DEVELOPMENT OF PREFABRICATED CONSTRUCTION PRODUCTS TO INCREASE USE OF NATURAL MATERIALS

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Summary

Natural building materials are gaining recognition for offering significant benefits in the delivery of lower carbon and healthier buildings. However, to compete successfully with existing solutions, natural materials must be able to demonstrate consistently reliable performance and be suitable for the demands of modern construction, including having the capacity for use throughout the year and delivery in all but the most severe weather conditions. Suppliers of natural building materials, such as straw bale, hemp-lime and unfired clay, are increasingly turning to prefabricated panelized products in place of more traditional on-site trade solutions. Drawing on the experience of straw bale panel construction in the UK, this paper sets out a case for increasing the use of natural materials in mainstream construction through the manufacture of prefabricated products.

Keywords: natural material, prefabrication, certification, straw bale

1 Introduction

Natural building materials, often based on traditional pre-industrialised technologies or materials, such as earth, lime, and straw, offer many benefits for the modern, airtight, low carbon building. They often have significantly lower embodied carbon and energy than the materials they seek to replace. Renewable supply chains for agricultural co-products such as straw and hemp shiv reduce reliance on products reliant on non-renewable resources such as crude oil and minerals. In addition natural materials also offer potential to create healthier internal environments by reducing chemical loadings and through their passive (hygroscopic) regulation of internal humidity levels.

Traditional in-situ craft based techniques, such as rammed earth or cob construction, have been successfully reintroduced into modern construction, but to date their uptake and impact has been limited. The simple reintroduction of traditional materials is not generally compatible with a wider construction industry increasingly moving away from wet trades, such as masonry or plastering, in favour of prefabricated modern methods of construction. In-situ wet trades that are reliant on weather conditions for application and drying out potentially delay construction times and increase risk. Any solution seeking to displace existing solutions must deliver comparable or better performance at similar or lower cost.

The construction industry is often cited to be conservative and reticent to adopt new innovative technologies. Disruptive technologies, such as natural building materials, must demonstrate reliability and consistency in quality if they are to be widely adopted into the mainstream. The development of mass produced individual components, such as insulation batts or masonry units, or larger building elements, such as cladding or loadbearing wall panels, provides a means for wider market adoption of natural materials.

This paper briefly outlines the development of prefabricated straw bale panel construction in the UK. Development of the technology over the past 7 years is summarised together with current work to ascertain it certification.

2 Prefabricated straw bale panels

Since its initial development in the nineteenth century straw bale construction has been used to form either loadbearing or non-loadbearing external walls [1, 2]. Traditional walls are built in-situ and without protection construction is delayed by inclement weather conditions since it is essential to keep the bales sufficiently dry. Although non-loadbearing in-fill provides the opportunity for weather protection from the surrounding structural framework, in-situ straw bale construction is limited by an inconsistency in material supply, fire risk during construction and storage problems. Wider perceptions of straw bale include poor fire resistance, poor durability, vermin infestations and low resistance to wind loads.

The use of straw bales as insulation within prefabricated timber framed panels has grown around the world. Details vary but examples are to be found in many countries including Australia, Austria, Belgium, Canada, Estonia, France, Italy, Switzerland and the UK. ModCell panels are one of the earliest examples with initial use in the UK in 2000. Initially developed as cladding panels, ModCell panels are comprised of an engineered timber (glulam or CLT) frame with straw bale infill and hydraulic lime render finish (**Fig. 1**). Panels typically measure 2.8–3.0 m high, 3.0 m wide and 0.48–0.50 m thick. The panels are made in a ‘flying factory’, a temporary place of panel manufacture set up in a building located within a few kilometres of the construction site.

Fig. 1 *ModCell panel under construction*

Since their initial use as cladding panels in a variety of successful projects, ModCell panels have evolved into loadbearing structural panels suitable for buildings up to three-stories high. The BRE Centre for Innovative Construction Materials at the University of Bath has worked with ModCell Ltd since 2006 in the development of the panels, completing structural, fire, acoustic, thermal transmittance and environmental testing of individual panels as well as on-going tests and monitoring of complete building projects. In developing a successful panel ModCell Ltd have addressed many existent barriers to straw bale construction and deliver a growing of successful buildings in the UK (**Fig. 2 and 3**). However, wider market growth in the domestic housing sector in particular has been limited by the lack of product certification.

Fig. 2 *BaleHaus, Bath (2009)*

Fig. 3 *Hayesfield School, Bath (2012)*

3 Certification

Certification schemes, including EU wide CE marking as well as national schemes such as British Board of Agrement (BBA) or BM Trada's Q-Mark in the UK, provide the basis for product acceptance and specification. Certification demonstrates compliance with agreed performance specifications appropriate to the product and proposed application. Importantly certification provides basis for the award of warranty (insurance) necessary for financing of projects. Whilst certification is not a requirement for product use and acceptance, having certificate of performance compliance addresses many barriers to wider adoption by a risk adverse construction industry. Development of a prefabricated panel provides the opportunity to obtain certification for straw bale construction.

ModCell Ltd and the University of Bath are currently working together, with three other partners, on an EACI Eco-Innovation funded project 'EuroCell' to obtain certification for the ModCell panel system. Tests are currently on going at the time of writing, with certification expected to be granted later in 2013 or earlier 2014. One of the challenges in this process has been absence of a quality control or regulatory framework for straw as a building material. Whilst there are many Euro Norm and national standards for industrialised construction products, that provide a framework for assessment and certification, there are very few such standards for straw bale construction. Although the award of certification does not ensure warranty of the product, it will provide the basis for wider market acceptance and specification.

4 Conclusions

The development of prefabricated panels was undertaken to address practical concerns for the delivery of straw bale construction, including variation in bale sizes, weather delays, negative perceptions to straw, and fire risk during construction. However, the successful development of panel products has also provided opportunity for addressing much wider barriers to market acceptance through certification and warranty.

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