4.0 Structures are designed, evaluated, and improved in order to meet human needs

4.1 Building Safe Structures in All Environments

Margin of Safety

Safety is important to designers and so they design based on a margin of safety. This refers to the limits within which a structure is expected to perform its function safely.
Certain ranges of performance provide the designers with upper and lower limits (thresholds) within which the structure will perform best. The margin of safety will always exceed the upper limit because failure of the structure may cause harm to human life.

Testing for Structural Safety

(Crash Test Dummies)

One way to ensure that the structure you have designed is safe, is to test it to extremes. Hockey helmets are tested in this way to ensure they provide the protection they are designed for.

Cars are driven into brick walls to see what happens and how it happens, so that designs can be improved upon. Testing occurs at each and every stage of development and involves real and simulated situations.

Monitoring Structural Safety

Another way to evaluate the safety of a structure is to look at the frequency and conditions under which a structure fails. This information, gathered first hand or through surveys – from people who have used the structure - when analyzed, will help designers redesign the structural components to improve the performance of the structure.

Accounting For Environmental Factors

Climate Conditions

Climate related factors include: precipitation (rain, snow, ice), wind, heat, cold, humidity, and dryness. In the far north, building on permafrost, which is frozen in the winter and becomes spongy in the summer is proving to be a challenge.

Terrain Conditions

The foundation upon which the structure is built must be stable, especially if it is moist, otherwise the compressive forces may cause the structure to tip and become unstable. If engineers and builders do not take into account the soil type and formations, the structures built may experience cracks in their foundations and walls. Foundations constructed on solid bedrock are best. Pilings (large metal, concrete or wood cylinders) can be used, if the layers of soil above the bedrock are loose enough. Some lightweight structures do not have to rest on the bedrock or, have to have a foundation that goes down very deep, because the ground doesn't freeze. Unstable soil and steep terrain make building stable structures almost impossible. Some structures have to be built in certain places where the conditions are not ideal. It is the designers job to find a way to make it work. (Lighthouses are necessary – they are constantly being bombarded by wind and waves, but have survived fairly well, thanks to the designers who made it work.)

Earthquake Risk

Earthquake proof building are being more closely monitored and improved upon. The forces of an earthquake are unpredictable and so the margin of safety in the design has to be extremely high and that has been a challenge.
Here's an activity for you to make an [Earthquake Proof Building]
http://school.discovery.com/lessonplans/programs/earthquakeproof/

4.2 Strengthening Materials to Improve Function and Safety

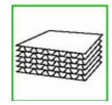
Science strives to provide solutions to practical problems. Structures are designed to meet human needs. Over time these needs may change and structures need to be modified or redesigned. Whatever the reason for this, it is the role of designers to utilize all available information to improve upon the structures we use.

Altering Materials For Strength

One way many structures can be improved is to combine materials and components into new arrangements, taking advantage of the best characteristics of each.

Corrugation

Corrugation is the process of forming a material into wave-like ridges or folds. Cardboard and metal are good examples.



Lamination

Layers of different materials (Tetra Pak) are pressed and glued together, combining the properties of the different materials. The layers are often called laminations.

Strengthening Component Arrangements

Making use of trusses and arches, or adding small supports for reinforcement can make structural components stronger.

Woven or Knit Materials

Spinning or twisting, looping or knotting fibres together gives material added strength. A loom is used to weave two or more pieces of yarn together in a criss-cross pattern to make cloth. Pressing, gluing, melting and dissolving are also ways to combine materials to gain strength.

Changing Methods of Fastening

Fasteners are usually the weakest part of a structure. Besides being an inconvenience when they fail, if the fastener was a vital component in the structure and it failed, it would be a safety concern. Changing the type of material used as a fastener, or even changing the type of fastener may hold structural parts together more effectively.

New Materials

Science and technology are creating new materials all the time. They are making it possible to build structures that are lighter, stronger and more stable. Composite materials and new technologically developed synthetic materials have made it possible for new designs and innovations in many areas.

4.3 Evaluating Designs from an Overall Perspective

When evaluating whether a structure is doing what it was designed to do, and doing it as well as it can, there are certain **factors to consider:**

Cost	Benefits	Safety	Impact on the Environment
- how much will it cost to build, operate and maintain the structure - can we afford to build it?	- is the appeal of the structure 'pleasing' over time? - who will enjoy the benefits of this structure?	**- is there a safety hazard? - who and what could be affected by these risks?**	- does the structure harm the environment? - does the structure conserve energy?

A Case Study In Improving Designs

'The Sherpa' – The first Rocky Mountain Bike, produced in 1982.
Read How Rocky Mountain Bicycles Makes Bikes on p. 335
Then answer the questions on p. 334.