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

2014 MSc Research Grant Scheme

Project title: Selfcentring NiTi Shape Memory Alloy Belleville Springs for Seismic Resisting Devices

University: Newcastle University

Supervisor: Dr Cheng Fang

Student: t.b.a

Aims of research: Innovative engineering technologies are often driven by the discovery of new materials. NiTi Shape Memory Alloys (SMAs) have recently found their promising engineering applications because of their ability, in austenite form, to undergo reversible deformations (up to 8% strain) and to dissipate energy when subjected to cyclic loading. This study aims to explore the potential of austenitic SMA Belleville springs in the applications of seismic resisting devices such as base isolations and dampers. The recovery and energy dissipation properties of individual springs and various spring combinations (parallel or series arrangement) are investigated towards the optimized design of the seismic resisting devices.

Description of method: Employing a Universal Testing Machine, uniaxial compression tests will be conducted on either individual Belleville springs or Belleville spring groups in different stack patterns. An interval of 1mm deformation increment will be employed as the loading protocol, and two cycles will be undertaken for each deformation level. The specimens will be ordered directly from a professional NiTi manufacturer, but additional prototyping service is required since currently there's no existing products. The main considered test parameters include geometric dimensions, stack arrangement, and strain rate. The geometric dimensions, especially the height and the thickness of the Belleville spring, could significantly influence the stress state, and thus affecting the key hysteretic properties such as the dissipated energy and residual deformation; therefore, a spectrum of geometric properties will be examined with the aim to optimizing the final seismic resisting device design. The possible stack arrangement includes series, which means their deflections add up, and parallel, where their forces add up. This allows different resistance and deformation capacities for various applications under different scenarios. The effect of friction, which can be beneficial for dissipating energy when the springs are stacked in parallel, will also be studied. Since seismic action is dynamic, the strain rate effect will be studied through applying different loading speeds. The above test results will form important basis on the key characteristics of SMA Belleville springs. With the knowledge barrier of the key information on SMA Belleville springs being surmounted, the final stage of the project is to propose a design recommendation on seismic resisting devices based on SMA Belleville springs. The device will consist of a series of Belleville springs and a movable cover. For the scope of this project, numerical studies are to be undertaken in order to validate the feasibility the designed device. Future physical tests should also be planned as a continuous study of this project.

Benefits to structural engineering: Belleville springs can sustain large loads with small installation space. Because of their annular shape, force transmission is even and concentric and thus they can be more stable compared with other springs. When they are endowed with superelastic ability, which enables self-recovery and hysteretic damping, their range of application can be significantly expanded taking advantage of nearly unlimited number of possible combinations. The Belleville spring-based device designed in this project could be an important addition to the 'arsenal' against seismic hazard. They are particularly promising in the field of innovative base isolation and damper design.

Proposed finish date: 08/2014