GIDM - Gandhinagar

Rapid Structural & Non-Structural Risk Assessment of School Building

21st – 24th January, 2020

Fire Hazard Prevention and Preparedness for School Buildings

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Abhay D Purandare
M.Eng(FPE), FIFireE, FIFE, PMSFPE

AP

TOPICS TO BE ADDRESSED

- Why Fire Safety – some case studies
- A look at some incident statistics & its relevance
- Fire hazards & code requirements
- Emergency Planning – Need & Concepts

STATISTICS & FIRE RISK IN SCHOOLS

Due to the fact that limited data is available in most developing countries, it is not possible to get an accurate picture of fire incident statistics of school fires

The fact remains that School fire incidents are not as common as in other occupancies such as Residential or Business premises.

However, the presence of young children incapable of self-preservation increases the risk considerably during fire incidents in Schools

A look at some related data…

DABWALI TENT FIRE, 1995

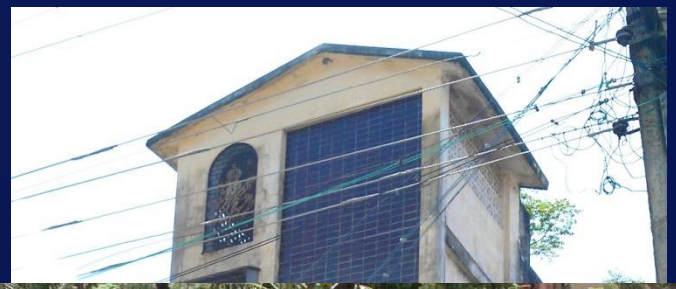
On 23 December, 1995, the annual function of a school was being at a private hall. A synthetic tent, which had been set up inside the building, caught alight when an electric generator short-circuited.

Many of the deaths were caused by the resultant stampede as 1,500 people tried to escape through the single exit door. Upto 540 people died, among them 170 were children.

KUMBAKONAM SCHOOL FIRE, 2004

A total of 94 students of Krishna English Medium School in Thanjavur, died during a school fire on 16 July 2004. It is the second worst school fire in the country's history

The fire began from the midday meal kitchen thatched roof & spread to the upper level, which also had thatched roofs. A narrow staircase with sundry material, prevented exit of children.



TAKSHASHILA ARCADE, 2019

A Mixed Use Occupancy requires the most stringent occupancy requirements to be applied

TAKSHASHILA ARCADE, 2019 - 2

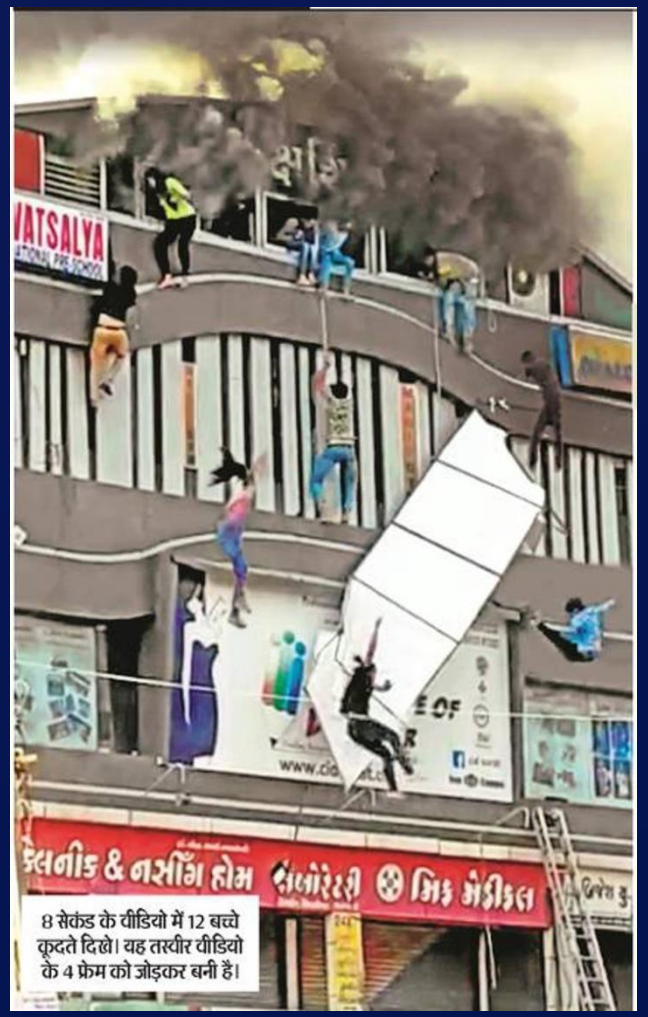
- South side - >12.0 m road, West side – 6.0 m road.
- Commercial complex on East side, Villa on North

HEAT & SMOKE MOVEMENT

FIRE GROWTH & DEVELOPMENT

Heat from initial fires ignited banner and the cable duct, and travelled to the fourth floor (other floors relatively unaffected)

TAKSHASHILA ARCADE FIRE, SURAT



SCHOOL FIRE STATISTICS

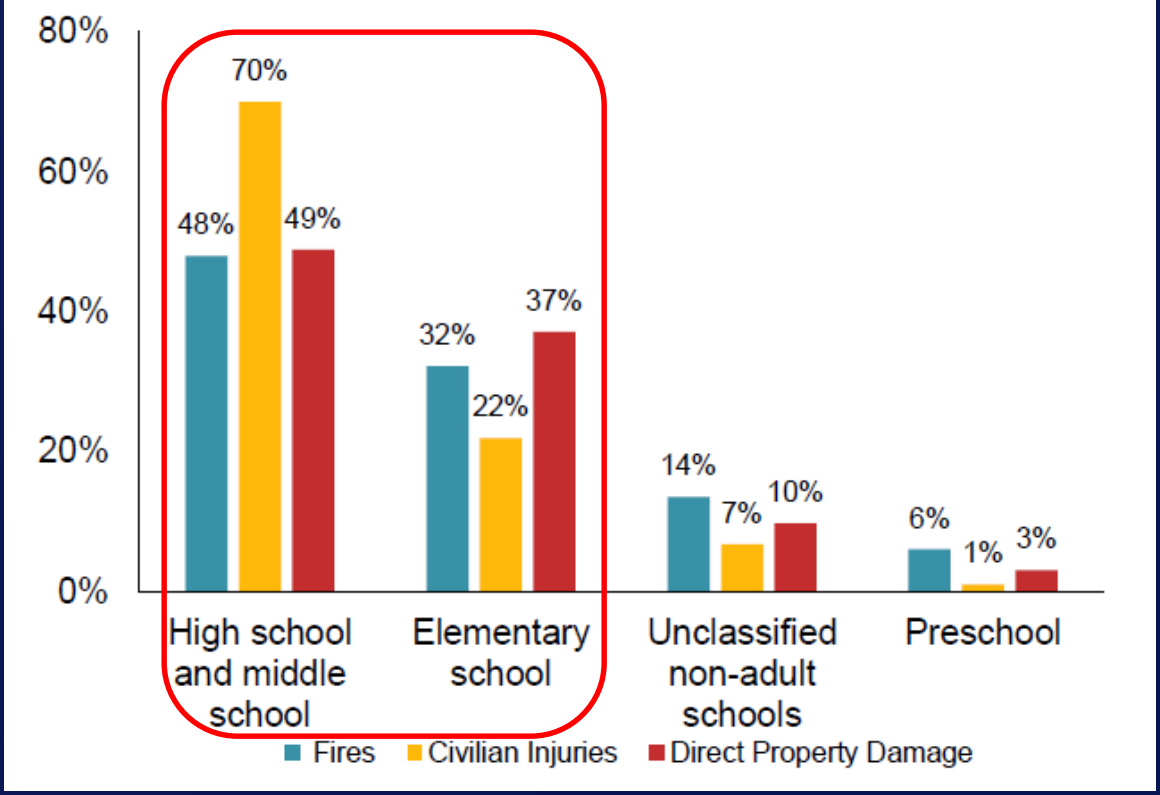
Due to the fact that limited data is available in most developing countries, it is not possible to get an accurate picture of fire incident statistics of school fires

The fact remains that School fire incidents are not as common as in other occupancies such as Residential or Business premises.

However, the presence of young children incapable of self-preservation or differently abled students increases the risk considerably during fire incidents in Schools

A look at some related data…

FIRE INCIDENT STATISTICS…



Structure Fires & Losses by School types – 2013-17
Source – NFPA statistics

Middle & High Schools account for the vast majority of fires, injuries & damage. Elementary schools are also significant

FIRE INCIDENT STATISTICS…(Contd) 1

Fires in School Properties, by Leading Cause
2013–2017 Annual Averages

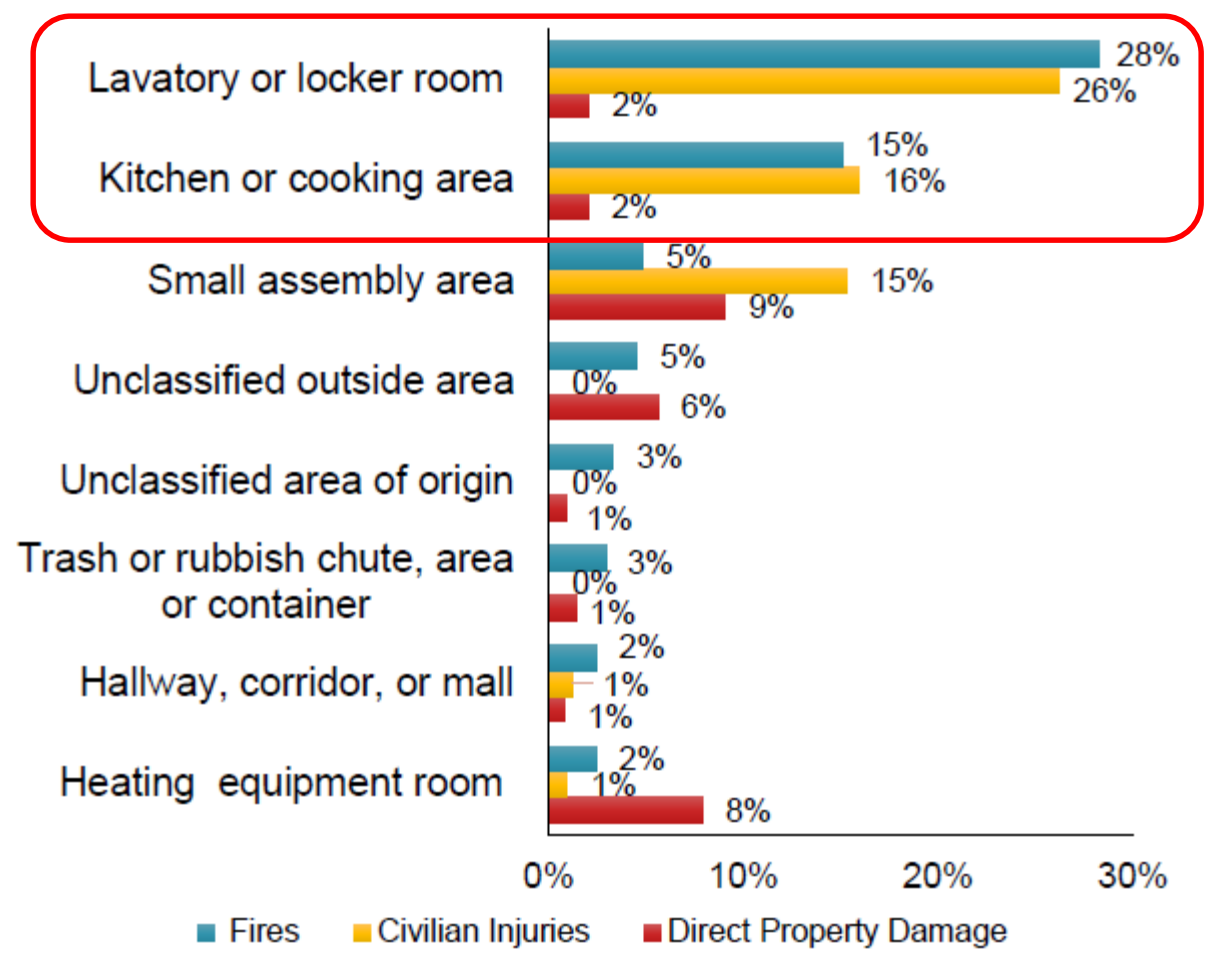
Leading Cause	Fires		Civilian Injuries		Direct Property Damage (in Millions)	
Intentional	1,370	(41%)	11	(26%)	$13	(31%)
Cooking equipment	1,020	(31%)	5	(12%)	$1	(2%)
Playing with heat source	660	(20%)	9	(20%)	$6	(15%)
Heating equipment	340	(10%)	6	(14%)	$2	(4%)
Smoking materials	110	(3%)	0	(0%)	$7	(16%)

Leading causes of fires – 2013-17

Source – NFPA statistics

Fires that were intentionally set and cooking equipment are the leading causes of fires as well as injuries/damage

FIRE INCIDENT STATISTICS…(Contd) 2

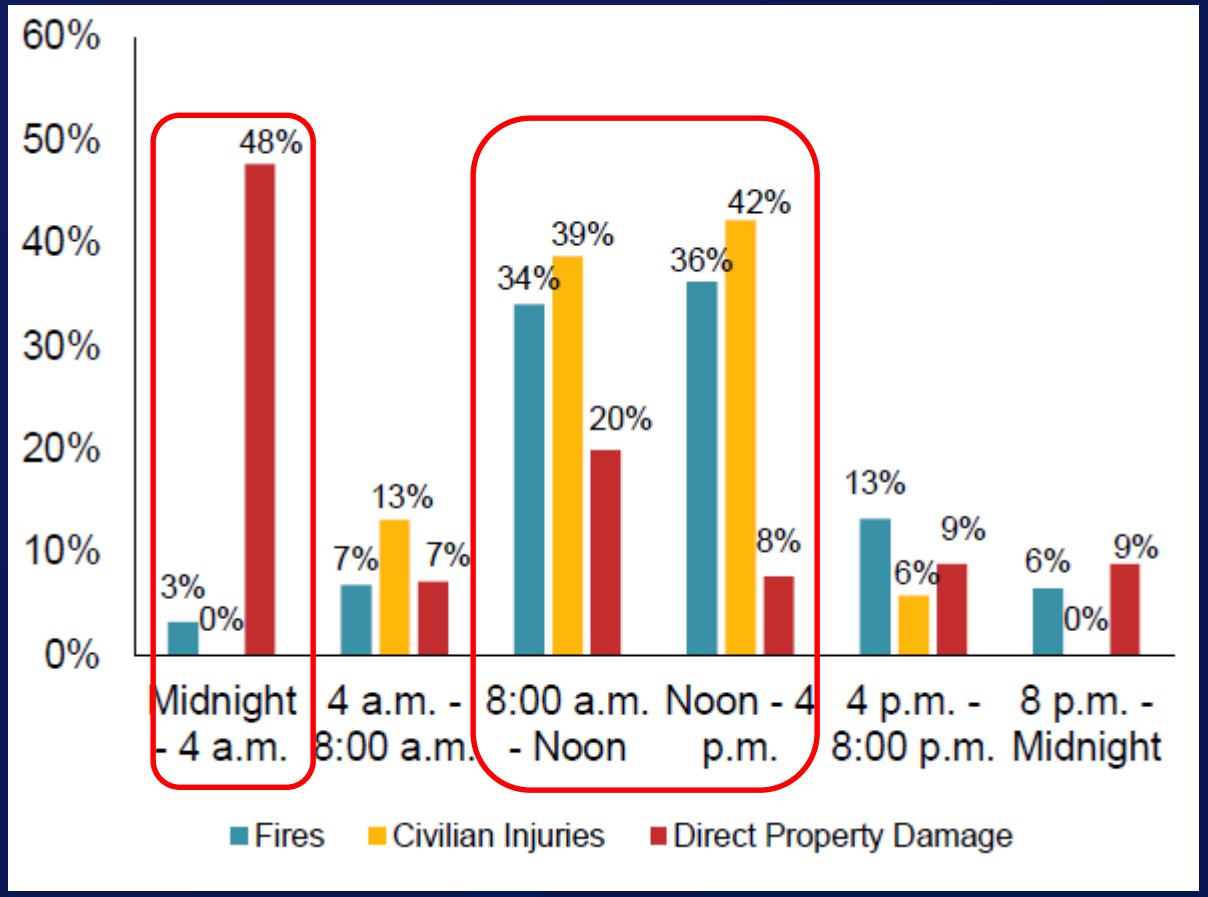


Area of Fire Origin – 2013-17

Source – NFPA statistics

Lavatory or locker room areas indicate arson or deliberate fire setting. Fires in kitches/cooking areas are also common

FIRE INCIDENT STATISTICS…(Contd) 3



Time of Fire Origin – 2013-17

Source – NFPA statistics

Most fires originated when students are present. However fires during late night hours result in maximum damage.

OTHER RELEVANT STATISTICS…

- Almost one-third of school fires were caused by cooking equipment and 10 percent by heating equipment.
- Elementary school fires most often began with the ignition of trash or cooking materials. In middle/high schools, rubbish, magazines, writing paper and cooking materials were the main reasons.
- Two in five school fires were intentionally set. Fires with an intentional cause were more prevalent in high school and middle schools (47% of total) than in elementary schools (37%).

FIRES & SMOKE

As a fire burns, it generates heat as well as products of combustion due to the chemical reactions associated with the combustion process.

These products of combustion can include gases, such as carbon dioxide, carbon monoxide, water vapor and other gases (depending upon the type of fuel), as well as solids such as “soot,” and liquids. For indoor fires, the products will also depend on the type of material involved and ventilation available to the fire.

FIRES IN ENCLOSED BUILDINGS

- The presence of a roof and walls over a fire prevents the heat and smoke from escaping the building
- Fire inside a compartment has limited oxygen depending on the ventilation available, resulting in different (and more toxic) products of combustion.

EFFECTS OF SMOKE

Smoke affects occupants and building in different ways. During building fires, its important effects on humans are:

- Reduction in visibility
- Effects of toxic gases (in smoke) on body systems
- Burns due to heat radiated from hot smoke

Though not strictly a thumb rule, the above effects occur more or less, in the order shown above.

VISIBILITY IN HOME FIRES

An experiment involving fire in a modern armchair. The room is connected through an open door to other rooms of the house.

After 3 minutes the smoke concentration starts to build up in the entire system. By 4 minutes it is dense and by 5 it is not possible even to see the fire.

TYPES OF FIRE GASES

Fire Gas Toxicants can be normally classified into–

Asphyxiants – those causing central nervous depression, resulting in loss of consciousness and ultimately, death. E.g. CO, HCN

Irritants – those which cause (i) sensory and (ii) pulmonary irritation. E.g. Halogen acids, NOx.

Other toxicants – those exhibiting other or unusual effects (this has few documented examples)

ASPHYXIANTS - Effects of CO

Concentration	Symptoms
35 ppm (0.0035%)	Headache and dizziness within six to eight hours of constant exposure
100 ppm (0.01%)	Slight headache in two to three hours
200 ppm (0.02%)	Slight headache within two to three hours; loss of judgment
400 ppm (0.04%)	Frontal headache within one to two hours
800 ppm (0.08%)	Dizziness, nausea, and convulsions within 45 min; insensible within 2 hours
1,600 ppm (0.16%)	Headache, tachycardia, dizziness, and nausea within 20 min; death in less than 2 hours
3,200 ppm (0.32%)	Headache, dizziness and nausea in five to ten minutes. Death within 30 minutes.
6,400 ppm (0.64%)	Headache and dizziness in one to two minutes. Convulsions, respiratory arrest, and death in less than 20 minutes.
12,800 ppm (1.28%)	Unconsciousness after 2-3 breaths. Death in less than three minutes.

SCHOOL OCCUPANT CHARACTERISTICS

- Occupants in educational occupancies vary in their ability to deal with an emergency condition, depending on their age, mental and physical conditions, as well as the facility's physical characteristics.
- Children younger than those in the third grade require special consideration because of their limited ability to traverse stairs or evacuate effectively in an emergency
- Schools having physically and mentally challenged students pose additional risk, and presence of trained staff offers a significant risk reduction in such cases.

BUILDING CHARACTERISTICS

- Local building codes will dictate school building designs and features. In most cases, if codes are strictly enforced, this should ensure a safe design.

- Economics, site restrictions, or other requirements often dictate design considerations, however the design can be made safe by adhering to design codes

- The main risk arises from occupancy changes i.e. use of other existing buildings for schools and/or modifications and alterations in existing design

COMMON FIRE HAZARDS & CHALLENGES

- Typically, a school has more than one type of occupancy e.g. assembly halls, laboratories, kitchens, office areas, etc, which has different fire hazards

- Normal fuels inside schools include wooden and plastic furniture, stationery and furnishings. Office areas typically have workstations, printers & other equipment

- Areas having higher fire hazard include laboratories, cooking areas, locker rooms, workshops, stores, etc, due to the materials handled/stored or ignition sources

COMMON FIRE HAZARDS & CHALLENGES - 2

- Clothing, personal effects, and other combustible materials pose additional fire hazards. Child-prepared artwork & teaching materials attached directly to walls are also considered hazards and should be restricted.

- Ignition sources include electrical equipment and systems, while incendiary material (matches/ lighters) are also significant, especially in middle/high schools.

- Areas having higher fire hazard include laboratories, cooking areas, locker rooms, workshops, stores, etc, due to the materials handled/stored or ignition sources

COMMON FIRE HAZARDS & CHALLENGES - 3

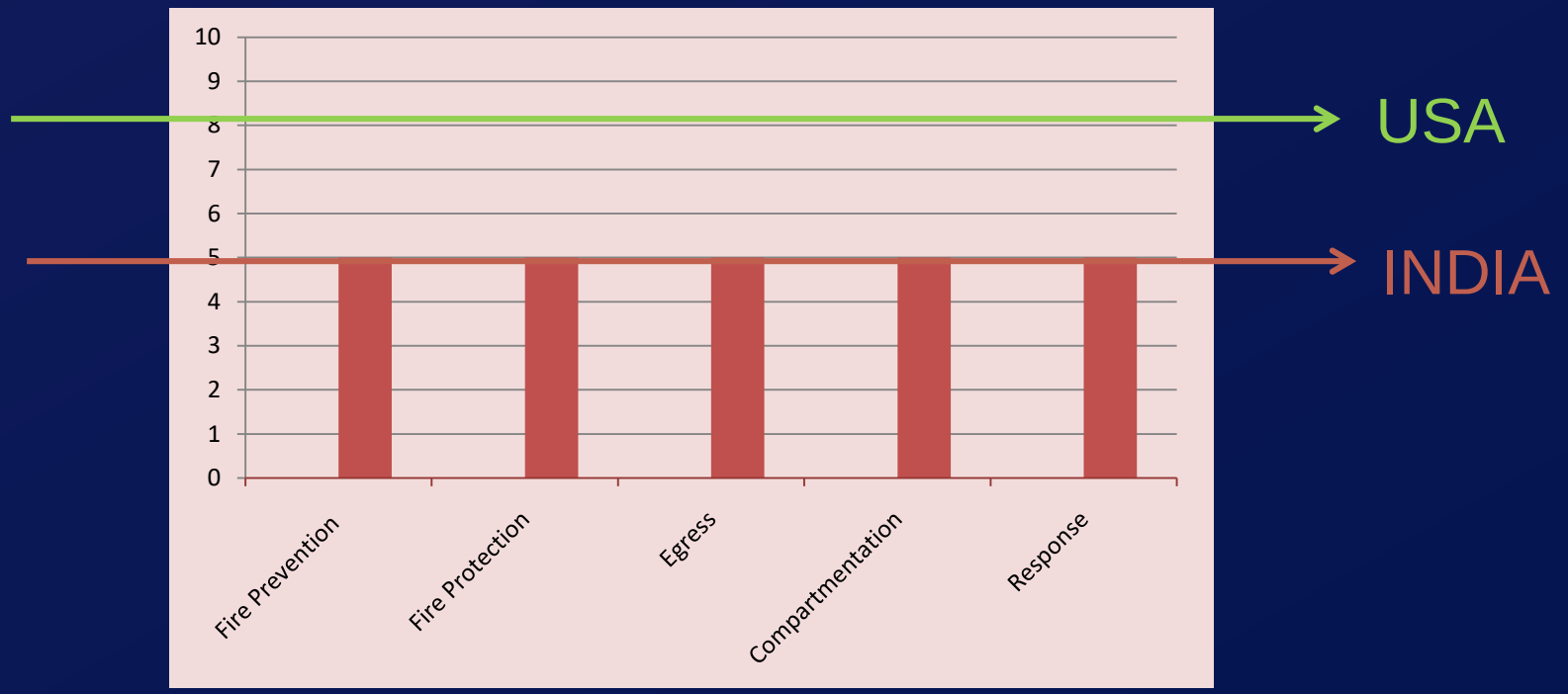
- The presence of a variety of occupants, right from adults to very young, and including physically/ mentally challenged children poses evacuation challenges

- Permanent/ temporary modifications/ changes in layouts need to be carefully studied from fire and life safety point of view.

- Handling/movement of furniture/ similar items need to be supervised to ensure that they are not stored inadvertently or cause impediments to exits.

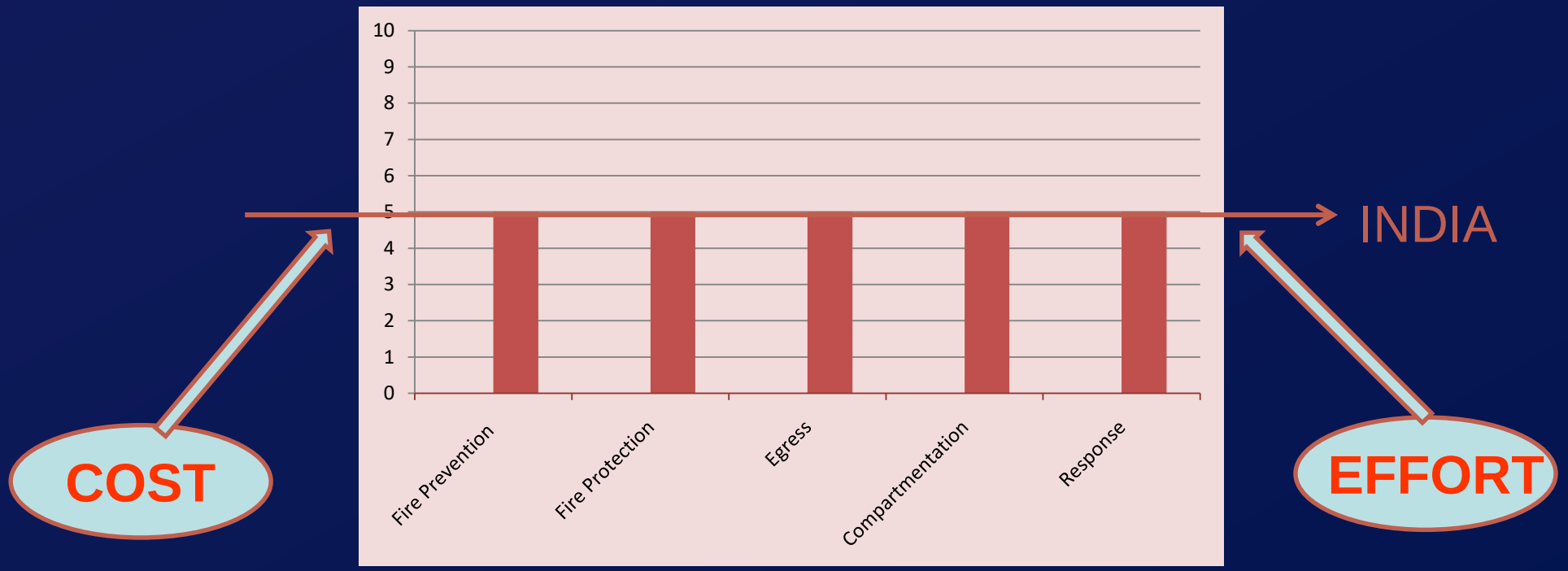
COMMON FIRE HAZARDS & CHALLENGES - 3

HOW MUCH FIRE SAFETY IS ENOUGH?



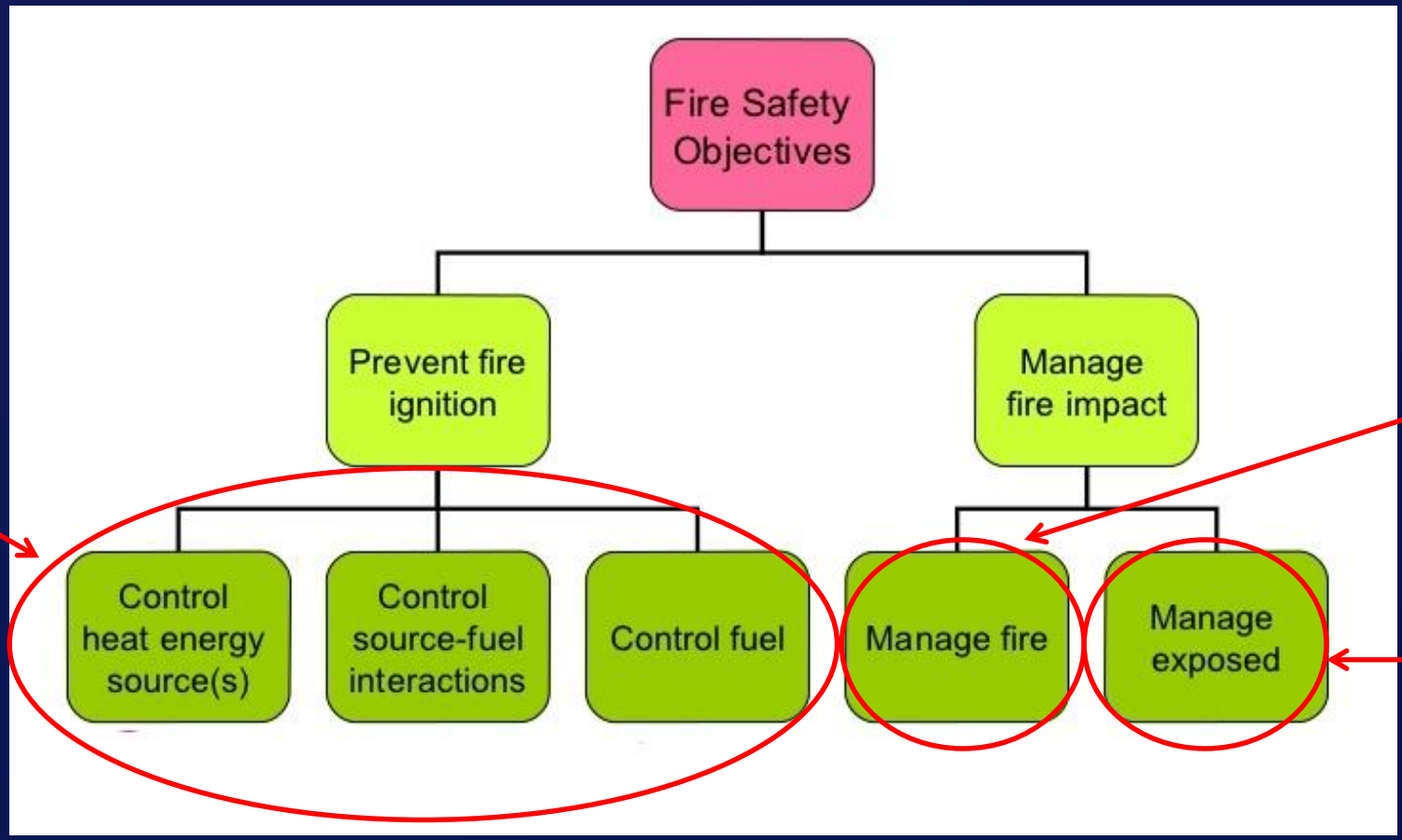
The Acceptable level of safety is determined by society. Different countries will have different acceptable levels of safety depending on their outlook and resources.

COST OF ACHIEVING FIRE SAFETY



Society should be willing to accept the cost implication and effort required to maintain the acceptable level of fire safety

FIRE SAFETY CONCEPTS TREE (NFPA)



The fire safety concepts tree provides the basic logic and concepts for achieving building fire safety. Further levels under each concept provide further information on actions required to meet the requirements of that concept/ activity .

OCCUPANCY REQUIREMENTS

The occupancy type then determines design factors related to the below. These are typically specified in codes.

- Building Height & Area
- Occupants Loads/ Exits
- Travel distances & routes
- Structural Fire Protection
- Compartmentation
- Fire brigade access
- Fire fighting equipment
- Fire detection/alarm systems
- Emergency signs/ lighting

CODE REQUIREMENTS - EDUCATIONAL OCCUPANCIES

Table 2 Comparative Floor Area Ratios for Occupancies Facing One Public Street at least 9 m Wide
(*Clause* 3.4.4.2)

Sl No.	Occupancy Classification	Type of Construction			
		Type 1	Type 2	Type 3	Type 4
(1)	(2)	(3)	(4)	(5)	(6)
i)	Residential	UL	2.0	1.4	1.0
ii)	Educational	UL	2.0	1.4	1.0
iii)	Institutional	UL	1.5	1.0	0.8
iv)	Assembly	UL	1.0	0.7	0.5
v)	Business	UL	2.9	2.3	1.6
vi)	Mercantile	8.0	1.8	1.4	1.0
vii)	Industrial	7.5	1.9	1.6	1.3
viii)	Storage (*see* Note 5)	6.0	1.5	1.3	1.0
ix)	Hazardous (*see* Note 5)	2.8	1.1	0.9	NP

UL — Unlimited.

NP — Not permitted.

Table 5 Travel Distance (Based on Occupancy and Construction Type)
(*Clauses* 4.4.2.1 *and* 4.4.2.2)

Sl No.	Occupancy Group	Maximum Travel Distance m	
		Types 1 and 2	Types 3 and 4
(1)	(2)	(3)	(4)
i)	Residential (Group A)	30.00	22.50
ii)	Educational (Group B)	30.00	22.50
iii)	Institutional (Group C)	30.00	22.50
iv)	Assembly (Group D)	30.00	30.00
v)	Business (Group E)	30.00	30.00
vi)	Mercantile (Group F)	30.00	30.00
vii)	Industrial (Group G)		
	G-1, G-2	45.00	*See* Note 3
	G-3	22.50	
viii)	Storage (Group H)	30.00	
ix)	Hazardous (Group J)	22.50	

NOTES

1 For fully sprinklered building, the travel distance may be increased by 50 percent of the values specified.

2 Ramp shall not be counted as an exit in case of basements below the first basement in car parking.

3 Construction of Type 3 or Type 4 is not permitted.

Source: NBC 2016

E.G. SPECIFIC CODE REQUIREMENTS

6.2.2 *Life Safety*

a) Every room with a capacity of over 45 persons in area shall have at least two doorways. Exit doors shall be operated by panic bars except that doors leading from classrooms directly to the outside may be equipped with the same type of lock as is used on classroom doors leading to corridor, with no provision whatsoever for locking against egress from the classroom.

c) Rooms or areas for use by the preschool, kindergarten, Class/Grade 1 students shall be located on ground floor/level of exit discharge. Rooms or areas occupied by Class/Grade II students shall be located not above one floor higher than ground floor/level of exit discharge.

6.2.3 *Additional Precautions*

a) Storage of volatile flammable liquids shall be prohibited and the handling of such liquids shall be restricted to science laboratories only.

Source: NBC 2016

MANAGING FIRE HAZARDS

- At design stage, it is important to ensure that code requirements are fully met. Any changes to design should be carefully evaluated.

- During occupancy and operation of school, all relevant stakeholders should be made aware of the fire hazards and the need for effective fire prevention practices.

- Response to fire emergencies cannot be effective unless there is a proper response plan in place, disseminated to all concerned, and is regularly rehearsed through drills.

EMERGENCY/CRISIS

Fire

Flash Flood

Earthquake

Fire

Chemical Spill

Planning
Awareness
Response

Student Riots

Terrorism

BOMB THREAT

PLANNING

- Collaborative
- Comprehensive
- Continuous
- Convenient

4 W’s (Who, What, When, Where)

AWARENESS

- Principals & Staff
- Pupils
- Parents
- Public

- All relevant people need to be made aware of their roles, responsibilities and procedures

- Awareness is created through training and communication

RESPONSE

- Rehearsed
- Rapid
- Right
- Reported

- Drills are required to be carried out to develop confidence and familiarity
- Review of drills are equally important to ensure mistakes are eliminated

DRILLS!!

DISASTER MANAGEMENT PLAN/ ERP

- School should develop a Disaster Management Plan defining procedures to confine, contain, consolidate and control the emergency and/or crisis

- This plan should include among other aspects, system of warnings, communication protocols within and outside the school (use of PA system), identification of evacuation routes, access by emergency vehicles, care of children with special needs, etc

DISASTER MANAGEMENT PLAN/ ERP - 2

- School Profile
- DMP Core & Supporting Teams - Roles & responsibilities
- Communication protocols and systems
- Hazard identification and safety assessment
- Emergency Procedures to be followed
- Inventory of resources available to the school
- Dissemination of the Plan
- Conduct of regular emergency drills (& review)
- Evaluation and updation of Plan for effectiveness

QUESTIONS?