Universidade do Minho
Escola de Engenharia

Semana da Escola de Engenharia
October 24 - 27, 2011

SANDWICH STRUCTURAL PANELS COMPRISING THIN-WALLED STEEL FIBRE REINFORCED SELF-COMPACTING CONCRETE (SFRSCC) AND FIBRE REINFORCED POLYMER (FRP) CONNECTORS

Rodrigo Lameiras, Joaquim Barros, Miguel Azenha and Isabel Valente
ISISE, Department of Civil Engineering
E-mail: rmlameiras@civil.uminho.pt

KEYWORDS
Sandwich structural panels, Steel Fibre Reinforced Self-Compacting Concrete (SFRSCC), Fibre Reinforced Polymers (FRP) connectors.

EXTENDED ABSTRACT

Introduction

The main interest on using construction sandwich panels is related to the structural and thermal efficiency that can be achieved with this technology. By putting together thin, strong, ductile facings and a thermally-efficient core material, it is possible to obtain lightweight panels that are energy efficient and that can be easily handled and erected (PCI Committee on Precast Sandwich Wall Panels 2011). Traditionally these sandwich panels adopt two conventionally reinforced concrete layers (also known as wythes) and metallic connectors between both of them. Due to their high thermal conductivity, the metallic connectors in these insulated wall panels generally cause thermal bridges on the building envelope that result in increased heat flow (Rizkalla and Dawood 2009). Particularly in the case of cold climates, these thermal bridges cause additional transmission losses, lower inner surface temperatures and possibly condensation and mould problems.

The present research work aims to propose an innovative thermally efficient prefabricated structural sandwich panel comprising thin-walled SFRSCC as facing material, a lightweight thermally insulating core material, and FRP shear connectors. The idea is to develop a fully prefabricated structural cladding wall system that incorporates all the installations, thermal insulation and finishes, which minimizes the set of operations that need to be performed at the construction site: placement of the panel and connections to foundations and adjacent elements. The wall system here proposed also acts as part of primary load carrying system of the structure transferring gravity loads and lateral loads due to wind or seismic events to the foundation of the structure. The inner wythes will also support flooring units above, eliminating the need for any other structural framework.

Preliminary Results

Optimization of the Sandwich Panel Concept

Firstly, the optimization of sandwich panel concept is done based on numerical modelling with recourse to linear finite element analyses (FEMIX). An initial optimization consisted in evaluating two solutions: (i) adopting ribbed wythes to minimize stress concentration along the onnectors;(ii) using either trusses or profiles as connectors. Panels with 5 m width and 2,5m tall were studied, with concrete layers represented by shell elements and the connectors by shell and beam elements. Horizontal loading associated to wind is induced to the panel and the maximum stresses in the wythes are parametrically evaluated as shown in Fig.1.

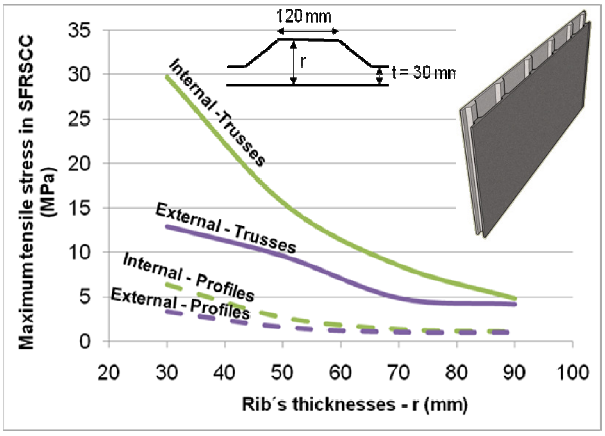

Figure 1: Optimization of the geometry of panel.

The results show that the use of trusses as connectors leads to higher stress levels on the SFRSCC layers and increase the thickness of the concrete in the vicinity of the connections is an effective solution for reducing

Universidade do Minho

Escola de Engenharia

Semana da Escola de Engenharia
October 24 - 27, 2011

tensile stresses in the wythes, thus providing wider safety margins for cracking.

Connections between FRP and SFRSCC– Pull out tests

A preliminary experimental study was performed to compare the mechanical behaviour of several connector configurations through pull-out tests. One type of adhesively bonded (C) and 3 types of embedded connections (referred to as Y, T and L) were tested. The experimental setup is shown in Figure 2. To increase the connection load capacity, circular holes were devised in the embedded connectors.

Figure 2: Experimental setup for the pull-out tests.

The pull-out force *vs.* slip diagrams obtained for the different types of connection are shown in Figure 3.

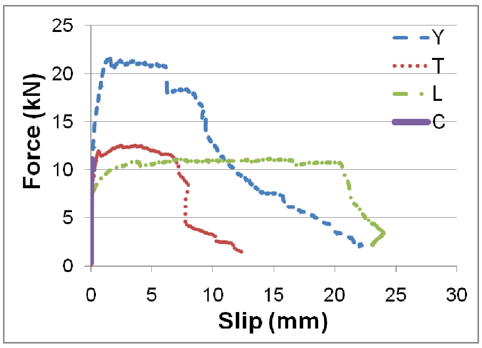

Figure 3: Force versus slip diagrams.

The typical failure modes obtained for the different types of connection are presented in the Figure 4.

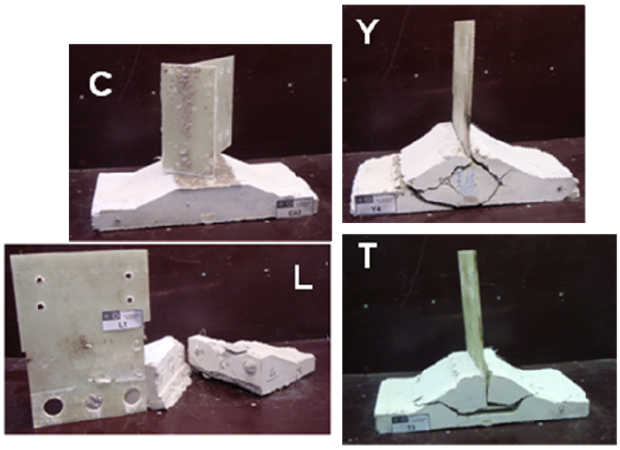

Figure 4: Typical failure modes.

These preliminary tests evidence the possibility of attaining a pullout load that is considered enough for expected stress levels in the present application. Contrary for what is observed for the bonded connections, the embedded connections have shown a quite large ductility.

ACKNOWLEDGEMENTS

The authors would like to thank the Portuguese Foundation for Science and Technology for financial support through the PhD grant SFRH/BD/64415/2009.

REFERENCES

PCI Committee on Precast Sandwich Wall Panels 2011. State-of-the-art of Precast/Prestressed Sandwich Wall Panels. *Precast/Prestressed Concrete Institute Journal*, Spring 2011, 131-176.

Rizkalla S. H. and Dawood M. 2009. Advances on the Use of FRP for the Precast Concrete Industry. In *FRPRCS-9*. Sydney, Australia.

AUTHOR BIOGRAPHY

RODRIGO LAMEIRAS was born in Maceió, Brasil, and is graduated in Civil Eng. by UFAL, Brasil, in 2004. Master in Civil Eng. by UFRGS, Brasil in 2007. He is a researcher of ISISE, Dep. of Civil Eng., University of Minho, since October 2009. E-mail address: rmlameiras@civil.uminho.pt.