05

INTRODUCTION TO BASIC AND ADVANCE MATERIALS

Ms. CHETANA RAJE
Sir Vithaldas Thackersey College of Home Science (Empowered Autonomous Status),
S.N.D.T. Women's University, Mumbai, Maharashtra.

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About the Author: Ms. Chetana Raje, *an Associate Professor and Department Head for Resource Management at SVT College of Home Science (Autonomous), SNDTWU, has 28 years of undergraduate and over 5 years of postgraduate teaching experience. She's a dedicated academician with a focus on curriculum restructuring for Resource Management programs. She's a seasoned freelance design practitioner having worked on residential and office interiors from 1999 to 2016. Actively engaging in workshops, seminars, and conferences, Ms. Raje specializes in Vernacular and heritage architecture, Building materials, Product Design, Technology in design, and Safety management. Currently, she is pursuing a Ph.D. in Safety design and planning.*

The building industry has a multi-material palate, with purpose and applications in the construction of structures, interior furnishing, mechanical, electric, plumbing, automation, specialty areas, and so on. It needs a different platform to have all these condensed in one space. Therefore, this chapter is an overview and the content is prepared to create awareness only about the core, eco-friendly, and smart architectural materials. There is an exhaustive referencing available to study, on the technological advancements and onsite application of all the other materials.

5.1 BASIC BUILDING MATERIALS

Building material is any material used for construction purposes such as materials for house building. Construction materials can be generally categorized into two sources, natural and synthetic. The construction industry has evolved from the basic need for shelter with ephemeral structures to advanced materials rendering permanence to habitats that can be occupied by generations. The added feature is the advancement in technology for creating robust structural systems. Natural materials are those that are unprocessed or minimally processed by industry, such as lumber or glass. Synthetic materials are made in industrial settings after much human manipulations, such as plastics and petroleum-based paints. Both have their uses. Mud, stone, and fibrous plants are the most basic materials, aside from tents made of flexible materials such as cloth or skins. People all over the world have used these three materials together to create homes to suit their local weather conditions. In general stone and/or brush are used as basic structural components in these buildings, while mud is used to fill in the space between, acting as a type of concrete and insulation. A basic example is wattle and daub mostly used as permanent housing in tropical countries or as summer structures by ancient northern peoples. Ice was used by the Inuit for igloos, but has also been used for ice hotels as a tourist attraction in northern areas that might not otherwise see many winter tourists.

Wood, cement, aggregates, metals, bricks, concrete, and clay are the most common types of building materials used in construction. The choice of these is based on their cost-effectiveness for building projects. Many naturally occurring substances, such as clay, sand, wood and rocks, even twigs and leaves have been used to construct buildings.

The manufacture of building materials is an established industry in many countries and the use of these materials is typically segmented into specific specialty trades, such as carpentry, plumbing, roofing, and insulation work. Cement, bricks, and tiles are the main building materials used in the construction of buildings. Many new building materials are environmental hazards, which have become a big concern to all.

Traditionally, the basic types of building materials used for construction were mud, stone, and brush. Mud was used for filling the spaces between bricks and acted as a concrete and insulation. Centuries ago, houses were made entirely of dirt and clay. This was followed by the use of rocks (mainly granite) as building material. From the Neolithic period through the medieval age to modern times, granite has been commonly used as a building material. Brush structures were commonly seen in tropical areas and were made entirely from plant parts such as branches, bark, twigs, and leaves. These structures were often used by Native Americans as resting places.

Stones and bricks were also common in construction. Different types of bricks have been and are still used for masonry. This includes specially shaped bricks for joints, striking, and tooling, as well as glazed or rubbed bricks for decorative purposes.

Thatch is one of the oldest types of building materials used for roofing. Another generic building material is wood. Because of the diverse character of different types of wood, it can be used for any type of structure in most climates. Even though wood structures were very common in earlier times, they disappeared with the approach of concrete structures.

Concrete is a composite building material comprised of aggregate and a binder (cement). Concrete finds good use in all types of building construction. Fly ash is a major ingredient in the concrete mix because of its lightweight and high thermal insulation.

More recently, new types of building materials have been used. These include metals (for the structural framework of larger buildings), plastics, asbestos, and fabrics. Tar-based waterproof materials, paper linoleum, polyvinyl chloride clay, and solvent coatings for inner walls are other building materials. The basic materials used in construction are briefly discussed below;

5.1.1 Mud and Clay

The amount of each material used leads to different styles of buildings. The deciding factor is usually connected with the quality of the soil being used. Larger amounts of clay usually mean using the cob/adobe style, while low clay soil is usually associated with sod building. The other main ingredients include sand/gravel and straw/grasses. Rammed earth is both an old and newer take on creating walls, once made by compacting clay soils between planks by hand, now forms and mechanical pneumatic compressors are used. Soil especially clay is good thermal mass; it is very good at keeping temperatures at a constant level. Homes built with earth tend to be naturally cool in the summer heat and warm in cold weather. Clay holds heat or cold, releasing it over a period like stone. Earthen walls change temperature slowly, so artificially raising or lowering the temperature can use more resources than in say a wood-built house, but the heat/coolness stays longer. Buildings with mostly dirt and clay, such as cob, sod, and adobe, resulted in homes that have been built for centuries in western and northern Europe as well as the rest of the world, and continue to be built, though on a smaller scale. Some of these buildings have remained habitable for hundreds of years.

5.1.2 Ceramics

Ceramics are clay-based products such as tiles, fixtures, etc. Ceramics are mostly used as fixtures or coverings in buildings. Ceramic floors, walls, countertops, even ceilings. Many countries use ceramic roofing tiles to cover many buildings. Ceramics used to be just a specialized form of clay-pottery firing in kilns, but it has evolved into more technical areas.

5.1.3 Thatch and Brush

Thatch is one of the oldest materials known; grass is a good insulator and easily harvested. Many African tribes have lived in homes made completely of grasses year-round. In Europe, thatch roofs on homes were once prevalent but the material fell out of favour as industrialization and improved transport increased the availability of other materials. Today, though, the practice is undergoing a revival. In the Netherlands, for instance, many new builds have thatched roofs with special ridge tiles on top. Villages in some parts of India have tribal housing with natural sustainable materials like thatch and mud.

Brush structures are built entirely from plant parts and are generally found in tropical and subtropical areas, such as rainforests, where very large leaves can be used in the building. Native Americans often built brush structures for resting and living in, too. These are built mostly with branches, twigs leaves, and bark, like a beaver's lodge.

5.1.4 Stone

Stone structures have existed for as long as history can recall. It is the longest-lasting building material available and is usually readily available. There are many types of rock throughout the world all with differing attributes that make them better or worse for use. A natural material of construction, which is obtained from, rocks by any suitable method is called a stone. The stone, that is used for the construction of engineering structures, is known as building stone. Stones when derived from rocks are very irregular in shape and size. They are, therefore dressed for proper bedding, thin joints, and speedy construction. Stone possesses long-lasting properties and is naturally available in large quantities. Dry-stone walls have been built for as long as humans have put one stone on top of another. Eventually, different forms of mortar were used to hold the stones together, cement being the most commonplace now. Circular huts were constructed from loose granite rocks throughout the Neolithic and early Bronze Age, and the remains of an estimated 5,000 can still be seen today. Granite continued to be used throughout the Medieval period and into modern times. Slate is another stone type, commonly used as roofing material in the United Kingdom and other parts of the world where it is found (Himachal Pradesh in India). Man has been using stones from very ancient times for constructing foundations, walls, pillars, lintels, beams, floors, roofs, etc. of buildings and for major engineering works such as weirs, dams, etc. Ancient temples and other important historical buildings in India and abroad were built with stones.

5.1.5 Wood

Wood is an elemental material. It has a warmth and beauty that is unique. It is a specialized tissue designed by nature and no other material can substitute it. Timber denotes wood, which is suitable for building and carpentry or other such purposes. and is applied to a tree having girth (circumstances not less than 600 mm). There are hundreds of variations in the surface, texture, and colour between the same and different types of wood. Wood is a product of trees, and sometimes other fibrous plants, used for construction purposes when cut or pressed into lumber and timber, such as boards, planks, and similar materials. It is a generic building material and is used in building just about any type of structure in most climates. There are many differing qualities to the different types of wood, even among the same tree species. This means specific species are better for various uses than others. And growing conditions are important for deciding quality. Wood can be very flexible under loads, keeping strength while bending, and is incredibly strong when compressed vertically. Historically, wood for building large structures was used in its unprocessed form as logs. Reconstructed timber is prepared scientifically in a factory. Industrial timber possesses the desired shape, appearance, and strength thickness. Broadly speaking, wood may be supplied as solid timber cut straight from a felled tree, or it may be in the form of timber products, such as plywood and MDF, HDF (medium/high-density fibreboards), where the raw timber has undergone some form of processing. Timber products can have many different surface treatments applied; ex. real wood veneers, spray paint, polish, lamination etc.

5.1.6 Brick and Block

A brick is a block made of kiln-fired material, usually clay or shale, but also may be of lower-quality mud, etc. Clay bricks are formed in a moulding (the soft mud method), or commercial manufacture more frequently by extruding clay through a die and then wire-cutting them to the proper size (the stiff mud process). Bricks were widely used as a construction material from the 1700s to 1900s. This was probably because it was much more flame retardant than wood in the ever-crowding cities, and cheap to produce. Another type of block replaced clay bricks in the late 20th century. It was the cinder block, made mostly of concrete. An important low-cost material in developing countries is the sand-crete block, which is weaker but cheaper than fired clay bricks.

5.1.7 Concrete

Concrete is a composite building material made from the combination of aggregate and a binder such as cement. The most common form of concrete is Portland cement concrete, which consists of mineral aggregate (generally gravel and sand), Portland cement, and water. After mixing, the cement hydrates and eventually hardens into a stone-like material. When used in the generic sense, this is the material referred to by the term concrete. For a concrete construction of any size, as concrete has a rather low tensile strength, it is generally strengthened using steel rods or bars (known as rebars). This strengthened concrete is then referred to as reinforced concrete. To minimize any air bubbles, that would weaken the structure, a vibrator is used to eliminate any air that has been entrained when the liquid concrete mix is poured around the ironwork. Concrete has been the predominant material in this modern age due to its longevity, formability, and ease of transport.

5.1.8 Metal

Metals form a core of the building and interior furnishing industry through varied applications. Due to space, strength, and durability, metals are used for structural & and ornamentation purposes more so in framing, skeletal forms, hardware for furniture, etc. Hardware comprises fixtures such as brackets, hinges, lock handles & and other fittings. The present trend allows the use of metal for furniture-making doors & and windows. It gives a touch of hi-tech to the interiors. Metals can bestow not only a strong character but also add to delicacy & and elegance. Metals are traditionally classified as Ferrous and Non-ferrous.

The term ferrous refers to those metals containing a large percentage of iron (Fe). Two or more metals combined in molten form into a substance that has metallic qualities is an alloy. Example – Brass, Bronze, etc. Alloys may be classed as ferrous or nonferrous, depending on the percentage of iron they contain. Examples of core non-ferrous metals – Aluminium, Copper

The ferrous metals important in construction include cast iron, wrought iron, and steel which is an iron alloy. Metal is used as a structural framework for larger buildings such as skyscrapers, or as an external surface covering. There are many types of metals used for building. Steel is a metal alloy whose major component is iron, and is the usual choice for metal structural construction. It is strong, flexible, and if refined well and/or treated lasts a long time. Corrosion is metal's prime enemy when it comes to longevity. The lower density and better corrosion resistance of aluminum alloys and tin sometimes overcome their greater cost. Brass was more common in the past but is usually restricted to specific uses or specialty items today. Metal figures quite prominently in prefabricated structures and can be seen used in most cosmopolitan cities. It requires a great deal of human labour to produce metal, especially in the large amounts needed for the building industries. Other metals used include titanium, chrome, gold, and silver. Titanium can be used for structural purposes, but it is much more expensive than steel. Chrome, gold, and silver are used as decoration because these materials are expensive and lack structural qualities such as tensile strength or hardness.

5.1.9 Glass

Glass is a material that has been used since ancient times. Glass comes out as the most versatile engineering material of modern times. Glass is generally made from mixtures of sand and silicates, and is very brittle. The glass has been used as an engineering material. Modern glass "curtain walls" can be used to cover the entire facade of a building. Glass can also be used to span over a wide roof structure in a "space frame". Clear windows have been used since the invention of glass to cover small openings in a building. They provided humans with the ability to let light into rooms while at the same time keeping inclement weather outside.

Interior designing has become stylish and elegant with glass usage. Glass provides all the possible ways to decorate homes, furniture, kitchens, floors, and doors with aesthetic looks. Even office writing boards, signage, lobbies, and staircases can be made vibrant while embellishing with various types of interior glass.

5.1.10 Plastic

The term plastics covers a range of synthetic or semi-synthetic organic condensation or polymerization products that can be moulded or extruded into objects or films or fibres. This name is derived from the fact that in their semi-liquid state, they are malleable, or have the property of plasticity. Plastics vary immensely in heat tolerance, hardness, and resiliency. Combined with this adaptability, the general uniformity of composition and lightness of plastics ensures their use in almost all industrial applications today. Examples are Acrylic, Polyvinyl chloride, Polycarbonate plastics, etc. The use of plastic materials in commercial and residential construction has dramatically increased due to improved material performance, efficient use of technologies in new applications, and the need for lightweight, durable materials for insulating and construction purposes. In commercial the most stringent fire is fire provided for a wide range of plastics applications, including - insulation materials, interior finish, and trim; light-transmitting plastics (e.g. covers), light-transmitting wall panels, skylights, and foam plastic insulation materials. Due to their properties, plastic materials may be found in the walls, roof, plenums, doors, attics, etc., and (or on) masonry. The myriad of applications has resulted in the development of specific fire performance and tests so in the event of a fire, the plastic does not contribute to fire growth based on the anticipated use and the potential impact on building occupants.

5.1.11 Cement composites

Cement-bonded composites are an important class of construction material. These products are made of hydrated cement paste that binds wood or similar particles or fibers to make precast building components. Various fibrous materials including paper and fiberglass have been used as binders. Wood and natural fibres are composed of various soluble organic compounds like carbohydrates, glycosides, and phenolics. These compounds are known to retard cement setting. Therefore, before using wood in making cement-boned composites, its compatibility with cement is assessed. Engineered stone is a composite material made of crushed stone bound together by an adhesive to create a solid surface, most commonly polymer resin, with some newer versions using a cement mix.

5.1.12 Fabric

The tent used to be the home of choice among nomadic groups the world over. Two well-known types include the conical teepee and the circular yurt. It has been revived as a major construction technique with the development of tensile architecture and synthetic fabrics. Modern buildings can be made of flexible material such as fabric membranes, and supported by a system of steel cables or internal air pressure. Carbon fibre fabric is an excellent example of technological innovation. It is a strong fiber that is light in weight and has long strands interwoven together so that it forms a fabric-like structure. It dominates the steel in terms of strength, stiffness, and load-bearing capacity. These leading properties make carbon fibre a perfect building material for construction projects. It works best with structures that receive high-impact loads.

Interior furnishing has evolved with a wide expanse of fabric applications in the form of soft furnishings like upholstery, drapes, curtains, tapestries, and other accessorizing products.

5.2 ECO-FRIENDLY AND RECYCLABLE MATERIALS

Conventional building materials such as wood, brick, steel, and cement are high in cost and utilize large amounts of natural non-renewable resources such as topsoil, minerals, forest cover, etc. Manufacturing processes can cause pollution, hence for a better quality environment and resource sustainability, eco-friendly materials should be manufactured that can be made from recycling polluting waste into useable materials that are non-endangering the bio-reserves, and nonpolluting, are self-sustaining, low in monitory cost, utilize renewable energy sources.

5.2.1 Fly Ash

Flyash is one of the types of coal combustion byproducts (CCBP's). When you burn coal, the ash you get is flyash which is used in making bricks have more strength. It does not have sand and alumina. It has no salts. It is light in weight. It is industrial waste arising from the thermos-electric plant. Although flyash offers environmental disadvantages as an air pollutant if not managed, it has a greater advantage as it greatly improves the performance and quality of concrete. It possesses ceramic properties that is it is malleable like clay and pozzolana properties that is it can withstand very high temp. Fly ash in a dry state is mixed with lime and a small amount of sand. After thoroughly mixing it, it is pressed into the required moulds by the hydraulic press for hardening it. Raw fly ash bricks are greenish in colour. Then they are heated in steamed chambers, at desired pressure and temp, and are superior in quality to normal bricks. They have more strength, are resistant to salts, absorb less amount of water, are smooth and uniform in size, require less quantity of cement mortar, are cheaper to transport, and are easy to handle. Flyash increases strength, reduces permeability, reduces corrosion of reinforcing steel, increases sulphate resistance, and reduces alkali-aggregate reaction. Coal fly-ash can also replace clay, sand, limestone, and gravel, saving the energy costs of mining such materials. By using fly ash building blocks, we are saving the fertile soil. Flyash used in concrete is a mature technology. By replacing cement, the ash produces less of the greenhouse gases that contribute to global warming.

5.2.2 Rubber Wood

Rubberwood is the name given to lumber from the rubber tree (Havea Brasiliense), which is a tree-producing latex that is then used to produce natural rubber. Other names today include parawood and Malaysian oak. It is a versatile wood substitute and is obtained from rubber trees, special rubber plantations are grown. Malaysia is the world’s leading supplier of rubber wood, to an extent of 45% of the world's supply. Because of the phenomenal export rate, the government has introduced strict replanting programs to ensure a continuous supply of trees and protect the environment. Rubber trees reach prime in over 25 years and afterward, it is not economical to supply rubber, then trees are felled and logs are taken to the factory where they are peeled in a factory in a sawmill. For handling convenience, they are cut down to the size of 6'. It is a light hardwood since it is strong but not dense to saw and cut. Its coloring is whitish yellow and becomes cream over some time. It is usually kiln-dried for fast drying which also prevents fungal and insect infestation, as a protection against woodworm. It has light density, easy workability, aesthetic appeal, versatility, looks like pine, but is harder, and cheaper. Generally, rubber wood furniture is produced with the help of a machine. Wood is used in the form of laminate, in the form of solid wood, in the form of moulding, and also in the form of ply sheets for which sap of trees is mixed with phenol and steam heated to desired temperature and pressure. This wood can be bent in any form by steam heating it. It is light in weight, and easy to transport. It has less nutritive value compared to other natural timber, but it is more termite-resistant. It takes natural polishing and looks very rich. All furniture pieces like chairs, tables, doors, and flooring boards are made up of rubber wood. No yielding woods are cut but trees are not economically viable and not yielding much of rubber latex are cut so that re-plantation is possible for fresh plantation.

5.2.3 Cellular Light Weight Concrete (CLC)

Industrial waste like fly ash is mixed with cement instead of sand and aggregates. It has fire-resistant properties because of fly ash. Sometimes even wood chips are used instead of aggregates as they are lighter in weight, compared to the aggregates of stone. It is air-cured, lightweight concrete suitable for low-rise, load-bearing construction as well as for partition works for multistoried buildings. They require minimum plastering. These partitions are thermal insulators, easy and fast to produce.

5.2.4 Cellulose Fibre

They are made from waste newspapers. Cellulose is the byproduct of trees. It is a substance in plant tissues which is used in making paper. For manufacturing cellulose fibres, the loose papers are recycled with borax and boric acid. This fibre is used as a filler or loose fill in roofs, walls, floors, and ceiling cavities by hand or by spray. They have interlocking pores that absorb and diffuse heat and thus can act as thermal insulators. It is fire-resistant, insect insect-proof. It is a completely recycled and nontoxic material perfectly suited for the contemporary environment as its manufacturing process requires much less energy.

5.2.5 Wood Fibre Board or Particle Board

Better quality particle board is called medium-density fibre board which is used extensively these days for modular office furniture as well as modular kitchen. For particle board manufacture, the sawmill waste in the timber production mill is reused, and the fibres are bonded together by natural resin that is gum without any chemical adhesive. Then thick chips forming alternate layers are pressed between two thin sheets of ply. They can be installed in partitions for wall claddings, roofs, and floors, for sound as well as thermal insulation. They also regulate interior humidity and they are available in various thicknesses to suit the application.

5.2.6 Coconut Fibre Board

It is a natural fibre board made from an outer husk of coconut with minimum processing and no outer additives. It has good thermal and acoustical insulation properties. It is used as an underlay for carpet and screed for timber flooring. Local labour, and low cost is the added advantage.

5.2.7 Phospho Gypsum

It is a by-product of the phosphoric acid-based fertilizers industry and is used to make several building materials like pop, gypsum, different kinds of plasterboards and tiles, specialized cement like white cement artificial marble, etc.

5.2.8 Red Mud Jute Fibre Polymer Composite

Red mud is a by-product of aluminum. It is a residual material that is slag which consists of alumina, silica, and iron oxide obtained during aluminum production. It is mixed with natural raw materials like jute and man-made polymers like plastic to make high-quality exposed brick, tiles, corrugated roofing sheets for making door panels, etc. It is easy to manufacture, light in weight, economical initially as well as maintenance cost is less. It is used in furniture paneling, electric boards, and insulating sheets.

5.2.9 Recycled Plastic

Plastics are very difficult to dispose of being a nonbiodegradable waste, hence it is mixed with multilayered plastics and can be shaped into usable materials such as tile, flooring, containers, lamps, railway sleeper, park benches, street furniture, fencing, etc. It can be used as a substitute for timber and concrete products. Unsaturated polyester resin from recyclable plastics can replace the conventional high-cost resin used in polymer mortars, polymer concretes which are used in structural treatments of polymerization of beams, columns, lofts, and wall cracks due to reinforcement rusting and getting loose from surrounding cement concrete. This is used for industrial flooring.

5.2.10 Fiber glass Reinforced Plastic (FRP)

Fibre glass-reinforced plastic is a composite material having different properties than the parent material. Glass fibres reinforce plastic which means it gives additional strength. The resin in plastic transfers the load to glass fibres. It is an organic recyclable material obtained from used plastic. It has resistance to moisture and chemicals. It has high strength and low weight ratio with corrosion resistance. It gives an excellent finish and, hence can be used for domes and skylights. It will allow the light. If it breaks, no splinters fly. It is a good material for interiors. There is also the long-term economic advantage of reduced maintenance costs. It is used in the automobile industry.

5.2.11 Plastic Wood

Plaswood are eco-friendly, produced using 100% recycled polythene diverting valuable waste from landfill. These are long-lasting; plywood has a lifespan of at least four times timber alternatives. Low maintenance, being rot-proof and resistant to algae there is little or no requirement for maintenance. It can be fully recycled at the end of its use. Completely inert, Plaswood will not leach any chemicals into the ground, or surrounding environment.

5.2.12 Recyclable Agro Waste

India produces agricultural waste because of the vegetable plantation, sawmill waste, sisal fibre, rice husk, jute stalk, etc. At a staggering figure of 500 million tonnes a year, till now much of this material was burnt and disposed of off which was causing pollution. But now renewable fibre is obtained from it and these fibre wastes are bonded under pressure to make several kinds of insulation boards, panels, and roofing sheets. The products are strong, lightweight, and have an aesthetic appearance.

5.2.13 Straw Board and Fibre Board Panels

They are bio-based building materials. They are light wt., easy to transport and are renewable. Wood and fibrous plants such as bamboo, thatch, and reeds are cultivated especially to be used as building materials. Fibre board is made from various plant fibres such as wheat, straw, grass stems, sugarcane, corn stalks, and sunflower seeds are bonded under heat and pressure with a resin binder to form panels used for shelves, cabinets, furniture, flooring, and as an underlay, etc.

5.2.14 Straw Bale

As a building material, straw is sustainable, plentiful, and inexpensive. In many places, straw is an unwanted farming waste product. When waste straw is burned in the field, it contributes to air quality problems and the destruction of the ozone layer. By using waste straw as a construction material, however, this source of pollution is eliminated.

Straw bale construction uses bales made from the leftover stems of harvested grain, mostly rice. The bales can be used in many ways, but the most common techniques are post and beam systems and structural bale systems. Straw bale buildings have highly insulated walls and boast low building and maintenance costs. They drastically reduce the amount of wood needed to construct a house, instead converting an agricultural waste product into a valued, sustainable building material. Straw bale walls are waterproof, extremely fire-resistant, and pest-free. Because construction techniques are so simple, a community house-raising effort can build most of a straw-bale house in a single day. The structural style of straw bale construction is also known as the "Nebraska" style, since the technique originated in that state around the 1880s, following the invention of the steam-powered baler. Some homes from that period remain in use after more than a century. A once-popular style of building that fell out of favor in the 1950s when mass-produced construction materials began to emerge, straw bale is making a comeback.

5.2.15 Adobe

Adobe is a traditional building material in the hot and arid climate zone (USA). In most of these areas, it is not only dry but there are also large temperature swings from day to night. Adobe Construction takes advantage of the wide daily differences in temperature. Adobe and other earth-based houses rely substantially on the natural principle of heating and cooling. Adobe Houses are ultimate in resource efficiency. the adobe blocks can be made entirely of renewable materials found on the site – soil, straw, and other plant fibers. The earthen mixture is set in forms and left to cure under the sun. The cured bricks are then laid one on top of another to form walls and are usually finished with a protective coat of stucco on the outside and plaster on the inside. Adobe blocks are rot-resistant, vermin-proof,

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fireproof, and soundproof. And recycling poses no problem, they can be reused easily, or left to return to earth. Buildings made of earth have a simple, basic, instinctive appeal. Earthen construction is particularly appropriate for dry climates. In areas where humidity and precipitation are more prevalent, mold and mildew can be a problem if the walls are not extremely waterproofed and treated with mildewcides.

5.3 SUSTAINABLE PRODUCT

Wood is a Sustainable Product: Clear, virgin lumber, once plentiful and inexpensive, has become increasingly more costly as demand for it has increased. In response, the construction industry has developed new building techniques using new products made from young trees and scraps of wood that once would have been discarded.

Forest management practices have changed, too. New trees are often planted to replace those cut for lumber, helping to sustain a supply of wood for the future.

By being a knowledgeable consumer, one can ensure that wood framing is as efficient and ecologically sound as possible. It is important to consider some suggestions;

- Avoid larger-sized framing members such as two-by-tens or two-by-twelve. These mature woods often come from old-growth forests. Instead, use engineered wood products such as trusses and I-joints.
- Try to purchase domestic wood, commonly used in most construction and interior finishing, that is produced through sustainable forest management.
- Consider using salvaged timber and wood products available from operators who disassemble old buildings and bridges and then clean, grade, and often re-saw the timber.

Stone or Bricks as sustainable building material: Both brick and stone materials are aesthetically pleasing, durable, and low maintenance. Exterior walls weather well, eliminating the need for constant refinishing and sealing. Interior use of brick and stone can also provide excellent thermal mass, or be used to provide radiant heat. Some stone and brick make an ideal flooring or exterior paving material, cool in summer, and possess good thermal properties for passive solar heating. These materials have long sustenance due to the durability factor.

Bricks are versatile and durable building materials, with good load-bearing properties, high thermal mass, and potential low energy impact. In the case of simple earth bricks such as adobe and compressed earth block, they measure high sustainability index, being made from locally available materials of clay, sand, and water using low technology compression equipment, solar energy, or kilns. While modern methods of brick construction have a much lower sustainability, overall bricks are a good example of a sustainable building practice and are currently gaining in popularity around the world.

5.4 BUILDING MATERIALS ARE AVAILABLE IN RECYCLED FORM

5.4.1 Metals

Steel and aluminum building elements are highly recyclable. Between 50 to 70 percent of the energy and pollution caused by steel production can be avoided by recycling steel. Re-melting aluminum avoids up to 85 percent of the energy and pollution of aluminum manufacturing.

5.4.2 Heavy Timber

Salvaged and re-sawn, heavy timber can be recycled.

5.4.3 Plastics

Although most plastics are recyclable, the process is often difficult to accomplish. Different types of plastic must be separated, an expensive and labor-intensive task. Plastic recycling is not yet a viable option for building materials, since they are usually combined with additives, coatings, and colorants. Companies are working to solve the problem, however, and more plastic may be reused in the future.

5.4.4 Glass

Re-melting glass offers few energy and pollution savings. As a result, little recycling of glass-building products occurs.

5.4.5 Masonry Products and Ceramics

Recycling concrete, clay, and other similar materials is difficult, but it can be done. Masonry products are often crushed and then reused for granular fill in roads and sidewalks.

5.4.6 Other Materials

There are other materials of similar category as innovations happen in the building industry, ecofriendly materials and practices are the way forward.

- **Autoclaved Aerated Concrete:** Autoclaved Aerated Concrete (AAC), developed by Swedish architects in 1928 and utilized in other industrial countries for years is a widely accepted material in developed countries like the USA. Also known as autoclaved cellular concrete, it is produced by adding small amounts of aluminum powder to a standard cement mix. The aluminum reacts chemically to create millions of tiny hydrogen bubbles within the concrete, expanding the material to twice its original volume. As the concrete cures, the hydrogen dissipates and the pockets fill with air. Once the expansion is complete, the material is cut into blocks, slabs, or other shapes and moved into an autoclave, an airtight chamber that is filled with pressurized steam. The 10 - 12-hour autoclaving process causes a second chemical reaction that gives the highly porous concrete its strength and durability.

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With high air content, AAC can weigh two-thirds less than conventional concrete and has a better insulation value. The pre-cast material is comparable in strength to its conventional counterparts, yet its lower weight makes it easier to transport, lift, and assemble.

Light in weight therefore can be easily worked with carpenters' tools, which makes it comparable to wood. Unlike wood, however, it resists rot and does not burn. It can be painted, plastered, or covered with wood paneling or tiles, or it can be left unsealed and unpainted. It costs more than ordinary concrete. The aggregate used to make AAC can be either sand or waste flyash from coal-burning power plants. Flyash can constitute as much as 70 percent of AAC, so the potential for recycling this huge waste is high.

- **Siporex:** Manufactured in India since 1972, in collaboration with Internationella Siporex AB of Sweden. The unique flexibility, structural, and physical properties of Siporex (ALC – "Aerated Light Weight Concrete) are appreciated by the world and are the preferred building material.

  Siporex is a structural material, steam-cured, cellular (aerated) concrete. It is available as blocks, floor and slab, and wall panels, for all types of buildings; especially for multi-storied buildings. It is ideal for all types of climate and seismic zones.

  Light Weight and just one-fourth ($1/4^{th}$) the weight of dense concrete, thus ensuring economic design. It also makes Siporex ideal for low-bearing soils, seismic zones, and for adding storeys to existing buildings. It is easy to handle, hoist, and transport. It is an ideal material for use in existing buildings where additional FSI is available.

  As a highly insulating material, it cuts the peaks of heat and cold to provide economy in the working of the air-conditioning and central heating. It is fire resistant, completely inorganic, and incombustible, and offers twice the fire protection of concrete. The structure is closed-celled, there is less capillary action and high surface activity allows for fast evaporation of moisture and therefore low water penetration.

  Siporex is versatile and can be comfortably worked. It can be drilled, chased, or nailed using simple carpentry tools. It is workable like wood and endures like stone. It has a high sound absorption ratio and therefore this material is ideal for auditoriums and theatres and for cutting workshop sounds from offices. Appropriate care is taken to treat the reinforcement bars of Siporex. Also, Silicon oil is used during production to make the slabs water-repellant and corrosion-resistant.

- **Foam Crete:** Technically known as polymer cellular concrete, is lightweight aerated concrete in which plastic foam is used in place of aggregates. It was developed by polymer chemist Gary Zeller. Unlike AAC, Foam Crete can be prepared on-site. It weighs one-third less than conventional concrete yet has good compressive strength and can be used for structural as well as non-structural support. Because it is prepared at the building site, transportation costs are minimal. It can be recycled though it contains no recycled material. Like AAC, Foam Crete is easily sawed, cut, carved, and nailed. It offers excellent insulation values rivaling polyurethane and polystyrene board insulations.

- **Syndecrete:** David Hertz invented Syndecrete, a precast lightweight surfacing material made with post-consumer carpeting and waste, that paved the way for all environmentally-conscious architecture to follow. The principal constituents are fly ash and polypropylene fiber.
  A variety of recycled materials such as metal shavings, plastic trimmings, glass chips, and wood can be added to create custom products that have been described as modern variations of Italian terrazzo. Up to 40 percent recycled material is used. Pigments can be added for colour variations.
  Syndecrete can be used to create any product that can be cast e.g. countertops, furniture, tiles, tubs, showers, sinks planters. It is strong enough to be cast as non-load-bearing walls or non-structural panels. It has better resistance to potential chipping and cracking than conventional concrete, tile, or stone, and has workability more akin to wood than concrete. It is assured as chemically inert and does not emit health-threatening indoor air pollution

5.5 SMART MATERIALS

Buildings and life in our buildings have changed over the last few decades. This is reflected in the changes in building technology and automation. Through the development of innovative materials, products, and constructions, the move is to endow buildings with more functions. We are standing at the threshold of the next generation of buildings: buildings with various degrees of high technology, which are extremely ecological in their behaviour through the intelligent use of functionally adaptive materials, products, and constructions and can react to changes in their direct or indirect surroundings and adjust themselves to suit.

5.5.1 A Brief History

Texts from as early as 300 BC were the first to document the ‘science’ of alchemy. Metallurgy was by then a well-developed technology practiced by the Greeks and Egyptians, but many philosophers were concerned that this empirical practice was not governed by a satisfactory scientific theory. Throughout most of its lifetime, alchemy was associated with the transmutation of metals, but was also substantially concerned with the ability to change the appearance, in particular the colour, of given substances. Nineteenth-century magic was similarly founded on the desire for something to be other than it is, and one of the most remarkable predecessors to today’s colour-changing materials was represented by an ingenious assembly known as a ‘blow book.’

The magician would flip through the pages of the book, demonstrating to the audience that all the pages were blank. He would then blow on the pages with his warm breath, and re-flip through the book, thrilling the audience with the sudden appearance of images on every page. That the book was composed of pages alternating between image and blank with carefully placed indentions to control which page flipped about the others makes it no less a conceptual twin to the modern **‘thermochromic’** material.

The relationship between architecture and materials had been fairly straightforward until the Industrial Revolution. Materials were chosen either pragmatically – for their utility and availability – or they were chosen formally – for their appearance and ornamental qualities. Locally available stone formed foundations and walls, and high-quality marbles often appeared as thin veneers covering the rough construction. Decisions about building and architecture

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determined the material choice, and as such, we can consider the pre-19th century use of materials in design to have been subordinate to issues in function and form. Furthermore, materials were not standardized, so builders and architects were forced to rely on an extrinsic understanding of their properties and performance. In essence, knowledge of materials was gained through experience and observation. The role of materials changed dramatically with the advent of the Industrial Revolution. Rather than depending on an intuitive and empirical understanding of material properties and performance, architects began to be confronted with engineered materials.

Beginning in the 19th century the widespread introduction of steel, led to the emergence of long-span and high-rise building forms. The industrialization of glass-making coupled with developments in environmental systems enabled the 'international style' in which a transparent architecture could be sited in any climate and any context. The broad proliferation of curtain wall systems allowed the disconnection of the facade material from the building's structure and infrastructure, freeing the material choice from utilitarian functions so that the facade could become a purely formal element.

Through advancements in Computer-Aided Design/Computer Aided Manufacturing technologies, engineering materials such as Aluminium and Titanium can now be efficiently and easily employed as building skins, allowing an unprecedented range of building façades and forms. Today's architects often think of materials as part of a design palette from which materials can be chosen and applied as compositional and visual surfaces. It is in this spirit that many have approached the use of smart materials. Smart materials are often considered to be a logical extension of the trajectory in materials development toward more selective and specialized performance.

5.5.2 Approaches for Classifying Materials

Materials can be classified on two bases:

i. **Engineering Discipline:** These include the physical properties of the materials e.g.: whether it's a metal or non-metal, ferrous or non-ferrous, solid, liquids or gases, etc. It also includes the process involved in making the material and its use and function
ii. **Design Discipline:** These include the aspects that cover the emotional feeling attached to a particular material. E.g.: steel gives the feeling of cold, warmth from wood. It also includes the aesthetics that the material offers and how we perceive it. E.g.: Steel gives a cold look and hence fits beautifully in modern minimal interiors.

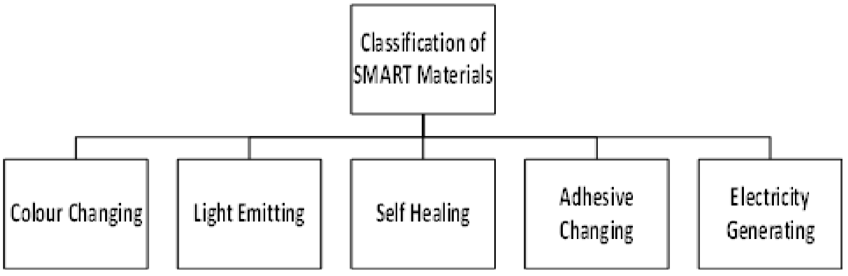
Smart materials are the materials that come under the overlapping of both approaches. They have engineered properties and functions but are used in a more aesthetic and design-related approach. NASA defines **smart materials** as 'materials that "remember" configurations and can conform to them when given a specific stimulus'. The definition from the Encyclopaedia of Chemical Technology: 'Smart Materials and Structures are those objects that sense environmental events, a process that sensory information, and then act on the environment'. These definitions refer to materials as substances, elements, alloys, or even compounds, which are identifiable and quantifiable by their molecular structure.

Smart materials are materials that receive, transmit, or process a stimulus and respond by producing a useful effect that may include a signal that the materials are acting upon it. The effects can be a colour change, a volume change, a change in the distribution of stresses and strains, etc.

What makes them Smart?

Whether a molecule, a material, a composite, an assembly, or a system, 'smart materials and technologies will exhibit the following characteristics:

- Immediacy – They respond in real-time.
- Transiency – They respond to more than one environmental state.
- Self-actuation – Intelligence is internal to rather than external to the 'material'.
- Selectivity – Their response is discrete and predictable.
- Directness – The response is local to the 'activating' event.



- **Colour Changing:** These include materials and products that can reversibly change their colour in response to the influence of light, temperature, compression, an electrical or magnetic field, and/or a chemical stimulus.
- **Photo-Chromic:** These materials change their colour when excited by the effect of light. Photo Chromic glass when used on facades or windows changes colour when excited by light. When used on windows, it gets dimmer and darker colour in response to the sunlight. Photo-Chromic Pigments - Wallpaper with UV- UV-sensitive inks, which can reversibly change from a monochromic to a bi-chromic red under the influence of light.
- **Thermo-Chromic:** These materials change their colour or optical properties when excited by the effect of temperature.
  - Thermo-Chromic Paints for Changing Interiors: As the temperature rises within a room the flowers on the branches slowly bloom, breathing additional life and colour into a given space. As night falls and cooler temperatures prevail, the colourful flower print slowly fades back to a mellow green.
  - Thermo-Chromic Pigments in Concrete: Graphics and alphanumeric characters were created on the surface using electric currents. This was done by adding thermo-chromic inks to the concrete and applying heat

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directly by current-carrying nickel-chromium wires. Local colour changes are produced on the surface, which may appear in the shape of dots, lines, or patches depending on the spacing of the wires.

- **Electro-Chromic:** These materials change their colour or optical properties when excited by the effect of electrical fields.
  - Electro-Chromic Glass: Glass is generally see-through, but this smart glass can become opaque at the flip of a switch. This means you can use the same piece of glass for a partition, window, privacy screen, and projection surface.
- **Light Emitting:** Light-emitting smart materials include materials or products with molecules that become excited by the effect of energy, e.g. the effects of light or an electrical field, to emit light.
- **Fluorescence:** After the excitement of a molecule by light, the transition from the excited state back to the ground state is accompanied by simultaneous light emission. The installation consists of fluorescent strips of paper, which are precisely cut on-site and then stuck onto two walls, two columns, and the floor of the exhibition room and excited by UV light.
- **Phosphorescence:** The transition from the excited state back to the ground state is accompanied by delayed light emission. Ex. Light-emitting furniture incorporating illuminating fabric
- **Electroluminescence:** An optical phenomenon in which a molecule emits light because of the electrons in an electrical field. Ex. Fabric with electroluminescent print.
- **Shape Changing:** These include materials and products that can reversibly change their shape and/or dimensions in response to one or more stimuli like light, temperature, pressure, an electric or magnetic field, or a chemical stimulus.
  - Thermo-Bimetals (TB): These are laminated composite materials and consist of at least two components, usually bands or strips, made from metals with different thermal expansion coefficients.
  - Shape Memory Alloy (SMA): They are also called shape memory metals, consist of at least two different metallic elements, and have the property, to take up, reversibly and temperature-dependent, a shape they were given earlier. A shape-memory alloy is an alloy that "remembers" its original, cold-forged shape: returning to the pre-deformed shape when heated.

  Ex. Shape Memory Interior Textiles are woven from conventional threads and incorporate parallel strands of SMA wires at a few places on the surface. This produces functional textiles suitable for black-out or privacy coverings for vertical, inclined, or horizontal window and door openings, or as components of room divider and wall cladding systems.
- **Self–healing:** Self-healing materials are a class of smart materials that have the structurally incorporated ability to repair damage caused by mechanical usage over time. They consist of a matrix with a catalyst present in it. This matrix also contains microcapsules that contain filler.

Historic structures such as Roman aqueducts or Gothic churches have lasted so long are the inherent self-healing properties of binder used. The self-healing effect is evident in a particular 18th-century bridge in Amsterdam; here water dissolves the calcite from the porous clay and transports it to any cracks where it permanently seals them. So-called self-healing concrete today has fibers added to it that break a particular load and release an effective filler.

- **Adhesion Changing:** Their inherent properties allow these materials to change reversibly their adhesion in response to light. **Titanium Dioxide (TiO_2):** After its photocatalytic effect had been discovered, the Japanese were successful in 1995 in using (TiO2) in ceramic surface coatings. The year 2002 saw the first self-cleaning glass with (TiO2) appear on the European market. Ceramic slabs with a surface coating of baked-on (TiO_2), currently available as facade slabs and as wall and floor tiles can be handled and used like conventional facade slabs and tiles. They are intended for use where their self-cleaning properties and their ability to improve air quality by breaking down organic pollutants are important.
- **Electricity Generating:** Electricity-generating smart materials include materials and products that can generate an electric current with a connected consumer in response to one or more stimuli from outside influences, viz;
  - Photoelectric**:** The effect of light.
  - Thermoelectric**:** The effect of temperature.
  - Piezoelectric**:** The effect of compression or tension (pressure).

  Build environment can be made increasingly interactive and intelligent to support the aesthetic and functional needs of the user. Complex kinetic materials like shape memory alloys and simulative lighting have the capability of enhancing the spatial and energy efficiency, security, aesthetics, and overall experience of the built environment. Therefore, the purpose of architecture and designing can be redefined and lies in creating spaces and objects that can physically reconfigure themselves to meet the changing needs of individuals, society, and the environment.

End of Chapter Exercise

1. What are the generic but important properties to be considered while selecting materials for interior furnishing? Give suitable examples.
2. What are the basic characteristics of environment-friendly materials?
3. Discuss the use of Smart Materials in Interiors and Architecture.
4. Give at least two examples of each: Products made from Cellulose; Reconstructed wood; Lightweight partitioning material; Uses of Mild steel, Copper, Brass; Simple hardware used in interiors; Plastics in residential interiors; and Glass in interior furnishing.

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