UNIVERSITY OF WARWICK

Proposal Form for New or Revised Modules (MA1 - version 7 - April 2014)

Approval information	
Approval Type	☐ New module ☒ Revised module ☐ Discontinue module
Date of Introduction/Change	01/10/2018
If new, does this module replace another? If so, enter module code and title:	
If revised/discontinued, please outline the rationale for the changes:	Updated Teaching and Learning Hours, introducing tutorial sessions. Updated syllabus to reflect the development of the module since previous review. Updated bibliography. Replacement learning outcomes that better reflect the module aims and content. Rewritten module aims that better communicate the module to a wider audience.
Confirmation that affected departments have been consulted:	Changes were made in consultations between the School of Engineering and WMG.

Module Summary	
1. Module Code (if known)	ES94V
2. Module Title	Tunnel Design
3a. Lead department:	School of Engineering (100%)
3b. Teaching Split (if known):	100% Engineering
4. Name of module leader	Dr Alan Bloodworth
5. Level	UG: ☐ Level 4 (Certificate) ☐ Level 5 (Intermediate) ☐ Level 6 (Honours) PG: ☒ Level 7 (Masters) ☐ Level 8 (Doctoral) See Guidance Notes for relationship to years of study
6. Credit value(s) (CATS)	15

Module Summary	
7. Principal Module Aims	This module aims to provide an understanding of the fundamental concepts of soil-structure interaction and their application in the analysis and design of a range of tunnel types, including consideration of extreme loading and ground movement effects. Design is considered in the context of clients' requirements and the broader regulatory, sustainability, whole life and health and safety framework.
8. Principal Learning Outcomes	By the end of the module students should be able to: • Understand the design process and current legal, health and safety, economic, social and sustainability influences on design, and interpret clients' requirements in the light of these constraints. • Evaluate the appropriateness of practical methods for soil-structure interaction and tunnel lining analysis. • Systematically apply methods of design of a range of tunnel lining types and configurations, and critique their output. • Demonstrate a conceptual understanding of the performance of tunnels under extreme loading and how to mitigate its effects. • Predict subsurface ground movements resulting from underground excavations and evaluate their effects on neighbouring structures,
9. Timetabled Teaching Activities (summary)	30 hrs lectures, 4 hrs tutorials and a 1 hr laboratory demonstration. **Total of 35 hours.**
10. Departmental Web-link	http://www2.warwick.ac.uk/fac/sci/eng/eso/modules/year4/es94v/
11. Other essential notes	The module is taught in a five-day intensive block (excluding Wednesday afternoon). Pre reading is required before the module with an unseen written test during the module. Cohort level feedback is given after the test. Advice and feedback hours are available for answering questions on the lecture material. The module is available as a standalone CPD course for external attendees.
12. Assessment methods (summary)	Written test 1 hour 20% 3-hour written examination 80%

For use by Strategic Planning and Analytics Office only - Do not fill in this section

Level	JACS3 Code	Teaching Split
		If not provided in 3b above

External Credit Level		Scheme	

Module Context
13. Please list all departments involved in the teaching of this module. If taught by more than one department, please indicate percentage split.
School of Engineering, 100%
14. Availability of module

Degree Code	Title	Study Year	C/OC/ A/B/C	Credits
H214	MSc Tunnelling and Underground Space FT	M1	C	15
H214	MSc Tunnelling and Underground Space PT	M1	OC	15
H214	MSc Tunnelling and Underground Space PT	M2	OC	15

15. Minimum number of registered students required for module to run
1
16. Pre- and Post-Requisite Modules
None

Module Content and Teaching	
17. Teaching and Learning Activities *(totals for module – please see guidance)*	
Module duration (weeks)	1
Lectures	30 hours
Seminars	
Tutorials	4 hours (2hr advice and feedback and 2hr revision)
Project Supervision	
Demonstration	1 hour laboratory demonstration
Practical Class/Workshops	
Supervised time in studio/workshop	
Fieldwork	
External visits	
Work based learning	
Placement	
Year abroad	
Other activity *(please describe): e.g. distance-learning, intensive weekend teaching etc.*	115 hours of guided independent learning

Module Content and Teaching		
18. Assessment Method (Standard)		
Type of assessment	**Length**	**% weighting**
Written Test	1 hr	20%
Written Examinations	3 hrs	80%
Practical Examinations	NA	NA
Assessed essays/coursework	NA	NA
18a. Final chronological assessment *(please see guidance*)	Written Examination	

19. Methods for providing feedback on assessment.

In Class Written Test: Cohort level feedback.
Examination: publication of recent past examination papers and model solutions or mock paper and solutions where past papers do not exist. Cohort level feedback on examinations.

20. Outline Syllabus

Fundamental principles of soil / structure interaction
Principles of reinforced concrete design relevant to tunnel linings, including fibre-reinforced concrete
Closed-form solutions for tunnel lining analysis
Concept and detailed design of primary and secondary lining systems: precast concrete segmental linings, sprayed concrete linings, ferrous metal and cast in situ reinforced concrete linings (shafts and tunnels)
Analysis and design at openings
Traditional timber heading design
Estimation of subsurface settlements and their effects on neighbouring buried structures
Design of secondary linings systems
Design under extreme loading (fire, seismic *etc*.)
Conceptual design of tunnels to meet clients' requirements
Design to appropriate standards to deliver required functionality (characteristic ground parameter determination, structural factor of safety, watertightness, design life *etc*.)
The design process in industry, and design in the context of sustainability, whole life cost, futureproofing and the CDM Regulations

21. Illustrative Bibliography

Chapman, D., Metje, N. and Stärk, A. 2010. *Introduction to Tunnel Construction*. London: Taylor & Francis. Available as an e-book, see
http://encore.lib.warwick.ac.uk/iii/encore/record/C__Rb2582697

Thomas, A. 2009. *Sprayed Concrete Lined Tunnels – an Introduction*. New York: Taylor and Francis.
http://encore.lib.warwick.ac.uk/iii/encore/record/C__Rb2325323

Module Content and Teaching
Mackenzie, C.N.P. 2014. *Traditional Timbering in Soft Ground Tunnelling - a Historical Review*. London: British Tunnelling Society. BTS/ICE 2004. *Tunnel Lining Design Guide*. London: Thomas Telford. BTS 2010. *Specification for Tunnelling (3rd ed.)*. London: Thomas Telford. BSI 2016. *Tunnel Design – Design of Concrete Segmental Tunnel Linings – Code of Practice, PAS 8810:2016*. British Standards Institution. Bond, A.J. et al. 2006. *How to Design Concrete Structures Using Eurocode 2*. Camberley, Surrey: The Concrete Centre.
22. Learning outcomes *Successful completion of the module leads to the learning outcomes. The learning outcomes identify the knowledge, skills and attributes developed by the module.* *Learning Outcomes should be presented in the format "By the end of the module students should be able to..." using the table at the end of the module approval form:*

Resources
23. List any additional requirements and indicate the outcome of any discussions about these.
N/A

Approval	
24. Module leader's signature	Dr Alan Bloodworth
25. Date of approval	25 April 2018
26. Name of Approving Committee (include minute reference if applicable)	School of Engineering and WMG Course and Module Approval Committee (CMAC), Minute 260-17/18
27. Chair of Committee's signature	Professor Gillian Cooke
28. Head of Department(s) signature	Professor David Towers

Examination Information		
A1. Name of examiner (if different from module leader)		
A2. Indicate all available methods of assessment in the table below		
% Examined	**% Assessed by other methods**	**Length of examination paper**
80	**20% Written Test 1 hour**	**3 hour**
A3. Will this module be examined together with any other module (sectioned paper)? If so, please give details below.		
No		
A4. How many papers will the module be examined by?	☒ 1 paper	☐ 2 papers
A5. When would you wish the exam take place (e.g. Jan, April, Summer)?	**May**	
A6. Is reading time required?	☐ Yes	☒ No
A7. Please specify any special exam timetable arrangements.		
None		
A8. Stationery requirements		
No. of Answer books?	**1**	
Graph paper?	**Yes**	
Calculator?	**Yes**	
Any other special stationery requirements (e.g. Data books, tables etc)?	**Extracts from British Standards**	
A9. Type of examination paper		
Seen?	☐ Yes	☒ No
Open Book?	☐ Yes	☒ No
Restricted?	☐ Yes	☒ No
If restricted, please provide a list of permitted texts:		

LEARNING OUTCOMES		
(By the end of the module the student should be able to....)	**Which teaching and learning methods enable students to achieve this learning outcome? (reference activities in section 17)**	**Which summative assessment method(s) will measure the achievement of this learning outcome? (reference activities in section 18)**
Understand the design process and current legal, health and safety, economic, social and sustainability influences on design, and interpret clients' requirements in the light of these constraints	Lectures, tutorials	Written examination
Evaluate the appropriateness of practical methods for soil-structure interaction and tunnel lining analysis	Lectures, tutorials, laboratory demonstration	Written Test, Written examination
Systematically apply methods of design of a range of tunnel lining types and configurations, and critique their output	Lectures, tutorials	Written examination
Demonstrate a conceptual understanding of the performance of tunnels under extreme loading and how to mitigate its effects	Lectures, tutorials	Written Test, Written examination
Predict subsurface ground movements resulting from underground excavations and evaluate their effects on neighbouring structures	Lectures, tutorials	Written examination