TAKSHASHILA ARCADE FIRE AT SURAT: A TECHNICAL ANALYSIS

By Abhay Purandare

The nation's residents were stunned on the afternoon of 24th May this year when shocking visuals of a fire in a Commercial complex in Surat began doing the rounds on social media. Within minutes, scenes of students of a coaching centre in this complex desperately trying to save themselves from the dense, billowing smoke of this fire, had gone viral and news channels were soon relaying the incident and related fire fighting operations live. Onlookers and viewers were appalled to see the rapid growth of the fire, with students clinging desperately to the exterior of the building to save themselves from its effects, and ultimately falling down as they lost hold. The fire was controlled and extinguished in the next couple of hours, but later searches confirmed 22 fatalities, most of them students of a particular institute located on the top floor of the building.

By any standards, the incident was unnerving for society, for seldom were such disturbing visuals seen before at a building fire, and so many young, innocent lives lost in a single incident in the recent past. The justifiable hue and cry was met with quick action from the authorities – an enquiry was announced, suspensions were handed out to government officials (in the Municipal and Fire departments), similar coaching institutes were sealed, and notices issued to many violators of similar and other occupancies (including hospitals, cinema halls, etc), in Surat as well as other cities. In the aftermath, indignant news anchors and participating panellists berated the government and fire service infrastructure, demanded major changes to fire safety laws & its implementation, and urged citizens to be more vigilant and fire safety conscious.

While an incident of this magnitude is bound to evoke emotional reactions, as fire safety professionals, it is important to analyse this incident from a scientific and technical perspective. We are all aware of the current state of fire safety and its level of implementation in the country, and the fact that there's a lot of ground to be covered before we can claim to be a fire safe country. At the same time, it is imperative that required lessons are learnt from this incident, and appropriate actions are initiated towards improvement. Only if we begin now, can we hope that our future generations will live in a society safer than the one we had.

A formal investigation report is not available for the public at the time of writing this article. An attempt has been made to analyze the incident with the objective of understanding what caused the incident, how it grew and spread, and why the incident resulted in such a high number of casualties. It is also attempted to identify shortcomings and look at possible areas of improvement.

The Building

Takshashila Arcade in Sarthana area of Surat is a commercial building, approximately 30 metres long by 15 metres wide, having ground plus three floors. As per information available through media reports[1], the terrace was later covered and used as a floor (thus technically making it four floors above ground floor). The building is oriented north to south lengthwise (the building side seen in the TV visuals is the front of the complex which faces the south) and has roads on the south and west side. There is a single stair located on the north-west corner of the building.

Road on south side of the complex is the main Sarthana Jakat Naka-Kamrej road, along with the Sarthana flyway (which gives a clear width of over 12.0 metres on this side). Road on the west side is a 6.0 metre wide road with the Sarthana nature park and zoo on the other side of the road. There is another commercial complex adjacent to it on the east side (with a gap of more than 6.0 metres) while the building abuts a 2 storey villa on the north side. From a fire brigade access point of view, the south and west side of the complex are easily accessible.

Building Use and Occupancy

The building is a commercial complex having different shops (hardware, hair cutting saloon, mobile shops) on the ground, first and second floor, a medical clinic and nursing home/ laboratory on the first floor and training

Photo courtesy: www.newkerala.com

Fig 1. Building complex layout and access

institutes on the second and third floor.

Hence technically, the building is a multiple (mixed) occupancy having mercantile, business and institutional occupancies (if the medical clinic is only having OPD facility, it would be a business occupancy; if it has beds for patients, it would be institutional C-1 occupancy). It should be noted that in a mixed occupancy, the occupancies are intermingled and the most stringent occupancy requirements apply (as opposed to a multiple (separated) occupancy, where the occupancies are separated by fire resisting construction, and hence each occupancy can be designed as per the requirements of that specific occupancy).

The third and fourth floor were being used by training institutes. The classification of training institutes as per NBC Part 4[2] is 'B-2 - All Others/ Training Institutions', however this classification specifies the number of students as 'not less than 100 in number' hence it is not clear how these should be classified under NBC part 4 (other international codes specify a class having less than 50 persons as a business occupancy, while classes having more than 50 students would be an assembly occupancy ; it should be noted that most codes specify two exits for any room having more than 50 occupants).

Egress Arrangements

As stated earlier, there is a single stair located on the north-west corner of the building which exits directly on the road (on west side). This stair, approximately 1.2 metre wide, extends from the ground to the third floor and is of concrete construction with metal railing. It appears (as is also mentioned in media reports) that the access to the fourth floor was added later on, and based on eyewitness reports, this was fabricated out of steel frame with wooden parts (the author assumes that either the treads or the landings or both were made of wood construction). An external metal stairs is present on the south-east corner (front side) of the building; however, this provides access only to the first floor.

The stairs are naturally ventilated (open from one side) and it is assumed that this must have some kind of opening at the original terrace level. This design would logically not allow accumulation of smoke; however, this is what happened in the incident. There are electric meters located below the staircase at ground floor, and cables for upper floors passed through a duct above the stair entrance (where it is believed the fire originated). On one side of the stairs (North-west corner) an illuminated banner (steel frame covered with plastic fabric or sheet) was fixed; this extended from the first to the third floor. On the other side of the stair is the enclosed duct carrying electrical cables (Refer Fig. 2).

NBC Part 4 as well as local regulations define a building above 15 metres in height as a high rise building. With four floors (ground + 3), the building would technically be a low-rise building (assuming that the height does not exceed 15 metres), but with formal addition of another floor above the third floor, it is not clear if it was recategorized as a high rise building. Readers may be aware that requirements for a high rise building are different from a low rise building in terms of fire prevention, life safety (egress arrangement) and fire fighting requirements. For e.g. clause 4.4.3.4.2.1 of NBC part 4 clearly states that all high-rise buildings (irrespective of type of occupancy) shall have minimum two stairs.

Fire Fighting Access & Fire Protection Systems

There is sufficiently wide fire brigade access from two sides of the building to carry out external firefighting and rescue operations (See Fig. 1). Access for internal rescue is from the only stairs on the north-west side. As most of the readers are aware, municipal hydrant systems are non-existent in almost all major Indian cities. This puts a strain on the water supply requirement at a fire incident scene, and the large numbers of fire vehicles at a scene (and reported in media) are required to cater for this arrangement. Where larger vehicles such as turntable ladders, or hydraulic platforms could be mobilized, the access path should have the load-bearing capacity of these heavy vehicles (which is specified in the building codes/ rules); this was not an issue in this incident.

The fire protection arrangement within the complex seems to have been limited to portable extinguishers. Fixed fire protection systems (such as dry riser with hose

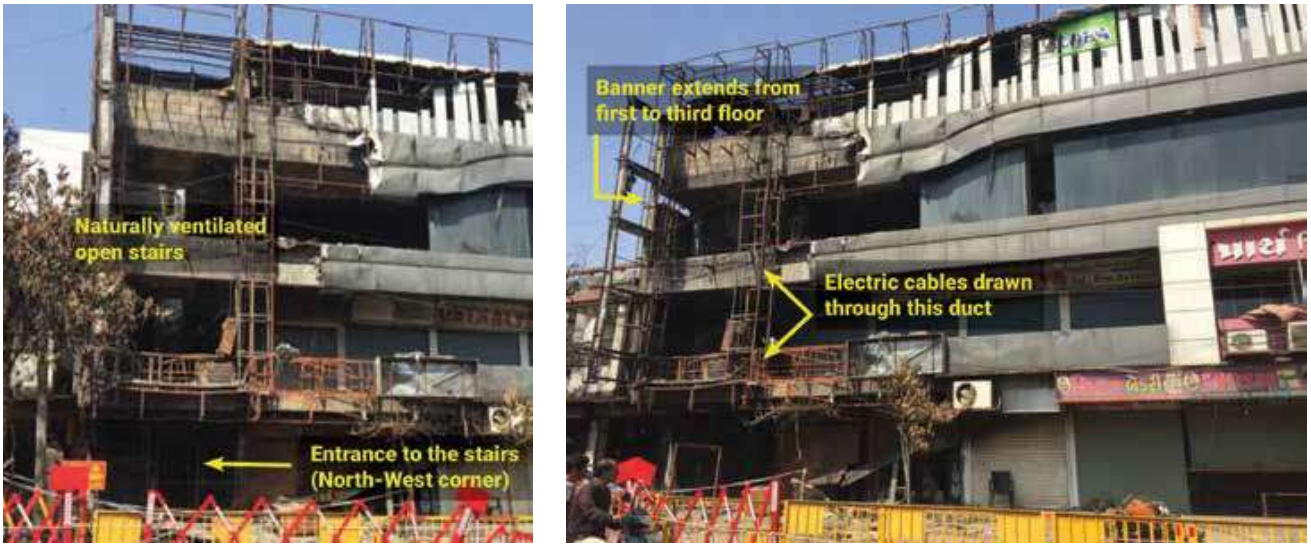

Photo courtesy: Abhay Purandare

Fig 2. Egress arrangements of the building

reels and fire brigade inlet) are not seen in the complex. This would be required as per NBC Table 7, but it is not clear if it was applicable as per existing building rules at the time of construction. Going strictly as per NBC Part 4, Table 7, a high-rise mercantile building would require a wet riser, fire pumps and storage tanks, automatic fire alarm system and yard hydrant, while a non high-rise building (the original status of the complex) would not, though it would be required to provide a dry riser and manual fire alarm.

Fire Ignition & Growth

It is reported that the fire began around 4 pm on 24th May, 2019. Once again, a forensic investigation report is not available at this stage and it is assumed that the ignition was electrical in origin based on the information available (eyewitness accounts, media reports, and videos available online[3]). All these point out to the ignition of electric cables above the stair entrance exit and eye-witness accounts and videos available further corroborate this. The electrical duct cover (plastic or laminates) ignited due to heat from the cable fire and this further ignited an AC compressor unit located above the duct. In videos available online, burning material can be seen falling near the stair entrance and the front of the first shop adjacent to the stairs. At least four 2-wheelers parked in front of the shop also ignited (most likely after sometime; probably as heat reached fuel vapours leaking from pipe connections). Once the plastic banner adjacent to the stairs and electric cable duct on the other side of stairs, it allowed flames to travel up quickly (this can be seen in videos available online).

It is evident from the condition of the building after the incident that the heat damage to the ground, first and second floors is minimal. Except the shutters of the two shops on the ground floor adjacent to the stairs (which are heavily damaged), other shops on the first floor and institutes on the second and third floor show minimal evidence of damage from the fire, except for some damage to the external ACP material fitted there. It is therefore, clear that smoke and heat from the original fire did not penetrate into the first and second floors. There is some damage on the third floor near the stairs, but again this is limited to around 5 metres from the stairs. It appears that material was stored near the stairs on the fourth floor and hot smoke travelling up the stairs finally ignited the pyrolysing material kept here, and flames were seen on the fourth floor, but not on the second and third floors (See Fig. 3). Construction on the terrace appears to be non-RCC, using synthetic materials, which may have contributed to the fire.

Smoke Generation and Movement

As the fire grew involving more of the electrical duct/ cables and the vertical banner adjacent to the stairs, the smoke generated was being pushed into the stair due to the wind direction prevalent at that time. As seen in videos, the wind was blowing from the west direction at the time of the incident (wind velocity in this period averages 10-15 kmph), and this pushed the smoke towards and into the stairs. The hot smoke travelled up vertically through the stair shaft till it was diverted horizontally onto the fourth floor, most likely due to vertical barrier created by the temporary roof provided on the stairs (which later got destroyed due to the fire). This allowed the hot smoke to enter and pyrolyze the materials on the fourth floor. Pyrolysis is the breakdown of material due to heat (in this case due to hot smoke), and results in the generation of gases and solid particles, which begin affecting the occupants. The products of combustion or pyrolysis depend on the materials present and it is not clear what kind of materials were

Failing to plan is planning to fail.
-Alan Lakein

stored here. But going by materials used in most such buildings, furniture using laminated wood, polymers (plastic furniture, foam used in furniture, lining material), and similar materials would be present. It is also stated that rubber tyres were used to create seating arrangement for students (though with a supposedly good intention of putting waste material to use), which would result in thick, acrid smoke when heated.

Effects of Fire Gases

Smoke from combustion or pyrolysis can endanger occupants in two basic ways: one, by reducing visibility due to the solid and liquid particles in smoke, and two, by the adverse effects of different toxic gases on the human body. A third effect is by burns caused by the hot gases, but this effect is likely to occur later than the visibility or toxicity effects, which can occur in early stages of the fire. Fire gases are divided into major groups - Asphyxiants and Irritants. Asphyxiants (such as Carbon Monoxide (CO) and Hydrogen Cyanide (HCN)) are gases which cause central nervous system depression, resulting in loss of consciousness and ultimately, death[4]. Carbon Monoxide is always present (in varying proportions) in all fires in buildings involving carbon fuels (Wood, Cotton, Plastics, etc), while Hydrogen Cyanide is generated when nitrogen-containing materials such as Acrylics, Polyurethane foams, Melamine, Nylon and Wool are involved in fires (which are very common nowadays). Presence of HCN alongwith CO greatly increases its asphyxiant potency. Common irritant gases include Halogen acids (HCl, HBr), Nitrogen oxides, Ammonia, Acrolein, etc, which can be given off when different materials such as PVC, Rubber, Nitrogen containing plastics are involved in fires[5]. Irritants result in sensory irritation i.e. affecting the eyes and upper respiratory tract. The irritation (and subsequent watering) of eyes leads to loss of clear vision, causing occupants to panic in a fire situation. Irritants enter the nose, mouth and throat causing burning sensation and secretion of mucus. This causes swelling of tissues, causing constriction of the wind pipe, and can also lead to pulmonary edema, resulting in death. However, much before these effects, just the presence of hot, irritant smoke is enough to cause panic amongst occupants. This is most likely what happened when the smoke began entering the room where the class was in progress.

Photo courtesy: www.thehindu.com

Fig 3. Fire incident in progress,

Probable Occupant Reaction

As the fire plume began travelling horizontally towards the class on the fourth floor, students (and their tutor) must have realized the gravity of the situation as smoke density began increasing. It must be noted that plastics of different types and rubber products will typically generate dense smoke both under flaming and non-flaming conditions. Polyurethane foams under flaming or non-flaming exposures generally yield dense smokes, and, with few exceptions, obscuration occurs in a fraction of a minute. Soon after, as irritant effects of smoke must have kicked in, causing irritation of eyes and the respiratory tract, students might have tried moving to the exit but realizing that the smoke was coming from the stairs, would have rushed towards the windows on the other side in the hope of getting fresh air. As smoke quantity and temperature increased, those present were getting exposed to all effects of smoke – loss of visibility, asphyxiation, irritation and high heat exposure. It is difficult to comprehend the psychosis of occupants in such conditions, but the reaction of many students to jump would have been as a result of this deadly exposure (it is not an easy decision to jump off the fourth floor of a building, but the conditions inside would have forced this decision).

Students who could not get reach to the windows and fresh air, would have been overcome by the asphyxiant effects of gases. In building fires, CO generation is high as the fire in ventilation limited due to construction; modern materials such as polymers and laminated wood burn faster than older traditional materials (natural wood) and this consumes oxygen much faster resulting in higher concentrations of CO (at concentrations above 2% v/v, 2-3 breaths are enough to render a person unconsciousness and further exposure leads to death). Those who fell unconscious further inhaled these toxic gases, thus increasing the dose in their body. Charring due to heat would actually be a subsequent effect – in most cases, occupants

would be dead before the heat from smoke affects them.

Important Observations

Certain important observations and findings on this incident are given below. Such tragic incidents leave an indelible scar on the public psyche. However, it is imperative that the lessons learnt from this incident are not forgotten and are used to improve fire safety for our future generations; this is the least we can do to honour the young lives lost in this incident.

- Smoke effects (visibility, toxicity and heat effects) are the leading cause of deaths in buildings. Even a small size fire can generate considerable amount of smoke to jeopardize safety of occupants in a building.
- It must be understood that egress design is of paramount importance in buildings (there's currently too much focus on fire protection in building fire safety). Even if fire fighting and rescue is delayed, occupants must be able to safely escape from the building in the event of emergency. Current DCRs related to egress design need to be revisited and revised, if required. For commercial buildings where outsiders are likely to be present, minimum of two exits should be made mandatory, irrespective of height.
- Older buildings (which are non-compliant from egress design point of view) need to be checked for design of stairs, fire hazards which could affect its safety (hoarding, materials, electrical equipment located in or near stairs).
- Modifications/ changes to building design need to be carefully evaluated from a fire risk perspective. Concerned (Municipal/ Fire) officials need to be trained and certified to carry out fire and life safety assessments for building designs. Implementation of building rules/ codes should be in spirit and not just for compliance. Concerned officials need to be trained and certified to carry out fire and life safety assessments for building designs. Fire & Life Safety features should be maintained throughout the working life of the building.
- Strengthening and upgrading fire services so that they can effectively carry out fire prevention and fire fighting services. Current shortages in fire service infrastructure, staffing and training are too large to expect them to deliver services effectively. Role of experts and consultants need to be seriously considered for fire & life safety design, installation and inspections in buildings, as fire services are currently not equipped for this role. Sensitization of society towards issue of fire and life safety. Fire Safety has to be a people's movement; simply enforcement is not a solution. Students must be taught about fire safety in school so we will have a generation that is conscious about fire and life safety issues.

Disclaimer

The analysis given above is not a formal report of the incident and is not meant to be used for formal/ legal purposes. This analysis is based on information available in the media (which has been carefully scrutinized for relevance and authenticity), a visit to the incident spot a week after the incident (the building site had been sealed off and it was not possible to see the building from inside) and eye-witness accounts. The collected information, along with the author's experience and knowledge, has been used to reconstruct and analyse the incident.

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Fires due to negligence can kill in an instant