Project Title:	Development of Precast BFRP Grid-reinforced Geopolymer Sandwich Wall Panels for Green Building Construction
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Research Institution:	The Hong Kong Polytechnic University
Subject Area:	Environment and Sustainability

Objective

- To investigate the mechanical performance of a new type of glass fiber-reinforced polymers (GFRP) tubular connector;
- To evaluate the structural performance of steel and fiber-reinforced polymers (FRP) reinforced geopolymer concrete one-way slabs acting as the two wythes in the precast concrete sandwich panels (PCSP) system;
- To investigate the structural performance of the GFRP connector-enabled precast geopolymer concrete sandwich panel (PGCSP); and
- To investigate the fire performance of the GFRP connector-enabled PGCSP.

Background

Precast concrete sandwich panels (PCSPs) as the typical structural element in precast industry, have been widely used as the facade walls or load-bearing walls in engineering practice. The components of a PCSP are inner and outer reinforced concrete (RC) wythes, core insulation and connectors penetrating through the insulation. Traditionally, concrete block and steel bent-up bar were used as the connectors, which could achieve a high degree of composite action (in terms of stiffness and strength). However, they were prone to thermal bridge effect which could occur due to the higher thermal conductivity of steel and concrete. Such a deficiency usually reduces the energy efficiency of the entire sandwich panel. Therefore, fiber-reinforced polymers (FRPs) have been used as the connectors due to their high strength but low thermal conductivity. However, limited investigations have been conducted on how the FRP connectors influence the structural performance of the fabricated PCSPs. In addition, most existing FRP connectors were designed to transfer one-directional shear force and the formed PCSPs were usually non-composite type due to the lower stiffness and lower capacity of the connectors. Hence, there is a need to develop a new type of PCSP.

Methodology

The performance of the proposed GFRP connectors was investigated experimentally and numerically. For the experiment investigation, twenty-five specimens were tested under in-plane direct shear with two identical specimens for each combination of test parameters. The overall dimensions of the test specimens were 400×300×300 mm (i.e., length×width×height) which represented a two back-to-back sandwich panel. In the specimens, extruded polystyrene (XPS) foam with a smooth surface condition was used as the insulation layer. The thickness of the insulation was 50 mm. In order to measure the relative slip between the core concrete wythe and the two outer concrete wythes, linear variable differential transformers (LVDTs) were placed at the front and back of each concrete wythe. The load was applied in a displacement-controlled manner at a loading rate of 1 mm/min. A load cell was placed at the top center of the core concrete wythe to measure the load. Furthermore, 2D FE analysis was conducted to reproduce the initial linear and the non-linear behavior of the in-plane direct shear test. A general-purpose FE program known as ABAQUS was used.

Results and Findings

For the development of the new type of GFRP connector and the performance characterization, it was concluded that:

(1) all connectors reflected a progressive failure;

(2) for a lower GFRP laminate thickness, the flat plate connector exhibited less deformability than the corrugated one due to the buckling of the laminate. Increasing the GFRP laminate thickness helped to avoid such buckling and improved the deformability; and

(3) the hexagonal tube connector performed similarly along two orthogonal directions, indicating its excellent potential for use in PCSPs as a two-way connector.

Recommendations

- In future research, an experimental investigation should be conducted to study the effect of section type (e.g. rectangular, pentagonal, hexagonal and circular tube) on the individual performance of the tubular FRP connector.
- The proposed simplified approach for predicting the deflection of basalt FRP (BFRP) reinforced PCSP needs further verifications.
- Details of the connection between the proposed PCSP system and other structural members need to be evaluated.