9 Content: Engineering Studies HSC course

Engineering application module: Civil structures

30 hours indicative time

Select one or more civil structures in this module. Some examples of civil structures include: bridges, roads, dams, buildings, cranes and lifting devices, parklands and children's playgrounds and equipment.

Outcomes

A student:

H1.2 differentiates between the properties and structure of materials and justifies the selection of materials in engineering applications

H2.1 determines suitable properties, uses and applications of materials, components and processes in engineering

H3.1 demonstrates proficiency in the use of mathematical, scientific and graphical methods to analyse and solve problems of engineering practice

H3.2 uses appropriate written, oral and presentation skills in the preparation of detailed engineering reports

H3.3 develops and uses specialised techniques in the application of graphics as a communication too

H4.1 investigates the extent of technological change in engineering

H4.2 applies knowledge of history and technological change to engineering-based problems

H5.1 works individually and in teams to solve specific engineering problems and prepare engineering reports

H4.3 applies understanding of social, environmental and cultural implications of technological change in engineering to the analysis of specific engineering problems

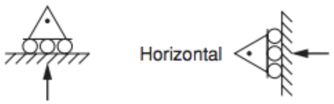
H6.1 demonstrates skills in research and problem-solving related to engineering

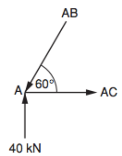
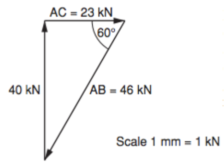
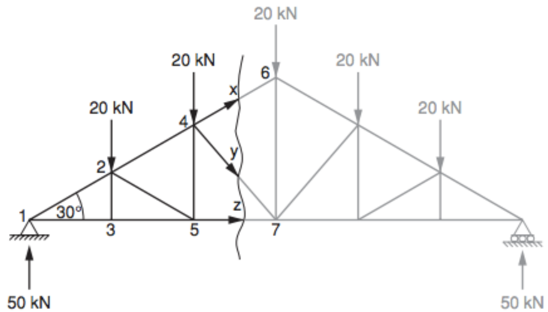
H6.2 demonstrates skills in analysis, synthesis and experimentation related to engineering.

1. Historical and societal influences	
Students learn about:	*Notes:*
▪ historical developments of civil structures	▪
▪ engineering innovation in civil structures and their effect on people's lives	▪
▪ construction and processing materials used in civil structures over time	▪
▪ environmental implications from the use of materials in civil structures	▪

Students learn to:	*Notes:*
▪ outline the history of technological change	▪
▪ investigate the construction processes and materials used in civil structures from a historical point of view	▪

▪ critically examine the impact of civil structures upon society and the environment	▪

2. Engineering mechanics	
Students learn about:	*Notes:*
▪ truss analysis – actions (loads) – reactions – pin jointed trusses only – method of joints – method of sections	▪ **Reactions** – Usually label **Rl** and **Rr** ▪ **Pin Joints** – Pin Joints  – **Roller Joints**  Figure 2.12 Reaction direction at a roller joint ▪ **Method of Joints**

	– Take equilibrium at Rl and Rr, then find the force with Moments at P, then Sum of Vertical and Horizontal Force Consider joint A.  Figure 2.19 Free body diagram joint A  Figure 2.20 Force diagram ▪ **Method of Section**  Figure 2.31 Howe truss
▪ bending stress induced by point loads only	▪ **Uniformed Distributed Load / Beam**

- concept of shear force and bending moment
- shear force and bending moment diagrams
- concept of neutral axis and outer fibre stress
- bending stress calculation (second moment of area given)

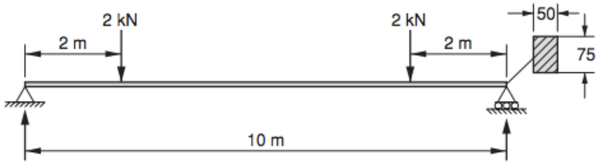


Figure 2.57 Rectangular beam loaded symmetrically

The maximum bending will occur when the shear force = 0.

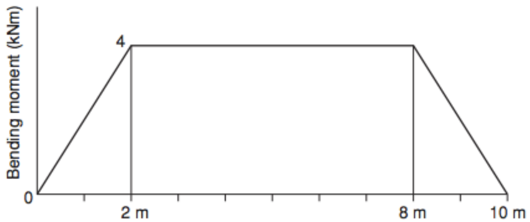


Figure 2.59 Bending moment diagram

- **Bending Stress Calculation**

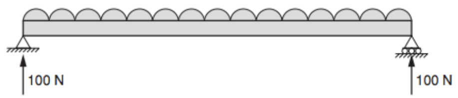
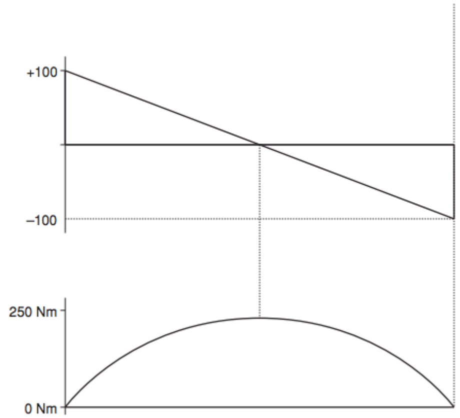
$$\sigma = \frac{MY}{I}$$

$$\sigma = \frac{My}{I} = \frac{4 \times 10^6 \times 37.5}{1.76 \times 10^6} = 85.2 \text{ MPa}$$

$$M = 4 \text{ kNm} = 4 \times 10^3 \times 10^3 \text{ Nmm}$$

$$y = \frac{75}{2} \text{ mm} = 37.5 \text{ mm}$$

$$I = 1.76 \times 10^6 \text{ mm}^4$$

▪ uniformly distributed loads	▪ **Uniformly Distributed Load (UDL)**  Figure 2.54 Shear force diagram  Figure 2.55 Bending diagram
▪ stress and strain – shear, compressive and tensile stress – engineering and true stress – yield stress, proof stress, toughness, Young's modulus, Hooke's law, engineering applications – factor of safety – stress/strain diagram	▪ Stress is defined as the measurement of the internal reaction that occurs in response to an externally applied load. Another meaning is the relationship between an applied load and a material's cross sectional area. ▪ Denoted by the formula: $\sigma = \frac{P}{A}$ $\sigma = \text{Stress (Pa)}(\text{N/m}^2)$ $\text{P} = \text{Force or Load (N)}$ $\text{A} = \text{Cross sectional area } (\text{m}^2)$ – **Shear, compressive and tensile stress** ▪ **Stress** – **Stress is normal stress, as a load is applied perpendicular to the surface area of the cross section. Measures ductility.** $\sigma = \frac{\text{Shear Force}}{\text{Shear Area}}$ $\sigma = \text{Stress (Pa)}(\text{N/m}^2)$ $\text{Shear Force} = \text{Force or Load (N)}$ $\text{Shear Area} = \text{Cross sectional area } (\text{m}^2)$

	▪ **Shear Stress** – **Shear Stress occurs** if the load creates a hole in the member, hence we must take the thickness of the material. NOTE: The Shear Area, is more of a perimeter of cross section x thickness. $$\sigma = \frac{\text{Shear Force}}{\text{Shear Area}}$$ $$\sigma = \text{Stress (Pa)(N/m}^2\text{)}$$ $$\text{Shear Force} = \text{Force or Load (N)}$$ ▪ **Compressive stress** – Compressive Stress measures the contraction of structural members. → ----------- ← ▪ **Tensile stress** – Tensile Stress measures the extension of structural members. ← ----------- → – **Engineering and true stress** ▪ **Engineering stress** – Engineering Stress is simply **Stress**. It is known as Engineering Stress **due to the changing cross section area of the specimen when a load is applied and the material experience necking down, losing stress and hence losing area, making it hard to calculate**. Hence, Engineering Stress, takes the **original area.** ▪ **True stress** – True Stress is used or safety purpose, ensuring the maximum allowable stress can be done. Must be lower than UTS and Yield Stress. – **Yield stress, proof stress, toughness, Young's modulus, Hooke's law, engineering applications:** ▪ **Yield stress:** – Yield stress is the **value of stress at the Progressive Yield Point** on the Stress/Strain diagram. It is used to **calculate the FOS for ductile materials**. ▪ **Proof stress:** – Proof stress is when the approximation of yield on materials that do not show a definite yield point. – Textbook definition: is the amount of stress necessary to bring about a amount of permanent strain in a material. – On Stress/Strain diagram, the tangent at the point proportional limit. The intersection on the graph will define proof stress. ▪ **Toughness:** ▪ **Young's Modulus:** – Also, known as **Modulus of stiffness OR Modulus of Elasticity**. Measure by the **gradient of the linear slope** on the **Stress/Strain Diagram.** This measures the **stiffness.** ▪ **Hooke's Law:**

- Hooke's Law is the **linear relationship of the Stress/Strain Diagram**.
  "Stress is proportional to strain up to the Elastic Limit"

$$E = \sigma/\varepsilon$$
$$E = \text{Hooke's Constatnt (gradient of the proportionity of stress and stain)}$$

$$\sigma = \text{Stress (Pa)}$$
$$\varepsilon = \text{Strain (Ratio)}$$

- Engineering applications:
  - Applications like UTS, necking down, work hardening, plastic deformation, elastic region, etc.

- **Factor of safety (FoS)**
  - Since material should be **working** at stresses **under the UTS, or breaking point**, the Factor of safety is an **allowable stres**s or tolerance a material can undergo. It is the ratio of Working stress.
  - Material is **ductile**:

$$\text{FoS} = \frac{\text{Yield Stress}}{\text{Maximum allowable stress (Safety Working Stress)}}$$

  - Material is **brittle**:

$$\text{FoS} = \frac{\text{UTS}}{\text{Maximum allowable stress (Safety Working Stress)}}$$

  - The **FoS in building and structure** are **usually large to ensure that there is no chance of failure.**
  - The **FoS in aircraft** should be as **low as possible** due to issues of **weight**.
- **Stress/Strain Diagram:**
  - First, there is a linear relationship of increase in stress and increase in strain. In this zone the sketched specimen, when released will return to its original shape [No deformation]. This occurs up to the Proportional Limit. This is region of no deformation is known as the Elastic Region.
  - The slope of the linear line is Modulus of Stiffness/Elasticity or Young's Modulus. This gives rise to Hooke's Law
  - At proportional Limit, the specimen sketch over it will be identified deformation. This is also known as Yield stress.
  - Next is the Elastic Limit is the stress up to which the strain is elastic. At this point the specimen can still return to its original shape.
  - Next is the Progressive Yield, which shown an increasing curve, meaning that beyond this point plastic deformation.
  - As Strain is increased Stress is increased up to the maximum point known as UTS. This is the Ultimate Tensile Strength, having the maximum possible engineering stress the specimen can take in tension.

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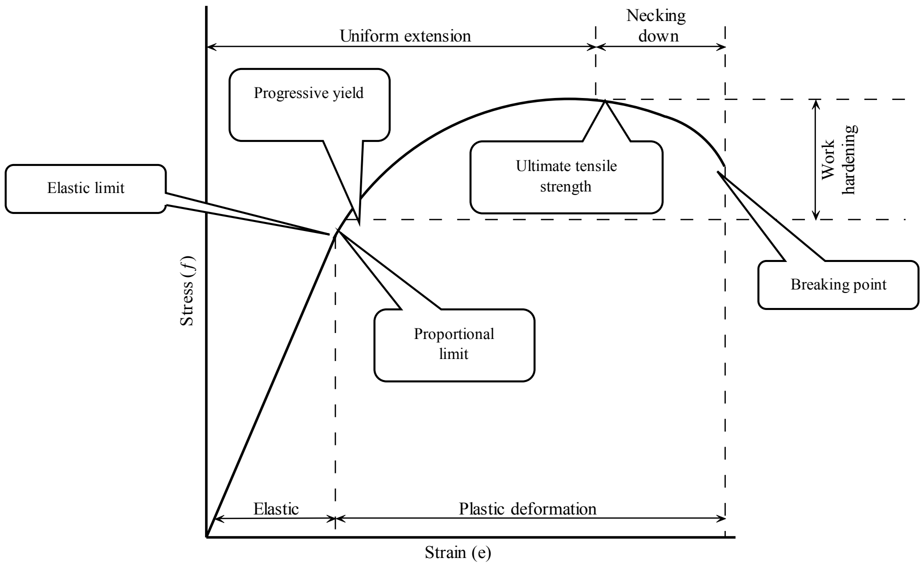
- After the UTS, the material will lose stress and degrade. This region is known as Necking down. As the graph curve, down until the point of fracture.
- Fracture point or breaking point is the failure point, where all the bond on the specimen are broken.
- Within this region of Elastic Limit to the fracture, it is in the plastic deformation region. And within the zone of Work Hardening.
- The area under the whole graph can be calculated using integration to found the toughness of the material.



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Students learn to:	*Notes:*
▪ apply mathematical and/or graphical methods to solve problems related to the design of pin jointed trusses	▪

▪ evaluate the importance of the stress/strain diagram in understanding the properties of materials	▪ **Malleability** – The ability for a material to be **hammered and rolled in thin sheets** with breaking. ▪ **Ductility** – The ability for a material to **rolled into thin wires**. Ductile materials are not the same as Malleable materials, for Ductility can be **stretch and elongated**. – Ductility is portrayed by the **Strain Axis**. A **short strain graph** will mean **low ductility**. A **long strain gra**ph will mean **high ductility**. ▪ Strength – The **ability to withstand heavy load without breaking**. – Strength is portrayed by the **Ultimate Tensile Strength**. ▪ **Stiffness** – The amount of **resistant in deformation when a load is applied**. Stiffness is related to **flexibility** of an object, (More flexible, less stiffness). – Stiffness is portrayed as the **linear line on stress/strain**, up to the Elastic Limit. ▪ **Hardness** – The ability for a material to **resist cracking, dents, scratching** and **abrasion.** ▪ **Plasticity** – The ability for a material **undergo permanent deformation without rapture**. – Plasticity is portrayed by the **plastic zone**. ▪ **Toughness** – The **amount of energy that a material can absorb before rapture**. – Toughness is measured by the **area under the curve**.
▪ calculate and graph the bending stress and shear force of simply supported beams involving vertical point loads only	▪
▪ describe the effect of uniformly distributed loads on a simple beam, without calculations	▪
▪ apply mathematical and/or graphical methods to solve	▪

problems related to stress and strain	
▪ apply mathematical methods to solve problems related to materials used in civil structures	▪

3. **Engineering materials**	
Students learn about:	*Notes:*
▪ testing of materials – specialised testing of engineering materials and systems – X-ray	▪ The testing of materials often helps engineers attain a knowledge full of properties about these materials. ▪ They test for the hardness, stiffness, toughness, resistivity, its deformation and crack structure. ▪ There are two types of tests – Destructive tests: ▪ Involves the physical breaking of a material. ▪ Allows engineers to watch and analyse materials behaviour under load. – Non-destructive tests: ▪ Involves external device to scan and examine to fault and determine properties without the need to break or deform the material. ▪ Does not destroy the material, hence provides more efficiency to material. ▪ Tests in Civil Structure:

Test	Type	Use
X-ray	Non-Destructive	To determine if cavities are present
Dye Penetrant	Non-Destructive	To find small cracks in the surface by placing a dye on the surface, applying a developer and then examining the surface after cleaning.
Ultrasonic	Non-Destructive	Ultrasonic pulses are used to determine if cavities are present
Tensile	Destructive	Used to determine the tensile strength of materials used. Test piece is stretched and load extension are recorded

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<tr><td>Compressive</td><td>Destructive</td><td>Used to determine the compressive strength of materials used. Test pieces is compressed and load and deformation are recorded.</td></tr>
<tr><td>Transverse</td><td>Destructive</td><td>This test is used to determine a materials performance when undergoing bending and shear.</td></tr>
<tr><td>Torsion</td><td>Destructive</td><td>Torsion tests are done on materials to see how they will cope with twisting forces.</td></tr>
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testing of concrete
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Two main testing method for concrete

Slump test

A slump is done to determine the concrete's fluidity for casting. It measures the consistency of the concrete, in ratio with the mixture of water within the concrete.
Method
Concrete is filled inside a slump cone (cylindered mould). A rod is used to tap the cone and is removed, leaving a coned shape concrete exposed.
Results
If the concrete collapses, it means that it is too wet.
If the concrete cracks, breaks or crumbles down, it means that the concrete lack fluidity and is too dry.
If the concrete tilts and slumps, then its fluidity can be measured by placing the rod on the original height of the slump and measure the difference.

Compressive test

Since concrete is strong in compression, engineers will cast various specimens with concrete and be test after a period time interval.
The varies specimens are to be compressive test and any fail in the concrete will result in a faulty mixture.

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crack theory

crack formation and growth
failure due to cracking
repair and/or elimination of failure due to cracking

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Cracks are imperfections within a material and are created when the materials have splits.
Cracks tend to propagate and cause further cracks as well as larger cracks, which eventually causes the material to split and fail.

Crack Formation and growth

Formation

Cracks are mainly formed when an applied load is placed in a wrong and weak position. Other reasons can be the due to the incorrect procedures of manufacturing processes (forging, machining), the applying inappropriate heat that causes thermal expansion or simply corrosion.

Growth

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	– When a material is **placed under a concentrated load**, it will **release strain energy**, slowly causing a **crack as the bonds of resisting the load weakens**. With this **resilience decrease** and will **start to propagate** when it reaches **it critical crack length.** When the **cracks rapture and is unable to handle the load, it will fail and break, leaving the neighbours bond to withstand the load** (meaning that more stress is placed on that bond). The remaining bonds will fail as larger and larger load is applied to neighbouring bonds causing a **domino effect**. – **Failure Due To Cracking** ▪ Failure begins are the domino effects starts to take effect. The as the adjacent bonds take on more load and stress, they will fail over to the next which in turn fail to the point of failure. All the load is placed in the tip of crack. – **Failure due to cracking.** ▪ All this can be prevented, if the **applied load doesn't exceed the threshold**, and thus the **crack will halt.** ▪ **Critical Crack Length** – The length that would cause the growth of the crack – Brittle materials will have very short CCL. – Ductile will have long CCL.
▪ ceramics – structure/property relationships and their application to civil structures – glass – cement – bricks	▪ Ceramics are a type of material that consist of inorganic and non-metallic properties. ▪ Ceramics in general semi-metals and are brittle and hard. – Structure/property relationships and their application to civil structures ▪ – **Glass** ▪ Amorphous solid, meaning a non-crystalline material ▪ The viscous liquid material, makes the structural feature of glass transparent. ▪ Glass is low in toughness, hence it very brittle and weak in tension. ▪ Window glass is a mixture of silica [SiO2], soda [Na2o] and lime [CaO] ▪ Glass creation [refining and annealing] – Is created by a mixture of materials, then heated in a furnace until it is in a liquid state. – Then it is homogenised and refined [removal of bubbles]. – Glass is formed, by allowing air which allows air force to be inside the molten glass. – Annealing is finalised to remove the stress of glass. ▪ Glass brittle and prone to breaking on impact can be overcome by toughened glass. ▪ Toughened glass formation [tempering] – Is created by heating the glass pane then the outer surfaces are quickly cooled by blasts of cold air, leaving the surface cool and the interior hot.

	– As the interior cools, it contracts and places the exterior in compression. Which prevents from cracking. – Cement ▪ **Cement is NOT concrete** ▪ Cement is one of the constitution for concrete [ceramic]. Whereas concrete is a mixture of cement, water and aggregate [composites]. They are formed by complex reaction when alumina, soda and lime are reacted at high temperatures. ▪ Two types of cement – Hydraulic cement ▪ These types of cement will harden underwater. ▪ Common hydraulic cement is Portland cement ➔ Silicate gel. – Non-Hydraulic cement ▪ These types of cement will not harden underwater. ▪ They are hardened in other methods. ▪ Cement powder is a mixture of various materials. They can be formed into cement. ▪ Cement creation – Limestone and shale are both crushed, then mixed together. – The mixture is then placed in the kiln at an approximated temperature of 1500 C. – In the kiln, the mixture will form clinkers and are grounded. – Clinkers are then mixed with gypsum [around 5 %]. – They mixed and are constantly grounded and refine until it becomes cement powder. – Bricks ▪ Bricks are generally rectangular prism that are made from clay, but more commonly concrete. Bricks are first built in rectangular prism with clay, then fired in the kiln to create a permanent brick shape clay. Bricks have holes embedded for air to flow through.
▪ composites – timber – concrete (reinforced, pre- and post- tensioned) – asphalt paved surface – laminates – geotextiles	▪ **Composite materials are made from two or more constitutes of differing materials.** ▪ They are a combination of **Fibre and Matrix.** – Fibres is the material that **carries the load**. – Matrix is the material that **supports and protects the fibre** and corrosion and allows for transfer of load. ▪ Type of composites – **Timber** ▪ Timber are organic **(natural)** composite. They are lightweight and are used to achieve other composites like fibreglass and carbon fibre.

	Hardwood: Porous materials that have pores and vessel running through the structure and allow for nutrient to be carried Softwood: Non-porous material that have a neater, more uniform structure. ▪ Advantages of Timber – Have an excellent strength/weight ratio which can withstand heavy load with their lightweight properties. – Great performance in bending. ▪ Disadvantage of Timber – Weak in exposure outside. The weather that cause timber to rot and moist. – Also, pest like termites will attack and feed of timber. – **Concrete** (reinforced, pre- and post- tensioned) ▪ Concrete is made from **Three main constituents, water, aggregate** and **cement.** They are fireproof and does not corrode. However low in tension and strong in compression making them in toughness. **NOTE: Cement is not concrete.** ▪ **Reinforced concrete** – Steel and iron can be inserted as fibre to help improve the strength. Rods and steel mesh can be placed to counter the tensile load and make concrete resistant to failure. ▪ **Pre-stressed Concrete** – Pre-stressed concrete consist of placing **high tensile cables and rods into the reinforced concrete**. When the cables are removed, the concrete **beam is manipulated into compression**, allowing more expected load. **Two types of Prestressing: Pre-tensioned and Post-tensioned.** ▪ **Pre-tensioned** – **Concrete is cast around tendon which are already in tension. Once the concrete sets, the external tension from the steel tendon are removed placing the structure in compression.** ▪ **Post-tensioned** – **Concrete is cast normally into it is beams with hole where steel tendon rods can be placed. The steels rods are stretched by a hydraulic jack, placing the rod in compression and allowing this compressive force to be transferred to the beam. Once the rods are removed, the gaps are filled with mortar.** – **Asphalt paved surface** ▪ Asphalt **(tarmac)** is a high viscous fluid that is **extracted from crude oil**. ▪ Mainly used in **roads.** – Used for road paving because of its **toughness** and **crack resistant (bitumen**). Asphalt are **laid hot** and when cooled, the **bitumen solidifies** making them hard and resistive. Hence they have **less wear**, and **do not generate much noise**. – Laminates

	▪ Lamination is the process of materials being sandwich and stacked together to increases reliability. ▪ Laminated glass – Laminated glass is the formation to shatter-resistant glass. Layers of glass are compressed with a vinyl in between. They are heated to remove air bubbles and cooled to become prevent cracks. This increases strength and insinuates noise making. ▪ Plywood – Plywood consist of layers of wood that are arranged and compressed so that the grains are perpendicular to each other. This is done to overcome the timber's weakness. It increases the cracking power compared to one full value wood. Also, excellent noise insulator. ▪ Bimetallic strips – This is when two metal are laminated back to back. These two metal must have different thermal expansion rate for them to be effective. This is done so that when the metal heats up, it will deflect from its neutral position. Mainly used for thermostats and protects from circuit in gas systems. – **Geotextiles** ▪ Geotextile are **permeable woven polymers** that are extensively used in ground works for protection against contamination of soil. It will act as **surface stabiliser**, filtering and manipulating the movement of soil where **geotextile sheets are placed in layers to separate the road** and **protect rocks and soil**, **drain water** from them and reinforce rock and soil. Generally made of **polypropylene and polyester**.
▪ corrosion – corrosive environments – dry corrosion, wet corrosion, stress corrosion, galvanic corrosion	▪ **Corrosion is defined to be the chemical deterioration of the material over time.** ▪ Corrosion doesn't necessary affect metals, ceramic and polymer. – **Corrosive environments** ▪ **Oxidation** – Oxidation occurs when **metal loses electron** and happens at the **anode.** – Oxidation == loss ▪ **Reduction** – Reduction is the **consumption of electron** and occurs at the **cathode.** – Reduction is the opposite of oxidation. – Reduction == gain – Dry corrosion, Wet corrosion, Stress corrosion, Galvanic corrosion ▪ Dry corrosion – Dry corrosion occurs through the chemical reaction when metal reacts with oxygen in the air.

	– They are sensitive to temperature, and hence it reacts much faster under an application of heat. – An oxide layer form known as rust and forms on the surface of the material, causing damage. – Some materials are porous; hence corrosion will occur deep. This is known as active corrosion. ▪ Wet corrosion – Wet corrosion occurs when a metal is placed in a galvanic cell, electrolyte or fluid. – It is an electro-chemical reaction. ▪ Uniform Attack – When a metal is placed in electrolyte, some parts will become anodic and other cathodic. The location of the two will continuously change resulting in uniform corrosion. ▪ Galvanic Attack – Galvanic corrosion – Concentration cells – Stress cells ▪ **Protection from corrosion** – Corrosion in all metal is bound to occurs, though they will occur at different rates. Protection is necessary to prolong the use of metals. – **Cathodic Protection** ▪ The protected object is **made mainly of cathodes** and hence provide protection from corroding. – **Sacrificial anodes** ▪ **Highly active metals** (Zinc, Aluminium, Magnesium) are bolted onto the objects, creating a protection layer that acts as sacrificial plates blocking the **absorbing the corrosion and protecting the metal**. – **Coating** ▪ The metal is **painted with steel alloy (Stainless steel),** where a protective layer is applied to prevent corrosion. However, coating method can **scrapped off over time**, hence requiring **regularly maintenance**. – **Hot Dip Galvanising (Best Method)** ▪ The **metal is cleaned and dipped in molten zinc**, as **Zinc is the best protection from corrosion**. When done, the metal is coated with a layer of **zinc carbonate** that is extremely corrosion resistant.
▪ recyclability of materials	▪ **Steel** – B.O.F (basic oxygen furnace) – 25% recycled steel possible – E.A.F (electric arc furnace) – 100% recycled steel possible ▪ **Concrete**

	– Concrete can be recycled by crushing and breaking in smaller piece. This results in them being **weaker then it original state**, as they are commonly used for **rubble and cheap covering**. ▪ **Wood** – Woods is the **most recyclable** material as **woods scraps** can be used as **chips for garden mulch, playground covering** or made in wood composites for **cardboards, paper and reused furniture.** ▪ **Asphalt** – Asphalts are stones made from petroleum, and can be recycled by **crushing them and refining with other materials** to reproduce stronger asphalt. ▪ **Glass** – Glass can be **smashed and burned** in furnace to reproduce glass again.

Students learn to:	*Notes:*
▪ describe basic and specialized testing conducted on materials used in civil structures	▪
▪ examine the properties, uses and appropriateness of materials used in civil structures	▪
▪ examine how failure due to cracking can be repaired or eliminated	▪
▪ make appropriate choices of materials and processes for use in civil structures	▪
▪ investigate the relationship of structure to properties of materials and their use in civil structures	▪
▪ explain the special properties produced by composite materials	▪

▪ compare simple reinforced, pre-tensioned and post-tensioned structures	▪
▪ evaluate the significance of corrosion problems in civil structures	▪
▪ describe methods used to protect civil structures against corrosion	▪ **Hot Dip Galvanising** with Molten Zinc, as they will provide a protective layer of corrosion resistive property, or simply **coating** or **painting** steel alloy, to produce stainless steel.
▪ describe methods used for recycling materials when civil structures are replaced	▪

4. Communication	
Students learn about:	*Notes:*
▪ Australian Standard (AS 1100)	▪ AS 1100 is an Australian Standard for technical drawing, both for mechanical and architecture designs. ▪ These drawings will be universal around Australia, and ONLY Australia.
▪ orthogonal assembly dimensioned drawings	▪ In Buts and Bolts drawing, they are usually specified in the AS 1100. ▪ Example: **M10 x 1** – **Where M = Metric (mm)** – **10 = diameter of the thread (mm)** – **1 = pitch of thread (mm)**
▪ freehand pictorial drawings	▪ Drawing
▪ graphical mechanics – graphical solutions to engineering problems	▪ Drawing
▪ computer graphics	▪ Drawing

– Computer Aided Drawing (CAD) – applications for solving problems	
▪ collaborative work practices	▪ Drawing
▪ Engineering Report writing	▪ Drawing

Students learn to:	*Notes:*
▪ produce orthogonal assembly dimensioned drawings applying appropriate Australian Standard (AS 1100)	▪ **Australian Standard 1100** (AS 1100) are used for **Nut and Bolt Drawing.**
▪ produce freehand pictorial drawings	▪ Drawing
▪ apply graphical methods to the solutions of relevant problems	▪ Drawing
▪ describe and/or use software to solve problems	▪ Drawing
▪ work with others and identify the benefits of working as a team	▪ Drawing
▪ complete an Engineering Report based on the analysis and synthesis of an aspect of civil structures using appropriate computer software	▪ Drawing