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THE INCIDENT AT THE PIRELLI SKYSCRAPER: A CASE STUDY

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Abstract

The paper presents a case study of the incident at the Pirelli skyscraper, one of the symbols of Milan. It is considered an important case study after the attacks of the WTC Towers in New York on September 11, 2001. The purpose of the study is to develop a better understanding of safety in tall buildings, especially of those to be used as offices. The case study illustrates the accident's occurrence, the structural response of the building and the procedures adopted for managing emergencies. In particular, this paper outlines the Italian normative approach concerning tall buildings in the framework of their application for a real case. The Pirelli skyscraper case has brought about a deep reflection on the need for a reconsideration of safety measures as a whole to prevention and protection system of buildings with particular to incidents caused by terrorist attacks or other unpredictable incident, which require different actions from conventional procedures normally adopted.

Keywords: Tall buildings, Life-safety, Emergency management, Evacuation

1 Introduction

The incident of the Pirelli skyscraper is an important tragedy for professionals to think and reconsider on the whole safety, and security of tall building and its occupant, resulting from unpredictable events such as incidental impacts or terrorist attacks. This paper gives an overview of lesson learnt from the Pirelli skyscraper accident and the analysis of the emergency plan for the building of Lombardia Region Administration. Some important considerations in adopting new criteria for emergency management measures will be discussed. The construction and structural characteristics of the building, the execution of procedures to deal with emergency situations as well as Italian normative approaches related to tall buildings are presented. Some proposal for new possible criteria to be adopted for prevention and planning in fire safety are discussed.

2. The Pirelli skyscraper

Together with Milan's Cathedral (Duomo), the Pirelli skyscraper is one of the symbols of Milan. It was erected between 1955 and 1959 after a project by Ponti, Fornaroli, Rosselli, Valtolina, Dell'Orto, Nervi. Its 127 meters height makes it the tallest building in Italy and one of the tallest reinforced concrete buildings in Europe. Thirty of its floors host, among others, the headquarters of the Regional Council and the offices of 8 General Directorates of the Lombardia Regional Administration, with a population of about 1200 people. The building was designed to host the offices of Pirelli s.p.a. and is still regarded as an example of technological optimization applied to a well defined image for a building that would become the emblem of the new post-industrial service society or better of Milan during the after-war period. The designer, Giò Ponti, chose the final formal solutions. Pier Luigi Nervi was in charge of the tapered double-fork load bearing structures, whose thickness progressively reduces with height [Cevini, 1996]. In June 1953 the Valtolina Dell'Orto office provided the estimate of costs. The foundation stone was officially laid on July 12, 1956. The mass media closely followed the construction of the skyscraper since the beginning until it was completed and inaugurated in 1960.

Table 1: Information of Pirelli skyscraper.

Ground surface	m ²	7200
Area destined to traffic and parking	m ²	3650
Green area	m ²	760
Area occupied by the buildings behind the tower	m ²	1627
Area occupied by the tower	m ²	1080
Height of the tower	m	127,10
Length of the tower	m	70,40
Above-ground floors	n°	31
Underground floors	n°	2
Width of the tower in the middle	m	18,50
Glazed surface of the tower's walls	m ²	9500
Cubic volume of the tower	m ³	122000
Cubic volume of adjacent buildings	m ³	23800
Useful surface for offices per standard floor	m ²	590
Envisaged population		2000
Auditorium capacity		600
Elevators		10
Lifts		2

3 The Incident

The incident is still under the investigation of the Italian authorities. According to mass media a small private aircraft, traveling from Locarno (Switzerland) reported a failure around 5 o'clock p.m.. The SOS sent by the pilot and received by the control tower of Linate Airport claimed some undercarriage problems. According to the news reported by ANSA (the Italian Associated Press Agency) the emergency landing strip was not available then, so the aircraft was diverted elsewhere.

The aircraft that crashed into the Pirelli skyscraper was a Rockwell Aero Commander 112TC registered in the Swiss Air Registration Board as HB-NCX and owned by the pilot, Mr. Luigi Fasulo. The Aero Commander is a small aircraft with 210 HP turbo supercharged piston-powered engine which can reach a maximum altitude of about 6.000 meters. The aircraft can accommodate three passengers on board including a pilot. The aircraft crashed into the skyscraper at 5.45 p.m. and the resulting explosion opened a wide hole in the building and started a fire which advance to several floors within the building. The 26th floor was directly hit by the aircraft whilst causing damage to areas between the 23rd and 27th floor of the Pirelli skyscraper[Fig.1].

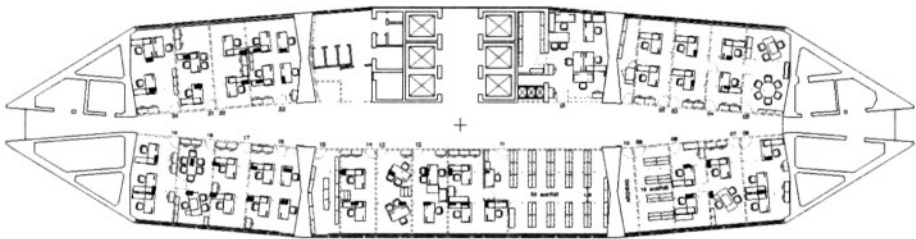


Fig.1: The Floor Plan of 26th Floor of Pirelli Skyscraper

Fire broke out immediately at the impact areas causing some people to be trapped in the lifts that went out of order. Pieces of rubbles and the bodies of two casualties dispersed over the Square, including the aircraft wreckage. The tragedy killed three people and twenty-nine injured. Some immediate investigation by the Fire Brigades and experts of the Civil Defense Services, reported that the extent of the damages suffered by the building was not serious considering the impacts by the aircraft. The aircraft appeared to thrust itself horizontally between the slab of the 26th floor and the 27th floor, damaging only the walls and partitions between slabs, however the horizontal elements remain intact to keep the building standing [Fig.2 and Fig.3]. The aircraft was thrust into the buildings with its engine projecting outside and finally fell on to the slab below between the two elevator shafts.



Fig. 2: The Pirelli after the impact

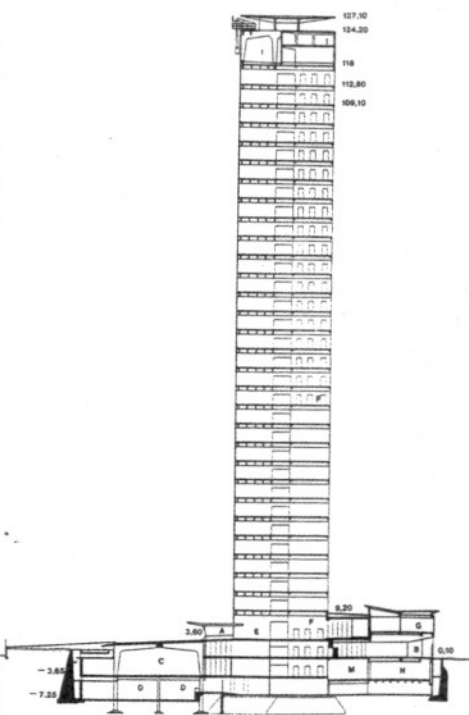


Fig. 3: Vertical section

4. The Damages

According to the investigations and measurements carried out, the most damaged part of the building was on the 26th floor; mainly internal partitions and walls. Several lifts and elevator doors at the different floors were destroyed following the aircraft explosion close to the elevator shafts. The aircraft impact caused some structural displacement on the floors below and above the 26th floor with consequential effects on the façade elements and internal partitions.

On the 26th floor damages were evident in the floor slab beams resulting in partial failures of the elements and now still under the investigation by the authorities in charge. The 26th floor of the building which housed the archives of the Lombardia Region Bar and many legal documents were damaged by the fire or the water used to extinguish it. Today, the 25th, 26th and 27th floors were still propped whilst several floors, adjacent to the 26th floor were protectively secured using sophisticated systems including nets lowered from the top floor in order to prevent falling objects and rubbles before reconstruction works begin.

5. Fire in Tall Buildings

The Pirelli skyscraper incident highlighted the need for a better prevention and protection plans in dealing with emergency in fire. Following the collapse of the Twin Towers in New York on September 11, 2001 despite the unusual and uncommon nature of such an accident, fire safety measures

especially for tall buildings are reconsidered and analyzed in order to ensure better protection and safety of occupants in case of fires [Bement, 2002]. It is obvious that in addition to existing standards, the design criteria to be used for tall buildings must be supplemented by some studies and planning for a better and safer design approach. The first consideration concerns the need to ensure the use of construction materials with high performances of fire resistance and fire protection which are able to protect occupants. In this new environment there is a need to evacuate a large density simultaneously in a very short time [Fahy (1995), Fahy and Proulx (1997)]. Considerable resources and investments are required in coming up with the relevant research and studies for new solutions [Grosshandler et.al, 2001],

6. The Italian regulations

In Italy, the main normative reference is the Ministerial Decree DM 10-03-98, General Fire Safety Criteria to Deal With Emergency in Working Places which specified the criteria for the assessment of fire risks at work places including fire prevention and protection measures for reducing the possibility of fire occurrences and limit its consequences [Fiameni et.al, 2000].

The Ministerial Decree DM 10-03-98 consider the following aspects:

Assessment of fire risks; Preventive, protective and precautionary service measures; Control and maintenance of fire-fighting installations and equipment; Dealing with emergency in the event of fire; Appointment of personnel in charge of fire-fighting service; Training of personnel in charge of fire prevention and fire-fighting activities and management of emergencies.

In particular, Article 3 specified that the employer must take all measures to:

- (i) reduce the probability of a fire
- (ii) provide emergency means and exits to ensure a safe evacuation of people in the event of fire
- (iii) apply all measures to notify occurrence of fire immediately so that the alarm system could be triggered and necessary actions taken
- (iv) extinguishing fire in compliance with the criteria contained in annex V of the Decree
- (v) ensure the effectiveness of fire protection systems
- (vi) provide workers with appropriate information and training on fire related risk.

The decree does not provide any specific standards or prescriptions for tall buildings. The only reference standard available is DM 246 of 1987: Fire Safety Rules for Civil Housing [3] together with circular communication 91/61 concerning fire resistance of structures [Circolare n.91].

For buildings with height exceeding 80 m. the decree specified the following requirements:

- Maximum surface area for compartment: 2000 m²
- Maximum surface area for each staircase: 350 m²
- Smoke-proof stairwell of width 1,20 m
- Stairwell and door opening: REI 120¹

Although the Pirelli skyscraper was built in the Sixties it conforms to the related standards and their respective amendments thus emphasizing its innovative design when it was constructed. For example, the structure complied to the fire resistance standards at the time the design and planning was first conceived.

7. The Emergency Management Plan

The management of emergency and the fire at the Pirelli skyscraper was based on procedures and instructions contained in the "Pirelli Emergency Plan". This Plan define the cases to deal with in the event of:

- Fire
- Black-out (power failure)
- Bomb alarm
- Street riots
- Hoax telephone calls
- Earthquake
- Medical emergency
- Aggression against employees
- Evacuation in general

In the case of a fire, the emergency procedures will be addressed to the following personnel: employees; persons in charge of emergency situations; employees working in the monitor room; duty workers in charge of the security service; security staff at the entrances and Porters and/or doorkeepers.

The main objectives of the Emergency Plan are the following:

- a) to tackle emergency at the early stage, for containment of its negative effects and to restore to the normal service conditions as soon as possible
- b) to oversee the necessary actions to protect occupants inside outside the building during evacuation
- c) to define the roles of operators during emergency and to co-ordinate the actions of people inside the building
- d) to limit damages to physical assets.

The Emergency Plan stated that in an extraordinary situation or event it is necessary to evacuate the building. It is also assumed that every employee working in the building must know the procedures to be adopted during an emergency situation.

The Plan contain detailed information concerning:

- (i) the definitions of risk, danger and emergency.
- (ii) the general rules related to the escape routes, the layout of the building, useful contacts and telephone numbers, procedures for calling monitor rooms and locations of fire-fighting equipment.
- (iii) rules of behavior particularly prohibitions to avoid fire occurrence and its spread including orders to facilitate access to escape routes.
- (iv) the features of the building including structural lay-out, monitor rooms, escape routes, lifts, thermal and electric plants, etc.
- (v) all fire safety systems such as detectors, sprinklers, compartmentation, emergency electric plants and the description of equipment contained in the building
- (vi) safety equipment and devices such as medical equipment, emergency telephones, alarm push buttons, portable extinguishers, fire hydrants and fireplugs
- (vii) signal system in general
- (viii) organization of emergency teams
- (ix) identification of signals
- (x) organization of visitors
- (xi) safe areas
- (xii) chronology of events

It should be noted that during the incident, the envisaged procedures to deal with the emergency were applied with a high level of effectiveness thus avoiding the loss of people during the evacuation

procedures. Had the accident occurred at a busier working time, say around 16.00 – 16.30, it would probably have made it harder and more complicated to deal with the evacuation and rescue of people. Although the Pirelli skyscraper incident had less serious effects, the likely potential danger such as incidents in the future would constantly require some development of new criteria for planning safety on the whole, and carrying out the necessary research development activities to improve safety of occupants and the building itself.

8. Emergency Management Measures

Beside those that has been envisaged by the regulations, the incident pointed out the necessity of making a distinction between different “levels” of emergency associated with different regional organization such as:

- 1) “emergencies of internal relevance”: this is where situations can be managed within a single location, where all human and equipment resources are available to tackle the situation, making decisions, taking action and apply all safety measures for people and goods;
- 2) “emergencies of external relevance”: this is where events are more extensive and taking place in a single location or resulting from external factors, whose solution will depend on the involvement of organizations outside the Administration and therefore require additional resources to restore the situation to normal conditions.

In the former case, the model proved to be quite effective, provided that it is supported by an effective monitoring, warning and communication system. Under circumstances involving “terrorist alarm” or biological hazard or danger to explosion or building collapse, it is deemed necessary to mobilize other forces or bodies which are able to interact with external sources. The Pirelli incident saw the intervention of several authorities working together such as fire brigade, first aid teams, public transport utility, public energy utility, etc., to co-ordinate emergency operations and that of regional authorities. In this case, it is essential to assume a more complex responding model, and the need of one or more “emergency units” capable to co-ordinate the action of different people and bodies, which may involve:

- political top management of the company
- personnel in charge of the branch office
- civil defence
- task force in charge of the intervention (prevention and protection; organization and personnel; management of internal resources, etc.)
- internal and external communication facilities.

The proposed organization model is capable of initiating the organization of operations in the event of a major emergency at a territorial level, through the involvement of external people and facilities. It is also pointed out the essential of creating a “safety network” amongst branch offices so that, in case of temporary unfitness of one of the branch offices, the main Regional Administration will enable to:

- (i) give shelter to those employees evacuated from the office hit by the event if the consequences require some length of time in undergoing the procedures aiming at certifying fitness for rehabilitation of the building
- (ii) provide a “logistic support” for handling the emergency
- (iii) reactivate the “primary functions” of the Regional Administration in the temporary office.

9. A New Outlook for the Co-ordination of People in Charge of Emergency Systems

The experience acquired in the safety management by the Lombardia Region has clearly outlined that all company organization must adopt and understand safety policy. For example, the company’s top managers must practice and accept safety as a key part of the company’s development and management process. All roles and activities performed within the company must be in accordance

with the safety policy and system. Managers are expected play a role in the planning for safety measures and make it an integral part of the strategic objectives of the company.

The activities to be carried and implemented for a successful model can be summarised in the following paragraphs:

Sharing safety objectives

- (i) Involvement of top managers in defining safety objectives;
- (ii) Insertion of safety objectives in strategic objectives of the company;
- (iii) Surveillance to be performed on the execution of programmes (safety plan).

Reorganization based on a widespread responsibility model

- (i) Creation of an integrated safety network within the company's organization
- (ii) Definition of responsibilities, roles and competences (who does what)
- (iii) Institutionalisation of the role and motivation of responsible personnel
- (iv) Acknowledgement of the role of the personnel in charge of emergency

Training of emergency teams

- (i) Involvement of top managers and personnel in "one-day safety events"
- (ii) Assignment of surveillance tasks to the emergency teams to inspect fire-prevention and safety systems
- (iii) Training of the personnel to be charged with the management of complex situations involving people from outside.

10. Internal and External Communications System

One of the important aspects to be addressed concerns the availability of communication systems devoted to emergency. It is therefore advisable to:

- establish a single emergency telephone number that employees, persons in charge of emergency and office manager may call at any time to report situations of danger
- define procedures to operate alarm systems and to set the emergency teams going
- use an "emergency switchboard" to operate emergency calls to alert external first aid and emergency teams.

It is also necessary to provide training of personnel in charge of the facilities pertaining to emergency points and for initiating of both internal and external emergency teams. This is a fundamental element for emergency situations to be dealt with effectively. It is critical that the emergency phone be constantly guarded by trained staff.

The organization of a special "emergency operations' room" to deal with serious emergency situations is also essential. This room may be located within the "emergency room" of the Civil Defence Department in order to allow the "emergency unit" (usually involved in such circumstances) to have a single location for monitoring of incoming and outgoing communications emergencies cases. Real time information is important, example on the number of people at the regional offices handling the emergency and needing aids. The attendance control system should keep the record of information outside the regional offices, to ensure the availability of these information when needed especially when it is not possible to access the emergency area concerned.

11. How to Deal with Priorities When Emergency is Over

After the emergency and evacuations, actions will be taken to allow investigations to be carried out, of which the office is declared fit or unfit for occupation in the short or long term.

The problems anticipated include:

- Logistics: it is necessary to have venues to host meetings, that will be taken into account when creating a "safety network" among regional offices
- Information: all information is needed to deal with emergency (personnel present at the office concerned, fitness of office occupation, time required for the restoration, etc.) and recommencement of the company's activities (disaster recovery plan)
- Communication: it is necessary to arrange strategies to transfer information in a very short time to the personnel, families, external bodies, citizens.

The new Emergency Plan envisages the following operations to be carried out in order to restart activities:

- Identification of decision-making personnel involved in the process
- Drafting plans to restart activities
- Proposals of temporary office in case the office questioned is declared unfit for occupation
- Communication tools to inform the public
- Establishing a system to save important information.

Conclusions

The Pirelli skyscraper incidents brought up several issues important to emergency management whereby some has not been covered by Italian regulations. However some notable points are worth to be considered for safety in future work places and to facilitate emergency management in buildings.

It is necessary to distinct the level of emergency in order to use resources efficiently, effective communication system, personnel training at different level, organization of emergency rooms and planning of operations at post-emergency. All have to be considered carefully in order that emergency situations be handled efficiently and effectively.

New buildings should be designed to facilitate emergency operations, however old ones should undergo appraisals, in order to increase safety precautions.

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