CONCRETE MATERIALS AND STRUCTURAL INTEGRITY RESEARCH UNIT

ANNUAL REPORT 2013

Annual Report 2013

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1 INTRODUCTION AND OVERVIEW

The Concrete Materials and Structural Integrity Research Unit (CoMSIRU) is a long-standing research entity in the Department of Civil Engineering at the University of Cape Town. It attracts annual industry support and funding, interacts with industry to set and monitor research priorities, and produces a steady stream of scientific, technological and human resource outputs.

The Research is strongly informed by the needs of owners and managers of large stocks of reinforced concrete infrastructure such as Eskom, the South African National Roads Agency, Department of Water Affairs and Environment, etc. Technology transfer activities (in the form of scientific papers, easy-read monographs, short courses and seminars) aimed at such entities, as well as the general cement and concrete industry and associated sectors of the economy, are also an important component.

The Research Programme is closely integrated with the postgraduate teaching programmes in *Civil Infrastructure Management and Maintenance* and *Structural Engineering and Materials* in the Department of Civil Engineering. Research students generally undertake a suite of postgraduate courses to improve their knowledge and to prepare them for their research work. Most students undertake an MSc (Eng) degree by way of 60 credits (min) of advanced coursework and a 120 credit research dissertation. Recently, there has been an encouraging increase in the number of doctoral research students.

2 HIGH-LEVEL OBJECTIVES

CoMSIRU takes as a foundational philosophy the importance of developing high-level human resources for industry, academia and research. Research is a vehicle towards this goal, and not merely an end in itself. This means that our research and activities will always be student-centred. We will endeavour to foster a collaborative attitude, critical thinking, and independent thought among students and encourage them to work in teams wherever possible. We will also regularly bring them into contact with industry and its needs so that they can better understand how their own research influences engineering practice.

In view of this, the high-level objectives of CoMSIRU are:

2.1 Materially expand and improve the pool of high-level skills in concrete materials and structural engineering, in South Africa

Our first responsibility is to educate and train students in the knowledge and application of concrete and concrete structures. This is done mainly via the pool of high-level research students (Masters and Doctoral) in our teaching and research programmes. We aim to expand and improve intellectual capacity for the concrete industry.

2.2 Influence the culture and practice of design

This needs to be done by creating a fundamental understanding in students and practitioners of the critical importance of materials in structural/civil design of infrastructure.
To do this we will undertake research aimed at the following aspects:

- Performance design.
- Life-cycle design.
- Materials and durability-based design.

These are considered points of departure from conventional design philosophies.
In addition, our post graduate courses and technology transfer activities will have a strong component of materials engineering and performance.

2.3 Improve management of the infrastructure

This will involve:

- Creating awareness of this topic among students and engineers.
- Developing improved understanding of deterioration mechanisms and maintenance/repair strategies.
- Mounting a 'Civil Infrastructure Management and Maintenance' programme from 2013 to more directly address this important issue.

2.4 Embed durability and sustainability in all aspects of concrete structural/civil engineering

This will require us to:

- Develop a more inclusive and integrated approach to design and management of infrastructure, in which a long-term, life-cycle approach is promoted.
- Consider resource efficiency for civil infrastructure in terms of design and construction practice.
- Consider ways of practical implementation of sustainability in structural/civil design, through re-thinking the design process.

2.5 Promote structural health monitoring as a key tool for structural performance assessment

This will include:

- Developing and implementing strategies for monitoring and evaluating structural performance based on appropriate sensing and data analysis procedures.
- Developing and implementing structural rehabilitation and retrofitting based on as built behaviour of structures.
- Developing strategies for transfer of structural health monitoring technology.

2.6 Influence Codes of Practice

We will need to:

- Actively participate in writing and editing codes of practice and specifications, and drafting new test methods.
- Assist engineers with interpretation and application of codes using alternative philosophies and approaches.

In addition to the above aspects, CoMSIRU's objective is to educate and develop students mainly at the postgraduate level. We intend to materially increase the pool of high-level expertise and human resources in our areas of expertise.

3 RESEARCH AND STUDENT TRAINING

As indicated under 'HIGH-LEVEL OBJECTIVES', CoMSIRU takes as a foundational philosophy the importance of developing high-level human resources for industry. Research is a vehicle towards this goal, and not an end in itself. Therefore, student education and training are our top priorities, and our activities are focused on these priorities.

4 AREAS OF RESEARCH

CoMSIRU has two broad areas of research. These intersect in key loci to permit interdisciplinary development.

4.1 Concrete materials and concrete construction

- Performance of cementitious materials.
- Deterioration studies on concrete structures.
- Durability studies on concrete structures.
- Development of durability-based design philosophies and practice.
- Development and verification of service life models.
- Repair and rehabilitation materials and methods.
- Sustainability of concrete construction.

4.2 Structural Integrity and health monitoring, and loading on bridges and structures

- Full-scale structural performance monitoring and assessment of concrete structures.
- Dynamic-based structural integrity assessment.
- Repair and strengthening of RC structures.
- Vibration serviceability of civil infrastructure.
- Bridge live loading.

4.3 Research topic areas

The research areas pursued in 2013 were:

- Studies on modern concretes and materials.
- Concrete mix design improvement through efficient use of supplementary cementitious materials.
- Service life models and prediction of service life.
- Performance-based specifications for concrete structures.
- Durability performance of concrete structures.
- Development of the Durability Index Approach to improve quality of concrete construction.
- Studies on durability index testing and correlations with other international approaches.
- Structural monitoring and performance assessment of concrete structures.
- Dynamic based condition assessment of RC structures.
- Railway bridge reliability assessment based on monitoring.
- Vibration serviceability of concrete floors and footbridges.

- Ambient vibration testing of concrete dams.
- Bridge loading.
- Strengthening of RC structures using fibre reinforced polymers.
- Repair and rehabilitation studies in concrete materials and structures.
- Cracking behaviour of concrete overlays and patch repairs.
- Studies on concrete sustainability issues.

5 IMPACT OF RESEARCH – HIGH LEVEL

The impact of research carried out in CoMSIRU, and more broadly in the postgraduate teaching and research programme in Concrete Materials and Structural Integrity at UCT, involves the following:

- A growing change of mind-set to durability of concrete infrastructure in South Africa. The discourse around this issue has changed markedly over the last 10 to 20 years, as indicated by incorporation of some of our research outcomes into specifications and codes of practice nationally, and a much greater concern with durability.
- A sounder approach to condition assessment and strengthening of concrete structures. This aspect of the Research Unit's work has grown substantially in the last 10 years.
- Input into national codes and standards, where research findings are being reflected.
- Publications, specifically the series of Monographs that is produced and regularly supplemented by new Monographs. As far as scientific papers are concerned, the output of the Unit is

substantial, and the vast majority appear in internationally respected journals and conferences.

- Local and international involvement and exposure of researchers in seminars, symposia, conferences, etc. In addition, researchers serve on or lead local and international organisations or technical committees of relevance to their areas of research.
- Existence of a laboratory and resources of national importance in concrete and concrete structures. This is particularly to be seen in the light of the reduction and loss in national agency resources, and to a significant degree, industry resources in these areas.
- Our Masters and Doctoral graduates are in high demand.

6 STUDENTS REGISTERED AND PROGRESS

In 2013, CoMSIRU had the following registered students: 9 doctoral, 31 masters, as well as 7 MEng. There were also 23 undergraduate dissertation students who worked in our areas of research for their final year projects.

2013 REGISTRATION STATISTICS

Registration	Total	Female	Male	Black/Indian	White	Foreign	South African
PhD MSc (Eng) MEng	9 31 7	3 3 0	6 28 7	9 18 6	0 13 1	9 17 3	0 14 4
Grand Total	47	6	41	33	14	29	18

2013 GRADUATION STATISTICS

Graduation	Total	Female	Male	Black/Indian	White	Foreign	South African
PhD MSc (Eng) MEng	0 8 0	0 0 0	0 8 0	0 4 0	0 4 0	0 4 0	0 4 0
Grand Total	8	0	8	4	4	4	4

6.1 Post Graduate students – details and research topics

POST GRADUATE STUDENTS 2013 MGA – Mark Alexander; HB – Hans Beushausen; PM – Pilate Moyo; VC – Vernon Collis						
Name	**Super-visor**	**Co-super-visor**	**Degree registered**	**Year first registered**	**Title of Research project**	**Progress on project**
R Heiyantuduwa	MGA	–	PhD	2004	Prediction model for concrete durability.	Anticipated Completion 2014
R Muigai	MGA	PM	PhD	2009	A Framework for the Design of more Sustainable Concrete Structures.	Submitted April 2014
M Otieno	HB	MGA	PhD	2009	Development of a chloride-induced corrosion rate prediction model for marine tidal/splash exposure conditions.	Anticipated Graduation 2014
R Gopinath	MGA	HB	PhD	2011	A Service Life prediction model based on Carbonation induced Corrosion for South African Conditions.	Anticipated Completion 2016
M Kabani	PM	HB	PhD	2011	Time dependent bridge network reliability assessment with health monitoring.	Anticipated Completion 2015
P Bukenya	PM	HB	PhD	2011	Dynamic characterization of concrete dams using operational modal analysis.	Anticipated Completion 2015
G Nganga	MGA	HB	PhD	2012	The Use of Low Clinker Cementitious Materials in Concrete.	Anticipated Completion 2016
P Arito	HB	MGA	PhD	2013	The Optimisation of Mix Design Parameters and Constituents to Minimise Cracking in Patch Repair Mortars.	Commenced 2013. Anticipated Completion 2016
M Kiliswa	MGA	HB	PhD	2013	The Influence of Sewer Environment Parameters on the Deterioration of Concrete Sewer Pipes.	Commenced 2013.
M Martin	HB	MGA	MSc (Eng)	2010	Concrete mix design and manufacturing techniques using durability enhancers.	Graduated End-2012

POST GRADUATE STUDENTS 2013
MGA – Mark Alexander; HB – Hans Beushausen; PM – Pilate Moyo; VC – Vernon Collis

Name	Super-visor	Co-super-visor	Degree registered	Year first registered	Title of Research project	Progress on project
S Gregan	PM	HB	MSc (Eng)	2010	Long term performance of corrosion damaged RC beams, patch repaired and externally strengthened using CFRP.	Graduated End-2012
M Chilwesa	HB	PM	MSc (Eng)	2010	Assessing the performance of concrete repair mortars/overlays.	Graduated Mid-2012
M Angelucci	HB	MGA	MSc (Eng)	2011	Mix Design Optimisation – The Effect of Mix Design Parameters and Mixture Properties on Concrete Durability.	Graduated Mid-2013
E Leo	PM	HB	MSc (Eng)	2011	Dynamic performance of concrete-concrete composite bridges.	Graduated Mid-2013
J Kanjee	HB	MGA	MSc (Eng)	2011	The influence of cracking on Durability and Service Life.	Graduating Mid-2014
N Kizito	HB	PM	MSc (Eng)	2011	Prediction and testing of tensile relaxation of concrete.	Graduated Mid-2013
S Starck	HB	PM	MSc (Eng)	2011	The Integration of Non-destructive Test Methods in the South African Durability Index Approach.	Graduated Mid-2013
B Walker	MGA	VC	MSc (Eng)	2011	Assessing the long term availability of construction aggregates of the Cape Town area from a sustainable perspective.	Graduating Mid- 2014
J Kessy	MGA	HB	MSc (Eng)	2011	Performance-based Design and Specification, including Service-Life Prediction Models and Experimental methods – an International comparison.	Graduated Mid-2013
K Wickins	MGA	VC	MSc (Eng)	2011	The use of construction and demolition waste in the Cape Peninsula.	Graduated End-2013
M Nzuza	PM	HB	MSc (Eng)	2011	Thermo-mechanical modelling of arch dams for performance assessment.	Graduated Mid-2013

POST GRADUATE STUDENTS 2013 MGA – Mark Alexander; HB – Hans Beushausen; PM – Pilate Moyo; VC – Vernon Collis						
Name	**Super-visor**	**Co-super-visor**	**Degree registered**	**Year first registered**	**Title of Research project**	**Progress on project**
M Talotti	HB	PM	MSc (Eng)	2012	The Influence of substrate moisture preparation on overlay bond strength.	Graduating Mid-2014
T Dittmer	HB	PM	MSc (Eng)	2012	Crack resistance of concrete subjected to restrained deformation.	Graduated End-2013
L Mutale	HB	MGA	MSc (Eng)	2012	Performance-based tailor made concrete.	Anticipated Graduation Mid-2014
Z Mukadam	MGA	HB	MSc (Eng)	2012	Critical Review of the South African Durability Index Tests, with Possible Improvements.	Graduating Mid-2014
M Loseby	MGA	HB	MSc (Eng)	2012	The effects of aggregate grading and packing on the transport properties of concrete.	Anticipated Graduation 2014
M Vezi	PM	MGA	MSc (Eng)	2012	Behaviour of concrete arch dams.	Graduating Mid-2014
T Dladla	PM	HB	MSc (Eng)	2012	The effect of varying patch sizes on strengthened beams with CFRP.	Anticipated Graduation 2014
S Mundeli	PM	-	MSc (Eng)	2012	Strengthening of Reinforced Concrete Structures.	Graduating Mid-2014
F Mullagee	PM	-	MSc (Eng)	2011	Impact behaviour of strengthened RC structures: Experimental investigation.	Anticipated Graduation 2014
T Townshend	PM	-	MSc (Eng)	2011	Design of footbridges for vibration serviceability.	Graduating Mid-2014
A Ruiters	PM	-	MSc (Eng)	2011	Dynamic behaviour of strengthened RC beams: Numerical study.	Anticipated Graduation 2014
T Mbanjwa	PM	HB	MSc (Eng)	2013	Deterioration Mechanism Analysis of Bridges and Culverts in the Western Cape, South Africa.	Commenced 2013
G Golden	MGA	HB	MSc (Eng)	2013	The Effect of Cyclic Wetting and Drying Regimes on Corrosion Rate in RC Structures.	Commenced 2013

POST GRADUATE STUDENTS 2013
MGA – Mark Alexander; HB – Hans Beushausen; PM – Pilate Moyo; VC – Vernon Collis

Name	Super-visor	Co-super-visor	Degree registered	Year first registered	Title of Research project	Progress on project
N Bester	HB	MGA	MSc (Eng)	2013	The Influence of Curing on Restrained Shrinkage Cracking of Bonded Overlays.	Commenced 2013
M Tsoana	HB	PM	MSc (Eng)	2013	Repair and Service Life Extension of Reinforced Concrete Structures.	Commenced 2013
N Makaring	PM	MGA	MSc (Eng)	2013	Review of Methods of Analysing Safety of Large Concrete Arch Dams.	Commenced 2013
O Alao	MGA	HB	MSc (Eng)	2013	Durability of Reinforced Concrete Structures in Marine Environment – Case Study: Cape Peninsula.	Commenced 2013
Y Amesu	PM	MGA	MSc (Eng)	2013	Fatigue Reliability of Pre-stressed Reinforced Concrete Box-Girder Railway Bridges.	Commenced 2013
P Habimana	PM	HB	MSc (Eng)	2013	Behaviour of FRP Strengthened RC Beams with Concrete Patch Repairs under Impact Loading.	Commenced 2013
E Okwori	PM	MGA	M (Eng)	2013	An Investigation into the Application of Impact Echo Techniques in Non-Destructive Testing of RC Piles/Slender Members.	Commenced 2013
K Emma-Iwuoha	PM	HB	M (Eng)	2013	Developing a Framework for Embodied Energy Assessment of Concrete Rehabilitation Options	Commenced 2013
A Khan	PM	-	M (Eng)	2012	Vibration serviceability of floors: Design guidelines	Graduated end 2013
R Kayonga	PM	-	M (Eng)	2012	Management of railway bridges	Graduated end 2013
W le Roux	PM	-	M (Eng)	2011	Effect partitions on vibration of slender floors	Graduated end 2013
L Leukes	PM	-	M (Eng)	2011	Management of highway bridges using Struman System.	Graduated end 2013
J Kamara	PM	MGA	M (Eng)	2013	Risk-Based Bridge Management Strategies: Literature Review and Synthesis.	Commenced 2013

6.2 Undergraduate students (final year dissertation students in our areas of research)

UNDERGRADUATE STUDENTS 2013 MGA – Mark Alexander; HB – Hans Beushausen; PM – Pilate Moyo			
Name	**Super-visor**	**Degree registered**	**Title of Research project**
D Bartlett	PM	BSc (Eng)	Experimental Modal Analysis and Finite Element Modelling (FEM) of Precast Beam-Slab Composite Structures
C Bedingfield	MGA	BSc (Eng)	Influence of Relative Humidity on Steel Corrosion in RC Structures
C Chibulu	HB	BSc (Eng)	Influence of Fine Fillers on Concrete Overlay Bond Strength
M Coleman	PM	BSc (Eng)	A review of Dynamics-Based Damage Detection in Composites
M Dalton	HB	BSc (Eng)	The Influence of Concrete Mix Parameters on Durability Indexes
W Galvaan	MGA	BSc (Eng)	Influence of Relative Humidity on Steel Corrosion in RC Structures
S Maharaj	MGA	BSc (Eng)	Technical and Economic Optimisation of Use of Admixtures with Western Cape Binders
D Manning	MGA	BSc (Eng)	Investigation of Different Methods of Measuring Porosity in Cement-Based Materials (not completed)
T Martinez	HB	BSc (Eng)	The Influence of Curing on Strength and Permeability of Concrete
M Masamba	PM	BSc (Eng)	A Fatigue Life Assessment of the Olifants River Bridge
R McKinley	HB	BSc (Eng)	The Influence of Curing on Strength and Permeability of Concrete
K Moyaba	MGA	BSc (Eng)	Concrete Design for Sustainability in Residential and Small Commercial Buildings – How Can 'structural Form' Contribute to Better Solutions?
C Naidoo	HB	BSc (Eng)	Evaluating the Quality of Concrete Construction in UCT's New Engineering Building
A Robinson	PM	BSc (Eng)	Comparison of the South African Bridge Design Code with Eurocode, using Traffic Loading
M Senthumule	MGA	BSc (Eng)	Technical and Economic Optimisation of Use of Admixtures with Western Cape Binders
R Talotti	HB	BSc (Eng)	Engineering Properties of Commercial Patch Repair Materials
T Thuku	HB	BSc (Eng)	Durability Properties of Commercial Patch Repair Materials
A v d Merwe	MGA	BSc (Eng)	Rainwater Harvesting in an Industrial Area of Cape Town
W v d Westhuizen	MGA	BSc (Eng)	Thermal Properties of Cements

UNDERGRADUATE STUDENTS 2013 MGA – Mark Alexander; HB – Hans Beushausen; PM – Pilate Moyo			
Name	**Super-visor**	**Degree registered**	**Title of Research project**
B Wang	PM	BSc (Eng)	Damage Detection of Steel Frame Structure by Modal Testing
N Waters	HB	BSc (Eng)	Testing the Compressive Strength of Existing Structures: Influence of Core Sample Dimensions on Strength Results
A Welihockyj	PM	BSc (Eng)	Dynamic Loading of the Kalbaskraal Railway Bridge FE Model
R Wylie	PM	BSc (Eng)	Research into the Structural Properties of Repaired Structures

7 PUBLICATIONS 2013

SUMMARY OF PUBLICATION STATISTICS

Year	TOTAL	Refereed Journals	Books/ Chapters	International Conferences	Other Outputs	Accepted/Submitted For publication
2013	24	8	1	9	1	5
2012	33	10	2	15	1	5
2011	44	13	5	9	3	14

7.1 Books

ALEXANDER, M.G., BERTRON, A., and DE BELIE, N. (Eds.). Performance of Cement-Based Materials in Aggressive Aqueous Environments. State-of-the-Art Report, RILEM TC 211 – PAE. Springer, 2013, 449 pp.

7.2 Refereed/peer reviewed journals

GITHACHURI. K. and ALEXANDER, M.G. "Durability performance potential and strength of blended portland limestone cement concrete". Cement and Concrete Composites, Vol 39, May 2013, pp. 115-121.
(Online March 2013, http://dx/doi.org/10.1016/j.cemconcomp.2013.03.027)

NGANGA, G., ALEXANDER, M.G. and BEUSHAUSEN, H. "Practical implementation of the durability index performance-based design approach". Construction and Building Materials. Construction and Building Materials. Vol 45, (2013) pp. 251-261.
(DOI information: 10.1016/j.conbuildmat.2013.03.069.)
(Online 6 May 2013, at: http://authors.elsevier.com/sd/article/S0950061813002791).

MUIGAI, R., ALEXANDER, M.G., and MOYO, P. "Cradle-to-Factory Gate Environmental Impacts of the Concrete Industry in South Africa". SAICE Journal, Vol 55 (2), Aug 2013, pp. 2-7.

OTIENO, M.B., BEUSHAUSEN, H. and ALEXANDER, M.G. "Effect of chemical composition of slag on chloride penetration resistance of concrete". Cement and Concrete Composites, (2013). DOI 10.1016/j.cemconcomp.2013.11.003.
http://www.sciencedirect.com/science/article/pii/S0958946513001807

GAYLARD, P.C., BALLIM, Y. and FATTI, L.P. "A model for the drying shrinkage of South African concretes". Journal of SAICE, Vol 55(1), April 2013, pp. 45-59.

NGANGA, G. and GOUWS, S.M. "The oxygen permeability index test: its application and addressing the variability issues". Concrete Beton (Jnl. of CSSA), No. 134, Aug 2013, pp. 6-12.

GAYLARD, P.C., FATTI, L.P. and BALLIM, Y. "Statistical modelling of the shrinkage behaviour of South African concretes". Accepted for publication, S A Statistical Journal, 15 November, 2013.

BEUSHAUSEN, H. and CHILWESA, M. "Assessment and prediction of drying shrinkage cracking in bonded mortar overlays". Cement and Concrete Research, Vol 53, 2013, pp. 256-266.

7.3 Proceedings of refereed international conferences

MUIGAI, R.M. and ALEXANDER, M.G. "A review of performance-based sustainability design method for concrete structures". Proceedings, 1st Int. Conference on Concrete Sustainability, Japan, May 2013.

KABANI, M., MOYO, P. and ALEXANDER, M. "Challenges in reliability based bridge life-cycle management". 11th International Conference on Structural Safety and Reliability, New York, June 2013.

MOYO, P., HATTINGH, L. and OOSTHUIZEN, C. "Ambient vibration measurements at Kouga dam – getting much more information than expected". ICOLD 2013 International Symposium, Seattle, Washington, August 2013, pp. 2507-2514. ISBN 978-1-884575-63-1.

MOYO, P., HATTINGH, L. and OOSTHUIZEN, C. "Dynamic based condition assessment of reinforced Concrete bridges over dam spillways". ICOLD 2013 International Symposium, Seattle, Washington, August 2013, pp. 372-379. ISBN 978-1-884575-63-1.

VEZI, M.M., MOYO, P. and OOSTHUIZEN, C. "Dynamic modelling of arch dams in the ambient state". SANCOLD 2013, Thaba 'Nchu, South Africa, November 2013, pp. 230-238. ISBN 978-0-7972-1463-7.

BUKENYA, P., MOYO, P. and OOSTHUIZEN, C. "Experimental modal identification of a South African concrete arch dam". 5th International Conference on Experimental Vibration Analysis for Civil Engineering Structures, Ouro Preto, Brazil, October 2013, pp. 133-138.

ALEXANDER, M. and SANTHANAM M. "Achieving durability in reinforced concrete structures: durability indices, durability design and performance-based specifications". Keynote paper at International Conferences on Advances in Building Sciences & Rehabilitation and Restoration of Structures, Feb 2013, IIT Madras, Chennai, India, 21pp.

BALLIM, Y. "Case studies in the use of optical microscopy for diagnosis of concrete damage and deterioration". International Conferences on Advances in Building Sciences & Rehabilitation and Restoration of Structures, Feb 2013, IIT Madras, Chennai, India, pp. 45-59.

ALEXANDER, M.G. and NGANGA, G. 'Reinforced concrete durability: some recent developments in performance-based approaches". Keynote paper, ISCC 2013 (International Seminar on Cement and Concrete), Nanjing, China, September 2013, 13 pp.

7.4 Proceedings of other conferences and symposia

NGANGA, G. and ALEXANDER, M.G. "Practical application of on-site durability testing for RC structures". ACCTA Conference (International Conference on Advances in Cement and Concrete Technology in Africa 2013), Emperor's Palace, Gauteng, Jan. 2013.

ARITO, P., BEUSHAUSEN, H., ALEXANDER, M.G. and OTIENO, M. "The use of sacrificial anodes in extending the service life of RC structures in South Africa". ACCTA Conference (International Conference on Advances in Cement and Concrete Technology in Africa 2013), Emperor's Palace, Gauteng, Jan. 2013.

Oral Presentations:

ALEXANDER, M.G. "Corrosion in reinforced concrete – aspects of cracking, durability, and service life". Anna Maria XIV Workshop, Holmes Beach, Florida, November 2013.

ALEXANDER, M.G. and KILISWA, M. "Performance testing and specification of concrete". TECON Seminar, Concrete Society of Southern Africa, October 2013.

ALEXANDER, M.G. Presentations on corrosion inhibitors, durability specifications, and carbonation at Workshop on Concrete Durability, IIT Madras, Chennai, India, February 2013.

ALEXANDER, M.G. and MUIGAI, R. "Performance-based durability design and sustainability". Presented at Totally Concrete Expo, Sandton, June 2013.

7.5 Papers accepted or submitted for publication or presentation:

BEUSHAUSEN, H. and BURMEISTER N. "The use of surface coatings to increase the service life of reinforced concrete structures for durability class XC". Submitted April 2013 to Materials and Structures, accepted July 2013.

BEUSHAUSEN, H, GILLMER, M and ALEXANDER, M. "The influence of superabsorbent polymers on strength and durability properties of blended cement mortars". Submitted April 2013 to Cement and Concrete Composites, accepted 2014.

BEUSHAUSEN, H, GILLMER, M and ALEXANDER, M. "The use of superabsorbent polymers to reduce cracking of bonded mortar overlays". Submitted April 2013 to Cement and Concrete Composites, accepted 2014.

OTIENO, M.B., ARITO, P., BEUSHAUSEN, H. and ALEXANDER, M. "Corrosion propagation of steel in concrete – induction and sustenance". Submitted 2013 to ACI Materials Journal.

OTIENO, M.B., ALEXANDER, M. and BEUSHAUSEN, H. "Resistivity versus corrosion risk in cracked RC structures". Submitted 2013 to ACI Materials Journal.

MUIGAI, R., ALEXANDER, M. and MOYO, P. "A review of life-cycle assessment studies on concrete frame buildings". Renewable and sustainable energy reviews, 2013. RSER-D-12-00160R1.

8 AWARDS, PRIZES, AND APPOINTMENTS DURING 2013

Prof Alexander is President of RILEM (International Union of Laboratories and Experts in Construction Materials, Systems and Structures, France) for 2012-2015.

Mr Mike Otieno, PhD student and Carnegie research scholar, was appointed to a lectureship at the University of the Witwatersrand from March 2014.

Dr Chris Oosthuizen (Panel Member) is currently Chairman of the ICOLD Technical Committee on Dam Surveillance. He received the SANCOLD 2013 Award for an outstanding contribution to Dam Engineering in South Africa.

Dr Sifiso Nhleko was awarded the C V Raman International Fellowship for African Researchers, by the Indian Ministry of Science and Technology.

Mr Mfundo Vezi, a Masters student in CoMSIRU, attended the South African National Committee on Large Dams (SANCOLD) conference in November, 2013. He was the recipient of the SANCOLD award for the best paper prepared and presented by a young engineer.

9 RESEARCH IMPACTS AND RESEARCH HIGHLIGHTS FOR YEAR UNDER REVIEW

9.1 Durability test methods

Durability test methods that have been under research development for more than a decade are now within the SABS system for acceptance as national standards.

9.2 Number of student graduates and publications

There have been an excellent number of student graduates and publication outputs over the past year, as can be seen under the relevant headings.

9.3 New approaches

New approaches from the research continue to be used in major national construction projects. For example: the structural health monitoring work is now being used in evaluating a growing number of large concrete dams; evaluation and strengthening of major railway bridge infrastructure is being brought into the research effort; deterioration and durability studies are increasingly being carried out on affected infrastructure.

9.4 The State-of-the-Art-Report of RILEM TC-230 (Chaired by Associate Prof Hans Beushausen) on performance based specifications for concrete durability will be published in 2014, summarizing developments in performance-based design approaches worldwide. This document is intended to serve as a reference guide for development and application of durability specifications.

10 COLLABORATIONS AND LINKAGES

CoMSIRU has strong links with the University of the Witwatersrand. A portion of the research programme is jointly administered with Wits University and certain joint funding arrangements exist.

CoMSIRU also has strong links with the University of Stellenbosch through students undertaking courses at UCT and Stellenbosch (movement both ways), and via research links.

10.1 International Collaborations

Prof Santhanam from IIT Madras is an Honorary Research Associate of CoMSIRU. Visits by researchers between IIT Madras and UCT are regularly undertaken. Co-supervision arrangements are also in place. Student exchanges are beginning to occur. IIT Madras has significant strengths in analytical areas that UCT finds valuable.

Prof A Bentur, Technion, Haifa, Israel. A new Student and Staff Exchange Agreement is now in place between CoMSIRU and Technion in Israel, having been negotiated in 2011-12. The first two UCT students took up these arrangements in late 2012/2013. Prof Bentur also teaches on our PG courses occasionally.

Prof Oded Rabinovitch, Technion, Haifa, Israel. A new link has been established between CoMSIRU and Technion in Israel, specific to Structural Integrity research.

Prof Steffen Marx, University of Hanover Germany. A new link has been established between CoMSIRU and University of Hanover.

Other active international collaborations are:

Prof	Karen Scrivener	EPFL Lausanne	Lausanne
Prof	Sidney Mindess	UBC	Vancouver
Prof	Douglas Hooton	University of Toronto	Toronto
Prof	Frank Dehn	MFPA	University of Leipzig
Dr	Peter Taylor	Iowa State University	Iowa
Prof	James Brownjohn	University of Sheffield	UK
Dr	Giovanna Concu	University of Cagliari	Italy
Prof	Oded Rabinovitch	Technion	Israel
Prof	Barbara De Nicolo	University of Cagliari	Italy
Prof	Alvaro Cuhna	University of Porto	Portugal

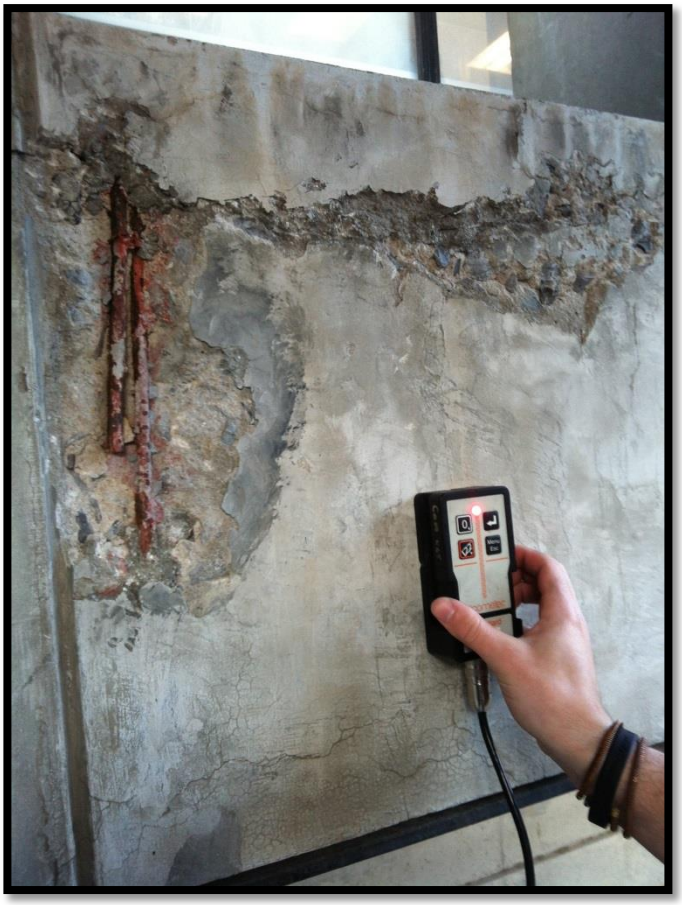
10.2 Visiting Scholars and Researchers

Professor Karen Scrivener of EPFL, Switzerland, visited CoMSIRU in January 2013 and gave a one-day CPD course on cement chemistry, well-supported by Industry.

Professor Alexander Taffe of BAM, Berlin, Germany, visited CoMSIRU in January 2013 and presented one-day workshops on non-destructive testing of concrete structures in Cape Town, Johannesburg and Durban.

Professor Steffen Marx of TU Hanover, Germany, visited CoMSIRU in February 2013 and presented two-day workshops on the design of concrete bridges in Cape Town, Johannesburg and Durban.

Professor Joost Walraven of TU Delft, the Netherlands, visited CoMSIRU in February 2013 and presented two-day workshops on the design of precast concrete structures in Cape Town, Johannesburg and Durban.



10.3 Industrial Linkages

	Industrial linkages	Personal contact	Nature of Linkage
1.	Cement Industry, via TCI	Mr B. Perrie, other TCI staff, Ms M. De Jager (Library), and Information Centre	Personal contact is maintained. C&CI closed at the beginning of 2013 and was replaced by TCI.
2.	PPC	Mr E Auger, Mr S Crosswell	Personal contact is maintained. One of our THRIP Industry Partners.
3.	ESKOM	Mr T Courtney	Personal contact is maintained. Contact is had with other ESKOM staff when particular problems arise.
4.	Dept. of Water Affairs	Dr C Oosthuizen	Research on dam safety.
5.	AfriSam	Mr M McDonald	Regular contact is had directly with the Cement Company, in order to review their needs and help set priorities.
6.	Water Research Commission	Mr W Nomquphu	Research on dam safety.
7	Sika	Mr W Smithers, Mr P Adams	Sika is sponsoring projects on the performance of protective coatings for concrete structures in UCT.
8.	Lafarge	Mr Craig Mills Mr Sibu Hlatshwayo, Mr Des Maharaj	Regular contact is had directly with the Cement Company, in order to review their needs and help set priorities.
9.	Sephaku	Mr Pieter Fourie, Mr Hennie van Heerden	Regular contact is had directly with the Cement Company, in order to review their needs and help set priorities.
10.	Transnet	Mr Josiah Mpofu	Research on railway bridges and structures.
11.	NNR	Dr. Sifiso Nhleko	Research on nuclear structures.
12.	Misc. Consultancies, Contractors, Public Authorities	Various	Queries, specialist lab work, limited consultancies carried out.

11 CONFERENCES, WORKSHOPS, SEMINARS

CONFERENCES/WORKSHOPS/TRAINING SEMINARS ORGANISED/ATTENDED OVER THE LAST YEAR.			
Year	**Organiser (O)/ Attendee (A)**	**Title of Conference/ workshop/seminar & Venue**	**No of Attendees**
2013	MGA/YB (A)	International Conference on Advances in Building Science and Rehabilitation and Restoration of Structures, Feb. 2013, IIT Madras, Chennai, India.	250
2013	MGA(A)	Keynote paper, ISCC 2013 (International Seminar on Cement and Concrete), Nanjing, China, September 2013.	400
2013	MGA/GN/PA (A)	ACCTA Conference (International Conference on Advances in Cement and Concrete Technology in Africa 2013), Emperor's Palace, Gauteng, Jan. 2013.	150
2013	MGA (A)	Anna Maria XIV Workshop, Holmes Beach, Florida, November 2013.	45
2013	MGA/MK (A)	TECON Seminar, Concrete Society of Southern Africa. October 2013 (4 main centres)	250
2013	MGA/YB (A)	Workshop on Concrete Durability, IIT Madras, Chennai, India, Feb. 2013.	100
2013	MGA/PM (A)	Totally Concrete Expo, Sandton, June, 2013.	80
2013	MGA/MO (O)	Corrosion of Steel in Reinforced Concrete: Influence of Cover Cracking and Concrete Quality, Cape Town, June 2013.	140
2013	HB (O)	Design Principles for Precast Concrete Structures, JHB/DBN/CT, February 2013.	200
2013	MGA (O)	Cement Chemistry for Engineers, Cape Town, February 2013.	50

CONFERENCES/WORKSHOPS/TRAINING SEMINARS ORGANISED/ATTENDED OVER THE LAST YEAR.			
2013	PM (A)	SANCOLD 2013, Thaba 'Nchu, South Africa, November 2013.	250
2013	PM (A)	5th International Conference on Experimental Vibration Analysis for Civil Engineering Structures, Ouro Preto, Brazil, October 2013.	400
2013	PM (A)	ICOLD 2013, International Symposium, Seattle, Washington, August 2013.	1000
2013	PM (O)	Strengthening of Existing Concrete structures using FRP.	100

12 ACTIVITIES OF AND COLLABORATION WITH HRAs

CoMSIRU has three Honorary Research Associates:

Prof Manu Santhanam, Department of Civil Engineering, IIT Madras, Chennai, India

Prof Santhanam spent a sabbatical period of 6 months at UCT in 2010. During this period, he worked with us on aspects specifically related to durability performance-based specifications, and provided valuable input for the current revision of SANS 10100. He also interacted extensively with the postgraduate students. Currently, he is a co-supervisor for an MSc project on particle packing and its influence on concrete durability.

Mr Vernon Collis, Independent Consultant, Cape Town

Mr Collis provides much of the intellectual background to the projects on sustainability being undertaken in CoMSIRU. He co-supervises several MSc students, as well as providing oversight and supervision to several final year thesis students. Through his practical work, he also feeds in opportunities for students and staff to be involved in unusual external work.

Dr Sifiso Nhleko, National Nuclear Regulator

Dr Nhleko holds a BSc (Honours) degree in Civil Engineering, as well as an MSc degree in Structural Engineering, both received from the University of Cape Town. In 2008 he joined the Department of Engineering Science at the University of Oxford, where he obtained his PhD in the field of Structural Dynamics. He is currently employed by the National Nuclear Regulator of South Africa, as a Civil and Structural Engineer.

13 LAB AND OTHER EXTERNAL WORK UNDERTAKEN

Major external work carried out by Prof Alexander in 2013, included, *inter alia*:

- Conclusion of work on the shotcrete linings of the Gautrain Tunnel, with a successful arbitration
- Input into several contracts for windfarms, specifically temperature issues in large concrete bases
- Work for Lafarge Mauritius on aspects of their concrete mixes and materials

Prof Moyo regularly consults industry on vibration problems, integrity assessment finite element modelling and calibration.

A/Prof Beushausen is very active in a wide range of external work – much of it related to durability assessments, structural evaluations, and development of repair and maintenance strategies for reinforced concrete structures. Much of this work is also channelled through the laboratory with PG students being involved.

14 CIVIL INFRASTRUCTURE MANAGEMENT AND MAINTENANCE PROGRAMME

The Department of Civil Engineering, via CoMSIRU, launched a new postgraduate specialisation programme in *Civil Infrastructure Management and Maintenance (CIMM)* in February 2013. The programme offers a broad suite of knowledge and skills including asset management, project management, maintenance, repair and rehabilitation of civil infrastructure. This programme accords with the South African Government's Immoveable Asset Management Act of 2007, the South African Government National Development Plan, vision 2013 and National Infrastructure Maintenance Strategies proposed by the Department of Works, 2006, the Department of Water Affairs, 2008, and the Department of Transport, 2008.

The program seeks to train high level human recourses [MSc, MEng and PhD] to address human capital shortages in this area. This should stimulate research and development in Infrastructure Management and maintenance, leading to innovative solutions to address challenges associated with infrastructure management and maintenance. Thus there is potential to create jobs in this sector as the number of professionals and innovative solutions grow. To date a total of 18 postgraduate students: 3 MSc(Eng) and 15 MEng students (by coursework) have registered on the programme. In addition there are more than 40 students enrolled in CIMM courses for continuing professional development (CPD).

The following courses were offered in 2013:

CIV5116Z: Durability & Condition Assessment of Concrete Structures

CON5016Z Project Planning and Implementation

CIV5067Z: Advanced Infrastructure Management

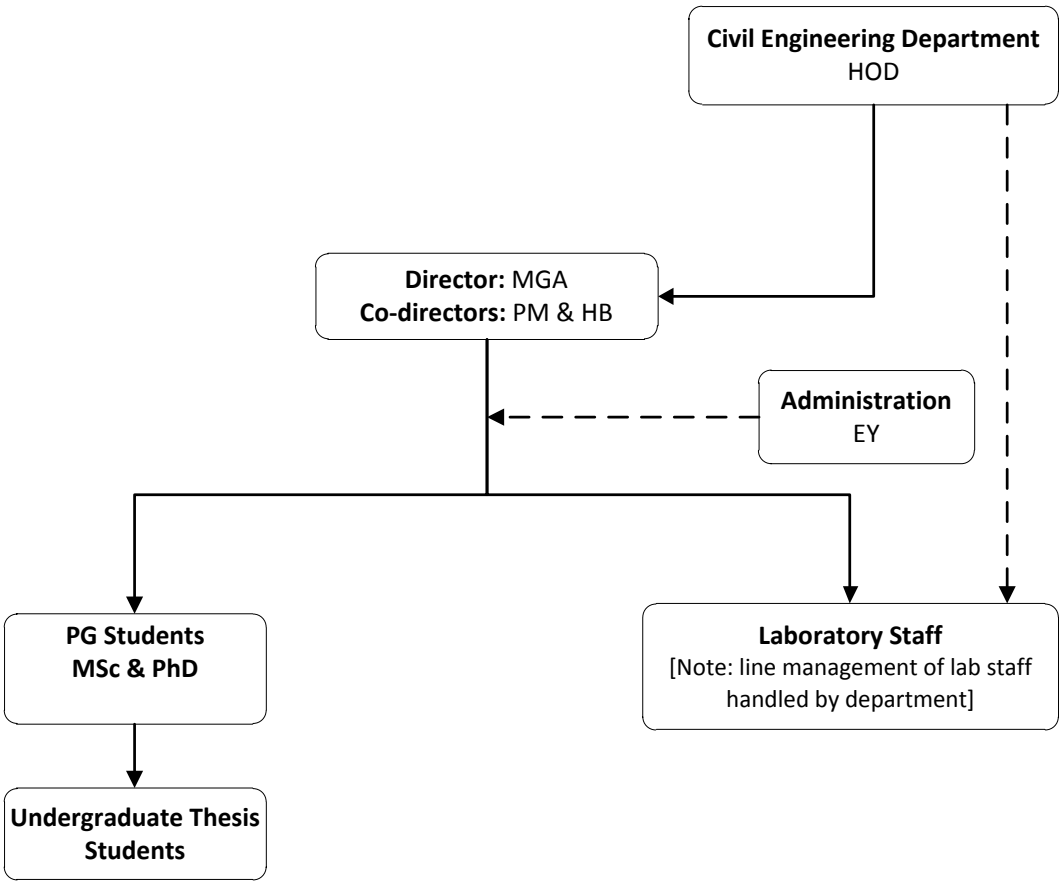
CIV5115Z: Bridge Management & Maintenance

15 ORGANISATIONAL ARRANGEMENTS

15.1 Governance

CoMSIRU is overseen by its three directors, Professor M Alexander, Professor P Moyo and Assoc Professor H Beushausen. Regular meetings are held by these three directors to discuss teaching, research, administration and budget issues. CoMSIRU is serviced administratively and financially by a Research Administrative Finance Officer, Ms E Yelverton.

15.2 Organogram



15.3 Staff active in the research unit for 2013

Prof M G Alexander (Team Leader); Prof P Moyo; A/Prof H-D Beushausen; Mr V Collis (Pr. Eng, Hon. Res Assoc.); Prof M Santhanam (Indian Institute of Technology Madras); Dr S Nhleko (National Nuclear Regulator) Mr C May, Mr L Adams and Mr D Ferus (Laboratory Assistants); Ms E Yelverton (Research Administrative Finance Officer).

15.4 Staffing challenges

Elly Yelverton will be retiring at the end of 2014 and Mark Alexander at the end of 2015. Plans need to be put in place to have a smooth transition, with a minimal amount of disruption. The appointment of a part-time administration assistant and a full-time laboratory assistant have assisted greatly in coping with the increase in workload over the past years, due to the larger intake of students.

16 MAJOR FUTURE RISKS/OPPORTUNITIES

16.1 Risks

Risks to CoMSIRU in the coming years encompass: staffing changes (retirement of Prof Mark Alexander and Ms Elly Yelverton); Civil Eng. Department decisions about staff appointments, in particular to fill Prof Alexander's post; sustained funding from our major funders, and also additional funders currently being approached (mainly construction companies); and possible prolonged downturn in the civil engineering and construction industries.

16.2 Opportunities

Opportunities involve: expansion of the CIMM Programme (subject to staffing continuity); expansion of involvement of postdoc students in CoMSIRU; expansion of laboratory capacity to handle increasing external work from industry; and possibility to rejuvenate the staffing if Prof Alexander's post is filled in the areas of CoMSIRU.

17 FINANCIAL STATEMENT 2013

INCOME AND EXPENDITURE 2013

Balance as at 1 January 2013 **R 2,075,140**

INCOME Source	Bursaries	Running Expenses	Total
Investment Fund (Interest)	R 0	R 12,620	R 12,620
TCI	R 0	R 53,980	R 53,980
TESP	R 119,140	R 105,860	R 225,000
SIKA	R 37,500	R 32,500	R 70,000
AfriSam	R 0	R 800,000	R 800,000
PPC	R 182,350	R 817,650	R 1,000,000
THRIP*	R 0	R 11,380	R 11,380
Transnet	R 0	R 1,200,000	R 1,200,000
WRC	R 250,000	R 227,800	R 477,800
NRF	R 100,000	R 40,000	R 140,000
URC	R 97,500	R 164,000	R 261,500
UEC/DHE Equipment Grant	R 0	R 3,500,000	R 3,500,000
Non-CoMSIRU Units contrib. to admin	R 0	R 22,400	R 22,400
Industry (Lab work)	R 282,570	R 1,109,530	R 1,392,100
Courses/Workshops	R 0	R 54,950	R 54,950
TOTAL	**R 1,069,060**	**R 8,152,670**	**R 9,221,730**

***THRIP cannot be used for bursaries - shortfall in bursaries paid via HR using income from industry (lab) work**

EXPENDITURE

Description	Total
Bursaries	R 786,490
Assets (Equipment)	R 4,874,040
Salaries (student bursary top-up via HR)	R 681,950
Consultancy (academics payments via HR)/Subventions	R 633,540
Admin Asst/Finance Officer/Lab Staff	R 360,340
Computers/Computer consumables	R 86,610
Equipment & Repairs	R 105,930
Chemicals/Workshop Sundries	R 179,310
Stationery/Telephone/Postage/Printing	R 115,790
Local Airfare	R 71,110
Local Subsistence and Travel	R 73,440
Foreign Airfare	R 201,410
Foreign Subsistence and Travel	R 250,500
Bakkie/Vehicle hire	R 94,060
Refreshments/Entertainment	R 55,570
Cost Recovery	R 453,240
Other (Books, Memberships, Conference Venue Hire, Miscellaneous)	R 126,780
TOTAL	**R 9,150,110**
SURPLUS/DEFICIT	**R71,620**
Add funds carried forward from 2012	**R 2,075,140**

Balance as at 31 December 2013 **R 2,146,760**

18 BUDGET FOR 2014

BUDGET 2014

Balance as at 1 January 2014 **R 2,146,760**

INCOME Source	Bursaries	Running Expenses	Total
Investment Fund (Interest)	R 0	R 40,000	R 40,000
TCI	R 0	R1,000,000	R1,000,000
TESP	R 0	R 100,000	R 100,000
SIKA	R 30,000	R 40,000	R 70,000
PPC	R 300,000	R 700,000	R 1,000,000
THRIP*	R 0	R 400,000	R 400,000
Transnet	R 0	R 1,200,000	R 1,200,000
WRC	R 150,000	R 100,000	R 250,000
NRF	R 100,000	R 60,000	R 160,000
URC/EBE	R 80,000	R 100,000	R 180,000
Non-CoMSIRU Units contrib. to admin	R 0	R 25,000	R 25,000
Industry (Lab work)	R 450,000	R 900,000	R 1,350,000
Courses/Workshops	R 0	R 55,000	R 55,000
TOTAL	**R 1,110,000**	**R 4,720,000**	**R 5,830,000**

EXPENDITURE

Description	Total
Bursaries	R 660,000
Assets (Equipment)	R 750,000
Salaries (student bursary top-up via HR)	R 850,000
Consultancy (academics payments via HR)/Post Docs/Subventions	R 1,130,000
Admin Asst/ Finance Officer/Lab Staff	R 568,000
Computers/Computer consumables	R 70,000
Equipment & Repairs	R 130,000
Chemicals/Workshop Sundries	R 200,000
Stationery/Telephone/Postage/Printing	R 100,000
Local Airfare	R 70,000
Local Subsistence and Travel	R 75,000
Foreign Airfare	R 250,000
Foreign Subsistence and Travel	R 250,000
Bakkie/Vehicle hire	R 100,000
Refreshments/Entertainment	R 65,000
Cost Recovery	R 500,000
Other (Books, Memberships, Conferences, Miscellaneous)	R 130,000
TOTAL	**R 5,898,000**
SURPLUS/DEFICIT	**-R 68,000**
Add funds carried forward from 2013	**R 2,146,760**

Balance as at 31 December 2014 **R 2,078,760**

19 APPENDICES

Eight post graduate students graduated during 2013. A condensed version of their research as represented by Abstracts from their theses is available on the CoMSIRU website www.**comsiru**.uct.ac.za/. The dissertation titles are:

NAME	TITLE
Matteo Angelucci	Mix Design Optimisation – The Effect of Mix Design Parameters and Mixture Properties on Concrete Durability.
Thomas Dittmer	Crack resistance of concrete subjected to restrained deformation.
Justine Kessey	Assessing the age at cracking of concrete repair mortars/overlays subjected to restrained drying shrinkage
Emmanuel Leo	Dynamic performance of concrete-concrete composite bridges.
Nicholas Kizito	Prediction and testing of tensile relaxation of concrete.
Mbongeni Nzuza	Thermo-mechanical modelling of arch dams for performance assessment.
Simon Starck	The Integration of Non-destructive Test Methods in the South African Durability Index Approach.
Kyle Wickins	The use of construction and demolition waste in the Cape Peninsula.