Civil Infrastructure Management and Maintenance (CIMM)
Postgraduate Programme
2018/19
Introduction

**South Africa is experiencing** a significant growth in new civil infrastructure such as roads, bridges, ports, dams and water reservoirs, power stations, power distribution facilities, etc. This is in addition to the large stock of ageing infrastructure built in previous decades.

The management and maintenance of this infrastructure poses a significant challenge both in the short-term and long-term. Some of the existing infrastructure is approaching the end of its design service life and requires measures for service-life extension in order to remain functional. Other infrastructure, such as roads and bridges may experience loads that by far exceed the original design load (due to increased traffic volumes, heavier vehicles, etc.) and require upgrading to remain functional and safe. These problems are exacerbated by the fact that a large part of our civil infrastructure is experiencing premature deterioration and degradation, which results in the need for repair and strengthening measures prior to the end of the design service life.

Strategic and effective management and maintenance programmes are therefore needed to ensure that the stock of infrastructure satisfactorily performs its function during its design life. In addition, appropriate strategies are required for the re-use of structures and materials once their service life has expired.

Failure to maintain infrastructure in a state of adequate serviceability has negative economic and social consequences. To this end the South African Government has put in place infrastructure management and maintenance strategies. However, despite these efforts, a substantial part of South African civil infrastructure remains in poor condition.

The key aspects of structural performance of civil infrastructure include the following:

- Structural condition and load-bearing capacity
- Durability and resistance against deterioration
- Serviceability and functional capacities
- Structural integrity in relation to potential failures
- Overall costs of maintenance during the lifespan

The condition and operational capacities of civil infrastructure and its various structural elements at any given point in the service life depend on multiple and interrelated factors, including:

- Original design parameters and specifications
- Initial quality of materials and construction procedures
- Environmental exposure conditions
- Corrosion and other deterioration processes
- Nature and timing of preventative maintenance and structural interventions
A sound understanding of the impact of these factors on structural performance and durability is essential in order to propose appropriate maintenance strategies, as well as timeous and effective interventions.

Why study CIMM at UCT

Most of the civil engineering infrastructure in South Africa is owned by the national government, provincial governments and local authorities. A major challenge for these authorities is the lack of trained human recourses, particularly in the area of infrastructure maintenance. An important value of the CIMM programme is the training of high level personnel (MSc, MEng, PM, PhD). The establishment of the programme was based on the evidence and conviction that the engineer of the future will spend more time dealing with infrastructure management and maintenance problems than designing new infrastructure.

Traditional education and training in infrastructure management focuses on management issues such as creating databases of infrastructure inventories. There is a lack of education and training in technical aspects such as non-destructive testing, design procedures, deterioration science, renewal engineering, concrete repair technology, structural strengthening, etc. In order to bridge this gap, the CIMM programme provides in-depth education in all these technical fields.

Budgets for infrastructure maintenance are substantial and will be larger than the budget for construction of new infrastructure in future. It is essential this is spent in a cost-effective manner.

Advanced studies in Infrastructure Management and Maintenance stimulate further research and optimal solutions for problems related to infrastructure management and maintenance.

At present none of the other African universities offers advanced studies in infrastructure management and maintenance in the form found in the CIMM programme at UCT. The programme therefore offers a unique opportunity to gain knowledge and skills in one of the most relevant fields in civil and structural engineering. Students graduating with a postgraduate degree in CIMM from the Department of Civil Engineering at UCT will belong to a small group of experts urgently needed in the local and international civil engineering industries.

Themes and objectives

The CIMM postgraduate programme at the University of Cape Town has a focus on structural and materials engineering with respect to maintenance, rehabilitation and management of civil infrastructure. This is largely based on the expertise of the Concrete Materials and Structural Integrity Research Unit (CoMSIRU) at UCT, which has been developing technologies and procedures for the design, assessment and management of concrete structures for over 20 years. Within the group, there
has been a marked focus on infrastructure performance and renewal research in the last decade largely in response to industry needs. The broad areas of interest cover deterioration science, assessment technologies, and renewal engineering.

**Deterioration science**

Deterioration science examines conditions and processes by which materials and structures break down or deteriorate over time. Our understanding needs to be improved to facilitate effective and rational design, construction and maintenance of structures so as to ensure they are durable, safe, and environmentally sound. Research efforts of the group are focused on developing performance-based design models for service life prediction of reinforced concrete structures, as well as understanding the impact of materials and construction procedures on the durability and serviceability of our infrastructure.

**Assessment technologies**

Assessment technologies are needed to evaluate the condition of materials and structures in relation to mechanical performance, structural capacity and deterioration. Research in this area is needed for the development of effective non-destructive evaluation techniques and improved sensor technologies and applications. Based on visual inspection, which in the past has been the predominant method for condition assessment of structures, preliminary decisions on structural repair and maintenance including associated can be made. However, infrastructure management systems should further be based on information about the evolution and the consequences of actual in-service loading and material deterioration. With a comprehensive condition assessment, effectiveness and long-term performance of planned repair interventions can be quantified. Consequently, the economics of interventions such as repair and maintenance is poorly defined. A rational approach to supplement visual inspection-based condition assessment is Structural Health Monitoring, which allows measurement and monitoring of critical structural parameters with the aim of checking if a structure behaves as expected.

**Renewal engineering**

Renewal engineering aims at the extension of the life of physical infrastructure and components, and at the enhancement of load capacities of these systems to meet the increased demands imposed on them. CoMSIRU has a strong research focus on developing and implementing effective repair and strengthening methods using cementitious materials, electrochemical techniques and high-performance advanced composite materials. Research is focused on the performance evaluation of repair and strengthening materials, with the aim of improving specifications, construction procedures and quality control methods.
**Key objectives**

Students are to develop a clear understanding of the following aspects:

- The concept and scope of civil infrastructure management
- Tools used in the practice of infrastructure management, e.g. databases, GIS, information theory and application
- Practical application of infrastructure management principles in selected infrastructure systems, e.g. bridges, power supply, water infrastructure
- Causes and implications of material and structural deterioration, e.g. concrete and steel
- Infrastructure assessment technologies such as non-destructive testing
- Infrastructure maintenance and rehabilitation strategies
- Principles of life cycle-life assessment as applied to various types of infrastructure
- Renewal decision making, relating for example to the effective allocation of limited funds for rehabilitation and maintenance
- Project management principles for infrastructure maintenance and renewal

**Research**

Dissertations and research projects are supervised by academic staff of the Concrete Materials and Structural Integrity Research Unit (CoMSIRU), drawing on their extensive research and industry experience, while benefiting from the research unit’s laboratory and testing facilities.

**About CoMSIRU**

The Concrete Materials and Structural Integrity Research Unit (CoMSIRU) is an active research unit in the Department of Civil Engineering at the University of Cape Town. The guiding principle of CoMSIRU is developing high-level personnel for industry, research and academia, while engaging in innovative and impactful research.

The unit’s research is focused on the durability of concrete structures, structural health monitoring and integrity assessment, as well as repair and rehabilitation strategies. CoMSIRU’s work is highly regarded due to its considerable scholarly productivity and quality, contribution to national standards, local and international reputation and the demand for its graduates in civil and structural engineering.

The CoMSIRU team has a combined research and consulting experience of more than 70 years. The on-site availability of our experts is complemented by the unit’s laboratory and testing facilities for concrete materials and structural engineering.
Course outline

Infrastructure management and maintenance is multidisciplinary, drawing from a number of fields including Civil and Structural Engineering, Construction and Project Management, Economics and Finance. A number of courses are offered in the Faculty of Engineering the Build Environment at UCT to cover these various fields.

Postgraduate education in CIMM at Masters level in the Department of Civil Engineering at UCT commonly results in one of three outputs:

- **Master of Science in Engineering / MSc(Eng):** This is a research-based degree (120 credit dissertation and 60 credits coursework). Generally, candidates entering this programme should have an equivalent of an Honours degree or a four-year engineering degree.

- **Master of Engineering / M(Eng):** This is a coursework masters (120 credits of coursework and 60 credits of a minor dissertation). Generally, candidates entering this programme should have a four-year engineering degree or its equivalent, based primarily on academic qualifications and work-place experience.

- **Professional Master / PM(Eng):** This is a coursework masters (135 credits of coursework and 45 credits of research projects). The same rules regarding entry qualifications as for the MEng apply.

All programmes can be completed in 1.5 – 2 years full-time. The M(Eng) and PM(Eng) degrees can further be completed over a maximum of 5 years on a part-time basis. Students registered for the different degree programmes need to register for a certain combination of courses, outlined below.

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<th>Master of Science in Engineering: MSc(Eng)</th>
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<th>Professional Master of Engineering: PM(Eng)</th>
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<td></td>
<td>Strengthening and Retrofitting of Concrete Structures [20]</td>
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<td>Repair and Rehabilitation of Concrete Structures [20]</td>
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<td>Structural Performance Assessment and Monitoring [20]</td>
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<td>Condition Assessment and Remedial Action on Steel Structures [20]</td>
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<td>Structural Concrete Properties and Practice [16]</td>
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<td>Structural Dynamics with Applications [16]</td>
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<td>Safety of Special Structures [10]</td>
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<td>Bridge Management and Maintenance [10]</td>
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All credits as per NQF = National Qualifications Framework.
All courses HEQSF Level 9, HEQSF = Higher Education Qualifications Sub-Framework.
Detailed Course Descriptions

**Advanced Infrastructure Management / CIV5067Z**
This module exposes students to the concepts of infrastructure asset management. These concepts include the context in which Infrastructure Management Planning is done, the process of Infrastructure Management Planning and the techniques required to prepare an Infrastructure Management Plan.

**Deterioration and Condition Assessment of Concrete Structures / CIV5138Z**
This advanced course aims to develop an understanding of durability aspects, service life design, and non-destructive testing of concrete structures. Topics include: concrete deterioration mechanisms (physical, mechanical and chemical deterioration); reinforcement corrosion (principles, mechanisms, modelling, assessment, prevention); Alkali Silica Reaction (ASR); chemical attack; cracking of concrete structures; fire damage to structures; prevention of concrete deterioration thorough material selection, mix design and construction; service-life modelling (principles, deterioration models, service life models, normative guidelines); impact of loads on concrete structures; on-site evaluation techniques; visual assessment of concrete structures; principles, planning and execution of assessments; test methods (types, application and limitations, interpretation of results, case studies); non-destructive test methods (NDT); classical NDT (rebound hammer, cover depth, half-cell potential), advanced NDT (radar, sonic methods, impact echo), imaging and interpretation of results; diagnostic investigations and laboratory testing. The course is based on lectures and projects and may include case studies, laboratory sessions, and site visits.

**Strengthening and Retrofitting of Concrete Structures / CIV5140Z**
This course deals with the strengthening and retrofitting of concrete structures and covers the following topics: introduction to structural condition surveys and assessment of concrete structures; materials and strategies for structural strengthening; compatibility aspects; structural requirements and procedures for rehabilitation; practical and contractual aspects; strengthening systems; FRP design and application; strengthening for shear, bending and torsion; bonded steel plates; external prestressing systems; design procedures; analysis of strengthened concrete structures.

**Repair and Rehabilitation of Concrete Structures / CIV5139Z**
This course deals with the repair and rehabilitation of concrete structures and covers the following topics: introduction to the assessment of deterioration of concrete structures; repair materials and strategies; compatibility aspects; durability and repair audits; service life predictions; economics of repair and life-cycle costing; practical and contractual aspects; strengthening systems; FRP design and application; repair of ASR-damaged structures; crack injection; bonded overlays and patch repairs; electrochemical repair techniques; surface coatings and durability extension; repair of fire damaged structures; repair materials for chemical resistance against acid and sulphate attack; maintenance planning.
Project Planning and Implementation / CON5016Z
The course is intended to provide Infrastructure Managers with tools for scoping and planning rehabilitation or maintenance projects. Contents include: rules for planning and control; scope management; project strategy; project methodology; project scheduling techniques; change management and project integration.

Structural Performance Assessment and Monitoring / CIV5119Z
This course introduces the concepts of structural health monitoring. Structural health monitoring is defined as the measurement of the operating and loading environment and the critical responses of a structure to track and evaluate the symptoms of operational incidents, anomalies, and/or deterioration or damage indicators that may affect operation, serviceability, or safety reliability. Through structural health monitoring some knowledge of the current condition of a structure can be established and appropriate interventions employed. The course covers the following topics: concepts of structural health monitoring; structural performance indicators; strategies for structural performance assessment; instrumentation, data acquisition, data quality assurance; measurement of strain, measurement of deflections, measurement of vibrations; introduction to experimental modal analysis; modal parameter estimation and validation; assessment of effectiveness of structural retrofitting or rehabilitation interventions.

Condition Assessment and Remedial Action on Steel Structures / CIV5141Z
The course aims to develop an understanding of durability aspects, service life design, condition assessment and non-destructive testing of steel structures. Topics include: basics of steel material science; material characteristics and properties; structural behaviour of steel; advantages of steel structures in industrial application; fire resistance of steel structures; deterioration of steel structures; fundamentals of steel corrosion; corrosion detection techniques; in-situ assessment of steel structures; protection of steel structures; coatings; cathodic protection; fatigue behaviour; strengthening and repair of steel structures.

Structural Concrete Properties and Practice / CIV5002Z
The aims of the course are to provide structural engineers with fundamental and practical knowledge in concrete materials technology, to establish an understanding on modelling and designing concrete properties relevant to structural design, and to create awareness on chemical and physical material characteristics of cementitious construction materials. The topics covered in this course include: constituent materials (cements, admixtures, cement extenders, aggregates); desirable properties for concrete (plastic and hardened properties, including strength, creep, shrinkage, elastic modulus, durability); concrete mix design; prediction and modelling of concrete structural properties; concrete failure and fracture; concrete quality control; deterioration mechanisms; special concretes such as high strength concrete, self compacting concrete and fibre reinforced concrete.
Structural Dynamics with Applications / CIV5113Z

Safety of Special Structures / CIV5118Z
The course introduces students the governance and management of special structures. The procedures employed for safety evaluation are generally not specified in codes of practice. Probabilistic based risk analysis and surveillance techniques for the evaluation of loading and consequences of failure will be introduced. Case studies are used to demonstrate the principles. The particular focus of the course will be adjusted to industry needs and may include concrete dams, nuclear facilities, mining structures, and coastal infrastructure.

Bridge Management and Maintenance / CIV5115Z
This course aims to introduce the principles of bridge management and maintenance. The focus is on both highway bridges and railway bridges. The course provides the basic philosophies behind bridge management systems, the structure of a bridge management system, and the implementation of bridge management system. Life cycle cost analysis of bridges are introduced. Linkages between bridge management, maintenance and rehabilitation of bridges is discussed. Key to this course are practical bridge inspections and case studies.
### Overview

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<th>Programme</th>
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<td>Qualification</td>
<td>M(Eng), MSc(Eng), PM(Eng)</td>
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<td>Delivery Mode</td>
<td>All courses will be run on block release mode, which usually entails a week of lectures, tutorials and assignments followed by an examination.</td>
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<td>Admission</td>
<td>Normal UCT admission rules to MSc and MEng programs apply. BTech holders should have at least 5 years relevant experience before applying.</td>
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| Application         | For registration details and online applications, visit the UCT website [http://www.students.uct.ac.za/students/applications/apply/postgraduates/apply-register](http://www.students.uct.ac.za/students/applications/apply/postgraduates/apply-register)  
International students should ensure that the application and issue of a valid study permit is completed well in advance of course commencement. |
| Fees                | As per UCT prescribed fee schedule [http://www.uct.ac.za/apply/fees/](http://www.uct.ac.za/apply/fees/) |

For more information, please visit the Civil Engineering website [civil.uct.ac.za/cimm](http://civil.uct.ac.za/cimm) or simply scan the QR code below to be directed to the page.