FIRE AND BUILDINGS: BUILDING MATERIALS

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1. INTRODUCTION

Fire results from the composition of three essential ingredients: fuel, heat and oxygen. A fire can be extinguished by removing or consuming any one of these ingredients. The more sources there are for starting fires the more interested human beings become in developing means of controlling fires and inventing new alarm systems.

With the rapid spread of civilized ways of living, fire fighting and prevention have become essential for the preservation of the human cultural heritage as well as the material achievements of mankind.

It is hardly surprising, then in the modern world that a great number of laws have been passed to deal with building control, safety regulations and industrial safety in establishments. Fires had a lion's in these laws especially as regards early alarms, precautions and fighting. New means have been devised to discover a fire as soon as it starts.

Insurance companies were quick to step in because of the grave losses which fires often bring about.

The effects of fires on buildings and constructions are serious enough to warrant a through investigation of the topic and a proper study of how to contain and control the threat of fires to human life and property.

This study deals with the issue in the following order:

- Ways of heat transmission from a heat source to a combustible material and raising its temperature.
- Causes of the increasing frequency of fires, the rapid spread of fires and the inefficiency often displayed in confronting fires.
- Properties of building materials from the point of view of combustion.
- The effects of fires on buildings.
- Elements of Protection from fire.
- Recommendations.

2. WAYS OF HEAT TRANSMISSION FROM A HEAT SOURCE TO A COMBUSTIBLE MATERIAL

Conductivity

This takes place through direct contact. Heat depends on the degree of conductivity of the material, the area coming into contact and the density of the material.

Radiation

Heat rays, like sun rays, are straight. Once they come into contact with a dark object, they are absorbed and stored. As a consequence, temperature rises. Transparent, smooth and glazed objects, on the other hand, reflect heat. Wind direction also has the effect of increasing or decreasing heat. Less heat will, certainly, pierce through a wet glass plate than a dry one.

Convection

Heat can be transferred through the moving currents in liquids and gases which rise upwards as a results of increasing heat and decreasing density.

That is why when a fire starts in a multi-storey building, hot gaes and hot flames move upwards, easing the pressure below and thus causing cold air to come in to replace the hot air.

Straicases, passages, lighting shafts and lift shafts increase the speed with which hot gases go up to the higher floors where they accumulate, adding further threats of fires unless they are dispelled quite rapidly. The pressure on walls and glass windows is also tremendous.

3. CAUSES OF THE INCREASING FREQUENCY OF FIRES, THEIR RAPID SPREAD AND THE INEFFICIENCY IN CONFRONTING THEMauses

- The use of highly combustible building materials without taking the proper precautions to guard them against direct fires.
- The use of buiding or finishing materials which change shape and properties when burnt and the use of materials which easily collapse, melt or burn.
- The lack of proper warning systems in buildings, the slowness of warning or the delay of fire fighters in coming to the location.
- The lake of rapid and efficient fire extinguisher which are suitable for the building in question or, if they are found, their crudity and lack of sophistication.
- The presence of wind help to spread the fire in parts of the building previously untouched by fire.
- The absence of necessary design considerations which are intended to lessen the impact of fire, control it, contain it in one place and make it easy for people to find their way out in cases of emergency.
- The height of the building, when existing means of extinguishing fires are incapable of coping at times of emergency.

4. THE PROPERTIES OF BUILDING MATERIALS FROM THE COMBUSTION POINT OF VIEW

Building materials can be divided according to how much they sustain and resist heat and fire as follows:
Materials resistant heat: 1520°C
Materials resistant to fire: 1520-1930°C
Materials highly resistant to fire: 1820°C
These properties can be clarified as follows:

- *Reinforced Concrete:*

Its resistance depends on its volume, the high quality of its ingredients and the thickness of the concrete cover enveloping the iron.

Its resistance increases considerably when it contains a net of light reinforcement or when there are divisions in the plates with metal plates or when foam asbestos is added to the mixture.

- *Pre-cast concrete:*

This is less resistant to heat than reinforced concre The concrete cover of iron should be increased by 3(more than the specifications of the reinforced concr

- *Metal and Steel Constructions:*

These do not resist heat and are subject to expansi(They become more resistant when the steel is cover with concrete, or when steel is sprayed with asbes or covered with sheets of asbestos. Steel loses properties at 900°f.

- *Aluminium:*

It does not stand heat and loses its properties 500°f.

- *Brick:*

It stands heat but it expands and therefore caus cracks in the concrete skeleton. It stands heat up 1800°f.

- *Asbestos:*

It stands heat and resists fire.

- *Gypsum:*

It stands heat and resists fire.

- *Glass:*

It does stand heat.

- *Wood:*

It stands heat and resists it but it burns it catches fir

- *Plastic:*

It does not stand heat and melts quickly.

- *Bitumen:*

It melts quickly.

5. THE EFFECT OF FIRE ON BUILDINGS

The following constructions are seriously affected by fire:

- Wooden constructions or thoses containing organic ingredients, reed, cotton or wood.
- Constructions extensively steel or metals using especially aluminium.
- Concrete constructions especially those without adequate cover to protect it form fire.

6. ELEMENTS OF PROTECTION FROM FIRE

- *The protection of vertical openings:*

It is paramount importance to protect and isolate all openings between the different floors of a building such as staircases, lift shafts, lighting shafts, ventilation openings and similar openings to stop the rapid spread of fire or smoke.

The walls between the openings found between different floors should be insulated. And these walls should be no less resistant to heat than the walls of the fire-escape stairs.

These openings should be isolated by doors resistant to heat or windows with wired glass, fixed in metal frames which are designed and installed to provide a barrier, stopping the spread of fire or smoke.

The resistance of these walls to fire is assessed according to Table N°1..

Table N°1: Type of building material and period of resistance to fire.

Type of building	Building material and the criterion of fire resistance
Buildings no less than 4 storeys high	Material which are not combustible and the period of resistance to fire no less than (2) hours.
Other buildings	Materials whose resistance to fire is no less than (1) hour.

- *Interior finishing*

It is natural that finishing materials and contents of the building have a direct connection with the seriousness of the fire, its rapid spread or of resisting attempts to extinguish it.

In old as well as modern projects a host of combustible finishing materials have been used. With the presence of such materials safety element against fire have to be observed such as special water connections, extinguishing systems, warning systems for fire or smoke. These materials include:

Wooden stairs, floors, doors, windows and furniture. Mattresses and pillows made of manufactured sponge or cotton. Cloth, Formica and plastic materials, polyester, varnish, lacquer, oil petrol, wall-to-wall carpets and dry hay.

It is advisable not to use materials made of plastic in interior finishing unless it has been proved by fire tests that such materials are resistant to fire and are at the same time capable of performing the function for which they are used.

Materials used in interior finishing are classified according to the main material constituting each one of them whether used alone or in combination with other materials. The exceptions to this rule are paint or wall paper no thicker than 0.9 mm. Interior finishing materials are classified into three categories as illustrated in Table (2) provided that the flame spread class and the smoke developed be specified.

Materials which are proved by laboratory tests to be dangerous for life on account of their constitution ought to be avoided. Interior finishing materials should be classified according to tests run in circumstances similar of those to which they are exposed in reality. The type of material used in exits, exit accesses and other areas of occupancy should be determined according to Table (3), taking into consideration the exceptions resulting from the use of automatic sprinklers.

Table N°2. Classification of interior building materials.

Type	Flame spread class		Smoke developed	
	Low	high	Low	high
A	0	25	0	450
B	26	75	0	450
C	76	200	0	450

Table N°3: Type of interior finishing according to accupancy.

Occupancy	Type of interior finishing		
	exists	exit accesses	other areas
Gathering places class (A) class (B) class (c)	 (A) (A) (A)	 (A) (A) (A)	 (A) or (B) (A) or (B) (A) or (B) or (C)
Educational occupancy with open or flexible design	(A)	(A)	(A)
Medical care occupancy and reformatories	(A)	(A)	(A) and (B) is for rooms with no more than (4) occupants
Residential occupancy Hotels Housing units Hostels Accommodation for one family or two	 (A) or (B) (A) or (B) (A) or (B) (A) or (B)	 (A) or (B) (A) or (B) (A) or (B) (A) or (B)	 (A) or (B) or (C) (A) or (B) or (C) (A) or (B) or (C) (A) or (B) or (C)
Commercial occupancy class (A) and (B)	(A) or (B)	(A) or (B)	(A) or (B) or (C)
Administrative occupancy and offices	(A) or (B)	(A) or (B)	(A) or (B)
Industrial occupancy	(A) or (B) or (C)	(A) or (B) or (C)	(A) or (B) or (C)
Storage occupancy	(A) or (B) or (C)	(A) or (B) or (C)	(A) or (B) or (C)

- *Fire alarm systems:*

Their aim is to warn the occupants of a building at the start of a fire and to operate the automatic systems for fighting the fire. Fire alarm systems are made up of three main parts:

- *Operating systems:*

These are either manual or automatic. Heat, smoke and flame detectors can be used.

- *Control units:*

These receive signal from the operating system and relay it directly to the warning systems.

- *Warning systems:*

These warn the occupants of the building or people in charge audibly, visually or both of the start of a fire.

Starting the operating systems:

Fire warning systems and automatic extinguisher will operate as a result of one or more of the following:

- The manual operation of the waring system.
- The detection of fire through heat, smoke or flame detectors and the automatic operation of the warning system as well as of the systems of fire fighing.
- Automatic detection and warning when an industrial accident or any similar circumstance posing a threat

to lives take place.

- The detection and warning indicating that there are conditions stopping the operation of the automatic extinguisher or the warning systems.

7. RECOMMENDATIONS:

There is no doubt that the future will witness great advances and constant researches in the field of automatic self-protection against fires in building. It is a challenge designers have to face especially since they are becoming more and more aware and knowledgeable about protection operations against fires. This study puts forward some recommendations concerning ways of protection against fire and fighting fire.

- *Covering with solid concrete:*

This is used in beams and steel columns. They are often cast on site, by means of special supports during the casting of ceilings. The amount of wires needed to keep the concrete cover in place and without the danger of collapsing should be considered even in case of fire.

Tests have proved that it is recommended to provide the concrete with a light-weight reinforced net. It is the trend now covering with imporous concrete to use this solid concrete not only to protect from fire but also to help to bear loads in the case of columns. Reinforcement steel is added in this case.

- *covering with brick's:*

This is mostly with steel columns only. These types of covering are not used frequently nowadays but they are still preferred for some constructions and locations.

- *Protection by light-weight concrete blocks:*

This has proved to be greatly advantageous. It is also considered to be one of the economical means of protecting a building against fire if used in suitable conditions. These blocks are arranged along the external perimeter of the steel column to give it a high degree of resistance to fire or even to heat.

It is an important means of protection against fire and it has the advantages of being easily and speedily installed which saves a good deal of time. In addition to its highly effective qualities of protection against fire, it has the advantage of not needing special supports to fix. The parts covered with these units have a rate of resistance to fire about 2 hours. After installing these units, they need finishing like paint and plaster works. This is because of the several connections in them. These finishings have a rate of resistance to fire exceeding 2 hours.

These units can also be used to cover iron beams. The advantages of this are making use of the full height of the building and reducing the cost of protective materials against fire in addition to the possibility of leaving some parts uncovered to install other connections.

On of the disadvantage of using these units is their weight which has to be taken into consideration. It is also possible for these units to hear part of the leads on the steel construction.

Obtaining concrete which is highly resistant to fire.

- Concrete aggregate can be tested according to the required degree of resistance to heat and fire.
- Aggregate containing Quartz, Carbonates, lime stone and sand should be avoided since Quartz crystals grow in size at 575°C while lime stones break into pieces from Calcium carbonate at 800°C.
- When aggregate of high resistance to fire is chosen, pebbles, Basalt, light stones and oven remains are excellent in this respect and are followed by broken bricks and light burnt aggregate.
- To obtain concrete which is highly resistant to fire, only aggregate with high degree of compactness and of melting should be used. The best of these are broken heat bricks, burnt products in special clay mixers.

- *The following factors should be taken into consideration:*

- Mixing the cement and the added material together before mixing with the components of the concrete.
- Spraying and melting the ceramic components added before mixing.
- Stirring the mixture well for several minutes.
- Warming the hardened concrete. This is important to increase its future resistance to fire. This is done

by heating gradually till 150°C and then leaving the concrete to dry at this temperature for several days. This is followed by heating to at least 1000°C for 20-30 hours.

- *Protection from fire by means of paint:*

Paint is a widespread means of protecting against fire. It is, however, preferred in steel buildings since its resistance to fire is fairly low, perhaps as low as half an hour while other means of protection can be as high as two hours or even more.

As for the advantages of this method is that it gives a beautiful and elegant facade. Unlike other methods which add considerable loads, the use of paint does not add any extra loads. These advantages balance its high cost. Paint can give highly glossy surfaces and very bright colours which may be toned down with some additions.

It is worth noting here that there are a great number of newly discovered materials which are highly resistant fire. These should be submitted to accurate and rigorous tests and should also be compared with already used materials in respect to resistance to fire, cost, components and how far they save time. There is also a marked tendency to avoid heavy materials and to use light weight materials which can be easily installed on location.

There are serious studies which earnestly urge the us of hollow iron sections or sections filled with water These sections are being used in buildings and their us has extended other types of constructions. Tests run o them are quite encouraging. This system has been use by overcoming the disadvantages, mainly freezing an rusting by the addition of chemicals to the water used

Future research in the field of paint aims a increasing the resistance to fire to one hour or more, obtaining a higher degree of resistance to humidity as well as improving the quality of colours which together with the general improvement of its other properties and reducing its cost, will make paint the ideal method. It is the aim of these studies to save time, and cost in addition to increase the durability of the building.

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