FINITE ELEMENT ANALYSIS OF AXIALLY LOADED PIERCED PROFILED COMPOSITE PANEL

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ABSTRACT

In this new era, the usage of profiled steel sheeting is getting popular in the construction. The usage of composite profiled steel sheeting can reduce the duration of construction and it is easy during installation. Besides, this two outer skins of profiled steel sheeting with an in filled of concrete also can act as load-bearing wall. Therefore, axial load, lateral load and in plane loads can be carried through to the composite system once the concrete has hardened. The pierced composite profiled steel sheeting such as doors and windows will affect the performance of the composite wall that will cause strength reduction. This project is to investigate the behavior of composite profiled steel sheeting panels under axial load by using finite element method. Six types of model have been analysed in this project and the dimension is 760 mm width and 1000 mm height with standard pierced size of 210 mm x 260 mm. All models are tested under linear analysis which will resulted the deformed mesh, maximum stress and strain and critical buckling load by using LUSAS Modeller 14.0 finite element software. The finite element analysis shows that Spandek composite panel is better than Trimdek composite panel.

ABSTRAK

Pada zaman yang moden ini, penggunaan kepingan besi berprofil semakin terkenal di sektor pembinaan. Konsep komposit kepingan besi berprofil dapat mengurangkan tempoh masa pembinaan dan juga memudahkan kerja-kerja pemasangan. Selain itu, komposit kepingan besi berprofil yang terdiri daripada dua kepingan besi berprofil yang diisi dengan konkrit berbuih juga dapat bertindak sebagai dinding tanggung beban. Oleh itu, Konsep komposit kepingan besi berprofil yang berlubang dapat menahankan beban pungak, beban mendatar dan beban dalaman setelah konkrit berbuih telah dikeraskan. Manakala, dinding berkomposit kepingan besi berprofil yang berlubang seperti pintu dan tingkap akan menjejaskan kekuatan konsep komposit. Dalam projek ini, enam jenis model akan dianalisakan dengan dimensinya yang berukuran 760mm lebar dan 1000mm tinggi serta mempunyai lubang sebesar 210 mm x 260 mm. Model-model akan diuji dengan analisa lelurus bagi mendapatkan pesongan, tegasan dan keterikan maksima di bawah beban paksi. Projek ini menguji perwatakan komposit kepingan besi berprofil yang berlubang apabila dikenalkan beban paksi dengan mengunakan perisian 'LUSAS 14.0 Modeller' eleman terhingga. Dengan menggunakan analisa keadah elemen terhingga, bahawa komposit kepingan besi berprofil Spandek adalah lebih stabil daripada Trimdek.

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LIST OF ABBREVIATIONS

SSS	=	Pierced Single Spandek Profiled Steel Sheeting Panel
SST	=	Pierced Single Trimdek Profiled Steel Sheeting Panel
SCP	=	Pierced Spandek Foamed Concrete Panel
TCP	=	Pierced Trimdek Foamed Concrete Panel
CSP	=	Profiled Steel Sheeting in Pierced Spandek Profiled Composite Panel
CTP	=	Profiled Steel Sheeting in Pierced Trimdek Profiled Composite Panel

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Composite wall or panel is a new building system including two outer skins of profiled steel sheeting with an infill of concrete walling development to a well-known floor system construction. Once the profiled steel sheeting is fixed, it will act to stabilise the building frame. The steel sheeting also provides permanent formwork for the infill concrete with the assistance of temporary waling supports. Composite walling was usually used as a core wall to stabilize steel frame building structures though with its potential which are used in concrete buildings as basement and blast-resistance structure. Axial load, lateral load and in plane loads will be carried through the composite system the once the concrete has hardened.

Foamed concrete is a lightweight concrete due to it is composed without coarse aggregate but with a substantial volume of foam bubbles. In the foamed concrete mortar, these bubbles provide the stability of the foamed concrete. In addition, foamed concrete is very effective isolating material. Buildings constructed from foamed concrete are able to accumulate cold or heat, which allows to greatly minimizing conditioning or heating expenses.

The advantages of composite walling lie in the speed and convenience of construction. However, it is necessary to establish the structural behaviour of the system when resisting construction and service loading.

1.2 Problem Statement

The usage of the profiled steel sheeting is a predominant system in steel framed structure but plain composite panel without profiled happened to be less strength if subjected to high load. In construct, plain composite panel can increase the stiffness and strength by using profiled steel sheeting as the composite panel's permanent formwork. In addition, the presence of pierce for windows and doors opening will affect the performances of the composite wall that cause the strength reduction (Mays et al. 1998).

1.3 Objective of Study

The objectives of the axial load test of the profiled steel sheeting panels are:

i. To analyse the stress- strain behaviour of pierced profiled composite panel under axial loading condition.

ii. To identify the effect of opening in the composites systems.

iii. To compare the buckling curvature between the Trimdek and Spandek profiled composite panel.

1.4 Scope of Study

The scope of studies for this project is the behaviour of profiled Trimdek and Spandek panel act as a load bearing structure which is important to determine the ultimate loading capacity due to axial load by. Axial compression load has significant impact on the transverse capacity of walls. It is due to second order effects. Thus, it is important to examine the behaviour of panel under different axial load levels. The testing can be investigated by using finite elements software simulation.

1.5 Significant of Study

Profiled steel sheeting acts as permanent formwork for the structure and it can reduces cost of formwork. It also consider as lightweight structure since foamed concrete as an infill. In addition, it can consider as a good finishing and do not need plastering as finishing. The profiled steel sheeting acts as formwork providing the necessary resistance to concrete pressure in the construction stage.

Thus, the research significance of this study was that of the performance and behaviour of profiled composite panel such as Trimdek and Spandek panel with an opening under axial load test condition. The axial loading caused brittle failure at the interface and breakage of chemical bond. It is due to the absence of sufficient strain to develop force in embossments (Anwar Hossain and Wright, 2004). Embossments are interlocking devices of the profiled steel sheeting to provide longitudinal and transverse shear resistances at the steel – concrete interface (Wright and Gallocher 1995). Moreover, the presence of holes for windows and doors opening will affect the performances of the composite wall that cause the strength reduction (Mays et al. 1998).

This study of research is to analyse the behaviour of profiled Trimdek and Spandek panel act as a load bearing wall. In the same time, it also can predict the critical region of Trimdek and Spandek panel when the axial load is applied on it by using LUSAS finite element analysis.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Composite structure such as walls, slabs and beams are becoming commercially used in construction industry. Composite materials are combination of steel and concrete used in the building construction. The usage of this composite structure has been run for a long time in construction industry and its have become more popular to civil engineering. According to Wright and Hossain (1997), when used in combination with steel frames, cold formed light-gauge profiled steel panels can offer considerable shear resistance to shear loads. This may be advantageous when the panels are used as formwork for composite walling. The potential shear resistance is offered by vertically aligned profiled steel sheet panels acting in a steel building frame. The application of profiled steel sheet sheeting as a permanent formwork for composite walling in a typical steel framed building is shown in Figure 2.1.

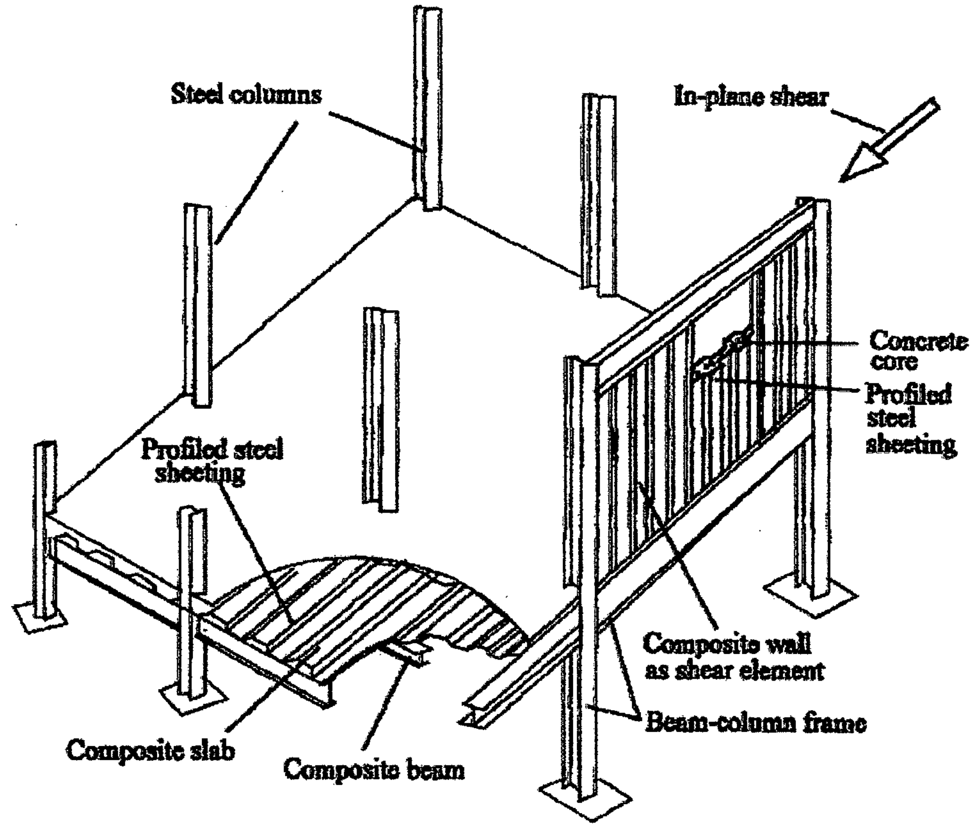

Figure 2.1: Application of Profiled Steel Sheeting in a Building Frame (Wright and Hossain, 1997)

According to Wright and Hossain (1997), composite walls are thought to be especially applicable as shear or core walls in steel frame buildings. In many of these structures, the beams and columns are assumed to be pinned with lateral stability and wind resistance provided by the core walls of concrete. In the use of a composite wall the profiled steel sheeting is fixed at the same time that the main steel is erected and therefore provides temporary shear bracing to wind and destabilizing forces during construction, in addition to acting as form work providing the necessary resistance to concrete pressure in the construction stage. In the service stage, they will act as a reinforcement to carry axial, lateral and in-plane forces.

The mode of connecting the sheeting to the surrounding frame will play an important role in governing the overall behavior of the panels. To predict the true behavior of such panels, it is necessary to consider their connection to the frame.

2.2 Profiled Steel Sheeting

Profiled steel sheeting is a sheet of steel that has been corrugated to increase its stiffness. It has been widely used in North America as permanent formwork for *in- situ* cast concrete slabs since 1940. Compare to a non profiled steel, profiled steel sheeting can produce more axial load resistance compare to plain profile. The steel also can act as the reinforce system for the wall structure. There are various types of profiled steel sheeting used in Malaysia such as Trimdek and Spandek.

Profiled steel sheeting is available with yield strengths ranging from 235 N/mm^2 to at least 460 N/mm^2, in profiles with depths ranging from 45 mm to over 200 mm, and with a wide range of shapes. Sheets are normally between 0.8 mm and 1.5 mm thick, and are protected from corrosion by a zinc coating about 0.02 mm thick in each face. Application of profiled steel sheeting as both permanent formworks and reinforcement to concrete slabs was developed in America in the early 1950s. Following its introduction into the United Kingdom in 1970s, it has become the most common form of floor system for the steel framed office building (Wright, 1994). According to Wright (1998), the axial load capacity was found to be influenced by the local buckling of the component plates in the steel sheeting and by the profiled shape of the concrete cross-section.

2.2.1 Trimdek

Trimdek profile is made of high strength steel and despite its lightness. It provides excellent spanning capacity and remarkable recovery after deformation. It also a subtle square fluted roofing and walling profile as shown in Figure 2.2. The fluting in the pans provides strength and long spanning capabilities, making one of the more economical profiled steel sheeting. It has bold, widely spaced ribs and is available in long lengths, governed only by transportation considerations. It also can be used with safety due to its strength, spanning ability, lightness and rigidity, wide support spacing.

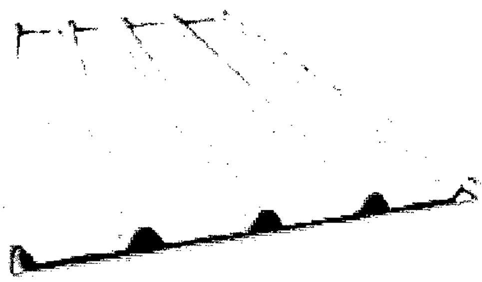

Figure 2.2 : Trimdek Profiled Steel Sheeting

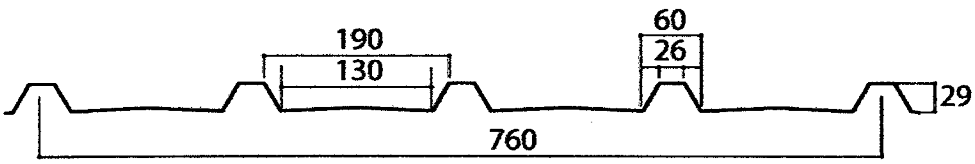

Figure 2.3 Cross Section of Trimdek Profiled Steel Sheeting

The Trimdek profiled steel sheeting can be curved by crimp curving process. It is available in both convex and concave shapes to provide versatility and creativity to building designs. The minimum radius of curvature must be at least 450mm to underside or pan of sheet. Custom cut length are available at any measurement to a maximum transportable length (LYSAGHT, 2008). Physical properties of Trimdek shown in Table 2.1.

Table 2.1: Physical Properties of Trimdek

Profiled	Lysaght Trimdek
Grade of Steel	G550 (550 N/mm^2 yield strength)
Effective coverage width	760 mm
Rib depth	29 mm
Base Metal Thickness(BMT)	0.42 mm
Total Coated Thickness(TCT)	0.47 mm
Packing	In strapped bundles of 1 tones maximum mass
Custom cut length	Any measurement to a maximum transportable length
Tolerances	Length, +/- 15 mm. Width, +/- 2 mm

2.2.2 Spandek

Spandek is an ideal combination of strength with lightness, rigidity and economy. It is also a tough, symmetrical trapezoidal ribbed roofing and wall cladding profiled, ideal where stronger, bolder and more modern corrugated appearance is required. Spandek capitalizes on buildings requiring long spans, it permits wider purlin spacing and utilizes fewer fasteners. Its rigid trapezoidal ribs make it an excellent choice among designers for contemporary roof and wall cladding designs as shown in Figure 2.4 and Figure 2.5.

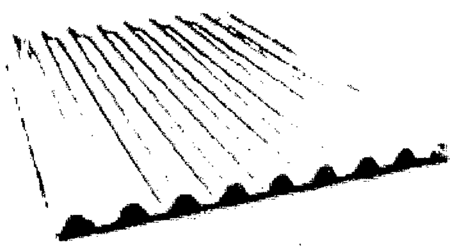

Figure 2.4: Spandek Profiled Steel Sheeting

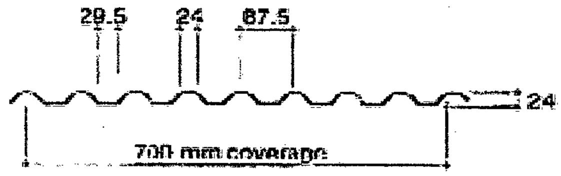

Figure 2.5: Cross Section of Spandek Profiled Steel Sheeting (all in mm)

Product features: simple, low cost fixing - long straight lengths of Spandek can be lowered into place and aligned easily. Fixing is simple and fast with fasteners. This profiled steel sheeting combines strength with lightness, rigidity and economy (LYSAGHT, 2008). Physical properties of Spandek shown in Table 2.2

Table 2.2 : Physical Properties of Spandek

Profiled	Lysaght Spandek
Grade of Steel	G550 (550 N/mm^2 yield strength)
Effective coverage width	700 mm
Rib depth	24 mm
Base Metal Thickness(BMT)	0.42 mm
Total Coated Thickness(TCT)	0.47 mm
Packing	In strapped bundles of 1 tones maximum mass
Custom cut length	Any measurement to a maximum transportable length
Tolerances	Length, +/- 15 mm. Width, +/- 2 mm

2.3 Foamed Concrete

Foamed concrete is a lightweight material consisting of Portland cement paste or cement filler matrix mortar) with a homogeneous void or pore structure created by introducing air in the form of small bubbles (Kunhanandan Nambiar and, Ramamurthy, 2006). It possesses high flow ability, low self-weight, minimal consumption of aggregate, controlled low strength and excellent thermal insulation properties.

Application of structural, partition, insulation and filling grades can be obtained by the proper control in dosage of foam with a wide range of densities (400– 1600 kg/m^3). The construction applications as lightweight non- and semi-structural material are increasing in the last few years although the material was first patented in 1923 (Valore, 1995).

2.3.1 Properties of Foamed Concrete

2.3.1.1 Porosity

The pore system in cement - based material is conventionally classified as gel pores, capillary pores, macropores due to deliberately entrained air, and macropores due to inadequate compaction. The gel pores do not influence the strength of concrete through its porosity, although these pores are directly related to creep and shrinkage. Capillary pores and other large pores are responsible for reduction in strength and elasticity etc. (Kumar and Battacharjee, 2003). As foam concrete is a self - flowing and self - compacting concrete and without coarse aggregate the possibility of entrapped air is negligible.

Based on these models and extending it, a few strength–porosity models have been developed for aerated concrete by Narayanan and Ramamurthy (2000) and for foam concrete by Hoff (1972) and Kearsley and Wainwright (2002). These models reflect the effect of porosity on the strength and may not adequately represent the pore structure.

Based on Cebeci (1981), air entraining agents introduce large air voids and do not alter the characteristics of fine pore structure of hardened cement paste appreciably. In addition , Kearsley and Visagie (1999) figure out that the air - void size distribution is one of the most important micro properties influencing the strength of foamed concrete.

2.3.1.2 Compressive Strength Mechanical Properties

Table 2.3 is shown an overview of composite strength of foamed concrete for various mixture composition and densities are reported in literature. Regarding to Kearsley (1996), the compressive strength decreases exponentially with a reduction in density of foamed concrete. The specimen size and shape, the method of pore formation, direction of loading, age, water content, characteristics of ingredients used and the method of curing are contribute the strength of cellular concrete in total (Valore, 1954).

The compressive strength decreases with an increase in void diameter for dry density of foamed concrete between 500 and 1000 kg/m^3. For densities higher than 1000 kg/m^3, as the air-voids are far apart to have an influence on the compressive strength, the composition of the paste determines the compressive strength (Visagle and Kearsely, 2002). In addition, Jones and McCarthy investigated that small changes in the water–cement ratio does not affect the strength of foamed concrete as in the case of normal weight concrete.

It has been concluded by Tam et al. (1987) that water–cement ratio and air–cement ratio and the combined effect should be considered when volumetric composition of air-voids approaches that of water voids will affect the strength of moist-cured foam concrete.