Lecture 11:

Glass, Asbestos, Bitumen

GLASS :

Glass has come out, in recent times, as the most versatile engineering material. The manufactured glass dates from pre-historic times in the Far East, India, and Egypt. With the help of techniques developed in the glass industry, the glass of any type and quality can be produced to suit the requirements of different industries.

Definition : Glass may be defined as a hard, brittle, transparent of transluscent material chiefly compound of silica, combined with various proportions of oxides of sodium, potassium, calcium, magnesia, iron and other materials. Glass is an amorphous substance having a homogeneous texture.

Structure of Glass:

The glass is a random arrangement of molecules, the great majority of which are oxygen ions bounded together with the network forming ions of silicon, boron or phosphorous. Using of silica alone involves high temperature and makes the manufacture expensive. So, network modifying ions of sodium, potassium and calcium ions are added to loosen the Si-O bonds. Certain other ions may substitute for either the network forming ions or network modifying ions. Aluminum, zinc, beryllium, lead and iron are a few of these intermediate ions.

Constituents and Functions: Various constituents and their functions are as follows:

Silica	Principal constituent, fuses at very high temperature,
Sodium and potassium carbonate	Alkaline component, in suitable proportion to reduce the melting point of silica and to impart viscosity to the molten glass
Lime	Added in form of chalk, imparts durability to the glass. In place of lime if lead oxide is also used which makes glass bright and shining
Manganese dioxide	Also called 'glass maker' soap, added in suitable proportion to correct the color of the glass due to the presence of iron in raw materials of glass
Cullet	Similar old broken glass, added in small quantity to provide body to the glass
Coloring substance	For black: cobalt, nickel and manganese oxide; for green: chromic oxide; for red: cuprous oxide, selemium; for violet: manganese dioxide; for white: cryolite, tin oxide; and for yellow: cadmium sulphate

Characteristics of Glass: Following characteristics of glass have made it popular and useful,

- Absorb, refracts or transmits light
- Has no definite crystalline structure
- Is affected by alkalies
- Available in beautiful colors
- Capable of being worked
- Not affected by air or water
- Possible to alter properties like harness
- At heating becomes liquid and can be drawn to any desired shape
- Can take up high polish
- Has no sharp melting point
- Excellent electrical insulator
- Behaves elastic as solid, then breaks
- Extremely brittle
- Not easily attacked by normal chemicals
- May be colorless, clear, defused, stained
- Transparent and transluscent

Manufacture of Glass: Five stages involved in the manufacture of glasses are,

- Collection of raw materials
- Preparation of the batch
- Melting in the furnace: raw materials are heated to as high as 1400 to 1500oC either in,
    - Pot furnace: used to make small amount of glass such as optical glass that require careful control of ingredients and of melting and fining operations
    - Tank furnace: consists of two, melting and working compartments, raw materials are added in batches and a constant level of molten glass is maintained in a continuous tank, adopted for large quantities of glass at a time
- Fabrication: the molten glass is given suitable shape or form in this stage. The different ways of fabrication are,
    - Blowing
    - Drawing
    - Rolling
    - Casting
    - Pressing
    - Spinning
- Annealing: the process of slow and homogeneous cooling of glass articles is annealing. The methods of annealing are,
    - Flue treatment: useful for large production
    - Oven treatment: useful for small scale production

Treatment of Glass: The glass may be given any of the following treatment,

- Bending: heated in the oven and are bent into desired shape
- Cutting: to required sizes with the help of diamond
- Opaque making: done by grinding the glass surface with emery
- Silvery: a very thin coat of tin is applied followed by deposition of silver.

Classification of Glass: As per composition and properties glass may be classified as:

- Soda-lime or crown glass: cheapest quality, available in clean and clear state, principal uses are for window glass, plate glass and container glass
- Flint glass: contains various proportion of lead oxide. Lead provides brilliance and high polish. It is also potash-lead glass used for better quality of table wares and for optical glass. Also used for electric lamps, thermometers, electron tubes, laboratory apparatuses, containers for food etc.
- Pyrex or heat resistant glass: Soda-lime and flint glasses are unable to withstand sudden temperature changes because of their large coefficient of thermal expansion. So the basic oxides in these, when are replaced by boron oxide a glass is produced which are very resistant to thermal shock and to chemical attack by water and acids. Pyrex glasses are extensively used for cooking utensils and laboratory wares.
- Common glass: also known as bottle glass, made from cheap raw material, sodium silicate, calcium silicate and iron silicate, fuses with difficulty, easily attacked by acids, mainly used in the manufacture of medicine bottles.

Special Types of Glasses:

- Sheet glass: Composition is 100 parts sand, 35 parts lime stone, 40 parts soda and 50 parts waste glass. Thickness varies 1.5 to 5mm, generally used for doors and widows

- Plate glass: composed of 100 parts white sand, 33 parts soda carbonate, 14 part slaked lime 100 parts waste glass and 0.15 parts manganese peroxide; thickness varies from 5 to 25 mm, stronger and more transparent to sheet glass, used for looking glasses, wind screens of motors, sales counter, table tops, etc.

- Bullet –proof glass: made of several layers of plate glass and alternate layers consist of vinyl-resin plastic, thickness varying from 15 mm to 75 mm, extensive used for glazing bank teller, cages, cashier booths, jewellery stores, display cases etc.

- Fluted glass: plate glass with one side corrugated are known as fluted glass, used in situations where privacy is required without obstruction of light, used for skylight roofs, for windows of railway stations and factories.

- Ground glass: also known as frosted or obscure glass, one side is ground by sand blasting or by melting powdered glass upon it, mostly transluscent, used for window panels, bathroom ventilators etc.

- Wired glass: glass with wire netting or similar strengthening material embedded in it during manufacture, used for skylight roofs, fire resisting doors and windows

- Safety glass: produced by sandwitching sheets of celluloid or other transparent plastic between two sheets of plate glass and then applying glue to make a single unit, also called shatter-proof glass.

- Insulating glass: transparent glass unit composed of two or more plate glass separated by 6 to 13 mm of dehydrated captive air, hermetically sealed inside, is scientifically cleaned and dried, provides high resistance to heat flow, keeps the apartment cool in summer and warm in winter, used in thermo-flasks etc.

- Foam glass: made by adding desired amount of carbon or any gas which makes the mass porous and light in weight, water proof, can be easily cut and work with, used for sound and heat insulation purposes, air conditioning of buildings.

- Glass block: consists of two halves fused together, provide insulation against heat, cold and noise, widely used for constructing wall partitions.

- Soluble glass: glass mass flows out from the furnace, cools rapidly and breaks up into pieces known as silica lumps, soluble in water, used for preparing acid resisting cement.

- Ultra-violet ray glass: made from raw mixture with minimum admixtures of iron, titanium and chrome, transmits ultra-violet rays effectively, used in the windows of school, hospitals

- Structural glass: these products are hollow, light and transparent, can be sawn, drilled like wood, widely used for pavement lights, partitions, lantern lights, roof covering of industrial buildings, factories etc.

- Perforated glass: perforations are made in the sheet glass with the help of rollers after or during manufacture, used in panels in ventilators.

Properties of Glass:

Glass is a hard, weather resistant but brittle material. It is weak in tension and compressive strength is four times the tensile strength. Hardness can be evaluated by scratch or abrasion test. Hardness of glass is normally a function of its tensile strength. When loaded there is no plastic deformation, and the curve of strain stress diagram is straight until the test specimen breaks.

Silica being the major constituent, the thermal conductivity is practically similar to that for dense clay bricks = 1.0 W/m2/oC (U value). For thermal movement the value is $5.6X10^{-6}/^{o}C$ for high silica glass and $9X\ 10^{-6}/^{o}C$ for lead crystal glass.

For light and heat transmission, normal glazing gives 90% direct transmission of light. Glass tends to absorb infra-red radiation so that the corresponding heat transmission is 80%.

Glass is unaffected by atmosphere and by most acids with the exception of hydrofluoric acid. Alkalis, as occur in cement or chemical paint strippers, attack glass and destroy the smooth surface and light transmission properties.

The sound reduction properties of glazing are typical of those of a thin panel or membrane. Double glazing with absorbent material in the cavity increases the sound insulation.

Glass Wool or Glass Fibre:

Glass fibres are made by letting the molten soda-lime drop through tiny orifices and blowing with air or steam to attenuate the fibres. They have very high tensile strength up to about 2750 N/mm^2. They are used for heat and sound insulation, fire-proof textiles, panel boards, filters, electrical insulating tape, cloth and rope. It is different from mineral wool.

ASBESTOS:

Definition: Asbestos is acid proof, fireproof natural fibrous mineral substance of different colours. It is a hydrous silicate of calcium and magnesium containing small amounts of iron oxide and alumina. The original source was the mineral ‘actinolite’ but the variety ‘chrysolite’ now furnishes most of the commercial asbestos. Its fibres are long and silky, tensile strength varying from 550 to 1370 MPa, the colour is white, amber, grey or greenish and the melting point is 1520oC. Natural asbestos can be divided into two groups,

- Acid resistant: comprising amosite, crocidolite, actinolite, trimolite and anthophylite asbestos
- Non-acid resistant: comprises of only chrysolite asbestos of great industrial importance

Asbestos is found in India, Canada and Rhodesia

Properties of Asbestos:

- Color is white, grey, greenish or brown
- It smooth like glass and silk
- It can be cut into pieces
- Excellent insulator for heat and electricity
- Can be drilled and screws can be fitted
- Its sp.gr. is 3.1
- Can easily mix with binding material
- It is fibrous in structure
- Acid proof (except chrysolite) and fire proof
- It is flexible
- It is incorrodible and vermin proof
- Capable of being interwoven with webbing
- Strong molecular binding in one direction

Uses of asbestos: Following are the uses of asbestos,

- Asbestos cement products are sheets for roofing and pipes for conveying water
- Asbestos felt(fibers coated with bitumen) is used for damp proofing
- It is widely employed for insulating furnaces, steam and exhaust pipes, boilers etc.
- It is used for covering material for magnetic coils
- It is used as lining material, for preparing fire proof cloths and asbestos paint.

Commercial Forms of Asbestos:

- Asbestos boards and sheets: it is a construction or insulating material in sheets made of asbestos fibre and Portland cement moulded under hydraulic pressure and are of the types,
    - Asbestos board: asbestos cement building boards are of two types,
        - Class A: thickness 6.5 mm, width 1.2 m
        - Class B: thickness 5.0 mm, width 1.2 m, length is 1.2 m, 1.8 m or 2.4 m
    - Asbestos sheets:
        - Flat asbestos sheet:
            - Compressed: min. bending stress, 22 MPa, density, 1600 kg/m^3
            - Uncompressed: min. bending stress, 16 MPa, density, 1200 kg/m^3
        - Corrugated asbestos sheets: for roofing of industrial buildings, thickness 4.76 to 66.35 mm, corrugation pitch, 10 cm, unit wt. 145 N/m^2

  Asbestos boards and sheets are used for, wall lining, paneling, false ceilings, toilet partitions, black boards, hoardings, sign boards, window panes and door panels etc.

- Asbestos cement pipes: are made of asbestos cement which is a mixture of asbestos fibers (15-20%), cement (80-85%), and required amount of water. Various forms of rain water and drainage asbestos pipes are available, they can be easily cut and require no painting. They are light, strong, easy to install. They are used as rain water pipe, soil waste and ventilating pipes, valley gutters, boundary wall gutters etc.

- Asbestos paper: used as a cover in electric motors and coils exposed to high temperature

- Asbestos paint: prepared by adding finely ground asbestos to an oil paint and distemper, fire, heat and vermin proof, prevents corrosion of metals

- Asbestos fibre: available in the for of fibres, have adequate strength and flexibility, used in making conveyer belts, boiler insulation, brake lining etc.

- Asbestos felt: made of asbestos fibres impregnated with mineral bitumen, are water proof, used as damp proof layer

- Asbestos fabric: it is the woven stuff from asbestos fibres and is used as cable insulation and for winding of motors

ASPHALT, BITUMEN & TAR:

Asphalt, bitumen and tar are referred to as ‘bituminous material’ are essentially mixture of hydrocarbons frequently accompanied by their non-metallic derivatives. They may be gaseous, liquid, semi-solid or solid in nature and are completely soluble in carbon-di-sulphide(CS2). They possess some common properties as follows:

- Thermo-viscosity, i.e. variance of viscosity with temperature
- Adhesion to solid surfaces
- Durability
- Water-proofing characteristics under normal circumstances

The above desirable properties of 'bituminous materials' render them very useful as a binding material, protective agent, and a sealant.

Manufacture and Types of Asphalt/Bitumen: major types are,

- Natural asphalt:
    - Lake asphalt: obtained in Trinidad, Bermudez, at 3-6m depth, composite material containing 40 to 70% pure bitumen, refined by boiling in a tank, water evaporates and impurities collected at the top are removed, widely used for road and pavement construction
    - Rock asphalt: limestone rocks impregnated with asphalt are found in Switzerland, France, Germany etc., contains 4-20% pure bitumen by volume, crushed, heated to construct road pavements.

- Residual or petroleum asphalt/bitumen: also known as artificial asphalt, obtained by fractional distillation of crude petroleum. Major classification is

    - Penetration grade asphalt:
        - Different grades depending on penetration/viscosity values

    - Cutback bitumen:
        - Slow curing
        - Medium curing
        - Rapid curing

    - Air blown asphalt:

    - Asphalt emulsion:
        - Anionic
        - cationic

Properties of Asphalt/Bitumen:

- it is characteristically solid, semi-solid or liquid
- it melts or softens on application of heat
- its specific gravity is 1.05-1.10
- it is completely soluble in carbon-di-suphide
- it possesses great chemical stability, but is affected by oil
- it has low permittivity and high insulation resistance

Asphalt/bitumen is used in wide variety of civil engineering constructions.

Tar: is a black solid or semi-solid mass obtained during the destructive distillation of coal, peat, wood, or other organic material. Its properties depend upon the raw material used, method of distillation and the proportion of residual matter incorporated. Tar hardens much quicker than asphalt, it is more adhesive and possesses more toxicity. It is used for road making and roofing and as a protective material for timber and wood products.