THEORY AND ACTIVITIES MODULE 2

(2nd week)

CONTENTS:

ACTIVITIES

A. Read the whole text below once to get the general meaning.

B. Read the whole text again out loud, checking the audio of the terms. Repeat the text (or chunks of texts) when you find yourself stumbling over words. Do it several times until you can read it fluently.

2.1. INTRODUCTION

The second module is about materials and techniques used in construction. We will study materials such as reinforced concrete or steel for structures; materials to build façades and roofs; gypsum or timber for finishings, and techniques such as masonry.

2.2. DEFINITION OF MATERIALS

A material is a substance that can be used to form products or construction works. A building material is any material used in construction, such as **steel, concrete, brick, glass, wood, cement, glass,** etc. Many materials we use today are **composites**: a combination of two or more basic materials, for example concrete. A composite combines different materials in such a way as to give the composite better properties than the individual components. In all composite materials strong fibers are added to make a stronger and stiffer material. For example, many buildings nowadays have **laminated glass** in them, this is much safer than ordinary glass or **toughened glass**. It is made by forming a sandwich of two sheets of glass and a sheet of **clear plastic**.

2.3. FORMED MATERIALS VS FORMELESS MATERIALS

Some building materials are formless, for example the powders such as cement, and liquids such as paint. On the contrary, others are formed materials such as natural **stone, metal**, etc. Have a look at the following table where you can see some examples of formed and formless materials:

Formed materials	Formless materials
Natural stone	Aggregates:
Precast concrete	Crushed stone
Clay (dried, fired)	Gravel
Metal	Sand
Wood	Lime and cement:
Vegetable and animal materials:	Binders
Fiber building boards	Mortars
Paper	Concretes
Bark, cork	Gypsum plasters
Wood, leather	Bituminous materials:
Inorganic fibers:	Asphalt
Glass wood/fibers	Tar
Asbestos wool/fibers	Pitch
Carbon fibers	Paints
Rubber	Adhesives
Plastics	Preservatives
Glass	Water
	Cleaning materials

Adapted from*: Architecture and building construction.* James Cumming

2.4. PROPERTIES OF MATERIALS

Regarding the relatively properties of materials, have a look at the table below where you can read properties, as flexibility, corrosion resistant or opacity. Observe the adjectives used to describe these material; for example if we want to speak about the rigidity of cast iron, we can say that cast iron is a relatively *rigid* material, this means that it is rigid compared to most other metals.

Noun	Adjective	Examples of materials
weight	a **light** material a **heavy** material	aluminum, magnesium, lead, copper
flexibility rigidity	a **flexible** material a **rigid** material	thin sheets of metal, plastics, stone, cast iron
combustibility	a **combustible** material	rubber, plastic
fire resistance	a **non-combustible** material	clay, glass
transparency	a **transparent** material	water, some plastics
opacity	an **opaque** material	stone
corrosion resistant	a **corrosion resistant** material a material which is **not corrosion resistant**	zinc, chromium, tin cast iron
conductor/ conductivity	a good **conductor** of heat a poor **conductor** of heat	silver rubber
elasticity	an **elastic** material	nylon
plasticity	a **plastic** material	copper, aluminum
softness	a **soft** material	rubber, nylon
hardness	a **hard** material	cast iron

Adapted from*: Architecture and building construction.* James Cumming

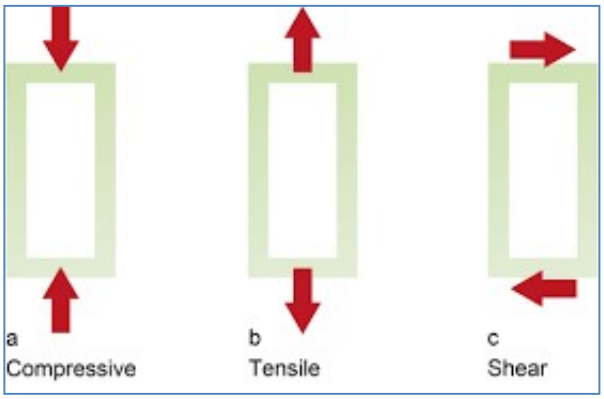
Any of the physical properties of a material that responds to applied forces is the **mechanical property**. For example, **tensile force** is an applied force tending to produce tension in an elastic body; as for **tensile strength** is the resistance of a material to longitudinal stress. There are other forces such as: c**ompressive force** or **shearing force**.

Now, have a look at the definition of these three forces:

a) **tension** is the force that stretches or pulls apart a material

b) **compression** is the force that presses or pushes two or more materials together

c) **shear** is the tendency of a material to fracture or break along the lines of stress, the force that deforms a structure or its parts. Note that the adjective is: **tensile compressive** and **shear** or **shearing**.



2.5. TYPES OF BUILDING MATERIALS

The manufacture of building materials is an established industry; the use of materials is segmented into detailed trades, such as **plumbing, roofing, carpentry,** and **insulation work.**

Building materials can be generally classified in two:

> **Natural:** those that are unprocessed or minimally processed by industry, such as **timber**.
>
> **Synthetic:** made in industrial settings after human manipulation, such as **plastics.**

Mud, stone, and fibrous plants are the most basic building materials. In general, stone is used as a basic structural component in these buildings; while mud is used to fill in space between, acting as a type of concrete and insulation. The other main ingredients include **sand, gravel** and **straw**.

2.6. MOST COMMON BUILDING MATERIALS

The production of raw materials for building is used all over the world. Environmental concerns are becoming a major topic regarding the availability and sustainability of certain materials, and the extraction of such large quantities is also considered.

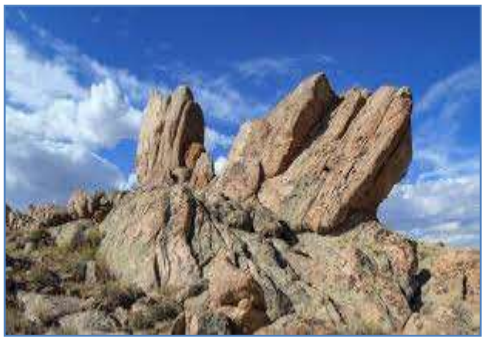
It takes many different kinds of materials to construct a building project. Most of these materials are detailed in the project working drawings including sometimes information about materials.

2.6.1. Rock vs stone

Rocks is the longest lasting building material available, and it is readily available. There are many types of rock in the world. Rock is a very dense material so it gives a lot of protection, the problem is its weight; it is hard to keep warm without using large amounts of heating resources.

Rocks are made of smaller stones and stones are made from rocks. Another difference is that rocks are normally immovable and stones are movable. A stone is formed from rocks after it has been trimmed or polished into tiny pieces. Rocks can be both hard and soft, however stones are only hard material and not soft. Stones are used in the construction of **lintels, claddings**, kitchen tops. Therefore, rocks as a whole are not used in the construction industry but are used when converted into stones.

Dry-stone walls have always been built having different forms of mortar to hold the stones together, being cement the most common one. Granite has been used till now. **Slate** is another stone type, normally used as a roofing material.



rock

slate

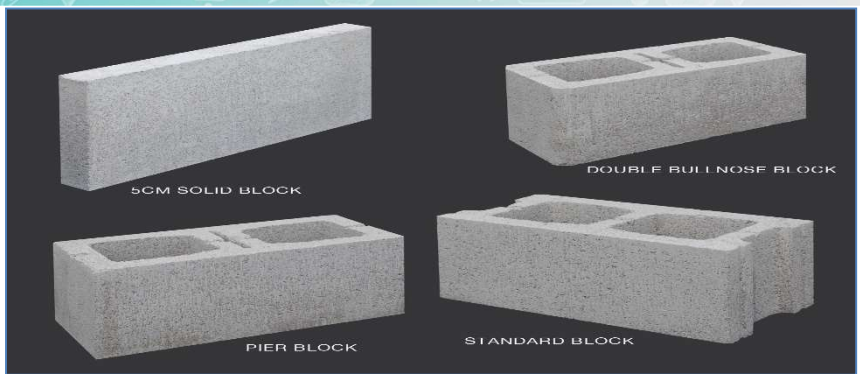
stone

2.6.2. Brick and block

A brick is a block made of kiln-fired material, usually **clay**, but it also may be of lower quality mud. Clay bricks are formed in a molding or in commercial manufacture more frequently by extruding clay and then cutting them to the proper size. In the 1700, 1800 and 1900s bricks were widely used due to the fact that they were much more flame retardant than wood and they were also cheap products.

Another type of block replaced clay bricks in the late 20th Century, the **cinder block** made mostly with concrete.

brick



block

2.6.3. Concrete

It is one of the oldest building materials, having been used by the Romans. It is a composite building material made from the combination of **aggregate** and a **binder** such as **cement**, and water. Hardening of the concrete is caused by a chemical reaction between the cement and water, called hydration. Concrete continues to harden for months after the initial set, but many times it reaches its compressive strength within 28 days.

A typical mix of concrete consists of 10% cement, 15% water, 25% **fine aggregate**, 45% **coarse aggregate**, and 1% to 5% air. Any material added to the concrete mix, other than cement, sand, aggregate, and water, is known as **admixture.** Admixtures are used to make the mix more workable, and retard or speed up hardening.

Reinforced concrete

Concrete has a rather low tensile strength, and it is generally strengthened using steel bars, known as **rebars**, then it is called **reinforced concrete.** The rebars are round shaped and have high tensile strength. In order to minimize any air bubbles that would weaken the structure, a vibrator is used to eliminate the air.

Bio concrete

Concrete that can heal itself; it is mixed like regular concrete, but with an extra ingredient the 'healing agent' that lies dormant until water starts leaking in through cracks. It was invented by Jonkers a professor at Delft University, he is a microbiologist and he used bacteria to make the self-healing.

2.6.4. Cement

A mixture of **clay** and **limestone** used to hold together the materials of concrete, **mortar,** etc. Cement bonded composites are made of hydrated cement paste that binds wood or particles of fibers to make precast building components. Various fibrous materials are used as **binders** to hold things together. Several methods are used to measure the hydration characteristics of a cement aggregate mix.


cement


clay


limestone


mortar


gravel


sand

The most common type of cement is Portland cement, which consists of mineral aggregate, generally **gravel** and **sand**, and water. After mixing, the cement hydrates and hardens into a stone-like material. Another variation used in construction is white Portland cement, which is light-colored and used mainly for architectural effects. White Portland cement is made from selected raw materials and develops the same strength as the normal gray colored Portland cement.

2.6.5. Gypsum

A soft mineral, hydrated calcium sulfate, used as a retarder in Portland cement and in the making of **gypsum plaster**. A plaster is a composition of gypsum or lime, sand, water, and fiber applied to surfaces of walls and ceilings in a plastic state and allowed to harden and dry.

gympum

2.6.6. Metals

They are widely used in the construction industry as structural **framework** for larger buildings such as **skyscrapers**, or as an external **surface covering**. There are many types of metals used for building, such as **steel** which is a metal **alloy** whose major component is **iron,** and it is the usual choice for metal structural building materials. It is strong, flexible, and if it is treated well, it lasts a long time. Its main enemy is corrosion.

Metals can be divided into two categories**: ferrous** and **nonferrous.** Ferrous metals contain iron as a principal element and they usually have more strength than nonferrous metals which do not contain iron. Nonferrous metals are typically lighter and less strong than ferrous metals.

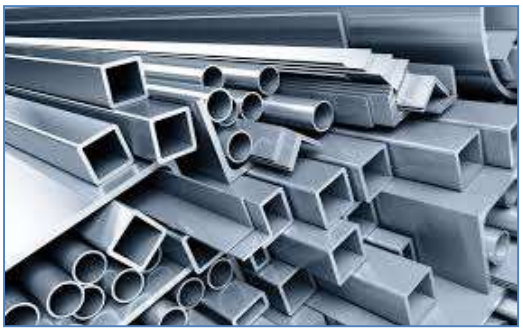
2.6.6.1. Ferrous metals

Iron: it is one of the principal ingredients of steel, it is malleable, ductile, magnetic, and has silver white color. There are many types or iron such as **cast iron** or **wrought iron**.

cast iron

wrought iron

Steel: an iron-based alloy with a carbon content; depending on the intended use, it has many chemical compositions such as **carbon steel, mild steel, stainless steel,** etc. Steel is the most widely used metal in construction with applications such as structural support or reinforcement and decorative uses. Steel members are connected to form building frames, the frame is then hidden behind other materials, such as **masonry wall**, **precast panels**. Steel angles are used as **bracing** in steel framing and to construct **joists**.



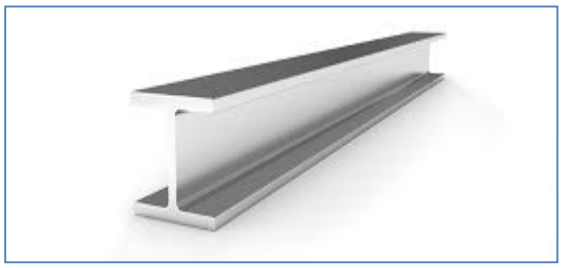
steel

2.6.6.2. Nonferrous metals

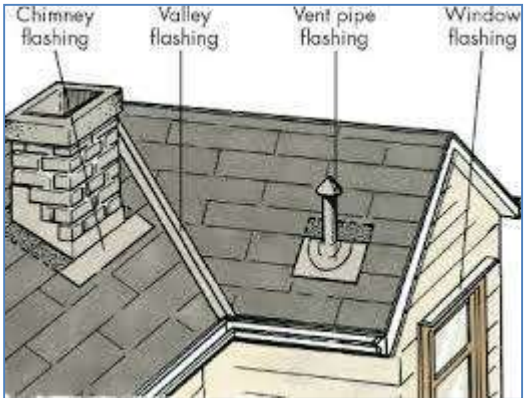
Aluminum: pure aluminum and aluminum alloys are used in many building applications where resistance to corrosion is important. Aluminum which is 99% is soft and ductile, but weak. It is usually used in building applications such as **flashing**, some kinds of roofing, doors, etc. Aluminum alloys are made in structural shapes for use as **H-beams, I-beams**, and angles.

Copper: copper and copper alloys have a high electrical conductivity and are resistant to corrosion; it is normally used in construction for water distribution, **electrical wiring**, and flashing.

Brass: it is copper with zinc. It is widely used for door and window hardware, **trim**, and railings.



aluminum H-beam



flashing

copper

brass trim

2.6.7. Glass

Glass has been used for a long time to cover small openings in a building. It provides light enter the rooms while at the same time keeps the cold weather out. Glass is generally made from mixtures of sand and silicates, and it is very brittle. Modern glass **curtain walls** can be used to cover the entire façade of a building. There are many types of glass, the most common ones are:

Sheet glass is commonly used for windows.

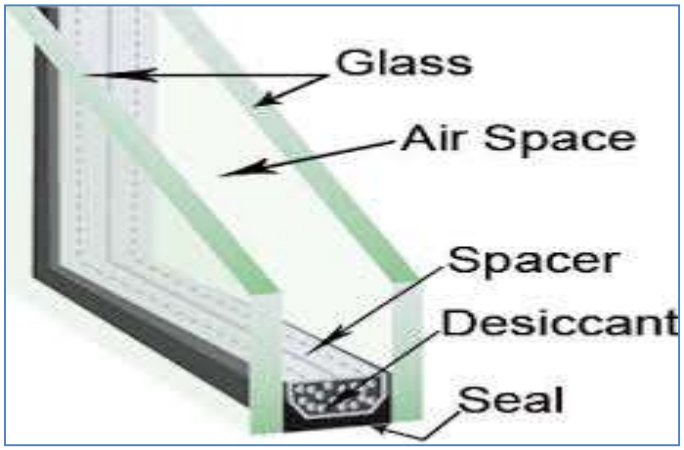
Plate glass is sheet glass that has been heat treated during forming, producing a brilliant surface that is polished when cooled.

Safety glass has been developed to overcome the hazards of sheet glass. There are three types of safety glass: **tempered, laminated** and **wired glass**.

Insulating glass is a unit or two or more sheets of glass separated by an air spaced that is dehydrated and sealed. These units are good insulators for heat and sound transfer.

sheet glass

plate glass



insulating glass

2.6.8. Ceramics

Any of various hard, brittle, noncorrosive, and nonconductive materials formed by the bonding of a metal and a nonmetal. It is usually made of **clay** or a similar material subject to a high temperature during manufacture as **porcelain**, stone or **terra-cotta.** They are usually stiff, but brittle.

Ceramic tiles are used in floors or walls, they are water resistant.

ceramic tiles

2.6.9. Plastic

It covers a range of synthetic or semi-synthetic organic condensation products that can be molded into objects or fibers. They are malleable and have the property of plasticity. Plastics vary in heat tolerance, hardness and resiliency. The general uniformity of composition and lightness of plastics ensures their use in almost all industrial applications today. Plastics have many uses in construction, for example plastic rain **gutters** which collect and distribute rain water, and plastic **pipes** that are used for water transmission, **drainage**, and **sewage systems**, or plastics for **trimming** and ornamental items, such as moldings on doors, etc.

plastic gutter

2.6.10. Foam

Polyurethane foam is light, easily shaped and an excellent insulator; it is generally used as part of a structural insulated panel where the foam is sandwiched between wood or cement.

polyurethane foam

2.6.11. Wood: timber vs lumber

Wood can be broadly classified as either hardwoods or softwoods depending on the tree type. Woods vary in strength, weight, texture, workability, and cost. There are many varieties used for construction and it continues to be one of the most important building materials. It is used for structural framing (rough carpentry), trim, floors, walls, and cabinetry (finish carpentry and architectural woodwork). It has high strength in compression, tension, and bending. It also has excellent impact resistance. With the invention of mechanizing saws wood has become the mass production of dimensional **lumber**.

When wood is cut into pieces is called **lumber** or **timber**. There are some differences between these two terms. Timber is considered as the wood that is still with the bark attached to the ground whereas lumber is no longer standing on the ground, however some authors do not make this difference. Timber is the term used to refer to wooden boards in the UK and Australia, while lumber is the term used in America and Canada.

timber

lumber

Lumber products include **rough framing** members, such as **beams, headers**, and **posts; finished lumber**, such as flooring, door and window trim, paneling, and moldings

Plywood is structural wood made of several layers of veneer joined with an adhesive, it uses an odd number of layers. Plywood speeds construction and it is an economical building material.

plywood

2.7. CONSTRUCTION TECHNIQUES

2.7.1. Masonry

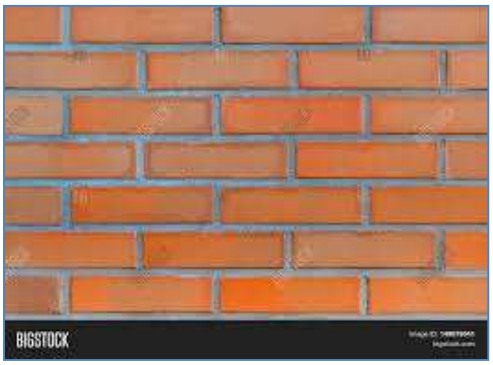
A loadbearing structure built of various natural or manufacture products, as stone, brick, or concrete block, usually having **mortar** as a **bonding agent**. These materials are strong in compression but weak in tension; therefore, the additional strength can be achieved by increasing the thickness of the masonry by the addition of **piers** or **buttresses**. Masonry walling of stone or brick is no longer used for tall buildings, its great thickness at ground level is too expensive and takes too much space. Masonry is generally used to form the walls and other solid elements of buildings and structures such as bridges and tunnels. It may be load-bearing or non-load bearing such as a **partition wall** or **cladding.**

Additionally, the term 'masonry' can be used to describe the trade of **masons**, that is, the work done by them, or the actual stonework, brickwork or block-work that they construct.

Generally, the size of the units is suitable for being laid by one person, although, increasingly, masonry is delivered to site in prefabricated panels that are **craned** into position. Generally, masonry does not require finishing and decorating and it is very durable, so it is relatively inexpensive to maintain and repair. It tends to offer good thermal mass, high acoustic insulation and good resistance to fire.

The most common units are:

Brick masonry: it uses bricks that are manufactured, rather than removed from quarries. There are many types such as adobe brick, glazed brick, fire brick, paving brick, etc.



Stone masonry: the most common materials used in stone masonry are granite, limestone, marble, sand stone and slate.

Gypsum masonry: these are blocks made from gypsum and a binder of vegetable fiber or wood chips; they can be given a plaster finish coat. Gypsum masonry is mostly used for interior nonbearing walls, fire-resistant partitions, and enclosures around structural steel.