

# Causes of Building Collapse: International Case Studies

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# Causes of Building Collapse: International Case Studies

## 1 Preface

The collapse of buildings can result from various factors, including design flaws, construction errors, material deficiencies, or a combination of these. Here are some common mistakes in construction that can increase the risk of building collapse.

## 2 Causes of Building Collapse

### 2.1 Poor Foundation Design or Construction

Poor foundation design or construction can lead to a variety of issues that compromise the stability, safety, and longevity of a structure. Foundations play a critical role in supporting the weight of buildings and transferring loads to the underlying soil or rock. Here are some common problems associated with poor foundation design or construction:

#### 2.1.1 Settlement and Uneven Subsidence

Cause: Inadequate assessment of soil conditions, improper foundation design, or poor construction practices.

Consequence: Uneven settlement can result in structural damage, cracks in walls and floors, and misalignment of doors and windows.

#### 2.1.2 Foundation Cracks

Cause: Inadequate reinforcement, poor concrete mix, or improper curing during construction.

Consequence: Cracks can compromise the structural integrity of the foundation, leading to water infiltration, reduced load-bearing capacity, and potential structural failure.

#### 2.1.3 Water Intrusion and Moisture Issues

Cause: Inadequate waterproofing, poor drainage design, or improper site grading.

Consequence: Water entering the foundation can lead to erosion, weakened foundation materials, and increased risk of mold and mildew growth.

#### 2.1.4 Poor Soil Bearing Capacity

Cause: Inaccurate assessment of soil conditions or failure to consider variations in soil properties.

Consequence: Foundations may not adequately support the structure, leading to settlement, tilting, or even collapse in extreme cases.

### **2.1.5 Lack of Lateral Support**

Cause: Inadequate consideration of lateral earth pressures, poor retaining wall design, or insufficient reinforcement.

Consequence: Without proper lateral support, structures may experience tilting or sliding, especially in areas with sloping terrain.

### **2.1.6 Insufficient Foundation Depth**

Cause: Failure to consider frost depth, inadequate depth for the type of soil, or poor construction practices.

Consequence: Shallow foundations can be susceptible to frost heave, leading to uneven settlement and potential damage.

To prevent these issues, it's essential to conduct thorough geotechnical investigations, soil testing, and engineering analyses during the design phase. Additionally, adherence to construction best practices, quality control, and proper supervision are crucial to ensure that foundations are constructed according to design specifications. Regular inspections during and after construction can help identify and address potential issues before they escalate. Engaging qualified professionals, including geotechnical engineers and structural engineers, is vital to the success and safety of any construction project.

## **2.2 Substandard Materials**

The use of substandard materials in construction projects can have serious consequences, compromising the integrity, safety, and durability of structures. Substandard materials may be of inferior quality, not meeting the required standards or specifications. Here are some potential issues associated with the use of substandard materials:

### **2.2.1 Reduced Structural Integrity**

Consequence: Substandard materials may lack the necessary strength and durability to withstand the loads and environmental conditions for which they were intended. This can lead to structural failures, including collapses or deformations.

### **2.2.2 Decreased Safety**

Consequence: Inferior materials may not provide the expected level of safety. This can lead to an increased risk of accidents, injuries, or even fatalities, especially in structures where safety is critical, such as in buildings, bridges, or industrial facilities.

### **2.2.3 Accelerated Deterioration**

Consequence: Substandard materials may be more susceptible to deterioration due to factors such as corrosion, weathering, or chemical reactions. This can result in premature aging and degradation of the structure.

### **2.2.4 Increased Maintenance Costs**

Consequence: Structures built with substandard materials may require more frequent and extensive maintenance to address issues such as corrosion, cracking, or wear and tear. This can lead to higher long-term maintenance costs.

### **2.2.5 Non-Compliance with Regulations**

Consequence: The use of materials that do not meet regulatory standards can lead to non-compliance with building codes and regulations. This not only jeopardizes the safety of occupants but also exposes the project to legal and financial risks.

### **2.2.6 Negative Impact on Project Timeline**

Consequence: Identifying and replacing substandard materials during or after construction can lead to delays in the project timeline. This may result in increased costs and disruptions to the overall schedule.

### **2.2.7 Loss of Reputation**

Consequence: The use of substandard materials can tarnish the reputation of the construction company or individuals involved in the project. This may lead to a loss of trust among clients, stakeholders, and the public.

To mitigate the risks associated with substandard materials, it's crucial to implement robust quality control measures throughout the construction process. This includes thorough material testing, supplier vetting, and adherence to industry standards and specifications. Engaging with reputable suppliers, conducting regular inspections, and involving qualified professionals in the design and construction phases can help ensure that only high-quality materials are used in the project. Additionally, regulatory compliance should be a top priority to meet safety and quality standards set by local building authorities.

## 2.3 Weak Structural Design

Weak structural design can lead to various issues that compromise the safety, stability, and functionality of a building or infrastructure. Structural design is a critical aspect of construction that involves determining the layout, materials, and dimensions of the structural elements to ensure they can safely support the intended loads. Here are some potential problems associated with weak structural design.

### 2.3.1 Structural Failure

Consequence: A weak structural design may result in the inability of the structure to support its intended loads, leading to partial or total collapse. This poses a significant risk to the safety of occupants and can cause extensive damage to property.

### 2.3.2 Excessive Deflections

Consequence: Inadequate structural design may lead to excessive deflections or deformations, causing issues such as sagging floors, cracked walls, or misaligned doors and windows. These problems can affect the usability and aesthetics of the structure.

### 2.3.3 Insufficient Load Capacity

Consequence: If the structural design does not account for the anticipated loads, the structure may not have sufficient load-carrying capacity. This can lead to overloading, stress concentrations, and structural damage.

### 2.3.4 Inadequate Lateral Stability

Consequence: Weak lateral stability can result in the structure being susceptible to lateral forces such as wind or earthquakes. In extreme cases, this may lead to tilting or toppling of the structure.

### 2.3.5 Vibration and Resonance Issues

Consequence: Poor structural design may lead to vibrations and resonance that can affect the comfort of occupants. This is particularly important in structures such as bridges and tall buildings where dynamic forces need careful consideration.

To address issues related to weak structural design, it's essential to involve qualified structural engineers and architects in the design process. Thorough analysis, consideration of the site conditions, proper load calculations, and adherence to building codes and standards are crucial elements of a strong structural design. Regular inspections and quality control during construction are also essential to ensure that the design is implemented correctly, and the

constructed structure meets the intended performance criteria. Engaging experienced professionals and conducting comprehensive structural analyses are key steps in preventing and mitigating the risks associated with weak structural design.

## **2.4 Inadequate Inspection and Quality Control**

Inadequate inspection and quality control during construction can lead to a range of issues that compromise the safety, durability, and overall quality of a project. Proper inspection and quality control are essential components of construction management to ensure that the work meets the required standards and specifications. Here are some common problems associated with inadequate inspection and quality control:

### **2.4.1 Deficient Workmanship**

Consequence: Without proper oversight, construction teams may neglect quality standards, leading to substandard workmanship. This can result in structural issues, safety hazards, and aesthetic problems.

### **2.4.2 Safety Hazard**

Consequence: Lack of inspection can lead to unsafe construction practices, increasing the risk of accidents and injuries for both workers and future occupants.

### **2.4.3 Environmental and Regulatory Non-Compliance**

Consequence: Inadequate inspection may lead to violations of environmental regulations or building codes, exposing the project to legal and financial risks.

### **2.4.4 Increased Risk of Project Delays**

Consequence: Discovering and addressing construction defects after completion can lead to costly rework, delays, and disruptions to the project timeline.

To address these issues, it's crucial to implement effective inspection and quality control measures:

Qualified Inspectors: Employ qualified and experienced inspectors who understand the specific requirements of the project, relevant codes, and industry standards.

Regular Site Inspections: Conduct regular inspections at various stages of construction to identify and rectify issues promptly. This includes inspections of foundations, structural elements, installations, and finishes.

Documentation and Reporting: Maintain thorough documentation of inspections, findings, and corrective actions. This documentation is essential for accountability and may be required for regulatory compliance.

Training Programs: Provide training for construction teams on quality control processes, standards, and the importance of adhering to specifications.

Third-Party Inspections: Consider engaging third-party inspection services to provide an independent assessment of the construction process and quality. This can offer an additional layer of assurance.

Clear Communication: Foster open communication channels between project stakeholders to ensure that everyone is aware of quality expectations and any corrective actions that need to be taken.

By prioritizing robust inspection and quality control processes, project managers can identify and address issues early in the construction process, preventing the escalation of problems and ensuring the delivery of a high-quality and safe built environment.

## 2.5 Ignoring Environmental Factors

Ignoring environmental factors in construction can indeed lead to building collapses and other structural failures. It's crucial to consider various environmental conditions to ensure the safety, stability, and longevity of a structure. Here are some environmental factors that, when ignored, can contribute to building collapses:

### 2.5.1 Weather and Climate

Issue: Neglecting the impact of weather conditions and climate on construction materials and structures.

Consequence: Exposure to extreme weather conditions, such as heavy rain, snow, or high temperatures, can cause deterioration, corrosion, and reduced structural integrity over time.

### 2.5.2 Wind Loads

Issue: Neglecting to consider wind loads and wind-induced forces in the structural design.

Consequence: Inadequate resistance to wind loads can result in structural instability, especially in high-rise buildings or structures in windy areas.

### 2.5.3 Vegetation and Trees

Issue: Ignoring the impact of nearby vegetation, trees, or roots on the foundation.



Consequence: Tree roots can cause soil movement, affecting the stability of foundations and leading to structural damage.

To mitigate these risks, it's essential to conduct thorough site assessments, engage qualified professionals, and adhere to building codes and standards that address environmental considerations. This includes implementing proper foundation design, corrosion protection measures, drainage systems, and seismic-resistant construction practices. Regular inspections and maintenance are also crucial to identify and address environmental impacts over time.

Building collapses due to the neglect of environmental factors underscore the importance of a comprehensive and environmentally aware approach to construction, ensuring the long-term safety and stability of structures.

## **2.6 Changes in Building Use**

Changes in building use without proper assessment, planning, and structural modifications can contribute to building collapses. When a building undergoes a change in use, it may experience different loads, occupancy patterns, and structural demands that the original design may not have considered. Here are some scenarios where changes in building use can lead to structural issues and potential collapse:

### **2.6.1 Increased Load Capacity**

Issue: Changing the use of a building to accommodate heavier equipment or machinery without assessing the structural capacity.

Consequence: The original structure may not be designed to support the increased loads, leading to structural overloading, foundation settlement, or other failures.

### **2.6.2 Occupancy Changes**

Issue: Converting a building from a residential to a commercial use or vice versa without considering the impact on structural and safety requirements.

Consequence: The building may not meet the necessary fire safety, egress, or structural requirements for the new occupancy type, posing risks to occupants.

### **2.6.3 Altered Traffic Patterns**

Issue: Changing the layout or function of a building without considering the impact on traffic patterns, load distribution, and structural stability.

Consequence: Changes in traffic flow or use of spaces may lead to uneven loading, which can affect the structural integrity of the building.

#### **2.6.4 Inadequate Ventilation and HVAC Systems**

Issue: Changing the building use without adjusting ventilation and HVAC systems to meet the new requirements.

Consequence: Inadequate airflow can result in issues such as poor indoor air quality, moisture accumulation, and potential damage to building materials.

#### **2.6.5 Structural Modifications**

Issue: Altering the building structure without proper engineering analysis or obtaining necessary permits.

Consequence: Unauthorized structural modifications may compromise the building's integrity and load-bearing capacity, increasing the risk of collapse.

#### **2.6.6 Introduction of Hazardous Materials**

Issue: Changing the use of a building to store or handle hazardous materials without proper safety measures.

Consequence: The introduction of hazardous materials can lead to chemical reactions, corrosion, or other detrimental effects on building materials, jeopardizing structural integrity.

To prevent building collapses due to changes in use, it's crucial to follow these guidelines:

Structural Assessment: Conduct a thorough structural assessment when considering changes in building use to ensure that the existing structure can safely accommodate the new requirements.

Code Compliance: Adhere to building codes and regulations applicable to the new use, including fire safety, occupancy loads, and structural requirements.

Engineering Consultation: Seek the expertise of structural engineers and other relevant professionals to assess the impact of changes on the building's structural integrity and safety.

Permitting Process: Obtain the necessary permits before making structural modifications or changes in building use to ensure compliance with local regulations.

Regular Inspections: Conduct regular inspections of the building to identify any signs of structural distress, deterioration, or issues related to changes in use.

By prioritizing proper planning, assessment, and compliance with regulations, building owners and stakeholders can mitigate the risks associated with changes in building use and ensure the ongoing safety and stability of the structure.

## **2.7 Corrosion and Deterioration**

Corrosion and deterioration are significant concerns in construction and infrastructure, impacting the integrity and durability of structures. Corrosion refers to the chemical or electrochemical breakdown of materials, often metals, due to reactions with environmental factors. Deterioration is a broader term that includes the gradual decay or impairment of the physical, chemical, or mechanical properties of materials. Here are some key aspects related to corrosion and deterioration in construction:

### **2.7.1 Corrosion of Metals**

**Cause:** Exposure to environmental elements, such as moisture, oxygen, and aggressive chemicals, can lead to corrosion of metals like steel and iron.

**Consequence:** Corrosion weakens the structural integrity of metal components, potentially leading to structural failures, such as the collapse of bridges, buildings, or other infrastructure.

### **2.7.2 Concrete Deterioration**

**Cause:** Factors like freeze-thaw cycles, exposure to aggressive chemicals, and carbonation can contribute to the deterioration of concrete.

**Consequence:** Deterioration of concrete can lead to cracking, spalling, and reduced load-carrying capacity, compromising the structural stability of a building or infrastructure.

### **2.7.3 Rebar Corrosion**

**Cause:** Corrosion of reinforcing steel (rebar) embedded in concrete can occur due to exposure to moisture and chloride ions.

**Consequence:** Rebar corrosion can result in expansive forces, causing concrete cracking and spalling. It also reduces the bond strength between the steel and concrete.

### **2.7.4 Wood Decay**

**Cause:** Exposure to moisture, fungi, insects, and other environmental factors can lead to the decay of wood.

**Consequence:** Decay weakens the structural integrity of wooden components, such as beams or columns, and can compromise the overall stability of a structure.

### **2.7.5 Masonry Deterioration**

Cause: Weathering, freeze-thaw cycles, and exposure to pollutants can contribute to the deterioration of masonry materials, such as brick or stone.

Consequence: Deterioration of masonry can result in the loss of material, reduced strength, and aesthetic degradation of the structure.

### **2.7.6 Corrosion of Infrastructure Components**

Cause: Infrastructure elements like bridges and pipelines are exposed to environmental elements, leading to corrosion of structural components.

Consequence: Corrosion compromises the structural integrity of infrastructure, leading to safety hazards, reduced lifespan, and increased maintenance costs.

### **2.7.7 Coastal and Marine Environments**

Cause: Structures in coastal or marine environments are exposed to saltwater, which accelerates corrosion.

Consequence: Increased corrosion rates in coastal areas can lead to rapid deterioration of structures, impacting their service life and safety.

Preventive Measures and Mitigation Strategies:

Protective Coatings: Applying protective coatings, such as paints, sealants, and corrosion-resistant coatings, can provide a barrier against environmental elements.

Cathodic Protection: Installing cathodic protection systems can mitigate corrosion by controlling the electrochemical reactions on metal surfaces.

Proper Drainage: Ensuring effective drainage systems helps prevent water accumulation, reducing the risk of deterioration due to moisture exposure.

Material Selection: Choosing corrosion-resistant materials and durable construction materials can enhance the longevity of structures.

Regular Inspections and Maintenance: Conducting regular inspections allows for the early detection of corrosion or deterioration, enabling timely repairs and maintenance.

Cyclic Monitoring: Employing monitoring systems to track environmental conditions and the structural health of components can aid in proactive maintenance.

By addressing corrosion and deterioration through a combination of preventive measures, appropriate material selection, and regular maintenance, it's possible to enhance the lifespan, safety, and performance of constructed structures.

## **2.8 Ignoring Building Codes and Regulations**

Ignoring building codes and regulations is a serious violation that can lead to a range of problems and risks in construction projects. Building codes are established to ensure the safety, health, and welfare of the public by setting standards for construction practices. Disregarding these codes can result in legal consequences, compromised safety, and structural issues. Here are some consequences of ignoring building codes and regulations:

### **2.8.1 Structural Instability**

Issue: Failure to adhere to structural design codes and regulations.

Consequence: Structures may lack the necessary strength and stability, leading to potential collapses or failures during normal use or in response to environmental forces.

### **2.8.2 Safety Hazards**

Issue: Non-compliance with safety codes and regulations.

Consequence: Buildings may pose safety hazards to occupants, with increased risks of fire, inadequate egress, or exposure to harmful materials.

### **2.8.3 Legal Consequences**

Issue: Ignoring local building regulations and codes.

Consequence: Legal actions, fines, and stop-work orders may be imposed on the project, resulting in delays and financial penalties.

### **2.8.4 Occupancy Limitations**

Issue: Failing to meet occupancy and use requirements.

Consequence: Buildings may be restricted in their use or occupancy due to non-compliance with zoning and occupancy regulations.

### **2.8.5 Resale and Property Value Impact**

Issue: Failure to comply with building codes can affect property value.

Consequence: Non-compliant structures may face challenges during resale, and property values may be adversely affected.

### 2.8.6 Infrastructure Strain

Issue: Ignoring codes related to utilities, drainage, and environmental impact.

Consequence: Strain on local infrastructure, including water supply, sewage systems, and stormwater management, can lead to environmental issues and community dissatisfaction.

To avoid these consequences, it's essential to:

Stay Informed: Keep abreast of current building codes and regulations at the local, regional, and national levels.

Engage Professionals: Consult with qualified architects, engineers, and other professionals who are knowledgeable about applicable codes and regulations.

Secure Permits: Obtain the necessary permits before starting construction, ensuring compliance with zoning and building regulations.

Regular Inspections: Conduct regular inspections during construction to verify compliance and address any issues promptly.

Training and Education: Provide training for construction teams to ensure awareness and understanding of relevant codes and regulations.

Professional Consultation: Seek legal advice and consultation with local authorities to ensure full compliance with applicable codes and regulations.

Ignoring building codes and regulations not only poses legal and safety risks but can also harm a project's reputation and financial viability. Adhering to established standards is a fundamental responsibility in the construction industry, contributing to the overall safety and well-being of communities.

### 2.9 Inadequate Fire Protection:

Inadequate fire protection in buildings poses significant risks to life, property, and the surrounding environment. Fire protection measures are essential to prevent and control fires, allowing for the safe evacuation of occupants and minimizing damage. Inadequacies in fire protection can lead to severe consequences. Here are some issues associated with inadequate fire protection:

### **2.9.1 Insufficient Fire Detection Systems:**

Issue: Lack of or poorly maintained fire detection systems, such as smoke detectors and fire alarms.

Consequence: Delayed or absent alerts can result in late responses to fire incidents, reducing the time available for evacuation and firefighting efforts.

### **2.9.2 Poorly Maintained Fire Suppression Systems:**

Issue: Neglecting regular maintenance and testing of fire suppression systems, including sprinklers and fire extinguishers.

Consequence: Malfunctioning or non-operational suppression systems may lead to uncontrolled fire spread and increased damage.

### **2.9.3 Inadequate Evacuation Plans:**

Issue: Lack of or poorly communicated evacuation plans.

Consequence: Confusion and delayed evacuation, increasing the risk of injuries or fatalities during a fire emergency.

### **2.9.4 Flammable Material Usage:**

Issue: Use of flammable materials in construction without proper precautions.

Consequence: Accelerated fire spread and increased severity due to the presence of materials that contribute to combustion.

### **2.9.5 Inadequate Fire Barriers and Compartmentation:**

Issue: Failure to implement fire barriers and compartmentation to contain and prevent the spread of fire.

Consequence: Rapid fire spread throughout a building, increasing the potential for extensive damage and making firefighting efforts more challenging.

### **2.9.6 Lack of Fire-resistant Construction:**

Issue: Ignoring fire-resistant building design and construction practices.

Consequence: Buildings may be more susceptible to structural failure during a fire, jeopardizing the safety of occupants and emergency responders.

### **2.9.7 Insufficient Firefighter Access and Infrastructure:**

Issue: Lack of proper infrastructure for firefighters, such as access roads and hydrants.

Consequence: Delayed response times and difficulty in accessing water sources can impede firefighting efforts.

### **2.9.8 Inadequate Emergency Lighting:**

Issue: Absence of or poorly maintained emergency lighting systems.

Consequence: Reduced visibility during evacuations, increasing the risk of accidents and hindering emergency response.

To address inadequate fire protection, it's essential to:

Comply with Codes and Regulations: Ensure strict adherence to local, regional, and national building codes and fire safety regulations.

Regular Inspections: Conduct regular inspections of fire protection systems and equipment to identify and address issues promptly.

Emergency Preparedness: Develop and communicate comprehensive emergency plans, including evacuation procedures and training for occupants.

Fire-resistant Materials: Use fire-resistant construction materials and design features to enhance the fire safety of buildings.

Professional Consultation: Engage with fire protection professionals, such as fire engineers, to assess and improve the fire safety of a building.

Training and Drills: Conduct regular fire drills and provide training for building occupants and staff on fire safety procedures.

Investing in robust fire protection measures is crucial for safeguarding lives and property. Proactive planning, adherence to regulations, and regular maintenance contribute to a safer built environment, reducing the impact of potential fire incidents.

## **3 Case Studies**

While specific case studies of building collapses can provide insights into the causes and lessons learned, it's important to note that each incident is unique, and a thorough investigation is typically required to determine the exact factors involved. Here are a few notable examples of building collapses with identified causes



### 3.1 Tacoma Narrows Bridge, Washington (1940)

Cause: Aerodynamic instability.

Details: The collapse of the Tacoma Narrows Bridge was caused by aeroelastic flutter, where strong winds induced violent oscillations in the bridge deck. This led to structural failure and the eventual collapse of the entire bridge (Grandić and Grandić, 2020), as can be seen in Figure 1.



*Figure 1*

### 3.2 Ronan Point, London (1968)

Cause: Gas explosion and progressive collapse.

Details: A gas explosion on the 18th floor of Ronan Point, a 22-story residential tower, led to the progressive collapse of the structure. The building lacked sufficient structural redundancy, and the collapse exposed vulnerabilities in the construction methods used at the time (Pearson and Delatte, 2005), as can be seen in Figure 2.



*Figure 2*

### 3.3 Hyatt Regency Walkway Collapse, Kansas City (1981)

Cause: Design flaw in the walkway support system.

Details: The collapse occurred during a crowded event when the fourth-floor walkway and the second-floor walkway above it collapsed. The design flaw in the walkway support system contributed to the structural failure, resulting in numerous fatalities (Marshall et.al., 1982), as can be seen in Figure 3.



*Figure 3*

### 3.4 Sampoong Department Store, Seoul (1995)

Cause: Structural alterations and overloading.

Details: The collapse of the Sampoong Department Store occurred due to illegal structural modifications, including the addition of a fifth floor that exceeded the original design load. The building collapsed, resulting in a significant loss of life (Heo et.al, 2022), as can be seen in Figure 4.



*Figure 4*

### 3.5 World Trade Center Towers, New York (2001)

Cause: Terrorist attacks and fire.

Details: The Twin Towers of the World Trade Center collapsed as a result of the impact of hijacked airplanes and subsequent fires. The intense heat weakened the steel structure, leading to the progressive collapse of the buildings (Kotsovinos and Usmani, 2012), as can be seen in Figure 5.



Figure 5

### 3.6 Windsor Tower, Madrid (2005)

Cause: Fire and structural failure.

Details: The Windsor Tower, a 32-story skyscraper in Madrid, caught fire in February 2005. The fire started on the 21st floor and rapidly spread vertically. Despite the concrete structure, the fire caused extensive damage to the building, leading to the collapse of several floors. The exact cause of the fire was never determined conclusively, but it highlighted challenges in high-rise firefighting and the potential for fire-induced structural failures (Martin et.al., 2006), as can be seen in Figure 6.



Figure 6

### 3.7 Canterbury Television (CTV) Building, New Zealand (2011)

Cause: Structural deficiencies in design and construction.

Details: The collapse of the CTV Building during an earthquake was attributed to design and construction flaws. The building did not meet proper construction standards, leading to the tragic loss of lives (Fleischman et.al., 2014), as can be seen in Figure 7.



*Figure 7*

### **3.8 Rana Plaza, Bangladesh (2013)**

Cause: Structural failures and poor construction practices.

Details: The collapse of the Rana Plaza, an eight-story commercial building, was attributed to structural failures caused by the illegal addition of extra floors and the use of substandard construction materials. The incident raised awareness about the need for improved safety standards in the garment industry (Bair et.al., 2020), as can be seen in Figure 8.



*Figure 8*

### 3.9 Thane Building Collapse, India (2013)

Cause: Poor construction and unauthorized alterations.

Details: An unauthorized additional floor was constructed without proper adherence to safety standards, leading to the collapse of an apartment building in Thane. The incident highlighted issues related to unauthorized construction and lax building code enforcement (Akinlabi and Adedeji, 2013), as can be seen in Figure 9.



*Figure 9*

### 3.10 Champlain Towers South, Florida (2021)

Cause: Ongoing investigations, but factors may include structural deficiencies.

Details: The collapse of Champlain Towers South raised questions about the structural integrity of the building. Investigations are ongoing, but preliminary findings suggest that long-term issues with the building's structural components may have played a role (Lu et.al., 2021), as can be seen in Figure 10.



Figure 10

## 4 Conclusion

These case studies highlight a range of causes, including structural deficiencies, overloading, illegal modifications, and poor construction practices. Lessons learned from these incidents emphasize the importance of adhering to building codes, conducting thorough inspections, addressing structural vulnerabilities, and ensuring proper construction and maintenance practices.

It's crucial to approach the analysis of building collapses with a multidisciplinary perspective, involving structural engineers, forensic experts, and other professionals to conduct thorough investigations. The findings from such investigations contribute to improvements in building design, construction practices, and safety standards, ultimately reducing the risks of future collapses.

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