Mechanical properties and experimental researches of new CSIPs sandwich panels

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Abstract. The advantages of glass fiber reinforced composites (FRP) and SIPs (structural insulated panels) are combined, and a new type of sandwich panel called composite structural insulated panels (CSIPs) is proposed. Through the adhesive bonding, CSIPs are made of FRP as face sheets and expanded polyethylene foam (EPS) as a core. To master the mechanical characteristics of CSIPs, firstly, adopting the large deflection theory of Reissener in this paper derived the calculation formula of displacement and the stability critical load of CSIPs. Then, ANSYS software was used to carry on the analysis of finite element simulation. Finally, a testing piece of CSIP with length 1000mm and breath 1000mm was made and a test was done. The results show that the theoretical analysis results, finite element simulation results and test results are basically coincide. So the calculating formula of deformation and bearing capacity of CSIPs are correct. And CSIPs have the outstanding advantages of light weight and high strength.

1 Introduction

The earliest sandwich construction originated from the corrugated board structure invented by the British in 1856. It adds a corrugated paper core between the two layers of paper to make the soft paper to obtain a certain stiffness[1].In 1935, a forest products laboratory (FPL) in the United States proposed sandwich panel structures, namely SIPs (Structural Insulated Panels) ,which is composed of two layers of the Oriented Strand Board (OSB) as face sheets and a layer of thermal insulation laminated composite panel as a core[2-3].Currently SIPs have been extensively used all over the world, however, the SIPs have the disadvantages of poor fire resistance, easy occurrence of pest and warping deformation.

In recent years, application of FRP (Fiber Reinforced Plastic Composites) in civil engineering structure developed rapidly. The FRP is comprised of enhanced fiber material and matrix material through unique moulding process with the advantages of light weight, high strength, corrosion resistant, the ability of customize, durability, energy conservation and environmental protection and so on. Based on the traditional SIPs, a new kind of sandwich panel structure, namely CSIPs (Composite Structural Insulated Panels), was proposed by this paper using the FRP instead of the OSB. CSIPs have inherited sandwich structural characteristic and production process of SIPs, at the same time, effectively overcome the disadvantages of poor fire resistance, easy occurrence of pest and warping deformation. Moreover, because the strength of FRP is much higher than wood, CSIPs can improve mechanical properties of SIPs greatly.

CSIPs are made of low-cost orthotropic thermoplastic glass/polypropylene (glass-PP) laminate as face sheets and expanded polyethylene (EPS) foam as a core through a hot-melt thermoplastic spray adhesive bonding together. Glass-PP laminates provide high strength-to-weight ratio, excellent impact resistance, and high durability. EPS, on the other hand, are marked by light weight, thermal insulation, good fire resistance and excellent impact properties. All these features lead finally to superior performance of the panels. Therefore, CSIPs have broad application prospects in the wall and roof structures [4-6].

In order to provide a good foundation for the application of CSIPs, the mechanistic properties of CSIPs were studied by means of theoretical analysis, finite element simulation and experimental study.

2 Theoretical analysis

2.1. Basic assumptions

In this paper, the calculation formulas of internal force and displacement in sandwich panels are derived from Reissner theory, which takes into account the basic high-order partial differential equation for the sandwich plate with large deflection bending. The following assumptions are advanced on CSIPs [7-8]: