UNNC – SDU (School of Qilu Transportation) Doctoral Training Partnership

It's essential that you have contacted the UNNC and/or SDU supervisors before applying.

Formal applications should follow the instructions in 'How to apply' section.

Research areas

1. Smart Construction
2. Building Materials
3. Intelligent Transportation
4. Geotechnical Engineering

Available PhD topics

PhD topic	**Continuous-discontinuous coupling simulation method for seepage failure of fault-filling soil and engineering application**
SDU Supervisor	Prof. Zongqing ZHOU
UNNC Supervisor(s)	Dr. Yunming Yang
Short introduction & description of the PhD project	As an important part of infrastructure construction, the construction scale and difficulty of the tunnel and underground engineering have already been the largest in the world. During the construction of the tunnel and underground engineering, adverse geological structures often occur, such as fault fracture zones and strong weathering troughs. Under the combined action of excavation unloading, construction disturbance, groundwater seepage and other factors, the soil in the fault or weathering trough is prone to seepage failure, resulting in rock mass instability and surrounding rock failure. Furthermore, the water penetrates the tunnel, leading to major water and mud inrush disaster, which seriously threatens construction safety. As one of the three pillars of scientific research, numerical simulation can provide an effective means for solving complex engineering problems. By accurate and efficient numerical methods, the seepage damage mechanism of fault-filling soil can be scientifically understood, and the evolution law of multi-field information during the construction can be revealed, which is of great significance to ensuring safe construction, shortening the construction period and saving construction costs. This project will focus on two major dimensions. (i) Scientific constitutive model: The seepage failure process of rock and soil is extremely complex, involving complex physical and mechanical behaviours such as erosion weakening and slip cracking. The establishment of a scientific constitutive model can effectively simulate and analyse the

	entire process from local damage to global failure, from continuous deformation to discontinuous failure. (ii) Efficient calculation method: The discrete element method faces the challenge of low computational efficiency when solving large-scale engineering problems, especially fluid-solid coupling problems. The establishment of efficient calculation methods such as continuous-discontinuous coupling and parallel computing can improve the efficiency of discrete element fluid-solid coupling calculation and effectively meet the needs of large-scale engineering calculations.
Contact points	Informal inquiries may be addressed to Prof. Zongqing ZHOU (Zongqing.Zhou@sdu.edu.cn) and Dr. Yunming Yang (ming.yang@nottingham.edu.cn).
PhD topic	**Monopile-soil interaction behaviour for offshore wind turbines**
SDU Supervisor	Zhanyong Yao
UNNC Supervisor(s)	Fangfang Zhu
Short introduction & description of the PhD project	Offshore wind produces clean electricity that competes with, and sometimes is cheaper than, existing fossil fuel-based technology. Offshore wind turbines must be grounded on various types of foundations, such as monopile, anchors or suction caissons, which usually account for 30% of the construction cost. Unreliable foundations may lead to excessive deformation and change of vibration characteristics, which are reasons for premature aging, damage or even instant failures of offshore wind turbines. Therefore, the major design concern of these foundations is their deformability and stability over external loadings, especially in the lateral direction. The current practice of foundation design is based on the wished-in-place scenario. Recent studies have highlighted the influence of offshore foundation installation methods on its post-installation behaviour. This indicates that modelling the installation phase is vital for the precise investigation of lateral monopile-soil interaction. After the installation phase, the monopile undergoes cyclic lateral loadings over its operational life which result in excessive deformations. Much of the previous studies reported are on sand with simple Mohr-Coulomb model or tresca soil models. Although advanced constitutive soil models have been reported in the recent past, they have not been employed successfully to study advanced soil-structure interaction due to their complexity in coding or unavailability in the public domain (e.g., SANISAND, SANICLAY, Hypoplastic sand, and Hypoplastic clay). In a floating wind turbine network, monopiles behave as anchor which is usually connected to three different wind turbines using cables. Therefore, the monopile undergoes multidirectional loading simultaneously with different load amplitudes in different directions. In addition, the cyclic loads arising from each floating wind turbine can have different frequencies and amplitudes. Concerning the effect of multidirectional lateral loading under cyclic conditions, the concept of p–y curve which is used traditionally for the design of piles could not simply be applied in two orthogonal directions. The PhD project aims for a comprehensive characterization of monopile-soil interaction behaviour for offshore wind turbines, including the research on the effect of installation method of offshore monopiles in clay, research on cyclic loading on monopile-clay interaction as well as the research on multi-directional loading on monopiles.

Contact points	Informal inquiries may be addressed to Zhanyong Yao (zhanyong-y@sdu.edu.cn email address) and Fangfang Zhu (fangfang.zhu@nottingham.edu.cn).
PhD topic	**Plastic shakedown solutions with application to pavement structure analysis**
SDU Supervisor	Prof. Xiuguang Song Prof. Peizhi Zhuang
UNNC Supervisor(s)	Dr Juan Wang
Short introduction & description of the PhD project	When a pavement structure, a typical layered elastic–plastic structure, is subjected to a cyclic load and the load level is higher than a yield limit but lower than a 'shakedown limit', the structure will adapt itself to the cyclic loads and respond purely elastically or with limited plastic deformation to the following load cycles. There are two important shakedown limits, namely elastic shakedown limit and plastic shakedown limit. Existing studies mostly focus on the former condition, which may lead to conservative design of pavement structures. This project aims to develop solutions for determining plastic shakedown limit of layered elastic–plastic structure, which will be used to the analysis and preliminary design of pavement structures considering more realistic surface loading conditions. Many advanced methods might be learned and used in this project for example analytical methods, numerical algorithms, simulations and laboratory testing.
Contact points	Informal inquiries may be addressed to Prof. **Peizhi Zhuang** (zhuangpeizhi@sdu.edu.cn) and Prof. **Juan Wang** (juan.wang@nottingham.edu.cn).
PhD topic	**Preparation of a supplementary cementitious material through synergy CO2 mineralization of fly ash and carbide slag**
SDU Supervisor	Hongzhi Zhang
UNNC Supervisor(s)	Bo Li
Short introduction & description of the PhD project	Using synergy carbonation treatment of fly ash and carbide slag under normal temperatures and pressures to produce supplementary cementitious materials for high-volume replacement of OPC can be a sustainable and economical solution for reducing the carbon footprint of the cement industry. This project aims to optimise the carbonation treatment process to enhance the reactivity of supplementary cementitious materials, which can increase the replacement ratio of OPC in concrete. Additionally, the enhancement mechanisms will also be elucidated through microstructural analyses.
Contact points	Informal inquiries may be addressed to Prof Hongzhi Zhang (Hzzhang@sdu.edu.cn) and Dr Bo Li (Bo.Li@nottingham.edu.cn).
PhD topic	**Preparation of superhydrophobic surface of concrete using mineralization of coal fly ash**
SDU Supervisor	Zhi Ge
UNNC Supervisor(s)	Bo Li
Short introduction & description of the PhD project	Water is the most frequent cause of concrete deterioration, as it can penetrate the porous material and reach the structure beneath. This exposure to water can oxidize steel particles in concrete and corrode reinforcing bars in reinforced concrete. Superhydrophobic properties have

	been induced into the concrete surface so that it exhibits non-wetting properties. This project will focus on producing highly efficient and low-cost superhydrophobic surfaces using the mineralisation of coal fly ash. The surface energy will be lowered by using a chemical film which is coated or adhered to the surface combined with generating micro- and nanotextures using carboned fly ash which can emulate the Cassie–Baxter or Wenzel effects.
Contact points	Informal inquiries may be addressed to Prof Zhi Ge (Zhige@sdu.edu.cn) and Dr Bo Li (Bo.Li@nottingham.edu.cn).
PhD topic	**Research on the performance of hybrid fibre composite concrete lining and its application design**
SDU Supervisor	Prof. Jianhong Wang
UNNC Supervisor(s)	Dr Bo Li
Short introduction & description of the PhD project	Composite material such steel fibre reinforced concrete has been widely used in the construction industry, and the replacement of the steel bar with hybrid fibre is currently discussed for reinforced concrete tunnel lining. However, the structural performance of hybrid fibre reinforced concrete is still unclear, as well as its durability in critical environment needs further study. The performance and application of hybrid fibre reinforced concrete lining is proposed in this PhD project. The failure mechanism and performance of hybrid fibre reinforced concrete material, member and structural lining will be first studied through experiment and numerical simulation. Afterwards, a design method will be proposed using the mechanical theory. Moreover, the research findings will be applied in engineering practice, such as second tunnel in Jiaozhou bay in Shandong province.
Contact points	Informal inquiries may be addressed to Prof Jianhong Wang (J.H.Wang@sdu.edu.cn) and Dr Bo Li (bo.li@nottingham.edu.cn).
PhD topic	**Research on vibration control technology of foundation reinforced by dynamic compaction in expressway**
SDU Supervisor	Zhanyong Yao
UNNC Supervisor(s)	Yunming Yang
Short introduction & description of the PhD project	Due to the excessive environmental vibration generated during dynamic compaction construction, it can easily lead to adverse effects on existing structures, facilities, and the surrounding environment, particularly on operational roads and traffic safety. This significantly hampers the application of dynamic consolidation technology in highway reconstruction and expansion projects. Therefore, finding a solution for dynamic compaction vibration isolation is an urgent issue that needs to be addressed. Through numerical simulation, laboratory model testing, and field testing, this study aims to uncover the vibration isolation mechanism of air cushion barriers while investigating the influence of design parameters on their effectiveness. Additionally, a design method for airbag barrier vibration isolation is proposed. These findings guide selecting appropriate design parameters for airbag vibration isolation barriers and offer a theoretical foundation for promoting their use in expressway reconstruction and expansion projects involving foundation reinforcement engineering. Ultimately, this research facilitates the widespread adoption

	of this technology in vibration-sensitive engineering applications such as expressway reconstruction and expansion projects.
Contact points	Informal inquiries may be addressed to Zhanyong Yao (zhanyong-y@sdu.edu.cn email address) and Yunming Yang (ming.yang@nottingham.edu.cn).
PhD topic	**Seismic Behaviour and Resilience Evaluation of Transport Infrastructure Crossing Active Faults**
SDU Supervisor	Prof. Jianhong Wang
UNNC Supervisor(s)	Yung-Tsang Chen
Short introduction & description of the PhD project	Transport Infrastructure such as tunnels and bridges crossing active faults is more vulnerable to earthquake damage due to the intense and unexpected ground movement from the faults. The seismic behaviour of the transport infrastructure near or cross active faults therefore needs to be analysed further to ensure their satisfactory seismic performance, as the near-fault ground movement may cause strong ground acceleration and permanent ground displacement to the infrastructure. In addition to conventional structural analysis following current design codes, a resilience analysis adopting the concepts of robustness, rapidity, redundancy, and resourcefulness (4R) should also be used to account for the seismic resistance and repairability of current existing transport infrastructure. In this project, relevant research literature review will be conducted first, followed by the analysis of the seismic behaviour of transport infrastructure near or crossing active faults. Numerical simulation of transportation infrastructure subjected to intense earthquake excitations will be conducted, and seismic behaviour and failure modes be analysed and compared with the current structural design codes. Scale-down model tests using shaking tables may as well be conducted to verify the simulation results. Meanwhile, the structural resilience of transport infrastructure under near-fault earthquakes will be investigated, with the aim of proposing indexes for the purpose of resilience evaluation. Measures for disaster prevention, in terms of disaster mitigation and post-disaster recovery methods, will be developed. Finally, a comprehensive resilience evaluation method and the associated resilience index will be proposed and applied in real engineering projects, such as Chuanzang Railway connecting Sichuan and Tibet.
Contact points	Informal inquiries may be addressed to Dr Yung-Tsang Chen (Yung-Tsang.Chen@nottingham.edu.cn) and Prof. Jianhong Wang (J.H.Wang@sdu.edu.cn).
PhD topic	**Shield structure safe excavation technology focusing on the destabilisation mechanism and stability control technology of shield structure traversing through water-rich sandy soil strata.**
SDU Supervisor	Prof Jing Wang
UNNC Supervisor(s)	Dr Yunming Yang
Short introduction & description of the PhD project	When shield traverses through sandy soil stratum (especially water-rich sandy soil stratum), it is very easy to have problems such as shield instability, sand gushing, surface settlement, etc. Therefore, the stability control technology of shield traversing through water-rich sandy soil stratum needs to be studied urgently.

	This project will focus on four major dimensions on (i) using numerical simulation and modelling to study the changing law of geotechnical pressure under shield disturbance and analyse its impact on surface settlement; (ii) revealing the mechanism of palm surface instability under shield crossing sandy soil strata (especially water-rich sand strata), and analysing the influence of shield tunnelling parameters on the stability of the palm surface; (iii) considering the shield structure diffusion mechanism of synchronous grouting under the disturbance, and proposing the stability control technology of shield structure crossing water-rich sand strata; (iv) considering the mechanism of synchronous grouting diffusion under disturbing effect, and proposing measures for safe and efficient tunnelling of shield structure through sandy soil stratum.
Contact points	Informal inquiries may be addressed to Dr. Yunming Yang (ming.yang@nottingham.edu.cn) and Prof. Jing Wang (wjingsdu@163.com).
PhD topic	**Soil-Pile Interaction Considering the Principal Stress Rotation**
SDU Supervisor	Prof Peizhi Zhuang
UNNC Supervisor(s)	Dr Yunming Yang
Short introduction & description of the PhD project	The principal stress rotation (PSR) exists in many geotechnical engineering applications, such as in soil behaviour under earthquake loading, wave loading, traffic loading and tunnelling. It is usually created by the shear stress and difference of normal stresses. The change of principal stress orientations generates additional deformation and non-coaxiality in soil. It is well known there is considerable shear stress in soil-pile interaction, and corresponding PSR, which is worth in-depth study. The project consists of three components. (i) analyze the stress-strain response of soil adjacent to piles, focusing on the its PSR and non-coaxiality. (ii) conduct experiments of soil based on its stress-strain analysis, and the experiments can consider one or multiple PSRs. (iii) numerically study the application soil-pile interaction in engineering practice, such as in the underground construction and operation, and compare the numerical results with centrifuge test results and in-field measurement.
Contact points	Informal inquiries may be addressed to Dr Yunming Yang (ming.yang@nottingham.edu.cn) and Prof Peizhi Zhuang (zhuangpeizhi@sdu.edu.cn).
PhD topic	**Use of superabsorbent polymers in concrete materials to improve longevity**
SDU Supervisor	Dr Hongzhi Zhang
UNNC Supervisor(s)	Dr Weizhuo Shi
Short introduction & description of the PhD project	Internal curing is the practice of providing small, well-distributed reservoirs of water throughout a concrete section such that the w/cm of the mixture can be kept low, but the water can later be delivered to hydrating cement as the system dries out. Internal curing has been reported to be effective in reducing shrinkage cracking, improving potential durability of concrete mixtures, and most notably, reducing warping and associated cracking in pavements and slabs on grade. Currently, the use of light-weight fine aggregate (LWA) is the most common practice in the worldwide to produce internally cured concrete. This method, however, necessitates pre-saturation of aggregate at

	concrete batch plants in accordance with a set timeline. This may increase costs related to stockpile management in addition to the costs and emissions associated with production and hauling the LWA. Furthermore, the use of LWA can reduce elastic modulus of concrete. Therefore, the fundamental aim of this study will be to provide the tools to minimize cracking, and increase longevity at minimum life cycle cost. The outcome of this research is to provide recommendations for improvement needed to ensure high quality concrete materials when using SAP for internal curing.
Contact points	Informal inquiries may be addressed to Dr Weizhuo Shi (Weizhuo.Shi@nottingham.edu.cn) and Prof Hongzhi Zhang (hzzhang@sdu.edu.cn).