

A. Types of Structures

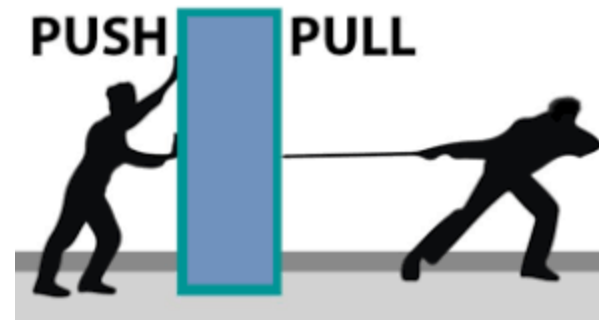


- structures are things with a definite size and shape
 - they serve a definite purpose or function
- in order to perform what the structure was made for it must be able to withstand forces
- forces are any push or pull

-as well as standing up to the forces that a structure may feel, it also must hold up the loads that it has been built for

-a load is the weight that must be carried or supported by the structure

ex) bridge must hold up people, cars, trucks or trains



Classifying Structures

-there are two main types of structures that are found in our world:

1. Natural structures
2. Manufactured structures



-a natural structure has the following characteristics:

1. It is not made by people
2. It has a definite shape
3. It has many parts held together in a complex pattern
example: spider web

-a manufactured structure has the following characteristics:

1. It is built by people
2. It is usually modelled after a natural structure
example: eiffel tower, fishing net



-you can also classify structures by the way they are built

1. The materials used to build the structure
2. How the structure is shaped
3. How the structure is put together (design)

-there are three major types of designs that we will be looking at

1. mass structures
2. frame structures
3. shell structures



Mass Structures:

-a mass structure is made by piling up or forming similar materials into a particular shape or design.

-a mass structures has 2 advantages in that the structure is:

1. Held firmly in place by its own weight
2. Will allow for small parts to be worn away without destroying the structure

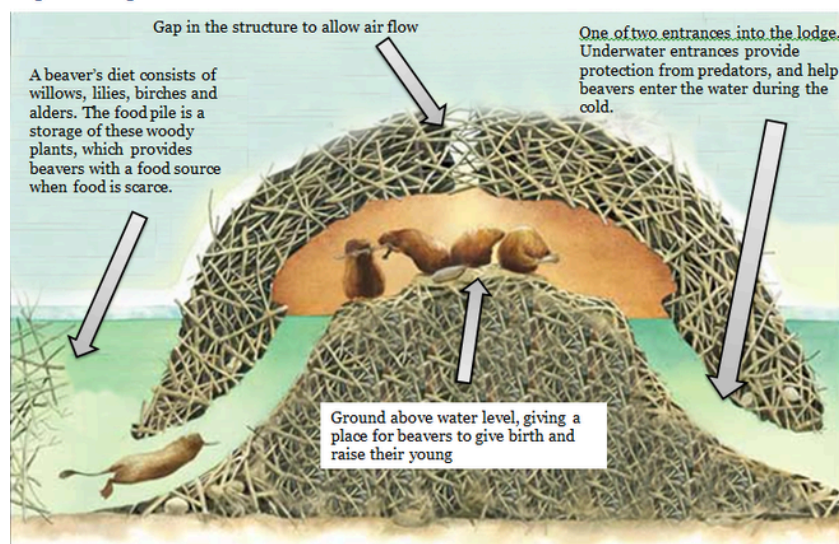
examples: coral reef, beaver dam, snow sculptures, brick walls

-a mass structure has one very key component to its building

-the pieces are arranged in a very specific order

-when a brick wall is made there is a definite pattern that they are laid in in order to provide the greatest strength

Figure 1: Diagram of a Beaver's Habitat



- a dam is a very good example of a mass structure
 - think about a beaver dam--it is a mass of sticks and mud that restricts the movement of water
 - now think about a manufactured dam--it is also a mass (usually of concrete) that restricts the movement of water

-each of the different materials has a specific purpose

Sticks are to provide structure

Mud is to keep sticks together and water out/in

-because of their large size and weight, mass structures must be carefully designed

-there are four ways in which a mass structure will fail

1. A wall may not be heavy enough to stay in place
 - a. with a dam the water may push the structure out of place
2. A wall may be too heavy, so that it compresses unevenly
 - a. with a dam it may cause it to become unstable
3. A wall might not be thick enough to stay in place
 - a. with a dam it will cause it to be broken apart
4. The structure is not anchored firmly to the ground.
 - a. with a dam it will be pushed over



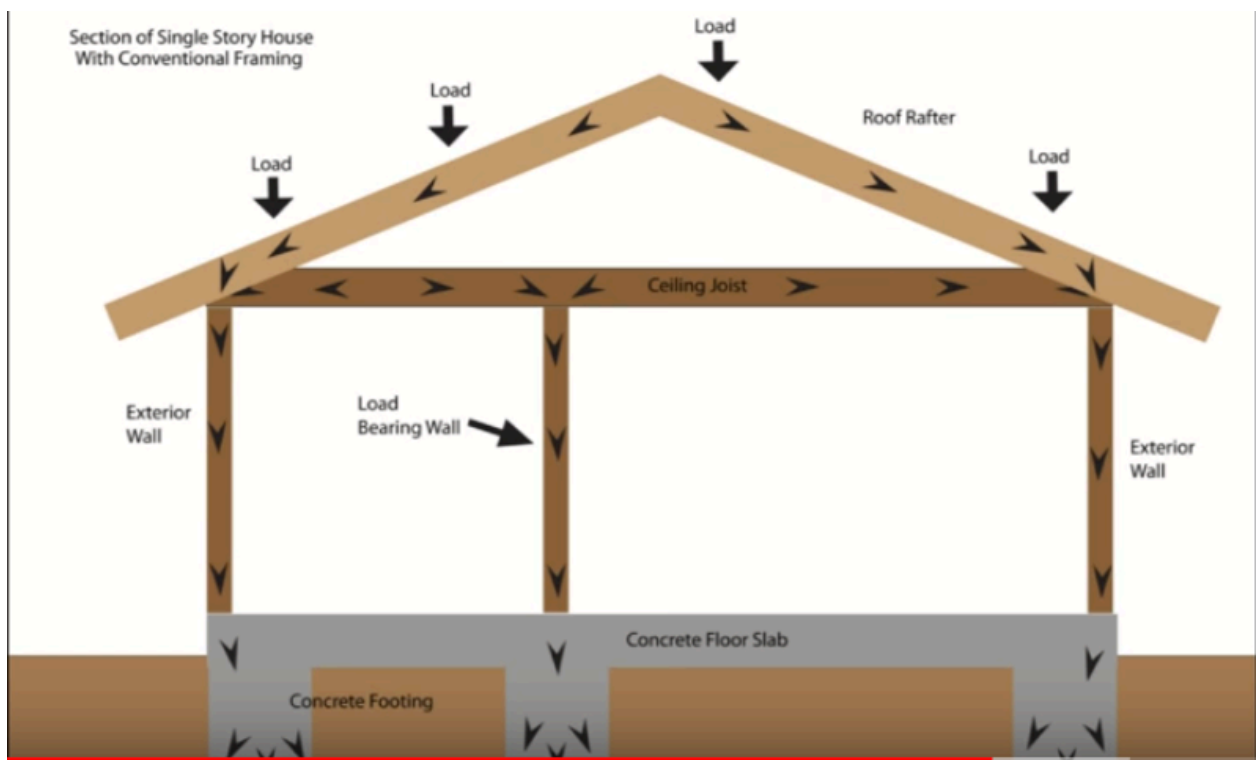
Hoover Dam



Three Gorges Dam

Frame Structures:

- frame structures are buildings that have a skeleton of very strong materials.
- the skeleton supports the weight of the roof and covering materials
- most of the inside is empty space.
- sometimes there needs to be a load bearing wall inside the structure to support it
- other walls are put up to partition the space
- some objects require only the frame to be fully functional
example: spider webs, fishing nets, ladder
- some objects have the frame hidden within the structure
example: automobile, humans
- frame structures are relatively easy to design and build
- frame structures do have some problems which need to be addressed
 - they need to be anchored very securely
 - they need to be braced so that they do not become unstable
 - they need to be strong without becoming too heavy



Shell Structures:

-the third type of structure is a shell structure

-they are strong and hollow

-it can keep its shape and support its load without a frame

examples: igloo, eggs, food can, dome tent.

-a shell structure uses a thin, carefully shaped outer layer of material to provide strength and rigidity

-shell structures have two very useful features:

1. They are completely empty, so they make great containers
2. They use very little material, so they are inexpensive to build

-the shape of the shell spreads forces through the whole structure

This allows each part of the structure to support only a small part of the load.

-there are fewer problems facing builders using shell structures

1. Tiny weaknesses (like scratches) can cause the whole structure to fail
2. If the shell is formed from hot or moist material uneven cooling or drying can cause stress and cracks
3. Special materials need to be use or the costs will greatly increase
4. Assembling flexible materials can sometimes be difficult to do



Mix and Match Structures (Mixed Structures)

-there are many different structures that use components of many different types of structures

examples: Football helmets use shell + frame

Hydroelectric dams use mass + frame

Sport + stadiums use shell + frame



Practice Questions: Classifying Structures

Structure	Natural or manufactured	Can also be classified as
sand castle		
igloo		
planet		
snowflake		
brick wall		
mushroom		
bird's feather		
comet		

sand dune		
cactus		
wheelchair		
the Eiffel Tower		
clay pot		
metal pipe		
telephone		
house/building		
jigsaw puzzle		
fishing net		
spider's web		
parachute		
umbrella		
the Sphinx		
Velcro fastener		

B. Design



- when an **architect or engineer** is designing a structure there are many things that they must consider
- when planning a new project they must consider: function, aesthetics, safety, and the materials
- we have already discussed the many types of materials that can be used

Function

- this answers the question: **What is the structure supposed to do?**
- one of the most important functions is that the structure must support its own weight
- a structure usually will have many different functions, so it is the job of the architect to provide a **compromise** between the functions to allow it to do the best job possible

Aesthetics

- one very important design specification is that **the design must look attractive**
- aesthetics is the study of beauty and art in nature
- a structure is built to function, but also to look good
 - the materials used will greatly affect the way that a structure can look
- Example: **The greek columns of an ancient building vs concrete columns of a bridge**

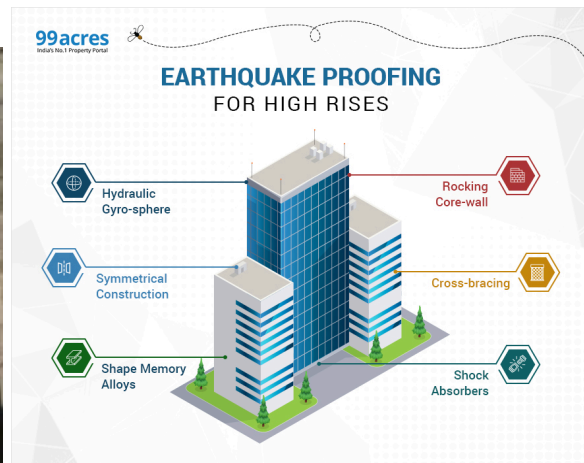
Safety

- when a structure is designed it must take into consideration the loads it will be dealing with and prepare for them
 - example: **maximum load of an elevator**
 - most structures are designed with a large **margin of safety**
 - this means the structure has extra strength built into it that allows it to withstand much larger loads than it would normally carry



MARGIN OF SAFETY

- in Canada there are large margins of safety for buildings especially their roof, because the snow builds up in the winter
- when building a house there are safety codes that must be met so that the house is safe to be lived in
- making a structure safer will usually cause it to be more expensive
 - this is usually due to better materials and more skilled craftsmen to build the structure
- a designer will plan their structure to withstand what they think might happen
 - Example: In Canada we think about snow, in California they think about earthquakes



C. Materials

-choosing the materials that will be used in a building is very important

-each material has properties that give it specific characteristics

-there are three types of materials that are used

1. Composite Materials

- a. More than one kind of material- uses the best properties from each material.

example: reinforced concrete

- Steel bars allow for some twisting, concrete can handle large forces.

2. Layered Materials

- a. Many layers are pressed together to provide for one strong piece.

example: safety glass in windshields- a layer of plastic prevents the glass from shattering everywhere.

3. Woven and Knit Materials

- a. Type of material used a lot in clothing.
 - b. when it has been woven with two yarns going crosswise from one another you can make cloth
 - c. when it has been looped and knotted together the material has been knitted
 - i. a knitted material will be able to stretch in all directions
- example: legging, toque, scarf, mittens

Choosing Materials:

- when you are choosing a material you must balance the advantages and disadvantages of each material and how it will be applied to your project
- many times the higher quality materials will be more expensive
- there are a few things that a person must consider when looking for the correct material to be used:
 - cost: low cost materials might not be a bargain.
 - if they have a short lifespan (wear out quickly or require a lot of maintenance)
 - If it is short term, low cost may work.
 - appearance: materials need to be attractive for the lifetime of the structure.
 - they need to not require expensive maintenance

- environmental impact: using recycled materials decreases the ecological footprint.
 - you can choose to buy products that are healthier for the Earth
- energy efficiency: if the structure requires energy on an ongoing basis, it may not be efficient.
 - your choice can again help with the ecological footprint

Practice Questions

Drag the examples to the correct column of the chart

Layered	Woven/Knit	Composite



Metal in knife building process



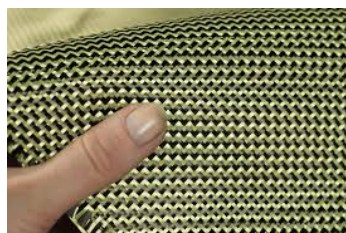
Sweater



Blanket



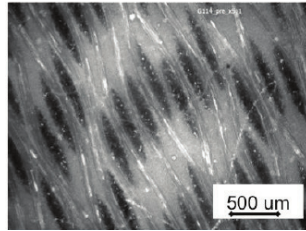
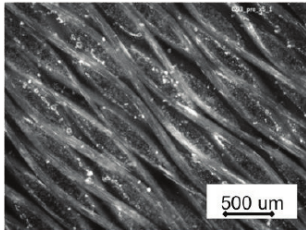
Reinforced concrete



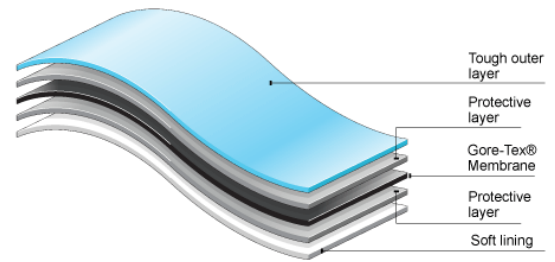
Kevlar



OSB -used for houses



Fiberglass



Gor-Tex (waterproof/windproof)



Windshield glass