Subject Description Form

Subject Code	BRE212
Subject Title	Construction Materials
Credit Value	3
Level	2
Pre-requisite / **Co-requisite/** **Exclusion**	Nil/ Nil/ Nil
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: a) 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). b) Appreciate and interpret results of different destructive or non-destructive material tests based on mechanical, thermal, acoustic, electromagnetic (dielectric) material properties. c) Apply statistical quality control techniques for steel and concrete. d) Select appropriate materials for building construction with the use of Ashby materials selection Charts. e) 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)

Laboratory:

<table>
<tr><td></td><td>

- 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.

</td></tr>
<tr><td>Teaching/Learning Methodology</td><td>

- 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.

</td></tr>
<tr><td>Assessment Methods in Alignment with Intended Learning Outcomes</td><td>

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>
<tr><td rowspan="2">Specific assessment methods/tasks</td><td rowspan="2">% weighting</td><td colspan="6">Intended subject learning outcomes to be assessed (Please tick as appropriate)</td></tr>
<tr><td>a</td><td>b</td><td>c</td><td>d</td><td>e</td><td></td></tr>
<tr><td>Examination</td><td>70%</td><td>√</td><td>√</td><td>√</td><td>√</td><td>√</td><td></td></tr>
<tr><td>Tutorial class assignments/</td><td>10%</td><td>√</td><td>√</td><td>√</td><td>√</td><td>√</td><td></td></tr>
<tr><td>In-class test or quizzes</td><td>5%</td><td>√</td><td>√</td><td>√</td><td>√</td><td>√</td><td></td></tr>
<tr><td>Investigative group project report</td><td>5%</td><td>√</td><td>√</td><td>√</td><td>√</td><td>√</td><td></td></tr>
<tr><td>Viva and presentation</td><td>5%</td><td>√</td><td>√</td><td>√</td><td>√</td><td>√</td><td></td></tr>
<tr><td>individual reflective Journal on the group project</td><td>5%</td><td>√</td><td>√</td><td>√</td><td>√</td><td>√</td><td></td></tr>
<tr><td>Total</td><td>100%</td><td colspan="6"></td></tr>
</table>

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

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

</td></tr>
<tr><td>Student Study</td><td>Class contact:</td><td></td></tr>
</table>

Effort Expected	▪ Lectures	21 Hrs.
	▪ Tutorial	10.5 Hrs.
	▪ Laboratory and demonstration classes	4.5 Hrs.
	▪ Viva	6 Hrs.
	Other student study effort:	
	▪ Hand-on Laboratory investigation on a chosen topic	3 Hrs.
	▪ Investigative group project	35 Hrs.
	▪ Self-study and reading and finishing assignment	40 Hrs.
	Total student study effort	120 Hrs.
Reading List and References	Smith W.F., *Principles of Materials Science and Engineering*, 3rd Edition, McGraw-Hill, 1996. Smith R.C. Materials of construction, McGraw-Hill, 1988. Callister W.D., Jr., *Materials Science and Engineering: An Introduction*, 4th Edition, John Wiley & Sons, 1997. Jackson N. and Dhir R.K. (editors), *Civil Engineering Materials*, 5th Edition, MacMillan Education, 1997, ISBN 0-333-63683-X.. Neville A.M., *Properties of Concrete*, 4th and Final Edition, Pearson Education Ltd., Paperback (July 25, 1996) ISBN 0-582-23070-5.. A.M., Brooks J.J. Concrete Technology (Paperback), Reprinted 2008, Pearson Education Ltd ISBN 978-0-582-98859-0. Taylor G.D., *Materials in Construction-An Introduction, 3rd Edition,* 2000, Pearson Education Ltd ISBN 978-0-582-36889-7 Taylor G.D., **Materials in Construction: Principles, Practice and Performance (Chartered Institute of Building), 2002,** Pearson Education Ltd ISBN 978-0-582-36934-4 (Previously published as Taylor G.D., *Construction Materials*, Longman Scientific & Technical, 1991). Higgins R.A. (1987) Properties of Engineering Materials, 2nd Edition, Industrial Press Inc. New York. ISBN 0-8311-3055-5. **Ashby Michael "Materials Selection in Mechanical Design"** (http://mielsvr1.ecs.umass.edu/mie497a/Ashby%20Materials%20Selection%20Charts.PDF) Construction Standard CS1: 1990 Testing Concrete Volume 1 and 2 published by CEDD of the Hong Kong Government. (http://www.cedd.gov.hk/eng/publications/standards_handbooks/stan_cs1.htm) Construction Standard CS2:1995 Carbon Steel Bars for the Reinforcement of Concrete published by CEDD of the Hong Kong Government.

(http://www.cedd.gov.hk/eng/publications/standards_handbooks/stan_cs2.htm)

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).

Guide Book on Non-destructive Testing of Concrete Structures, Published by IAEA, Vienna, 2002, IAEA-TCS-17, ISBN-1018-6518.

Malhotra V. Mohan and Carino Nicholas J. Handbook of Non-destructive Testing of Concrete, CRC Press 2004, Print ISBN: 978-0-8493-1485-8, eBook ISBN: 978-1-4200-4005-0

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.

ACI - Concrete Repair Manual Volume 1 and 2- 3rd Edition, Published by American Concrete Institute, ISBN:13-978-0-87031-262-5**.**. (Inspection copy available at CARE).

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

LAI W.L., KOU S.C., POON C.S., TSANG W.F., LAI C.C. *"Effects of elevated water temperatures on interfacial delaminations, failure modes and shear strength in externally-bonded CFRP-concrete beams using infrared thermography, gray-scale images and direct shear test".* CONSTRUCTION AND BUILDING MATERIALS, Vol. 23, No. 10, pp.3152-3160 (October 2009)
http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V2G-4WTRWJY-1&_user=217827&_origUdi=B6TWF)

LAI W.L., KOU S.C., POON C.S., TSANG W.F., LAI C.C *"Characterization of the deterioration of externally bonded CFRP-concrete composites using quantitative infrared thermography".* CEMENT AND CONCRETE COMPOSITES, pp.999-9999 (2010) (http://www.sciencedirect.com/science?_ob=MImg&_imagekey=B6TWF-4YPPPYB-1-R&_cdi=5561&_user=217827&_pi) (27 March 2010)

LAI W.L., KOU S.C., TSANG W.F., POON C.S. *"Characterization of concrete properties from dielectric properties using ground penetrating radar"*. CEMENT AND CONCRETE RESEARCH, Vol. 39, No. 8, pp.687-695 (2009)
(http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6TWG-4WFPPJR-2&_user=107833&_rdoc=1&_fmt=&)

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*

Infrared Thermography and Shearography". Journal of Nondestructive Evaluation, Vol. Volume 28, No. Issue1 , pp.Page 27-35 ((2009)

TSANG, Steven Wai Fan *"Structural Integrity Assessment of Building Components Having Been Exposed to Fire Using Modal Forced Vibration Testing"*. In Brian S. Neale, ed., Fourth International Conference on Forensic Engineering, London , 2-4 December 2008., Thomas Telford Ltd, UK (07/01/2009) (http://www.thomastelford.com/books/bookshop_main.asp?ISBN=9780727736130) (ISBN: 9780727736130)

TSANG, Steven Wai Fan *"Correct Determination of Dielectrics of Soils as A Precursor For Correct Ranging of Buried Utilities"*. First International Conference on Utility and Safety ICUMAS 2009, Hong Kong, 1-4 March 2009, HK Utility Research Center, Hong Kong (2009) (http://www.cast.org.cn/n435777/n435792/n435854/n435951/appendix/200852310248.pdf)

LAI W L, TSANG W F *"Characterization of pore systems of air/water-cured concrete using ground penetrating radar (GPR) through continuous water injection)"*. Construction and Building Materials, Vol. March 2008 (2008) (http://www.highbeam.com/doc/1G1-175109513.html)

LAI W L, TSANG W F *"Characterization of pore systems of air/water-cured concrete using ground penetrating radar (GPR) through continuous water injection)"*. Construction and Building Materials, Vol. March 2008 (2008) (http://www.highbeam.com/doc/1G1-175109513.html)

POON C.S., KOU S.C., TENG J.G., LAI W.L., TSANG W.F., LAI C.C. *"Quantitative study on bond behavior between fiber-reinforced polymer (FRP) and concrete interface using Infra-Red Thermography (IRT)"*. The First Asia-Pacific Conference on FRP in Structures, Hong Kong, December 2007, pp.717-722 (2007)

POON, C.S., KOU, S.C., TENG, J.G., LAI, W.L., TSANG, W.F., LAI, C.C. *"Quantitative Study on Bond Behavior between Fiber-reinforced Polymer (FRP) and Concrete Interface Using Infra-red Thermography (IRT)"*. The First Asia-Pacific Conference on FRP in Structures, HK, December 2007 (2007)

CHAN, F.W.Y., TSANG, S.W.F. *"Quality Assurance of Concrete Foundation Elements using an Ultrasonic Evaluation Technique"*. Insight, Vol. 48, No. 6, pp.360-367 (2006)
HO, S. L., TSANG, W.F., LEE, K.K., LEE, K.Y., LAI, W.L., TAM, H.Y., HO, T.K. *"Monitoring of the Vertical Movement of Rail Sleepers with the Passage of Trains"*. International Conference on Railway Condition Monitoring, Birmingham, UK,, 29 - 30 November 2006 (2006)

LAI W. L., TSANG W. F., FANG H., XIAO D. *"Experimental determination of bulk dielectric properties and porosity of porous asphalt and soils using GPR and a cyclic moisture variation technique"*. Geophysics, Vol. 71, No. 4, pp.K93-K102 (July-August 2006)

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)

	CHAN, FIONA W Y, TSANG, STEVEN W F *"Effects of Different Sonic Access Tube Materials on the Signal Strength of Ultrasonic Waves in the Cross-hole Sonic Logging Technique"*. HKIE Transactions, Vol. 12, No. 2, pp.1-7 (2005) TSANG W.F., CHAN F.W.Y *"Earth Echo Sounding Technique for Quality Control of Drilled Shaft Foundations"***.** INSIGHT Journal of the British Institute of Non-Destructive Testing (BINDT), Vol. 46, No. 1, pp.17-22 (January 2004) TSANG W.F., LAI W.L., CHAN W.Y. *"A Preliminary Study of Data Fusion Techniques (DFTs) on Evaluation of Defective Concrete by Pulsed Radar and Ultrasonic Systems"***.** Conference Proceedings of the British Institute of Non-Destructive Testing, NDT, UK, (2003) TSANG W.F., CHU Y.L. *"Structural Integrity Assessment of Reinforced Concrete Balcony by Instrumented Impact Hammer Technique"*. Conference Proceedings of the British Institute of Non-Destructive Testing, NDT, UK, (2003) TSANG W.F., CHAN F.W.Y. *"The Application of an In-house Multiple Referencing System (MRS) for Evaluation of Foundation Concrete Elements"*. Conference Proceedings of the British Institute of Non-Destructive Testing, NDT, UK, (2003)