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Architectural Fire Safety: A Handbook on Prevention Through Design (Ptd) and Early Design Considerations as Per the Nbc of India

A.S. Menon

Professor and Fire Protection Specialist

Abstract

India's rapid urbanization, coupled with the collaboration between international and Indian architects, has led to the delivery of globally recognized projects that adhere to various design and construction codes. This synergy plays a critical role in meeting evolving standards and ensuring that the design and construction process is streamlined, efficient, and compliant with both local and international regulations. Fire and life safety codes are pivotal in regulating building practices to prevent fires and safeguard lives. Architects, being at the heart of community development, play a vital role in integrating these safety regulations into their designs. The design process, with its multiple stages, must consistently align with fire and life safety requirements of the National Building Code of India. One of the primary challenges that often causes delays in architectural projects is the late incorporation of life safety considerations into the design.

To address this, the study suggests that architects take a proactive approach by prevention through design (PtD) by ensuring the Hazards are classified and the sustainable aspects of safety measures are embedded early in the design process, improving project timelines and ensuring compliance with the fire and life safety code.

Keywords: Fire and life safety codes, National building code of India, Fire safety engineering, Fire safety Preventive through design, Passive fire protection techniques, Fire risk assessments, Building safety codes, Fire safety compliance, fire prevention, electrical systems, fire detection, early warning...

INTRODUCTION

Architects do not normally want to be Fire Scientist but to ensure a Reasonable Standard of Fire Safety in the Buildings or Facilities designed by them, it is necessary to be aware of what happens in a Fire and how the standards are classified.

FIRE SCIENCE

- **Ignition**

For combustion to occur, Oxygen, Heat and Fuel source must be present and Fire is only a series of very rapid chemical reaction of above said ingredients of Fire.

Triangle of Fire is known to everybody and removal of any said substance will lead to termination of Fire. During the Design Process, Architects will also bear this objective in mind.

Flames are the visible manifestation of this reaction between gaseous fuel and oxygen. Once gas fuel is mixed with oxygen, then the said mixture is ready to react and create fire instantly which is described as "Pre-mixed flame". Once Fuel is solid or liquid, it is to be heated to gives off flammable vapors, then such Flames are described as "Diffusion Flames". Since the Rate of Burning of any Building is directly linked to type of Flames, Architects should aware of such Technicalities of combustion process. Any amount of Fire Protection to the Building is to be designed according to the anticipation of Fire.

- **Types of Fire or NFPA Classes of Fire**

The Fire classification scheme used by the U.S. Coast Guard was originally devised by the National Fire Protection Association (NFPA). In this scheme, Fires are classed according to the Fuel involved in Combustion process or Fire.

They are:

CLASS "A" Fires: Fires involving common combustible materials (ash- producing substances) which can be extinguished by the use of water or water solutions. Materials in this category include wood, furniture's or wood-based materials, foam products, cloth, paper, rubber and certain plastics.

CLASS "B" Fires: Fires involving Flammable or Combustible liquids, greases, certain chemicals, etc. Extinguishment of B Class Fire is accomplished by cutting off the supply of oxygen to the Fire or by preventing emission of Flammable vapours from being given off. This method of extinguishment is also called as blanketing which is used for killing Fires in Petrol, Diesel or much highly Flammable liquids. Class B Fires can be put off by applying Foam (Chemical or Mechanical Foam), Co2, Inert gas, Dry Chemical Powder etc.

CLASS "C" Fires: Fires involving energized electrical equipment's, conductors or appliances and Flammable gases. Non-Conducting type Extinguishment Agents like Co2, FM-200, Clean Agent, Dry Chemical Powder, can be effectively used to kill "C" Class Fire

CLASS "D" Fires: Fires involving combustible Metals like Sodium. Potassium, Magnesium, Titanium, Aluminum and Reactive Chemicals are called as Class D Fires. Any heat-absorbing materials or TEC (Tetro Eutectic Chloride) can be used effectively to tackle such Fires.

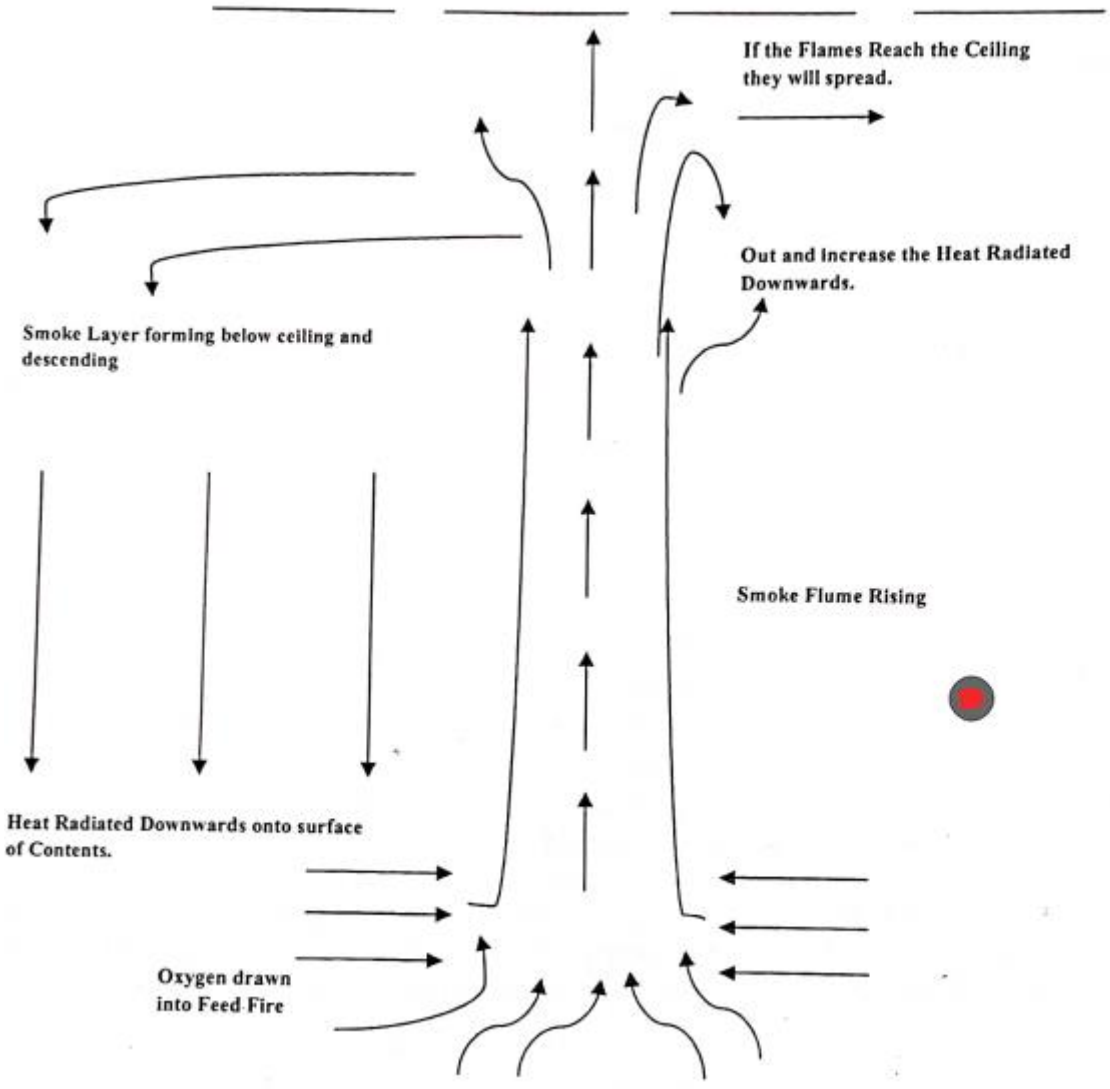
The main objectives of this classification scheme are to aid an Architect in selecting the appropriate in selecting the appropriate extinguishing agent. However, Water is termed as BEST and EASILY AVAILABLE FIRE KNOCK DOWN agent which can be applied effectively on Fires according to behavior of Fuel involved, eg for burning liquid application of direct jet of water is forbidden but Fog can be created from Water by adopting and provisioning a Fog Nozzle. Mist application is resorted now-a-days to control Transformer Fires. So, a sound Fire Fighting Principle is to be devised by Architect while designing the Facility or Building. Wood is composed mainly of carbon, hydrogen and oxygen and smaller amounts of nitrogen and other elements. The ignition temperature of wood depends on many factors such as size, shape, moisture content and type. Generally, the ignition temperature of wood is about 204℃. However, it is believed that 100℃ is the maximum temperature to which wood can be subjected over a long period of time without self-ignition taking place.

The properties of wood and wood-based materials depend on the particular type involved. For example, seasoned air-dried maple (a hard wood) produces greater heat on burning than does Pine (a soft wood) that has been seasoned and dried similarly. However, a source of ignition such as spark, open flame, contact with hot surface or exposure to heat radiation is usually necessary. Wood based products produce Water vapor, heat, carbon dioxide and carbon monoxide, hydrogen sulphide and hence Architect has to bear in mind while designing his building to balance the usage of wood-based products.

Textiles in the form of clothing, furniture's, carpets, bedding etc are extensively used in Buildings. Almost all Textile Fibers are combustible, but wool is difficult to ignite, it tends to smoulder and char rather than to burn freely. Silk is the least dangerous Fiber.

- **Fire Growth**

Understanding the burning characteristics of Fire and its growth mechanism is very important for Architects. The three basic mechanisms of heat transfer are Conduction, Convection and Radiation and all are common in any Building Fires. Conduction is the mode of heat transfer within Solids and Convection involves the movement of the medium and it is restricted to liquids and gases. Radiation is a form of heat transfer which does not require an intervening medium between the source and receiver. It is important for the Architect to understand the stages in the development of an enclosed Fire as they will be most common in any Building.



A BUILDING FIRE

Steel will loose two-thirds of its tensile strength by the time it is heated to 600℃. The Survey indicates, the temperature in a small Fire in Building will reach 550℃ within a few seconds and lead to total collapse of structure. So heat generation in any building is to be controlled. Collapse of Building by heat is common but not due to smoke. Smoke kills occupants due to toxicity.

IS: 432 – 1966 (Part -1) MECHANICAL PROPERTIES OF BARS

Sl.No	**Type and Nominal Size of Bar**	**Ultimate Tensile Stress Min**	**Yield Stress Min**	**Elongation* percent Min**
1	**Mild Steel Grade I**			
	For bars up to and including 20mm	410	250	23
	For bars over 20 mm, up to and including 50 mm	410	240	23
2	**Mild Steel Grade II**			
	For bars up to and including 20mm	370	225	23
	For bars over 20 mm, up to and including 50 mm	370	215	23
3	**Medium Tensile Steel**			
	For bars up to and including 16mm	540	350	20
	For bars over 16 mm, up to and including 32 mm	540	340	20
	For bars over 32 mm, up to and including 50 mm	510	330	20

* Elongation on a gauge length $5{\cdot}65\sqrt{}$ So where So is the cross-sectional area of the test piece.

IS : 961 – 1975 ** STRUCTURAL STEELS (HIGH TENSILE)

Grade	Materials	Chemical Composition Percent				Mechanical Properties		
		C Max	S Max	P Max	Nominal Thickness dia / mm	Tensile Strength N/mm^2 kgf /mm^2	Yield Stress N/mm^2 kgf /mm^2	Elongation percent min
Fe570HT (St 58-HT	Semi Killed or Killed	0.27	0.055	0.055	Below 6 6 upto and including 28	* Bend test 570 (58)	Only shall 350 (36)	20

					Over 28 upto and including 45	570 (58)	340 (35)	20
					Over 45 upto and including 63	570 (58)	320 (33)	20
					Over 63	540 (55)	290 (30)	20
Fe 540WHT (St.55.HT w)	Killed	0.20	0.055	0.055	Below 6	* Bend Test required	Only shall	
					6 upto and including 16	540 (55)	350 (36)	20
					Over 16 upto and including 32	540 (55)	340 (35)	20
					Over 32 upto and including 63	510 (52)	330 (34)	20
					Over 63	490 (50)	280 (29)	20

* In the case of thickness or diameter below 6mm, the yield stress shall be assumed to be at least the same as that for thickness or diameter between 6mm and 16mm

* In the case of thickness or diameter below 6mm, the yield stress shall be assumed to be at least the same as that for thickness or diameter between 6mm and 28mm

NOTE:

1. In case of Fe 570- HT steel Phosphorus higher than that specified above is allowed if it is added deliverately as an alloying element.
2. When chromium is used as an alloying element in Fe 540 WHTsteel. It is desirable that the combined percentages of manganese and chromium should not exceed 20 percent.
3. Copper maybe percent between 0.20 and 0.35 percent as mutually agreed upon between the supplier and purchaser.
4. When the steel is silicon killed the product analysis is shall show a minimum of 0.10% silicon. When the steel is aluminum killed or killed with a combination of aluminum and silicon the requirement regarding minimum silicon content does not apply.

- **Fire Safety Objectives & Tactics**

Architect should be aware of Fire Safety Objectives and Tactics in any type of Building, he designed and erected. Objectives & Tactics are similar in any type of Building.

Objectives will include aesthetic, functional, technological and economic issues. If the Design of Building is to be successful, then the objectives will need to be integrated into a Coherent and balanced. Whole Fire Safety is normally considered to cover both the Safety of People and of property in the Building and surrounding areas. The degree of Fire Protection may vary from Building to Building according to the occupancies viz Fire Safety Design of a Hospital where maintenance of the service is considered to be an important aspect due to consequential loss of life due to postponed operation and treatment

Five tactics available to the Architect seeking to fulfil the Objectives of Life Safety and Property Protection are:

Prevention - ensuring that Fires do not start by controlling ignition and fuel sources.

Communication- ensuring that if ignition occurs, the occupants are informed and any Active Fire Systems are triggered.

Escape - ensuring that the occupants of the building and the surrounding areas are able to move to places of safety before they are threatened by the heat and smoke.

Containment - ensuring that the Fire is contained to the smallest possible area limiting the amount of property likely to be damaged and the threat to life safety.

Extinguishment - Ensuring that the Fire can be extinguished quickly and with minimum consequential damage to the building.

CLASSIFICATION OF BUILDING BASED ON OCCUPANCY:

All Buildings first shall be classified according to the use or the character of occupancies like

GROUP A - Residential
GROUP B - Educational
GROUP C - Institutional
GROUP D - Assembly
GROUP E - Business
GROUP F - Mercantile
GROUP G - Industrial
GROUP H - Storage
GROUP J - Hazardous

GROUP A

Any building in which Sleeping accommodation is provided for Normal residential purposes with or without cooking. GROUP A is further subdivided into

Subdivision A-1-Lodging or rooming houses

(INNS, Clubs, These shall include any building or group of Buildings Motels & Guest Houses) With separate sleeping accommodation for a total of not more than 40 persons (beds) with dinning facilities but not with individual working facilities.

Subdivision A-2- One or Two Family Private dwellings

These shall include any private dwellings which is Occupied by one or two families and has a Total Sleeping accommodation for not more than 20.

Subdivision A-3 – Dormitories

(School, College, Any building in which group sleeping –Hostels, Private Hostel, accommodation is provided. Military Barracks)

Subdivision A-4-Apartment houses (flats)

(Apartments houses, These shall include any building or structure in which Mansions) living Quarters are provided.

Subdivision A-5- Hotels

(Hotels upto These shall include any building or group of buildings 4 star category) where sleeping accommodation with or without dining
facilities are provided.

Subdivision A-6- Hotels (Starred)

Buildings approved as 5 Star or more by authorities
concerned.

GROUP B - Educational Buildings

These shall include any building used for School, College, other Training institutions for day -care purposes involving assembly for instruction, education or recreation for not less than 20 students.

GROUP B shall be further Sub - divided as

Sub Division B-1 - Schools up to semi Secondary level
Sub Division B-2 - All other Training Institutions not less than 100 in number.
Note: If Residential Accommodation is provided, Treat it as A-3

GROUP C-Institutional Buildings

These Buildings are used for purposes such as Medical or other Treatment or Care of persons, suffering from Physical or Mental illness, disease or infirmity, care of infants. These Building ordinarily provide sleeping accommodation for the occupants but liberty of the INNATES is restricted.

GROUP C- further subdivided into

Subdivision C-1- Hospitals and sanatoria
Subdivision C-2- Custodial Institutions
Eg. Homes for aged, Convalescent homes & Orphanages
Subdivision C-3 – For housing persons under restraint like Jails, Mental Hospitals, Reformatories

GROUP D - Assembly Buildings

These shall include any Building where number of person not less than 50 congregate or gather for amusement, recreation, social, religious, patriotic, civil, travel & similar purposes Eg. Theatres, Motion picture houses. Assembly Halls, Auditorium, Exhibition Halls, Museum, restaurants, Places of worship, dance halls, Air terminal, Public transportation places, clubs, etc.
Further divisions are:
Subdivision D-1 - Buildings having a theatrical or motion Picture or any other stage and fixed scats for area 1000 persons
Subdivision D-2- Buildings having a theatrical or motion picture seats up to 1000
Subdivision D-3- Buildings without performance stage for 300 or more
Subdivision D-4- Buildings without performance stage less than 300
Subdivision D-5- All other structures including Temporary structures.
Subdivision D-6- Buildings with mixed occupancies like Restaurant, Theatre, Shopping malls

Subdivision D-7- All other structures not covered above.

GROUP E - BUSINESS BUILDINGS

Any Building or part of a building which is used for transaction of business.

City Halls, Town Halls, Court Houses and Libraries shall be classified in this group so far as the principal function of these is transaction of public business and keeping of books & records.

Further Sub-Divisions of Business Building are:

Sub division E-1 - Office, Banks, professional establishments like office of architects, consultants, Lawyers, Engineers, Doctors & Police station

Sub division E-2 - Laboratories, Restaurants Establishments, Libraries & Test houses.

Sub division E-3 - Computer Installations

Sub division E-4 - Telephone Exchanges

Sub division E-5 - Broad Casting & TV Stations.

GROUP F- MERCANTILE BUILDINGS

Buildings used as shops, stores & markets for display & sale of merchandize either whole sale or Retail.

Subdivision are as follow:

1. Sub division F-1 - Shops, Departmental stores etc., with area upto 500m²
2. Sub division F-2 - Shops, Departmental stores etc., with ares more than 500m²
3. Sub division F-3 - UG Shopping Centres

GROUP G- INDUSTRIAL BUILDINGS

Buildings in which Products & Materials are fabricated, assembled, manufactured or processed- Eg. Assembly plants, Industrial Labs Dry Cleaning Plants, Power plants, Generating Units, Pumping stations, Gas Plants, Refineries, Diaries, Saw mills etc

These Buildings are sub divided into followings:

Subdivision G-1 – Buildings used for low hazards industries, where contents are of such comparative low combustibility and Processes or Operations Conducted therein are such a Nature that there are hardly any possibilities for any self-propagating Fire to occur.

Subdivision G-2 - Moderate hazard industries where contents stored or industrial processes or operations conducted therein are liable to give RISE to a Fire which will burn with moderate rapidly or result in other hazardous situation and may give off a high volume of smoke.

Subdivision G-3 - The buildings in which the contents or industrial process or operations conducted therein are liable to give rise to Fire which will burn with extreme rapidity or result in other hazardous situation or form which poisonous fumes or explosions are to be feared in the event of Fire.

GROUP H - Storage Buildings

Buildings used primarily for the storage or sheltering (including servicing, processing, of repairs incidental to storage) of goods, ware or merchandise (expect those that involve highly combustible or explosive product or materials)- Eg., Transit sheets, store houses, truck & marine Terminals, Garages, hangers, grain elevators etc.

GROUP J - Hazardous Buildings

Buildings used for the storage, handling, manufacture or processing of highly combustible or explosive materials or products which are liable to burn with extreme rapidity. Fire in this type of Building may lead to explosion and emit poisonous fumes Eg:

1. Storage under pressure of more than 0.1 N/mm² and in quantities exceeding 70m² of acetylene, hydrogen, illuminating & natural gases, ammonia, chlorine, phosgene, sulphur- dioxide, Co-2 etc.
2. (b) Storage of LPG-1, rocket propellants, etc.
3. Explosive materials
4. Artificial flowers, synthetic leathers, ammunition, Fire works etc.

FIRE ZONES

The City or Area under the jurisdiction of authority shall for the purpose of the code, be demarcated in to district Zones, based on Fire Hazard inherent in the buildings and structu accessing to **occupancy** which shall be called as Fire Zones.

Number & Designation of Fire Zones

It depends upon the existing layout, types of Buildings construction, classification of existing Buildings and expected future developments of the City or Area.

Fire Zone no: 1 - residential (Group A)
Educational (G-B), Institutional (G-C),
Assembly (G-B) Small business
(sub division E-J) & Retails
Mercantile (G-F)
Fire Zone no : 2
Comprise Business (Sub division E-2 to E-5) and Industrial buildings (sub division
G- 1 & G-2) except High Hazard industry undertakes (Sub division G-3)
Fire Zone no: 3
Comprise of High Hazards Buildings (sub division C-3) Storage Buildings (G-H)
Buildings for hazardous (GROUP J)
Change in Fire Zone Boundaries

When administration intends to change Boundaries or When it is intended to include other areas or types of occupancies in any Fire Zone, it will promulgate Rules & Ordinances.

Overlapping Fire Zones:

When a building occupies more number of Fire Zones, the hazardous Zone will be considered

Temporary buildings:

They shall be permitted only in Fire Zone No 1 & 2 and a special permit is to be obtained Adequate Fire Protection system is to be installed.

Restrictions on the type of Construction for New Buildings:

Building erected in Fire Zone No.1 Shall conform to type 1, 2, 3 or 4.
Building erected in F.Z No.2 shall conform to construction of type 1, 2, or 3.
Building erected in F.2. No.3 shall conform to construction of Type 1 or 2

FIRE IN DWELLING HOUSES

Dwelling houses which is also termed as Lodges, is an alternatives to Expensive Hotels. A part of occup-

ants in such facility may perhaps be Psychiatric patients capable of living in less restrictive environments like Mental Hospitals, who are allowed to live in general populations or community with a warning to be careful. Such personnel prefer not to assume all the responsibilities of independent living, meal preparations and the like. Other occupants perhaps a major share may be Travellers who need bed-and-breakfast & Meals support for Dwelling Houses.

Most of above-detailed occupants leave mercantiles or belongings at the Ground Floor under Clock Room, which should have at least 1hr Fire Resistant Wall and Automatic Sprinkler. Sleeping Room will be on subsequent Floors and Code or Rules do not allow such arrangement.

Most of Dwelling Houses in India are modified from some other Classes of occupancy, where care is not taken to provide appropriate protection from Fire starting. There may not be separate Ducts for Fire, electrical ducts may not be sealed properly or Cables are not protected or laid as per requirements or rules and contribute to :

Lack of Fire Stopping

Lack of Fire stopping at inceptional stage is the result of strict code of practice implemented by Fire Service. Occupants in the facility are not trained as they are not bothered to stop Fire detected at pathways. Improper escape routes will be another lacunae. Improper storage of combustible materials is also detected in such class of occupancy.

Unprotected Vertical Openings

Unprotected Vertical Openings Unprotected vertical openings will be abundantly found. Apart from usable Ducts, you will find many unused, and also holes made on old floors, which never closed. All will work as chimney during Fire out break.

Building Services

Generally it is limited to attend calls of occupants to purchase something from outside. In some places, there may be a person or Two will be available for taking care of Electrical System, Generator and air Conditioning systems. However they are not bothered shout prevention of electrical overloading.

Improper storage of Personnel Belongings

In most of Places, personnel belongings are stored under staircases locked with chains to a hook. Eventually egress corridors are filled with smoke created from Fire of such belongings.

Means of Escape

It is a paramount concerns, and most of Escape Routes do not conform to strict Rules laid down by the authorities. It will not be a SAFE EGRESS to outside the Building. For details, study of SAFE ESCAPE ROUTE, Architects can refer NFPA 101, Chapter 5.

Detection & Alarm Systems & Sprinkler System

Both these systems play a critical role but most of Dwelling Houses are not provided with such systems.

FIRES IN FAMILY DWELLINGS

Family Dwellings are defined as Residential structures in which not more than two households reside. These Dwelling Units may be attached to or detached from one another and typical styles include detached single Family dwellings, Town Houses and Duplexes

Fires in most of Residential Category or class will be almost similar as Chemical reaction during Fire. Fires in Lodging or Rooming Houses earlier indicated before will be almost similar but in Family Dwelling, Kitchen appliances and materials are also involved and hence Fire will be severe. Since 83% of Residential Fires in U.S. are reported from one-and-Two Family Dwellings, proper installation and use of

Residential-type Smoke Detectors is compulsory in U.S. NFPA-72 recommends Smoke Detectors be installed on each level of Dwellings. After the occupants have been alerted, they must promptly evacuate. A written Fire Plan should be made showing Two Means of Escape from every rooms especially from Bed Rooms, and such plan is to be exhibited in every Room, and is to be practised periodically

Residential type automatic sprinkler systems provide a High Degree of Protections. This is in fact relatively a new automatic system which is not widely installed but technology is gaining in acceptance and use

Most of Fire Fatalities are a result of Toxic Gases, not burns and most victima die in Room that is not the Room or area of Fire Origin. In most of Fire deaths is due to inhalation of Toxic gases during sleeping or in unconscious state.

Causes of Ignition of Fire

The major cause of Fire starting is lighted tobacco products or smoking materials, Ignition of upholstered furniture, mattresses, or bedding is very common in one-and-Two Family Dwellings. Failure of Electrical Equipments, A.Cs, Cooking Arson are the other causes to start fire.

FIRES IN PUBLIC BUILDINGS LIKE EDUCATIONAL INSTITUTIONS OR SCHOOLS

Most of Schools and Colleges will have occupants who need directions to move to safe places during Fire. As quantum of student is not known to Architects, appropriate protection arrangement is to be provided. The following preventive measures can be initiated.

Proper usage of Building or Facility

Every class Rooms, Labs and Offices can be notified and labelled with details of equipments, area etc and suitably protected with First-aid equipments. Every m should have a minimum of Two Escape Rites and Escape plan is to be exhibited everywhere. Children should be trained properly and a quick evacuation should be monitored periodically

Signages

Proper signage for the use of First aid Fire Fighting Equipment should be provided. If major system like Fire Hydrant System is available, directions for the use of equipment or systems should be exhibited.

Lighting including Alternative Lighting:

Proper Lighting especially Emergency Lighting to illuminate the means of escape and signs must be provided. Emergency Lighting must be on, when normal light is failed. Separate wiring is essential.

Fires in any Educational Institutions involve children and hence proper care should be taken while designing any schools or colleges. When it is Residential Accommodation for Schools or Colleges termed as Hostels, maximum care should be taken to achieve optimum safety. Third party certification of such safety arrangement is advisable, which is essential in countries like U.S.

Fires in Offices-E-1

Since office is used for business transactions, appropriate Fire Protection could be given to such facilities. However the measure of Fire Protection depends upon the height of Building.

FIRES in large public gathering areas like Theatres, Wedding Halls, etc.:

(Group D-Assembly Buildings)

Fires in Assembly Building will have maximum Fire Deaths as most of Theatres, Churches, Temples, Wedding Halls, have narrow Escape Routes, which is in no way match the movements of occupants to a Safe Place within the limited Time Frame according to the nature of Fire and growth parameters. As persons assemble for amusement, recreation, social, religious or Travel Purposes, they are not known to

each other and help during evacuation will be minimum. Moreover their attention or concentration will be on the matter for which they assembled and hence escape during Fire take time, by the time which crowding and running may happen which will kill the people themselves. Inhalation of Toxic gases will be another cause of death.

FIRES in Godown and Warehouses:

Due to importance of Fires in Godowns and warehouses, an overview of the basic principles of Fire Protection & Storage Practices was published by NFPA. Modern Warehouses and Storage Occupancies are especially subject to rapidly developing Fires of great intensity because complex configurations of storage are conducive to rapid Fire Spread presenting numerous obstacles to manual Fire Suppression efforts. The only proven method of controlling a warehouse or godown fire is with properly designed and maintained automatic sprinkler system and if it is not provided, the likely hood of controlling a significant fire in a godown is at best minimal.

It is essential to recognize the significant difference between Control of a Fire and Extinguishment of a Fire in a Godown. A Fire is said to be under control when enough Fire Sprinklers have operated to stop the spread of the Fire by wetting Fuel ahead of the Fire. It also means that temperatures within the Building have been reduced to a point where the structure is no longer in danger of collapsing. Only a few minutes may be required for a sprinkler system to control Fire but it is far from extinguishment. Perhaps, it needs hours or days to extinguish the complete Fire.

In most of cases, the Godown owners may be busy in concentrating on good business climate instead of protecting the warehouse. If the warehouse or godown is insured, it will not solve the problems. When your warehouse is protected poorly, Insurance Companies cannot admit the claim for the full value of goods and for the warehouse itself.

For good storage, open aisles should be marked and followed. Maximum height of storage is to be fixed. Even an additional layer of storage may lead to failed spray from sprinklers.

High hazard commodities should be stored separately and adequately protected. Extensive storage of Plastic materials is dangerous and many Plastics emit dangerous toxic gases like polygene, which will kill the occupant instantaneously.

Warehouse Fire Fighting Operations and Pre-Incident Planning is to be organized by a committee consisting of Architect and Local Fire Officer and Divisional Fire Officer.

Visibility inside a warehouse during Fire incident is usually limited. Most of warehouses are built with limited sources of light. Hazards posed by stock will lead to Fire Death and hence personnel working at warehouse must be aware of Flammable liquids, Flammable aerosols, toxic chemicals stored therein. Ventilation is important in a warehouse fire. Automatic smoke and heat vents or mechanical smoke exhaust systems must aid Fire Fighters. Fire Fighter Orientation in Big Godowns can become confusing and personnel will loose the way and can easily become disoriented and lost.

Fires in Industrial Complexes:

Industrial Occupancies encompass a broad spectrum of purposes. Some employ many people to work in a single building. Other facilities house large items of equipment but have very few employees. As stated above it is very hard for the Architect to design an Industrial Facility unless he knows the method of operation and occupants involved in it. Method of operation must also indicate the items or contents under process, temperature at which they are heated, and hazardous nature of content and toxic gases emitted. However for better management, every facility can be divided in to Low, Medium and High Hazard Categories and Fire Protection can be aligned according to the above category initially.

It is advisable to conduct a Hazard Assessment and Evaluation of Production Facility and design fire protection as required. For more details, students can refer NFPA 101.

"It is better to be careful a hundred times than to get killed once", said Mark Twain. When we need this quote, the incidents which come to our mind immediately are Bhopal Tragedy, Fire & Explosion at Hind Matches Ltd, Sivakasi (where 39 Personnel were charred to death), Fire Crackers explosion at DMK Public meeting at Pallavaram, etc.

Pre-Incident Planning

Pre-incident Planning can be defined as a Written or Drawn document of what to do and what should not do during a Fire Incident in Industrial Complex. Such Document will be very valuable document for Fire Service, In-house Staff to act upon emergency. An Architect should be able to publish such Document and exhibit at appropriate places. Facility Management Department in Consultation with Fire Service, study Building or Factory Construction, Structural Protection, Building materials used in Construction, interior and exterior finishes, etc. Then occupancies stored and under process are studied carefully. They also look into the passive & active Fire protection systems available in the Building.

Emergency Planning in any Industrial Complex is the joint efforts of Manufacturing or Processing Exports and Enforcement Authorities. It reflects a level of practicability, maturity and refinement that have been acquired through years of experience in their respective areas of specialization and put together to achieve a Common Aim of protecting Lives & Natural Properties. There is no such thing as "Zero Risk". So the need for emergency preparedness and advance planning to contain and restrict to attain NO HUMAN LOSS and also lowest minimum damage to Machineries and Processing Plants. Emergency preparedness for Industrial Complexes in very important as losses in terms of Human beings and Property will be quite large. It meets a detailed and systematic approach at both the macro as well as micro levels. Usually the macro level aspects get proper attention while micro level ones are assumed to sort themselves out automatically. This is the flawed thinking leading to disasters. To achieve the desired result, Planning at the lower levels must be given equal and as much attention. An accident in a High Hazard Factory or Chemical Factory affects not only the personnel and property within the premises but very often those in the vicinity outside its boundaries too, those outside may suffer unfold misery for years to come as evidened in Bhopal Tragedy, or in Chernobyl Nuclear Disaster in Russia. What is important in Disaster Management, is the Emergency Plan must be practiced, exercised and most importantly rehearsed repeatedly to ensure that no response action contemplated before hand has been overlook, missed, eliminated or has overlapped.

(F) SIMPLE COMBUSTIBLE MATERIALS LIKE WOOD, CLOTH & PAPER

It may be hard fact to digest but fact remains true-wood is the simple most versatile structural material in use today. Wood also stands as the first structural material to be utilized by pre- historic man apart from its advantageous qualities of Light in weight, strong, durable, flexible and resistant, yet it possesses an intrinsic beauty. These characteristics have made it a persistent first choice construction material. Once construction is over, then most of spaces are filled with wood-based furniture's, furnishings and eventually an architect has to understand thoroughly of its nature as a Fuel and its behaviour as a structural material under conditions of Fire Break-out.

Raw wood can be used to make variety of wood-based building products like multiple-ply glue laminations, fibre board, insulation board, ceiling tile, plywood, particle board, etc.

Primary and secondary forest products are usually not consumed directly. They are the material from wh-

ich directly consumed products are constructed. Lumber a primary forest product is cut and shaped and used in making furnitures.

Wood is also a major raw-materials source for paper and paper based products, such as card board, box board, corrigated board, etc.

CHEMICAL FIRES, PAINTS, GLUE AND PETROLEUM, ETC.:

Chemicals play a significant role in today's society. We cannot imagine our lives without chemicals. Our progress in the scientific and technological fields depends on the use of chemicals. However, chemicals are not without hazards. Exposure to chemicals even in small quantities for a prolonged period can be dangerous. It not only affects the health of the persons handling them but also those working in the vicinity and those indirectly coming in contact with them. Our environment too is at Risk by the improper use of chemicals. Health hazards of Paints, Glue and Petroleum products when involved in Fire Hazard condition, is as bad as chemicals. The health hazards associated with Fire Condition, with Paints, Glue and Petroleum Products like skin problem, breathing problems, blood disorders, problem with nervous system, effect on kidney, liver etc., are well known and should be careful. The Health hazards of chemicals may be quite different. One example is water, whose chemical name is hydrogen oxide (H2O). Water is essential for our lives, without it we cannot survive for long. Another chemical with similar formula is called hydrogen peroxide (H2O2). It is a very reactive chemical and would cause serious poisoning if someone tried to drink it.

Some chemicals are inherently more toxic than others. Lead is an example of a toxic metal. It can cause serious health problems related to nervous system even in small doses. However, dosage determines the effect on our health and exposure is expressed in terms of ppm (Parts of the Chemical to a million parts of air) for most gases, vapours, and other aerosols. Brief exposure in hazardous chemicals is usually referred to as acute exposure. However, more concern is repeated exposure to small doses of hazardous chemicals over long periods, referred to as Chronic Exposure. Children and old people are more susceptible to the health hazards of chemicals. Women during Pregnancy may be more susceptible to certain chemicals and some chemicals have adverse health effects on the foetus. Again if a person is a smoker and is also exposed to Asbestos fibres the risk of having Lung Cancer increases 40 times more than the risk of exposure to Asbestos fibres alone.

Many chemicals and materials can catch fire or explode, causing extensive damage to Life and Property. Chemicals are in gaseous, liquid and solid states. Some chemicals are in glue or paste form too. One thing common to all chemicals including petroleum products is that they catch fire in the vapour form. When heat is applied to liquid flammable chemicals, they produce a flame if it comes in contact with a source of ignition of sufficient strength. Generally, all liquid chemicals produce vapours at all temperatures, but at a certain temperature called the Flash Point, they produce enough vapour to sustain a flash of Fire if external source of Ignition like a spark is provided. Petrol emit vapours even much below ambient temperature, eg smell of petrol in cold places. The lower the flash point, the higher will be the risk of the materials catching Fire. For Example the flash point of gasoline is 32°C, that of Acetone is -17.8°C and that of Methanol is +11°C. For a flammable liquid chemical to continue burning without external source of ignition, its temperature must be raised to its Fire Point, which is slightly higher than its flash point.

A number of sources may result in Fires and Explosions - Open Flames such as those from Lighters, burners, matches and welding torches are the most common sources of ignition and are known to cause most Fires in households and industry. Radiation coming from hot surfaces may provide enough heat to

start Fires. An Architect who design a facility for storing chemicals, petroleum products, paints, etc., should bear the above facts and figures in mind while designing the Building Services, including Fire protection Arrangement to face any Fire Outbreak. The most significant fact is that a PERFECT DESIGN to house all dangerous chemicals and relevant materials at appropriate places and avoid any contact of ignition or sparks, should be the dream of Architect

GAS BASED FIRES - KITCHEN COOKING:

Kitchen is the most essential and important place in the house. Precautions to be undertaken to have a SAFE KITCHEN are as below:

a. Do not leave cooking unattended. If you have to leave the cooking area turn off the burners.
b. Density of LPG is higher than air and hence ventilation at bottom level is to be given.
c. If a Pan catches fire, put a cover over it and turn off the burner
d. Keep stove tops always clean of greases and food particles
e. Fix LPG Detector at or near the Gas Cylinder storage and verify indicator time and again
f. If an electrical appliance emits smoke, unplug it immediately
g. Do not overload switches or plugs
h. Electrical equipment should never be left plugged
i. While allowing adolescents to prepare simple meals, make sure that essential ingredients are stored near-by and you are there to supervise them.
j. Ensure that children use microwave oven only after they have fully understood its use
k. Hot items should be kept at a safe distance from children
l. Always turn the handles of pots and pans away from the front.
m. Store sharp objects like knives away from children. Kitchen tools used for cutting and slicing should never be left unguarded.

While designing good kitchen, Architects may bear the above points.

THE CAUSES OF FIRES

ELECTRICAL - SHORT CIRCUITS, POOR QUALITY OF CABLES

Accidents involving Electricity are a common phenomenon world wide - It could be either due to over voltage, poor cables, switchboards, poor workmanship in cable laying etc. etc..

A slightest malfunction in the switchboard can cause disastrous accidents with resultant loss of Life and Property. How hazard free operation can be ensured by making safety precautions integral to the process right from the selection, construction and installation to the use and maintenance of switchboards is outlined.

Since most of Electrical Fire starts from Short Circuits, this perhaps might be the wrong voltage or current supply from a faulty switchboard. Perhaps this switchboard is located in a Factory, it may lead to havoc incident in the said factory. This incident or fire accident is preventable.

A switchboard is the collection of switches or fuses, conductors and other related apparatus used for controlling the current or voltage in any system. They could be the Indoor or Outdoor type and cover a wide range of sizes from the smallest switchboard in the house with just an ordinary 5 amps switch to the huge ones in the Factories controlling thousands of amps. Circuit Breakers, Relays, contractors, measuring equipment and meters form a part of switch boards. The majority of switch Boards used in industries are assembled in the factory and are custom-made. These have sheet steel enclosures with one or two units

for the incoming supplies and a number of units tapped from a Bus bar system feeding the outgoing circuits. Such Boards are known by various names such as Main Distribution Boards (DB), Power Control Centres (PCC) etc., When such boards are used to feed Motors they are known as Motor Control Centres. The use of Proper Cable and Cabling as per IS:732 are also very important.

The safety aspects of any job or procedure are greatly enhanced by having a team of trained and competent Man power. Since Electrical Equipment & Cables, are quite essentially needed to maintain a fault free operation of any facility whether it is a small house or large Industrial Undertaking, the significance of this system protection is prime important. An Architect can suggest suitable Fire Suppression System for Switchboards, proper Fire Retardant Chemicals for cable protection (only for Higher Capacity Cables) and multi fire system for transformer protection.

III) COMBATING FIRE:

WATER

Water is one of our most precious natural resources. Conservation of this precious material and efficient usage of it is prime important for the whole humanity. Various conservation and preservation techniques are used to store it properly and in some advanced countries, its usage and re-usage are regulated with Laws and Rules. In India Rain Water Harvesting and banning of sand quarries at certain places is part of such Rules. Rules will be strict for punishing the offenders as this precious material become more and more scarce.

Change your water use patterns to ensure adequate supply and help save environment. There are various water saving techniques which are detailed below:

- Use water wisely - even when supplies are abundant.
- Never pour water down the drain when there may be another use for it. Use it for watering your Garden.
- Make sure taps do not drip. A dripping tap can waste approximately 13Ltrs of Water a day. Get leaks repaired quickly.
- Install a flush tank that cuts down on the amount of water used for each Flush.
- Avoid Flushing the toilet unnecessarily.
- Do not use the Toilet as a Waste bin and increase Water usage.
- Use a broom instead of a Hose Reel to clean offices, balconies and pathways
- Clean vegetables in a Pan filled with Water than running Water from the tap.
- Re-use the water that vegetables are washed in for cleaning.

There are more techniques to restrict water wastage - KNOW WHERE THE STOP.

What will we accomplish by saving water in Fire Fighting Industry?

As you know, water is used abundantly to kill Fire in most of Fire Outbreaks - called as Universal Fires. Whether Fires in Textile Mill, wood based products manufacturing Plants, Furniture Factory, Decorative paper Manufacturing Plants, Rubber Manufacturing, plastic Manufacturing, Garment Factory etc., etc. We use for better use of Water and get maximum cooling effect to control fires.

They are :

- Water Fire Hydrant System with cooling chemical embedded or solved water.
- Sprinkler system-automatic ie, restriction of usage by the place where Heat from Fire is generated to the level pre-decided.
- Water Spray System - Low Velocity, Medium Velocity and High Velocity applications as required by the Fire anticipated. Eg. Only Transformer or oil fires need High Velocity Mulsifer system.

- Water Mist System

The above are water saving but yet effective control system of Fire. For environmental sensed Architects, he can design cities and towns to have water reservoirs which will have better chance to refill again and again. Allow Free Flowing rivers which will be able to sustain water. We plan to save for better vegetation. Work with a sense to preserve National Resources for Next Generation.

(B) FOAM

Foam is a homogeneous mass of tiny air or gas filled in bubbles of low specific gravity which, when applied in the correct manner and in sufficient quantity, form a compact fluid and stable blanket which is capable of floating on the surface of flammable liquids and preventing atmospheric air from reaching the liquid. It is produced by mechanically mixing a gas or air to a solution of a Foam Compound (Concentrate) in water.

The Foam produced from concentrates are of low expansion (up to 20 times), medium expansion (above 20 and up to 200 times) and high expansion (above 200 times). Generally used Foam is Low Expansion and they are of following types:

(a) Protein Foam
(b) Aqueous Film Foaming Foam (AFFF)
(c) Fluoro-Protein Foam
(d) Synthetic Foam (This can be Medium or High Expansion too)
(e) Alcohol Resistant Foam

As stated above, many types of Foams are available but Protein Foam Concentrate as per IS:4989 P-1 is abundantly used with Mechanical Foams generating equipment for extinguishing Fire in flammable liquids other than Polar Solvents. This Foam shall be of Dark Brown Color and free from offensive odour. This can be stored in Polyethylene Jerry Cans or in galvanized mild steel drums.

AFFF as per IS:4989 Part II can be used with Mechanical Foam Generating equipment. It is available in Two types viz.,

Type 3 - To be used as 3 parts of concentrate to 97 parts of water v/v to produce AFFF.
Type 6 - To be used as 6 parts of concentrate to 94 parts of water v/v to produce AFFF.

Fluoro-Protein Foam concentrate is again as per IS: 4989, Part 3 and shall be of dark brown or reddish brown colour. Its physical requirement differ from other foams and it is detailed in B/S book IS:4989 Part3.

Foam can be used effectively on any liquid fires. Foam is also used in ship fires.

(C) DRY CHEMICALS

Various Dry Chemical Powders are used to lgive a blanket effect on Fires - mainly effective for "B" and "C" Class of Fires. Out of many types available, Sodium Bi Carbonate based Dry Powder is quite famous and it is found in many Dry Powder type Fire extinguisher whether it is cartridge type or stored pressure type. It is white in colour and non- corrosive and can be stored in -5°C to +50°C. It is most effective for Electrical and Gas Fires.

For handling most dangerous Fires in Petrochemical Industry, Potassium Bi Carbonate Powder is used.

Both the above Powders are manufactured as per IS:4308 specification.

Another Powder manufactured is as per IS: 14609. This powder will be of Yellowish colour and suitable for Class A, B and C Fires. So we can eliminate the use of Water which is abundantly used for killing Cl-

ass A Fires.

In order to handle High Temperature Fire, TERNARYEUTECTIC CHLORIDE (TEC) lis developed by ISRO, and manufactured and marketed by several Manufacturing units as per the requirements specified by ISRO. It conforms to IS: 4861 and have approvals from ISRO, Lloyds, DNV, BV, etc., It can be used towards Metal Fires (D) and TEC poses at Temperature of 600°C-650°C and has high latent heat of fusion forming a hard crust on the burning metal surface.

Dry Chemicals can be used either through Fire Extinguisher or through Fire Monitors. In case of Extinguishers the expelling media will be either CO2 (in a Cartridge) or Nitrogen. In case through Monitors to handle BIG OIL FIRES, expelling is done with the help of pumps specially designed for such operation.

IV) FIRE DETECTION SYSTEM OR FIRE ALARM

In order to ensure Life Safety and reduce Property Loss, there is need to detect Fires in the incipient stage which will provide a reasonable interval of time for inmates to escape to a Place of Safety and give Fire Fighters a reasonable chance to control and extinguish the Fire with minimum loss. The basic objective of any Fire Detection System is to respond to a Fire and transform this response into a audio-visual signal which would simultaneously alert the Building Occupants and inform others related to the Fire Safety to take immediate measures.

The most common elements of Fire that can be detected are "Heat" and "Smoke" and Flame". All Fires do not generate all the elements in the same proportions, some Non-Fire Conditions can also produce similar ambient conditions. Therefore, selection of Fire Detectors should depend on individual circumstances in course of development of any Fire and it should be matched to the hazard present. So, during selection of Fire detection, the user has to see which of the elements might be expected from Fire and which similar elements might be expected from non-fire conditions. Major Servicing devices are explained below:

1. The Detectors which detect Fire by sensing woke generated by Fire are known as Smoke Detectors. Smoke in a Fire or Combustion process creates smoke at smoldering stage i.e. one step before the actual Fire takes place. So, it is an early warning instrument which detects Fire.
2. The Heat Detector - This is a "fixed temperature" type Heat Detector. This is generally set at 68 deg C.
3. Raise-in-temperature type Heat Detector. This detector detects Heat which is shooting up abnormally. Only during Fire such shooting up of Temperature is happening. In all other situation, temperature gradually increases
4. Multi Criteria Type - There are various types of Detectors which are not used abundantly. Multi Criteria is one amongst. There are other types like Flame Detector, etc.
5. Photoelectric Smoke Detector - Photoelectric smoke detector operate on high beam principle. The smoke entering a Light beam either obscures the beams path to a photoelectric cell or reflects Light into a Photoelectric cell

Light Obstruction Type

Detectors operating on this principle, employ a Light source, a light beam collimating system and a Photo-Voltaic or Photo-Resistive Cell. When smoke particles enter the Light Chamber or Light Beam, the light reaching the Photo sensitive device is either blocked or reduced.

Apart from various types of Detectors, the major Device in the Fire Detection System is Control Panel

which receives signal from Detector or any other devices, and give audio and visual alarm. Other devices are Manual Call Point (MCP), Hooter (Sounder), Response Indicator etc. etc.

The location and spacing of Smoke Detectors should be done on the basis of the burning characteristics of Combustible material present, configuration of the contents, Ceiling shape, surface and ventilation. The detectors may be installed very close to the hazard for a rapid response. However, smoke detectors are designed to be used indoor and the ionization type is especially susceptible to humidity, dust and vibration. Spot type smoke detectors should be located on the Ceiling not less than 10cm from a side wall.

There are many and Infra-Red combined Flame Detector with IP-67 Protection. The detector makes use of Infra-Red sensitive Photoelectric sensor for Detection of Flame. IR has a narrow spectral sensitivity of 3 to 5pm, completely insensitive to visible light.

Detectors also make use of Ultra Violet Sensitive Photo Cathode for detection of Flame. It has a narrow Spectral sensitivity of 185 to 260nm, completely insensitive to visible light. In short, Flame Detector employs UV & IR Sensors to detect Fire. This combination is very quick, and eliminate any chance of false alarm.

Another type Flame Detectors available is for Hazardous Areas. Here again UV & IR Flame Detector with IP-66 Protection. This also can be connected to Standard Fire Alarm Panel.

IR Ember Detector is known for detecting Weak Infra-Red Radiation emitted from ember most reliably and quickly. Ember is created from smoldering fragment of wood or coal. IR Ember Detector is an efficient alternative to any Flame Detector which has the limitation of low sensitivity to ember.

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Triple Sensor Flame Detector with IP-67 Protection is specially designed to use in the area where smoke detector and heat are less effective. Here again IR and UV sensors are used to identify Fire. This type of Detectors are mainly placed on Production Line, Storage/ Godown, Paint booths, and conveyor

V) FIRE FIGHTING SYSTEMS

Once Fire is detected, then immediate arrangement to put off it or make it under control, is to be initiated. Some of the techniques used for Fire Control are detailed below:

- Fires can be controlled and put off with the help of Fire Extinguishers. It starts from 15 kg powder to various types like Water, Co2, Clean Agent and 2000kgs capacity Tender as per IS. 10993. This Unit will be based on Vehicle and apart from Dry Powder Contained vessel, it will have Hose Reel to discharge Powder.
- In Clean Rooms or Areas, Fire is knock down with the help of Inert gases like FM200 or NAF gases. Co2 Flooding is also used on Fires in such areas. This system is used where Water or Foam cannot be used for Fire Extinguishment because of special nature of the contents of the area to be protected. This type of installation is essential for the occupancies where an inert electrically non-conductive medium

is essential or desirable or where cleaning up operation after Fire extinguishment presents problem. Bonded Warehouses, Carding Machines in Spinning Unit, chemical Works & Stores, Drawing offices, Server Room, Alternators, Diesel Electric Locomotives, Printing Presses, Solvent Stores, Engine Test Beds, etc.

- Fixed Fire Extinguishing Installation are usually employed for Protecting Buildings & Industrial Units, where it is desired to keep Fire Losses to the minimum level possible
- Fire Hydrant System is one of the System commonly used. It is again mandatory to have such Fixed System to protect the Facility which makes most of people resort to Hydrant System. The system will consist of Pumps for pumping (One Dieselized Pump, One Main Electrical Pump and One Jockey Pump to take care of small loss in Pressure), Pipeline Network, Sump, Foot Valve with Suction, Control Valves, Fire Hydrants to regulate Water Supply and Force, Fire Hose, Branch Pipe and Nozzle. Specially designed Nozzles are used to create Fog where direct water jet is forbidden.
- The places where occupants are not available to fight Fire, Fire Hydrant System is not useful, where Automatic Sprinkler System is designed and installed. It is as per the Hydraulic Calculation required for the facility, which is decided on the basis of area and item to be protected.
- There are various Water Spray Systems like Mist Suppression System, Low, Medium High velocity Mulsifier System to protect Transformers and High Hazard Chemicals.
- Water Tender for Fire Brigade Use also can be considered as a Major Equipment to handle Major Fire. Water Tank, Pump, Suction & Delivery Valves are described in IS:950.

VI) HOW TO PREVENT FIRE FROM SPREADING

Most of us and to think in terms of slow-growing Fires, where we have time to grab the nearest extinguisher and take the necessary action. If diesel or hydraulic oil impinge upon a hot surface, such as an exhaust manifold and a spark or other form of hotness or ignition is introduced, the chances are that there will initially be an explosion, rather than a Fire. The same applies with gas and petrol vapor. The advance warning provided by the gas alarm may well prevent the explosion or Fire and the early warming of a Fire via the Flame Detector or IR Ember Detector, particularly in the Engine Room, could result in early suppression. Water Mist Fire Suppression can also be advantageously used to Control Fire. A small Fire is normally caser to extinguish than a raging inferno, limits the damage to the electrical insulation and may permit the engines to be restarted after the fault is rectified.

VII) ARCHITECTURAL REQUIREMENTS

TYPES OF CONSTRUCTION:

The design of any building and the type of materials used in its construction are important factors in making the building resistant to a complete burn-out & preventing the rapid spread of Fare, Smoke or Fumes, which may otherwise contribute to the loss of lives and property.

EXIT ACCESS:

An exit may be a doorway, corridor, passage ways to an internal staircase or external staircase, which have access to the street or to a refuge area. An exit may also include a horizontal exit leading to an adjoining building at the same level. Eg. EXITS or passage ways found in venis. Lifts & Escalators shall not be considered as Exits. All exits should be free from all obstructions or impediments. Every Building meant for human occupancy shall be provided with exits sufficient to permit safe escape of occupants in case of Fire or other emergencies.

Exit shall be clearly visible and the route to reach the exits shall be clearly marked and signs posted to guide the occupants of the floor concerned. Signs shall be illuminated and wired to our independent electrical circuits as an alternative source of supply. (Not applicable to A-2 & A-4 occupancies & less than 15M Ht.)

The Floors of areas covered for the means of exit shall be illuminated to values not less than 1 ft candle (10 Lux) at floor level. In auditoriums, Theatres, concert halls and much other places of assembly, the illumination of floor exit/access may be reduced during period of performances to values not less than 115ft candle (2 Lux).

Fire Doors with 2 hours fire resistance shall be provided at appropriate places along the escape route and particularly at the entrance to lift lobby and stair well where a Funnel may be created, inducing an upward spread of fire to prevent spread of fire and smoke.

All exits shall provide continuous means of egress to the exterior of a Building. Exits should not be through another occupied unit.

NUMBER OF STAIRCASES

NFPA 101 and most of the model building codes use the term "means of egress". A means of egress is a Continuous path of travel from any point in a Building or structure to a public way that is in the Open air outside at ground level. The specific placement of exits is a matter of design judgement, allowable dead ends, common path of travel and exit capacity. NFPA 101 states that exits must be remote from each other, thus providing two separate means of egress so located that occupants can travel either of two opposite directions to reach an exit.

DISTANCE BETWEEN EXITS:

For determining the EXITS required, the number of persons within any floor area or the OCCUPANT LOAD shall be based as the actual number of occupants, but in no case less than that specified Table 20.

Table 20 Occupant Load
(Clause 4.3)

Sl.No	Group of Occupancy	Occupant Load, Floor Area in m^2 / person
(1)	(2)	(3)
i)	Residential (A)	12.5
ii)	Educational (B)	4
iii)	Institutional (C)	15 (see Note 1)
iv)	Assembly (D) a) With fixed or loose seats and dance floors b) Without seating facilities including dining rooms	 0.6 (see Note 2) 1.5 (see Note 2)
v)	Mercantile (F) a) Street floor and sales Basement b) Upper sale floors	 3 6
vi)	Business and industrial (E & G)	10

vii)	**Storage (H)**	**30**
viii)	**Hazardous (J)**	**10**

NOTE:

1. Occupant load in dormitory portions of homes for the aged, orphanages, in same asylums, etc, where sleeping accommodation is provided, shall be calculated at not less than 7.5m^2 gross floor area/person.
2. The gross floor area shall include, in addition to the main assembly room or space, any occupied connecting room or space in the same storey or in the storeys above or below where entrance is common to such rooms and spaces and they are available for use by the occupants of the assembly place. No deductions shall be made in the gross area for corridors, closets or other subdivisions; the area shall include all space serving the particular assembly occupancy.

The Total occupants from a particular floor must evacuate within 21/2 minutes for Type 1 Construction, 11/2 minutes for Type 2 construction and 1 minute for Type 3 Construction. Size of the Exit door/ Exit way shall be calculated accordingly keeping in new the Travel Distance and Occupant Load.

ARRANGEMENT OF EXITS:

Exits shall be so located that the Travel Distance on the floor shall not exceed the distance given in Table 22.

TRAVEL DISTANCE:

TRAVEL DISTANCE FOR OCCUPANCY AND TYPE OF CONSTRUCTION:

(Clause 4.4.1, 4.5.1 and 4.5.2)

Sl.No	**Group of Occupancy**	**Maximum Travel Distance Construction**	
		TYPE 1 & 2	**TYPE 3 & 4**
(1)	**(2)**	**(3)M**	**(4)M**
i)	Residential (A)	30	22.5
ii)	Educational (B)	30	22.5
iii)	Institutional (C)	30	22.5
iv)	Assembly (D)	30	30
v)	Business (E)	30	30
vi)	Mercantile (F)	30	30
vii)	Industrial (G)	45	-
viii)	Storage (H)	30	-
ix)	Hazardous(J)	22.5	-

NOTE:

1. For Fully sprinklered building, the travel distance may be increased by 50 percent of the values specified.
2. Ramps shall be protected with automatic sprinkler system and shall be counted as one of the means of escape.
3. Construction of type 3 or 4 is not permitted.

NUMBER OF EXITS:

All buildings, which are 15m in Ht. or above, and all buildings used as educational, assembly, institutional, industrial, storage, and hazardous occupancies and mixed occupancies with any of the aforesaid

occupancies, having area more than 500m² on each floor shall have a minimum of TWO STAIRCASES. They shall be of ENCLOSED TYPE, at least one of them shall be as EXTERNAL WALLS of buildings and shall open directly to the EXTERIOR, interior open space or to on open place of safety.

DOORWALLS:

Every exit doorway shall open into an enclosed stairway or a horizontal exit of corridor or passageway proceeding continuous and protected means of egress.

No exit doorway shall be less than 1000mm in width except assembly building where it must be 2000mm.

Ht of Doorways is to be minimum 2000mm.

EXIT DOOR ways shall open outwards. Mirrors shall not be placed in Exit ways.

CORRIDORS & PASSAGE WAYS:

They shall be of width not less than the aggregate required width of EXIT DOOR WAYS leading from them in the direction of Travel to the Exterior.

INTERNAL STAIRCASE:

They shall be constructed of Non-combustible materials throughout. Internal staircases will be constructed as a SELF-CONTAINED UNIT with an External wall of the building. A Staircase shall not be arranged round a "Lift Shaft".

Hollow combustible Construction Shall not be permitted.

No gas piping or Electrical Panels shall be allowed in the stairway. Ducting in Stairway may be permitted if it is 1Hr Fire resistance Rating. Notwithstanding the detailed provision for exits, the following minimum width shall be preceded for staircases.

1. Residential Building (dwellings) - 1-0m
2. Residential Hotel Buildings -1.5m
3. Assembly Buildings like Auditoriums, Theatres & Cinemas. - 2.0m
4. Education Buildings up to 30m in Ht - 1.5m
5. Institutional Building Like Hospitals - 2.0m
6. All other Buildings - 1.5m

Hand Rails shall be provided at a height of 1000mm.

The number of people in between floor landings in staircase shall not be less than the population in each floor for the purpose of Design of Staircase.

DESIGN GUIDELINES OF STAIRCASE:

- The Minimum Head Room in a passage under the Landing of a staircase and under staircase shall be 2.2m.
- For Building 15m in height or more, to main staircase shall be through a FIRE/SMOKE Check Door of a minimum 21Hr. Fire Resistances Rating. Only for Residential Buildings Fire Resistance may be reduced to 1 Hr.
- No living space, Store, or other Fire Risk shall open directly into the staircase.
- External Exit Door of Staircase enclosure at ground level shall open directly to the Open spaces or through a Large Lobby if necessary.
- The main & External staircases shall be continues from Ground Floor to Terrace level

- No electrical shaft/ AC Ducts or Gas pipes etc. Shall pass through or open in the staircases. Lifts shall not open in staircase.
- No combustible materials shall be used for decoration/wall paneling in the staircase
- Beams/ Colum's and other Building Feature's shall not reduce the Head Room or width of the staircase.
- The Exit sign with arrow indicating the way to the Escape Route shall he provided at a Suitable height from the floor level as the wall and shall be illuminated by electrical light connected to corridor circuits. All Signage's (Size 0.5m X 0.5m) should be flash with wall in order to avoid any mechanical damage. Further, all landings of floor shall have FLOOR INDICATING BOARDS.
- Individual floors shall be permanently induced on the wall facing the staircase.
- In case of single staircase, it shall terminate at the Ground floor level & the access to the Basement shall be by a separate staircase

PRESSURISATION OF STAIRCASES:

Pressurization is a method adopted for PROTECTED ESCAPE ROUTES against INGRESS of smoke, especially high-rise building. In pressurization, air is injected into the staircases, Lobbies & Corridors to raise their PRESSURE slightly above the pressure in adjacent parts of the building. As a result, ingress of smoke or toxic gases into the ESCAPE routes will be prevented. The Pressure difference for staircases shall be as under,

Building Height	**Pressure Difference**	
	Reduced operation (Stage 1 of a 2 – Stage System) (Pa)	Emergency Operation (Stage 2 of a 2 – stage System or single stage system) (Pa)
Less than 15m	8	50
15m or above	15	50

If possible, the same levels shall be used for lobbies and corridor, but levels slightly lower may be for these spaces if desired. The difference in pressurization level between staircases and lobbies for corridor) shall not be greater than 5 pa.

PRESSURIZATION SYSTEM MAY OF TWO TYPES:

a) Single-stage, designed for operation only in the event of an emergency, and
b) Two-stage, where normally a level of pressurization is maintained in the protected escape routes and an increased level of pressurization can be brought into operation in an emergency.

EXTERNAL STAIRS:

An external staircase is desirable to be provided in all high-rise Buildings.
External stairs shall always be kept in found operable conditions. It shall be directly connected to ground.

TRAVEL DISTANCE:

Having considered the characteristics of the occupants which will influence escape and having seen how these can be related to building type, it is important to look at the stages in the process of escape and the maximum distances people can be expected to travel. ESCAPE is generally considered in FOUR STAGES.

STAGE 1 - Escape from the Room or Area fire Origin.
STAGE 2 - Escape from the compartment of origin by the circulation route to a FINAL EXIT, exiting to a protected stair or to our adjoining compartment offering Refuge.
STAGE 3 - ESCAPE from the floor of origin to the ground level.
STAGE 4 - FINAL escape at ground level.
In High Rise Buildings it may not be practicable or disable to commence total evacuation and instead the Design must allow for a phased evacuation.

MINIMUM NUMBER OF EXITS :

No. of People	No of Exits
1-50	1
51-500	2
501-1000	3
1001-2000	4
2001-4000	5
4001-8000	6
8001-12000	7

MINIMUM TOTAL WIDTH OF EXITS :

1-50	800mm
51-100	900mm
101-180	1000mm
181-200	1100mm
201-220	1200mm
221-240	1300mm
241-260	1400mm
261-280	1500mm
281-300	1600mm
301-320	1700mm

MODELLING OF EGRESS DESIGN :
Computer simulation and modeling have become important tools in designing adequate means of egress under a variety of occupancy and structural conditions.
In are study of the critical variables for fire safety in relation to buildings used to house the elderly, the problem of fire Development and Evacuation as a time structured problem was considered.
Clearly defined evacuation procedures and processes that must be followed in a fire or other emergency are an integral part of emergency planning. Training is a vital element in planning for an emergency but it matters little how well laid the plans are, if those who may need to use than are fully familiar with then or worse still, do not even know they exist. Training is essential, but not a panacea. Effective preparedness requires not only meticulous and regular training of all general and Fire/Security staff, but also stringent enforcement of policies to prevent carelessness such as blocking emergency exists.

Staff efficiency and competences is paramount, from ensuring emergency exists are left. Clear at all times to undertaking or assuming for regular system cheerless, regardless of illness, holidays, or changing shift/Hospitals/Theatres with a high staff turnover.

RESPONSE GUIDELINES :

The need to instruct visitors or public sun familiars with auditorium/Concert Halls/Theatres can be overlooked. In Industries such as higher education, airports or hospitality with a high proportion of international staff and visitors, there may be more potential for confusion in our evacuation situation, increasing the requirement for CLEAR & APPROPRIATE TRAINNING for all building occupants. A good example here is the Green ISO: 7010:2011. RUNNING MAN emergency exists sign, which is widely used and understood is many parts of the world. In Auditorium or concert Halls, well planned evacuation may lead to cent percentage success, but the more remote the side, the longer it takes emergency services to mobilize, which increases the challenge. In Hospitals & Airports, Self-rescue in limited and full evacuation is a last resort.

EFFECTIVE COMMUNICATIONS:

Assuming people do respond to our alarm in an emergency, they are invariably in a heightened emotional state although this is a dangerous assumption, as the lack of Reaction to Fire alarms is a Common problem. Many believe the alarm to be a TEST rather than a Real Emergency, and in buildings with a history of false alarms, our understandable reaction is to think that it must be yet another.

If people do react, the fight or flight instruct can cause PANIC and DISORIENTATION. A simple tone-based alarm does not provide the necessary guidance in how to respond to a certain incident, and the lack of international consistency and range of multiple alarm tones can result in confusions.

VOICE EVACUTION:

Voice evacuation warnings and public address broadcasts enable the SAFE& ORDERLY EVACUATION of people from area affected by our emergency. Generally, these systems sound an alarm tone and then a spoken warning instructing whether the BUILDING is to be evacuated and what to do NEXT Instructions to protected to the relevant assembly point or not to use elevators are prime assembler. A MASS BROADCAST should be avoided as such evacuation instructions may not be appropriate in, say, Hospitals where they could cause unnecessary panic among patients in non-affected areas. Mass Notification through mobile phones is legally required in U.S., but such notification provided concise instruction via live or pre-defined messages to guide than to SAFETY.

INTEGRATED SYSTEMS:

It is increasingly common for Fire Detection System to be integrated with VOICE ALARMS and mass notification systems emergency lighting, unformatted extinguishing building management and security systems to control smoke, lifts and doors is any life-threatening situation. Response system of the future so called intelligent response systems. Will take this stage further with fully integrated, multi-modal Technologies.

In future, a demand-controlled response to incidents, in which systems analyze all relevant data from the various sensors, field devices and building management systems across a given site, will trigger the appropriate response mechanisms depending on the nature, size and criticality of the incident. This

automated provision of dynamically updated and targeted instructions will guide everyone-regardless of circumstances quickly and efficiently to a place of safety.

DAMAGE & LIABILITY:

A Staggering 70% of businesses that experiences a serious Fire close down after THREE YEARS which illustrates the potential commercial impact. KARUR TEXTILE MILL. is an example to it.

FIRE LIFTS:

Where applicable Fire lifts shall be provided with a minimum capacity for & passengers and fully automated with emergency switch as ground level. In general buildings 15m in Ht or above shall be provided with FIRE LIFTS.

In case of fire, only Fireman shall operate the fire lift. In normal course, it may be used by other persons.

Each fire lifts shall be equipped with suitable inter-communication equipment for communicating with the control Room on the ground floor of the Building.

The No. & location of Fire lifts is a Building shall be decided after taking into consideration various factors like building population, Floor Area, Compartmentation etc.

RAMPS:

Ramps shall comply with all the applicable requirements for stairway, regarding enclosure, capacity and limitary dimensions except where specified for special uses and occupancies.

The slope of a RAMP shall not exceed 1 in 10. In certain cases sleeper slopes may be permitted but in no case greater than 1 in 8.

For all slopes exceeding I in 10 and whenever the use is such as to involve danger of slipping, the Ramp shall be surfaced with approved non-slipping material.

FIRE DOORS

A door or shutter provided for the passage of persons, air or things which, together with its frame and fixture as installed in a building, is intended, when closed, to resist the passage of fire and/or gaseous products of combustion and is capable of meeting specified performance criteria to those ends. The Fire doors may be insulated or uninsulated.

MEANS OF ESCAPE:

The fire doors may be Structural means whereby a safe route is provided for persons to travel from any point in a building to a place of safety without outside assistance.

CONCLUSION:

This research and findings are practitioner's perspective, enriched by over 40 years of experience in the field of fire safety, aims to provide a comprehensive guide to architects on incorporating fire safety measures through Prevention Through Design (PtD). By aligning with the National Building Code (NBC) of India, this handbook highlights the importance of considering fire and life safety from the early stages of architectural design. With an emphasis on pre-incident planning, the document encourages architects to proactively integrate fire safety regulations, ensuring that buildings not only comply with the code but also promote safety and resilience. The insights provided are intended to empower architects to adopt a

holistic approach to design, preventing potential hazards before they arise and enhancing the overall safety of the built environment. Through this guidance, architects can create spaces that prioritize the well-being of occupants while contributing to the long-term sustainability of their projects.

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