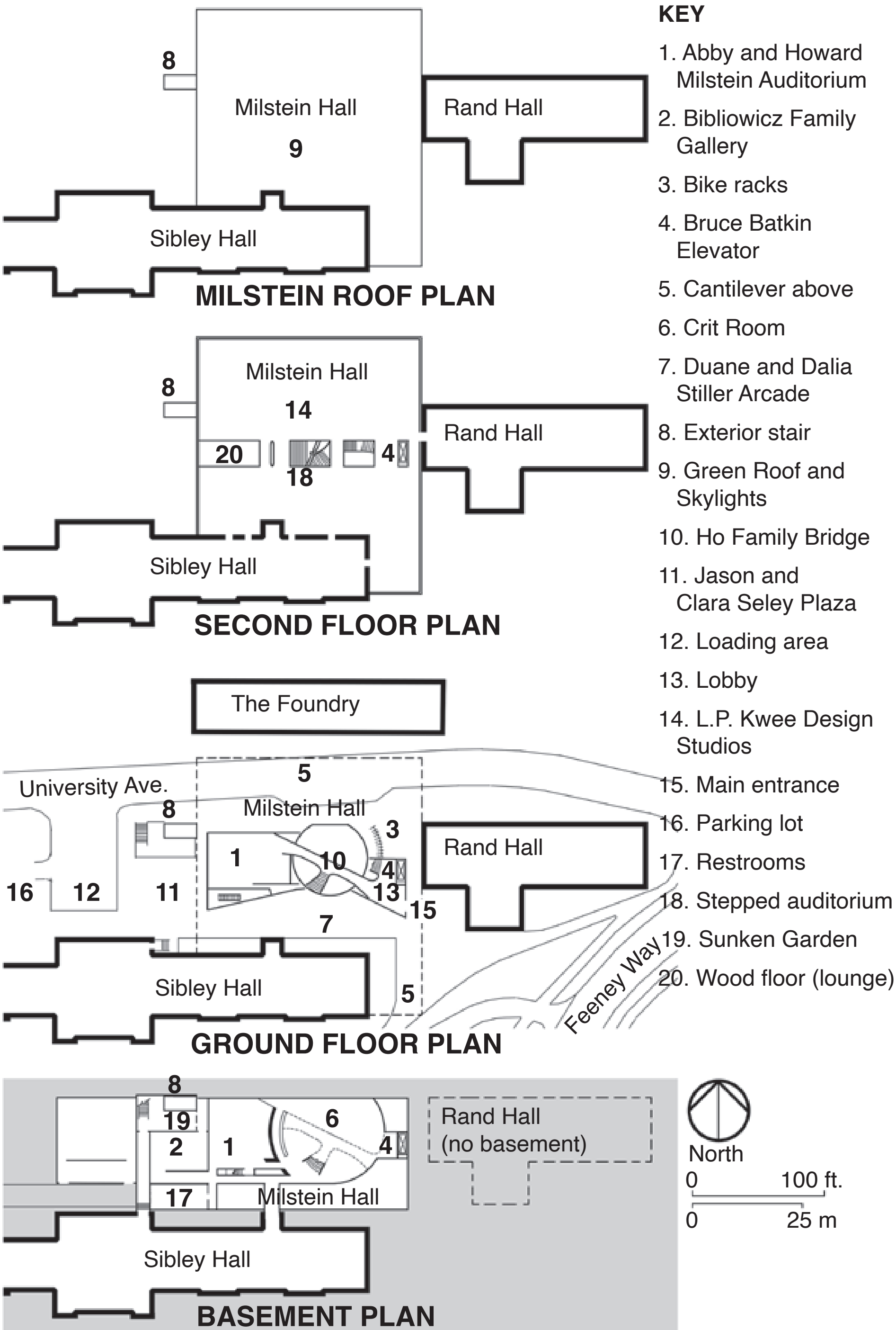


Figure 0.3. Schematic plans for Milstein Hall, in the context of Sibley and Rand Halls.

PART I

DYSFUNCTION AND INFLEXIBILITY

1 OPENING REMARKS ON FUNCTION AND FLEXIBILITY

Most modern buildings are subdivided into more-or-less distinct compartments, or rooms. In the case of Milstein Hall—an addition to Cornell University's College of Architecture, Art, and Planning, designed by the Office for Metropolitan Architecture (OMA) and completed in 2011—these compartments include design studios, an auditorium, an assembly/critique space (Crit Room), a small art gallery, bathrooms, an entry lobby, and three primary outdoor spaces—an arcade, a plaza, and a vegetated roof.

Supporting the activities corresponding to the various "occupancies" or uses within a building involves paying attention to the intended *functions* of the various spaces, while also making sure that the building is *flexible* enough to accommodate changes. Aside from the obvious requirement for things to *work*—e.g., for mechanical systems to supply conditioned air; for building enclosures to control the movement of heat, air, rainwater, and water vapor; and so on—function in this context is also affected by geometry (size and shape), the desire for privacy, control of light and sound, and circulation (movement around and within buildings, including *accessible* movement).

Flexibility in this context might enable, on the one hand, changes in function or occupancy *within* building compartments, even if the boundaries separating such compartments stay the same—for example, a studio space becoming a classroom or an office. On the other hand, the boundaries defining such compartments might themselves change; existing partitions might move or be removed or new partitions might be created, even while the occupancies of those compartments might either change or stay the same. As in building function, both geometry and circulation play an important role in fostering building flexibility. Of course, understanding *how* change can either be hindered or facilitated is a crucial aspect of flexibility. Much of my discussion of flexibility has been informed by Stewart Brand's excellent book, *How Buildings Learn*.[1] In fact, if you haven't already read it, I suggest that you put this book down and read Brand's book first. Go ahead; I'll wait…

Three especially important and complex building functions do not appear in Part I of this book. Instead, a detailed discussion of fire safety, nonstructural failure, and sustainability in Milstein Hall will follow in Parts II, III, and IV respectively.

2 FLEXIBILITY

Millard doctrine

Where a space is designed to be appreciated aesthetically as a single entity—think of the Sistine Chapel in the Apostolic Palace in Vatican City or the Main Concourse of Grand Central Terminal in New York City—such a space can only be changed by doing violence to the design. In Milstein Hall, virtually all of the spaces (compartments) have this quality: the auditorium and the Crit Room are designed explicitly as idiosyncratic sculptural volumes—figural elements—whose geometry is essentially fixed forever.

Bill Millard explains the rationale for such a strategy in the works of OMA by arguing that "the most striking feature of a building must now be the one that all the more mundane features require, the one whose subtraction would demolish the structure. Beauty that also solves problems is free to remain beauty."[1] Such an attitude may well succeed in getting one's beautiful building built without compromise, but it simultaneously forecloses the possibility of flexibility when critical building compartments (e.g., Milstein Hall's Crit Room and auditorium) cannot be altered except with great difficulty. I have described in chapter 16 how the requirement for a new exit from the concrete-domed Crit Room necessitated the literal demolition of reinforced concrete walls to create an egress passage through the auditorium. That this new exit created acoustical "bridges" between the Crit Room and the auditorium—making it difficult to use both spaces simultaneously because sounds generated in one space interfere with the activities in the other space—demonstrates another way in which flexibility is constrained in this building. Stewart Brand has described this phenomenon as follows:

> Institutions aspire to be eternal, and they let that ambition lead them to the wrong physical strategy. Instead of opting for long-term flexibility, they go for monumentality, seeking to

> embody their power in physical grandeur. Post offices, colleges, and state capitals belie and hinder their high-flux information function with stone walls, useless columns, and wasteful domes. The building tries to stand for the function instead of serving it.[2]

Shearing layers

Architectural flexibility can mean adaptation as an ongoing operating condition of the building, but is more generally understood as the ability to anticipate and facilitate future change.[3] All buildings must adapt to the future, a future in which some changes are quite predictable—even if their precise content is unclear (e.g., replacement of furniture, painting of walls and ceilings, repair or maintenance of interior and exterior construction, upgraded appliances and mechanical equipment, and so on)—and in which some changes are unexpected and, at least when the building is designed and built, unknown. On the other hand, some buildings must also adapt to ongoing changes as part of their utilitarian functionality: this includes many museums, where new exhibits may well require reconfigured partitions or newly painted walls.

But all buildings change, whether or not these changes are anticipated by their designers. Stewart Brand quotes the British architect Frank Duffy, who prefers to think of buildings, not as "buildings," but rather as "several layers of longevity of built components," categorized as shell, services, scenery, and set (fig. 2.1). In this formulation, the shell, or structure, ought to survive for the life of the building, whereas services (like HVAC systems) might last 15 years, scenery (such as suspended ceilings or partitions) might last 5–7 years, and set (primarily furniture) may well be moved around or replaced far more frequently.[4] "Thinking about buildings in this time-laden way is very practical," says Duffy. "As a designer you avoid such classic mistakes as solving a five-minute problem with a fifty-year solution, or vice versa."[5]

Instead of designing buildings that explicitly account for the time-based functions diagrammed by Brand and Duffy, architects often invoke a literal (and short-sighted) ideal of functionalism that fixes in place, and formally articulates, some current idea about the requirements of, and relationships among, specialized rooms and circulation systems, thereby foreclosing the possibility of adapting to future programmatic changes. Critiquing the work of architects Hugo Häring and Hans Scharoun in the 1920s, the German critic and historian Adolf Behne anticipated precisely this problem, arguing that the articulation of different corridor widths in their buildings, based on a biological analogy of "living arteries" that are allowed "to narrow, to shrink, in places where there is less traffic" was actually dysfunctional:

> This is all right provided that traffic always follows this same path until the death of the building; that the same conditions prevail as on the first day; in the same way as is the case for blood corpuscles in an organism. But it is wrong, and the functional becomes antifunctional as soon as the traffic finds different conditions—such as through a change of owner or when purpose alters traffic requirements—whereby it could be heaviest in precisely those places where the plan requires it to be lightest.[6]

On the other hand, even accepting the critique of Behne and the advice of Duffy, it's hardly self-evident how to make buildings truly flexible, since both culture and technology change in ways that simply cannot be predicted.

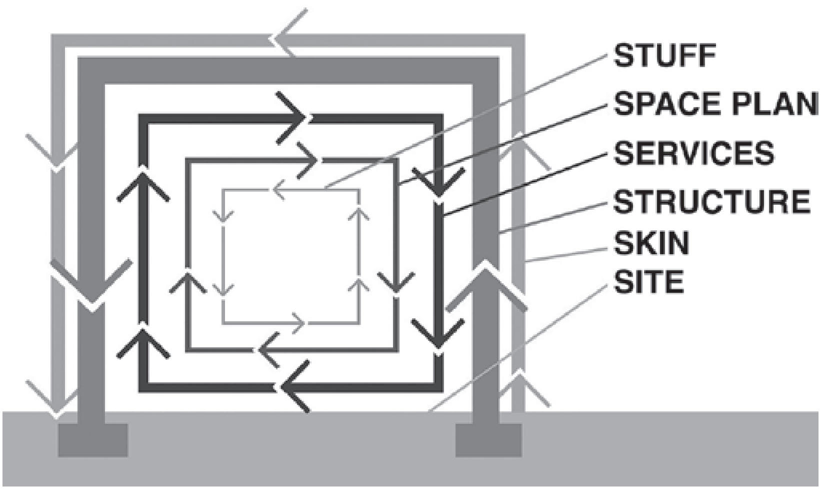


Figure 2.1. Stewart Brand's revised diagram of time-based building systems, based on Frank Duffy's categories, but with two more S's and some changed names ("site, structure, skin, services, space plan, and stuff"), each with its own characteristic time-frame for repair, maintenance, or replacement.

Integration of mechanical, electrical, and plumbing into structure

Where mechanical, electrical, plumbing, sprinkler, or lighting systems are designed for one specific spatial geometry, it can be difficult to alter or subdivide such a space. In the case of Milstein Hall, the foolishness of such specificity and fixity has been taken to an extreme. Even the bathrooms have been turned into inflexible and bespoke interlocking puzzle pieces which cannot easily be modified. Specifying built-in stainless-steel urinals that terminate in a cracking (and therefore noncompliant) concrete floor slab[7] cannot even be called foolish—perhaps the word "unfathomable" would do it justice (fig. 2.2).

Figure 2.2. Stainless steel urinals in Milstein Hall are built into the noncompliant (cracking) concrete floor slab and cannot easily be repaired or replaced.

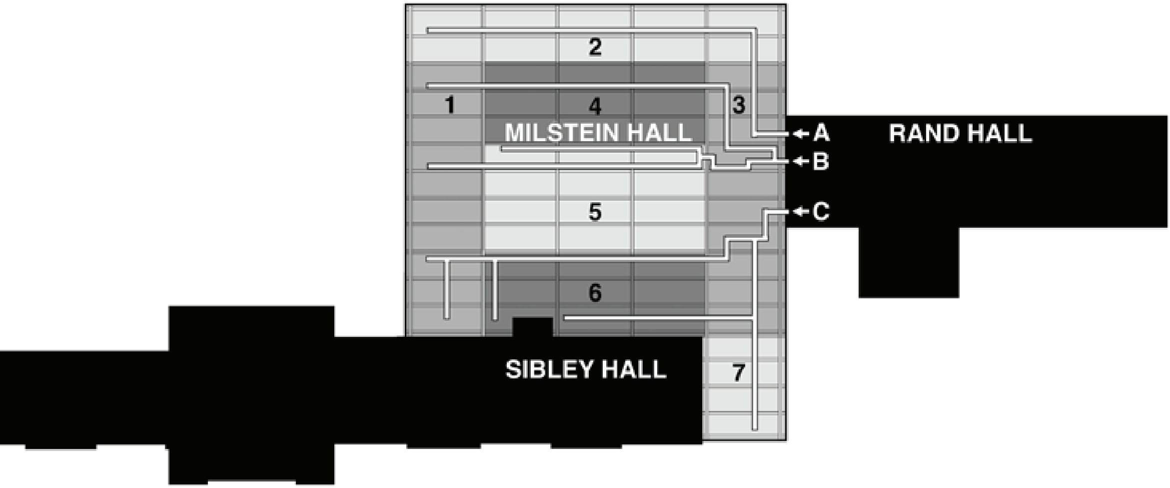


Figure 2.3. The second-floor studio space is subdivided into three zones for fresh air distribution, originating in a mechanical room placed on the third floor of Rand Hall (labeled *A, B,* and *C*); and divided into seven zones for heating and cooling (labeled 1–7).

Even the "adaptable and open floor plan"[8] on the second-floor studio level cannot be easily subdivided or partitioned, not only because the space was explicitly designed to be understood as a single entity and to have no interior partitions, but because lighting, fresh air, heating, and cooling systems are all designed for a single open space. As but one example, fresh air is brought into the space through special ducts, triggered by CO_2 sensors that are placed in several zones within the larger space. Any newly partitioned room would therefore have no way to control the provision of fresh air unless a CO_2 sensor happened to be in that space. But, even in that case, fresh air would also be supplied throughout the entire zone controlled by that particular sensor, irrespective of where the partitions were placed. The same type of zoning, but with *different* zones than those designated for the fresh air supply, determines the provision of heat (using radiant heating in the floor slab) in the winter and coolness (using so-called chilled beams hanging from the ceiling) in the summer (fig. 2.3).

Furthermore, because this ductwork was threaded through holes in the webs of the structural beams, and because the system as a whole was designed for a large, undivided space, it becomes extremely difficult to

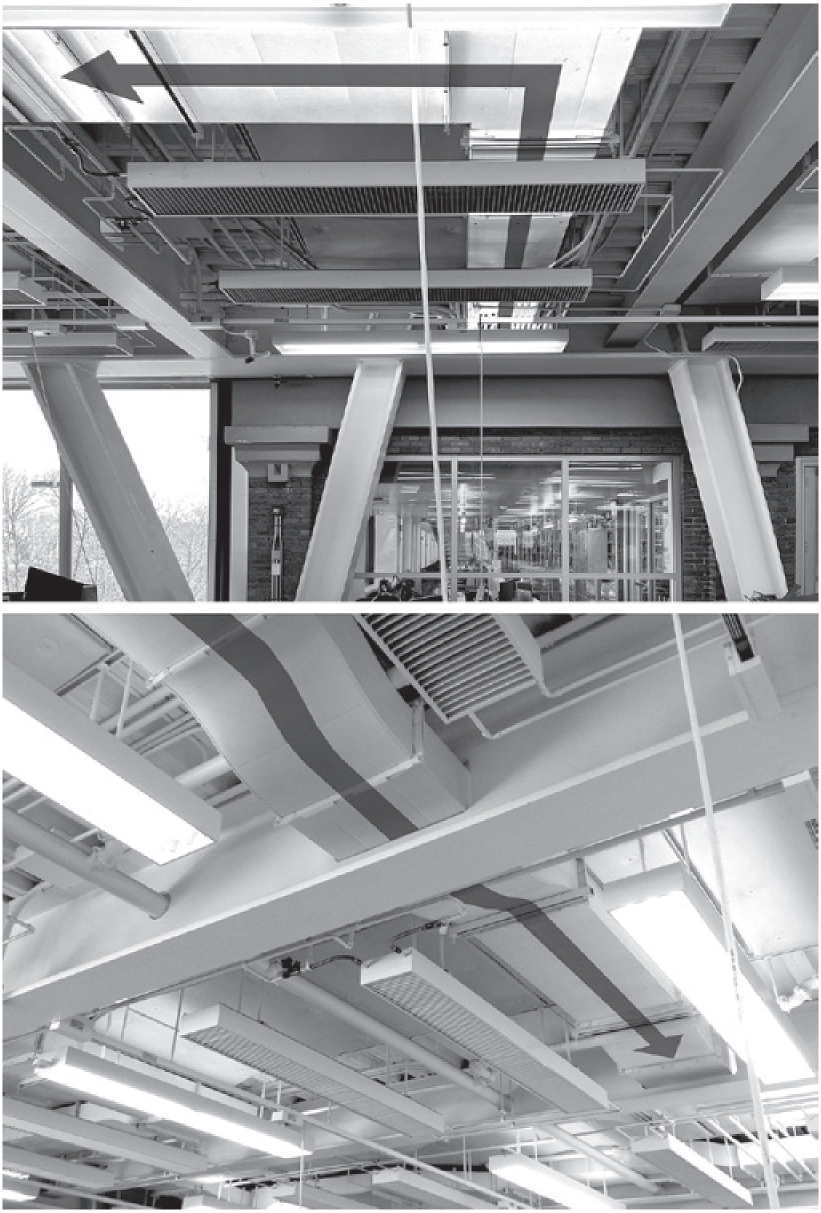


Figure 2.4. A duct for outside air distribution—labeled "A" in figure 2.3—is shown emerging from adjacent Rand Hall, where the mechanical room is located one level above (*top*). These ducts carrying fresh air are threaded through the webs of structural steel beams (*bottom*), making future alterations difficult. Light fixtures and matching chilled beams can be seen just below the ducts. Illustrative arrows added by the author.

modify, since a new pattern of ducts and sensors would not necessarily fit through the holes in the beam webs that were designed specifically for only one possible configuration (fig. 2.4). And like the fresh air system, the zoned heating and cooling systems cannot be reconfigured in any future subdivision of the second-floor studio space without essentially destroying the building (fig. 2.5).

This issue of embedding mechanical, plumbing, and so on *within* the structural elements of the building is pervasive in Milstein Hall, a classic error that locks "quick" systems within "slow" ones, making maintenance, repair, replacement, or more comprehensive changes extremely difficult. Stewart Brand puts it this way: "An adaptive building has to allow slippage between the differently-paced systems of Site, Structure, Skin, Services, Space plan, and Stuff. Otherwise the slow systems block the flow of the quick ones, and the quick ones tear up the slow ones with their constant change."[9]

Figure 2.5. Radiant heating tubes are embedded in the structural concrete floor deck of the second-floor studio space.

Aside from the ducts providing fresh air, and radiant heating tubes embedded in the floor slab, fire sprinkler pipes and electrical conduits are embedded within concrete slabs, ducts for the auditorium are buried under concrete slabs-on-ground or built into the auditorium seating structure, and stormwater drainpipes are embedded between the double concrete faces of the Crit Room dome. In the Crit Room itself, lighting fixtures are carved into the concrete surface, so that their dimensions and locations are fixed forever and conduits that provide them with power are inaccessible—buried within the concrete. The structure of the dome

Figure 2.6. Mechanical, electrical, and fire safety items buried within structure: storm drainpipes within concrete dome (*top left*); conditioned air plenum within concrete seating structure in auditorium (*top right*); lighting fixture cutouts in the Crit Room dome placed in formwork (*middle left*); cutout in dome concrete, (*middle right*); mechanical ducts below slab-on-ground (*bottom left*); and sprinkler pipes embedded in concrete ceiling above Crit Room and elsewhere (*bottom right*).

itself needed to be thickened by the depth of these lighting fixtures in order to provide adequate concrete cover for the bottom reinforcement bars, since the cover which ordinarily would have been provided at the bottom of the dome was compromised by the slots in the concrete cut out for the recessed light fixtures (fig. 2.6).

Complex and curved formal elements, like Milstein's dome, need not have been cast in concrete. The same geometry and expression can be achieved with less material, less money, and a greater ability to avoid conflicts between the structure and the building's electrical, mechanical, fire safety, and plumbing services. The Broad, an art museum in Los Angeles designed by Diller Scofidio + Renfro, achieves an equally complex formal expression of curved surfaces using plaster on lath—a technique often used in traditional construction—thereby avoiding all the constructional and functional complications seen in Milstein Hall (fig. 2.7).

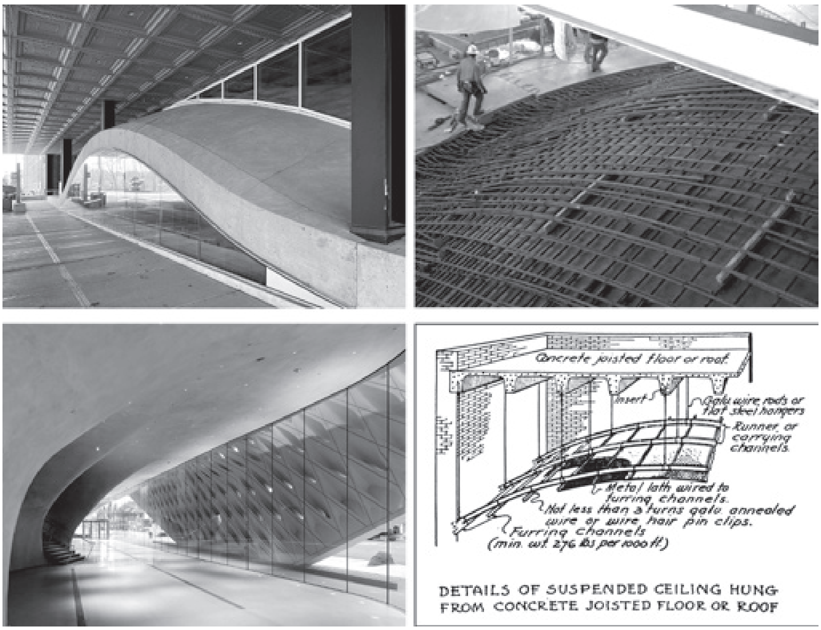


Figure 2.7. The Broad Museum (*bottom left*) creates a complex curvature using lightweight metal framing, plaster, and lath, similar in principle to traditional plaster techniques (*bottom right)*; while Milstein Hall's dome achieves a similarly complex curvature (*top left*), but with far greater cost and complication, using cast-in-place reinforced concrete (*top right*).

3 ROOM GEOMETRY

Doors and exits

Design guidelines, even when legally codified, cannot possibly cover all of the ways in which rooms or spaces might become dysfunctional. For example, something apparently innocuous, like the position of the office door in the plan shown in figure 3.1*a*, would make it impossible to accommodate a bookcase like the one shown in figure 3.1*b*, whose door position anticipates the space necessary for that type of furnishing and thereby increases the room's functionality and flexibility. This can be seen in Sibley Hall, the building connected to Milstein Hall where I had an office for many years. In the digital fabrication lab across the hall from my former office (fig. 3.1*a*, bottom), large objects such as desks, printers, and laser cutters create an awkward and inefficient space as they converge in front of the door in the room's corner. In order to enter and exit the room through the corner door, twice as much perimeter floor area must be reserved for circulation space as would be the case if the door occupied a position further from the corner, allowing a typical desk or another piece of equipment to squeeze in (compare fig. 3.1*a* and fig. 3.1*b*, *middle* images). In my former office, on the other hand (fig. 3.1*b*, *right*), a door opening relatively close to the corner still allows for narrow bookshelves to efficiently occupy the space between door and perpendicular wall.

Milstein Hall has virtually no rooms with conventional doors, except for a few exit doors, fire-barrier doors, and doors into service/mechanical rooms; and yet the same type of issue still emerges. For example, the exit door from the Crit Room into the auditorium was placed at the corner of the room, leading to frequent problems as people and objects block the fire exit on both sides—portable monitors are moved to the wall on the Crit Room side and chairs are placed against the wall on the auditorium side (fig. 3.2 *top*). Due to constraints that the geometry of the space places on design reviews, one also discovers a creative (and dangerous) deployment of chairs and models placed precisely in locations

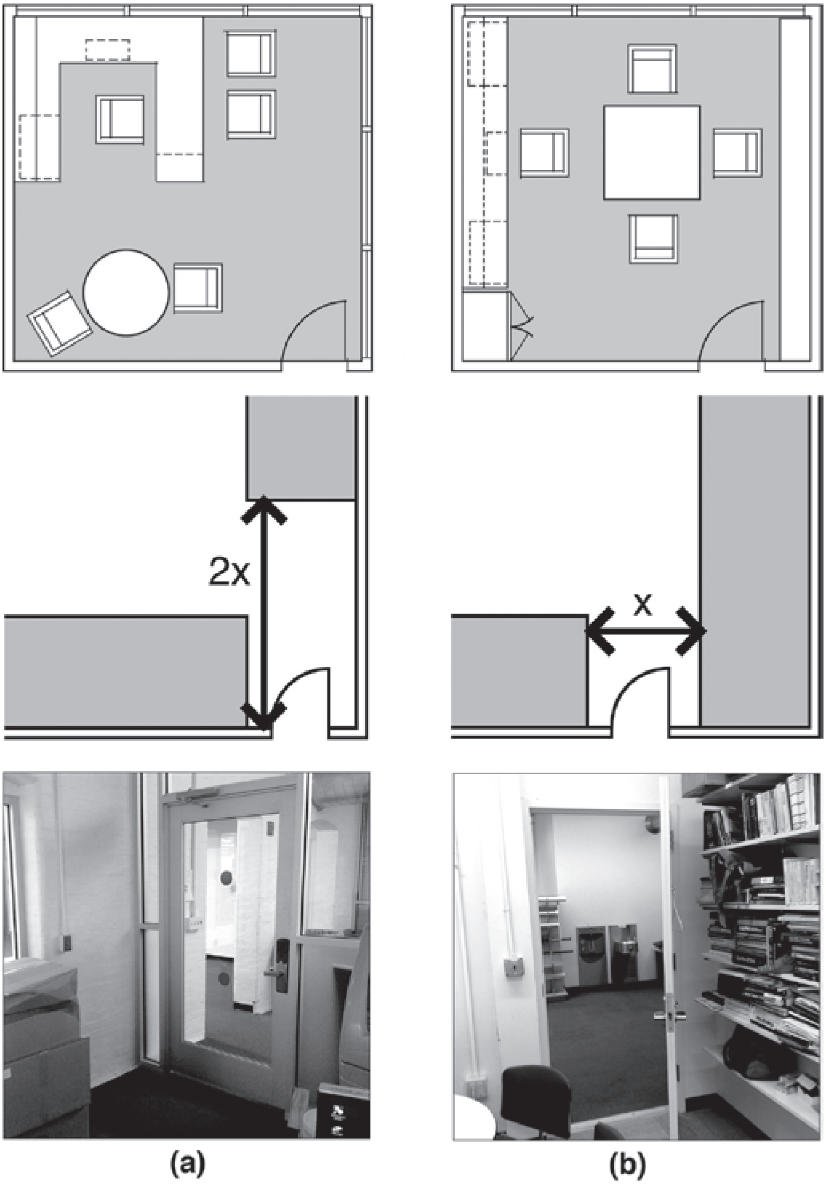


Figure 3.1. The position of a door in a room can affect its functionality, by allowing more or less use of wall space: A door placed at the corner (*a*) is less efficient than a door moved away from the corner (*b*); middle diagrams show schematically how more wall space becomes available in case *b* compared to case *a*; and photos at the bottom show two rooms representing these two door placement conditions.

blocking both of the room's egress points (fig. 3.2 *bottom*).

And speaking of egress, it certainly doesn't help matters when highly combustible black foamed plastic solids,[1] used as display stands

Figure 3.2. Position of exit door in the Milstein Crit Room makes it difficult to productively use the space immediately adjacent to the side wall for monitors and other objects necessary for design reviews, while still providing space for required exit access (*top*); the lack of clarity about egress paths also encourages the dangerous deployment of seating and presentation material blocking required exits (*bottom*).

for reviews and exhibits, are stored under the Crit Room stair (fig. 3.3).

Similar issues affect the position of the exit door leading to the outdoor stair in Milstein Hall's auditorium, as can be seen in figure 3.4, where—as in the Crit Room—the desire to place objects along the surface of the wall comes into conflict with the position of the door and the circulation required by that position.

Auditorium dysfunction

The dysfunctional geometry of Milstein Hall's auditorium may well have been exacerbated by two factors: first, the decision to place auditorium seating on the outer surface of a concrete dome enclosing the Crit Room; and second, the peculiar decision to place a set of leather-clad motorized chairs—intended exclusively for infrequent meetings of Cornell's Board

Figure 3.3. Highly combustible foamed plastic display stands are stored under the Crit Room exit stairway.

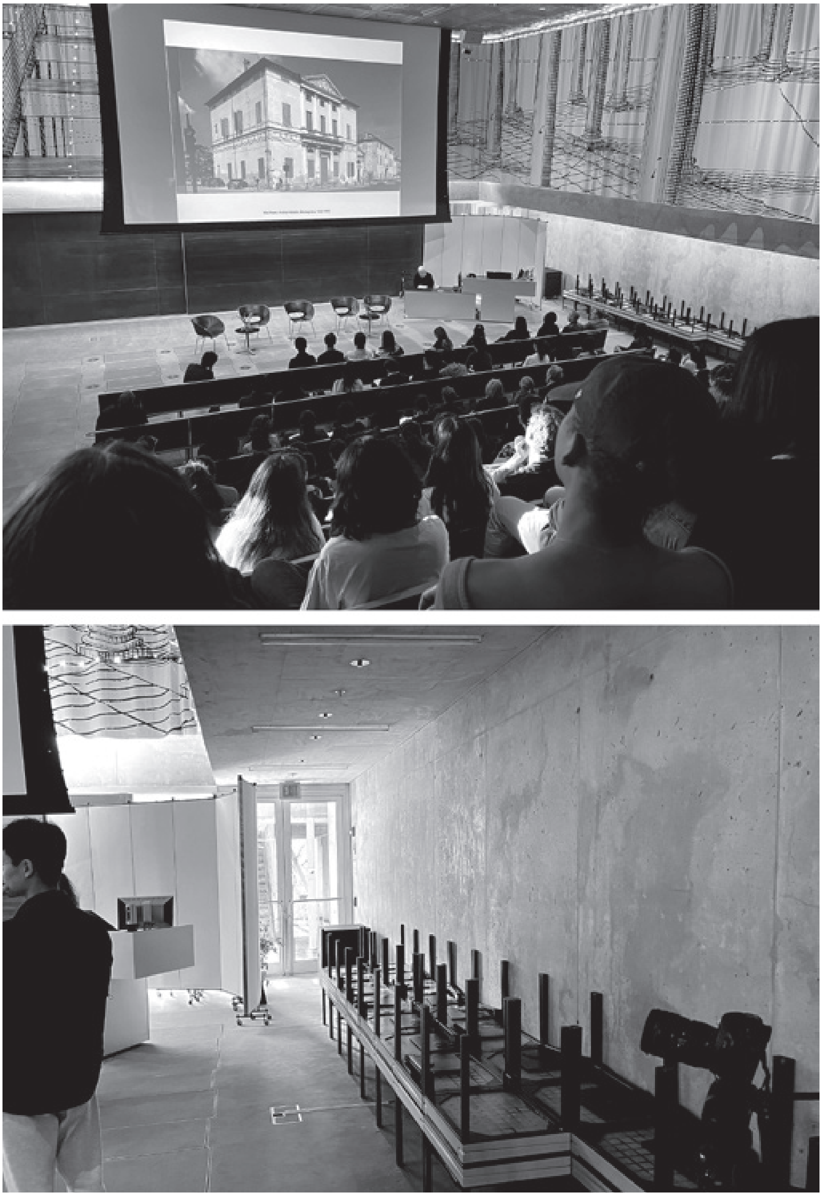


Figure 3.4. Position of an exit door in Milstein Hall's auditorium makes it difficult to productively use the space immediately adjacent to the side wall for either seats or required exit access. Peter Eisenman inaugurates the "Peter Eisenman Lecture Series" (*top*) on April 26, 2023, with a story about Colin Rowe and a certain Palladian villa projected on the screen, seemingly oblivious to the blocked exit door immediately to his left; the same blocked exit door is viewed from ground level (*bottom*).

of Trustees—at the front of the auditorium. Aside from the bizarre politics that resulted in Milstein Hall's auditorium being used for Board meetings, the underlying premise behind the actual design of these seats is so strange as to defy all efforts aimed at comprehension (fig. 3.5). Suffice it to say that comfortable and motorized leather seats are stored *under the raised floor* of the auditorium for use only three times a year when the Trustees are in town, at which times complex motorized mechanisms

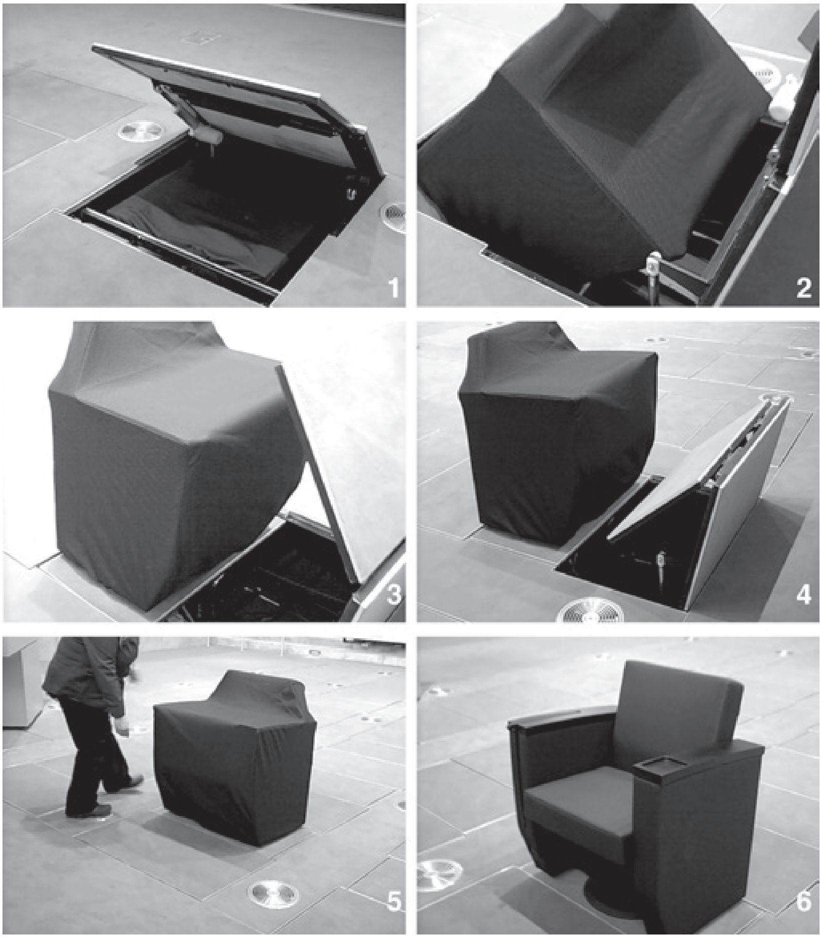


Figure 3.5. "Board of Trustee" seats mechanically rise out of their slumber at the bottom of Milstein Hall's auditorium.

are activated and the chairs rise out of their hidden spaces. In a quaintly anachronistic nod to the treatment of royalty (or perhaps to captains of industry), faculty and students—the common people at Cornell—are asked to use *ordinary chairs* that are moved in from some remote storage location when the Trustees leave Ithaca in their corporate jets.[2] But the complex mechanisms that raise and lower the Trustee chairs can easily break down: a panicky email was sent out to students and faculty in May 2013 ("Please note that no one should uncover or sit in the trustee seats for any reason") when some of the leather seats could not be returned to their hidden position, and it was necessary to leave them exposed to the *hoi polloi*.

The removable rows of "regular" seats that are brought in when the "Trustee" seats get lowered into their below-the-slab home are rarely used, since the sightlines to the projection screen from this part of the auditorium require an uncomfortable and unhealthy tilting of the head relative to the neck (fig. 3.6), well beyond the 15° maximum angle of incline recommended by experts, based on anthropometric data.[3] There is also a palpable sense that these lower seats are less desirable, perhaps because—being ad hoc, seemingly temporary, and placed on the same flat floor surface with the lectern—they deny users the anonymity gained by sitting further back on the sloped surface of the dome.

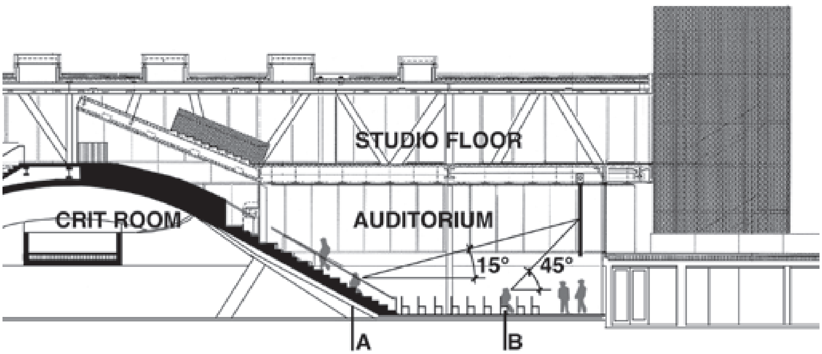


Figure 3.6. The seats at line "A" are the lowest acceptable seats in the auditorium, providing the maximum 15° inclined sightline to the midpoint of the screen; all seats below line "A," e.g., those shown at line "B," are uncomfortable and unhealthy.

Size

A common problem in interior rooms or spaces is inadequate size: difficulty opening a door to a toilet stall because it swings in against the toilet; difficulty leaving your seat at a dining table because there is not enough room behind the seat to easily pass through; difficulty in moving an appliance or large piece of furniture into a room because the door size, or corridor shape, does not accommodate the geometry of the item to be moved; and so on. Making rooms or spaces big—i.e., bigger than they would be to merely satisfy whatever minimum requirements have been calculated for the current function—is therefore an obvious remedy for functional problems of this sort, and also a factor in making a room or space flexible, i.e., able to accommodate different, or unanticipated, functional requirements. Yet "bigness" is also problematic from both a purely functional standpoint as well as an ideological one.

While size solves many problems, it does so by making buildings less efficient, where efficiency is here defined as providing adequate functionality at least cost. To compensate for merely adequate size, greater attention must be paid to various geometric or dimensional relationships within the room or space. Like size, this too has implications for flexibility, since room dimensions, wall geometry, and the position of fixed elements such as doors and windows can make a room not only more, or less, functional, but can also facilitate *changes* in the room's organization.

Some building geometries and dimensions lend themselves to adaptability better than others.[4] This is not to say a single building geometry can be found to accommodate all the activities encountered in modern society: an apartment house, for example, cannot be expected to easily transform into a museum. Still, within a given context, flexibility can be enhanced, rather than constrained, by planning for the types of activities, and their interrelationships, commonly encountered within that context, rather than designing precisely for the activities programmed at that point in time.

Stewart Brand argues, for example, that a small reduction of building width, from 64 feet (19.5 m) to 55 feet (16.8 m), constrains flexibility in typical academic buildings: "MIT's Main Building, which is still the core of the campus, is a web of high, narrow wings 64 feet wide—just right for a wide corridor in the middle, with space for a variety of classrooms, laboratories, and offices on each side. (A later MIT building of 55-foot width was found to be inflexibly restrictive.)"[5] On the other hand, such anecdotal observations cannot always be verified: many academic buildings seem to provide adequate space for offices and classrooms—even large lecture halls—with dimensions that are quite a bit smaller than Brand's "optimal" 64 feet (19.5 m). For example, both Rand Hall and Sibley Hall—buildings that connect to Milstein Hall—seem relatively flexible and adaptable with dimensions ranging from 45 feet (13.7 m) to 55 feet (16.7 m) in width.

Nevertheless, size matters, a fact that has led various architects to suggest that simply making things bigger solves many problems involving the anticipation of future needs. This is because whereas a larger space can usually accommodate any and all activities that "fit" inside its envelope—even when those activities require less space than is available—a smaller space can never accommodate activities requiring more space than is available. This much is self-evident, although it should be noted that some activities do require a space of a particular size, and would not function well in a space made arbitrarily bigger for the sole purpose of fostering flexibility. One would not, for example, expect a squash court to function properly if the distance between opposing walls was greater (or smaller) than 32 feet (9.75 m).

A space that is larger than required may indeed accommodate activities that "fit" within it (like the hypothetical squash court), but in doing so may require modifications, i.e., new or altered partitions, ceiling heights, mechanical/electrical services, and so on. Additionally, changes in occupancy may also trigger building code issues (especially related to fire safety and egress) or structural issues. This type of flexibility therefore comes with a cost, since such modifications may not only be expensive, but also may disrupt activities within the building while being implemented. In fact, the cost may be so great that such modifications are precluded, in which case the space's flexibility is to that extent moot.

Robert Venturi suggested that "most buildings should not be designed like a glove that fits every finger exactly, but like a mitten that allows 'wiggle-room'—flexibility—inside."[6] In the same vein, Kari Jormakka recounts an argument between Mies van der Rohe and Hugo Häring in which Häring explained a specific architectural geometry on the basis of a careful functional analysis: "Mies, however, rejected such attempts to optimize shape and told his colleague: 'Hugo, just make your rooms big, then you can do everything in them.' Although Mies is obviously right to a degree," writes Jormakka, "it is clear that any room which is equally good for every function is not particularly good for any of them, nor it is [sic] exactly economical."[7]

Here again, a note of caution is needed: while "bigness" is often useful in accommodating unanticipated functions, there is more to functional flexibility than mere size: issues involving acoustical separation, fire safety, accessibility, structural strength, plumbing, daylight, and so on, may well constrain not only the utility but also the flexibility of even the biggest space.

In Milstein Hall, the articulation of enormous cantilevered rigid frames (called "hybrid trusses" by the engineers and architects) was accomplished by making the floor plate bigger—i.e., by adding gratuitous space between the hybrid trusses and the glazed curtain wall around the entire perimeter of the building. The reasons for adding this unusable perimeter space may have had something to do with moving the lines of structure away from Rand Hall's brick facade in order to provide adequate space for column foundations or possibly to allow Milstein Hall's steel columns, those that support the trusses, to bypass the continuous brick water table at the base of Rand Hall. Perhaps elaborate floor-to-ceiling curtains needed a zone within which they could operate freely (although for reasons I explain below, the curtains are not consistently deployed between the trusses and the curtain wall and, in any case, the space provided is far in excess of what is required for this purpose). Alternatively, perhaps, a freestanding ideological interest in "wasted" space informed this design decision (fig. 3.7).

I make the case in one of my Milstein Hall construction videos[8] that

Figure 3.7. Excess space between windows and hybrid trusses in Milstein Hall encourages illicit storage of material.

the articulation of trusses on the building's east "gateway" side, but not on the building's west side, also betrays an archaic gendered sensibility that creates a zone of wasted space in order to prioritize "masculine" trusses over "feminine" curtains: "The trusses, with their hyper-extended cantilevers, are brought to the foreground in a classic display of heroic and masculine postering while the curtains, assuming the traditional role of the feminine and domestic, are pushed into the background."[9]

Waste

The potential flexibility of "bigness," in the case of Milstein Hall's studio floor, devolves into the pseudo-flexibility of waste. The space between trusses and glazing, while excessive, is hardly the primary reason for such gross inefficiency. As illustrated in figure 3.8, the programmed space on Milstein Hall's studio floor—including studio classrooms, assembly spaces (wood-floored studio lounge and small stepped auditorium), and worktables—constitutes barely over 55 percent of its 26,442 gross square feet (2,457 square meters), an inefficient and wasteful net to gross ratio. In contrast, the net to gross ratio in Rand Hall, when it served as studio and support spaces—before its conversion into the present Mui Ho Fine Arts Library—was over 80 percent.

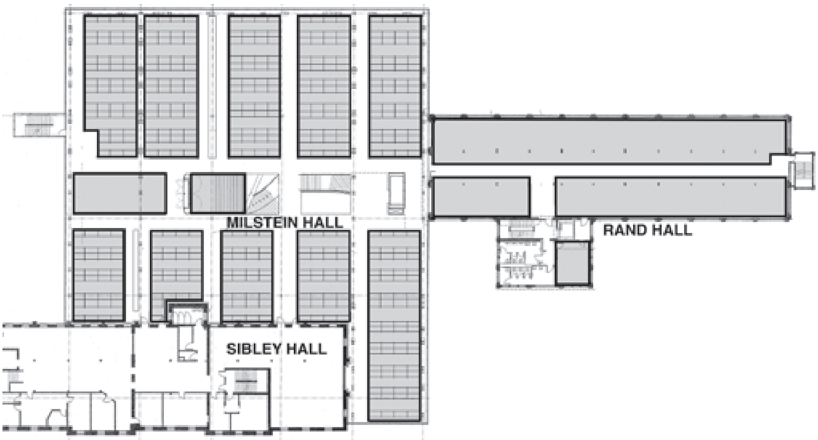


Figure 3.8. Rectangles with gray tone outline programmed studio and support spaces in Milstein Hall and Rand Hall (when Rand Hall was used for such purposes, before its conversion into the Fine Arts Library). In computing the net to gross ratio for Milstein Hall, the required bathrooms and exit stairway in Rand Hall are included.

One might think that the large amount of unprogrammed space on the studio floor of Milstein Hall would at least contribute, somehow, to the culture or ambiance of the architecture program, but one would be wrong: these spaces are unused and unloved (fig. 3.9, *top*). And, unlike the more efficient studio layout previously deployed in Rand Hall, the Milstein layout provides no clues as to the identity of individual studios or the various studio years and programs; no walls or partitions for pinning up drawings or for informal reviews; no control over visual or acoustic privacy; and—even with such an extravagant net to gross floor area ratio—no sense of spaciousness (fig. 3.9, *bottom*).

The theory of waste in fashion and architecture has an interesting trajectory, beginning in the mid-nineteenth century with the religious idealism of John Ruskin, reaching a high point in the late-nineteenth- and early-twentieth century with the caustic insights of Thorstein Veblen, and descending to an almost comically servile status with the writings and work of Rem Koolhaas, co-founder and principle intellectual guru of OMA. I describe this trajectory in my book, *Building Bad*:

> For Veblen, addressing ostensibly useful questions is nothing more than a smokescreen employed to soft-sell fashionable (wasteful) content. … "If beauty or comfort is achieved—and it is a more or less fortuitous circumstance if they are—they must be achieved by means and methods that commend themselves to the *great economic law of wasted effort*."
>
> The idea that waste is an important element of architectural design not only precedes Veblen, but survives, intact, well into the 21st century. But unlike Veblen's negative and caustic analysis, some influential theorists, both before and after him, turn his critique upside-down. John Ruskin, for example, criticizes the "modern" interest in efficiency by extolling the virtues of apparently wasteful expenditures, writing that the "Spirit of Sacrifice . . . is a spirit, for instance, which of two marbles, equally beautiful, applicable and durable, would choose the more costly because it was so, and of two kinds of decoration, equally effective, would choose the more elaborate because it was so, in order

Figure 3.9 (facing page). Unprogrammed space is unused and unloved (*top*); and the layout provides neither clues to the identity of individual studios nor partitions for privacy and pin-ups (*bottom*).


WE
RECYCLE

that it might in the same compass present more cost and more thought. It is therefore most unreasoning and enthusiastic, and perhaps best negatively defined, as the opposite of the prevalent feeling of modern times, which desires to produce the largest results at the least cost."

On the other hand, the Dutch architect Rem Koolhaas acts more like Veblen's acolyte. Referring to his own work for the luxury Italian fashion house Prada, for example, Koolhaas remarks: "At the time we started collaborating, everything in the world of art and fashion was polished. Everything was smooth, so we felt that Prada must be rough. *We put an emphasis on concepts like waste. In real estate terms, the ultimate luxury is wasted space*." Compare this with Veblen's "great economic law of wasted effort" in the service of luxury.[10]

Perhaps the most outrageous expression of elitist waste can be seen in OMA's rendering showing their proposal for an oversized glass-paneled elevator servicing the three floors of Milstein Hall, in which was placed an explicitly useless, but symbolically potent, Barcelona chair (fig. 3.10). As I wrote in a blog post in 2009, before the building was completed and in the wake of the financial meltdown of 2008:

Figure 3.10. OMA's original rendering (*left*) showing Barcelona chair in the Milstein Hall elevator; this was ultimately replaced with a plain vanilla chair (*right*). Neither the chair nor the lamp was ever actually purchased and installed (but a floor-mounted electric outlet in the elevator's plywood floor, located precisely where the lamp would have been, survived the budget cuts).

> In a stunning, though entirely symbolic, concession to economic pragmatism or, more likely, to mitigate Milstein Hall's apparent extravagance and elitist sensibility at a time when workers are being laid off and faculty salaries are frozen, Cornell has eliminated the symbolic centerpiece of Rem Koolhaas's design for its new architecture building: Ludwig Mies van der Rohe's iconic Barcelona chair has been rendered out of the official rendering of Milstein's glass elevator, replaced with a plain vanilla chair.[11]

Thus, it is clear that OMA is predisposed to think of waste in positive terms, as a mark of wealth and status ("the ultimate luxury"). What is interesting about reframing "bigness" as "waste" is that, in this transformation, the rationale of increasing minimum spatial requirements to foster flexibility—grounded in a pragmatic functionalism—is replaced with little more than a transparently elitist sensibility. This, then, is the function of wasted space in Milstein Hall: to serve as a didactic clue for architecture students who might otherwise be tempted to search for more socially conscious (politically correct) content as they prepare to join their historically aristocratic profession.

Shape

Many guidelines exist for minimum room dimensions, both in architectural handbooks such as *Architectural Graphic Standards* as well as in building codes, which provide minimum dimensions for room widths and areas. Handbooks of architectural data tend to be somewhat generic and arbitrary in their determinations of what, exactly, constitutes functional space in various building types. Such handbooks provide useful information about functionality of interior rooms and spaces—mainly in the form of plans, sections, and tabulated data—for common building types based on precedents that capture the conventional wisdom, but do not typically derive from, and cannot necessarily be justified by, a logical theory of function. Building codes, on the other hand, provide only minimum dimensions and areas for rooms, and in written, rather than graphic, form. As an example, the 2002 *New York State Building Code*, under which Milstein Hall was permitted, requires that "every dwelling unit have at least one room that shall have not less than 150 square feet (13.9 m^2) of net floor area. Other habitable rooms except kitchens shall have a net area of not less than 70 square feet (6.5 m2)."[12]

In such codes and guidelines, it is often assumed that the boundaries of rooms are orthogonal, yet the building code would permit a habitable room to be cylindrical in shape, as long as its diameter was at least 9.44 feet (2.88 meters) to satisfy the minimum area requirement of 70 square feet (6.5 square meters). Orthogonal rooms have the same minimum area requirement, but the smallest plan dimension can be as little as 7.0 feet (2.13 meters). That rooms function better with an orthogonal geometry is fairly well established, but there are some dissenting views. Frank Lloyd Wright, for example, worked extensively with non-orthogonal grids. Speaking about his Hanna House in California, he said: "We call it the Honeycomb House because the structure was fashioned upon a hexagonal unit system. The hexangle is better suited to human movement than the rectangle."[13] A similar "organic" argument was made by Adolf Behne about 15 years earlier, in his mid-1920s book on the modern, functional building: "The rectangular room and the straight line are not functional but mechanical creations. If I were to work consistently from biological function, then the rectangular room is nonsensical, for its four corners are unusable dead space. If I were to outline the areas in a room that are actually used and walked upon, then I would inevitably arrive at a curve."[14] Yet even Behne was forced to admit that the aggregation of several curved rooms is problematic: "It is correct to say that a single rectangular room is uneconomical, that a curve is a better biological transcription of real usable space. But if it is a matter if arranging several rooms together, the result is different."[15]

There are essentially three arguments favoring the functionality of right angles. First, vertical walls (i.e., walls perpendicular to a horizontal ground or floor plane) have several functional advantages, as explained by dome "apostate" Lloyd Kahn: "They don't catch dust, rain doesn't sit on them; easy to add to; gravity, not tension, holds them in place. It's easy to build in counters, shelves, arrange furniture, bathtubs, beds. We are 90 degrees to the earth."[16] In Milstein Hall, nonvertical walls can be found in the Crit Room (under the "dome"), on the south face of the auditorium and entry, and, therefore, on the north face of the covered arcade. In the Crit Room, sloped surfaces preclude the display of work, and must be isolated from the rest of the space since they would otherwise act as protruding objects. In other words, the slope is both wasteful and dysfunctional (since it prevents both floor area and wall area from being used productively). The sloping curtain wall separating the arcade from the auditorium and entry is similarly wasteful and dysfunctional—for the same reasons—and also must be isolated from the main arcade space by cane-detection guards since it would otherwise protrude into the arcade space in violation of ADA and building code requirements for accessibility. I discuss this aspect of Milstein Hall's dysfunction in the section on accessibility in chapter 6.

Second, things fit well, nest well, and tile well when disciplined by an orthogonal grid. Stewart Brand argues that: "Right-angled shapes nest and tile with each other universally, so tables fit into corners, and clothes into closets, and buildings into city lots, and lots into city blocks." Christopher Alexander is somewhat more lenient about the necessary precision implied by the functional logic of the right angle, but arrives at essentially the same conclusion: "It is an uphill struggle to make an acute angle in a room, which works. … Most often rooms will pack in such a way that angles somewhere near right angles (say between 80 and 100 degrees) make most sense. The reason, simply, is that other obtuse angles do not pack well at corners where several rooms meet."[17]

Milstein Hall is able to "pack" its nonorthogonal and domed Crit Room into the larger floor plan of the building because it tolerates wasted space on its curved boundary with the adjacent auditorium (fig. 3.11) and because its other neighbor is a mechanical room, whose

Figure 3.11. Much of the floor area of the Milstein Hall auditorium is unusable because of the way it is cut into the curved surface of the concrete dome; the large space has remarkably little seating capacity.

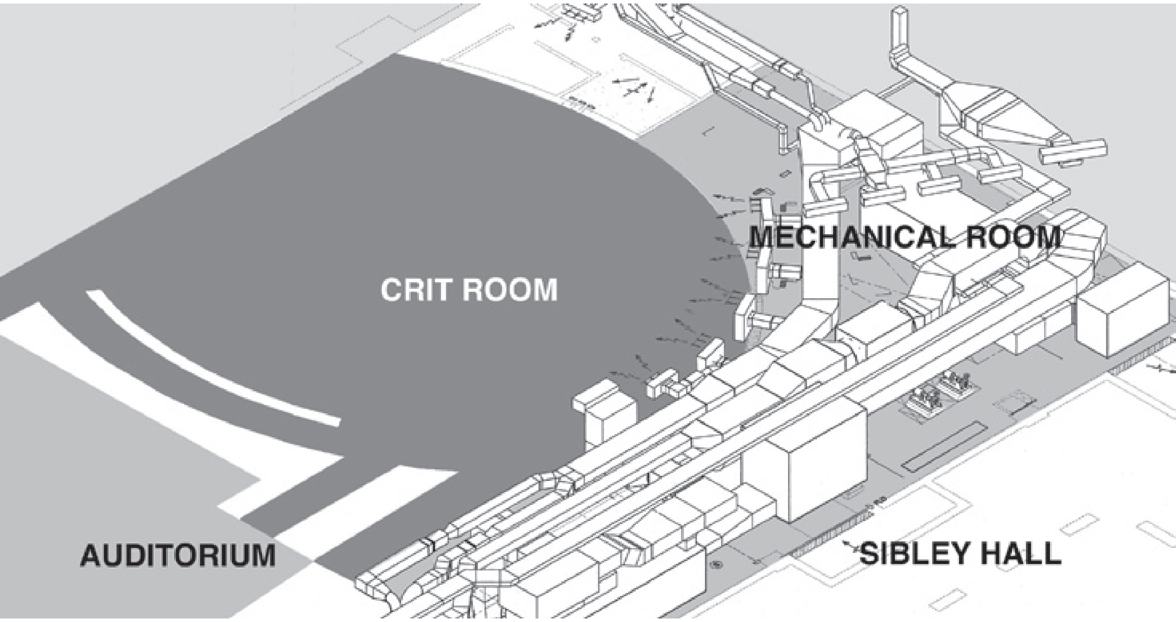


Figure 3.12. Mechanical 3-D diagram (adapted from the Milstein Hall mechanical working drawings by the author).

equipment has sufficient flexibility to accommodate the curve (fig. 3.12). In any case, with structural reinforced concrete loadbearing walls defining the boundaries of this curved space, there is little opportunity to make significant functional or spatial adjustments in the future.

Third, the straight sides of rectangular buildings can be constructed with straight elements; these, in turn, are intrinsic to manufacturing processes for many building products including float glass, rolled steel, extruded aluminum, sawn lumber, etc. It's not always possible (or easy) to bend and distort the constituent pieces of a total assembly, even if it is increasingly easy to *represent* such things in drawings or digital models. What is true for surfaces (flat versus bent or curved) is also true for the intersections of surfaces: A right angle connection is always easier to make than one at an acute/obtuse angle. For example, standard connections in structural steel rely on clip angles that are manufactured with right-angled legs; standard joist hangers in light wood framing assume right-angle relationships between joist and girder; standard reusable formwork in reinforced concrete construction, whether for grid-slab floors or intersecting walls, works best within an orthogonal design; and so on. And even if some materials can be bent or curved, difficulties often emerge where "secondary" materials (e.g., baseboards, handrails, copings, etc.) attempt to follow their deviant geometries. Of course, it is possible to overcome such problems with sufficient time, research, and the expenditure of money, but the culture of building in contemporary society works against such careful detailing, as each party involved—architects, consulting engineers, contractors, and their subcontractors—seeks to maximize their profit by reducing the amount of time spent on design research, detailing, and construction.[18]

4 PRIVACY AND CONTROL: LIGHTING AND ACOUSTICS

A basic principle of function and flexibility is control over the parameters that determine how a space accommodates various conditions desired by users of that space. Such parameters include basic environmental prerequisites for comfort, measured by air speed, temperature, humidity, and air quality; but also illumination levels, visual privacy, acoustical quality, and acoustical separation.

Lighting and glare

In several of Milstein Hall's rooms and spaces, the control of lighting is problematic. In both the auditorium and second-floor studio space, glazing is deployed without consideration of potential negative impacts caused by the position of the sun in relation to the activities intended for the spaces. Modern auditoriums, like movie theaters, are almost always darkened in order to project images on a screen. But Milstein Hall's auditorium, according to OMA, is wrapped in a glazed curtain wall to enable "views both into the lecture theatre for passersby and out of it for students." [1] In other words, the actual utility of the auditorium—providing a comfortable setting for lectures involving digital projection of images or videos—is compromised in favor of gratuitous visual connections between inside and outside.

This notion that "passersby" should be able to peer into classroom or event spaces, without being able to actually participate in the activities revealed to them as they walk by, is symptomatic of the superficial "branding" attitude that pervades architectural culture, one that values imageable (Instagrammable) moments rather than function and content. I won't bother rebutting the equally specious argument that auditorium windows are useful because students can look out of them. It should also be noted that these windows are not placed along circulation paths that are commonly used, so there simply are not enough "passersby" to justify this move, even if, in principle, it was a good idea. University Avenue, on the north side of both the auditorium and Crit Room windows, provides vehicular access to Milstein, Sibley, and Rand Halls, but is rarely used by pedestrians. In fact, the sidewalk directly in front of these windows neither connects with the main pedestrian intersection to the east, at Feeney Way (formerly East Avenue), nor extends westward beyond Milstein Hall itself. It exists primarily to host a bus stop, from which students generally move directly south to the Arts Quad, and to provide a landing spot for two of Milstein Hall's egress stairs (fig. 4.1).

Moreover, the University Avenue sidewalk is actually depressed by about three feet (about one meter) from the level of the auditorium

Figure 4.1. Because the sidewalk adjacent to Milstein Hall's auditorium on University Avenue does not extend in either direction beyond Milstein Hall itself, there are virtually no people who use it, and therefore virtually no passersby who might look into the auditorium or through the eyebrow window into the Crit Room. The extent of the sidewalk is indicated by the white arrow.

windows and is separated from those windows by what appears to be *another* sidewalk, or concrete platform, precisely at the level of the auditorium windows. This latter platform—part of a pseudo-podium defined by the concrete foundation walls of Milstein Hall's basement level—forms a continuous horizontal surface that wraps around all sides of the auditorium, potentially providing passersby with views into the auditorium. The problem with this continuous exterior viewing platform (podium) is that it is inaccessible to pedestrians: a metal guard rail blocks access from the plaza on the west side of the auditorium, creating a puzzling dead-end circulation path leading nowhere (fig. 4.2).

The windows on the south side of the auditorium face the "Duane

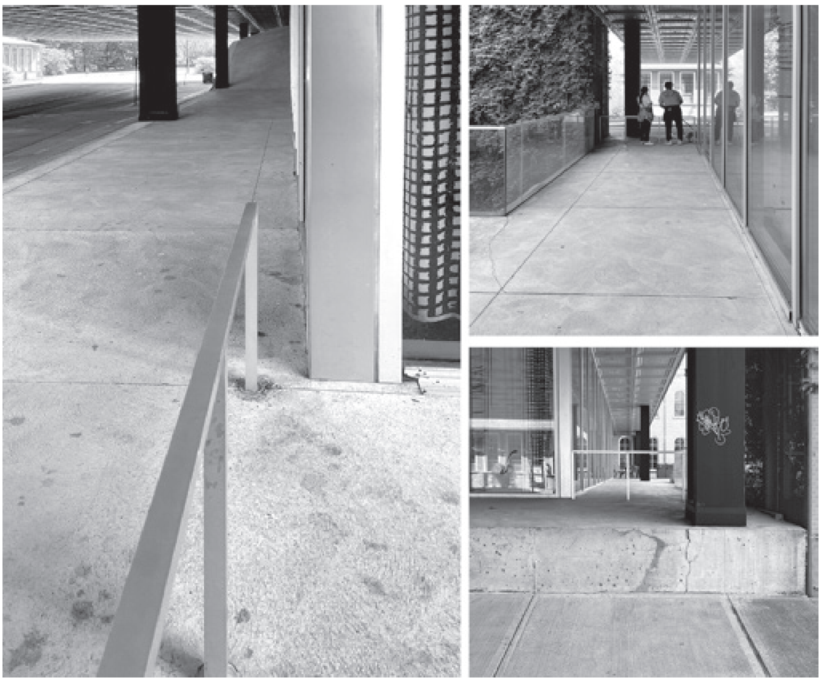


Figure 4.2. Two visitors walk to the end of Milstein Hall's path to nowhere (*top right*); the guard rail blocking access to the auditorium windows on the north facade can be seen from University Avenue (*bottom right*); and even if one hopped over, or slid under, this guard rail, the upper sidewalk/platform/podium parallel to University Avenue also leads nowhere, terminating in the curved concrete surface of the dome (*left*).

Figure 4.3. Windows on the south side of Milstein Hall's auditorium face the "Duane and Dalia Stiller Arcade," a dismal and dark outdoor covered space that is almost always empty.

and Dalia Stiller Arcade," a dismal and dark outdoor covered space that is almost always empty (fig. 4.3), for reasons discussed in chapter 6. There have been attempts to program this arcade with activities—for example, as a gathering place for food and drink used in conjunction with events in Milstein Hall's auditorium or Crit Room—but the lighting is poorly designed and illumination levels in this space are grossly inadequate (fig. 4.4). It doesn't help that some of the LED lights that have been integrated into the sloping curtain wall mullions are almost always defective (fig. 4.5), even with periodic visits from puzzled electricians—another instance of locking "quick" systems (the custom-designed lighting fixtures) within "slow" ones (the sloping mullions).

To make it possible to actually use the auditorium, compensatory measures need to be taken: the glazing needs to be inordinately thick to provide acoustical separation between inside and outside, and a complex

Figure 4.4. Milstein's arcade, viewed from the Milstein plaza (*right*) and from outside Rand Hall (*left*), remains dark and uninviting, even with soffit lights and integral curtain wall mullion fixtures turned on.

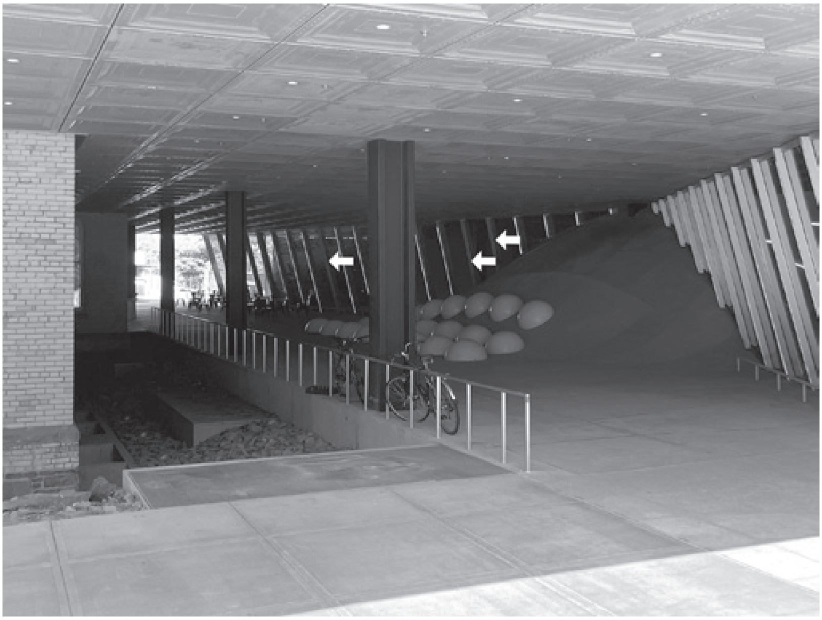


Figure 4.5. Some of the custom-designed LED lighting fixtures in the arcade that have been integrated into sloping curtain wall mullions turn themselves off for mysterious reasons, even after visits by puzzled electricians.

Figure 4.6 Glare on the projection screen in Milstein Hall's auditorium is presumably caused by the low western light working its way through decorative grommets in the curtains and bouncing off reflective surfaces in the auditorium.

system of mechanically operated shades and curtains must be deployed in order to darken the room. The curtains at the front of the auditorium are particularly stressed by the low western sun during late afternoon or early evening events. The sun penetrates through decorative grommets in the curtains, forcing unlucky attendees to adjust the position of their heads to avoid these laser-like rays; at the same time, patches of unwanted light emerge on the screen, presumably caused by light bouncing off of reflective surfaces in the auditorium itself (fig. 4.6). And, of course, the need to deploy blinds and curtains to control lighting levels in the auditorium contradicts the desire for "views both into the lecture theatre for passersby and out of it for students" (fig. 4.7).

The same western sun and the same floor-to-ceiling wrap-around glazing has a similar effect in the second-floor studios. In particular, a specially designated wooden "studio lounge" area (the rest of the studio floor is concrete)—situated along the western curtain wall and intended for special events, reviews, or presentations—is also negatively impacted by excessive lighting levels during late afternoon or early evening events. In this space, even with curtains drawn, the western sun makes it virtually impossible to use portable LCD mobile units when they are positioned facing the windows. The situation is equally bad when the monitor is turned to face the opposite direction since, in that case, audience members must deal with glare and high heat loads, even with ad hoc barriers placed in front of the drawn curtains (fig. 4.8). The lack of separation between this assembly space and adjacent studios creates additional acoustical problems for both the events scheduled in this space as well as in the adjacent studios.

A description of Milstein Hall's second-floor studio lighting—found on OMA's website—claims that the space is "all suffused with light from floor-to-ceiling windows and a grid of skylights."[2] Skylights were placed on the roof to compensate for the large distances from the interior of the studio to the perimeter curtain wall, in theory creating a relatively even level of illumination over the entire floor plate. But this theory is challenged by several dysfunctional design decisions.

Figure 4.7. Blinds and curtains are often deployed in the Milstein Hall auditorium, blocking all views, both in and out, and thereby negating the rationale for wrapping the auditorium with glass in order to allow this hypothetical and counterproductive visual interconnection.

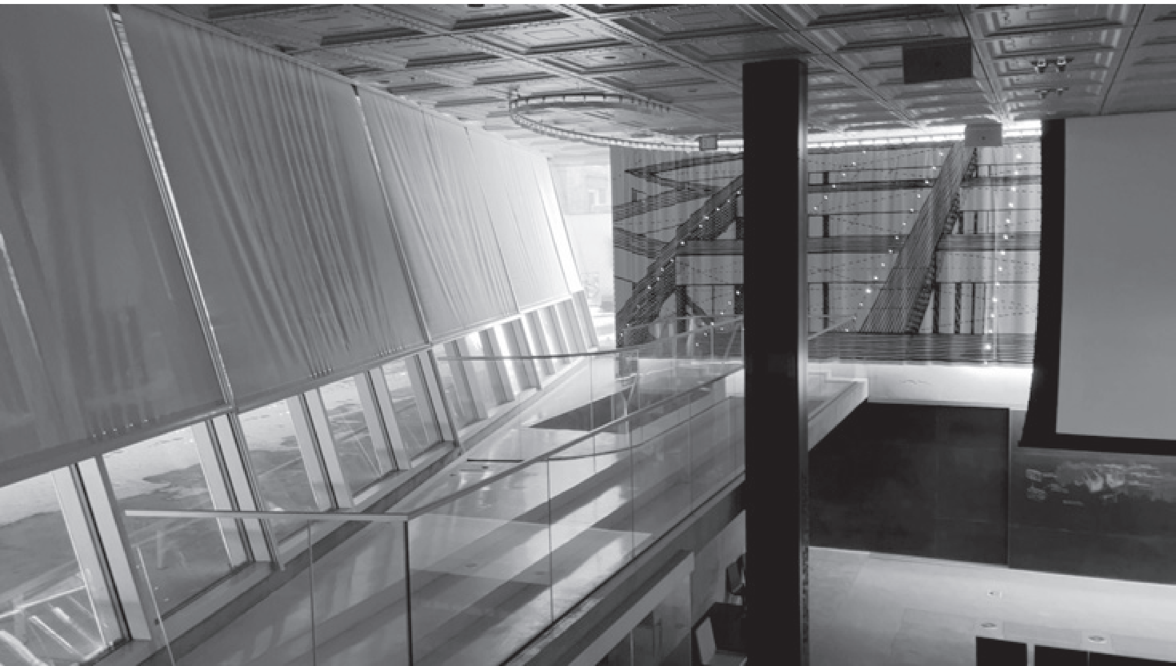


Figure 4.8. The special wood floor assembly area in Milstein Hall becomes uncomfortable and dysfunctional in late afternoon and early evenings as the western sun penetrates through the floor-to-ceiling glazing, even with curtains drawn and ad hoc barriers placed in front of the curtains. Students at this "Living Room" event held on April 19, 2023, with Nancy Lin and Curt Gambetta, shield their eyes (*top*) against the sun and its glare (*bottom*).

First, floor-to-ceiling glazing is deployed around the entire floor, irrespective of its orientation. Problems with the western sun have already been noted, but there are also problems with unwanted sun coming through glazed facades facing east and facing south. Second, skylights were designed with relatively transparent glass, tilted slightly to the north, but not tilted sufficiently to block direct solar gain and glare from the high southern sun (fig. 4.9). Naturally, the degree to which this affects any given student depends on the season, the time of day, and the position of the student's desk and monitor relative to the sun's angle. And unlike the glazed perimeter, which is provided with curtains (albeit not always effective in controlling the lighting conditions in the space), the skylights have no means of controlling light—no baffles, no blinds, no shading devices.

North light is well known to be desirable for northern-hemisphere

Figure 4.9. The southern sun penetrates through the glazed skylights, creating conditions of glare.

artists, especially painters, since it consists entirely of ambient light and is therefore more constant and consistent, eliminating glare associated with direct light. Such north-facing windows or skylights can be seen in the college's art facility, Tjaden Hall (fig. 4.10). Yet even truly north-facing windows or skylights would not solve the problem of lighting in Milstein Hall's design studios. Like traditional painters, architects typically work with media and modalities that are extremely sensitive to ambient illumination levels and glare. But unlike traditional painters, architects sometimes must reduce or eliminate even ambient light: *control* of light is more important than its orientation.

Third, studio spaces are open (and often occupied) 24/7, so that electric lighting must be provided during those times when the studio might not be sufficiently "suffused with light." Based on descriptions provided by the architects, *ArchDaily* reported that "lighting is programmed by a highly customizable and efficient Lutron control system connected to daylight sensors to maintain constant light levels that balance the daylight with artificial light."[3] But it turns out that the lights are always on (triggered by motion sensors, but not by light sensors), even during the day, negating the entire rationale on which the sophisticated skylight pattern was based. And the "efficient Lutron control system" is

Figure 4.10. North-facing skylights and windows—appropriate for artists, especially painters—can be seen in Tjaden Hall, the college's facility for fine arts.

apparently incapable of handling anything other than fluorescent tubes, so a logical transition to energy-efficient LED tubes was never made.

Individual studios and individual students therefore have no control over the illumination levels in their space. Electric lights are automatically turned on whenever human motion is detected, irrespective of any ambient light that may be present. What results is the worst of all possible outcomes: the skylights and perimeter glazing, when they are not creating too much glare or unwanted illumination, are entirely redundant since electric lighting is turned on 24/7 (without any user control); and the extensive glazing of the perimeter and roof creates enormous gaps in the thermal control layer, resulting in the needless energy consumption.

A similar inability to control lighting compromises the functionality and flexibility of the Crit Room. Aside from the fluorescent fixtures permanently embedded in the reinforced concrete dome—problematic for violating the basic principle of "shearing layers of change" and for affecting the concrete cover that protects the reinforcement, as described in chapter 2—the flexibility of the room is hopelessly compromised because light entering through a large "eyebrow" window, facing University Avenue, cannot be controlled: the room can never be darkened (fig. 4.11).

Figure 4.11. Eyebrow window in Crit Room.

Acoustic and visual privacy

Lack of visual privacy and acoustical isolation are related to each other and are particularly problematic in Milstein Hall. Their relationship is clear: a visual sightline, unless mediated by transparent glazing, is also an acoustical connection. In many cases where a visual connection is desired by architects seeking to overcome the spatial boredom of separated rooms, neither the destruction of visual privacy nor the ramifications of acoustical interpenetration are adequately considered.

There are three acoustical functions that need to be addressed in buildings, two of which are relevant to interior rooms and spaces: first, sound *quality* within any given room, and second, sound *isolation* between adjacent rooms or spaces. The third aspect is a function of the building enclosure—isolating interior spaces from outside sound (e.g., highways or airports) or isolating exterior spaces from interior sound (e.g., loud music).

The first two acoustical functions are often problematic in contemporary architecture, in part because architects are trained to "view" architecture as a predominantly visual phenomenon. The architectural *parti* is a diagram schematically representing spatial organization, and architects are trained to "see" space through vision. The primary tool used to design, represent, and communicate about space is the drawing (whether sketched or precisely delineated, hand-drawn, or digitally modeled, orthographic or perspectival), and drawings contain information that can only be seen (i.e., neither heard, smelled, tasted, nor touched). That sight is prioritized in architectural design and criticism is hardly illogical, since most critically important information in the built environment is accessible primarily through vision.

Still, acoustical quality remains an important, and sometimes a critically important function, of rooms and spaces in terms of their ability to flexibly accommodate varying functions. Restaurant dining rooms with consistently hard surfaces (i.e., with *no* fabric wall coverings, carpeted floors, or acoustically treated ceilings) are beloved by architects with both "minimalist" and "brutalist" sensibilities; their visually informed design preference results in a sonic environment characterized by a loud, reverberant background din that can make conversation difficult and, if attempted, virtually unintelligible. On the other hand, the same spatial and surface conditions might be perfectly functional in a context where such a background din was desired. Acoustical quality, therefore, must be judged in relation to its functional intention.

Consider, for example, the Guastavino Company's vaulted "whispering gallery" in front of the Oyster Bar at Grand Central Terminal in New York City, which produces (whether intended or not) an interesting and tourist-worthy sonic effect.[4] The same effect—unexpectedly hearing conversations (or in this case, critiques) occurring across the room due to sound "traveling" along the contours of a circular or otherwise curved form—makes the Milstein Hall Crit Room acoustically dysfunctional, especially when more than one design review is scheduled for the same time in different sections of the space (fig. 4.12).

Perhaps a more common acoustical problem occurs when adjacent rooms are not acoustically isolated from each other. This happens not only when walls, partitions, and floor-ceiling assemblies are not properly designed to attenuate both air-borne and structure-born sounds, but when architects become so enamored of spatial continuities and transparencies—whether literal or phenomenal—that they ignore functional considerations that cannot be "seen." Christopher Alexander and Serge Chermayeff argue that "the conflict between the current image of 'visually exciting' open space and the functional specifications for a modern dwelling capable of meeting the demands of the electronic age is obvious. Those who are sharp of hearing and sensitive to interruptions are better off if they live in houses of an earlier structural technology where, as it happens, the separate, insulated rooms are better suited to present-day communications."[5]

Figure 4.12. A Guastavino vault in Grand Central Terminal in New York City (*left*) acts as a "whispering gallery" in front of the Oyster Bar restaurant; the same effect makes conversation difficult in Milstein Hall's Crit Room (*right*), which was designed below a domical concrete surface.

One classic instance in which visual/spatial continuities are prioritized at the expense of acoustical separation occurs in Le Corbusier's Unité d'Habitation apartment building in Marseille, France. The famous cross section (fig. 4.13) shows how two 2-story dwelling units, occupying a total of three floors within the larger apartment slab, wrap around a single access corridor. This clever geometry reduces the number of corridors, while allowing each unit to have windows on opposite sides of the building (thereby promoting through-circulation of air) as well as providing dramatic volumetric relationships (*visual* connections) between living, dining, and sleeping areas. However, linking the primary sleeping area with living, dining, and kitchen functions presumes a lifestyle in which acoustical (or visual) isolation between those spaces would never

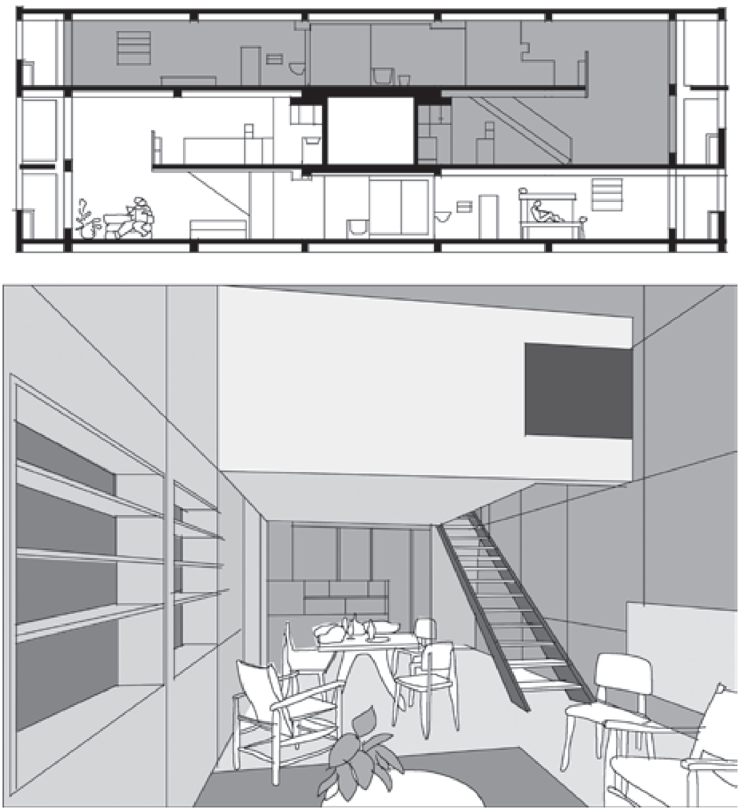


Figure 4.13. Le Corbusier's Unité d´habitation apartment house in Marseille, France, with interlocking section (*top*) and view of apartment (*bottom*) with no acoustical separation between living, dining, kitchen, and master bedroom.

prove useful or necessary, i.e., a lifestyle designed to satisfy the *architect's* interest in spatial and visual connections rather than each apartment dweller's need for privacy. Privacy takes many forms, some of which are acoustical in nature. For example, one member of a household might choose to listen to music, television, or radio, or to play a musical instrument; while another member of the household might prefer to be sleeping, or listening to something else, or engaging in an activity for which concentration and relative silence is preferred. The deliberate creation of spatial/visual connections of this sort (and therefore of acoustical continuities) presumes a degree of coordination—or control—by one dominant member of the household, whose preferences govern the behavior of the entire family unit.

Several similar instances of dysfunctional acoustical continuity occur in Milstein Hall at Cornell. Glass doors that visually connect the auditorium to the adjacent Crit Room and the adjacent corridor do not provide acoustic isolation, so that people having conversations in either space disrupt events in the adjacent space (fig. 4.14). Put another way, it is not possible to schedule events in both the auditorium and the Crit Room at the same time.

Figure 4.14. Glass doors provide no acoustic isolation for the auditorium. From top-left, clockwise: glass door from entry-level bridge; glass door from second-floor studios; glass doors into adjacent crit room; and glass door to corridor.

Similarly, the smaller stepped auditorium on the second floor, "an informal presentation and meeting space set within the open studios,"[6] also lacks acoustical separation. This latter space has other issues—for one thing, it was designed *without seats*, presumably because students would never object to sitting on uncomfortable and filthy plywood steps—but its main problem is the complete lack of visual or acoustic separation from the design studios that surround it on all sides, based on the ocularcentric belief that "digital presentations, seminars, or broadcasting of the main auditorium events"[7] require neither acoustic isolation from adjacent studios, nor generate noises that might interfere with faculty or students attempting to work in the studios themselves (fig. 4.15).

Additionally, the studios surrounding the small, stepped auditorium are not acoustically isolated from each other—instead, an "adaptable and open floor plan on the top level provides opportunities to respond to the changing needs of design curriculum,"[8] that is, provided that visual and acoustical privacy are not among those "changing needs."

Figure 4.15. The "stepped auditorium" in Milstein Hall at Cornell University has no actual seats, and is neither visually nor acoustically separated from adjacent studio spaces.

Finally, the same Crit Room that mimics the behavior of a whispering gallery also has no acoustical separation from vertically connected bridges and studio classrooms on the floors above, so that even ordinary circulation from the main building entrance, over the trussed concrete bridge, to the main auditorium or lower-level gallery interferes with ongoing design reviews (fig. 4.16).

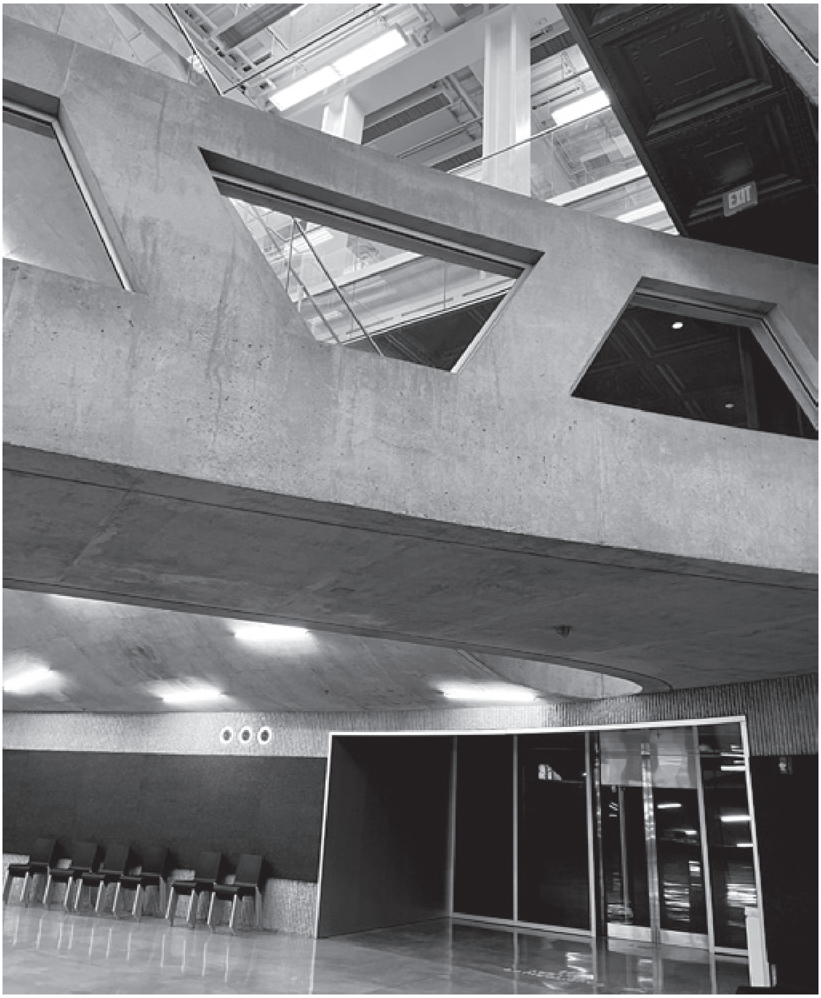


Figure 4.16. Lobby-Crit Room-studio interpenetration: The spatial excitement of interconnected spaces at three levels results in acoustical conflicts between circulation (over the trussed bridge at the entry level), second-floor studio spaces, and the Crit Room below.

5 CIRCULATION

General principles

Circulation—describing the movement of people in, outside, and between buildings—is central to both function and flexibility. In the built environment that exists *outside* of buildings, an array of connected streets, sidewalks, plazas, and similar pathways are most often established in the public rights-of-way that simultaneously define the boundaries of privately or publicly owned parcels of land while enabling the unfettered movement of people, goods, and services between these parcels. Within buildings themselves, circulation facilitates the movement of people *horizontally* on any floor level through lobbies, corridors, hallways, aisles, or rooms that enable access to all the functionally separated spaces or rooms on that floor; and *vertically* between all floor levels, using stairs, elevators, ramps, and escalators. A system of emergency exits and exit access (parts of the means of egress) is a specialized form of horizontal and vertical circulation designed for fire safety that may utilize the building's normal circulation routes or rely, in part, on specially designated emergency-only routes, sometimes protected with fire-resistance-rated enclosures.

A key characteristic of circulation systems in buildings is that they function analogously to the rights-of-way that legally define circulation zones outside of privately held parcels of property on which buildings are built. The status of rights-of-way as *public* zones, permanently available for free passage, is fundamental to the ability of *private* property to function. Clearly, if the public right-of-way was controlled privately and speculatively, i.e., organized for the advantage of its owners, the entire system of private property—relying on unfettered circulation systems to gain access to the world of goods and services, and vice versa—would cease to exist. The public rights-of-way also benefit from being organized into a coherent system of sidewalks, roads, utilities, and various other transportation modalities that facilitates orientation and efficient movement.

In the same way, functional circulation systems in buildings have the quality of "public" zones to enable free movement of people, goods, and services among the "private" rooms and spaces in the building, and also to facilitate orientation and efficient movement. Filling a building with rooms and spaces is clearly not enough, no matter how compelling their programmatic juxtapositions and adjacencies may seem: without an independent ("public") system of circulation to which all these rooms and spaces are linked, movement within the building—*between and among* the rooms and spaces—is forever constrained by the requirement to move through one room to get to another.

To provide a reliable and permanent framework for movement, circulation systems in buildings—much like enclosure systems that define the outside boundary of buildings—are less likely to be moved than, for example, the nonstructural partitions that define the boundaries of individual rooms, especially in multi-story buildings. This is because the *vertical* circulation components—things like stairs, elevators, ramps, and escalators—cannot easily be moved once they are constructed. They rely on shafts (holes) that penetrate through floors, creating unique structural and spatial conditions that, once constructed, cannot easily be altered. Horizontal circulation systems like corridors are also relatively difficult to reconfigure once established, in part because they sometimes have special fire-resistant construction on all four surfaces (walls, floors, and ceilings) but more importantly, because they tend to be connected, ideally in a rational and efficient manner, to the fixed vertical circulation nodes on each floor. Horizontal circulation systems, and even vertical circulation, can certainly be changed to accommodate new configurations of rooms and spaces on any particular floor, but doing so is often an expensive and disruptive exercise: imagine changing the location of elevators in a multistory office building in order to make room for one large conference room on an upper floor. In general, flexibility is enhanced when the circulation system in a building is carefully configured at the outset to anticipate the types of spatial changes that might occur in the future.

Aside from inadequate means of egress for the Crit Room, discussed in chapter 16, general circulation systems in Milstein Hall contradict these fundamental principles in numerous ways.

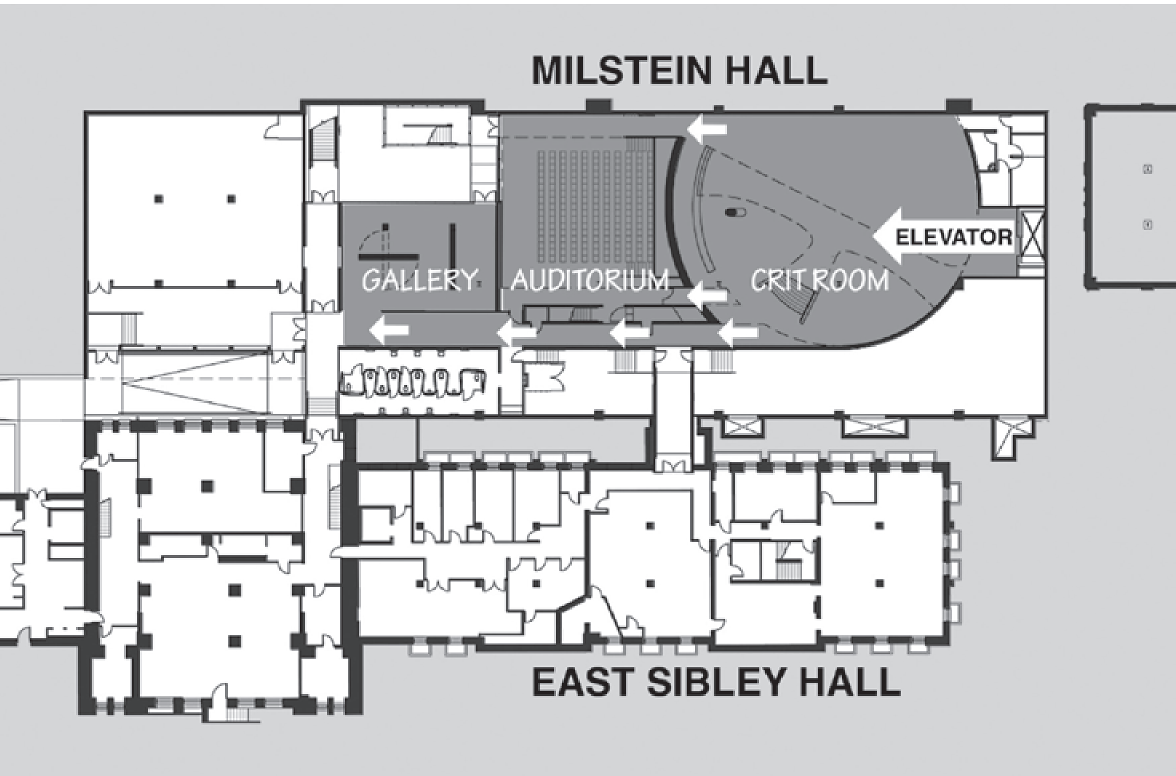
Compromised right-of-way

Milstein Hall's circulation system violates the essential requirement of acting as a "right-of-way" to provide "public" access to all the various rooms and spaces in the building. This is true not only because the entry-lobby-bridge has no visual or acoustic separation from studio and Crit Room spaces above and below, but, more fundamentally, because Milstein Hall's glass elevator has been designed so that users are forced to pass *through* the Crit Room in order to gain access to either the auditorium or the gallery at the lower level (fig. 5.1). The middle level of the auditorium can be accessed directly from the entry-level bridge without using the elevator, but this level does not provide an accessible path to the lectern or lower-level seating. These design decisions effectively preclude having independent events occurring simultaneously in the Crit Room and either the auditorium or the gallery.

Second-floor circulation system

Looking only at the second-floor studio level, we see that the main horizontal circulation aisles, shown as a gray tone on either side of the

Figure 5.1. Taking the elevator to the gallery or auditorium in the basement of Milstein Hall requires passing through the Crit Room.



interior exit access stairway labeled No. 2 in figure 5.2, are not logically connected to the outdoor vertical circulation/egress stair labeled No. 1, which is offset to the north. Because the plan is "open," without fixed horizontal hallways or corridors, it is certainly possible to get from these parallel circulation aisles to egress stair No. 1, but the connection is awkward. Moreover, the discontinuity between the main horizontal circulation path and this required fire stair would make future subdivisions of the space more difficult since some sort of formal corridor would need to be created linking the main east-west exit access to this vertical exit.

OMA, on their website, describes Milstein Hall's second-floor studio level as a "type of space currently absent from the campus: a wide-open expanse that stimulates the interaction of programs, and allows flexibility over time."[1] If Milstein Hall were a stand-alone building with its second floor programmed exclusively for a vast array of studio desks—a "wide open expanse" with no privacy, acoustic separation, or individual control of lighting levels—the circulation system designated by the gray aisles in figure 5.2 would be almost adequate; Stair No. 1 still compromises the functionality of the studio desks in its vicinity since it functions as a vertical circulation node without being connected to the horizontal circulation system.

But such an arrangement is hardly flexible, unless "flexible" is taken to mean moving around studio desks within the open spaces between the columns and hybrid trusses. The type of flexibility that this arrangement *does not* support is the type of change typical in academic campus buildings: subdividing large spaces into smaller ones or combining small spaces into larger ones to account for changes in *what* programs are to be housed in the space (e.g., to accommodate art, planning, real estate, or any number of unanticipated departmental or college entities) and *how* existing programs are expected to operate (e.g., with drafting tables, laptops and monitors, 3-D printers, large groups, small groups, and all the variables that define desired levels of thermal, acoustic, and visual comfort and control).

The particular geometry—the "wide open expanse"—that distinguishes Milstein Hall's second floor from typical academic building layouts makes it difficult to plan alternative arrangements of rooms within the space. For example, my schematic and unsolicited subdivision of the studio floor into offices, classrooms, seminar rooms, and lecture halls (fig. 5.3) would create many interior rooms with no windows, and a rather awkward circulation system whose constraints include the offset location of Stair No. 1, the position of existing doors into Sibley Hall,

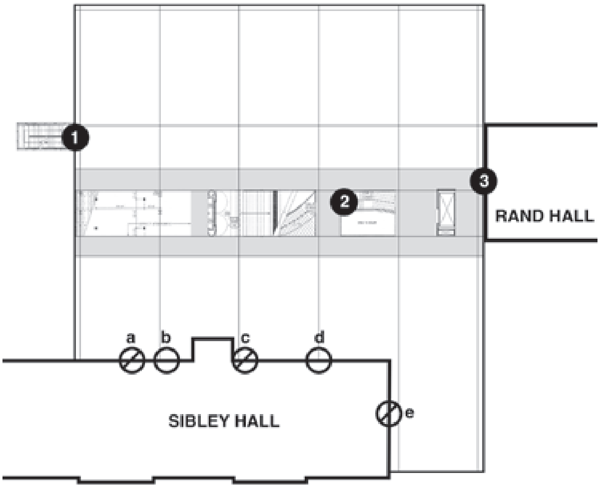


Figure 5.2. Circulation patterns on the second floor of Milstein Hall are defined by required fire exits (No. 1 is an outdoor stair; No. 2 is an open exit access stairway; and No. 3 is an exit into Rand Hall) and by five connecting doors into East Sibley Hall (*a, b, c, d,* and *e*), two of which are open (*b* and *d*), two of which are locked at all times (*a* and *c*), and one of which—on the eastern wall of Sibley—has been removed (*e*).

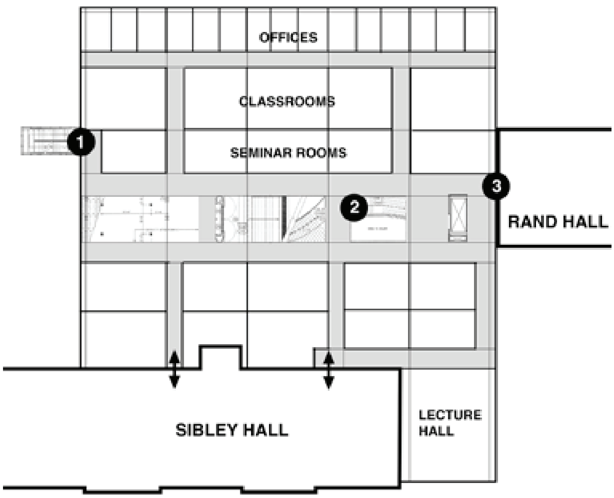


Figure 5.3. Milstein Hall's second floor shown subdivided into offices, classrooms, etc. The three required fire exits are labeled Nos. 1, 2, and 3; existing connections into Sibley Hall are shown with double arrows.

and at least three fire-safety concerns: the requirement to limit dead-end corridors to 50 feet (15 m); the requirement to limit common path of egress travel distances to 100 feet (30 m); and the need to configure large lecture rooms so that the distance between their two required exit doors is at least half the diagonal length of the room itself. Of course, other subdivisions of Milstein Hall's studio floor are possible, and might even be necessary—depending on specific programmatic needs that may arise in the future—but the basic constraints illustrated in figure 5.3 would remain.

Milstein-Sibley connection

In Milstein Hall, the proliferation of doors on the second-floor studio level within the Sibley Hall fire barrier (described in chapter 15) creates an appearance of flexibility, but, in reality, not only makes circulation between Milstein and Sibley Hall more difficult, but also makes it difficult to efficiently configure space in both buildings. A system of circulation should facilitate movement of people, goods, and services by enabling "public" access to the various "private" rooms and spaces on both sides of the fire barrier wall separating the two buildings. But rather than create such a permanent and coherent "right of way"—a true horizontal circulation system—connected to the nodes of vertical circulation in both Sibley Hall and Milstein Hall, the architects instead designed an abstract and idealized *diagram* of programmatic adjacencies without any consideration of the need for "public" access to the as-yet-unspecified and "private" programmatic content in both buildings.

Before Milstein Hall was constructed, the rooms in Sibley Hall were deployed on either side of a double-loaded corridor, with the potential for larger assembly spaces (e.g., lecture halls) at the ends of the building. After Milstein Hall was constructed, four connecting doors were created by enlarging window openings in Sibley Hall's brick loadbearing wall that became a fire barrier separating (and connecting) the two buildings. A fifth door was inserted in Sibley Hall's eastern wall, not simply by enlarging an existing window opening, but by removing a long section of loadbearing brick wall and replacing it with a steel beam acting as a large lintel spanning the opening. A dramatic fire-rated glass wall and door were intended for this large opening, but instead, an ordinary steel door was specified, and the remainder of the opening was unceremoniously covered up with drywall (fig. 5.4). That situation persisted for a decade or so; at the time of this writing, the door has been removed, and all evidence of its intended grandeur has been covered up entirely with fire-rated drywall. Circulation through this door has been foreclosed.

In any case, to allow circulation through the four remaining doors connecting Sibley Hall and Milstein Hall, the rooms adjacent to these openings would need to be reconfigured as circulation space, thereby effectively destroying their utility as rooms. Initially, this problem was solved by simply locking all four doors: this was done because East Sibley Hall, at that time, was home to the Fine Arts Library and the security of books and other library materials precluded such unfettered circulation into Milstein Hall. When the library was moved into Rand Hall, it became possible to open the doors, at least until it was discovered

Figure 5.4. The fifth door connecting Milstein Hall and Sibley Hall was changed from a glass wall and door in Sibley Hall's eastern loadbearing wall—the opening was created at great expense to allow for this expanse of fire-rated glass—to an ordinary steel door with the adjacent space unceremoniously filled with fire-rated gypsum board. At the time of this writing, the door has been removed and the opening has been covered with fire-rated drywall.

that doing so compromised the functionality of spaces in Sibley Hall, which could not simultaneously facilitate "public" circulation between the two buildings while serving their own needs as "private" rooms. At the present time, an awkward compromise has been reached: two doors have been locked and disabled; a third door opens into a new IT support space in Sibley Hall (fig. 5.5) and a fourth door opens into a room used for trimming large-format prints (fig. 5.6). In these two latter cases, the rooms in Sibley Hall with functioning doors into Milstein Hall have effectively been turned into "servant spaces" for Milstein Hall. This is problematic for the same reason that using adjacent Rand Hall for "servant spaces"—bathrooms, egress stair, and mechanical room—is problematic: it compromises the flexibility of the "servant" buildings by assigning their spaces to Milstein Hall and it compromises the flexibility of the "served spaces" in Milstein Hall by placing required functions in adjacent buildings in ways that may constrain future renovations, upgrades, or unanticipated types of changes.

Figure 5.5. One of the four doors linking Milstein and Sibley Halls provides access to an IT support room, visible behind the glass door (*right*); in Milstein Hall, the circulation aisle to this door is bisected by a row of steel columns (*left*).

Figure 5.6. A second unlocked door between Milstein and Sibley Halls provides access to a room used for trimming large-format prints, shown as viewed from Milstein Hall (*top right*) and from Sibley Hall (*bottom right*). The latter view shows how other potential uses such as office and classroom space are precluded by the need for spaces that can function for circulation. Both views also show that this door, a protected opening in a fire barrier that is required to be closed, has been improperly (and dangerously) propped open to facilitate access between the two buildings; the danger is heightened by the mass of combustible material left on tables and on the floor of Sibley Hall, and by the iron on the table adjacent to the door (*left*).

For example, the mechanical room for Milstein Hall that was placed in Rand Hall is now permanently boxed in by the Mui Ho Fine Arts Library, and cannot easily be expanded or even upgraded without affecting the adjacent library. Similarly, neither the circulation system for Sibley Hall's second floor nor the circulation system for Milstein Hall's second

Figure 5.7. Combustible material placed in front of locked doors and windows in the fire barrier wall between Milstein Hall and Sibley Hall.

floor can be altered without impacting the other building. This would not be such a problem if the three conjoined buildings were actually treated as a single building and designed accordingly, but as is typical in privately endowed universities, each building maintains its own identity, especially in relation to upgrades and changes made possible by donors. Money for Milstein Hall, partially funded by a gift from the Milstein family, was restricted, in large part, to that building alone.[2] Similarly, money for the Mui Ho Fine Arts Library was allocated only for Rand Hall. And when it comes time for an upgrade to East Sibley Hall, one can confidently predict that the money will be used only for East Sibley Hall.

So much for the two doors that facilitate circulation between Milstein Hall and Sibley Hall. The other two doors that are now permanently locked have created a fire safety problem—not because they are masquerading as exit doors that turn out to be locked, but because they were built with a lower fire-resistance rating than that required for the fire barrier wall in which they function as "openings." This lower fire-resistance for openings in fire barriers is permitted by building codes, but this permission is based on an assumption that such doors are functioning *as doors,* rather than as walls. The rationale is explained in the International Building Code *Commentary* as follows: "The fire protection rating required for an opening protective is generally less than the required fire resistance of the wall … This is based upon the ability of the wall to have material or a fuel package directly against the assembly while fire doors and windows are assumed to have the fuel package remote from the surface of the assembly."[3] Combustible material (constituting a "fuel package") is often placed directly in front of the openings in the fire barrier separating Milstein Hall and Sibley Hall, as shown in fig. 5.7.

Enabling college-wide circulation

The design architects for Milstein Hall have characterized the building as "*a connecting structure*: a large elevated horizontal plate that links the second levels of Sibley and Rand Halls and cantilevers over University Avenue, reaching towards the Foundry building."[4] When the college's Fine Arts Library was moved into Rand Hall from East Sibley Hall shortly after Milstein Hall was completed, the argument that Milstein Hall was a "connecting structure" became more urgent, since the departments of Art and Planning could not otherwise circulate easily into this allegedly integrated college facility. In fact, the idea of some internal college connection linking the Fine Arts Library to all the college's departments was deemed so important that the argument showed up explicitly in a "Site Narrative" prepared by *the library's* architect:[5]

In this document, the internal college connections to the library are shown as an arrow originating in Tjaden Hall, home of the Department of Art, and then moving from west to east through the Department of City and Regional Planning in West Sibley Hall, the architecture facility in East Sibley Hall, and finally curving into Rand Hall by way of Milstein Hall (fig. 5.8). I describe the difficulty of actually maneuvering

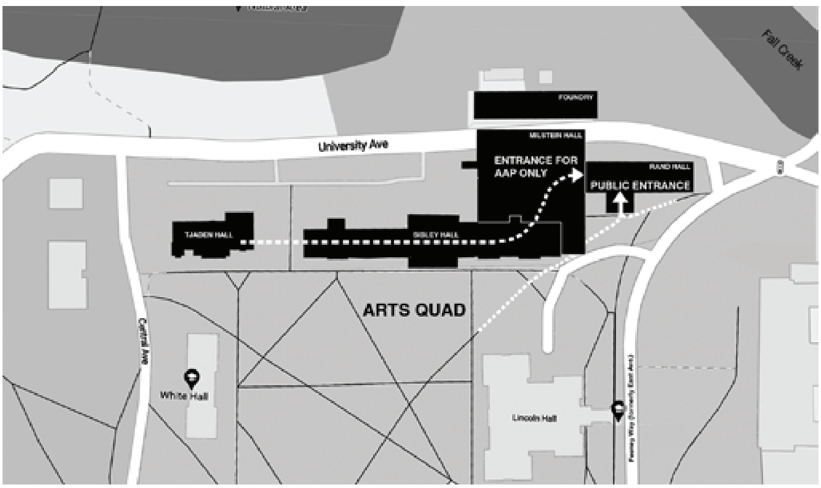


Figure 5.8. Site plan showing college buildings and purported circulation paths to the Fine Arts Library in Rand Hall.

through these perimeter doors in my critique of the Fine Arts Library Site Narrative that was prepared by *its* architect:[6]

> What's peculiar about this plan diagram is the fiction that some sort of purposeful path connects the three departments of AAP (art, planning, and architecture) to the second-floor "AAP" library entrance. The … dotted line shown on the site plan, starting with Tjaden Hall (Art) on the left, actually crashes through a side wall of the art facility, not bothering with the formality of using an actual door, then enters into the basement of West Sibley Hall through a locked exit-only door, then presumably takes a stair or elevator to the second floor, where it moves through the Sibley Dome into E. Sibley, from which it enters Milstein Hall's architecture studio and finds its way into the Rand Hall library. The path through Milstein Hall is not well-defined by hallways or corridors; rather, one must figure out a way to move diagonally through the orthogonal studio layout without invading the privacy of the studio classes.
>
> In spite of all the talk about Milstein Hall being designed for the "college" and creating a "sense of connection across disciplines" ("Walkways and doorways connecting Milstein Hall to Rand and Sibley halls provide the practical advantage of moving through the college's buildings along with promoting a sense of connection across disciplines"[7]), it's clear that the second floor level of Milstein Hall which connects to the proposed library in Rand Hall is an architecture-only space, making it more than a bit awkward for faculty and students from the two other departments to avail themselves of this special AAP entry.

The awkward circulation from Sibley Hall, through Milstein Hall's second-floor studios, to the Fine Arts Library's "college-only" entrance is directly related to the flawed notion that abstract and schematic *plan adjacencies* constitute, and can be substituted for, an actual circulation system. As shown in figure 5.9, the path often taken by students and faculty coming from Tjaden Hall or West Sibley Hall (i.e., from the Departments of Art and City and Regional Planning) or even from East Sibley Hall (i.e., from the Department of Architecture) winds its way through the IT service room in Sibley Hall and then through "private" studio spaces in Milstein Hall, in order to gain access to the Fine Arts Library in Rand Hall.

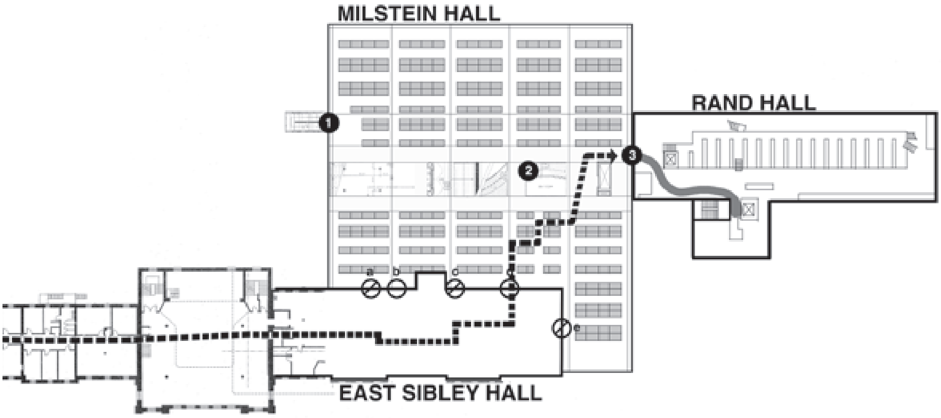


Figure 5.9. Actual circulation patterns at the second-floor level, to gain access to the Fine Arts Library in Rand Hall, require maneuvering awkwardly through the IT service room in Sibley Hall and "private" studio spaces in Milstein Hall. Numbers (1–3) refer to required exits from Milstein Hall.

Parasitic use of adjacent buildings

Exit No. 3 into Rand Hall (fig. 5.9) was not originally designed as a required means of egress from the second floor of Milstein Hall, but merely as a connection from one building to the other. This changed when the occupancy numbers for Milstein's second floor were recomputed—apparently to account for the increased occupancy of assembly areas like the wood-floored "studio lounge" (fig. 5.10)—and the path of least resistance (pun intended) was to use Rand Hall's existing interior

Figure 5.10. Milstein Hall's wood floor area counts as an assembly space.

Figure 5.11. The main horizontal circulation aisles in Milstein Hall align with the entrance into Rand Hall, Exit No. 3, shown here at the end of the circulation aisle.

exit stairway for the additional egress capacity now required for Milstein Hall.

That being said, Exit No. 3 is problematic in its own way, even though it aligns with the primary horizontal circulation aisles in Milstein Hall on either side of Stair No. 2 (fig. 5.11). Because the Rand Hall exit stair is not directly connected to Milstein Hall, but rather is in the middle of Rand Hall, users of this stair coming from Milstein Hall must circulate through the Fine Arts Library, which was placed in Rand Hall after Milstein Hall was constructed. Aside from the incompatibility of some "Milstein" activities with the library occupancy in Rand—for example, bringing architectural models or materials from the first-floor Rand Hall shop up to the second-floor Milstein Hall studios in order to avoid going outside—the library is closed each night, while Milstein studios remain open.

This necessitated the construction of a sliding security shutter, to create a dedicated circulation aisle separated from the rest of the library, that must be rolled into place each night when the library is closed (fig. 5.12). This security shutter also allows 24/7 access to Rand Hall's

Figure 5.12. Milstein Hall egress and access to bathrooms in Rand Hall through the Fine Arts Library.

second-floor bathrooms which, like Exit No. 3, must remain open to Milstein Hall's occupants at all times since bathrooms for the studio floor were not provided in Milstein Hall itself.

In other words, the open plan for Milstein Hall's second-floor studios was created by parasitically using adjacent Rand Hall as a dumping ground for utilitarian "servant spaces" that would have threatened Milstein Hall's openness: not only bathrooms and an exit stair, but also a second mechanical equipment room for the studio floor (the lower levels of Milstein Hall are served by a mechanical room in the basement, as described in chapter 3) were assigned to Rand Hall.

Aside from the arrogance of this strategy—the sublime contours of Milstein Hall were not to be sullied by such mundane necessities as mechanical rooms, bathrooms, and egress stairs—the flexibility of both Milstein Hall and Rand Hall is seriously compromised. This became evident when Rand Hall, soon after the completion of Milstein Hall, was redesigned as the Mui Ho Fine Arts Library: on the one hand, the design of the new Fine Arts Library was constrained by the presence of Milstein Hall's mechanical room on the third floor of Rand Hall; on the other hand, the construction of the library meant that both the egress stair and second-floor bathrooms in Rand Hall—both required for the continued operation of Milstein Hall—would be inaccessible for two years.

Bathrooms and egress: a parody

Rather than create temporary egress and bathrooms for Milstein Hall during the two-year construction period for the Mui Ho Fine Arts Library in Rand Hall, Cornell did what it does best when confronted with issues of building code noncompliance: it requested and received a code variance from New York State's Division of Code Enforcement and Administration (DCEA) to keep Milstein Hall open during the construction period, even with inadequate bathroom and exit capacity. I wrote a parody news article in 2017, reproduced below in lightly edited form. Much of the introductory text is taken verbatim from Guy Horton's "What's so Different about Koolhaas's Venice Biennale?" The photoshopped images in figure 5.13 accompanied the parody:[8]

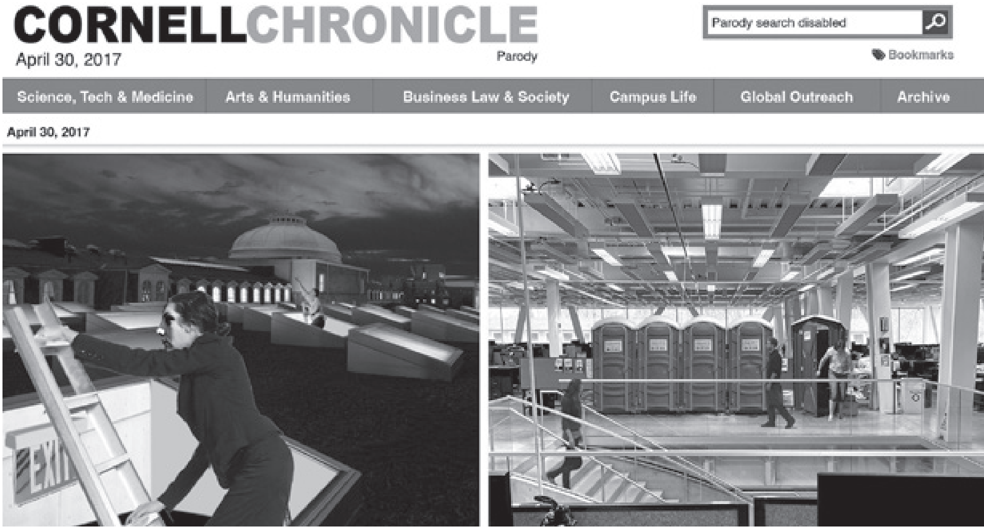


Figure 5.13. Photoshopped parody images for Rem Koolhaas's proposal advocating architectural fundamentals in Milstein Hall: exits (*left*) and toilets (*right*) accompanied the parody article reproduced below.

Koolhaas proposes temporary toilets and fire exits in "flexible" Milstein Hall as Rand Hall closes for two years (parody)

When the 14th International Architecture Exhibition at the Venice Biennale, provocatively titled "Fundamentals," opened in June 2014, it was bound to produce controversy.

True to form, its director, Dutch architect Rem Koolhaas, a master at harnessing the drama of the contrary, promised a Biennale quite different from those that had come before. Under his gaze, rather than spotlight the specific works of contemporary architects, his Biennale focused on larger historical dynamics, going back in time and, literally, back to the basics.

The operational theme, which Koolhaas called Elements of Architecture, covered basic, even mundane building parts like stairs and, of course, toilets. When asked by Cornell College of

Architecture, Art and Planning (AAP) Dean Kent Kleinman to help with a temporary renovation of Milstein Hall—Koolhaas's signature building for AAP—he immediately agreed, seeing the project as a rare opportunity to test the conceptual framework he had proposed for Venice in a "real-life" situation.

"Because Rand Hall was parasitically used as a dumping ground for many of the nasty things—like mechanical rooms, toilets, and egress stairs—that would otherwise have diluted the conceptual clarity of the Milstein Hall design," he explained, "it is now impossible to make any alterations in Rand Hall without compromising the operation of the combined buildings." But, says Koolhaas, this was a deliberate strategy to make sure that his design would remain forever inflexible and resistant to change.

"My friend, Bill Millard," Koolhaas explained, "understood that OMA builds so-called 'ducks' to avoid the cost-cutting that inevitably threatens the aesthetic integrity of decorated sheds. Millard believes, and I agree completely, that the most striking feature of a building must now be the one that all the more mundane features require, the one whose subtraction would demolish the structure."[9]

Because Milstein Hall was designed, under the "Millard" doctrine, to make any subsequent changes virtually impossible, Koolhaas's current proposal cleverly invokes the newer strategy that he developed for the Venice Biennale: it goes "back to basics" with a radical scheme that brings toilet and egress capabilities into Milstein Hall itself. "This is necessary," according to AAP Dean Kleinman, "because with the construction of a new Fine Arts Library in Rand Hall, those very toilet and egress capabilities that had been parasitically placed in Rand Hall will be out of commission for at least two years."

Koolhaas justifies his new "back to basics" approach by arguing that architecture students will benefit from a process of defamiliarization in which the conventional, bourgeois concepts of "toilet" and "stair" are reframed in light of their basic, or fundamental, nature. "What is a toilet, after all?" asked Koolhaas, rhetorically. "And why does a fire stair need to always look like a conventional fire stair?" The essence of a toilet, says Koolhaas, "is just a hole in a horizontal surface with a pail to catch human excrement." And the experience of escaping from fire, he added, "will be much more primal and significant" when occupants are "forced to climb up ladders leading to Milstein Hall's green roof instead of dutifully filing down compartmentalized egress stairs like so many sheep being led to the slaughter. I doubt very much," he continued, "whether Cornell will ever want to go back to the old system once students and faculty experience the more fundamental processes that we have organized for these basic activities."

"Of course," Koolhaas continued, "I also launched the suggestion that after 25 years you could simply declare buildings redundant because they are so mediocre. Milstein Hall is only about one third of the way to total obsolescence; Rand Hall, being over 100 years old, must therefore be completely worthless."[10]

6 MOVEMENT, ORIENTATION, ACCESS

A short digression on Cornell's gorges

OMA's stated desire, as mentioned earlier, was to connect the college's buildings. "Where a car park once stood between Sibley and Rand, a contiguous, multi-layer system of buildings and plazas unites the disparate elements of the AAP, creating a public space adjacent to the campus's most beautiful feature, just to the north—the Fall Creek Gorge."[1]

The idea that Milstein Hall created a public space ("plaza") adjacent to the Fall Creek Gorge is misleading on several counts and requires a short digression. First, the plaza *is* adjacent to four things on its four sides, but none of those things is the Fall Creek Gorge. As can be seen in the annotated Google Map satellite image (fig. 6.1), the plaza—labeled "E"—is

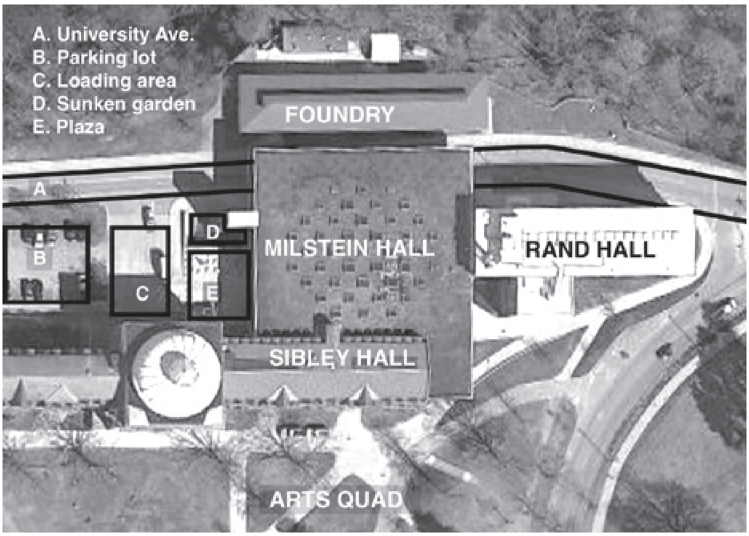


Figure 6.1. Milstein's "plaza" in relation to the Fall Creek Gorge.

actually adjacent to the following spaces: Sibley Hall to the south; a loading dock and parking lot to the west; a sunken garden and University Avenue to the north; and Milstein Hall to the east. Fall Creek does indeed exist north of University Avenue, but there is no functional connection between Fall Creek and Milstein Hall's plaza (fig. 6.2).

Second, the idea of making visual or conceptual connections to the Gorge is a tired trope having little if any value. As I argued in a blog post from 2013:

> It's both a bit weird, but also quite expected, to see the same design tropes appearing over and over again within the same time period at the same place. I hinted at this phenomenon in my 2009 song, "Prisoner of Art."[2]
>
> Two examples from the Cornell campus follow. The first is based on the idea that, because Cornell is situated between

Figure 6.2. Milstein's plaza has no functional connection to Fall Creek Gorge, but rather sits awkwardly on the edge of a sunken garden and stair tower (*right*) with a loading area and parking lot to the west (*left*).

> two gorges, the idea of the gorge should somehow be expressed in new campus construction. So not only do we get the West Campus dorms designed by Kieran Timberlake referencing the glacial topography of the Finger Lakes, but also more literal representations of the gorges in Bailey Plaza (Michael Van Valkenburgh Associates: "A tilted, striated bluestone fountain presents a mysterious dark pool at its base, making material reference to Ithaca's famous gorges") and the Pew Engineering Quad (EDAW, Inc.: "The created landscape will dramatize the topography by adding landscaped slopes that recall the natural character of the nearby Cascadilla Gorge").[3]

All such architectural or landscape instances of this trope miss the essential nature of Cornell's unique siting. Fall Creek and Cascadilla Gorges are natural barriers that separate Cornell from adjacent commercial and residential areas. As such, they create a "protected" zone for academic life, irrespective of their spectacular natural features, i.e., the trails, waterfalls, flora, fauna, and the characteristic siltstones, sandstones, and shales that define their steep rocky walls. But those natural features of the gorge do not themselves factor into the academic life that they bracket and contain. Rather, the protected and isolated "ivory tower" draws upon the conventions of traditional campus design, especially the quadrangles traversed by functional paths and bounded by understated brick or stone buildings; the quads serve as both circulation and gathering points for faculty and students. Kermit Parsons, former dean of Cornell's College of Architecture, Art and Planning, argued that views of the Cayuga Lake valley from traditional academic quadrangles were the primary site planning considerations of the founders, rather than connections with the two gorges: "Ezra Cornell wanted as many durable, useful buildings as he could get. He wanted to make it possible for Cornellians to survey the sweeping landscape of the Cayuga Lake valley, and he wanted the town to see University buildings on the hill against the skyline. Andrew D. White, though he was a scholarly revolutionist in most matters of higher education, admired the traditional ordered beauty of collegiate quadrangles."[4]

Such an academic vision, however clichéd, neither requires nor benefits from the literal intrusion of the gorges' natural features. These natural features, if brought literally or even metaphorically into the campus, would only distract from the academic tasks at hand and contravene the vision cultivated by the original campus designers. The gorges were, and are, certainly appreciated as natural attractions, but their utilitarian function—providing water power for nineteenth-century mills and hydraulic investigations—was more relevant (fig. 6.3). When Ezra Cornell "worked as the manager, mechanic, and millwright at Colonel Jeremiah Beebe's mills at the foot of Ithaca Falls, he superintended the blasting of a long tunnel through the rock wall of the gorge to tap the water power of Fall Creek, and he built a stone dam at Triphammer Falls to conserve the Creek's water supply. He had built sawmills, and now he built machinery, workshops, and several houses, including his own, near the mills."[5]

Third, the idea that architecture or landscape ought to serve as an icon—a facile didactic signifier of some nearby and notable environmental feature—is (and here I'm using the most charitable word possible) questionable. The main formal consequence of the two gorges that bound Cornell's main campus is their sublime and unexpected presence in the landscape. One comes upon these natural wonders by crossing

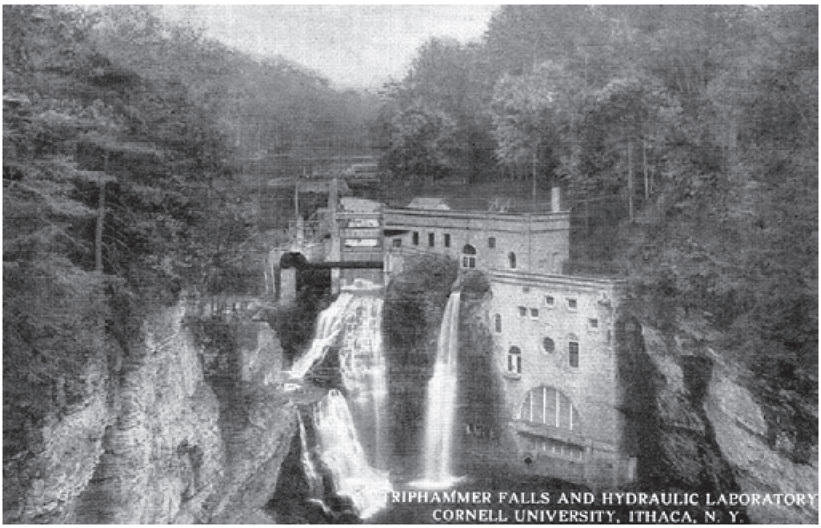


Figure 6.3. The gorges bounding Cornell were appreciated as scenic attractions, but their utilitarian aspect, providing power for mills and water for hydraulic experiments—the Hydraulic Laboratory in Fall Creek from around 1898 is shown here—was more important for early campus planning. Tragically, this amazing structure was allowed to decay and collapsed in 2009.

them (to enter or leave campus) or by descending into them (on various trails). It is precisely the *contrast* between the normative landscape of the adjacent campus/city and the gorges' dramatic rifts within that landscape that makes the experience so special. Abstracting and replicating the form of the gorge within the adjacent context only serves to trivialize this experience.

Fourth, the very idea of establishing some sort of public zone on the service side of Sibley Hall is flawed. Campus academic life is organized around the Arts Quad; Cornell's main buildings for the College of Architecture, Art and Planning are fortunate to have prime real estate fronting on this quad. The traditional campus buildings on the Arts Quad have a public face (on the quad) and a backside for servicing. This creates an appropriate and useful density of students and faculty on the Arts Quad, as well as optimal conditions on the quad for orientation, circulation, and causal leisure activities where one can watch and be watched. It also maintains the class-based distinction between a pedestrian-only enclave for elite student and faculty interactions versus the required servicing of this enterprise with cars, parking lots, trucks, dumpsters, and so on. Reducing the density and intensity of the pedestrian-only activities by creating a rival entrance and plaza away from the quad is therefore counterproductive from two standpoints. First, it damages the traditional quad by *removing* desired activity and circulation. Second, the new node of activity and circulation that has been placed away from the quad becomes dysfunctional in two ways: it mimics the *form* of an active gathering and circulation space associated with a real plaza without providing the necessary density of people to make the plaza "work"; and it places any student-faculty activity in the plaza side by side with the "back-door" requirements of servicing, thereby compromising the carefully cultivated image of Ivy League campus life.

The tired trope of Cornell's Fall Creek Gorge shows up not only in the "public plaza" placed on the service side of Sibley Hall—this can at least be explained by the donor's presumed desire to give the Milstein Hall addition not only its own name but also its own identity—but also in the inane arrangement of colored sedums planted on Milstein Hall's green roof: "The entire roof, with the exception of the skylights, is vegetated in a graphic pattern of two types of sedum plantings. The sedum 'dots' gradually increase in diameter as they approach the gorge, creating a landscape that is orderly and structured nearest the Arts Quad, and a denser, less structured field as it reaches the gorge."[6] First, it was quite clear when this idea was first revealed that any such arrangement of colored sedums would be transformed over time into an entirely random pattern, given the vicissitudes of natural vegetative processes and the necessity of constant roof repair. With close to 24,000 individual sedum plants initially planted by hand in the colored pattern described above (fig. 6.4), there was never going to be a maintenance budget large enough to continually restore that pattern as it was inevitably compromised over time.

Second, the roof itself is hardly visible, except from third-floor studios in adjacent Sibley Hall and obliquely from Rand Hall's roof terrace (fig. 6.5).

Third, the roof is inaccessible, so viewing Fall Creek Gorge from the northern edge of the roof is impossible, except for maintenance

Figure 6.4. Milstein Hall's inaccessible green roof is planted with about 24,000 sedums in two colors, with a pattern of dots that gradually increase in size toward the Fall Creek Gorge. The squares in the center of the roof are skylights.

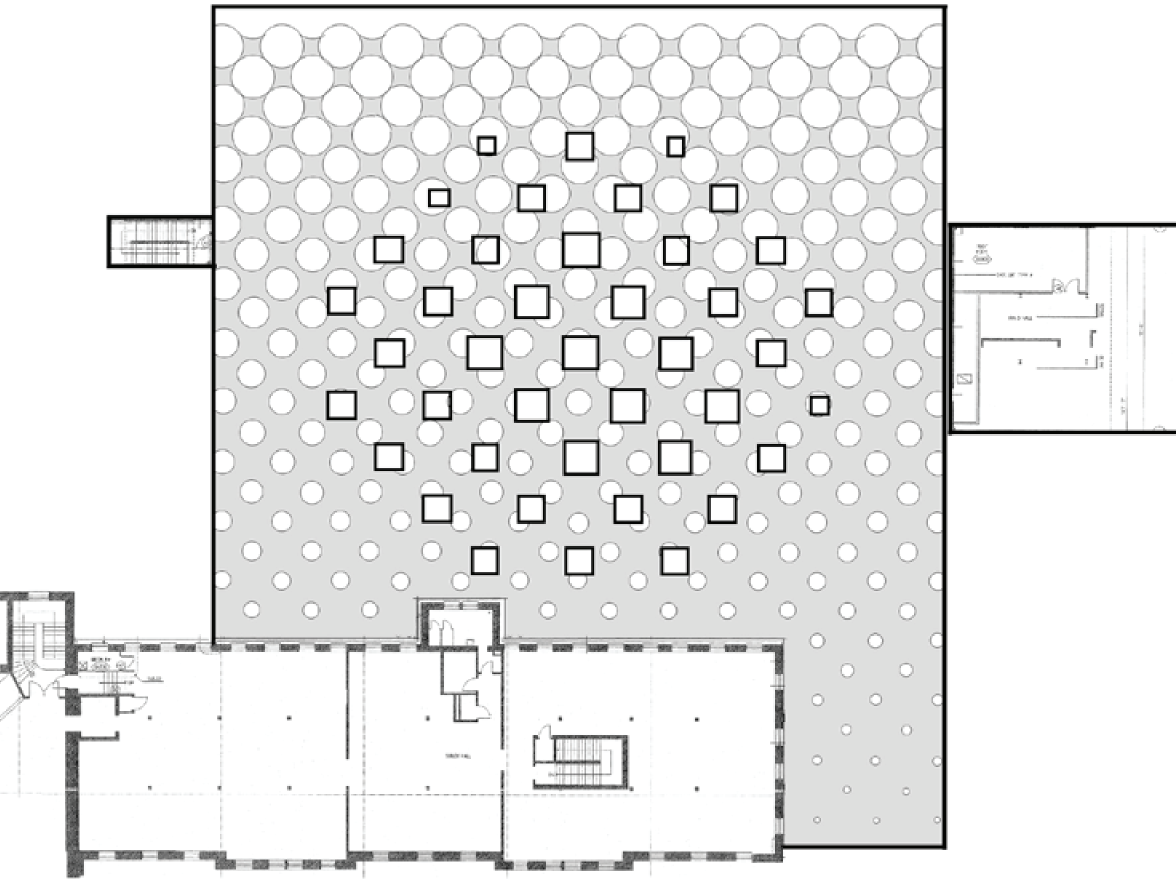


Figure 6.5. Milstein Hall's green roof cannot be seen, except from the third-floor studios in Sibley Hall (*top*) and obliquely from a corner of the rooftop gallery in Rand Hall (*bottom*). What appear to be green-roof plantings visible from Sibley Hall's third-floor studios are, in reality, trees located across University Avenue on the edge of Fall Creek gorge.

workers strapped securely in place with OSHA-certified personal fall arrest systems.[7] In the final analysis, Milstein Hall's vegetated roof, with its obscure reference to the "order" and "structure" of vegetation in

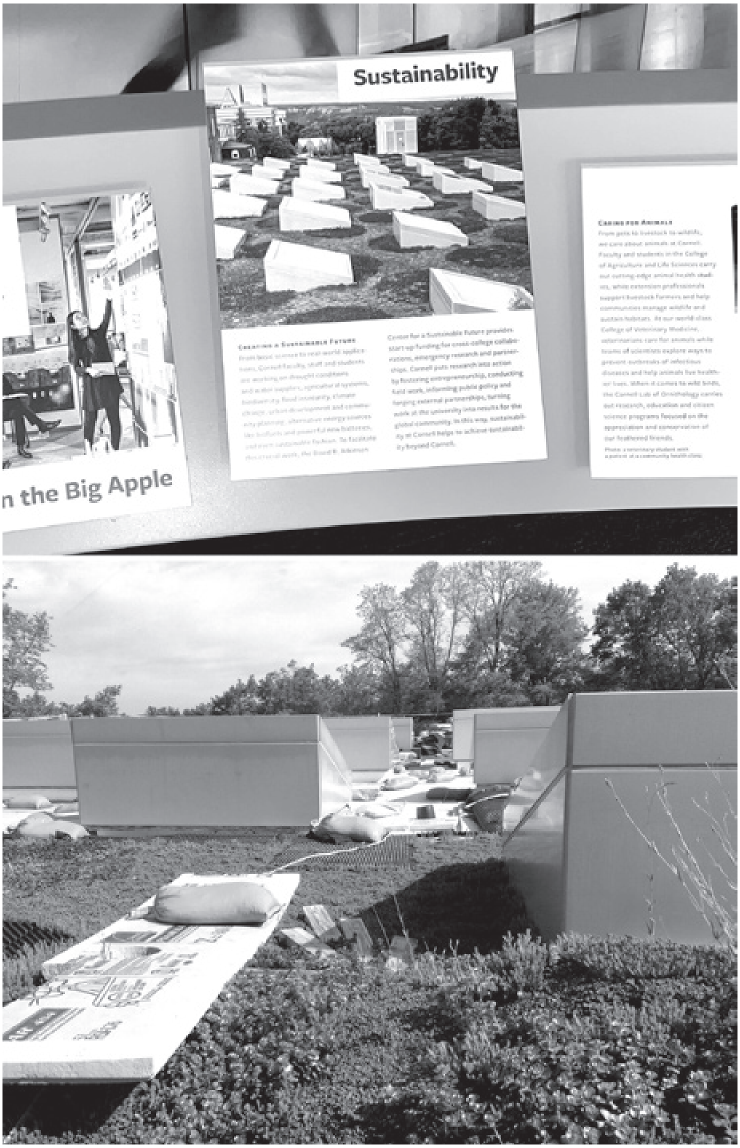


Figure 6.6. Milstein's green roof, as a branding device for "Sustainability" at Cornell's Martin Y. Tang Welcome Center (*top*); and as it has devolved over time (*bottom*).

Fall Creek Gorge versus the Arts Quad, becomes nothing more than an expensive and transient branding tool—a one-time photo op for greenwashing (fig. 6.6).

A dysfunctional arcade

There are two primary reasons that the Duane and Dalia Stiller Arcade, located between Sibley Hall and Milstein Hall at ground level, is almost always empty. First, it doesn't provide a useful connection to anywhere in particular, so it is rarely used as a shortcut or path from somewhere to someplace else. The primary circulation paths at this end of campus—labeled "B" and "C" in figure 6.7—connect the Arts Quad (and also the rest of the campus, accessed via Feeney Way, formerly East Avenue) with undergraduate dormitories in North Campus. There is virtually no reason for anyone to circulate through the arcade, labeled "A."

Second, it meets none of the criteria for being a successful outdoor space in its own right: it is dark and dismal, it is freezing in the winter, there is often no seating (the infantile plastic "bubbles" set into the concrete dome might work in a nursery school setting, but are inexplicable in the context of a major research university), and there is no compelling

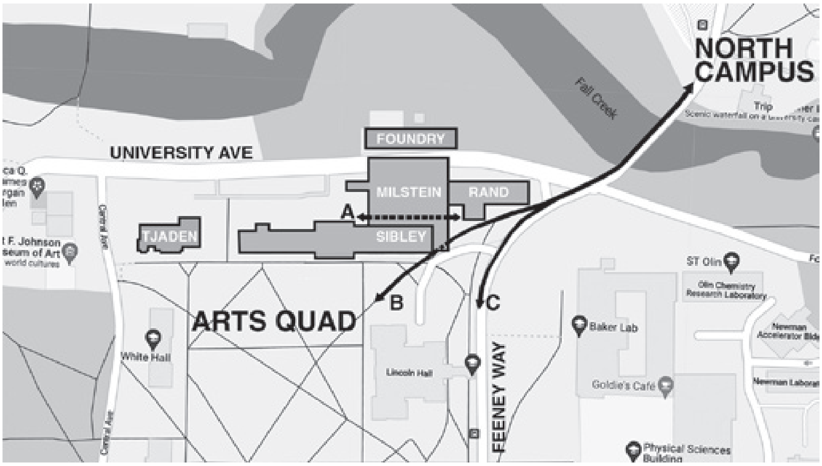


Figure 6.7. Campus circulation in the vicinity of Milstein Hall: Path "A" is the Duane and Dalia Stiller Arcade; paths "B" and "C" connect North Campus dormitories with the Arts Quad and the rest of campus.

activity generated in the arcade from adjacent buildings (fig. 6.8).

It is instructive to compare Milstein Hall's underutilized outdoor arcade with that of Duffield Hall, a nearby and heavily used enclosed arcade that was created between two campus building on the Engineering Quad. Both Milstein Hall and Duffield Hall were additions to existing buildings and, as such, had similar design challenges in joining a new with an existing building. Zimmer Gunsul Frasca (ZGF), the architects for Duffield Hall, activated the connection to the existing building (Phillips Hall) by creating a covered arcade bounded by Phillips Hall on one side and the new Duffield Hall on the other side. In this space, they designed useful seating areas in which students can study or collaborate in relative privacy, but with visual connections back to the main circulation spine of the arcade, so that both those seated along the perimeter of the arcade and those circulating down the middle feel active and engaged. Naturally, there is also food available, and plenty of places to sit, eat, and drink (fig. 6.9). The architects for Milstein Hall, in contrast, left the arcade space between Sibley Hall and Milstein Hall unenclosed and unpleasant, with no collaborative seating, no ability to see and be seen, no compelling

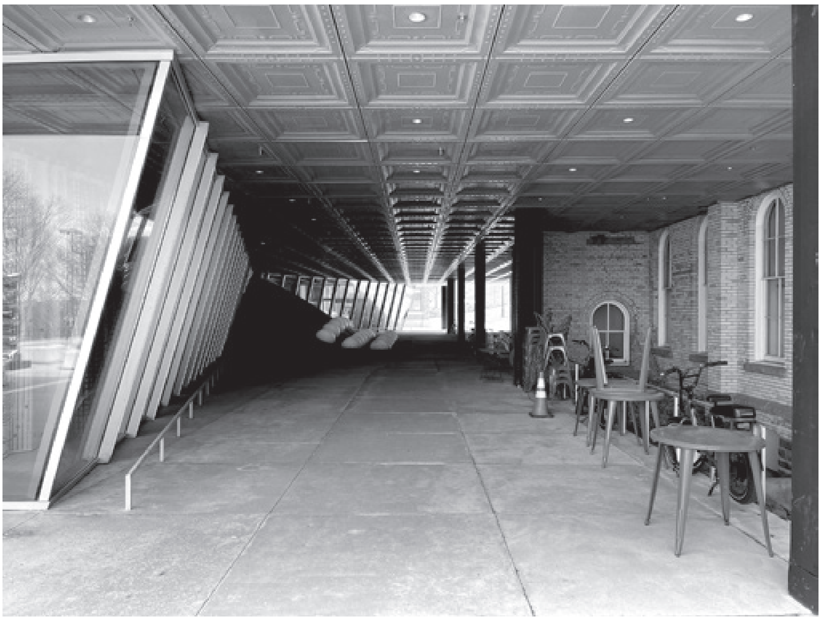


Figure 6.8. The arcade in Milstein Hall, with seating bubbles visible in the background, is almost always empty.

activities visible in the adjacent buildings, and—as a result—with no particular reason for anyone to enter (fig. 6.8). The images in figure 6.9 and figure 6.8 show the two arcades at the same time on the same day (Tuesday, March 21, 2023, at noon), but this contrast in functionality could be demonstrated on virtually any day and any time when students are on campus.

Koolhaas's "Junkspace," written just a few years before OMA began the Milstein Hall project, may provide some insight into the origin of the arcade's dysfunction, although it is risky to allege such links between the office's theory and practice. In this article, a brilliant 7,500-word rant formatted into a single, continuous paragraph, the enclosed mall (aka Junkspace) comes under withering attack:

> Junkspace seems an aberration, but it is the essence, the main thing… the product of an encounter between escalator and air-conditioning, conceived in an incubator of Sheetrock (all three missing from the history books). Continuity is the essence of Junkspace; it exploits any invention that enables expansion,

Figure 6.9. The arcade in Duffield Hall is constantly filled with activity.

> deploys the infrastructure of seamlessness: escalator, air-conditioning, sprinkler, fire shutter, hot-air curtain… It is always interior, so extensive that you rarely perceive limits; it promotes disorientation by any means (mirror, polish, echo)…[8]

This hyperbolic descriptive text soon turns into an explicitly anti-atrium warning: "Note to architects: You thought that you could ignore Junkspace, visit it surreptitiously, treat it with condescending contempt or enjoy it vicariously… […] But now your own architecture is infected, has become equally smooth, all-inclusive, continuous, warped, busy, atrium-ridden…"[9] And not only that, this atrium culture fosters complacency and destroys our ability to think: "Junkspace is political. It depends on the central removal of the critical facility in the name of comfort and pleasure."[10] So it's possible that this ideological posturing had some influence on the decision to leave Milstein Hall's arcade unconditioned, unenclosed, and—most importantly—without any formal or functional references to the despised prototype of the atrium/mall.

On the other hand, the danger of taking such theoretical diatribes seriously as determinants of OMA's practical design strategies can be illustrated by the following passage from the same article, where the text disparages vast open spaces, not that dissimilar to Milstein Hall's studio floor—a space with no walls, except for a shimmering, mirror-like stainless steel electrical closet enclosure (fig. 11.21), that is penetrated and supported by huge hybrid trusses:

> There are no walls, only partitions, shimmering membranes frequently covered in mirror or gold. Structure groans invisibly underneath decoration, or worse, has become ornamental; small, shiny, space frames support nominal loads, or huge beams deliver cyclopic burdens to unsuspecting destinations.[11]

Movement versus circulation

Just as abstract programmatic adjacencies are confused with circulation systems in the design of Milstein Hall, there is also an implicit conflation of a type of performative athletic movement—whether featuring trained dancers, "free runners," or skateboarders—with the type of movement in and around buildings that constitutes useful circulation. As far as I know, nothing has been produced for Milstein Hall comparable to Tomas

Koolhaas's video of Chris Lodge "free running" through OMA's Casa De Musica building in Porto, Portugal,[12] although not for lack of trying. For example, I was told that the choreographer William Forsythe, who had accepted a prestigious Cornell position as an A.D. White Professor-at-Large, was asked to stage an avant-garde dance performance in Milstein Hall shortly after it opened, but rejected the venue, preferring instead the unpretentious industrial aesthetic of Rand Hall next door.[13]

There has also been a love-hate relationship with skateboarders, who—even more than Forsythe and his dancers—would show how the building encourages kinesthetic movement, while also providing some street cred. Medina Lasansky describes the "multi-sensory appeal" of Milstein Hall to practitioners of the skateboarding craft, in particular their attraction to the curved surface the of the dome with its spherical bubbles. Yet, as Lasansky points out, "the rampant skateboarding has proven irksome to the college administration. Signs have gone up in an attempt to limit the boarding and a high-level official has been spotted scrubbing scuffmarks off the 'bubble bank' … Undoubtedly there are liability concerns, and worries about the extent to which skateboarders might damage the building."[14] As illustrated in figure 6.10, skateboarders

Figure 6.10. Skateboarders are warned away from Milstein Hall's dome (*top left*) but show up anyway (*top right*); lighting fixtures and glazing panels have been damaged (*bottom left and right*), possibly from collisions with skateboards.

are indeed attracted to the building's curved and sloping surfaces, in spite of warning signs (which were put in place shortly after the building opened but then removed) and damage to the building itself (I can't confirm that the broken glass and light fixture were caused by skateboarders, but it seems likely).

Orientation, and signage

Circulation presupposes *orientation*, and orientation can be enhanced both by signage as well as by the clarity and coherence of the building's circulation system. In general, orientation is facilitated by hierarchical elements (major circulation axes, or open atriums) which provide easy-to-read clues relating *where one is to where one was and where one wants to be*. In contrast, buildings with a maze of corridors, or multiple symmetries that confuse front-back or side-to-side relationships, make it easy to get lost—disoriented—in a building.

Milstein Hall's connection to Sibley Hall and Rand Hall, according to OMA, was intended to remedy a problem of spatial incoherence in the college's existing buildings caused by "linear, corridor-based buildings that segregate the AAP's disciplines in closed rooms behind a labyrinth of entrances, security codes and dead ends."[15] In fact, the opposite is true. Before Milstein Hall was constructed, circulation into and within the four existing college buildings was absolutely straightforward and clear: Tjaden, Sibley, and Rand Halls each had main entry doors facing the Arts Quad (Tjaden and Sibley Halls) or the main circulation path connecting the Arts Quad to North Campus (Rand Hall); while each of these buildings had secondary service entrances facing University Avenue. The Foundry, "originally designed as a blacksmith shop in the 1860s by Charles Babcock, the first professor of architecture at Cornell,"[16] was always isolated from the main campus buildings surrounding the Arts Quad, and remains so, even after the addition of Milstein Hall.

With the addition of Milstein Hall, circulation into and within the college buildings became much more confusing. First, connections between *all three* of the interconnected buildings happen only at the second floor, and—as argued above—there is no coherent system of circulation at that level, but instead only a diagram of abstract adjacencies that actually inhibits circulation. Second, even if the three buildings were linked at the second floor with a coherent and articulated circulation system, there is no appropriately designed connection of such a system to the *first-floor* entrances of Sibley and Rand Hall. Third, the multiple entries and exits for Milstein Hall's auditorium create a truly labyrinthian circulation system that is confusing even to seasoned users of the space. All in all, the auditorium has six entrances at three levels, none of which appear to be hierarchically more important than the others—in other words, there is no apparent main entrance to the auditorium. Of the six doors, three are required fire exits, so *their* doors swing outward from inside the auditorium space, as is required. Unfortunately, the other doors either swing inward, or slide horizontally, which could create a life-safety problem in the event of a fire, even though it is technically legal to have "extra" doors not designated as fire exits. The only interior connection from Sibley Hall to the auditorium in Milstein Hall, without going through the second-floor design studios, is through the basement. From Rand Hall, which has no basement, the only interior connection is at the second floor, through the Fine Arts Library in Rand Hall and the design studios in Milstein Hall.

Circulation systems can be so complex that movement and orientation require a comprehensive system of signs. In some cases, e.g., in the Port Authority Bus Terminal in New York City, signs are needed to compensate for an otherwise incoherent system of circulation. In other cases, e.g., in Grand Central Terminal in New York City, signs are needed even when the system of circulation is coherent and memorable, simply because there are so many interconnected activities and destinations: surrounding streets, ticket machines, train tracks, subways, stores, restaurants, bathrooms, and so on (fig. 6.11).

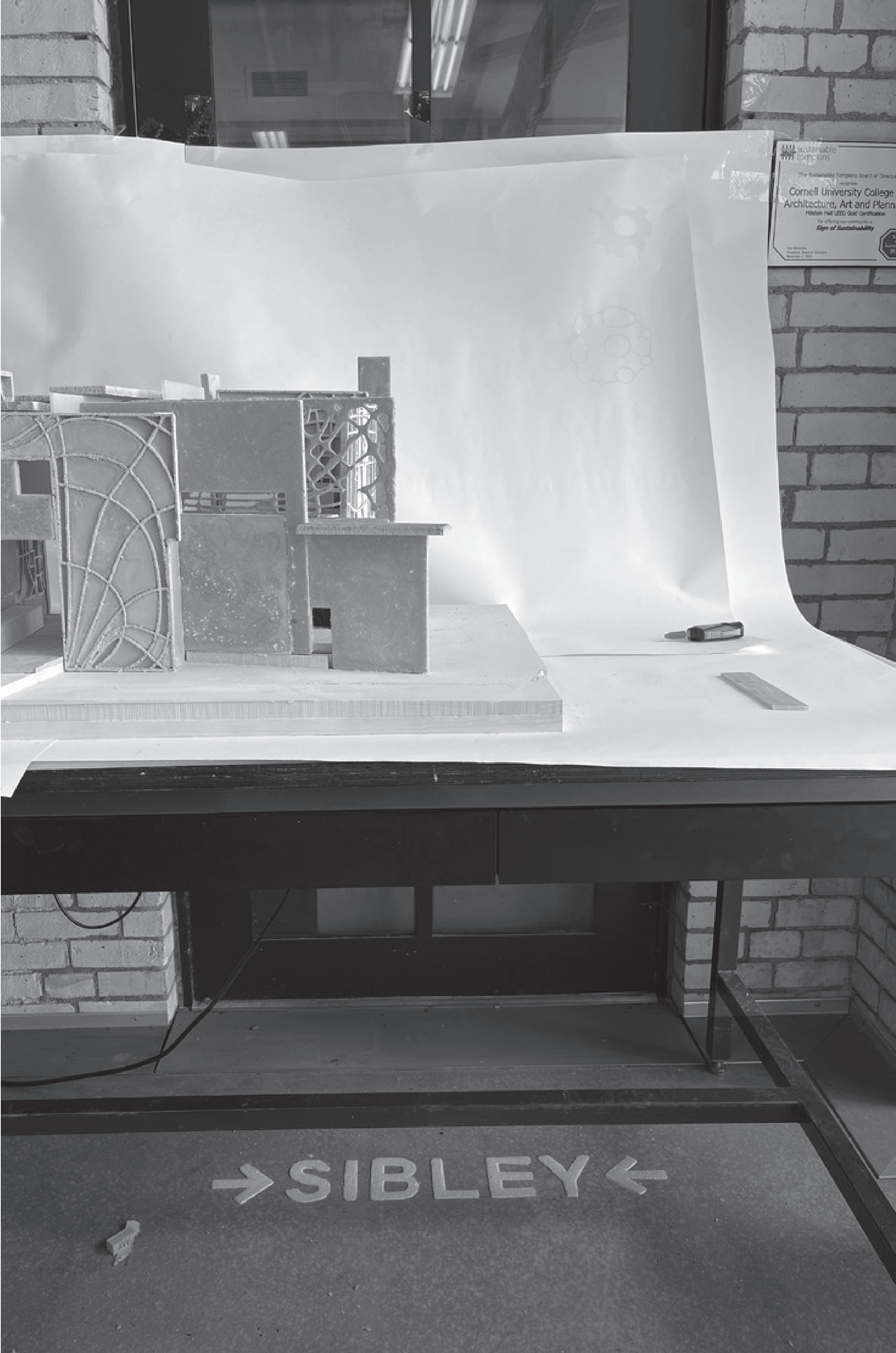
Milstein Hall has a system of signage to direct people both to the adjacent connected buildings and to internal programmed spaces like the

Figure 6.11. Signs are needed in Grand Central Terminal (*left*) and at the Port Authority Bus Terminal (*right*), both in New York City.

auditorium and gallery. These signs were subcontracted to 2x4, a "global design consultancy headquartered in New York City," whose mission is to "identify and clarify core institutional values and create innovative, experiential, participatory and visually-dynamic ways to engage key audiences worldwide."[17] Given this mission, one can only wonder how the college's "core institutional values" were translated into floor-mounted signs torched directly onto Milstein Hall's concrete floors, where they are stepped on, abused by cleaning protocols, and—as a result, in many instances—damaged or destroyed (fig. 6.12). The permanence of these torched-on letters becomes particularly absurd in the context of Sibley Hall's locked doors (fig. 6.13).

Figure 6.12. Milstein Hall's signage system is assembled with individual letters and symbols that are placed on the concrete slab (*top-left*), torched onto the concrete surface (*top right*), and then left to be damaged or destroyed by foot traffic and cleaning protocols (*bottom left and right*).

Figure 6.13 (facing page). Torched-on directional signs point to a permanently locked door to Sibley Hall.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Front and back: formal and service systems

Circulation systems have a political content, to the extent that they are designed to separate various classes of people, both to facilitate the utilitarian functionality that such class-based separation entails, and also to express the ideals embedded in this type of separation. Examples can be found at the urban scale as well as within individual buildings.

At the urban scale, the separation of circulation systems shows up, of course, in the purely functional differentiation between incompatible modes of transport: sidewalks for pedestrians; streets for cars, taxis, buses, trucks, service vehicles, and bicycles (if they have not been provided with separate paths); rails for trains and streetcars; helipads, airports, and so on. But there is also a political and ideological type of separation in which we find circulation systems that explicitly separate servicing functions from the formal public domain. Mews and other types of back alleys are organized to the side of, or more commonly behind, public entrances so that the class-differentiated functions of servicing—garbage collection, recycling, maintenance, storage, and so on—can operate out of sight. Similar "front-back" separations of services (in the back) from public circulation (in the front) occur in many commercial buildings as well, so that the ideal image of public space is not compromised by the reality of trash storage, loading docks, and similar things.

Where urban street plans have been organized so that this type of back alley is not possible, separation can be organized on a temporal basis, with deliveries and garbage pickup scheduled for early mornings, before the public commercial business gets started. And where incremental growth, or changes in function over time, make it impossible to physically or temporally separate ceremonial, public circulation space from utilitarian, service-type circulation, we see awkward juxtapositions of public entrances and loading docks; front doors and trash barrels.

The same types of issues appear in individual buildings, for example with separate and isolated circulation zones for servants working, or sometimes living, in upscale residences—often connected with apartment kitchens. This explicit separation of public and service circulation also shows up in restaurants, shops, supermarkets, and shopping malls. At times, the separation of circulation becomes even more specialized, for example, in the design of modern courthouses, where a tripartite circulation scheme is often required to separate public visitors, court staff, and criminal defendants (fig. 6.14).

The separation of circulation systems into distinct pathways for menial workers and ordinary citizens (or into pathways for visitors, criminals, and judges) may appear natural, sensible, and even inevitable, yet it presupposes a social organization in which not only are classes of people differentiated from each other, but also in which a social *ideal*—often implemented on the basis of racial or religious differences, but in any case abstracted from the low-wage activities that allow the system to function—is expressed.

With the construction of Milstein Hall, what had been a clear separation between front and back—i.e., between formal versus service zones—has become muddled and dysfunctional. The plaza constructed on the back side of Milstein Hall, with no connection to the Arts Quad, is hopelessly compromised by its adjacency to a loading area and parking lot. Even adorned with concrete seating elements (and later with the addition of a food truck and several Jason Seley sculptures[18]), the space cannot overcome the same problems that compromise the arcade: it is often in shadow (being on the north side of Sibley Hall and the west side

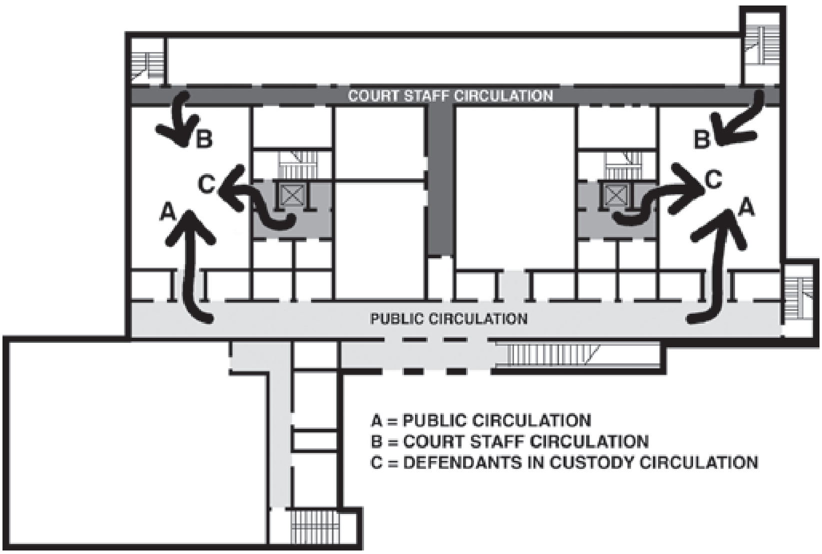


Figure 6.14. Courthouse circulation systems: public, court staff, and defendants in custody each have their own separate and distinct circulation system, all leading to the various courtrooms as shown by the arrows.

Figure 6.15. Milstein Hall's plaza, north of Sibley Hall, has gained some lunchtime activity with the addition of sculpture, food truck, tables, and chairs that were not part of the original design; but even with these added elements and its proximity to the arcade, the plaza remains hopelessly compromised by being isolated from activity on the Arts Quad, being often in shadow, and being adjacent to a loading area, parking lot, and University Avenue.

of Milstein Hall), and "people watching" is not possible since people use neither University Avenue nor the arcade as primary circulation paths (fig. 6.15).

Discontinuities: single steps and curbs

The curb separating Milstein Hall's plaza from the adjacent loading area was intended to create a discontinuity in an otherwise continuous concrete slab. Unfortunately, the lack of any further articulation of the curb edge—an articulation ordinarily created by the use of contrasting curb materials, or by contrasting concretes (asphaltic- and Portland cement-based) for the upper and lower paved surfaces, or by the use of grass or stone strips separating the upper pavement from the curb edge—makes the vertical discontinuity difficult to see and, as a result, creates a tripping hazard at the curb edge. This is especially true in the late afternoon and evening when western sunlight hits the vertical face of the curb directly and no shadows are cast that would otherwise help define a more visible boundary (fig. 6.16). Temporary yellow safety tape was eventually applied to the curb edge, and this expedient was soon after replaced with a metal curb edge that provided some functional differentiation between the upper and lower concrete pavements. Inexplicably, that protection

Figure 6.16. The discontinuity of Milstein Hall's plaza and the loading area, even with the addition of tactile circular discs, is extremely hard to pick up, especially in the late afternoon or early evening when there are no shadows cast by the western sun.

was later removed, so that the curb—at this writing—remains problematic (fig. 6.17).

While this particular curb condition was configured in a functionally unsafe manner, building codes offer only indirect guidance for such curb design. Single *steps* along egress paths are explicitly forbidden, since they "may not be readily apparent during normal use or emergency egress and are considered to present a potential tripping hazard," but a curb in this context does not constitute a "step" within a means of egress. Even so, the logic underlying the prohibition of single steps is applicable to this curb condition, and architects familiar with egress requirements and their rationale would be more likely to avoid such errors.

Instead of single steps within a means of egress, the International Building Code *Commentary* recommends that a ramp be used whose presence is "readily apparent from the directions from which it is approached. Handrails are one method of identifying the ramp's change in elevation.

Figure 6.17. After a curb with no articulation was constructed at the loading dock for Milstein Hall, temporary yellow warning tape (*top left and top right*) was placed over the "invisible" edge; later a textured metal curb cover (*bottom left*) was installed, but later removed, so that the current condition as of this writing (*bottom right*) has the same lack of articulation as the original.

In lieu of handrails, the *surface of the ramp must be finished with materials that visually contrast with the surrounding floor surfaces. The walking surface of the ramp should contrast both visually and physically.*"[19]

The code requirement to use a ramp rather than a single step was not followed by the architects of Milstein Hall at a pedestrian passage between Rand Hall and Milstein Hall along University Avenue. Even though this single step is outside Milstein Hall proper, it is still within the building's means of egress, since the means of egress includes the so-called exit discharge between the main entrance to Milstein Hall (which is also an exit) and the so-called public way (which, in this context, is University Avenue). An exception to this rule for single risers "at locations not required to be accessible" does not apply because this single stair links the main entrance to Milstein Hall (and its auditorium) to public transportation stops on University Avenue and therefore constitutes an "accessible route."[20]

But the point is not whether the fine print in the building code does or does not prohibit single steps in this context. The question is why an architect—unconstrained, for example, by difficult existing conditions in which non-accessible and relatively dangerous details are impossible to avoid—would purposely *design* such a condition. As shown in fig. 6.18, the single step (*left*, actual as-built image) could easily have been replaced with a continuous ramp (*right*, photoshopped image).

Figure 6.18. The single step at the end of a ramp leading from the Main entrance (exit) from Milstein Hall to University Avenue represents a noncompliant elevation change (*left*, as-built image); simply extending the ramp to the University Avenue sidewalk would have eliminated that problem (*right*, photoshopped image).

Accessible paths

Many aspects of accessibility have become second nature for architects after the passage of the Americans with Disabilities Act (ADA) in 1990 made them requirements for all commercial and institutional buildings. Things like necessary turning radii for wheelchairs, ramps, and elevators are routinely provided for in new construction, even if "mainstreaming"—the idea that people with disabilities should not be singled out by creating a building with, for example, monumental stairs in the front and a "handicapped entrance" around the back—still has a ways to go. However, as I have written previously:

> One element in the standards—created to accommodate people with vision disabilities—remains widely misunderstood and ignored: constraints placed on protruding objects, that is, objects that extend ("protrude") into circulation paths in such a way that they cannot be detected by people with vision disabilities and thus present a hazard … This issue has become increasingly important as works of architecture manifest non-orthogonal geometries in which elements, designed to challenge the orthodoxy of traditional vertical or horizontal surfaces, extend into circulation paths above the cane-sweep zone used by vision-impaired individuals to maneuver safely through the built environment.[21]

There are numerous instances in Milstein Hall where sloping structural elements, fenestration, and even works of art create protruding objects within the path of egress. The 2002 *New York State Building Code* regulates protruding objects, not in its "Accessibility" section, but in its section on "Means of egress," requiring a "minimum headroom of 80 inches (2032 mm)" and the provision of a barrier whose leading edge is at most 27 inches (686 mm) above the floor in cases "where the vertical clearance is less than 80 inches (2032 mm) high."[22] The federal Americans with Disabilities Act (ADA) clarifies that any protruding object that is neither within the cane sweep zone—from the floor to a point 27 inches (686 mm) above the floor—nor higher than 80 inches (686 mm) cannot protrude more than 4 inches (100 mm), as illustrated in figure 6.19.[23]

Although the building code prohibits protruding objects only in means of egress, the term "means of egress" is defined in the code as a "continuous and unobstructed path of vertical and horizontal egress travel *from any occupied point in a building or structure to a public way*,"[24] so pretty much all walking surfaces inside and outside of Milstein Hall must comply. The United States Access Board guidelines on protruding objects, referencing the ADA, make it clear that these requirements "apply to all circulation paths and are not limited to accessible routes. Circulation paths include interior and exterior walks, paths, hallways, courtyards, elevators, platform lifts, ramps, stairways, and landings."[25] Numerous instances of noncompliant protruding objects can be found throughout Milstein Hall. Some examples follow:

Milstein Hall's hybrid trusses consist of inclined steel elements that protrude into the circulation path. Some of these protruding structural elements are "protected" by cane-detection guards—painted steel

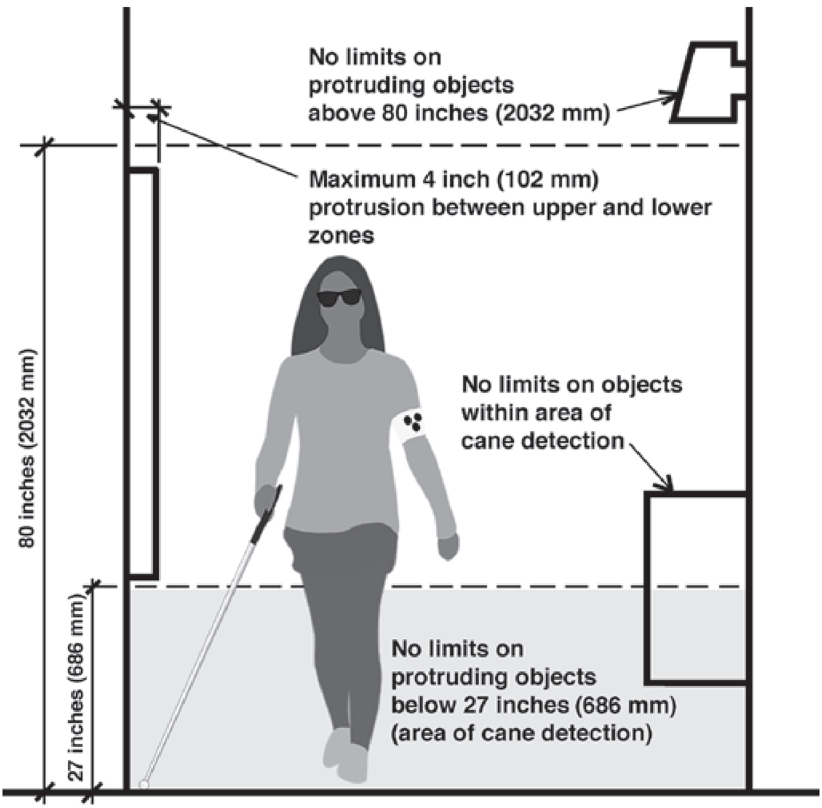


Figure 6.19. Graphic illustration showing limits of protruding objects.

assemblages resembling wire-frame renderings of rectangular solids—that are permanently anchored into the floor slab (fig. 6.20).

However, many other inclined structural elements in Milstein Hall are either not protected at all, or are inadequately protected (fig. 6.21).

Figure 6.20. Typical cane-detection guard at inclined (protruding) structural element in Milstein Hall.

If it is claimed that angled structural elements along the outside edge of the second-floor plate in Milstein Hall are not *in* the means of egress because they form a boundary to the egress pathway, it should be noted that without a cane-detection barrier, the boundary remains invisible to those with visual impairments, and becomes especially dangerous if the room fills with smoke—precisely the reasons for requiring cane-detection boundaries around such protrusions. These protruding objects create a hazard, not just for the visually impaired, but for all building users. Everyone, at one time or another, may become distracted and unaware that they are approaching such dangerous objects within the circulation space. Smartphone texting, in particular, is a known impediment to pedestrian safety on sidewalks and roads;[26] the same dangers exist for people when surfaces of buildings protrude into circulation spaces.

There are other instances where cane-detection guards were installed incorrectly, so that the protrusions they were designed to guard against still presented hazards. In some cases, the guards were cut and extended

Figure 6.21. Cane protection guards are consistently missing at inclined elements of the hybrid trusses on the second floor of Milstein Hall that are adjacent to curtain walls or, as illustrated here, are close to the brick walls of Rand and Sibley Halls (*left*); other inclined elements have inadequate cane-detection guards, as illustrated in this image (*right*) where the guard only protects people to a height of 64 inches (1626 mm) instead of the required 80 inches (2032 mm).

after the building was occupied so that they would provide adequate protection (fig. 6.22).

Several cane-detection guards were not specified at all, as part of the original design for Milstein Hall, but were installed after the building was built and occupied, apparently as a result of my complaints. Figure 6.23 shows how cane-detection guards were added to the sloping curtain wall in the arcade; figure 6.24 shows how cane detection guards were added to a sloping concrete column in the Crit Room. There are published images showing these sloping (protruding) elements *before* guards were installed (avant-guard?),[27] but I have chosen to simulate the original conditions by editing my own "post-guard" photos, finding this photoshopping process more pleasurable than arranging permissions with the copyright holder.

Accessibility issues involving protruding objects seem to keep popping up in Milstein Hall. Three works by the sculptor, Jason Seley, were placed in Milstein Hall's plaza in October 2017; one had a pedestal that acted as a cane-detection guard; the others did not. Eventually, concrete "benches" were moved below one of the offending sculptural

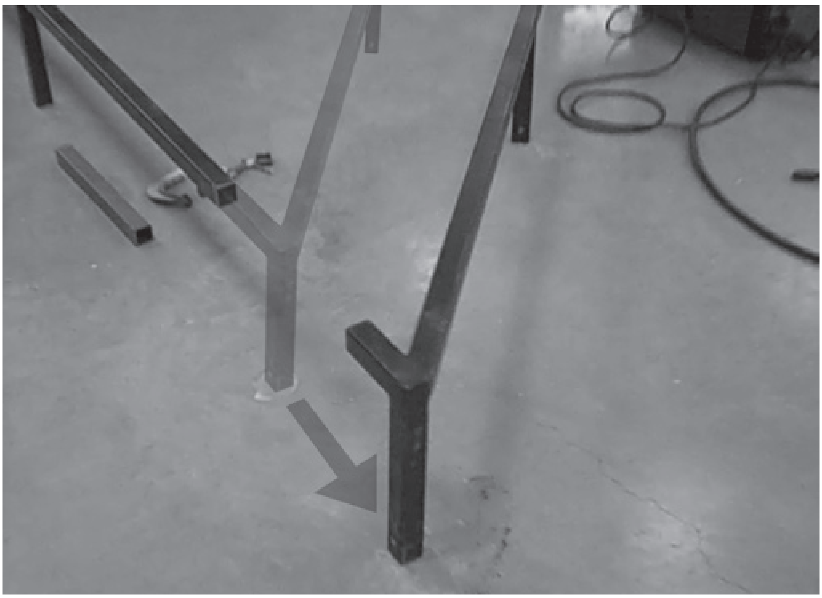


Figure 6.22. This photo, edited with Photoshop, shows how a cane-detection guard in the Crit Room needed to be cut and extended after the building was occupied.

Figure 6.23. Cane-detection guards were added to the sloping curtain wall in the arcade: before, simulated (*left*) and after (*right*).

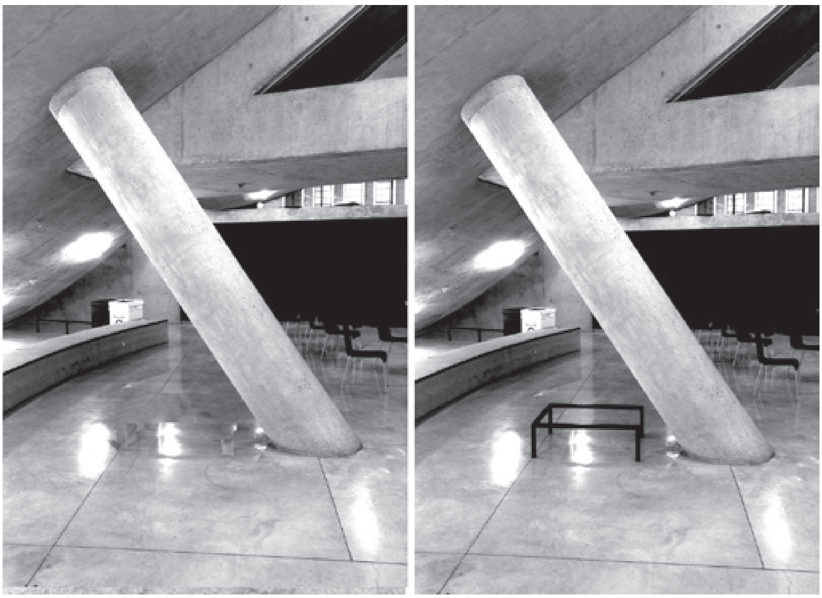


Figure 6.24. Cane-detection guards were added to the inclined reinforced concrete column in the Crit Room: before, simulated (*left*) and after (*right*).

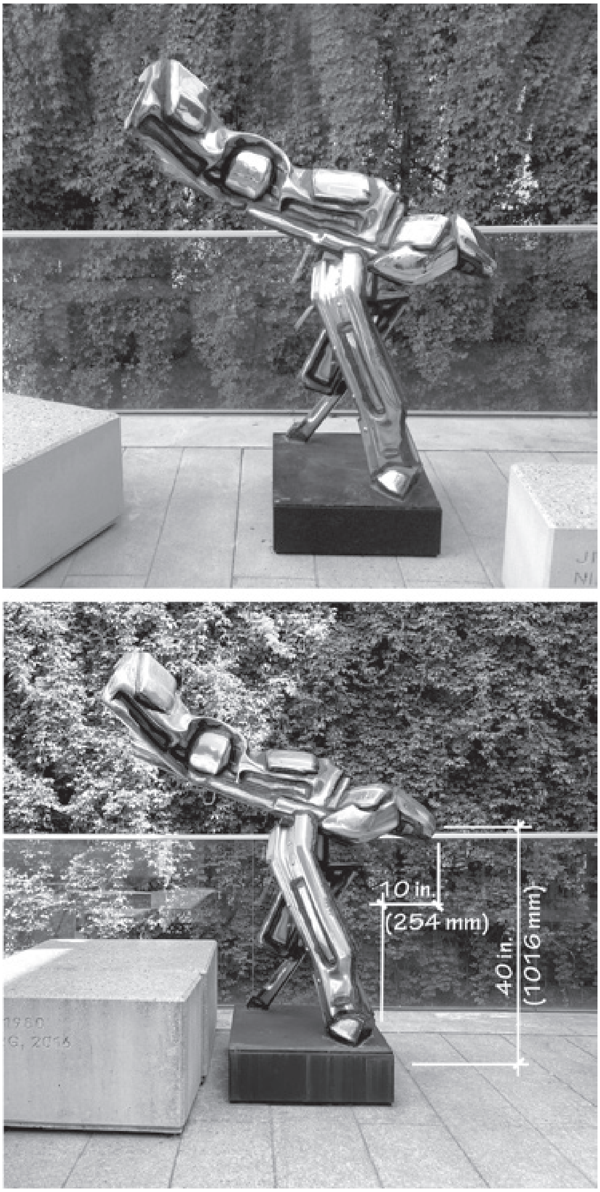
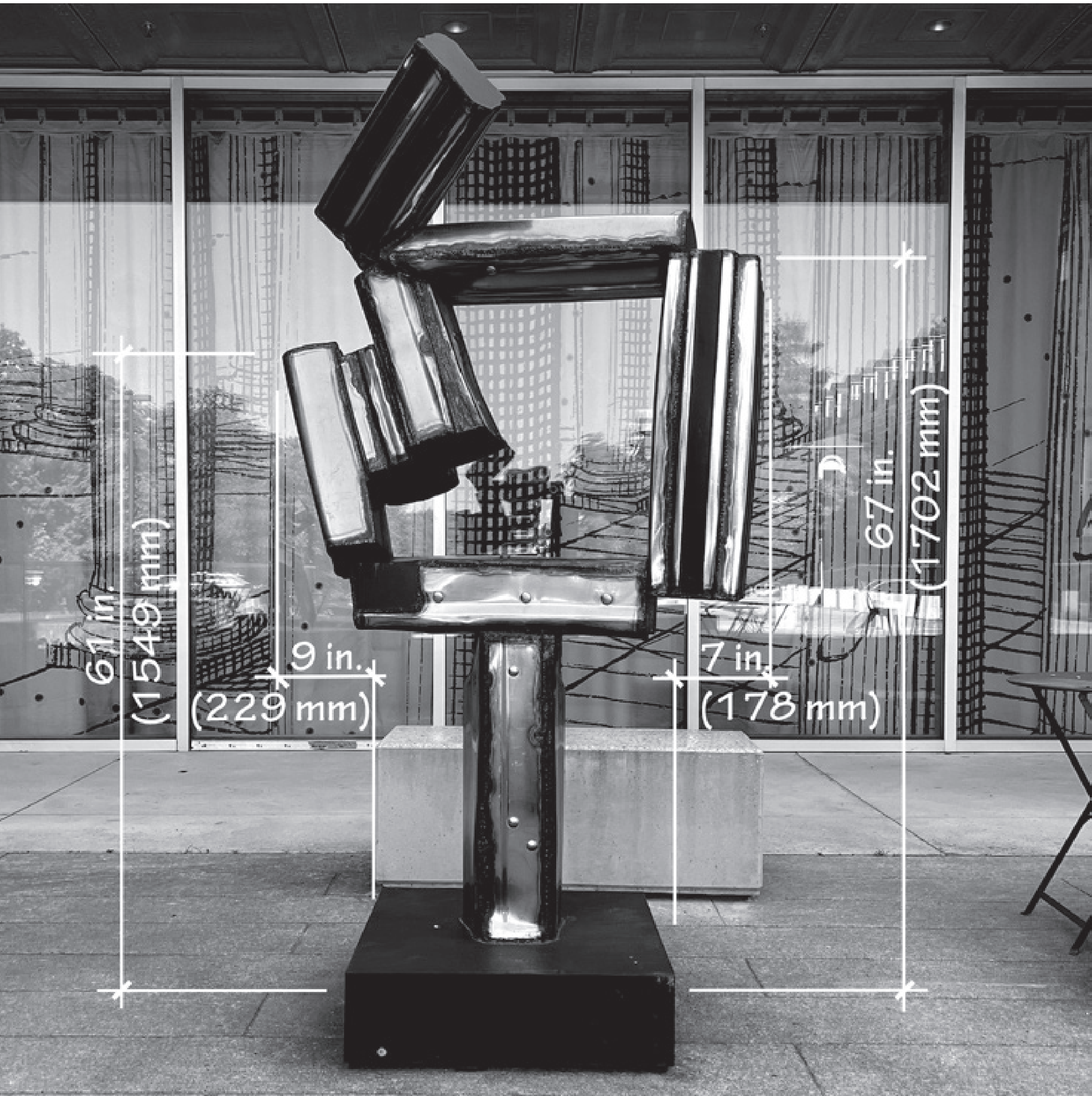


Figure 6.25. Sculpture as protruding object. A sculpture by Jason Seley was placed on Milstein Hall's concrete deck, creating a protruding object hazard (*top*); eventually, the issue was "resolved" by moving two of the plaza's concrete benches below the protruding part of the artwork, which created a cane-detection guard on one side of the sculpture, but not on the other side (*bottom*), where the welded car bumpers still protrude 10 in. (254 mm) into the circulation zone.

protrusions after I brought the issue of ADA and code noncompliance to the attention of the college. But while this improvised cane-detection solution offered nominal protection on *one* side of the sculpture, the other side remains noncompliant (fig. 6.25).

A second Seley sculpture on the plaza is also noncompliant, with both sides protruding more than the allowable 4 inches (100 mm) beyond the pedestal (fig. 6.26).

Figure 6.26. This sculpture by Jason Seley has protruding elements in violation of the ADA and the building code.



In the same outdoor space, a food truck with dangerous and illegal protruding canopies was designed and installed after Milstein Hall was completed and occupied and, like the Jason Seley sculptures, was not part of the design brief given to OMA (fig. 6.27). Two and a half years after I complained about its ADA/code violation, Cornell finally modified the protruding canopy supports so that they would not extend beyond the 4-in. (100 mm) limit.

Figure 6.27. Food truck canopy as protruding object: the canopy was designed and built to extend beyond the acceptable limits for protruding objects, creating a hazard for people moving along the circulation path (*left*); two and a half years after I complained about the code/ADA violation, the problem was finally remediated (*right*).

7 BUILDING GOOD: STRATEGIES, OBSTACLES, FICTIONS

Understanding how buildings function and adapt to changing conditions is not self-evident. Clients don't always know what they want, the future is always uncertain, and what appears as an appropriate response may bring unanticipated negative consequences.

Strategies

In order to "build good," i.e., to avoid creating dysfunctional or inflexible buildings in this baffling context, two seemingly contradictory strategies are available to designers. On the one hand, designers can carefully examine and, where appropriate, reproduce traditional building elements that seem to work. At best, such building elements, having evolved over long periods of time, solve problems without creating new ones—even if their multi-dimensional functionality is not fully understood by the designer. Ignoring such traditional wisdom may result in dysfunctional solutions since the multiplicity of functions, often combined and therefore hidden within traditional designs, may not be recognized as such or, even worse, may be discarded out of contempt for what is seen as being merely prosaic and functional.

On the other hand, designers must understand and account for changes in social behaviors, building science, and building materials, since strategies that might have been appropriate in the past (i.e., precisely the traditional or vernacular logic that was just cited) may be incompatible with modern practice. Ideally, what remains relevant in traditional practice is integrated into contemporary building theory, so that one can safely discard the ideological baggage of the vernacular without completely losing its wisdom.

It would be nice if there were a few concise bullet points to encapsulate the essential elements of good building, analogous to Michael Pollen's advice for healthy eating ("Eat food. Not too much. Mostly plants.").[1]

Joseph Lstiburek makes an attempt with his advice for sustainable building ("Use lots of insulation, airtight construction, controlled ventilation, and not a lot of glass"),[2] but his four prerequisites for low-energy construction—while important—address only one aspect of good building, out of hundreds or even thousands of building issues. In fact, there simply is no way to cover all the *specific* elements of good building in a few bullet points; Christopher Alexander, for example, identified 253 patterns and took over one thousand pages of text to explicate his system of interrelated building problems and solutions.[3] Still, it may be possible to offer the following general principles for building good:

- Pay attention to what has worked in the past, unless contradicted by current building science and social conventions.
- Prioritize health, safety, and welfare.
- Refuse to compete on the basis of defamiliarized form, dysfunctional features, or diagrammatic fictions.

Obstacles

While these strategies for building good might prove useful within some small corners of architectural culture, none of this advice is relevant to designers pursuing avant-garde notoriety. As I argued in a blog post introducing my book, *Building Bad*:

> The question posed in the epilogue—'whether and how the art of architecture can adjust its trajectory so that it aligns with the most fundamental requirements of building science'—remains unanswered, as it must: Architecture's dysfunction, running parallel to the dysfunction of society as a whole, constitutes an essential feature of avant-garde production, not a flaw. This dysfunction is consistent with and, in fact, thrives within the ethos of human and environmental damage that undergirds modern democratic states.[4]

Aside from the dysfunctional competition that drives defamiliarized avant-garde design,[5] the hidden multi-dimensional functionality of many traditional building elements can be problematic even for designers who eschew the pretensions of avant-garde production. The temptation to solve a problem by deviating from some normative standard is often present, since the negative ramifications of doing so may not be obvious. But such modifications may well affect a crucial aspect of an element's multi-dimensional functionality that was not recognized as such.

Fictions

In Milstein Hall, many problems with function and flexibility can be attributed to the architects' disinclination to integrate and reconcile traditional wisdom, drawn from careful study of past practices, with an evolving building science, driven by new materials and new standards for energy, carbon, and comfort. Instead, the architect's priority is to defamiliarize traditional elements in order to exploit the *expressive* potential of purposefully distorted or abstracted geometries based on diagrammatically clear, single function "cartoons" of solutions. In such cases, the functions *not* considered inevitably show up, uninvited, at the designer's or client's metaphorical door demanding ransom and exacting revenge.

The underlying diagrammatic cartoon from which much of Milstein Hall's dysfunction originates can be understood by examining a campus site plan (fig. 7.1) in which an east-west zone is delineated such that it brackets the primary buildings of the college (Tjaden, Sibley, and Rand

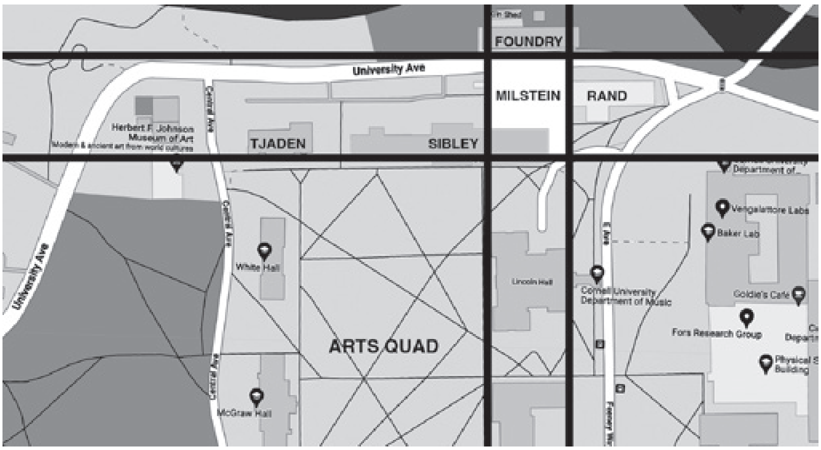


Figure 7.1. I've interpreted the diagrammatic basis for Milstein Hall's siting on this campus plan: an east-west zone brackets the primary buildings of the college (Tjaden, Sibley, and Rand Halls as well as the art museum to the west); while a north-south zone conceptually ties the college's Foundry structure to the eastern buildings of the Arts Quad. Milstein Hall occupies the intersection of these two zones.

Halls as well as the Herbert F. Johnson Museum of Art to the west); while a north-south zone conceptually ties the college's Foundry structure, north of University Avenue, to the eastern buildings of the Arts Quad along Feeney Way (formerly East Avenue). Milstein Hall is then placed precisely at the intersection of these two zones, symbolically forming a linchpin or connecting structure—a "contiguous, multi-layer system of buildings and plazas" that, according to the architects, "unites the disparate elements of the AAP."[6]

We've already seen in chapter 5, on circulation, that merely placing Milstein Hall at a location between Sibley Hall, Rand Hall, and the Foundry is not something that, in and of itself, "unites the disparate elements of the AAP." Rather, the explanation is a conceptual fiction designed to provide plausible deniability to the charge of gratuitous defamiliarization. Or, to reiterate Thorstein Veblen's argument in his analysis of women's dress, it is just a smokescreen where "each added or altered detail strives to avoid instant condemnation by showing some ostensible purpose, at the same time that the requirement of conspicuous waste prevents the purposefulness of these innovations from becoming anything more than a somewhat transparent pretense."[7]

The idea of embracing fictional constructs is a recurring theme in the writings of Rem Koolhaas. In *Delirious New York*, he argues not only that "the Appendix should be regarded as a *fictional conclusion*, an interpretation of the same material, not through words, but in a series of architectural projects," but also that the book itself "describes a *theoretical Manhattan*, a *Manhattan as conjecture*, of which the present city is the compromised and imperfect realization."[8] In fact, fiction for Koolhaas is not a flaw, but a feature of his presentation. Channeling Salvador Dalí's so-called paranoid-critical method, and anticipating Donald Trump, he extols fake news and speculation: "Paranoid-Critical activity is the fabrication of evidence for unprovable speculations and the subsequent grafting of this evidence on the world, so that a 'false' fact takes its unlawful place among the 'real' facts."[9] In Milstein Hall, additional conceptual fictions, distortions, and half-truths —embodying Veblen's "transparent pretense"—have been promoted by the architects or their acolytes. A partial list follows:

1. *From OMA's website*: "Milstein Hall provides a type of space currently absent from the campus: a wide-open expanse that stimulates the interaction of programs, and allows flexibility over time."[10]

The geometry of Milstein Hall's second-floor plate, filling up the diagrammatic space shown in figure 7.1, makes it difficult to use the building for typical classroom, office, and related functions. Only a few Cornell campus buildings have similar dimensions (fig. 7.2), and in those buildings—like Uris Hall, designed by Pritzker Laureate Gordon Bunshaft of S.O.M.—the deep floor plan leaves many offices and classrooms

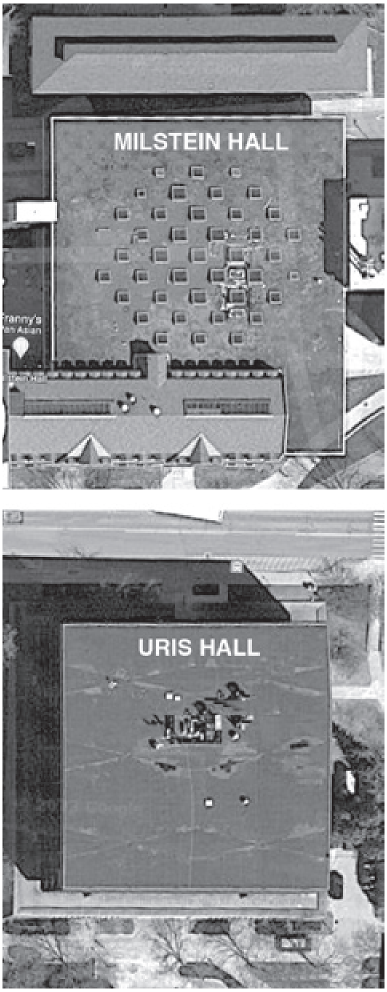


Figure 7.2. Milstein Hall (*top*) and Uris Hall (*bottom*) on the Cornell University campus are of similar size and shape, as can be seen in these Google Map satellite views taken at the same scale and orientation.

windowless, and creates a maze of circulation corridors making orientation difficult, even with a more rational placement of core elements like stairs, elevators, and bathrooms, in the building's center (fig. 7.3). In Milstein Hall, a large percentage of perimeter space can have no windows to the outside because of adjacencies to Sibley Hall and Rand Hall. Similarly, what *were* flexible office or classroom spaces on the second floor of East Sibley Hall have become less useful and less flexible since their "windows" now look directly into Milstein Hall's studio floor and have become non-operable components of a fire barrier separating the two buildings.

2. *From Cornell's website:* "The sustainable design goals for Milstein Hall are met through the use of good design practice to provide a healthy and comfortable environment for the building occupants."[11]

Having defined the building location for Milstein Hall at the intersection

Figure 7.3. Uris Hall at Cornell University has similar dimensions as Milstein Hall, and illustrates the difficulty of placing classroom and office occupancies in such a deep floor plan without creating windowless rooms and a maze of circulation corridors.

of conceptual east-west and north-south zones shown in figure 7.1, the architects then make the building as energy-inefficient as it is physically possible to do, wrapping the entire perimeter at all levels with "floor-to-ceiling windows," irrespective or orientation or function. More problematic, from an energy perspective, is the decision to lift the second-floor studio into the air to align with and connect to the second floors of Sibley and Rand Halls, while depressing the lower level into the ground to align with the basement of Sibley Hall (Rand Hall has no basement). Aside from a small portion of below-ground basement ceiling/roof area and upper-level soffit that is enclosed by the glazed perimeter of the auditorium and entry mezzanine, the enormous expanse of second-floor soffit and basement ceiling/roof area becomes exposed to the weather, along with the green roof, punctuated by skylights, over the second-floor studios. And, as the architects note with approval, not only the auditorium but also Milstein Hall's second-floor studios are surrounded by "floor-to-ceiling windows," except where Milstein Hall's second floor connects with Sibley Hall and Rand Hall (fig. 7.4).

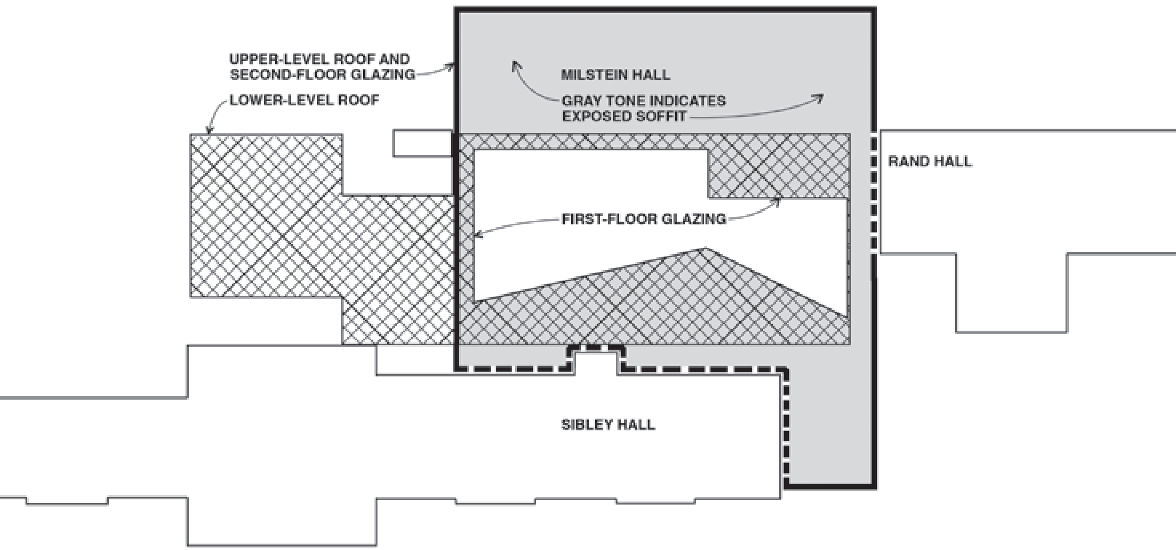


Figure 7.4. Surfaces of Milstein Hall that are exposed to the weather: The black perimeter line bounds the upper studio level, defining the roof; the gray-toned area within the black perimeter line represents the exposed second-floor soffit; the cross-hatched area represents the exposed roof of the basement, which extends under the outdoor plaza and loading area to the west of the main part of the building.

Traditional or vernacular wisdom suggests that, in Ithaca's severe climate region, architects should employ the opposite strategy for a building's massing. Rather than articulating and separating the building's constituent parts, thereby maximizing the surface-area-to-volume ratio, they should "use a compact design with a *minimum* surface-area-to-volume ratio."[12] Yet as a result of OMA's complex form-making, Milstein Hall's volume of 723,795 cubic feet (20,496 cubic meters) corresponds to an incredibly large exposed surface area of 73,984 square feet (6,873 square meters).[13] To show how these numbers compare to a hypothetical building with a more rationally configured geometry, we can take Milstein Hall's volume but organize it within a normative 3-story building with an occupiable basement (similar to many of Cornell's traditional campus buildings). Giving this hypothetical building a width of 64 feet (20 m)—the "optimal" width for a campus building proposed by Stewart Brand that was discussed earlier—and using Milstein Hall's basic floor-to-floor heights, we get, for the same volume of 723,795 cubic feet (20,496 cubic meters), a reduced total exposed surface area of 36,639 square feet (3,404 square meters). In other words, a rationally configured geometry with the same volume as in Milstein Hall would have *half* of Milstein Hall's exposed surface area, making it far more energy efficient. Of course, this hypothetical version of Milstein Hall would also be far more *functionally* efficient and flexible.

3. *From OMA's website*: "The new Milstein Hall," according to the architects, features "a large elevated horizontal plate that links the second levels of Sibley and Rand Halls and cantilevers over University Avenue, reaching towards the Foundry building."[14]

The extreme cantilevers of Milstein Hall's top story—extending 48 feet (14.6 m) over University Avenue—necessitate an elaborate and material-intensive structural work-around consisting of five floor-to-ceiling-height hybrid trusses that have been distorted, at the architect's insistence, so that none of the vertical or diagonal members intersect at common nodes along the top and bottom chords, as would be the case in a true truss with predominantly axial forces. This distortion effectively destroys the structural logic of the truss by introducing enormous bending moments into all of the structural members, so that it becomes less of an efficient axial-force structure, and more of an inefficient rigid-frame structure. The convoluted logic underlying this geometry is "explained" by OMA partner-in-charge Shohei Shigematsu:

The decision to put all the studios into one single linking space meant that the building would have to cantilever far out over the road at the edge of the site, which then meant that two extra trusses had to run down inside the studios. The circulation problems created by these trusses prompted a clever hybrid solution, whereby in the less stressed middle part of the building the frame can be a vertical (or "Vierendeel") truss, while as the strains get greater towards the edges, the truss becomes more

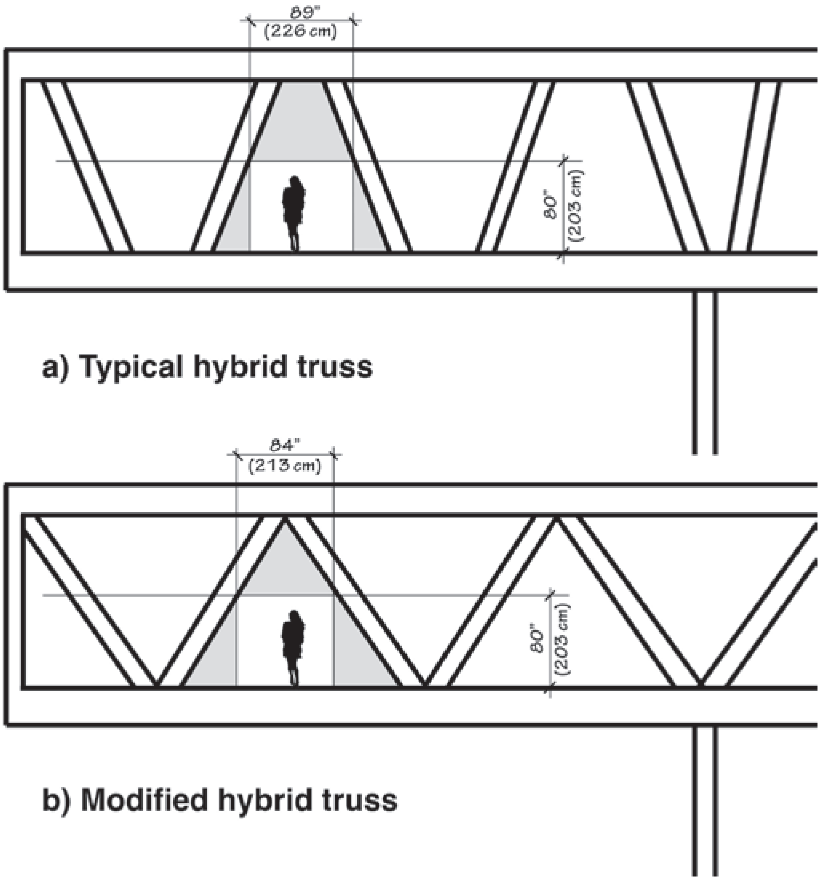


Figure 7.5. Milstein Hall's typical hybrid trusses (*a*) provide about 89 inches (226 cm) of space for circulation over the cantilever; a modified and more structurally efficient design (*b*) would provide about 84 inches (213 cm) of space—virtually the same amount.

> angular. "You can instantly see where the forces are going," Shigematsu says. "We thought it was interesting for the students pedagogically to see how the forces are actually in the truss."[15]

None of this is true. The argument starts with the premise that "all the studios" have been placed into "one single linking space." In fact, numerous architecture studios are assigned to spaces outside of Milstein Hall—some are on the third floor of East Sibley Hall, and the rest are in the college's New York City and Rome facilities. The entire justification (putting "all the studios into one … space") for this audacious cantilever is bogus. The argument continues by claiming that the distortion of the truss into a "hybrid" rigid frame is a result of "circulation problems created by these trusses." In fact, one can circulate quite easily through a normative truss, as shown in figure 7.5.

Next comes the structural justification for the distorted truss geometry at the cantilevered section, where it is argued that "as the strains get greater towards the edges, the truss becomes more angular." But this turns the structural logic inside-out: instead of starting with the most efficient truss form—one where all diagonals and verticals intersect at nodes along the top and bottom chords—and *only then* making whatever modifications are deemed necessary to facilitate circulation, OMA's argument starts with the most inefficient truss form imaginable—a so-called Vierendeel truss with no diagonal members—and then modifies this grossly inefficient rigid frame by angling some of the vertical members slightly where internal forces and moments would otherwise be higher. It is a type of argument eerily similar to Milstein Hall's bogus energy cost calculation, described in chapter 22, in which a "baseline" (i.e., worst-possible) building is used as a point of comparison with the actual modeled building, so that even a terrible proposal, compared with the baseline, looks good.

As can be seen in figure 7.6, the maximum bending moment in the hybrid truss, resulting from this cascading series of bad decisions and bogus explanations, is more than three times the equivalent value in a hypothetical and slightly *less illogical* hybrid truss where diagonals in the cantilevered section, still rigidly connected, are made to intersect at common nodes along the top and bottom chords. And while my modified structural model and load assumptions are simplified compared to the actual structural design, the conclusions can be taken as sound.[16]

The final argument that the architects make for these hybrid trusses is that they serve as a teaching tool: "We thought it was interesting for

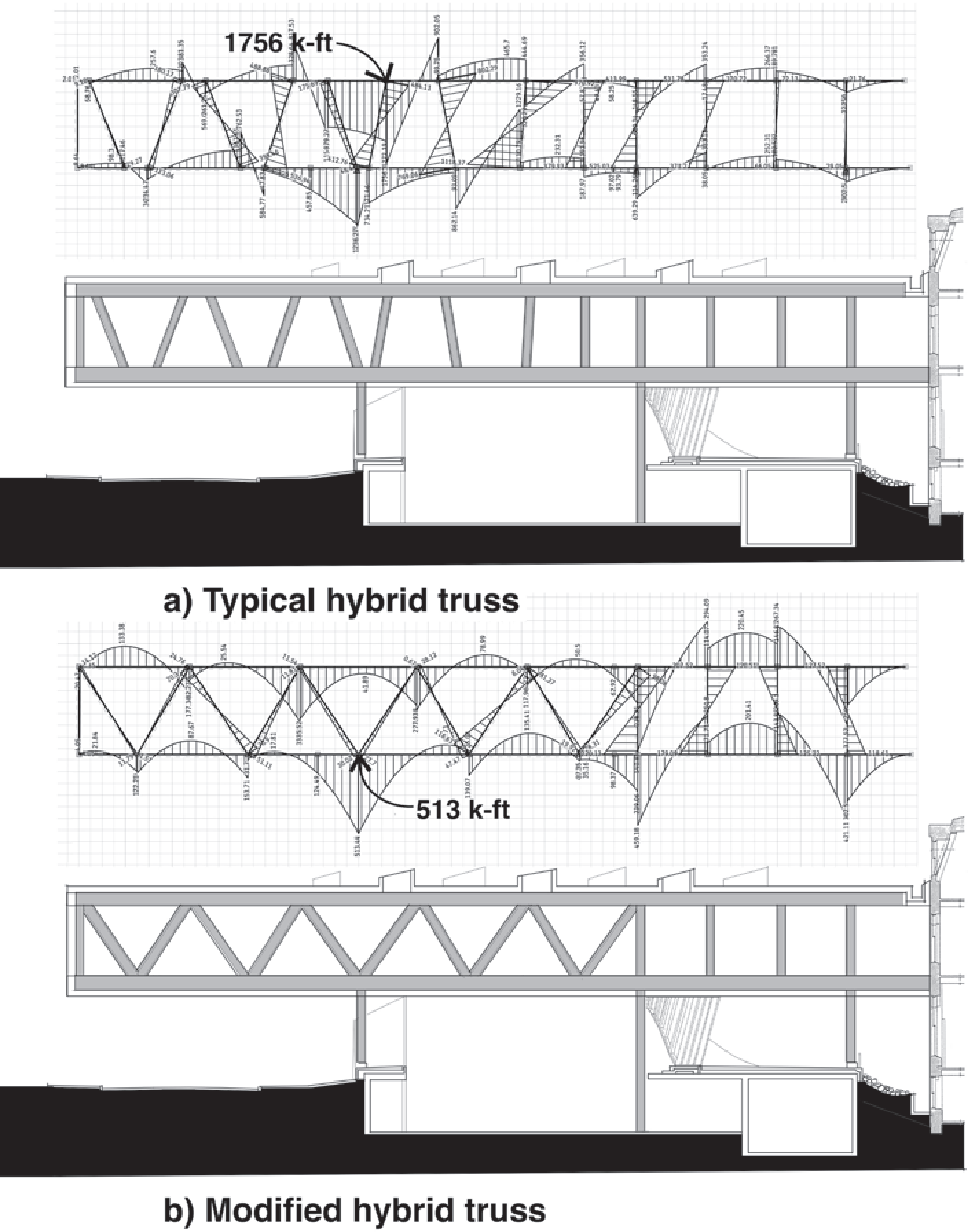


Figure 7.6. Making simplified assumptions about the structural geometry and loads, one can see that (*a*) Milstein Hall's "clever hybrid solution" produces bending moments that are more than three times greater than (*b*) a modified version with more rational deployment of diagonal members over the cantilever.

the students pedagogically to see how the forces are actually in the truss," says OMA's Shigematsu. Cornell's website goes even further, arguing that "in its own right, the hybrid truss becomes a laboratory for teaching architects structural design concepts."[17] These contentions are particularly annoying for two reasons. First, students cannot see forces, bending moments, or any other structural action, when they look at these hybrid trusses. As I have written elsewhere, "Not only is the expression of structure different from structural behavior, but the actual behavior of structural elements and systems is not at all self-evident: all structural action takes place 'beneath the surface' so that our view of structure is, literally, superficial. We do not see tension in a suspension bridge cable or compression in a stone column."[18] Rather, the path to structural insight is, like all forms of creativity, a patient search: Felix Candela wrote that architects "appear to be convinced that there is no need to make any great effort—that a 'flash of genius,' a sudden inspiration, is quite enough to create a structure of novel and original conception. Unfortunately, the creative act is hardly ever the result of effortless inspiration. It is, instead, the—sometimes belated—result of long and painstaking work, the fruit of many years of constant effort and steadfast mental occupation with the problem concerned."[19]

The behavior of a simple truss is so sensitive to span and load conditions that even structural form-finding methods embodied in graphical statics—certainly a step above merely "seeing" the trusses—are still virtually useless as pedagogic tools for students. In my paper, "Revisiting Form and Forces," I argued that when "using graphical statics, trusses of radically different spans … end up 'finding' exactly the same form. The author's analytic optimization exercise, on the other hand, shows that the optimal aspect ratio for a truss actually increases as its span increases, revealing the limits of a graphical statics 'form-finding' approach."[20]

Second, it is distressing to think that students would ever be tempted to take this dysfunctional architectural form, and the structural gymnastics that enable it, as a precedent for their own design explorations. Yet characterizing Milstein Hall as a structural laboratory implies that the building might serve as a positive role model in this respect. As if…

4. *Shohei Shigematsu of OMA states*: "Our ambition was that this was almost like a covered interior space, so we looked at typical American tin decorated ceilings, and then we just blew them up four times as big and used them as ceiling panels."[21]

Many of Milstein Hall's problems with function and flexibility can be attributed to the architects' disinclination to integrate and reconcile traditional wisdom, drawn from careful study of past practices, with an evolving building science, driven by new materials and new standards for energy, carbon, and comfort—except where those elements are mined for their expressive potential, as in the appropriation of traditional "American tin decorated ceilings" for the underside of the second floor (fig. 7.7).

Tin ceilings were invented in the U.S. in the late nineteenth century as "a more affordable and more durable option to intricate plasterwork that was popular on European ceilings in the late 1800s."[22] In Milstein Hall, the ceiling/soffit panels certainly work as eye candy, but fail to take advantage of their ambiance—whether construed as nostalgic or ironic—to enliven Milstein Hall's covered outdoor spaces. Instead, unlike so many restaurants, bars, and other commercial establishments

Figure 7.7. Milstein Hall's stamped aluminum soffit panels reference traditional Victorian tin ceilings. Image shows the cantilevered portion over University Avenue facing the Foundry.

that have embraced their Victorian-era tin ceilings, the spaces under Milstein Hall's stamped aluminum panels remain largely empty and dysfunctional (fig. 7.8).

Such an expressive gesture may well have been deemed necessary, given the enormous extent of exposed surface area that needed to be covered *with something*. My criticism isn't that these panels are out of place within "the permanent warfare between the box and the blob" that constitutes the building's primary expressive conceit.[23] In fact, the aluminum panels' Postmodern irony (warning: this sentence betrays the author's subjective taste and really has no place in an objective critique) is a welcome relief from the building's other ponderous pretensions. It also helps that these panels are probably the most successfully implemented material detail in the entire building: they have been designed, manufactured, and constructed with thoroughness and precision. The problem is that they can't possibly compensate for the unsustainable design decision that made them necessary in the first place—to lift the entire second floor off the ground, thereby exposing an enormous amount of second-floor surface area to heat loss and heat gain, both directly through the floor as well as through the steel columns that necessarily penetrate the floor insulation as thermal bridges.

Figure 7.8. The spaces beneath Milstein Hall's faux-Victorian soffits, in particular the arcade (*left*), remain largely empty and dysfunctional; the ceiling tile design is modeled after a type of pressed tin ceiling, shown here in Ithaca's historic "Andrus Printing / Home Dairy / Firebrand Books Building" (*right*), that was invented in the U.S. in the late nineteenth century.

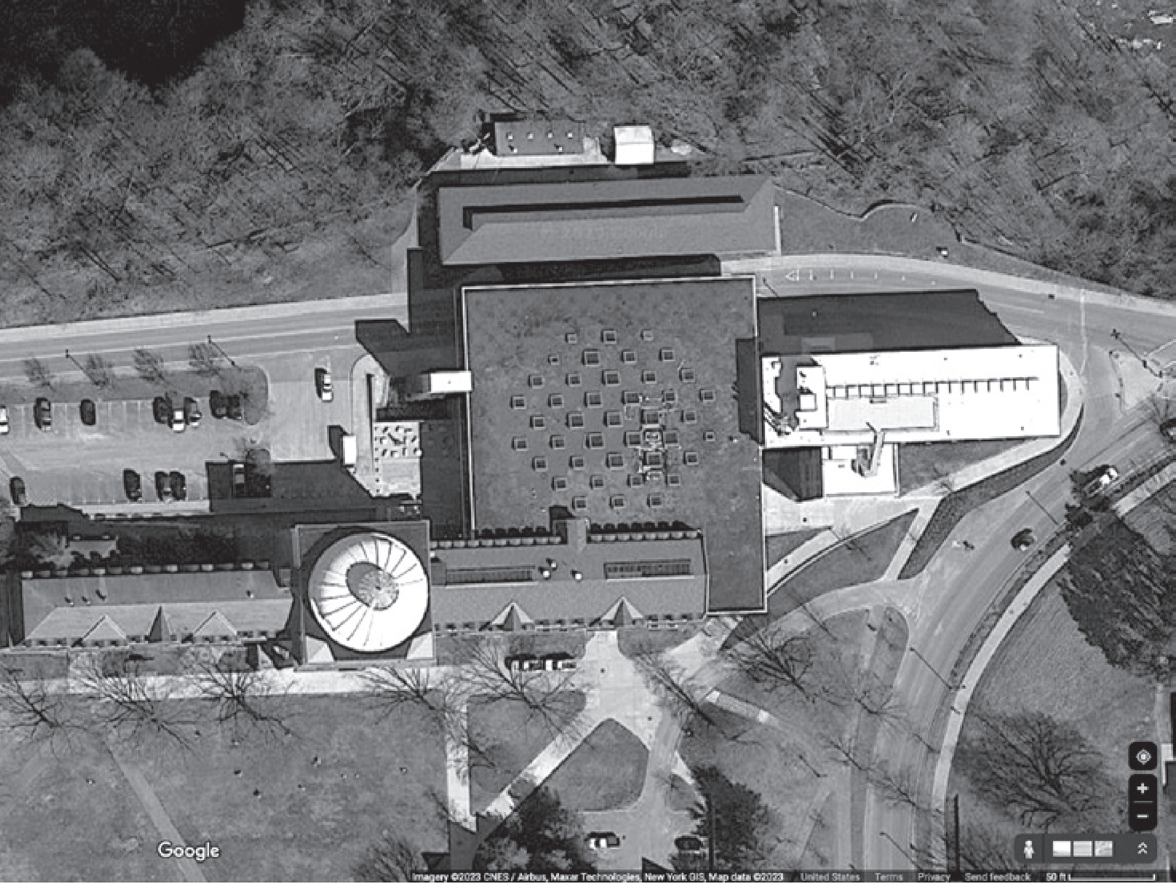


Figure 7.9. This Google Map satellite image shows how the “graphic pattern” of circles created by colored sedums on the vegetated roof of Milstein Hall has been virtually obliterated, both by natural processes and by maintenance; see also figure 6.6.

5. *From Cornell’s website*: “The roof of Milstein Hall is considered another facade of the building, reinforcing the concept of the building as a connector. The entire roof, with the exception of the skylights, is vegetated in a graphic pattern of two types of sedum plantings.”[24]

Characterizing the roof of Milstein Hall as a “facade” is problematic for a number of reasons, some of which have been discussed previously. First, the roof is barely visible, and—when it is seen at all—it is seen obliquely, e.g., from the third-floor studios in Sibley Hall, rather than frontally. On this basis alone, the term “facade” seems inappropriate. Second, the “graphic pattern” painstakingly created with circles of colored sedums has been virtually obliterated, both by natural processes and by maintenance (fig. 7.9).

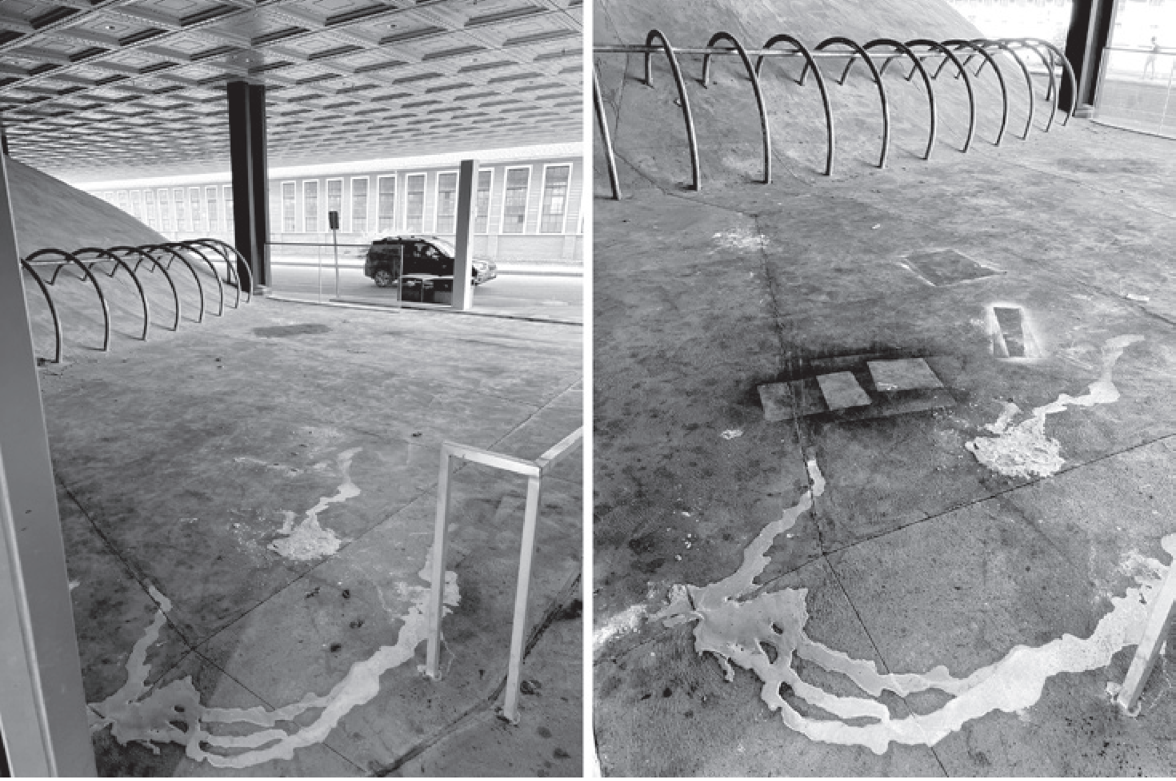


Figure 7.10. These Milstein Hall images of the covered outdoor space across from the Foundry were taken about a month apart in April (*left*) and May (*right*) 2023; one can see the addition of spray paint to the illicit composition that was already in place on the concrete surface: a work in progress!

Third, the flatness of the roof may have been partly responsible for the ongoing problem of leaks that has plagued the building since it first opened, discussed in chapter 10.

6. *From Cornell's website*: "Covered outdoor areas give architects, artists, and fabricators virtually boundless studio space, where they can construct large-scale prototypes, models, and sculptures."[25]

There are five "covered outdoor areas" in Milstein Hall, and none of them provide "boundless studio space" for the construction of anything, although many of them *are* used inappropriately for spray painting models and off-loading cigarette butts and other detritus. The dark, dismal, and almost-always-empty arcade (see fig. 6.8 or fig. 7.8 *left*) has already been discussed; it certainly does not provide any useful studio space for the college.

The four other covered spaces have even less chance of being used than the arcade. Three of these spaces, like the arcade, are covered by

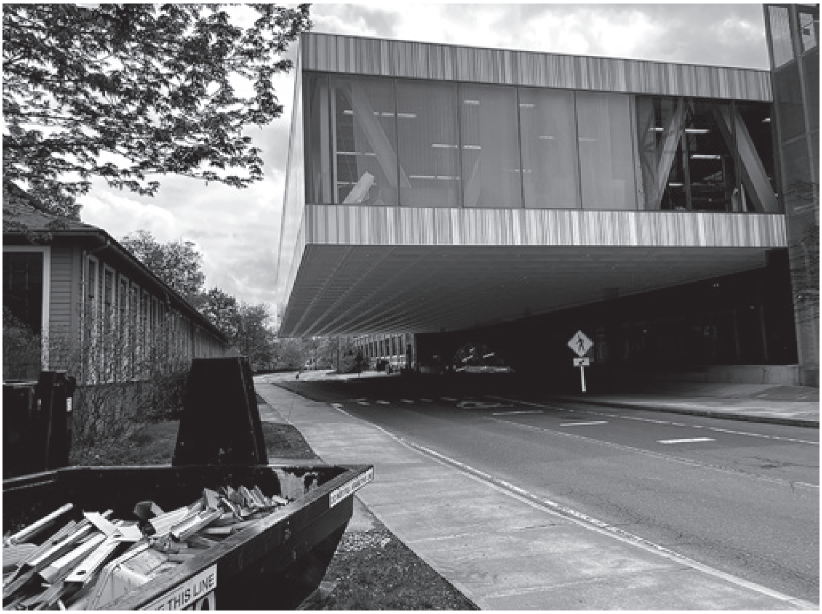


Figure 7.11. The outdoor covered space below Milstein Hall's primary cantilever functions as a road and sidewalk—nothing else.

the stamped aluminum soffit under the second-floor studio. The first of these spaces consists of a flat concrete surface off University Avenue, across from the Foundry, that morphs into the Crit Room's domed ceiling where it supports some circular bike racks, but certainly no "boundless studio space." Students do use the space occasionally and inappropriately, for spray painting models and for whatever else may have caused those white Giacometti-like residues (fig. 7.10).

The second of these covered spaces is the largest of them all, and the most useless: this is the portion of University Avenue that runs below Milstein Hall's cantilevered second-floor studios (fig. 7.11). Clearly, it does not, and cannot, function as anything other than a road and sidewalk—certainly not as "boundless studio space [for the construction of] large-scale prototypes, models, and sculptures."

The third covered space is under Milstein Hall's cantilevered projection to the south, hugging the east wall of Sibley Hall. This cantilever awkwardly protrudes over the main circulation path from the North Campus residential dorms to the Arts Quad and the space below

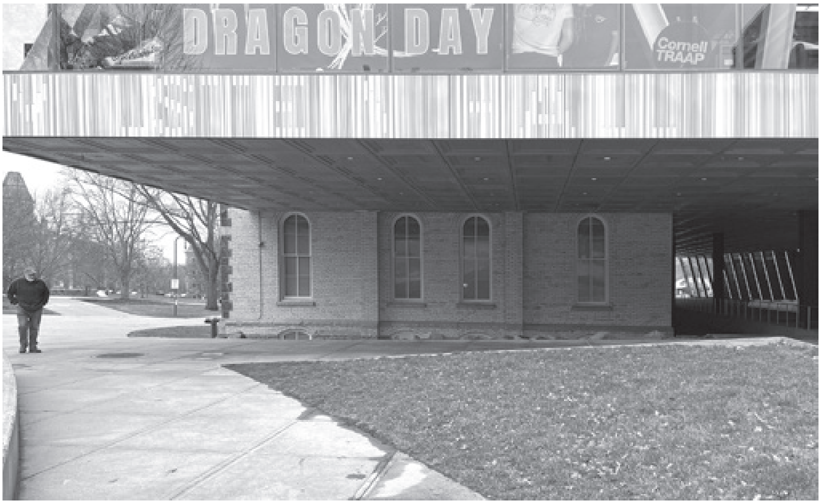


Figure 7.12. The south cantilever of Milstein Hall protrudes awkwardly over the main circulation path from North Campus to the Arts Quad; the space below consists of circulation paths to the arcade and to University Avenue.

Figure 7.13. An air supply grille for Milstein Hall's basement mechanical room provides an opportunity for students to spray paint their models while simultaneously poisoning the air supply for the auditorium and Crit Room.

consists of nothing other than circulation paths leading to the arcade and to University Avenue (fig. 7.12). There is certainly no evidence here of "boundless studio space."

There is, however, an air intake grille adjacent to the circulation path (fig. 7.13), which provides an opportunity for students to spray paint their models while simultaneously poisoning the air supply for Milstein Hall's auditorium, Crit Room, and other below-ground spaces.

The final covered outdoor space, and the only one not under Milstein Hall's pressed aluminum soffit panels, is the exterior exit stairway on the west side of the building. Clearly, the open spaces in this stairway should not be used for anything other than entering or exiting the building, and the building code prevents "the open space *under* exterior stairways [from being used] for any purpose."[26] This doesn't prevent the stairway from being appropriated as a de facto spray paint booth, solid waste disposal site, and smoking room (fig. 7.14). So the last opportunity to find useful outdoor covered areas has fallen short. The claim that Milstein Hall's covered outdoor areas provide "architects, artists, and fabricators virtually boundless studio space, where they can construct large-scale prototypes, models, and sculptures" turns out to be nothing but a transparent and egregious fiction.

Figure 7.14. The exterior stairway on the west side of Milstein Hall has been appropriated as a de facto spray paint booth, solid waste disposal site, and smoking room, but certainly cannot function as "boundless studio space."

PART II

NONSTRUCTURAL FAILURE

8 OPENING REMARKS ON NONSTRUCTURAL FAILURE

I have written previously about nonstructural building failure. My paper, "Designing Building Failures" examines the "relationship between building envelope failure and attitudes towards design," with a concluding section that "examines the implications for pedagogy and practice."[1] "A Probabilistic Approach to Nonstructural Failure" takes a closer look at one of the conclusions suggested in the first paper: that only a risk-based approach to the design of nonstructural building elements—analogous to limit-state design methods in structural engineering—can create conditions in which building design becomes rational and nonstructural failure is thereby reduced.[2] In the second of the two papers cited, I outline two characteristics of buildings that can increase or reduce the risk of nonstructural failure: a greater degree of peculiarity or complexity can *increase* the risk, while certain types of redundancy *reduce* the risk.

By *nonstructural* building failure, I mean problems with the actual constructed elements of a building that include things like rainwater and thermal control issues; sloppy, dysfunctional, or dangerous details; maintenance issues; and blotched or cracked finishes. I have excluded a discussion of *structural* failure since the design of structural systems has been largely removed from the purview of architects and is not only strictly regulated by building codes which reference design manuals promulgated by the major consensus-based structural materials organizations, but is also largely in the hands of professional engineers who are inclined by training and temperament to follow best practices embedded in those codes.

Whereas the probability of structural failure (i.e., the actual collapse of buildings or structural components like beams or columns) is made explicit within the design methods enforced by building codes and, in fact, forms the very basis of structural design, the design of nonstructural parts of buildings typically has no underlying probabilistic basis. In other words, when architects create drawings and specifications for buildings, they often have no basis for determining the probability of nonstructural failure. Where a clear pattern of architectural failure emerges, building codes may or may not be modified, depending on the severity of the problem. Even in those cases, however, the recommended "fixes" do not approach the problem from an explicitly probabilistic standpoint, so that it is still not possible to assess the reliability of one system in comparison with another, or to assume that an equivalent level of risk resides in all systems sanctioned by the codes.

A probabilistic basis for architectural failure is beginning to be acknowledged in theory but is still difficult to implement in practice. Nevertheless, it is still possible to draw some important conclusions about the nature of such failure.

Peculiarity

The most important conclusion derives from the fact that, for unusual architectural designs, the interaction of materials, systems, geometries, environmental conditions, installation methods, and so on, is rarely systematically tested or theoretically grasped. Conventional construction details and methods, on the other hand, have at least a track record of generally successful (or unsuccessful) application. While the lack of a consistent measure of reliability applies to such conventional systems as well, there is at least an informal understanding of how such systems perform over time. For this reason alone, one can state that architectural failure will generally increase as the peculiarity of the architecture (i.e., the deviation of the design from well-established norms) increases.

This conclusion requires a disclaimer: it presupposes an ordinary level of attention given to all aspects of building design and construction. In other words, it is assumed that little or no original research (i.e., research following protocols such as those sanctioned by ASTM) is undertaken to establish the behavior of unusual design elements or their interactions; and that little or no additional time is spent in order to properly identify and document all special building conditions resulting from unusual geometries or materials. Of course, if one has the budget, the time, and the expertise, it is certainly possible to reduce the probability of failure when designing unusual or complex buildings. However, doing so requires not only a commitment to research, but also sufficient time and money to conduct the research, produce the necessarily complex and complete construction documents consistent with the research results, and hire contractors willing and able to carry out such a project.

Clearly, the parameter "peculiarity" has not been rigorously defined, but it is worth noting the following characteristics of peculiarity in architectural construction:

- Within a given length, area, or volume, the number of building elements is unusually large, or unusually small; what constitutes an unusual density of such elements is simply a comparison to what is usual. In general, increasing the number of building elements increases the probability of failure since it is typically at the intersection or interface of such elements that failure occurs (and increasing the number of elements increases the quantity of such intersections). However, there are instances where reducing the number of elements actually increases the probability of failure. For example, a smaller number of uninsulated facade panels means that thermal movement of the panels, relative to an insulated structural frame, is concentrated over fewer joints, so that joint movement is greater. Greater joint movement can increase the likelihood of certain types of sealant failure, for example.

- The number of different types of building elements is unusually large.

- Well-understood details are distorted/twisted/altered—or else simply invented without reference to any precedent—to accommodate unusual geometries, or to subvert conventional formal expectations. In particular, the right angle is eschewed in favor of bent, curved, or otherwise non-orthogonal geometries, and conventional expectations about "walls" and "roofs" are discarded in favor of more abstract characterizations.

- Materials are used in combinations, or in applications, that have not been well tested.

As a result of this peculiarity, the following outcomes become more likely:

- Structural movement in buildings with "peculiar" geometries is less well understood and less well modeled and predicted. Complex structural geometries make it more difficult to, first, coordinate the interaction of things like structural movement and cladding, and second, model the structure accurately. Even if a geometrically simple building is modeled inaccurately, the simplicity and uniformity of the model suggest that errors will at least correspond to behavioral tendencies of the actual structure, even if numerically out of scale.

- Junctions (intersections) of materials or systems deviate from well-established norms.

- Architectural drawings and specifications are less likely to address the full range of conditions present within the building, especially in their three-dimensional manifestations.

- Contractors are more likely to apply conventional knowledge to unconventional situations. Ironically, in the case of so-called green buildings where more environmentally benign, but less well-understood, materials are employed, the opposite situation may occur with the same result: contractors are more likely to apply unconventional knowledge to conventional situations (see the following bullet point).

- Untested material combinations are more likely to interact in unpredictable ways.

- Basic strategies for enclosure (continuity) are more likely to be violated: membranes become penetrated rather than continuous, or penetrated in ad hoc ways; surface complexities promote discontinuities in thermal/vapor/water/air control membranes or materials.

Redundancy

The benefit of redundancy, examined from a probabilistic standpoint, is a relatively unexplored and potentially fruitful area of research. For example, providing two roof membranes instead of one doesn't merely cut the risk of failure in half, but—assuming that the failure of each membrane is independent of failure in the other—rather decreases the risk of failure by an order of magnitude. Of course, it is crucial that any strategy employing redundancy take into account the specific mode of failure: adding an extra (redundant) layer of paint over an improperly prepared substrate confers no particular advantage since the utility of the redundant layer depends on the integrity of the layer below. In other words, the conditional probability of failure of the redundant layer, given failure of the layer below (and therefore failure of the system as a whole), is 1.0, conferring no advantage. At the other extreme, the conditional probability of system failure for the two membranes discussed earlier—if each membrane is assumed, for example, to have a failure probability of 0.1—would be $0.1 \times 0.1 = 0.01$, a significant improvement.

Conventional practices, such as the provision of roof overhangs, can be reevaluated in this light. For a given exterior wall surface area, if the probability of failure due to water intrusion through an unintended hole in the wall is, say, 0.05, and if the probability that wind-driven rain will reach that wall surface is 0.07 when an overhang is in place (both values are entirely hypothetical), then the conditional probability of failure with an overhang is $0.05 \times 0.07 = 0.0035$, a dramatic reduction in risk compared with the hypothetical failure probability of 0.05 without the overhang.

The failure mode interaction described above—involving a combination of two or more failure modes where the redundant combination actually decreases the probability of failure—can explain the benefits of redundancy from a probabilistic standpoint. Having two barriers instead of one doesn't just double the safety (cut the probability of failure in half), but rather can be shown to be much more significant.

Roof overhangs could also reduce the probability of icicles forming on an exterior wall. In this case, the formation of icicles requires two things: on the one hand, a portion of the wall needs to be warm enough to melt wind-driven snow while a lower portion of the wall needs to be cold enough to freeze the melted water, causing icicles to form. On the other hand, wind-driven snow must be able to reach the wall surface. Now compare the use of overhangs on Frank Lloyd Wright's Robie House with the lack of overhangs on Milstein Hall. While leaking roofs are not unknown within Frank Lloyd Wright's oeuvre, the likelihood of icicles forming on the brick walls of the Robie House is dramatically reduced by the use of roof overhangs (Figure 8.1 *top*). On the exterior facade of Milstein Hall, on the other hand, icicles can form through the same process associated with classic ice damming. Snow melts on floor-to-ceiling glass panels, or perhaps on stone cladding panels—where

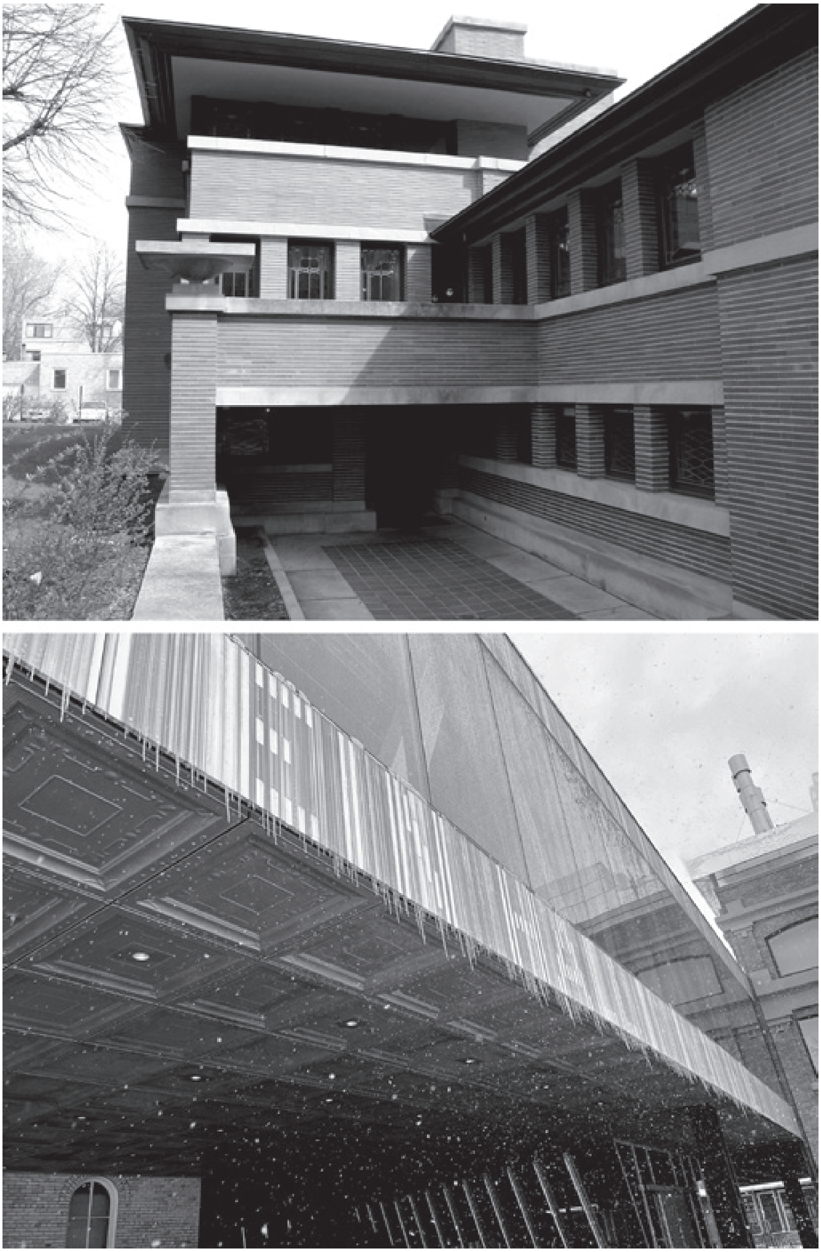


Figure 8.1. While leaking roofs are not unknown within Frank Lloyd Wright's oeuvre, the likelihood of water issues on exterior walls or windows of his Robie House is dramatically reduced by the use of roof overhangs (*top*); the exterior facade of Milstein Hall, on the other hand, forms icicles as snow striking the surface melts and then freezes (*bottom*).

radiant heat originating in the concrete floor slab (near the top of the stone panels) works its way through various insulation layers via thermal bridges—and then freezes (at the bottom of the stone panels) where the stone is colder. Such icicles, especially if they become bigger, pose a threat to pedestrians circulating directly under this cantilevered corner of Milstein Hall (fig. 8.1 *bottom*).

Of course, the problem with icicles on the facade of Milstein Hall should have been addressed by decreasing the U-value of glazing or, as discussed later in this section, by eliminating thermal bridges through the stone panels. Both strategies not only reduce the probability of icicle formation, but also reduce gratuitous energy consumption. The point is that buildings are constructed in a probabilistic environment where the risk of nonstructural failure is reduced by employing redundant strategies. In this example, even if an unexpected thermal bridge creates the conditions for icicle formation, an overhang could prevent wind-driven snow from reaching the wall surface in the first place.

Complacency

Aside from causes originating in the complexity or peculiarity of buildings (or their lack of redundant details), buildings also experience nonstructural failure because of designers' "complacency." I use this term to includes things like sloppy detailing and inattention to functional considerations. Some of this is related to the peculiarity or complexity of their buildings since such buildings require a great deal more attention to detailing. This means that a great deal more time, money, and expertise needs to be devoted to such detailing; it is dangerous to assume that the complexity will be somehow dealt with "in the field."

Architects do not necessarily need to sacrifice the expressive qualities of their designs in order to reduce the risk of nonstructural failure. But an architectural design strategy that starts off with heroic intentions and then attempts to "make it work" by superimposing some rational elements will be more likely to experience nonstructural failure than a design strategy that starts off on a rational basis and then "adds" expressive elements that leave the rational basis intact.

Nonstructural failure in Milstein Hall

Milstein Hall is a classic example of a peculiar and complex building for which only routine attention was given to nonstructural detailing and performance. Contract documents were produced, and contracts for construction were signed, without having established a clear and comprehensive understanding of critical construction details. Even from casual observation, without having official access to records or correspondence, several instances of this phenomenon can be seen, including rainwater infiltration through building enclosure elements, extensive cracking of concrete slabs, blotching of concrete wall finishes due apparently to VOC-compliant form-release agents, staining of concrete floor finishes apparently due to premature contact with plywood protection boards, and cracked exterior lighting fixtures. Given the secrecy surrounding the actual construction process—the ongoing crises, panicky phone calls, hastily-called meetings, negotiated remedies, and the change orders that invariably accompany such complex projects, are not made public—it is likely that those defects and failures immediately visible in Milstein Hall represent only a small fraction of actual nonstructural failure incidents.

Yet is it fair to classify Milstein Hall as a "peculiar" building? Unlike building designs that obviously deviate from traditional constructional geometric norms (e.g., those manifesting things like "splines, nurbs, and subdivs"[3]), Milstein Hall is, at least in part, designed with a regular orthogonal grid of columns, rigid frames, girders, and beams, and is clad with an expensive, but otherwise conventional, glass and stone veneer curtain wall. It is true that the lower-level geometry is far more complex, consisting of a reinforced concrete doubly curved "dome" and inclined glazing. However, even the "conventional" orthogonal steel framework is itself highly unusual (peculiar) in terms of its large cantilevers, hybrid trusses, and moment-connections for lateral-force resistance. As a result of both the peculiarity of the design and the lack of adequate attention given to its detailing, numerous sites of actual or potential nonstructural failure can be identified. These are described in the chapters that follow.

9 THERMAL CONTROL

Controlling heat flow (energy) is a basic requirement of building design, if not architectural design. The idea that the latter is endangered by the former is certainly a legitimate fear—given the increasingly perverse interest in understanding architecture as a heroic project—yet the outcome of such an attitude is always disheartening for both architect and client.

What follows is not necessarily an all-inclusive list of such thermal control failures at Milstein Hall. Without official access to such information, I must rely primarily on random observations of the building.

Thermal bridging at stone cladding

Attachment of stone veneer panels, based on approved shop drawings, differed considerably from contract document details—with unintended consequences for thermal bridging and heat loss. Specifically, the original stone anchoring system consisted of a two-part adjustable bracket system that penetrated the thermal control layer, i.e., the rigid insulation, only at the four points where steel anchors, grouted into the stone cladding panels, attached to the brackets (fig. 9.1*a*). This was replaced by virtually continuous horizontal steel angles that interrupt the rigid insulation, creating a highly conductive pathway, i.e., a thermal bridge, for heat loss or heat gain (fig. 9.1*b*).

In these sections, it's hard to see the extent to which the steel angles interrupt the rigid insulation, but the image screen-captured from one of my Milstein Hall construction videos (fig. 9.2 *left*) makes this clear. A better strategy, even when long or continuous shelf angles are used, is to detail them so that they "stand off" from the structural slab (fig. 9.2 *right*). In this way, the thermal control layer (insulation) can extend behind the shelf angle, minimizing thermal bridging.

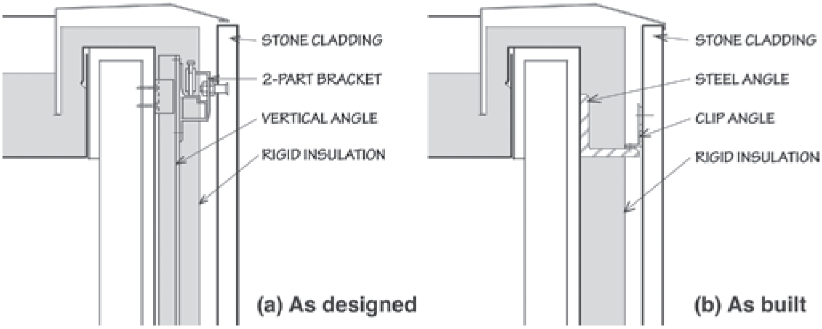


Figure 9.1. The original design (*a*) shows an adjustable 2-part bracket system which minimizes thermal bridging; the detail as built (*b*) replaces this "hi-tech" system with a "low-tech" assemblage of angles and clip angles which interrupt the continuity of the rigid insulation, creating a significant thermal bridge.

Figure 9.2 A significant thermal bridge can be seen in this construction photo of Milstein Hall (*left*), with horizontal steel angles, to support stone cladding panels, interrupting the thermal control layer, i.e., the rigid insulation. I've revised this screen-captured image to illustrate how a "stand-off" works (*right*): the horizontal angle would need to be moved 2 inches (50 mm) away from the sheathing and air barrier so that rigid insulation can be placed behind the steel angle, minimizing the thermal bridging.

Bollards as thermal bridges

Bollards were installed above below-grade, heated, spaces in Milstein Hall in order to protect pedestrians from vehicles in a loading area that is situated directly above those heated spaces. Inexplicably, these bollards are attached, not to the concrete sidewalks on which they appear to sit, but to the structural concrete for the underground portion of Milstein Hall below. Construction images show the bollards installed directly over the structural concrete slab, above heated and occupied below-grade space (fig. 9.3 *top*). Rigid insulation boards are then placed *around* the bollards (fig. 9.3 *bottom*), leaving a series of gaps through which heat can escape.

The bollards interrupt not just the insulation boards, but also the continuity of waterproofing that has been installed above the structural concrete slab to which the bollards are attached.[1] As a result, there is a risk that any vehicle-bollard collision could dislodge the waterproofing membrane which is flashed onto the surface of the bollard below (fig. 9.4). Because all the connections are below grade, it would be impossible to know whether any damage has occurred until water leakage, or its many manifestations, appears in the space below.

The discontinuous insulation layer results in thermal bridging, as heat from the spaces below is conducted directly through the concrete slab and bollards above, which have interrupted all three layers of rigid insulation placed over the structural slab. This shows up, quite artistically, as a series of almost perfect circles surrounding each of the bollards after it snows (fig. 9.5 *top*). A photoshopped cut-away version of the same photo (fig. 9.5 *bottom*) shows how the bollard is fastened to the structural concrete slab, penetrating three layers of rigid insulation, and thereby creating a perfect thermal bridge connecting below-grade heated spaces with the exterior loading area.

Figure 9.3. Bollards are installed directly on the structural concrete slab above occupied and heated space (*left*); insulation boards are then placed around the bollards (*right*).

Figure 9.4. Concrete cracking and slight displacement of the bollard suggests a vehicle-bollard collision that may have compromised the waterproofing hidden below grade.

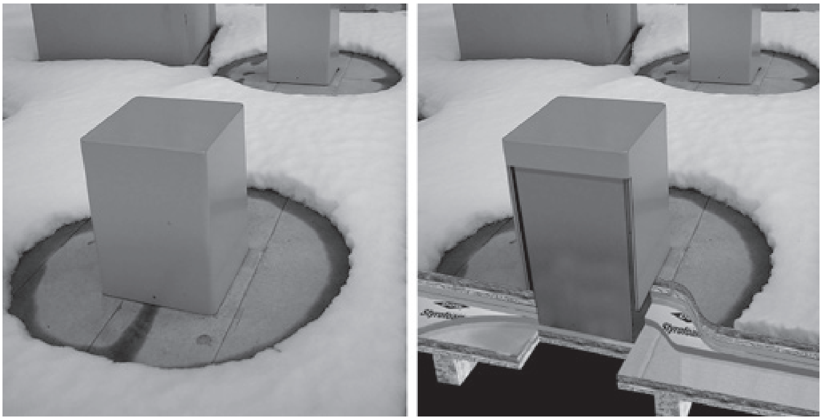


Figure 9.5. Bollards placed over Milstein Hall's below-grade heated space penetrate all three layers of below-grade rigid insulation, causing unimpeded heat loss from those below-grade spaces (*right*, photoshopped cut-away image—waterproofing and drainage layers not shown); the circular areas of melted snow around each bollard (*left*, original photo) attest to the heat loss through the bollards from the occupied space below.

Thermal bridging through seismic joints

All buildings must be designed to withstand an assortment of load combinations, including live and dead loads (which act vertically on the structure) as well as earthquake and wind loads (which act predominantly in a horizontal direction). While live and dead loads are essentially added together, since it is certain that dead loads will be present when live loads are acting on the structure, the same is not true for earthquake and wind loads: the probability of a structure experiencing high wind *and* earthquake forces simultaneously is so low that designers are permitted to determine relevant internal forces and bending moments based on load combinations that include wind and earthquake loads, but not both at the same time.

Clearly, there are areas in the world where earthquake forces almost always govern the design of lateral-force-resisting systems—e.g., parts of Chile, California, Alaska, Japan, and other regions along the seismically active Pacific rim—whereas lateral-force-resisting systems for buildings in places like Ithaca, New York, are generally designed on the basis of wind loads. Milstein Hall is an exception. Unlike probably every other building at Cornell, or in the City of Ithaca, Milstein Hall's structural design is governed by seismic loads rather than wind loads. This anomalous situation has been brought about by a perfect storm of unusual design decisions: the cantilever over University Avenue has made the building's structure extraordinarily heavy; this extremely heavy structure is then raised up in the air on steel columns that resist horizontal forces with rigid (moment) connections rather than with shear walls or diagonal braces of any kind; and the above-ground volume of Milstein Hall is flattened into a large second-floor plate sitting above a smaller glass enclosure for the entry and below-grade spaces. What this means is that—relative to the volume and weight of the building—the surface area exposed to horizontal wind loads is small. But the placement of an extremely heavy superstructure on relatively few columns creates a classic inverted pendulum or "soft story"—the very worst condition for seismic resistance. So with a raised and heavy second floor highly susceptible to seismic ground motion and relatively little vertical surface area affected by wind loading, it is not that surprising that the lateral-force-resisting system is governed by seismic loads. And the seismic drift or lateral deflection of the second-floor plate, combined with whatever lateral movement is computed for Sibley and Rand Halls, has made it necessary to provide a flexible "seismic joint" with a width of 5 inches (127 mm) so that flexible Milstein Hall and relatively stiff Sibley and Rand Halls do not pound into each other during a seismic event (fig. 9.6). The seismic joint, as built, appears to be different from the detail, in that no curved profile is evident (fig. 9.7). It is difficult to say what exactly was fabricated and installed, and in what manner it was designed to accommodate movement, if at all.

The seismic joints have also, apparently, been kept free of insulation,

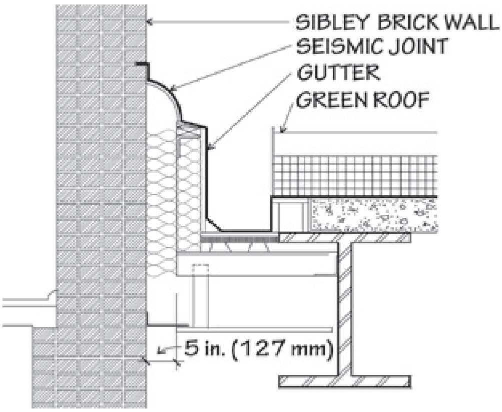


Figure 9.6. The 5-inch-wide seismic joint as detailed between Milstein and Sibley Halls (similar for Rand Hall).

not stuffed with batt insulation as shown in the detail. I had emailed the College of Architecture, Art, and Planning's project liaison in November 2009, remarking that "…the 5-inch space immediately below the curved expansion joint cover is filled with 'batt insulation,' but not otherwise protected against vapor intrusion from the interior space below… It may be that, even without humidifying the Milstein space, there would be high enough relative humidity (generated by building occupants) that such air, working its way up into the insulation, would reach the colder surface of the expansion joint cover and condense, wetting the insulation, and potentially causing other nasty problems during the winter months." The project manager replied in January 2010 that he "has looked at the issue … and discussed it with team members. It is still a bit on the back burner since we have so many other pressing issues that need to be dealt with immediately. Be assured that we will close the loop with you on this issue." Well, he never "closed the loop" with me, but I was told much later that the seismic joints were, in fact, uninsulated, constituting one more thermal bridge in the building. This can be seen at the intersection of Milstein and Rand Halls (fig. 9.8), which has no cover plate hiding the thermal bridge, unlike the situation at the intersection of Milstein and Sibley Halls, where a metal plate covers the joint.

Figure 9.8. Seismic joints between Milstein Hall and Rand Hall create a 5-inch (127 mm) uninsulated gap where the buildings come together.

Figure 9.7 (facing page). Milstein Hall's seismic joint, as built at the edge of Sibley Hall, differs from the circular profile shown in the working drawings.

Thermal bridge through skylight curbs

Skylight curbs were cast in reinforced concrete and interrupt the three layers of rigid insulation on the roof deck under the green roof plantings. Before rigid insulation was adhered to these concrete curbs, circles of melted snow could be seen on the roof around the skylights

Figure 9.9. Effects of heat loss can be seen in circles of melted snow around uninsulated skylights during construction (*top left*); insulation adhered to concrete skylight curbs is not continuous with horizontal insulation placed over the roof deck, creating thermal bridges (*right*); and because the reinforced concrete skylight insulation is not continuous, the effects of heat loss (thermal bridging) can be seen in the adjacent depressions within the otherwise even bed of snow (*bottom left*).

(fig. 9.9 *top left*); while the insulation improved the thermal performance, one can see that discontinuities in the thermal control layer (fig. 9.9 *right*) still melt the snow immediately adjacent to the skylight curbs (fig. 9.9 *bottom left*).

Inside Milstein Hall, one can see that snow melts from much of the skylights in the winter, as would be expected, due to the increased heat loss through the glass compared with the rigid insulation under the green roof (fig. 9.10).

From the standpoint of energy consumption, there is a potential trade-off, since daylight within the space is improved, as described on Cornell's "Innovative Design" webpage for Milstein Hall: "Three sizes of skylights are arranged in a radial pattern on the roof with the larger ones at the center and smaller ones toward the perimeter of the building. This creates consistent natural light levels across the entire second floor studio space."[2] An evaluation of the energy-saving benefit of daylighting compared with the energy-losing heat loss through the glass was

Figure 9.10. Snow melts on the Milstein Hall skylights, attesting to heat loss through these openings. The rectangular fixture to the right of the skylight is not illuminated because it is not a lighting fixture; rather, it is a chilled beam unit (for cooling) that was designed with the same enclosure finishes and dimensions, and arrayed within the same geometric grid, as the lighting fixtures.

presumably never done and, if it was done, certainly was never made public. But whatever the cost-benefit outcome of such a calculation (and the potential for energy savings is unlikely), it is rendered moot since electric lights are almost always on—triggered by motion sensors—whether or not adequate daylighting is available.

Thermal bridging through steel columns

Thermal bridging, caused by steel columns that penetrate Milstein Hall's insulated soffit below the second floor, is not inconsequential. Even without a sophisticated thermal analysis, one can make a rough estimate of the energy penalty by comparing the heat loss *with* studio floor column penetrations to the heat loss through an insulated floor without column penetrations.

As can be seen in figure 9.11, there are fourteen exterior columns holding up the second-floor plate; each of these W14×605 wide-flange

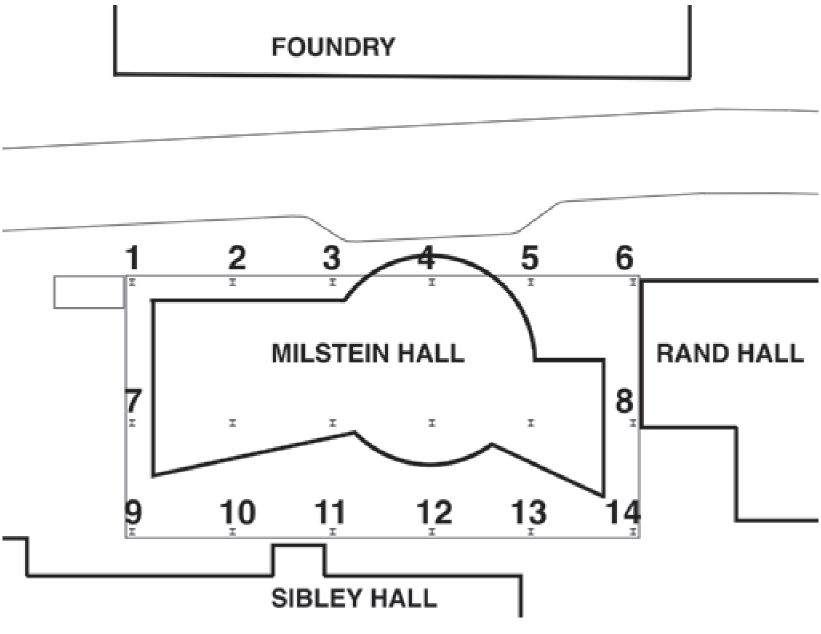


Figure 9.11. This schematic first-floor plan shows all 18 first-floor columns that support the large second-floor plate. Of these 18 columns, only four are within the building enclosure at the first-floor level; 14 are outside and contribute to thermal bridging.

shapes has a cross-sectional area of 178 square inches (0.115 square meters). The column labeled No. 4 in the plan appears to be inside the first-floor enclosing walls, but is actually exposed to the elements above the concrete dome and so contributes to thermal bridging—not only with respect to the second-floor studios, but also the Crit Room space below (fig. 9.12).

Figure 9.12. Exterior column No. 4 penetrates both the second-floor soffit above and the Crit Room space below.

The total uninsulated steel-column area penetrating the studio floor is therefore 14 × 178 = 2492 square inches or 17.3 square feet (1.6 square meters). These large column sizes penetrate the insulation under the second-floor composite steel-concrete deck, since they are welded to the bottom chords of story-height hybrid trusses that have stiffener plates reproducing the dimensions of, and aligning with, the column flanges (fig. 9.13).

The insulated second-floor area (total floor area minus the portion of the floor plate over insulated space) is approximately 25,500 – 5,685 = 19,815 square feet (1841 square meters). Subtracting the column area, the exterior *insulated* floor area is 19,815 – 17.3 = 19,798 square feet (1839 square meters). The heat loss values through the insulated floor, on the one hand, and through the steel columns that penetrate the insulation, on the other hand, are found by multiplying their respective areas by their U-values and by an assumed temperature differential between outdoors and indoors of, say, 70° F (37° C).[3] The U-value, measuring the total conductance of an assembly, is found by taking the inverse of

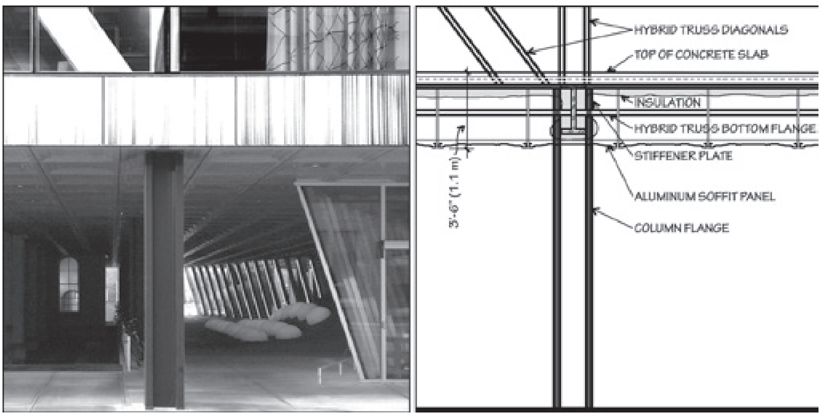


Figure 9.13. Milstein Hall's exterior columns, painted black as if to make them disappear, are all uninsulated (*left*). A schematic section (*right*) shows how the columns, and matching stiffener plates in the bottom chord of the hybrid truss, penetrate the insulation under the second-floor composite steel-concrete deck. Steel flanges that penetrate the insulation, creating a thermal bridge, are shown with a dark tone.

the total R-value; the R-value measures the resistance of an assembly to heat loss through conduction. For simplicity, we'll use inch-pound units for the following calculations, although the final percentages arrived at will apply to any system of units. We assume an R-value for the floor of 40 based on about 6 inches, or 152 mm, of spray-foam insulation. The steel column has an R-value of 0.003 per inch and, as a rough measure of its resistance to heat loss, we assume an average curved trajectory length, from outside to inside through the steel column, of 48 inches, or 1.2 meters. This accounts for the fact that the column, and the stiffener plates that extend vertically over the column flanges into the hybrid truss, are insulated for much of the vertical distance between the second-floor slab and the aluminum soffit because of insulation covering the W24×279 wide-flange beams that frame into those columns, as illustrated in figure 9.13. The total R-value for the steel columns is therefore 0.003 per inch times 48 inches, or 0.144. The U-values for the floor and steel are, respectively, 1/40 = 0.025 and 1/0.144 = 6.94. Heat loss values for the insulated floor and penetrating steel columns are as follows:

- Floor: 0.025 × 19,798 × 70 = 34,647 BTU/hr.
- Columns: 6.94 × 17.3 × 70 = 8,404 BTU/hr.

In these calculations, heat loss (BTU/hr.) is found by multiplying three quantities: U-value, area, and temperature differential between inside and outside. The total heat loss through the floor, found by adding these two components, is 34,647 + 8,404 = 43,051 BTU/hr.

Without these columns acting as thermal bridges, the heat loss through the floor would be 0.025 × 19,815 × 70 = 34,676 BTU/hr. The difference in total heat loss caused by the thermal bridging of the columns is 43,051 – 34,676 = 8,375 BTU/hr. Remarkably, even though the column thermal bridges constitute only 17.3 square feet (1.6 square meters) out of a total exterior floor area of 19,815 square feet (1,841 square meters), or just 0.09 percent of the exterior floor area, their high conductivity has the effect of increasing the heat loss through the floor—i.e., compared to the same insulated floor not penetrated by steel columns—of 24 percent. To put it another way: the design decision to raise the second floor on columns, thereby exposing large parts of its underside to the weather, creates an amount of additional heat loss greater than that generated by a typical code-compliant 2,500 square foot (2232 square meters) house.[4]

Heat loss through automated entry door

The sliding entry door to Milstein Hall is automated by a motion sensor. This is entirely appropriate for entrances that are approached on axis—that is, perpendicular to the door itself. However, the door in Milstein Hall is immediately adjacent to a parallel circulation path that is used by many people who have no intention of entering Milstein Hall. The automated motion sensor triggers the door anyway (fig. 9.14 *left*), leading to heat loss or heat gain, depending on the season, not to mention wear and tear on the motorized mechanism itself. Eventually, the motion sensor on the exterior was disabled and replaced with push buttons wired into vertical mullions on both sides of the door (fig. 9.14 *right*). It's not clear why an automated door was specified in the first place, since—as far as I know—there are no other such entrances on the entire Ithaca campus.

Figure 9.14. The automated motion-sensing entry door to Milstein Hall is adjacent to, and parallel to, a circulation path connecting University Avenue, seen in the background, with the Arts Quad (*left*). The door opens, as it did when I took the video from which the left image was obtained, whether or not the person triggering the motion sensor has any intention of entering the building, leading to gratuitous heat loss or heat gain. Eventually, push buttons were wired into the vertical mullions on both sides of the door (*right*), and the outside motion sensor was disabled.

10 RAINWATER CONTROL

The probability of water leaking through joints increases when "critical" seals—those designed to exclude water—are detailed and constructed using only sealants, as is the case with many joints in Milstein Hall. The causes of sealant failure are too numerous to outline here. Karen Warseck suggests that while such failure is usually due to "a combination of factors," the underlying reason is "a lack of attention to detail. Too often, since the sealants are a small percentage of the work, they are perfunctorily specified, easily substituted, and haphazardly applied. Yet successful joints require meticulous design, precise sealant selection, and painstaking application."[1] Numerous instances of leaks, including some which seem to be sealant joint failures, have already arisen in Milstein Hall, through both roofs and curtain walls.

Water leaking through walls

The first leaks in Milstein Hall occurred in the below-grade level. Shortly before construction was completed in 2011, water appeared in the corridor adjacent to the lower-level gallery (fig. 10.1). At the same time, leaks

Figure 10.1. Water was leaking into the lower level of Milstein Hall in September 2011, just before it was occupied, in a corridor next to the gallery.

appeared at the edge of a stair leading to a different hallway to Sibley Hall (fig. 10.2 *top left*) and four years later, in 2015, leaks continued at the same place (fig. 10.2 *bottom left*).

In a sense, this leak is not surprising—it occurs at the intersection of Milstein Hall and Sibley Hall, two buildings with extremely different enclosure systems. East Sibley Hall was completed in 1894 and its rear wall is solid brick over a stone foundation that was covered, according to the Milstein Hall demolition drawings, with a "concrete shelf … to hide old foundation demolition" (fig. 10.2 *right*). Milstein Hall, on the other hand, is a modern building with a storefront-type curtain wall system on an insulated concrete foundation protected with a waterproofing membrane.

The two systems simply do not join together very well, since the control layers in Milstein Hall (i.e., the various membranes and insulation for water, air, vapor, and thermal control) have no appropriate analogues in Sibley Hall, which is a mass reservoir wall consisting of solid brick. A rainwater control layer in Milstein Hall, for example, cannot be attached to a rainwater control layer in Sibley Hall where the two buildings come together, because Sibley Hall has no rainwater control layer. Like all traditional mass-reservoir-type building enclosures, Sibley Hall's brick wall is designed to absorb rainwater, which eventually evaporates to the exterior or interior. Therefore, Milstein Hall's rainwater control layer (its waterproofing membrane) must somehow be flashed deep enough into Sibley Hall's brick wall so that rainwater, penetrating above the flashing into Sibley Hall's brick wall, cannot bypass the flashing and return, below the flashing, into Milstein Hall. Yet many flashing details at the intersection of Milstein and Sibley Halls, for example at the seismic joint illustrated schematically in fig. 9.6, consist only of reglets (grooves within the mortar joints) that barely penetrate into the brick. And reglets simply do not work in this context.[2]

The general question of flashing where Milstein and Sibley Halls come together is made even more difficult because the geometry of the two buildings at the location of the leak is actually quite complex, with a concrete ledge ("shelf" or "seat") at the foundation of Sibley Hall aligning with the upper landing of a concrete stair in Milstein Hall. An insulated wall with a metal finish on both sides separates them at the upper landing, while a curtain wall system butts up against this metal-clad wall beyond the landing—these two wall systems are "connected" with nothing more than sealant joints. Sealant joints are also used at the intersection of the new metal partition with the existing masonry wall of

Figure 10.2. The joint between Milstein Hall's stair landing at the basement level, leading into Sibley Hall, leaked initially in September 2011 (*top left*), just before the building was occupied. It leaked again in March 2015 (*bottom left*) at the same location. The complexity of this condition (*right*) is evident in this exterior view, from May 2023: Milstein Hall's concrete stair and landing can be seen through the glazed curtain wall; the landing aligns with a concrete ledge ("seat") covering the foundation of Sibley Hall.

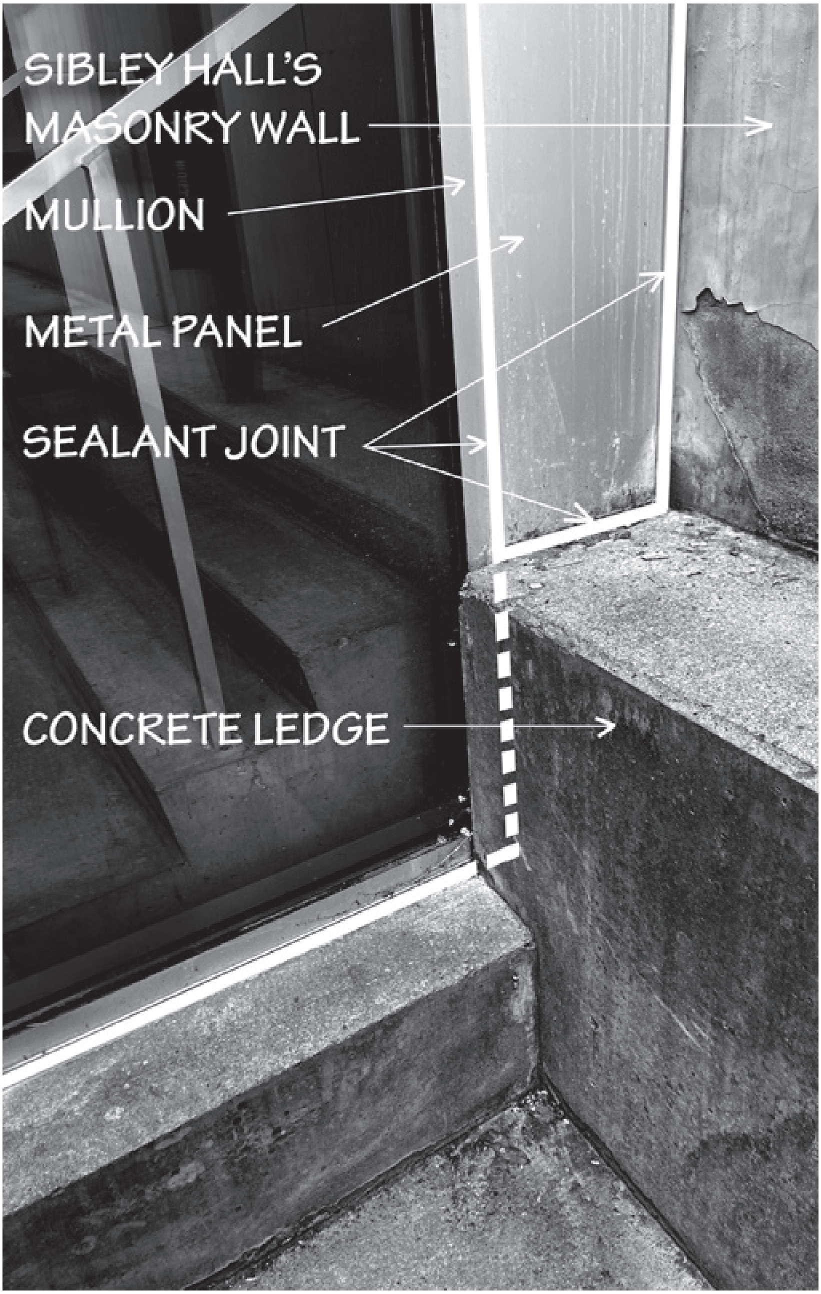


Figure 10.3. Intersection of Milstein and Sibley Halls at basement stair landing, May 2023: trying to create a water control layer by relying on sealant joints, especially at the intersection of concrete or masonry surfaces, is likely to fail.

Sibley Hall *and* with the new concrete ledge covering Sibley Hall's old masonry foundation (fig. 10.3). Relying on sealant joints for rainwater control where modern control layers intersect traditional masonry or concrete walls, ledges, or decks is even worse than relying on reglets, since not only can water work its way through cracks in masonry or concrete surfaces as with reglets, but the sealant joints themselves—as noted above—are notoriously difficult to execute properly.

Water leaking through basement roofs: efflorescence

In addition to leaking of rainwater through the building enclosure, water leaks can manifest themselves in other ways, especially when water is conducted in or through certain mortar, masonry, or concrete materials. This seems to be the case at the lower level of Milstein Hall, where white powdery material has appeared in the ceiling itself, and especially on the aluminum "storefront" mullions at the west end of Milstein Hall (fig. 10.4). This is an example of efflorescence, a phenomenon in which soluble salt

Figure 10.4. Efflorescence in Milstein Hall (July 2013) has occurred where water enters the concrete roof deck, e.g., above the gallery near the loading area, and migrates to interior surfaces, carrying soluble salts.

deposits are left behind on the concrete surface as water evaporates after leaking through the concrete slab. There is some question about the origin of these salt deposits: "The essential process involves the dissolving of an internally held salt in water… The water, with the salt now held in solution, migrates to the surface, then evaporates, leaving a coating of the salt. In what has been described as 'primary efflorescence,' the water is the invader and the salt was already present internally, and a reverse process, where the salt is originally present externally and is then carried inside in solution, is referred to as 'secondary efflorescence.' "[3]

In fact, researchers have discovered that it is not the movement of excess water in the concrete, but rather it is calcium hydroxide, formed as cement cures, that does the moving. In other words, the calcium hydroxide "diffuses up through the water-filled capillary system of the concrete to the surface" where it reacts with CO_2 in the air to form calcium carbonate, the white powdery substance that is given the name efflorescence.[4]

It's not clear whether the salts in these instances of efflorescence come from snow-melting protocols (winter road salt) above the deck, or whether the salts were already in the concrete. In either case, water continues to migrate into the concrete deck from above, and works its way through the deck to various interior surfaces. It appears that the problem with efflorescence in Milstein Hall is different from the mostly benign "primary" efflorescence, a one-time phenomenon caused by excess

Figure 10.5. Efflorescence can still be seen on the soffit and fascia of the concrete deck supporting the loading area at Milstein Hall, more than a decade after its construction (image taken May 2023). Stalactites, possibly caused by dissolved cement stone, are an indication of a potential structural problem.

water in the cement that ceases to be a problem after a few months, when the excess water evaporates. Rather, it may be the more problematic "secondary" type, and could well be exacerbated by the use of road salt in the winter. More than a decade after Milstein Hall's completion, instances of what appear to be secondary efflorescence can still be found (fig. 10.5). The potential problem with this type of efflorescence is that the absorbed salt "can begin to dissolve cement stone, which is of primary structural importance. Virtual stalactites can be formed in some cases as a result of dissolved cement stone, hanging off cracks in concrete structures. Where this process has taken hold, the structural integrity of a concrete element is at risk."[5]

The mechanism for water entry into the concrete deck above occupied basement spaces in Milstein Hall is discussed in the following section.

Water leaking through basement roofs: Bibliowicz Gallery

I was walking outside of Milstein Hall in the summer of 2012 when I noticed some construction activity in the Milstein Hall basement gallery. The entire storefront glazing system had been dismantled, with the aluminum frames and glazing panels stockpiled in the adjacent garden (fig. 10.6).

Figure 10.6. Windows and window frames were removed from the Bibliowicz Gallery in Milstein Hall during the summer 2012; aluminum window frames were temporarily stored against the exterior stair tower in the sunken garden; glazing panels were also stored in the garden.

Over the next few days, the mullions were put back in place, and the glass was re-inserted. It turns out that water had been leaking into the gallery space where the concrete ceiling meets the top of the aluminum frames for the glazing, possibly through cracks in the concrete deck over the gallery, as shown schematically in figure 10.7 (*left*). In this detail, as originally designed and built, water seems to have a clear pathway to the top of the aluminum mullion, where the waterproof membrane intended to direct such water through weep holes to the outside would have been difficult to implement in practice. And even if it had worked in that manner, directing water through the concrete deck and fascia would have resulted in efflorescence appearing on the exterior surfaces of the concrete, aluminum, and glass.

Water, once it penetrates into the concrete slab, can easily get through or around the rigid insulation, which is not designed as a waterproof

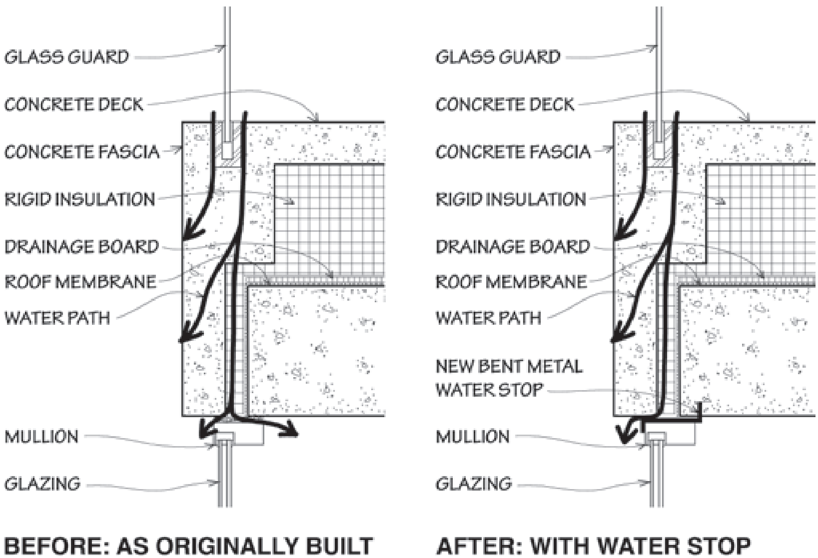


Figure 10.7. Water appears in the gallery in Milstein Hall and causes efflorescence to appear on the fascia and exterior glazing, presumably entering through cracks in the concrete deck, and working its way down to the top of the mullion (*left*); a bent metal water stop was inserted above the mullion, in 2012, to direct water reaching the mullion to the exterior (*right*). In these schematic sections, based on Milstein Hall working drawings, a second drainage board, that seems to have been installed above the insulation, is not shown.

layer. The repairs that I witnessed in the summer of 2012, a little more than one year after Milstein Hall was first occupied, involved removing the aluminum mullions and glass; cutting a kerf into the concrete ceiling of the gallery just inside the top horizontal mullion; inserting a bent metal plate, intended to function as a water stop, to prevent water from entering the gallery; and finally replacing the aluminum mullions and glazing (fig. 10.7 *right*).

After these repairs were completed, one could still see residual efflorescence and water stains in the gallery ceiling, adjacent to the new bent metal water stop at the top of the aluminum mullions (fig. 10.8).

In addition, as I remarked at the end of a short Milstein Hall video, part of my online critique of Milstein Hall uploaded in 2013, "it is likely that water will still be an issue, as the underlying problem was not fixed."[6] Water was still entering through cracks in the concrete deck and causing

Figure 10.8. Water stains and efflorescence are still visible after a bent metal water stop was inserted into a kerf cut into the concrete ceiling of the Bibliowicz Gallery at Milstein Hall in 2012.

efflorescence to appear on the concrete fascia and soffit, as well as on the exterior glazing (fig. 10.9). It turns out that these problems were the result of numerous errors in the design of the plaza deck slab that forms the roof of the gallery space. Such a slab deck is really a roof, and such decks need to be designed as a roof, incorporating the following six characteristics:[7]

1. The design must provide drainage below the traffic surface, including a drainage gap above the rainwater control layer, that is, above the roof membrane.

2. The roof membrane must slope to a drain.

3. The design should really incorporate a double drain, i.e., a second drain from the traffic surface.

4. Insulation should be installed above the roof membrane with a drainage mat above and below it.

5. All drainage should slope away from the edge of the deck, towards an interior drain.

6. The rainwater control layer of the deck must be connected to the water control layer in the walls of the adjacent existing building, Sibley Hall. Of course, the load-bearing brick wall of Sibley Hall has no water control membrane, so it is important (and difficult) to properly flash this wall-deck intersection.

Figure 10.9. The Bibliowicz Gallery windows at Milstein Hall were covered in efflorescence due to water leaking through the plaza deck above (March 2015).

Of these six guidelines, only one was correctly implemented in Milstein Hall—the fourth one requiring insulation above the roof membrane with drainage mats above and below the insulation.[8] A series of images screen-captured from my low-resolution video clips, part of my online critique of Milstein Hall,[9] shows a roof membrane, drainage mats, and insulation being placed above a perfectly flat structural slab; after that, a topping slab—also perfectly flat—is placed above the insulation and drainage mat (fig. 10.10).

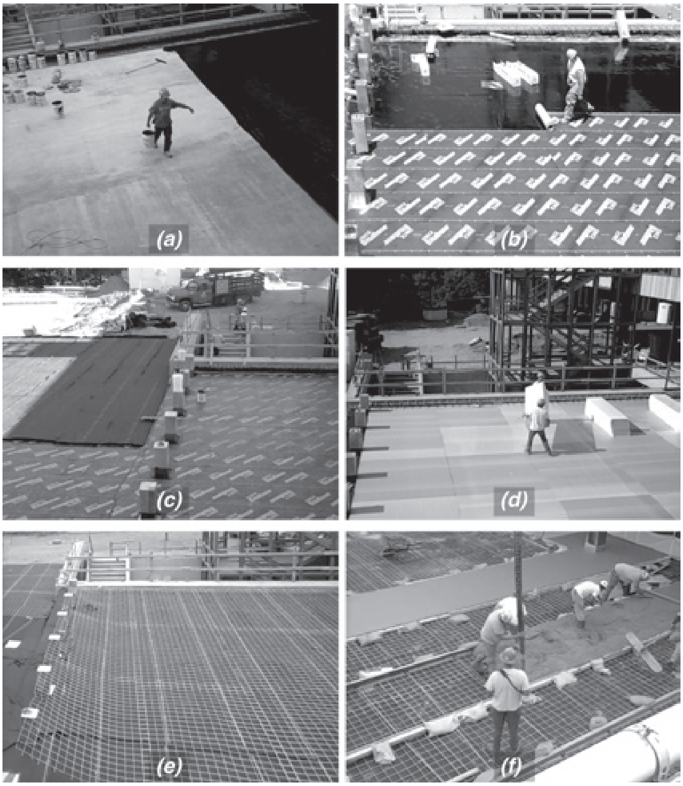


Figure 10.10. The plaza roof deck at Milstein Hall was constructed over a perfectly flat structural slab. All subsequent layers were also perfectly flat: (*a*) initially, some sort of mastic or primer was applied to the structural concrete slab; (*b*) next, a waterproof membrane was rolled out over the primer/mastic; (*c*) a drainage mat came next; (*d*) then three layers of rigid insulation were placed over the drainage mat; (*e*) a second drainage mat was placed over the insulation, along with welded wire mesh reinforcement for (*f*) the final perfectly flat layer, a concrete topping slab.

But the other five requirements for a slab deck over heated space were simply not specified in the design drawings and therefore were not implemented: there was no explicit drainage gap below the traffic surface; not only was the deck designed with no slope, but there was no drain specified for the plaza; with no drain specified, there could be no double-drain; because the water control layer did not slope, and therefore did not slope away from the edge of the deck, water was able to enter the fascia above the gallery windows and threaten the integrity of the concrete while staining the windows below; and finally, the intersection of the roof membrane and the brick wall of Sibley Hall was not properly flashed.

As it turned out, there was also an additional problem with the structural design of the slab deck itself—for some reason, this concrete slab experienced exceptionally large, and unexpected, deflections. In fact, the deflection may possibly have been the reason that the rotating gallery

Figure 10.11. The rotating wall in Milstein Hall's Bibliowicz Gallery was taken apart and reconstructed, shown here with the wall finishes removed in the summer of 2012, possibly because of damage caused by excessive deflections in the concrete slab above.

wall directly below was taken apart and rebuilt (fig. 10.11). Because of the slab's deflected shape, water would pool at its center, and remain there long after any rain had stopped (fig. 10.12).

However, this very problem of slab deflection actually allowed Cornell to retroactively address some of the major mistakes from the original design. Because of the unintended sloping of the deck, it became possible, in the summer of 2015, to install *a new drain* at the low-point of the deflected slab which would carry excess water away from the edge of

Figure 10.12. Water would pool at the center of Milstein Hall's plaza long after any rain had stopped, for two reasons: first there was no drain; and second, the slab deflected so that rainwater tended to move to the center of the concrete deck's span.

Figure 10.13. The topping slab of Milstein Hall's plaza deck was cut at the approximate low point and most of the rigid insulation was removed to accommodate a linear channel, sloping to a new drain.

the deck—three years after the initial attempt at remediation. The topping slab was cut at the approximate low point of the plaza, caused by the unintended deflection, and most of the rigid insulation was removed to accommodate a linear channel, sloping to a new drain (fig. 10.13). A hole was drilled through the concrete deck so that the drain pipe could enter the gallery below, find its way through an existing gallery wall, and continue into the basement slab, where it was connected to a storm sewer pipe below grade that happened to be in the vicinity (fig. 10.14).

Meanwhile, additional reconstruction was undertaken at the edges of the plaza, over the gallery windows and also on the western edge near Sibley Hall. Workers used concrete saws and jackhammers to remove most of the perimeter fascia above the gallery windows (fig. 10.15) and

Figure 10.14. Rainwater from the plaza above now enters the Bibliowicz Gallery through a new drain connected to a pipe drilled through the concrete deck above and threaded through the fixed gallery wall at *A*, after which it continues through the basement slab at *B*, eventually connecting with a storm sewer pipe at or near *C*. The patched basement slab can be seen with a lighter surface finish. Image photoshopped by the author to reveal hidden pipe.

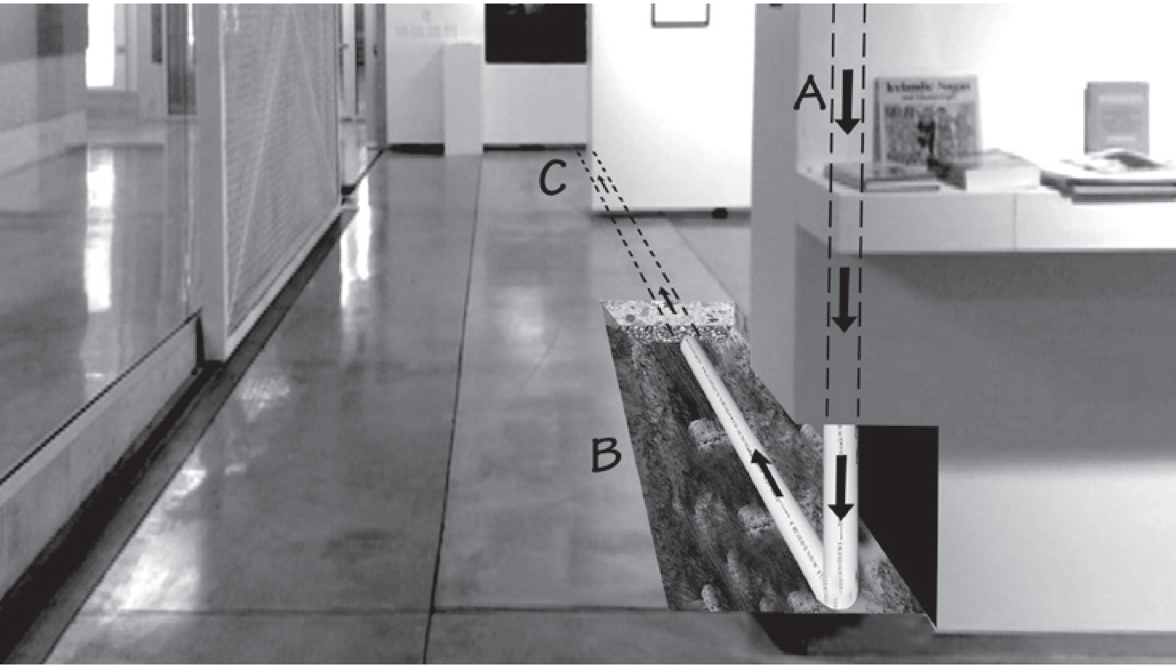


Figure 10.15. Workers remove most of the concrete fascia of Milstein Hall's Bibliowicz Gallery.

a metal drip edge was installed over the one previously installed during the initial reconstruction of the gallery wall—where the bent metal water stop had been installed into a kerf cut into the concrete three years earlier.

A waterproofing membrane was joined to flashing, new insulation was placed over this new air/water barrier, and *another* piece of stainless-steel was installed over the drip edge to form a base, or pour-stop, for the reconstructed concrete fascia while also allowing water entering the concrete from above to exit by traveling between the two pieces of metal (fig. 10.16). One can see that when it rains, the new drain doesn't exactly capture all the surface water. Puddles always remain because a

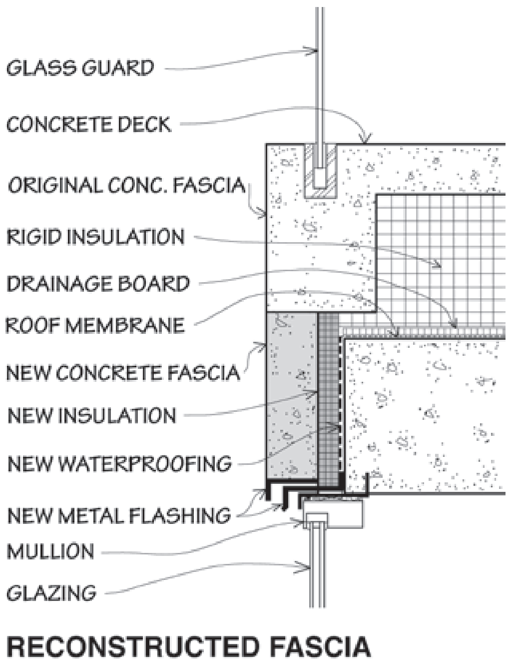


Figure 10.16. The second gallery reconstruction, in 2015, removed and replaced much of the concrete fascia, installed new waterproofing and insulation behind the new fascia panel, and placed two pieces of metal flashing above the bent metal water stop that had been inserted into the concrete ceiling above the mullion in 2012. Water entering the slab from the deck above and working its way down to the mullion will now be directed between the two pieces of flashing to the exterior. This is a speculative and schematic section based on my observations of the reconstruction that occurred in 2015.

Figure 10.17. Puddles still form, and remain, on the Milstein Hall plaza because the slope caused by the slab's unintended deflection does not create a consistent low point that aligns with the position of the linear drain that was added later, visible in the middle of the image.

Figure 10.18. Water can enter the concrete slab of the plaza deck through cracks in the concrete and openings in the glass guard inserts around the sunken garden, above the below-grade gallery. (Image taken May 2023.)

slope was never actually built into the design (fig. 10.17).

More importantly, even after this substantial renovation of the plaza deck and gallery fascia, the underlying problems have not been resolved, as of this writing in 2023. Water still finds its way through cracks in the concrete (fig. 10.18), and may well be pooling under the insulation, since there is still no primary drain at the level of the waterproofing membrane. If so, this water could be damaging the rigid extruded polystyrene insulation above the waterproof layer. According to Sharif Asiri, "water can still be absorbed into the gaps between each bead. Long term studies on rigid XPS (extruded polystyrene) reveal that in below grade applications, the area where rigid insulation is most likely to get wet, XPS absorbs 19% of its weight in water, resulting in a 48% reduction in R-value."[10]

And the same mechanism which permitted water to enter the slab and work its way into the fascia remains unchanged, resulting not only in dampness and efflorescence on the fascia, but also—something I noticed for the first time in 2023—serious spalling of the concrete at the edge of the plaza deck (fig. 10.19). Water also picks up some rather nasty artifacts

Figure 10.19. Even after substantial renovation of the gallery fascia and plaza deck in 2015, major spalling of concrete is occurring at the fascia-deck intersection. (Image taken July 2023.)

Figure 10.20. Water also picks up some rather nasty artifacts as it enters the concrete, passes through both intended and unintended channels, and drips down to the gallery sill below. (Image taken May 2023.)

as it enters the concrete, passes through both intended and unintended channels, and drips down to the sill below (fig. 10.20).

Water leaking through basement roofs: electrical panel box

More leaks were discovered through the ground-level concrete slab under the arcade between Milstein and Sibley Hall that is adjacent to the plaza deck. Apparently, this leak, into the electrical room below, had been active for years, but only in 2019 was it being investigated and repaired. One can see electrical conduit penetrating the waterproofing layer under the rigid insulation that is, in turn, under the concrete topping slab of the arcade (fig. 10.21). These penetrations provide a convenient pathway for rainwater to enter the electrical room below. Rainwater gets into this covered location because the concrete slabs of the arcade and adjacent plaza were designed to be perfectly flat surfaces, without any sort of slope for drainage. The actual—as-built and unintended—slopes of these concrete slabs directed rainwater into the covered arcade directly above the electrical room.

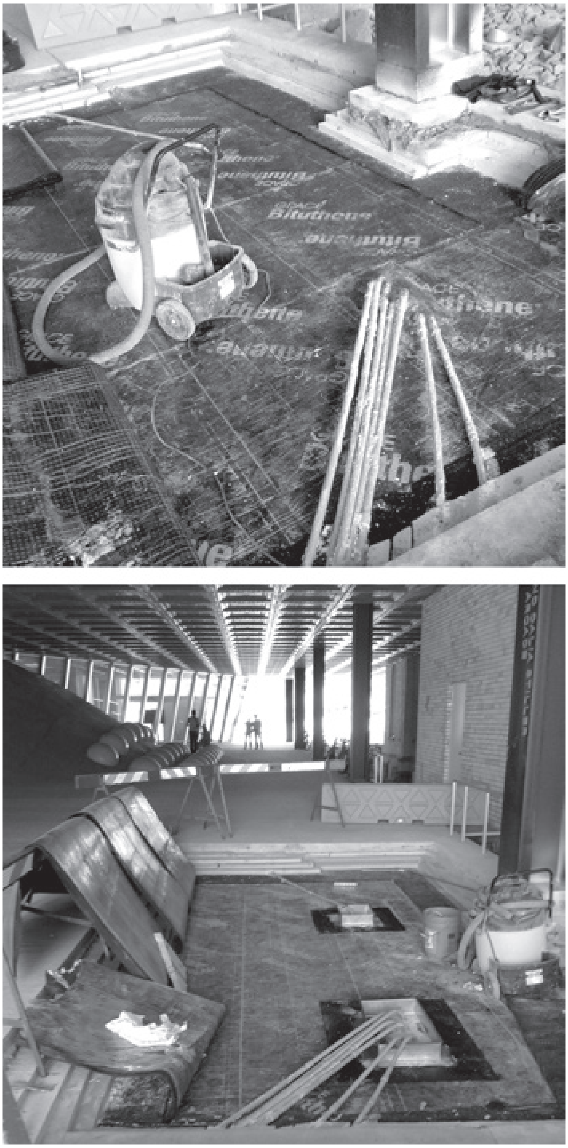


Figure 10.21. Electrical conduits are cast into the roof deck concrete slab under Milstein Hall's arcade; once over the basement electrical room, they penetrate through the structural concrete slab below the topping slab with only nominal attention to waterproofing, providing a pathway for rainwater to enter the electrical room (*top*). To repair this condition, the concrete topping slab, insulation, and drainage mats were removed so that metal "dams" could be placed around the areas where conduit penetrations occur (*bottom*). The drainage mats and insulation were then re-installed, and new concrete was cast to repair the topping slab.

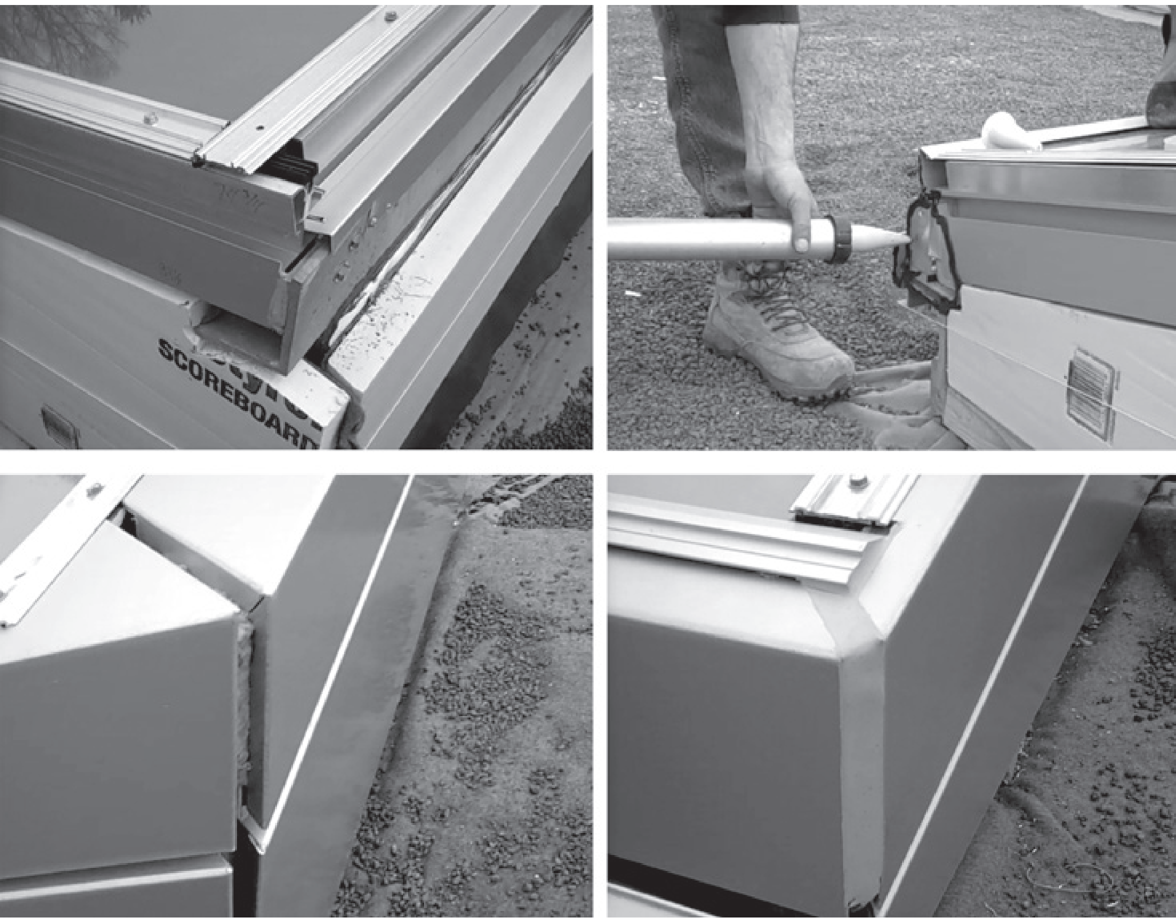
Water leaking through green roof

Leaks began to be noticed on the upper level of Milstein Hall, through the green roof, soon after the building was occupied in 2011, continuing for the following decade, with no solution in sight (fig. 10.22).[11] As is common with roof leaks, the Milstein Hall leaks appear to be related to

Figure 10.22. Trash cans appeared in Milstein Hall's cantilevered second floor design studios soon after the building was occupied in 2011, placed strategically to catch rainwater leaks from the vegetated roof above (*top left*), both through skylights and at the intersection of Rand Hall and Milstein Hall. Leaks continued in 2015 (*top right*), triggering a major roof repair that lasted for at least two years (*bottom left*), during which time sedums, engineered soil medium, insulation, drainage mats, and protection layers were removed and stockpiled elsewhere on the roof. This major repair also proved unsuccessful, as leaks continued in some of the same places during the fall of 2022—at the stepped auditorium (*bottom right*) and at the intersection of Rand Hall and Milstein Hall (not shown).

defects in the flashing strategy and/or execution both at skylights as well as at the joint between the roof and masonry walls of existing buildings—Rand Hall, in this case. Skylights appeared to be designed with large gaps, discontinuous insulation, and a reliance on sealants to close openings in aluminum cover plates (fig. 10.23).

Figure 10.23. Skylights in Milstein Hall have large openings where metal enclosure panels meet at the corners (*top left*); at some of these intersections, pieces of metal were "glued" in place with some sort of adhesive sealant (*top right*). Aluminum cover plates came together with mitered joints at the corner, leaving large gaps (*bottom left*) that were filled with sealant (*bottom right*).



At the intersection of Rand Hall and Milstein Hall, the seismic joint between the two buildings relies on reglets—minimal saw-cut openings in the horizontal brick mortar joints of Rand Hall—that not only are unreliable because water can penetrate around such flashing through cracks between mortar and brick (fig. 10.24), but especially because, in this case, the reglet and flashing need to negotiate tricky geometries where brick protrudes to cover Rand Hall's steel columns (fig. 10.25). This is a complex three-dimensional condition that is represented in the Milstein Hall working drawings as a simple two-dimensional section, as if the reglet flashing—even if it *were* effective in its two-dimensional incarnation, something far from certain—could somehow be fashioned into this more complex three-dimensional form based solely on the goodwill and expertise of the installers.

An additional factor in Milstein Hall's persistent roof leaks is the virtual flatness of the roof, discussed earlier in terms of various conceptual fictions, distortions, and half-truths that have been promoted by the architects. The ultra-low slope of the roof may well have been partly responsible for the ongoing problem of leaks that has plagued the

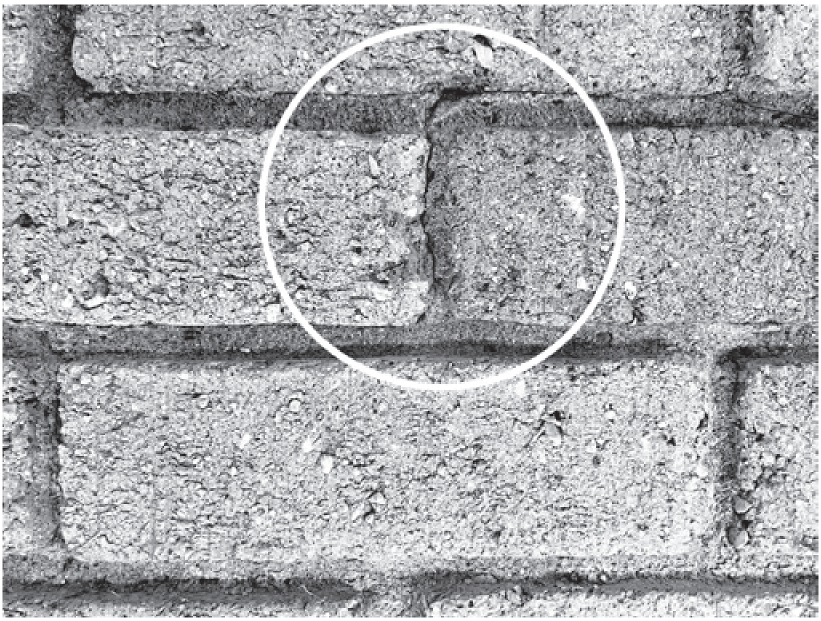


Figure 10.24. This detail of Rand Hall's facade shows a typical crack between brick and mortar through which water can enter the wall, bypassing flashing in saw-cut reglets.

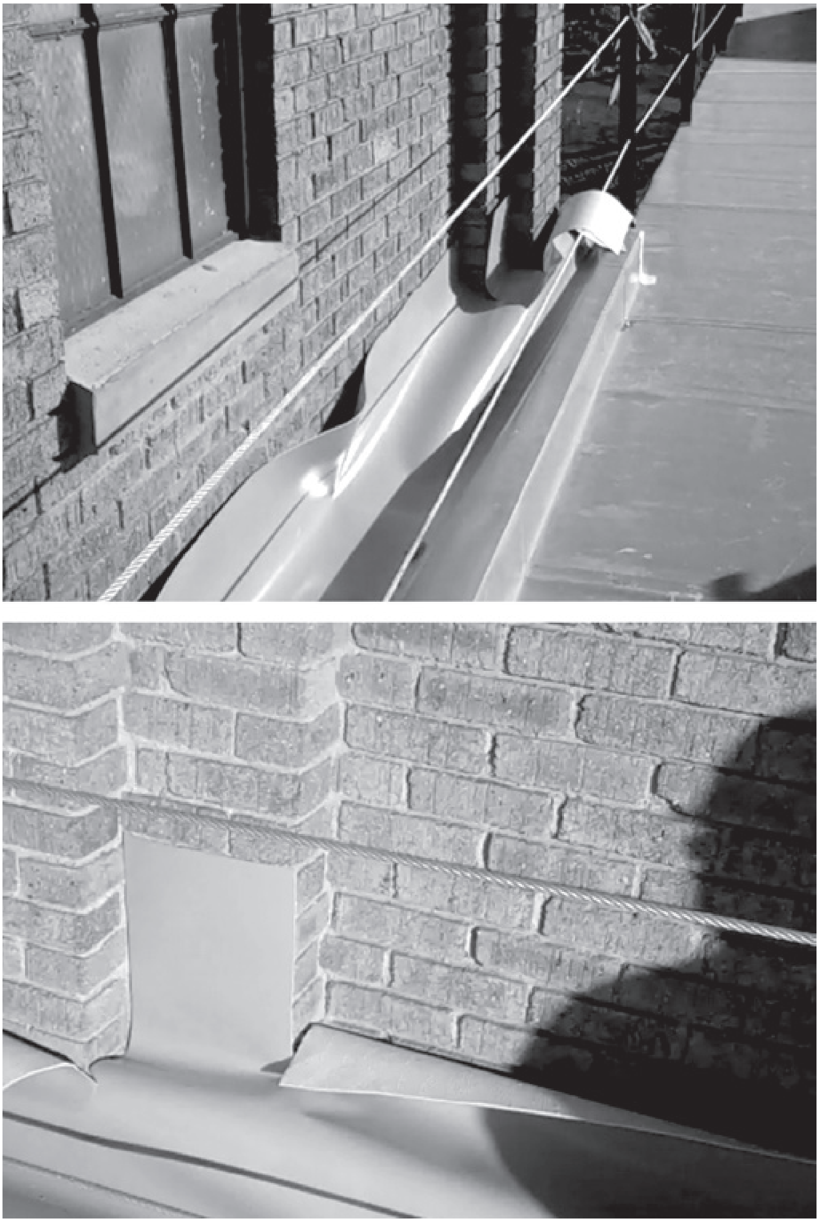
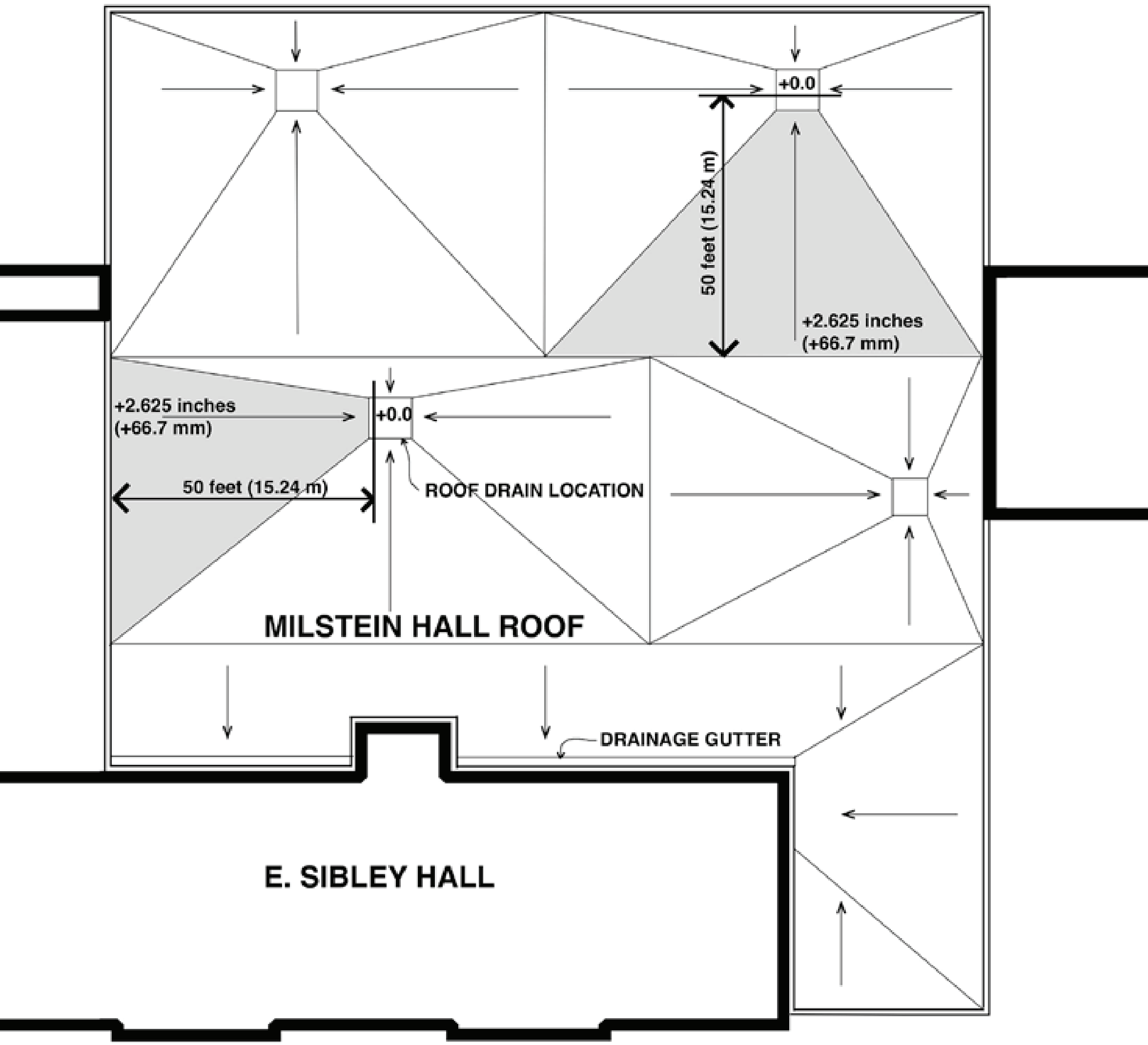


Figure 10.25. The intersection of Milstein Hall's roof with the brick cladding of Rand Hall was sealed with a seismic joint, similar to the joint at Sibley Hall illustrated schematically in Figure 9.6. Here, Milstein Hall's PVC roof membrane is shown prior to the creation of a reglet in the brick wall and the completion of a seismic joint (*top*) and at the challenging geometry where brick protrudes to cover Rand Hall's steel columns (*bottom*).

building since it first opened and that has continued for at least twelve years since, even after a substantial re-roofing operation that began in 2015 and took more than two years to complete. The flatness of the roof is not literal, since the roof has a topping slab that slopes to gutters along the edge of Sibley Hall and also to several internal roof drains. But the slope is insufficient—not even close to the minimum code-required two percent slope for single-ply thermoplastic roofing, i.e., "a minimum of one-fourth unit vertical in 12 units horizontal."[12] As can be seen in Milstein Hall's roof drainage plan, redrawn schematically in figure 10.26,

Figure 10.26. Milstein Hall's roof drainage plan, drawn without the skylights for clarity, shows a change in vertical elevation almost five times less than what is required by the *New York State Building Code*.



the horizontal distance between the roof high point and the roof drain is 50 feet (15.24 m) yet the vertical change in elevation is only 2-5/8 inches (66.7 mm). To comply with best practices (and with the requirements of the *New York State Building Code* for a two percent slope), this change of elevation should have been a minimum of 12-1/2 inches (317.5 mm)—almost five times greater than what was actually provided. This is evident in figure 10.27, which shows a roof slope being created with a topping slab poured over the flat structural concrete slab; the wood guide for the screeding operation is virtually horizontal!

Figure 10.27. Milstein Hall's topping slab is shown being poured over the flat structural slab. The wooden guide for the screed has almost no inclination and certainly not a two-percent slope.

I can't say for sure why the architects chose to defy best practices and create a virtually flat roof with inadequate slope for drainage, but my best guess is that the decision was ideological rather than logical. The proposition that this roof is a *facade*—a canvas on which a colored circular sedum pattern can be metaphorically painted—is certainly compatible with the idea that such a canvas should be flat. But the Milstein Hall canvas isn't literally flat. The fact that it has a nominal, though inadequate slope, shows that the architects were aware that roofs must slope to drains. What really caused the slope to be inadequate and the green roof to be "extensive" rather than "intensive"—i.e., to have only about two inches (50 mm) of engineered soil medium supporting its sedum plants—almost certainly derives from Milstein Hall's initial diagrammatic cartoon and its spatial constraints, discussed earlier. Once a decision was made to place Milstein Hall's new second-floor plate, lifted off the ground, at the intersection of the east-west and north-south conceptual zones discussed in chapter seven and shown in figure 7.1, the second floor needed to be high enough to align with (and connect to) the floors of Sibley Hall and Rand Hall, while the roof of Milstein Hall needed to be low enough so that it would fit under the existing and historic third-floor windows of Sibley Hall. With these self-imposed constraints, there simply wasn't enough room to raise the height of the roof coping to accommodate an adequate (and required) slope for the roof membrane without coming into conflict with the third-floor windows in Sibley Hall (fig. 10.28).

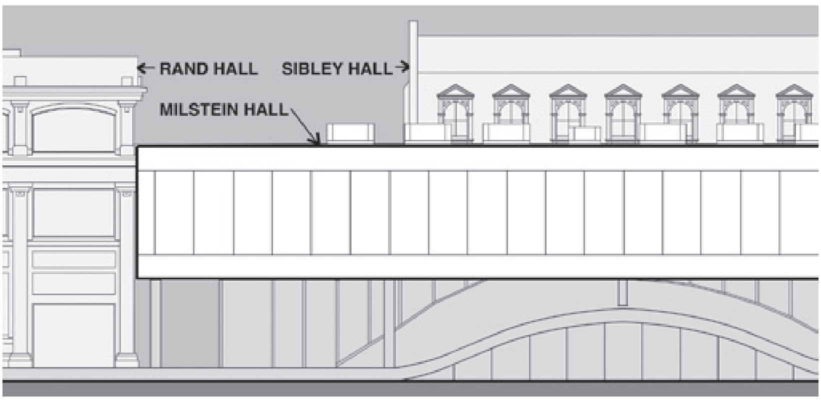


Figure 10.28. The second floor of Milstein Hall needed to be high enough to align with (and connect to) the second floors of Sibley Hall and Rand Hall, while the roof of Milstein Hall needed to be low enough so that it would fit under the existing third-floor windows of Sibley Hall.

11 SLOPPY OR DYSFUNCTIONAL DETAILS

Detailing failures are not inevitable, even in complex or peculiar buildings like Milstein Hall. There is, however, a higher probability that such design problems will occur when complex or peculiar buildings are produced and, for that reason, more attention must be paid in both the design and construction phases to avoid them. By analogy to "defensive driving" techniques employed to reduce automobile accidents, architects should always employ "defensive detailing" to reduce the likelihood of sloppy or dysfunctional details.

As buildings get more complex, more collisions of geometries and of materials can be expected; each potential collision must be investigated and resolved. Anticipating problems means understanding architecture as something in motion rather than as a fixed and static object—i.e., to think of buildings as objects to be inhabited rather than merely modeled or photographed. Everything moves: structures move under dead, live, and environmental loads; elements expand and contract due to thermal and moisture changes; while water, vapor, air, and heat flows make the building enclosure a virtual laboratory of physical and chemical changes. Defensive detailing simply means that the unanticipated must, instead, be anticipated.

Unintended entomological display case

Milstein Hall's roof beams and corrugated steel deck are exposed in the upper-level studio space, but the second-floor structure is mostly covered up by stamped aluminum soffit panels. Where a rectangular hole was punched through this floor structure to accommodate an egress stair to the lobby below, glass fascia panels were installed along the edges of this opening to reveal parts of the steel structure that would otherwise have been hidden, creating what amounts to a structural display case (fig. 11.1).

Although very little additional insight into the building's structure can be gleaned by looking through these glass panels, something unexpected *can* be seen. The spaces between these glass panels were neither sealed nor covered with vertical mullions, creating numerous access points for moths and other insects and arachnids. They get in, but cannot find their way out, and so this glazed area has inadvertently become more of an entomological than a structural display case (fig. 11.2).

Sloppy details at the second-floor auditorium entrance

There are many ways to characterize nonstructural building failure. One type of nonstructural failure comes about because of the difference between drawing or modeling something and actually building

Figure 11.1. Glass panels at the second-floor stair opening create what amounts to a structural display case.

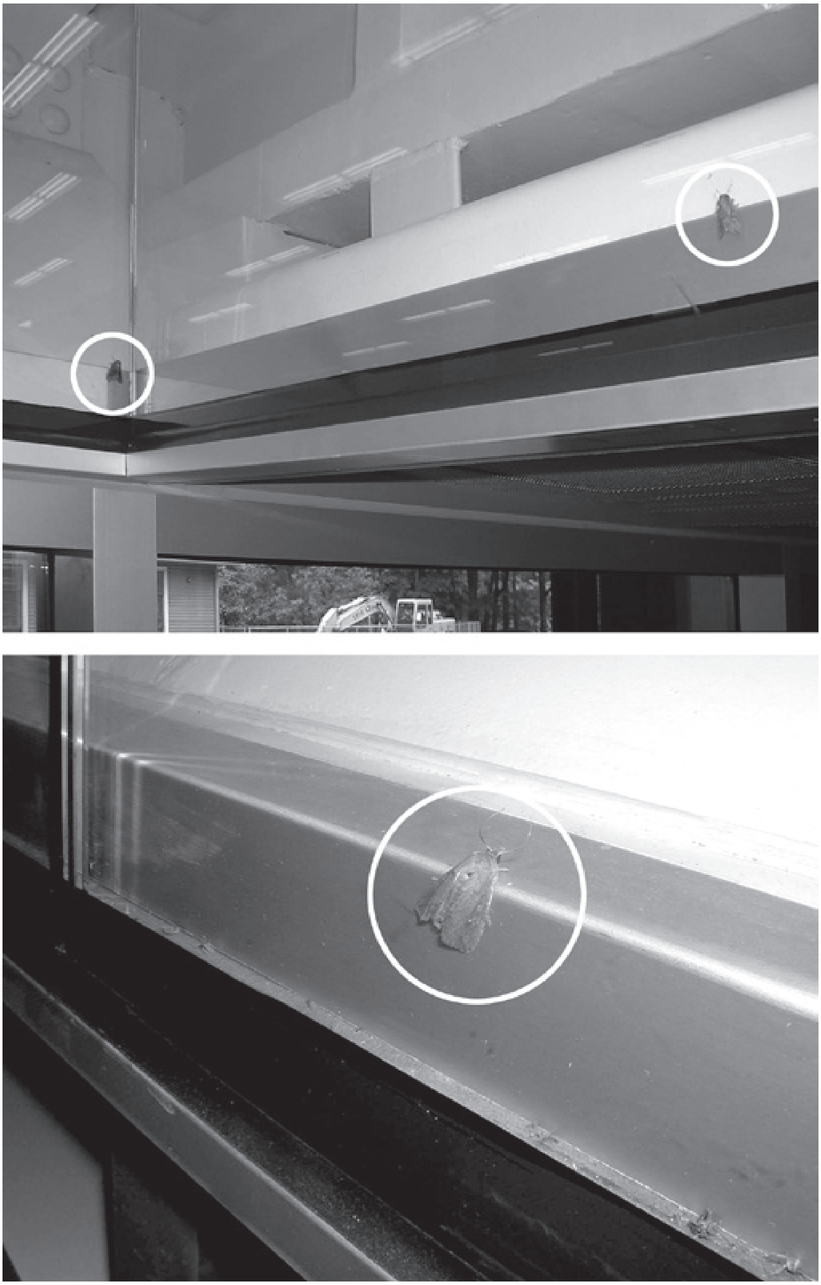


Figure 11.2. Moths and other insects and arachnids get in, but cannot find their way out, and so this glazed area—that reveals Milstein Hall's floor steel structure at the rectangular cut-out for the main entry (and egress) stair—has inadvertently become something of an entomological display case.

something. It may seem obvious that representation and reality are different, yet this difference is often ignored when architects design buildings. As discussed below in terms of room geometry, many products are manufactured as extrusions (aluminum sections, for example), or are rolled or otherwise molded into straight elements. In some cases, such elements can be bent (drywall and steel rolled sections, for example), but in many cases, building components manufactured in straight sections cannot easily be reconfigured into curved geometries. Even intersections of straight elements that are not at right angles can cause problems.

In Milstein Hall, most sloppy details are at the intersection of straight elements, probably because—aside from the cast-in-place concrete dome structure—there are not that many curved elements in the design. The glass enclosure providing an entrance from the upper-level studios to the auditorium below is an example of a sloppy and seemingly ad hoc transition where straight elements are joined (fig. 11.3). It's not completely clear why this detail should have presented such complications until one searches in the working drawings for an indication of what was intended. While there are detail sections through the *front of the enclosure* and elevations of the front and side panels, there are no drawings that show how the front and side elevations are reconciled—i.e., how the two surfaces come together at this corner.

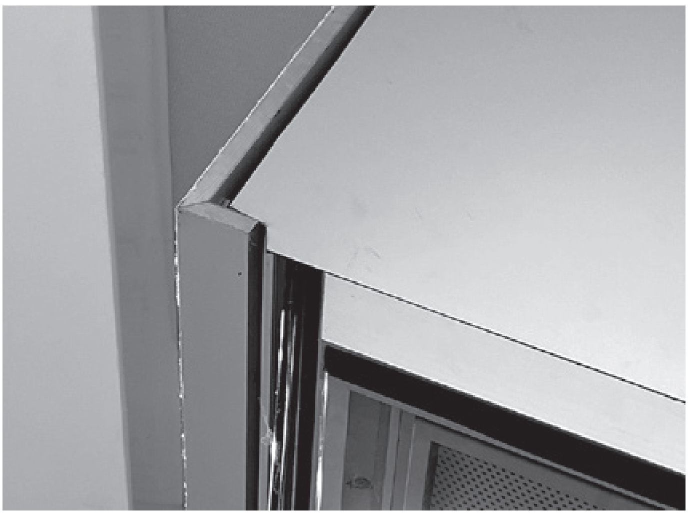


Figure 11.3. Metal panels come together awkwardly at the angled enclosure providing an entrance from second-floor studios to the auditorium below.

Metal panels are similarly mistreated within the same enclosure, where the steel Miesian "box" meets the auditorium stair carved into the concrete "blob" (fig. 11.4). Even abstracting from the poor condition of the concrete itself, detailing of the metal trim in relation to the concrete stair seems entirely ad hoc and awkward—as if so much intellectual

Figure 11.4. Metal trim creates an awkward transition between the Miesian "box" of the second floor and the concrete "blob" that includes auditorium stairs.

effort went into framing the conceptual juxtaposition of box and blob that no further thought was available for its implementation. And, as bad as the metal trim is, the concrete itself, along with the sliding door seal, also seem to be self-destructing at the same entrance to the auditorium, from the second-floor studios (fig. 11.5).

Figure 11.5. Major concrete slab cracking has occurred at the second-floor entrance to the Milstein Hall auditorium; the acoustic seal for the sliding door is also falling apart.

Metal cover plate and cladding issues

There are many other examples of poorly detailed metal plates that have come apart or delaminated in Milstein Hall, both inside and outside the building. On the outside, a number of curtain wall sill cover plates are no longer functioning as intended (fig. 11.6). On the inside, some poorly

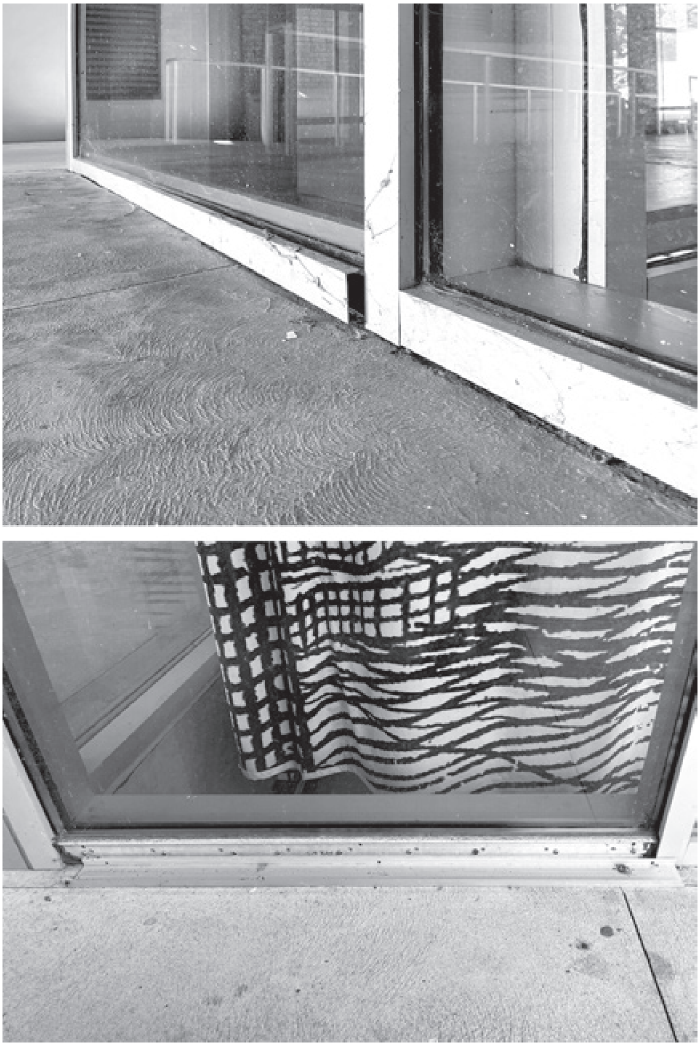


Figure 11.6. Curtain wall sill cover plates have partially or completely detached at the north side of Milstein Hall's lobby (*top*) and at the west side of the auditorium (*bottom*).

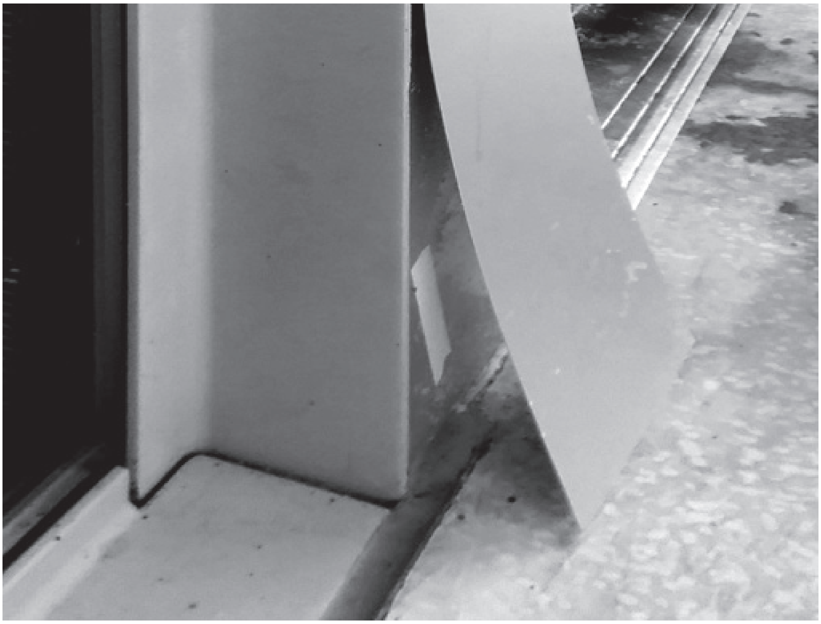


Figure 11.7. Poorly detailed metal cladding has delaminated near the exterior stair exit door on the second floor.

Figure 11.8. Aluminum trim pieces at the top edge of exterior glass guards are coming apart at their joints.

detailed metal cladding has delaminated, near the exterior stair exit door on the second floor (fig. 11.7), although it appears to have been eventually glued back in place.

Glass guard aluminum trim problems

And then there are the aluminum trim pieces at the top edge of all those exterior glass guards that seem to be coming apart at their joints (fig. 11.8). The aluminum trim pieces for interior glass guards are doing a bit better, but are still hardly perfect; over time, the mitered joints for the guards at the second-floor stair opening have also opened up (fig. 11.9).

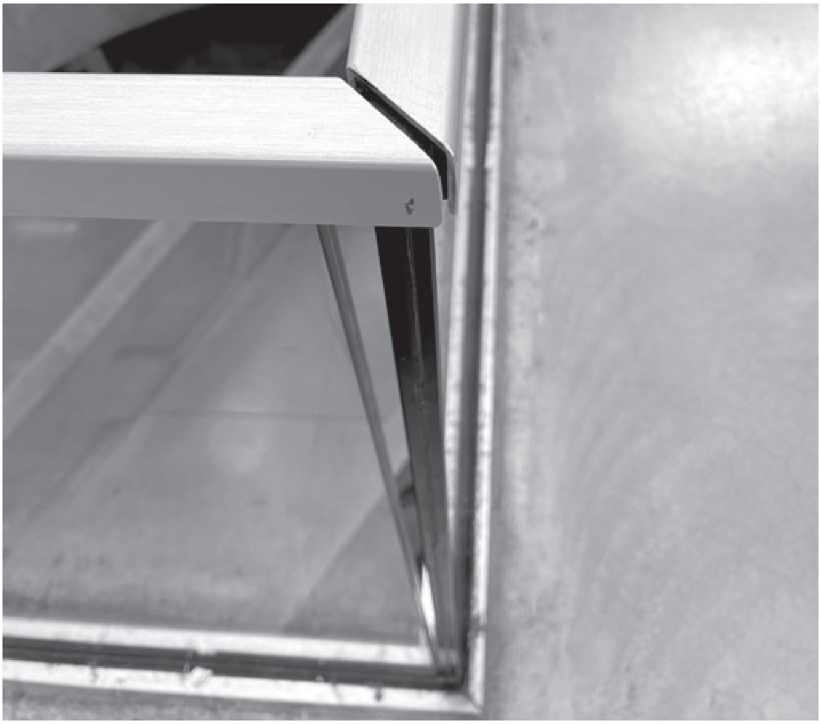


Figure 11.9. Aluminum trim at the top of interior guards in Milstein Hall, like the exterior trim, is also coming apart at the seams.

Figure 11.10. Cracks have proliferated throughout the topping slab on the second floor of Milstein Hall; especially at corners—here, where the wood floor area meets the concrete.

Cracks in concrete slabs

Concrete has a tendency to crack, simply because it shrinks when it cures. We've already seen how this has manifested itself in Milstein Hall's bathroom (fig. 2.2). If the concrete is somehow restrained—prevented from shrinking—cracks will develop. On the other hand, if unrestrained, or subdivided with control joints, or properly reinforced, such cracking can be controlled. There has been extensive cracking of the topping slabs in Milstein Hall, not only at "corners" where stress concentrations could be expected (fig. 11.10), but also in the general field fig. 11.11). The fact that there are no control joints anywhere on the second-floor slab—neither in the underlying structural corrugated steel and concrete deck nor in the 2-inch (51 mm) topping slab—may have contributed to this problem, in

Figure 11.11. Cracks appear not only at re-entrant corners of Milstein Hall's second-floor slab, but also throughout the general field.

spite of the welded-wire mesh that was placed in both slabs.

Slab cracking has also occurred around basement columns where isolation joints were not properly detailed or constructed. Without properly detailed joints to isolate the column from the rest of the slab-on-ground, the slab will crack—effectively creating its own "control joints"—since movement of the slab will, in general, be different from movement of the heavily-loaded column (fig. 11.12).

While control and movement joints are routinely placed in exterior

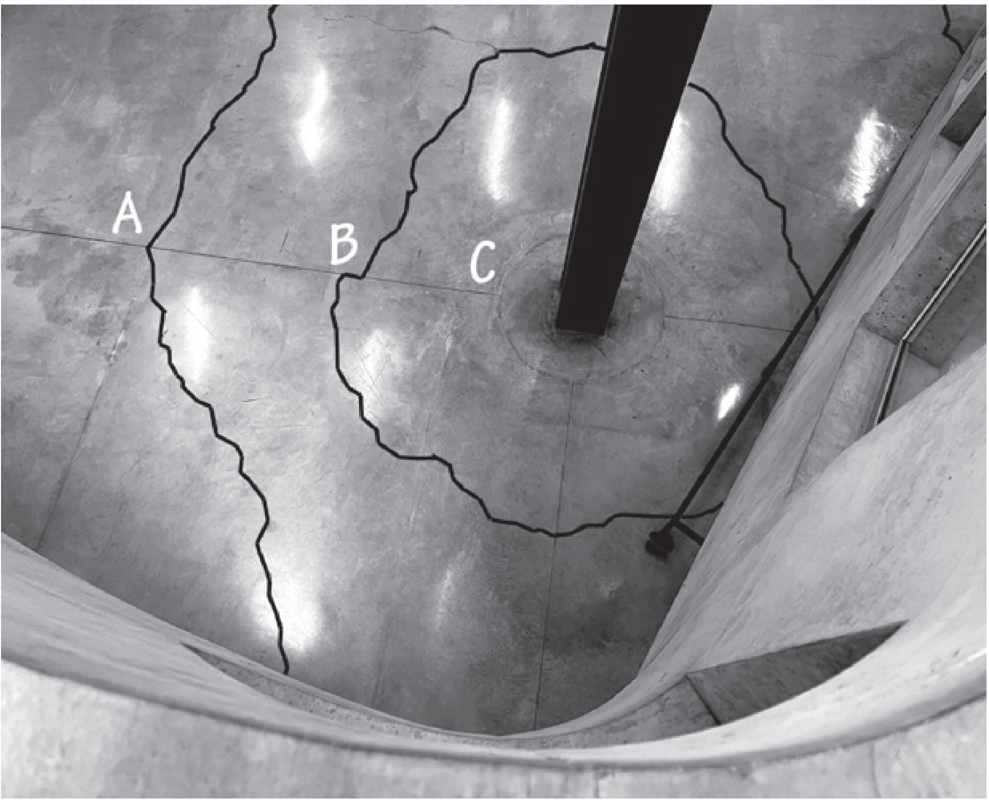


Figure 11.12. Concrete slab-on-ground cracks have occurred, not only in the general field, but especially around columns where control joints were not correctly detailed or constructed. Concentric cracks around a column in the Crit Room have been highlighted at *A* and *B*, while neither the "aesthetic" circular control joint around the column at *C*, nor the orthogonal grid of saw-cut control joints aligning with the centerline of the columns, proved effective at controlling cracks.

pavement and sidewalks, the presence of cracks in that context is fairly common, in part because such surfaces are placed directly on grade, with less attention paid to preparation of the underlying substrates, and less control over the potentially expansive properties of soil, the presence of unruly tree roots, and other such things. Nevertheless, the cracking of pavement at the corner of Milstein Hall's exterior column (fig. 11.13) is far more predictable and preventable, by using the same sort of isolation joints that should have been used in Milstein Hall's basement spaces.

Figure 11.13. With no isolation joints at exterior columns, slab cracking is fairly predictable.

Cracks in brick walls

Cracking has also occurred in the brick load-bearing and cross-bracing walls of East Sibley Hall (fig. 11.14). While no officially sanctioned study of the causes of these masonry cracks has been made public, one plausible explanation is that inadequately tied-back underpinned foundations,

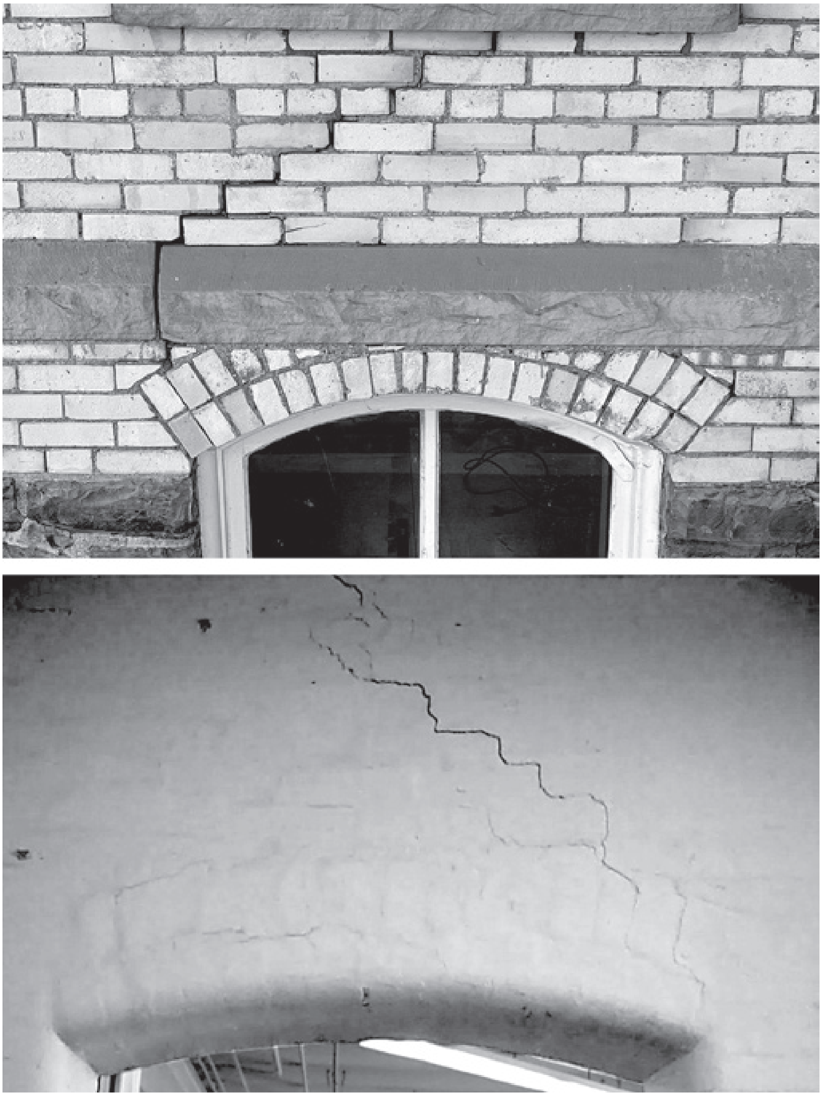


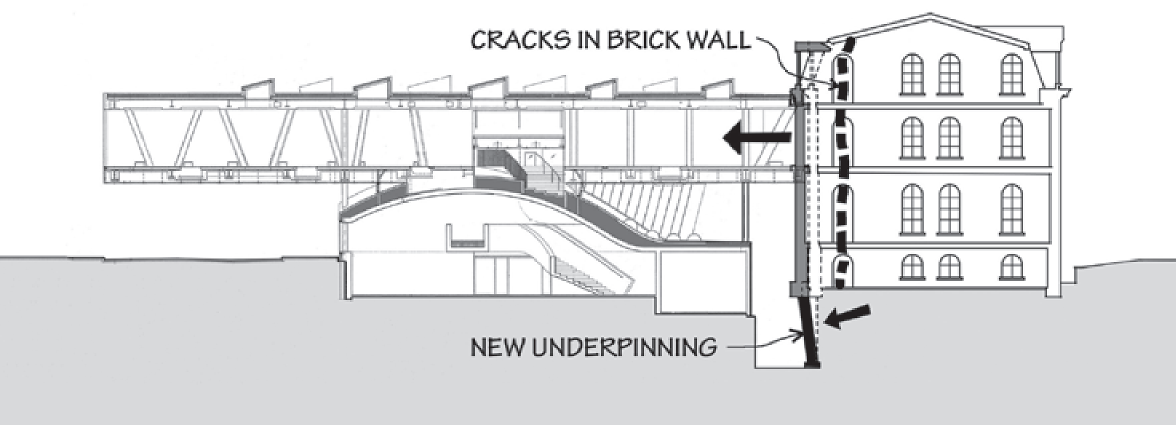
Figure 11.14. Cracking in the brick walls of Sibley Hall occurred after the foundations of Sibley Hall were underpinned and the Milstein Hall site was excavated.

together with excessive vibrations from caisson drilling, contributed to the cracking.

During the construction of—and excavation for—Milstein Hall, the century-old foundations on the north side of East Sibley Hall were underpinned by creating a new reinforced concrete foundation wall *under* the existing shallow foundation. This was necessary because the excavation for Milstein Hall was so deep, relative to the bottom of the Sibley Hall footings, that Sibley Hall itself would have become destabilized without extending the existing foundations deeper into the earth. However, no tiebacks were used to prevent lateral movement of the new underpinned foundation wall for Sibley Hall, so they were able to rotate in a northward direction—toward the excavation created for Milstein Hall (fig. 11.15).

Some combination of lateral thrust originating in the brick arches cut into the perpendicular (north-south) walls of Sibley Hall and from its Mansard roof above, along with vibrations from the drilling of caissons immediately adjacent to this new wall, may have triggered these substantial cracks in the perpendicular masonry walls of East Sibley Hall. In other words, the entire north wall of Sibley Hall appears to have moved laterally towards the excavated Milstein Hall construction site, because (1) the existing arches in Sibley Hall's perpendicular brick cross-bracing walls already provided a discontinuity—a line of weakness; (2) a horizontal force (thrust) was already present in those walls due to the action of the arches themselves as well as the geometry of the Mansard roof above; (3) the vibration of the masonry structure by caisson drilling facilitated the cracking of relatively weak brick mortar joints; and (4) the laterally-unbraced underpinned foundation wall was able to rotate on its footing since no horizontal tie-backs were provided.

Figure 11.15. Section through Milstein and Sibley Halls showing excavated area in front of underpinned foundation wall with assumed rotation of foundation underpinning causing cracking in the bracing walls of Sibley Hall.



Retaining wall displacement

A glass guard separating Milstein Hall's loading area from an accessible ramp shattered, due in part to a series of bad design decisions (fig. 11.16). The accessible ramp behind the retaining wall was built to link the parking lot at West Sibley Hall to Milstein Hall's basement entry doors below the loading area. This ramp slopes downward along the basement wall of West Sibley Hall, continuing its slope along the basement wall of Sibley Dome, at which point one can enter Milstein Hall at the basement level. On the side of the ramp opposite Sibley Hall, a reinforced concrete retaining wall separates the ramp from the parking lot. However, precisely when the ramp reaches Sibley Dome, the concrete retaining wall ends and Milstein Hall's loading area begins, below which is a basement storage area and corridor with a concrete and glass wall facing the ramp. The glass guard is situated on, and spans over, the top of these two walls—the concrete retaining wall at West Sibley Hall and the concrete basement wall at Sibley Dome—providing a necessary barrier at the edge of the parking lot and loading area.

The retaining wall, which holds back soil beneath the parking lot, was not part of the original Milstein Hall plan. Instead of the current surface parking, the original plans, approved by the City of Ithaca's Planning and Development Board in early 2009, called for "a parking garage that will

Figure 11.16. A glass guard separating Milstein Hall's loading area from an accessible ramp shattered in 2015.

provide 199 spaces, with two underground levels accessible from Central Avenue and one surface level accessible from University Avenue."[1] This proposed structured parking lot would have been more like an underground building, negating the need for a retaining wall at the edge of the ramp, but it was cut from the project because of budgetary concerns stemming from the financial crisis of 2008. The retaining wall—added to the project when the parking garage was eliminated—was structurally connected to the underground storage room and corridor wall at the western end of Milstein Hall, beneath the loading area.

A retaining wall would typically be completely separated from an adjacent building with some sort of isolation joint since the wall and building behave quite differently under lateral loads: the retaining wall must resist lateral soil pressure as a cantilevered structure fixed at its footing, whereas the building's basement-foundation wall is braced laterally by its ceiling—the concrete deck of Milstein Hall's loading area in this case—and is not subject to lateral soil pressure at this location. As soon as the retaining wall was connected to the concrete wall of Milstein Hall, lateral pressure on the retaining wall was transferred, through its structural connection, to Milstein Hall's basement wall and caused the basement wall to crack (fig. 11.17).

The precise mechanism of failure became clearer two years later,

Figure 11.17. A large crack appeared in Milstein Hall's basement-foundation wall immediately adjacent to the concrete retaining wall to its left, shown here in 2013.

in 2015, when the glass guard immediately over this cracked foundation wall shattered. The top of the retaining wall displaced approximately 0.75 inches (19 mm) relative to the position of Milstein Hall's basement-foundation wall, dragging the glass guard with it. However, this particular glass guard panel—inexplicably—had been constructed so that it spanned *over the joint* between the retaining wall and the building wall, thereby being restrained by the building as it was being displaced by the retaining wall. Something had to give, and, unsurprisingly, the glass shattered (fig. 11.18 *left*). The concrete crack that had emerged shortly after the building was constructed was not, apparently, taken as a sign of potential structural danger and over the following two years, the lateral soil pressure continued to push on the retaining wall, leading ultimately to this failure. It is also possible that spalling of the concrete and widening of the crack was triggered, not only by lateral soil pressure on the retaining wall, but also by water, with road salt, working its way through cracks in the concrete and corroding the horizontal reinforcing bars that were placed between the retaining wall and the building (fig. 11.18 *right*).

Ultimately, the shattered glass panel was replaced, but problems remain. Figure 11.19 (*top*), from 2023, shows that continued relative

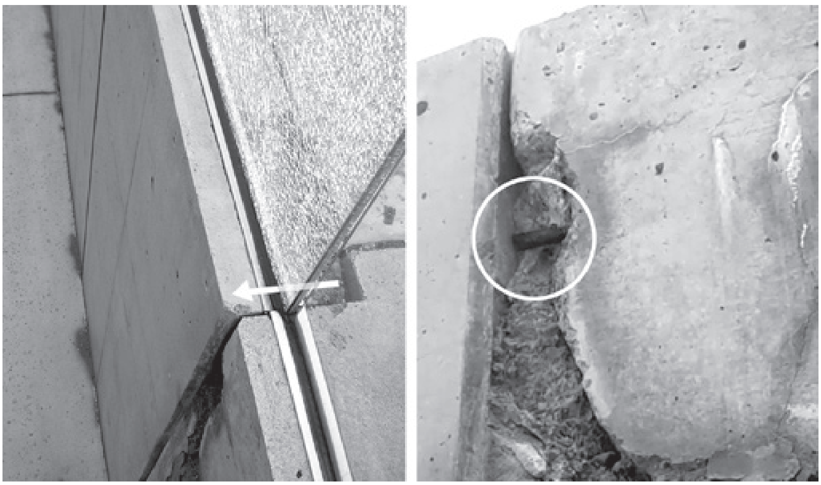


Figure 11.18. The glass guard panel between Milstein Hall's loading area and the accessible ramp from the parking lot (*left*), shown here in 2015, can be seen spanning over the joint between the displaced retaining wall and the building; spalling of the concrete could also have been triggered by corrosion of reinforcement, visible in the highlighted circle, placed between the retaining wall and the building (*right*).

movement between the two walls seems to have caused the aluminum trim at the top of the guard to displace; figure 11.19 (*bottom left*), from 2018, shows that a gasket at the bottom of the glass guard panel had detached from the U-shaped shoe holding the glass in place. This same image shows a sealant joint between the retaining wall and the building, but my guess is that the two walls remain structurally connected. And the underlying problems with water, and possibly road salt, entering the wall continue to cause efflorescence in 2023 (fig. 11.19 *bottom right*), even after all the cracks and spalled concrete have been patched up.

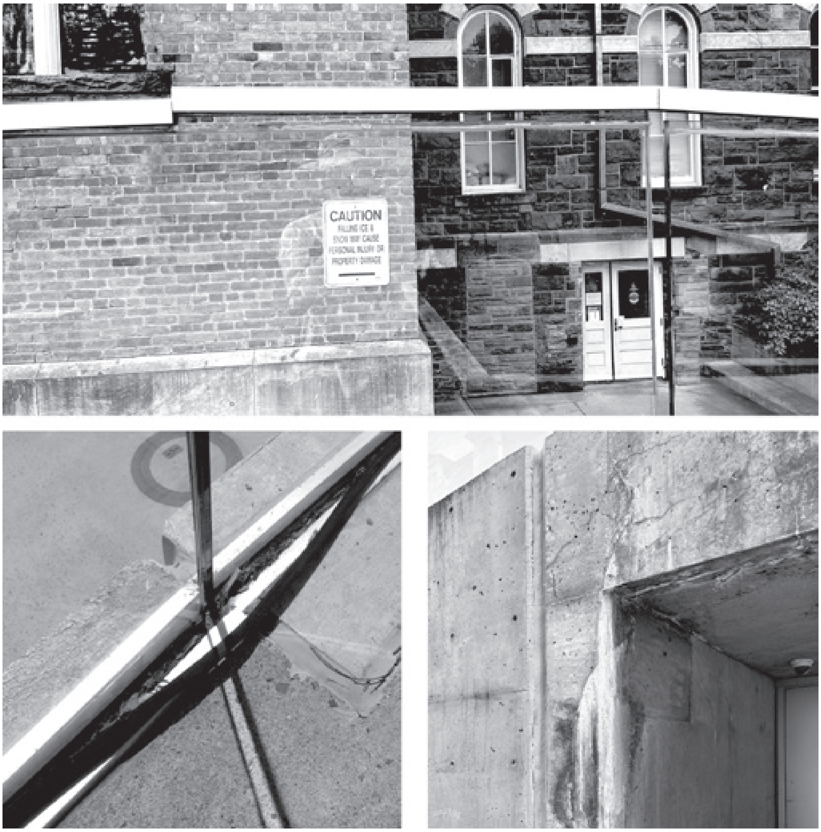


Figure 11.19. The glass guard panel between Milstein Hall's loading area and the accessible ramp from the parking lot, shown here with displaced trim in 2023 (*top*), a detached gasket in 2018 (*bottom left*), and continued efflorescence in 2023 (*bottom right*).

Aluminum gridded guard failure

Milstein Hall's stepped auditorium was designed and constructed with aluminum gridded guards at its edges (fig. 11.20 *top*). This design quickly proved inadequate—the guards were apparently too flexible and unstable—so they were removed and replaced in January 2012 with painted steel guards—having a similar gridded design—just a few months after the building was occupied (fig. 11.20 *bottom*).

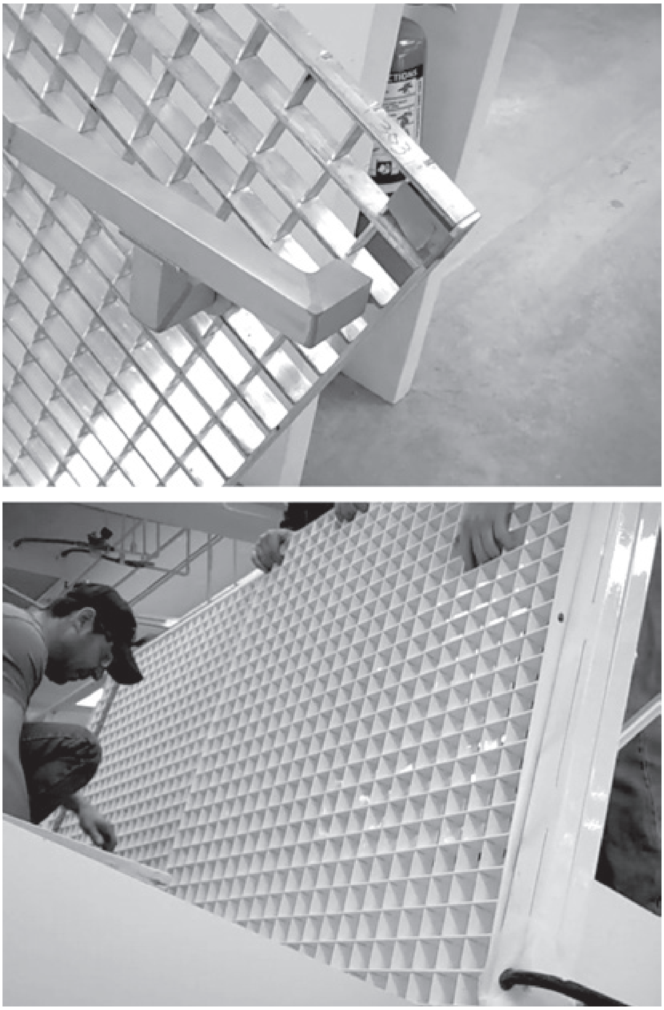


Figure 11.20. Milstein Hall's original aluminum guards were apparently too flexible (*top*) and were replaced with welded steel guards having a similar gridded design (*bottom*) just a few months after the building was occupied.

Cupping of wood floor boards

"Cupping" of wood floorboards occurs due to differential expansion or contraction on the top and bottom faces of the boards. If the wood grain is not perfectly consistent (where such perfection is found only in the finest quarter-sawn lumber), moisture will have a different effect on the two faces, as these faces will differ in the degree to which their grain is oriented radially rather than tangentially—wood expands and contracts more tangentially than radially. It is possible that, even with the wood grain perfectly consistent throughout the cross section, moisture will be present to a greater or lesser degree where the boards are in closer contact with moisture, either from the underlying concrete slab, or from the air above the boards. Since wood expands or contracts depending on its moisture content, which is in turn sensitive to atmospheric conditions, any such exposure to moisture may cause cupping or its opposite—crowning—of the boards. Furthermore, this effect is more pronounced with wide boards such as the ash planks specified for Milstein Hall (fig. 11.21) since the warping of the boards occurs over a greater cross-sectional dimension. In any case, the issue seems to have been largely resolved with sanding and refinishing of the floor in the summer of 2023.

Figure 11.21. The wide ash planks in Milstein Hall's wood floor have cupped, i.e., warped so that the center of each board is lower than its edges, due to differential moisture conditions above and below the wood surface. When light strikes the floor obliquely, the curved surface of the boards creates a repeating pattern of light and shadow. The stainless-steel-clad wall in the background is Milstein Hall's second-floor electrical closet.

Mottling of concrete surfaces

There have been several instances of unintended concrete staining, or mottling, on Milstein Hall's walls and floor slabs. In the case of the floor slabs, a red stain appeared in the Crit Room, possibly caused by wooden protection boards that were placed over the slab before it was fully cured. In the case of exposed concrete walls, also in the Crit Room as well as the auditorium, mottling or staining apparently resulted from the combination of two form release agents that were applied to wooden forms (fig. 11.22). The field Superintendent for the general contractor, Welliver, put it this way:

> We experienced a little problem on this wall here with two form-release agents reacting. That's why we've got the mottling, the odd color, and then it looks like staining. That's what we determined it was: a release agent that was on the plywood previously, compared to what was specified and put on. And we ended up with these dark stains that you see on the corner there. It actually changed the texture of the concrete. So in an attempt to unify the whole thing, we're trying to use an acid wash which is a masonry cleaner with the acid in it to try to blend and bleach out the dark color.[2]

In some cases—not necessarily, but quite possibly, in this instance—the specification of LEED-friendly, but relatively untested, products may have contributed to these unintended problems.

Figure 11.22. The contractor's field superintendent explains the mottling of concrete surfaces in Milstein Hall's Crit Room.

12 DANGEROUS DETAILS

The first and last word on dangerous architectural details is Monty Python's legendary "Architects Sketch," whose satirical architectural proposal for an apartment building was excerpted in the opening paragraph of my book, *Building Bad*: "The tenants arrive in the entrance hall here, are carried along the corridor on a conveyor belt in extreme comfort and pass murals depicting Mediterranean scenes towards the rotating knives…"[1]

One might wonder why architects—at least those who are not engaged in satire or parody—would create buildings that could cause injury. In most cases, the answer seems to be a pathologically narrow focus on how building elements appear—i.e., what they look like—and a corresponding inattention to qualities of these same building elements that could cause harm. This is, at least in part, related to building complexity or peculiarity, as such buildings invariably contain elements that are original, newly conceived, and untested. That these elements are untested or unprecedented doesn't completely explain their danger; rather it is the combination of their being untested, while at the same time being designed from a standpoint that is almost exclusively formal, artistic, and expressive, that increases the likelihood of danger.

Missing or noncompliant guards

As poorly executed as many of Milstein Hall's guards are, they at least function as guards—preventing people from inadvertently falling over discontinuities in the horizontal walking surface. But some guards in Milstein Hall do not provide such protection, and some discontinuities in the horizontal walking surface are not protected by any guards. Building codes have long required that "guards shall be located along open-sided walking surfaces … more than 30 inches (762 mm) measured vertically to the floor or grade below…" and that such guards "shall have balusters or ornamental patterns such that 4-inch-diameter (102 mm) sphere cannot pass through any opening…"[2]

Yet at the ground level connection to Sibley Hall within the Duane and Dalia Stiller arcade, the grated bridge connecting Milstein Hall's concrete podium with the door into Sibley Hall has no guard at all along its edge, while the guard rail immediately adjacent to the bridge has a noncompliant guard that allows passage of a 4-inch-diameter (102-mm-diameter) sphere in violation of the building code. (fig. 12.1). The sphere requirement is "based on anthropometric research that indicates children in the 99th percentile that have developed to the point of being able to crawl will have chest depth and head size of at least 4-3/4 inches [121 mm]…"[3]

Figure 12.1. Guards are both missing and, where they appear, noncompliant at the grated bridge connecting Milstein Hall's arcade to Sibley Hall.

There is another missing guard at Milstein Hall, which presents a danger to small children even though it may, or may not, be strictly noncompliant. The flat plaza concrete deck transitions seamlessly onto the top surface of a concrete wall separating the loading area from the sunken garden (fig. 12.2).

While there is a compliant glass guard on the *garden side* of this surface, the loading-area side is unprotected. At a certain point along the wall, as the loading area slopes down to University Avenue, the vertical discontinuity exceeds 30 inches (762 mm). From a code-compliance standpoint, the relevant question is whether the top of this wall constitutes an "open-sided walking surface." As a practical matter, the wall's top surface certainly functions as a continuation of the plaza's walking surface and, as such, poses a threat to young children.

In Milstein Hall's auditorium, guards have been provided around mezzanine seating, but these guards are ignored by students looking for places to sit. Designing a new auditorium that cannot even accommodate all the students in the department of architecture is a puzzling

Figure 12.2. The flat plaza concrete deck transitions seamlessly into the top surface of a concrete wall separating the loading area from the sunken garden, creating a vertical discontinuity with no guard rail.

programming decision; here, students required to be in attendance for start-of-the-semester studio presentations not only sit at the edge of the mezzanine slab, unprotected by guards (fig. 12.3), but also find seats in the aisles, illegally blocking the egress path—as the dean of the college watches (fig. 12.4).

Figure 12.3. Students climb over the glass guard in the Milstein Hall auditorium mezzanine to find seating for required start-of-the-semester studio presentations, fall 2013.

Figure 12.4. Students sit in aisles that are required to be kept clear for fire safety (egress) as the college dean (center, dark suit) watches.

Snow drifts at roof edge

Snow drifts that form on the roof, unconstrained by railings or parapet walls (there are none), often extend far over the roof edge, presenting a hazard to cars and pedestrians below. This phenomenon depends, of course, on the amount and consistency of the snow, and the direction of the prevailing winds, but the danger is real—just ask a lawyer:

> While slip-and-fall, or slip-and-crash, accidents immediately come to mind as common winter hazards, falling ice and snow from roofs can also cause serious injury to the unsuspecting traveler. Serious head, neck and back injuries, including severe concussions, can result from a snowpack sliding off a steep roof and onto an unlucky passerby. Along with the possibility of a concussion and neck injuries, if the passerby is knocked off his or her feet there might also be the typical injuries of a slip-and-fall accident.
>
> If such a sliding snowpack is heavy enough, or includes a hefty chunk of ice, it may very well knock the person unconscious or cause deep lacerations. Even a small amount of falling snow and ice from a sign, building ledge, or scaffolding can cause serious bodily damage and long term injury.[4]

At Milstein Hall, cantilevering hunks of snow often protrude over the roof coping, sometimes immediately above the main circulation path linking North Campus with the Arts Quad (fig. 12.5).

Figure 12.5. Hunks of snow often cantilever out over the roof edge of Milstein Hall, which has no protective parapet or railing.

Icicles at soffit

As discussed in the section on thermal bridging (fig. 8.1), Milstein Hall has problems with icicles that form on its facades through the same process associated with classic ice damming. Aside from energy inefficiency implied by the thermal bridging, icicles are also quite dangerous: they can "start crashing down to the ground below and can cause injuries" according to emergency medicine physician Tom Waters, MD. The doctor adds that "if an icicle hits you in the head, you may see an alarming amount of blood at first. That's because the scalp contains a lot of blood vessels. But it's important to remain calm and get the bleeding under control with direct pressure."[5]

***

Two additional dangerous practices discussed previously in a different context—involving Milstein Hall's love-hate relationship with skateboarding, and the design of single steps or other similar discontinuities along circulation paths—will not be repeated in this section. The subject of fire safety will be discussed in Part III, which follows.

PART III

FIRE HAZARD

13 OPENING REMARKS ON FIRE SAFETY

Building codes play a prominent role in this discussion of fire safety. At the outset, I want to emphasize two things: first, that such codes are *political* documents and do not derive their minimum standards directly from fire science, but rather balance the benefits of adopting potentially more rigorous fire safety strategies against the economic costs of doing so; and second, that following requirements embedded in model building codes, however flawed they might be, is still the only reasonable alternative to literally "following the science"—something beyond the expertise of most architects and building code officials. Moreover, building according to legally-mandated prescriptions in codes will reduce the risk of death, injury, and property damage due to fire. So when I refer to various code provisions, I take them to be both necessary and sufficient to reduce fire risk, even if the political and economic reality is more nuanced. The one exception is a uniquely bad provision found only in the 2002 iteration of the *New York State Building Code*—Appendix K—which, by radically deviating from the provisions found in all other codes, seriously upset this balance between safety and economics.

There are no national building codes in the U.S. Rather, each state is free to adopt its own code. This is because the U.S. constitution gives various powers to congress—to collect taxes, to establish post offices, to declare war, and so on—and creating a national building code is not one of them. Moreover, the tenth amendment to the constitution makes it clear that "powers not delegated to the United States by the Constitution … are reserved to the States, or to the people."[1] As a result, U.S. codes have historically been largely regional, with three private model code organizations creating the standards that were then turned into legal documents by individual states (and sometimes by individual cities). The earthquake-oriented *Uniform Building Code* was adopted by western states, the hurricane-oriented *Standard Building Code* was adopted by southeastern states, and the wind/snow-oriented *Basic National Building Code* was adopted by northeastern states.[2] This situation only changed with the consolidation of these model code organizations into the International Code Council (ICC), which issued its first version of the model *International Building Code* (IBC) in 2000. Accounting for the inevitable legislative time lag, this model code became the basis for the 2002 *New York State Building Code*, under which Milstein Hall was permitted.

Strictly speaking, Milstein Hall is an *addition* to two existing buildings on the Cornell University campus in Ithaca, New York—Rand Hall and Sibley Hall. Under all current and previous New York State building codes—i.e., for all New York State codes except for the 2002 iteration under which Milstein Hall was permitted—a fire wall is required between Milstein Hall and the adjacent buildings (Sibley and Rand Halls) since otherwise the combined floor area would exceed limits specified under code sections specifying "Allowable Height and Building Areas."

However, Milstein Hall obtained a building permit under the 2002 *New York State Building Code* which regulates additions to existing buildings, not by standard provisions based on the *International Building Code* (IBC), but by a unique appendix promulgated only in New York State, and only for this particular iteration of the New York State code.

Since Milstein Hall does not satisfy current code requirements, it is a nonconforming building, and quite possibly a noncompliant building, not only with respect to fire safety codes currently in effect, but also with respect to fire safety codes in effect when its construction began. As such, it is less safe than it would have been, and could have been, had it been built according to prevalent fire safety standards codified by the International Code Council (ICC) and embodied in their IBC and *International Existing Building Code* (IEBC).

Under former Governor Pataki, New York State created its own code language for existing buildings (rather than using the language contained in the inaugural version of the 2000 IBC). This was done by deleting most of the IBC chapter governing existing buildings (chapter 34) and replacing it with an appendix unique to New York State: Appendix K. The idea was to make it easier for developers to renovate or add to existing—often abandoned—buildings, and thus to spur redevelopment, especially of historic structures, where the costs of doing so would otherwise be prohibitive. In a compromise between economically viable redevelopment of old building stock and modern standards of fire safety, modern standards of fire safety were sacrificed to some extent, in order to reduce the costs of, and thereby to encourage, such redevelopment.

Not surprisingly, Appendix K had the support of both development and preservation interests in New York State. A New York State publication explained it this way:

> The new rehabilitation provisions of New York's Uniform Fire Prevention and Building Code are changing the way developers and investors look at existing buildings across the State. Known as Appendix K, this new and progressive approach to building rehabilitation is providing much needed flexibility to allow for the safe and cost effective revitalization of our existing buildings.[3]

The Preservation League of New York was also enthusiastic about the new code provisions embedded in Appendix K:

> The League is committed to a New York State Building Code that meets public safety goals while eliminating barriers to the redevelopment of existing and historic commercial buildings. In 2002, a new interim building code went into effect in New York State, one in which the League played a key role in reviewing and proposing enhancements to "Appendix K," which guides the rehabilitation of existing buildings. This interim code will be in use until the state adopts the International Building Code, a new national model code. … The League is advocating for further evaluation of the draft IEBC in 2003. The League's efforts have Governor Pataki's support, as code reform is an integral element of the state's Quality Communities initiative. Adoption of an effective code is critical to providing communities across New York State with a renewed opportunity for investment and growth, while helping to curb sprawl.[4]

This type of compromise between development and fire safety was already being discussed for a yet-to-be-issued *International Existing Building Code* (IEBC) being developed by the ICC, so the development of Appendix K in New York State can be seen as a temporary measure to bring the New York building codes in line with anticipated developments in the national model code. Unfortunately, in at least one key section of Appendix K, the language and intentions of the soon-to-be-issued IEBC were—for unknown reasons—altered, and the carefully-contrived balance between redevelopment and fire safety implicit in the model code was seriously upset.

A building permit was applied for and granted to Milstein Hall *just before* the 2007 *New York State Building Code* became effective. This rush to secure a building permit under the old, soon to expire, 2002 code appears to have been motivated by the existence of Appendix K in the old code—an appendix whose development-friendly provisions were no longer entirely sanctioned by the 2007 code. However, the permit drawings originally submitted for Milstein Hall were grossly noncompliant, even considering the reduced fire safety standards permitted under the 2002 code. It seems therefore entirely inappropriate for a building permit to have been issued based on the submitted drawings.

Nonconforming buildings are quite common and are not improper per se. They come into existence as building codes become more stringent over time. Virtually all codes permit existing buildings that were compliant when they were built to remain as they are (were), even when they no longer conform to the more rigorous standards of newer codes. The rationale for allowing nonconforming buildings is not that the old buildings are just as safe as newer ones that comply with more stringent code provisions. Rather, the rationale is entirely pragmatic: economic and practical constraints make it virtually impossible to constantly upgrade buildings with every 3-year code cycle. That being said, there are exceptional circumstances when nonconforming buildings are forced to make changes in order to meet current standards. For example, the Americans with Disabilities Act (ADA) requires most existing buildings to become accessible, even when there was no accessibility requirement in place at the time the building was constructed. The new elevators in Sibley and Rand Halls at Cornell are examples of this mandate being implemented (even if it took Cornell 20 years after passage of the ADA to get around to it). Another example is a judicial ruling that prevented Cornell from continuing use of lecture rooms (so-called assembly occupancies with more than 49 occupants, including a lecture room in East Sibley Hall) where only one means of egress was present—even though the lecture rooms may have been legal when they were built.[5] A third example is the required strengthening of existing unreinforced masonry (URM) buildings in California for increased seismic resistance, even when those buildings were constructed according to seismic codes in place when they were built.

In the first two examples of required retrofitting of nonconforming buildings, both applicable to the architecture facilities at Cornell,

Cornell's response was to either delay implementation (20 years in the case of Sibley and Rand Hall ADA-mandated elevators), or to challenge in court the legal basis of the code interpretation whose intent was to make buildings safer by requiring conformance with current lecture hall egress standards. In each case, Cornell was acting within its rights—yes, one could interpret the ADA regulations governing conformance with accessibility requirements as applying to the campus as a whole rather than to individual buildings and in that way claim to have satisfied the letter, if not the spirit, of the ADA; and yes, one could challenge the legal basis of the code interpretation in order to maintain a nonconforming condition in which several large lecture halls had only one means of egress (Cornell lost this legal challenge)—but the question remains why an institution committed to access and safety[6] would adopt ad hoc policies that actually reduce access and safety. That this institutional attitude is not limited to the two instances cited above can be seen by examining the design decisions leading to the construction of Milstein Hall.

The initial schematic design for Milstein Hall, unveiled with much fanfare at a public lecture by OMA/Rem Koolhaas in Bailey Hall at Cornell in September 2006, was fundamentally flawed from a fire-safety standpoint, and should not have been approved for design development. These problems do not derive from obscure or "academic" fire safety principles that could easily be overcome with money or advanced technology. Rather, the problems go to the very heart of fire safety regulations: the requirement that combustible material that might fuel a fire must be limited in quantity so as to preserve life safety and limit property damage in the event of a fire; the compartmentation of buildings into smaller units separated by continuous or protected assemblies; and the provision of adequate means of egress.

14 EXCESSIVE AREA

Building codes limit a building's floor area depending on the combined impact of four parameters—these variables are (1) the type and combustibility of the building's construction system; (2) the building's function or occupancy; (3) how close the building is to other structures; and (4) whether the building has an automatic sprinkler system. Such limits, regulated and constrained in chapter 5 of the code, create a 4-dimensional matrix for the determination of floor area (and other) limits, based partly on principles of fire science, partly on the empirical history of buildings and fires, partly on evidence of the effectiveness of automatic sprinkler systems, and partly on the relatively recent political desire to reconcile standards embedded in various competing model codes so that a single, "national code" could be promulgated—i.e., the *International Building Code* or IBC, developed by the International Code Council, or ICC.

Alternative scenarios

The parameters that determine allowable areas in chapter 5 of the code are affected by how "the building" is defined, i.e., whether Milstein Hall is considered (1) free-standing, i.e., Milstein only; (2) combined with both of its neighbors, i.e., Milstein-Sibley-Rand; (3) combined with only one of its neighbors, i.e., Milstein-Sibley; or (4) combined with its other neighbor, i.e., Milstein-Rand. These four alternative scenarios for computing allowable floor area are outlined in Table 1. Why and how these scenarios might be implemented will be addressed later. But to begin, we discuss the determination of allowable floor area as shown in Table 1, starting with the top row, and working our way down.[1]

Construction type. The key distinction among the five main construction types outlined in the building code is whether the building's primary elements of construction are combustible (i.e., whether they include wood framing elements) or noncombustible (i.e., whether they're constructed from pretty much anything else—steel, reinforced concrete, or masonry).

Construction types I and II are noncombustible; Types III, IV, and V are combustible, in that they all can contain wood elements. Once that primary distinction is made, four of the five construction types are further divided into sub-types—A and B—where subtype A has a greater fire-resistance rating on some or all of its components than subtype B. (Type IV construction had only one subtype—"heavy timber," or HT—when Milstein Hall was built. With the development of mass timber and its incorporation, for the first time, into the 2021 IBC, Type IV has been expanded to include three new subtypes, A, B, and C, in addition to the traditional HT.)

Specifications for construction types are found in chapter 6 of the building code. Table 601, in particular, itemizes the required fire-resistance rating of constituent building parts (e.g., primary structural frame, floor

Table 1. Calculation of allowable second-floor area for A-3 occupancies.

	Milstein only	**Milstein, Sibley, and Rand**	**Milstein and Sibley**	**Milstein and Rand**
Construction type	IIB	VB	VB	IIB
Occupancy group	A-3	A-3	A-3	A-3
Tabular area, A_t, for *SM* (sq. ft.)	28,500	18,000	18,000	28,500
Tabular area, A_t, for *NS* (sq. ft.)	9,500	6,000	6,000	9,500
Perimeter, *P*, for frontage (ft.)	1,045	1,190	800	1,135
Partial perimeter, *F*, for frontage (ft.)	328	973	704	766
Average width, *W*, for frontage (ft.)	30	30	30	30
Frontage coefficient, I_f	0.19	0.57	0.63	0.42
Allowable area, A_a (sq. ft.)	30,305	21,420	21,780	32,490
Actual area (sq. ft.)	26,512	43,954	34,684	35,782

and roof construction, etc.) for all construction types.[2] There are only two construction types which require *no fire-resistance ratings on any of their components*—Type IIB (basically non-fireproofed steel framing like Rand and Milstein Halls, assuming that they were not connected to Sibley Hall) and Type VB (basically non-fireproofed light wood framing like Sibley Hall). For this reason, the construction types for all three buildings—Milstein and Rand Halls (IIB) and Sibley Hall (VB)—are objectively the "worst" construction types in terms of fire safety. The code takes this into account when it tabulates and constrains allowable floor areas and building heights.

Only a fire wall between buildings allows those building to be considered separately from their immediately adjacent neighbors, and fire walls were not constructed between Milstein, Sibley, and Rand Halls. For that reason, the combined Milstein-Sibley-Rand Hall constitutes a single building from the standpoint of allowable area calculations, and a single building can only have one construction type. Because Sibley Hall is a combustible wood-framed building with the least fire-resistance of any code construction type, Milstein Hall, in combination with either Sibley and Rand Halls, or just Sibley Hall, is subjected to area limits determined by the weakest link in the combined building complex: Sibley Hall with Type VB construction.

Sibley Hall, with its loadbearing exterior masonry walls, appears at first glance to have more robust construction than Type VB, which is generally associated with entirely combustible wood-frame structures. In other words, having exterior masonry walls would seem to place it in the category of so-called "ordinary construction," i.e., Type IIIB. However, because Sibley Hall's third-floor walls transition from masonry to wood, creating a Mansard roof (fig. 14.1), the building's construction type must be downgraded to type VB. This, in turn, means that the allowable floor area for the combined Milstein-Sibley-Rand Hall must be determined on the basis of Type VB construction.

If Sibley Hall's Mansard wood-framed walls were upgraded to 2-hour fire-rated construction, its construction type would be upgraded to IIIB, allowing increased floor area. However, such an upgrade would apply only to Sibley Hall as a freestanding, independent building, and would have no effect on the construction type of a *combined* building that included Sibley Hall (i.e., Milstein-Sibley-Rand Hall or Milstein-Sibley Hall). This is because Type IIIB construction requires 2-hour fire-rated exterior bearing walls, which a freestanding (and upgraded) Sibley Hall would have but which a combined building that included Milstein Hall would not have. The only construction type that permits all elements to have no fire-resistance rating and permits combustible elements (i.e., the wood floors and roof framing of Sibley Hall) is VB.

Occupancy group. The building code requires that all spaces in a building be identified in terms of their use-function, since the "occupancy" of a space has important ramifications for fire risk and, therefore, fire safety requirements. This risk can take two forms: first, some occupancies, like lecture halls, or exhibition spaces, may contain lots of people, often packed closely together; second, some occupancies, like storage buildings or libraries, contain large quantities of hazardous (flammable) materials. The code gives each occupancy group a letter designation—e.g., A for assembly, B for business—and, in some cases, a number indicating its subtype—e.g., A-3 for art galleries, libraries, lecture halls, and so on. Taken together, Milstein-Sibley-Rand Hall combines several different occupancy groups, including university classrooms and offices

Figure 14.1. The inclined wooden structure of Sibley Hall's Mansard roof downgrades its construction type from IIIB (fire-rated masonry exterior walls and wood-framed floors and roof) to VB (non-fireproofed wood frame).

(group B), lecture halls, galleries, and libraries (group A-3), wood-metal shops (group F-1), and even some exterior space below the cantilevered second floor over University Avenue (S-2).

While there can be only one construction type for a single building such as Milstein-Sibley-Rand Hall, there can be multiple occupancies. However, because these multiple occupancies are not consistently separated with fire-resistance-rated walls and floors (fire barriers and horizontal assemblies), the 2002 code mandated that the "required type of construction for the building shall be determined by applying the height and area limitations for each of the applicable occupancies to the entire building" and, in addition, that "the most restrictive type of construction, so determined, shall apply to the entire building."[3] This is a rather convoluted way of saying, as the 2020 code clarified, that the "allowable building area, height and number of stories of the building … shall be based on the most restrictive allowance for the occupancy groups under consideration for the type of construction of the building …"[4] Milstein, Sibley, and Rand Halls have no fire-rated construction separating their various floors, and each building has group A-3 assembly spaces as follows: Milstein Hall has gallery, exhibition, and auditorium spaces; East Sibley has a large lecture hall; and Rand added a library soon after Milstein Hall was occupied. For this reason, each building's allowable area—even if examined separately—would be governed by the A-3 occupancy group, as shown in Table 1.

Fire barriers—basically fire-rated infill walls between the floor and ceiling of any given story—can be provided in order to separate different occupancies from each other, or divide a single occupancy into separate fire areas, but such fire barriers do not change the underlying construction type of the combined building, which remains that of a combustible wood-frame structure (Type VB). Where mixed occupancies are separated by vertical fire barriers and fire-rated horizontal assemblies in a single building, building codes stipulate that the sum of the ratio of proposed to allowable floor areas for each separated occupancy, in each story, be no greater than 1.0. However, this strategy of creating "separated occupancies" with fire barriers would not be feasible for the combined Milstein-Sibley-Rand Hall, since the combined ratios of proposed to allowable floor areas for the second floor would still come up short, and would, in addition, necessitate the construction of fire barriers and horizontal assemblies separating the Crit Room from studios above, something that might solve the acoustical issues illustrated in figure 4.16, but would also fatally compromise the design intent.

Tabular area (A_t) for SM and NS. For any specific occupancy group and construction type—where occupancy group and construction type constitute two of the four parameters in the code's 4-dimensional matrix found in chapter 5—modern codes define two *tabular* allowable floor areas, A_t, for multi-story buildings, which form the basis for computing the allowable floor area, A_a. *SM* is the tabular area for multi-story buildings with automatic sprinkler systems; *NS* is the tabular area for buildings without automatic sprinkler systems. For sprinklered buildings, these tabular values depend only on construction type and occupancy group. Since the occupancy group is taken as A-3 for all four scenarios in Table 1, the tabular values in these two rows of the table are identical for the two Type IIB building scenarios (Milstein alone or Milstein-Rand) and for the two Type VB building scenarios (Milstein-Sibley-Rand or Milstein-Sibley). The 2002 *New York State Building Code* uses a different, and now obsolete, calculation method based on a single tabular area for non-sprinklered buildings but arrives at the same results.

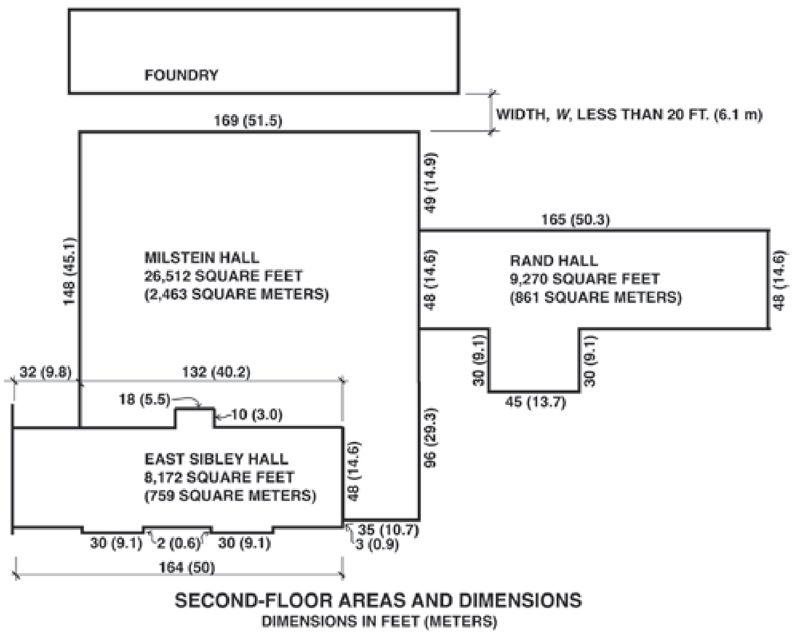


Figure 14.2. Schematic plan showing approximate dimensions and second-floor areas of Milstein, East Sibley, and Rand Halls.

Perimeter, P, and partial perimeter, F, for frontage. To calculate the "bonus" allowable floor area given to buildings that are relatively far away from other structures, the calculation of a so-called frontage coefficient, called an "area factor increase due to frontage" in the code, starts with the determination of the building's exterior perimeter length (*P*) and that portion of the perimeter (*F*) which faces an open space or public way for a distance or width of no less than 20 feet (6.1 m), measured perpendicular to the building. For example, the portion of Milstein Hall's perimeter which faces the Foundry to the north is not counted when computing *F*, since the distance between the two structures is less than 20 feet (6.1 m) along that portion of Milstein Hall's perimeter (fig. 14.2). Figure 14.3 illustrates the extent of the perimeter, *P*, and partial perimeter, *F*, for the four scenarios outlined in Table 1.

Average width, W, for frontage. The crucial parameter in the frontage calculation is the determination of the average width, or distance, measured

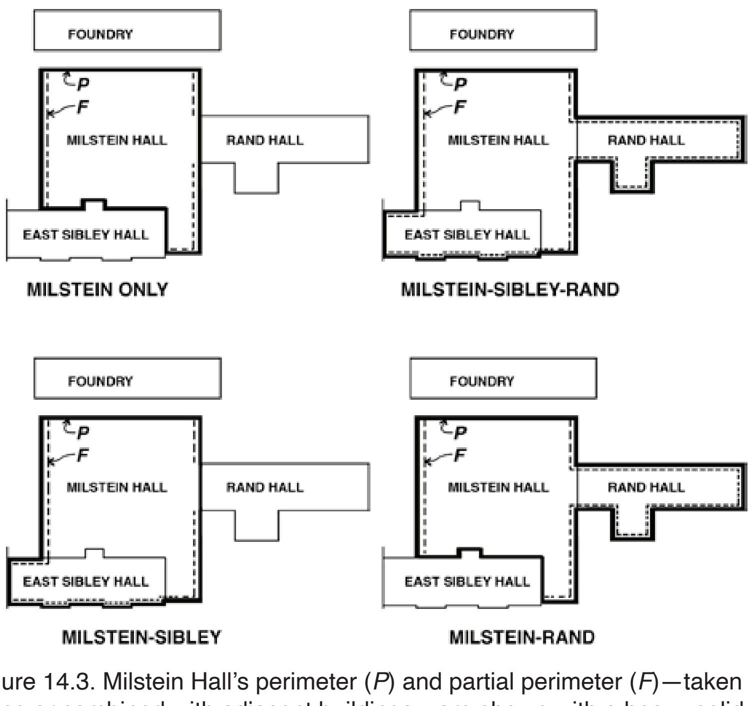


Figure 14.3. Milstein Hall's perimeter (*P*) and partial perimeter (*F*)—taken alone or combined with adjacent buildings—are shown with a heavy solid line and a dotted line, respectively, for the four scenarios outlined in Table 1. Approximate dimensions for perimeter segments are shown in figure 14.2.

from the building's perimeter to the farthest point where open space or streets (public ways) preclude the construction of other buildings that might present a fire hazard. According to the International Code Council's *Commentary*, frontage width "provides access to the structure by fire service personnel, a temporary refuge area for occupants as they leave the building in a fire emergency and a reduced exposure to and from adjacent structures."[5] Typically, the width is measured perpendicular from any building face to the property line (for side and rear yards) or to the far side of the right-of-way containing a street (for the front yard). Any perpendicular distance less than 20 feet (6.1 m) is considered *too small* for that section of the perimeter to be counted in the calculation of the partial perimeter, *F*. Any perpendicular distance greater than 30 ft. (9.1 m) is considered *needlessly large* from the standpoint of fire safety, and so the value of 30 ft. (9.1 m) is used as the width for any such sections of the partial perimeter, *F*, even though the actual width may be larger. The average width for the whole building is found by multiplying the various perimeter segments constituting the partial perimeter, *F*, by each of their individual widths, and then dividing the sum of those products by the partial perimeter, *F*.

In the case of Milstein Hall, or any of the four scenarios listed in Table 1, this calculation is rendered moot, since each of the individual widths for the entire partial perimeter, *F*, is greater or equal to 30 ft. (9.1 m)—and therefore counted as 30 ft. (9.1 m). For this reason, the average width, *W*, calculated as the sum of the products of segment lengths × 30 ft. divided by the sum of the segment lengths (i.e., *F*), must be 30 ft. (9.1 m) in all cases.

Frontage coefficient (I_f). The area factor increase based on frontage is defined as follows, using imperial units: $I_f = (F/P - 0.25) \times (W/30)$. We can make sense of this equation by examining the two parenthetical portions at their extremes. First, looking at $(F/P - 0.25)$, we see that the greatest frontage benefit occurs when no segment of the exterior perimeter is excluded—i.e., when the partial perimeter, *F*, equals the total perimeter, *P*. In that case, $F/P = 1.0$, and the parenthetical expression becomes $1.0 - 0.25 = 0.75$. At the other extreme, as defined in the code, only 25 percent of the perimeter qualifies for the frontage bonus, because the width measured from the other 75 percent of the perimeter is less than 20 ft (6.1 m). In that case, $F/P = 0.25$, and the parenthetical expression becomes $0.25 - 0.25 = 0$.

Second, looking at $(W/30)$, we see that the maximum value occurs when the average width, $W = 30$ ft. (since W can never be taken greater than 30 ft.), in which case $(W/30) = 1.0$. At the other extreme, the smallest possible value for W is 20 ft., since any width less than 20 ft. is excluded from consideration. The minimum value is therefore $(20/30) = 0.67$. Putting the two parenthetical extremes together, we get a maximum value for $I_f = (0.75) \times (1.0) = 0.75$; and a minimum value for $I_f = (0) \times (0.67) = 0$. In other words, the values for the frontage coefficient range from 0 to 0.75, with the minimum value corresponding to a building without sufficient frontage to qualify for any bonus, and the maximum value of 0.75 corresponding to a building with at least 30 ft. (9.1 m) frontage on all four sides.

Milstein Hall, in any of the four scenarios outlined in Table 1, will have a frontage coefficient somewhere between 0 and 0.75, depending on the ratio of F to P in the first parenthetical portion of the equation. In all four cases, the second parenthetical expression will be $(30/30) = 1.0$ since the width measured from all qualifying perimeter segments is greater or equal to 30 ft. (9.1 m).

Allowable area (A_a). The allowable area is based on the two tabular areas and the frontage coefficient, as follows: $A_a = A_t + (NS \times I_f)$. In this equation, At is the tabular value for SM (since Milstein Hall and its variants are all multi-story buildings with automatic sprinklers), NS is the tabular value for a building without automatic sprinklers, and I_f is the frontage coefficient. It may seem puzzling why NS, the tabular value for a building with no sprinklers, is used in this calculation for a building with automatic sprinklers. The rationale was clearer in prior versions of the code, when there was only a single tabular value listed for non-sprinklered buildings (what is now called NS) and the calculations for allowable area were based on that single tabular value: an area bonus for having a multi-story sprinklered building was found by multiplying the tabular value by 2; a bonus for frontage was computed by multiplying the same tabular value by the frontage coefficient; and these two "bonus" values were added to the tabular value to arrive at the allowable area. In the current codes, separate tabular values were added for single-story sprinklered buildings ($S1$) and for multi-story sprinklered buildings (SM), but the bonus for frontage was, as before, based on the tabular value for a non-sprinklered building. Hence the continued use of NS for frontage calculations, whether or not the building in question has automatic sprinklers. The allowable floor area applies, not to the whole building, but to any given floor—in our analysis, we examine the second floor, because it has the largest floor area.

Actual area. The actual second-floor areas for Milstein Hall, either taken alone or in combination with Sibley and/or Rand Halls, are found based on the same perimeter dimensions that were used in the frontage calculations (Figure 14.2). These actual areas must be compared with the allowable areas that were computed on the basis of construction type, occupancy group, sprinklers, and frontage. It may be self-evident, but I'll say it anyway: *actual areas cannot exceed allowable areas*. If they do, the building becomes noncompliant, and a building permit cannot be obtained. More importantly, a building whose actual floor area exceeds the allowable area specified in the building code is considered unsafe.

Floor areas were first regulated in the early eighteenth century: limits of 3,500 square feet (325 square meters) with a maximum volume of 210,000 cubic feet (5,947 cubic meters) can be found in Great Britain's Building Act of 1744.[6] The rationale for such limits has not changed substantially since then, even if new technologies, especially automatic sprinklers, have increased those limits in some circumstances. J.K. Freitag outlined the rationale in his compendious early-twentieth-century *Fire Prevention and Fire Protection Handbook*:

> It has been pointed out that the volume and intensity of fire, and the rapidity with which it will gain headway, are all vastly greater in large areas than in small ones. It is also a much more difficult matter for a fire department effectively to surround and fight a fire of large area. Much valuable time is lost in running long lines of hose, in addition to which, smoke conditions are often so bad that the actual location of the fire cannot either be found, or reached if found. There is a limit to the ability of firemen to inhale smoke or withstand heat, and once this limit is reached, the offensive operations of extinction cease, the firemen are put on the defensive, and the fire is master of the situation. These considerations would point to the desirability of fixing what might be termed the maximum area which can be efficiently handled by a city fire department. "As a working unit, 5,000 square feet has been suggested, with a limit of 100 feet in any direction (or a rectangle of 50 by 100), which is as large an undivided area as the experience of the New York Fire Department indicates to be within the capacities of effective fire department operations."[7]

This suggested floor-area limit of 5,000 square feet (465 square meters) is only slightly larger than historical limits written into the Building Act of 1744. However, by the mid-nineteenth century, a work-around was articulated that made it possible for floor areas to exceed the stipulated limits. The 1844 Metropolitan Act in London provided that "if such Building contain more than 200,000 Cubic Feet,—then such Building must be divided by Party-Walls, so that there be not in any one Part of such Building more than 200,000 Cubic Feet without Party-Walls."[8] The term, "party wall," as used in the 1844 law, is equivalent to what modern codes call fire walls[9] (whereas a modern *party wall* is defined as a specific type of fire wall that is built on the lot line between adjacent buildings). The strategy of building a *fire wall*, articulated in 1844, remains the only way to exceed area limits, even in modern building codes: fire walls can subdivide a building into smaller pieces, effectively creating separate buildings, each with a compliant floor area.

As can be seen by examining the bottom two rows of Table 1, the combined Milstein-Sibley-Rand Hall's actual second-floor area of 43,954 square feet (4083 square meters) is more than double the allowable area of 21,420 square feet (1990 square meters). The only scenario in which the actual area does *not* exceed the allowable area is when Milstein Hall is considered as an independent, stand-alone, building, requiring the construction of fire walls to separate the three buildings. Any other scenario, either combining Milstein Hall with *both* Sibley and Rand Halls without any fire walls, or using just a single fire wall between Milstein Hall and *one* of its neighbors—i.e., building a fire wall between Milstein and Rand Hall, thereby combining Milstein Hall and Sibley Hall into a single building; or building a fire wall between Milstein and Sibley Hall, thereby combining Milstein Hall and Rand Hall into a single building—is noncompliant, since the actual floor areas exceed the allowable areas in those cases.

Fire walls

Fire walls separating Milstein Hall from both Sibley and Rand Halls constitute the only possible strategy to rescue Milstein Hall's formal design concept from this apparently fatal flaw:[10] Milstein Hall must not only be separated from the limiting wood-frame construction type of Sibley Hall, but also separated from the non-fireproofed steel construction of Rand Hall.

There is nothing particularly unusual about using fire walls to, in effect, divide a single building (from a fire code standpoint) into two or more separate buildings, each with its own area, story, and height limits determined in each case by its own construction type, occupancy, and so on. If fire walls had been built between Milstein Hall and its neighbors, Sibley Hall would have been permitted to remain as a nonconforming Type VB sprinklered building, Rand Hall could have remained as a noncombustible Type IIB sprinklered building, and Milstein Hall could have been built as an independent, noncombustible Type IIB sprinklered building meeting all requirements for floor area.

The problem is that, unlike a fire *barrier*, a conventional fire *wall* is difficult to build. First, it must "extend from the foundation to a termination point not less than 30 inches (762 mm) above both adjacent roofs"[11] (with some alternative arrangements or exceptions listed in the code, none of which make the construction any easier). That is, a fire wall cannot merely fill the spaces between stories like a fire barrier, but must be independent and continuous from the bottom to the top of the building. Second, a fire wall must "have sufficient structural stability under fire conditions to allow collapse of construction on either side without collapse of the wall for the duration of time indicated by the required fire-resistance rating."[12] This is never easy to do with a single wall, especially since Milstein Hall was designed to be structurally *separated* from Sibley and Rand Halls to enable translation (lateral movement) when subjected to seismic forces. In other words, it would be extremely difficult to design Milstein Hall so that it could stabilize the exterior masonry walls of Sibley and Rand Halls should *their* floor construction collapse in a fire, and simultaneously maintain a 5-inch (127 mm) separation, i.e., a seismic isolation joint.

There is, however, an alternative, especially useful when constructing additions to existing buildings. The IBC permits "double fire walls" instead of conventional (single) fire walls, built according to specifications outlined in the National Fire Protection Association publication, NFPA 221.[13] Basically, this entails building two 1-hour walls separating Milstein and Sibley Halls, equivalent to a standard two-hour fire wall; and building two 2-hour walls separating Milstein and Rand Halls, equivalent to a standard three-hour fire wall. The separation between Milstein and Rand Halls needs greater fire resistance than the separation between Milstein and Sibley Halls because the wood shop in Rand Hall, with occupancy group F-1, triggers this higher value.[14] Building a double fire wall would have been relatively easy to implement because the exterior masonry walls of Sibley and Rand Halls are already almost acceptable as *one* of the two walls needed in a double fire wall—they are already built, and they already have adequate fire resistance once their windows and doors are upgraded. Therefore, all that would have been required is the construction of a *second* fire-rated wall, parallel to the existing masonry walls of Sibley and Rand Halls, that would be part of, and connected to, Milstein Hall. Since each wall would remain in place and provide fire protection if the *other* wall collapsed, the onerous requirement that applies to a single fire wall—to remain stable if the structure on either side collapses—is moot. This second wall, however, would cover up the existing masonry walls of Rand and Sibley Halls, walls that are currently visible from the interior of Milstein Hall. This might have some expressive ramifications, in that the diagrammatic ideal of Milstein Hall as an abstract connector, an unimpeded circulation link between Sibley and Rand Halls at the second-floor level, would be compromised—even if the practical requirements for circulation would remain unchanged. Putting a new wall up against the back side of Sibley Hall might also upset the Ithaca Landmarks Preservation Committee, whose approval is needed (Rand Hall was excluded from the local historic district to enable its demolition per the initial competition brief for Milstein Hall, a competition won by Steven Holl in 2001).

In any case, fire walls between Milstein, Sibley, and Rand Halls were never specified and never built. Without fire walls, and with an actual floor area more than twice the allowable floor area, the design for Milstein Hall should have been stopped in its tracks. In fact, discussions among the "design architects" (OMA), the architects of record (KHA) and the Ithaca Building Department (Ithaca Deputy Building Commissioner Mike Niechwiadowicz), show that the "fire wall" question was discussed well before the design was finalized, more than two years before an application for a building permit was filed, and more than four years before construction started. In March 2005, the Deputy Building Commissioner offered the architects a choice of creating separate "fire areas" using fire *barriers*, or isolating Milstein Hall as a separate building using fire *walls*: "I do believe we can go with separate fire area, which would mean it is all one building… The separate building would require a fire wall."[15] Yet a year later, in March 2006, a code summary prepared by KHA, the architect of record, questioned whether the code logic of merely using fire barriers was sound: "I do not see how an addition of the proposed size [i.e., Milstein Hall] can be incorporated since Sibley currently exceeds the allowable area for Type 5 construction and the new construction to be inserted would increase the size."[16]

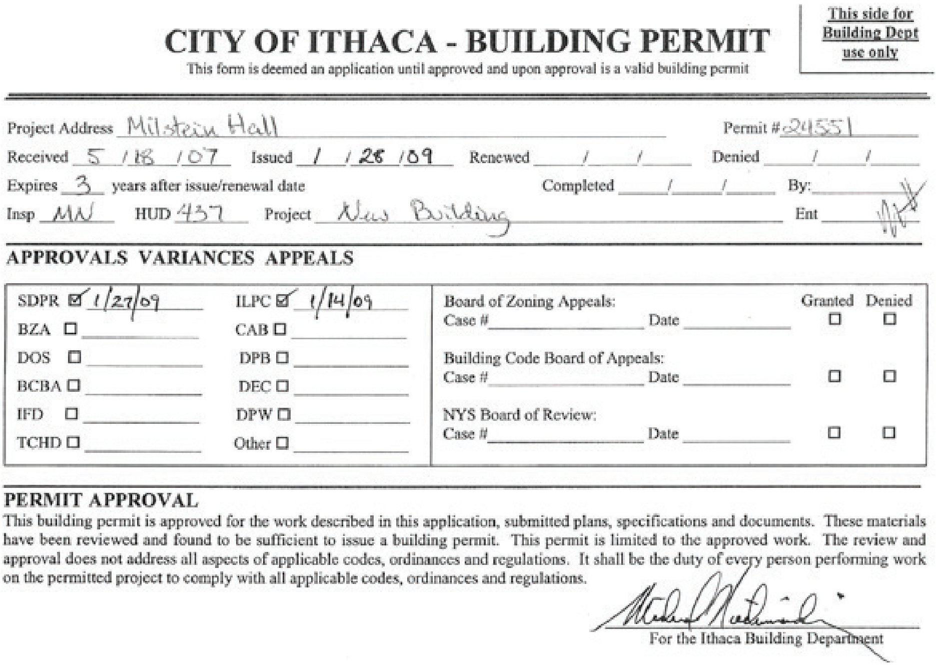
During the next year, apparently with the support and active encouragement of the Deputy Building Commissioner, the fire barrier strategy was adopted. Justification for an increased allowable floor area, beyond what would have been permitted under chapter 5 of the building code without providing fire walls, hinged on a superficial and overly generous reading of an unprecedented and flawed document: Appendix K in the 2002 *New York State Building Code*. But the apparent loophole available through Appendix K was about to expire with the adoption of the *2007 New York State Building Code* on January 1, 2008. Rather than recognizing that the proposal was seriously flawed from a fire safety perspective, was enabled by a contradictory and absurd document, and would be nonconforming with the soon-to-be-adopted 2007 *New York State Building Code*, the architects filed an application for a building permit with the Ithaca Building Department on May 18, 2007, in order to obtain a building permit based on the 2002 code containing Appendix K.

This timeline is important: the application for a building permit was filed six months *before* the new code was to be implemented,[17] it was filed in violation of regulations requiring a complete and compliant set of working drawings,[18] and it was filed well before construction of Milstein Hall was set to begin. In fact, a building permit wasn't issued for another year and a half, and construction didn't start until the summer of 2009, two full years *after* the building permit application was filed. That a building permit was actually issued, given the unresolved and noncompliant status of its fire safety strategy, is something that can only be explained by the Ithaca Code Enforcement Officials who granted the permit (fig. 14.4).

Appendix K

Ithaca's Deputy Building Commissioner argued that Appendix K, a unique and unprecedented provision that applied only to the 2002 *New York State Building Code* and that was set to expire on January 1, 2008, would permit additions to existing buildings to exceed floor areas ordinarily constrained by those chapter 5 provisions in the building code that were outlined above—as long as a fire *barrier* (not a fire *wall*) was provided. The relevant language in section K902.2 of Appendix K consists of a single sentence: "No addition shall increase the area of an existing building beyond that permitted under the applicable provisions of chapter 5 of the Building Code for new buildings, unless a fire barrier in accordance with section 706 of the Building Code is provided."[19] In all other codes, additions can increase the floor area of an existing building only if a fire *wall* (not a fire *barrier*) is constructed between the existing building and the addition, effectively re-defining the "addition" as a separate building with its own construction type and occupancy group.

Requiring the use of fire walls in such cases is consistent with all other sections of the code and presents no contradictions. But when "fire barrier" replaces "fire wall" in this context, as was done in Appendix K, confusion and contradiction abound. Let's examine the single sentence carefully by inverting its clauses: If a fire barrier separates an existing



CITY OF ITHACA - BUILDING PERMIT

This form is deemed an application until approved and upon approval is a valid building permit

This side for Building Dept use only

Project Address Milstein Hall Permit # 24551

Received 5 / 18 / 07 Issued 1 / 28 / 09 Renewed __ / __ / __ Denied __ / __ / __

Expires 3 years after issue/renewal date Completed __ / __ / __ By:

Insp MN HUD 437 Project New Building Ent

APPROVALS VARIANCES APPEALS

SDPR ☑ 1/27/09	ILPC ☑ 1/14/09	Board of Zoning Appeals: Case # __ Date __	☐ Granted	☐ Denied
BZA ☐	CAB ☐			
DOS ☐	DPB ☐	Building Code Board of Appeals: Case # __ Date __	☐	☐
BCBA ☐	DEC ☐			
IFD ☐	DPW ☐	NYS Board of Review: Case # __ Date __	☐	☐
TCHD ☐	Other ☐			

PERMIT APPROVAL

This building permit is approved for the work described in this application, submitted plans, specifications and documents. These materials have been reviewed and found to be sufficient to issue a building permit. This permit is limited to the approved work. The review and approval does not address all aspects of applicable codes, ordinances and regulations. It shall be the duty of every person performing work on the permitted project to comply with all applicable codes, ordinances and regulations.

For the Ithaca Building Department

Figure 14.4. Milstein Hall's building permit application was filed on May 18, 2007, well before a complete set of working drawings and specifications were available, one and a half years before a permit was issued, and two full years before construction started—in order to avoid meeting the requirements of the *2007 New York State Building Code* which was set to become effective on January 1, 2008.

building from an addition, then the area of the existing building can be increased beyond the limits specified in chapter 5 of the code. Chapter 5 of the code, as we saw above, determines allowable areas by considering the interaction of four parameters: construction type, occupancy group, sprinklers, and frontage. When separated by a fire wall, an addition effectively becomes a separate building, and its allowable area can be determined separately from that of the existing building, based on its own construction type, occupancy group, sprinklers, and frontage. But with a fire barrier, the addition and existing building remain combined as a single building with a single construction type. Under Appendix K, the allowable area is simply increased, without any apparent bounds, beyond the limits specified in chapter 5. To find out how, and if, the area allowed by Appendix K is constrained in any way, we need to examine the last part of its one-sentence definition that requires "a fire barrier [provided] in accordance with section 706 of the Building Code."

Section 706 (Fire barriers) in the 2002 code begins with a general statement of purpose: "Fire barriers used … to separate different occupancies or to separate a single occupancy into different fire areas, shall comply with this section."[20] And to comply with this section, the specification of fire-resistance rating for fire barriers, used to separate occupancies and fire areas, must be followed. The specifications in section 706 (Fire Barriers) are as follows: "Where the provisions of Section 302.3.3 are applicable, the fire barrier separating mixed occupancies or a single occupancy into different fire areas shall have a fire-resistance rating of not less than that indicated in Section 302.3.3 based on the occupancies being separated."[21] In other words, section 706 directs us to check section 302.3.3 for the appropriate fire rating, but only when "the provisions of Section 302.3.3 are applicable."

The required fire rating, found in Table 302.3.3 "Required Separation of Occupancies (Hours)" for the separation of an A-3 occupancy from another A-3 occupancy, is 1-hour. This is based on a tabular value of 2-hours and an exception which allows the tabular value to be reduced by 1 hour where the building is sprinklered. This much is relatively straight-forward. However, as argued below, the requirement that "the provisions of Section 302.3.3 are applicable" is *not* met in Milstein Hall, so the use of *any* fire barrier to increase the area of an existing building with an addition is simply not permitted.

Section 302.3.3 of the 2002 *New York State Building Code* regulates so-called s*eparated uses*, i.e., occupancy groups that are separated from each other by fire barriers and/or horizontal assemblies. The key provision of this section—a provision that must be satisfied in order to use fire barriers as proposed in Milstein Hall based on Appendix K—is as follows: "In each story, the building area shall be such that the sum of the ratios of the floor area of each use divided by the allowable area for each use shall not exceed 1."[22] As shown in the right-hand column of Table 2 (assuming A-3 occupancies and Type VB construction), the sum of the ratios of floor area divided by allowable area exceeds 1, and the building is noncompliant.

The building remains noncompliant (the sum of the ratios still exceeds one) even if the construction type for the single Milstein-Sibley-Rand building is taken as IIB (i.e., if Sibley Hall is magically upgraded to a non-fireproofed steel-frame building just like Milstein and Rand Halls), as shown in Table 3.

Table 2. Separated use calculations with Type VB construction and A-3 occupancy.

	Milstein Hall	**Sibley Hall**	**Rand Hall**	**Sum (total)**
Actual area	26,512 sq. ft.	8,172 sq. ft.	9,270 sq. ft.	
Allowable area	21,420 sq. ft.	21,420 sq. ft.	21,420 sq. ft.	
Ratio	1.24	0.38	0.43	**2.05**

Table 3. Separated use calculations with type IIB construction and A-3 occupancy.

	Milstein Hall	**Sibley Hall**	**Rand Hall**	**Sum (total)**
Actual area	26,512 sq. ft.	8,172 sq. ft.	9,270 sq. ft.	
Allowable area	33,915 sq. ft.	33,915 sq. ft.	33,915 sq. ft.	
Ratio	0.78	0.24	0.27	**1.30**

The error made by the building's architects, sanctioned by the Ithaca Building Department, was to assume that each fire area created by fire barriers between Milstein, Sibley, and Rand Halls can be designed not only according to its occupancy, but also according to its individual construction type. But only a fire wall—not a fire barrier—creates separate buildings, each with its own construction type. And only a fire *wall* permits the evaluation of allowable area for each individual fire area considered separately, rather than the evaluation of allowable area based on the combined fire areas when separated by fire *barriers*.

Other than these references to section 706 (Fire Barriers) and section 302.3.3 (separated uses), there is nothing in Appendix K that provides any guidance as to how the increased area it appears to permit with fire barriers should be regulated or limited. Furthermore, while Appendix K was promoted as a state-of-the-art reform of existing building regulations based on work already found in the *New Jersey Rehab Code*[23] and the "Nationally Applicable Recommended Rehabilitation Provisions" (NARRP)[24] prepared for the U.S. Department of Housing and Urban Development in 1997, the specific provision in New York's Appendix K allowing fire barriers to "increase the area of an existing building" has no precedent in either of these documents. Not only that, every other building code—including the old pre-IBC *New York State Building Code,* including all subsequent *New York State Building Codes* (i.e., 2007, 2010, etc.), including all editions of the *International Building Code* and *International Existing Building Code*, and including both the *New Jersey Rehab Code* and NARRP—every single code *prevents* additions to existing buildings from using fire barriers to exceed floor area limits. Only a fire wall (not just a fire barrier) can effectively create two separate buildings in which different construction types apply. The original transcripts of the New York State Code Council's deliberations—this is the group empowered to maintain and update the *New York State Building Code*—contain not a single word of text describing or explaining this unique and peculiar section of Appendix K in the 2002 *New York State Building Code*. Nor have any of numerous experts, many of whom actually served on the Code Council that developed Appendix K, any knowledge or recollection of how or why this unprecedented section was included, or how it ought to be interpreted.[25]

Given that no other code, past or present, has ever permitted a fire barrier to increase the size of an existing building beyond the limits permitted under normal building code provisions, and given that every other code, past or present, requires that a fire wall be used to increase the area of an existing building beyond the limits prescribed in the codes, it is possible that the language in Appendix K was included in error. For example, the requirements in the two codes that served as models for Appendix K both require fire walls in such circumstances. The *New Jersey Rehab Code* states: "No addition shall increase the area of an existing building beyond that permitted under the applicable provisions of the building subcode unless a fire wall is provided in accordance with Section 705 of the building subcode."[26] The NARRP states: "No addition shall increase the area of an existing building beyond that permitted under the applicable provisions of chapter 5 of the Building Code for new buildings unless fire separation as required in the Building Code [i.e., a fire wall] is provided."[27] Both of these codes require a fire wall, not a fire barrier, where additions to existing buildings increase the floor area beyond that permitted under relevant provisions of the building code. Milstein Hall, it bears repeating, would not have been compliant under the 2007 *New York State Building Code* which became effective on January 1, 2008—a year *before* a building permit was issued and a year and a half before construction started—because this code contained explicit language requiring a fire wall in such circumstances.

Because Appendix K does not specify how the increased area of the combined Milstein-Sibley-Rand Hall should be regulated when a fire barrier is provided, except by reference to other applicable sections of the code which would prohibit the construction of Milstein Hall as an addition separated by a fire barrier, the entire premise of combining these three buildings based on Appendix K is problematic. The building's architects claimed that the fire barrier separating Milstein Hall from the existing buildings to which it connects permits Milstein Hall to be effectively designed as a separate building, with its own construction type. Yet there is nothing in Appendix K which supports such an assumption, and everything else in the code contradicts such an assumption.

Thomas Hoard, Cornell's code consultant for a separate proposed occupancy change to Milstein-Sibley-Rand Hall, had a different justification for exceeding the floor areas allowed in the code: he agreed that the combined Milstein-Sibley-Rand Hall is actually a single building, but claimed that the combined building had multiple construction types separated by fire barriers:

> To summarize, Professor Ochshorn is correct that the construction of Milstein Hall has resulted in the combining of West Sibley, Sibley Dome, East Sibley, Milstein, and Rand into a single

building, because they are separated by fire barriers rather than fire walls. However, he did not consider that the combined building is a mixed occupancy building with five separate fire areas, each of which meets the allowable fire areas with permitted area and height increases for sprinkler protection and frontage increases, as shown in the following chart:[28]

Building, Construction Type, Use	Basic Allowable Area per BCNYS Table 503	Frontage Increase per BCNYS 506.2		Sprinkler Increase per BCNYS 506.3		Total Allowable Fire Area
	SF	%	SF	%	SF	SF
East Sibley, VB, A-3	6,000	0%	0	200%	12,000	18,000
Sibley Dome, IIIB, A-3	9,500	25%	2,375	200%	19,000	30,875
West Sibley, IIIB, B	19,000	50%	9,500	200%	38,000	66,500
Milstein, IIB, A-3	9,500	25%	2,375	200%	19,000	30,875
Rand, IIB, A-3	9,500	25%	2,375	200%	19,000	30,875

But Hoard's interpretation of the Code cannot be sustained: the allowable area for *each part* of the single building, Milstein-Sibley-Rand Hall, cannot be calculated as if it were, itself, a single building. Once you accept that the fact that Milstein, Sibley, and Rand Halls have been combined into a single building separated into fire areas with fire barriers, then the calculation of allowable areas is based on the sum of the ratio of actual to allowable areas for the three sections, as specified in section 302.3.3 of the 2002 *New York State Building Code* for "separated uses"—and reiterated in every subsequent code developed by the ICC.

Changes in later codes

For code-savvy and attentive readers who have made it this far, there is one more clarification to make. In modern building codes based on the IBC, the section on separated uses has been moved from chapter 3, where it appeared in the 2002 *New York State Building Code* along with other issues pertaining to occupancy, to chapter 5, where it could more directly inform the determination of building heights and areas. Allowable area limits for additions—found by following the instructions in Appendix K to create a fire barrier on the basis of section 706, which, in turn, requires compliance with section 302.33 (separated uses) in chapter 3—would therefore have become meaningless if the section concerning separated uses had been in chapter 5, as it is in modern iterations of the code. This is because Appendix K states that all "applicable provisions of chapter 5" are superseded if "a fire barrier in accordance with Section 706" is provided. Because the modern section on fire barriers still requires that the applicable requirements for separated uses—now in chapter 5—are met, this thought experiment would collapse into a classic Catch 22 paradox: the area limits in chapter 5, including those based on separated uses, would be superseded; but using fire barriers to increase the existing buildings' area beyond the limits in chapter 5 would require those area limits in chapter 5 that are based on separated uses be met, i.e., *not superseded*.

The largely incoherent and inconsistent section of Appendix K that attempted to lower standards for adding area to existing buildings by substituting the word, "fire barrier" for the word "fire wall," only becomes plausible because separated use provisions are in chapter 3, rather than chapter 5. But the irony is that, by taking the instructions in Appendix K literally and following the trail of referenced instructions from section 706 to section 302.33, the requirements for allowable area, for additions to existing buildings that are separated by fire barriers, are the same as they would be using any conventional code. Code standards were not actually weakened since, as is the case in all other codes, only a fire wall allows the area in an addition to exceed the allowable area of the combined building without a fire wall.

But none of this logic entered into the determinations of the architects and building department. They simply embraced the incoherence of Appendix K and designed Milstein Hall as if it were a separate building, with its own construction type and its own separate area, rather than an addition constrained by uses separated by fire barriers.

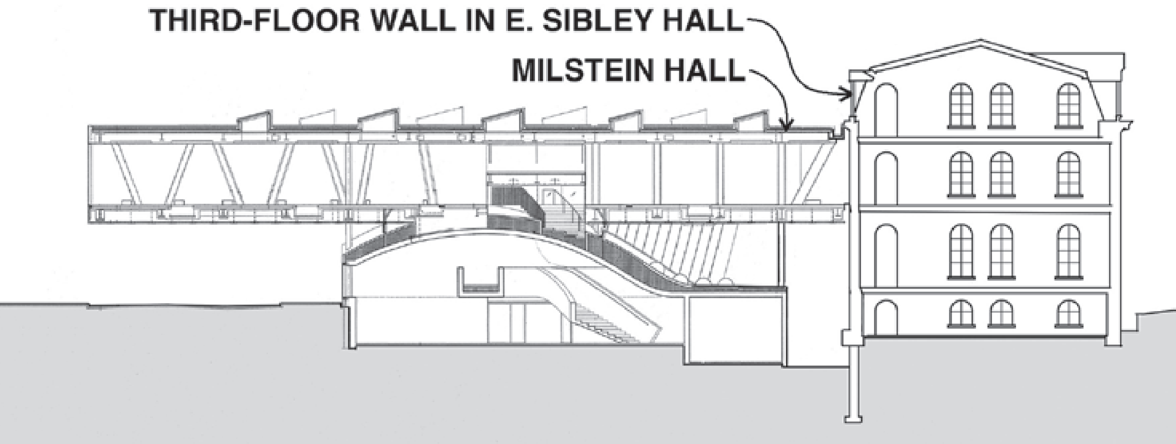
Sibley Hall's problematic third floor

Even if one accepts the mistaken premise that Milstein Hall can be designed as if it were a separate building with its own construction type, occupancy group, and allowable area, the lack of adequate fire separation distance between Milstein and Sibley Halls makes the combustible wood-framed third-floor wall of Sibley Hall noncompliant (fig. 14.5).

The 2002 *New York State Building Code* (specifically, section 704.10 "Vertical exposure") requires that "opening protectives" be provided "in every opening that is less than 15 feet (4572 mm) vertically above the roof of an adjoining building or adjacent structure that is within a horizontal fire separation distance of 15 feet (4572 mm) of the wall in which the opening is located."[29] All of the window openings in the third floor of Sibley Hall that overlook Milstein Hall qualify under this section for opening protectives. The only exception to this requirement is where the roof construction below the openings has a 1-hour fire-resistance rating and its structure (i.e., the steel beams and girders supporting the roof) has a 1-hour fire-resistance rating. Milstein Hall's roof structure has no fire-resistance rating, so the exception does not apply.

Not only would Sibley's third-floor windows require opening protectives, but the entire exterior wall on the third floor of Sibley (facing Milstein Hall) would need to be reconstructed with a 1-hour fire-resistance rating. Footnote *f* in Table 601 of the 2002 code (exterior bearing walls) requires that the fire-resistance rating of the wall be not less than that based on fire separation distance (Table 602). Table 602, in turn,

Figure 14.5. A section through Milstein and Sibley Halls shows that the position of the third-floor wood-framed wall in Sibley Hall relative to the non-fireproofed roof of Milstein Hall would be noncompliant if Milstein and Sibley Halls were considered as two separate buildings from a code standpoint.



requires a 1-hour fire-resistance rating for Occupancy Groups A or B if the fire separation distance is less than 5 feet (1.5 m). The fire separation distance between Sibley and Milstein Halls is 0 feet (0 m), since the two buildings are physically connected.

If a fire barrier between Milstein and Sibley Halls is seen as replacing a fire wall that "serves as an exterior wall for a building and separates buildings having different roof levels [as is the case with the Milstein-Sibley fire barrier—see figure 14.5], such wall shall terminate at a point not less than 30 inches [792 mm] above the lower roof level, provided the exterior wall for a height of 15 feet [4.6 m] above the lower roof is not less than 1-hour fire-resistance-rated construction from both sides with openings protected by assemblies having a 3/4-hour fire protection rating."[30] The third floor of Sibley Hall does not meet this criteria.

The architects of Milstein Hall have apparently decided to have it both ways: i.e., to design Milstein-Sibley-Rand as a single building, but to calculate allowable areas on the basis of fire areas, separated by fire barriers, as if each fire area were a *separate* building. Not only does this violate basic building code principles (since the allowable area of a building with separated uses must account for the sum of the ratios of actual to allowable area for *all* the separated fire areas), but there is absolutely nothing in Appendix K, or anywhere else in the 2002 *New York State Building Code*, that supports such an interpretation. Appendix K does not say that a fire barrier can act as a fire wall. It does not say that a fire barrier in this context can create two (or three) separate buildings, each with its own construction type. It says absolutely nothing about how the increased area that it appears to permit should actually be determined, except by reference to the section in chapter 3 on separated uses. Allowing fire barriers to effectively create separate buildings, with separate construction types, and then permitting those separate buildings to violate fire separation distance requirements established for separate buildings (or for separate structures on a single site, or for stepped buildings with fire walls) cannot be justified by any specific text in Appendix K and makes Milstein Hall less safe than it could have been and should have been.

15 NONCOMPLIANT FIRE BARRIER

Even with floor area limits exceeded, based on the incorrect assumption that Appendix K allows fire barriers to be substituted for fire walls, the actual fire barriers provided between Milstein, Sibley, and Rand Halls are noncompliant for a number of reasons, outlined in the following sections. Therefore, the argument that floor area limits can be exceeded by constructing fire barriers between Milstein, Sibley, and Rand Halls falls apart on this basis as well.

Aggregate opening width

The 2002 *New York State Building Code* states that: "Openings in a fire barrier wall … shall be limited to a maximum aggregate width of 25 percent of the length of the wall …"[1] For 1-hour fire barriers separating Milstein Hall from Sibley and Rand Halls, Table 714.2 (Opening protective fire-protection ratings) requires a minimum opening protection assembly rating of 3/4 hour. In other words, at least 75 percent of the fire barrier wall's total width must have a 1-hour fire-resistance rating, while "protected" openings in the wall, constituting no more than 25 percent of the aggregate width, are permitted to have a lower fire-resistance rating of 3/4 hour. The logic behind allowing lower fire resistance for openings is "based on the ability of a wall to have material or a fuel package directly against the assembly while fire doors and windows are assumed to have the fuel package remote from the surface of the assembly."[2] It is also possible for an opening protective to be upgraded so that it meets the requirements for a 1-hour wall, in which case, the opening can be counted as a wall.

As can be seen in figure 15.1, the second-floor fire barrier width, separating Milstein from Sibley Hall, is 200 feet (61 m), so that the aggregate width of protected openings, i.e., all the doors and windows in the fire barrier wall, cannot exceed 25 percent of 200 feet (61 m), or 50 feet (15.2 m). The actual aggregate width is found by multiplying the typical width of a window or door by the number of these openings, i.e., multiplying 3'-8" (1.1 m) by 16, and then adding the special 5'-0" (1.5 m) door on the east side of Sibley Hall, for a total aggregate width of 63'-8" (19.4 m). Since the actual aggregate width exceeds the permitted width of openings, the fire barrier wall is noncompliant.[3]

Noncompliant sprinklers

After I brought this issue of noncompliant aggregate width to the attention of Cornell, its architects, and the Ithaca Building Department, it became clear to all concerned that at least several of the fire barrier windows would need to be upgraded to a 1-hour fire-resistance rating, so that they would count as "walls" instead of "openings." Rather than replacing them with appropriate 1-hour fire-rated glazing and frames, a decision was reached to install special sprinklers on six of the offending

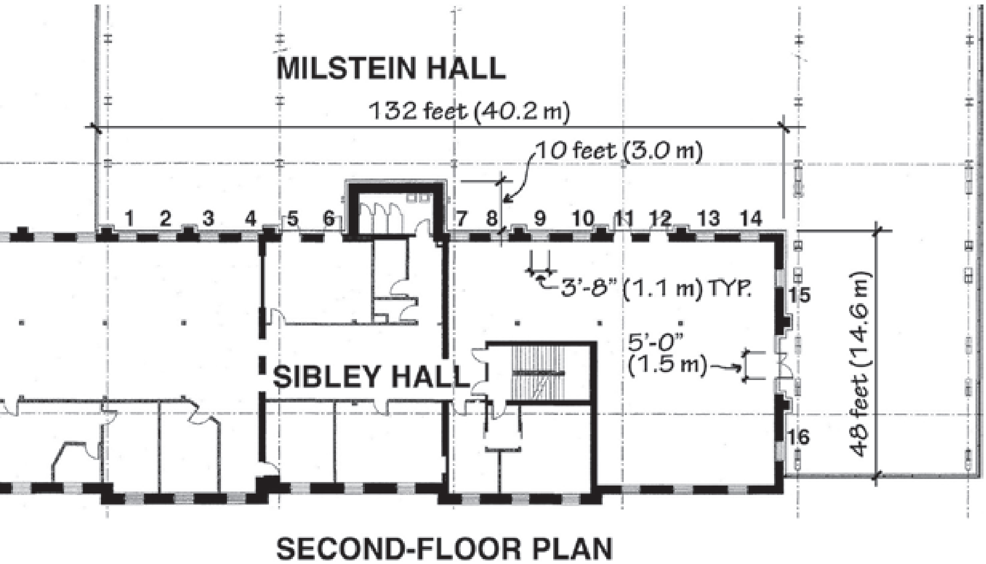


Figure 15.1. Fire barrier wall dimensions between Milstein and Sibley Hall are based on the dimensions shown in Figure 14.2. The aggregate opening width, consisting of 16 typical windows and doors, each 3'-8" (1.1 m) wide plus one special door 5'-0" (1.5 m) wide, exceeds 25% of the fire barrier width.

glass panels so that the maximum width limit would not be exceeded. This special sprinkler system developed by Tyco Fire Products (Tyco 5.6 K-Factor Model WS Specific Application Window Sprinklers) essentially allows the window openings that had been protected with 3/4-hour fire-rated glazing to count as 1-hour fire-resistance-rated walls. I examined the specifications for this product and found that the intended application in the fire barrier wall between Milstein and Sibley halls violated the manufacturer's specifications in three ways (fig. 15.2).

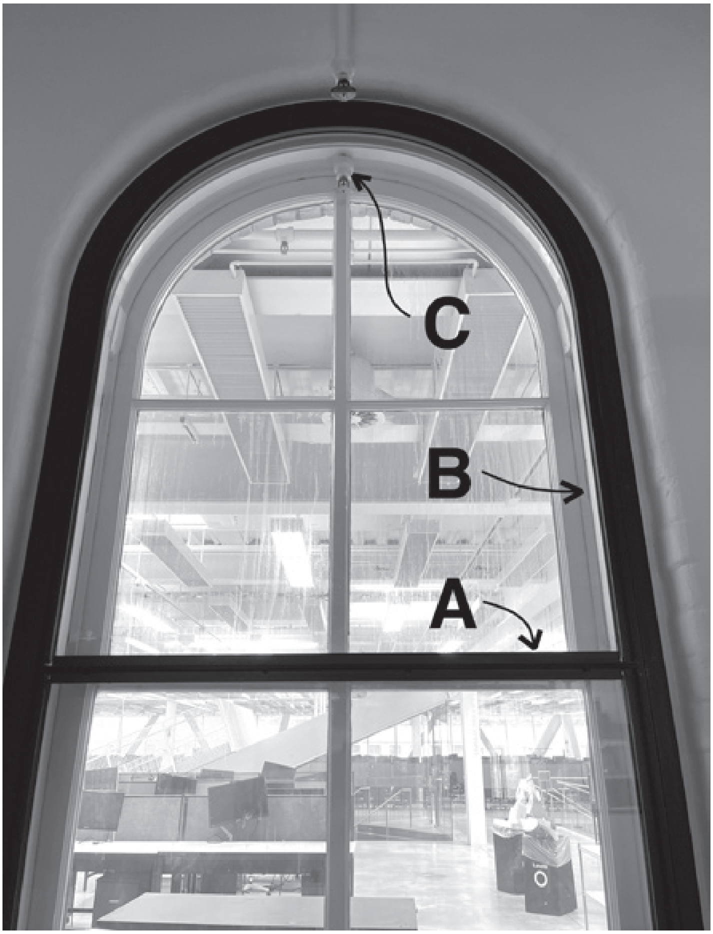


Figure 15.2. Installation of Tyco sprinklers violated the manufacturer's specifications in three ways: horizontal mullions are not permitted (*A*); combustible material is within 2 inches (51 mm) of fire-rated glazing (*B*); and sprinklers are sandwiched between fire-rated glazing and the existing window (*C*).

First, Tyco sprinklers cannot be used to protect windows when intermediate horizontal mullions are present: "Intermediate Horizontal Mullions were not tested with the Model WS Window Sprinkler. Their use is outside the scope of the 'Specific Application' Listing for the window sprinklers. Refer to Figure 3B-3."[4] Tyco's Figure 3B-3, reproduced in figure 15.3, reiterates that "window sprinklers are NOT listed to protect windows when intermediate horizontal mullions are present." In the Milstein Hall application, horizontal mullions are present in the fire-rated glazing (see fig. 15.2, item "A"). The problem with horizontal mullions is that they can interfere with the operation of the sprinklers by deflecting the stream of water away from the surface of the glass, thereby eliminating the intended cooling effect provided by the water which justifies the increased fire-resistance rating of the system.

Second, Tyco specifications require that "all combustible materials shall be kept 2" (50.8 mm) from the front face of the glass."[5] In the Milstein Hall application, wooden window frames are closer than two inches (50.8 mm) from the glass; in fact, fire-rated glazing was installed flush with the wood window frame and wood trim (fig. 15.4).

Third, sprinklers cannot be sandwiched between fire-rated glazing and existing windows, as they are in this Milstein Hall application. A technical representative from Tyco confirmed that their sprinkler system, to be effective, must be in contact with the heat of the fire; placing a barrier like an ordinary window between a potential fire and the sprinklers renders the sprinklers nonfunctional and therefore noncompliant. Even if the heat of a fire caused the existing (non-fire-rated) window to crack and fall apart, thereby allowing the fire's heat to trigger sprinkler operation, shards of broken glass could fall against the fire-rated glazing, preventing sprinkler water from cooling the fire-rated surface and rendering the system dysfunctional.[6]

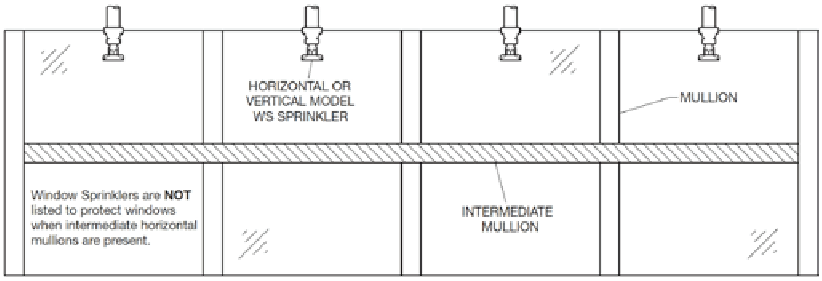


Figure 15.3. Reproduction of Tyco's Figure 3B-3 prohibiting horizontal mullions (see notation in bottom left window pane).

Figure 15.4. Fire-rated glazing is installed directly in front of wood framing for the existing window in the fire barrier wall between Milstein and Sibley Halls.

Noncompliant opening protection below the second floor

Milstein Hall's history and pattern of systematic code noncompliance can be illustrated by the way in which a fire barrier was initially specified. When Milstein Hall's building permit was originally granted, a fire barrier was specified only for the second floor between Milstein Hall and Sibley Hall. Only later were the drawings and specifications revised to extend the fire barrier to the first floor and basement. Because the basement and first-floor fire barriers have a similar pattern of openings as the second floor, special Tyco sprinklers—similar to the ones deployed on the second floor—were also used on those two floors. On the second floor, each opening requiring additional fire resistance was protected as an "interior fire separation [where] window sprinklers are installed on both sides of the window,"[7] since a fire could originate on either the Milstein Hall side or the Sibley Hall side of the fire barrier. However, the basement and first-floor openings were treated as an "exterior spatial separation (that is, separation from adjacent space) … defined as protecting an adjacent building from a fire in your building," in which case "window sprinklers are installed on the interior side of the building…"[8]

In other words, sprinklers were installed only on the Sibley Hall side, and not on the Milstein Hall side, of the basement and first-floor fire barrier openings, as if there was an "adjacent building" outside of Sibley Hall that needed protection from a fire originating in Sibley Hall and as if Milstein Hall did not present a fire risk to Sibley Hall at those floor levels. Neither of these assumptions is true. Just as on the second floor, both the basement and first-floor fire barriers separate Milstein Hall from Sibley Hall and a fire could originate on either side. That the space in Milstein Hall adjacent to Sibley Hall at the basement and first-floor levels is covered exterior space, rather than e*nclosed interior space*, is not relevant. The 2002 *New York State Building Code* treats both types of space equally and considers both types of space as part of the building area: "Areas of the building not provided with surrounding walls shall be included in the building area if such areas are included within the horizontal projection of the roof or floor above."[9] The spaces in Milstein Hall adjacent to Sibley Hall clearly meet this criterion (fig. 15.5) and so Tyco sprinklers

Figure 15.5. Spaces in Milstein Hall adjacent to Sibley Hall at the basement and first-floor levels "are included within the horizontal projection of the roof or floor above" and therefore part of the building area.

used to increase the fire resistance of openings in this portion of the fire barrier should have been protected as an "interior fire separation" with sprinklers on both sides of the fire-rated glazing. Of course, for the reasons outlined above, the Tyco system—even with sprinklers on both sides—would still not comply with the manufacturer's specifications.

Noncompliant fire barrier between Milstein and Rand Halls

Rand Hall is similar to Sibley Hall in that its masonry cladding provides adequate fire resistance to qualify as a fire barrier, and its openings require protection. The one difference is that the wood shop in Rand Hall is an F-1 occupancy, so the required fire rating for the fire barrier, found in Table 302.3.3 "Required Separation of Occupancies (Hours)"[10] for the separation of an A-3 occupancy from an F-1 occupancy, is 2-hours, taking the sprinkler exception into account. With a 2-hour required fire rating, opening protectives need 1-1/2-hour fire resistance. None of these details matter, however, since opening protectives for the required fire barrier between Rand and Milstein Halls at the ground floor level were never provided. As shown in figure 15.6, existing windows and exhaust ducts in that location have neither opening protectives nor fire dampers: the fire barrier is therefore noncompliant.[11]

Figure 15.6. Openings in the fire barrier between Milstein and Rand Halls have neither opening protectives nor fire dampers.

Fire barrier continuity

Even if all the fire barrier opening protective issues described above were resolved, there is still one fatal flaw in the argument that masonry walls separating Milstein Hall from Sibley and Rand Halls can be considered fire barriers: the problem of continuity. The 2002 *New York State Building Code*, in its section on fire barriers, explains requirements for continuity as follows:

> 706.4 Continuity. Fire barriers shall extend from the top of the floor/ceiling assembly below to the underside of the floor or roof slab or deck above and shall be securely attached thereto. These walls shall be continuous through concealed spaces such as the space above a suspended ceiling. *The supporting construction shall be protected to afford the required fire-resistance rating of the fire barrier supported* except for 1-hour fire-resistance-rated incidental use area separations…[12]

What this means is that all structural elements in Sibley and Rand Halls that support the fire barrier wall must themselves have the same protection (fire-resistance rating) as the wall does. Otherwise, a fire in Sibley or Rand Hall that compromised these supporting elements would negate the fire-resistance of the fire barrier, which depends on the supporting elements to remain viable. Neither Sibley nor Rand Hall has any fire-resistant construction, other than portions of their exterior walls which were designated as fire barriers when Milstein Hall was designed, and portions of the Rand Hall floor and roof deck supported on non-fireproofed steel beams. So, the question is: are any of those non-fireproofed elements in Sibley and Rand Hall necessary to support the fire barrier walls?

In Rand Hall, the answer is unambiguous. The masonry walls of Rand Hall that separate Rand Hall from Milstein Hall are *not* loadbearing; rather, they are embedded in and supported by Rand Hall's non-fireproofed steel frame (fig. 15.7). A fire in Rand Hall which compromised the non-fireproofed steel frame would, in turn, compromise the viability of the masonry cladding constituting its fire barrier. And Rand Hall's steel columns are braced, in turn, by non-fire-rated floors and roof, which would therefore also need to be upgraded so that their fire-resistance matched the required 2-hour fire-resistance rating of the fire barrier (a 2-hour rating, rather than a 1-hour rating as in the Sibley Hall fire barrier, is necessary because of the F-1 occupancy—i.e., the wood shop—in Rand Hall). Since the fire resistance of Rand Hall's steel structure was

Figure 15.7. Rand Hall's non-fireproofed steel frame in 2017, before it was converted into the Mui Ho Fine Arts Library.

never upgraded to have a 2-hour fire-resistance rating, the fire barrier fails the continuity test, and is noncompliant.

In Sibley Hall, the question of continuity is more complex. Since the fire barrier is a loadbearing brick wall, the issue is whether this fire barrier wall relies upon any "supporting construction," or whether it would remain viable—i.e., stable—without the non-fireproofed floor and roof construction that frames into it at all levels (fig. 15.8).

Figure 15.8. Sibley's brick fire barrier wall is supported laterally by its non-fireproofed wood floor and roof assemblies, shown here at the second floor.

The question of masonry stability is too complex for me to analyze numerically, but the 2002 code does provide some guidance for the "empirical design of masonry." Essentially, loadbearing masonry walls require lateral support by "cross walls, pilasters, buttresses or structural frame members when the limiting distance is taken horizontally, or by floors, roofs acting as diaphragms, or structural frame members when the limiting distance is taken vertically."[13] And these limiting distances are provided in code Table 2109.4.1 (Wall lateral support requirements). For solid (e.g., brick) loadbearing walls, the "maximum wall length to thickness or wall height to thickness" ratio is 20.[14] Sibley Hall's brick wall thickness is 1'-6" (0.46 m) at the second floor and 1'-10" (0.56 m) at the first floor and basement levels.[15] For the second-floor thickness of 1'-6" (0.46 m), the maximum distance between cross walls or between floor and roofs would be 1.5 × 20 = 30 feet (9.12 m). Since the structural cross walls (shear walls) in Sibley Hall are far greater than 30 feet (9.1 m) apart—see the second-floor plan in figure 15.1—the floor and roof structure, acting as diaphragms, are necessary to provide required lateral stability for the Sibley Hall fire barrier wall. And because those floor and roof assemblies are made with non-fireproofed wood joists and wood decks, the Sibley Hall fire barrier also fails the continuity test, and is noncompliant.

16 CRIT ROOM EGRESS PROBLEMS

The Crit Room in Milstein Hall's lowest level, directly under its concrete dome, is an assembly space with an area of 4,506 square feet (419 square meters), as shown in figure 16.1.[1]

Required number of exits

The 2002 *New York State Building Code* requires a certain number of exits (or access to exits) from assembly spaces, based on the number of occupants that might be using the room at any given time. Table 1005.2.1 in

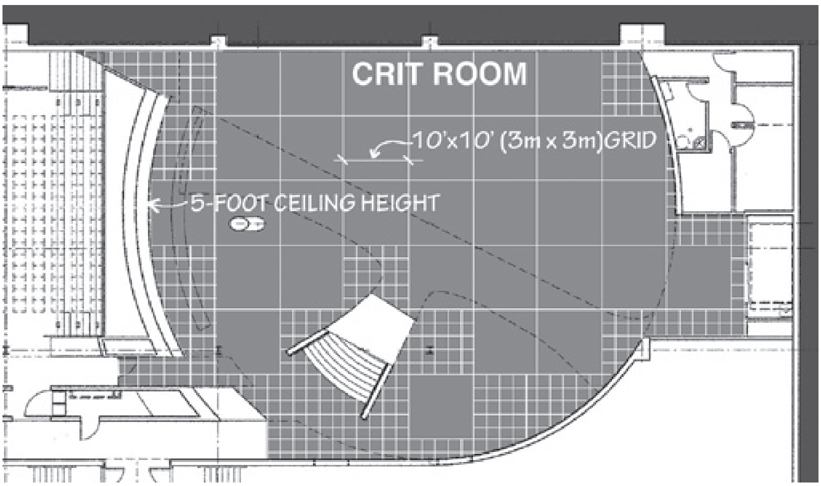


Figure 16.1. I computed the 4,506 square feet (419 square meters) floor area of the Crit Room in Milstein Hall by superimposing a 10-foot × 10-foot (3-m × 3-m) grid over the irregular floor plan, subtracting areas where the sloping ceiling is less than 5 feet (1.5 meters) from the floor.

the code tabulates the "minimum number of exits for occupant load" as two exits for up to 500 occupants, three exits for 501–1,000 occupants, and four exits for more than 1,000 occupants. However, section 1008.2 (Assembly other exits) was modified in the New York State code, deviating from the generic IBC version, and requires that "the minimum number of exits provided … shall be at least three exits for an occupant load of 350 to 700 persons and at least four exits for an occupant load of more than 700 persons."[2]

To find the number of required exits from the Crit Room, we need to first find out the number of Crit Room occupants by examining Table 1003.2.2.2 (Minimum Floor Area Allowances per Occupant).[3] The appropriate functional category for this type of assembly space is "Assembly without fixed seats, standing space" for which the floor area in square feet per occupant is listed as "5 net" (0.46 square meters). The choice of "standing space" corresponds to the actual "worst-case" use of the Crit Room (fig. 16.2), which is what the code requires for the calculation of occupancy load and exits.

Since each "standing" occupant is assigned 5 square feet (0.46 square

Figure 16.2. Photos appearing in the college's newsletter under the headline, "AAP Buzzes as Hundreds of Alumni, Students, and Faculty Gather During Celebrate Milstein Hall" demonstrate that the appropriate "function" category for the Crit Room assembly space is "standing space."

meters), the number of occupants in a space with an area of 4,506 square feet (419 square meters) is 4,506 / 5 = 901 occupants, for which four exits are required. And if it is claimed that the entire Crit Room floor area is never devoted exclusively to "standing space," since tables with food and drink are always part of these assembly functions, we could assume that up to 1,000 square feet (93 square meters) is typically devoted to tables and therefore excluded entirely from "standing space." However, even in this case, the number of required exits would still be four, based on the following calculation using the revised "standing space" area: (4,506 – 1,000) / 5 = 701 occupants, which corresponds to a requirement for four exits.

Milstein Hall's Crit Room was designed and built with only two exits or exit access openings, making the space noncompliant. The first exit access opening (labeled "1" in figure 16.3) leads into a corridor and from there to an exit and exit discharge near the gallery to the west; and the second exit, originating in a stair leading to the ground-level entry bridge (labeled "2" in fig. 16.3) discharges at the main entrance to Milstein Hall to the east.

Figure 16.3. The Crit Room only has two exit access doors or openings: an exit access opening (1) leading to an exit near the gallery; and an exit access stair (2) leading to second exit at the main entry level within the Crit Room.

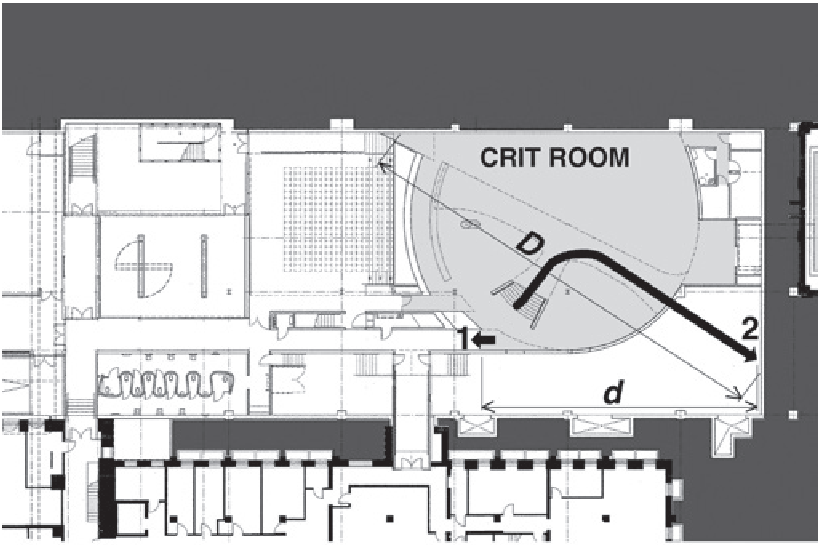
In spite of having only two exits, or access to exits, instead of four, as required, this dangerous and noncompliant underground assembly space was designed, approved, built, and ultimately occupied by hundreds of people. The comedy of errors in judgement and interpretation that allowed this dangerous space to be built is described in the following sections.

Required exit separation (Error No. 1)

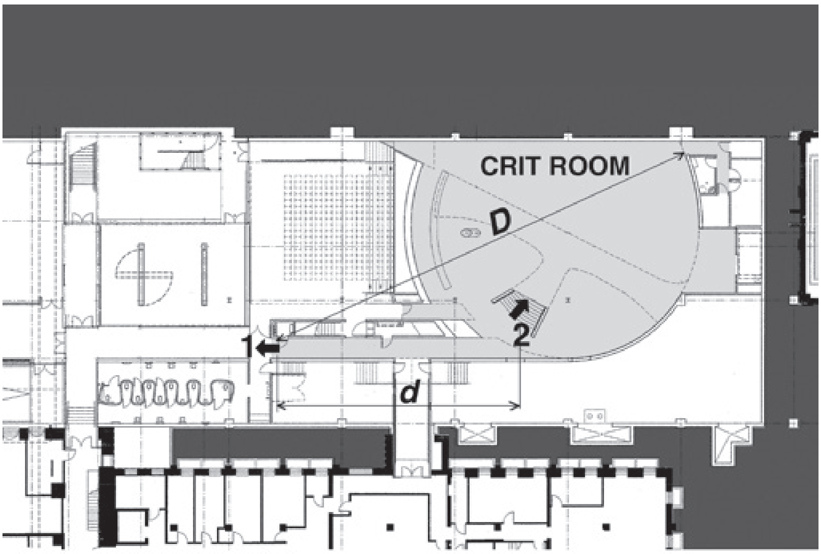
The first justification for inadequate exits was provided by the Milstein Hall Project Director at Cornell. But instead of explaining why only two exits were provided instead of four, his justification involved "moving" the location of both exits in order to remediate a problem of required exit separation that, assuming that the entry-bridge level qualifies as a mezzanine, didn't actually exist. Section 1004.2.2.1 of the code requires that "the exit doors or exit access doorways shall be placed a distance apart equal to not less than one-half [*or one-third in a sprinklered building*] of the length of the maximum overall diagonal dimension of the building or area to be served measured in a straight line between exit doors or exit access doorways."[4]

Thinking that the Crit Room exits corresponded to the locations of the two arrows in Figure 16.3, and worrying that the separation between those two arrows would not meet the separation requirements in section 1004.2.2.1—of course, being only 15 feet (4.6 m) apart, they wouldn't—he argued that egress compliance for the Crit Room was achieved by considering the corridor that leads from the crit room space to be part of the Crit Room itself, thereby extending the separation distance between the first exit (now "moved" to the far end of the corridor) and the second exit (assumed to be located at the bottom of the stair). But if the Crit Room, which extends upward to the top of the dome, is assumed to include the entry level lobby and bridge as a mezzanine (more on this later), the stair leading to the bridge would *not* count as an exit from the Crit Room, but rather would be considered part of the exit access within the Crit Room that leads, ultimately, to a real exit at the far end of the bridge and lobby, marked "2" in Figure 16.4*a*.

The other real exit access opening, marked "1" in Figure 16.4*a*, leads to an exit access corridor and, ultimately, to an exit near the gallery. The distance between these real Crit Room exits, as shown in the Figure 16.4*a*, is $d = 80$ feet (24.4 m). This separation distance is far greater than one-third of the diagonal length, $D = 125$ feet (38.1 m). Therefore, if



(a) Actual Crit Room exit separation



(b) Fictitious Crit Room exit separation

Figure 16.4. Exit separation requirements are based on two parameters shown for the Crit Room in Milstein Hall: the maximum diagonal length of the room (shown as dimension, *D*); and the actual separation between exits (shown as dimension, *d*). For exits to be compliant in a sprinklered building, d must be at least one-third the length of *D*.

the entry-bridge level satisfies the criteria for a mezzanine, then the Crit Room exits meet the separation criterion in the code.

Because the Milstein Hall Project Director assumed that the bottom of the stair constituted an exit access *from* the Crit Room, rather than being part of the exit access *within* the Crit Room, he felt compelled to solve an exit separation problem that, at least based on his own assumptions about the status of the bridge-entry as a mezzanine, didn't exist. He accomplished this by first pretending that the exit access, marked "1" in Figure 16.4*b*, was at the *end of the corridor*, and second, by assuming that the other exit access from the room, marked "2" in Figure 16.4*b*, was at the bottom of the stair that leads to the real exit.

As shown in Figure 16.4, exit separation requirements are based on two parameters: the maximum diagonal length of the room (shown as dimension, *D*); and the actual separation between exits (shown as dimension, *d*). For exits to be compliant in a sprinklered building, *d* must be at least one-third the length of *D*. The two Crit Room exits are marked "1" and "2" in figure 16.4. In the top plan (*a*), the actual required separation between exits is found by taking the diagonal length of the room, *D* = 125 feet (38.1 m), and dividing it by three to find the minimum required separation distance of 42 feet (12.7 m). The actual separation distance between the two exits, *d* = 80 feet (24.46 m), is compliant because it is greater than the required separation distance. In the bottom plan (*b*), the fictitious required exit separation is found by taking a diagonal length as if the corridor were part of the room, *D* = 130 feet (39.6 m), and dividing this length by three to find the minimum required separation distance of 43.3 feet (13.2 m). The separation distance between the stair and this fictitious exit, *d* = 70 feet (21.3 m), appears compliant because it is less than the fictitious required separation distance.

Naturally, by increasing the separation distance between exits in this devious manner, the numbers seem to work. The problem with this exercise is that neither of the exit locations assumed by the Project Director is correct, at least if the mezzanine assumption can be sustained.

Even so, two code issues remain problematic: first, the proper number of exits is not provided and second, as we'll see below, the distance one needs to travel within the Crit Room before having access to *both* of these exits—the so-called common path of egress travel distance—is inadequate. And if the bridge and lobby do *not* meet the requirements for a mezzanine, then the exit access using the stair from the Crit Room would be placed at the bottom of the stair (fig. 16.5).

In this case, there would be three noncompliant issues with respect

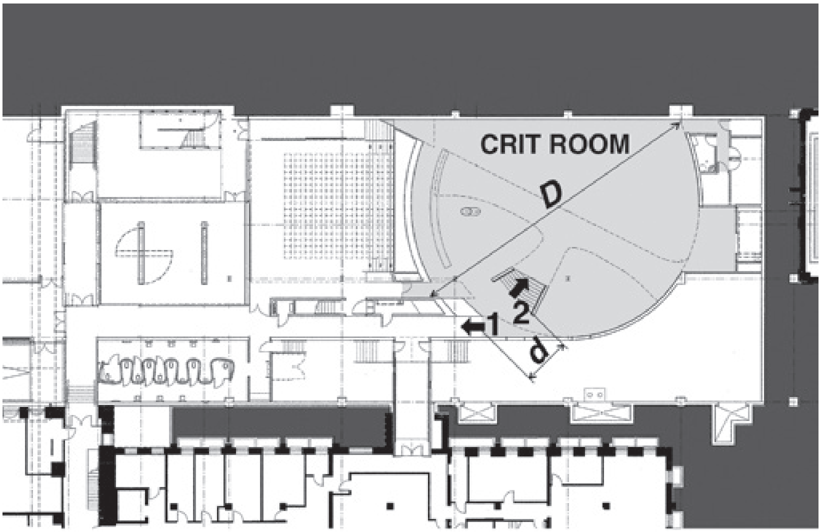


Figure 16.5. Without a mezzanine, the actual required separation between exits is found by taking the diagonal length of the room, *D* = 90 feet (27.4 m), and dividing it by three to find the minimum required separation distance of 30 feet (9.1 m). The actual separation distance between the two exits, *d* = 15 feet (4.6 m), is noncompliant because it is less than the required separation distance.

to Crit Room egress: not having four exits or exit access openings, not having adequate separation distance between the two exit access openings, and exceeding the allowable common path of egress travel distance. But before examining the common path of egress travel, a short digression concerning mezzanines is in order.

Noncompliant openings, mezzanines, and atriums (Error No. 2)

One of the fundamental principles of fire safety is to compartmentalize buildings so that a fire that originates in one section of the building does not spread to other parts of the building. One basic means of compartmentalization is to separate the various stories in a building from each other with a continuous floor-ceiling assembly, and to protect any openings between stories with a shaft enclosure. In other words, ideally, there would be no unprotected openings between floors in a building.

And, in fact, the 2002 *New York State Building Code* states that: "Openings through a floor/ceiling assembly shall be protected by a shaft enclosure complying with this section."[5] But, as anyone who has been in a modern building can attest, openings between floors are quite common, and—if they satisfy building code requirements—compliant. The 2002 code lists eleven "exceptions" to the shaft enclosure rule,[6] almost all of them having alternate and more-or-less equivalent fire safety provisions that allow the openings while simultaneously mitigating problems due to what would otherwise be a violation of the compartmentation rule. Of these eleven exceptions, three are potentially relevant to the dramatic opening that connects the basement Crit Room level, the ground-level entry-bridge, and the second floor studio level in Milstein Hall (fig. 16.6).

Figure 16.6. A dramatic opening in Milstein Hall connects the studio level to the intermediate entry lobby-bridge level and the basement Crit Room level below.

These three exceptions are for atriums, for openings between only two stories, and for mezzanines, as follows:

Exception 5 for atriums. This exception states that: "A shaft enclosure is not required for floor openings complying with the provisions for covered malls or atriums."[7]

Provisions for atriums are contained in section 404 of the 2002 code, starting with this definition:

> An opening connecting two or more floor levels other than enclosed stairways, elevators, hoistways, escalators, plumbing, electrical, air-conditioning or other equipment, which is closed at the top and not defined as a mall. Floor levels, as used in this definition, do not include balconies within assembly groups or mezzanines that comply with Section 505.[8]

While large atriums need to be "separated from adjacent spaces by a 1-hour fire barrier wall," an exception states that "the adjacent spaces of any three floors of the atrium shall not be required to be separated from the atrium where such spaces are included in computing the atrium volume for the design of the smoke control system."[9] In other words, the unprotected opening connecting the three floor levels of Milstein Hall would be compliant if it were designated as an atrium and designed with a smoke control system that took into account the non-separated spaces of Milstein Hall at all three floor levels. But Milstein Hall has no smoke control system, so *exception 5* for atriums cannot be invoked.

Exception 7 for openings between only two stories. This exception states that: "In other than Groups I-2 and I-3, a shaft enclosure is not required for a floor opening that complies with the following: 7.1. Does not connect more than two stories; and 7.2. Is not part of the required means of egress system except as permitted in Section 1005.3.2 …"[10] [the remaining items are not relevant here].

This exception does not appear to apply to Milstein Hall because the opening in question *is* part of a required means of egress system: it contains an unenclosed exit access stairway from the basement Crit Room, an exit access bridge from the auditorium at the ground level, and an exit access stairway down from the second-floor studio level. But before jumping to this conclusion, there are some possible exceptions *to exception 7* ("…except as permitted in Section 1005.3.2") that must be checked—the reader is advised to keep *those* exceptions, generated by a necessary digression down the section 1005.3.2 rabbit hole, differentiated from the three exceptions we started off with—i.e., the exceptions for atriums, for openings between only two stories, and for mezzanines. So here we go: section 1005.3.2 (Enclosures) requires that interior exit stairways be enclosed with fire barriers *unless they satisfy any of the following exceptions* (with only the relevant exceptions listed below):

> *Exception No. 8 in section 1005.3.2 (Enclosures).* This exception states that: "In other than occupancy Groups H and I, a maximum of 50 percent of egress stairways serving one adjacent floor are not required to be enclosed, provided at least two means of egress are provided from both floors served by the unenclosed stairways. Any two such interconnected floors shall not be open to other floors."

> *Exception No. 9 in section 1005.3.2 (Enclosures).* This exception states that: "In other than occupancy Groups H and I, interior egress stairways serving only the first and second stories of a building equipped throughout with an automatic sprinkler system in accordance with Section 903.3.1.1 are not required to be enclosed, provided at least two means of egress are provided from both floors served by the unenclosed stairways. Such interconnected floors shall not be open to other floors."[11]

Neither of these exceptions applies to Milstein Hall: *Exception No. 8 in section 1005.3.2 (Enclosures)* does not apply because the open stair in Milstein Hall serves more than one adjacent floor; the entry lobby and bridge, even if they are not designated as a "story," are still part of a "floor," and egress stairways in that opening serve two floors adjacent to the entry-bridge level —the studio floor above and the Crit Room floor below.

Exception No. 9 in section 1005.3.2 (Enclosures) does not apply because the open stair in Milstein Hall does not serve "only the first and second stories of a building." This is because the Crit Room level of Milstein Hall is a *basement*, not a story. It's true that certain basements can be considered a "story above grade plane," and not just a "floor," but Milstein's basement doesn't qualify. A "story above grade plane" is defined as:

> Any story having its finish floor surface entirely above grade plane, except that a basement shall be considered as a story above grade plane where the finished surface of the floor above the basement is: (1) More than 6 feet (1829 mm) above grade plane; (2) More than 6 feet (1829 mm) above the finished ground level for more than 50 percent of the total building perimeter; or (3) More than 12 feet (3658 mm) above the finished ground level at any point.[12]

Milstein Hall's basement level is *not* a story above grade plane since the finished surface of the floor *above* the basement—containing the entry lobby and bridge—is *at* grade plane, not 6 or 12 feet (1829 or 3658 mm) above. And even if this floor above the basement was not a "story," i.e., if it was defined as a mezzanine, it would still count as a "floor." The building code is careful to distinguish between "floor" and "story." For example, section 1005.3.2, cited above, requires that "the number of stories shall be computed at all floor levels, including basements but excluding mezzanines." In other words, because basement and mezzanine levels are ordinarily considered to be "floors," but not "stories," the clarification in section 1005.3.2 was necessary in order to include the basement level as a "story" for the purposes of that section only, i.e., to count the *number* of stories. Section 1005.3.2 does not change the "floor above the basement" to a story.

This ends our digression into the exceptions listed in section 1005.3.2 (Enclosures), none of which apply, and we can now state with certainty that Milstein Hall's opening *is* part of a required means of egress and therefore that *exception 7 for openings between two stories* cannot be invoked—assuming that there really are only two stories connected by the opening, and not three. We can now examine the last of the three exceptions to the shaft enclosure rule:

Exception 9 for mezzanines. This exception states that: "A shaft enclosure is not required for floor openings between a mezzanine and the floor below."

We start with the definition of mezzanine in the 2002 *New York State Building Code*: "An intermediate level or levels between the floor and ceiling of any story with an aggregate floor area of not more than one-third of the area of the room or space in which the level or levels are located."[13] There is no exception in the 2002 code allowing the mezzanine area to be up to one-half, rather than only one-third, the floor area of the room, but such an exception—which appears in later iterations of the code—would not help in this case. This is because that exception applies only to buildings of Type I or II construction and Milstein Hall, being connected to Sibley Hall without a fire wall, is designated as Type VB construction.

Mezzanines, in other words, are intermediate floor levels placed in rooms with double volume heights, and their floor area cannot exceed one-third the floor area of the room they are in. If such a floor level meets these criteria, then it is considered part of the room it is in, and is not considered to be a separate story. Defining such floors as mezzanines originated when rooms were understood as discrete, often orthogonal, entities, whose boundaries were self-evident. As such, a mezzanine level placed in a room would clearly be "in" the room, and would share a "common atmosphere" with the larger room, thereby enabling occupants in either the main level of the room or the mezzanine level to be aware of smoke and fire, an element of fire safety that mitigates the risk of fire spreading before occupants become aware of it.

But owing to the complex and nonorthogonal geometry of Milstein Hall's entry level and crit room, the question of whether the entry and bridge are "in" the Crit Room is less obvious. The entry lobby itself is clearly *not* under the concrete dome that forms the ceiling of the Crit Room; instead, its ceiling consists of pressed aluminum panels situated below the second-floor studio level (fig. 16.7).

So is it "in" the Crit Room? Because the code doesn't have a clear answer to this question, we'll assume that the complex geometry of the intersecting spaces could plausibly support such a contention. The more interesting question is whether the Crit Room is less than three times the size of the entry lobby and bridge, in which case the entry and bridge would *not qualify as a mezzanine within the Crit Room.*

Maximum allowable floor areas are determined by the number of exits, the type of occupancy, and the function of the space. Working backwards, we can say that the number of exits in a room determines its maximum occupancy which, in turn, determines its maximum floor area. The design occupancy of the room cannot be artificially lowered in order to justify having fewer legal exits in a room of a given size. Section 1003.2.2 (Design Occupant Load) in the 2002 code states that

Figure 16.7. Milstein Hall's complex nonorthogonal geometry makes it difficult to determine whether the entry and bridge are "in" the Crit Room, thereby satisfying the definition of mezzanine.

"the number of occupants for whom means of egress facilities shall be provided shall be established by the largest number computed in accordance with Sections 1003.2.2.1 through 1003.2.2.3."[14] The three choices in sections 1003.2.2.1 through 1003.2.2.3, from which the *largest* must be selected, are: a) using the actual number of occupants for whom the room is designed; b) using 5 square feet (0.46 square meters) per occupant for "Assembly without fixed seats—standing space" per Table 1003.2.2.2 (Maximum floor area allowances per occupant); or c) where applicable, including any additional occupants egressing through the Crit Room from an accessory space.

Since the occupancy of the Crit Room is constrained by the number of exits (i.e., no more than 50 occupants for one exit, 349 for 2 exits, and 700 for 3 exits), and since the area assigned to each occupant is 5 square feet (0.46 square meters), an argument could be made that the Crit Room floor area must be reduced to the values shown in Table 4 based on the number of exits. The code does not permit a room or space to have a floor area larger than the number of exits would allow.

Since the maximum occupancy of a given space is determined by the available floor area, we end up with four possible values for maximum Crit Room area depending on the number of legal exits, as shown in Table 4. If there are only two exits from the Crit Room, this corresponds to a maximum Crit Room area of 1,745 square feet (162 square meters). And since the Crit Room must be at least three times the bridge

Table 4. Maximum Crit Room area, assuming 5 square feet (0.46 square meters) per occupant.

Number of exits	**Maximum number of occupants**	**Maximum Crit Room area based on exits**	**Required Crit Room area based on 3 times area of mezzanine**
1	50	250 ft^2 (23 m^2)	3 × 1,245 = 3,737 ft^2 (347 m^2)
2	349	1,745 ft^2 (162 m^2)	3 × 1,245 = 3,737 ft^2 (347 m^2)
3	700	3,500 ft^2 (325 m^2)	3 × 1,245 = 3,737 ft^2 (347 m^2)
4	More than 700	unlimited	3 × 1,245 = 3,737 ft^2 (347 m^2)

and entry lobby area of 1,245 square foot (116 square meter) if those ground-level spaces are defined as a mezzanine, the required area of the Crit Room, from this standpoint, is 3 × 1,245 = 3,737 square feet (347 square meters). But the maximum Crit Room area of 1,745 square feet (162 square meters), based on the number of exits from the room, is far smaller than the 3,737 square feet (347 square meters) required to satisfy the mezzanine criteria.

So does this mean that the mezzanine classification is flawed? It's true that the *actual* Crit Room area is more than three times the area of the bridge and entry lobby, satisfying area limits for mezzanines even if the Crit Room area is noncompliant because it has too few exits. But the opening that connects three Milstein Hall floor levels—part of a means of egress system that includes the mezzanine—is noncompliant. The only way to have such an opening connecting three floor levels that contains a means of egress is to design the opening as an atrium rather than as a mezzanine.[15] Therefore the mezzanine must be considered noncompliant under the 2002 code.

Incorrectly defining the common path of egress travel (Error No. 3)

Worried about the Project Director's spurious assumption that one of two Crit Room exits was at the far end of the corridor, and concluding that the two exits therefore might not meet the separation criterion in the code, the City of Ithaca Deputy Building Commissioner informed me that, in his view, the space did not even need two exits because occupants could move along a common path of egress travel,[16] no more than 75 feet in length, to a point where two distinct egress paths were available: In an email to me, he argued that the

> 2003 Building Code of NYS Section 1004.2.5 'Common path of egress travel' allows a 75 foot common path of travel before access to two exits is required. The definition of 'common path of egress travel' is in Section 1002. Basically, for up to 75 feet only one path to the two exits is required. The Crit space meets this requirement; therefore, it does have two code compliant exits.[17]

First, this is not what the building code requires: the common path of egress travel limits specified in section 1004.2.5 must be complied with, *and* the two required exits must be separated from each other by a minimum code-specified distance specified in section 1004.2.2.1. Neither of these code sections claims the other as an exception. Meeting one of these requirements does not allow you to violate the other. In fact, the *2020 New York State Building Code*, based on the 2018 IBC, actually combines the two requirements into a single section (section 1006.2.1 Egress based on occupant load and common path of egress travel distance): "Two exits or exit access doorways from any space shall be provided where the design occupant load *or* the common path of egress travel exceeds the values listed in Table 1006.2.1."[18] And, when the occupancy load is no greater than 50, the maximum common path of egress travel distance that permits a single exit is 75 feet (23 m).

Second, and more importantly, it is simply not true that the 75-foot limit for common path of egress travel is satisfied in the Crit Room. As can be seen in figure 16.8, the distance from the most remote part of the room to a point where two separate paths of egress travel are available is 85 feet (25.9 m), and so the room is noncompliant on that basis alone.

Because the common path of egress travel is part of the exit access

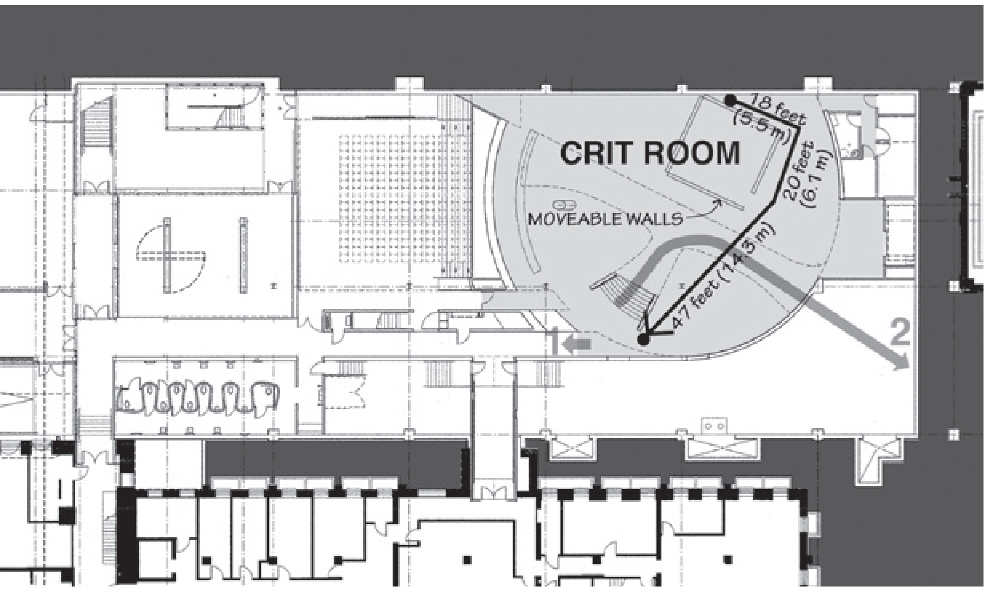


Figure 16.8. Milstein Hall's Crit Room plan showing moveable walls and common path of egress travel, accounting for necessary movement around those partitions.

travel distance, the code requires that it must be "measured from the most remote point to the entrance to an exit *along the natural and unobstructed path* of egress travel,"[19] which is why it would be improper to use a straight-line ("as the crow flies") distance from a remote point in the room to a point where two separate exit paths become available. This requirement is discussed in the *Commentary* to the IBC:

> The route must be assumed to be the natural path of travel without obstruction. This commonly results in a rectilinear path similar to what can be experienced in most occupancies, such as a schoolroom or an office with rows of desks … The "arc" method, using an "as the crow flies" linear measurement, must be used with caution, as it seldom represents typical floor design and layout and, in most cases, would not be deemed to be the natural, unobstructed path.[20]

Permanent partitions ("moveable walls") in the Crit Room (fig. 16.9) make it absolutely critical for the common path of egress travel distance

Figure 16.9. Moveable walls in the Crit Room prevent a linear "natural path of travel," so that the common path of egress travel distance must take such obstructions into account.

to be measured around such partitions, tables, or chairs in order to accurately reflect the "natural path of travel."

Neither of these code-required provisions—having an adequate number of exits and satisfying common path of egress travel distance requirements—are met in the Crit Room space, making it doubly noncompliant and dangerous.

Incorrectly calculating occupant load (Error No. 4)

Milstein Hall's "Issued for Construction" working drawings[21] provide another false justification for having only a single exit from the Crit Room. On the building code analysis page, the Crit Room is specified as a "Business" occupancy with 100 square feet (9.3 square meters) assigned to each occupant. This would be appropriate for a typical office space with actual offices or cubicles. It is absolutely inappropriate for an assembly space where there are no offices or desks, and where crowds of people routinely gather for events, reviews, or exhibits. What is even more peculiar is that the architects make reference to section 303.1 of the 2002 *New York State Building Code* to justify this occupancy classification. "Per Section 303.1," they write: "the crit rooms are a business occupancy since they are accessory use by less than 50 persons to Assembly A-3 Occupancy"[22] (fig. 16.10).

But section 303.1 of the code, concerning Assembly Group A, has an entirely different meaning. While the architects of Milstein Hall claim, in their code analysis, that "the crit rooms are a *business* occupancy since

OCCUPANCY LOAD TABLE

OCCUPANY NUMBER OF EXITS	SF / OCCUPANCY	NUMBER OF EXITS
BUSINESS STUDIOS COMPUTER LABS CRIT ROOM	100 GROSS	PER 303.1 THE CRIT ROOMS ARE A BUSINESS OCCUPANCY SINCE THEY ARE ACCESSORY USE BY LESS THAN 50 PERSONS TO ASSEMBLY A-3 OCCUPANCY

Figure 16.10. Excerpt based on the "Code and Life Safety Analysis" of the Milstein Hall working drawings showing occupancy assumptions for the Crit Room, with a box drawn by the author around the relevant text.

they are accessory use by less than 50 persons to assembly A-3 occupancy" (italics added by author), the code section that they reference says the exact opposite, stating that "…a room or space *used for assembly purposes* by less than 50 persons and accessory to another occupancy shall be included as a part of that occupancy."[23] In other words, the code allows an assembly occupancy that is used by less than 50 persons and is accessory to, for example, a business occupancy, to be treated as part of the business occupancy. But in the case of Milstein Hall, there is no assembly occupancy used by less than 50 persons; on the contrary, the Crit Room assembly occupancy is used by as many as 901 people!

Calling the Crit Room a "business occupancy" on the basis of section 303.1 is possibly the most egregious and dangerous misreading of the building code proposed by the architects of Milstein Hall and approved by the City of Ithaca Building Department. What makes it so dangerous is a second mistake that compounded the first: since "business areas" in the 2002 code can be assigned a floor area per occupant of 100 square feet (9.3 square meters),[24] and since the architects assumed a Crit Room floor area of 4,935 square feet (458 square meters), the occupant load they assigned to this room in their "Egress Calculations" was 4,935 / 100 = 49.35 people (fig. 16.11).

Assigning 100 square feet (9.3 square meters) per person in an assembly use characterized by "standing space," even if it actually were "accessory to another occupancy," e.g., business, and was "included as a part of that occupancy" is another dangerous misinterpretation of code language. The "occupancies" listed in Table 1003.2.2.2 (Maximum

EGRESS CALCULATIONS

ROOM		SQ. FT.	FACTOR	OCCUPANT
FLOOR B1 (GROUP A/B OCCUPANCY)				
AUDITORIUM	ASSEMBLY			
FIXED CHAIRS			ACTUAL	138.00
CHAIRS ONLY — NOT FIXED			ACTUAL	136.00
BALCONY		125	5	25.00
BALCONY	ASSEMBLY		ACTUAL	50.00
EXHIBITION	ASSEMBLY	970		
CRIT	BUSINESS	4935	100	49.35

Figure 16.11. Excerpt based on the "Code and Life Safety Analysis" section of the Milstein Hall working drawings showing egress calculations for the Crit Room, with a box redrawn by the author around the relevant text.

Floor Area Allowances per Occupant) in the 2002 code are intended to represent "the function or actual use of the space (not group classification)," as clarified in the 2018 ICC *Code and Commentary*.[25] So even if the Crit Room could be classified as being within the "Business" occupancy group—and, to be clear, it can't—its correct "function or actual use" would remain that of "Assembly without fixed seats—Standing Space" with a floor area per occupant of 5 square feet (0.46 square meters). The calculation of occupant load and required exits would not change.

But the architects of Milstein Hall turned this gross misreading of the code—first, incorrectly arguing that the Crit Room could be considered as a business occupancy and second, incorrectly arguing that all business occupancies can be assigned a floor area per occupant of 100 square feet (9.3 meters), even when the "function or actual use" is assembly—into an invitation to reduce the number of exits to one! Because the 2002 code allows an assembly (or business) room with an occupant load of 50 or less to have only one means of egress,[26] the Crit Room—in reality, a large below-grade assembly space for as many as 900 people and therefore required to have four exits—was deemed acceptable in spite of its noncompliant common path of egress travel distance, questionable mezzanine designation and exit separation, and its single viable exit.

17 HEARING BOARD APPEAL

As a registered architect and user of Milstein-Sibley-Rand Hall, I was certainly aware of the code issues discussed above, both while Milstein Hall was being designed, and after it was constructed and occupied. Naturally, I brought these code issues to the attention of Cornell's Milstein Hall project director as well as code enforcement officials in the City of Ithaca Building Department. Some of these issues were addressed, but many remained unresolved. Therefore, I filed a formal complaint with the Ithaca Building Department, dated December 13, 2011.[1]

The response I received from the City of Ithaca Building Department, dated March 16, 2012, did not address any of the specific code irregularities that I itemized in my complaint. Rather, Ithaca Building Commissioner Phyllis Radke expressed confidence that the architects of record, Cornell University, and the Ithaca Building Department were "truly interested in making sure that all life-safety and health imperatives are met…" and that my "concerns had already been responded to by the project Architect Kendall Heaton and Holt Architects." However, because my concerns remained unaddressed and because life-safety issues remained unresolved, I submitted a "Local Code Enforcement Complaint Form" to the New York State Division of Code Enforcement and Administration (DCEA) on April 10, 2012.

After more than a year passed, I was told by Brian Tollisen of the DCEA on April 24, 2013, that "in lieu of the complaint, you could apply for an appeal to our Regional Board of Review." This was confirmed by Charles Bliss of DCEA in an email to me dated May 10, 2013, in which he attached an application and offered to waive the required fee.

In the appeal that I submitted to the Regional Board of Review,[2] I identified several code irregularities or violations concerning Milstein Hall, including the fire safety issues discussed above:

- That Milstein-Sibley-Rand Hall exceeded the allowable area for a single (combined) building.

- That the fire barriers constructed between Milstein Hall and its neighbors were noncompliant.

- That the Crit Room in Milstein Hall violated common path of egress travel distance limits, had too few exits, and had inadequate separation between the exits.

- That Milstein Hall's lobby and entry bridge were improperly designated as a mezzanine within the Crit Room.

I also argued that the move of Cornell's Fine Arts library into the third floor of Rand Hall shortly after Milstein Hall was completed, creating a temporary home for the library pending the construction of a more elaborate design, violated height limits for the combined Milstein-Sibley-Rand Hall building.

On the question of whether Milstein-Sibley-Rand Hall exceeded the allowable area for a single (combined) building, the Board upheld the decision of the code enforcement official. The Board's "Findings of Fact" provided very little in the way of explanation, stating only that "Milstein/Sibley/Rand Hall exceeds Table 503 floor area limits based on Appendix K. In Appendix K, there is a statement that additions are allowed to exceed values greater than noted in chapter 5 if a fire barrier is constructed."[3] The fact that Appendix K also required the fire barrier to meet *chapter 3* floor area limits—in which case the combined areas of Milstein-Sibley-Rand Halls become noncompliant—did not seem to concern the Board. However, on the related question of whether Cornell's Fine Arts Library could remain on the third floor of Rand Hall, where it exceeded the height limit for an A-3 occupancy (library) in a sprinklered building with Type VB construction, the Board ruled in my favor, reversing the determination of the code enforcement official.[4]

This latter decision made the temporary third-floor Fine Arts Library noncompliant. But rather than addressing the root cause of the problem—lack of a fire wall separating Rand from Milstein Hall—Cornell applied for a series of code variances, each one more outrageous than the one before, that led ultimately to the construction of the Mui Ho Fine Arts Library in Rand Hall. I have written about this elsewhere.[5]

On the question of noncompliant fire barriers, the Board upheld the decision of the code enforcement official, but with a disclaimer: since the Board's decision was based on "information submitted and testimony given today that adequate code-compliant fire separation does exist, … the Board of Review will expect a submittal from the City of Ithaca on the testified approvals from the compliance testing lab."[6] Of course, the City of Ithaca was unable to supply any document that validated the use of Tyco sprinklers to create the equivalent of a 1-hour fire-resistance-rated wall assembly in the context of Milstein Hall's fire barrier openings, because no such document exists. Instead, the document referenced by the City of Ithaca was the same so-called "Legacy Report," NER-216, which specifically cites two of the conditions that make Cornell's use of such sprinklers *noncompliant*: that "the glazing assembly shall not have intermediate horizontal mullions," and that "all combustible materials shall be kept 2 inches (51 mm) from the face of the glass."[7] Ken Dias, an Applications Specialist at Tyco, also argued that Cornell's placement of sprinkler heads between the required fire-resistance-rated glass and an existing window "was not considered in the UL testing nor is it addressed within the evaluation service reports," concluding that "this installation does not appear to be in compliance with the UL Listing per Tyco data sheet TFP620, ESR-2397 or NER-516."[8] And the Board did not even consider the argument that—irrespective of whether Tyco sprinklers can create the equivalent of a 1-hour fire-rated wall when deployed in window openings—the fire barrier is noncompliant because it lacks "continuity," i.e., it does not meet the requirement that all structural elements supporting the fire barrier wall must have at least the same fire-resistance rating as wall itself. The fact that I didn't bring up this issue in my appeal may well explain the Board's silence, but doesn't excuse the architects of record, who bear the legal responsibility for designing a safe and code-compliant building.

On the question of inadequate exits from the Crit Room assembly space, the Board ruled in my favor, reversing the determination of the code enforcement official.[9] In response to this judgment, Cornell pondered what to do for more than a year, in the meantime posting a sign in the space limiting occupancy to 49 persons. Ultimately, Cornell decided to create an additional exit from the space by opening up a wall between the Crit Room and the auditorium and providing a new means of egress from the Crit Room through the adjacent auditorium. Doing so required extensive modifications to the auditorium itself, including removal of fixed glazing, demolition of concrete surfaces, patching of floors and walls, and the construction of a new concrete wall, glass partition, and glass exit door (fig. 17.1).[10]

Cornell currently posts an occupancy limit of 655 in the Crit Room, presumably in order to comply with the 700-person occupancy limit for assembly spaces with only three exits. But this violates the code in two ways. First, the code does not permit the Crit Room's posted occupancy load to be smaller than its calculated occupancy load. As I argued earlier, section 1003.2.2 (Design Occupant Load) states that "the number of occupants for whom means of egress facilities shall be provided shall be established by the *largest* number computed in accordance with sections 1003.2.2.1 through 1003.2.2.3,"[11] and that largest number is 901 occupants rather than 655. Second, the code requires four exits, not three exits, for an occupancy load greater than 700. To repeat: even if as much as 1,000 square feet (93 square meters) is excluded from the area designated as "standing space" so that it could be used for tables or displays—and excluding areas on this arbitrary basis is not even permitted by the code, which is designed to protect against "worst case" scenarios—the Crit Room would still have a computed occupancy load greater than 700 and would still require four exits.

On the question of improper mezzanine designation, the Board upheld the decision of the code enforcement official.[12] To be fair, I had not made the argument to the Board that the entry-bridge opening must be designed as an atrium, rather than as a mezzanine, because it contains a means of egress. This argument, had I made it, might, or might not, have changed the Board's decision. But it never came up. In retrospect, even though I believe that the Board's decision was incorrect, it could be considered moot. Subsequent iterations of the code, such as the 2020 *New York State Building Code*, now allow two-story openings to contain a required means of egress (so-called exit access stairs), so the mezzanine can no longer be criticized on that basis. With the mezzanine being part of the Crit Room, the three current exits from the Crit Room meet the code's separation requirements, and with a third exit having been constructed, the common path of egress travel distance limit is now met. But the requirement for four exits is still not met.

Before moving on, consider one final digression about the differences in safety brought about by, on the one hand, designating the opening connecting the Crit Room, entry-bridge, and studio floor as a two-story opening, with the entry-bridge being a mezzanine within the

Figure 17.1. Extensive modifications were made to auditorium seating and to the wall separating the Crit Room from the auditorium in Milstein Hall in order to create a new exit from the Crit Room, through the auditorium.

Crit Room; or, on the other hand, considering the opening as an atrium connecting three floors. Assuming, for the sake of argument, that only two exits are needed in the Crit Room, these two alternate designs point out some of the inconsistencies in the code when unusual geometries are encountered. If the opening connecting the three floors was designed as an atrium, with a required smoke control system, then the entry-bridge level would be considered a *story*, rather than a mezzanine *floor* within the Crit Room, and—ironically—the separation distance between the two exits in the Crit Room (without a third exit) would be noncompliant.

This is because the exit access point through the entry-bridge level would be at the bottom of the stair so as to remain in the Crit Room (Figure 16.5). But if the entry-bridge floor was considered a mezzanine within the Crit Room, that same exit access point would be moved up the stair to the exit from the lobby, since that more remote location, now part of the mezzanine, would also now be in the Crit Room (Figure 16.4*a*). Thus the safer option—building an atrium with a smoke control system—would *not* have met the code standards for exit separation, while the exact same spatial geometry, *but minus any smoke control system*, would have been considered compliant since the intermediate level, being a mezzanine, would have allowed the exit access point to be "moved" farther away.

18 CONCLUDING REMARKS ON FIRE SAFETY

Fire safety regulations, initially promulgated to prevent conflagrations that routinely destroyed large portions of cities, have been incrementally improved over the past several centuries, first to prevent fires from spreading to adjacent buildings, then to prevent fires from spreading from their floor of origin, and now to prevent fires from spreading even from their room of origin. Automatic sprinkler systems, combined with more traditional passive construction elements (including fire barriers and fire walls), have greatly reduced the risk of loss of life and property damage. Yet even so, fire still exacts an enormous cost: in the U.S., structural fires cause thousands of injuries and deaths each year, both to civilians and firefighters.[1] Loss of property is measured in the hundreds of millions of dollars annually, just in New York State.

At Cornell University, fires routinely occur in both lab buildings and dormitories, and numerous Cornell students have been killed in off-campus houses and clubs.[2] Outside of Cornell, even buildings designed by noted architects like OMA/Rem Koolhaas have been damaged by fire. OMA's New York City Prada store "became one of Prada's most successful stores, but on Saturday night [Jan. 21, 2006] a fire that began in neighboring American Eagle Outfitters injured seven people, including six firefighters, and caused extensive water and smoke damage throughout the building."[3] OMA's 34-story hotel under construction as part of the CCTV (China Central Television) headquarters in Beijing was engulfed by "a fierce blaze started by an illegal fireworks show"[4] in 2009.

Such examples illustrate precisely the issues at stake with the construction of Milstein Hall at Cornell University and, in particular, with the inadequate fire barrier installed between Milstein, Sibley, and Rand Halls. The Prada store, a retail establishment that should have been isolated from adjacent building areas by a fire barrier, suffered extensive damage when that isolation proved illusory. While it is difficult to determine precisely why the fire spread from the American Eagle store, it is likely that fire separation between the adjacent stores was inadequate, even though the two stores were "separated by a brick wall and 16 feet of lobby area."[5] Legal documents allege that the fire "originated in a first-floor HVAC duct/mechanical room and that the fire was permitted to spread via a voids [sic] or voids in the HVAC duct/mechanical room." It was further alleged that "the installation of firestopping material in about the aforestated HVAC duct shaft/mechanical room located on the first floor of the building at 573-575 Broadway, New York, New York was negligently performed." Building code provisions cited in legal documents stemming from the Prada fire reference numerous sections of the 2002 *Building Code of New York State*, including those that deal specifically with fire barriers.[6]

The Prada fire caused numerous injuries, mainly to firefighters. One firefighter, in particular, allegedly "sustained serious personal injuries, severe physical pain and mental anguish as a result thereof, incapacitation from his usual vocation and avocation, and was caused to undergo medical care and attention…"[7] In response to this five-alarm fire requiring the deployment of "nearly 200 firefighters and scores of fire trucks and other equipment"[8] and causing not only injuries to seven people (six of whom were firefighters) but extensive property loss, architect Koolhaas appeared capable only of considering the extensive water damage at the store as a source of wry amusement. As reported in the *New York Times:* "A sense of humor was also water resistant. Through an assistant in his Rotterdam office, Mr. Koolhaas relayed his condolences: 'It's raincoats next season,' he said."[9]

In a separate incident, a fire at OMA's Beijing Mandarin Oriental Hotel, under construction and adjacent to—but spatially separated from—OMA's more famous CCTV tower, did enormous damage to the hotel, but did not spread to the CCTV tower. While damage was extensive in the hotel where the fire started, the effectiveness of code-based requirements for either physical separation (frontage), or fire-resistive barriers (fire barriers or fire walls) was clearly borne out here. Reducing code-sanctioned fire separation strategies to lower construction costs or to achieve some formal design objective, as has apparently been done at Milstein Hall, is a risky strategy.

It is clear that many architects and even building owners often don't appreciate the risk of fire, and make assumptions about the safety of buildings without any logical basis. Such attitudes gain currency in part because fire safety is assessed in a probabilistic environment where the risk of damage, injury, or death is not immediately evident. Yet fires are a recurring threat, even on Cornell's campus, and even in buildings connected to Milstein Hall.

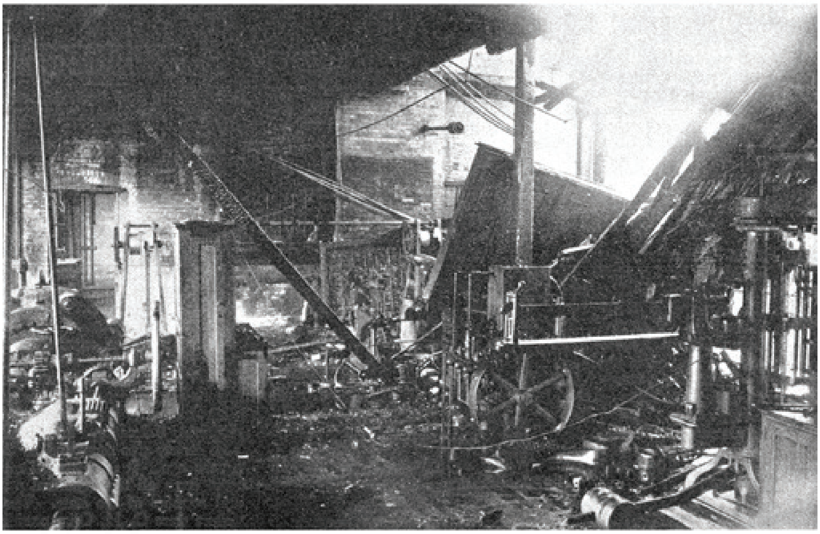
Referring to noncompliant lecture halls in Sibley and Myron Taylor Halls at Cornell that were required by a New York State ruling to be either upgraded with a second exit or downgraded to a maximum occupancy of 49 people, Cornell's Deputy University Spokesperson Simeon Moss explained that the University had appealed the State's ruling that required such upgrades or exits because: "We're quite confident in the safety of the buildings."[10] Such confidence, however, has no basis in building science or logic. In fact, Cornell's legal complaint against the New York State Department of State's Director of Code Enforcement and Administration and others made no reference to any actual fire science that would, in even the smallest way, justify confidence in the safety of those buildings. Rather, it hinged entirely on a dubious and ultimately discredited legal judgment that the State's Code Interpretation 2008-01 "is invalid and contrary to law."[11]

Can campus buildings catch on fire at Cornell? "Morse Hall, which housed the University's department of chemistry, was almost wholly destroyed by fire last Sunday, February 13. Little more was left standing than the walls of the building."[12] "A laboratory fire today damaged a portion of Cornell University's Space Sciences building, where research financed by NASA and the National Science Foundation is conducted."[13] "The S.T. Olin Chemistry Research Laboratory at Cornell University returned to use this morning after a second-floor fire in a research lab Thursday evening, July 8. The fire began at approximately 10 p.m. and involved a quantity of flammable liquids. The building was evacuated and the fire was extinguished by the Ithaca Fire Department."[14] "Early yesterday morning, an electrical transformer device erupted in flames at the Wilson Synchrotron Laboratory, which houses a particle physics accelerator. Ithaca firefighters responded to the fire alarm at 12:47 a.m., at first with only two fire engines, but because of the severity of the smoke, a third engine was dispatched. The cause of the fire appears to be accidental, but it is still under investigation, according to the IFD."[15] "A small fire broke out at the Wilson Synchrotron Laboratory yesterday afternoon around 2:47 p.m., marking the second fire in less than a month at the laboratory. An internal a power supply for a vacuum pump short-circuited and caused the fire, according to the Ithaca Fire Department."[16]

Finally, Sibley Hall, currently home to the College of Architecture, Art, and Planning, and now separated from Milstein Hall with a deficient fire barrier, also has experienced a damaging fire (fig. 18.1). The 1906 fire in Sibley was reported by the Cornell Alumni News:

CORNELL ALUMNI NEWS

Vol. IX. No. 3 Ithaca, N. Y., October 17, 1906 Price 10 Cents



THE MECHANICAL LABORATORY AFTER THE FIRE.

Figure 18.1. Sibley Hall's "Mechanical Laboratory After the Fire" in 1906.

> Fire early last Friday morning caused damage of $5,000 [$168,960 in 2023 dollars] to the mechanical laboratory in the rear of Sibley College, and threatened to destroy the entire building. Good work by the Ithaca fire department, assisted by University officers and students, confined the flames to two rooms. The loss is covered by insurance.
>
> How the fire started is not known, but it is supposed to have been the result of a crossing of electric wires. … *Brick fire walls had kept the flames confined to this section*, and the firemen prevented it from spreading further. Pressure was obtained from the big pump directly west of the building. By 6 o'clock the fire was all out. …[17]

The efficacy of fire barriers or fire walls ("Brick fire walls had kept the flames confined…") was evident in 1906 when Sibley Hall, now connected to Milstein Hall, experienced a serious fire. Yet such barriers can be compromised, either by the actions of complacent architects and code enforcement officers, as evidenced in the design of Milstein Hall; or—ubiquitously—by the behavior of ordinary building users who, as students, faculty, and staff within a Department of Architecture, ought to know better (see, for example, figure 5.6).

One cannot say with certainty either that Milstein Hall would be free of risk by adopting modern fire-safety standards, or that Milstein Hall will experience fire damage if designed, as it has been, according to more lax standards. What can be stated with certainty, however, is that Milstein Hall is less safe than it could be and less safe than current building codes would require it to be.

PART IV

UNSUSTAINABLE DESIGN

19 OPENING REMARKS ON SUSTAINABILITY

By any rational calculation, Milstein Hall is not a sustainable building. It is basically a sealed glass box with undifferentiated facade treatment on all four elevations. It is a flat pancake of a building that maximizes weather-exposed surface area not only by spreading out the bulk of its program area on one enormous floor plate, but also by lifting this floor plate off the ground, thereby exposing not only its roof but also its underside to the weather—while simultaneously creating outdoor decks directly above underground rooms that then become exposed to the weather as well. It turns thermal bridging into an art form, with uninsulated structural steel columns and steel shelf angles bypassing insulation to funnel heat into cool spaces and cold into heated spaces. It proudly exposes its floor-to-ceiling continuous glass facades to the eastern, southern, and western sun without mediation (well, you can draw the curtains). It promotes daylighting (which is not even available most of the time the building is used, and is increasingly dubious in an age of computer monitors and digital projection) at the expense of energy conservation. Milstein Hall, with its structural exhibitionism, uses far more building materials than would otherwise be needed: the quantity of steel used in this two-story building—some of its structural components have four-inch (102 mm) thick flanges—is mind-boggling. In virtually every aspect of the building's design, decisions have been made that increase complexity, cost, and quantity of material resources expended. For example, glass is placed around an auditorium that requires darkness and acoustical isolation: so the glass is made inordinately thick (to keep sound out), and then covered with elaborate curtains (to make the room dark).

Complexity, if not matched by a rigorous program of design research and testing, leads to unsustainable buildings. This is because needlessly complex design elements will experience a greater rate of failure than more conventional elements, which results in the expenditure of more resources over time for maintenance, repair, and replacement.

In fact, there is only one possible way to pretend that this building is "green": by buying into (literally) the USGBC's LEED rating system. "The benchmark for measuring 'Green' Buildings is the Leadership in Energy and Environmental Design (LEED) Rating System developed by the U.S. Green Building Council. As part of developing a sustainable campus, Cornell has embraced the LEED Rating System and requires that new construction and major renovation projects achieve a minimum LEED Silver Rating."[1]

As will be shown, achieving a LEED silver, or even a gold, rating has nothing to do with any rational measure of sustainability. In fact, Cornell's own internal goals are simpler and more ambitious: "In addition to LEED Silver requirements, to support our Climate Action Plan goals of climate neutrality by 2050, projects initiated since 2008 need to use 30% less energy than current energy standards and strive towards 50% less energy."[2] How Milstein Hall fails to stack up to other recent Cornell projects in reaching these internal goals is illustrated in Table 5:[3]

Table 5 shows that Milstein Hall (labeled "Paul Milstein Hall" before the name was changed to "Milstein Hall") uses energy at a rate virtually

Table 5. Milstein Hall compared with other Cornell buildings.

Project name/completion year	**Gross Square Footage**	**% Energy Reduction**	**LEED Rating Target**
Physical Sciences Building/2010	197,000	29%	NC-Gold
Paul Milstein Hall/2011	69,000	2%	NC-Silver
Combined heat & Power Office/2010	3,000	61%	NC-Gold
Animal Health Diagnostic Center/2011	109,000	22%	NC-Gold
Plantations Welcome Center/2010	6,000	53%	NC-Gold
Riley-Robb Biofuels research Lab/2009	21,000	38%	NC-Gold
Human Ecology Center for Science/2011	227,000	33%	NC-Gold
MVR '33 Phase 1 Renovation/2010	58,000	31%	CI-Gold

identical to current, presumably non-sustainable, standards. In contrast, every other project initiated by Cornell during this time period is reducing energy consumption by 22 percent to 66 percent. That Cornell's flagship architecture building—a building with nothing but a large floor plate for desks, an auditorium, a small gallery, and a critique space—cannot figure out how to reduce its energy consumption beyond currently mandated standards is consistent with the architecture program's historic values, but hardly in tune with either the University's or the profession's stated goals. Cornell architecture has always been fixated on form and the intellectual/artistic basis underlying formal design:

> If one could identify a singular philosophy for the architecture program at Cornell, it would be that architecture is a conceptual problem-solving discipline… The intention has always been to instruct architecture students in issues of basic and more sophisticated formal principles… The development of form and space is critical to architectural design… The excellence of architectural art, however, derives from the exploration and refinement of ideas, upon which form, purpose, and structure are dependent.[4]

In contrast, the American Institute of Architects Committee on the Environment (COTE)

> reflects the profession's commitment to provide healthy and safe environments for people and is dedicated to preserving the earth's capability of sustaining a shared high quality of life. The committee's mission is to lead and coordinate the profession's involvement in environmental and energy-related issues and to promote the role of the architect as a leader in preserving and protecting the planet and its living systems.[5]

If we temporarily suspend our disbelief, it is possible to evaluate Milstein Hall's sustainable attributes based on the LEED rating system. The version under which Milstein Hall was rated—LEED-NC 2.2—divides sustainability into five categories, each of which will be examined in turn: site, water, energy/atmosphere, materials, and indoor environmental quality.[6] A sixth category for "Innovation & Design Process" provides extra points for projects that either exceed expectations, or provide innovations that were not anticipated under these five categories. Items listed as "prerequisites" are mandatory for LEED certification; all other so-called credits are discretionary. One can completely disregard whole categories of green building design so long as enough points are collected in the remaining categories to satisfy the criteria for the various ratings. In LEED v.2, unlike later versions, a maximum of 69 points is available: 26–32 points to be merely *certified*; 33–38 points for a silver rating; 39–51 points for gold; and 52–69 points for platinum. As might be expected, most projects are certified[7] at the bottom range of their rating classification rather than at the top. In other words, a project with a projected point total of 32—the top of the lowly "certified" range—would most likely find a way to "buy" one more point in order to get the LEED-silver designation. Milstein Hall, aiming for gold, was one point short of that goal in September 2011 but managed to find enough points to achieve the "Gold" designation in June 2012.[8]

In the sections that follow, all 69 LEED points and 7 prerequisites, listed in the order established by the U.S. Green Building Council in their Version 2.2 guide, are examined in terms of their relationship to sustainable building and, where applicable, in terms of Milstein Hall's design. LEED continues to evolve, and so the specific requirements discussed below are different from current LEED requirements. Indeed, some of my criticisms have been addressed in later versions. Nevertheless, I'm sticking with the older Version 2.2 credits and prerequisites for two reasons: first, and most important, this is the version of LEED under which Milstein Hall was certified as a LEED-gold building; and second, while there have been adjustments and improvements, the fundamental strategies, principles, and contradictions underlying the LEED guide have not substantially changed. The older guide, in some ways, is more revealing than newer versions which have buried some of its more incriminating ideological imperatives deeper in the manual's fine print.

20 SUSTAINABLE SITES

Construction Activity Pollution Prevention

Prerequisite 1. LEED requires all certified buildings to make a plan to reduce construction-related pollution and degradation (including soil erosion, dust). This is a fairly routine requirement, and is probably standard operating procedure in most municipalities even without the LEED incentive.

Site Selection

Credit 1. To get this point, the project cannot be built on farmland, undeveloped land in a flood plain, parks, habitats for threatened or endangered species, or undeveloped land within 50 feet (15.2 m) of water bodies. In other words, it would have been impossible for Milstein Hall not to get this point, except perhaps by extending its cantilevered floor plate another 150 feet (45.7 m) over the Fall Creek gorge.

This credit prioritizes development on previously developed land, even for sites within flood plains. This makes no sense from a rational planning standpoint, as there may well be instances where, for example, development on previously undeveloped land is sensible. However, such an analysis cannot occur when virtually the entire planet is divided into parcels under the control of individual owners seeking to exploit their property for private gain. In that context, rational planning becomes an oxymoron, and the stipulations of Credit 1 become entirely arbitrary. Why, for example, does building in a flood plain, or near a water body, become desirable simply because the site has already been inappropriately developed?[1]

Development Density & Community Connectivity

Credit 2. For this point, there are two choices, both of which require that the site has been previously developed (and Milstein Hall's site was previously developed, having supported both buildings and parking lots in the past). The first choice is to build in a location where the local building density is at least 60,000 square feet per acre (13,774 square meters per hectare), much like a typical two-story "downtown." Both the project on its own site, as well as the local density measured within a circle somewhat arbitrarily defined as having an area about 28 (actually 9 × π) times that of the building site, must meet this criterion (fig. 20.1).

If Milstein Hall has about 50,000 square feet (4,645 square meters) of program area and if its site, defined by the construction project limit line in the contract documents, has about 65,000 square feet (6,039 square meters), or 1.49 acres (0.60 hectare), then its density is 50,000 square feet / 1.49 acres = 33,557 square feet per acre (7,704 square meters per hectare), and does not meet the "downtown" criteria.[2]

For the larger "regional" density, we need to compute the total building area in a circle centered on the site with a radius of about 765 feet (233 m). Making gross assumptions about the building area on this

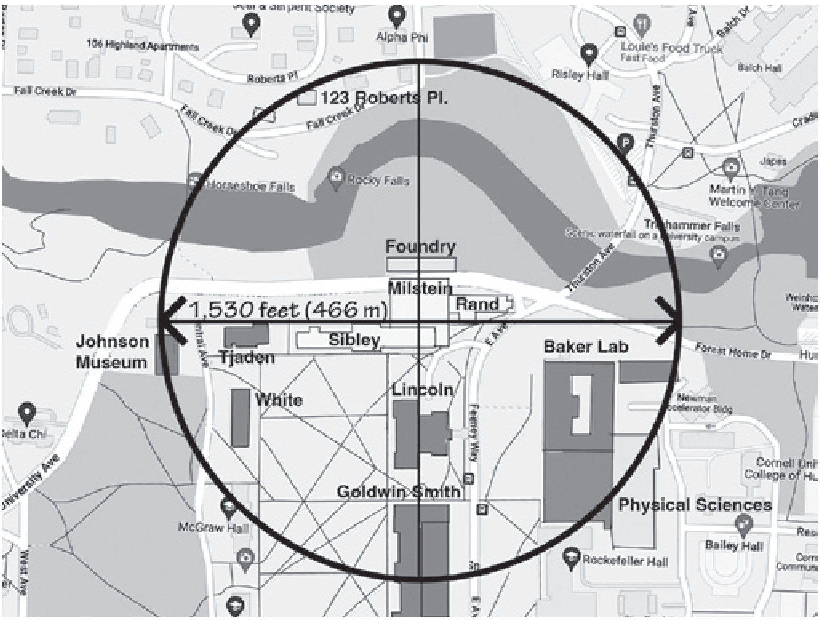


Figure 20.1. Milstein Hall and its larger "urban" context: the circle represents an area approximately 28 times that of the building site.

regional site—i.e., assuming Baker Lab has 200,000 square feet (18,581 square meters); Sibley Hall has 54,000 square feet (5,017 square meters); Rand Hall has 27,000 square feet (2,508 square meters); and so on—we get a total building area of 855,000 square feet (79,432 square meters).

The regional site area is $\pi \times 765^2 = 1{,}838{,}540$ square feet, or 42.2 acres (170,806 square meters or 17 hectares). Therefore, the regional density is 855,000 square feet / 42.2 acres = 20,260 square feet per acre (4,651 square meters per hectare), which also does not meet the criterion. This is not particularly surprising since the Arts Quad at Cornell was not intended to be an "urban" space.

Luckily, there is another way to satisfy this credit. If the site is within 1/2 mile (0.8 km) of a residential area (Cornell Heights and Cayuga Heights, as well as all the Cornell dorms west and north of the site seem to qualify) and within 1/2 mile (0.8 km) of 10 "basic services" (things like banks, grocery stores, laundry, etc.), then you can still get the LEED point. As can be seen in figure 20.2, there is enough stuff within this 1/2 mile (0.8 km) radius actually on campus—including the Statler Hotel, Cornell Store, numerous eateries, fitness centers, and bowling—to satisfy the requirements for this LEED point.

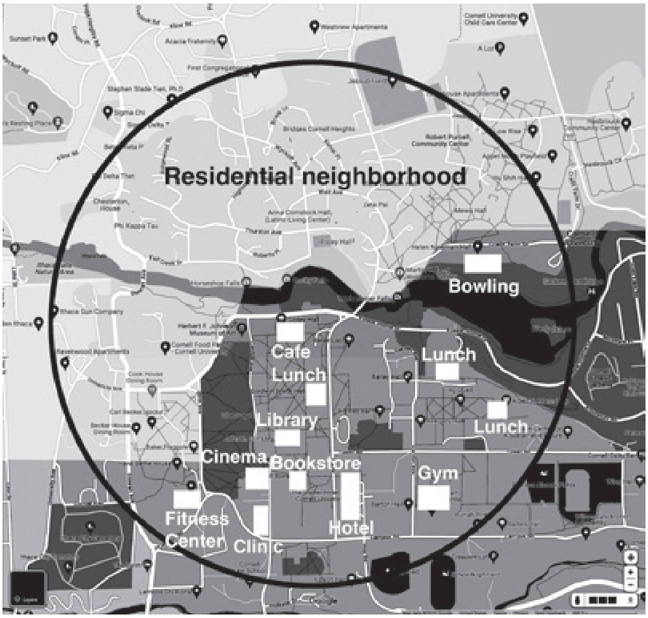


Figure 20.2. Basic services and residential neighborhood within 1/2 mile (0.8 km) of Milstein Hall.

This credit idealizes urban density, which it correlates with sustainability, while at the same time prioritizing the exact opposite tendency in its open space initiatives (Credits 5.1 and 5.2). That points in both categories can be awarded to a single project—i.e., a project can maximize open space while achieving urban densities—demonstrates the futility of finding any coherence in the LEED guidelines. Furthermore, businesses may need to locate in an urban area for reasons that have nothing to do with preserving greenfields or fostering "community." In many cases, there is no impact on "community" or on the preservation of greenfields (i.e., the nature of such a business may preclude development outside of urban areas so that greenfields, in any case, were never threatened) as a result of such development, yet the LEED credit is still awarded. In the case of Milstein Hall, a point is awarded for "density" based on proximity to campus services like cafes and fitness centers which could not *not* have been awarded, given the decision to expand program facilities in that particular spot on campus. Is this a "sustainable" decision that deserves recognition (and points), when more resource-efficient schemes that would not involve new building construction at all, but rather would focus on improvements and modest additions to existing buildings, were not implemented? Such questions are never asked within the LEED rating system.

Brownfield Redevelopment

Credit 3. This point is only given to projects that remediate damaged sites. While this credit does not apply to Milstein Hall, it demonstrates an important problem with the LEED system. In virtually every section of the guidelines that explains how points are awarded, the LEED authors promote the notion that market forces ought to direct savvy business owners to sustainable practices. In other words, LEED is merely itemizing and rewarding practices that businesses would do on their own, without any recognition or certification, purely on the basis of self-interest—if only information about such practices was organized in a useful way. That this self-serving ideology runs counter to virtually the entire history of environmental practices is somehow not noticed: for wasn't it precisely the search for the best (most profitable) industrial and agricultural fuels that led to the use and abuse of first wood and then coal, gas, oil, and uranium? Back-and-forth pronouncements emanating from market-driven guardians of the environment like T. Boone Pickens demonstrate that the time for investment in wind energy is, or perhaps is not, now—depending, of course, on the relative cost of coal, oil, and gas.[3]

In the case of Credit 3, the LEED authors implicitly acknowledge that market forces would leave brownfields pretty much unremediated, since fixing them up is usually not a profitable practice. The LEED commentary references CERCLA (the 1980 Comprehensive Environmental Response, Compensation, and Liability Act, a.k.a. the "Superfund") which funds governmental intervention to remediate contaminated sites; the use of incentives at all levels of government is also mentioned as a way of encouraging "brownfield redevelopment by enacting laws that reduce the liability of developers who choose to remediate contaminated sites."[4] From this, it is clear that sustainable development often does not make economic sense to businesses without state intervention (where such intervention takes the form of subsidies or is directly legislated as a specific requirement). And state intervention depends on competitive calculations of the state rather than on free-floating environmental ideals.

Alternative Transportation; Public Transportation Access

Credit 4.1. To get this point, the project needs to be within 1/2 mile (0.8 km) of a rail line—unfortunately, the campus-downtown trolley ceased operation in 1927—or to be within 1/4 mile (0.4 km) of at least two bus lines. Even with bus routes temporarily altered when they needed to detour around the Milstein Hall construction site, there were plenty of other routes within a 1/4 mile (0.4 km) radius (fig. 20.3), so Milstein Hall gets this point.

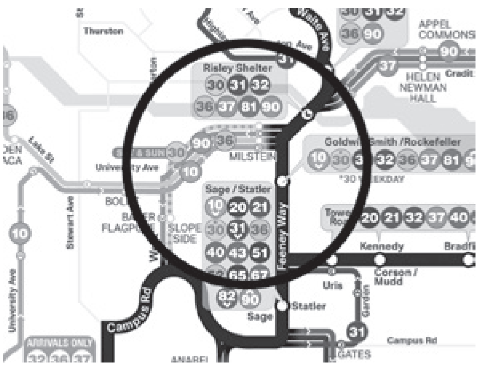


Figure 20.3. Bus route map showing plenty of stops within a 1/4 (0.4 km) mile radius of Milstein Hall.

Alternative Transportation, Bicycle Storage & Changing Rooms

Credit 4.2. This credit requires bike racks for 1/20 of the project's "peak" user population and showers for 1/200 of the building's full-time equivalent occupants. If we assume peak loads of 20 FTE (full-time equivalent) and 500 transients (this assumption is based on design phase programming estimates[5]), the required number of bike racks is 26, found by dividing 520 by 20. There appear to be about 22 spaces provided for bikes on Milstein Hall's dome (fig. 20.4), which seems insufficient.

Additional bike storage is possible on the site if the guardrails adjacent to Sibley Hall are included; they are certainly used by students for this purpose, but it is unclear whether such use is sanctioned or

Figure 20.4. Milstein Hall bike racks contain 11 semi-circular supports, presumably to accommodate 22 bikes, less than the 26 bike storage spaces required for a LEED point.

unsanctioned. Certainly, the use of required handrails (fig. 20.5) for bike storage is unsanctioned.

In any case, there are no changing rooms or showers in the building, which are required in order to get this LEED point. However, the fine print in the LEED guidelines permits campus buildings to share shower facilities, as long as the showers are no further than 600 feet (183 m) from the entrance to the building seeking certification. As it turns out, Baker Lab—a campus building diagonally across Feeney Way (formerly East Avenue) from Milstein Hall—has a single unisex shower on the second floor and on this basis Milstein Hall is claiming the bike rack credit. With only 20 FTE occupants of Milstein Hall (the remainder are classified as "transient"), this single shower would be more than enough

Figure 20.5. LEED-recommended storage for 26 bikes is clearly inadequate for 520 bike-friendly building users. Here, unsanctioned bike storage takes place along ADA-required handrails.

to satisfy the mandate of 20 divided by 200, or 0.1 required showers. Unfortunately, the shower room is more than 600 feet from the entrance to Milstein (fig. 20.6) so this additional criterion for the LEED point is also not met. And even if the distance limit were overcome, the remote shower would not qualify since the hours of operation of the building it is in do not match the 24/7 operating hours of the architecture studios in Milstein Hall.[6] In spite of this, Cornell has claimed the credit and LEED's reviewers have accepted the claim based on plans "provided showing the location of the shower/changing facilities and the bike storage facilities."[7]

LEED's bike-rack-as-sustainable-building-element credit is widely disparaged and ridiculed, although there are some persuasive arguments in support of the credit.[8] However, the issue really isn't whether or not bike riding saves energy, reduces pollution, and encourages healthy

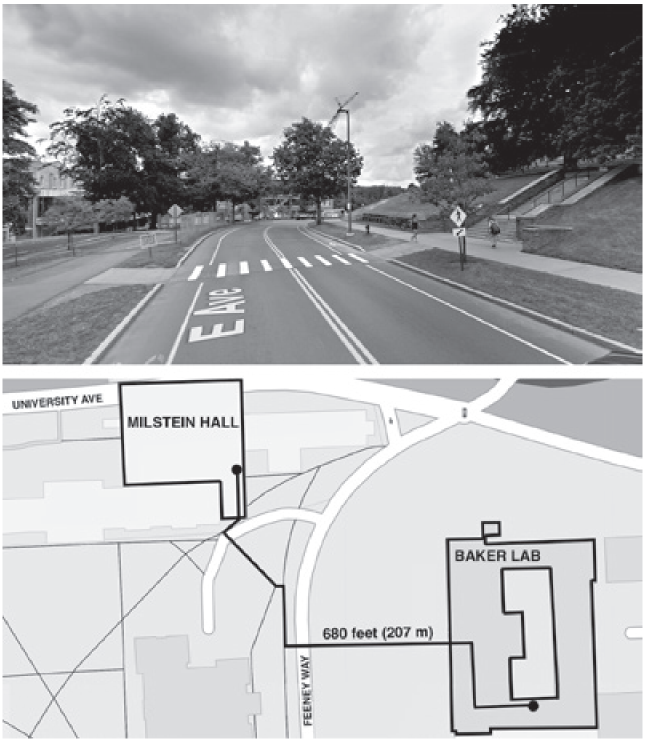


Figure 20.6. The path from Milstein Hall's entrance to the LEED bike-point-required showers involves crossing Feeney Way, formerly East Avenue, and climbing the steps to Baker Lab (*top*); even so, the path distance exceeds the 600 feet (183 m) limit (*bottom*).

lifestyles compared with car driving. All of these arguments are clearly valid. Whether the provision of bike storage is a "building energy" issue that belongs in a "green building" guideline at all might be a reasonable criticism if there existed a logical hierarchy of "green" standards that addressed sustainability at various scales—from the individual to the community to the entire planet. Given that no such mandates exist, it seems premature to unilaterally exclude bike racks from a green building guideline on this basis. Whether the credit given for provision of bike storage is consistent with the allocation of credits elsewhere in the LEED guidelines is actually impossible to determine, since simply providing a bike rack does not automatically cause people to stop commuting with cars, buses, or trains in any consistent manner. In other words, the real issue is whether providing bike racks and showers per the LEED specifications actually accomplishes any of desirable goals for which bike use is properly credited.

At one extreme, one can certainly identify projects where either the program (e.g., luxury business hotel) or environmental conditions (e.g., unfriendly roads or steep hills with no provision or accommodation for bicycles) simply do not support cycling. Even the "LEEDuser" website suggests that providing bike racks in such circumstances may not be an efficient use of resources.[9] But it seems clear that some building owners will install such bike racks for the cynical purpose of achieving a higher LEED certification level, even when the anticipated use of bike storage is uncertain or unlikely.

At the other extreme one can find projects where a bike culture already exists, and where the provision of bike racks is not only necessary to support this existing culture, but where LEED specifications actually hinder bike usage by dramatically understating the actual need for such facilities. Such a condition applies to Milstein Hall at Cornell, where the LEED-recommended bike racks are woefully inadequate.

The cynical collection (purchase) of LEED points is hardly unusual; the bike rack credit serves as a prime example in Milstein Hall, not because bike use shouldn't be encouraged and supported for all the reasons mentioned above, but because neither the explicit goal of this credit—supporting bike use to reduce pollution, reduce reliance on non-sustainable fossil fuels, and support healthy life styles—nor even the straight-forward, if misguided, criteria for implementation of the credit—providing bike storage for 5 percent of the building's peak users and showers for 0.5 percent of the FTE population no farther than 600 feet (183 m) from the building entrance—are met. Milstein Hall's expropriation of the Baker Lab shower is particularly egregious: I can state with some certainty that not a single Milstein Hall bicycle user is aware that such a shower exists, or has been informed that this shower has been made available to them (not that any of them would have the slightest interest in using it if they were made aware of its existence). Furthermore, the fact that this LEED credit was actually "earned" in Cornell's LEED design application, in spite of the fact that the criteria for the credit were not met, illustrates how the need to collect points in order to meet threshold requirements for a desired certification level (in this case, "gold") encourages a kind of sloppy (corrupt? cynical?) book-keeping where the points themselves become more important than actually understanding and creating the conditions for sustainable building.

Low-emitting and Fuel-Efficient Vehicles

Credit 4.3. There are several options to get this point, none of which are attempted or met by Milstein Hall.

Alternative Transportation, Parking Capacity

Credit 4.4. To get this point, you need to provide five percent of total parking as "preferred parking" for carpools or vanpools; or you need to provide no new parking for the project. Cornell has various programs to encourage carpooling, but none are directly tied to this project.[10] Both structured underground and surface parking were originally planned adjacent to the Milstein site, but the underground component was cut in response to the financial crisis of 2008. Cornell had already cut down Redbud Woods in 2005 to build a new parking lot a few blocks from Milstein Hall, but this lot was not built specifically for any single building project. Remarkably, Cornell has used the case of Redbud Woods to demonstrate its commitment to a sustainable environment in an article that is no longer accessible online. After describing how Cornell successfully sued both the Ithaca Planning Board and the Ithaca Landmark Preservation Commission in order to overturn each of their independent rulings against the proposed parking lot, and after describing how Cornell Police arrested students engaged in a sit-in at the President's office and finally bought off students, faculty, and community members who had occupied the Redbud Woods site with a $50,000 sustainability research commitment and a memorial plaque (fig. 20.7), the article

Figure 20.7. Cornell's Redbud Woods memorial plaque tells why and how a historic woods was bulldozed to create a parking lot: "The land before you was once home to the extended family of Robert H. Treman, creator of parks and protector of green spaces throughout Tompkins County. The woodland that grew up here was inhabited for decades by diverse wildlife and more than 50 plant species, including numerous redbud trees. Redbud Woods was razed on July 20, 2005 by the Cornell administration to build a parking lot. This plaque has been erected by Ithaca community members in memory of this cherished woodland. Remember the trees… Remember all who tried to save them."

concludes that being sustainable is inherently contingent and unpredictable since "people value both cars and natural or historic lands."[11]

Since parking on campus is often (always?) disengaged from particular buildings on campus, Cornell can claim that no new parking has ever been created for any building and in this way apply for a LEED point. The reality is different: buildings get built and parking gets increased on campus.

In fact, new underground parking next to Milstein Hall may well get built at some point: "Construction of an adjacent plaza will incorporate a turnaround for vehicles and access to an eventual parking garage on the site. The building of Milstein Hall will eliminate about two-thirds of existing parking space behind Sibley, 'with the hope that the parking garage will be built in the future, with more spaces than the existing parking lot'…"[12]

The "Alternative Transportation" credit provides LEED points even though it would be virtually impossible not to satisfy the listed criteria for this campus building. In the case of Milstein Hall, campus and city buses stop near the site, so the points for "public transportation access" are automatic, and have nothing to do with the building itself. I've also noticed that students often take these buses to get to classes that are only a half mile or so away, rather than walking or biking: is this really a "sustainable" (i.e., energy-conserving or health-encouraging) practice? Such buses also bring faculty and staff from "remote" parking lots to the central campus—again both encouraging car use while simultaneously discouraging the half mile walk from the remote lot. In other words, the ideology of "public transportation" obscures actual practices that discourage healthful and energy-conserving activity.

Site Development, Protect or Restore Habitat

Credit 5.1. To get this point for a non-greenfield site, at least half the site (not counting the building) needs to be planted with native or adapted vegetation. As most of the Milstein site is paved, this point appears not to be possible. Certain green roofs can, however, be counted in dense urban sites, in which case only 20 percent of the site area (including the vegetated roof area) needs be so planted. The vegetated roof plantings need to actually support a diverse range of birds and insects. While Milstein Hall is, apparently, a "dense urban site" (having earned Credit 2, Development density and community connectivity) and would seem to qualify for this site development point based on the size of its green roof, it may be that a lack of habitat diversity prevents Cornell from earning this LEED point: Milstein's vegetated roof appears to be more decorative than ecologically functional.

Site Development, Maximize Open Space

Credit 5.2. This credit can be satisfied in numerous ways, depending on zoning requirements for open space. Cornell University is governed by the City of Ithaca Zoning ordinance, which has a 35 percent maximum lot coverage for so-called U-1 (post-secondary) zones; in other words, there is a 65 percent open space requirement. LEED requires that vegetated open space exceed this zoning requirement by 25 percent. The Milstein site therefore would need 81.25 percent vegetated open space for this credit. Of course, Milstein Hall isn't really a "site" from the City's perspective; it is just one part of a larger campus for which the 35 percent maximum building area applies.

So, it isn't clear whether Milstein Hall gets this LEED point by meeting the 81.25 percent open space requirement on its own construction site, or rather by identifying some far-away campus green space, perhaps part of the Cornell Botanic Gardens, and assigning it as Milstein Hall's vegetated open space.

In the first case, and assuming that the site area is 65,000 square feet (6,039 square meters), the required vegetated open space is 0.8125 × 65,000 = 52,812 square feet (4,906 square meters). In reality, most of the open space on the site consists of a paved area to the west of Milstein Hall used for parking and vehicular service access. The small garden and other assorted green spaces account for only about 4,000 square feet (372 square meters)—this is an approximation; the actual green space may be a somewhat different—far short of the required vegetated area.

However, since Milstein Hall will presumably earn Credit 2 (Development Density & Community Connectivity) and will therefore count as an urban site in the eyes of LEED, it can get this point by providing up to 75 percent of required vegetated open space as "pedestrian oriented hardscape," and can also count the green roof as open space in this calculation. Because Milstein Hall's upper floor plate is raised above the ground plane, it may be possible to count the space *under* this floor as well as the area *over* this floor plate (the vegetated roof). In this way, Milstein Hall may well satisfy the requirements for this credit based on open space within its own site area.

In the second case, if it is determined that the City's zoning requirement for maximum lot coverage cannot be applied to the unofficial and ad hoc "site" area that has been designated for Milstein Hall's LEED calculations, then the credit can certainly be gained using LEED's remote-campus-open-space loophole.

The "Site Development" credit rewards habitat protection/restoration and open space, in contradiction to Credit 2 incentives for urbanity and density. But creating such bizarre incentives for individual parcels of land makes no sense in any case. Individual owners of property, acting in their own self-interest, simply cannot be expected to manage environmental conditions in a sustainable manner: first, the "environment" is a bit bigger than any individual land holding; second, the necessity for business owners to exploit their own property in order to compete successfully with other business owners (or for governmental entities to compete successfully with other governmental entities) makes environmental and health concerns just another line item in a cost-benefit calculation, not an end in itself.

Rather than confronting the true nature of capital and of environmental exploitation, the LEED commentary simply invents an imaginary world where business owners don't really care about the bottom line. For example, the LEED commentary's economic justification for open space is articulated as follows: "Even in cases where rent values are high and the incentive for building out to the property line is strong, well designed open space can significantly increase property values."[13] This type of justification has no logical underpinning, in as much as the same premise could generate the opposite conclusion (i.e., it is equally plausible that in cases where rent values are high and the incentive for building out to the property line is strong, well designed open space—where such open space replaces otherwise rentable area—would significantly reduce property values).

The point is that real capitalist development is based on calculations to maximize profitability, where the provision of "open space" may or may not pay off for the developer. Furthermore, increasing the value of property is not the same as increasing profits: a developer can build an entire facade of gold bricks to create a building of extraordinarily high value while going broke at the same time. This is, in fact, exactly the case with Milstein Hall, which would certainly fall apart under its own financial weight were it not for the peculiar infrastructure of alumni and other benefactors who seem willing to subsidize such projects.

In its final submission for LEED review, Cornell claims that "the project has been developed in an area with zoning requirements, but with no requirement for open space…"[14] This is inaccurate, since the requirement for 35 percent maximum lot coverage in its U-1 zoning district seems identical to a stipulation for 65 percent open space. In any case, the credit is easy to obtain for a building on a large campus with a vegetated roof.

Stormwater Design, Quantity Control

Credit 6.1. This credit requires that peak discharge rates of stormwater—water landing on the site from rain or snow—are reduced or controlled. Different criteria apply depending on the site's imperviousness; various strategies are suggested, including water retention facilities, harvesting and reusing rainwater, and so on. Milstein Hall, on the other hand, discharges virtually all stormwater from the site and so doesn't satisfy the criteria for this credit. Its vegetated roof, described in more detail below, is not particularly effective at reducing stormwater discharge during serious storm events.

Stormwater Design, Quality Control

Credit 6.2. To get this credit, 90 percent of an average year's stormwater must be captured and treated. Milstein Hall's green roof becomes saturated pretty quickly because it consists of only a few inches of growing media (one cannot really say "soil," as the medium is more like a fine gravel). A great deal of water falling on the green roof actually ends up finding its way to roof drains, coursing through enormous drainpipes that are visible within the building (fig. 20.8), and ending up in the storm sewer system, rather than being "captured" by the roof's nominal growing medium or plantings, or directed into cisterns for use on site (there are none).

This "Stormwater Design" credit encourages quality and quantity control of run-off from rainstorms. Like the site development credits discussed earlier, the underlying premise of dealing with such environmental issues on a site-by-site basis may, or may not, make any sense. In some cases, dealing with stormwater design on a larger regional scale may be more efficient, and more sustainable. Yet LEED has no interest in actually solving regional or global problems: each site is considered in isolation from all others, so that questions about regional or global outcomes are never asked, and therefore never addressed.

In the case of Milstein Hall, the issue of stormwater runoff is particularly interesting given the provision of a vegetated ("green") roof. A more serious, heavy, and "intensive" green roof might have contributed significantly to the mitigation of storm runoff, but would not have been compatible with the architectural design. The actual green roof is thought of more as a nuanced pattern of colors than as a useful environmental feature.

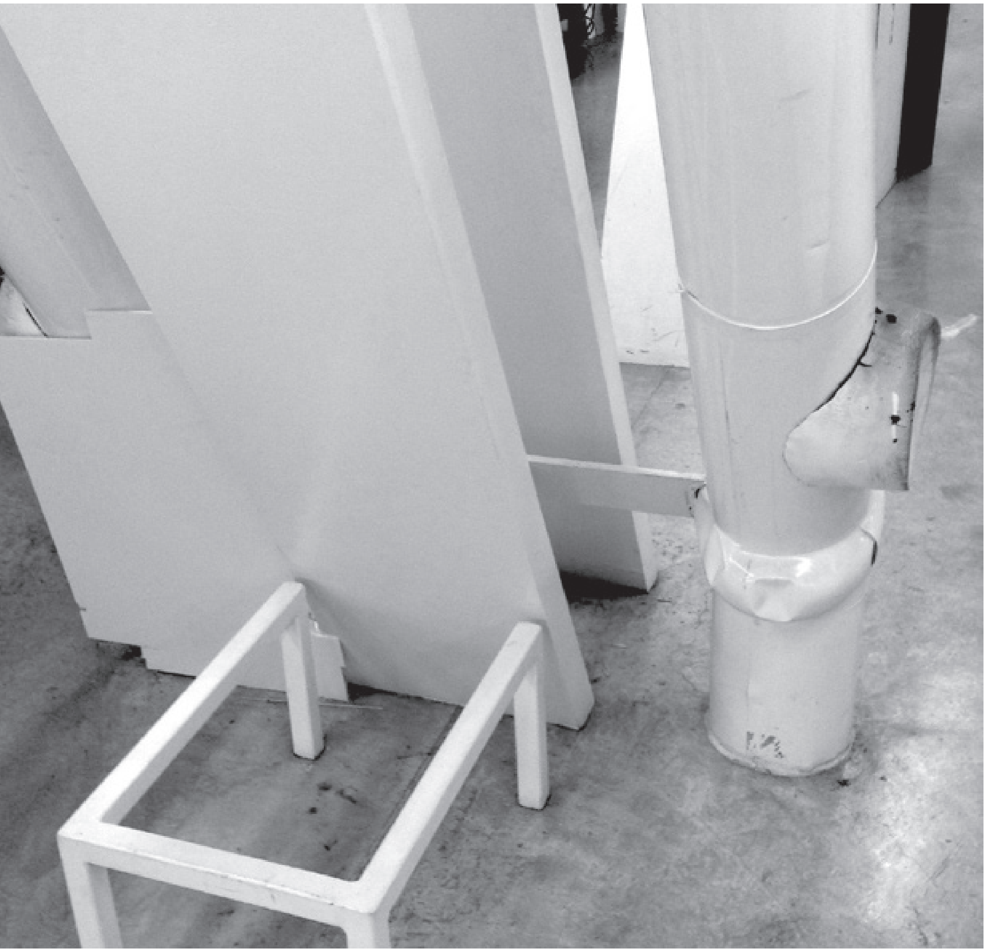


Figure 20.8. Milstein Hall's rainwater system originates in drains on the vegetated roof, courses through several large drainpipes, shown here in the second-floor studios, continues through the outer layers of the Crit Room dome (as shown in figure 2.6), connects into the regional storm sewer system under University Avenue, and finally is discharged, untreated, into Cayuga Lake.

Heat Island Effect, Non-Roof

Credit 7.1. It's hard to take this credit seriously when vegetated campus sites get points for using relatively reflective pavement for drives and parking areas. Is anyone really concerned that Cornell is heating up when asphalt paving is used? In any case, I presume that this credit is obtained because concrete with a solar reflectance index of 29 or higher—actually, it has an SRI of about 47—has been used for hardscape areas around Milstein Hall. The SRI is defined on a scale of 0 (black) to 100 (white), so a dark asphaltic pavement would presumably not qualify, although it is not at all clear that its use would have any negative impact on anything. In fact, the final LEED review indicates that 58 percent of the 39,110 square feet (3,633 square meters) of site hardscape is paved with reflective concrete, satisfying the criteria for this credit.

Heat Island Effect, Roof

Credit 7.2. This is where a credit can be earned by having a vegetated roof. The green roof doesn't do much for stormwater control, and isn't at all necessary to reduce the heat island effect—any light colored roofing material would do as well or better. It's also not clear that having a light (cool) roof saves energy in this climate, where basically half the year is governed by heating rather than cooling loads (fig. 20.9). According to the U.S. Department of Energy: "Your climate is an important consideration when deciding whether to install a cool roof. Cool roofs achieve

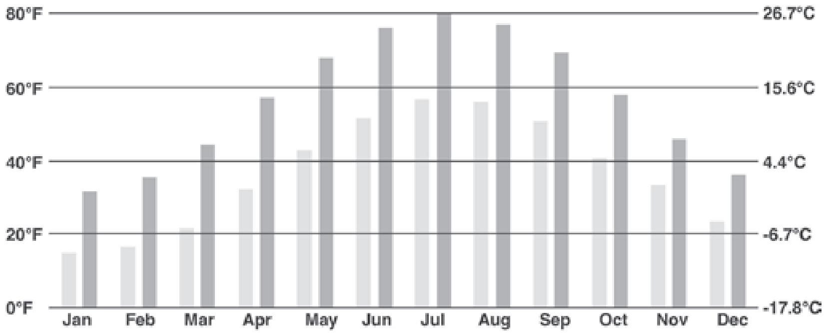


Figure 20.9. Ithaca's climate graph (average highs and lows for each month) shows that roughly half the year is governed by heating rather than cooling loads.

the greatest cooling savings in hot climates, but can increase energy costs in colder climates if the annual heating penalty exceeds the annual cooling savings."[15]

Milstein Hall's vegetated roof, while comprising most of what appears as the building's roof—other than about 1900 square feet (177 square meters) of skylights—covers only 60 percent of the actual building roof area, since much of the concrete hardscape surrounding the "building" is really a roof for below-grade spaces.

Light Pollution Reduction

Credit 8. Not even close. In a previous, and unbuilt, competition-winning scheme for Milstein Hall designed by Steven Holl, the idea of the building as a metaphorical lantern was actually exploited as a positive value. OMA's design is no different in that respect, as floor-to-ceiling wraparound glazing does nothing to mitigate light pollution. Architecture studio instruction promotes all-nighters as a de facto hazing ritual, so the glass facades of both schemes—projecting this idiocy as a point of pride for the community's "enlightenment"—is no accident.

21 WATER EFFICIENCY

Water Efficient Landscaping

Credits 1.1 and 1.2. The intention of these credits is to discourage the use of landscape irrigation, either by planting things which don't require added water (i.e., native or adapted species that survive using whatever falls from the sky); or by collecting—harvesting—rainwater or using cleaned-up wastewater (or graywater) to irrigate plants that otherwise would not survive in the environment in which they are planted. This is not hard to accomplish in the northeastern part of the U.S., which enjoys a temperate climate with adequate quantities of rain to sustain a varied assortment of planted things. In the case of Milstein Hall, the major planted element is a vegetated (green) roof, which consists of sedums—an adapted species of succulent plants that do well in the shallow engineered media characteristic of extensive green roofs.

Now, if lots of things grow in this region without irrigation anyway, why does planting a green roof count as "water-efficient"? In Los Angeles, it might be reasonable to recognize building projects that eschew turf grass and other rain-loving species, but should a New York State building be promoted as "green" just because its plantings need no irrigation? LEED answers this question by granting two points for Milstein Hall.

Innovative Wastewater Technology

Credit 2. This credit is designed to discourage use of potable water to wash away human waste. There are two benefits: less potable water is used, so that either less infrastructure is needed to produce and transport the potable water, or potable water can be diverted to other industrial or agricultural purposes; and less infrastructure for wastewater treatment is needed. Rather than investing in this type of sustainable activity, the architects for, and owners of, Milstein Hall instead have chosen to design and build an expensive architectural joke whose subject could be construed to be human waste: the toilets and urinals for Milstein Hall are defined by a curving stainless steel wall reminiscent of certain paintings by Wassily Kandinsky or, more to the point, the interlocking geometry of the small intestine (fig. 21.1).

This illustrates in a concise manner the priorities for this building and for this type of architecture: like Kandinsky's painting, the concerns are almost entirely visual and expressive. But unlike Kandinsky's painting, which by its nature can *only* be visual and expressive, works of architecture are also, and primarily, utilitarian constructions. Milstein Hall prioritizes artistry and irony while sacrificing sustainability.

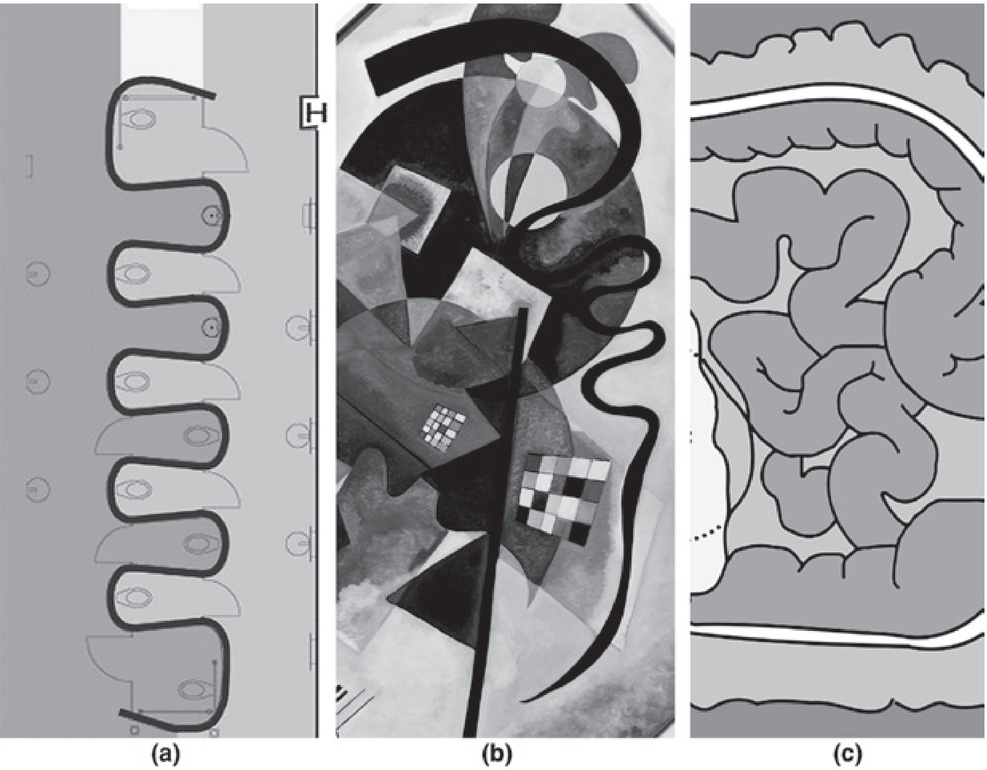


Figure 21.1. Toilets and urinals for Milstein Hall are defined by a curving stainless steel wall (*a*) reminiscent of the paintings of Wassily Kandinsky (*b*), or the interlocking geometry of the small intestine (*c*).

Water Use Reduction

Credits 3.1 and 3.2. This is the third leg of LEED's three-legged water-use stool. Aside from irrigation and wastewater reduction (Credits 1 and 2), one can also reduce the use of potable water by installing high-efficiency toilets, urinals, or showers (i.e., using fixtures that use less water per flush or that reduce the flow of water) or by reusing stormwater or graywater for flushing (so that potable water does not need to be used for this purpose) or by using sensors or similar devices on faucets (so that the quantity of water coming out of faucets is controlled). One point is gained by reducing the 1992 Energy Policy Act performance requirements by 20 percent. Two points are awarded for a 30 percent reduction. Milstein Hall gains these points presumably by purchasing high-efficiency toilets and urinals, and by installing sensors on lavatory faucets. There is no attempt to harvest and reuse rainwater that falls on the vegetated roof.

The Energy Policy Act, a federal law that mandates low-flow showerheads and water-efficient toilets and urinals, does not exist in a political vacuum. In fact, it has aroused the ire of many free-market conservatives, libertarians, as well as representatives from water-rich states. U.S. Senator Rand Paul delivered the classic rant against governmental regulation in general and low-flow toilets in particular, castigating the deputy secretary for energy efficiency at a hearing in 2011: "Frankly, the toilets don't work in my house," he said. "And I blame you, and people like you who want to tell me what I can install in my house, what I can do."[1] Paul accused the deputy secretary of hypocrisy because, even though she and others in the Obama administration were presumably "pro-choice" on the issue of abortion, they challenged his God-given right to squander environmental resources.

22 ENERGY & ATMOSPHERE

Fundamental Commissioning of the Building Energy Systems

Prerequisite 1. It is not enough to specify energy-conserving equipment and to design energy-efficient buildings: one must also make sure that such designs and equipment are actually installed and operating as intended. That a properly functioning building is not necessarily the outcome of an ordinary design process is itself a remarkable admission; in any case, this prerequisite requires that at least some "commissioning," involving the main energy-using building systems (i.e., HVAC&R, lighting and daylighting controls, domestic hot water, and renewable energy systems, if any) are included in the project. The building envelope—including Milstein Hall's stone veneer, floor-to-ceiling glass, stamped aluminum soffit panels, and so on—is excluded, although the LEED commentary suggests that "significant financial savings and reduced risk of poor indoor air quality" can be achieved by voluntarily including it within this prerequisite. And there is a commissioning *credit* which goes beyond the requirements in this prerequisite.

This prerequisite describes two documents identifying project objectives that the so-called commissioning authority (CxA) must review: the "Owner's Project Requirements" (OPR) and the "Basis of Design" (BOD), the latter of which is prepared by the design team.

Minimum Energy Performance

Prerequisite 2. This prerequisite prevents projects from obtaining LEED certification without at least meeting minimum guidelines for energy efficiency established by ASHRAE/IESNA Standard 90.1-2004. Included are requirements for the building envelope, HVAC, service water heating, power, lighting, and other equipment that are adjusted according to climate zone. Because these minimum requirements are already requirements of many state building codes, this prerequisite doesn't really force LEED-certified projects to meet energy-conservation goals that they wouldn't be compelled to meet in any case.

Even so, Milstein Hall apparently only barely satisfies this energy performance prerequisite. As discussed previously with respect to Table 5, Milstein Hall is projected to be two percent more efficient than current Code-mandated energy standards. However, it achieves this dubious energy distinction only by leaning up against two existing buildings, Sibley and Rand Halls, along parts of its southern, eastern, and western facades: both heating and cooling loads are reduced for Milstein Hall since approximately 3,000 square feet (279 square meters) of its "exterior" wall area does not actually face the exterior. As a free-standing building without the benefit of such shared wall surfaces, Milstein Hall would experience greater heat loss and heat gain, and would have difficulty meeting even the minimum standards of ASHRAE 90.1-2004.

Fundamental Refrigerant Management

Prerequisite 3. This prerequisite is, like No. 2, difficult not to meet for new construction, as chlorofluorocarbon (CFC) based refrigerants are no longer used in new HVAC&R equipment. Milstein Hall is connected to Cornell's campus-wide lake-source cooling system, so that refrigeration equipment has been already eliminated in any case.

Optimize Energy Performance

Credit 1. While there are three "compliance paths" for this credit, there is only one way to get up to 10 points for energy-efficiency: one must create an energy simulation (a computer model) for the proposed building and compare it to what is called a "baseline" condition. This is immediately very strange: how can a baseline design be created when every building—especially an idiosyncratic structure like Milstein Hall—is unique? Before describing what such a baseline building is under the LEED guidelines, a simpler and more rational basis for judging energy efficiency can easily be imagined: one could simply assign energy points based on a project's projected energy use, e.g., the number of BTUs consumed per hour per square feet (Watts per square meter) for a particular building type in a particular climate zone. Projects that used less energy per unit area would get more points. Adjustments would be made for building type (lab vs. hotel vs. office building, etc.) and climate zone.

Rather than judging energy use in this straightforward way, LEED's Credit 1 method compares the proposed building, not to objective metrics based on the rate of energy consumption, but to an imaginary baseline building that is designed just like the proposed building, but even more thoughtlessly. Using standard light framing and insulation, with ordinary windows equally distributed on all four sides, and the orientation arbitrarily varied, an average baseline energy value can be computed. If the original design fundamentally made no sense from an energy standpoint, then the baseline design will almost certainly make even less sense. In this way, even foolish design strategies can be labeled "energy-efficient," to the extent that their thoughtless original proposals perform better than their even-more-thoughtless baseline brothers.[1]

There is one additional aspect to this LEED energy-efficiency credit that makes no sense from an environmental standpoint. Energy use, or efficiency, is not measured within the LEED system by computing how much energy is used. Nor is it measured by evaluating the negative environmental impacts of such energy use. Instead, it is measured by cost. This means that proposals that cost more to heat and cool than their standard baseline variations will not be rewarded with LEED points, even if costlier approaches have environmental benefits compared to the baseline. The market-driven ideology that defines the LEED system makes cost the ultimate arbiter of virtually all environmental questions (with a few exceptions within the LEED guidelines), notwithstanding the almost embarrassingly obvious fact that it is precisely this market-driven thirst for profit that is responsible for most of the planet's environmental problems in the first place.

Milstein Hall will get six "Credit 1" points based on energy-cost savings of 28.58 percent over its baseline design—the maximum 10 points for this credit requires energy-cost savings of 42 percent. These points are based on the energy efficiency of the thermal envelope (including its high-efficiency glazing), reduced interior and exterior lighting power density (including occupancy sensors, but no illumination sensors), passive chilled beams, radiant floor heating, heat recovery, and VAV air handlers. The envelope model presumably does not account for substantial thermal bridging along the entire length of seismic expansion joints separating Milstein Hall from the existing buildings it connects to, nor substantial thermal bridging due to the continuity of uninsulated steel columns originating on the building's exterior, nor substantial thermal bridging due to shelf angles supporting stone veneer panels that cut into rigid insulation panels, nor substantial thermal bridging due to metal bollards above underground spaces that interrupt rigid insulation, nor numerous discontinuities in the building's air barrier that permit substantial air leakage. Thermal bridging in Milstein Hall was discussed earlier in the section on thermal control.

Onsite Renewable Energy

Credit 2. One to three LEED points can be awarded by obtaining 2.5 percent, 7.5 percent, or 12.5 percent of the building's energy (again measured in units of cost rather than in units of energy) onsite, e.g., from solar, wind, geothermal, biomass, bio-gas, or low-impact hydro sources. Systems can be either electrical (e.g., wind, hydro, photo-voltaic, etc.); geo-thermal (deep-earth water or steam generating either thermal or electrical energy); or solar-thermal (active solar). In other words, sustainability is measured by the cost of renewable energy, rather than by its environmental sustainability. For example, as photovoltaics get cheaper, LEED gives you fewer points for using them, since a given amount will "save" less money. Here's a hypothetical comparison:

Case 1: Proposed building uses $875 for fossil fuels (95 percent energy used) + $125 renewable energy (5 percent energy used). Total energy cost = $1,000, of which 12.5 percent of the cost is for renewable energy, resulting in three LEED points, the maximum possible. The actual percentage of renewable energy used is 5 percent of the total.

Case 2: Proposed building uses $975 for fossil fuels (90 percent energy used) + $25 renewable energy (10 percent energy used). Total energy cost = $1,000, of which 2.5 percent of the cost is for renewable energy, resulting in one LEED point. The actual percentage of renewable energy used is 10 percent of the total.

In these hypothetical scenarios, the cost of renewable energy relative to the cost of fossil fuels has gone down in Case 2, compared to Case 1. Twice the energy is derived from renewable sources in Case 2, compared to Case 1. Which case is more sustainable? According to LEED, Case 1—with only 5 percent of energy use derived from renewables—is much better than Case 2, for which 10 percent of energy is derived from renewables. Not only that, but the Case 1 building receives the maximum number of points possible for this credit (3 points) while the superior Case 2 building barely gets 1 point—and wouldn't get any points if the cost of its renewable energy dropped from $25 to $24.

Related to the use of an energy-cost metric to measure energy sustainability is the repeated insistence that market forces (costs and profitability) are consistent with energy-efficient green design. Pat Murphy wonders why "the USGBC and other LEED advocates continue to insist that green buildings with significant energy savings do not 'have to cost more?' " His answer is that "if energy-efficient green buildings do cost more (and maybe significantly more), then fewer owners and builders would take the financial risk, being unsure of the market."[2] This then leads to the conclusion, supported by the historic record, that only governmental intervention in the form of more stringent building code requirements—leveling the playing field for all developers—would lead to significant changes.

Milstein Hall has none of the conventional symbols of "green building" design, not only because its architects eschew such trite forms of expression, but also because they had—at least as manifested in this design—no serious interest in sustainable design to begin with. In spite of having an enormous amount of roof area with an ideal orientation to the southern sun, Milstein Hall employs neither photovoltaics nor any other type of renewable energy system. Is this rational from a cost standpoint? Probably. Does this demonstrate a serious interest—even if only an academic-research interest within an architecture department situated within a university with a stated commitment to sustainability—in sustainable (renewable) energy sources? Probably not.

Enhanced Commissioning

Credit 3. This credit, earned by Milstein Hall, is an extension of Prerequisite 1 (Fundamental Commissioning of the Building Energy Systems), adding the following commissioning steps:

- The commissioning authority (CxA) must be hired prior to the construction documents phase, must be independent of the design/construction teams, and experienced in at least two building projects.

- The CxA must review the owner's project requirements (OPR), the basis of design (BOD), and the design documents no later than the mid-point of the construction documents phase, rechecking later.

- The CxA must review contractor submittals.
- A "systems manual" must be produced, and a process for training building occupants and operating staff must be created.
- The CxA must review building operations 8–10 months after substantial completion (handover) of the project, and a plan must be developed to resolve anything within the commissioning scope that is unsatisfactory.

Like Prerequisite 1, the real puzzle with this LEED point is the implicit acknowledgment that buildings are not ordinarily checked out in this way. What is also striking is the fact that no further commissioning is required after 10 months of operation. The building can fall apart and its energy systems can degrade into serious states of inefficiency, but the LEED rating remains intact forever.

A more serious criticism is that such commissioning does not guarantee that LEED-rated buildings actually perform well. In late 2007, the USGBC released the results of a study it had commissioned to analyze the actual performance of LEED buildings.[3] The claim that their results "show average LEED energy use 25–30 percent better than the national average" was famously challenged by Henry Gifford, who wrote that "what the data actually indicate is that the 22 percent of LEED buildings whose owners participated in the study and reported their energy data used an average of 29 percent more energy than the most similar buildings in the dataset that the study authors chose to use as a comparison! Going to so much trouble and expense to end up with buildings that use more energy than comparable buildings is not only a tragedy, it is also a fraud perpetuated on US consumers trying their best to achieve true environmental friendliness."[4]

Enhanced Refrigerant Management

Credit 4. This credit is an extension of Prerequisite 3, to support "early compliance" with the Montreal Protocol (1989 with subsequent revisions) which was developed to protect and heal the ozone layer. It basically adds a concern about global warming potential (GWP) to the concern about ozone depletion potential (ODP) found in Prerequisite 3. To do this, the weighted average annual "life cycle" potentials of the proposed refrigerant in terms of both global warming and ozone depletion, accounting for expected annual leakage, end-of-life loss, and refrigerant charge, are considered. Small units like window air conditioners or small refrigerators are excluded. Not using refrigerants at all is another option for compliance. Milstein Hall gets this credit because Cornell's lake-source cooling eliminates refrigerants, not because of any particular design decision related specifically to the building.

Measurement and Verification

Credit 5. This credit is earned by making a plan to measure and verify energy use for at least one year, post-occupancy, using simulation or analysis methods. In other words, it is something that one would probably do anyway in earning the Credit 3 point for "enhanced commissioning." Like Credit 3, it raises questions about why such feedback is not ordinarily gathered, and why a building's LEED rating survives forever even though this measurement exercise may terminate after one year of occupancy. Most importantly, the credit, while useful in as much as it encourages owners to actually measure and examine their energy use, does nothing to actually create an energy-efficient building: the LEED point is awarded just for making the plan, not for actually meeting any energy standard. Milstein Hall earns this point, in any case.

Green Power

Credit 6. This credit requires that at least 35 percent of "grid-source" electricity—electricity not produced onsite—is from renewable sources and is produced on a "net zero pollution" basis, for a period of two years. The "green-ness" of the energy is measured per the Center for Resource Solutions (CRS) "Green-e" certification, and includes solar, wind, geothermal, bio-mass, and low-impact hydro.

The actual power purchased need not be "green," if one uses *renewable energy certificates* (RECs), *tradable renewable certificates* (TRCs), or other similar things. This credit is really designed for projects that need to buy LEED points in order to become certified, or for projects that wish to move up a notch in the LEED rating hierarchy—e.g., from certified to silver, from silver to gold, or from gold to platinum.

23 MATERIALS & RESOURCES

Storage & Collection of Recyclables

Prerequisite 1. All LEED-certified buildings must have a recycling room, with room size related to building area. Milstein Hall falls somewhere in the 50,001–100,000 square foot (4,645–9,290 square meter) range, corresponding to a required recycling room size of 225 square feet (21 square meters). I haven't actually seen a recycling room, either in Milstein Hall or in the working drawings, but it turns out that there is a small room in adjacent Sibley Hall that serves as a staging area for waste that is ultimately transferred to bins at the far end of the parking lot behind Sibley Hall. Aside from the fact that this room in Sibley Hall is much smaller than the 225 square feet (21 square meters) specified in the LEED prerequisite, the larger problem is that recyclable material is not always separated from waste destined for landfill: especially at the end of each semester, enormous quantities of mixed waste left over from final reviews overwhelm the capacity of staff charged with cleaning up the mess, and—like the discharge of sewage into water bodies in combined stormwater and wastewater systems after heavy rainfall—are "discharged" into dumpsters heading for landfill.

Building Reuse

Credits 1.1, 1.2, and 1.3. This credit doesn't apply to Milstein Hall, as it is being considered "new construction," rather than an "addition" to an existing building. Where existing exterior elements (enclosure), structure (walls and floors), and interior nonstructural elements are preserved, up to 3 points can be gained.

Construction Waste Management

Credits 2.1 and 2.2. The idea is to get the contractor to divert 50 percent (or 75 percent for a second point) of waste from disposal—landfill—by finding alternate uses, i.e., to recycle or reuse the waste. Such waste can be measured by volume or weight, but land-clearing debris is not included at all. One can count the reuse of building materials where there isn't enough surface area for those materials to count under Credit 1.

Comments within the LEED manual suggest that it would be better to focus on "source control" rather than recycling or reuse, i.e., to generate less waste to begin with by more careful planning or more logical design. Yet this credit rewards exactly the opposite practice. At the extreme, a project that generates only 1 pound (0.45 kg) of *non*-recyclable waste (but no recyclable waste) cannot get this credit, whereas a project recycling half of 100 tons (90.7 metric tons) of waste does. Milstein sent more than 68 tons (61.7 metric tons) of waste to the landfill, yet still gained 2 LEED points for recycling construction waste, as this 68 tons (61.7 metric tons) represented only 15 percent of the total waste generated by the project.

The LEED commentary also points out that low landfill costs in the past made recycling or reuse of construction waste "not economically feasible." In other words, LEED first suggests that sustainable design features should be implemented on the basis of profitability, it then notices the negative historic results of such an attitude (i.e., the current state of the planet), and yet it continues to make the profitable exploitation of the environment the "bottom line" criterion for its recommendations.

In the case of Milstein Hall, the irony of this peculiar credit can be illustrated by a particular and peculiar act of recycling: a large cast-in-place reinforced concrete wall was apparently torn down and sent off for recycling because a horizontal line on the surface of the wall—formed by the joint between two formwork panels—was not at the precise location called for in the architectural drawings. Therefore, the wall had to be built twice, using twice the labor, and twice the materials. The production of cement used in the new concrete generated additional global warming gases, as did the fuel burned in the vehicles that brought the old concrete to a recycling facility and brought the new concrete from the batching plant. And so on. Yet this costly mistake was not punished by LEED; on the contrary, by bringing this destroyed concrete wall to a recycling facility, a greater percentage of Milstein's waste was "diverted from landfill" and—according to the LEED criteria—the project became more "green." Milstein Hall received both of these waste management points.

Materials Reuse

Credits 3.1 and 3.2. Similar to the first credit, one gets a point for reusing 5 percent (or 10 percent for an extra point) salvaged, refurbished, or reused materials in the building. Since some expensive items are difficult to find used—and would generally be energy-inefficient even if available—one is allowed to exclude things like elevators, mechanical systems, plumbing, etc. from the calculation of total building materials, making it easier to qualify for the credit.

As is usual under the LEED guidelines, this calculation is based on cost so that, at the extreme, one could meet the criterion for this point by finding a small quantity of an incredibly expensive object for the building—perhaps a stained-glass window salvaged from Frank Lloyd Wright's Darwin Martin House. Because that single reused item, worth in this case about $100,000, might be valued at 5 percent of the material cost of the building, that single item could generate one LEED point.[1] In the case of Milstein Hall, no points are awarded since all material in the building is new, even if some contain recycled content.

Recycled Content

Credits 4.1 and 4.2. One gets a single point for having 10 percent of the materials in the project consisting of recycled content—with the same exclusions for plumbing, mechanical, etc. that were described under Credit 3 for materials reuse. To get the second point, this percentage must be doubled. Milstein Hall's recycled content is most likely derived primarily from its steel and concrete, which together constitute a fairly high proportion of material costs. There are two main categories of recycled content:

- Post-consumer is waste generated by the end-users of the product, whether ordinary people or facilities, that is no longer useable for its original purpose. Such things as newspapers, or plastic bottles are examples.

- Pre-consumer refers to waste that is diverted from the manufacturing process but cannot be reclaimed as part of that same process. So, if one is making sawdust, and a chip of wood falls into the waste stream, such a chip doesn't count for pre-consumer recycling since it could be sent back to the grinder to make more sawdust. But if that same chip of wood is a byproduct of a milling

> operation that produces table legs, it cannot be reclaimed in the table-leg manufacturing process, and so becomes eligible for pre-consumer recycling.

The total amount of recycled materials used for this credit is computed based on cost and must comply with the following proportions: at least 66.7 percent of the 10 percent is post-consumer with the remainder of the 10 percent permitted to be pre-consumer.

In other words, of all the materials used to make the building (excluding mechanical systems, etc.), at least 6.67 percent must be post-consumer recycled materials with the balance making up the required 10 percent being pre-consumer recycled materials for one point (requirements doubled for two points). Where some recycled content is embedded within a product, one prorates its cost according to the weight of the recycled content as a proportion of the total product weight.

The primary construction materials with recycled content that are used in Milstein Hall have high scores here: structural steel is often over 90 percent post-consumer recycled material since it is made from junked American cars; while concrete "fly ash"—considered a pre-consumer product—is generated during the production of coal to produce electricity (a notorious source of global warming gases). In both of these cases, the awarding of "green building" points raises interesting issues.

In the case of Milstein's steel structure, the extravagance of the design—including large, cantilevered hybrid trusses weighing over 1,400 pounds per linear foot (2,080 kilograms per meter of length)—creates an enormous amount of post-consumer recycled content since far more steel weight (and cost) is used compared with steel weight in a normally-configured building. For example, Rand Hall, one of two buildings connecting to Milstein Hall, is a three-story steel-framed building with about 10 pounds of structural steel per square foot of floor area (50 kilograms of structural steel for each square meter of floor area). In contrast, the 1,125 tons (1,020,583 kilograms) of structural steel in two-story Milstein Hall support a floor area—excluding the basement, framed entirely with reinforced concrete walls and slabs—of about 31,000 square feet (2,880 square meters), which works out to more than 70 pounds of steel per square foot (342 kg per square meter) of floor area. Taller buildings generally use proportionally more steel, since their columns support greater loads, yet even typical mid-rise buildings use only about 50 pounds per square foot (244 kg per square meter), while an efficient 100-story high-rise building can be built using less than

30 pounds of steel per square foot (147 kg of steel per square meter) of floor area.[2] The LEED rating system not only tolerates the inefficiency and extravagance of Milstein Hall's steel structure, but actually rewards it under this credit.

Giving points for the use of recycled steel also raises another issue: the larger context in which structural steel is produced from recycled cars encourages a culture in which cars are junked rather than repaired and kept on the road. To the extent that the market for junked cars dries up, the availability of those car bodies in the steel manufacturing process is reduced. There are contradictory imperatives at work here: on the one hand, it's good to recycle; on the other hand, it's bad to throw away potentially serviceable vehicles. Milstein's extravagant use of steel makes use of recycled cars (good) but simultaneously encourages a "disposable culture" of planned obsolescence (bad).

Fly ash used in concrete raises some of the same issues: it's good to find a use for what otherwise would remain on the ground as toxic mountains of waste, but it's questionable whether encouraging the production of such material (along with the generation of global warming gases) by burning coal is an environmentally sound policy.

There's one other interesting aspect to LEED's love affair with fly ash: by allowing its recycled content within concrete to be based on the weight of cementitious materials only, rather than on the much heavier total weight of the concrete, the use of fly ash is uniquely encouraged. Fly ash itself constitutes a cementitious material within the concrete mix. Cements are the pricey component of concrete (the heavy aggregate is basically free); since one gets points based on cost, having the fly ash computed as a fraction of the cement weight (and cost) produces a much higher valuation for the fly ash as a recycled component of concrete. To see why this is so, we can examine the calculations of fly ash value computed both ways, i.e., measuring the fly ash as a percentage of total concrete weight versus total cement weight. In Table 6, the numbers have been made up so that the calculations are easy to follow, but the basic ramifications of considering only the cementitious ingredients—and excluding the aggregate—show up clearly:

The value of the fly ash is taken as $9 (see note 3, Table 6), computed per LEED according to its weight as a fraction of the total weight of cementitious materials; it would be valued at only $2 if computed as a recycled component of the entire concrete (see note 4, Table 6). The actual (hypothetical) cost of the fly ash—not directly relevant in these LEED calculations—is $6.

This relatively detailed examination of fly ash in the LEED system is not intended as a criticism of fly ash, which has many beneficial qualities when added to concrete. Rather, it illustrates the entirely arbitrary criteria that LEED uses to make judgments about the "green-ness" of recycled products. The idea that the "use-value"—the actual contribution to environmental sustainability—of recycled products should be measured by "exchange value"—cost—makes of environmental sustainability just another line item in the corporate calculation of profitability. And in cases, such as the use of fly ash, where LEED's formula for computing recycled content based on cost appears irrational even to LEED, their formula is arbitrarily tweaked until the desired outcome is achieved.

While recycling is a positive and sustainable idea in principle, the LEED rating system encourages inefficiencies and bad habits. Inefficiencies in the manufacturing process are rewarded, since they would tend to generate more pre-consumer recycling material, leading to more LEED points; and bad habits in the production of other goods, for example, over-packaging, are also rewarded, for the same reason. Milstein Hall received 2 points for such recycling.

Table 6. Hypothetical costs and weights of major concrete ingredients.

Concrete ingredients	**Weight**	**Cost**
Fly ash	1 lb.	$6
Other cement	1 lb.	$12
Aggregate	8 lb.	$2

Table notes:

1. The weight of fly ash, measured as a fraction of the weight of cementitious materials (i.e., the combined weight of fly ash and other cements) is 1 lb. / 2 lb. = 0.5.
2. The weight of fly ash, measured as a fraction of the total concrete weight is 1 lb. / 10 lb. = 0.1.
3. The value (cost) of fly ash, prorated according to the weight and cost of cementitious materials is 0.5 x $18 = $9.
4. The value (cost) of fly ash, prorated according to total concrete weight and cost is 0.1 x $20 = $2.

Regional Materials

Credits 5.1 and 5.2. One point is awarded for having 10 percent of materials (also excluding mechanical systems, etc., as explained in prior credits) extracted, processed, and manufactured within 500 miles (805 km) of the project site. A second point is awarded for doubling this percentage.

As usual, the 10 percent (or 20 percent) is based on cost so that a single diamond of sufficient value used as decorative embellishment for a building in Lichtenburg, South Africa, for example, would presumably qualify for 2 LEED points, in spite of its dubious relationship to sustainability.

The LEED rationale for using regional materials is not only to reduce the environmental costs of transportation over long distances, but also to support "the use of indigenous resources" for its own sake. The claim that "the local economy is supported…"[3] seems specious, since local manufacturers who sell beyond the 500 mile (805 km) radius would lose out to the same extent that manufacturers who sell only locally would gain. To the extent that Boeing sells its products only within 500 miles (805 km) of Seattle, the economy of Seattle suffers. Is it rational, or sustainable, to manufacture such products "locally," or even "regionally"?

LEED claims in their guidelines that "money paid for these [regionally produced] materials is retained in the region, supporting the regional economy…"[4] This is questionable for the same reason. It also is an idealization of a profit-driven, global economic system that knows no national boundaries, let alone artificial boundaries defined by a 500-mile (805 km) radius. Unlike other credits, the value of this credit is not measured by comparing costs of using local/regional materials to costs of other options, thereby contradicting the entire LEED premise that market-driven decisions underlie sustainable building practices. Here, the "market" that LEED seeks to encourage has nothing to do with the international marketplace that increasingly characterizes global capitalism. That LEED places a positive value on market inefficiencies associated with local production can only be explained by the internal ideologies and politics within the LEED consensus process, and not by any objective measure of sustainability.

Like the LEED credit for reduced landscape irrigation in rainy climates with no need for irrigation, the credit for "regional materials" rewards buildings that happen to be near manufacturing facilities for products that would have been used in any case. Conversely, buildings in locations without a regional manufacturing base are still encouraged to build with "local" materials—manufactured within 500 miles (805 km) of the building site—even if a product manufactured 621 miles (1000 km) away would have superior "green" attributes and lower life-cycle costs.

In the case of Milstein Hall, not as much of the materials used in the building were manufactured within the required 500-mile (805 km) radius as one would expect (so while one point will be earned, a second point will not). For example, the unusually large steel W-sections used for hybrid truss chords and columns were *fabricated* within the 500-mile

Figure 23.1. Acceptable locations for "regional materials": the circle represents a 500-mile (805 km) radius around Ithaca, NY. The site labeled "A" is Milstein Hall in Ithaca; site "B" is Milstein Hall's truss-fabrication plant in Quebec; site "C" is one of the few steel mills that actually make W-sections on the east coast; Site "D" is a steel mill operated by Steel Dynamics, Inc. in Columbia City, Indiana.

(805 km) radius in a specialized facility located in Quebec, Canada, but it is not clear where they were produced. The large steel hybrid trusses and columns therefore may or may not qualify for points since, under LEED guidelines, the entire extraction, production, and fabrication process must occur within that magic circle. Of course, even if the steel sections were produced, say, in Columbia City, Indiana, by Steel Dynamics (fig. 23.1, location "D") and fabricated in Quebec by Canatal Industries (fig. 23.1, location "B")—both sites within the 500-mile (805 km) boundary—it would still be necessary to truck the steel sections 938 miles (1,509 km) from Indiana to Quebec, and then truck the finished truss segments another 475 miles (764 km) from Quebec to Ithaca, for a total transport distance of 1,412 miles (2,273 km). In contrast, a single production-fabrication plant located outside the circle, say at site "C" in figure 23.1, would have far less transport impacts yet would be disqualified under the LEED guidelines.

Rapidly Renewable Materials

Credit 6. This credit encourages the use of materials that are harvested from plants having a 10-year (or shorter) cycle of growth, and requires that 2.5 percent of the total material value (i.e. cost), excluding the usual mechanical systems and so on, comes from such plants. Examples of rapidly renewable materials include the following: bamboo, wool (not exactly from a plant, but we get the idea), cotton for insulation, agrifiber, linoleum, wheatboard, strawboard, and cork.

What this credit points to, without actually requiring it, is scientific ("responsible") management of renewable plant-based materials, whatever their growth cycle might be. Suggesting instead that the use of plants with a short growth cycle should be rewarded makes no sense. Should we also require that the grains we eat every day have a corresponding growth cycle of one day? Or that Johnnie Walker Black Label Scotch Whiskey cannot be sustainably produced because its constituent whiskies are each aged for at least 12 years? A rational society would organize the production of grain or of any other product so that its use is consistent with its production cycle. One would expect a similar stipulation for products used in construction rather than an arbitrary value assigned to things that grow quickly.

The LEED commentary suggests that because "rapidly renewable resources may be harvested more quickly, they tend to give a faster payback on investment for manufacturers."[5] First, this may make sense from the standpoint of capital, which prefers a fast rate of turnover from the start, but only to the extent that the rapidly renewable product is comparable to the not-so-rapidly renewable product—e.g., that bamboo is interchangeable with Douglas-fir for use in a building's structural framing (it isn't).

Second, if two different forest species are harvested for lumber, one with a growth period of 10 years and one with growth period of twenty years, the extraction of wood need not happen only on a 10- or 20-year cycle. Production can be organized so that sections of the forest are harvested on a daily, weekly, monthly, or yearly basis, depending on the judgment and calculations of the business owners. Neither their "investment" nor their "payback" has any necessary relationship to the growth cycle of an individual tree, unless—as argued above—the two species are otherwise indistinguishable, in which case a quicker turnover is advantageous for a capital investment.

Third, the LEED commentary goes on to suggest that rapidly renewable resources take up less space since they can be harvested at a more rapid pace, and that this is somehow advantageous: "The land saved [?] from the production requirements of rapidly renewable resources may be used for a variety of other uses…"[6] as if slow-growth forests are not a legitimate use of real estate.

Finally, what does this have to do with sustainability? Throughout history, humans have proven themselves capable of destroying both fast- and slow-growing species of plants and animals—including large segments of their own human species (a notoriously slow-growing product). Humans have also proven capable of managing the consumption of both fast- and slow-growing species of plants and animals in such a way that these species remain viable over time. The first case is, by definition, not sustainable. The second case is, by definition, sustainable. Neither case has anything to do with the rapidity with which the "resource" renews itself.

While Milstein Hall utilizes some rapidly renewable materials (e.g., cork trim surrounding the wood floor of the studio lounge), not nearly enough material value is embedded in such things to qualify for this point. To get a rough idea about how much rapidly renewable material would be required, we can attempt to calculate 2.5 percent of Milstein Hall's material cost (excluding mechanical systems, elevators, and so on). LEED allows us to assume, as a rough approximation, that 45 percent of the total building cost goes to materials (minus the excluded equipment and systems), so if the cost of Milstein is about $55 million (this is just a guess; the actual real cost is probably higher), then the cost of materials can be assumed to be 0.45 × $55 million = $24.75 million, and the required value of rapidly renewable materials would be 0.025 × $24.75 million = $618,750. One would need to buy a lot of cork to get this point.

Certified Wood

Credit 7. This point is awarded when half the wood products used in the building come from responsibly managed forests, as certified by the Forest Stewardship Council's (FSC) "Principles and Criteria."[7] It is possible, but not required, to include temporary products—e.g., formwork, shoring, etc.—in these calculations, but only if all such wood products are included.

The concept of "chain-of-custody" (COC) is important here, since wood that has been obtained from forests and then used in all sorts of products cannot easily be identified as "responsible" merely by observation: it must have a "birth certificate" of sorts that proves it comes from the right family. The fraction of good wood is based on cost, which helps, since such wood is invariably more expensive. Where the wood is embedded in some other product, one is instructed by LEED to prorate its value using any consistent measure—weight, volume, or cost.

In the case of Milstein Hall, enormous quantities of non-certified wood were used during the construction process, especially plywood and MDO boards for concrete formwork and ordinary sawn lumber for shoring. Large amounts of engineered wood trusses made from ordinary dimension lumber were designed and fabricated to support three layers of plywood constituting the forms under the reinforced concrete dome. All of this wood was taken down and removed, possibly recycled, but not reused, and all at great expense. A far smaller quantity of wood made its way into the final building design, mostly within the upper-level studio space, but also in the elevator, and as underlayment behind felt pin-up boards. The underlayment, while not made with wood from certified forests, still may be "certified" under new rules promulgated by the FSC.[8] The plywood elevator finishes appear not to qualify.

The small studio lounge on the second floor has what was initially intended to be a certified ash floor, but the wider ash planks finally specified and installed do not meet FSC standards (fig. 11.21), most likely because they come from old-growth trees. Some sloped wooden seating on this level is also framed and finished with wood. But because these finished materials—even if certified—are fastened to non-certified substrates of ordinary lumber or plywood, the certified portion constitutes less than half of the total weight or volume. This is where LEED's emphasis on cost becomes so important: since certified products are more expensive than the ordinary lumber used elsewhere, a LEED point remains possible even when the quantity of such certified wood is quite small. And one can always "buy" the point by searching for even more expensive certified products to compensate for the larger quantities of non-certified (non-sustainable) lumber actually used.

What is also striking about this LEED point is that it is awarded even when a relatively tiny portion of the building uses wood products: virtually everything in Milstein Hall is constructed and finished with reinforced concrete, structural steel, stainless steel, aluminum, and glass. LEED makes no distinction between two buildings of the same size, one of which is built entirely with certified wood structure and finishes, and one of which is constructed almost entirely with concrete, metal, and glass, but with a tiny amount of wood flooring or underlayment—most of which (measured by weight or volume) isn't even certified. Each building can get one point for its use of certified wood. But Milstein Hall did not get the certified wood point, in part because the ash floor no longer complies.[9] In retrospect, the final word on the sustainability of ash flooring has come, not from LEED, but from larvae of the Emerald Ash Borer which, since their discovery in 2002, have "killed hundreds of millions of ash trees in North America" by "feed[ing] on the inner bark of ash trees, disrupting the tree's ability to transport water and nutrients."[10]

24 INDOOR ENVIRONMENTAL QUALITY

Minimum IAQ Performance

Prerequisite 1. The required baseline for indoor air quality (IAQ) is defined in four sections of ASHRAE 62.1-2004, Ventilation for Acceptable Indoor Air Quality. Buildings that are naturally ventilated, i.e., those relying on windows or "passive ventilation," as well as buildings that rely on mechanical equipment or "active" ventilation are covered in that standard. For passive buildings, occupiable spaces must be within 25 feet (7.6 m) of a window (or roof opening) which must provide a "vent" area equal to at least four percent of the occupied floor area. These requirements are standard operating procedure in many places; the four percent requirement has been embedded in the *International Building Code* (IBC) since its inaugural 2000 version; prior codes and regulations, going back to the New York State Tenement House Act of 1901, actually required a greater percentage of floor area for the area of ventilation openings (i.e., the operable parts of windows). According to the LEED guidelines, when this minimum four percent vent area requirement is met, "no additional design effort or capital cost will be required to meet this prerequisite."[1] In other words, this prerequisite for IAQ sets the bar pretty much where it has already been lowered.

Even so, major problems concerning naturally ventilated spaces in Sibley Hall were created by the design and construction of Milstein Hall: on the one hand, the need for protected openings in the fire barrier between the Milstein Hall and Sibley Hall rendered those openings inoperable; on the other hand, Milstein Hall itself blocked access to fresh air for basement, first-floor, and second-floor Sibley Hall windows on Sibley's north and east facades. Remarkably, mechanical ventilation for those spaces in Sibley Hall affected by the construction of Milstein Hall was not specified as part of the Milstein Hall design, and was installed only after I brought these code violations (and unhealthy conditions) to the attention of Cornell.

There is a conflict between indoor air quality (IAQ)—one of the major elements within the broader category of indoor environmental quality (IEQ)—and energy use. This conflict comes about because fresh air is more expensive to produce (more energy-intensive) than recycled stale air. In a hot, humid, air-conditioned environment, fresh air needs to be both cooled and dehumidified, processes that consume a great deal of energy. In a cold climate, fresh air needs to be heated, a process also requiring energy. In both cases, air filters are often required to remove contaminants—such filters must be periodically replaced, adding to the cost. To the extent that the energy needed to produce this fresh air is created largely from fossil fuels, global warming gases are also released. This conflict is noted, but not resolved, within the LEED guidelines.

A larger question is why indoor environmental quality issues are even included within a green building rating system at all, as they have either no direct impact, or a negative impact, on energy use and global warming. Ideologies from the right and from the left both miss the point.

Ideologies on the right. LEED's market-driven rationale is that "Americans spend an average of 90 percent of their time indoors, so the quality of the indoor environment has a significant influence on their well-being, productivity, and quality of life."[2] In other words, breathing fresh air rather than contaminated air is useful for human health, so providing it, at least to the extent required by most building codes, should be a prerequisite for any green building. And in case a building owner/developer is tempted to skimp on this provision, LEED makes the dubious claim, supported by dubious research, that business "productivity" is improved when workers are healthier. The fallacy in this argument is easiest to see where workers do not get paid sick leave (this includes approximately half of all full-time private sector workers in the U.S.). When sick workers don't get paid, productivity (a measure of output per amount invested) doesn't necessarily suffer, since either remaining workers will pick up the slack, actually increasing productivity, or temporary workers will fill in, either improving productivity or leaving it unchanged. The suffering of workers—admittedly increased by conditions of poor air quality—cannot simply be equated with reduced productivity of capital.

Even where a certain allowance is made for sickness (e.g., company policies or legislation mandating a certain number of "sick days"), this simply becomes the new baseline factored into business calculations; in this context as well, improved worker health due to improved IAQ does not necessarily translate into increased rates of output (productivity).

Studies that purport to show productivity gains due to increased indoor air quality are often flawed, in that they do not actually measure productivity, but rather measure health improvements which are then carelessly extrapolated into productivity claims. For example, given a potential reduction in respiratory illness of 9 percent to 20 percent based on improved indoor air quality, one scholarly study concludes that "16 to 37 million cases of common cold or influenza would be avoided each year in the US. The corresponding range in the annual economic benefit is $6 billion to $14 billion."[3] This so-called "benefit" is calculated by multiplying the average wages of the workers studied (apparently $375 per sickness) by "16 to 37 million" incidents of colds or flu per year. But it is not at all clear that this "benefit" is lost, or, if it is lost, who the loser is: to repeat the point already made, when sick workers are not paid, productivity may actually increase (as fellow workers pick up the slack), or at least stay more or less the same as replacement workers are hired.

Another criticism of productivity claims is that "worker productivity goes up when employees move to a new office space, but that the result is often short-lived." In other words, "since most green buildings have been around for less than five years, any long-term studies of costs and productivity are simply not yet available."[4] I haven't been able to independently verify this claim.

Practices that damage worker health have always been perfectly compatible with both productivity and profitability. It is always state intervention (40-hour work week, child labor laws, and so on) that establishes the baseline conditions for acceptable damage to worker health that promotes growth of the economy as a whole. While it may be true that competition for the highest-level elite workers impels owners in such industries to offer higher-quality interior environments, low levels of indoor air quality for the rest of the work force threaten neither productivity nor profitability.

Ideologies on the left. Criticism from the left focuses, not on alleged productivity gains, but on the other two aspects of sustainability attributed by the LEED guidelines to improved indoor air quality: "well-being" and "quality of life." Left ideologues can point to LEED-rated prisons (the Federal Prison Camp in Butler, NC is the country's first LEED-certified prison[5]) or military facilities (the U.S. army has been committed to building LEED-silver since 2006[6]) and argue that the criteria of "well-being" and "quality of life" are voided of all useful meaning when they embrace building practices through which humans are incarcerated or killed. Extrapolating further, Jeff Dardozzi in *Monthly Review* has written: "The logic of LEED is that it can be applied to any building, regardless of social context and the consequences of the activity taking place within the structure. A nuclear weapons factory, a biological warfare lab, or a concentration camp could carry a platinum rating. Guantánamo could be redeemed by virtue of bike racks, orange jumpsuits made from recycled fiber, cattle prods energized by photovoltaics, and water-boarding conducted with reclaimed grey-water."[7]

But this type of criticism is flawed in its implication that LEED-rated buildings, whether real or hypothetical, are uniquely problematic. Exploitation, damage, and destruction of both humans and environments is systemic, not an aberration at the fringes of "green" building design that could be corrected by prohibiting prisons and military facilities from getting their coveted LEED certificates. Rather, the activities within virtually all LEED-rated buildings as well as within virtually all non-LEED-rated buildings contribute to the destructive outcomes associated with market economies: there is no other game in town.

Environmental Tobacco Smoke Control

Prerequisite 2. Environmental Tobacco Smoke (ETS) is another name for secondhand smoke. There are three options for compliance with this LEED prerequisite: either prohibit smoking in the building and limit outside smoking to designated areas at least 25 feet (7.6 m) from entries or windows; or allow smoking inside within designated smoking areas which are sealed, depressurized, and exhausted to the exterior while also having the same outside smoking limits as in the first option; or, for residential occupancies only, prohibit smoking in common areas, limit outside smoking as in the other options, make sure all penetrations between dwelling units are sealed, and either weatherstrip doors to corridors or maintain positive pressure in corridors relative to dwelling units.

This is a bit strange to have in a sustainability guideline, since it is impossible to assess its impact over time. Nothing prevents the current building owner, or a new owner, from changing a smoking policy once the LEED certification is awarded. On the other hand, smoking is already prohibited in many buildings by state or local law. In the case of Milstein Hall, existing campus regulations cover essentially the same ground as this LEED credit.

Outdoor Air Delivery Monitoring

Credit 1. The idea of this credit is to monitor indoor air quality by measuring CO_2 levels either directly in densely-occupied spaces, i.e., those with at least one person per 40 square feet (12 square meters), or in non-dense spaces at points where air is exhausted. CO_2 levels do not, by themselves, define indoor air quality, but they are a convenient indicator of potential IAQ problems—convenient both because high CO_2 levels may indicate the presence of other pollutants, and also because CO_2 levels are relatively easy to measure. On the other hand, such readings are not conclusive:

> The relationship between the concentrations of CO_2 and other indoor contaminants depends on the sources of these other contaminants. The rate at which CO_2 is generated in a space depends on the number of people, their size and their level of physical activity. If other contaminants are generated at a rate that also depends on the occupancy level, then CO_2 may be a good indicator of the concentrations of these contaminants. However, only some contaminants are generated at a rate that depends on occupancy, and many contaminant sources are not a function of occupancy, for example emissions from building materials and contaminants entering a building from outdoors. Carbon dioxide concentrations do not provide any information on the concentration of contaminants emitted by occupant-independent sources.[8]

To get this LEED point, any CO_2 reading measured above 10 percent of the setpoint must set off an alarm to maintenance personnel or occupants. This is another instance where the baseline for LEED compliance is set arbitrarily low—so low, in fact, that EQ Credit 2 for increased ventilation (coming up next) mandates more fresh (make-up) air than would be required for Credit 1. And even Credit 2 is viewed as a compromise between what is needed and what is "practical." Milstein Hall gets one point here.

Increased Ventilation

Credit 2. The requirements for this credit vary for active and passive systems. For mechanically-ventilated spaces, one must provide 30 percent more outdoor air than mandated per ASHRAE 62.1-2004 (i.e., 30 percent more than Prerequisite 1 requirements). For naturally-ventilated spaces, one must comply with "Carbon Trust Good Practice Guide 237 (1998)" as well as some requirements of the "Chartered Institution of Building Service Engineers (CIBSE) Applications Manual 10:2005, Natural Ventilation in non-Domestic Buildings," while demonstrating compliance with either the CIBSE recommendations or the "macro-scopic, multi-zone, analytical model" in ASHRAE 62.1-2004, chapter 6.

This increased ventilation rate is admittedly lower than what research findings suggest would be necessary to achieve acceptable IAQ, i.e., 25 cubic feet per minute (11.8 liters per second) per person ventilation rates, equivalent to an increase of 50 percent over the ASHRAE (and Prerequisite 1) requirements. The LEED commentary admits that "30% was chosen as a compromise between indoor air quality and energy efficiency." In other words, one can get two LEED points for IAQ without adequately protecting occupant health. Actually, some experts feel that, even though "there is no magic number for ventilation rate/person… there are demonstrated health benefits from increasing ventilation up to 50 cfm (24 L/s)/person."[9] This amount of fresh air is twice as great as the hypothetical upper limit suggested, but not even required, by LEED in their discussion of the subject.

The idea that increased ventilation rates necessarily improve indoor air quality is however—and paradoxically—questionable, since overventilation, especially in hot, humid climates, can overwhelm mechanical systems, with the result being mold growth and, as a result, worse indoor air quality.[10]

Milstein Hall, in any case, does not satisfy the fresh air criteria for this credit.

Construction IAQ Management Plan

Credits 3.1 and 3.2. Two points are available for dealing with IAQ at the (a) construction and (b) pre-occupancy phases—Milstein Hall gets only 1 point for the construction phase. The pre-occupancy phase credit was denied because Cornell did not test for 4-Phenylcyclohexene (4-PCH), a gas released from carpets and fabrics with styrene butadiene rubber (SBR) latex backing material.

During construction, a plan must be developed with the following goals: comply with Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) IAQ guidelines, 1995, chapter 3; protect absorptive materials from moisture; provide filters for any building air handlers used during construction with a minimum efficiency reporting value (MERV) of 8 at each return grille; replace these filters prior to occupancy; specify low-toxicity paints, carpets, etc. (also covered in EQ Credit 4); and ventilate VOC-emitting materials directly outside.

Immediately before occupancy, a plan for the second LEED point (Credit 3.2) requires that fresh air be supplied at a rate of 14,000 cubic feet per square foot (4,267 cubic meters per square meter) of floor area, with the internal temperature at least 60° F (16° C) and relative humidity no more than 60 percent, before the building is occupied. Where occupancy needs to happen before such a "flush-out" can be completed, different—but equivalent—procedures are specified.

Optionally, one can test the air quality before occupancy to comply with these maximum pollutant levels: formaldehyde at no more than 50 parts per billion; particulates (PM10) at no more than 50 micrograms per cubic meter; total volatile organic compounds (TVOC) at no more than 500 micrograms per cubic meter; and 4-phenylcyclohexene (4-PCH) at no more than 6.5 micrograms per cubic meter—this last requirement applies only when styrene butadiene rubber, used commonly as a carpet backing, is installed in the base building.

The LEED rationale for improving IAQ, discussed in relationship to Prerequisite 1, is repeated here: increasing worker productivity translates to "greater profitability for companies." The trade-off between energy cost and indoor air quality is made explicit elsewhere in the LEED guidelines, so that the claim here that IAQ improvements, in and of themselves, lead to "greater profitability" is contradicted by the admission that the added costs of heating and cooling fresh air may outweigh any productivity gains.

Low-Emitting Materials

Credits 4.1–4.4. The intention of this credit is to reduce the emission of harmful contaminants associated with various building materials. One point is available in each of the following four categories applicable, in general, to interior construction only:

- Adhesives and sealants must comply with South Coast Air Quality Management District (SCAQMD) Rule #1168 and, for aerosol adhesives, with Green Seal Standard for Commercial Adhesives GS-36.

- Paints and coatings must comply with SCAQMD VOC limits for clear wood finishes, floor coatings, stains, sealers, shellacs; Green Seal Standard GS-11 for paints, coatings, and primers; and Green Seal Standard GC-03 for anti-rust paints.

- Carpet systems must comply with requirements of the Carpet and Rug Institute's Green Label Plus program, while simultaneously meeting the adhesive standards listed above.

- Composite wood and agrifiber products must be produced with no added urea-formaldehyde resins; since exterior products are commonly made with phenol formaldehyde which, unlike urea-formaldehyde, does not off-gas at normal temperatures, they are considered acceptable under these guidelines. Included are such things as plywood, particle board, medium-density fiberboard, and so on.

Milstein Hall gets points for the first three of these categories, but not without some difficulties: it is likely that some of the "green" products used—for example, form-release agents applied to formwork surfaces in contact with newly-cast concrete—caused unexpected and unacceptable discoloration of the finished concrete surface which, in turn, required extra materials and work. The third credit is awarded because a token amount of "Bentley Prince Street" carpet, used only at the bottom level of the auditorium, is certified to meet the requirements of Green Label Plus (fig. 24.1). The last of these credits was not awarded, possibly because of plywood or other urea-formaldehyde emitting wood products used inside the building.

Indoor Chemical and Pollutant Source Control

Credit 5. This credit seeks to reduce the ongoing contamination of occupied space, not from construction materials, but from exterior pollutants and interior processes that release hazardous gases. Milstein Hall gets this point by complying with all of the following:

- Provide 6-foot long entry mat, grate, grille, etc. to capture dirt and other particulate matter.

- Treat any space in which hazardous gases or chemicals are present

Figure 24.1. A small amount of "sustainable" carpet, used at the bottom level of the auditorium space, generates a LEED point.

much like designated smoking areas (Prerequisite 2): floor-to-deck sealed partitions, negative pressure, and direct exhaust to the exterior. "Convenience" copiers and printers are excluded.

- Where mechanical ventilation is used, process both supply air, and any return air that will become supply air; and use pre-occupancy filters with MERV = 13 or better (not just MERV = 8 as in Credit 3).

Milstein Hall complies, in part, by outsourcing all the potentially hazardous equipment used in modern architecture programs to its neighbors—Sibley and Rand Halls. And in doing so, the hazards don't simply disappear: Sibley Hall's digital fabrication lab, for example, contains 3-D printers, some of which use material that is both toxic and carcinogenic. The manufacturer's instruction to use the printer "only outdoors or in a well-ventilated area" is addressed by installing transfer grilles between the adjacent corridor and the room. This strategy would be noncompliant except that several printers placed in the corridor allow the corridor to be labeled as a "room," and room-to-room air transfer, unlike corridor-to-room air transfer, is permitted (fig. 24.2).[11]

Controllability of Systems

Credits 6.1 and 6.2. This credit consists of two points, one each for providing decentralized control of lighting and heating/cooling.

Lighting: To comply with Credit 6.1, lighting controls must be provided for 90 percent of occupants (individual users) and for 100 percent of all multi-occupant spaces, so that lighting can be adjusted to suit particular tasks according to individual preferences.

Milstein Hall embodies the exact opposite attitude, which shows up as well in Sustainable Site Credit 8 for light pollution reduction—the same non-controllable interior lighting that pollutes the night sky also influences the interior environment. Milstein is a glass box that is illuminated 24/7, even when the building is lightly occupied. Not only do students and faculty have no individual control over illumination levels from overhead lights, but glare from skylights has also proved to be a problem in certain locations on the studio level under the skylights. It appears to be practically impossible to control lights in areas where digital projection devices are used, or for individual workstations where lower light levels may well be preferred when working with computer monitors.

Thermal comfort (heating/cooling): To comply with Credit 6.2, "comfort control" must be provided for 50 percent of occupants (individual space users) and for 100 percent of multi-occupant spaces. Such controls can be hi-tech or low-tech (e.g., operable windows count), and can address any one of the four thermal comfort parameters: air temperature, radiant temperature, air speed, and humidity.

Milstein Hall has no such individual thermal comfort controls.

Thermal Comfort

Credits 7.1 and 7.2. This credit has a "design" and "verification" component, each worth one point. Milstein Hall gets them both.

Design: To comply with Credit 7.1, the project must satisfy ASHRAE

Figure 24.2. Sibley Hall's digital fabrication lab, immediately adjacent to Milstein Hall (visible through the fire barrier windows), has no fresh air supply—except for what gets in the room through transfer grilles visible above the glazed wall—in spite of containing 3-D printers, some of which use material that is both toxic and carcinogenic.

Standard 55-2004 Thermal Comfort Conditions for Human Occupancy.

Verification: Compliance with Credit 7.2 is determined by surveying occupants 6–18 months after the building is completed. Per the ASHRAE standard cited above, 20 percent or greater occupant dissatisfaction requires that thermal issues be addressed and fixed. However, a survey conducted six months after occupancy will not necessarily reveal thermal problems that are seasonal in nature, e.g., overheating in the summer, or cold indoor temperatures in the winter. It also offers no guarantee that building operators will maintain adequate comfort levels in the years after such a survey is conducted.

Daylight and Views

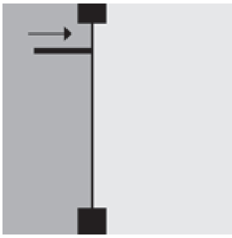
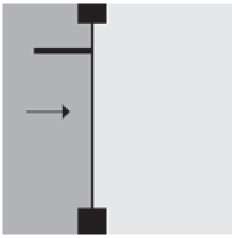
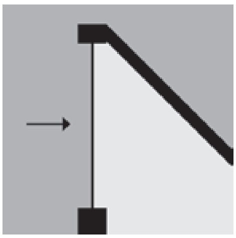
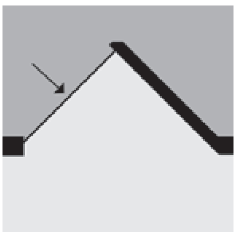
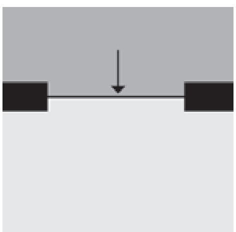
Credits 8.1 and 8.2. This credit deals with glass and glazing from two points of view, and allows one point for each: first, bringing daylight inside and second, providing views to the outside.

Daylight: The basic criterion for this credit is to supply daylight to 75 percent of the building's regularly occupied interior spaces. This is defined in three different ways, any of which can be used to demonstrate compliance:

(a) Achieve a glazing factor (*GF*) of two percent measured at the back of all required spaces (i.e., in 75 percent of the building's regularly occupied areas). *GF* is calculated as: (window area / floor area) × (window geometry factor) × (actual T_{vis} / minimum T_{vis}) × (window height factor). In this equation, T_{vis} is the visible light transmittance defined as the ratio of transmitted light to total incident light (where "light" is the visible spectrum, i.e., having wavelengths of 380–780 nanometers). The minimum value is shown in Table 7, adapted from the LEED guidelines, along with geometry and height factors for five typical window/skylight configurations (from top to bottom: side light with daylight glazing, side light with vision glazing, top light vertical monitor, top light sawtooth monitor, and top light horizontal skylight).

(b) Use computer simulation to prove that daylighting provides 25 footcandles of illumination (assuming clear sky, noon, equinox, measured 30 inches above floor) in the required 75 percent of spaces.

Table 7. LEED glazing factor (GF) parameters.

Diagram	**Geometry factor**	**Minimum T_{vis}**	**Height factor**	**Glare control**
	0.1	0.7	1.4	Blinds, light shelves, exterior shading
	0.1	0.4	0.8	Blinds, exterior shading
	0.2	0.4	1.0	Fixed interior blinds, adjustable exterior blinds
	0.33	0.4	1.0	Fixed interior blinds, adjustable exterior blinds
	0.5	0.4	1.0	Interior or exterior fins, louvers

(c) Same as option (b), but use actual measurements of illumination levels on a 10-foot (3 m) grid instead of computer simulation. Only rooms that comply completely can contribute to the 75 percent area requirement.

Glare control is also a critical aspect of this credit; guidelines can be found in Table 7. It is unclear why the lack of such controls in Milstein's studio floor skylights did not prevent LEED from awarding this credit, in which Cornell claims compliance with a minimum two percent glazing factor in 100 percent of all regularly occupied spaces (Option 1).

Views: The basic criterion of Credit 8.2 is to provide a direct line of sight to outdoor space via "vision glazing," i.e., glazing positioned between 2'-6" (0.76 m) and 7'-6" (2.3 m) above the floor for 90 percent of the occupants of regularly occupied areas. The entire area of a single-person space counts if at least 75 percent of the space meets the sightline criteria; and the entire space does not count if less than 75 percent of the area complies. On the other hand, only the actual compliant areas (i.e., those areas within the room where sightlines can be drawn through windows) count in multi-occupant spaces.

Milstein Hall's upper-level studio is entirely open, except for an electrical closet that doubles as a projection screen. While students may be seated as far as 80 feet (24.4 m) from perimeter glazing, they still have a "direct line of sight" to outdoor space. That the point for this credit was not awarded is perhaps due to the 90 percent threshold criteria not being met.

25 INNOVATION & DESIGN PROCESS

Milstein Hall gets four points in this "innovation" category (the maximum possible) for developing and implementing strategies that address sustainability issues in ways that are either not covered in the LEED guidelines or that substantially exceed base LEED requirements. In order to get these points, the same sort of documentation normally required for LEED credits is expected: i.e., identifying the intent, the proposed requirements, the required submittals, and strategies (design approach).

There are some general guidelines for what constitutes an acceptable credit under this category: where existing LEED guidelines are exceeded, one should double the required outcome, or get to the next percentage increment; and where something new is proposed, it must "demonstrate a comprehensive approach and have significant, measurable environmental benefits…"[1]

Transportation Demand Management

Credit 1.1. This credit is boiler-plate "innovation" that Cornell applies to all its LEED-seeking buildings, based on a program initiated in 1990 "to reduce commuter demand for parking spaces by providing efficient, cost-effective and environmentally friendly alternatives to commuting via single-occupancy, personal vehicles (SOVs)." The program has little to do with Milstein Hall, since Milstein Hall is occupied overwhelmingly by students. Cornell's Transportation Demand Management Program "concentrates on faculty and staff at the university, because it was their commuting habits that could be most impacted, and as a group, students own or operate far fewer vehicles than do employees."[2] As was pointed out under Sustainable Sites Credit 4.4, Cornell was, and still is, intending to actually increase parking adjacent to Milstein Hall. While it is often difficult to assign particular parking spaces to specific buildings on a campus like Cornell, the connection between Milstein Hall and the proposed adjacent parking structure was made explicit by linking them together in a single Draft Environmental Impact Statement (DEIS), exposing the hypocrisy of applying for LEED's transportation innovation credit in this context.[3]

Exemplary Performance, Open Space

Credit 1.2. For this innovation credit, the base requirement found in Sustainable Sites Credit 5.2 must be doubled: in other words, instead of a 25 percent open space increase, one needs to provide a 50 percent increase over the standard zoning requirement of 65 percent; i.e., one needs 1.5 × 65 = 97.5 percent open space on the site rather than 1.25 × 65 = 81.25 percent. So, yes, 50 percent (for "innovation") is twice the increase required under the normal Sustainable Sites credit, but notice that the "innovative" outcome is only marginally different than before: the actual open space area required for this extra innovation point represents only a 20 percent increase in open space over the normal Sustainable Sites requirement.

In the first case, this credit might be awarded because, as an "urban" project qualifying for SS Credit 2, Milstein Hall can count its vegetated roof as well as 75 percent of the concrete "hardscape" as vegetated open space, and this hardscape extends under the floor plate carrying the vegetated roof.

But if this proves insufficient, the same loophole available for Sustainable Sites credit 5.2 might be invoked here: a remote vegetated open space somewhere on campus can be assigned to Milstein Hall for the purpose of satisfying this credit.

That Milstein Hall's non-vegetated ground-level pedestrian zones are credited not only with being a "green" design feature, but actually as representing an innovation in the design of vegetated open space illustrates clearly how the LEED system can be gamed. The one potentially innovative feature of the paved areas—using the curved and sloped ground surfaces as a kind of skateboard park—seems to have been an unintended consequence of other formal interests and, in any case, has been strictly forbidden if not completely extirpated (fig. 6.10).

Green Cleaning

Credit 1.3. This credit is a boiler-plate "innovation" that Cornell applies to all its LEED-seeking buildings, based on a university-wide program that reviews "cleaning chemicals, paper products, equipment and custodial protocol" to "protect the health of the Cornell community without harming the environment," "improve air quality by reducing the amount of contaminants in the air through our custodial maintenance processes," and "preserve the infrastructure by extending the life of carpeting, hard floor surfaces and other materials through a variety of cleaning methods."[4]

Exemplary Performance, Heat island Effect, Roof

Credit 1.4. Milstein Hall's green roof covers about 60 percent of the building's true roof area (including both above-ground and underground spaces), sufficient for one "sustainable site" heat island effect point. This second "exemplary performance" point is awarded, not for the large area of white concrete pavement that covers much of the building's underground spaces, but for covering the entire above-ground roof (100 percent) with vegetation. In other words, underground spaces roofed with reinforced concrete slabs and covered with layers of waterproofing and insulation below grade are not counted as roofs under the LEED guidelines, and are excluded from such calculations. That virtually all of Milstein Hall's roof area reduces "heat island effects" doesn't make claims of sustainability or innovation any more plausible: heat island impacts are simply not an issue on Cornell's spacious campus; and, in fact, reflecting rather than absorbing solar radiation may actually increase energy consumption in a cold climate.

LEED Accredited Professional

Credit 2. The U.S. Green Building Council (USGBC) has created a category of people deemed especially qualified to organize and coordinate the LEED certification process: so-called LEED accredited professionals, or LEED APs. When Milstein Hall applied for its LEED certification, it was possible to become a LEEP AP by studying the LEED guidelines, paying a fee, and passing an examination. As long as a "principal participant" of the project team is a LEED AP—and there are many such people involved with the design of Milstein Hall—the project is in compliance with this credit, and gets an innovation point.

26 CORNELL'S SUSTAINABLE VISION FOR MILSTEIN HALL

Cornell lists the "sustainable design initiatives" it has taken in the design and construction of Milstein Hall[1] and summarizes these initiatives with the image reproduced in figure 26.1. These initiatives are grouped by Cornell into eight specious claims, discussed below.

Reduce energy usage for building heating and cooling

Specious claim #1. "Utilize cogeneration produced steam for building heating and lake-chilled water for building cooling. Incorporate energy

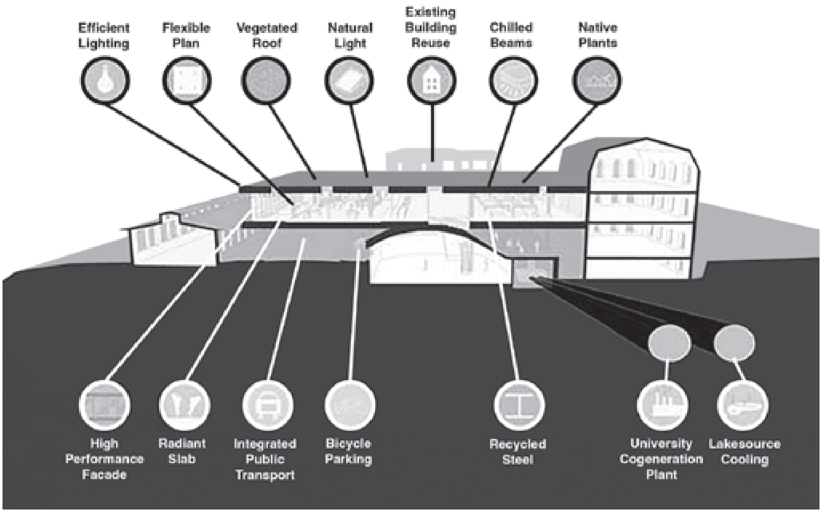


Figure 26.1. Milstein Hall's sustainable design initiatives (based on image from Cornell's Milstein Hall website; edited for clarity).

efficient chilled beams for cooling. Employ insulated walls and glazing to reduce building air loss. Employ a vegetated roof to reduce solar heat gain and to reduce building air loss."[2]

Cornell's cogeneration and lake-source cooling initiatives, however commendable, are not design initiatives of Milstein Hall. Chilled beams are relatively efficient, but hardly radical. Insulated walls and glazing to reduce building air loss? This both makes no sense and is inaccurate. It makes no sense because "air loss" (infiltration) is reduced by designing and installing a continuous air barrier system for the building, not by providing "insulation." Milstein Hall actually performs extremely poorly on both counts (air barriers and insulation). First, the building has a relatively ineffective air barrier system. Especially at seismic building separation joints along the entire perimeter between Milstein and Rand/Sibley Halls, not only has air barrier continuity not been established, but insulation has not been installed with seismic joints detailed to accommodate movement. Second, rather than being a role model for building insulation, Milstein Hall is actually a case-study in inefficient thermal form and thermal bridging.

Purely from an energy-efficiency and insulation standpoint, the most logical geometry for a building is one that minimizes surface area. Milstein Hall does exactly the opposite, by creating a large, extended floor plate that is then elevated above the ground, exposing not only its roof but also its underside to the exterior. Below-grade spaces also extend well beyond the boundaries of the upper floor plates, so that they too are needlessly exposed to the exterior. The entire wall area of the building, excluding most, but not all below-grade spaces, is glazed. Of course, insulated glazing is better than uninsulated glazing, but this misses the point: all glazing, unless designed as part of a passive-solar system, is less thermally efficient than an insulated wall. Milstein's undifferentiated glazing (all vertical surfaces, whether facing north, south, east, or west, are glazed) has not been designed in this way and so only contributes to gratuitous heat gain or heat loss. The contribution of the glass to daylighting is certainly real, but in no way compensates for the increased energy usage for heating and cooling. Given an already tenuous thermal-design strategy consisting primarily of undifferentiated glazing for all four facades, the building is then detailed with substantial thermal bridges creating additional express pathways for heat loss, as described in chapter 9 (thermal control).

Employing a vegetated roof does not reduce solar heat gain nor does it reduce building air loss, as claimed by Cornell, if such a system is compared to a well-detailed but otherwise ordinary insulated roof with a reflective surface.

Reduce energy usage for transportation

Specious claim #2. "Incorporate existing public transportation network. Accommodate pedestrian access and bicycle parking. Specify locally manufactured materials."[3]

These claims mirror some of the LEED credits in "Sustainable Sites" and "Materials & Resources." Milstein Hall's location next to existing bus lines made it impossible not to tie into a public transport network—this "initiative" has nothing to do with the design of Milstein Hall. As described above, Milstein Hall, using the minimum bike storage standards of the LEED guidelines instead of actually responding to the needs of bike users, does an extremely poor job of accommodating them. As to the "sustainability initiative" accomplished by accommodating "pedestrian access," one is at a loss to imagine what this could possibly mean. Is it that the building has a door at ground level, thereby permitting pedestrians to enter? Or that Cornell's existing system of walks and paths is not separated from the entrance to Milstein Hall by some sort of moat or electronic barrier?

Reduce energy use for building lighting

Specious claim #3. "Employ skylights and glazing for natural day-lighting. Specify energy efficient light fixtures."[4]

Daylighting, in the form of continuous perimeter glazing and skylights, can only be considered a sustainable (i.e., energy-saving) design feature if it reduces the need for electric lighting. On Milstein Hall's large studio floor, electric lighting is triggered by motion sensors, even if adequate illumination is provided by perimeter glazing and skylights, so that no energy saving can be attributed to its daylighting sources. In fact, both the day- and night-lighting conditions have been criticized by users of the space:

> The arch. department may not be aware that the building has already become a teaching tool: students are witnessing a

> lighting system (that affects us day and night) that some believe was an [sic] overlooked from a sustainable design perspective. In our Environmental Systems II class, a third year undergrad shared their observation that we have moved into a supposedly sustainable building yet the lights are constantly on, even when there is adequate daylight delivered to the space via skylights during the daytime.
>
> I have measured the illuminance at my desk and the daylight level is around 250 fc and the night reading is 55 fc. The night-time level is excessive for a space where the students are primarily using computers. The human eye is adapted to deal with natural light and its dynamic nature, so the daylight level does not concern me. People will put up with a lot of light as long as there is not uncomfortable glare. However, shadowless, even lighting at night to an excessive level can cause eye strain, especially when one is looking at a computer screen. The IES (Illuminating Engineering Society) currently recommends a range of 15–25 for office spaces with a separately controlled task light for user comfort.
>
> Sorry to seem like such a pest on this issue but I thought you should know that I am not the only one that is aware of the lighting and some of the BArch students seem to be getting cynical about the dept's stance on sustainability (wasting energy = wasting money).[5]

Energy-efficient light fixtures are, of course, better than, say, incandescent fixtures, but using energy-efficient fixtures inefficiently—as is being done in Milstein Hall—should not be characterized as "sustainable." And, as of this writing, built-in and custom-designed fluorescent fixtures have still not been replaced with more-efficient LED lights; I've been told that Milstein's dimming system is not compatible with LED drivers (fig. 26.2).

Reduce energy use for material production

Specious claim #4. "Employ recycled steel and concrete aggregate. Employ recycled finish materials where appropriate. Design building finishes to reduce building material use."[6]

As described elsewhere, Milstein Hall uses steel not just inefficiently, but

Figure 26.2. Custom-designed lighting fixture for Milstein Hall's studio floor: fluorescent light fixtures have still not been upgraded to LED (July 2023).

extraordinarily inefficiently, with more steel per square foot of floor area than in the 100-story Hancock Tower in Chicago. That this steel has recycled content does not make such an incredibly inefficient design sustainable, especially when the basis of this recycled steel—junked cars—is the disposable culture of planned obsolescence. Milstein's concrete recycles fly ash as part of its cementitious content; whether recycled "concrete aggregate" is also used is unlikely, but possible. The claim that Milstein Hall's finishes reduce material use is puzzling, since one can always imagine a design that has either more, or less, material content in its finished surfaces. Milstein Hall, for example, has concrete floors, and does not have carpet or tile on these floor surfaces. Other than being cracked and unsightly, the concrete surface seems perfectly adequate for its intended use. If *not* using an additional and unnecessary finishing material over the concrete topping slab is counted as "sustainable," then the bar for sustainable design has been set pretty low.

Reduce material use and landfill waste

Specious claim #5. "Reuse of existing buildings. Specify contractor sorting and recycling of demolition material. Reduce construction material packaging. Design a flexible building to increase long-term use and adaptability."[7]

It's hard to see how a large new building addition that uses far more material than comparable buildings—see discussion of steel use in item #4 above—can possibly "reduce material use." The same criticism applies to the remarkably unsustainable geometry of Milstein Hall: aside from the impact of its inordinately large surface area on energy usage, the same non-compact shape requires much more surface area for enclosure-system materials than would otherwise be required. As shown schematically in figure 26.3, a building like Milstein Hall with its floor area spread out, half on a raised floor and half in a basement, has more than twice the exposed surface area—roof, soffit, and cladding—than a more compact design with the same floor area, but with three stories and a basement. While both buildings have exactly the same 20,000

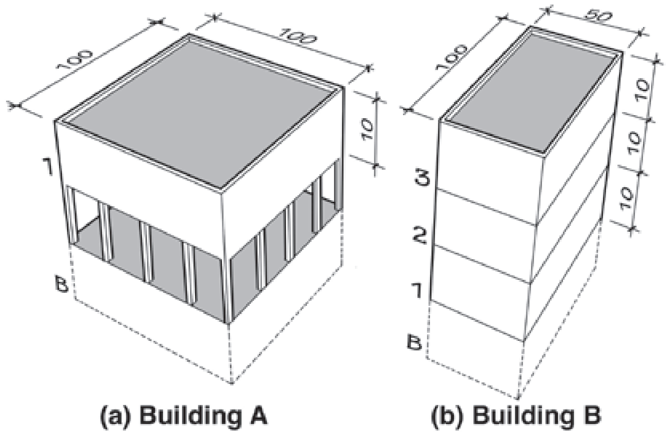


Figure 26.3. *Building A*, schematically representing the geometry of Milstein Hall, has much more exposed surface area—and therefore uses more energy and materials—than the more compact *Building B*.

square units of area (the actual units are not relevant here), *Building A* has 34,000 square units of exposed surface area (including the soffit), whereas *Building B* has only 14,000 square units of exposed surface area. Not only is *Building B* more efficient in terms of energy and materials, but its dimensions are likely to create a more flexible plan.

It's also hard to see how parasitically using adjacent Rand Hall as a kind of dumping ground for necessary mechanical equipment, bathrooms, and egress—compromising the flexibility of both buildings—is a sustainable "reuse" of an existing building. Other aspects of Milstein Hall's flexibility myth have been debunked in chapter 2.

It is sometimes claimed that Milstein Hall's design "saved" Rand Hall from demolition.[8] This, too, is spurious. Rand Hall was slated for demolition when Milstein Hall was the subject of a design competition in 2000. In the same way that the University made the (bad) decision to demolish Rand in 2000, it then reversed the decision at a later date. If the University had not unilaterally made the bad decision to demolish Rand Hall in 2000, the building would never have needed to be "saved." In any case, it was the University's decision, not the design of Milstein Hall, which "saved" the building.

Reduce stormwater pollution

Specious claim #6. "Employ vegetated roof or stormwater retention system to filter stormwater. Incorporate quantity and quality stormwater measures. Specify native plants to eliminate pesticide usage."[9]

All three of these claims are at least partly incorrect. First, Milstein Hall's vegetated roof may or may not be useful in filtering stormwater. Some studies have measured increased amounts of nitrogen and phosphorus in green-roof runoff compared with conventional roof runoff during heavy rainfall.[10] Second, Milstein Hall meets neither the quantity nor quality stormwater standards for LEED credit. Instead, virtually all stormwater falling on the vegetated roof during heavy rainfall is directed through the building and into the storm sewer system, rather than being controlled or improved on site. Third, Milstein Hall's green roof *has no native plants*. The sedums planted on the roof are adapted plants, not native species.[11] Using adapted, non-invasive, plants is not bad. It just isn't accurate to call them native. It is also more than a bit hypocritical of Cornell to boast about eliminating pesticide usage on this small, vegetated roof, while simultaneously employing pesticides (e.g.,

Figure 26.4. *Left image*: Cornell's "Tall grass" greenwashing sign on Libe Slope ("TALL GRASS. SMALL GAS. Natural landscapes reduce mowing and chemical use. Smarter land management. Helping us reach carbon neutrality by 2035.") *Right image*: Cornell's arts quad with Ezra Cornell statue in background and pesticide warning in foreground.

broadleaf herbicide SpeedZone at the time of Milstein Hall's construction, then Battleship Herbicide III, and more recently Triamine[12]) over large parts of its grounds, including the Arts Quad adjacent to Milstein Hall (fig. 26.4).

Reduce water usage

Specious claim #7. "Specify native plants to reduce irrigation water usage. Provide a temporary irrigation system for the vegetated roof. Specify low-flow plumbing fixtures to reduce potable water usage."[13]

This is simply reaching for the low-hanging fruit. For example, not using irrigation in Ithaca, NY, is hardly a sustainable accomplishment, as it rains here quite a bit.

Increase environmental comfort of building occupants

Specious claim #8. "Employ radiant slab system and chilled beams. Employ day-lighting. Specify low volatile organic compounds (VOC)-emitting material. Employ outside air system. Provide visual and direct connections to natural areas."[14]

There is nothing radically sustainable about chilled beams and radiant slabs. They provide no individual comfort controls, so that individual variations in the experience of comfort cannot be accommodated. Daylighting, entering through floor-to-ceiling glazing and skylights, has already been described as unnecessary (since the electric lights are on irrespective of daylighting levels) and often counter-productive (causing both glare and unwanted illumination). Milstein Hall does not consistently eliminate products with high VOC content. While it gains a LEED point for using a small amount of "Green Label Plus" carpet in the auditorium, it still uses composite wood products indoors that do not satisfy the LEED criteria for indoor air quality. Milstein Hall provides outside air, as do all buildings, both old and new. This is a requirement of building and mechanical codes, not a sustainable design initiative.

As to Milstein Hall's alleged visual and direct connections to natural areas, one simply needs to walk through the second-floor studio to form a more accurate impression: to the east is a parking lot, admittedly with some trees visible on the edge of Fall Creek gorge; to the north is the asphalt roof of the Foundry, which blocks any view of Fall Creek; to the west is Rand Hall; and to the south is Sibley Hall, along with a view towards other campus buildings. The floor plate is so deep that most workstations are located far from Milstein's glazed edges, and have even less of a chance to connect with nature. There are certainly no direct connections to natural areas from Milstein Hall, which is separated from Fall Creek (the only plausible "natural area" in the vicinity) by University Avenue and the Foundry. In fact, what Milstein Hall accomplished was to *eliminate* numerous windows and outdoor views from Rand and Sibley Halls.

Conclusions

Milstein Hall will get 40 LEED points out of a maximum 69 possible points. It therefore qualifies for a LEED-gold rating, albeit at the bottom of the "gold" range (fig. 26.5). To understand the significance of this LEED certification rating, it is useful to group Milstein Hall's LEED points into categories that indicate their actual relationship both to sustainability, and to the specific design of the building (rather than to characteristics of the site that have nothing to do with the building's actual design).

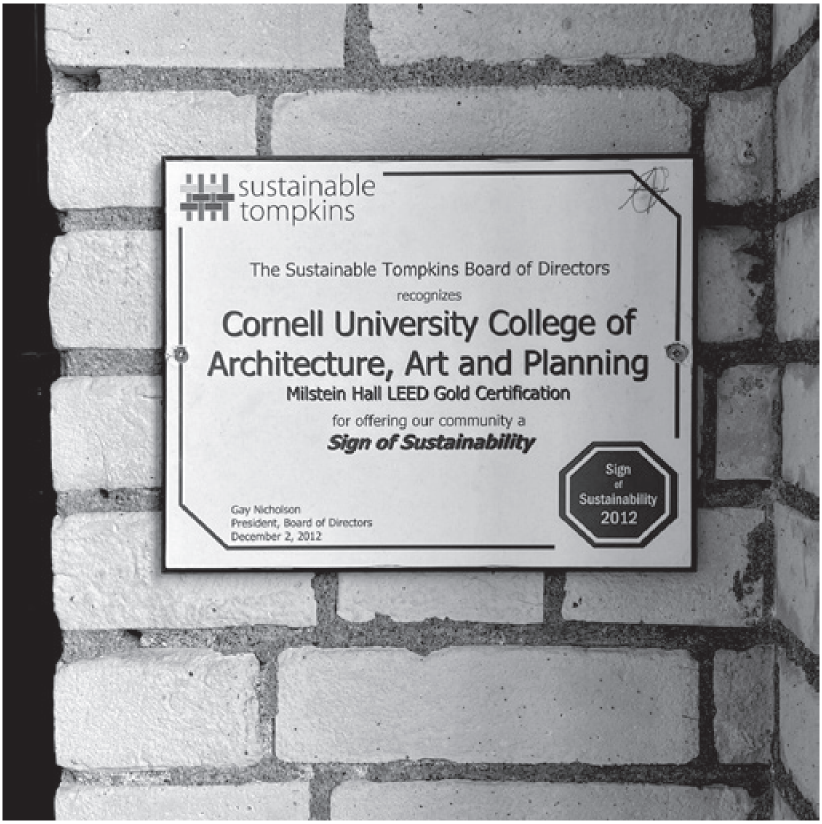


Figure 26.5. Milstein Hall's LEED-gold certification is recognized by the "Sustainable Tompkins Board of Directors" on a plaque fastened to the brick fire barrier wall separating Milstein Hall from Sibley Hall.

Of the 40 points earned, 10 have nothing to do with the design of the building and 23 are related to the building design but have little or nothing to do with sustainability. This leaves only seven earned points that might be construed as having some sustainable attributes, beyond what would be associated with conventional construction practices. The credits, organized from this standpoint, are shown in Table 8. My rationale for placing particular credits in these categories can be inferred from the detailed discussion of Milstein Hall's specious sustainability claims above.

What is perhaps more telling are the 18 LEED points *not earned* that might otherwise have contributed to sustainable goals, including such things as stormwater control, innovative wastewater technologies, better energy performance, use of on-site or off-site renewable energy, user control of lighting and thermal comfort systems, and better indoor air quality through increased ventilation. But even achieving all of these credits would not make the world a "greener" place. Creating extravagant and largely unnecessary green buildings still adds to, rather than reduces, the use of non-renewable fossil fuels and the release of global warming gases. This is doubly true of the Milstein Hall project, as it not only added an energy-hog to the Cornell campus, but also specifically excluded consideration of desperately needed energy-conserving renovations for Rand and Sibley Halls that could have not only reduced energy use, but also improved indoor environmental quality and reduced global warming gases.

The useful LEED points earned by Milstein Hall—buying water-efficient plumbing fixtures, making IAQ management plans (e.g., specifying better air filters for HVAC equipment), installing dirt-capturing entry mats, and specifying low-VOC interior materials for some but not all categories of interior materials—are all things that have absolutely nothing to do with the architectural (i.e., formal) design of the building, a design which is incomprehensible from an environmental or energy-conserving standpoint. Instead, Milstein Hall exemplifies an attitude of design-as-usual, with LEED validation assigned to the mechanical engineers, construction managers, and specification writers.

Table 8. Distribution of Milstein Hall's earned and unearned LEED points (as of June 2012).

Points earned having nothing to do with the design of Milstein Hall (10 points)	SS 1.Site selection SS 2. Development density & community connectivity SS 4.1 Public transportation access SS 4.4 Parking capacity WE 1.1 Water efficient landscaping—reduce water use 50% WE 1.2 Water efficient landscaping—no potable use ID 1.1 Green cleaning ID 1.2 Exemplary performance—open space ID 1.3 Transportation demand management ID 2 LEED AP
Points earned that have something to do with the design of Milstein Hall, but have little or nothing to do with sustainability, at least in the context of this building (23 points)	SS 4.2 Bicycle storage & changing rooms SS 5.2 Maximize open space SS 7.1 Heat island effect, non-roof SS 7.2 Heat island effect, roof EA 1 Optimize energy performance (6 points) EA 3 Enhanced commissioning EA 4 Enhanced refrigerant management EA 5 Measurement and verification MR 2.1 Construction waste management—divert 50% MR 2.2 Construction waste management—divert 75% MR 4.1 Recycled content—10% MR 4.2 Recycled content—20% MR 5.1 Regional materials—10% IEQ 1 Outdoor air delivery monitoring IEQ 7.1 Thermal comfort—design IEQ 7.2 Thermal comfort—verification IEQ 8.1 Daylighting 75% of spaces ID 1.4 Exemplary performance—heat island effect, roof
Points earned that have something to do with the design of Milstein Hall that are also valuable sustainable design features (7 points)	WE 3.1 Water use reduction—20% WE 3.2 Water use reduction—30% IEQ 3.1 Construction IAQ management plan—during construction IEQ 4.1 Low-emitting materials—adhesives and sealants IEQ 4.2 Low-emitting materials—paints and coatings IEQ 4.3 Low-emitting materials—carpet systems IEQ 5 Indoor chemical & pollution source control

(Table continues on following page)

Table 8 (continued)

Points not earned that actually correspond to valuable sustainable goals (18 points)	SS 6.1 Stormwater quality control SS 6.2 Stormwater quantity control SS 8. Light pollution reduction WE 2 Innovative wastewater technologies EA 1 Optimize energy performance (4 points not earned) EA 2 On-site renewable energy (all 3 points not earned) EA 6 Green power MR 7 Certified wood IEQ 2 Increased ventilation IEQ 3.2 Construction IAQ management plan—before occupancy IEQ 4.4 Low-emitting materials—composite wood and agrifiber IEQ 6.1 Controllability of systems—lighting IEQ 6.2 Controllability of systems—thermal comfort
Points not earned that either could not be earned, are not relevant to this building, or are not particularly valuable sustainable goals (11 points)	SS 3 Brownfield redevelopment SS 4.3 Low-emitting and fuel-efficient vehicles SS 5.1 Protect or restore habitat MR 1.1 Building reuse—75% existing walls, floors, roof MR 1.2 Building reuse—95% existing walls, floors, roof MR 1.3 Building reuse—50% interior non-structural elements MR 3.1 Materials reuse—5% MR 3.2 Materials reuse—10% MR 5.2 Regional materials—20% MR 6 Rapidly renewable materials IEQ 8.2 Views—views for 90% of spaces

NOTES

INTRODUCTION

1 Email from Kent Kleinman, dean of Cornell's College of Architecture, Art and Planning, to college faculty, Feb. 6, 2009.
2 For links to my Milstein Hall construction videos on YouTube, see Jonathan Ochshorn, "Milstein Hall Construction Videos," https://jonochshorn.com/scholarship/videos/milstein.
3 Ochshorn, *Building Bad.*
4 "AMO: Company—Rotterdam, Netherlands," *Spatial Agency,* https://www.spatialagency.net/database/amo.

1 OPENING REMARKS ON FUNCTION AND FLEXIBILITY

1 Brand, *How Buildings Learn.*

2 FLEXIBILITY

1 Millard, "Banned Words."
2 Brand, *How Buildings Learn,* 44.
3 This section is adapted from Ochshorn, "Flexibility and its discontents."
4 Frank Duffy, quoted in Brand, *How Buildings Learn,* 12.
5 Frank Duffy, quoted in Brand, *How Buildings Learn,* 17.
6 Behne, *The Modern Functional Building,* 129.
7 "In other than dwelling units, toilet, bathing and shower rooms floor finish materials shall have a smoot, hard, nonabsorbent surface. The intersections of such floors with walls shall have a smooth, hard, nonabsorbent vertical base that extends upward onto the walls not less than 4 inches (102 mm)." ICC, "1209.2.1 Floors and Wall Bases," in *Building Code,* 2020.
8 "Milstein Hall: Built to Inspire."
9 Brand, *How Buildings Learn,* 20.

3 ROOM GEOMETRY

1 I wasn't sure if the foamed plastic display stands under the exit access stairway in Milstein Hall's Crit Room were combustible, since they were not labeled in any way, so I took a small sample home that had detached from one of the older pieces and set it on fire in my driveway. This little adventure is documented on my YouTube video. See Jonathan Ochshorn. "Combustible foamed plastic display stands." https://youtu.be/fn2HBJxSQMI.
2 I can't say for sure how Trustees get to Ithaca, or if they really travel to Ithaca in their "corporate jets." Perhaps some drive, or take the bus.
3 "Rule 5. Vertical Viewing Angle. Students should be limited to 15 degrees maximum head tilt excursion above horizontal, to reference the center of the projection screen." See "Lecture Hall Design Standards University of Maryland, Baltimore County," August 29, 2000, https://www.scribd.com/document/89354607/Lec-Hall-Standard#.
4 Parts of this section are adapted from Ochshorn, "Flexibility and its discontents."
5 Brand, *How Buildings Learn,* 177.
6 Obrist, "Re-learning from Las Vegas," 155.
7 Jormakka, "The Manhattan Project," 118.
8 Jonathan Ochshorn, "The Construction of Milstein Hall—Part 7 Studio Floor" (video), https://youtu.be/1lxhoS-P1WU.
9 Jonathan Ochshorn, "The Construction of Milstein Hall—Part 7.
10 Ochshorn, *Building Bad,* 200–201. The quoted passages are as follows: Ruskin, *The Seven Lamps of Architecture,* 17; Veblen, *The Theory of the Leisure Class,* 82–83; Koolhaas, see Jack Self, "OMA AMO w/for Prada," 032c, February 16, 2017, https://032c.com/magazine/oma-prada (my italics).
11 Jonathan Ochshorn, "Milstein Hall Loses Its Barcelona Chair," ImpatientSearch (blog), June 30, 2009, https://jon.ochshorn.org/2009/06/milstein-hall-loses-its-barcelona-chair.
12 ICC, *New York State Building Code,* 2002, 252.
13 Wright, *An Organic Architecture,* 39.
14 Behne, *The Modern Functional Building,* 121.
15 Behne, *The Modern Functional Building,* 129.
16 Lloyd Kahn is quoted in Brand, *How Buildings Learn,* 60.
17 Alexander, *Pattern language,* 885–86.
18 "The architect should accept the methods and the elements he already has. He often fails when he attempts per se the search for form hopefully new, and the research for techniques hopefully advanced. Technical innovations require investments in time and skills and money beyond the architect's reach, at least in our kind of society." Venturi, *Complexity and Contradiction,* 49.

4 PRIVACY AND CONTROL: LIGHTING AND ACOUSTICS

1 "Milstein Hall Cornell University."
2 "Milstein Hall Cornell University."
3 "Milstein Hall at Cornell University / OMA."
4 "Whispering Arch, Grand Central Station," Sound Tourism: A Travel Guide to Sonic Wonders, accessed May 21, 2017, http://www.sonicwonders.org/whispering-walls-grand-central-station.

5 Chermayeff and Alexander, *Community and Privacy,* 135.
6 "Milstein Hall's Innovative Design."
7 "Milstein Hall's Innovative Design."
8 "Milstein Hall: Built to Inspire."

5 CIRCULATION

1 "Milstein Hall Cornell University."
2 The fact that limited work was done in Rand Hall as part of the Milstein project had much to do with the anomalous character of Rand Hall compared with other campus buildings: it was built as a type of utilitarian structure at the beginning of the twentieth century to house a machine shop, pattern shop, and electrical laboratory, and was slated to be emptied of the architectural design studios that had camped out there since the mid-1970s once Milstein Hall was completed.
3 ICC, *Code and Commentary*, 7-93.
4 "Milstein Hall Cornell University."
5 Wolfgang Tschapeller Architekt, "Site narrative," Cornell University Fine Arts Library 100% Schematic Design, Dec. 2, 2014, accessed April 17, 2023, https://www.cityofithaca.org/DocumentCenter/View/2866.
6 Jonathan Ochshorn, "The Cornell Fine Arts Library Site Narrative," Impatient Search (blog), https://jon.ochshorn.org/2015/08/the-cornell-fine-arts-library-site-narrative.
7 "Milstein Hall's Innovative Design."
8 Jonathan Ochshorn, "Koolhaas proposes temporary toilets and fire exits in 'flexible' Milstein Hall as Rand Hall closes for two years," Cornell Chronicle parody, April 30, 2017, https://jonochshorn.com/scholarship/writings/rand-chronicle-parody-2. This parody uses and alters much of the text from: Guy Horton, "What's so Different about Koolhaas's Venice Biennale?" *Metropolis* (March 27, 2014), accessed April 11, 2023, https://metropolismag.com/projects/whats-so-different-about-koolhaass-venice-biennale.
9 For Bill Millard's recommendation to build ducks in order to avoid value-engineering cost cutting, see Millard, "Banned Words," 91.
10 Koolhaas's comment about buildings becoming obsolete in 25 years is based on a quote from Obrist, "Dynamic Labyrinth (Seoul)," 66.

6 MOVEMENT, ORIENTATION, ACCESS

1 "Milstein Hall Cornell University."
2 For lyrics, music video, and other pertinent information about the author's song, "Prisoner of Art," see https://jonochshorn.com/music/songs/prisoner-of-art.html.
3 Jonathan Ochshorn, "Prisoner of Art (Again)," ImpatientSearch (blog), https://jon.ochshorn.org/2017/07/prisoner-of-art-again.
4 Parsons, *The Cornell Campus*, 1–2.
5 Parsons, *The Cornell Campus,* 3.
6 "Milstein Hall's Innovative Design."
7 The requirement for workers to be strapped in makes routine maintenance of

the vegetated roof cumbersome and expensive. There is no permanent guard rail at the roof perimeter that would have allowed maintenance workers free access; instead the architects disingenuously (and inaccurately) claim ease of maintenance on the basis of a required access stair: "On the west side of Milstein Hall an ivy-covered, open-air metal clad stair tower contrasts the long horizontal upper plate. The stair tower connects all levels of Milstein Hall and provides access to the green roof *for ease of maintenance*." "Milstein Hall's Innovative Design Cornell" (my italics).

8 Koolhaas, "Junkspace," 175.

9 Koolhaas, "Junkspace," 182.

10 Koolhaas, "Junkspace," 183.

11 Koolhaas, "Junkspace," 176.

12 Tomas Koolhaas, "Official trailer for 'Rem' Documentary," 2014, accessed April 18, 2023, https://vimeo.com/75328510.

13 The director of Forsythe Productions GmbH confirmed this in an email to the author dated Sept. 25, 2023: "Having spoken with William Forsythe, since this was before my time working with him, he thought that the Rand Hall was more appropriate for the work that was being presented." Information on the performance itself can be found at Daniel Aloi, "Choreographer William Forsythe to visit, present new work in a Cornell space," *Cornell Chronicle* (March 1, 2012), https://news.cornell.edu/stories/2012/03/choreographer-forsythe-stages-work-rand-hall.

14 Lasansky, "Sensationalizing OMA's Milstein Hall," 104.

15 "Milstein Hall Cornell University."

16 "The future of The Foundry," *Cornell Chronicle,* February 10, 2023, https://news.cornell.edu/stories/2023/02/future-foundry.

17 "About," 2x4, accessed April 18, 2023, at https://2x4.org/about/.

18 Undoubtedly related to Cornell's acquisition of these sculptures by the late professor Jason Seely, the plaza has been rebranded as the "Jason and Clara Seley sculpture court."

19 ICC, *Code and Commentary*, 10-8 (my italics).

20 Definitions and rules about means of egress, exit discharge, accessible routes, and elevation change (i.e., single steps) are taken from ICC, *New York State Building Code,* (2020). A means of egress includes the exit discharge, which is "that portion of a means of egress system between the termination of an exit and a public way" (Definitions, chapter 2); a public way is "a street, alley or other parcel of land open to the outside leading to a street, that has been deeded, dedicated or otherwise permanently appropriated to the public for public use and which has as a clear width and height of not less than 10 feet (3048 mm)" (Definitions, chapter 2). Regarding single steps: "Where changes in elevation of less than 12 inches (305 mm) exist in the means of egress, sloped surfaces shall be used. Where the slope is greater than one unit vertical in 20 units horizontal (5-percent slope), ramps complying with Section 1012 shall be used. Where the difference in elevation is 6 inches (152 mm) or less, the ramp shall be equipped with either handrails or floor finish materials that contrast with adjacent floor finish materials." There is an exception for single risers "at locations not required to be accessible by chapter 11" ("1003.5 Elevation change"). However, this location in Milstein Hall is required to be accessible since it connects Milstein Hall's main entrance (and its auditorium) to public transportation stops and therefore qualifies as a required "accessible route" ("1104.1 Site arrival points").

21 Ochshorn, *Building Bad,* 44–45.
22 ICC, "1003.2.5 Protruding objects," *New York State Building Code,* 2002, 202–203.
23 "Protruding Objects," *Guide to the ADA Accessibility Standards,* accessed June 3, 2023, https://www.access-board.gov/ada/guides/chapter-3-protruding-objects.
24 "Definitions," ICC, *Building Code of New York State,* 2020 (my italics).
25 "Protruding Objects," *Guide to the ADA Accessibility Standards*.
26 "Smartphone texting linked to compromised pedestrian safety," *ScienceDaily,* Feb. 3, 2020, accessed March 19, 2023, at https://www.sciencedaily.com/releases/2020/02/200203210601.htm.
27 For photos of Milstein Hall by Matthew Carbone, showing various protruding elements *without* cane-detection guards, see "Milstein Hall at Cornell University / OMA."

7 BUILDING GOOD: STRAGTEGIES, OBSTACLES, FICTIONS

1 " 'In Defense of Food' Author Offers Advice For Health," NPR, Jan 1, 2008, accessed May 2, 2023, https://www.npr.org/2008/01/01/ 17725932/in-defense-of-food-author-offers-advice-for-health.
2 Lstiburek, "BSI-018: Westford House," 5.
3 "The pattern language we have given here contains 253 patterns. You can therefore use it to generate an almost unimaginably large number of possible different smaller languages…" Alexander, *Pattern Language,* xxxviii.
4 Jonathan Ochshorn, "Introducing: Building Bad by Jonathan Ochshorn," Lund Humphries (blog), Jan. 8, 2021, accessed April 20, 2023, at https://www.lundhumphries.com/blogs/features/introducing-building-bad-by-jonathan-ochshorn.
5 For a discussion of the dysfunctional competition that drives defamiliarized avant-garde design, see Ochshorn, *Building Bad.*
6 "Milstein Hall Cornell University."
7 Veblen, *Theory of the Leisure Class,* 176–77.
8 Koolhaas, *Delirious New York*. See "fictional conclusion," 293 and "theoretical Manhattan," 11 (italics in the original).
9 Koolhaas, *Delirious New York*, 241.
10 "Milstein Hall Cornell University."
11 "Milstein Hall's Innovative Design."
12 Lechner, *Heating, Cooling, Lighting*, 130.
13 I made the following rough calculations for the volume and exposed surface area of Milstein Hall (using Imperial units). The volume was calculated by multiplying the various floor areas by their floor-to-floor heights:

- Second floor = 25,919 square feet × 15.5 ft = 401,745 cubic feet
- First floor = 6,470 square feet × 15.6 ft = 100,932 cubic feet
- Basement = 19,568 square feet × 11.3 ft = 221,118 cubic feet
- Total volume: 723,795 cubic feet

The exposed surface area (roofs, exterior soffits, and exterior walls) are as follows:

- Second-floor roof = 25,919 square feet
- Exterior soffit = 19,449 square feet
- Basement roof = 13,098 square feet
- Second floor glazed walls = 7,642 square feet
- First floor glazed walls = 6,724 square feet
- Basement garden walls = 1,153 square feet

- Total exposed surface area = 73,984 square feet

To compute the surface area of a more rationally configured building with a width of 64 feet, I assumed a total building height equal to that of Milstein Hall (15.5 + 15.6 + 11.3 feet) plus an additional story of 15.5 feet for a total height, including the basement, of 57.9 feet. Dividing the building volume of 723,795 cubic feet by this height of 57.9 feet, we get a per-floor area of 12,500 square feet. The plan dimensions (with a 64-foot width) are therefore 195 feet × 64 feet. The exposed surface area consists of a roof of 12,500 square feet plus a total wall area equal to the building height above grade times the building perimeter, or 46.6 feet × 518 feet = 24,139 square feet, for a total exposed surface area, including the roof, of 36,639 square feet.

14 "Milstein Hall Cornell University" (my italics).

15 Murphy, "Milstein Hall by OMA."

16 I used a simplified structural model created with STRIAN (https://structural-analyser.com/domains/www/online-free-structural-analysis.html). The same steel wide-flange cross-sections and plate girders specified in the structural working drawings for Milstein Hall's "Truss 3" were used, both for the existing hybrid condition and for my modified version. Centerline dimensions were rounded to the nearest foot, and the truss's three rigidly connected columns were replaced with a pin (hinge) and two rollers at the equivalent locations under the bottom chord. Importantly, I have computed moments, shears, axial forces, and deflections based only on a uniformly distributed load of 5 kips/foot (73 kn/m) placed on the top and bottom chords, and have not computed the maximum moments and internal forces based on the consideration of all relevant load scenarios. The distributed load of 5 kips/foot (73 kn/m) is equivalent to floor and roof loads of about 150 psf (7.2 kPa), somewhat lower than the distributed live and dead loads specified for this building. The point was not to replicate the forces, moments, and deflections computed by the structural engineers, but rather to show that the decision to misalign vertical and diagonal members in the hybrid truss greatly increases the magnitude of bending moments in particular.

17 "Milstein Hall's Innovative Design."

18 Ochshorn, *Building Bad,* 146.

19 Ochshorn, "Revisiting Form and Forces," 75.

20 Ochshorn, "Revisiting Form and Forces," 75.

21 Shohei Shigematsu is quoted in Murphy, "Milstein Hall by OMA."

22 "The Unassuming History of Tin Ceilings," *American Tin Ceilings,* accessed April 21, 2023, https://www.americantinceilings.com/blogs/home/history-of-tin-ceiling-tiles.

23 Shohei Shigematsu is quoted in Pearson, "Milstein Hall."

24 "Milstein Hall's Innovative Design."

25 "Milstein Hall's Innovative Design."

26 "1011.7.4 Enclosures under exterior stairways," ICC, *Building Code of New York State*, 2020 (my italics).

8 OPENING REMARKS ON NONSTRUCTURAL FAILURE

1 Ochshorn, "Designing Building Failures."

2 Ochshorn, "A Probabilistic Approach to Nonstructural Failure." The discussion of peculiarity and redundancy that follows is largely derived from this paper.

3 "Instead of the classical and modern reliance on ideal (hermetic, rigid) geometrical figures – straight lines, rectangles, as well as cubes, cylinders, pyramids, and (semi-) spheres – the new primitives of parametricism are animate (dynamic, adaptive, interactive) geometrical entities – splines, nurbs, and subdivs – as fundamental geometrical building blocks for dynamical systems like 'hair', 'cloth', 'blobs', and 'metaballs' etc. that react to 'attractors' and that can be made to resonate with each other via scripts." Schumacher, "The Parametricist Epoch."

9 THERMAL CONTROL

1 For video showing construction of thermal-bridging bollards at the edge of Milstein Hall's loading area, see Jonathan Ochshorn, "9. Stone & Soffit," Milstein Hall Construction Videos (starting at about 2:55 minutes), https://jonochshorn.com/scholarship/videos/milstein.

2 "Milstein Hall's Innovative Design."

3 The conversion of 70°F to 37°C should not be confused with the "temperature" conversion of 70°F to 21°C. What we are converting here is not a temperature of 70°F, but rather a temperature *differential* of 70°F.

4 "As lousy as BTU/hr per square foot rules of thumb are, a typical reasonably-tight 2500' house built to IRC 2018 code levels without excessive amounts of window will usually come in around 30,000–35,000 BTU/hr (12–14 BTU/hr per square foot) @ 0F outdoors, 70F indoors …" "Average Heating Load," *Green Building Advisor,* accessed May 17, 2023, https://www.greenbuildingadvisor.com/question/average-heating-load.

10 RAINWATER CONTROL

1 Karen Warseck, "Why Sealant Joints Fail," BuildingDiagnostics.com, accessed online Aug. 15, 2013 (no longer available).

2 "Regletting Does Not Work—Saw cutting a 'notch' or 'reglet' into the brick and inserting a 'counter flashing' will not do the trick. No chance." Lstiburek, "BSI-122: If You Want to Save Cash … Flash…"

3 Wikipedia, s.v. "Efflorescence" last modified November 12, 2022, 06:49 (UTC), https://en.wikipedia.org/wiki/Efflorescence.

4 Sutan and Hamdan, "Efflorescence Phenomenon," 748.

5 Wikipedia, s.v. "Efflorescence."

6 Jonathan Ochshorn, "Milstein Hall Nonstructural Failure: Gallery Leaks," August 28, 2013, https://youtu.be/Jv058H1bU-A.

7 Lstiburek, "BSI-051: Decks—Roofs You Can Walk On."

8 Milstein Hall's working drawings only called for one drainage board, below the insulation on the roof deck above the gallery, although my videos show an additional membrane or board also placed on top of the insulation boards.

9 I made two videos to illustrate and explain problems with Milstein Hall's flat plaza deck, the gallery beneath, as well as remedies undertaken by Cornell. See Jonathan Ochshorn, "Milstein Hall Nonstructural Failure: Gallery Leaks" (note 6) and Jonathan Ochshorn, "Milstein Hall Nonstructural Failure: Gallery Leaks (2015 update)," https://youtu.be/Vguog472JBk. Much of this section, about the gallery water problems and the flat plaza roof deck, is based on my commentary in these

videos.

10 Sharif Asiri, "Can Rigid Insulation Get Wet?", Asiri Designs, accessed May 25, 2023, https://asiri-designs.com/resources-1/f/can-rigid-insulation-get-wet.

11 I made several videos that illustrate and explain the construction of Milstein Hall's green roof as well as some of the roof leaks and attempted repairs. See Jonathan Ochshorn, "The Construction of Milstein Hall Part 10—Green Roof," https://youtu.be/6kEegkO_R6Q, Jonathan Ochshorn, "Milstein Hall Nonstructural Failure: Roof Leaks," https://youtu.be/HvhGVeKfcb4, and Jonathan Ochshorn, "Milstein Hall Nonstructural Failure: More Roof Leaks," https://youtu.be/aBsm19ikasM.

12 "1507.13 Thermoplastic single-ply roofing." ICC, *New York State Building Code,* 2002, 277.

11 SLOPPY OR DYSFUNCTION DETAILS

1 Dani Neuharth-Keusch, "Ithaca Board Grants Final Approval For Milstein Plan," *Cornell Daily Sun,* Jan. 28, 2009, https://cornellsun.com/2009/01/28/ithaca-board-grants-final-approval-milstein-plan.

2 Mike Fulkerson, Field Superintendent for Welliver (general contractor) transcribed from the author's video. See Jonathan Ochshorn, "Milstein Hall Nonstructural Failure: Concrete Staining," https://youtu.be/SpkGK2ouC68.

12 DANGEROUS DETAILS

1 "The Architects Sketch," Monty Python's Flying Circus episode 17, "The Buzz Aldrin Show" (1970), transcript accessed Nov. 9, 2019, http://www.montypython.net/scripts/architec.php.

2 ICC, "1003.2.12 Guards," *New York State Building Code,* 2002, 205.

3 ICC, *Code and Commentary,* 10-127.

4 "The Dangers of Falling Snow and Ice," Briones Law Group, accessed May 29, 2023, https://www.brioneslawgroup.com/personal-injury/the-dangers-of-falling-snow-and-ice.

5 "How Icicles Can Be Surprisingly Dangerous," Heath Essentials, Cleveland Clinic (Feb. 3, 2020), accessed May 29, 2023, https://health.clevelandclinic.org/how-icicles-can-be-surprisingly-dangerous.

13 OPENING REMARKS ON FIRE SAFETY

1 "Constitution of the United States," United States Senate, https://www.senate.gov/about/origins-foundations/senate-and-constitution/constitution.htm.

2 Rossberg and Leon, "Evolution of Codes in the USA."

3 *Quality Communities*, 4, no. 1 (Fall 2005), 3, https://jonochshorn.com/milsteinhall/doc/QCNews.pdf (author copy).

4 "Preservation League of New York 2002 Annual Report," 7, accessed June 4, 2023, https://jonochshorn.com/milsteinhall/doc/PLNYS.pdf (author copy).

5 For an analysis of Sibley Hall's retroactive egress issue, see Jonathan Ochshorn, "Shock and Awe: Cornell Attacks the Building Code!," Impatient Search (blog), https://jon.ochshorn.org/2009/06/

shock-and-awe-cornell-attacks-the-building-code.

6 "Cornell University is committed to diversity and inclusiveness with the goal of providing an accessible, usable and welcoming environment for faculty, staff, students and visitors with disabilities." See "Accessibility Information," Cornell University, accessed June 4, 2023, https://accessibility.cornell.edu. "The University Fire Marshal works with the Campus Community and Stakeholders by providing education and helpful tips for Fire Code Compliance and individual Safe Work Practices. This provides an additional layer to ensure that campus facilities are as safe as possible." See "Fire and Life Safety," Environment, Health and Safety (Cornell University), accessed June 4, 2023, https://ehs.cornell.edu/campus-health-safety/fire-and-life-safety.

14 EXCESSIVE FLOOR AREA

1 ICC, "506 Building area," *Building Code of New York State, 2020*. The computational method to determine building and floor area in the 2020 code is different from that in the 2002 New York State Building Code, but the results are identical. I've used the newer code here since it may be more familiar to modern readers and is available online. In the 2020 code, the tabular data for allowable area is found in Table 506.2, and frontage increases are discussed in section 506.3. In the 2002 code, tabular data for allowable area are found in Table 503 (Allowable Height and Building Areas), and area modifications in section 506. The difference in method is essentially this: the 2002 code used a single tabular area value for non-sprinklered buildings and provided multipliers for single-story or multi-story sprinklered buildings, whereas the 2020 code provides separate tabular values for non-sprinklered, single-story sprinklered, and multi-story sprinklered buildings. In addition, the 2002 code used a single table for allowable area, height, and number of stories, whereas the 2020 code has separate tables for each of those parameters.

2 ICC, "Chapter 6 Types of Construction," *Building Code of New York State*, 2002. See, in particular, Table 601.

3 ICC, "302.3.2 Nonseparated Uses," *Building Code of New York State,* 2002, 18.

4 ICC, "508.3 Nonseparated occupancies," *Building Code of New York State*, 2020.

5 ICC, *Code and Commentary*, 5-21.

6 "…the 1774 Act permitted buildings of the first rate to be up to 60 feet in height and 35 squares [3,500 square feet], which equates to 210,00 cubical feet. This limit likely relates, through experience of the fire brigade, to the total quantity of combustibles and subsequent fire expected within an unbroken space." "The Historical Development of the Building Size Limits in the National Building Code of Canada," Sereca Consulting Inc., The Canadian Wood Council (March 19, 2015), https://cwc.ca/wp-content/uploads/2019/03/HistoricalDevelopment-BldgSizeLimits-NBCC-2015-s.pdf.

7 Freitag, *Fire Prevention and Fire Protection,* 308. The quote within this block quote is attributed to the *Journal of Fire* (July 1906), 8.

8 Gibbons, *The Metropolitan Buildings Act,* 128.

9 I'm using the *International Building Code* (ICC) spelling of "fire wall" as two words, rather than the commonly used single word, firewall.

10 Without fire walls, even if the construction type of the combined building was IIIB (i.e., if Sibley Hall's Mansard roof was upgraded to 2-hour fire-rated construction and if Milstein and Rand Halls' exterior walls somehow turned

into fire-rated bearing walls) or IIB (i.e., if all of Sibley Hall's combustible wood floors, roof, and Mansard walls somehow became noncombustible), the combined Milstein-Sibley-Rand Hall would still have an actual floor area that exceeded its allowable floor area.

11 "705.6 Vertical continuity," ICC, *Building Code of New York State,* 2022, 90–91.

12 "705.2 Structural Stability," ICC, *Building Code of New York State*, 2002, 89.

13 For a discussion of double fire walls, see Jonathan Ochshorn, "How to build a double fire wall between Rand and Milstein Halls," Impatient Search (blog), https://jon.ochshorn.org/2017/06/how-to-build-a-double-fire-wall-between-rand-and-milstein-halls.

14 "Table 706.4 Fire Wall Fire-Resistance Ratings," ICC, *Building Code of New York State*, 2020.

15 Telephone conference meeting (Mar. 3, 2005), in "Addendum to Application," 70.

16 "Building Code Summary" prepared by KHA, (March 28, 2006), in "Addendum to Application," 70.

17 "The requirements for fire walls between new and existing construction will be difficult to achieve with the design of Milstein Hall so 50% CD documents will be submitted to the City for review before 1 August 2007 when the new code is expected to be adopted." KHA Architects, "I. Building Construction and Separation, Building Code and Fire Protection Meeting Report" (March 13, 2007), in "Addendum to Application," 71.

18 Although the current (at the time of this writing) version of §1203.3 has been revised since Milstein Hall obtained its building permit, the essential requirements are the same: "Each authority having jurisdiction shall include in its code enforcement program provisions requiring an application for a building permit, or an amendment thereto, to include information sufficient to enable the authority having jurisdiction to determine that the intended work accords with the requirements of the Codes. … The authority having jurisdiction shall not approve required construction documents unless they show in sufficient detail that they contain the information and/or documentation required by the applicable provisions of either or both of the Codes…" For New York State "Minimum features of a program for administration and enforcement" of building permits, see 19 NYCRR Part 1203, §1203.3, https://dos.ny.gov/system/files/documents/2021/12/2021-12-10-full-text-of-rule-part-1203.pdf.

19 ICC, "K902.2, Appendix K," *New York State Building Code*, 2002, 729. The reference to section 706 simply links Appendix K's requirement for a fire barrier to the specifications for fire barriers elsewhere in the building code and lends no additional coherence to the single sentence constituting this section of Appendix K.

20 ICC, "706.1 General," *New York State Building Code*, 2002, 91.

21 ICC, "706.3.5 Separation of Occupancies and Fire Areas," *New York State Building Code,* 2002, 92.

22 ICC, "302.3.3 Separated Uses," *New York State Building Code*, 2002, 18.

23 *New Jersey Rehab Code.*

24 NAHB Research Center, Inc., et al., "Nationally Applicable Recommended Rehabilitation Provisions" (NARRP), U.S. Department of Housing and Urban Development, Office of Policy Development and Research (May 1997), https://www.huduser.gov/Publications/pdf/HUD-7842.pdf.

25 Conclusions about the difficulty of tracing the origin and rationale for the "fire barrier" vs. "fire wall" anomaly in Appendix K are based on my own research

at the New York State Dept. of State Division of Code Enforcement and Administration (DCEA), One Commerce Plaza, 99 Washington Avenue, Suite 1160, Albany, New York 12231, on Oct. 31, 2011. While my examination of New York State Code Council transcripts was fairly comprehensive, it is possible that some written explanation eluded my search. On the other hand, my subsequent conversations with numerous experts, some of whom served on the Code Council, validates my initial conclusion: no one was able to explain the anomaly. These experts include Michael Auerbach and Cathy Karp of the DCEA, Melvyn Green (worked on NARRP and is an expert on the history of code provisions for existing buildings), and Gary Higbee (a staff member who chaired the subcommittee that wrote Appendix K).

26 *New Jersey Rehab Code.*

27 "Nationally Applicable Recommended Rehabilitation Provisions."

28 Thomas D. Hoard, Codes Analyst for HOLT Architects, P.C. in letter to Peter Turner, Assistant Dean for Administration, College of Architecture, Art and Planning, Cornell University (Sept. 6, 2011), copied to Mike Niechwiadowicz, City of Ithaca Building Department, and Graham Gillespie, HOLT Architects, https://jonochshorn.com/milsteinhall/doc/TDH.pdf.

29 ICC, "704.10 Vertical Exposure," *New York State Building Code*, 2002, 88.

30 ICC, "705.6.1 Stepped Buildings," *New York State Building Code*, 2002, 91.

15 NONCOMPLIANT FIRE BARRIER

1 ICC, "706.6 Openings," *New York State Building Code,* 2002, 92.

2 ICC, "716 Opening Protectives," *Code and Commentary,* 7-93.

3 There is additional fire barrier aggregate width at the intersection of Milstein and Rand Halls, not included in these calculations. However, the conclusion remains the same, even if the actual total values for aggregate widths of fire barrier wall and fire barrier openings are different.

4 "Model WS Specific Application Window Sprinklers," 3.

5 "Model WS Specific Application Window Sprinklers," 3.

6 For a description of Tyco sprinkler installation problems, see Jonathan Ochshorn, "Milstein Hall's noncompliant fire barrier," Impatient Search (blog), March 9, 2012, https://jon.ochshorn.org/2012/03/milstein-halls-noncompliant-fire-barrier.

7 "Model WS Specific Application Window Sprinklers," 3.

8 "Model WS Specific Application Window Sprinklers," 3.

9 ICC, "502.1 Definitions (Area, building)," *New York State Building Code*, 2002, 71.

10 ICC, "Table 302.3.3 Required Separation of Occupancies (Hours)," *New York State Building Code*, 2002, 19.

11 Opening protectives in the fire barrier between Milstein and Rand Halls have subsequently been upgraded with the construction of the Mui Ho Fine Arts Library in Rand Hall (2017–2019). The fire barrier itself, however, remains noncompliant.

12 ICC, "706.4 Continuity," *New York State Building Code,* 2002, 92 (my italics).

13 ICC, "2109.4.3 Lateral Support," *New York State Building Code,* 2002, 487.

14 ICC, "Table 2109.4.1 Wall Lateral Support Requirements," *New York State Building Code*, 2002, 487.

15 For brick wall thicknesses, see "Appendix D, Building Envelope and Structural Condition Assessment: Sibley Hall, Cornell University" (May 2009), Ryan-Biggs Associates, Troy, New York, SK-4.

16 CRIT ROOM EGRESS PROBLEMS

1 I computed the Crit Room floor area by superimposing a measured grid onto the floor plan, and thereby accounting for its curved walls and sloping ceiling, with the floor area only counted when the sloped ceiling height is greater than 5 feet (1.5 m) per ICC, "1207.2 Minimum Ceiling Heights," Exception 3, *New York State Building Code,* 2022, 251–252. My area calculation of 4,506 square feet (419 Square meters) differs slightly from the area of 4,935 square feet (458 square meters) tabulated in Milstein Hall Working Drawings, "Code and Life Safety Analysis."

2 ICC, "1008.2 Assembly Other Exits," *New York State Building Code*, 2002, 230.

3 ICC, "Table 1003.2.2.2 Maximum Floor Area Allowances per Occupant," *New York State Building Code,* 2002, 201.

4 ICC, "1004.2.2.1 Two Exit or Exit Access Doorways," *New York State Building Code,* 2002, 218–19.

5 ICC, "707.2 Shaft Enclosure Required," *New York State Building Code*, 2002, 92–93.

6 The 2002 *New York State Building Code* first states that openings in floor-ceiling assemblies are prohibited and then proceeds to list 11 exceptions that allow openings. In modern versions of the code, starting with the 2012 IBC, the negativity of the prior code has been eliminated: vertical openings in floor-ceiling assemblies are now allowed as long as they comply with various protection methods. In other words—abstracting from the normal modifications made in each new code version—nothing has changed.

7 ICC, "707.2 Shaft Enclosure Required," *New York State Building Code,* 2002, 92–93.

8 ICC, "404.1.1 Definition (Atrium)," *New York State Building Code,* 2002, 37.

9 ICC, "404.5 Enclosure of Atriums," *New York State Building Code*, 2002, 37–38.

10 ICC, "707.2 Shaft Enclosure Required," *New York State Building Code,* 2002, 92–93.

11 ICC, "1005.3.2 Enclosures," *New York State Building Code*, 2002, 224.

12 ICC, "202 Definitions (Story above Grade Plane)," *New York State Building Code,* 2002, 15.

13 ICC, "502.1 Definitions (Mezzanine)," *New York State Building Code,* 2002, 71.

14 ICC, "1003.2.2 Design Occupant Load," *New York State Building Code,* 2002, 200.

15 In later iterations of the IBC, there are ways to include an unenclosed stairway in an opening connecting three (or more) floor levels. In the 2020 IBC, for example, 2-story openings are possible even when they contain means of egress, so that a room or space containing a mezzanine with an opening to a second story above the mezzanine could contain an egress stair: see ICC, "712.1.9 Two-Story Openings," *New York State Building Code*, 2020. The newer code also defines "exit access stairways," like the unenclosed egress stair in Milstein Hall's Crit Room, and permits such stairs, if in sprinklered buildings with assembly occupancies, to be unenclosed for up to four stories as long as the "vertical opening between stories does not exceed twice the horizontal projected area of the stairway … and the opening is protected by a draft curtain and closely spaced sprinklers…": ICC, "1019.3 Occupancies Other than Groups I-2 and I-3, item 4," *New York State Building Code*, 2020.

16 The common path of egress travel is defined as: "That portion of exit access which the occupants are required to traverse before two separate and distinct paths of egress travel to two exits are available. Paths that merge are common paths of travel…": ICC, "1002.1 Definitions (Common Path of Egress Travel)," *New York State Building Code,* 2002, 199.

17 Email to the author from Michael Niechwiadowicz, Deputy Building Commissioner, City of Ithaca (March 7, 2012). The reference in this email to the "2003" building code refers to the 2002 code, which became effective in January 2003.

18 ICC, "1006.2.1 Egress Based on Occupant Load and Common Path of Egress Travel Distance," *New York State Building Code*, 2020 (my italicizing of the word, "or."

19 ICC, "1004.2.4 Exit Access Travel Distance," *New York State Building Code*, 2002, 219–220 (my italics).

20 ICC, "1017.3 Measurement," *Code and Commentary,* 10-135–10-136.

21 Milstein Hall Working Drawings, "Code and Life Safety Analysis."

22 Milstein Hall Working Drawings, "Code and Life Safety Analysis."

23 ICC, "303.1 Assembly Group A," *New York State Building Code,* 2002, 19.

24 ICC, "Table 1003.2.2.2 Maximum Floor Area Allowances per Occupant," *New York State Building Code,* 2002, 201.

25 ICC, "Table 1003.2.2.2 Maximum Floor Area Allowances per Occupant," *Code and Commentary*, 10-11.

26 ICC, "Table 1004.2.1 Spaces with One Means of Egress," *New York State Building Code,* 2002, 218. Subsequent iterations of the IBC changed the maximum occupant load for assembly spaces with one means of egress from 50 to 49.

17 HEARING BOARD APPEAL

1 My complaint to the City of Ithaca Building Department was filed under Title 19 of the Official Compilation of Codes, Rules and Regulations of the State of New York (1203.3 Minimum features of a program for administration and enforcement of the Uniform Code), on Dec. 13, 2011.

2 The Code Appeal Hearing that I initiated was held July 18, 2013, at the Hughes State Office Building, 333 E. Washington St., Syracuse, NY, before the Capital Region-Syracuse Board of Review. The Board consisted of: Michael Hrab, George R. Maney (Chair), Mark L. Dedrick, and Richard Lafferty, AIA. Representing Cornell: Gary Wilhelm, Milstein Hall Project Manager; Bob Stundtner, Director of Capital Projects Management; and Shirley Egan, Associate University Counsel. Representing HOLT Architects, who had been hired by Cornell as code consultant, was Thomas Hoard. Representing the City of Ithaca Building Department was Acting Building Commissioner Mike Niechwiadowicz. In this context, I was the petitioner.

3 "Decision. Appealing a determination."

4 "Decision. Appealing a determination."

5 Jonathan Ochshorn, "Appeal regarding building code violations in Cornell's Fine Arts Library," unpublished analysis, last updated March 17, 2021, https://jonochshorn.com/scholarship/writings/rand-appeal-2020.

6 "Decision. Appealing a determination."

7 "ICC ES Legacy Report," Evaluation Report No. NER-516, Division 13—Special Construction, section 13930—Wet-Pipe Fire Suppression Sprinklers, "Tyco Fire Products (TFP)/Central Sprinkler Company (CSC) Window Sprinkler Model WS, 1/2 inch orifice quick response vertical and horizontal sidewall sprinklers SIN TY3388, TY3488, C3388 and C3488," reissued Jan. 1, 2003, https://jonochshorn.com/milsteinhall/doc/Tyco-NER.pdf (author's copy).

8 Email from Ken Dias, Applications Specialist at Tyco, to the author (July 24, 2013).
9 "Decision. Appealing a determination."
10 For documentation of the construction of a new Crit Room exit, see Jonathan Ochshorn, "Milstein Hall's New Crit Room Exit" (March 14, 2015), https://youtu.be/ZUzOpNv361Q.
11 ICC, "1003.2.2 Design Occupant Load," *New York State Building Code*, 2002, 200, (my italics).
12 "Decision. Appealing a determination."

18 CONCLUDING REMARKS ON FIRE SAFETY

1 "Civilian Deaths Caused by Fire in the United States from 1977 to 2021," *Statista*, accessed June 24, 2023, https://www.statista.com/statistics/376703/us-civilian-fire-deaths.
2 See, for example: "Student Dies in Early Morning Cook Street Fire," *Cornell Daily Sun*, May 5, 2011, https://cornellsun.com/2011/05/05/student-dies-in-early-morning-cook-street-fire; and "Student Dies in Apartment Fire," *Cornell Daily Sun*, May 14, 2006, https://cornellsun.com/2006/05/14/student-dies-apartment-fire. Nine Cornell students were killed in a 1967 fire at the Cornell Residential Heights Club; there have been dorm fires in Balch Hall and the Low Rise dorms in 2004 and 2006 respectively; and there have been "129 campus-related fire fatalities nationwide since 2000" (up until Nov. 10, 2008) per Brian Fetterolf, "Renovation Highlights Fire Safety Issues," *Cornell Daily Sun* (Nov. 10, 2008), https://cornellsun.com/2008/11/10/renovation-highlights-fire-safety-issues.
3 Eric Wilson, "Prada Store Wrings Out," *New York Times* (Jan. 26, 2006), https://www.nytimes.com/2006/01/26/fashion/thursdaystyles/prada-store-wrings-out.html.
4 Andrew Jacobs, "Fire Ravages Renowned Building in Beijing," *New York Times* (Feb. 9, 2009), https://www.nytimes.com/2009/02/10/world/asia/10beijing.html.
5 "Blanco v. Prada USA Corp.," 2009 NY Slip Op 33030(U), Robert Blanco, Plaintiff, v. Prada USA Corp., American Eagle Outfitters, Inc., 575 Broadway LLC, 575 Broadway Associates L.P. and 575 Broadway Corporation and A.R.I. Investors, INC., Defendants. No. 101644/07, Seq. No. 003. Supreme Court, New York County. December 21, 2009, and December 30, 2009, accessed June 24, 2023, at https://www.leagle.com/decision/innyco20100106308.xml.
6 "Robert Blanco, Plaintiff against Prada USA Corp., American Eagle Outfitters, Inc. etc.," Supreme Court of the State of New York, County of New York, Feb. 2, 2007, (website no longer available).
7 "Robert Blanco, Plaintiff, against Prada USA Corp, American Eagle Outfitters, Inc., et. al.," Supreme Court of the State of New York, Verified Complaint, https://jonochshorn.com/milsteinhall/doc/Prada.pdf (author's copy).
8 "7 Injured in Soho Blaze," *New York Times* (Jan. 22, 2006), https://www.nytimes.com/2006/01/22/nyregion/7-injured-in-soho-blaze.html.
9 Eric Wilson, "Prada Store Wrings Out" *New York Times*.
10 Krisy Gashler, "Cornell Sues State, City over Fire Code," *Ithaca Journal* (June 17, 2009).
11 "Decision & Order, Cornell University, Petitioner/Plaintiff, vs. New York State Department of State, Ronald E. Peister et al.," State of New York

Supreme Court, County of Tompkins, Index No. 2009-0220 (Aug. 6, 2009), https://jon.ochshorn.org/wp-content/uploads/2009/06/CB140799819.pdf (author's copy).

12 "Morse Hall Destroyed by Fire," *Cornell Alumni News*, 18, no. 20, Ithaca, N. Y. (Feb. 17, 1916), http://dspace.library.cornell.edu/bitstream/1813/26394/1/018_20.pdf.

13 "Cornell Space Lab Is Damaged by Fire," *New York Times* (April 26, 1995), https://www.nytimes.com/1995/04/26/nyregion/cornell-space-lab-is-damaged-by-fire.html.

14 "S.T. Olin Lab at Cornell back in use after fire," *Cornell News* (July 9, 1999), https://news.cornell.edu/stories/1999/07/stolin-lab-cornell-back-use-after-fire.

15 Ayala Falk, "Electrical Unit Catches Fire At Synchrotron Laboratory," *Cornell Daily Sun* (September 17, 2009), accessed July 24, 2012, but no longer available.

16 Seth Shapiro, "Old Equipment Sparks Fire at Synchrotron," *Cornell Daily Sun* (Oct. 14, 2009), accessed July 24, 2012, but no longer available.

17 "Fire Threatens Sibley," *Cornell Alumni News*, 9, no. 3, Ithaca, N. Y. (Oct. 17, 1906), http://dspace.library.cornell.edu/bitstream/1813/26016/1/009_03.pdf (my italics). This article also is the source for Figure 18.1.

19 OPENING REMARKS ON SUSTAINABILITY

1 A Cornell handout specifies a minimum silver rating for new construction and major renovations: see "Cornell LEEDing."

2 "Cornell LEEDing."

3 Based on table in "Cornell LEEDing."

4 "Department of Architecture Program Mission," Archived Catalog (2011–2012), accessed June 25, 2023, https://courses.cornell.edu/preview_program.php?catoid=12&poid=3229.

5 "COTE Mission," AIA Committee on the environment, (website no longer available). A later and more generic COTE mission statement was accessed June 25, 2023, https://network.aia.org/blogs/brian-mclaren/2017/12/31/cotes-mission-and-goals.

6 For Milstein Hall's anticipated LEED points, see "Milstein LEED Checklist," (based on LEED-NC Version 2.2 Registered Project Checklist), Sept. 2, 2011, BVM Engineering. For a detailed description of LEED credits and prerequisites, see USGBC, *LEED 2.2 New Construction*. For Milstein Hall's final "scorecard," accessed June 25, 2023, see https://www.usgbc.org/projects/cornell-university-milstein-hall.

7 Yes, it's confusing: buildings can be certified by LEED at "silver," "gold," and "platinum" levels, but can also be certified at the lowest level, called "certified."

8 "LEED for New Construction Application Review."

20 SUSTAINABLE SITES

1 This comment, and many that follow, appear in my summaries and critiques of the LEED Green Building Design & Construction Reference Guides. See Jonathan Ochshorn, "Links to my summary and critique," unpublished writing, https://jonochshorn.com/scholarship/writings/leed-comparisons.html.

2 Values for building and site area are based on educated guesses since I don't have

access to the official data.

3 "Since the billionaire's plans for the world's largest wind farm fell apart in the Texas Panhandle, Pickens has edited his much-hyped 'Pickens Plan' to focus primarily on his other big business interest: natural gas." Jennifer Alsever, "Pickens Plan no longer features wind energy," *NBC Business News*, Dec. 14, 2010, https://www.nbcnews.com/id/wbna40612094.

4 "Environmental Issues," in "Sustainable Sites, Credit 3," USGBC, *LEED 2.2 New Construction,* 44.

5 Milstein Hall occupancy estimates provided by Matthew Kozlowski, Project Coordinator, Facilities Engineering, Cornell University in email to the author dated Nov. 30, 2011.

6 "If shower/changing facilities are located in another building, be sure that the building allows project occupants full access to the facilities during the same hours as the project building." "LEED Project Submittal Tips: New Construction 2009," Green Building Certification Institute, Dec. 23, 2011, 4, https://www.usgbc.org/sites/default/files/LEED-Project-Submittal-Tips-NC2009.pdf.

7 "LEED for New Construction Application Review."

8 See, for example, Lloyd Alter, "Getting Person out of Car and Onto a Bike Saves More Energy & Carbon Than Going Net Zero," *Treehugger Voices* (updated Aug. 30. 2020), https://www.treehugger.com/defence-leed-six-years-later-why-are-people-still-bashing-bike-racks-4851149.

9 "You can lead a horse to water… But you can't make it drink. In other words, bike racks and showers will probably not be enough to encourage biking in an area that's unfriendly to bicyclists. If you're thinking of pursuing this credit, first consider the realities of the neighborhood around your project. Is it realistic that building occupants will ride bicycles and make use of the bike racks and storage or the shower facilities? It's important to consider whether the intent of this credit will bear out in reality or if your resources might be better allocated elsewhere." "NC 2009 SSc4.2: Alternative Transportation—Bicycle Storage and Changing Rooms," LEEDuser.com (website no longer available).

10 See, for example: "Ridesharing & Carsharing," *Cornell Sustainable Campus*, https://sustainablecampus.cornell.edu/campus-initiatives/transportation/ride-car-sharing.

11 "Transportation—University Ave. Parking Lot Redbud Woods: A Controversial Development Case," *Cornell Sustainable Campus* (website no longer available).

12 Daniel Aloi, "Construction under way on Milstein Hall project," *Chronicle Online* (Aug. 4, 2009), https://news.cornell.edu/stories/2009/08/construction-under-way-milstein-hall-project.

13 "Economic Issues," in "Sustainable Sites, Credit 5.2," USGBC, *LEED 2.2 New Construction,* 73.

14 "LEED for New Construction Application Review."

15 "Cool roofs," *Energy Saver*, https://www.energy.gov/energysaver/cool-roofs. See also: Tyler, "Rethinking Cool Roofing." In particular, Figure 1 shows a net loss in energy savings for all U.S. cities modeled except for Phoenix and Miami when a "cool roof" is used.

21 WATER EFFICIENCY

1 Chris Good, "Rand Paul and the 19-Year Libertarian War on Low-Flow Toilets," *Atlantic* (March 16, 2011) https://www.theatlantic.com/politics/archive/2011/03/rand-paul-and-the-19-year-libertarian-war-on-low-flow-toilets/72545.

22 ENERGY & ATMOSPHERE

1 There is another big problem with comparing a baseline building to the building as designed: "…many dissimilarities exist, such as size and heating characteristics of the glazing, heating characteristics of other envelope elements, lighting density, and type of HVAC system. However, these are not the main differences between the buildings. *The real difference is that the design building almost certainly will be built, and the base building is just an imaginary building*." Inevitable variations in the actual vs. "designed" elements comprising the real building "can cause the energy modeling to be off by up to 15% from the deterministic modeling output… Energy modeling software that compares design and base buildings needs to be revised so that it can allocate uncertainties to the inputs of the design building and present a probabilistic output." See Khazaii, "Rethinking Energy Modeling," 79 (my italics).

2 Murphy, *The Green Tragedy*.

3 For the final report released in 2008, see: Cathy Turner and Mark Frankel, "Energy Performance of LEED for New Construction Buildings," *New Buildings Institute,* March 4, 2008, https://newbuildings.org/wp-content/uploads/2015/11/Energy_Performance_of_LEED-NC_Buildings-Final_3-4-08b1.pdf.

4 Henry Gifford, "A Better Way to Rate Green Buildings," undated (but probably from about Spring 2009), http://www.solaripedia.com/files/223.pdf.

23 MATERIALS & RESOURCES

1 "An original window from the Darwin Martin carriage house is returning home thanks to a generous donation by a Buffalo couple. Will and Nan Clarkson have given the Frank Lloyd Wright designed window to the Darwin Martin Restoration Corporation to display in the rebuilt carriage house. The couple had owned the window since the mid-1980's and its value on the resale market was estimated at over $100,000." From "Carriage House Window Donated Back to Martin House," *Buffalo Rising*, https://www.buffalorising.com/2011/07/carriage-house-window-donated-back-to-martin-house.

2 "With the foundations in place, 1,125 tons of steel have been rising on the site of Milstein Hall, including five trusses that support the building's massive cantilever." Sherrie Negrea, "Steel framework nearly complete for Milstein Hall," AAP/Architecture Art Planning website (June 11, 2010). Milstein Hall, a two-story building, uses more than twice as much steel per square foot of floor area as the Hancock Center in Chicago, a 100-story, 1127-foot-high skyscraper: "…the structural steel in a typical medium-rise Chicago building weighs about 50 pounds for each square foot or area. Yet in this extreme high-rise [the Hancock Center in Chicago], the ratio is only 29.7 pounds of steel per square foot of area…" LeBlanc, *The Architecture Traveler,* 134.

3 "Environmental Issues," in "Materials & Resources, Credit 5," USGBC, *LEED 2.2 New Construction,* 275.

4 "Environmental Issues," in "Materials & Resources, Credit 5," USGBC, *LEED 2.2 New Construction,* 275.

5 "Economic Issues," in "Materials & Resources, Credit 6," USGBC, *LEED 2.2 New Construction,* 279.

6 "Economic Issues," in "Materials & Resources, Credit 6," USGBC, *LEED 2.2 New Construction,* 279.

7 LEED now permits additional organizations (not just the FSC) to certify wood: "Builders and architects can use wood and paper products certified to the Sustainable Forestry Initiative (SFI), American Tree Farm System (ATFS), Canadian Standards Association (CSA), Forest Stewardship Council (FSC), and Programme for the Endorsement of Forest Certification (PEFC) standards to achieve a point in the Certified Wood Pilot ACP under LEED 2009 and achieve a point in the Sourcing of Raw Materials Pilot ACP under LEED v4." See "Earning LEED points with certified wood," USGBC, https://www.usgbc.org/articles/earning-leed-points-certified-wood.

8 Homasote is an underlayment product used behind felt pin-up walls in Milstein Hall. "The Forest Stewardship Council (FSC), a non-profit organization devoted to encouraging the responsible management of the world's forests, has certified Homasote under recently extended certification criteria that now includes firms whose products are made from post-consumer materials." "Homasote Products Earns FSC Certification," Homasote, Jan. 21, 2009, https://www.homasote.com/blog/10/homasote-products-earns-fsc-certification.

9 Discussion of wide-plank ash not meeting FSC standards is based on author's conversation with John McKeown, Milstein Hall Project Manager for the College of Architecture, Art, and Planning at Cornell, Jan. 4, 2012.

10 "About the Emerald Ash Borer," Emerald Ash Borer Network, http://www.emeraldashborer.info/about-eab.

24 INDOOR ENVIRONMENTAL QUALITY

1 "Considerations," in "Indoor Environmental Quality, Prerequisite 1," USGBC, *LEED 2.2 New Construction,* 292.

2 "Overview," USGBC, *LEED Reference,* 2009, 401.

3 William J. Fisk, "Health and Productivity Gains from Better Indoor Environments and Their Implications for the U.S. Department of Energy," *E-Vision 2000 Conference* (Oct. 11–13. 2000), Washington, D.C., https://www.osti.gov/servlets/purl/780590.

4 Anne Whitacre, "Another perspective on green," letter to the editor, *Construction Specifier* (Feb. 2008, 12) https://www.constructionspecifier.com/publications/de/200802/index.html.

5 Yuka Yoneda, "Bernie Madoff Serves Sentence at U.S.'s Only LEED-Certified Prison," Inhabit.com (website no longer available).

6 Paula Melton, "Army Targets Aggressive LEED, Green Building Goals," *Environmental Building News* (July 2011), https://www.buildinggreen.com/news-analysis/army-targets-aggressive-leed-green-building-goals.

7 Jeff Dardozzi, "The Indiscreet Banality of the Bourgeoisie: The Church of LEED, Passive House, and the Dangers of Going Green," *Monthly Review* 62, no. 07 (December 2010), https://monthlyreview.org/2010/12/01/the-indiscreet-banality-of-the-bourgeoisie.

8 Persily, "Indoor Air Quality and Carbon Dioxide" (my italics).

9 Schoen, P.E., "Indoor Air 2011." Schoen refers to conclusions reached by Hal Levin, Jan Sundell, and Eduardo Fernandez in a forum on "Ventilation Rates and Health" at the 12th International Conference on Indoor Air Quality and Climate sponsored by the International Society of Indoor Air and Climate (ISIAQ), June 2011.

10 "My insider's perspective (on Standard 62.2 at least) is that there is a lot of mileage to be made by scaring people about underventilation, and folks are rising to the occasion. Unfortunately, overventilation in hot, humid climates has led to more indoor air problems due to mold resulting from part-load issues than underventilation anywhere else… Doesn't anyone at the U.S. Green Building Council know anything about energy and part-load humidity?" Lstiburek, "Building Sciences: Energy Flow," (footnote, page 64).

11 Sibley Hall's potentially hazardous digital fabrication lab addressed its noncompliant transfer of makeup air from a corridor into the room by adding several printers to the corridor and calling it a "room"; see Jonathan Ochshorn, "Egress, Toilets, and Carcinogens: Cornell's Transition Plans during Fine Arts Library Construction," Impatient Search (blog), updated Jan. 19, 2018, https://jon.ochshorn.org/2017/04/egress-toilets-and-carcinogens-cornells-transition-plans-during-fine-arts-library-construction.

25 INNOVATION & DESIGN PROCESS

1 "Approach and Implementation," in "Innovation in Design, Credits 1.1–1.4," USGBC, *LEED 2.2 New Construction,* 392.

2 UrbanTrans Consultants, "Transportation Demand Management Study report," Regional Municipality of Peel (June 2004), C-19, https://www.bart.gov/sites/default/files/docs/MacArthur_BART_Access_Feasibility_Study.pdf.

3 "Draft Environmental Impact Statement, Paul Milstein Hall and Central Avenue Parking Garage Projects," Cornell University, Trowbridge & Wolf (July 25, 2008), https://jonochshorn.com/milsteinhall/doc/DEIS.pdf (author's copy).

4 Cornell's Green Cleaning Program website has been updated and moved since these quotations were found on Oct. 27, 2011; Cornell's new website, containing substantially the same information, was accessed June 28, 2023, https://sustainablecampus.cornell.edu/buildings-energy/building-standards.

26 CORNELL'S SUSTAINABLE VISION FOR MILSTEIN HALL

1 "Milstein Hall and Sustainability."

2 "Milstein Hall and Sustainability."

3 "Milstein Hall and Sustainability."

4 "Milstein Hall and Sustainability."

5 Email written to the chair of the Department of Architecture by a graduate architecture student Sept. 1, 2011—shortly after Milstein Hall was completed and occupied—reproduced and displayed at "OMA/Progress" exhibition at the Barbican Gallery in London that opened Oct. 4, 2011.

6 "Milstein Hall and Sustainability."

7 "Milstein Hall and Sustainability."

8 "This is a building whose design leaves intact Rand Hall, whereas all previous schemes that have been developed for this project have proposed tearing down this perfectly functional building…": "Arch Profs Ardently Support Building Milstein," *Cornell Daily Sun*, Feb. 11, 2009, accessed Dec. 7, 2011 (website no longer available).

9 "Milstein Hall and Sustainability."

10 "Another study conducted in Estonia investigated the water quality of a lightweight aggregate and humus green roof runoff compared a bituminous membrane roof found that during light to moderate rainfall events the concentrations of COD, BOD, total nitrogen, and total phosphorus were greater in the bituminous roof. However during heavy rainfalls greater amounts of nitrogen and phosphorus washed from the green roof (Teemusk, 2007)." Brett Long, Shirley E. Clark, et al., "Green Roofs: Optimizing the Water Quality of Rooftop Runoff," http://annemariemaes.net/wp-content/uploads/2014/01/moss-rooftops.pdf.

11 Information on Milstein Hall's sedums was provided by Marguerite Wells of MotherPlants, a nursery in upstate New York specializing in growing plants for green roofs (including Milstein Hall's roof).

12 See MSDS for SpeedZone, manufactured by PBI/Gordon Corporation, https://jonochshorn.com/milsteinhall/doc/speedzone.pdf (author copy). According to the Cornell Grounds Department's "Mission and Scope of Services," accessed June 29, 2023, https://fcs.cornell.edu/departments/facilities-management/grounds-department/grounds-department-mission-scope-services: "Weed controls (herbicides) are kept to an absolute minimum and are applied on a limited basis. Many lawns will have varying populations of broad leaf and grass weed species present." According to Kevin McGraw, Landscape Manager at Cornell (phone conversation with the author Dec. 8, 2011), herbicide application may change in Spring 2012, utilizing Battleship Herbicide III, manufactured by the Helena Chemical Company. See its MSDS, accessed June 29, 2023, https://jonochshorn.com/milsteinhall/doc/battleship3.pdf (author copy). At the time of this writing, Cornell's herbicide-du-jour appears to be Triamine, applied by TruGreen. See its MSDS, accessed June 29, 2023, https://jonochshorn.com/milsteinhall/doc/triamine.pdf (author copy).

13 "Milstein Hall and Sustainability."

14 "Milstein Hall and Sustainability."

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ILLUSTRATION CREDITS

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15.3 Image scanned from Figure 3B-3, "Model WS Specific Application Window Sprinklers Horizontal and Pendent Vertical Sidewall 5.6 K-Factor," TFP620, Tyco Fire Suppression & Building Products, April 2011.

16.2 Photo from "AAP buzzes as hundreds of alumni, students, and faculty gather during Celebrate Milstein Hall," *Cornell AAP News*, website no longer available.

16.8. Drawn by author, based on "Moveable Wall Plans" contained in a 10 December 2010 email from Kim Cleveland of Accufab —"Experienced Metal Fabricators" in Ithaca, NY—to Ziad Shehab of OMA. Segmented arrow and dimensions representing the common path of egress travel were added by the author.

16.10 Drawn by the author based on Milstein Hall "Code and Life Safety Analysis" working drawings.

16.11 Drawn by the author based on Milstein Hall "Code and Life Safety Analysis" worming drawings.

18.1 Public domain (Cornell Alumni News, 1906).

20.3 Tompkins County bus map, annotated by the author.

20.9 Graph drawn by the author based on: "Climate Ithaca – New York," *U.S. Climate Data*, accessed June 26, 2023, at https://www.usclimatedata.com/climate/ithaca/new-york/united-states/usny0717.

21.1 Image (a) is drawn by the author; image (b) is a rotated fragment of a Wassily Kandinsky painting taken from "Jaune Rouge Bleu" (Yellow Red Blue), painted in 1925, accessed June 26, 2023 (public domain) at https://en.wikipedia.org/wiki/Wassily_Kandinsky#/media/File:Kandinsky_-_Jaune_Rouge_Bleu.jpg; image (c) is drawn by the author, derived from a stomach colon rectum diagram, accessed June 26, 2023, at https://en.wikipedia.org/wiki/Jejunum.

26.1 Drawing, no longer available on Cornell's Milstein Hall website, has been edited by the author.

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