Images from *100 of the World's Tallest Buildings*

Citicorp Center
Location: **New York, New York, USA**
Completion Date: **1977/8**
Cost: **$175 million**
Height: **915 feet**
Stories: **59**
Materials: **steel**
Facing Materials: **aluminum, reflective glass**
Architect: **Hugh Stubbins Jr. and Associates**
Engineer: **William LeMessurier and Associates**

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ARC 211
Prof. Mac Namara
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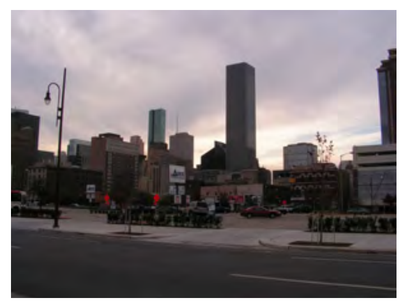
In 1971, when planning began on the Citicorp Center, engineer William J. LeMessurier had no idea how much of an effect this building was going to have on his life, and potentially the lives of others. Yet even from the start, the fifty-nine story skyscraper (at the time of its completion, the seventh tallest building in the world) was an enormous engineering challenge, met with true design ingenuity and, eventually, courage.

To begin, the social context the Citicorp Center was destined to be born into was a difficult one. The 1970s were a period of extended economic hardship for New York City, where dozens of major corporations and well over six-hundred thousand jobs were lost. This was the time when the President Ford's 1975 decision regarding Federal Aid prompted the famous *Daily News* headline "FORD TO CITY: DROP DEAD." In these hard times, Citicorp harnessed the public's frustration to show them that they were truly a bank on the people's side. The Citicorp advertisements during construction proudly exclaimed words of defiance, establishing it early as a political symbol, its very shape later becoming the Citibank icon.[1]

"A skyscraper in the New York tradition. 59 stories. A multi-million-dollar investment in New York. New York is our town...We grew up here. We're staying here."

But how did Citibank end up in such a position? In 1961, Citibank, then the First National Bank of New York, moved into 399 Park Avenue, a building directly across Lexington Avenue from the site-to-be and just to the north of the Seagram Building. That tower was thirty-nine stories, bland, and undistinguished[2]. That same year, Chase Manhattan Bank, First National's chief rival, by opening its enormous new center, designed by the established architecture firm, Skidmore, Owings & Merrill, drastically changed the New York City skyline.



Chase Manhattan

After a few years of living at 399 Park Avenue, however, Citibank realized its headquarters building was too small for its growth and began considering expansion. At the same time, St. Peter's Lutheran Church was experiencing financial difficulties and began to consider selling its

1 Kremer, Eugene. "(RE)EXAMINING THE CITICORP CASE". *Cross Currents* http://www.crosscurrents.org/kremer2002.htm.

2 Horsley. "The Citicorp Center." *The Midtown Book* (March 2007) http://www.thecityreview.com/citicorp.html.

increasingly valuable property on the northeast corner of Lexington Avenue and 54th Street and moving into a smaller and more affordable building.

The church's plans attracted the attention of the real estate company of Julien J. Studley & Co., who thought that they might be able to convince a developer to use the church's property as the spot for a major new office building project. They approached Citibank, an obvious choice because it was across the street, and quickly found themselves trying to offset the public disapproval that would soon generate when hearing that a major bank wanted to develop such an important religious site (Louis Armstrong's funeral service was here)[3]. They did this by setting up several decoy companies for the purpose of discretely acquiring the properties on the church's block.

Thus, Citicorp had found their rare opportunity to build in midtown Manhattan at a time when they were one of few with the money to do so. The one major stipulation posed on the construction of the site was that St. Peter's Lutheran Church would only allow Citicorp to build the skyscraper if a new church was built in that same corner as its current location, having no connection to the Citicorp building and with no columns passing through it. Citicorp didn't find this too jarring, but the architect of the project, Hugh Stubbins Jr., wondered at the time if this demand was a design limitation that would prevent any worthwhile construction; a major skyscraper had never been built without structure at the bottom corners.[4]

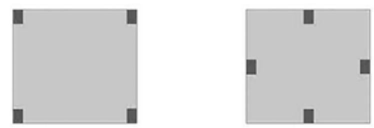
At this point, Stubbins enlisted the help of LeMessurier and his firm, who had previously established a reputation working on the Boston City Hall. LeMessurier, an energetic manager with a "fondness for heroic designs" accepted the challenge of the Citicorp Center and came out

3 Bierut, Michael. "When Design is a Matter of Life or Death." *Design Observer* (April 2006), http://www.designobserver.com/archives/012583.html.

4 Plosky, Eric. "A Lesson in Professional Behavior." *Online Ethics* (2005), http://onlineethics.org/moral/lemessurier/.

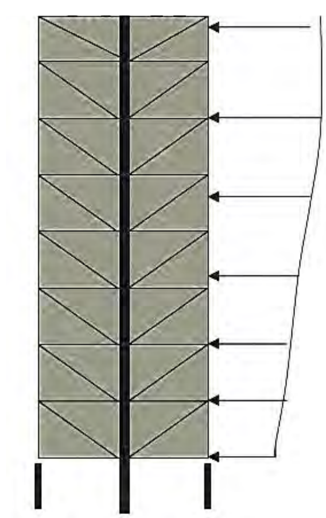
with a truly innovative solution, maximizing the size of the floors without compromising structure or the area occupied by St. Peter's.[5]

LeMessurier's design centers around a modified layout of major piers, connecting the bulk of the Citicorp Center to the ground. These columns, comprising the first nine-stories of the tower, are rotated to the center of each face. The center pier runs through the entire building, and takes in approximately half of the load[6]. The rest of the load is handled by a modified chevron system of diagonally placed girders that are not seen from the outside (though LeMessurier would have preferred that they were). The client preferred a certain majestic purity and sleekness, but the braces are still visible from within the offices. These help direct the load down into the rotated piers. To further offset the effect of wind on the structure, LeMessurier employed the first tuned-mass-damper to be used on a skyscraper in the United States. This four hundred ton concrete block slides along a film of oil, cutting the effect of wind in half through its delayed response to inertia, converting the kinetic energy of sway into friction[7].



conventional innovation

With the building constructed in all its pragmatic glory, it's fascinating to look at what aesthetic and programmatic choices were made with regard to the resulting spaces. The structural layout of the bottom piers easily helped to shape a seven-story atrium space, which although being widely received by critics as an attractive, well-laid out space, has had very little success with its occupying businesses[8]. Some have suggested the space has not been used to its full potential; one of the leasable spaces, if used for a café, has the potential to be "very visually exciting", but it only seems that company after retail



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5 Morgenstern, Joe "The Fifty-Nine-Story Crisis", *The New Yorker*, May 29, 1995. p. 47, 52.

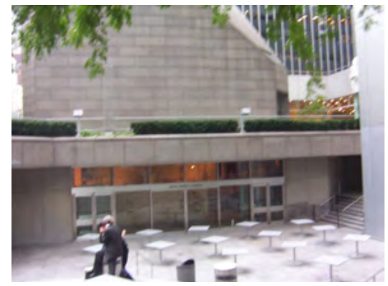
6 Horsley, Carter B. "The Citicorp Center."

7 Bellows, Alan. "A Potentially Disastrous Design Error." *Damn Interesting* (2006), http://www.damninteresting.com/?p=500#more-500.

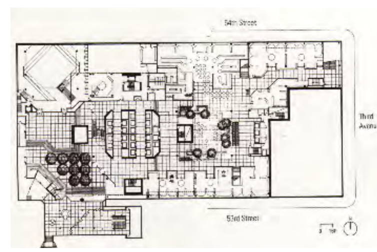
8 ibid

company has cycled through, hardly enjoying any significant business[9].

This strikes me as odd, considering that the atrium is easily seen from the street with three distinct entrances, and the basement level shops are even viewable from clerestory glass, all making it very clear to a passerby that this is a place to shop. When I was in New York City, I was immediately drawn to this building without having any idea of its significance; the very idea of having a strong open public area rather than a blank wall to the streetscape struck me as a rather nice urbanistic touch. This was only further complimented by the fact that the plaza is sunken, emphasizing the height of the atrium space and drawing attention to the waterfall on the 53rd St. corner which, while relating little to the rest of the scheme, is a serene moment in the design.



When one looks at the Citicorp Center from a distance though, of course its most distinguishing feature in the New York City skyline is its slanted roof, cut at forty-five degrees. This came about for a number of reasons, none of which were able to manifest themselves and so the shape seems arbitrary to many. Originally, Citibank had hoped that it could convince the city to extend the special zoning district it had created for much of midtown Fifth Avenue to its new site so that it could build a bigger building by including apartments at the top, composed of setback penthouses facing south and thus allowing for maximum exposure. The city did not respond to these suggestions[10].



Also for a long time, the slant was planned to go down from the top to the west to relate to the top of the Chrysler Building (also angled) as viewed from north on Lexington Avenue. When the apartment component of the mixed-use project was dropped, however, the bank considered its present configuration, facing south, to maximize its potential for using

9 Horsley. “The Citicorp Center”
10 ibid

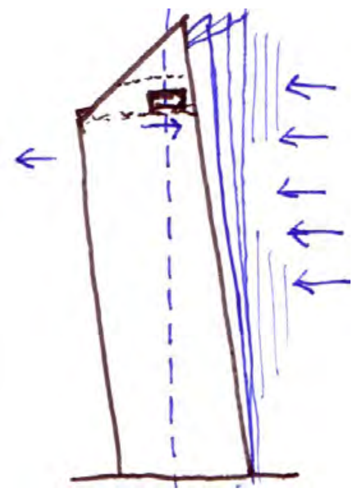
solar collectors to help lower the building's energy costs. That technology, however, was not yet developed enough and so the plan was dropped, but the form was still kept.[11] The space, in the end became mainly a set of service floors, including in particular the tuned-mass-damper.

I find the slant to be a nice distinguishing characteristic as a skyscraper (now a Citicorp icon), but in an aesthetic sense I wish the alternating aluminum/glass cladding that bands around the majority of the floors continued into the slanted floors. This would provide a greater sense of continuity and add some dynamism to that rigidly placed rhythm. However, in the programmatic sense, because this is a service space I see no reason why it should receive special experiential attention.

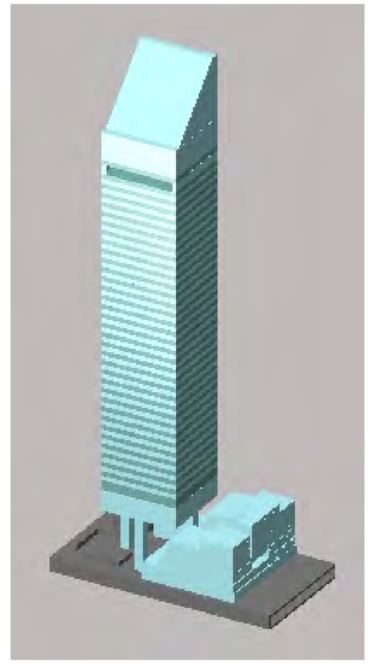
All in all though, the building was widely acclaimed by architectural and engineering critics alike as a masterpiece. The building was seen as one "epitomizing the client's intention to create a visible statement announcing its corporate identity," as well as celebrating loyalty to the city of New York and performing as a "responsible citizen" in both the neighborhood and the larger city[12]. This initial praise had not died down when, in June of 1978, less than a year after 'completion', engineer LeMessurier realized that the steel frame of the Citicorp Center was structurally inadequate.

Prompted by an engineering student trying to understand how the Citicorp Center functioned, LeMessurier was alerted to the fact that despite his firm's initial design, the joints of the chevrons were bolted instead of welded. Unperturbed by this fact at first, LeMessurier understood this decision as an effort to save two-hundred and fifty thousand dollars in construction and labor costs; after all, in traditional construction, bolting joints is almost always as effective as welding. However, upon

11 ibid
12 Kremer. "(RE)EXAMINING"



If the building sways left, the tuned mass damper moves to the right, straightening the building further analysis done by him, secluded in his Maine getaway house for days, LeMessurier realized that this change had the potential to cause a joint on the thirtieth floor to break in the event of seventy mile-per-hour quartering wind (angled) and subsequently cause the whole structure to collapse. The problem was not discovered due to a recent change in New York City's building code, which had simplified it to only require perpendicular calculations of wind load, which the building held up against fine. The kind of storm that would prompt the shearing of bolts on held the probability of hitting New York City once in sixteen years[13].



At risk of ruining his professional reputation and after contemplating several ways to handle the situation (including suicide), LeMessurier consulted with other professionals and eventually Citicorp on the dire situation at hand. With the help of Leslie Robertson, the engineer of the World Trade Center, a small team devised a plan to methodically reinforce all the bracing joints one floor at a time. The repairs took place over the course of the next three months. Evacuation plans were put in place and the Red Cross was ready to mobilize, estimating that two-hundred thousand people could potentially die in an ensuing collapse. Three decades ago, it was unimaginable that a building would fall down in Manhattan, and no one could be sure how extensive the damage might be.[14] The repairs cost eight-million dollars tacked onto the one-hundred-and-seventy-five million already spent, yet all of these events were largely unknown until Joe Morgenstern published a story in the *New Yorker* almost twenty years later. LeMessurier's error almost certainly would have been exposed in its time if it wasn't for a press strike that began the same week as the repairs.

This situation of course brings to light the role of ethics in engineering. LeMessurier's act of alerting Citicorp to the problem inherent in his

13 Morgenstern. "Crisis". 49
14 Kremer. "(RE)EXAMINING"

own design is often used now as an example of ethical behavior in engineering textbooks. Alan Bellows explains in an article on the Citicorp Building, “It is clear that it takes a lot of character to admit one’s own mistakes, but in accepting responsibility for this flaw and then leading the repair effort, the character shown by William J. LeMessurier was nothing short of heroic.”[15] However, some criticize LeMessurier for his oversight leading to bolted rather than welded joints, for misleading the public about the extent of the danger during the reinforcement process, and for keeping the engineering insights from his peers for two decades. Even in his book, “Forty Years of Wind Engineering: A Personal Memoir”, presented in early 1995, LeMessurier makes no mention of the averted disaster situation with the Citicorp Center[16].

Eugene Kremer finds LeMessurier’s actions far from noble. He points out that there are only six fundamental canons in the National Society of Professional Engineers Code of Ethics, and Canon 3 states that in the fulfillment of their professional duties, engineers shall “Issue public statements only in an objective and truthful manner.”[17] Furthermore, he explains that despite perceived heroic status of LeMessurier in the engineering community, the National Society of Professional Engineers published a scenario very similar to that of the Citicorp Center entitled Case 98-9 in which they concluded that “withholding critical information from thousands of individuals whose safety is compromised over a significant period of time” is not a valid way to handle one’s own mistake[18].

Personally, I deeply question the ability for the public to handle news such as that which LeMessurier had. Especially to those who know nothing about engineering, I imagine many people working in

15 Bellows. “Potentially”
16 Kremer. “(RE)EXAMINING”
17 ibid
18 “Case 98–9, Duty to Report Unsafe Conditions/Client Request for Secrecy,” *National Society of Professional Engineers Board of Ethical Review*, http://www.niee.org/cases/98%20cases/cases98-9.htm

the building would quit their jobs, feeling unsafe, despite the fact that the building was still perfectly fit to occupy without the event of a seventy mile-per-hour wind. On the other hand, I find it hard to understand how LeMessurier couldn't have discovered the problem sooner. It just seems irresponsible that just because the New York City building code didn't 'require' checking of quartering winds, that he didn't (or at least not in detail). In the end, I feel that alerting the public of the situation before fixing it would have caused far more panic than 'the truth' merits, but once the problem was fixed, it only seems disrespectful to hide a truth as great as that, waiting until one's reputation has reached unbreakable heights.

From the context in which the Citicorp Center was built, to its innovative structure, to its aesthetic decisions, and finally to the ethics surrounding its repair, few structures have caused such fuss only to end up as one of the safest skyscrapers on the planet[19]. Compare its twenty-five thousand tons of structural steel versus the Empire State Building's sixty-thousand, or I.M. Pei's Bank of China, which despite being eleven stories higher, only has one-hundred thousand more square feet of office space. The biggest setback, understandably, is the cost, which at one-hundred-and-seventy-five-thousand dollars puts it at even more expensive than taller buildings than itself, like the Sears Tower which only cost one-hundred-fifty-million dollars. Thus, the Citicorp tale is one of triumph, status, betrayal, and learning.

19 Zaknic, Ivan, Matthew Smith, and Dolores Rice. *100 of the World's Tallest Building* (Corte Madera, CA: Gingko Press, 1998): 150.

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How the Piers Hold Up the Weight of the Citicorp Building

Loads
Dead + Live
Dead= concrete@150 lb/ft^2, 6" floor slab
partitions/walls/etc.@60 lb/ft^2
steel@25,000 tons x 2000 = 50,000,000 lbs = 50,000 kips
tuned mass damper@400 tons x 2000 = 800,000 lbs= 800 kips

Live= 80 lbs/sq. ft (class notes)

Total floor area= 1.3 mil ft^2

Total Dead=
Q_{dead}= 1,300,000(75+60) + 50,000,000 + 800,000 = 226,300 kips

Total Live=
Q_{live}= 1,300,000(80) = 104,000 kips

Total Vertical=

$Q_{total} = Q_{live} + Q_{dead}$ = 330,300, kips

Central pier takes one quarter of the load (Kremer, "(RE)Examining")

Q_{center} = 330,300/4 = 82,575 kips

Q_{ring} = 330,300(.75) = 247,725 kips

Q_{pier} = 247,725 k/4 piers = 61,931 kips per pier

Factor of Safety= fstrength/fstress

fstress= force/area

Area= 22' x 22' = 484 ft^2 – (20' x 20') = 84 ft^2 = 12,096 in^2

fstress= 61,931k/12,096 in^2 = 5.2 ksi

fstrength= 30 ksi

fstrength/fstress = 30ksi/5.2ksi = 5.8 factor of safety

Efficiency = 5.2ksi/30ksi = .17%

Thus, although far more safe than need be, a factor or safety this high eliminates all worries one might have from seeing columns positioned in faces instead of corners.

How the Trusses Take in Loads

Each truss has to transfer the load equivalent to one pier, therefore

Compression, 61,931k, taken in from the two corners at an angle, found by Pythagoras by taking the 8 story module (8x15= 120') by half of the horizontal length of the building (72').

$120^2 + 72^2 = 19584\ ft^2$

Square root of 19584 is 140 ft, and by trigonometry, tan^{-1}=(140'/72') = 62.8 degrees.

61,931k/2 = 30,965k per joint

To analyze the loads, the joints are actually being acted on the z axis, but by vector geometry it can be flattened to act like a downward load.

Joint 1

∑V=0

$V_1=V_A$= 30,965k

∑H=0

tan62.8= 30,965/H_A

H_A = 30,968/tan62.8 = 15,913k

N_A= sq. rt. of $30{,}965^2 + 15{,}913^2$ = 34,815 k

Joint 2

we know there's symmetry

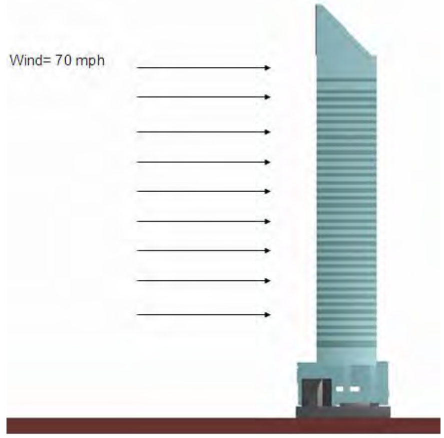
∑V=0

$V_D = V_A + F_A$ =61,931k

∑H=0

HC= HA= HG = HF = 15,913k

Thus, we see that the full load of the building is carried through the trusses down into the central columns.



LOOKING AT WIND LOAD

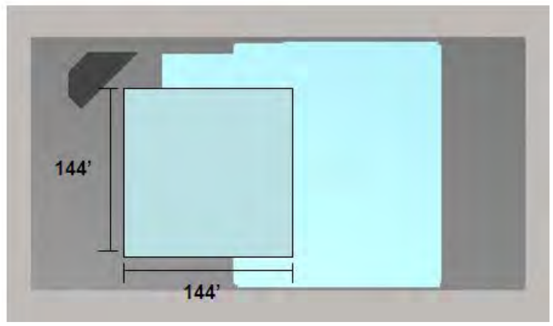
M= F*D

70 mph wind

½(.00253)103^2 = 13.42 psf

Total area of face = 845' x 144'= 121,680 sf

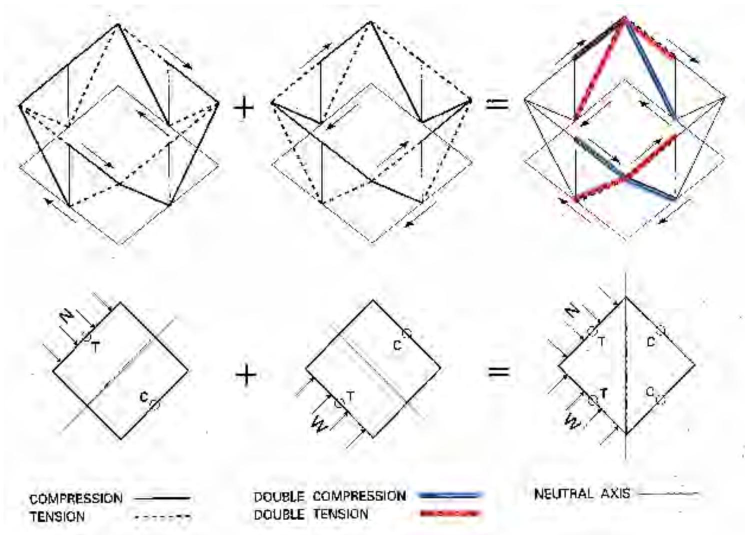
121,680 x 13.42 = 1,633 kips



M = 1,633k x 915' = 1,494,195 kft

Total Tension and Compression

T = -C = M/D = +- 1,494,195kft/144ft= +-10,376 k



+10,376k dead load -10,376k

recall- 61,931 kips per pier

61,931 k + 10,376=	2(61,931)+ 82,575	61,931k – 10,376
72,307k	206,437k	51,555k

Thus, wind load does not seem to be a significant factor on the perpendicular access. However, observe the diagram and see that the wind effects the building differently at a 45 degree angle, due to lack of columns and the right angled connection of the bracing.