Structural Engineering and Civil Informatics Research Topics 2024

Supervisor(s)	Degree	Preliminary title of research project	Brief description of project	Scholarship per year
Dr Jacques Kruger	MEng[R]	3DPC interfacial improvement towards watertightness	Develop, test and confirm strategies for improved, watertight 3DCP interfaces for durable water retaining structures.	Funding might become available for MEng[R].
Dr Jacques Kruger	MEng[R]/PhD	Maximise the strength-to-weight ratio of 3DPC elements	Improve the structural performance of 3DPC elements while reducing their weight. Develop innovative strategies, concepts, and methods and apply these to large-scale experimental tests for validation. This project is envisaged for upgrade to PhD.	Funding might become available for MEng[R]/PhD.
Dr Jacques Kruger	MEng[R]/PhD	Facilitate the certification process of 3DPC houses in South Africa	3DPC is a new building technology with an adapted concrete material. Existing design and building codes are therefore not applicable to 3DPC houses. Work together with regulatory bodies in RSA to develop documentation toward facilitating certification of 3DPC houses. Validate proffered solutions with laboratory tests. This study could be upgraded to a PhD.	Funding might become available for MEng[R]/PhD.
Dr Jacques Kruger	MEng[R]	Investigate the effects of vertical pumping height on 3DPC material properties	3DPC buildings are increasingly becoming taller as printing machines increase in size. Investigate what effect pumping to > 10 m heights has on a 3DPC material's properties. This study involves printing on the engineering building's roof (and possibly the highest in the world to date).	Funding might become available for MEng[R].
Prof GPAG van Zijl, Dr Humaira Fataar	MEng[R]	Integral bridge soil-structure interaction	Be part of the team performing a SANRAL research project on integral RC bridges. This M-project will follow up on an M on numerical modelling and requires nonlinear finite element modelling. From the models and their agreement with an instrumented bridge, and scaled physical experiments performed at U Pretoria, derive design recommendations for abutment backfill soil type, and modelling considerations for their design.	R 100,000
Prof GPAG van Zijl, Dr AS van Rooyen	MEng[R]	Concrete Durability Design - investigation of resistivity as in-situ vs laboratory testing	Develop, as part of the team performing a SANRAL durability research project, a simpler in-situ test than laboratory tests currently performed to assess the structural durability of infrastructure. Build a data base of Resistivity and Chloride Conductivity Index (CCI) readings on reinforced concrete structures in SA, and internationally. Perform in-situ resistivity measurements as well as laboratory CCI tests on specimens collected from SA coastal infrastructure, and study the correlation between these results to establish the accuracy of resistivity-based test methods for design against chloride-induced reinforcement corrosion. Perform a laboratory test program to enrich the test data.	R 100 000
Prof GPAG van Zijl, Dr PJ Kruger	MEng[R]	Durability of 3D printed concrete	Work with an international 3DPC construction company that has printed schools and housing developments in Africa on durability of these structures. Current focus in this emerging construction technology is on reducing the cost and ecological impact of the printable concrete, exploring larger filler/aggregate content from waste sources including construction and demolition waste, and alternative binders from agricultural or manufacturing industry waste streams. Long term stability of these concretes must be investigated, through accelerated durability testing, and field monitoring of existing structures.	R100 000+ to be confirmed by sponsor
Prof GPAG van Zijl, Dr WI de Villiers	MEng[R]	3D printed concrete design standard chapter for *SANS51992 The design of concrete structures*	Eurocode 2 is currently in process of being adopted as South African Standard for the design of concrete structures, SANS51992-1-1. Refer to *Chapter 10 Additional rules for precast concrete elements and structures* to develop Additional rules for 3D printed concrete elements and structures for the near future extension of SANS51992-1-1 to include 3DPC.	R100 000
Prof AJ Babafemi, Dr WI de Villiers	MEng[R]	Construction circularity: Construction and demolition waste in 3D printed concrete.	Develop 3D printed concrete mixes with similar aggregate volume fraction as conventional concrete. Then, replace the natural sand with construction and demolition waste. 3DPC currently has higher water and binder content than conventional concrete, hence it is more expensive. The lower aggregate content causes lower elastic modulus, and higher shrinkage and creep.	R110 000 Department of Science and Innovation bursary per year for South African students
Prof T Haas, Dr AS van Rooyen	MEng [R] / PhD	Determining the effect of replacing concrete with "alternative" concrete for **circular** slender double skinned tubular columns subjected to eccentric loading.	Concrete Filled Double Skin Tubular (CFDST) columns can be used to enhance the construction process and is also a viable alternative in seismic prone areas. The aim is to evaluate the effects of using "alternative" concrete [i.e. alkali actived material / geopolimers, lightweight foamed concrete] on the mechanical performance of the **circular** slender CFDST columns subjetced to eccentric loading. The research will be conducted using experimental and FE analysis.	TBC

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Prof T Haas, Dr AS van Rooyen	MEng [R] / PhD	Determining the effect of replacing concrete with "alternative" concrete for **rectangular** slender double skinned tubular columns subjected to eccentric loading.	Concrete Filled Double Skin Tubular (CFDST) columns can be used to enhance the construction process and is also a viable alternative in seismic prone areas. The aim is to evaluate the effects of using "alternative" concrete [i.e. alkali actived material / geopolimers, lightweight foamed concrete] on the mechanical performance of the **rectangular** slender CFDST columns subjetced to eccentric loading. The research will be conducted using experimental and FE analysis.	TBC
Prof T Haas	MEng [R] / PhD	Evaluating the effect of eccentric loading on **circular** slender Concrete Filled Double Skin Tubular columns strenghtened with carbon fibre reinforced polymers.	The strength of Concrete Filled Double Skin Tubular (CFDST) columns can be significantly enhanced rapping the outer tube with carbon fibre reinforced polymers (CFRP). Limited research is availble on the enhancement when the load is concentric, while no published work is available on eccentric loading of **circular** slender CFDST columns strengthened with CFRP. The research will be conducted using experimental and FE analysis.	TBC
Prof T Haas	MEng [R] / PhD	Evaluating the effect of eccentric loading on **recangular** slender Concrete Filled Double Skin Tubular columns strenghtened with carbon fibre reinforced polymers.	The strength of Concrete Filled Double Skin Tubular (CFDST) columns can be significantly enhanced rapping the outer tube with carbon fibre reinforced polymers (CFRP). Limited research is availble on the enhancement when the load is concentric, while no published work is available on eccentric loading of **rectangular** slender CFDST columns strengthened with CFRP. The research will be conducted using experimental and FE analysis.	TBC
Prof T Haas	MEng [R] / PhD	Quantifying the potential risk of a moderate seismic event on infrastructure in earthquake prone regions in South Africa.	A significant number of insfrastructure in South Africa were either designed prior to the 1st seismic provision (SABS 0160-1980) or designed thereafter but did not consider the effects of seismicity for various reasons. This places these infrastructure at risk when subjected to a moderate intensity earthquake. The aim is to evaluate a number of different infrastructure to evaluate whether it meants the codified requirements; i.e. SANS 10160-4:2017	TBC
Prof T Haas / Prof J Babfemi	MEng [R] / PhD	Determining the robustness of 3D printed concrete structures when subjected to seismicity.	Steel reinforcement in reinforced concrete structures absorb the tensile forces when subjected to lateral forces. The absence of tensile reinforcement in 3D printed concrete, may compromise the abilty of these structures to resist lateral forces arising from earthquake loading. It is anticipated to study the behaviour of 3D printed concrete structures through experimental and FE analysis when these structures are subjected to various acceleration ground motions.	TBC
Prof GPAG van Zijl	MEng [S]	Alkali-silica reaction affected concrete stadium structural assessment	ASR is a well-documented deterioration process in concrete. Prevention or limitation is possible through appropriate concrete mix design. Affected structures, designed and constructed globally before guidelines to prevent/limit ASR were published, are to be monitored regularly. Given significant impact on concrete strength and stiffness, altered structural response to loading actions is expected. Stadiums, designed to avoid natural vibrational frequencies to avoid excessive accelerations leading to human discomfort, must be re-analysed given their evolving mechanical properties. Perform condition assessment on an affected local reinforced or post-tensioned concrete stadium, including the analysis of structural dynamic response to spectator dynamic loads.	
Prof GPAG van Zijl	MEng [S]	Fibre-reinforced concrete practise and performance in South Africa	After roughly half a century of research and, increasingly, application of FRC, structural design standards are slow to include design FRC guidelines. The *fib* Model Code 2010 includes FRC as construction material, and work is under way to include it in later Eurocode 2 versions. South Africa is in process of adopting EC2 as SANS51992. A review of FRC practice in South Africa, both microfibre, typically used for secondary reinforcement to control cracking in fresh and hardened state, and macrofibre more typically used in slabs-on-grade or suspended beams and slabs, will benefit the construction industry. Include FRC mechanics governing its design, and performance of existing FRC infrastrucure.	
Prof GPAG van Zijl	MEng [S]	The South African Structural Engineering history	Perform a review of structural engineering roots and development in South Africa. The perspective and treatment is directed at undergraduate and structural engineering graduates. Include commercial and residential buildings, bridges, mass and arch dams design and construction. No start date is prescribed, and reference to early local South African structures is encouraged, Attention for local development, and adoption/ adaption of global trends as witnessed by the influence of global design standards in structural timber, masonry, concrete and steel design standards. Identify iconic structural engineers over the centuries and their works.	

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Prof John Babafemi	MEng [R]/PhD	Development and performance evaluation of geopolymer (zero-cement) concrete with environmentally friendly activators	Currently, the alkaline activators used in producing geopolymers have a high carbon footprint; hence, they are not environmentally friendly. This study will use possible environmentally friendly activators in developing geopolymer concrete using low-grade metakaolin and other aluminosilicate materials, and the performance investigated. Furthermore, a life cycle assessment for the concrete will be conducted.	
Prof John Babafemi	MEng [R]/PhD	Time-dependent behaviour of geopolymer (zero-cement) concrete exposed to external conditions and sustained loadings	Geopolymer concrete has shown tendency to disintegrate when exposed to external environmental conditions. This study will test geopolymer concrete exposed to long-term laboratory and external conditions.	
Prof John Babafemi / Prof GPAG van Zijl	MEng[R]/PhD	3D-printed limestone-calcined clay lightweight concrete	Develop lightweight 3D printable mixes with low-cement content (300-320 kg/m^3) to be substituted with limestone calcined clay (LC^2) at 50%, effectively reducing the cement to 150 kg/m^3 and other low-carbon binders. Carbonated recycled fine aggregate will then be used as substitute for natural sand, while preserving the required pumpability, extrudability and buildability properties at an aggregate-binder ratio greater than 2.	
Prof John Babafemi / Prof RS Walls	MEng[R] / PhD	Fire resistance of 3D printed concrete incorporating waste plastic	SU has developed both normal 3D printed concrete and 3D printed concrete incorporating waste plastic. Test at elevated temperature such mixes to determine how their material properties change in fire.	
Prof John Babafemi / Prof Riaan Combrinck	MEng [R]/PhD	Metakaolin concrete	This study will investigate the optimal content of metakaolin that can be used with the various types of cement available in the SA market for normal strength and high strength concrete. The compatibility of metakaolin with different chemical admixtures will also be investigated. The fresh, mechanical, and durability properties, including shrinkage tests will be performed.	
Prof Riaan Combrinck	MEng [R]/PhD	Carbon capture in concrete using CO_2 Nanobubble infused water	Stable Nanobubble infused CO_2 water can be used to replace the mixing water of any concrete. This is an effective method of storing CO_2 in concrete to lower concrete's environmental impact. This study should investigate the properties and environmental impact of concrete with CO_2 infused Nanobubble water.	Speak to lecturer for funding options
Prof Riaan Combrinck	MEng [R]/PhD	Using South African tree gums/saps as admixture in concrete	The gums of trees are widely used in various industries. This study should test the influence of several gums from trees available in South Africa on the fresh and hardened properties of concrete, with the aim of using these tree gums as admixtures.	Speak to lecturer for funding options
Prof Riaan Combrinck	MEng [R]/PhD	Admixtures for LC2/3 concrete	LC2 and LC3 cements are gaining popularity internationally and locally. These cement have the potential to greatly reduce the CO_2-emissions of the cement industry. However, these cements lower the workability and flowability of concrete. Admixture can be used to solve this problem, but these cements behave differently to admixture compared to traditional cements. This study should determine the most suitable admixtures to be used with LC2/3 cements.	Speak to lecturer for funding options
Prof Riaan Combrinck	MEng [S]	Chemistry of concrete admixtures	Concrete is composed of cement, aggregates and water. Most modern concrete also contains admixtures. There is a wide range and applications of admixtures in concrete. Most are aimed to improve the fresh concrete properties, but there are also admixtures to improve durability, water resistance and mechanical properties. This study should perform a desktop study of the chemistry and formulation of all admixtures used in concrete as well as the how these admixtures interact with the concrete chemistry.	Speak to lecturer for funding options
Prof Riaan Combrinck	MEng [R]/PhD	Air milling of cementitious material	Air or jet milling is an effective method for milling particles without the damage caused by more traditional mechanical milling methods. This study should investigate the impact of using air milled cementitious material on the properties of concrete.	Speak to lecturer for funding options

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Prof C Viljoen / Prof NPJ de Koker	MEng[R] / PhD	Target reliabilities for existing structures	Because maintenance is associated with a significantly different cost profile than new structures, a separate target reliability value for maintenance must be determined to avoid overdesigned maintenance or retrofitting solutions. This target reliability value is needed to calibrate partial safety factors used in designing retrofitting and maintenance solutions. This project will aim to interpret and adapt currently available literature on target reliability for existing structures for use in maintenance planning of typical SA bridges. Establish the links that may allow available bridge condition data to inform the choice of input parameters including partial factors for assessment.	
Prof NPJ de Koker / Prof C Viljoen	MEng[R] / PhD	Time-dependent reliability of reinforced concrete structures due to material deterioration	Modern structural design codes are calibrated to target reliability values (safety levels). With the course of time as a structure is exposed to various environmental and loading factors, the concrete and reinforcing steel will decay and corrode, resulting in a systematic reduction in structural capacity. The structural reliability will decay along with the capacity, and once a critical minimum safety level is reached, maintenance work should be performed to return the structure to a more acceptable reliability value. Determining the service life from the perspective of reliability requires a description of the systematic decay in reliability in response to material deterioration. This project will aim to interpret and adapt currently available literature on material decay to obtain a practical description of time-dependent reliability of structures in a South African context.	
Prof NPJ de Koker	MEng[R] / PhD	Open topic in materials modeling and uncertainty quatification	Details of the project can be developed based on the intersection of interests between student and supervisor.	
Dr Humaira Fataar	MEng [R]	Durability of structural timber	Timber is a valuable construction material due to its high strength-to-weigh ratio, reduced energy consumption, design flexibility, etc. However, unlike its counterpart construction materials (concrete and steel), limited research has been done to investigate its durability properties. This work will focus on the durability of mass timber from an environmental degradation perspective,	Discuss funding options with lecturer
Dr Humaira Fataar	MEng [R]/[S]	Timber construction in South Africa	With the increase in sustainable construction practices and materials on the rise globally and in SA, this work will look at the viability of timber as a construction material in SA.	Discuss funding options with lecturer
Dr Humaira Fataar / Prof G.P.A.G van Zijl	MEng [R]	Modeling of FRC subjected to fatigue loading	Fatigue loading is the repetition of loads on a structure until failure occurs. This work will focus on the modeling of fibre reinforced concrete (FRC) subjected to fatigue loads to predict the number of fatigue load cycles to failure.	Discuss funding options with lecturer
Dr AS van Rooyen	MEng [R]	Bio-based construction material	Investigate the feasibility of bio-based construction material in South Africa.	