

Subject Description Form

Subject Code	BRE450
Subject Title	Building Maintenance for Sustainability
Credit Value	3
Level	4
Pre-requisite / Co-requisite/ Exclusion	BRE212 (preferably) or BRE391 or equivalent/ Nil/ BRE326
Objectives	<ol style="list-style-type: none"> 1. equip students with the practical knowledge and skills in their future roles as building construction and maintenance professionals 2. provide students an understanding and appreciation of sustainable construction/building 3. provide students an understanding that sustainability can be achieved by not only constructing sustainable new buildings but also by effective maintenance and repair of existing buildings (i.e. by prolonging their service life through upholding/enhancing their integrity, safety, durability and hygiene). (This subject focuses on the aspects of building structures/elements/fabrics/materials and not building services systems that are installed inside.) 4. provide students an understanding that building energy-wise sustainability can be enhanced through appropriate retrofitting
Intended Learning Outcomes	<p>Upon completion of the subject, students will be able to:</p> <p>Part A (Dr. Steven Tsang)</p> <ol style="list-style-type: none"> a) understand that CM acts as a precursor for effective maintenance and repair b) Understand that RT and ST are effective repairs/remedies to building defects c) Understand the fundamental physical principles of and conduct advanced Condition Monitoring (CM), Rehabilitation Techniques (RT) and Strengthening Techniques (ST) on buildings and their fabrics (typical high-rise RC buildings) d) Acquire the practical skills in undertaking measurement, acquiring data in the aspects of building integrity, safety and energy performance (with occasional specialist technical support in the cases of some very sophisticated equipment) as well as in the applications of RT and ST e) conduct building pathology and defect diagnostics by interpreting appropriately data/charts/visual images obtained by the equipment with due regards paid to the strength, weakness and limitations of each technique f) enhance a building's energy-wise sustainability through retrofitting of advanced glass or films technologies as well as low-energy consuming lighting <p>Part B (by another member of the teaching team or invited speakers)</p> <ol style="list-style-type: none"> g) understand fundamental principles and various attributes of sustainability of the built environment in balancing economic, environmental and social objectives

	<p>h) understand current legislations, regulations, assessment schemes relating to building sustainability in the aspects of repair and maintenance</p> <p>i) make informed selection of construction materials with the awareness of embodied energy and carbon contents of construction materials</p>
<p>Subject Synopsis/ Indicative Syllabus</p>	<p>Need of sustainability in global and local context - issues and impacts on environmental, economic and social sectors, Kyoto Protocol.</p> <p>Principle of construction sustainability: concepts and principles, roles and responsibilities of building professionals.</p> <p>Strategy for sustainable construction:</p> <ul style="list-style-type: none"> • active measures: <ul style="list-style-type: none"> ○ design /construction stages: green building / materials, HKBEAM, BREEAM, LEED, BHHI ○ building in use : importance of building maintenance • passive measures: <ul style="list-style-type: none"> ○ legislations and regulations (e.g. on thermal, ventilation, electricity, etc.) ○ energy auditing and life cycle assessment ○ inspection for regular maintenance <p>Building maintenance for sustainability:</p> <ul style="list-style-type: none"> • choices of building materials - application, re-use and recycling; embodied energy and carbon contents of construction materials • rehabilitation • condition appraisal, building inspection - Mandatory Building Inspection Scheme in Hong Kong • different building defects diagnostic techniques and their applications and subsequent remedial maintenance work <p>Retrofitting using advanced materials and technologies:</p> <ul style="list-style-type: none"> • use advanced glazing (glass technologies) and solar-energy-reducing films • use advanced energy-reducing lighting • use repair/replacement materials with appropriate balance regarding embodied energy and carbon contents
<p>Teaching/Learning Methodology</p>	<p>The subject covers theoretical, conceptual, statutory as well as practical issues in building maintenance for sustainability. Much of these will be taught in lectures and reinforced in tutorials and seminars. Laboratory classes and practical tests will cover the experimental and practical aspects.</p> <ul style="list-style-type: none"> • Interactive lecture • A series of laboratory demonstrations • practical and workshop (guided) • hands-on experience as reinforcement of knowledge by undertaking Group Projects • Peer learning from other Groups during project Viva and presentation

Assessment Methods in Alignment with Intended Learning Outcomes	Assessed 100% by coursework and no written examination.	
	Part A:	
	Specific assessment methods/tasks	% weighting
	Intended subject learning outcomes to be assessed (Please tick as appropriate)	
	a	b
	c	d
	e	f
	Group Project Report	40%
	Viva	20%
individual reflective Journal on the group project	10%	
Total	70%	
(Each Group is expected to perform in the respective Group Projects on either 2 of the 3 areas of CM, RT, ST)		
Part B:		
Specific assessment methods/tasks	% weighting	
Intended subject learning outcomes to be assessed (Please tick as appropriate)		
g	h	
i		
class assignments/ class tests or quizzes	10%	
Seminar Paper/essay	20%	
Total	30%	
Explanation of the appropriateness of the assessment methods in assessing the intended learning outcomes:		
Student Study Effort Expected	Class contact:	
	▪ Lecture	
	▪ TU/LAB/ FIELD TEST	
	▪ Viva and Presentation	
	Other student study effort:	
	▪ Practical work	
	▪ Self Study and reading	
Total student study effort		
	21 Hrs.	
	10.5/ 4.5 /3.0 Hrs.	
	3 Hrs.	
	38 Hrs.	
	40 Hrs.	
	120 Hrs.	

**Reading List and
References**

Sustainability of Construction:

CIB (1998), Sustainable development and the future of construction, *CIB report publication* 225, United States of America.

Claude-Alain Roulet, Flourentzos Flourentzou, Flavio Foradini, Philomena Bluysen, Chrit Cox, Claire Aizlewood (2006), Multicriteria analysis of health, comfort and energy efficiency in buildings, *Building Research & Information*, Volume 34, Issue 5 September 2006, pages 475 – 482.

Hill, R.C. and Bowen, P.A. (1997). Sustainable construction: principles and a framework for attainment, *Construction Management and Economics*, 1997(15), pp. 223-239.

Raymond J. Cole, Shared markets: coexisting building environmental assessment methods, *Building Research & Information*, Volume 34, Issue 4 July 2006, pages 357 – 371.

Shen, L. Y., Lu, W. S., Yao, H., and Wu, D. H. (2005b). ‘An IT supported scoring method for measuring the environmental performance of construction activities’, *Automation in Construction*, AIC Special Issue, 14 (2005), pp. 297-309.

Sjostrom, C. and Bakens, W. (1999). Sustainable construction: Why, how, and what, *Building Research & Information*, Vol. 27(6), pp. 347-353.

W.L. Lee, J. Burnett (2008), Benchmarking energy use assessment of HK-BEAM, BREEAM and LEED, *Building and Environment*, Volume 43, Issue 11, November 2008, Pages 1882-1891.

Warren L. Paul, Peter A. Taylor (2008), A comparison of occupant comfort and satisfaction between a green building and a conventional building, *Building and Environment*, Pages 1858-1870.

WCED (World Commission on Environment and Development), (1987). *Our common future*, Oxford University Press, 1-23.

MOC (1999). *A guide to sustainable development construction in China*, Ministry of Construction, 27-30.

Sustainability of materials: Tables of Embodied Energy and Embodied Carbon Dioxide (ECO²).

Cole, R.J. and Kernan, P.C. (1996), Life-Cycle Energy Use in Office Buildings, *Building and Environment*, Vol. 31, No. 4, pp. 307-317.

Comparing the Environmental Effects of Building Systems, Wood the Renewable Resource Case Study No.4, Canadian Wood Council, Ottawa, 1997.

The ECO₂ figures for GEN 1, RC32/40 and RC40/50 were derived using industry agreed representative figures for cementitious materials, aggregates, reinforcement, admixtures and an appropriate figure for water.

BRE Environmental Profiles database, Building Research Establishment (BRE), 2006

Building Diagnostic or 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).

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 website).

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 Building Diagnostic or Non-destructive Testing (NDT) Techniques:

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)

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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)

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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>)

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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)

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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)

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