



**UNIVERSITI PUTRA MALAYSIA**

**STRUCTURAL BEHAVIOUR OF LOAD-BEARING  
INTERLOCKING HOLLOW BLOCK MASONRY**

**AMAD M.S. NAJM**

**FH 2001 45**

**STRUCTURAL BEHAVIOUR OF LOAD-BEARING  
INTERLOCKING HOLLOW BLOCK MASONRY**

**By  
AMAD M.S. NAJM**

**Thesis Submitted in Fulfilment of the Requirement for the  
Degree of Master of Science in the Faculty of Engineering  
Universiti Putra Malaysia**

**May 2001**



***Dedicated to my beloved  
Family and Friends***



Abstract of thesis submitted to Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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**Chairman : Associate Professor Waleed Abdel Malik Thanoon, Ph.D.**

**Faculty : Engineering**

The structural behaviour of an interlocking block system has been investigated in this research. The interlocking blocks developed by the Housing Research Center, Universiti Putra Malaysia have been used to assemble a number of prisms and wall panels. This interlocking block system has been filed for a patent. Three types of individual blocks are utilized in this research, these are stretcher, corner and half block units.

The research covers the production of the block using a manually controlled machine which has been developed for the production of the three different types of block. The test program includes testing of individual blocks, prisms and different wall panels.

Forty individual blocks have been tested under axial compression. Ten prisms have been tested under axial load. The failure mechanism were recorded for each type of



specimen. Sixteen wall specimens having different height (slenderness ratio), subjected to load applied at different eccentricities, have been tested. The selected heights of the tested walls are 1.2, 1.8, 2.4 and 3.0m. The eccentricity of the applied load is another important parameter considered in testing the wall specimens to simulate the actual nature of the applied load in construction. The values are 0, 20, 40 and 55mm measured from the centerline of the wall panels. The structural behaviour of the wall panel specimens were studied in terms of the load-deflection characteristic, strain-stress distribution, efficiency of the wall and the failure mode of the interlocking walls.

The study focuses on the differences and similarities of the behaviour of interlocking walls compared to bonded walls. BS 5628: Part 1: 1978 was used to explore the behaviour of the bonded walls. The study showed that the strength of the interlocking block and its interlocking mechanism were sufficient and that the block can be used for construction of load bearing walls.

Based on the test results, a number of mathematical equations have been proposed to predict the reduction in the wall efficiency with the increases of the eccentricity of the applied load and the slenderness ratio of the wall. A design procedure has also been proposed to be used in the design of load bearing interlocking hollow block system.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

**KELAKUAN STRUKTUR  
SISTEM BLOK BERONGGA TANGGUNG BEBAN KAIT PANCA**

Oleh

**AMAD M.S. NAJM**

**Mei 2001**

**Pengerusi : Profesor Madya Waleed Abdel Malik Thanoon, Ph.D.**

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Dalam penyelidikan ini, kelakuan struktur sistem blok berongga kait panca telah dikajikan. Blok kait panca ini yang telah dibangunkan oleh Housing Research Centre, Universiti Putra Malaysia telah diguna untuk menghimpunkan beberapa panel prisma dan dinding. Ianya juga telah difailkan untuk tujuan paten. Tiga jenis blok individu telah digunakan dalam penyelidikan iaitu unit blok 'stretcher', 'corner' dan 'half'.

Penyelidikan ini merangkumi pengeluaran blok dengan menggunakan mesin kawalan manual yang menghasilkan ketiga-tiga jenis blok tersebut. Program ujian termasuk pengujian ke atas blok individu, prisma dan dinding panel yang berbeza.

Sebanyak 40 blok individu telah diuji di bawah mampatan paksi bersama-sama dengan kiub. Manakala 10 prisma telah diuji di bawah beban paksi. Mekanisme kegagalan telah direkodkan untuk setiap spesimen. 16 spesimen dinding yang berlainan



ketinggian (nisbah kelangsingan), bergantung kepada beban yang dikenakan pada sifat atau kelakuan yang berbeza juga telah diuji. Ketinggian yang dipilih untuk dinding adalah 1.2m, 1.8m, 2.4m dan 3.0m. Sifat beban yang dikenakan merupakan salah satu parameter penting dengan mengambilkira ujian dalam spesimen dinding yang menyerupai keadaan sebenar yang digunakan dalam pembinaan. Nilai yang digunakan adalah 0, 20, 40 dan 55mm; diukur dari garisan tengah panel dinding tersebut. Kelakuan struktur untuk spesimen panel telah dikaji dari segi ciri-ciri beban pesongan, pengagihan daya regangan-tegangan, kecekapan dan mod kegagalan dinding saling mengunci.

Kajian ini juga difokuskan pada perbezaan dan persamaan kelakuan dinding kait panca berbanding dinding terikat. BS 5628:Part 1; 1978 telah digunakan untuk mengkaji kelakuan ikatan dinding tersebut. Kajian ini menunjukkan bahawa kekuatan dan mekanisme blok ini adalah sangat sesuai dan boleh digunakan dalam pembinaan dinding tanggung beban.

Berdasarkan kepada keputusan ujian, berapa persamaan matematik telah digunakan untuk melihat pengurangan dalam keupayaan dinding dengan menambah sifat beban yang dikenakan dan nisbah kelangsingan pada dinding. Prosedur rekabentuk telah dicadangkan untuk digunakan dalam merekabentuk 'Sistem Blok Berongga Kait Panca Tanggung Beban'.

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ALLHAMDULILAH





I certify that an Examination Committee met on 26<sup>th</sup> May 2001 to conduct the final examination of Amad M.S. Najm on his Master of science thesis entitled "Structural Behaviour Of Load-Bearing Interlocking Hollow Block Masonary" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

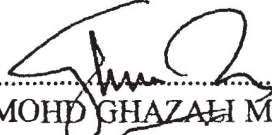
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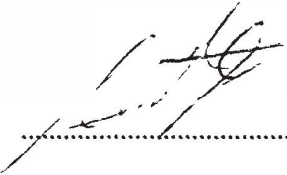
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## DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Putra Malaysia or other institutions.



.....

AMAD M.S. NAJM

DATE: 8 / 6 / 2001

# TABLE OF CONTENTS

	Page
<b>DEDICATION</b> .....	ii
<b>ABSTRACT</b> .....	iii
<b>ABSTRAK</b> .....	v
<b>ACKNOWLEDGMENTS</b> .....	vii
<b>APPROVAL</b> .....	viii
<b>DECLARATION</b> .....	x
<b>LIST OF TABLE</b> .....	xiii
<b>LIST OF FIGURES</b> .....	xv
<b>LIST OF SYMBOLS</b> .....	xviii
 <b>CHAPTER</b>	
<b>I INTRODUCTION</b> .....	1
1.1 General.....	1
1.2 Significance Of Research.....	2
1.3 Scope .....	3
1.4 Objective.....	3
1.5 Layout Of Thesis.....	4
<b>II LITERATURE REVIEW</b> .....	5
2.1 Introduction.....	5
2.2 Hollow Block Specification... ..	6
2.3 Interlocking Block system.....	7
2.4 Concluding Remarks.....	25
<b>III BLOCK PRODUCTION AND TESTING</b> .....	27
3.1 General.....	27
3.2 Interlocking Hollow Block.....	28
3.3 Materials And Equipment .....	34
3.3.1 Materials.....	34
3.3.2 Equipment.....	35
3.4 Block Production.....	39
3.4.1 Production Of Mix.....	39
3.4.2 Casting Procedure.....	39
3.4.3 Stacking And Curing.....	40
3.5 Testing Procedure.....	42
3.5.1 Individual Block.....	42
3.5.2 Prism.....	42
3.5.3 Wall Panel.....	44
3.6 Conclusion Remarks.....	62



<b>IV</b>	<b>RESULTS AND DISCUSSION.....</b>	<b>63</b>
4.1	Introduction.....	63
4.2	Compressive Strength Of Individual Block.....	63
4.3	Compressive Strength Of Cubes.....	67
4.4	Remarks.....	67
4.5	Prism Test Result.....	68
4.6	Basic (Standard) Wall Panel.....	70
4.7	Comparison Between Cube, Individual Block, Prism And Basic Wall Panel Of Interlocking System, With Bonded Masonry System.....	71
4.8	Structural Behaviour Of Interlocking Wall Panels.....	73
4.8.1	Load-Lateral Deflection Relationship.....	73
4.8.2	Structural Elastic Response And Stress Distribution.....	78
4.8.3		
4.8.4	Effects Of Slenderness On Wall Behaviour.....	88
4.8.5	Effects Of Eccentricity On Wall Behaviour.....	89
4.8.6	Comparison The Compressive Test Result With BS 5268 : Part 1.....	90
4.8.7	Crack Patters And Failure Mode.....	93
4.8.8	Design Procedure.....	101
4.8.9	Definitions Of Strength On Basis Of Gross Area.....	104
<b>V</b>	<b>SUMMARY AND CONCLUSION</b>	
5.1	Introduction.....	107
5.1.1	Production Of Interlocking Block.....	108
5.1.2	Structural Behaviour Of Interlocking System, Individual Block, Prisms And Basic Wall Panel.....	108
5.1.3	Structural Behaviour Of Interlocking Wall Panels .....	109
5.1.4	Design Procedure.....	112
5.2	Recommendation For Future Work.....	112
	<b>REFERENCES.....</b>	<b>114</b>
	<b>APPENDICES.....</b>	<b>116</b>
	A: Experimental Test Result.....	118
	B: Evaluation Strength Reduction Factor For Bonded Masonry As Stated In BS 5628 :Part 1: 1978.....	140
	C: Material Test Result.....	142
	D: Example For a Three Story Residential Building.....	146



## LIST OF TABLES

<b>Table</b>	<b>Page</b>
3.1: The Physical Properties Of Different Block Units Used In Construction	29
3.2: Materials Description	34
3.3: Wall Panels Description	52
4.1: Compressive Strength (based on net area) and Strength Reduction Factor Of Wall Panels	87
4.2: Comparison Between Wall Efficiency Factor For Interlocked Wall Panel (Test Result) And Mortar Masonry (Bs 5628: Part 1: 1978)	91
4.3: Evaluation Of Strength Reduction Factor By Mathematical Equations	103
4.4: Compressive Strength of Individual Block, Prism and Basic Wall Panel on Basis of Gross Area	105
4.5: Compressive Strength (based on gross area) and Strength Reduction Factor Of Wall Panels	106
A.1: Load -Lateral Deflection Of Panel 1	118
A.2: Load -Lateral Deflection Of Panel 2	118
A.3: Load -Lateral Deflection Of Panel 3	119
A.4: Load -Lateral Deflection Of Panel 4	119
A.5: Load -Lateral Deflection Of Panel 5	120
A.6: Load -Lateral Deflection Of Panel 6	120
A.7: Load -Lateral Deflection Of Panel 7	121
A.8: Load -Lateral Deflection Of Panel 8	121
A.9: Load -Lateral Deflection Of Panel 9	122
A.10: Load -Lateral Deflection Of Panel 10	122
A.11: Load -Lateral Deflection Of Panel 11	123
A.12: Load -Lateral Deflection Of Panel 12	123
A.13: Load -Lateral Deflection Of Panel 13	124
A.14: Load -Lateral Deflection Of Panel 14	124
A.15: Load -Lateral Deflection Of Panel 15	125



A.16: Load -Lateral Deflection Of Panel 16	125
A17: Load-Strain Gages Reading Of Panel 1	126
A18: Load-Strain Gages Reading Of Panel 2	126
A19: Load-Strain Gages Reading Of Panel 3	127
A20: Load-Strain Gages Reading Of Panel 4	127
A21: Load-Strain Gages Reading Of Panel 5	128
A22: Load-Strain Gages Reading Of Panel 6	128
A23: Load-Strain Gages Reading Of Panel 7	129
A24: Load-Strain Gages Reading Of Panel 8	129
A25: Load-Strain Gages Reading Of Panel 9	130
A26: Load-Strain Gages Reading Of Panel 10	130
A27: Load-Strain Gages Reading Of Panel 11	131
A28: Load-Strain Gages Reading Of Panel 12	131
A29: Load-Strain Gages Reading Of Panel 13	132
A30: Load-Strain Gages Reading Of Panel 14	132
A31: Load-Strain Gages Reading Of Panel 15	133
A32: Load-Strain Gages Reading Of Panel 16	133
A33: Cube Test Result	134
A34a: Compression Test Of Stretcher Block Type 1	136
A34b: Compression Test Of Stretcher Block Type 2	137
A35: Compression Test Of Corner Block	138
A36: Compression Test Of Half- Block	139
B1: Characteristic Compressive Strength Of Bonded Masonry, $f_k$ , In N/Mm <sup>2</sup> Constructed With Hollow Blocks Having A Ratio Of Height To Least Horizontal Dimension Of Between 2.0 To 4.0 As Shown In Table 2d Of Bs 5628 :Part 1: 1978	140
B2: Capacity Reduction Factor, $\beta$ , For Bonded Masonry As Presented In Table 7 Of Bs 5628 : Part 1: 1978	141
C1: Physical Properties Test Result	142
C2: Sieve Analysis For The Quarry Sand Sample 1	143
C3: Sieve Analysis For The Quarry Sand Sample 2	144
C4: Sieve Analysis For The Quarry Sand Sample 3	145

## LIST OF FIGURES

Figure	Page
2.1:Thallon Interlocking System	9
2.2: Haenar Interlocking System	10
2.3: Mecano Interlocking System	13
2.4:Test Result Of Mecano System	15
2.5:Lok Block Interlocking System	16
2.6:H-Block Interlocking System Developed At Drexel University	18
2.7:WHD-Block Interlocking System Developed At Drexel University	19
2.8:Abang Interlocking System	20
2.9: Crack Pattern Of Walls Under Centric Loading Using Abang Interlocking System	21
2.10:Abang Test Result (Load Verse Vertical Deflection)	23
2.11: Miswary Interlocking Block	24
2.12:Test Result Of Miswary Interlocking System	25
3.1a:Interlocking Block Units	30
3.1:Stretcher-Block Unit	31
3.2: Corner Block Unit	32
3.3: Half Block Unit	33
3.4: Manually Operated Making Block Machine	37
3.5: Magnus Frame And Secondary Frame	38
3.6: Block Stacking	41
3.7: Prism Test Arrangement	43
3.8: Prism Test	44
3.9: Block Arrangement Of Panels Group A	45
3.10: Set Up Of Panels Group A	46
3.11: Block Arrangement Of Panels Group B	47
3.12: Set Up Of Panels Group B	47
3.13: Block Arrangement For Panels Group C	48





3.14: Set Up Of Panels Group C	49
3.15: Block Arrangement Of Panels Group D	50
3.16: Setting Of Panels Group D	51
3.17a: Typical Panel Set Up	54
3.17b: Typical Setting Of Panel Before Testing	55
3.18a: Typical Setting For The Top Edge	56
3.18b: Typical Top Edge Arrangement	57
3.19a: Setting Of The Bottom Edge	58
3.19b: Bottom Edge Arrangement	58
3.20: Dial Gage Setting	60
3.21: Strain Gages Arrangement	61
4.1: Variation Of Compressive Strength Of Stretcher Block	65
4.2: Variation Of Compressive Strength Of Corner Block	66
4.3: Variation Of Compressive Strength Of Half Block	67
4.4: Compressive Strength Of Different Interlocking Prism Specimens	69
4.5: Tension Stress Action In 3-Courses Prism	70
4.6: Crack Pattern and Mode Of Failure Of (a) Individual Block, (b) Prism And (c) Basic Panel	72
4.7: Comparison Between Test Result Of Interlocking Hollow Block System With The Bonded Hollow Block System As Stated In BS 5628 Part 1: 1978	72
4.8: Indication Of Deflection Direction	73
4.9: Load-Lateral Deflection Curve For Panels Of Group A	74
4.10: Load-Lateral Deflection Curve For Panels Of Group B	74
4.11: Load-Lateral Deflection Curves For Panels Of Group C	75
4.12: Load-Lateral Deflection Curves For Panels Of Group D	75
4.13 Lateral Deflection Before Failure For Panels Of Different Groups	76
4.14: Setting Of Strain Gages At The Tension And Compression Sides Of The Wall Panels	79
4.15 Vertical Load-Strain Curves For Panels Of Group (A)	80
4.16 Vertical Load-Strain Curves For Panels Of Group (B)	81
4.17 Vertical Load-Strain Curves For Panels Of Group (C)	82



4.18: Vertical Load-Strain Curves For Panels Of Group (D)	83
4.19: Height-Stress Distribution Curves Of Panels Of Different Groups	85
4.20: Variation Of Wall Panel Efficiency Due To Slenderness Effect For Axially Applied Load	88
4.21: Variations Of Wall Panel Efficiency Due To Eccentricity Effects For Different Groups (Slenderness)	89
4.22: Comparison Of Interlocking Test Result With BS 5628: Part 1: 1978 For Bonded Mortar System	92
4.23: Crack Pattern Of Group A (Slenderness Ratio = 8)	97
4.24: Crack Pattern Of Group B (Slenderness Ratio = 12)	98
4.25: Crack Pattern Of Group C (Slenderness Ratio = 16)	99
4.26: Crack Pattern Of Group D (Slenderness Ratio = 20)	100
4.27: Linear Models For Evaluating the Strength Reduction Factor For Interlocking Load Bearing Wall	102



## LIST OF SYMBOLS

- $f_{cu}$  Compression strength of the cube.
- $f_{cb}$  Compression strength of the individual block unit.
- $f_{cp}$  Compression strength of the prism.
- $f_k$  Design strength of the interlocking load bearing wall.
- SR Slenderness ratio of the wall equal to height divided by the least dimension of the wall (height / thickness of the wall).
- $\beta$  Strength reduction factor (efficiency) of the wall. It is equal to  $f_k / f_{cb}$ .
- $e$  Eccentricity of the applied load measured from the centerline of the wall in (mm) and it is equal to the moment divided by the axial load (M/P).
- SF Appropriate safety factor (1.5-2.5) depend on the quality control of manufacturing the interlocking block.

# CHAPTER 1

## INTRODUCTION

### 1.1 General

The world started to use the hollow blocks as building materials at the beginning of the 20th century. Throughout the eighty years of application, it has been shown that hollow blocks can be used as structural, fencing and decorative materials. Hollow block has good heat, sound and fire insulation properties. Moreover earthquake resistance can be greatly improved after the introduction of steel bars in the hollow block construction for multistory structures. In addition to the above, its simplicity, efficiency, flexibility low cost of production are also responsible for it to being popularly used in the construction industry.

The use of structural masonry may result in cheaper and faster construction of structures compared with the conventional approach of framed building construction. Structural masonry eliminates the need for beams and columns of the framed structure hence it leads to a significant saving on costly formwork and construction material in addition to reducing the construction time. The concrete blocks in use today which are not of the interlocking type look quite uniform but their dimensions actually vary so much that mortar is necessary not only to hold them together but also to adjust the level at each layer.

Interlocking block work system is promoted as a new building technique that may result to a more economical construction. The use of interlocking load bearing hollow blocks in building construction will further speed up the construction process as a result of the elimination of mortar layers. Being light and with self-aligning features, the interlocking hollow blocks can be assembled much faster compared to the conventional mortar masonry construction. New parameters have arisen in using the new block system and considerable research is required to understand the structural behavior of the system and to establish the design procedure. The alignment of the interlocking system can be achieved by suitable and efficient design. Moreover, the interconnection between the blocks has to be designed to withstand the different stresses developed in the wall due to the applied load. Practically the shapes of the block must be as simple as possible for easy production and construction.

## **1.2 Significance of the research**

In Malaysia, the supply of houses by both public and private sectors is still far from meeting the demand, especially in the low cost housing sector. For the purpose of developing and promoting a new system, that is fast in construction and more economical, the use of interlocking hollow block systems is adopted. This research is aimed at assessing the feasibility of using the new design of interlocking hollow block in the construction of residential or official buildings.

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### **1.3 Scope**

To understand the load-bearing characteristics of the Putra block and to develop design procedures for the load bearing walls using interlocking hollow blocks.

### **1.4 Objective**

The purpose of this research is:

- To study the structural behavior of interlocking block system in terms of crack pattern, load-deflection, strain-stress distribution, ultimate load capacity and modes of failure.
- To study the effects of slenderness of the interlocked block wall on its structural behaviour.
- To study the effects of different eccentricities observed in walls have been considered.
- To provide design recommendations for un-stiffened interlocking load bearing walls subjected to axial and eccentric loading.

The tests include individual block units, prisms and wall panels.

## 1.5 Layout of the thesis

This thesis is divided into 5 chapters; a brief description of the content of these chapters is presented below:

The first chapter contains the introduction and the scope of the study. Chapter II is devoted to the literature review, which includes topics related to the development of the interlocking system. Chapter III covers the methodology employed in this study presenting the procedures implemented to conduct the experimental work. In chapter IV results of the experimental works were demonstrated and discussed. Chapter V is devoted to the conclusion and recommendations for future work.



## CHAPTER II

### LITERATURE REVIEW

#### 2.1 Introduction

Presently, hollow block construction is adopted as one of the building construction systems in many countries in the world. It is used quite substantially in the construction of high-rise and apartment buildings. According to practical experience hollow block construction system is most economical for four to seventeen story buildings. The advanced facilities in the hollow block production plant leads to better quality and quantity of the produced block. The search for more rapid and less workman ship dependent building system has led to the development of interlocking dry stackable block masonry units which can be laid without mortar layers. Interlocking hollow block system (IHBS) is a new concept to render the hollow block construction more economical and faster compared with the framed structure. If the interlocking mechanism in the interlocked block is capable of developing good bonding between the blocks and the courses to withstand all the stresses developed due to the applied load, it will be crucial competitor in the construction industry. In the last thirty years many countries are known to be interested of developing and implementing this system in the low cost housing scheme. Many claimed in saving cost and time when this construction system is implemented.