THE INTEGRITY OF STRUCTURE: SHOULD WHAT IS HIDDEN INSIDE THE WALL BE CONSIDERED A PART OF A HISTORIC BUILDING'S CULTURAL VALUE?

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«In conducting business (especially for the office) never forget that the greatest danger arises from cocksure pride. Beware of over-confidence; especially in matters of structure.»

From Cass Gilbert, Architect (1859-1934)
Maxims for My Office Organization (*from Arttoday.com*)

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The collapse of the World Trade Center towers has irrevocably changed our perceptions of buildings, at least for a generation. Even now, a year after the event, we struggle to make sense of an event that, until it occurred, was beyond our imagination. Bridges, radio towers, or other structures can fall down, but, absent an earthquake, major modern engineered buildings are simply not known to do so. They seem so solid, so permanent. Or course, intellectually the collapse made sense. How could any building stand up to the fiery crash of a large fully loaded commercial airplane? But in fact they withstood that force – only to suddenly collapse an hour later into an indefinable pile of debris – except for the evocative Gothic ruin of the broken facade of each tower. (Photo 1)

Buildings have collapsed in history, but these collapses were broadcast on international television. Almost every camera in New York was trained on them when it happened, and millions watched in horror as they fell to the ground. The only thing missing from the experience of those who watched in on television was the earthquake-like thump when the pancaked floors – 110 of them – struck bottom. Who can now not think of structure when looking at a building – particularly when looking up at a tall building? How fragile they now seem.

After the disaster, one of the original principle engineers, Leslie Robertson, who still lived and worked in New York City, was both excoriated and praised for the structural system of the buildings, a system unique in its time and unusual even today. On the one hand he was praised for how they withstood the crash long enough for most to escape, and blamed for a pancake collapse that killed those who were unfortunate enough to still be in the buildings. In all of this, Robertson had to personally endure what few have ever had to endure – witnessing his life's masterwork collapse to the ground carrying more than 3,000 people to their deaths. It is an image that will remain forever engraved in his mind.

After this catastrophe, who can now argue with the importance of structural design and building construction on history and culture. Even the fleeting but powerful image of the collapsing towers, and of their tilted and broken facades in the days that followed, was shaped by the engineering design that had kept them from immediately collapsing at the time of the attacks. They were constructed like a hollow tube, with a central core and a perimeter wall of steel, rather than the more standard evenly spaced grid of columns. When the heat of the fires weakened the perimeter columns and the core, there was nothing to stop the progressive collapse of the pancaking floors between the core and the perimeter. Nothing could hold up such a weight once it was mobilized.

These buildings have passed into history while they were still young –wiped completely from the face of the earth except for a few select pieces stacked in New Jersey scrap yards and at the ironically named "Fresh Kills"[1] landfill site on Staten Island (Photo 2). In addition, in the penumbra of their collapse, the other buildings of the World Trade Center complex were set on fire from the falling debris and destroyed as well. One of them, WTC #7, became the world's first steel-frame high-rise building to collapse solely because of fire, when it collapsed about six hours after Towers 1 and 2 came down. All of the other buildings in the complex remained standing, with gaping holes and missing sections that were squashed by the cascade of debris, but their structures were twisted and warped by the uncontrolled fires that raged in them for hours.

90 West Street

On one side of the World Trade Center complex stood a much older building that was also almost completely burned out. It was not only older; it was more than half a century older. At the time it was constructed, at 28 stories, it was one of the tallest buildings in the world of its day. Located at 90 West Street, it was designed by Cass Gilbert and completed in 1907. Gilbert was also the architect of the more well known 792 foot high Woolworth Building nearby, which, after the demise of the World Trade towers, again holds the rank of the tallest building in lower Manhattan – remarkable for a building completed in 1913! (Photo 3)

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1 The name "kill" came from the Dutch word for a small stream.

A year after the collapse of the towers, the interior of 90 West Street is a burned out ruin. Almost every floor suffered extensive fire damage, and some became sufficiently hot (Photo 4) to soften the steel columns. This building stands as evidence of how far the burning debris was catapulted into the surrounding area. However, unlike all of the other burned out buildings, not only did it not collapse, as did the 50 story World Trade Center #7, *its structural system was only slightly damaged.* That system, which consists of hollow clay tile and riveted steel, proved to be more durable and capable of avoiding the destructive warping of the steel joists and columns that occurred in the massive group of 1960's seven-story buildings that surrounded the towers. Only a few columns were slightly buckled, (photo 5)a testament to the fact that even though the fires were hot, the onset of collapse was arrested (most probably by the rivets) just as it had been for many similarly constructed high-rise buildings which were thoroughly burned out in the San Francisco Earthquake and Fire of 1906 almost a century earlier.

This building stands as a testament to the resilience of the now archaic structural and fireproofing system of the building's structure. It also stands as a remarkable present-day chance to study what happened in San Francisco to the cluster of early high-rise buildings that existed in that city when the great 1906 earthquake and fire ravaged the entire downtown area, destroying all in its path except the high-rise buildings of similar construction as 90 West Street. Even more remarkable: almost all of the buildings in San Francisco in 1906 of this type were repaired and remain extant to this day.

The detailed reports on the performance of the burned out San Francisco buildings show that their performance in the extremely hot fires, although far from perfect, was in many cases good enough to allow the building to be restored. In fact, it was the 1906 earthquake and fire that demonstrated some of the problems with hollow clay tile fireproofing, as it was often compromised, but the earlier steel structural systems of riveted steel members, rather than welded rolled wide flange beams and columns of today, proved to be remarkably stable even where the tile had fallen. As a result, these badly damaged buildings could be repaired.

Few people today are even aware that when they stay in the luxurious stately Fairmont Hotel or the equally impressive St. Francis Hotel that they are in the restored interiors of what had been burned out hulks in 1906. While it remains to be seen if the restoration of 90 West Street will be undertaken, the mere fact that it is possible provides an opportunity to study the technical attributes of the first phase of skyscraper design known as the Chicago Frame. It is this phase of building structural design that laid the groundwork for the evolution of building construction to what is now the almost universal use of frame construction for large buildings in all parts of the globe – a revolutionary transition in construction technology away from the masonry bearing wall that had dated back almost to the beginning of historic time.

Hagia Sophia

Historically, it was much more rare for buildings to be completely removed than it is today. This is true even for heavily damaged buildings. Hagia Sophia, constructed in the 6th Century, has lasted 40 times the life span of the World Trade Center towers, yet an earthquake collapsed part of the dome in 557. In the rebuilding process, the shape of the dome was changed, making it more stable, and the great buttresses were built, wiping out the original Justinian period exterior design with its late classical portico.

After centuries of earthquakes and differential settlement, the former church has now taken on an almost organic character. What we see today as the historical monument is radically different than what was designed and first constructed back in the 6th Century, yet few would propose that it be reconstructed to that original appearance. To do so would mean that the building would no longer be old – thus not a genuine relic of history. It is not just the patina from the effects of time that settles onto the materials, but also the massive added buttresses and the shape of the reconstructed dome that are now as important in the building's history of the building, as they are responsible for its continued survival. Structural analysis and rehabilitation is a continuous process. Work is being carried out today to restore the interior, but no one would consider replacing the bearing masonry structure of this building with reinforced concrete, as has been done in many other historic buildings (Photo 6).

Examining such histories is also a way of understanding the field of historic preservation. The field has gone through many changes over the past two centuries. While in Great Britain and Europe, the 19th Century was characterized by the restoration of ruins into artistic, but sometimes fanciful, recreations of what had been thought to have once existed, the 20th Century has been marked by the growth of a separate professional discipline of conservation practice that has placed an emphasis on the protection of the surviving parts of historic structures, rather than their reconstruction to an earlier date. This shift is straightforward in those familiar cases involving ancient masonry monuments and ruins, where the structural system is one and the same as the architectural finish. Where complications and conflicts tend to arise is with those buildings, particularly of the 19th and the 20th centuries, where the elements of the structural system are largely hidden underneath the architectural finishes and do not in themselves determine the shape of the architectural detailing.

This presents a conservation dilemma, particularly where structural issues are involved in the rehabilitation, such as in earthquake areas. *Is the historical integrity of the building dependent on the integrity of a given building's structural system? Is it the duty of a conservator to consider the structural systems of buildings when a conservation plan is developed?* Even more basic is this question: *what is the* *cultural value of the structural system of an historic structure– and what is its contribution to the cultural value of the building as a whole?* These questions could also apply to other technological aspects of a building such as heating, and ventilation, but the issue of the structural system also can be considered in a special category, as it provides the armature on which the visual identity of the building as an artifact is dependent.

Apart from the relationship between the structure and the architecture, the history of structures has its own trajectory, sometimes independent of architectural history per-se. Sometimes a building of only modest note in terms of architectural history may hold a pivotal position in structural history, or in terms of its place in the evolution of building construction technology.

It has often been particularly challenging to focus conservation efforts on the technology of structures and construction when, as is often the case, the surviving artifacts of this history are hidden, only to be revealed and thus discovered when work is undertaken. In addition, building technology has gone through such a radical change over the course of the last 150 years that when confronted with conservation questions, there are few people available either to recognize cultural and historical value in archaic systems, much less be able to properly assess them and come up with methodologies for preservation and interpretation. In addition, the often-stringent requirements of current codes that stipulate sometimes radical restructuring work. These codes have been written often without any recognition of the kinds of building systems that are being affected in rehabilitation work, and thus they are blind to any recognition of inherent qualities that may exist in such systems.

The collision between integrity of original fabric and current engineering and construction methods has become most apparent around the issue of earthquake safety. Earthquakes affect both historic and modern buildings, and the demand in the affected parts of the world of advancing hazard mitigation efforts to reduce the potential for catastrophe in an earthquake has advanced the cause of seismic strengthening of existing buildings along with the improvement of the codes for new construction. At the same time, the need is overwhelming, and it is unlikely that the vulnerable areas of the world will ever be able to address all of the risks before future earthquakes. An important building conservation question thus is: *do we strengthen historic structures at risk of earthquake damage, and, if so, how is the destruction of the structural integrity of the given historic building to be avoided? Is it better to a building it intact when it may be heavily damaged or destroyed in an earthquake, or strengthen it? If strengthened, then how is its integrity to be preserved when current codes often preclude the use of archaic practices in new work on existing buildings?* Under such circumstances, it may be best to leave the structure alone to take its chances, because at least then it will be preserved for as long as possible *– or is this position irresponsible, because of the risk to its inhabitants?*

Many projects in the United States and Europe involving the seismic strengthening of an historic structure have suffered from a separation of the architectural conservation from the structural strengthening. While the highest grade of ancient monuments have usually benefited from an integrated consideration of all of these issues, the buildings of lesser symbolic importance, which are nonetheless of great value in defining the architecture and culture of cities and regions, have frequently suffered from major structural upgrading. Sometimes this has even consisted of the complete internal demolition of a given structure, and its reconstruction in an entirely different system. Indeed, it was not just wartime damage that has lead to the reconstruction of historic masonry and timber structures into reinforced concrete, preserving only the exterior masonry. This practice has been widespread throughout Europe, especially where buildings have gone through a change of use. In the United States, notable examples of this practice include even the White House in Washington DC in the 1950's, and the California State Capital in Sacramento in the 1980's. (photo 7)

University of California's South Hall:

One example that particularly brought this issue to light was the seismic upgrading of the oldest building on the University of California, Berkeley campus, South Hall, in the 1980s. South Hall was constructed of brick and iron in 1873, having been designed by Architect David Farquharson.[2] (Photo 8)

In the mid 1980's the University of California, Berkeley embarked on a seismic retrofit program, and South Hall, a handsome High Victorian brick building with a Mansard roof, was first on the list because it, as an "unreinforced" masonry building, had been deemed in the earlier surveys to be a high hazard. The engineers who undertook the study were unaware that the building had been constructed with its own original system of reinforcement of the masonry designed to resist earthquake damage. At the time it was constructed, it was already known that the Bay Area was subject to earthquakes. After examining this building when it was torn apart for a modern-day seismic retrofit, it was impressive to see what measures that the stewards of the fledgling university went to in order to protect the first building on the campus in what was yet still a part of the "wild West." Unfortunately, this unique chance for research was only briefly available for a small number of people, as this remarkable structural system was largely destroyed without being documented.

When the walls were opened up to install reinforced concrete pilasters and a new reinforced concrete wall covering the surface of the historic masonry, it was discovered that the

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[2] Stephen Tobriner, *South Hall and Seismic Safety at the University of California in 1870*, Chronical of the University of California, Spring 1998.

masonry had been constructed with "bond iron" – a system of wrought iron bars – that tied the building together above and below the windows on every level. (Photo 9) In addition, the beams and joists were anchored to the walls with iron ties that were imbedded into the walls so that they would be hidden on the exterior. (Photo 10) What was visible on the exterior, and what should have provided a clue to what was inside, were large cast iron ornamental plates with large bosses attached to the corners of the building. The bosses were in fact the nuts that held the ends of the bond iron straps that ran from corner to corner through the length of every wall. Ironically, there was historical evidence in the University's own records of the existence of this reinforcing, but historical research was not included as part of the design phase of the project.

The tragedy of this project is that, once discovered, nothing was done either to (1) adapt the modern retrofit project to either preserve or to take advantage of the original system, or (2) accurately document it for the historical record of a nineteenth century earthquake resistant building technology. In the process of installing the new system, the iron rods were all cut and destroyed. The brick structure was encased in concrete "shotcrete," a material that is impossible to remove or replace. The destruction of this record of historic technology is thus a loss of an important historical engineering artifact (Photo 11).

Would the original system have performed well in an earthquake? While it is impossible to say for sure, we do know that the building survived the 1906 earthquake. However, Berkeley was not so severely affected as San Francisco and the University's concern has to do with the nearby Hayward Fault. It is known from the performance of other buildings that joist anchors significantly improve the performance of unreinforced masonry buildings compared to those without them, and South Hall has bond-iron laid directly into each wall in addition. The best local example of the performance of bond iron subjected to the full brunt of a great earthquake is San Francisco's original Palace Hotel. When constructed in 1873, the 6 story block-sized building was reported to be the largest hotel in the country. In 1906, reports of its condition before the fire consumed it were that the earthquake itself did not damage it. In fact, even after the fire, which raged out of control in the city that lacked the means to fight it, consumed all of the wooden parts of the building, the brick walls remained standing to their entire eight story height, topped even by the chimneys, which remained in place despite both the severe earthquake and the raging blaze (photo 12, photo 13).

The South Hall retrofit project presents an existential problem. *Has the cultural value of the building been forever compromised by the destruction of its interior and imbedded structural elements? What about the large cast iron ornamental places on the corners that remain? Now that they have been reduced to only an ornamental purpose, are they diminished in significance?*

These cultural heritage questions are not the only critical questions. *What about the life safety issues that spawned the project in the first place? Has the real or perceived risk that had been identified by the structural engineers for this (what was thought to be) unreinforced masonry building justified the destruction? Or, by contrast, has the destruction of the older system actually made the building riskier now than before, or at least little better for the effort?*

The conflict between earthquake safety and historic preservation is a difficult one to mediate, as both issues are relative. There is neither an absolute correct level of earthquake safety, nor a single immutable definition of cultural significance. Both concepts shift over time. While earthquake safety may seem relative to how closely a building meets code, this is not always the case. As can be seen from South Hall and the buildings in San Francisco that survived the 1906 earthquake and fire, as well as 90 West Street, earlier technologies of construction were sometimes at least as good – and sometimes better – than modern construction, regardless of the prevailing codes. Thus buildings constructed to an earlier pre-code technology may suffer more from the perception of risk than from any particular risk itself.

This is an important problem, and it must be understood on a number of levels if conservation goals are to be achieved for examples of early structural design and construction. The problem is not the codes, as most codes provide for alternative means of meeting the intent of the code provisions – but any alternative to the letter of the code requires more analytical work, and work justifying and defending the existing structure. With all of the ambiguities that exist, few people are willing to take on this endeavor, and historic structures suffer radical and costly changes as a result of the effort to make them more easily confirm to the present day's conventions. The tragedy is that this can often reveal a level of arrogance that blocks out any possibility of learning from what was done in the past – and of gaining insights into contemporary design that may actually improve the way buildings are constructed now and in the future, not just preserving what was competently created in the past.

To illustrate this point, one can turn to the issue of masonry mortar strength in both old and new construction. Today building codes require extremely strong, cement-rich mortars in new construction. This common practice now sits alongside the now well-accepted conservation practice that weaker, more lime rich mortars perform better than the use of cement. Yet this acquired knowledge stands in contrast to standard modern building practice, despite the often-rapid deterioration and prevalence of leaks found in modern masonry cladding. In addition, modern designs have had to incorporate frequent short-lived and disfiguring putty joints into masonry walls – reducing what is meant to look like solid masonry to the appearance of tile or wallpaper. Putty joints did not exist in masonry in the nineteenth century or earlier.

In the end, a study of the structure and construction of older buildings can teach us the importance of what Cass Gilbert posted on his office wall – humility. Just when one is convinced that what we do now must be better than anything that preceded us, we often discover that our predecessors have been there before – and we discover that, with fewer materials at their disposal, they accomplished more. The thousands of pancake-collapsed buildings in recent earthquakes standing next to both ancient monuments and older vernacular buildings – all still standing – should provide reason enough to look more carefully at archaic structures, and to give them the same measure of respect that we give to the architecture they support. It should also motivate us to insist on conserving them as an integral part of the historic buildings that we work to save for our children.

Ruins of North Tower Façade with the Woolwroth Building Constructed in 1913, behind.(photo 1)

Photo 3

Steel from the World Trade Towers stacked for scrap at Fresh Kills Landfil (photo w (photo 2)

Photo 4

Photo 5

Photo 6

Photo 7

Photo 9

Photo 8

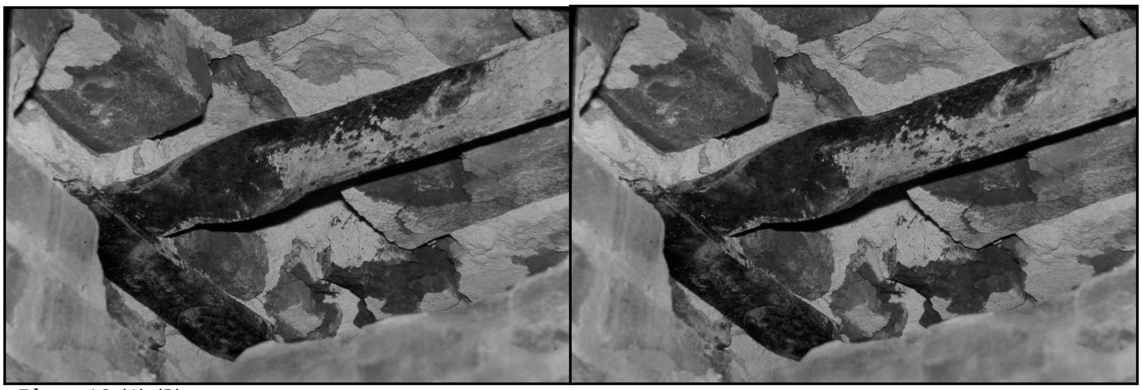

Photo 10 (1) (2)

Photo 11 (1) (2)

Photo 12

Photo 13