Construction Materials

Introduction

The effects of the built environment have been considered in the previous modules on global warming, the ozone layer, deforestation etc. In this module the effects of the construction industry are considered.

A construction industry has been around for thousands of years in one form or another. Ever since primitive man decided to live in structures that he or she had built for themselves rather than living in caves.

The building of structures has become more and more damaging to the environment. As people demand more from modern life our buildings become increasingly complex, requiring more energy to heat or cool them and more energy is used in extracting the raw materials from which buildings are made.

As the world's population increases the need for shelter imposes greater and greater demands on the natural environment. We are mainly dependant on non renewable resources. This, unfortunately, means excavating, drilling and blasting our way to the various aggregates, metals, clays etc. that form the basis of modern construction technology.

Construction materials can affect the natural environment in different ways. Some affect the global environment, e.g. CFC's and tropical hardwoods, while others affect the environment inside buildings, e.g. solvent based paints and varnishes.

Obtaining and processing materials can affect the environment in various ways:

- **Extraction**

  Extraction of materials requires heavy construction plant which consumes energy, and produces noise and dust. In the process, the landscape is changed and unsightly spoil heaps are often formed.

- **Processing**

  Processing the material into a form that can be used requires more energy consuming plant, often with associated noise and creation of waste products.

- **Transportation**

  The materials will then need to be transported to the location they are to be used or to a location where they undergo further processing to produce components such as windows.

Examples of the environmental impact of some building materials will now be considered.

Mineral Extraction

Industrialised societies are highly dependant on mineral resources. They provide fuel and raw materials for everything from bottles to computers. Although these natural resources are finite, they have to cater for ever increasing needs. Some materials can be reclaimed and / or recycled and this option will be increasingly important.

Modern industry routinely makes use of more than 100 minerals. No nation is self sufficient as these resources are distributed unevenly around the world. Methods of mineral extraction include:

- **underground mining**

  Minerals are extracted from tunnels bored under the ground. There is often a large amount of waste that is left as spoil heaps.

- **extraction from open pits**

  This method is used where the minerals are near the surface, e.g. chalk, limestone, sand, gravel, coal. Use of large scale equipment makes this economic. Again, there will be waste material.

  The ratio of valuable material to waste varies from 1 : 7 for china clay to 1:100 for some metals.

- **boreholes**

  Mineral in liquid (oil) or gaseous (natural gas) forms are pumped to the surface by means of drilling a borehole.

There are various environmental impacts caused by the extraction of minerals, including:

- **air pollution**

  Dust produced by drilling, blasting and excavation causes nuisance in the locality. This can be partially controlled by spraying water over the working areas.

- **waste disposal**

  This is an issue at various stages - extraction, processing, construction and at the end of the useful life of building materials. Waste control is important as is recycling and re use of materials and components.

- **water pollution**

  Water sources can be contaminated by heavy metals, acids and sulphides. This problem can affect both surface water and ground water.

- **subsidence**

  This occurs as a result of underground mining, especially for coal. It can damage buildings, roads and underground services.

- **visual impact**

  Mines, pits and quarries all have a visual impact on the landscape.

Non renewable materials

- **Metals**

  Aluminium and iron make up about 8% and 5%, respectively, of the earth's crust. It is, therefore, unlikely that world supplies of aluminium or iron will soon, or perhaps ever, run out.

  The extraction and processing of metals are not without their problems, however. These include:

  - **adverse visual impact on the landscape**

  The need to extract and process ever increasing quantities of metal ores is leading to more and more visual impact on the landscape over more extensive land areas.

  The effects of both deep and open cast mining mean that surface disturbance is the most obvious effect on the local area, although the discharge of pollutants into the atmosphere and water supplies has the potential to affect a much larger area.

  Large quantities of solid wastes are also produced, and much of their storage area has yet to be reclaimed.

  - **high energy use for production of metals and metallic products**

  Large amounts of energy are required at the various stage of metal production:

    - during the extraction process
    - when the ore is transported to the crushing plant
    - transport to take the waste material to spoil heaps
    - when the selected material is transported to the smelting plant
    - when the metal is transported to the factory
    - when the metal is formed into the final product
    - when the metal product is transported to the construction site

  - **problems relating to air and water pollution**

  Dust emission occurs both when metals are mined and during processing. Despite controls, with up to 90% efficiency, the quantity of atmospheric emissions is large.

  The gases emitted during processing, smelting and transportation all add to the greenhouse effect.

  Water use is high, but a lot of this is recycled. Waste water discharge can be toxic and have adverse effects on aquatic plants and animals. Polluted water can also leach down into the ground water.

  - **declining ore quality**

  The current average copper concentration in ore is about 0.5%, approximately one sixth of what it was 100 years ago. This means that it is necessary to extract and process six times as much ore to get the same amount of copper.

  Decreasing ore quality also means greater energy consumption and greater quantities of waste per unit of finished metal obtained.

Non renewable materials

- **Cement Based Products**

  Cement based products are made from non-renewable materials: limestone, chalk, clay, gypsum and aggregates (sand and gravel) . These are, however, available in large quantities worldwide. Thus, just as the world is unlikely to run out of metals such as iron and aluminium, shortages of raw materials for cement based products are also unlikely far into the future.

  The raw materials for making cement based materials must be mined, meaning that large amounts of material must be extracted, the desired materials removed and processed.

  The main environmental concern regarding cement production do not, however, relate to the extraction, but rather with the very large quantities of energy consumed in processing.

  It is estimated that about 8% of the total worldwide human generated carbon dioxide originates from cement production about 1.6 billion tons!

  The energy consumed per unit to produce concrete is less than for cement, because concrete usually contains only 12 to 15% of cement and the energy required to obtain aggregates is very low.

  Nevertheless, the energy required to produce concrete structures, such as floors, foundations and walls, is still significantly higher than that of timber structures. In addition, structural concrete beams and columns, which contain steel reinforcing bars, carry the negative environmental attributes of steel.

- **Plastics and Fibreglass**

  Plastics are petrochemical based products. If petrochemical supplies become scarce in the future, as appears possible, then the future of plastics made from petrochemicals could be doubtful.

  However, plastics can also be made from coal, which is currently abundant. In addition, research is currently investigating plastics made from components of trees and agricultural crops, so it appears that plastics will remain as a materials option for a long time to come.

  Fibreglass, which can be formed into structural shapes is one of a number of products now used as a substitute for timber. The raw materials used in making fibreglass, including sand and small amounts of lime, are non-renewable. However, as with other materials discussed above, the world is unlikely to run out of these basic materials.

  As the rate of innovation relating to structural materials continues to accelerate, driven in part by the instability of petrochemical supplies, an range of new products can be expected to appear on the market.

  Though many of these will be made of non-renewable materials, they can be expected to provide long term alternatives to timber and other traditionally used products.

Renewable Materials

- **Timber**

  The use of timber as a construction material has low environmental impact. There is little energy consumed in the logging and seasoning processes, but transportation does use energy. However, trees perform the environmental function of turning carbon dioxide into oxygen.

  The UK imports about 80% of the timber used, mostly from North America, and Scandinavia. This comes from both natural forests and plantations.

  There is a huge potential for increasing the harvest of natural forest. However, it is constrained to relatively few areas of the world, including Siberia, northern Europe, and several western European nations.

  In addition, the vast hardwood forests of Brazil and other parts of South America could support a larger sustainable harvest. However, the fact that these are being destroyed for other reasons limits increases in harvest activity.

  Tree plantations generally produce more timber per unit area than natural forests. This is mainly because plantations tend to be established on highly productive sites, often combined with intensive use of fertilisers and increasingly the use of genetically selected growing stock.

  Plantations will play a significant role in providing future wood supplies. In the short term (the next 20 to 30 years), however, it appears that timber plantations would not be able to meet the anticipated increased demand for timber or to compensate for the expected decreases in harvest levels in natural forests.

Embodied Energy

All construction materials require energy to produce them and transport them to the construction site. This is called the "embodied energy." The embodied energy in the materials used to build a house may actually be greater than the energy used to operate the house over its lifetime.

"Embodied energy" in several common building materials (excluding transportation energy)

Material	**Energy for production** (relative to timber)
Timber	1
Brick	4
Cement	5
Plastic	6
Glass	14
Steel	24
Aluminium	126

Assessment

Construction Materials

Questions 1 to 5 - Select the correct response for the following questions :

1. Which of the following stages in the production of construction materials can affect the environment ?

   A mineral extraction
   B processing
   C transportation
   D all the above

2. What % of the earth's crust is composed of iron ?

   A 3%
   B 5%
   C 8%
   D 12%

3. What fraction is the average concentration of copper ore compared to what it was 100 years ago ?

   A one quarter
   B one sixth
   C one eighth
   D one tenth

4. What % of the total worldwide human generated carbon dioxide originates from the production of cement ?

   A 2%
   B 4%
   C 6%
   D 8%

5. How much more embodied energy is there in steel than in brick ?

   A 2 times as much
   B 4 times as much
   C 6 times as much
   D 8 times as much

Questions 6 to 10 - Decide whether each of these statements is True (T) or False (F).

6. i) When minerals are extracted from tunnels bored under the ground, there is often a large amount of waste that is left as spoil heaps.
   ii) Minerals in liquid or gaseous forms can be pumped to the surface by means of drilling a borehole.

   Which option best describes the two statements?
   A i) T ii) T
   B i) T ii) F
   C ii) F ii) T
   D ii) F ii) F

7. i) Dust produced by drilling, blasting and excavation causes nuisance in the locality. This can be partially controlled by spraying water over the working areas.
   ii) Subsidence can occur as a result of underground mining, especially for coal. It can damage buildings, roads and underground services.

   Which option best describes the two statements?
   A i) T ii) T
   B i) T ii) F
   C i) F ii) T
   D i) F ii) F

8. i) The need to extract and process ever increasing quantities of metal ores is leading to more and more visual impact on the landscape.
   ii) The gases emitted during processing, smelting and transportation of metals all add to the greenhouse effect.

   Which option best describes the two statements?
   A i) T ii) T
   B i) T ii) F
   C i) F ii) T
   D i) F ii) F

9. i) The main environmental concerns regarding cement production relate to the extraction of materials, not to the quantities of energy consumed in processing.
   ii) The energy consumed per unit to produce concrete is less than for cement, because concrete usually contains only 12 to 15% of cement and the energy required to obtain aggregates is very low.

   Which option best describes the two statements?
   A i) T ii) T
   B i) T ii) F
   C i) F ii) T
   D i) F ii) F

10. i) If petrochemical supplies become scarce in the future, as appears possible, then the future of plastics made from petrochemicals could be doubtful.
    ii) The use of timber as a construction material has high environmental impact.

    Which option best describes the two statements?
    A i) T ii) T
    B i) T ii) F
    C i) F ii) T
    D i) F ii) F