Operational Risk Management

A Case Study Approach to Effective Planning and Response

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PREFACE

The idea for this book actually began several years ago. At the time, I was asked to develop a course on risk management based on case studies of actual historical events. The intent was to examine what went wrong and to extract lessons learned from these events that could improve our quality of life today and in the future. Little did I know where it might lead.

Fast forwarding to the present time, this course has evolved into a steady and popular offering on campus. Each year, cases of historical importance are researched, debated, and reconciled. Some focus on natural disasters, others on man-made accidents, and the remainder on terrorist acts. Could the incident have been prevented? Preventable or not, what could have been done to manage the emergency response more effectively? What actions have we taken since the event occurred to make the world a safer place? Could it happen again?

These are the very same questions that confront and worry families, communities, businesses, and government officials. With media attention devoted to each catastrophe as it occurs around the globe, our anxiety grows, our perception of various risks can become distorted, and a feeling of uncertainty pervades much of how we think and act. Somehow we must be able to sort out the most important risks we face, determine how vulnerable we really are, and decide where our risk management resources can be most wisely used. At the same time, we must come to grips with the notion that some risks are simply beyond our control or are too small to warrant priority attention. In such circumstances, we must learn to become more tolerant of those risks.

Learning from real-world case studies is important and often overlooked. By examining disasters through a retrospective lens, we have a complete history of the event to review and interpret. Hindsight reveals much about the cause, impact, and ripple effect, allowing us to judge how likely it is that history could repeat itself. By going "back to the future," this process enables us to prepare for a better tomorrow.

This book contains many of my favorite case studies. Undoubtedly, you will be familiar with some of them, although perhaps not the important details. They have been carefully selected to cover all three hazard types (man-made accidents, terrorist acts, and natural disasters), in a variety of scenarios across many different industries and environments, both in the United States and abroad.

When you have finished reading, it is my hope that you no longer feel hostage to the anxiety and uncertainty that is limiting our quality of life. My aim is to show that risks can be successfully managed—it is just a matter of dealing with risks in the right way. And you can do your part.

As in any endeavor of this scale, this work would not have been possible without the assistance of many others. I am particularly appreciative of the students at Vanderbilt University who have participated in the risk management class and the encouragement of my colleagues for recognizing the importance of this topic. Special thanks, however, goes to Dr. Derek Bryant, whose dedicated and tireless research formed the basis of the case study narratives. I am also appreciative of his assistance in formalizing the book manuscript. In addition, I would like to acknowledge the support and encouragement of Sheck Cho at John Wiley & Sons, Inc.

Finally, the importance of family in motivating an author to dedicate the time and energy it takes to write a book cannot be understated. For me, the daily interactions with Susan, Alyssa, Kendra, and Jason kept me on an even keel throughout the project. Mom, your confidence in me has been a constant from as far back as I can remember. And Dad, thanks for inspiring me to become a teacher and for instilling in me such important life values. I can only hope that I am living up to them.

CHAPTER 1

WHY DO DISASTERS HAPPEN?

It seems like every time we turn on the news, a disaster has occurred. A tornado has touched down creating a swath of destruction, a chemical explosion is spewing toxic fumes into the air, an earthquake has crippled a populated area, wildfires are burning out of control, terrorists have attacked a major public transportation system, a hurricane is ravaging the coastline, buildings are collapsing, ships are sinking. And the list goes on.

Why do these disasters happen? With all of our knowledge, skill, and technology, why can't we do something to prevent them or at least keep them from causing such devastation? The more that we ask this question without a good explanation, the more frustrated and fearful we become of the world we live in. This situation has generated so much uncertainty and anxiety in today's society that our concern for these events seriously affects the way we think and act. It is truly unfortunate . . . and unnecessary.

Disasters come in many different forms, which can be conveniently organized into three groups. *Man-made accidents* are the result of human action or inaction that starts a chain of events leading to a catastrophic outcome. These errors in judgment are not considered intentional or malicious. However, *terrorist acts* are conscious actions made by people with purposeful and destructive intent. These acts are typically well planned, with a specific target in mind, directed at causing heavy casualties and creating mass hysteria. *Natural disasters*, which make up the third category, are considered acts of God, the cause of which is beyond human control. Most natural disasters ultimately can be attributed to weather patterns or movements of the earth's crust. Although humans are not responsible for the occurrence of natural disasters, we can have a profound impact on the severity of the consequences.

While these disaster groups may seem quite different, when one takes a closer look at how these events evolve, there is remarkable similarity. That is to say, there emerges a pattern or "recipe" for disaster. The question that then arises is: What are the ingredients to this recipe, and how do they mix together to form such a lethal outcome?

Each ingredient can be thought of as an underlying *risk factor* that, when present, alone or in combination with other risk factors, erodes into a margin of safety that we normally try to build into our lives. Once that margin of safety is compromised, however, the situation is free to unravel to epic proportions.

I consider there to be 10 basic risk factors:

1. **Design and construction flaws.** Major facilities, such as power plants, skyscrapers, refineries, and ships, are built according to detailed blueprints, otherwise known as design specifications. These specifications are based on engineering analyses that focus on designing the structure to withstand the forces that will be imposed on it, such as load, wind, vibration, puncture, or blast. If there is a flaw in the design process and it is not discovered in time, when those forces are applied to the structure, it will be prone to failure. This failure can lead to a partial or complete collapse of the facility.

   Even when the design specification is valid, problems still can arise if the materials used to fabricate the building components are faulty or the components are not assembled properly. In either case, the integrity of the structure is compromised, making it susceptible to failure, with outcomes similar to those that occur when a design flaw is present. Because of the close relationship between design and construction, it is not uncommon in a structural failure for opposing sides to argue whether the fault rests with a flaw in the design or in the construction.

2. **Deferred maintenance.** In the helter-skelter of trying to keep an operation up and running, discovery of a mechanical problem spurs a debate on whether to shut down the operation and fix the problem immediately, or to keep going and make the repair at a more convenient time. This is a judgment call, where the risk of deferring maintenance is weighed against the benefit of maintaining continuous operations. In these instances, it is human nature to choose to deal with problems at a later time, especially if the system is not actually malfunctioning. Unfortunately, decisions to defer maintenance often lead to the failure of a key system component before the repair can be made, causing a serious accident to occur. Moreover, within a culture where maintenance problems are customarily deferred, the situation is ripe for multiple component failures, allowing the consequences of the ensuing accident to propagate and intensify.
3. **Economic pressures.** As might be expected, one of the more common risk factors involves money. Whether exploring space, building a major facility, moving large quantities of cargo, or protecting a community from natural disasters, one is always dealing with a limited amount of available funding. Therefore, resources must be invested wisely. When a budget is too tight or spending is not controlled adequately, pressure intensifies to implement strict cost-cutting measures. This can translate into shoddy workmanship, purchasing lower-quality materials, eliminating the use of backup operating and safety equipment, or ignoring problems that arise. While economic pressures alone are rarely considered a root cause, they often serve as a catalyst for causing human errors that initiate a disastrous event.
4. **Schedule constraints.** Economic pressures and schedule constraints often go hand in hand as risk factors, as evidenced by the

phrase "Time is money." When a deadline has been imposed, and the project or operation has fallen behind, pressure to make up ground can cause the responsible party to cast a blind eye toward important details. Often this situation leads to the elimination of critical tasks, trying to accomplish tasks in parallel that should be done in sequence, or not pursuing certain considerations in sufficient depth to fully understand their impact on safety. As in the case of economic pressure, schedule constraints are considered a catalyst for committing errors in judgment that can lead to a destructive outcome.

5. **Inadequate training.** Most tasks in today's world have been made more complicated by the complexity of the technology being used and the highly integrated nature of various systems. Consequently, the performance of many important functions requires an individual to be highly trained. At the same time, some organizations view training as a burden because it can be costly to perform and because employees are not being productive while participating in a training program. This shortsighted perspective can place in positions of responsibility individuals whose lack of training causes them to make a mistake that either initiates an accident or allows a crisis situation to intensify.

   Problems with inadequate training go beyond the time when an individual first joins an organization. When there are personnel shortages, individuals may be thrown into an important decision-making role while covering for others, performing a function for which they were not properly trained. Because individuals tend to forget what they were originally taught and because processes change over time and require new learning, lack of retraining can also be a problem.

6. **Not following procedures.** Most organizations have well-defined procedures for how employees should perform a task or function. These procedures are often documented and made available during training and for reference purposes when individuals are on

the job. Moreover, job supervisors have as one of their duties to ensure that each employee is following standard procedures. Surprisingly, procedural errors are a frequent root cause of failure. When engaged in a repetitive activity, complacency can set in, and individuals tend to drift away from following a strict protocol. Consequently, they either neglect to perform certain steps or invent other ways to accomplish the same task, often not considering the ramifications of their actions on safety. Failing to follow procedure can create a hazardous situation, one that is exacerbated by coworkers whose actions are based on assuming that those procedures are being followed.

7. **Lack of planning and preparedness.** Planning and preparedness make up a proactive effort focused on applying resources in advance of an undesirable event to improve understanding and response to the threats with the greatest potential to cause serious harm. Depending on the nature of the threat, attention can be directed at preventing an undesirable event from occurring, mitigating the consequences of an event once it has occurred, or both. Planning and preparedness activities include the gathering of knowledge (intelligence), assessment of the likelihood and consequence of various disaster scenarios, evaluation of alternative risk reduction strategies, and conduct of exercises and drills to determine the effectiveness of ongoing efforts and maintain a state of readiness.

   Unfortunately, lack of planning and preparedness is evident in virtually every catastrophe recorded in history. Because of the luxury of time and the fact that a disastrous event may not have been experienced in recent memory, people tend to place a low priority on making the effort and spending the resources to be adequately prepared for a crisis situation. All too often, little forethought is given to the variety of disaster scenarios that could occur, the magnitude and impact of these events are underestimated if the scenario is considered, or the ability of the response community to handle mass casualty situations is overestimated.

Even in circumstances where significant effort has been devoted to planning and preparedness, the product of this effort can be a written plan that is not practiced or updated, rendering it of little value when a calamity arises.

8. **Communication failure.** This risk factor also is present in nearly every historical disaster, contributing to either the cause or the consequence of the event. Communication failures can occur at various stages, altering an outcome in different ways. One common form of communication failure occurs between members of the same organization. In this instance, critical information is not shared, such as when one group decides to shut down a critical protection system for maintenance while another group is carrying out a dangerous experiment. Poor communication between organizations is also problematic. A typical scenario is two agencies engaged in a response effort, each of which is unaware of what the other is doing. Finally, lack of communication with the public or the provision of inaccurate information can place people at risk either because they do not know the hazards they are facing or because they are not properly advised on how to protect themselves.
9. **Arrogance.** This risk factor is a human trait that can complicate what might otherwise be a safe operation. Arrogance can rear its head in many forms but usually appears as either the person in charge being driven to succeed for individual gain without sufficient regard for the safety of others or an experienced individual who has become overconfident with his or her ability to deal with any problem that might present itself. The former case creates an environment in which concerns expressed fall on deaf ears or, worse yet, a culture of fear of reprisal if an employee complains about personal safety. In the latter circumstance, the individual can underestimate the risk at hand, believing that "I've seen everything before and was able to handle it" or "This is not going to get the better of me." Arrogance displayed in either form can have serious repercussions.

While often associated with a key individual, arrogance can also appear at the institutional level. Such instances occur when the organizational culture has become dominated by an attitude of disregard for the well-being of others, overconfidence in the organization's ability to solve problems, or disdain for individuals whose beliefs threaten the ability to achieve desired goals and objectives.

10. **Stifling political agendas.** Government policies can have a powerful effect on the propensity for disasters. If these political agendas are hard-nosed, with little room for dialogue and compromise, then affected parties can feel that they have little recourse other than to resort to extreme and often hostile measures. Historically, political agendas have been closely associated with the vast majority of terrorist acts, an intentional reaction to what the aggressor perceives to be oppressive governmental policy. This risk factor is not limited to terrorist acts, however. It is also evident in developing countries where governments attempting to become more economically competitive are willing to relax safety standards to attract business, or among nations whose desire for an elevated status in global politics can put its citizens at greater risk.

An interesting observation when reviewing these ten basic risk factors is that we, as humans, are involved in each and every one of them. While this implies that we contribute to the cause or impact of every disaster, it also means that we have an opportunity to control these factors more effectively to achieve a better outcome: a safer tomorrow.

So, where do we begin? A good place to start is to go back in time and carefully review disasters that have occurred in the recent past, selecting a potpourri of those that were accidental in nature, terrorist acts, or due to natural causes. If we can follow the sequence of events that caused each disaster and analyze what went wrong, then we can extract important lessons learned about how to better control these risk factors. Moreover, if we also review actions taken in the aftermath of each disaster so as to reduce the risk of it happening again, we can evaluate our susceptibility to a recurring event in the future. Doing this will allow us to understand how we can become more savvy in making the world a safer place.

The intent of this book is to encourage adoption of such an approach. The parts that follow document and evaluate several case studies of major disasters that have occurred in the past 30 years. Each case study contains a narrative describing what happened, an analysis of what went wrong, a review of what actions have been taken in the aftermath of the event, and a perspective on whether a similar event could happen again. The case studies are separated according to whether they were man-made accidents, terrorist acts, or natural disasters. Also included are cases where disaster was averted because of the exemplary risk management practices of affected individuals and organizations. These success stories become important learning experiences by allowing us to observe what went right. The book closes by summarizing what the case studies have taught us about the ten basic risk factors, followed by a glimpse into what the future could look like if we take these lessons to heart.

PART ONE

MAN-MADE ACCIDENTS

We live in a society in which technology has provided significant lifestyle improvements that consumers have come to demand as necessities. Our dependence on electric power, advanced telecommunications, household goods, transportation, and other amenities has put considerable pressure on the economy to manufacture large quantities of product in a timely and economical fashion. Beyond this, the human race is not easily satisfied with the status quo, preferring instead to push the technology envelope toward bigger and better things, and doing it sooner rather than later. Whether putting men and women in space, erecting the tallest building, or constructing the largest vessel, we often forgo our common sense in pursuit of these endeavors.

It should therefore come as no surprise that history is filled with disasters of an accidental nature caused by human error. Some of these mistakes were specific in nature, attributed to a single individual who "fell asleep at the wheel." In other cases, the fault rests more with an entire organization, where a sloppy culture fostered a breeding ground for poor decisions. Sometimes the problem began by neglecting to examine a minute detail, which became a catalyst in unleashing a chain of destructive events. In other circumstances, the opportunity for tragedy was painstakingly clear and evident to many.

The five cases you will read about in this part involve accidental disasters that have occurred in a variety of disciplines, covering the construction, nuclear, chemical, transportation, and space industries. In one instance, separate tragedies occurred several years apart, due to similar causes. All of these events were considered preventable, and some were met with such public scrutiny that the perception of safety in certain industries continues to suffer to this day, even though the events took place decades ago.

CHAPTER 2

HYATT REGENCY WALKWAY COLLAPSE

A tea dance hosted in the atrium of the Hyatt Regency Hotel in Kansas City on July 17, 1981, ended in tragedy when the second- and fourth-floor skywalks collapsed onto a crowded dance floor, leaving 114 people dead and another 216 injured. Flaws in a simple design change made to a support mechanism went unnoticed, allowing the skywalk to buckle at the worst possible moment.

The Hyatt Regency hotel opened its doors in Kansas City in July of 1980. A facility over four years and $50 million in the making, the building stood 45 stories and 500 feet tall, occupying a prominent position on the city skyline. The most notable of its eye-catching design elements was a 60-foot, four-story glass atrium lobby, crossed by three skywalks, one each on the second, third, and fourth floors. On a summer night in 1981, the beauty of these features would be all but forgotten, as two of the skywalks crashed to the floor in one of the worst structural failures in U.S. history.

Construction of the Kansas City Hyatt dated back to early 1976, when Crown Center Redevelopment Corporation (CCRC) began the initiative, retaining PBNDML Architects, Planners, Inc. as the project architect. In April 1978, the firm of Gillum Colaco was hired to provide structural engineering services. One of the subsidiaries of this firm, Jack D. Gillum & Associates, was subcontracted to perform all of the engineering work for the hotel construction. Gillum, engineer of record for the project, was an experienced professional who held more than 20 professional engineering licenses throughout the United States. He had won several awards for his work on other high-profile projects, including facilities for the Olympic Games and other buildings for the CCRC. At the time he took on this assignment, Gillum was in charge of up to 100 engineers and specialists, working on as many as 70 projects. Daniel Duncan, one of the engineers under Gillum's supervision, was designated as project engineer for the Kansas City Hyatt.

The Hyatt project was scheduled according to the "fast-track" construction method. This building technique, which became popular in the late 1970s, involved commencing construction before the final designs were complete, thereby reducing the amount of time taken to build a facility. Eldridge Construction Company (ECC) was selected as the construction contractor. ECC subsequently sub-contracted with Havens Steel Company (HSC) to fabricate and erect the atrium steel.

In mid-1978, the first plans for the hotel's trademark skywalks were drawn by Gillum & Associates, with construction on the hotel tower already under way. The design called for the fourth-floor walkway to hang directly above the second-floor walkway, with the third-floor skywalk offset, suspended parallel to the others. The engineering sketch called for the second- and fourth-floor walkways to hang from a single set of rods, anchored to the atrium ceiling (see Exhibit 2.1). According to these drawings, each rod had to be threaded continuously from one level to the next to accommodate the nuts that would support the walkways. The details of the design for connecting the walkways to the hanger rods were left up to the fabricator (HSC), a practice not uncommon in Kansas City in the late 1970s.

On the construction site, it became apparent that using a single set of rods to hang both walkways would not be feasible. It is unclear whether this was due to the inability of HSC to obtain rods of sufficient length or from a realization that threading the rods continuously would be impractical and potentially unsafe. In early January 1979, HSC's engineering manager called Gillum & Associates to request that the design be changed to incorporate two rods, offset at the fourth floor (see

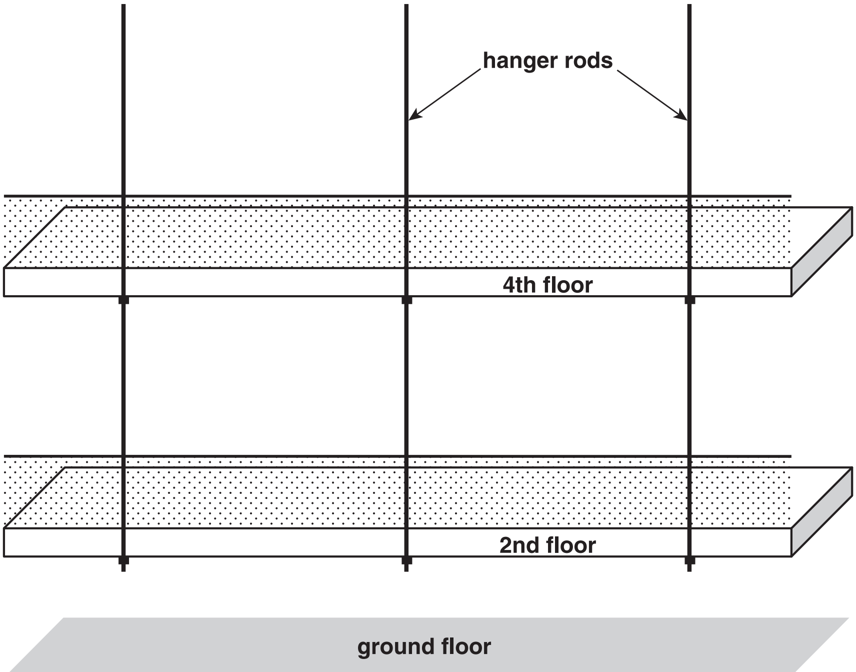

EXHIBIT **2.1** *Configuration of the second- and fourth-floor walkways (not to scale)*

Exhibit 2.2). The structural engineer agreed to the change over the phone but requested that the change be submitted formally. HSC's engineer later testified that he viewed the change as minor and never submitted it through official channels, though Duncan and Gillum both admitted to being aware of the change and approving it. On January 12, 1979, HSC halted work on the project and subcontracted it to an experienced outside engineering firm for detailing to free up resources for a larger, newly awarded project.

HSC had not flagged the change in the design of the rod/walkway connection in the shop drawings before handing the plans over to the detailer. As a result, the detailer assumed that the design process for the connection was complete and did not redesign it to account for the doubling of the weight placed on the nuts supporting the fourth-floor

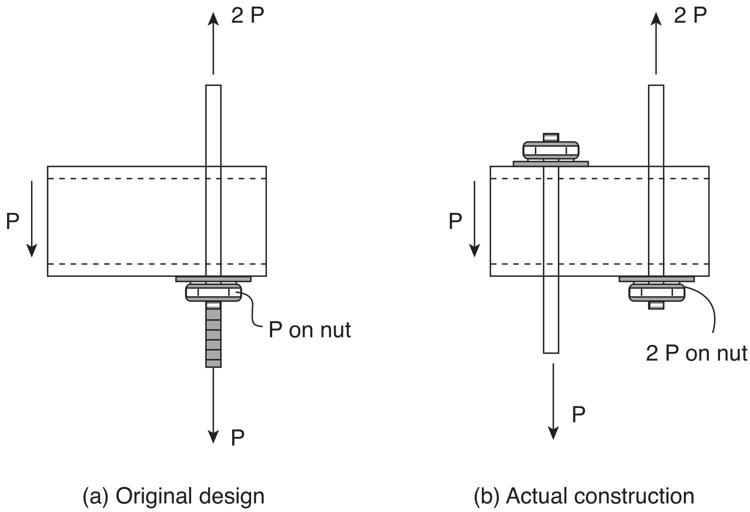

EXHIBIT 2.2 *Configuration of hanger rods and the connection at the fourth-floor walkway according to the original engineering sketches (a) and actual construction (b). "P" represents the weight of an individual walkway. The configuration shown in (b) doubles the weight supported by the nuts on the underside of the fourth-floor walkway.*

Source: Marshall, R.D., et al. Investigation of the Kansas City Hyatt Regency Walkways Collapse. *Washington, DC: National Bureau of Standards, 1982.*

walkway. When the subcontractors completed the drawings, they reviewed them for consistency, but the change to the hangers went unnoticed.

On February 16, 1979, the drawings were delivered to Gillum & Associates for review. ECC, under increasing pressure to erect the walkways, requested an expedited approval of the plans. Due to personnel changes within Gillum & Associates and a heavy workload, review of the drawings was assigned to an unlicensed, but highly experienced, senior technician rather than one of the project leaders. Despite questions raised about the hanger/walkway system by the technician and at least six inquiries to Duncan about the implications of the design change, the plans were approved, sealed by Gillum, and handed over to the contractor on February 26.

The atrium was erected during the summer of 1979. The following October, construction work on the atrium was revealed to be deficient when a section of the roof collapsed. Gillum called the quality of construction an "abomination" and promised CCRC that his firm would check the design of all of the connections in the atrium roof. CCRC, in turn, hired an independent firm (Seiden-Page) to inspect the construction of the atrium while Gillum & Associates carried out its review of the atrium design. While these reviews did uncover other potentially serious design flaws with the roof, the structural integrity of the skywalks went unnoticed. In fact, the design of the connections in the walkways was never even checked, despite Duncan's written assurance to the contrary.

Hotel construction continued without any major setbacks after the roof collapse. Seven weeks prior to scheduled completion, a worker noticed deformation of the walkway and reported it to the architect's onsite representative. Unfortunately, this report was never followed up. The Hyatt subsequently held its grand opening in July 1980. The following February, two more observations were made of deformation in the walkways, but both were discounted.

On the night of July 17, 1981, a year after the Hyatt's opening, a party was being held in the atrium. Diners in the restaurant overlooking the lobby watched as nearly 2,000 local residents gathered for a weekly tea dance, featuring big band music and a dance contest. Suddenly, at 7:05 PM, there was a loud snap and a deafening roar as the fourth-floor skywalk began to break free. The walkway fell 30 feet to the floor below, but not before landing on the second-floor sky bridge, causing it to collapse as well. Over 70 tons of debris fell, crushing or trapping hundreds of partygoers, some of whom could not be reached for more than seven hours.

Emergency crews arrived on the scene within minutes. Despite being hampered by gas leaks and broken water pipes that flooded the lobby, a well-organized response ensued, due in large part to a preformulated citywide disaster plan and the resources afforded by an urban environment. Despite this organized and dedicated effort, the number of casualties was staggering. Faced with over 100 fatalities, hotel rooms had to be transformed into makeshift morgues. Taxis, buses, helicopters, and more than 40 emergency vehicles were used to evacuate over 200 people injured in the collapse.

In the hours after collapse of the second- and fourth-floor walkways, responders noticed that the third-floor walkway had separated from the atrium walls and was itself in danger of collapsing. Six days later, despite the possibility of obstructing investigations into the cause of the accident, the third walkway was removed, circumventing further disaster.

The cause of the walkway collapse was attributed directly to the change in connection design and the resulting increased weight on the hanger bolts supporting the fourth floor. This configuration allowed the supporting beam to fail at the point of the nuts and slide downward over them (see Exhibit 2.3). In hindsight, this problem could have been solved with very minor design changes, such as the addition of a stiffening plate to the fourth-floor support beam, thereby providing sufficient strength to the connection.

While poor design of the hanger connections was the mechanical reason for failure, the catalyst was poor communication and inability to follow procedures among the many parties involved in project design and construction. HSC's request to Gillum & Associates for a change from a single-rod to a double-rod system was conducted over the phone with no written follow-up by either party. This lapse in communication undermined the formal review process for such a critical change and helped it to remain unnoticed throughout the rest of the design and construction process. Because of a drafting error made at Gillum & Associates, the weight of the walkways was left off the sketch of the connection. Without this information, HSC began redesigning the

EXHIBIT 2.3 *Fourth-floor box beam showing a hole where it pulled free from the ceiling suspension rod. The hanger rod to the second floor is still in place.*

Source: http://ethics.tamu.edu/ethics/hyatt/hyatt2.htm.

connection to the two-rod configuration and was unable to account for the resulting change in weight that the connection would need to support. Before the redesign was finalized, HSC sent the drawings out for completion without indicating which elements remained incomplete. The outside detailer hired by HSC assumed that all of the drawings it received were essentially complete and never addressed the strength of the fourth-floor connection. Clearly, the delegation of duties created a high-risk environment in which individuals carried out work with a lack of accountability.

Ironically, had the hanger design not been changed, the original connection still would have violated local safety standards. According to Kansas City building code, in order to safely support the walkway and any load it might bear, the connections should have been designed to hold approximately 17 tons. Yet the connections as indicated by the engineering drawings for the single-hanger system would have supported