A REVIEW PAPER ON CONSTRUCTION MATERIALS

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ABSTRACT

Material science, in the guises of high-tech techniques, smart substances, Intelligent interfaces and sensory surfaces, are radically redefining the world we live in. Today's generation of materials breaks new ground, many are able to anticipate and respond to changes in the environment. Now dynamic and interactive, materials have the power to change how the human body experiences and how the urban environment is built. Combined with the new potentials they create for industrial design and medical science, they have the capacity to transform our way of life more radically now than ever before.

KEYWORDS: *Material science, Building Construction, Cement, Concrete*

1. INTRODUCTION

The engineering structures are composed of materials. These materials are known as the engineering materials or building materials or materials of construction. It is necessary for the civil engineer to become conversant with the properties of such materials. The service conditions of buildings demand a wide range of materials and various properties such as water resistance, strength, durability, temperature resistance, appearance, permeability, etc. are to be properly studied before making final selection of any building material for a particular use.

Several factors need to be considered when choosing the materials for a construction job, including:

- Type and function of the building or structure and the specific characteristics required of the materials used, i.e. great strength, water resistance, wear resistance, attractive appearance, etc.
- Economic aspects of the building/structure in terms of original investment and annual cost of maintenance.
- Availability of materials in the area.
- Availability of the skilled labor required to install some types of material.
- Quality and durability of different types of material.
- Transportation costs.
- Selection of materials with compatible properties, dimensions and means of installation.
- Cultural acceptability or personal preference.

2. CLASSIFICATION OF BUILDING MATERIALS

There are two types of building materials as follows:

2.1 NATURALLY OCCURRING SUBSTANCES

Naturally occurring materials are as follows:

- Rock
- Wood

- Sand

2.1.1 ROCK

Naturally occurring compact, solid and massive material in the earth's crust or on the surface are known as rocks. Rocks don't have definite shape and chemical composition. They are mixture of two or more minerals. Rock 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 particular uses. Rock is a very dense material so it gives a lot of protection too; its main drawback as a material is its weight and awkwardness. Its energy density is also considered a big drawback, as stone is hard to keep warm without using large amounts of heating resources. 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. Stone buildings can be seen in most major cities; some civilizations built entirely with stone such as the Egyptian and Aztec pyramids and the remains of the Inca civilization.

CLASSIFICATION OF ROCKS

The rocks from which stones are derived are broadly classified into three types. They are:

i. Geological classification
ii. Structural or Physical classification
iii. Chemical classification

GEOLOGICAL CLASSIFICATION:

The classification of rock based on the mode of formation or the process of formation is known as geological classification. According to this classification rocks/ stones are of three types.

i. Igneous rocks
ii. Sedimentary rocks
iii. Metamorphic rocks

CHEMICAL CLASSIFICATION

On the basis of dominant chemical composition, three main types of rocks are:

i. Silicious rocks
ii. Calcareous rock
iii. Argillaceous rocks

STRUCTURAL CLASSIFICATION

On the basis of physical characteristics of the rocks, the manner and arrangement of different particles rocks are classified into three categories. They are:

i. Stratified
ii. Un-stratified
iii. Foliated

2.1.2 WOOD

Wood is one of the most used natural building materials in the world. A number of valuable properties such as low heat conductivity, small bulk density, relatively high strength, amenability to mechanical working etc. makes wood as famous building material. Timber can be used in most economical way without wasting any of the derivatives of it. Even the saw dust obtained during wood sawing can also be used to make fiber boards, paper etc.

Properties	Lower	Higher
Basic density (g/cm^3)	0.40	0.49
Moisture content at the time of testing (%)	17	16
Elasticity modulus in bending, MOE (x1000 MPa)	7.8	10.7
Flexural strength parallel to grain (MPa)	61.5	75.8
Compressive strength parallel to grain (MPa)	33.4	38.1
Compressive strength perpendicular to grain (MPa)	4.7	6.3
Shear strength parallel to grain (MPa)	6.3	10.1
Tensile strength parallel to grain (MPa)	47.8	64.1
Tensile strength perpendicular to grain (MPa)	1.6	1.8

Fig: Properties of Timber

2.1.3 SAND

Sand is a type of naturally-occurring material that is of a granular, loose, fragmented composition, consisting of particulate matter such as rock, coral, shells, and so on. **Sand** is typically finer than gravel but coarser than silt. The precise composition of **sand** varies depending on its source and the conditions prevalent at that location. In in-land continental regions, the predominant constituent of **sand** is silica (silicon dioxide), typically in the form of quartz. **Sand** that has been created over millions of years by such things as coral and shellfish is typically aragonite, which is a form of calcium carbonate.

2.2 MAN-MADE SUBSTANCES

Man-made substances are as follows:

- BRICKS
- CEMENT
- CONCRETE
- STEEL
- PLASTIC

2.2.1 BRICKS

Bricks are structural units of rectangular shape and convenient size, and are made of suitable clay by the process of moulding, drying and burning. Since long, bricks are believed to have been used by the people of ancient

civilization. This has been established beyond doubt from the excavation of prehistoric sites like Indus Valley civilization at Mohen-jo-daro and Harrappa. Bricks are the most favored structural units used for construction in the modern day world around the globe.

This is on account of the following reasons in favor of bricks.

i. Easy availability of clay
ii. Knowhow of construction methods
iii. Ready-to-use size, shape and handling
iv. Cost

All the above factors combined together go in favor of bricks to make them a very convenient building material.

2.2.2 CEMENT

Cement bonded composites are made of hydrated cement paste that binds wood, particles, or fibers to make pre-cast building components. Various fibrous materials, including paper, fiberglass, and carbon fiber have been used as binders. Wood and natural fibers are composed of various soluble organic compounds like carbohydrates, glycosides and phenolic. These compounds are known to retard cement setting. Therefore, before using a wood in making cement bonded composites, its compatibility with cement is assessed. Wood-cement compatibility is the ratio of a parameter related to the property of a wood-cement composite to that of a neat cement paste. The compatibility is often expressed as a percentage value. To determine wood-cement compatibility, methods based on different properties are used, such as, hydration characteristics, strength, interfacial bond and morphology. Various methods are used by researchers such as the measurement of hydration characteristics of a cement-aggregate mix; the comparison of the mechanical properties of cement-aggregate mixes and the visual assessment of micro structural properties of the wood-cement mixes. It has been found that the hydration test by measuring the change in hydration temperature with time is the most convenient method.

Portland cement properties	
Physical properties	
Initial Setting Time (minute)	64
Final Setting Time (minute)	121
Specific Surface Area (cm^2/gm)	3907
28 Days Compressive Strength (MPa)	31.5
Chemical properties	
Calcium Oxide (CaO)	62.25%
Silicon Dioxide (SiO_2)	21%
Aluminum Oxide (Al_2O_3)	5.9%
Sulphur Trioxide (SO_3)	2.4%
Ferric Oxide (Fe_2O_3)	3.4%
Magnesium Oxide (MgO)	1.5%
Sodium Oxide (Na_2O)	0.2%
Potassium Oxide (K_2O)	0.45%
Loss of Ignition	1.1%

2.2.3 CONCRETE

Concrete is a composite material made from mixing cement, aggregates such as sand and crushed stone and water. The properties of concrete depend on the ratios used in the mix design. Therefore, it's a standard practice for concrete suppliers to provide material properties and test results for each concrete patch. Fresh concrete can be poured into form works to take any shape or form and takes time to harden into a stone-like material. It takes up to 7 days for concrete to reach the majority of its strength and will need special attention to curing to avoid cracking or reduction in capacity. Concrete is very versatile and is my go to material for applications that require a combination of strength and durability. For example, concrete is an excellent material for building foundations where the weight of the structure meets the ground. This requires strength to carry the load and also durability to withstand the contact with the surrounding soil. Concrete is very strong when exposed to compression stresses however, it's brittle and has limited tensile strength. Combined with steel rebar, reinforced concrete is stronger and more suitable for a wide range of structures such as tall multi-story buildings, bridges, roads, tunnels and so many other applications.

Sr. No.	Description	Value	Unit
1	Compressive strength of concrete	53.00	MPa
2	Tensile strength of concrete	2.70	MPa
3	Yield stress of main reinforcement	460	MPa
4	Yield stress of ties and stirrups	250	MPa
5	Modulus of elasticity of concrete	3.64e04	MPa
6	Modulus of elasticity of steel	2.0e05	MPa
7	Poisson's ratio	0.15	

Fig: Properties of Concrete & Steel r/f

2.2.4 STEEL

Steel is one of the strongest building materials available with excellent strength capacity in both tension and compression. Because of its high strength-to-weight ratio, it is ideal for structural framework of tall buildings and large industrial facilities. Structural steel is available in standard shapes such are angles, I beams and C-channels. These shapes can be welded together or connected using high-strength bolts to build structures capable of resisting large forces and deformations. Steel is a relatively expensive building material so it is the structural engineer's responsibility to choose economic sizes and shapes according to the actual loads on the building to avoid overdesign. Because of the the higher cost of steel, I often get questions from our clients asking if there is a way to reduce the weight and size of some of steel members in the structure. This can be done if the loads can be reduced on the members and/or additional vertical supports can be introduced. The installation of steel is less time consuming compared to concrete and can be installed in any type of environment.

2.2.5 PLASTIC

The term "plastics" covers a range of synthetic or semi-synthetic organic condensation or polymerization products that can be molded or extruded into objects, films, or fibers. Their 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.

3. CHARACTERISTICS OF MATERIALS

For a material to be considered as building material, it should have required engineering properties suitable for construction works. These properties of building materials are responsible for its quality and capacity and help to decide applications of these materials.
We will discuss two main properties of building materials as follows

I. Physical properties
II. Mechanical properties

3.1 PHYSICAL PROPERTIES

These are the properties required to estimate the quality and condition of the material without any external force. The physical properties of engineering materials are as follows.

- Bulk density
- Porosity
- Durability
- Density
- Density index
- Specific gravity
- Fire resistance
- Frost resistance
- Weathering resistance
- Spalling resistance
- Water absorption
- Water permeability
- Hygroscopicity
- Coefficient of softening
- Refractoriness

3.2 MECHANICAL PROPERTIES

Mechanical properties of the materials are finding out by applying external forces on them. These are very important properties which are responsible for behavior of a material in its job. The mechanical properties are,

- Strength
- Hardness
- Elasticity
- Plasticity
- Brittleness
- Fatigue
- Impact strength

- Abrasion resistance
- Creep

4. ADVANCED BUILDING MATERIALS

Many of today's most widely used building materials have limitations, especially with regard to their impact on the environment. In response, innovative engineers around the world have developed new building materials that could provide an alternative.
Some new advanced building materials we can explore:

4.1 HYDROCERAMICS

The material is a kind of façade made of ceramic panels imbued with hydrogel, an insoluble polymer that can absorb up to 500 times its weight in water. When applied to buildings, this has rather intriguing possibilities. Since the hydrogel is built into the ceramic façade of a building, it is able to absorb humidity from the air. During hot days, the water held in the polymer begins to evaporate, which has a cooling effect on the building – the IAAC describes it as the building 'breathing' through evaporation and perspiration. The researchers suggest that buildings clad with this material would be 5°C to 6°C cooler than the outside temperature and could reduce air-conditioning bills by 28 per cent.

4.2 PROGRAMMABLE CEMENT

In an effort to make concrete structures more durable, programmable cement can be used to achieve water and chemical resistance. Programmable cement is essentially a form of cement that can be designed to achieve less porous and more chemically resistant shapes. These innovative shapes limit damage to concrete and increase the durability of structures.

4.3 CARDBOARD

Recycled cardboard is another useful construction material to watch out for. Cardboard can be used to create a cellulose-based insulation for both residential and commercial buildings. For structures that are built in cold or hot climates, cardboard creates a higher quality insulation material than many other options in the market.

4.4 SELF-HEALING CONCRETE

Cracks in concrete have been a long-standing problem in the construction industry. A small crack often becomes larger and wears away the structure over time. Self-healing concrete can be used to solve this challenge. This innovative building material consists of living spores and water capsules within the mixed concrete. When damage occurs, the capsules crack open and mix with water. This mixture produces calcite, a material that fills the damaged area and later solidifies in place. By using self-healing concrete, structures such as tunnels, buildings and bridges will cost less to build and maintain.

4.5 CIGARETTE BUTTS

Cigarette butts are another innovative material that can be used in construction. They can be infused into bricks, where they provide durability and efficiency to building materials. Because cigarette butts result in millions of tons of waste every year, using them as a construction material helps clean up the environment and reduce material costs. The bricks made from cigarette butts are often lighter, more convenient to use, and highly energy efficient.

4.6 AIR-CLEANING BRICKS

New construction materials are also improving the quality of indoor air. Because air quality is always a top concern for commercial structures, using passive air filtration systems can significantly benefit builders and building

owners. Air-cleaning bricks are innovative construction materials that can filter incoming air to remove pollutants. These bricks are placed on the outside of a building and they filter heavy air particles as air flows indoors.

5. CONCLUSIONS

Technology has changed our vision, expectations and abilities to control the material world. The developments in nano-science can also have a great impact on the field of construction materials. Better understanding and engineering of complex structure of cement based materials at nano-level will has resulted in a new generation of stronger and more durable, with desired stress-strain behavior and possibly with the whole range of newly introduced smart properties in materials. Today's innovation can be considered as an incubator for strategic design and development of continuous improvement and innovation for lifelong learning.

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