FIRE IN HIGH-RISE BUILDING UNDER CONSTRUCTION INVOLVING NON COMBUSTIBLE ACP (ALUMINUM COMPOSITE PANELS)

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ABSTRACT

This paper reports the effects of a big fire in high-rise building under construction, and the reaction to fire performance of the aluminium composite panels (ACP) involved.
During the stud welding with tip ignition on mill-finished surfaces a blaze breaks out. The fire was also fueled by the wind. It immediately spread to all ACP panels already mounted and therefore also to those of external finish. All involved panels fell off and fell to the ground, after having had an upward movement due to the large amount of fumes
The case study presents numerous and unique challenges to the fire service. Responding firefighters had to deal with a number of concerns that extended beyond what firefighters are normally used to in a completed or occupied building.
The investigation of the causes of the fire is also presented. Safety failures enter into causal relationship with the fire because the actions taken by the workers were ineffective in minimizing fire risk.

1 INTRODUCTION

The building “ENEL Tower”, the event theater, is located in the Management Centre of Naples. Its plant has a rectangular shape. It is a building tower that develops in height on 32 floors over the ground floor and 2 floors underground, for a total height of about 120 m.
The structure of the underground levels is completely realized in reinforced concrete; the above-ground structure is formed by two trapezoidal cores reinforced concrete, opposing along the longitudinal axis, and a central steel structure, suspended to a large metal beam in truck cover and resting place on the two reinforced concrete cores. In the cylinder head cores connections are located vertical, consist of three elevators in view and by a scale located at the extreme edge of the building, as well as services; in the central part are located mainly offices.
The structural nature of the building has clearly influenced the definition of the facades. The long sides are characterized by a continuous all-glass facade for almost total height of the building. Near the tower there is among others, a building that assumes particular importance in the event in question because it will suffer extensive damage caused by the fire. It presents in plan with a C-

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shape and presents in the square interior a pedestrian path, covered by domes made of polycarbonate.


a)


b)

Fig. 1. a) The fire in high-rise building construction. b) The fire involved ACP panels

2 TIMING OF EVENTS

The burning of the "ENEL Tower" had origin of around 10.30 of 2nd June 1995. In that time the facades cladding assembly works (between the 10th and 12th floor) on the wall in reinforced concrete were in progress. The height is more than 45.00 meters below ground level. The fire was spreading at speeds towards the polyurethane panels already mounted, both in the overlying portion, due to the high flames and the ascending hot gases in the area below, for effect of the the 'drip' and the fall of the hot combustion residues (see *Fig. 1*).

Just detected the existence of the fire, the workers abandoned precipitately mobile platforms and the building without activating any system fixed or mobile switching off. In about 10 minutes from fire alarm to operations center 115 Brigade Fire, the oncoming first teams from the headquarters and simultaneously also from the other fire stations.

The technical direction of intervention predisposed four fronts:

1) fire attack at high altitude, the height of the 10th floor with firefighters arranged on platform snorkel and ladder truck to operate by even larger share;
2) prevention work of a team of firefighters staying on the roof terrace of the near building to extinguish inflamed debris falling on the terrace by the skyscraper;
3) continue reconnaissance inside the building in order to verify the keeping of "smoke-proof filters", closing the fire doors;
4) monitoring of firefighters at street level, to prevent the fire spreading to building materials (cables electrical, machinery etc) places at the foot of the building.

No one person was on the top of the building, so the fire department helicopter didn't operate in that way. The coordinated action of the teams of firefighters extinguished the fire. The fire had a duration indicatively of about 3 hours, while the critical phase lasted less than one hour.
At the end of the intervention, the entire facade of the nucleus on the right wall appeared devastated, with extensive damage caused also the adjacent building (see *Fig. 2*). About 20 m of the facade were affected by the fire, to varying heights from 30 m (for the first part) to 90 m (for the other two neighboring facades to those in which the fire has developed).
The fire developed at about 47.00 meters from the plane country (between 10th and the 12th floor) during the coating assembly in correspondence of the facade of the southwestern core wall of the "ENEL tower". The call to the fire brigade was made at 10:59, so the workers began to safety abandoning the high-rise and walk down the stairs to several tens of floors; the fire caused also the block power supply in the mobile service platforms used for assembly. Fire extinguishers were not used, workers were unprepared for this risk and they were not equipped with instruments suited to this emergency. Firemen did not find extinguishers on the platform stops at 12^{th} floor among working tools used in the site, so it is plausible that they were not supplied.

3 FIRE REGULATIONS

The fire prevention regulations in Italy imposes to obtain the Fire Prevention Certificate. It must, however, distinguish between:

- the necessary fire preventive measures (fixed and final) that are functional at work completed construction (i.e. functional to the particular type of exercise for which the work has been designed and realized;
- measures (furniture and evolving) equally necessary, that, from time to time and with technical different, must be follow during construction, that is, in function of specific dangerous work related to different phases of the construction.

4 THE COATING CHARACTERISTICS FACADE AND ASSEMBLY PROCEDURE

The cladding used in correspondence of the walls reinforced concrete had to be realized with:

- support structure profiles aluminum placed vertically at a maximum spacing of 1.20 m., appropriately fixed to reinforced concrete walls by aluminum teams and metal plugs to expansion;
- insulating material consisting of Polyurethane panel of the thickness of 60 mm, directly fixed to the rear wall;
- finishing panels consist of two sheets of aluminum with an interposed polyvinyl layer (ACP aluminum composite panels) to a thickness total of 4 mm, fixed to the support structure with a suitable system not in view.

In particular, as regards the polyurethane panel forming the insulating material, the chosen type had technical and dimensional characteristics perfectly in line with those provided in the tender documents. For the laying of such coating the following processes were necessary:

a) supply of the materials at the construction site on the part of the suppliers;
b) discharge of materials from the media transport and handling the same to work site via tower crane, forklift or other appropriate means;
c) installation of scaffolding mast climbing (or platforms furniture) for the implementation of the coating;
d) hand movement and installation of the coating with the use suitable tools.

The assembly of the coating external happened in the following stages:

1) implementation of support structure aluminum profiles;
2) placement of the panel material insulation (polyurethane);
3) fixing of the panels of finish of aluminum plates (ACP panels).

5 ACP PANELS REACTION TO FIRE

Knowing a material's reaction to fire allows to foresee its behavior in a fire: how it will start, evolve and spread the combustion. To evaluate materials' reaction to fire and classify them according to their performance you need to determine their levels of flammability, combustibility, smoke toxicity and combustion heat, among others.
The Testing Centre of the Interior Ministry (CSE) and other private laboratories that are officially recognized by the Ministry itself, release a test certificate, in which certifies the class of fire reaction of the sample material subjected to examination.
As stated previously the term "*self-extinguishing*" or "c*ombustible*" makes sense only when the material is subjected to an intensity equal focus to that used in the tests.
For material considered "structure or compartmentation" like these ACP panels, the reaction to fire test must show the material's behaviour when exposed to a direct flame of ignition. It is subdivided in reference classes based on the method of test used.
The ACP panels used for the coating of the walls in reinforced concrete had the rating : "*Fire Reaction - CSE RF 1/75 / RF 3/77 A – Class 1*" with reference to old Italian standards (D.M. Int. 26.08.84). This specification can be seen from the Certificate Reaction to Fire performed installer stating, by authorized Laboratory by the Interior Ministry.
For material with a CE marking, the fire reaction rating is defined by the system Euroclass (EN 13501-01), based on the combination of various harmonized tests (EN 11925-2 and EN 13823). The system divides insulation products in 7 classes (A1, A2, B, C, D, E, F).
These ACP panel could be classified, according to international approvals and fire classifications "Class A2, s1, d0". It means that the panels had characteristics suitable for the application expected, resulting in lower participation in the fire.
Nevertheless it should be emphasized that it is not a combustible material according literal connotation, but this feature should be read in operation legislation and practice technique. Even a material classified as "Class A2", in fact, if involved by a fire which submits it to a high thermal ordeal, will burn together to all other materials.

6 THE DYNAMICS OF THE FIRE: POINT OF IGNITION AND PROPAGATION

The practice in the techniques of 'fire investigation' is starting from the identification of the fire's point of origin. The source points are certainly located outside of the building in the core correspondence southwest. In particular, they may localize in processing of the mobile platform positioned externally to the facade up to the 12th floor.
The temporal reconstruction events showed that the fire has developed indicatively between 10.30 and 11.00 of day 2nd June 1995. At that time workers were ongoing assembly the cladding on the wall in reinforced concrete of the core. During the coating installation work the fire has developed panels of insulating material. The fire, fed also by the wind, was propagated immediately to all of ACP panels already mounted. The panels that were affected by the fire fell off and fell to the ground, after having undergone an upward movement due to the large amount of flue gas produced.
The facade of the adjacent building was completely blackened from smoke and soot, with many windows, as well as many others irreparably ruined by plastic. The roof terrace was invested by a remarkable amount of burning material, which damaged the cover and the lighting system. Also polycarbonate domes covering the trenches, the atria and the stairs accesses in the courtyard have mostly been invested from incandescent material and hopelessly damaged.


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b)

Fig. 2. a) The fire in high-rise building construction. b) In the fire there were no victims

7 THE CAUSES

In this paper we reviewed the reaching the general fire phase, the structures and the systems involved from the event possible points, the evaluation of origin and the different types of ignition.
This has led to the identification of a high power ignition source. The type of material involved and the big thermal energy indicates that there was a fire, which has grown very rapidly from the initial stage. This source of ignition, as part of the equipment normally used on a construction site, could be produced for example by an electric welding machine, which is operating in a limited area.
This fact creates the conditions for a rapid and violent development of flames, whose high temperature may come to affect the entire front panels of the building.
The dynamics of the fire and the characteristics of involved materials indicate that the power required for the primer cannot be minimal (like a spark) but it must have been at least medium entities (such as naked flame, or incandescent welding residues with higher temperature to 250° C) and that the source was located at a point and persistent, if you consider the rapid expansion of the fire.
Therefore the misuse of an electrical welding machine by the workers that assembly the cladding can reasonably be identified as a specific cause. The workers handled recklessly and negligently the above-mentioned welding machine, and they did not controlled appropriately incandescent slag on the mobile platform on the 12th floor, so they determined the source trigger just described.
Work instruments to avoid direct or indirect contact of the necessary heat sources (welding machine electric) with combustible existing materials were not provided on site.
Certainly the provided instructions to minimize any accidental fire were insufficient. The workers in fact, abandoned the workplace, and they could not perform a first intervention.

8 CONCLUSIONS

The fire analysis of a building under construction must be made with reference the rules of proper fire risk management. Any reference to plants or passive protection measures is totally not applicable.
In this case it can be said that the ACP panels presented suitable features for the application, because they have a good reaction to fire, a low participation to the fire and suitably certificates.
On the other hand, safety failures enter into causal relationship with the fire because:

- the workers had complied formally to the rules of safety at work, but they made actions that were ineffective in minimizing fire risk
- when fire broke out, the workers precipitately abandoned the construction site. They did not have suitable information and training, and not immediate availability of portable fire extinguishers. In this way they could not execute timely and effective shutdown of fire.