

**A STUDY ON LOAD BEARING CAPACITY OF
SANDWICH WALL PANELS**

Rupasinghe Arachchige Don Lalindra Jayamevan Rupasinghe

(09/8927)



University of Moratuwa, Sri Lanka
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

Degree of Master of Engineering in Structural Engineering Designs

Department of Civil Engineering

University of Moratuwa

Sri Lanka

January 2013

**A STUDY ON LOAD BEARING CAPACITY OF
SANDWICH WALL PANELS**

Rupasinghe Arachchige Don Lalindra Jayamevan Rupasinghe
(09/8927)

**Dissertation submitted in partial fulfillment of the requirements for
the degree Master of Engineering in Structural Engineering**

Department of Civil Engineering

University of Moratuwa

Sri Lanka

January 2013

Declaration

I declare that this is my own work and this dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Also, I hereby grant to University of Moratuwa the non-exclusive right to reproduce and distribute my dissertation, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as article or books).

Signature:

Date:.....

R.A.D.L.J. Rupasinghe



University of Moratuwa, Sri Lanka
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

(09 / 8927)

The above candidate has carried out research for the Masters Dissertation under my supervision.

Signature:

Date:.....

Research Supervisor

Dr.K.Baskaran

Senior Lecturer

Abstract

Sandwich wall panel technology is a new system introduced to Sri Lanka. Thermal insulation, sound insulation, light weight and reduction in natural resources like sand have lead to its popularity in Sri Lanka. The system is faster in construction than conventional wall systems.

The sandwich wall panel system is used in Sri Lanka as partitioned walls in construction industry today. Load from above floors are taken by separate column and beam system. If accurate load bearing estimate is available, it can minimize or omit use of other load bearing systems.

The scope of this research was to recognize suitability of available codes and to identify the reduction in load bearing capacity due to a window opening in a sandwich wall panel.

In this dissertation, method of production of locally available sandwich wall panels and load bearing capacity according to available literature are presented.

Three 1200mm width, 100mm thick and 2400mm high sandwich wall panels were cast. Out of these three, two panels had openings to represent windows. The panels were tested in axial compression while monitoring transverse deflection at mid height of the panel. All three panels' ultimate load bearing capacity was nearly equal. Only one panel had higher degree of lateral movement while loading. All panels have shown local crushing failure near top and bottom loading points.

Three sandwich panel blocks of 600mm length, 100mm thick and 300mm height were tested in a Universal testing machine to get ultimate load bearing capacity. The blocks' ultimate load bearing capacities are also nearly equal to that of 2400mm height panels.

Six numbers of 150mm mortar cubes were also tested in Universal testing machine to find ultimate compressive strength. Samples of diagonal shear connectors (Gauge 9 GI wire) were cut out from specimen and tested for compression capacity in Universal timber testing machine. The samples failed in buckling. 100mm high samples had about 0.7kN compression capacity.

It was concluded that 600mm width and 900mm high opening in the given orientation did not affect load bearing capacity of panel.

Key words: Sandwich wall panel, Load bearing capacity, openings, wythe, insulation layer.

Acknowledgement

I wish to express my sincere gratitude to my research supervisor Dr.K.Baskaran, Senior Lecturer, Department of Civil Engineering, University of Moratuwa, Sri Lanka for his guidance, suggestions and continuous support throughout my research work.

I also extend my sincere gratitude to the Head of Department of Civil Engineering, University of Moratuwa, Sri Lanka for allowing me to use the laboratory facilities and the resources available at the university, for successful completion of my research project.

I wish to thank the Micro Construction (Pvt) Ltd for providing sandwich panels and other test samples for the research. Their kind assistance and knowledge helped me for the success of my research.

I would like to take this opportunity to convey my sincere gratitude to Mr.H.N.Fernando (Lab Assistant-Structural Testing Laboratory) for the assistance extended to me in numerous ways throughout this period.



I also extend my appreciation to my family for the valued cooperation and encouragement received to make my M. Eng. programme a success.

Table of Contents

Abstract	ii
Acknowledgement	iii
Table of content	iv
List of Figures	vii
List of Tables	ix
List of Abbreviations	x
1. Introduction	01
1.1 General Introduction	01
1.2 Research Objectives	03
1.3 Research Scope	03
1.4 Outline of the Report	03
2. Literature Review	04
2.1 General Introduction	04
2.2 Materials use for sandwich wall panels	05
2.2.1 Wythes	05
2.2.2 Shear Connectors	05
2.2.3 Insulation	07
2.2.4 Steel reinforcements for wythes	09
2.3 Precast panel sizes	09
2.4 Bowing in sandwich wall panels	10
2.5 Thermal performance	10
2.6 Composite and non-composite behaviour of sandwich wall panel	11
2.7 Axial load bearing capacity	13
2.8 Flexural loading capacity of SWP	24
2.9 Summary	28

3. Experimental Study	30
3.1 General Introduction	30
3.2 Equipments used to produce SWP	31
3.2.1 Cement mortar sprayer	31
3.2.2 Pair of pliers	33
3.2.3 Pneumatic “c” ring gun	33
3.2.4 Air compressor	34
3.3. Panel casting	35
3.4 150mm Test cube casting	38
3.5 Testing panels under axial compression load	39
3.6 Testing small SWP blocks for compression	42
3.7 Testing mortar test cubes for compression	43
3.8 Testing gauge 9 GI wire diagonal members in compression	43
4. Analysis and Discussion of Results	44
4.1 General Introduction	44
4.2 Experimental results	44
4.2.1 Panel A	44
4.2.2 Panel B	46
4.2.3 Panel C	47
4.2.4 600mm x 100mm x 300mm Blocks in axial compression	49
4.2.5 150mm Mortar cubes in compression	50
4.2.6 Gauge 9 GI wires in compression	50
4.3 Summary of test results	50
4.4 Estimation of axial load capacity according to literature	51
4.4.1 BOCA (1999)	51
4.4.2 ICBO (1999)	52

4.5 Discussion	53
4.5.1 Comparison of Panel A with BOCA (1999)	53
4.5.2 Comparison between Panel A and ICBO (1999)	53
4.5.3 Load bearing reduction due to opening	53
4.5.4 Compression capacity of SWP blocks	54
4.5.5 Comparison of SWP blocks and panels with BS 5628-1	54
4.5.6 Finite element modelling	56
5. Conclusions and Recommendations	57
5.1 General Introduction	57
5.2 Conclusions	57
5.3 Recommendations for Future Works	57
References	59



University of Moratuwa, Sri Lanka
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

List of Figures


Figure 1.1 Basic elements of a sandwich wall panel	01
Figure 2.1 Examples for shear connectors	06
Figure 2.2 Non composite and fully composite panels' theoretical behaviour	11
Figure 2.3 Test set-up and test frame of Benayoune et al. (2005a)	16
Figure 2.4 Top end condition and loading arrangement of Benayoune et al. (2005b)	18
Figure 2.5 The Artzer panel specified by BOCA International Evaluation (1999)	20
Figure 2.6 SWP specified by ICBO (1999)	21
Figure 2.7 Standard KIO panel section	22
Figure 2.8 50mm insulated Micro Construction SWP	23
Figure 2.9 Loading system of first two panels of Benayoune et al. (2006)	24
Figure 3.1 Dimensions of test panels with opening	31
Figure 3.2 Mortar sprayer	32
Figure 3.3 Four nozzles at bottom	32
Figure 3.4 Pair of pliers 	33
Figure 3.5 "C" ring cartridge	33
Figure 3.6 Pneumatic C ring gun	34
Figure 3.7 Air compressor	34
Figure 3.8 Marking the opening	35
Figure 3.9 Cutting EPS layer by hacksaw	35
Figure 3.10 Reinforcements tying using C ring gun	36
Figure 3.11 First plaster layer levelling	37
Figure 3.12 Plastering third mortar layer of the wall	37
Figure 3.13 Test cubes casting	38
Figure 3.14 Test setup	39
Figure 3.15 Test setup of panels with opening	40
Figure 3.16 Two dial gauges	41

Figure 3.17 600mm x 100mm x 300mm blocks testing	42
Figure 4.1 Panel A	44
Figure 4.2 Axial load vs. central lateral deflection for Panel A	45
Figure 4.3 Panel B	46
Figure 4.4 Axial load vs. lateral deflection for Panel B	47
Figure 4.5 Panel C	48
Figure 4.6 Axial load vs. lateral deflection for Panel C	49
Figure 4.7 Eccentric load vs. lateral deflection for PA1 at mid-height of the panel	53
Figure 4.8 Axial load vs. lateral deflection for PA1 at mid-height of the panel	54



List of Tables

Table 2.1 Physical properties of insulation material (PCI committee,1997)	08
Table 2.2 Allowable axial load taken from BOCA (1999) report	20
Table 2.3 Allowable axial load taken from ICBO (1999) report	22
Table 2.4 Allowable transverse loads as per BOCA (1999)	26
Table 2.5 Transverse load vs. span for SWP taken from ICBO (1999)	27
Table 4.1 Compression capacity of SWP blocks	49
Table 4.2 Compressive strength of mortar cubes	50
Table 4.3 Summary of results	50



List of Abbreviations

SWP	: Sandwich Wall Panel
EPS	: Expanded Polystyrene Foam
XPS	: Extruded Polystyrene Foam
BS	: British Standard
GI	: Galvanized Iron
PCI	: Precast/ Prestressed concrete Institute
BOCA	: Building Officials and Code Administrators
ICBO	: International Conference of Building Officials
FEM	: Finite Element Model
OPC	: Ordinary Portland cement
W/C	: Water to Cement Ratio
FRP	: Fibre reinforced plastic
BRC	: Trade name of a wire mesh manufacturer

