BUILDING DIGEST

CENTRAL BUILDING RESEARCH INSTITUTE INDIA

PLASTICS FOR BUILDING

The synthetic organic plastics are assuming an important position among building materials. They provide design engineers and architects with combinations of properties not obtainable with older materials. This Digest briefly describes the properties and principal applications of plastics in building construction.

What are plastics ? A substance is said to be plastic if it possesses plasticity; that is, if it can be deformed under mechanical stress without losing its cohesion and can retain the new form given to it. Many materials such as clay, mortar, concrete, some metals and glass are plastic under certain conditions but they are not included in the plastics family which consists of organic materials based mainly on carbon compounds.

The property of plasticity is associated with the amorphous state as distinct from the crystalline state. In the crystalline state, matter is arranged in an orderly manner but in the amorphous state the arrangement is random. In plastics this random arrangement results from the large size of their molecules which are built up from thousands or tens of thousands of atoms.

Large molecules, usually known as polymers, are found widespread in nature. Many of the materials we encounter daily such as wood, paper, cotton, silk, wool, leather and rubber are polymers.

Chemists have enormously increased the variety of polymers by artificial means. Synthetic fibres, plastics and rubbers are examples of synthetic polymers.

Polymers are manufactured from simple short molecules known as monomers which in turn are produced from the starting raw materials, mainly coal and petroleum. The monomer units are fitted together in the form of a long chain to produce a polymer molecule.

Polymers are often referred to as resins because several of them have physical characteristics similar to those of natural resins.

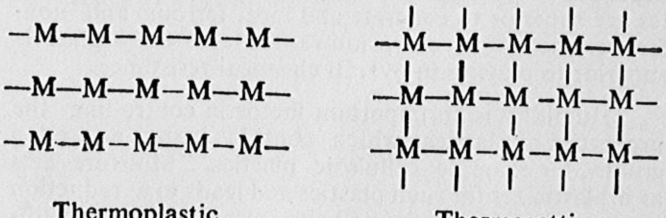
Some polymers are made from one monomer each as for example polyethylene from ethylene, polyvinyl chloride from vinyl chloride and polystyrene from styrene. Others are made from two or three monomers. Examples are phenol-formaldehyde resin from phenol and formaldehyde and acrylonitrile-butadiene-styrene polymer from acrylonitrile, butadiene and styrene monomers.

The length of a polymer molecule depends on the number of monomer units in the chain. Useful plastic properties are exhibited by the molecules only when the number of units exceeds a certain limit. Above this limit also the properties of the polymer vary with variations in chain length. Polymers of different chain lengths suited to specific uses are being manufactured. Taking the example of polyvinyl chloride, pipes and fittings are fabricated from a polymer having about 1000 units of vinyl chloride in the chain whereas some types of sheets are manufactured from a polymer of about half the number of units.

In addition to controlling the chemical nature of the monomer and the number of monomer units which go into building a polymer, chemists are also beginning to exercise control over the spatial arrangement of the atoms in the polymer molecule. A wide range of polymers are produced in this way, and the architecture of the polymer molecule is ultimately responsible for its being a fibre, plastic or rubber.

Polymers are seldom used in their pure state. One or more of such ingredients as plasticizer, stabilizer, antioxidant, pigment and filler are usually compounded with them to make plastics as they are known commercially. Polymers are nontoxic but some of the ingredients compounded with them may have toxic effects. When a plastics material is to be used in contact with food or water supply, steps must be taken to ensure freedom from toxic effects.

Plastics may be broadly classified into two types, the thermoplastic and the thermosetting. Thermoplastic materials can be repeatedly softened by the application of heat and are usually soluble in specific solvents. This group includes polyethylene, polyvinyl chloride and nylon. Thermosetting materials, though fusible and soluble in the early stages of their manufacture, are transformed by chemical reaction into an infusible and insoluble state. This reaction, known as curing or hardening, is brought about either by the action of heat or by chemicals. Examples are phenolic plastics, urea-formaldehyde resins, polyesters and epoxy resins. The difference between the two classes of plastics can be understood from Fig. 1, where M represents a molecule of the monomer used in chain building.



Thermoplastic　　Thermosetting

Fig. 1

The chains in thermoplastic material are free to move apart and slide past one another under the action of heat and pressure, whereas in thermosetting material the chains are rigidly held in place by the links between them. The extent of cross linking between chains can be controlled.

Properties of plastics. Plastics, like metals, constitute a group of materials. In appearance some are completely transparent. Many plastics can be pigmented to give attractive, stable, translucent and opaque colours.

Whether thermoplastic or thermosetting, plastics are characterized by their low specific gravities which are about one fifth that of cast iron and one to two times that of constructional woods. Plastics have very good electrical insulating properties. Their thermal conductivity is also low, comparable to that of wood. Foamed or expanded plastics are amongst the best known thermal insulators.

Plastics are affected by heat to a much greater extent than other building materials. Their coefficient of thermal expansion is about ten times that of steel. The maximum use temperature of some plastics is only of the order of 50°C. This is, however, high enough for most building applications. Thermoplastic varieties are more susceptible to heat than the thermosetting. Glass fibre reinforcement increases the resistance of plastics to heat.

Being organic in nature all plastics are combustible but they vary considerably in their resistance to high temperature and fire. Phenolic plastics are inherently self-extinguishing and so also is polyvinyl chloride. Plastics are made self-extinguishing by the addition of chlorinated or phosphated compounds.

Plastics are surprisingly strong and may be reinforced with various fibrous materials. Their strength to weight ratio in tension approaches that of metals but their stiffness is generally low and their characteristics are far more sensitive to changes in temperature than those of metals. Plastics are also subject to creep under sustained loads. These factors coupled with their high cost have tended to discourage their use in structural applications. In general, thermo setting materials have higher strengths than thermoplastic materials and reinforced plastics exhibit the highest strength.

Pressure-bonded veneer and paper laminates impregnated with phenol-formaldehyde and melamine-formaldehyde resins belong to the category of reinforced plastics. More recently glass fibre in various forms has been used to reinforce plastics, usually of the polyester type.

The resistance of plastics to the action of moisture, chemicals and solvents varies considerably and is dependent on their chemical composition. Many plastics are superior to concrete and most ferrous and non-ferrous metals in corrosion resistance. Only glass is superior to plastics in overall chemical resistance.

Humidity is an important factor in controlling the properties of plastics which contain water attracting groups, for example cellulosic plastics. Moisture acts as a plasticizer for such plastics and leads to a reduction in strength. On the other hand, plastics like polyethylene and polyvinyl chloride which do not have water-attracting groups are very resistant to moisture.

Weathering is a complex phenomenon whose effect on plastics is not always easy to forecast. Some plastics like polymethyl methacrylate, epoxy resin and phenol-formaldehyde resin are remarkably resistant to weathering and retain their physical properties over long periods. But certain plastics are affected by ultraviolet light and as they degrade in the presence of sunlight they are not recommended for outdoor applications. Unprotected polyethylene is an example. Resistance to sunlight is improved by the incorporation of pigments and fillers which absorb or reflect the ultraviolet light at the surface thereby protecting the interior of the plastics.

Plastics, especially the thermoplastic varieties, are susceptible to attack by termites and rodents, but since plastics have no nutritional value the risk of attack is not considered unduly high.

It is essential to recognize that each plastics material has its own particular properties which make it suited to its own particular uses. Success in the use of plastics in building will depend on the correct choice of material and the care with which it is applied.

Plastics for building. Plastics are manufactured in different forms such as mouldings, pipes, sheets and films. They are foamed or expanded to produce materials of low density. Dissolved in solvents or dispersed as emulsions they are used in paints, varnishes and adhesives.

Weight for weight or bulk for bulk plastics to-day are much dearer than traditional building materials, but whereas the cost of the latter tends to rise steadily, there is every prospect of the cost of plastics coming down with the expansion of the petrochemical industry. At the present time plastics find use in buildings mainly in thin coverings, panels, sheets, foams, pipes, adhesives and products in which a little material goes a long way. Skilful use of plastics will expand the usefulness and life of conventional building materials and help them to function more efficiently and economically.

Typical uses of plastics in building are given in Table 1. It is proposed to describe some of these uses in greater detail in future Digests.

Table 1.

Typical uses of plastics in building

Thermoplastics	
Polyethylene (Low density)	Film for water proofing damp proofing and concrete curing. Pipes for cold water services. Cistern ball floats.
Polyethylene (High density)	Pipes and fittings for cold water services; overhead water tanks.
Polyethylmethacrylate (Acrylic plastics)	Rooflights, lighting fittings, bath and sink units.
Polystyrene	Expanded form for thermal insulation. Wall tiles.
Polyvinyl acetate	Jointless flooring. Emulsion paints.
Polyvinyl chloride (PVC)	Wall and floor tiles and coverings. Corrugated and plane sheets. Pipes and fittings for water supply and drainage. Electrical conduits.
Silicones	Water proofing and damp proofing.

Thermosets

Epoxy resins	Coatings, adhesives, floor finishes. Concrete repair material.
Melamine-formaldehyde	Decorative laminates in light colours for wall and ceiling linings, table and counter tops.
Phenol-formaldehyde	Laminates and mouldings in dark colours, electrical fittings, W. C. seats. Water-resistant adhesives for plywood and particle board manufacture.
Polyesters	With glass fibre reinforcement as (1) plane and corrugated panels for roofs, rooflights and partitions, (2) sanitary appliances. With fillers for floor finishes.
Polyurethane	Foams for thermal insulation.
Urea-formaldehyde	Adhesives for wood and wood products.

There is a demand for short notes summarising available information on selected building topics for the use of Engineers and Architects in India. To meet the need, this Institute is bringing out a series of Building Digests from time to time and the present one is the 51st in the series. Readers are requested to send to the Institute their experience of adopting the suggestion given in this Digest.

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