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Breakthroughs in perception

Measuring THE forces OF nature

SWINBURNE UNIVERSITY OF TECHNOLOGY

MAKING FUTURE BUILDINGS SAFER

KEY POINTS

- **A new laboratory will drive the next generation of high-rise construction.**
- **Hybrid technology in the laboratory lowers material testing costs.**
- **The facility will also help to build smarter housing.**

Inside a glass-walled laboratory, the effects of earthquakes and other forces of nature can be simulated on tomorrow's structures BY BRAD COLLIS

THE CAPACITY to more realistically test the integrity of new materials and structures such as buildings, bridges and even airframes has been boosted with the recently commissioned Smart Structures Laboratory at Swinburne University of Technology.

The laboratory houses Australia's first Hybrid Testing Facility (HTF). This state-of-the-art technology integrates what is happening to a physical model being stress-tested with a virtual model of the whole structure in which it would be a component. For example, in the case of support columns in a building or bridge, a real column is subjected to physical tests, while the cause-and-effect relationships with the rest of the structure are computer-simulated.

The technology elevates the rigorous testing required in many fields of manufacturing and construction to a new level, because stresses such as earthquakes can be taken to extremes.

The new laboratory's director, Professor Riadh Al-Mahaidi, explains that not all components of a structure are critical to its stability. The HTF lets researchers isolate and test the critical components physically. In an earthquake simulation, for example, the effects on the key structural components of a building under stress are fed into the physical test, and the impact is simultaneously fed back into the simulated building. This builds a realistic, real-time profile of the complex structural relationships that determine a building's capacity to withstand extreme forces.

Professor Al-Mahaidi adds that because a digitised structure replaces the need to build a physical-scale model, the cost of testing is reduced considerably.

"It also minimises error because we are able to test the full-scale component, like a support column, which is far more realistic than a small-scale model."

The idea is not new, but what is new is the computer processing power able to analyse what is happening in a test in milliseconds.

"Of course this system is not just about earthquakes, but wind loads on buildings, heavy traffic on a bridge, blasts, impacts, ocean waves, materials fatigue … any source of pressure or stress on a structure."

Crucial to the laboratory's contribution to the future of Australia's infrastructure are (from left) Professor Jay Sanjayan, Professor John Wilson, senior technical officer Michael Culton, Professor Riadh Al-Mahaidi and Professor Emad Gad. Passersby on the street can glimpse the experiments inside.

The team members assembled to run the facility have been drawn from key fields of expertise: Professor John Wilson, earthquake engineering, Professor Emad Gad, structural engineering, and Professor Jay Sanjayan, geopolymers. Professor Al-Mahaidi is an international leader in the field of bridge engineering, structural systems and structural retrofitting using fibre-reinforced polymer composites.

The facility is jointly funded by Swinburne and the Australian Research Council with contributions from 11 collaborating universities.

Tests strengthen case for new materials

The facility opens the way for the next generation of construction materials to be thoroughly tested and to provide industry and consumers with the necessary level of confidence in performance and safety.

For example, Professor Sanjayan will be using the HTF to demonstrate to industry the advances in geopolymers and their potential as an alternative to cement. Geopolymers are manufactured from industrial wastes such as fly ash, slag and waste glass.

"Conventional cement has been around for over 100 years, so there is a natural hesitation to use something new," he says. "This facility will help us demonstrate geopolymers are not only better environmentally, but also have improved structural properties."

Professor Sanjayan explains that conventional cement is a heavy contributor to the carbon cycle and it loses its strength (can explode) when subjected to the heat of an intense fire. "Geopolymers have high fire resistance and can be a superior product overall."

Professor Sanjayan expects the new facility to be able to steer geopolymers into commercial use within five years.

Earthquake security

Professor Wilson intends to use the laboratory to push the boundaries of knowledge on 'building drift' in an earthquake.

"We know a lot about gravity load, which ultimately causes a building to collapse, and about the lateral strength needed to accommodate wind pressure and ground shake; but an area needing more research is 'building drift'," he says. "If a building drifts too far (through earth movement), gravity load takes over … but how far is too far?"

Professor Wilson is keen to explore this issue of 'drift' in building systems, especially integral systems such as lift shafts. "A lift shaft is not just for vertical people transport. It forms the spine for the building's lateral construction. So knowing how far lift shafts can drift before they cause the building to collapse is a key question."

Professor Wilson says this is where the new hybrid facility's advanced simulation capabilities will come into their own. Already the integration of digital and physical models has lifted the accuracy of testing beyond what was previously achieved with physical models alone.

Affordable housing closer to home

The research closer to home is that of Professor Emad Gad, whose area of speciality is residential structures. Through his research the HTF will play a crucial role in the evolution of new housing materials and building systems needed to develop more affordable and more environmentally attuned dwellings.

"The tests we undertake will help establish new approaches to housing by testing and calibrating the new materials and construction methods that will influence design, functionality and affordability."

Professor Gad says the new facility will allow researchers to test full-scale structures such as entire wall and floor systems, new construction methods such as factory-built houses and new 'assembly' technologies. "Even the humble screw is continuing to develop … So as community pressure grows for more affordable and more environmental housing, the HTF will speed up the R&D needed to achieve these goals," he says.

MORE INFORMATION

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National benefit

The Hybrid Testing Facility is a key capability of Swinburne's $15 million Smart Structures Laboratory. It is available to other Australian universities and to government and industry bodies collaborating with universities.

This is expected to lead to the development of more efficient infrastructure systems and safer buildings, bridges, offshore structures and mining structures. Economic and social benefits should come from more resilient, robust and efficient infrastructure constructed with innovative materials designed to lower costs, improve energy efficiency, and reduce environmental impacts generally.

All this has the potential to lift the international competitiveness of Australian construction and manufacturing industries. Australia spends about $100 billion annually on building and infrastructure.

ONLINE EDUCATION

Working the online space

Denice Pitt

CHIEF EXECUTIVE OFFICER, SWINBURNE ONLINE

Drawing on her background in building successful start-ups in the corporate service industry, Denice leads Swinburne's new joint venture with jobs website SEEK providing degree programs online.

What attracted you to this role?

I am a firm believer in the value of education. I have seen the potential that degree qualifications can unlock. SEEK and Swinburne partnered to combine their respective online smarts and academic knowledge – I get to take the best from both.

What is revolutionary about Swinburne Online?

'Revolutionise' is a strong word but it does capture our approach. We want to ensure we meet the needs of working adults, so we don't want to modify; we are transforming the on-campus university degree model so it meets their needs in a totally online environment.

Why target working adults?

We believe working Australians are not as well serviced as other groups. We are focused on providing a whole-of-degree experience, rather than offering individual units. Everything we are creating is aimed at meeting the needs of busy, working adults who are looking for new qualifications to achieve their career goals.

How is research influencing the company?

Research shows working, studying adults need both flexibility and regular interaction, which is reflected in our approach. We won't invest in technology just because it is leading-edge – it must enhance the student experience and be accessible on all devices. There have been spectacular successes and failures in the online education space internationally, providing valuable experiences for us to learn from.

Isn't the online education market saturated?

Our success will be in the high quality of our programs and teaching and student support. We are using a high-touch approach, which means lower student-to-tutor ratios. Our e-moderators will focus on mentoring and coaching students, rather than disseminating content. Our aim is to create Swinburne's five-star student experience in a virtual campus for working adults.

MORE INFORMATION

www.swinburne.edu.au/online