### Subject Description Form

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>BRE212</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject Title</td>
<td>Construction Materials</td>
</tr>
<tr>
<td>Credit Value</td>
<td>3</td>
</tr>
<tr>
<td>Level</td>
<td>2</td>
</tr>
<tr>
<td>Pre-requisite / Co-requisite / Exclusion</td>
<td>Nil / Nil / Nil</td>
</tr>
</tbody>
</table>
| Objectives | 1. Enable students to be conversant with the properties and behaviour of some common materials of building construction.  
2. Develop the ability to test and select materials for such construction. |

### Intended Learning Outcomes

Upon completion of the subject, students will be able to:

1. Understand and identify the properties of common construction materials (steel, concrete, plastic and timber) and theoretical modeling of their behaviour under different environments, short- or long-term (i.e. instantaneous as well as time-dependent).
2. Appreciate and interpret results of different destructive or non-destructive material tests based on mechanical, thermal, acoustic, electromagnetic (dielectric) material properties.
3. Apply statistical quality control techniques for steel and concrete.
4. Select appropriate materials for building construction with the use of Ashby materials selection Charts.
5. Understand Environmental performance and common agents of deterioration of materials.

### Subject Synopsis/Indicative Syllabus

**Fundamental Material Science**

- Atomic, molecular and solid structures, phases, types of bonding and their effects on properties of elements and materials,

- Modeling behavior of materials (instantaneous as well as time-dependent) by appropriate combination of springs (elastic) and dash pots (plastic flow)

**Metal (in particular Iron and steels):**

- Structure of metals: metallic bonding, crystallography (crystal structures and geometry).

- Alloys (solid solutions and intermediate compounds), Iron-carbon phase equilibrium diagrams, effects of carbon content on mechanical properties of steel, heat treatments of steels, time-temperature-transformation or TTT diagrams.

- Deformation mechanism of metals: Elastic deformation, plastic flow, ideal strength, mechanisms of slip, origin of dislocations.

- Behaviour in Service: strength and stiffness, brittle and ductile behavior, fracture, creep, fatigue, corrosion and its prevention.

- Mechanical Testing (tensile test, hardness test, impact test, fatigue test, creep test).
**Concrete:**

Constituent materials:

- Cements – chemical composition, fineness, hydration (rate and heat of hydration), setting and hardening, microstructure of cement gel matrix. Types.
- Aggregates – physical properties, shapes and surface textures, grading. Types.
- Admixtures – types.

Influence of constituent materials

- preparation, curing, elastic and plastic behaviour, creep, durability, weathering, chemical attack (carbonation and sulphate attack), alkali–aggregate reaction, volume changes, permeability and absorption, shrinkage.

Concrete mix design

- Mix to satisfy required concrete properties: durability, strength, workability.

Statistical quality control

- Shewhart charts and Cumulative sum quality control charts.

Properties of fresh concrete

- workability and factors affecting workability.

Properties of hardened concrete

- strength and factors affecting strength.

**Timber**

- microstructure of wood, mechanical properties, structural or stress grading and effects of moisture contents, use as Douglas fir timber as formwork and falsework.

**Plastics**

- microstructure of common polymers: molecular structure, polymerization, basic mechanical properties and their use in pipes and window frames, structural adhesives and GFRP

**Selection of Materials**

*Ashby* materials selection charts

**Environmental performance and deterioration of materials:**

- UV (on plastics), corrosion of metals (electrochemistry)
• Mechanical testing of metals (Tensile test, hardness test, impact test, fatigue test, creep test).
• Concrete mix design.
• Destructive (cube compression tests) and Non-destructive testing of hardened concrete.

### Teaching/Learning Methodology

- Lectures will be provided on basic theories and knowledge of construction materials (to be interactively with discussion and Q & A).
- Tutorials will be conducted mainly in the form of example classes and problem-solving sessions to enhance students’ understanding of the subject matters on a range of important topics (such as crystallography, statistical quality control techniques, use of Ashby Charts etc.).
- Laboratory and demonstration classes provide opportunities for witnessing the testing of a range of different construction materials in particular: destructive and non-destructive testing of hardened concrete, metals, plastics, timber (to be performed mainly at the Building Technology Laboratory of BRE or classroom).
- Investigative group project allow deeper learning and group interaction.
- Viva and presentation provide an opportunity of assessment and peer learning.

### Assessment Methods in Alignment with Intended Learning Outcomes

70% examination + 30% coursework. The coursework component will consist of a combination of tutorial problems-set, investigative group project report, in-class test and Viva/presentation.

<table>
<thead>
<tr>
<th>Specific assessment methods/tasks</th>
<th>% weighting</th>
<th>Intended subject learning outcomes to be assessed (Please tick as appropriate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Examination</td>
<td>70%</td>
<td>√ a √ b √ c √ d √ e</td>
</tr>
<tr>
<td>Tutorial class assignments/</td>
<td>10%</td>
<td>√ a √ b √ c √ d √ e</td>
</tr>
<tr>
<td>In-class test or quizzes</td>
<td>5%</td>
<td>√ a √ b √ c √ d √ e</td>
</tr>
<tr>
<td>Investigative group project report</td>
<td>5%</td>
<td>√ a √ b √ c √ d √ e</td>
</tr>
<tr>
<td>Viva and presentation</td>
<td>5%</td>
<td>√ a √ b √ c √ d √ e</td>
</tr>
<tr>
<td>individual reflective Journal on the group project</td>
<td>5%</td>
<td>√ a √ b √ c √ d √ e</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

*The subject will be graded between F to A+.

Explanation of the appropriateness of the assessment methods in assessing the intended learning outcomes:

### Student Study

Class contact:
### Effort Expected

<table>
<thead>
<tr>
<th>Activity</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lectures</td>
<td>21 Hrs.</td>
</tr>
<tr>
<td>Tutorial</td>
<td>10.5 Hrs.</td>
</tr>
<tr>
<td>Laboratory and demonstration classes</td>
<td>4.5 Hrs.</td>
</tr>
<tr>
<td>Viva</td>
<td>6 Hrs.</td>
</tr>
</tbody>
</table>

Other student study effort:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand-on Laboratory investigation on a chosen topic</td>
<td>3 Hrs.</td>
</tr>
<tr>
<td>Investigative group project</td>
<td>35 Hrs.</td>
</tr>
<tr>
<td>Self-study and reading and finishing assignment</td>
<td>40 Hrs.</td>
</tr>
</tbody>
</table>

Total student study effort: 120 Hrs.

### Reading List and References


Ashby Michael “Materials Selection in Mechanical Design” ([http://mielsvr1.eecs.umass.edu/mie497a/Ashby%20Materials%20Selection%20Charts.PDF](http://mielsvr1.eecs.umass.edu/mie497a/Ashby%20Materials%20Selection%20Charts.PDF))


Non-destructive Testing (NDT) Techniques:

HKCI: TM1 ‘Test Method for Detection of Building Surface Defect by Infrared thermography’. Published by the Hong Kong Institute of Concrete (HKCI), May 2009. (Inspection copy available at CARE)

HKCI: TM2 ‘Test Method for Determination of Concrete Cover and Distribution of Steel rebar by Surface Penetration Radar’. Published by the Hong Kong Institute of Concrete (HKCI), May 2009. (Inspection copy available at CARE).

HKCI: TM3 ‘Test Method for Ultrasonic earth Echo Sounding of drilled foundation”. Published by the Hong Kong Institute of Concrete (HKCI), May 2009. (Inspection copy available at CARE).


Trade Catalogue of Equipment (Mostly available on the internet of the Manufacturer’s web-site).

ACI 546R-04 - Concrete Repair Guide, Published by the American Concrete Institute.


Published papers on Non-destructive Testing (NDT) Techniques and FRP:


LAI W.L., KOU S.C., POON C.S., TSANG W.F., NG S.P., HUNG Y.Y. "Characterization of Flaws Embedded in Externally Bonded CFRP on Concrete Beams by..."


LAI, W. L, TSANG, W. F. "Experimental Evaluation of Honeycombed Concrete by Surface Penetrating Radar". The ASNT Fall Conference and Exhibition, Columbus, Ohio, USA, October 17-21, 2005 , pp.435-438 (2005)

LAI, W. L., TSANG, W. F. "Characterization of Soil Texture by Dielectric Constant using Ground Penetrating Radar and Cyclic Variation of Moisture Content of Soils". The SEG International Exposition and Seventy-Fifth Annual Meeting, the George R. Brown Convention Center, Houston, Texas, USA, 6-11 November 2005, pp.1192-1195 (2005)


