The Creation of a Living Laboratory for Engineering at NUI Galway

Jamie Goggins[1,2,3], Eamonn Cannon[1,] David Byrne[1], Marcus Keane [1,2,3], Maeve Duffy[1,2]
[1]College of Engineering and Informatics, National University of Ireland, Galway
[2]Ryan Institute for Environmental, Marine and Energy Research
[3]Informatics Research Unit for Sustainable Engineering (IRUSE), NUI Galway
jamie.goggins@nuigalway.ie

Background to the Project

The New Engineering Building(NEB)at NUI Galway (Fig 1) will integrate all engineering activities on campus into an exclusive, state of the art academic facility by September 2011. The building will not only provide a learning environment, but will itself act as a teaching and learning tool. It will be a 'living laboratory' for engineering, where live data sets from numerous types of sensors will be provided for use in illustrating structural engineering and building performance concepts in undergraduate teaching, and in the development of full-scale research in structural engineering and energy. Environmental, energy and structural characteristics of the structure are to be systematically capture, transformed and monitored throughout the buildings entire life cycle. Data measuring the strains, temperatures and movements due to loading of the building will be gathered along with energy demands and performance of the building. Monitoring of the power consumption of different electrical loads such as lighting, computing and HVAC equipment will be performed, so that their relative energy costs can be demonstrated. The information gained from this instrumentation is being used to create interactive tools for students, form the basis for future research projects and facilitate the advancement of engineering teaching methods. The vision is for a building whereby future students will be able to analyse and understand a building's defining characteristics at first hand and on a personal level.

Figure 1: *The recently completed New Engineering Building at the National University of Ireland, Galway*

The New Engineering Building

- Gross floor area of 14,100 m^2.
- Largest school of engineering in the country (facilities for 1300 undergraduate and postgraduate students).
- Designed using green building initiatives
  - high-tech renewable energy systems
  - environmentally friendly heat generation using carbon-neutral biomass
  - rainwater recycling
  - ground source heat pump
  - low-embodied energy construction materials
- Structural engineering aspects instrumented as teaching and learning tools:
  - Comprises of concrete (in-situ & precast) & structural steel.
  - 40 tonne prestressed concrete transfer beams
  - prestressed double tee units
  - novel Cobiax void-formed flooring system
  - structural steel plate girder

Aims of the Project

- Create a 'living laboratory' and interactive teaching environment.
- Collate data from all sensors in the building into an overall database.
- Use the sensor data for the detailed analysis of building elements, both structural and energy.
- Create an integrated network where data will be available via visual display units within the building and also to a wider audience via the internet, which can then be used for teaching and learning.
- Aims are summarised in Fig.2 with a visual representation of sensors and how they interact with the building given in Fig. 3.

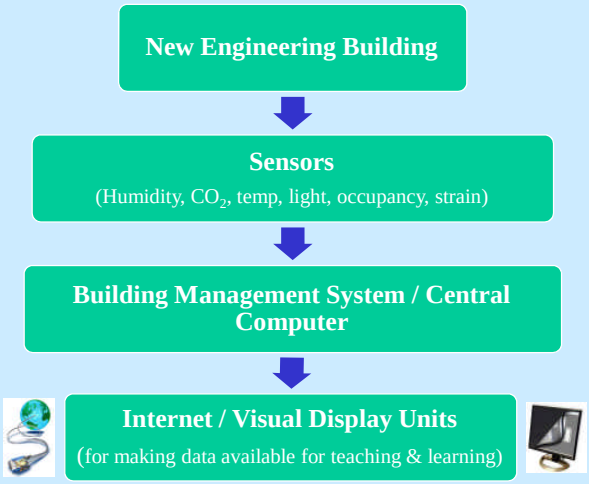
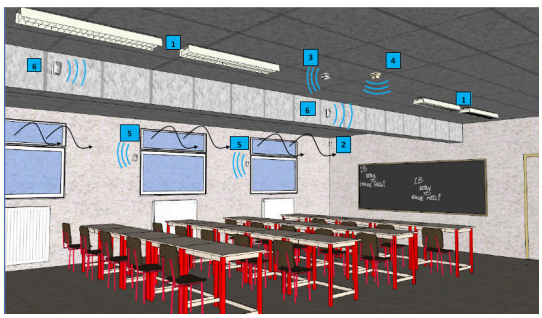


Figure 2: *Flow diagram showing aims of project.*



1) Light sensors automatically measure LUX in a room and operate lighting accordingly.
2) Occupancy sensors adjust temperature and turns off lights when a room is not in use.
3) Room temperature sensors for minimal energy consumption.
4) Humidity and CO_2 sensors to monitor air quality.
5) Passive ventilation will cool room and reduces the need for air-conditioning.
6) Strain gauges to monitor response of structural elements in the building.

Figure 3: *Typical room in NEB showing instrumentation and how it interacts with its surrounding environment.*

Case Study: Void-form flat slab system

- Novel form of flat slab system (Fig. 4).
- 1st of its kind to be used in Ireland.
- Comprises pre-cast element (made off site) and in-situ element). See Fig. 5.
- 164 sensors installed in slab element in NEB.
  - 64 vibrating wire gauges
  - 100 electrical resistance strain gauges
- Gauges monitoring temperature and strain in slab element
- Aim is to investigate two-way spanning action of this novel form of slab.

Figure 4: *'Cobiax' void -form flat slab system being installed in the NEB (left) and with gauges installed (right).*

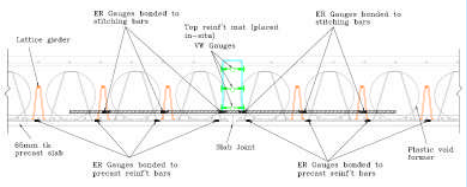


Figure 5: *Typical section showing instrumentation of gauges in the void-form flat slab system.*

Outcomes

- Data for research to understand the behaviour of novel flat slab systems.
- Live data that can be used as a teaching tool for undergraduate and postgraduate programmes.
- Possible to see significant changes in the temperature of the concrete due to heat of hydration and variation in ambient temperature.
- This in turn has an effect on the strain within the concrete as can be seen from Figs 6 below.
- Possible to see strain increases due to early creep and shrinkage.

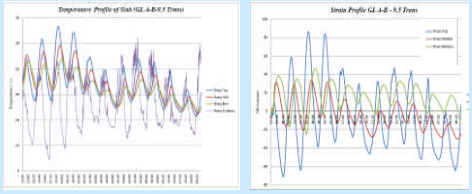


Figure 6: *Graph showing data obtained from initial instrumentation of the void -form flat slab system and the correlation between temperature and strain in concrete.*

Acknowledgements

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Project Team: Architect: *RMJM/ Taylor Architects* Structural Engineer: *Arup* Building services engineers: *PMG* Main Contractor: *BAM Contractors* M&E Contractors: *Mercury Engineering* Cost Consultant: *Davis Langdon PKS* Precast Subcontractors: *Oran Pre-cast Ltd.; Banagher Concrete Ltd.*

IRUSE
NUI Galway OÉ Gaillimh Ryan Institute Environmental, Marine and Energy Research