IIT GANDHINAGAR

SAFETY MATTERS

JULY - SEPT 2019 ISSUE 04

*A Quarterly issue from **Centre for Safety Engineering**(CSE), IITGN*

FROM THE EDITOR'S DESK

This edition of Safety Matters covers two topics, a technical analysis of the Surat Fire incident [24th May 2019] and the Part 2 of the article on Electrical Causes of Fires. In the case of the Surat fire incident, there obviously are more questions than answers, even 5 months after the event. This underlines the need for much higher levels of action when it comes to Incident investigation. The article on Electrical causes of Fires [Part 2] looks at the common electrical faults that occur, the symptoms and what can be done.

Taking this opportunity to wish you a Happy and Safe Diwali,

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TAKSHASHILA ARCADE FIRE AT SURAT: A TECHNICAL ANALYSIS | ABHAY D PURANDARE

1.0 INTRODUCTION

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. This incident was characterized by a rapid growth of fire, large quantity of smoke generated, failure of egress arrangements for occupants, and 22 fatalities, most of them students of an institute located on the top floor of the building. While the incident shocked society, it is important to analyse this incident from a scientific and technical perspective, so that required lessons are learnt from this incident, and appropriate actions are initiated towards improvement.

Figure 3. Complex layout and access (Image Source: 1)

2.0 THE BUILDING

Takshashila Arcade in Sarthana area of Surat is a commercial building, approximately 30 metres long by 15 metres wide, having G+3 floors. As per information available through media reports[1], the terrace was later covered and used as a floor (thus technically making it G+4 floors). The building is oriented north to south lengthwise and has roads on the south and west side (Sarthana Jakat Naka-Kamrej road on South sidewith a clear width of over 12.0 metres, and a 6.0 metre wide road on west side). There is another commercial complex adjacent to it on the east side and 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.

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 institutes on the second, third floor and the fourth floor. Technically, the building is a multiple (mixed) occupancy having mercantile, business and institutional occupancies.

NBC Part 4 and local regulations define a building above 15 metres in height as a high rise building. It is not clear if after formal addition of 4th floor, it was recategorized as a high rise building. 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. NBC part 4 clearly states that all high-rise buildings (irrespective of type of occupancy) shall have minimum two stairs.

There is a single concrete stair of approx. 1.2 metre width, located in the north-west corner, extending from ground to third floor; this exits directly on the road (on west side). As per media reports, access to the fourth floor was added later on and this was fabricated out of steel frame with wooden treads/ landing. The stairs being naturally ventilated (open from one side), should logically not allow accumulation of smoke; however, this is what happened in the incident. Electric meters are 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. 4).

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 reels and fire brigade inlet) are not seen in the complex.

Figure 4. Egress arrangements of Building (Image Sources: 2,3)

3.0 FIRE GROWTH & SMOKE MOVEMENT

All available information points out to the ignition of electric cables above the stair entrance exit. The electrical duct cover (plastic/laminates?) later ignited, and due to the resultant heat, at least four 2-wheelers parked close by also caught fire. Once the plastic banner adjacent to the stairs and electric cable duct ignited, it allowed flames to travel up vertically quickly. It appears that material was stored near the stairs on the fourth floor and flames and hot smoke finally ignited the pyrolyzing material kept here, and flames were seen on the fourth floor, but not on the second and third floors (See Fig. 5).

The smoke generated due to burning materials was being pushed into the stair due to the wind direction prevalent at that time (from the west direction; wind velocity in this period averages 10-15 kmph. This allowed the hot smoke to enter and pyrolyze (and finally ignite) the materials on the fourth floor (most likely furniture using laminated wood, polymers (plastic furniture, foam used in furniture, lining material). It is also stated that rubber tyres were used to create seating arrangement for students, which would have generated dense, acrid smoke on ignition.

4.0 SMOKE GENERATION & EFFECT ON OCCUPANTS

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 occur later than the visibility or toxicity effects. 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). 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.

Figure 5. Fire Incident In Progress (Image Source: 4)

4.1 PROBABLE OCCUPANT REACTION

As smoke entered the fourth floor, students (and their tutor) must have realized the gravity of the situation with smoke density increasing quickly. 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 up 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 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 consciousness 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 fire & smoke affects them.

5.0 IMPORTANT OBSERVATIONS

Certain important observations and findings on this incident are given below.

- 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.
- 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.
- Implementation of building rules/ codes should be in spirit and not just for compliance. Fire & Life Safety features should be maintained throughout the working life of the building.
- Strengthening and upgrading fire services as current shortages in fire service infrastructure, staffing and training are too large to expect them to deliver services effectively.
- Sensitization of society towards issue of fire and life safety is a must. Fire Safety has to be a people movement; simply enforcement is not a solution.

Disclaimer: The above is a technical analysis and reconstruction of the incident, and not to be construed to be a legal/formal report.

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FIGURES

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ELECTRICAL SHORT CIRCUIT ..... CATCHING THE CULPRIT [PART 2] | DR. TEJAS JHAVERI

[THE PART 1 OF THIS ARTICLE APPEARED IN SAFETY MATTERS 3]

Building fires are becoming a very common headlines in India. The headlines on 28th of December read "Fire in Residential building kills 5 in Mumbai". Let us recount the event. On 27th of December 2018, just as people were returning back from work,a fire was reported at 7:45 pm in Chembur (Mumbai). People had heard an CNG cylinder explosion.

Forensic analysis revealed; the fire initiated from an electrical fault on decorative lights on the christmas tree, it then spread through the curtains and finally escalated when the CNG cylinder exploded.

How often do you think about the quality of electrical installation on your Christmas tree?

Well, you should! Now, the more challenging question. How do you ensure that my electrical installations and systems at home are safe to not ensure a fire. In 'Electrical Short Circuit ..... Catching the Culprit [Part 1]' we discussed the 20 electrical faults that lead to fire risk, electrocution, equipment loss or efficiency losses. In this article we take a closer look at the faults leading to fires.

Electrical Fire Risk	Description of fault	Why does it occur
Short circuit	Extremely high current flowing between two live wires via an unintentional low resistance path. It generates excessive heat that becomes an ignition event for the fires.	(a) Exposed wires or (b) failure in devices
Arcing	The flow of electricity after the breakdown of a non-conductive material. There are two types of arc (a) Parallel arcing is when the arc flows between two wires of different electric potential. These can be detected in over current conditions (b) Series arcing occurs when the arc flows between two wires of the same potential such as in the case of loose connection or a partially broken wire. Arcs generate up to 3750 C of heat and are a primary cause of electrical fires.	(a) Loose connections (b) Insulation damage (c) Rodents
Over current (Overload)	Excessive currents flowing through wires and switchgear such that it is higher than the rated currents. It generates excessive heat that becomes an ignition event for the fires. Overload conditions also increase the probability of arcing events	(a) A damaged equipment or (b) unplanned addition of electrical loads
Earth Leakage	High leakage current flowing in to earth wire. Currents greater than 20mA can cause electrocution. Higher currents can also cause connections to the earthing systems to heat up and become ignition events for fires	1. Equipment degradation 2. Improper wiring
Critical overvoltage	High voltages observed from the electric supply company. Voltage higher than 10% of nominal can cause excessive current for resistive loads that leads to overheating. Under certain conditions higher voltages will also lead to components such as capacitors exploding. Last over voltages also increases the probability of arcing events.	Poor power quality from the electric distribution company

Electrical Fire Risk	Description of fault	Why does it occur
Critical undervoltage	High voltages observed from the electric supply company. Voltage lower than 10% of nominal can cause excessive current for non-linear and motor loads such that it leads to overheating.	(a) Poor power quality from electric distribution company (b) Poor sizing of cables
Phase loss	Disconnection of at least 1 phase from a 3 phase supply. This condition leads to excessive currents for 3 phase equipments such as motors and power supplies that becomes a source of ignition for fires.	(a) Disconnection from supply (b) Damage to wiring or switchgear
Neutral loss	Disconnection of the neutral wire. This is one of the most critical conditions in facilities that have 3 phase supply. A neutral loss is very difficult to diagnose manually. A loss of neutral will appear as a normal operating condition but only under certain unbalanced loads will it trigger extremely high voltages that are greater than 50% of the nominal voltage. These voltages are sufficient to triggers explosions in capacitors in air conditions or power supplies.	(a) Disconnection from supply (b) Damage to wiring or switchgear (c) Overload/unbalanced loads
Surge	Sudden increase in voltage for few microseconds. Typically observed during load changes or lighting conductions. If there is not adequate surge protection it can lead to equipments failures and components exploding.	(a) Poor power quality from electric distribution (b) Sudden load changes
High Earth Voltage	Increase voltage measured between earth and neutral. This voltage is an indication of poort earth resistance, poor connection to neutral or a faulty equipment. High earth voltages is often observed because of increased resistance on earth and neutral path. A poor connection, loose connection, oxidized busbar or carbon formation are all possible causes. High earth to neutral voltages can also been seen as an early sign of exposed wires in some cases. Not correcting this fault early enough will lead to overheating of busbar, contacts and in some cases arcing events.	(a) poor earthing (b) Faulty neutral (c) Leakage in devices (d) poor quality of busbar and contacts
Current Unbalance	Uneven current between 3 phases. Unbalanced currents lead to higher currents in the neutral wires. In facilities that have 3 ½ core wiring it can also lead to overheating of neutral and neutral loss condition.	(a) Poor electrical plannign and maintenance (b) unbalanced loading
Current Harmonics	Distortion in the shape of the current waveform. Current harmonics have become a much talked about topic when in comes to power quality issues. Although, a critical risk of current harmonics is the introduction of triplen harmonics that lead to 3 times the current through the neutral wire for 3rd, 9th, 15th, etc harmonics. The high neutral current can lead to neutral wire overheating and even a neutral loss condition if the wire becomes open. Current harmonics also lead to overheating of transformer windings which is another fire risk.	(a) Poor equipment design (b) harmonic generating electronic loads (c) Transformer saturation

These 12 conditions if monitored carefully can lead us to develop methodologies to protect from electrical fires. The rather interesting to note that there are devices available to protect from all these electrical conditions that could lead to fires but common practices, standards and codes only rely on protection for short circuit, overload and earth leakage. In effect we are only protecting ourselves for 25% of the overall fire risks.

In today's context the recommended approach to Electrical and Fire Safety, a three-stage approach as below can be considered.

1. Use 'smart' electrical systems that can 'self-diagnose' and correct or 'warn' or 'fail safely' as appropriate. With improvement in electronics, such systems are available and are very affordable in India today. One such device is POWEReasy. Designed for India, Designed in India and Manufactured in India by Jhaveri Power Labs.
2. Electrical audits in homes and buildings, say once in five years, to ensure that the systems and wiring are in good shape of installation and the electrical load is as planned.
3. Educate the users at different levels to enhance awareness including the occupants, owners, electrical contractors, governmental authorities, civic authorities like fire and electrical departments, manufacturers and others.

If we want to cure India of electrical fires we need a concerted approach towards incorporating all the three prescribed preventive steps through both the commercial markets and policy making.

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CSE SHORT COURSES

The Centre for Safety Engineering organized two short-courses on fire safety recently. The first one focused on 'building design for fire and life safety' and covered topics related to architectural and structural design, and aspects of MEP services pertaining to fire and life safety. Fire behavior of facade systems and firestop systems was also discussed. Course instructors included Mr Sandeep Goel (Member, NBC Part IV], Mr Abhay Purandare (Fire Consultant), Mr Brij Bhushan Singh (Hilti India Pvt Ltd), Prof Anil Agarwal (IIT Hyderabad) and Prof Gaurav Srivastava (IIT Gandhinagar). The second short course was conducted by Dr Pravinray Gandhi (Director, R&D, Underwriters Laboratories). This focused on fundamentals of fire engineering and covered topics such as basic fire behavior, material characterization and discussion on building codes and standards.

The progarms were attended by participants from across India and abroad from industry and academia