The Institution of Structural Engineers

International HQ
11 Upper Belgrave Street
London SW1X 8BH
United Kingdom
tel: +44 (0)20 7235 4535
fax: +44 (0)20 7235 4294
mail@istructe.org
www.istructe.org

2013 MSc Research Grant Scheme

Project title: Innovative grid shell structures in fibre reinforced polymer composites

University: University of Bradford

Supervisor: Dr Ashraf Ashour

Student: t.b.a

Aims of research: Most FRP applications in structural engineering have focused on using them as a replacement for steel reinforcement. However, FRP composites have been successfully used in their own right in many other fields. The main aim is to investigate the feasibility of using FRP for constructing grid shells. The dynamic explicit finite element simulation in ABAQUS software will be used for form-finding of FRP grid shells. The computational model will be also used to explore the response of grid shells having different configurations under various vertical and/or horizontal loading. Physical testing of FRP samples under bending creep will be also conducted.

Description of method: Grid shells are aesthetically pleasing structures with a minimum use of materials for the large span covered. Most of the existing grid shells have been built with timber due to their high strain limit. However, fibre reinforced polymer (FRP) composites have higher elastic strain at rupture giving more freedom of curvature formation, higher elastic modulus resisting higher buckling load and higher rupture strength than timber.

The project will develop a dynamic explicit finite element model using ABAQUS software for form-finding and analysis of grid shells constructed from FRP. The stability and convergence rate of the model will be tested by changing various parameters, for example, the number of elements of each member in the grid shell, time step, and different grid shell configurations. After validating the grid shell model, it will be used to predict the serviceability and ultimate limit state behaviour of FRP grid shells.

Grid shells in their deformed shape are subjected to sustained high bending loads; therefore, it is crucial to anticipate their ultimate strength and deflection as a function of load level and time. The long-term creep of FRP elements subjected to bending will be evaluated at various orders of magnitude of strain rates. FRP material samples will be physically tested under bending loading at various stress/strain levels for long time durations (possibly three months). Short-term FRP testing for measuring the longitudinal elastic modulus and ultimate compression and tensile stresses will be conducted first on similar coupon samples to identify the levels of stress/strain for the creep test specimens. A simple apparatus using dead weight creep fixture will be designed and manufactured to test the coupon samples under creep. The strain measurements over time will establish the creep trend and relaxation of FRP materials and will identify the ultimate load of FRP.

Benefits to structural engineering: Grid shells made from FRP composites are innovative and very few researchers across the world are investigating such structure. This project will pave the way for future experimental testing of the designed grid shell configurations to complete the development of new, aesthetically pleasing grid shell structures made from FRP composites. The project will provide new knowledge and understanding of the behaviour of grid shells made from FRP composites, consequently making them a more viable option for structural engineers. The construction industry will be benefited from a new flexible, quicker method of construction with less use of materials.

Proposed finish date: 10/2013