Subject Description Form

Subject Code	BRE450
Subject Title	Building Maintenance for Sustainability
Credit Value	3
Level	4
Pre-requisite	BRE261 & BRE361 or equivalent
Objectives	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.); and 4. provide students an understanding that building energy-wise sustainability can be enhanced through appropriate retrofitting.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: Part A Sustainability a) understand fundamental principles and various attributes of sustainability of the built environment in balancing economic, environmental and social objectives b) understand current legislations, regulations, assessment schemes relating to building sustainability in the aspects of repair and maintenance c) make informed selection of construction materials with the awareness of embodied energy and carbon contents of construction materials d) enhance a building's energy-wise sustainability through retrofitting of advanced glass or films technologies as well as low-energy consuming lighting Part B Building Maintenance e) understand that Condition Monitoring (CM) acts as a precursor for effective maintenance and repair f) 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) g) 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 h) 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
Subject Synopsis/ Indicative Syllabus	**Need of sustainability** in global and local context - issues and impacts on environmental, economic and social sectors, Kyoto Protocol. **Principle of construction sustainability**: concepts and principles, roles and responsibilities of building professionals.

Strategy for sustainable construction:

- active measures:
  - design /construction stages: green building / materials, HKBEAM, BREEAM, LEED, BHHI
  - building in use: importance of building maintenance
- passive measures:
  - legislations and regulations (e.g. on thermal, ventilation, electricity, etc.);
  - energy auditing and life cycle assessment;
  - inspection for regular maintenance

Building maintenance for sustainability:

- choices of building materials - application, re-use and recycling; embodied energy and carbon contents of construction materials;
- rehabilitation and strengthening techniques;
- condition appraisal, building inspection - Mandatory Building Inspection Scheme in Hong Kong;
- different building defects diagnostic techniques and their applications and subsequent remedial maintenance work;
- maintenance management using Building Information Modeling.

Retrofitting using advanced materials and technologies:

- 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.

Teaching/Learning Methodology

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.

Interactive lecture

- 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 I:

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed (Please tick as appropriate)					
		a	b	c	d		
Group Project Report	40%	√	√	√	√		
Viva	10%	√	√	√	√		
individual reflective Journal on the group project	20%	√	√	√	√		
Total	70%						

Part II:

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed (Please tick as appropriate)					
		b	c	d	e	g	h
Class assignment/ Class Tests/ Essay/	30%	√	√	√	√	√	√
Total	30%						

Student Study Effort Expected	Class contact:	
	▪ Lecture	26 Hrs.
	▪ TU/LAB/ FIELD TEST	12 Hrs.
	▪ Viva and Presentation	2 Hrs.
	Other student study effort:	
	▪ Practical work	40 Hrs.
	▪ Self Study and reading	40 Hrs.
	Total student study effort	120 Hrs.

Reading List and References

Sustainability of Construction:

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

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

Diesendorf, M. (2000). "Sustainability and sustainable development." *Sustainability: The corporate challenge of the 21st century*, 2, 19-37.

Cole, R.J. (2006). "Shared markets: coexisting building environmental assessment methods", *Building Research & Information*, 34(4), 357-371.

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

Omer, A. M. (2008). "Energy, environment and sustainable development." *Renewable and Sustainable Energy Reviews*, 12(9), 2265-2300.

Warren L. P., Taylor, P.A. (2008). "A comparison of occupant comfort and satisfaction between a green building and a conventional building", *Building and Environment*, 43(11), 1858-1870.

Li, B., and Yao, R. (2015). "Delivering sustainable built environments by an integrated approach." *Renewable Energy*, 73, 1-2.

Sing, M.C.P., Chan, H.C., Love, P.E.D., and Leung, A.Y.T. (2015). "Building Maintenance and Repair: Determining the Workforce Demand and Supply for a Mandatory Building-Inspection Scheme." *ASCE Journal of Performance of Constructed Facilities*, 04015014.

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

Hammond, G. P., and Jones, C. I. (2008). "Embodied energy and carbon in construction materials", *Proceedings of the Institution of Civil Engineers-Energy*, *161*(2), 87-98.

DEFRA(2008). "Development of an embedded carbon emissions indicator", Department for Environment, Food and Rural Affairs.

Monahan, J., and Powell, J. C. (2011). "An embodied carbon and energy analysis of modern methods of construction in housing: A case study using a lifecycle assessment framework", *Energy and Buildings*, *43*(1), 179-188.

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

McCann, D., and Forde, M. (2001). "Review of NDT methods in the assessment of concrete and masonry structures." *NDT & E International*, 34(2), 71-84.

Broomfield, J. P., Davies, K., and Hladky, K. (2002). "The use of permanent corrosion monitoring in new and existing reinforced concrete structures." *Cement and Concrete Composites*, 24(1), 27-34.

Maierhofer, C., Arndt, R., Röllig, M., Rieck, C., Walther, A., Scheel, H., and Hillemeier, B. (2006). "Application of impulse-thermography for non-destructive assessment of concrete structures." *Cement and Concrete Composites*, 28(4), 393-401.

Akhtar, S. (2013). "Review of nondestructive testing methods for condition monitoring of concrete structures." *Journal of construction engineering*, 2013.

Sing, M.C.P., Love, P.E.D., and Davis, P.R. (2014). "Experimental study on condition assessment of reinforced concrete structure using a dynamics response approach." *Structural Survey*, 32(2), 89-101.

Rehabilitation and Structural Strengthening:

Santos, S., Modena, C., Vientzileou, E., Tomazevic, M., Laurenco, P., Capozucca, R., Chidiac, S., and Jaeger, W. "Guide for the structural rehabilitation of heritage buildings." *Proc., CIB Publication.*

Vilhena, A., Costa Branco De Oliveira Pedro, J., and Vasconcelos de Paiva, J. "Assessment method for buildings' Rehabilitation needs: Development and application." *Proc., Building a Better World: CIB World Congress 2010, May 10-*

	13, Salford UK, CIB 2010 World Congress. Costa, A., Guedes, J. M., and Varum, H. (2014). *Structural rehabilitation of old buildings*, Springer. ***Building Information Modeling on Maintenance Management*** Chang, C.-Y., and Tsai, M.-D. (2013). "Knowledge-based navigation system for building health diagnosis." *Advanced Engineering Informatics*, 27(2), 246-260. Chen, H.-M., Hou, C.-C., and Wang, Y.-H. (2013). "A 3D visualized expert system for maintenance and management of existing building facilities using reliability-based method." *Expert Systems with Applications*, 40(1), 287-299.