DEPARTMENT OF
CIVIL ENGINEERING

Postgraduate Programme

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Civil Infrastructure Management and Maintenance (CIMM)

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

CONTENTS

INTRODUCTION

The Southern African region is experiencing a significant growth in new civil infrastructure such as roads, bridges, ports, dams and water reservoirs, power stations and power distribution facilities. 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, for example) 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.

THE PROGRAMME

THE CIMM POSTGRAD PROGRAMME

The CIMM postgraduate programme at the University of Cape Town focuses 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 is a marked focus on infrastructure performance and renewal research, largely in response to industry needs. The broad areas of interest cover deterioration science, assessment technologies, and renewal engineering.

THEMES

1. 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.

2. 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. 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 can be properly 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.

3. Renewal engineering

Renewal engineering aims at the extension of the life of physical infrastructure and its 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. transport, power supply, coastal, and water infrastructure
- Design for durability
- Service life prediction and performance monitoring of structures
- 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
- The civil engineer's responsibility in supporting sustainability in the built environment

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 state-of-the-art laboratory and testing facilities for concrete materials and structural engineering.

COURSE DELIVERY

The CIMM programme is taught in a hybrid manner, combining online teaching with contact sessions. The programme is suitable for distance learning; however, a minimum of 25% of the CIMM course activities require the students' in-person attendance. Students can expect:

- Online lectures (live and recorded)
- Online discussions and Q&A sessions (live only)
- Regular assessments, such as assignments and projects
- Practical sessions, such as seminars and laboratory activities on campus
- Site visits

WHO SHOULD APPLY

The programme prides itself to have a diverse student body consisting of local and international students. In addition, staff collaborations with peers and partners across the globe provide many opportunities for students to participate and enrich their learning experience.

Prospective CIMM students are required to have a background in civil or structural engineering, either by degree or substantive working experience. During the programme they will acquire a range of skills, including:

- Knowledge of the professional topics and fields covered
- Sustainability principles and practices
- Scientific principles and their translation into practical engineering applications
- Experimental investigation principles and interpretation thereof
- Project planning and management
- Critical thinking
- Professional communication and presentation, both oral and written

Career prospects

CIMM graduates are sought-after professionals who can pursue a career in the public, private or academic sectors. Career perspectives range from engineering consultancies or specialised contractors to governmental agencies tasked with developing and maintaining infrastructure, research institutes and academia or the construction material industry.

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, 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 design for durability and structural resilience, condition assessment planning and execution, non-destructive testing, deterioration science, renewal engineering, concrete repair technology, structural strengthening, service life extension, etc. In order to bridge this gap, the CIMM programme provides in-depth education in all these technical fields.

All around the world, including both industrialised and developing regions and countries, budgets for infrastructure maintenance are substantial and will continue to be significantly larger than the budgets for construction of new infrastructure in future. It is essential that the related available funds are 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 no other African university offers advanced studies in infrastructure management and maintenance in the form found in the CIMM programme at UCT. Similarly, there exists no equivalent postgraduate programme in the leading universities in Europe, North America or elsewhere in the world. 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.

About UCT

The University of Cape Town (UCT) is a leading university on the African continent. It is dedicated to innovative, cutting-edge research and scholarship and attracts students and faculty of a high calibre. The University amplifies

its reach and impact by collaborating across disciplines (on-campus and off-campus), engaging with industry, and participating in global networks.

The New Engineering Building (NEB) is the home of, among others, the civil engineering department and associated research groups. Here, students have access to state-of-the-art teaching facilities and laboratories. The building is located at UCT Upper Campus, which is known for its picturesque setting featuring modern and historic buildings side-by-side and Cape Town's iconic Table Mountain as a backdrop.

PROGRAMME OUTLINE

Civil 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 (civil / structural engineering).
- **Master of Engineering specialising in Civil Infrastructure Management and Maintenance / MEng:** 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 (civil / structural engineering).
- **Professional Master of Civil Infrastructure Management and Maintenance / MEng (CIMME):** 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.

The MSc(Eng) and MEng are available as **fast-track programmes** and can be completed over a minimum of 12 months full-time study. The MEng (CIMME) degree (and also the MEng degree) can 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 on the following pages.

OVERVIEW OF COURSES

COURSE [CREDITS]	MSc(Eng)	MEng	MEng (CIMME)	CPD*
Advanced Infrastructure Management [20]	●	●	●	●
Deterioration and Condition Assessment of Concrete Structures [20]	●	●	●	●
Repair and Rehabilitation of Concrete Structures [20]	○	○	○	●
Strengthening and Retrofitting of Concrete Structures [20]	○	○	○	●
Structural Performance Assessment and Monitoring [20]	○	○	○	●
Condition Assessment and Remedial Action on Steel Structures [20]	○	○	○	●
Bridge Management and Maintenance [10]	○	○	○	●
Non-Destructive Testing of Concrete Structures [10]	○	○	○	●
Safety of Special Structures [10]	○	○	○	●
Structural Dynamics with Applications [16]	○	○	○	●
Project Planning and Implementation [20]	○	○	○	–
Research Design and Methodology for Civil Engineers [16]	○	○	○	–
Special Topics in Infrastructure Management [10]	○	○	○	●

● Core course ○ Elective Course *CPD course at 5 CPD points each

Total of [180] credits required for all degrees.

COURSE DESCRIPTIONS

DETAILED COURSE DESCRIPTIONS / COURSE CODES

Advanced Infrastructure Management / CIV5067Z

This course exposes the student to the concepts of municipal infrastructure management. These concepts include the context of Infrastructure Asset Management Planning, the process of Infrastructure Asset Management Planning and the techniques required to prepare an Infrastructure Asset Management Plan. The course will also introduce the student to the following asset management practices and processes: Customer profiling, investment appraisal and financial planning, and lifecycle delivery.

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: introduction to advanced concrete technology; 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); introduction to non-destructive test methods (NDT); diagnostic investigations and laboratory testing. The course is based on lectures and projects and includes case studies, laboratory sessions, and site visits.

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; repair methods and materials; reinforcement corrosion repair; 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.

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.

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

This 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.

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.

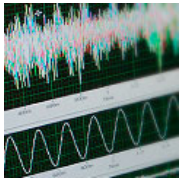
Non-Destructive Testing of Concrete Structures / CIV5153

This course addresses the detection and quantification of concrete degradation and associated mechanical, physical and chemical processes. Several test methods for the quality assessment of hardened concrete cover have been developed world-wide. In future, these methods will increasingly be used for design and quality assurance of concrete and concrete structures. The course deals with non-destructive testing methods (NDT) in civil engineering for quality control and condition assessment. Condition assessment contributes to the choice of appropriate methods for concrete repair projects. Quality control helps to assure a high-quality standard for concrete members or concrete repair. NDT methods for new constructions as well as methods to assess existing structures are discussed: classical NDT (rebound hammer, cover depth, half-cell potential), advanced NDT (radar, sonic methods, impact echo), imaging and interpretation of results. The purpose of the course is to provide students with a basic understanding of methods, their principles and techniques for non-destructive testing and condition assessment of concrete structures. Both theoretical and practical issues are considered.

Safety of Special Structures / CIV5118Z

This 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.

Structural Dynamics with Applications / CIV5113Z



This course aims to introduce the concepts of structural dynamics and its applications in structural engineering. Topics covered include dynamic equilibrium of structures. Response of a single degree of freedom system to dynamic excitation: free vibration, harmonic loads, impulse loading and general loading. Response of multi-degree-of-freedom systems. Free vibrations: mass, damping and stiffness matrices. Rayleigh damping. Forced vibrations: modal superposition and step by step methods. Continuous systems. Applications to seismic design of structures, blast and impact effects on structures and wind engineering.

Project Planning and Implementation / CON5016Z

This 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.

Research Design and Methodology for Civil Engineers / CIV5131Z

This course aims to develop conceptual skills for conducting research at the master's level. Topics include: the scientific method, induction and deduction, inference, statistical thinking and ethics, as well as technical skills which include technical

writing, searching and interpretation of scientific literature, proper use of citations, and communication of research outputs.

Special Topics in Infrastructure Management / CIV5152Z

This course is aimed to address special topics in infrastructure management and to highlight specialised content which is currently not represented in the curriculum. Topics previously covered in this course included: integrating sustainability in engineering design; and building information management.

SUMMARY

Programme: Civil Infrastructure Management and Maintenance (CIMM)

Qualification: MSc(Eng), MEng, MEng (CIMME)

Delivery Mode: All courses will be run on block release mode, which usually entails a week of lectures, tutorials and assignments followed by an examination.

Admission: Normal UCT admission rules to MSc and MEng programs apply. BTech holders should have at least 5 years relevant experience before applying.

Application: For registration details and online applications, visit the UCT website 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 available on uct.ac.za/apply/fees/

Contact: For more information, visit the our website comsiru.uct.ac.za/con/cimm or simply scan the QR code below to be directed to the page.

Alternatively, write us an email: comsiru@uct.ac.za.

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