<table>
<thead>
<tr>
<th>Name</th>
<th>Email</th>
<th>Webpage</th>
<th>Title of PhD project</th>
<th>Short Abstract</th>
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<tbody>
<tr>
<td>Prof Michael Bruen</td>
<td><a href="mailto:michael.bruen@ucd.ie">michael.bruen@ucd.ie</a></td>
<td><a href="http://www.ucd.ie/eacollege/csee/staffmembers/michaelbruen/staff,98193,en.html">http://www.ucd.ie/eacollege/csee/staffmembers/michaelbruen/staff,98193,en.html</a></td>
<td>Flood forecasting and the use of hydrological and hydraulic models and remotely sensed data, particularly radar.</td>
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<td>Prof Michael Bruen</td>
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<td>River water quality modelling and catchment management decision support systems, especially related to Nitrogen, Phosphorus, sediment.</td>
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<td>Impacts of water quality on terrestrial environment and the valuation of ecosystem services.</td>
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<td>Water related natural disasters, risk evaluation and mitigation</td>
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<td>Multi-criteria decision methods in Engineering applications.</td>
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<td>Dr Yaqian Zhao</td>
<td><a href="mailto:yaqian.zhao@ucd.ie">yaqian.zhao@ucd.ie</a></td>
<td><a href="http://www.ucd.ie/eacollege/csee/staffmembers/yaqianzhao/staff,98300,en.html">http://www.ucd.ie/eacollege/csee/staffmembers/yaqianzhao/staff,98300,en.html</a></td>
<td>Development of constructed wetland microbial fuel cell (CW-MFC) for simultaneous electricity production and wastewater treatment</td>
<td>Microbial fuel cell (MFC) is a relatively new technology which is gaining lot of attention among researchers because of its bioelectricity generation potential during wastewater treatment. MFC consists of two chambers i.e. anaerobic and aerobic where oxidation and reduction take place. Constructed wetland (CW) is a low-cost and promising technology for wastewater treatment. This project is a challenge with the aim to develop the CW-MFC for electricity production and wastewater treatment.</td>
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<tr>
<td>Dr Yaqian Zhao</td>
<td><a href="mailto:yaqian.zhao@ucd.ie">yaqian.zhao@ucd.ie</a></td>
<td><a href="http://www.ucd.ie/eacollege/csee/staffmembers/yaqianzhao/staff,98300,en.html">http://www.ucd.ie/eacollege/csee/staffmembers/yaqianzhao/staff,98300,en.html</a></td>
<td>Design strategies and pathways of integrated constructed wetland (ICW) system for wastewater treatment and pleasing landscapes</td>
<td>Conventional constructed wetlands are increasingly being used to treat wastewater from small to medium sized communities. The project would examine field data and investigate the modelling of the hydraulics and processes occurring in these systems.</td>
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<tr>
<td>Dr. Patrick J. Purcell</td>
<td><a href="mailto:pj.purcell@ucd.ie">pj.purcell@ucd.ie</a></td>
<td><a href="http://www.ucd.ie/eacollege/csee/staffmembers/pjpurcell/staff,98292,en.html">http://www.ucd.ie/eacollege/csee/staffmembers/pjpurcell/staff,98292,en.html</a></td>
<td>Modelling performance of integrated constructed wetlands</td>
<td>Conventional constructed wetlands are significant consumers of energy. There is considerable scope both to reduce energy input to plants and to recover energy for subsequent reuse. This project would gather full-scale plant data and examine the potential for modelling processes to optimise energy usage.</td>
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<td>Low energy wastewater treatment</td>
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<tr>
<td>Dr. John O'Sullivan</td>
<td><a href="mailto:j.osullivan@ucd.ie">j.osullivan@ucd.ie</a></td>
<td><a href="http://www.ucd.ie/eacollege/csee/staffmembers/johnosullivan/staff,98291,en.html">http://www.ucd.ie/eacollege/csee/staffmembers/johnosullivan/staff,98291,en.html</a></td>
<td>Microbial source tracking at catchment scale using deterministic rainfall-runoff models</td>
<td>The quality of coastal waters is heavily dependent on catchment rainfall-runoff processes in which faecal indicator bacteria (FIB) is transported from land, through river and stream networks and delivered to coastal zones. FIB in this regard typically includes waste from farm animals and sheep. However, in urbanised or upland catchments, FIB from human sources (resulting from sewer disconnections or septic tanks) can also be present in rivers and streams. With recent advances in DNA tracking of microbial pollution, it is now possible to quantify the individual contributions of catchment FIB from ruminant, home and human sources. The ability to model the transport and fate of these FIB sources at catchment scale would present a significant tool for identifying hotspots where different FIB originate within a catchment. Such knowledge would allow catchment managers to mitigate actions to reduce FIB entry into the river and stream systems and thereby improve the water quality of coastal areas for the benefit of bathing and aquaculture. This project will develop and test a new concept – the ‘fractal dimension’ to measure changes in the ecosystem and use them as indicators of bridge damage.</td>
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<td>Bridge Damage Detection Using Fractal Dimension of EigenModes</td>
<td>Bridge inspection is currently done visually – trained inspectors look for signs of distress such as cracking. There is a lot of research ongoing to develop more reliable and automated approaches using the dynamic properties of the bridge as an indication that damage has taken place. In a dynamic analysis, the signal can be broken down to determine the natural frequencies and the mode shapes or eigenmodes. Recent advances with cameras mean that it’s now feasible to monitor eigenmodes much more accurately than before. This project will test a new concept – the ‘fractal dimension’ to measure changes in the eigenmodes and use them as indications of bridge damage.</td>
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<td>Shape Optimisation of 3-D Printed Struts</td>
<td>Structural Optimisation has been around for many years but the choices of geometry were constrained by manufacturing techniques – it has been impractical to manufacture highly complex member geometries. With the advent of 3-D printing, this situation is changing rapidly. It is now possible to conceive highly complex structural shapes that are far more resistant to buckling than regular practical shapes. In this project, it is proposed to design columns that are much lighter than anything conceived today. The project will involve geometrically non-linear analysis of truss structures, combined with shape optimisation.</td>
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<td>Bridge Weigh-in-Motion and Damage Detection</td>
<td>Bridge Weigh-in-Motion (BWM) is the idea of using an existing bridge as a weighing scale to find the weights of trucks passing overhead. BWM has been around for quite a few years now and is used commercially (including in Brazil) to find truck weights and to help police to catch overloaded trucks. In this project, the BWM concept will be used to identify what trucks are crossing the bridge at a given time. The truck weights will be then used to determine the bridge’s ‘health’, i.e., if it is damaged. This will be done by placing sensors and examining acceleration signals on the bridge and finding out if they are consistent with the truck weights. Any inconsistency between truck weights and measurements will indicate that the bridge is damaged.</td>
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Traffic Loading on Long Span Bridges

Much is known about the statistics of traffic loading on short-span bridges. A bridge is generally designed for the worst combination of trucks that can be reasonably expected to cross it in its lifetime. "Reasonably expected" is defined by a return period— for example, the American AASHTO code assumes a 75-year return period, i.e., the bridge is designed for the worst combination of trucks that will occur just once in 75 years. Much less is known about long span than short span bridges. Whereas a short bridge may have one or two large trucks on it, a long span bridge may have dozens or more trucks. At present, designers assume long convoys of trucks jammed on the bridge with no cars between. This is not reasonable as (a) there are always cars and (b) traffic is rarely completely stopped—the more likely situation is that there is "stop-and-go" behaviour, similar to the waves of congestion that happen in a city in rush hour. In this project, a technique known as Markov chain theory will be used to simulate these stop-and-go waves of heavy trucks on long span bridges. This will be used to generate a load model that can be used for the design of long-span bridges.

Overturning moments in cable-stayed bridge towers

In recent years suspension bridges have fallen out of favour because of the difficulty of ever replacing the main cable. For longer bridges, multi-span cable-stayed bridges are now becoming popular. However, for these bridges, the risk of uneven loading between spans is resulting in large overturning moments in the towers. Designs are highly conservative because little is known about the phenomenon of uneven traffic loading, i.e., what is the probability of a large concentration of traffic on one span at the same time as light loading in the next span? In this project, we will develop a traffic load model for the design of multi-span cable-stayed bridges. The project will involve micro-simulation modelling of traffic on bridges, i.e., simulating the random behaviour of individual drivers.

Using Drones to Monitor the Health of Bridges

Drones and other aerial vehicles (UAV's) or drones are being increasingly used to do visually inspect those parts of bridges that are not easily accessible. In this project a new use for drones is proposed. In the monitoring of smaller bridges, the biggest challenge is power—it is generally considered too expensive to install mains electricity on site and all the data acquisition electronics to download and store data from the sensors. In this project, a power-free bridge monitoring approach will be developed. Energy harvesting smart sensors using the bridge's own vibrations as a power source, will collect and store data on the bridge behaviour. Auto-piloted drones will periodically visit the bridge to download the data from the smart sensors and to perform a visual inspection if there is any cause for concern.

Low Energy Pavement Material Investigation

Low energy mixes for road construction offer an attractive sustainable proposition. Climatic conditions have a major influencing effect on the development of the properties of these materials over time. This project will review the design and testing methodologies used in specifications internationally along with identifying linkages to in-situ performance. Laboratory and field testing will be undertaken with a view to furthering knowledge on performance prediction.

Characterization of Loads Applied to a Structure via Inverse Dynamics

When assessing an existing structure, load statistics can be more accurately specified from measurements on site. In some cases, the direct measurement of loads can prove to be difficult and these new methods have been developed indirectly from the structural response. The latter requires the fitting of a mathematical model to the measurements using an inverse dynamics algorithm, i.e., based on dynamic programming with FIShONics regularisation (applications include calculation of traffic loads from bridge measurements). The presence of noise, the lack of agreement between reality and theoretical models and the limited number of available measurements are sources of inaccuracy that this project aims to minimise through the development of a more robust algorithm.

Impact of Climatic Changes on Transport Infrastructure

In the last decades, climatic changes have brought the occurrence of unexpected extreme floods, earthquakes, temperatures and other environmental effects that has hit transport infrastructure throughout the world. In some occasions, the impact of these extreme climatic events has led to severe deterioration of bridges and even their failure. The statistical trend of the environmental loads within the last few decades is clearly different than in the last century. There is a critical need to adapt to the climatic change that this project will address by assessing the consequences of more variable and uncertain environmental loads on the transport infrastructure stock.

Monitoring Dynamic Characteristics of the Structural Response Using the Hilbert-Huang Transform

A specific bridge is excited differently depending on the type of vehicle traversing it. The total response varies with respect to the vehicle load and therefore must be measured with some degree of accuracy. In this project, we will use the Hilbert-Huang transform to obtain instantaneous frequencies, separate periods in free- and forced-vibration and detect structural changes at an early stage.

Strength & Ductility of Mechanical Timber Joints

Mechanical joints are the most common in timber construction. These joints must be ductile enough and strong enough. International codes of practice use relatively simple two dimensional models to ensure adequate joint strength and ductility. By definition these two dimensional models do not adequately capture the three dimensional stresses in these joints. The objectives of this research is to (i) develop and validate robust three dimensional modeling approaches for timber joints and (ii) update current simplified models for strength and ductility predictions. The research will also consider the implications for the design of timber joints under both static and cyclic loading and evaluate a range of existing and novel joint arrangements.

Using Ambient Vibration Response Data to Predict Remaining Life of Post-Tensioned Bridges

Post-tensioned concrete bridges are a commonly used bridge form. There is evidence in the literature to demonstrate that natural frequencies of post-tensioned bridges reduce over time. Studies have attributed this reduction to a reduction in stiffness of the superstructure— while it is believed that this reduction is due to deterioration (creep and/or corrosion) of the post-tensioning system this has yet to be proven using mathematical models which include deterioration models associated with the post-tensioning system. The objective of this PhD proposal is to develop a deterioration model for post-tensioning systems that can be included in numerical models of bridges to capture the reduction in frequency that is evident in these bridges over time. The deterioration model developed will be validated using frequencies extracted from ambient vibration response data measured at currently instrumented bridges.
Dr Mike Long  
mike.long@ucd.ie  
http://www.ucd.ie/eacollege/csee/staffmembers/mikelong/staff,98254,en.html  
Free fall cone penetrometers (FFCPT)  
There has been considerable recent effort in the investigation of the ground conditions on the sea floor for energy-related projects. A major issue is the cost of such investigations and therefore much focus has been placed on doing the work as quickly as possible. One such recently developed rapid technique is The Free Fall Cone Penetrometer (FFCPT) which was developed to collect geotechnical data during route location surveys for seabed cable and pipeline installations. FFCPT is designed to free fall through the water column, then impact the seabed. On board acceleration and pressure sensors monitor the sediment penetration response. Some such data is available for several sites near Trondheim, Norway and the project will involve the analysis of the data comparisons between this data and existing information and an assessment of the usefulness of the FFCPT for future works and on the application of the data to offshore problems such as slope instability.

Dr. Ken Gavin  
kenneth.gavin@ucd.ie  
http://www.ucd.ie/eacollege/csee/staffmembers/kengavin/staff,98213,en.html  
Foundation Design Framework for Offshore Wind Energy Devices  
Design methods for offshore monopile foundations were developed by the oil and gas industry. Foundations for offshore wind turbines are of larger scale and are influenced much more by environmental dynamic loading. UCD are engaged in experimental investigations of the behaviour of offshore piles at their geotechnical test bed-site and as part of the international FISH project (with Oxford University and Imperial College). This project will investigate the development of new CPT based design methods for offshore piles.

Dr Debra Laefer  
debra.laefer@ucd.ie  
http://www.ucd.ie/eacollege/csee/staffmembers/debralaefer/staff,98258,en.html  
Auto-generating Urban-scale Models for Pollution Tracking by Application of Advanced Statistical Methods to Aerial Laser Scanning  
Predictions of pollution concentration for asthma risk and other airborne health hazards require highly detailed, large-scale models of the environment. The challenges involved in creating such models relate to the difficulties and costs surrounding the creation of neighbourhood or city-scale models, as much as in the development of equations for computational fluid dynamics. Generating such models by hand is generally cost prohibitive and inaccurate. However, recent breakthroughs in converting some remote sensing data (i.e. laser scanning) into computational models has opened the door for fully automated creation of accurate city-scale models. Notwithstanding this major advance, critical research is still needed for small-scale feature detection (e.g. identifying cosmetics versus whole buildings). Identifying these features is crucial, as airflow is highly influenced by a building’s profile and surface characteristics. The proposed project seeks to identify these features by employing the most advanced Bayesian statistical methods for small-feature detection within high-density laser scanning datasets. The project will be co-supervised between Civil Engineering and Statistics. Students may come from either discipline. The project involves highly interdisciplinary research on an architectural feature detection from remote sensing data. A dense urban data set is to be mined combining advanced Bayesian statistical methods, computational statistics, spatial analysis, and machine learning. The goal is to fully automate feature detection within these irregularly populated data sets without relying upon any a-priori knowledge. Candidates should have rudimentary programming skills or a willingness to obtain them and an ability to work in a cross-disciplinary team.

Dr Debra Laefer  
debra.laefer@ucd.ie  
http://www.ucd.ie/eacollege/csee/staffmembers/debralaefer/staff,98258,en.html  
Complete 3D: a platform for a three-dimensional point cloud data management  
A large proportion of today’s digital data has a spatial component. The effective storage and management of which poses particular challenges, especially with Light Detection and Ranging (LiDAR), where datasets of even small geographic areas may contain several hundred million points. Despite growing data availability, current spatial information systems do not provide suitable support for the data’s 3D feature. Consequently, one system is needed to store the data and another for its processing, thereby necessitating format transformations. The project undertaken herein aims at a more efficient, seamless and cost-effective way for managing LiDAR data that allows for storage and manipulation within a single system by exploiting ocreen indexing for spatial database management technology. This project will be based in the Computer Science programme, but will be co-supervised in Civil Engineering, which will enable the candidate full access to new resources from an EU funded ERC grant.

Dr Debra Laefer  
debra.laefer@ucd.ie  
http://www.ucd.ie/eacollege/csee/staffmembers/debralaefer/staff,98258,en.html  
Art Object Protection from Earthquakes and Manmade Vibrations  
This collaboration with the J. Paul Getty Museum aims to provide systematic, quantitative guidance on the protection of movable art objects from subsurface vibrations (both seismic and transport-induced). This will be done through a combination of experimental and numerical investigations. The project will have three branches: (1) develop fundamental relationships to describe the sliding, rocking, and overturning of pottery based on the object’s shape, weight, centre-of-gravity, and interface frictional characteristics when subjected to both the subsurface loading of transport vibrations and the non-seismic loading from seismic events; (2) implement a computational model based on (1) and verify the model experimentally; and (3) investigate mitigation strategies based on the physico-chemical properties of microcrystalline waxes with respect to their ductile response under dynamic loads. This project seeks a student with a master’s degree in structural engineering with an emphasis in dynamics, an interest in art, and a strong grounding in chemistry. The student will be expected to undertake a highly interdisciplinary project between civil engineering and materials science, while being highly cognizant of the special needs and concerns of the art conservation community.

Dr Debra Laefer  
debra.laefer@ucd.ie  
http://www.ucd.ie/eacollege/csee/staffmembers/debralaefer/staff,98258,en.html  
Creating a New Generation of Digital Inventories for Cultural Heritage  
Cultural Heritage represents over 1/3rd of Europe’s tourism and an area where Europe has dominated intellectual debate and training. Unfortunately, 21st century realities related to infrastructure renewal, mega-city needs, and climate change pose new threats to heritage landscapes and structures – threats that cannot be easily legislated into absence. Instead, new tools must be brought to bear. Critical to this is fully adapting existing technological opportunities to advance how heritage landscapes and structures are documented and monitored in the larger planning and permitting processes. This project unites world-class conservation with new spatial data infrastructure opportunities to help Ireland meet its EU obligations for inventoring its cultural heritage. Specifically advances in three-dimensional database hosting will be combined with existing geographic information systems to pioneer a new generation of digital resources for heritage documentation and protection. The project partners architecture, civil engineering, planning, and computer science with Ireland’s National Inventory of Architectural Heritage. This project seeks a student with documented training or involvement in both architectural conservation and computer science. The project involves development of a prototype spatial data infrastructure (SDK) to archive, manage, and highlight heritage landscapes and structures by exploiting recent advances in three-dimensional databases and the requisite interfacing with traditional geographic information systems. The project will be done in cooperation with the National Inventory of Architectural Heritage and use the upcoming re-inventory of Dublin under the Granada Convention requirements to create a prototype system that can be scaled to include all of Ireland as a resource for planning and tourism. Challenges relate to (1) streamlining and converting existing datasets to enable compatibility with new datasets such as laser scanning point clouds; (2) creating new indexing structures and algorithms that can be effectively used at multiple scales (e.g. building, block, neighbourhood, region); and (3) exploiting new 3D capabilities for effective visualization.
Development and Verification of an Expansive Cement Cracking Model

Increasing concerns regarding litigation and terrorism provide a strong dual motivation to decrease the use of high explosives in the construction industry. This project proposes the exploration of a 2D finite element model to a 3D model replicate and optimise the behaviour of expansive cements (also known as soundless chemical demolition agents) in concrete and rock. The ultimate goal of project include a commercially viable subroutine applicable to a wide variety of site conditions and a set of industry usage guidelines for consulting engineers for use near environmentally and historically sensitive sites. This constitutive model will include both the behavior of expansive cements and crack behaviour of concrete/rock material based on standard experimental test data. The initial model will be verified by comparing the experimental results of 32 unconfined concrete blocks (approximately a cubic meter each) of varying concrete strengths and stiffnesses that were tested in various temperature environments with differing expansive agents, confinement levels, and post-cracking treatments. The initial model will employ the highly detailed crack development records, including crack initiation, crack propagation, and crack patterns, as an initial means of benchmarking. Once the initial benchmarking is complete, the model will be used to predict behaviour of larger and disparate geometries. These will then be tested in the laboratory as further benchmarking. Once the expansive cement cracking model is validated, simulations to optimise the use of SCDA will be performed to improve the efficiency of these products with respect to temperature, confinement levels, and post-cracking treatments.

Total Energy Input as an Alternative to Peak Particle Velocity for Blasting and Vibration Limitations

No consensus exists as to what constitutes an acceptable vibration level for blasting, construction activity, and heavy traffic. Various countries states impose different levels of restriction based on maximum particle velocities (PPVs). The absence of agreement is easy to understand, because the single parameter criterion fails to consider the total energy exerted. Instead of relying upon peak acceleration to characterize the magnitude of a dynamic event, a total energy input (TEI) approach considers the entire performance record. This way, the assessment of peak velocity can provide an incomplete picture of the severity of vibration. The TEI has a number of advantages over the PPV, and it becomes more important in relation to blast damage in the context of development. This project will constitute an integrated program and testing laboratory facility, often element modeling to evaluate the effectiveness of a TEI approach for a variety of typical, urban vibration problems that include heavy traffic, tunneling, and pile driving. The result will be an objective set of criteria for vehicular and construction related vibrations through the application of recent advances in the earthquake community.

Development of a New Analytical Model to Characterize Building Load Transfer during Adjacent-Excavation and Tunnel-induced Subsidence

Deep Beam Theory considers a building only at a single moment in time, and that is at the peak loading just prior to the onset of cracking. The formation of new cracks in the subsidence region, as well as the opening of existing cracks, is not considered. Instead, the structural response of a building is modeled by means of the superposition of a series of deep beams. The formation of new cracks in the subsidence region, as well as the opening of existing cracks, is not considered. Instead, the structural response of a building is modeled by means of the superposition of a series of deep beams. The ideal student would have a strong analytical background in engineering mechanics.

Biomimicry in structural engineering

There are numerous examples in nature of biological components that are incredibly advanced from a structural engineering perspective. From spider silk to toucan beaks to bird bones, we see elements with engineering properties that are far beyond what should be technically possible to achieve using the materials available. This project will seek to follow nature's example to design complex structures and forms using a programming technique known as Grammatical Evolution. This will involve building on existing research that is currently taking place in the School.

Concrete design for 3D printing

Advances are continuously being made within the field of 3D printing, but there are still significant challenges that must be overcome before we can print viable structures in concrete. A key aspect of this is optimisation of concrete properties that allow extraction by a 3D printer while continuing to provide structural performance and other functionality. This project will investigate this developing technology through a combination of concrete performance testing and print optimisation trials and will build on UCD's current expertise in these fields.

University Travel choices: the implications for policy and infrastructure

Many universities seek to encourage smarter travel and more environmentally friendly travel in students. This PhD will build upon work already conducted by Dr. Ahern in UCD and Dr. Lisa Dawson and Professor Mike in University of Ulster (UU) on university travel choices in the UK and Ireland and will look at policies that might be introduced to bring about more sustainable university travel. It is envisaged that someone embarking on this PhD will work with both UCD and UU and spend time in both universities.

Valuing mobility for vulnerable groups: a case study of older men in rural Ireland

Travel for older men in rural areas: This research will focus on the challenges that are faced by older men in rural areas when they make the transition from being able to drive to life with a car. Men are less likely to use existing community transport schemes and are more likely to have been car-dependent throughout their lives, so often find the transition from car dependency to a car-less life more difficult. This research will look at the travel patterns of older men living alone in rural areas, and will examine what policies or infrastructure development can be put in place to ensure better and more sustainable travel options for this group.