- GOVERNMENT POLYTECHNIC FOR GIRLS
- AHMEDABAD
- COURSE: BUILDING SERVICES
- COURSE CODE : 3360604
- TOPIC: FIRE PROTECTION
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CONTENT :-

1) INTRODUCTION:-

- Fire protection is the study and practice of mitigating the unwanted effects of potentially destructive fires.
- Buildings must be constructed in accordance with the version of the building code that is in effect when an application for a building permit is made. Building inspectors check on compliance of a building under construction with the building code.
- Once construction is complete, a building must be maintained in accordance with the current fire code, which is enforced by the fire prevention officers of a local fire department.
- Fire protection within a structure is a system that relies on all of its components. The building is designed in compliance with the local building code and fire code by the architect and other consultants.
- **Fire safety in a building deemed to cover the following aspects:-**

1. Fire prevention and reduction of number of outbreaks of fire.
2. Spread of fire, both internally and externally.
3. Safe exit of occupants in the event of an out-break of fire.
4. Fire extinguishing apparatus.

- **The following facts in connection with fire protection in buildings should remembered:-**

1. The main purpose of making a building fire resistant is the protection of life, goods and activities within the building.
2. The degree of fire resistance required will largely depend on the use of building. For instance, a theatre or a town hall will demand greater degree of fire resistant construction than an warehouse or a go-down.
3. In the case of fire hazard, the danger is from fire, smoke and panic. The fire capable of consuming and destroying and the tragic part of it is the nothing is left to rise from the ashes except the fumes of smoke.
4. The preventive measures include suitable planning, proper method of construction and satisfactory means of escape.

2) CAUSES OF FIRE AND PRECAUTIONARY MEASURES:-

- **Following are the chief causes of fire :-**

1. Smoking in unauthorised places and careless discarding of lighted ends of cigarettes, cigars, matches and tobacco.
2. Faulty electrical wiring or short-circuiting.
3. Heating and cooking equipment.
4. Children playing with matches.
5. Open flam and sparks.
6. Lighting.
7. Flammable liquids.
8. Burn candles and potpourri only when you are in the room.
9. If you have an older heating system, get it checked by a professional for safety.
10. Be sure that your home’s wiring is updated and adequate to handle electrical loads.
11. Pay special attention to hot grease or oil.

Precautionary measures :-

1. Provide adequate means of escape.
2. Outline clear pathways to exit doors.
3. Install smoke detection systems.
4. Maintain smoke suppression systems.
5. Conduct regular fire drills.
6. Use flame-retardant materials in interiors.
7. Make your office accessible to firefighters.
8. Keep the building plans handy.
9. Ask the local fire brigade to assess safety.
10. Comply with National Building Code.

Effects of fire:-

- Various types of construction materials produce different gases when ignited by fire.

The effects of theses gases are as follows:-

a) Carbon monoxide:- This is a very poisonous gas. it hampers oxygen from reaching the brain. it is invisible and odourless. it is the most abundant of fire gases.

b) Carbon dioxide:- This gas increases the rate of breathing and it is thus responsible for increasing the intake of other toxic gases.

c) Hydrogen sulphide:- This gas affects the nervous system and it causes dizziness and pain in the respiratory system.

d) Nitrogen sulphide:- This gas is extremely poisonous and it numbs the throat.

- At the time of fire, about 800 C temperature is generated. but the human body can withstand temperature of only between 65 C to 120 C.

3) FIRE HAZARDS:-

- The nature of damages or dangers caused by fire can be broadly divided into three types:-

1. Personal hazard
2. Damage hazard
3. Exposure hazard

Personal hazard :-

- It is the hazard to the occupants of the building. this danger can be taken care of by providing adequate means of escape for the occupants to that they can reach the place of safety in the shortest possible time in the event of a fire.
- Thus the building should be so planned that it has sufficient provisions for safe exit from within the building by way of definite escape ways, passages, stairs, corridors etc. leading to a street or to an open space. lift and escalators are not considered as exits. the size of corridor, width of staircases, and the location of the staircase halls should be suitably located keeping the above requirement in view.

Damage hazard :-

- The hazard to the structure and its contents is called damage hazards.
- The danger can be minimised by use of fire resisting materials and by carrying out the construction od structural elements like column, beams, floors, load bearing walls, lintels, arches etc. in such a way that at the time of fire they should continue to function as structural elements till such a time as would enable the occupants to escape the safe places.
- Keeping in view the high cos of construction of a fire resistant building it is not desirable to make all buildings fully protected against fire.
- The degree of fire resistant to be provided depends to a great extent upon the use of the building as well as the extent of the number of people it accommodates. in general building like schools, hospitals, cinema, theatres etc. should be designed to offer a greater degree of fire resistant as compared to warehouses and go-downs.
- NBC has classified the construction in to four classes on the basis of fire resiance offerd by building components as :

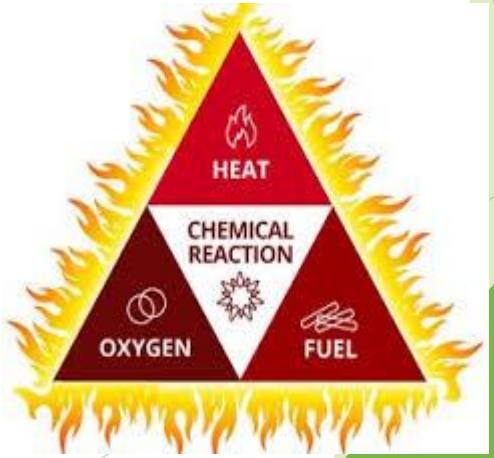
  Type - 1 : Fire resistance 4 hours

  Type - 2 : Fire resistance 3 hours

  Type - 3 : Fire resistance 2 hours

  Type - 4 : Fire resistance 1 hour

compartment enclosed by floors and walls. each compartment should be so created that it is capable of restraining fire within the compartment for appropriate duration of time. besides this, each stairwell, elevator and service shaft should also be suitably treated so as to enable it to function in the form of vertical compartment extending from top to bottom of the building.



4) FIRE LOAD:-

- The fire loading of a building or compartment is a way of establishing the potential severity of a hypothetical future fire.
- Fire Load is the amount of heat in kilocalories (kcal) which is liberated per square meter of floor area of any compartment by the combustion of the contents of the building and any combustible part of the building itself. this amount of heat is used as the basis of grading of occupancies.
- The fire load is determined by multiplying the weights of all combustible material by their respective calorific values and dividing by the floor area under consideration.

- As per IS : 1641-1960 fire load is divided into the following three classes :

1. Low fire load
2. Moderate fire load
3. High fire load

5) GENRAL REQUIREMENTS OF FIRE RESISTING BUILDINGS:-

- **1. Using Suitable Materials:-**
- Stone
- Brick
- Timber
- Concrete
- Steel
- Glass
- Aluminium
  - It should not disintegrate under the effect of heat.
  - It should not expand under heat so as to introduce unnecessary stresses in the building.
  - The material should not catch fire easily.
  - It should not lose its strength when subjected to fire.

- **2. Taking Precautions in Building Construction :-**
  - Dimensions of building components
  - Compartmentation
  - Fire-protection materials
  - Exit requirements as per NBC of India which involves Provision of sufficient exits to every building to permit safe escape in the case of fire, exits should be free of obstruction, and provision of adequate illumination(lighting).
- **3. Provision of Fire Alarm Systems and Fire Extinguishers :-**
  - These are active measures used which include fire alarm and detection systems or sprinklers that require either human intervention or automatic activation.
- 4. All electrical installation should be provided in accordance with the stander code of practice to prevent fire from electric sparks due to leakages.
- 5. Air conditioning and ventilating systems shall be so installed and maintained as to minimize the danger of spread of fire, smoke or fumes from one floor to other or from outside to any occupied building.
- 6. Smoke venin facilities for safe use of exits in windowless buildings, underground structures, large area factories, hotels and assembly buildings shall be automatic in action with manual controls in addition.

- 7. The wired glass glazing shall be of minimum ½ hour fire resistance rating.
- 8. The wired glass for skylights or monitor lights shall be of minimum ½ hour fire resistance rating.
- 9. Any exit may be door way , corridor, passageway to an internal staircase or external staircase or to a verandah, which have access of the street or to the roof of a building or a refuge area.
- 10. All buildings which are 15 m in height or above and all buildings used as educational, assembly, institutional, storage and hazardous occupancies having area more than 500 m2 on each floor shal have a minimum of two staircases.
- 11. Every exit doorway shall open in to an enclosed stairway or a horizontal exit of a corridor or passageway providing continuous and protected means of escape.
- 12. Internal stairs shall be constructed of non combustible materials.
- 13. All external stairs shall be directly connected to the ground. The route to the external stairs shall be free of obstructions at all times.
- 14. Fire towers are the preferred type of escape route for storeyed buildings and these shall be considered as the safest route for escape.
- 15. In buildings, 15 m in height or above shall be provided with fire lifts.
- 16. The slope of a ramp shall not exceed 1 in 10.
- 17. Emergency lighting shall be powered from a source independent of the suppling the normal lighting.
- 18. In all multi-storeyed buildings automatic fire detection and alarm facilities shall be provided.

6) CHARACTERISTICS OF FIRE RESISTING MATERIALS :-

- **The ideal fire resisting materials should possess the following characteristics :-**

1. . The material used in the construction should be a bad conductor of heat. When subject to high temperatures, the material does not significantly lose their strength.
2. Expansion and contraction of the material due to the rise and fall of temperature, respectively should not be excessive.
3. The contraction due to sudden cooling is more dangerous than the expansion effect. A good fire resisting material should not be cooled rapidly as it may break into pieces.
4. . The composition of the material should be such that it does not disintegrate or crumble under the effect of high temperature.
5. The material should be non-combustible as far as possible. It should never be understood that non-combustible materials are good in heat resistant.

- **Non - combustible materials :-**
  - These material do not contribute to the growth of spread of fire, but are damaged and decomposed when high temperatures are reached.

e.g. :- Stones and bricks

Concrete

Clay products

Metal

Glass , etc.

- **Combustible materials :-**
  - Combustible materials are those which, during fire, combine exothermically with oxygen resulting in evolution of lot of heat and giving rise to flame or glow . such materials burn and also contribute to the growth of fire.

e.g. :- Wood

Wood products

Fibre board

Straw board, etc.

MATERIALS:-

1. **STONE:-**

- The stone is a bad conductor of heat. But it suffers appreciably under the effects of fire. The stone is also liable to disintegrate into small pieces when heated and suddenly cooled. Granite explodes and gets easily disintegrated in case of a fire. Limestone is easily crumbled even by ordinary fire. Sandstones of compact composition with fine grains can generally stand moderate fire successfully without the formation of serious cracks.

2. **BRICKS:-**

- It is found that bricks are not seriously affected until very high temperature of 12000C to 13000 C are reached. This is due to the fact that a brick is a poor conductor of heat. If the type of mortar and quality of workmanship are good, brick masonry generally offers good resistance to fire. However, a brick has its own structural limitation for use in buildings.

3. **TIMBER:-**

- As a general rule, structural elements made of timber ignite and get rapidly destroyed in case of fire. Further, they add to the intensity of fire. But timber used in heavy sections may attain a high degree of fire-resistance because timber is a very bad conductor of heat. This is the reason why time is required to build up sufficient heat so as to cause a flame in timber. In order to make timber more fire resistant, the surfaces of timber are sometimes coated with certain chemicals such as ammonium phosphate and sulphate, borax and boric acid, zinc chloride, etc. such a treatment on timber surfaces retards the

4. CAST IRON:-

- This material is rarely used as structural material at present. This material flies into pieces when heated and suddenly cooled. Hence, when this material is used in construction, it is covered either by brickwork of one brick thickness or any other fire resisting material such as concrete.

5. GLASS:-

- This material is a poor conductor of heat and its expansion due to heat is small. Cracks are formed I this material when heated and then suddenly cooled. Reinforced glass with steel wire is ore fire-resistant than ordinary glass and it can resist sudden variation in temperature without the formation of cracks. Wired glass, even if it breaks, keeps the fractured glass in its original position.

6. STEEL:-

- Steel is a good conductor of heat and hence, it is rapidly heated in case of fire. It is found that steel loses its tensile strength with the increase in heat and the yield stress of mild steel at 6000C is about one-third of its value at normal temperature. Hence, under intense fire, the unprotected steel beams sag, the unprotected steel columns buckle and the structure collapses. Steel completely melts at a temperature of 14000C. It is also found that if the surface paint is not specially made fire-resistant, it assists in spreading the flame on the surface and thereby it adds to the intensity of fire.
- If steel plate or sheet form is fixed to framework, it becomes affective is resisting the passage of flame. Such construction is widely adopted in manufacturing fire-resisting doors and windows.

7. CONCRETE:-

- Concrete has got very good fire resistance. The actual behaviour of concrete in case of fire depends upon the quality of cement and aggregates used. In case of reinforced concrete and prestressed concrete, it also depends upon the position of steel. Larger the concrete cover, better is the fire resistance of the member.
- There is no loss in strength in concrete when it is heated up to 250°C. The reduction in strength starts if the temperature goes beyond 250°C. Normally reinforced concrete structures can resist fire for about one hour at a temperature of 1000°C. Hence cement concrete is ideally used fire resistant material.

8) FIRE RESISTANT CONSTRUCTION:-

- To obtain fire resistant construction, use of combustible material like wood, cardboard, baled cotton, plastic, fabrics etc. should be avoided while to construct the structural elements.
- To achieve fire resistant construction, due considerations should be made in design and construction of the following structural element of a structure.

1. Walls and columns
2. Floor and roofs
3. Wall openings, and
4. Building fire escape elements

1. Walls and Columns:-

- The load bearing walls or column of masonry or RCC should be thicker in section so that they can resist fire for a longer time and also act as vertical barriers for the passage of heat and fire and give minimum smoke.
- If the construction is of solid bearing walls, bricks should be preferred to stone.
- If it happens to be a framed structure then R.C.C frames are preferred to those of steel frames.

- If the use of steel only is to be made due to specific demand then it should be protected by embedding it in concrete or by covering it with some other fire-insulating material, such as burnt clay blocks or terra-cotta.
- Walls of lightweight concrete are preferred to dense concrete as far as fire resisting qualities are concerned.
- Both load-bearing and non-load bearing walls should be plastered with fire resistant mortar to get the fire-resistant construction.
- Normally, 20 cm thickness of the common wall (i.e. wall separating two building) is sufficient from fire-resistant point of view but it should be raised above the roof level by at least 90 cm.
- The partition walls should similarly be of fire-resistant materials such as, R.C.C or reinforced brickwork, hollow concrete, burnt clay tiles, reinforced glass, asbestos cement board, or metal lath covered with cement plaster.
- As steel columns are liable to twist or buckle or distort under intense fire, they should be protected by use of insulating materials such as concrete, hollow clay tiles, bricks, metal lath followed by plaster etc.
- **Following are the minimum thickness of cover recommended in R.C.C element:-**
- Column: 25-35 mm
- Beam: 25-35 mm
- Slab: 20-30 mm
- Footing: 50 mm
- Retaining wall: 30 mm
- Shear wall: 25 mm

2. Floors and Roofs:-

- The floors and roofs should be made of fire resisting materials as they act as horizontal barriers for spreading of heat and fire in a vertical direction.
- Flooring with a material, like concrete, ceramic tiles and brick, is regarded to be most suitable from the viewpoint of fire-resisting qualities. The use of terrazzo, marble and slate as floor surfaces is also quite satisfactory.
- For fire resistance of roofs, the flat roof should be preferred to sloping roofs or pitched roofs and all the considerations made above for floors also hold true in case of roofs.
- In case, the use of sloping roof is restricted due to some reasons, then the trusses should be of either R.C.C. or protected rigid steel should be used with a covering of asbestos cement sheet.

3. Wall Openings:-

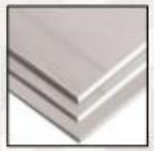
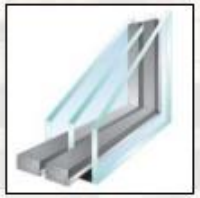
- From fire resistant construction point of view, firstly the opening in the walls should be restricted to a minimum and secondly, they should be protected by suitable arrangements in case of fire.
- If properly protected these openings also serve as means of escape in a fire. Otherwise, they provide the passage for the spread of fire in the horizontal direction. Doors and windows should be made of suitable fire-resistant material. These days wire-glass panels are preferred for windows.
- Solid timber doors having a minimum thickness of 4 cm should be used where some degree of fire-resistance is desired.

- All those openings which are used for communication should have double fire-proof doors and other openings may have single fire-proof doors.
- Any window exposed to the roof or other structure should be protected by fireproof shutters.
- If any structure has a separation less than 6 meters from adjoining structure, then all doors, windows or exposed side should be made fireproof.

➢ **4. Fire Escape Elements:-**

- All these firescape elements should be constructed of fire-resistant material and well separated from the rest of the building.
- Doors to the staircases, corridors and lifts should be made of fireproof materials.
- Staircases should be located next to the outer walls and should be accessible from any floor in the direction of the exits from the building.
- The fireproof doors to these emergency staircases should be fixed in such a way so that they can be closed from inside only. Such an arrangement will help the people to leave and evacuate the building safely and quickly in case of fire accident.
- In single storey building, provision of an accessible fireproof window should be large enough for leaving the building.
- In the case of multi-storeyed structures, the number and placement of the staircase should be decided in such a way so that it provides equitable distribution of the population of the floor overall the staircases. Local norms should be followed.

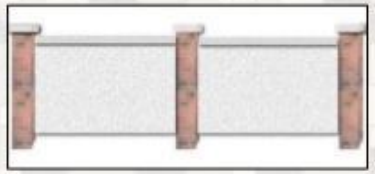
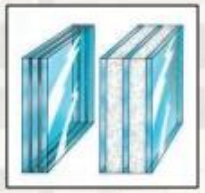
FIRE-RESISTIVE CONSTRUCTION

FIRE-RESISTANT BUILDING MATERIALS

- FIRE-RESISTANT GLASS FOR WINDOWS
- CONCRETE
- STUCCO
- GYPSUM
- BRICK



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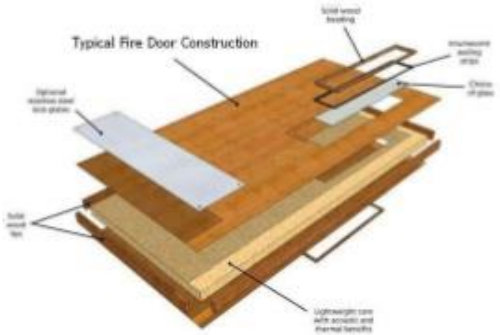
FIRE RESISTANT DOORS & WALLS

- A **fire door & Walls** is a door & wall with a fire-resistance rating.
- These are used to reduce the spread of fire or smoke between compartment.



9) FIRE DETECTION AND EXTINGUISHING SYSTEM:-

- In important structures particularly in multi stored buildings, besides fire resisting materials and method of construction, it is obligatory to make provision of fire detection and / or fire extinguishing systems. These systems are described below:-

a) Fire detection system :-

b) Fire extinguishing system :-

a) Fire detection system :-

- A fire detection system uses a smoke detector to detect a fire before it actually starts. An effective fire detection system eliminates damage by ensuring that a fire can be prevented before it even starts. A fire detector may also have a direct connection to an alarm monitoring centre.
- 1. Manual alarm system
- 2. Automatic alarm system

1. **Manual alarm system :** A building fire emergency notification system consisting minimally of audible and visual alarm notification appliances installed within all common-use areas of a building and manual alarm stations installed at every exit from every level. Activation of any manual pull station or water flow through the sprinkler system will activate all interior alarm notification appliances. Certain minimum fire alarm signal audibility levels, which are based on the average ambient sound levels within the building, are required to be met and are measured by the fire district during the acceptance test of the system.

MANUAL ALARM SYSTEM:

AUTOMATIC ALARM SYSTEM:

- Each building should have suitable fire extinguishing system, depending upon the importance of the building and the associated fire hazards.
- 1. Manual fire extinguishing equipment
- 2. Fire hydrants
- 3. wet riser system
- 4. Automatic sprinkler system
- 5. Carbon dioxide system
- 6. Dry chemical system
- 7. Foam system

1. **Manual Fire Extinguishing Equipment :** Portable fire extinguisher is the equipment most commonly adopted in this category. These devices are useful for extinguishing fire as soon as it starts. They are not useful when once the ire has spread. Portable fire extinguisher can be of carbon dioxide type, large foam generation type etc. Depending upon the capacity , the discharge from a fire extinguisher may last from 20 to 120 seconds. Sometimes bucket full of water and dry sand are also installed at convenient places for takin care of minor fires.
2. **Fire Hydrants :** This consists in providing a 150 mm dia. ring main outside in the ground around the periphery of the building. Fire hydrants are provided on the ring main. The ring main is fed from an underground water tank. it is ensured that the water pressure available at each fire hydrant is of the order of 3.5 to 4 kg/m2 .
3. **Wet Riser System :** This consists in providing 100 to 50 mm dia. vertical G.I. pipes at suitable location within the building. the pipes are also known as risers and are fed from an underground water storage tank through a fire pump which ensures supply of water at 3 kg/cm2 at the topmost outlet. the wet risers have suitable connections at each floors from constant supply of water can be drawn in the event of fire.
4. **Automatic Sprinkler System :** A fire sprinkler system is an active fire protection method, consisting of a water supply system, providing adequate pressure and flowrate to a water distribution piping system, onto which fire sprinklers are connected. Although historically only used in factories and large commercial buildings, systems for homes and small buildings are now available at a cost-effective price.[1] Fire sprinkler systems are extensively used worldwide, with over 40 million sprinkler heads fitted each year. In buildings completely protected by fire sprinkler systems, over 96% of fires were controlled by fire sprinklers alone.

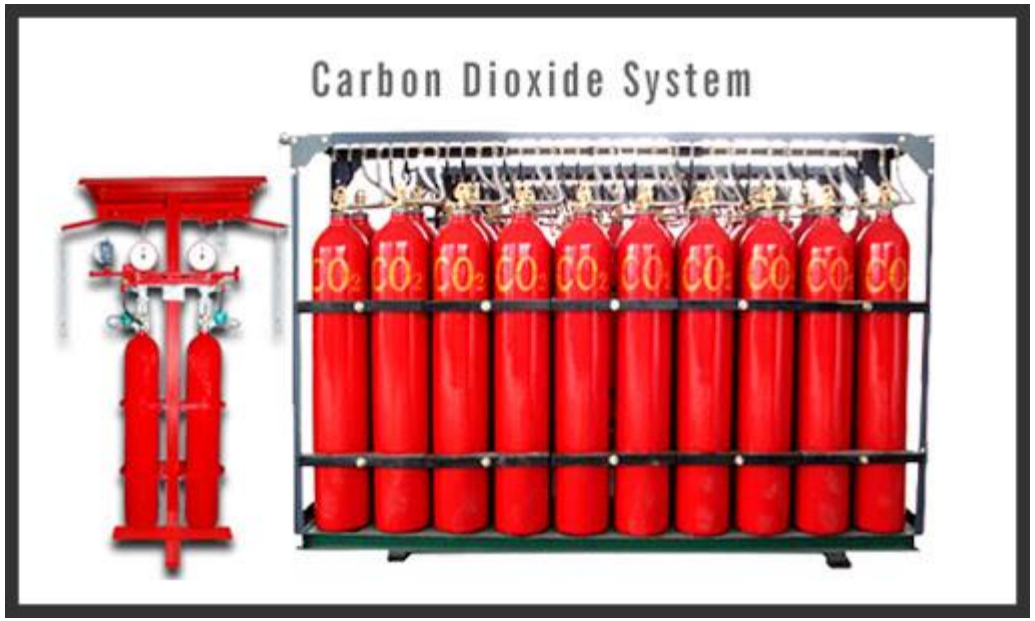
3. SP :

5. **Carbon Dioxide System :** Carbon dioxide or CO2 is a colourless, odourless, electrically non-conductive gas that is highly efficient as a fire suppression agent. Carbon Dioxide fire protection systems use intelligent, reliable and fast-acting control panels to quickly sense a fire before it can cause damage to property. the carbon dioxide is a clean, non-corrosive and non-combustible gas. it extinguishes fire by diluting flammable mixtures of air and flammable gas or vapour to proportions below their flammable limits. it dos not conduct electricity and it penetrates and spreads as a gas over the entire area to be protected from fire. the carbon dioxide is stored in containers either at high pressure or low pressure. the low pressure containers are found to be economical.

- This system granted instantaneous protection on the occurance of fire and it can be easily maintained after its installation. this system is adopted for the fire protection of areas containing flammable liquids, paint mixing rooms, petroleum research laboratories, computer rooms, etc. it is , however not suitable for chemical containing their own oxygen supply or for reactive chemicals which decompose carbon such as potassium or sodium.

6. **Dry Chemical System :** Dry Chemical is a powder composed of very small particles usually of sodium. bicarbonate, potassium bicarbonate, urea-based potassium bicarbonate, or mono-ammonium phosphate with added particulate material supplemented by special treatment to provide resistance to packing, resistance to moisture absorption (caking) and the proper flow capabilities.

- The dry chemical system can be applied in two ways, namely total flooding and local application. the former is used for enclosed areas where all openings can be closed automatically when the system starts working. the later is used for areas which can be effectively isolated from other sources of ignition.


Carbon Dioxide System

- The main components of this system are proportioning apparatus, concentrated storage tank , water supply , foam maker or spray foam heads, heat detecting devices, alarm system etc.
- This system is suitable for oil refineries , chemical plants , aircraft hangers , liquid solvent plants. etc.

7. FOAM SYSTEM :

THANK YOU…