Case Study - The Fifty-Nine Story Crisis

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Introduction

William LeMessurier, one of the nation's most distinguished structural engineers, served as design and construction consultant on the innovative Citicorp headquarters tower, which was completed in 1977 in New York. The next year, after a college student studying the tower design had called him to point out a possible deficiency, LeMessurier discovered that the building was indeed structurally deficient. LeMessurier faced a complex and difficult problem of professional responsibility in which he had to alert a broad group of people to the structural deficiency and enlist their cooperation in repairing the deficiency before a hurricane brought the building down.

His story was recounted in detail in "The Fifty-Nine-Story Crisis," which appeared in the May 29, 1995 issue of The New Yorker, and on November 17, 1995, LeMessurier himself came to MIT, from which he received his doctorate, to speak to prospective engineers about the decisions he had to make and the actions he took.

Part 1: Background and the History of Skyscrapers

By the early 1970s, when Citibank began plans for a huge new headquarters tower in midtown New York, the art of designing and building a strong, safe skyscraper seemed nearly perfected.

The skyscraper, like any other architectural form, had gone through a long period of evolution. After Elisha Otis's successful introduction of the first safety-brake-equipped elevator in the 1850s and the introduction of steel-frame construction, buildings began to grow upward. In 1910, the Metropolitan Life Building broke all records for height until that time: it was 50 stories high.

Figure 1: The Hancock Building in Chicago

By the 1930s, with the construction of the 102-story Empire State Building skyscrapers, thanks to their widespread success, had begun to sprout in many cities worldwide. Areas populated with these tall buildings found themselves growing, literally, ever upward. The skyscraper, coupled with the introduction of modern, efficient subway systems in cities like New York, made it possible for companies to employ workforces unprecedented in size. Consequently, city populations increased immensely.

By 1930, daring, creative architects and engineers had even begun to depart from what had been accepted as the "traditional" method of designing and constructing skyscrapers. Innovations in skyscraper design such as lighter materials, increased window area, and cantilevered supports, resulted in taller, lighter, and slimmer buildings. For instance, Chicago's record-breaking Hancock Building, incorporating an innovative system of diagonal bracing, shown in Figure 1, that allowed the building to be much leaner and lighter than it could be if it had been constructed in a traditional manner.

Part 2: LeMessurier's Innovative Citicorp Design

William LeMessurier was one of the country's most distinguished structural engineers when his Cambridge firm was called upon to act as a consultant to the planned Citibank corporate headquarters. LeMessurier had a vast array of experience with skyscrapers; the first building he designed, Boston's State Street Bank, incorporate an inventive cantilever girder system, and his famous Boston Federal Reserve Bank, was designed so that an airplane could, quite literally, fly directly through what appeared to be a large hole in the building.

Figure 2: Citicorp tower design

LeMessurier's experience with innovative designs was fortunate, since there was a criterion peculiar to the planned Citibank building. A church had partial ownership of the block where Citicorp planned tobuild. As a resolution, Citicorp agreed to build a new free-standing structure, located at one corner of the lot, to replace the current antiquated, dilapidated church. In return, the church granted "air rights" above its part of the block to Citicorp. Figure 2 depicts the bottom part of the first rendering of the Citicorp tower design, clearly showing the nine-story high, mid-wall-mounted stilts that would need to support the building.

In order to provide space for the new church, the Citicorp tower would therefore have to be situated on nine-story-high stilts, so the church could be constructed underneath. However, the church was to be located at a corner of the block, not in the middle of a block. This meant that the Citicorp tower's stilts would have to be in the middle of each of its walls, and not at the building's corners -- an unprecedented feat of engineering if it could be accomplished.

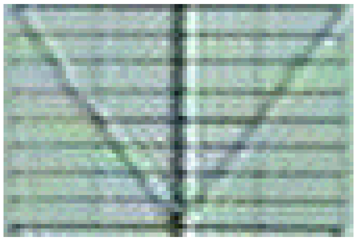


Figure 3: Citicorp tower's framework and column support system

The innovative LeMessurier sketched an idea for the Citicorp tower's framework and column support system. Figure 3 depicts an eight-story section of his design. It called for large diagonal girders throughout the building. The girders would transfer the tower's great weight to the four huge columns that would anchor the structure to the ground. The new church could then be constructed as planned, underneath one of the tower's corners.

Part 3: The Discovery of the Change from Welds to Bolts

The Citicorp tower was constructed using LeMessurier's diagonal-bracing design, and work was finished in 1977. LeMessurier's innovation translated into a great weight savings; the tower was unusually light for its size. However, this meant that it would have a fair tendency to sway in the wind, so a tuned-mass damper was installed at the top of the building. The inertia of this 400-ton concrete block, which floated on pressurized oil bearings, worked to combat the tower's expected slight swaying. The Citicorp tower was the first structure ever to incorporate mechanical assistance to combat wind sway.

Figure 4: Citicorp tower under construction

In May 1978, LeMessurier, acting as structural consultant to a new building being planned in Pittsburgh, again thought of using a sort of diagonal brace as part of his design. As in the Citicorp tower, the braces were intended to be joined with full-penetration welds, but the process of welding, though it resulted in extremely strong joints, was expensive and time-consuming. A potential contractor for the Pittsburgh construction job pointed this out to LeMessurier, who immediately thought to counteract the contractor's fears with the success story of his Citicorp tower and its welded joints.

Unknown to LeMessurier, however, was that during the Citicorp tower's construction. Figure 4 shows the tower under construction. The Citicorp contractors had decided, based on the cost of welding, to put the braces together using less expensive bolted joints. Though bolted joints were weaker than welded joints, the New York contractors had agreed that welds would be unnecessarily strong and that bolts would be sufficient for the job.

When LeMessurier referred the Pittsburgh contractor, concerned over the cost of welding, to the successful Citicorp job, he was told of the substitution of bolts for welds in the Citicorp project. LeMessurier did not consider the change to pose a safety hazard, however, since the substitution was rather reasonable from an engineering standpoint, and there wasn't any reason for LeMessurier, a distant consultant, to have been previously informed. This assessment would change over the next month, however, as LeMessurier would soon encounter new data indicating that the switch from welds to bolts compounded another danger with potentially catastrophic consequences.

Part 4: Exploring the Effects of Quartering Winds

In June 1978, a month after LeMessurier was told of the switch from welds to bolts in the Citicorp building, he received a telephone call from a student. This student's professor had been studying LeMessurier's Citicorp design and had concluded that LeMessurier had put the building's nine-story supports in the wrong place. The supports belonged on the tower's corners, according to this professor, not at the tower's midpoints.

The professor had not understood the design problem that had been faced, so LeMessurier explained his entire line of reasoning for putting the tower's supports at the building's midpoints. He added that his unique design, including the supports and the diagonal-brace system, made the building particularly resistant to quartering, or diagonal, winds -- that is, winds coming on the diagonal and so hitting two sides of the building simultaneously. Figure 5 presents a diagram of why perpendicular winds cause sway in a building.

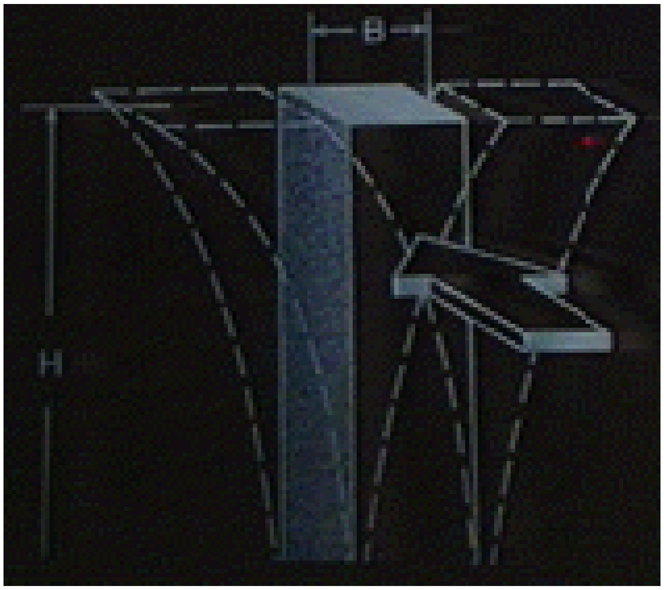


Figure 5: Perpendicular winds causing sway in building

Shortly thereafter, LeMessurier decided that the subject of the Citicorp tower and quartering winds would make an interesting topic for the structural engineering class he taught at Harvard. Since at the time the requirements of the New York building code, like all other building codes, had covered only perpendicular winds, LeMessurier did not know how his design would fare in quartering winds.

Interested to see if the building's diagonal braces would be as strong in quartering winds as they had been calculated to be in perpendicular winds, LeMessurier did some computations. He found that for a given quartering wind, stresses in half of a certain number of structural members increased by 40 percent.

Then he became concerned about the substitution of bolts for welds. Had the New York contractors taken quartering winds into account when they replaced the welds with bolts? Had they used the right number of bolts? The second question was particularly important -- a 40 percent increase in stress on certain structural members resulted in a 160 percent increase of stress on the building's joints, so it was vital that the correct number of bolts be used to ensure that each joint was the proper strength.

What he found out was disturbing. The New York firm had disregarded quartering winds when they substituted bolted joints for welded ones. Furthermore, the contractors had interpreted the New York building code in such a way as to exempt many of the tower's diagonal braces from loadbearing calculations, so they had used far too few bolts.

Shaken, LeMessurier reviewed old wind-tunnel tests of the building's design against his new quartering-wind calculations (these tests had modeled a large part of midtown Manhattan), and found that under adverse weather conditions, the tower's bracing system would be put under even further stress. The innovative tuned-mass damper, designed to reduce the building's normal slight swaying, was not designed to keep the building from being blown down in a major storm; this further worried LeMessurier.

Part 5: Further Evidence of the Danger

LeMessurier now believed there might be serious danger. He turned to Alan Davenport, a Canadian consultant during the building's design. Davenport, who had run the original wind tunnel tests, now ran the tests again, using new calculations to reflect quartering winds and the change from welds to bolts.

The results, when compared with the building's original testing, confirmed LeMessurier's suspicions about increased stress in some of the building's structural members. His concern grew, since the results indicated that a 40 percent theoretical increase in a member's structural stress would be much greater under real-world conditions. During a storm, the whole building could shake, causing the structural members to all vibrate synchronously.

LeMessurier worked through the revised wind tunnel data, and quickly discovered that the entire building was vulnerable to a total structural failure -- if a storm pulled a joint apart on the 30th floor, the whole building would collapse. A "sixteen-year storm," that is, a storm occurring once every sixteen years, would have the strength to cause total structural failure. Though the electric tuned-mass damper had an enormous steadying effect on the building, and might help to reduce the stress on that joint, a strong storm would knock out the electricity necessary for running the damper.

Solving the problem was not difficult from an engineering perspective; heavy steel welded "Band-Aids" over the joints would give the building more strength than it was even originally designed to have. But it was the last day of July, and in order to complete repairs before the start of hurricane season, LeMessurier would have to announce the building's vulnerability and take responsibility upon himself. Doing so could cost LeMessurier his career and reputation as a structural engineer. He did not know how his news would be received by Citibank leadership, city officials, or the general public.

Part 6: Mobilizing Support

On July 31, 1978, LeMessurier contacted the lawyer of the architectural firm that had retained him as its structural consultant for the Citicorp tower and then the firm's insurance company. As a result, a meeting was arranged the following day with several lawyers for the insurers, to whom LeMessurier related the entire story. The lawyers soon decided to bring in a special consultant -- Les Robertson, a respected structural engineer. Robertson listened to LeMessurier's description of the situation and soon took a more critical view than even LeMessurier himself. Robertson did not believe, for instance, that the tuned mass damper would serve as a safety device despite LeMessurier's assurances that generators could keep the dampers running during an electrical power loss.

Citicorp had to be informed of the danger, so LeMessurier and his partner went about contacting Citicorp's chairman, Walter Wriston. Initially, Wriston was unavailable to them, but LeMessurier's partner was able to arranging a meeting with Citicorp's executive vice president, John Reed, who had engineering experience and played a part in the construction of the tower. LeMessurier detailed the situation once more. When prompted for a cost estimate, LeMessurier guessed that one million dollars would be sufficient. He also explained that the repairs could be done without inconvenience to the tenants by isolating the bolted joints within plywood 'houses' and doing the necessary work at night within those 'houses.'

Reed appreciated the gravity of the situation, and arranged for a meeting with Wriston on August 2, at which point LeMessurier once again told his story. Much to his relief, Wriston recognized the importance of the tower as Citicorp's new corporate emblem, and so readily agreed to the repair proposal. He approved a plan to install emergency generators as a backup power supply for the tuned mass damper, and oversaw much of the relations with the public as well as with the building tenants.

The next day, LeMessurier met with two engineers from the construction company that was to perform the repairs. After examining the joints, these engineers approved LeMessurier's plan to reinforce the bolted joints with welded "Band-Aids."

Before undertaking the repairs, several steps were necessary. LeMessurier contacted the company that had constructed the tuned mass damper to help assure the device's continuous operation. Meteorological experts were retained in order to give advance warning of any storm that could cause the building's destruction. LeMessurier reluctantly agreed with Robertson that, as a further precaution, an emergency evacuation plan for the building and the ten-block-diameter surrounding neighborhood be drafted. In its final form, the plan was to involve up to 2,000 emergency workers provided by the Red Cross.

LeMessurier had to explain the situation to city officials, both to secure their cooperation with the evacuation plan and to comply with the building code. They responded with approval and encouragement, rather than the cynicism that LeMessurier expected. They too recognized both the seriousness of the problem and the immediate need to solve it. Energy was not wasted on rancor or placing blame.

The final task, the one that LeMessurier most dreaded, was informing the press of what was going to be a major undertaking on the brand-new Citicorp tower. An initial press release was issued. It indicated that the building was being refitted in order to withstand slightly higher winds. This was true to some extent, for the meteorological data suggested that the winds for that year were going to be somewhat higher than normal. But the *New York Times*, for one, was sure to express further interest in what could be a very juicy story. After an initial phone call from a reporter, though, LeMessurier found an unexpected reprieve in a citywide press strike.

Part 7: Accomplishing the Repair Without Causing Panic

Repairs to the Citicorp building commenced immediately. The plan of action was to expose each bolted joint in the building by ripping away the flooring and walls around it, to cover each joint with a plywood 'house' in order to minimize any visible signs that things were awry with the building's structure, and to complete the repair welding at night when the tenants were not in the building, so as not to inconvenience them.

The pace of work was fast. Parts of the interior around the bolted joints were torn up at night and put back together in the morning. LeMessurier occupied himself with repair process calculations. Les Robertson calculated how to repair the joints, and, suspecting that other components of the building could be vulnerable, went about investigating the floors, columns, and braces for weakness.

The repair work was in full swing on the first of September, when a hurricane moving toward New York was detected. The news was met with alarm. The partial repairs -- along with the tuned mass damper -- greatly improved the building's strength, but no one wanted to see it tested. There was great relief when the hurricane moved out over the ocean.

Two weeks later, repairs had progressed to the point that, with no storms predicted, the elaborate evacuation plans could be scrapped. The next month, repairs were complete. Even if the tuned mass damper were to fail, a 700-year storm would not pose a threat to the Citicorp Center.

The engineering problem had been solved, and today the repaired building now exceeds even its originally intended safety factor.

Part 8: The Final Touch: LeMessurier's Good Name

LeMessurier feared for his career but did not allow any worries or self-protective impulses to sidetrack his attention from carrying out the repairs. In the middle of September, when repairs were almost complete, Citicorp notified LeMessurier and his partner that it expected to be reimbursed for the cost of the repairs.

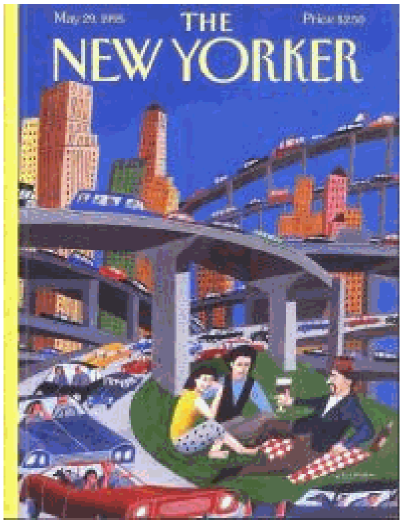
The estimated total cost for the building's repair ranged between a high of $8 million for the structural work alone, given by one of the construction companies involved, to $4 million, which, according to LeMessurier, was the Citicorp estimate (Citicorp did not make public its estimate).

LeMessurier's liability insurance company had agreed to pay $2 million, and LeMessurier brought that figure to the negotiating table. The Citicorp officials eventually agreed to accept the $2 million, to find no fault with LeMessurier's firm, and to close the entire matter.

A relieved LeMessurier nevertheless expected his insurance company to raise the premiums on his liability insurance. He would, he reasoned, appear as an engineer who had bungled an expensive job and brought about a large cash settlement.

At a meeting with officials from the insurance company, LeMessurier's secretary was able to convince them that LeMessurier had "prevented one of the worst insurance disasters of all time!" Far from behaving in an incompetent or devious manner, LeMessurier had acted in a commendable way: he had discovered an unforeseen problem, acted immediately, appropriately, and efficiently to solve it, and solved it.

LeMessurier's handling of the Citicorp situation increased his reputation as an exceptionally competent, forthright structural engineer. It also prompted his liability insurers to lower his premium.



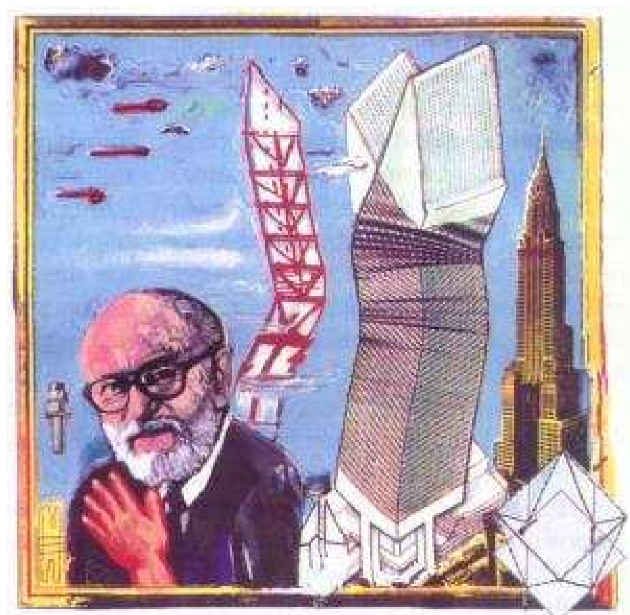
CITY PERILS

THE FIFTY-NINE-STORY CRISIS

THE NEW YORKER, MAY 29, 1995, pp 45-53

What's an engineer's worst nightmare? To realize that the supports he designed for a skyscraper like Citicorp Center are flawed---and hurricane season is approaching.

BY JOE MORGENSTERN



ON a warm June day in 1978, William J. LeMessurier, one of the nation's leading structural engineers, received a phone call at his headquarters, in Cambridge, Massachusetts, from an engineering student in New Jersey. The young man, whose name has been lost in the swirl of subsequent events, said that his professor had assigned him to write a paper on the Citicorp tower, the slash-topped silver skyscraper that had become, on its completion in Manhattan the year before, the seventh-tallest building in the world.

LeMessurier found the subject hard to resist, even though the call caught him in the middle of a meeting. As a structural consultant to the architect Hugh Stubbins, Jr., he had designed the twenty-five-thousand-ton steel skeleton beneath the tower's sleek aluminum skin. And, in a field where architects usually get all the credit, the engineer, then fifty-two, had won his own share of praise for the tower's technical elegance and singular grace; indeed, earlier that year he had been elected to the National Academy of Engineering, the highest honor his profession bestows. Excusing himself from the meeting, LeMessurier asked his caller how he could help.

The student wondered about the columns--there are four--that held the building up. According to his professor, LeMessurier had put them in the wrong place.

"I was very nice to this young man," LeMessurier recalls. "But I said, 'Listen, I want you to tell your teacher that he doesn't know what the hell he's talking about, because he doesn't know the problem that had to be solved.' I promised to call back after my meeting and explain the whole thing."

The problem had been posed by a church. When planning for Citicorp Center began, in the early nineteen-seventies, the site of choice was on the east side of Lexington Avenue between Fifty-third and Fifty-fourth Streets, directly across the street from Citicorp's headquarters. But the northwest corner of that block was occupied by St. Peter's Church, a decaying Gothic structure built in 1905. Since St. Peter's owned the corner, and one of the world's biggest banking corporations wanted the whole block, the church was able to strike a deal that seemed heaven-sent: its old building would be demolished and a new one built as a free-standing part of Citicorp Center.

To clear space for the new church, Hugh Stubbins and Bill LeMessurier (he pronounces his name "LeMeasure") set their fifty-nine-story tower on four massive, nine-story-high stilts, and positioned them at the center of each side, rather than at each comer. This daring scheme allowed the designers to cantilever the building's corners seventy-two feet out over the church, on the northwest, and over a plaza on the southwest. The columns also produced high visual drama: a nine-hundred-and-fourteen-foot monolith that seemed all but weightless as it hovered above the street.

When LeMessurier called the student back, he related this with the pride of a master builder and the elaborate patience of a pedagogue; he, too, taught a structural-engineering class, to architecture students at Harvard. Then he explained how the peculiar geometry of the building, far from constituting a mistake, put the columns in the strongest position to resist what sailors call quartering winds--those which come from a diagonal and, by flowing across two sides of a building at once, increase the forces on both. For further enlightenment on the matter, he referred the student to a technical article written by LeMessurier's partner in New York, an engineer named Stanley Goldstein. LeMessurier recalls, "I gave him a lot of information, and I said, 'Now you really have something on your professor, because you can explain all of this to him yourself.'"

Later that day, LeMessurier decided that the information would interest his own students; like sailors, designers of tall buildings must know the wind and respect its power. And the columns were only part of the tower's defense against swaying in severe winds. A classroom lecture would also look at the tower's unusual system of wind braces, which LeMessurier had first sketched out, in a burst of almost ecstatic invention, on a napkin in a Greek restaurant in Cambridge: forty-eight braces, in six tiers of eight, arrayed like giant chevrons behind the building's curtain of aluminum and glass. ("I'm very vain," LeMessurier says. "I would have liked my stuff to be expressed on the outside of the building, but Stubbins wouldn't have it. In the end, I told myself I didn't give a damn--the structure was there, it'd be seen by God.")

LeMessurier had long since established the strength of those braces in perpendicular winds--the only calculation required by New York City's building code. Now, in the spirit of intellectual play, he wanted to see if they were just as strong in winds hitting from forty-five degrees. His new calculations surprised him. In four of the eight chevrons in each tier, a quartering wind increased the strain by forty per cent. Under normal circumstances, the wind braces would have absorbed the extra load without so much as a tremor. But the circumstances were not normal. A few weeks before, during a meeting in his office, LeMessurier had learned of a crucial change in the way the braces were joined.

THE meeting had been called, during the month of May, to review plans for two new skyscrapers in Pittsburgh. Those towers, too, were designed by Hugh Stubbins with LeMessurier as structural consultant, and the plans called for wind braces similar to those used in Citicorp Center, with the same specifications for welded joints. This was top of the-line engineering; two structural members joined by a skilled welder become as strong as one. But welded joints, which are labor-intensive and therefore expensive, can be needlessly strong; in most cases, bolted joints are more practical and equally safe. That was the position taken at the May meeting by a man from U.S. Steel, a potential bidder on the contract to erect the Pittsburgh towers. If welded joints were a condition, the project might be too expensive and his firm might not want to take it on.

To reassure him, LeMessurier put in a call to his office in New York. "I spoke to Stanley Goldstein and said, 'Tell me about your success with those welded joints in Citicorp.' And Stanley said, 'Oh, didn't you know? They were changed--they were never welded at all, because Bethlehem Steel came to us and said they didn't think we needed to do it.'' Bethlehem, which built the Citicorp tower, had made the same objection--welds were stronger than necessary, bolts were the right way to do the job. On August 1, 1974, LeMessurier's New York office--actually a venture in conjunction with an old-line Manhattan firm called the Office of James Ruderman--had accepted Bethlehem's proposal.

This news gave LeMessurier no cause for concern in the days immediately following the meeting. The choice of bolted joints was technically sound and professionally correct. Even the failure of his associates to flag him on the design change was justifiable; had every decision on the site in Manhattan waited for approval from Cambridge, the building would never have been finished. Most important, modern skyscrapers are so strong that catastrophic collapse is not considered a realistic prospect; when engineers seek to limit a building's sway, they do so for the tenants' comfort.

Yet now, a month after the May meeting, the substitution of bolted joints raised a troubling question. If the bracing system was unusually sensitive to quartering winds, as LeMessurier had just discovered, so were the joints that held it together. The question was whether the Manhattan team had considered such winds when it designed the bolts. "I didn't go into a panic over it," LeMessurier says. "But I was haunted by a hunch that it was something I'd better look into,"

On July 24th, he flew to New York, where his hunch was soon confirmed: his people had taken only perpendicular winds into account. And he discovered another "subtle conceptual error," as he calls it now--one that threatened to make the situation much worse.

To understand why, one must look at the interplay of opposing forces in a windblown building. The wind causes tension in the structural members--that is, it tries to blow the building down. At the same time, some of' that tension, measured in thousands, or even millions, of pounds, is offset by the force of gravity, which, by pressing the members together, tends to hold the building in place. The joints must be strong enough to resist the differential between these forces--the amount of wind tension minus the amount of compression.

Within this seemingly simple computation, however, lurks a powerful multiplier. At any given level of the building, the compression figure remains constant; the wind may blow harder, but the structure doesn't get any heavier. Thus, immense leverage can result from higher wind forces. In the Citicorp tower, the forty-per-cent increase in tension produced by a quartering wind became a hundred-and-sixty-per-cent increase on the building's bolts.

Precisely because of that leverage, a margin of safety is built into the standard formulas for calculating how strong a joint must be; these formulas are contained in an American Institute of Steel Construction specification that deals with joints in structural columns. What LeMessurier found in New York, however, was that the people on his team had disregarded the standard. They had chosen to define the diagonal wind braces not as columns but as trusses, which are exempt from the safety factor. As a result, the bolts holding the joints together were perilously few. "By then," LeMessurier says, "I was getting pretty shaky."

He later detailed these mistakes in a thirty-page document called "Project SERENE''; the acronym, both rueful and apt, stands for "Special Engineering Review of Events Nobody Envisioned." What emerges from this document, which has been confidential until now, and from interviews with LeMessurier and other principals in the events, is not malfeasance, or even negligence, but a series of miscalculations that flowed from a specific mind-set. In the case of the Citicorp tower, the first event that nobody envisioned had taken place when LeMessurier sketched, on a restaurant napkin, a bracing system with an inherent sensitivity to quartering winds. None of his associates identified this as a problem, let alone understood that they were compounding it with their fuzzy semantics. In the stiff, angular language of "Project SERENE," "consideration of wind from non-perpendicular directions on ordinary rectangular buildings is generally not discussed in the literature or in the classroom."

LeMessurier tried to take comfort from another element of Citicorp's advanced design: the building's tuned mass damper. This machine, built at his behest and perched where the bells would have been if the Citicorp tower had been a cathedral, was essentially a four-hundred-and-ten-ton block of concrete, attached to huge springs and floating on a film of oil. When the building swayed, the block's inertia worked to damp the movement and calm tenants' queasy stomachs. Reducing sway was of special importance, because the Citicorp tower was an unusually lightweight building;, the twenty-five thousand tons of steel in its skeleton contrasted with the Empire State

Building's sixty-thousand-ton superstructure. Yet the damper, the first of its kind in a large building, was never meant to be a safety device. At best, the machine might reduce the danger, not dispel it.

BEFORE making a final judgment on how dangerous the bolted joints were, LeMessurier turned to a Canadian engineer named Alan Davenport, the director of the Boundary Layer Wind Tunnel Laboratory, at the University of Western Ontario, and a world authority on the behavior of buildings in high winds. During the Citicorp tower's design, Davenport had run extensive tests on scale models of the structure. Now LeMessurier asked him and his deputy to retrieve the relevant files and magnetic tapes. "If we were going to think about such things as the possibility of failure," LeMessurier says--the word "failure" being a euphemism for the Citicorp tower's falling down--"we would think about it in terms of the best knowledge that the state of the art can produce, which is what these guys could provide for me."

On July 26th, he flew to London, Ontario, and met with Davenport. Presenting his new calculations, LeMessurier asked the Canadians to evaluate them in the light of the original data. "And you have to tell me the truth," he added. "Don't go easy if it doesn't come out the right way." It didn't, and they didn't. The tale told by the wind-tunnel experts was more alarming than LeMessurier had expected. His assumption of a forty-per-cent increase in stress from diagonal winds was theoretically correct, but it could go higher in the real world, when storms lashed at the building and set it vibrating like a tuning fork. "Oh, my God," he thought, "now we've got that on top of an error from the bolts being under-designed." Refining their data further, the Canadians teased out wind-tunnel forces for each structural member in the building, with and without the tuned mass damper in operation; it remained for LeMessurier to interpret the numbers' meaning.

First, he went to Cambridge, where he talked to a trusted associate, and then he called his wife at their summer house in Maine. "Dorothy knew what I was up to," he says. "I told her, 'I think we've got a problem here, and I'm going to sit down and try to think about it.'" On July 28th, he drove to the northern shore of Sebago Lake, took an outboard motorboat a quarter of a mile across the water to his house on a twelve-acre private island, and worked through the wind-tunnel numbers, joint by joint and floor by floor.

The weakest joint, he discovered, was at the building's thirtieth floor; if that one gave way, catastrophic failure of the whole structure would follow. Next, he took New York City weather records provided by Alan Davenport and calculated the probability of a storm severe enough to tear that joint apart. His figures told him that such an event had a statistical probability of occurring as often as once every sixteen years--what meteorologists call a sixteen-year storm.

"That was very low, awesomely low," LeMessurier said, his voice hushed as if the horror of discovery were still fresh. "To put it another way, there was one chance in sixteen in any year, including that one." When the steadying influence of the tuned mass damper was factored in, the probability dwindled to one in fifty-five--a fifty-five-year storm. But the machine required electric current, which might fail as soon as a major storm hit.

As an experienced engineer, LeMessurier liked to think he could solve most structural problems, and the Citicorp tower was no exception. The bolted joints were readily accessible, thanks to Hugh Stubbins' insistence on putting the chevrons inside the building's skin rather than displaying them outside. With money and materials, the joints could be reinforced by welding heavy steel plates over them, like giant Band-Aids. But time was short; this was the end of July, and the height of the hurricane season was approaching. To avert disaster, LeMessurier would have to blow the whistle quickly on himself. That meant facing the pain of possible protracted litigation, probable bankruptcy, and professional disgrace. It also meant shock and dismay for Citicorp's officers and shareholders when they learned that the bank's proud new corporate symbol, built at a cost of a hundred and seventy-five million dollars, was threatened with collapse.

On the island, LeMessurier considered his options. Silence was one of them; only Davenport knew the full implications of what he had found, and he would not disclose them on his own. Suicide was another, if LeMessurier drove along the Maine Turnpike at a hundred miles an hour and steered into a bridge abutment, that would be that. But keeping silent required betting other people's lives against the odds, while suicide struck him as a coward's way out and--although he was passionate about nineteenth-century classical music--unconvincingly melodramatic. What seized him an instant later was entirely convincing, because it was so unexpected almost giddy sense of power. "I had information that nobody else in the world had," LeMessurier recalls. "I had power in my hands to effect extraordinary events that only I could initiate. I mean, sixteen years to failure--that was very simple, very clear-cut. I almost said, thank you, dear Lord, for making this problem so sharply defined that there's no choice to make.' '

At his office in Cambridge on the morning of Monday, July 31st, LeMessurier tried to reach Hugh Stubbins whose firm was upstairs in the same building, but Stubbins was in California and unavailable by phone. Then he called Stubbins' lawyer, Carl Sapers, and outlined the emergency over lunch. Sapers advised him against telling Citicorp until he had consulted with his own company's liability insurers, the Northbrook Insurance Company, in Northbrook, Illinois. When LeMessurier called Northbrook, which represented the Office of James Ruderman as well, someone there referred him to the company's attorneys in New York and warned him not to discuss the matter with anyone else.

At 9 A.M. on Tuesday, in New York, LeMessurier faced a battery of lawyers who, he says, "wanted to meet me to find out if I was nutty." Being lawyers, not engineers, they were hard put to reconcile his dispassionate tone with the apocalyptic thrust of his prophecy. They also bridled at his carefully qualified answers to seemingly simple questions. When they asked how big a storm it would take to blow the building down, LeMessurier confined himself to statistical probabilities-- storm that might occur once in sixteen years.

When they pressed him for specific wind velocities--would the wind have to be at eighty miles per hour, or ninety, or ninety-five?--he insisted that such figures were not significant in themselves, since every structure was uniquely sensitive to certain winds; an eighty-five-mile-per-hour wind that blew for sixteen minutes from the northwest might pose less of a threat to a particular building than an eighty-mile-per-hour wind that blew for fourteen minutes from the southwest.

But the lawyers certainly understood that they had a crisis on their hands, so they sent for an expert adviser they trusted: Leslie Robertson, an engineer who had been a structural consultant for the World Trade Center. "I got a phone call out of the blue from some lawyer summoning me to a meeting," Robertson says." 'What's it about?' 'You'll find out when you get there.' 'Sorry, I have other things to do--I don't attend meetings on that basis.' A few minutes later, I got another call, from another lawyer, who said there'd been a problem with Citicorp Center. I went to the meeting that morning, and I didn't know anybody there but Bill. He stood up and explained what he perceived were the difficulties with the building, and everyone, of course, was very concerned. Then they turned to me and said, 'Well?' I said, 'Look, if this is in fact the case, you have a very serious problem.'"

The two structural engineers were peers, but not friends. LeMessurier was a visionary with a fondness for heroic designs, though he was also an energetic manager. Robertson was a stickler for technical detail, a man fascinated by how things fit together. LeMessurier, older by two years, was voluble and intense, with a courtly rhetorical style. Robertson was tall, trim, brisk, and edgily funny, but made no effort to hide his impatience with things that didn't interest him.

In addition to his engineering expertise, Robertson brought to the table a background in disaster management. He had worked with such groups as the National Science Foundation and the National Research Council on teams that studied the aftermaths of earthquakes, hurricanes, and floods. (In 1993, he worked with the F.B.I. on the World Trade Center bombing.) For the liability lawyers, this special perspective enhanced his stature as a consultant, but it unsettled LeMessurier from the start. As he remembers it, "Robertson predicted to everybody present that within hours of the time Citicorp heard about this the whole building would be evacuated. I almost fainted. I didn't want that to happen." (For his part, Robertson recalls making no such dire prediction.)

LeMessurier didn't think an evacuation would be necessary. He believed that the building was safe for occupancy in all but the most violent weather, thanks to the tuned mass damper, and he insisted that the damper's reliability in a storm could be assured by installing emergency generators. Robertson conceded the importance of keeping the damper running--it had performed flawlessly since it became operational earlier that year---but, because, in his view, its value as a safety device was unproved, he flatly refused to consider it as a mitigating factor. (In a conversation shortly after the World Trade Center bombing, Robertson noted dryly that the twin towers' emergency generators "lasted for fifteen minutes.")

One point on which everyone agreed was that LeMessurier, together with Stubbins, needed to inform Citicorp as soon as possible. Only Stubbins had ever dealt directly with Citicorp's chairman, Walter B. Wriston, and he was flying home that same day from California and still didn't know his building was flawed. That evening, LeMessurier took the shuttle to Boston, went to Stubbins' house in Cambridge, and broke the news. "He winced, I must admit--here was his masterpiece," LeMessurier says. "But he's a man of enormous resilience, a very grown man, and fortunately we had a lifelong relationship of trust."

The next morning, August 2nd, Stubbins and LeMessurier flew to New York, went to LeMessurier's office at 515 Madison Avenue, put in a call to Wriston, but failed to penetrate the layers of secretaries and assistants that insulated Citicorp's chairman from the outside world. They were no more successful in reaching the bank's president, William I. Spencer, but Stubbins finally managed to get an appointment with Citicorp's executive vice-president, John S. Reed, the man who has now succeeded Wriston as chairman. LeMessurier and Stubbins went to see Reed at the bank's ornate executive offices, in an older building on Lexington Avenue, across the street from Citicorp Center. LeMessurier began by saying, "I have a real problem for you, sir."

Reed was well equipped to understand the problem. He had an engineering background, and he had been involved in the design and construction of Citicorp Center, the company had called him in when it was considering the tuned mass damper. Reed listened impassively as LeMessurier detailed the structural defect and how he thought it could be fixed. LeMessurier says, "I'd already conceived that you could build a little plywood house around each of the connections that were critical, and a welder could work inside it without damaging the tenants' space. You might have to take up the carpet, take down the sheetrock, and work at night, but all this could be done. But the real message I conveyed to him was 'I need your help--at once.' '

When Reed asked how much the repairs would cost, LeMessurier offered an estimate of a million dollars. At the end of the meeting, which lasted half an hour, Reed thanked the two men courteously, though noncommittally, and told them to go back to their office and await further instructions. They did so, but after waiting for more than an hour they decided to go out to lunch. As they were finishing their meal, a secretary from LeMessurier's office called to say that John Reed would be in the office in ten minutes with Walter Wriston.

In the late nineteen-seventies, when Citicorp began its expansion into global banking, Wriston was one of the most influential bankers in the country. A tall man of piercing intelligence, he was not known for effusiveness in the best of circumstances, and LeMessurier expected none now, what with Citicorp Center--and his own career---literally hanging in the balance. But the bank's chairman was genuinely proud of the building, and he offered his support in getting it fixed.

"Wriston was fantastic," LeMessurier says. "He said, 'I guess my job is to handle the public relations of this, so I'll have to start drafting a press release.'" But he didn't have anything to write on, so someone handed him a yellow pad. That made him laugh. According to LeMessurier, "'All wars,' Wriston said, 'are won by generals writing on yellow pads.'" In fact, Wriston simply took notes; the press release would not go out for six days. But his laughter put the others at ease. Citicorp's general was on their side.

WITHIN hours of Wriston's visit, LeMessurier's office arranged for emergency generators for the tower's tuned mass damper. The bank issued beepers to LeMessurier and his key engineers, assuring them that Reed and other top managers could be reached by phone at any hour of the day or night. Citicorp also assigned two vicepresidents, Henry DeFord III and Robert Dexter, to manage the repairs; both had overseen the building's construction and knew it well.

The next morning, Thursday, August 3rd, LeMessurier, Robertson, and four of LeMessurier's associates met with DeFord and Dexter in a conference room on the thirtieth floor of Citicorp Center. (The decision to hold the initial meeting near the structure's weakest point was purely coincidental.) LeMessurier outlined his plan to fix the wind braces by welding two-inch-thick steel plates over each of more than two hundred bolted joints. The plan was tentatively approved, pending actual examination of a typical joint, but putting it into effect depended on the availability of a contractor and on an adequate supply of steel plate. Since Bethlehem Steel had dropped out of the business of fabricating and erecting skyscraper structures, Robertson suggested Karl Koch Erecting, a New Jersey-based firm that had put up the World Trade Center.

"I called them," Robertson says, "and got, 'Well, we're a little busy right now,' and I said, 'Hey, you don't understand what we're talking about here.'" A few hours later, two Koch engineers joined the meeting. LeMessurier and Robertson took them to an unoccupied floor of the building, and there workmen tore apart enough sheetrock to expose a diagonal connection. Comparing the original drawings of the joints with the nuts-and-bolts reality before their eyes, the engineers concluded that LeMessurier's plan was indeed feasible. Koch also happened to have all the necessary steel plate on band, so Citicorp negotiated a contract for welding to begin as soon as LeMessurier's office could issue new drawings.

Two more contracts were drawn up before the end of the following day. One of them went out to MTS Systems Corporation, the Minneapolis firm that had manufactured the tuned mass damper. MTS was asked to provide full-time technical support--in effect, around-the-clock nurses--to keep its machine in perfect health. The company flew one of its technicians to New York that night. Four days later, in a letter of agreement, MTS asked Citicorp to provide a long list of materials and spare parts, which included three buckets, a grease gun, rags, cleaning solvent, and "1 Radio with weather band."

The other contract engaged a California firm, also recommended by Robertson, to fit the building with a number of instruments called strain guages--pieces of tape with zigzag wires running through them. The guages would be affixed to individual structural members, and electrical impulses from them would be funneled to an improvised communications center in Robertson's office, eight blocks away, at 230 Park Avenue; like a patient in intensive care, the tower would have every shiver and twitch monitored. But this required new telephone lines, and the phone company refused to budge on its leisurely installation schedule. When Robertson voiced his frustration about this during a late-night meeting in Walter Wriston's office, Wriston picked up the phone on his desk and called his friend Charles Brown, the president and chief operating officer of AT&T. The new lines went in the next morning.

A different problem-solving approach was taken by Robertson during another nighttime meeting in Citicorp's executive suite. Wriston wanted copies of some documents that Robertson had shown him, but all the secretaries had gone home--the only people' on the floor were Wriston, Robertson, and John Reed--and every copying machine was locked. "I'm an engineer," Robertson says, "so I kneeled down, tipped the door off one of the machines, and we made our copies. I looked up at them a little apologetically, but, what the hell--fixing the door was a few hundred bucks, and these guys had a hundred-and-seventy-five-million-dollar building in trouble across the street."

Robertson also assembled an advisory group of weather experts from academia and the government's Brookhaven National Laboratory, on Long Island, and hired two independent weather forecasters to provide wind predictions four times a day. "What worried us more than hurricanes, which give you hours and days to anticipate, were unpredictable events," Robertson says. "From time to time, we've had small tornadoes in this area, and there was a worry that a much bigger one would come down and take hold." Then Robertson raised an issue that LeMessurier had dreaded discussing. In a meeting on Friday that included LeMessurier, Robertson told Citicorp's representatives, DeFord and Dexter, that they needed to plan for evacuating Citicorp Center and a large area around it in the event of a high-wind alert.

DURING the first week of August, discussions had involved only a small circle of company officials and engineers. But the circle widened on Monday, August 7th, when final drawings for the steel plates went out to Arthur Nusbaum, the veteran project manager of HRH Construction, which was the original contractor for Citicorp Center, and Nusbaum, in turn, provided them to Koch Erecting. And it would widen again, because work could not go forward, as Robertson reminded the officials, without consulting the city's Department of Buildings. Citicorp faced a public-relations debacle unless it came up with a plausible explanation of why its brand-new skyscraper needed fixing.

That night, DeFord and Dexter, following Robertson's advice, met with Mike Reilly, the American Red Cross's director of disaster services for the New York metropolitan area. 'They laid out the dilemma, and it was clearly an ominous event," Reilly recalls. From that first meeting, which was attended by Robertson but not by LeMessurier, and from half a dozen subsequent working sessions with other disaster agencies, came plans for joint action by the police and the mayor's Office of Emergency Management, along with the Red Cross. In the event of a wind alert, the police and the mayor's emergency forces would evacuate the building and the surrounding neighborhood, and the Red Cross would mobilize between twelve hundred and two thousand workers to provide food and temporary shelter. "Hal DeFord was the bank's point man for all this," Reilly says. "The anxiety was so heavy on him that we wondered if he was going to make it."

On Tuesday morning, August 8th, the public-affairs department of Citibank, Citicorp's chief subsidiary, put out the long delayed press release. In language as bland as a loan officer's wardrobe, the three-paragraph document said unnamed "engineers who designed the building" had recommended that "certain of the connections in Citicorp Center's wind bracing system be strengthened through additional welding.'' The engineers, the press release added, "have assured us that there is no danger." When DeFord expanded on the handout in interviews, he portrayed the bank as a corporate citizen of exemplary caution--"We wear both belts and suspenders here," he told a reporter for the *News*--that had decided on the welds as soon as it learned of new data based on dynamic-wind tests conducted at the University of Western Ontario.

There was some truth in all this. During LeMessurier's recent trip to Canada, one of Alan Davenport's assistants had mentioned to him that probable wind velocities might be slightly higher, on a statistical basis, than predicted in 1973, during the original tests for Citicorp Center. At the time, LeMessurier viewed this piece of information as one more nail in the coffin of his career, but later, recognizing it as a blessing in disguise, he passed it on to Citicorp as the possible basis of a cover story for the press and for tenants in the building.

On Tuesday- afternoon at a meeting in Robertson's office, LeMessurier told the whole truth to New York City's Acting Building Commissioner and nine other senior city officials. For more than an hour, he spoke about the effect of diagonal winds on the Citicorp tower, about the failure of his own office to perceive and communicate the danger, and about the intended repairs.

In the discussion that followed, the city officials asked a few technical questions, and Arthur Nusbaum expressed concern over a shortage of certified welders who had passed the city's structural-welding test. That would not be a problem, the representatives from the Department of Buildings replied; one of the area's most trusted steel inspectors, Neil Moreton, would have the power to test and immediately certify any welder that Citicorp's repair project required. Nusbaum recalls, "Once they said that, I knew we were O.K., because there were steamfitter welders all over the place who could do a fantastic job."

Before the city officials left, they commended LeMessurier for his courage and candor, and expressed a desire to be kept informed as the repair work progressed. Given the urgency of the situation, that was all they could reasonably do. "It wasn't a case of 'We caught you, you skunk,'" Nusbaum says. "It started with a guy who stood up and said, 'I got a problem, I made the problem, let's fix the problem.' If you're gonna kill a guy like LeMessurier, why should anybody ever talk?"

Meanwhile, Robertson's switchboard was besieged by calls. "Every reporter in town wanted to know how come all these people were in our office," Robertson says. Once the meeting ended, the Building Commissioner returned the reporters' calls and, hewing to Citicorp's line, reassured them that the structural work was only a prudent response to new meteorological data.

As a result, press coverage in New York City the next day was as uninformative as the handout: a short piece in the Wall Street Journal, which raised no questions about the nature of the new data, and one in the *News*, which dutifully quoted DeFord's remark about belts and suspenders. But when LeMessurier went back to his hotel room, at about 5 P.M. on Wednesday, he learned from his wife, who had come down from Cambridge to join him, that a reporter from the *Times* had been trying to reach him all afternoon. That worried him greatly', being candid with city officials was one thing, but being interrogated by the *Times* was another. Before returning the call, LeMessurier phoned his friend Carl Sapers, the Boston attorney who represented Hugh Stubbins, and mixed himself a Martini. Sapers understood the need for secrecy, but he saw no real choice; talk to them, he said, and do the best you can. Two minutes after six o'clock, LeMessurier called the *Times* switchboard. As he braced himself for an unpleasant conversation, he heard a recording. The *Times*, along with all the other major papers in the city, had just been shut down by a strike.

WELDERS started work almost immediately, their torches a dazzlement in the night sky. The weather was sticky, as it had been since the beginning of the month--New Jersey's tomato crop was rotting from too much rain. Forecasts called for temperatures in the mid-eighties the next day, with no wind; in other words, a perfect day for Citicorp Center.

Yet tropical storms were already churning the Caribbean. Citicorp pushed for repair work around the clock, but Nusbaum refused to allow welding during office hours, for fear that clouds of acrid smoke would cause panic among the tenants and set off every smoke detector in the building. Instead, he brought in drywall crews and carpenters to work from 5 P.M. to 8 P.M., putting up plywood enclosures around the chevrons and tearing down Sheetrock; welders to weld from 8 P.M. until 4 A.M., with the building's fire-alarm system shut off; and then laborers to clean up the epic mess before the first secretaries arrived.

The welders worked seven days a week. Sometimes they worked on unoccupied floors; sometimes they invaded lavish offices. But decor, or the lack of it, had no bearing on their priorities, which were set by LeMessurier. "It was a tense time for the whole month," he says. "I was constantly calculating which joint to fix next, which level of the building was more critical, and I developed charts and graphs of all the consequences: if you fix this, then the rarity of the storm that will cause any trouble lengthens to that."

At Robertson's office, a steady stream of data poured in from the weather forecasters and from the building itself. Occasionally, the strain-gage readings jumped, like spikes on an electrocardiogram, when the technicians from MTS Systems exercised their tuned mass damper to make sure it was working properly. One time, the readings went off the chart, then stopped. This provoked more bafflement than fear, since it seemed unlikely that a hurricane raging on Lexington and Fifty-third Street would go otherwise unnoticed at Forty-sixth and Park. The cause proved to be straightforward enough: When the instrumentation experts from California installed their strain guages, they had neglected to hire union electricians. "Someone heard about it," LeMessurier says, "went up there in the middle of the night, and snipped all the wires."

For most of August, the weather smiled on Citicorp, or at least held its breath, and the welders made steady progress. LeMessurier felt confident enough to fly off with his wife for a weekend in Maine. As their return flight was coming in for a landing at LaGuardia Airport Sunday night, they looked out across the East River and saw a pillar of fire on the Manhattan skyline. "The welders were working up and down the building, fixing the joints," LeMessurier recalls. "It was an absolutely marvelous thing to see. I said to Dorothy, 'Isn't this wonderful? Nobody knows what's going on, but we know and we can see it light up the sky.'"

A great deal of work remained. Robertson was insisting on a complete reevaluation of the Citicorp tower: not just the sensitivity of the chevrons to quartering winds but the strength of other skeletal members, the adequacy of braces that kept the supporting columns in plumb, and the rigidity of the building's corrugated metal-and-concrete floors, which Robertson feared might be compromised by trenches carrying electrical connections.

His insistence was proper--settling for less would have compromised Robertson's own position. It amounted to a post-construction autopsy by teams of forensic engineers. For LeMessurier, the reevaluation was harrowing in the extreme; every new doubt about his design for Citicorp Center reflected on him.

In one instance, Robertson's fears were unwarranted: tests showed that the tower floors were entirely sound--the trenches were not a source of weakness. In another, Robertson, assuming the worst about construction tolerances, decided that the columns might be slightly, even though undetectably, out of plumb, and therefore he ordered the installation of supplemental bracing above the fourteenth floor.

Shortly before dawn on Friday, September 1st, weather services carried the news that everyone had been dreading-- major storm, Hurricane Ella, was off Cape Hatteras and heading for New York. At 6:30 A.M., an emergency-planning group convened at the command center in Robertson's office. "Nobody said, 'We're probably going to press the panic button,'" LeMessurier recalls. "Nobody dared say that. But everybody was sweating blood."

As the storm bore down on the city, the bank's representatives, DeFord and Dexter, asked LeMessurier for a report on the status of repairs. He told them that the most critical joints had already been fixed and that the building, with its tuned mass damper operating, could now withstand a two-hundred-year storm. It didn't have to, however. A few hours later, Hurricane Ella veered from its northwesterly course and began moving out to sea.

LeMessurier spent the following night in Manhattan, having canceled plans to spend the Labor Day weekend with his family in Maine. But the hurricane kept moving eastward, and daybreak dispelled any lingering thoughts of evacuation. "Saturday was the most beautiful day that the world's ever seen," LeMessurier says, "with all the humidity drawn away and the skies sunny and crystal dear." Alone in the city, he gave himself a treat he'd been thinking about for years--his first visit to the Cloisters, where he basked in an ineffable calm.

THE weather watch ended on September 13th. That same day, Robertson recommended terminating the evacuation plans, too. Welding was completed in October, several weeks before most of the city's newspapers resumed publication. No further stories on the subject appeared in the wake of the strike. The building, in fact, was now strong enough to withstand a seven-hundred-year storm even without the damper, which made it one of the safest structures ever built--and rebuilt--by the hand of man.

Throughout the summer, Citicorp's top management team had concentrated on facilitating repairs, while keeping the lawyers on the sidelines. That changed on September 13th, when Citicorp served notice on LeMessurier and Hugh Stubbins, whose firm held the primary contract, of its intention to seek indemnification for all costs. Their estimate of the costs, according to LeMessurier, amounted to $4.3 million, including management fees. A much higher total was suggested by Arthur Nusbaum, who recalled that his firm, HRH Construction, spent eight million dollars on structural repairs alone. Citicorp has declined to provide its own figure.

Whatever the actual cost, Citicorp's effort to recoup it was remarkably free of the punitive impulse that often poisons such negotiations. When the terms of a settlement were first discussed--without lawyers--by LeMessurier, on one side, and DeFord and Dexter, on the other, LeMessurier spoke of two million dollars, which was the amount that his liability insurer, the Northbrook Insurance Company, had agreed to pay. "DeFord and Dexter said, 'Well, we've been deeply wounded here,' and they tried to play hardball," LeMessurier says. "But they didn't do it with much conviction.'' After a second meeting, which included a Northbrook lawyer, the bank agreed to hold Stubbins' firm harmless and to accept the two-million-dollar payment from LeMessurier and his joint-venture partners; no litigation ever ensued. Eight years ago, Citicorp turned the building into a condominium, retaining the land and the shops but selling all the office space, to Japanese buyers, at a handsome profit.

The crisis at Citicorp Center was noteworthy in another respect. It produced heroes, but no villains; everyone connected with the repairs behaved in exemplary fashion, from Walter Wriston and his Citicorp management team to the officials at the city's Department of Buildings. The most striking example, of course, was set by LeMessurier, who emerged with his reputation not merely unscathed but enhanced. When Robertson speaks of him, he says, "I have a lot of admiration for Bill, because he was very forthcoming. While we say that all engineers would behave as he did, I carry in my mind some skepticism about that."

In the last few years, LeMessurier has been talking about the summer of 1978 to his classes at Harvard. The tale, as he tells it, is by turns painful, self-deprecating, and self-dramatizing--an engineer who did the right thing. But it also speaks to the larger question of how professional people should behave. "You have a social obligation," LeMessurier reminds his students. "In return for getting a license and being regarded with respect, you're supposed to be self-sacrificing and look beyond the interests of yourself and your client to society as a whole. And the most wonderful part of my story is that when I did it nothing bad happened."