Our environments

In recent times, we have all become aware of the need to protect the *environment*. When we refer to the environment in this sense we usually mean the *natural environment*, the earth itself, trees, rivers and the surrounding atmosphere. This natural environment is distinguished from the *built environment*.

Over many years, scientists have developed theories to explain various features of the natural environment such as the sun's light, rainbows, lightning, the air we breathe, and the way the whole *ecosystem* is inter-related. At the same time, as we construct the built environment, we use many of the earth's natural resources. Our roads, bridges, railways, houses and office blocks all use steel and concrete. These widely used materials are produced by extracting and processing natural resources.

Using natural resources

CRH is a major company in the *extractive industry* and a world leader in the production of building materials. CRH produces both primary materials and value-added products for use by the construction industry all over the world. Value-added products include bricks, roof tiles and insulating materials. Primary materials are the basic products used for construction. *Cement* is a well known and widely used primary material. Cement is a key ingredient in concrete which is a vital product used in the construction of our *built environment.* The science of cement production is well known. Essentially, the basic raw material, *limestone*, is crushed and mixed with silica bearing materials, mainly *shale*, and heated to a high temperature. The output of this process is called *clinker*. This clinker is then ground with a small amount of *gypsum* to produce the final product – Portland cement.

Limestone (*calcium carbonate,* $CaCO_3$) is a commonly occurring mineral in nature and there is little danger that it will run out. However, when it is broken down at high temperature in the kiln, *calcium oxide* and *carbon dioxide* are produced ($CaCO_3 => CaO + CO_2$). This process can be demonstrated in a laboratory by one person. However, millions of tonnes of cement are required each year, so it usually produced in bulk in a large *manufacturing plant*. Clearly, cement manufacturing must be carefully managed and controlled. This challenge falls to *engineers* and in this lesson we look at some of the activities in which they are engaged.

Fig. 1 Irish Cement Works at Limerick and Platin

The real world

CRH is currently installing one of the most modern cement production plants in the world at Platin, near Drogheda, Co. Meath. This is known as the *Kiln 3 Project* and many engineers are involved in this vast undertaking.

In fact, a facility such as Kiln 3 is a triumph of *engineering* and *technology*. To plan, design and install such a plant requires the input of many engineering disciplines, including mechanical, electrical, civil, structural, electronic, and environmental. The company's project team of engineers is working in co-operation with external contractors to complete this installation. Kiln 3 will cost some €200 million. In effect, the plant is a combination of *machinery*, processes and *control systems* and to operate it, the engineers require a deep knowledge and understanding of these elements.

Protecting the environment

The Kiln 3 operation is designed for world-class *energy efficient* production and environmental protection. The engineers will accomplish these objectives by using the Best Available Technology (BAT) at all stages in the manufacturing process. Clearly the company's engineers must be thoroughly familiar with these technologies. In particular, the environmental engineers will be closely monitoring performance to ensure that the plant meets the company's environmental policy objectives of:

- minimising emissions to air and to water
- conserving mineral and energy resources
- minimising waste generation
- minimising the visual impact of operations.

Components of Kiln 3

The limestone store

The new *limestone store* has a distinctive domed aluminium roof. This is where tonnes of limestone, the critical ingredient of cement, will be stored.

The raw mill

As the first stage in the process, the limestone and the other materials are ground into fine powder. This is done in the raw mill.

The Preheater Tower

It is well known in the industry that pre-heating the materials before they enter the kiln contributes significantly to the *energy efficiency* of the process. The *pre-heater* tower is the tallest structure on the site. The temperature in the tower can exceed 1000 °C.

Fig. 2 The Preheater tower

The Kiln

The kiln is the centre of the manufacturing process where the raw materials are transformed into clinker. Kilns use large amounts of energy. Many hours of engineering design have been spent ensuring that this process is as efficient as possible. The temperature of the materials in the kiln reaches 1450 °C.

Energy recovery

The cost of the fuel, which is currently petroleum coke, to heat the materials and the electricity to drive motors and conveyors etc. is significant in cement manufacturing. Considerable savings are made when heat energy recovered from the clinker leaving the kiln is used for pre-heating the raw materials.

The Cement Mill

The machinery that grinds the clinker and gypsum together to finally produce the cement is called a *cement mill*. The Kiln 3 Project includes a Vertical Roller Mill. The materials are crushed on a steel table by vertical steel wheels. The table is driven by motors of typically 2000 kW – 4000 kW (Motors are often specified in terms of horsepower where1 *horsepower* = *746 W* or 0.746 kW)

Control Systems

Sophisticated control systems are required to operate a plant like Kiln 3. There are thousands of sensors and several computer systems involved in this process. Data are continually fed back to a central control room where process engineers monitor temperatures, flow rates, valves etc. interpret the data and take appropriate action. Clearly, information technology (IT) plays a central role in the operations of a modern cement manufacturing plant

Fig. 3 Control Systems

Applied Science

CRH employ engineers from various disciplines and in many roles. These engineers work with technology on a daily basis. Technology is based on scientific principles and engineers apply these principles to achieve practical outcomes. ***Kiln 3*** is a major example of such application, with engineers involved in every stage of the process. They may be leaders or members of project teams, or work with the production staff in supervisory or managerial roles. As well as operating in their own specialised fields, they must also work in close co-operation with others inside and outside the company. They will frequently advise customers, work with external consultants and interface with local authorities and government departments. Engineering is truly science in action.

Sustainability

The cement industry is constantly seeking ways of improving energy efficiency and of minimising environmental impact. *Overburden* removed from the limestone quarry is used to replace shale, thus conserving natural resources. Depleted quarries are landscaped and planted with trees. In these and other ways cement production is made more environmentally friendly.

Unburnt limestone is now being ground with the cement clinker in producing the final cement to reduce the clinker content, thus reducing the carbon emissions per tonne of product. Also, plans are currently being put in place to replace a proportion of the fossil fuel used with alternative fuels. Materials which would otherwise have to be land filled and which have a calorific value such as used tyres, recovered plastics, cardboard and paper and other materials which arise as wastes can be used as fuel in cement kilns. This reduces CO_2 emissions. The CO_2 associated with cement production needs to be balanced against the key role cement and concrete play in reducing CO_2 emissions in use. For example, roads and bridges reduce journey times and traffic congestion and in buildings the thermal mass of concrete stores heat, thus reducing the energy required to heat the buildings.

CRH is an international leader in the manufacture and distribution of building materials.

The company employs over 92,000 employees in 34 countries. The product range is vast and includes cement, lime, aggregates, asphalt, ready-mixed concrete, pre-cast concrete products, glass and many other building materials, The Company's annual sales are over €20 billion. CRH shares are listed on the Irish (ISE) and London (LSE) Stock Exchanges and on the New York Stock Exchange (NYSE).

Irish Cement Ltd is a subsidiary of CRH and operates two manufacturing plants at Castlemungret, Co Limerick and at Platin, Co. Meath. Platin is the site of Kiln 3, the new €200 million plant. The technologies used are designed to produce a new generation of environmentally friendly, lower carbon cements.

The company operates its cement plants in line with the requirements of Integrated Pollution Control Licences, which are issued by the Environmental Protection Agency (EPA). The company commits to an Annual Environmental Programme as part of its environmental protection strategy. The company has also adopted a policy of open communication on environmental performance and aims to operate as a good neighbour with those living close to the manufacturing plants.

You can find out more about CRH at **www.crh.com** and about engineering careers at Irish Cement at **www.irishcement.ie**.

Engineering and the Environment

Syllabus References

Leaving Certificate Technology (p. 2)

(Students should) gain an appreciation and understanding of the complex interface between technology and society. As citizens they should have the capacity to enter discussion about, and make personal judgements on, issues related to the impact of technology on their own lives, on society, and on the environment. …

- Technological capability includes:
- the understanding of appropriate concepts and processes
- skills of design and realisation
- the ability to apply knowledge and skills by thinking and acting confidently, imaginatively, creatively and with sensitivity
- the ability to evaluate technological activities, artefacts and systems critically and constructively.

Leaving Certificate Geography Elective Unit 4: Patterns and Processes in Economic Activity (p. 26)

4.5 Environmental impact Statement: Economic:- activities have an environmental impact.

Students should study

- the use of renewable and non-renewable resources in the economy
- the impact of the burning of fossil fuels and the use of alternative energy sources
- environmental pollution at a local/national and global scale
- sustainable economic development so as to control its environmental impact
- conflicts that may develop between local and global economic interests and environmental interests.

Leaving Certificate Chemistry Option 1A: Additional Industrial Chemistry (p. 65)

Batch, continuous and semicontinuous industrial chemical processes.

Characteristics of effective and successful industrial chemical processes.

Learning Outcomes

On completing this lesson students will be able to:

- Distinguish between the natural and built environment
- Outline how cement is produced and know what natural materials are used in the process
- Outline how energy can be recovered and reused in cement production
- Describe the main components of the Kiln 3 Project
- Appreciate how the Kiln 3 Project has a part in protecting the environment.

General Learning Points

- The built environment refers to bridges, roads, houses and other constructions whereas the natural environment refers to ecosystems and nature.
- Cement is a key ingredient in concrete which is a vital product used in the construction of our built environment.
- Cement is made from limestone, shale and gypsum.
- Limestone is a naturally occurring material. At high temperature it decomposes into calcium oxide and carbon dioxide.
- New processes of cement production aim at reducing the emission of CO_2 which is a greenhouse gas.
- The most modern cement production plant is at Platin, Drogheda, Co. Meath and is known as the Kiln 3 Project.
- Limestone and other materials are ground into powder in the raw mill.
- Energy is saved if materials are heated in the pre-heater tower before entering the main rotary kiln.
- The rotary kiln is the centre of the manufacturing process.
- The machinery that grinds the clinker and gypsum together to finally produce the cement is called a cement mill.

Student Activity

1. Make a model of a cement manufacturing plant. Label the separate processes and show the path followed by the materials during manufacture. (This is best done as a group task.)

2. What is the dominant landform in the vicinity of your school. Investigate the processes that led to its formation. What raw materials are derived from it?

True/False Questions

a) The built environment consists of inter-related ecosystems. **T F**

b) Concrete and cement are essentially the same thing. **T F**

c) To make cement limestone and shale are crushed, mixed, and heated to a high temperature. **T F**

d) When calcium carbonate is broken down in the heating process calcium oxide and carbon dioxide are produced. **T F**

e) The Kiln 3 process produces cement with lower overall carbon dioxide emissions. **T F**

f) The limestone store at Platin has a circular domed roof made of steel. **T F**

g) The preheater tower is where the limestone is heated before it enters the kiln. **T F**

h) The machinery that grinds the clinker and gypsum together to finally produce the cement is called a cement mill. **T F**

Check your answers to these questions on www.sta.ie

Examination Questions

Leaving Cert. Geography, Higher Level, 2006 Part 2, Q. 1 c

Examine how humans interact with the rock cycle in the case of one of the following: mining, quarrying, oil/gas exploration, geothermal energy production.

Leaving Cert. Geography, Higher Level, 2007 Part 2 Q 7 b

Examine the influence of any two of the factors listed (in the diagram) on the location of one secondary economic activity that you have studied.

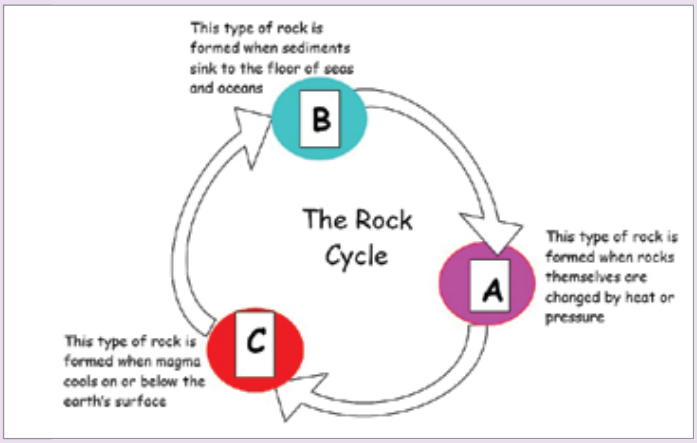
Leaving Cert. Geography, Higher Level, 2005 Section A, Q. 4 b

Manufacturing Industry

(i) The factors influencing the location of manufacturing industry have changed over time. Examine the truth of this statement, referring to examples that you have studied.

(ii) Using examples that you have studied, examine how manufacturing industry may have both positive and negative effects on the environment.

Leaving Cert. Geography, Ordinary Level, 2008 Part 2 Q. 3 A



With reference to the boxes labelled A, B and C on the above diagram of the Rock Cycle state in your answer book which letter represents each of the following: Sedimentary Rock, Metamorphic Rock, Igneous Rock

B. Karst Regions
What is the chief type of rock found in Karst regions such as the Burren in County Clare? Describe fully how this type of rock is formed.

For further examples of past questions check www.sta.ie

Did You Know?

The name "cement" dates back to the Romans who used the term "opus caementicium" to describe masonry which resembled concrete. The masonry was made from crushed rock with burnt lime as binder. Volcanic ash and pulverized brick were added to the burnt lime to produce a hydraulic binder. These were later referred to as cementum, cimentum, cäment and cement.

Cement refers to the dry powder substance. When water is added along with variable amounts of gravel and sand the mixture is referred to as concrete.

The cement used by ancient Egyptians was made from calcium carbonate and gypsum.

In 1756, British engineer, John Smeaton made the first modern concrete from hydraulic cement.

Biographical Notes

John Smeaton (1724 – 1792)

John Smeaton is often regarded as the "father of civil engineering". He was responsible for the design of bridges, lighthouses, canals and harbours. He designed the third Eddystone Lighthouse and pioneered the use of hydraulic lime – a lime mortar that can set under water. His lighthouse remained in use until 1877 when the rock underlying the foundations began to erode. He identified the compositional requirements needed to obtain hydraulicity in lime. This work led ultimately to the invention of Portland Cement by Joseph Aspidin.

Joseph Aspdin (1778 – 1855)

Joseph Aspdin, a British cement manufacturer, obtained a patent for Portland Cement on 21 October 1824. He was granted the British Patent BP 5022 entitled 'An improvement in the Mode of Producing an Artificial Stone' and coined the term Portland Cement. Soon after, he set up a production plant in Kirkgate, Wakefield.

Revise The Terms

Can you recall the meaning of the following terms?

aluminium, built environment, calcium carbonate, calcium oxide, carbon dioxide, cement, cement mill, clinker, control systems, ecosystem, energy efficiency, engineer, extracting, greenhouse gas, gypsum, limestone, natural environment, natural resources, pre-heater tower, primary materials, overburden, processing, raw mill, sensors , shale, technology, value-added products.

Check the Glossary of Terms for this lesson at www.sta.ie