LOAD CARRYING CAPACITY OF DRY FLOOR PANEL SYSTEM

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ABSTRACT

This paper describes the application of finite element modelling to study structural performances of a dry floor system, consisting of plywood attached to top layer of profiled steel sheet by self-drilling, self-tapping screws connector. Parametric study was carried out by using various profiled steel sheet thickness, plywood thickness and different geometry of profiled steel sheet. The preliminary FE model was validated using experimental study. Parametric studies showed 96.72% increased in flexural stiffness when the thickness of profiled steel sheet was changed from 0.8mm to 1.8mm. The increment of plywood thickness from 9.5mm to 25mm has increased flexural stiffness of the slab up to 23.00% in a quadratic form. Different geometry of profiled steel sheet affects the load carrying capacity of the proposed dry floor panel where SDP gives 1.42 to 1.49 higher in flexural stiffness per 1 unit area of steel compared with PEVA. This means SDP profile will give more economical design compared with PEVA profile. A theoretical formula was proposed to predict the flexural strength of the slab. Moment capacity predicted from FE analysis preformed 1.06 safety factor over theoretical formula and 1.40 over experimental results. FE analysis had indicated high degree of accuracy and revealed that the prediction moment capacity using FE analysis and theoretical formula are conservative and safe for design purpose.It can be concluded that the proposed dry floor panel has a great potential to be exploited as alternative flooring system.

Keywords: Profiled steel sheet; dry flooring system; composite panel

ABSTRAK

Kertas kerja ini membincangkan penggunaan kaedah permodelan unsur terhingga untuk mengkaji kelakuan struktur sistem lantai kering. Cadangan sistem lantai kering ini terdiri daripada papan lapis disambungkan ke atas plat keluli berprofil secara mekanikal mudah dengan mengunakan skru. Kajian parameter melingkungi kesan ketebalan plat keluli berprofil, kesan ketebalan papan lapis and kesan bentuk geometri yang berbeza ke atas keupayaan galas beban sistem lantai kering. Analisis permodelan pertama diselaraskan dengan keputusan eksperimen. Daripada kajian parameter dengan analisis unsur terhingga, kesan ketebalan plat keluli berprofil menunjukkan pertambahan sebanyak 96.72% dari segi kekuatan lenturan apabila tebal plat keluli berprofil bertukar dari 0.8mm ke 1.8mm. Manakala kesan ketebalan papan lapis hanya menunjukkan pertambahan sebanyak 23% apabila tebal papan lapis bertukar dari 9.5mm ke 25mm. Profil SDP lebih kuat sebanyak factor 1.42 ke 1.49 berbanding profil PEVA dari segi kekuatan lenturan per unit keluasan profil . Ini menunjukkan geometri SDP menonjolkan rekabentuk yang lebih ekonomi. Keupayaan moment kapasiti yang berdasarkan analisis unsur terhingga mensyorkan faktor 1.06 berbanding dengan keupayaan moment kapasiti yang dikira melalui penggunaan formula teori bahan elastik; dan faktor sebanyak 1.40 berbanding dengan keupayaan moment kapasiti yang dikira berdasarkan keputusan eksperimen. Analisis penggunaan unsur terhingga menunjukkan nilai ketetapan yang tinggi. Secara bandingan dengan keputusan eksperimen, anggaran moment kapasiti mengunakan kaedah unsur terhingga dan formula teori bahan adalah selamat digunakan dalam proses rekabentuk. Sebagai kesimpulan, cadangan sistem papak kering mempunyai potensi yang tinggi diesploitasikan sebagai alternatif sistem lantai konvensional sekarang.

Kata Kekunci: Plat keluli berprofil; lantai kering; komposit

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SYMBOL		DESCRIPTIONS
mm	-	Milimeter
N/mm^2	-	Newton/ milimeter square
kNm	-	kiloNewton meter
kN/m^2	-	kiloNewton/ meter square
MPa	-	Mega Pascal
f	-	Mode of rupture
z	-	distance from neutral axis
I	-	second moment of area of each element
E	-	modulus of elasticity of each element
I’	-	second moment of area of the full cross-section
t	-	total thickness of steel sheet

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CHAPTER 1

INTRODUCTION

1.1 Current Development of Construction Technology in Malaysia

The construction industry plays a big role in Malaysia's development and is expected to be a major contributor towards the realisation of Vision 2020. Thus, as envisaged in the Third Outline Perspective Plan (OPP3) 2001-2010, the industry is expected to grow at 6.6% per annum and contribute 3.1% to the GDP in the year 2010 (Shahrul Nizar Shaari and Elias Ismail, 2003). Unfortunately, local construction industry technology still dominated by conventional cast in-situ reinforced concrete system, which is very labour-intensive method. The reasons why local construction player would not opt for alternative methods are caused by the followings factors:

a) Lack of knowledge in alternative construction technique resulting in fear and avoidance.

b) Cheap rates and abundant supply of labours sourced from neighbouring countries.

c) Failure of local players to have proper technology transfer – resulting in problems during production and installation.

d) High prices of systems caused by high set-up costs, low demand and designs originally meant for in-situ construction.

Nevertheless, the cheap labour and huge supply of labour in the local construction industry would not last forever and a disruption of the supply would generate huge problems to the industry; as experience in 2002. Also, besides increasing the outflow of Ringgit to foreign economies, dependency on foreign labours also brings about negative impact to the nation, socially and culturally.

Because of this, it is important for local industry players to begin sourcing alternatives to labour-intensive construction methods. Instead of "builder" the contractors should be functioning as "assemblers" at sites. CIDB actively promoting the usage of new technologies know as "Industrialised Building System" (IBS).

IBS can be defined as products, systems and techniques used in making construction less labour- orientated, faster as well as quality controlled. It generally involves prefabricated products – factory manufactured elements that are transported to the construction sites and erected. IBS can be structurally divided into 5 major groups:

Table 1.1: 5 major systems promoting in IBS system in Malaysia construction industry (Economic Planning Unit, Prime Minister's Department, 2003)

Group 1: Precast Concrete Framing, Panel and Box Systems	The most common IBS are the precast concrete elements, precast concrete columns, beams, slabs walls, "3-D" components (e.g. balconies, staircases, toilets, lift chambers, refuse chambers), lightweight precast concrete, as well as permanent concrete formworks.
Group 2: Steel Formwork Systems	Considered as one of the "low-level" or the "least prefabricated" IBS as the systems generally involve site casting. Thus, the question of the structural

	quality control still arises. Nevertheless, these systems, tunnel forms, tilt-up systems, beams and columns moulding forms, a dn permanent steel formwork (metal decks) do offer high quality finishes and fast construction with less site labour and material requirement.
Group 3: Steel Framing Systems	Commonly used with precast concrete, slabs, steels columns and beams have always been the popular choice and used extensively in the fast-track construction of skyscrapers. Recent development in these types of IBS includes the increased usage of light steel trusses cocsisting of cost-effective profiled cold-formed channels and steel portal frame systems as an alternative to the heavier traditional hot-rolled sections.
Group 4: Timber Framing Systems	Among the products listed in this category are timber building frames and timber roof trusses.
Group 5: Brickwork Systems	The construction method of suing the conventional bricks has been revolutionised by the development and usage of interlocking concrete masonry units (CMU) abd lighlight concrete blocks. The tedious and time-consuming traditional brick-laying tasks are greatly simplified by the usage of these effective alternative solutions

The main benefits offered by the usage of these systems are:

a) High quality of finished products and minimal wastages due to factory-controlled prefabrication environment.

b) Elimination of conventional timber formworks and great reduction of props through the usage of prefabricated elements or system formwork for site casting.

c) Sturdy and safe platforms provided by the prefabricated elements.

d) Faster completion due to the introduction of components replacing in-situ construction.

e) Neater, cleaner and safer sites due to reductions of construction debris, site workers and materials.

f) Lower total construction cot due to all of the above.

1.2 Problem Statement

Recent development of alternative construction system has encouraged studies on various innovative lightweight composite structural flooring panel systems. One of the lightweight systems is dry floor panel consisting plywood attached to top layer of profiled steel sheet by self-drilling, self-tapping screws connector. Two major structural components of the system, profile steel sheets and plywood are both readily available material in market and in pre-fabricated form. The new system is introduced to meet IBS concepts, which is making construction less labour-orientated, faster and better quality control.

1.3 Aim and Objectives

The proposed dry floor system consists of plywood attached to top layer of profiled steel sheet by self-drilling, self-tapping screws connector. The aim of the study was to investigate the structural performance of the system using various profiled steel sheet thickness, plywood thickness and different geometry of profiled steel sheet by using finite element method. In order to achieve the aim of the study, 4 objectives were set as below:

a) To develop a finite element modeling for dry floor system by using Lusas Modeller Finite Element Software.

b) To perform non-linear FE analysis to determine the behavior and load carrying capacity of the proposed dry floor system.

c) Parametric study on the effect of the thickness of profiled steel sheet, thickness of plywood and effect of different geometry of profiled steel sheet on the load carrying capacity of the proposed system.

d) To compare bending moment capacity obtained from FE analysis and experimental results with theoretical formula based on elastic section properties.

1.4 Scope of research

The scopes of this study are:

a) The FE model was in 3-Dimensional.

b) Only material non-linearity included in the analysis.

a) The load carrying capacity of the proposed dry floor panel increased with the increment of the profiled steel sheet. The capacity increased as much as 96.72% when the thickness increased from 0.8mm to 1.8mm.

b) The load carrying capacity of the proposed dry floor panel increased by thickness of plywood by a value 23% when thickness increased from 9.5mm to 25mm.

c) Load carrying capacity increased linearly with the profiled steel thickness and plywood thickness. The profiled steel thickness give higher rate of load carrying capacity compared to the plywood thickness.

d) Different geometry of profiled steel sheet affects the load carrying capacity of the proposed dry floor panel. SDP profile gives higher flexural stiffness per 1 unit
area of steel section compared to PEVA profile. This means SDP profile will give more economical design compared with PEVA profiled at same load carrying capacity.

e) Moment capacity predicted from FE analysis had performed acceptable results compared with the proposed theoretical formula and experimental results. FE results with 1.06 times higher than theoretical results indicated high degree of accuracy of FE analysis. Whilst the average experimental results with 1.4 times higher than the theoretical results. This revealed that prediction of moment capacity using FE analysis and theoretical formula are conservative and safe for design purpose.

5.2 Recommendations

Several recommendations are outlined below to improve the study of the proposed dry floor panel in future:

a) In this study, the geometric profile of the proposed dry floor panel had been modelled using assembly of 3-D isotropic plates. The 3-D model is much time consuming. It is recommended that the profiled steel sheet should be modelled as an equivalent orthotropic plate of uniform thickness in order to reduce computation time and memory.

b) The effect of connector on the behaviour of proposed panel should be studied in future. This includes the effect of the spacing of the connectors and the load-slip relationship, in order to gain better understanding on the interaction between plywood and profiled steel sheet.

c) The contact condition between profiled steel sheet and plywood should be taken into consideration in future study. It is suggested that an appropriate surface contact condition shall be inserted between profiled steel sheet and plywood by assigning slideline dataset to the required lines or surfaces. It is expected that the contact condition may contribute to the partial composite action.

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