Structural Woven Formwork

LimesNet

Woven Structural Formwork

Mission Leader: **Dr Julie Soden (University of Ulster)**
Mission Partners: Professor Remo Pedreschi (University of Edinburgh), Professor Pete Walker and Dr Martin Ansell (University of Bath)

About this Case Study

The main objectives of the cross-disciplinary team were focused on the use of textile in construction, including:

1) use as the key load-bearing element within permanent fabric formworks;
2) reinforced natural fibre systems for building components;
3) applications of geo-textiles in large–scale infrastructure.

The objectives were discussed and developed with expert contributions and during a series of one or two-day meetings led to a dynamic exchange of knowledge and ideas. The team met with key experts in the various fields, Prof Mark West, C.A.S.T. University of Manitoba, Mercedes Alcock (product innovation team) at the Composites Innovation Centre, Winnipeg and Dr Richard Brachman of the Geo-Engineering Centre, Queens University Kingston. Visits were also made to the Alternative Village, University of Manitoba and Red River College, Manitoba. Discussions considered the need for enhanced structural performance through the emergence of new textile assemblages, improvement of disaster area infrastructure and how concrete, hemp-lime and other in-fill materials inform the process (and design) of construction, both practically and conceptually.

Fast Facts

- Using fabric formwork enables structurally efficient, custom shaped and aesthetically appealing concrete members to be formed.
- Lightweight textile formwork is suitable for concrete.
- Dewatering of fresh concrete during casting improves strength and durability of hardened material.
- Geotextiles suffer from elongation, buckling and rupture when stressed in buried containment infrastructure.
- A high performing Geotextile reduces amount of aggregate required.

About this Mission

The main objective of the mission was to discuss and assess the potential benefits for developing new, advanced textiles for formwork systems with a variety of in-fill materials, to improve construction efficiency and structural performance and durability. Building components such as columns, beams, vaults, panel products, natural fibre composites and moulded architectures were studied as exemplars of good practice. The mission team learned of their achievement and attributes in terms of fabrication, economy of process and structural performance and how these could be further enhanced using advanced textiles. Following the visit to the Geo-engineering Centre at Queens University Kingston, the improved design of buried geo-composite and geo-textile containment materials emerged as a focus applicable to the mission.

A two-day engagement with Prof Mark West and his team from the CAST Centre and architecture colleagues enabled a hands-on exchange with the mission team. Issues discussed included identifying the key characteristics and properties of a range of textile reinforcements, natural fibre performance, selection and variation of in-fill materials, impact

"From reinforced wall structures and conceptual formwork to new containment infrastructure, weaving is a key technology enabling new solutions to be realised for the built environment"

of formwork and geotextile required in the build process, and finally the design approach. Responding to requirements for material efficiency, improved integral strength and adapting established formwork techniques to produce larger scale span structures, new ideas for in-filled formwork through the use of load-bearing textile reinforcement evolved.

The mission team presented their individual research expertise (3D woven and load-bearing textile design, the properties and analysis of natural fibre composites, processes and methods in formwork concrete and sustainable building practices using straw-bale) with specific relevance to the mission topic. Discussions with the Composites Innovation Centre focused on test procedures for natural fibres and with the mission's textile focus, concentrated on the textile supply chain and material sourcing in North America, economical ways to improve the structural performance of non-woven natural fibre mats and the development of natural fibre composite products for dwellings.

The team also met with Dr Richard Brachman and Prof. Ian Moore from the Geo-engineering Centre at Queens University Kingston, who highlighted the performance shortcomings in geo-composite materials for underground containment structures that result in subsequent economic problems. The potential in an improved textile geo-composite solution was realised. The visit included a tour of the buried infrastructure test laboratory.

Benefits/Impacts of the Mission

The LimesNet funding was critical to bring the cross-disciplinary group of experts together. Approaching the topic from a materials (design) perspective generated debate about the use of 'ubiquitous' commercially available materials, the issues regarding the introduction of new materials and processes to the construction industry and the need to understand the client user group. Allied discussions revolved around the anthropology of dwellings, producing structures for the varied terrain and climatic conditions, and inhabitant behaviour. Other discussions brought in an interest of digital 'tagging' building materials and systems to record their design, construction and history.

There is a significant impact on non-research groups and a definite benefit to a wide range of inhabitants for the development of these new formwork materials, particularly in disaster relief areas, areas prone to flood, building on reclaimed land etc.

Outputs

- Mark West invited to attend the next fabric formwork workshop at the University of Edinburgh, along with the other members of the mission.
- Prototypes developed at Ulster (patent pending) to be used in trials at University of Edinburgh and University of Bath.
- Invited to submit collaborative research paper at Geotechnical Engineering Conference, Montreal, Canada 2013.
- Contact with Red River College will lead to proposals for some collaborative study projects.
- Potential contribution to new composite product for Alternative Village.
- Attracted a number of interested Industrial parties.

Follow up activities

- New directions in formwork design, geo-composite and reinforcing fibre structures for either feasibility study or full grant proposal status.
- The funding strategy to target collaborative AHRC / EPSRC initiatives with strategies to collaborate with International partners.
- Develop both short-term speculative research projects (with specific manufactured outcomes).
- Develop cross-discipline practical workshops for students to escalate the ideas and raise overall profile of the materials.
- Apply for funding an International PhD in a formwork related topic.
- Collaborative conference papers are planned once prototype and workshop outputs are complete.
- Continue to seek additional committed industrial and NGO humanitarian partners.

www.limesnet.org.

If you have any queries, comments or ideas about any aspect of LimesNet, please email limesnet@bath.ac.uk, or contact:

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This partnership received financial support from the LimesNet network. LimesNet is an EPSRC funded network aimed at developing novel and innovative interdisciplinary research activities in the future development of low impact/low carbon construction materials and technologies in structural and ground engineering. Membership consists of internationally renowned universities, industry and other interested third party stakeholders. For further information, please refer to www.limesnet.org.

The Potential of Advanced Textiles for Fabric Formwork

Artist Name: Julie Brennan
Output Number: 3 of 3
Output Title: The Potential of Advanced Textiles for Fabric Formwork
Main Publication: Journal paper
Year: Pending -2013

This journal paper discusses the development of fabric formwork from a textile perspective, where the adoption of more sophisticated textile construction proposes the manufacture of new types of flexible and embedded fabric formworks for potential use in the construction Industry. These include fibre systems for reinforcing building components, containment structures arranged with open cavities to accept in-fill and layered geo-textiles. In-filled with concrete, aggregate or earth, tailored performance characteristics built-into the textile design can enhance the overall properties of formwork elements. The developments provide key pointers for the progression of the discipline and automation of the process.

The journal paper describes the collaborative outcomes of an International research mission funded by EPSRC to Canada in 2012. Entitled ' Woven Structural Formwork'. The author led a multidiscipline team of experts to engage with International leaders in the Fabric Formwork field with the objective of developing advanced woven textiles for use as new structural formwork containment and reinforcement systems to improve construction efficiency, structural performance and durability. A driving force was to minimise the use of supporting timber frameworks and to provide innovative and sustainable solutions for the built environment in the UK as well as resettlement dwellings for displaced persons in areas of natural disaster.

Limes Net – Low Impact Materials and Innovative Engineering Solutions for the Built Environment is an EPSRC funded International Network led by the University of Bath aimed at developing novel and interdisciplinary research activities in the future development of low carbon construction materials and technologies in ground and structural engineering.

The journal is pending publication in Aug 2013.

This mission case study can be found here:
http://limesnet.org/wp-content/uploads/2012/09/IMF003_finalLimesnetCase-study_Soden.pdf

The main Limesnet website: Http://www.limesnet.org

Portfolio Contents List

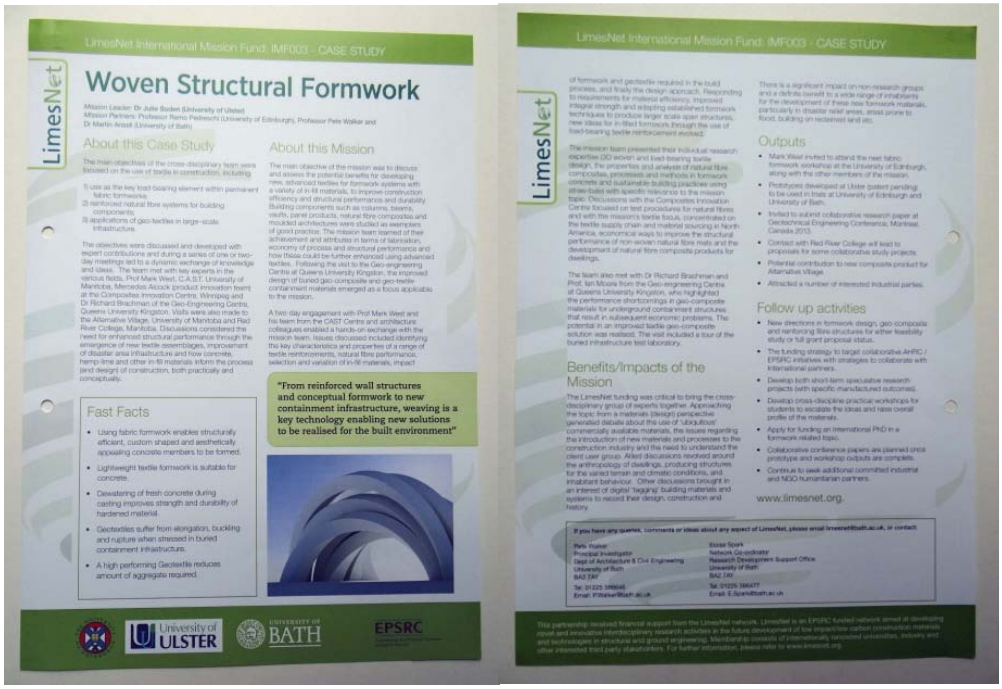
Dissemination: Journal, Case Study and Research Workshops

The journal paper is due to be published in the Institute of Civil Engineering Journal of Construction Materials in Aug 2013 as a special Limesnet issue.

The cross discipline mission team included Prof Pete Walker, BRE Trust Chair in Innovative Construction Materials at University of Bath, Prof Remo Pedreschi, Professor of Architectural Technology at University of Edinburgh and Dr Martin Ansell, Reader in Materials at University of Bath. In engagement with Prof Mark West, the primary global expert in the formwork field, the team visited the Centre for Architectural Structures and Technology (CAST) Centre at University of Manitoba, Canada, the Composites Innovation Centre, Winnipeg Canada, The Alternative (sustainable building) Village, Manitoba and the Geotechnical Engineering Centre at Queens University Kingston, Canada.

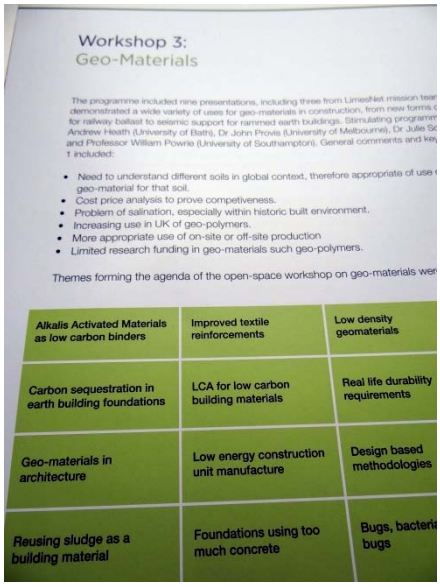
The mission and subsequent outputs were endorsed and published by EPSRC and the Limes-net board. Further dissemination took place in May, June and July 2012 through 3 day interactive research workshops at Bath Innovation Centre, the Formwork Workshop at Edinburgh University, The Limes Net Conference (Bath, 200+ delegates), and through published case study (see below). The work also generated secondary and tertiary impact through substantial membership of the Limes Net Network, via the website (www.limesnet.org), the limes Net Wiki and in electronic form.

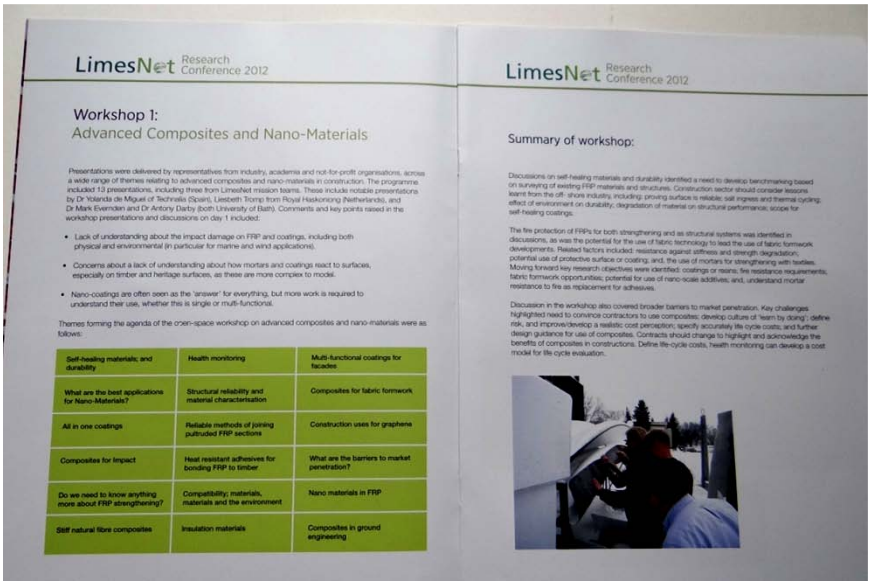
Mission Case Study:



All the funded Limesnet missions can be found here:
http://limesnet.org/research-and-scope/international-mission-fund/library/

Research Workshops:





- Mission team formwork trials at Bath and Edinburgh May-July 2012
- Workshop weaving trials at Ulster 28 May- 12 June 2012
- University Edinburgh formwork workshop – 6-15 June 2012
- Limesnet Conference –10-13 July 2012, Bath

Info one	Info two	Info three	Info four
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Research context: Advanced Textile formwork

The mission researchers investigated where improvements to the fabric formwork process could be readily identified through the introduction of advanced or specifically tailored textile reinforcement.

Learning how current formworks are utilised for construction and identifying the 'ideal' formwork material characteristics would help establish a specification for future materials. The team investigated textile constructions produced at UU and debated their potential for advanced structural formwork particularly for more challenging constructions like vaults, curvatures and rapid deployment wall systems. The impact of In-fill materials such as concrete, aggregate, earth and rubble were considered as were their use for Geo-textile buried infrastructure and containment. Reportage, dissemination, future research collaborations, and workshops were a key feature of the project.

The mission findings - Advantages of textile systems:

- Improved structural performance with specific 'load' zones could be achieved by designing a robust multiple layer or cavity construction that increases compressive strength and prevents racking.
- Robust fabric resists against high tension forces of in-fill, aggregate and the hydro-static pressure of concrete during installation. It aims to provide increased resistance to uneven in-fill settling.
- The textile cavity product provides a predominantly timber-free, free-standing solution which eliminates the reliance on substantial timber frameworks and sacrificial timber during installation.
- Textile structures offer potential for scaffold and gabion structures for flood prone areas with seasonal floods and natural disasters.
- Breathable wall performance through fibre choice can be achieved.
- Compatible coating agents/ lime renders improve fire resistance and guard against insect invasion and fungal growth.
- Easily transportable to inhospitable terrain and particularly suited for economies where natural disaster has eliminated all vegetation.

A very large collaborative EPSRC Limesnet research proposal was submitted to the Ground and Engineering Research call in Oct 2011 (led by Univ. Bath) of which the author was a co-investigator entitled 'Intelligent Concrete: Fabric formwork for Lower Impact Construction' . The proposal was recommended for resubmission with a smaller focus at a later date.

Mission and workshop Evidence

Centre for Architectural Structures and Technology (CAST Centre), University of Manitoba, Canada – Prof Mark West
Composites Innovation Centre, Winnipeg, Canada - Mercedes Alcock (product development)
The Alternative sustainable Village, University of Manitoba, Canada
Geoengineering Centre, Queens University Kingston - Dr Richard Brachman

Factual Information

This project was funded by EPSRC through the Low Impact Materials and Innovative Engineering Solutions for the Built Environment (Limesnet) Network, PI Prof Pete Walker, University of Bath, Nov 2011-Sept2012, International Mission Funding, £8,000.

Progressive 'formwork-specific' textile prototypes were designed to simultaneously minimise the use of timber, utilize sustainable in-fill (earth, hemp-lime) and produce efficient forms with lower environmental impact within one system. Their unique characteristics are described in a recent GB Patent application awaiting examination (PCT/GB2012/0528513, Nov 2012)

Soden has also secured Invest Northern Ireland 'Proof of Principle' Funding in conjunction with UU Office of Innovation (2012).

Please note author Soden is now using her married name (Brennan) and outputs on the UIR will be found under Brennan.