Numerical Simulation of Profiled Steel Sheeting in Compression: A Case of Double-Deck Paneling

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ABSTRACT

Profile Steel Sheet Dry Board (PSSDB) composite material is one of the innovations in construction technology for a variety of structural purposes such as floor and roof unit. This paper aims to simulate the behavior and potential of cellular arrangement of two PSSDB as a panel unit under compression loading. A mathematical and computational model is presented for the analysis to predict the potential of the PSSDB. A programme based on a finite element analysis is developed using LUSAS 13.5 to determine the buckling and maximum load that can be supported by PSSDB. The same material property through thickness is used to model single and cellular arrangement of two PSSDB. These models are analysed and the results obtained are also compared to prove that the cellular arrangement of two PSSDB could offer a better strength than single PSSDB. The displacement, buckling and ultimate load have shown that the cellular arrangement of two PSSDB can be used as a panel in the construction industry.

Keywords: *Buckling load, displacement, finite element analysis, maximum load*

Introduction

In structural engineering applications, composite construction refers to the casting of concrete slab on steel section and using the whole assembly as a single structural unit. The composite material now may include all types of construction that is formed by arranging two or more structural materials in an optimum geometrical configuration, so that the desirable properties of each material will be fully utilised by virtue of their designated position.

Profile Steel Sheet Dry Board (PSSDB) is one of the innovations in the construction technology. Wright and Evan pioneered this technique of construction in 1989 in United Kingdom. Further studies were carried out in Universiti Kebangsaan Malaysia (UKM) by Wan Hamidon in 1994 and

Ahmed in 1996. The extension of the early works was carried out to study the behaviour of the system as roofing unit. However there no published report on the behaviour of PSSDB as paneling unit has been found.

Thus, this paper studies the PSSDB behaviour and potential of the single and cellular arrangement of two PSSDB as paneling unit under compression load and proves the significance performance of PSSDB to be used in the construction industry.

Materials and Methods

The material used is Peva 45 PSS with dry board, which is combine by the laying and reinforcing of the form which gives remarkable savings in material, work and expenses. Peva 45 is made of steel sheet Z36-27N by rolling. It is available in thickness between 0.8mm and 1.00mm. The zinc coating (both sides together) is 275 g/m^2. The dimension of Peva 45 shows in Figure 1.

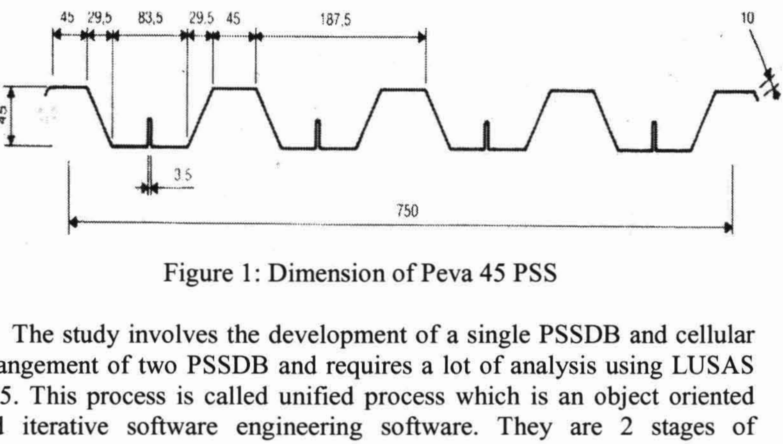


Figure 1: Dimension of Peva 45 PSS

The study involves the development of a single PSSDB and cellular arrangement of two PSSDB and requires a lot of analysis using LUSAS 13.5. This process is called unified process which is an object oriented and iterative software engineering software. They are 2 stages of processing carried out to make sure all the objectives are met. The first stage is pre-processing where it supports on-screen modeling and offers excellent options to the model by mirroring, translation or rotation, about an axis or a plane to generate the entire structure. After that, the attributes of the material are assigned to the models as shown in Table 1 and complete models are analysed using numerical testing. Numerical testing is a step to define deformation, displacement, buckling load and reaction-displacement relationship by deriving element equation and application of boundary condition.

Table 1: Attributes of Peva 45 and Dry Board

Attributes	Peva 45 PSS	Dry Board
Mesh	QS14 thin shell	QS14 thin shell
Geometric	Thickness of Peva = 1mm	Thickness of plate = 20mm
Material	Linear (Elastic) Young's Modulus = 205E3 kN/mm^2	Linear (Elastic) Young's Modulus = 300E3 kN/mm^2

The second stage is called post-processing options which include colouring plots of stress, straining contour and deforming shape of the model.

Results and Discussion

A series of numerical simulations of the deformational response of a single profiled steel sheet and cellular arrangement of two profiled steel sheets in compression was carried, and several observations were noted.

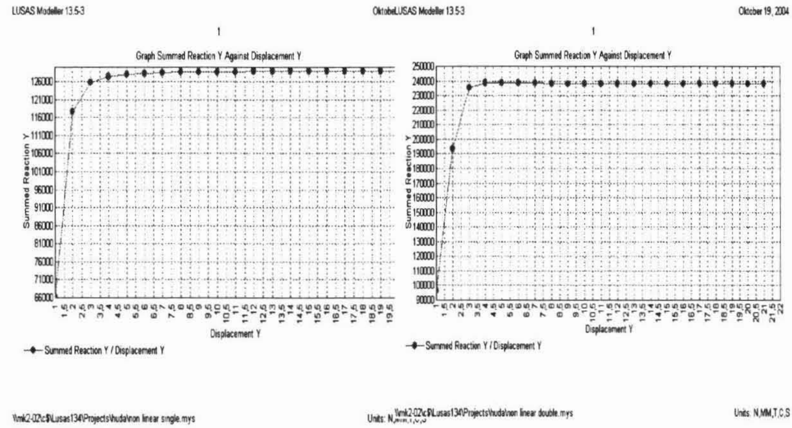
Solving the structural systems as eigen-problems resulted in the respective buckling loads of 173.6 N/mm and 272.5 N/mm for the concentric-loading of the single PSSDB and concentric-loading of the cellular arrangement of two PSSDB which is about 56.97% increment.

Table 2: Buckling Loads of Single-Deck and Double-Deck PSSDB

Model	Single-Deck PSSDB	Double-Deck PSSDB	% Increase
Buckling Load, N/ mm	173.6	272.5	56.97

Figure 2 shows the graph of summed reaction-displacement for single PSSDB and cellular arrangement of two PSSDB which indicate the maximum loading supported by the both model.

For the single PSSDB analysis, maximum loading is present at point 135000N (135kN), while the maximum loading for cellular arrangement of two PSSDB is at 240000N (240kN). This indicates that, there is 43.75% potential increment for cellular arrangement of two PSSDB compared to single PSSDB.



(a) **(b)**

Figure 2: Graph of Summed Reaction-Displacement
(a) Single-Deck PSSDB
(b) Double-Deck PSSDB

Table 3: Comparison of Ultimate Load between Single-Deck and Double-Deck PSSDB

Model	Single-Deck PSSDB	Double-Deck PSSDB	% Increase
Load, kN	135	240	43.75

Conclusion

This study has looked into the behaviour of cellular arrangement of two PSSDB structures to further explore the potential use of the system as panel in buildings. The basic components of the system are PSS and the plates at the top and bottom of the PSS. The potentials of the system have been highlighted. It is concluded that both of the models proposed could be used to determine the structural performance of composite construction.

The objectives of the paper were validated by numerical model proposed which has already been available to be used in construction. The behaviour in terms of deformation, displacement and buckling load for both model were investigated. Therefore, it can be concluded that cellular arrangement of the two PSSDB panels is more suitable for composite material used as panel in heavy construction. It can lead to a very significant increase in performance to be used in the construction industry.

The recommendations in achieving more accurate result are:

1. use more fine meshing to model;
2. analyse the model with lateral load (dynamic load) due to real life load;
3. use non-linear analysis for more detail result; and
4. test the various types of PSS to compare its performance.

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