

## **Chain Reaction Collapse of a High-rise Apartment due to a Gas Explosion May 16, 1968 in Ronan Point, East London, England**

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A gas explosion on the 18th floor caused the collapse of an entire corner of a 24-story block of flats called Ronan Point in east London. Three were killed and 11 people were injured after the 22-story southeast corner came crashing down. A gas explosion triggered the domino style collapse of the structurally unsound building which was an assembly of prefabricated concrete panels.

### **1. Event**

A gas explosion on the 18th floor caused the collapse of an entire corner of a 24-story block of flats called Ronan Point in east London. Three were killed and 11 people were injured after the 22-story southeast corner came crashing down. Photo 1 shows the collapsed building.



Photo 1. Collapsed 22-Story Southeast Corner [1]

### **2. Course**

Prefabricated construction techniques known as “system building” were developed in early 1960’s. A system-built structure was assembled from prefabricated concrete panels lifted into position by cranes and held together by bolts to form the walls, floors and roof slabs. It had a benefit of reducing construction time

and the number of skilled workers required for housing construction. Ronan Point, a 23-story block of flats in the east end of London, was one of more than 3,000 new flats and houses system-built by 1968.

In the early morning of May 16, 1968, a gas explosion occurred in the southeast corner flat on the 18th floor of Ronan Point. The pressure of the gas explosion blew out the pre-cast concrete panels which formed the side of the building, then ripped through four flats above and sent all the floors below crashing down like falling dominoes. The entire corner of Ronan Point collapsed as shown in Photo 1, killing 3 people and injuring 11.

### 3. Cause

The force of the explosion knocked out external walls of the southeast corner flat on the 18th floor, leaving the panels above unsupported. This created a chain reaction in which the 19th floor collapsed, then the 20th floor and so on, propagating upward. The collapse of four floors on to the 18th floor initiated a second phase of progressive collapse. The sudden impact loading on the 18th floor caused it to give way, smashing the 17th floor and progressing until it reached the ground (Figure 1). The collapse of Ronan Point was due to its lack of structural redundancy. The structure had no fail-safe mechanisms, and no alternative load paths for the upper floors when a lower level gave way.

The investigation panels reported that gas leaks, which had caused the explosion, occurred too frequently in high-rise homes than expected.

The public inquiry into the collapse publicized a report that quoted a general building code that states it is absolutely necessary to effectively joint all components so that the building would not be like a “house built of cards,” however, the building codes back then did not have thorough evaluation of this “system-building”.

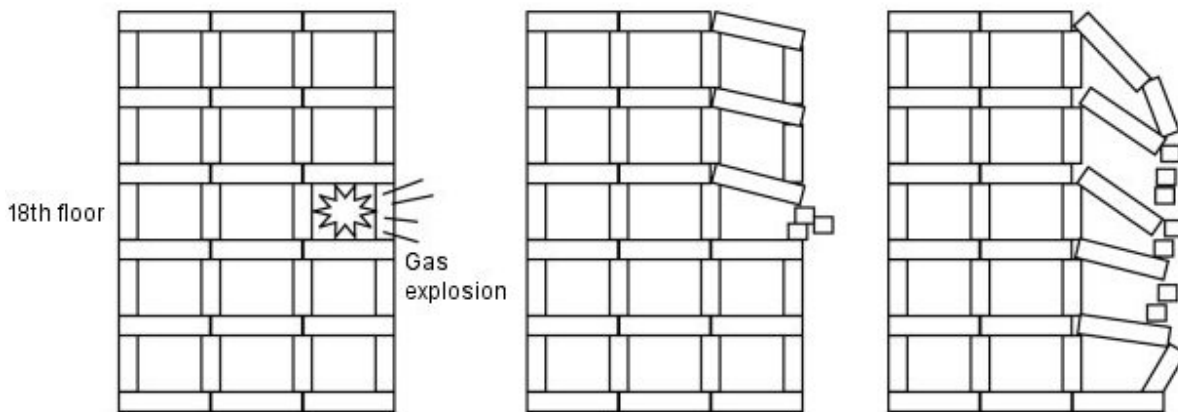


Figure 1. Domino Style Collapse

### 4. Immediate Action

The investigation panels determined that the explosion from the gas leak had initiated the collapse of the building. Due to frequent gas leaks in high-rise homes and work by unlicensed gas fitters, gas and gas

cylinders for cooking or heating the air were banned from high-rise buildings.

## 5. Countermeasure

Since the Ronan Point collapse, the public confidence in safety of high-rise homes had largely disappeared, and few subsequent developments included high-rise blocks of flats. The Greater London Council (GLC) admitted in late 1970's that the post-war housing solution with high-rise homes and redevelopment of faltering areas within the conurbation was not adequate.

The Building Regulations and the Code of Practice for concrete design added special that the structure would provide a certain minimum resistance to special load conditions, like gas explosion, and progressive collapses.

During the reinforcement efforts made to the structure of the Ronan Point and 600 other similar buildings, poor workmanship was discovered. The architect who examined the structure found that joints within the structure were filled with newspapers rather than concrete, and walls rested on leveling bolts instead of on a continuous bed of mortar, allowing rainwater to seep in to the joints. Determined to be unsafe, Ronan Point and other similar buildings were demolished. The last of the kind was demolished 20 years after the Ronan Point collapse.

## 6. Summary

Prefabricated construction techniques known as "system building" gained popularity during the post war era, because they offered cheaper, easier and quicker construction of high-rise flats than traditional construction. Prefabricated concrete panels were all manufactured at factories, which enabled through quality control of building material and components.

However, the Ronan Point collapse revealed vulnerability of system building. Post-accident inquiries proved that the large panel construction system, in which panels of prefabricated concrete formed the walls, floors and roof slabs, was particularly vulnerable to progressive collapse due to gas explosion or other accidental damage. The incident revealed a fundamental error in the design concept.

In addition to the design fault, the following repair construction revealed poor workmanship (a problem still occasionally found today), which is a sign of poor organization.

## 7. Knowledge

New construction techniques potentially have the devil inside. People tend to look at only the merits of new designs, however, checking the design if anything may go wrong is absolutely necessary.

Design errors are often revealed for the first time when the wrong idea was accepted in the past and not found to be wrong until a catastrophe hits. Structural safety, performance, integrity and stability must be assured by means including simulations and model testing assuming abnormal (loading) events of a general nature. We must also study facts of past structural failures and turn them into knowledge to pass them on to the next generation.

## 8. Background

The U.K., which led the world in the Industrial Revolution during the 18th century, had to deal with social issues related to concentration of the population into industrial areas. The pressure for decent housing arose from overcrowding in the large cities in the 19th century. During the latter half of 19th century, several charitable housing projects began to provide housing in tenement blocks. Redevelopment and re-housing efforts were also launched to build multi-unit dwellings and provide better homes for those who live in damp, overcrowded slum conditions. The housing issue led to the Housing of the Working Classes Act 1890, which encouraged local authorities to improve the housing in their areas. As a consequence, many local councils began building flats and houses in the early 20th century.

There was a major boom in housing construction in areas badly mauled by the World War II with several areas approaching slum conditions. In the 1960's the administration put priority on redeveloping the already built urban areas. Many multi-story tower blocks were built to accommodate the needs of thousands of people, transforming the former factory sites and overcrowded slum areas. While local people were hesitant about new non-traditional high-density housing, high-rise flatted blocks were easy and quick to provide new homes for many.

## 9. On the Side

There are increasing areas forested with high-rise multi-unit dwellings in Japan. High-rise structures have higher natural frequency than several-story structures. Gusty wind makes them sway laterally, which sometimes cause motion sickness among those who are inside. If a structure's natural vibration frequency coincides with seismic waves of the same frequency, then even more of the seismic kinetic energy can enter the structure, causing greater potential for damage. Seismic vibration may possibly be amplified, resulting the structure to sway several meters laterally. One can only imagine what it is like to be on the top floor when the structure is swaying violently.

High-rise structures may need some dynamic damping systems to control vibrations so that seismic vibration does not transfer to the structure, like the Akashi Bridge active control that sways the roof-top water tank in the phase opposite to the seismic vibration.

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