Title:	**Material Science in Civil Engineering**
Level:	3
Credit value:	10
GLH	60
Unique Reference Number:	**J/651/0577**
Sector Subject Area:	**5.2 Building and Construction**
Aim:	The aim of this unit is to provide learners with the skills and knowledge to be able to calculate forces and loads on civil engineering structures and know how selected materials will perform under load.
Assessment Type:	Technical report, presentation and professional discussion
Assessment Guidance:	Assessment of this unit will be through the completion of a mandatory technical report drawing together key artefacts from each unit presented holistically, reflecting workplace requirements. Applying the skills and knowledge developed in this unit, learners will use materials science principles in the design and construction of a civil engineering asset. Learners will identify the relevant aspects of the completed assessment to include within the technical report to meet a set brief.

Learning outcomes *The learner will:*
1. Know about the properties of materials used in civil engineering.
Delivery content: The aim of this learning outcome is to provide the learners with the skills and knowledge of the properties of different materials used in construction and civil engineering projects. The learner must: • detail the **different materials** used in civil engineering. • detail the **key properties** of different materials used in civil engineering. • outline the **performance specification** of a range of materials.) • explain the **effects of temperature change** on materials.
2. Know how materials are processed or manufactured in civil engineering.

Delivery content: The aim of this learning outcome is to provide the learners with the skills and knowledge of how construction materials are processed or manufactured for use in civil engineering. The learner must: • explain how **materials are produced and/or manufactured** for use in construction. • describe the important features of materials and how they benefit the construction. • Explain how different construction materials can be combined to improve performance.
3. Know why construction materials fail in use and how such failures can be prevented.
Delivery content: The aim of this learning outcome is to provide the learners with the skills and knowledge of the causes of deterioration of a range of materials in civil engineering and how failure due to deterioration can be prevented. The learner must: • explain the **causes of deterioration** of materials in civil engineering. • outline how materials deteriorate in situ. • explain what **preventative measures** can be applied to extend the life of a range of materials.
4. Know how structural members react to forces.
Delivery content: The aim of this learning outcome is to provide the learners with the skills and knowledge to calculate the forces on structural members under loading conditions. Learners will apply this knowledge by calculating forces and assessing additional support requirements for a civil engineering structure to meet a given brief. The learner must: • define different **types of loads** experienced by structural members. • explain how **structural members** react under **loading conditions**. • summarise the effects of different loading conditions on a **range of materials**. • outline how to prevent failure of structural members when under load. • **calculate the forces** on civil engineering structure and assess where additional support is required to ensure stability.

Scope of Training	
The Scope of Training identifies areas that must be covered during the delivery of this unit. This is the minimum that is expected but tutors are expected to include other areas, knowledge of which will benefit their learners, based on location, types of work available and from the tutors own professional experience.	
Different materials	**Metals** Aluminium alloys Steel (galvanised, high strength, mild, stainless) **Masonry** Bricks: common, Engineering A and B, damp-proof course (DPC1 and DPC2) Concrete blocks: insulated, aerated, high density Concrete: mixes (design, prescribed, with additives, by ratio of weight/volume); smart concrete, screed concrete, hempcrete **Mortar** Mixes: cement, lime, cement lime, coloured **Sand** Sharp, building, silver **Glass** Glass finishes: tempered, laminated, clear, float, obscured, smart, structural **Timber** Hardwoods, softwoods **Engineered timber** Structural insulated panels, glulam beams, joists **Manufactured boards** Plywood, particle board, chip board, MDF (medium density fibre board) Plasterboard **Plastics** Damp-proof courses and membranes Door and window frames; soffits; facia; bargeboards; guttering; PVC/uPVC (Polyvinylchloride / unplasticised Polyvinylchloride) **Insulation materials** Fibreglass; mineral wool; expanded polystyrene, cellulose, straw, polyurethane **Roofing materials** Slate; concrete; felt; thatch; ridge; lead flashing; solar coverings; pantile; smart roofing materials

Key properties	Including, but not limited to: • Hardness • Toughness • Strength – bending, compressive, shear, tensile • Mass and density • Malleability • Stiffness • Workability • Fatigue and creep • Fire resistance • Absorption • Electrical conductivity and conductance • Thermal conductivity and conductance • Resistance to moisture penetration • Resistance to vapour penetration • Resistance to degradation • Embedded energy • Recycling potential.
Performance specification	Operational requirements How properties impact on performance Materials used for different situations How materials cope with exposure to the elements Specification should include elements of strength, durability, water absorption, weight and resistance to external influences.
Effects of temperature change	Transfer of heat: conduction, convection, radiation. Heat types: latent (amount of energy absorbed/released during a phase transition at constant temperature); sensible (energy required to change the temperature of a substance with no phase change) Expansion and contraction Evaporation Changes in material state
Materials – (how they are) **produced and/or manufactured**	Steels: galvanised, mild, stainless Aluminium alloys Bricks: facing and engineering Cement: ordinary, sulphate-resisting Concrete: with/without additives, hempcrete, microcement, polished concrete Glass: tempered, float, laminated, smart, structural Manufacturing technologies: • CNC (computer numerical control) machining / manufacturing of structural elements • 3D printing • Use of robotics to perform routine and repetitive tasks in construction off site (in factory) and on-site.
Combined to improve performance	Define ‘composite’ Categories of composite materials: • Polymer matrix composites (PMCs) • Metal matrix composites (MMCs) • Ceramic matrix composites (CMCs) • Carbon matrix composites (CAMCs) 5 Basic types of composite materials used in construction: • Reinforced concrete and masonry • Composite wood, e.g., plywood

	• Reinforced plastics, e.g., fibre-reinforced polymer or fibreglass • Ceramic matrix composites, e.g., composite ceramic and metal matrices • Metal matrix composites Advantages and disadvantages of each type.
Causes of deterioration	Inadequate design or construction Operational accidents Aggressive elements: weathering, humidity, freeze-thaw conditions, thermal ageing, wind loading, snow loading Metal corrosion Timber issues: decay (wet/dry rot, lichens, mosses); infestation (fungal, insects) Chemical: acid rain; leaching; effects of sulphates and alkalis Moisture: capillary action; shrinkage Loading Fire Fatigue / aging processes Any combination of the above
Preventative measures	Advantages and disadvantages of using: • Protective coatings • Paints
Types of loads	Point and distributed loads Dead and live loads Imposed and wind loads Internal / external
Structural members	Columns, walls and frames Beams and lintels Struts and ties
Loading conditions	Compression Tension Bending moments Shear forces
Range of materials	Reinforced concrete Timber Steel
Calculate the forces	Columns Beams / girders Floors / walls / roofs To meet a given civil engineering brief.

Mapping to Civil Engineering Technician Standard ST0091

Learning Outcome	Knowledge Statements	Skills Statements	Behaviour Statements
1. Know about the properties of materials used in civil engineering.	K1		
2. Know how materials are processed or manufactured in civil engineering.	K1		
3. Know why construction materials fail in use and how such failures can be prevented.	K1		
4. Know how structural members react to forces.	K1, K3, K6	S1, S2	B3

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