



NUMERICAL AND PHYSICAL MODELLING OF CRACKS IN MASONRY WALLS DUE TO THERMAL MOVEMENTS OF AN OVERLYING SLAB

By
K G S Dilrukshi

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Professor W P S Dias

DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF MORA TUWA
MORATUWA
SRI LANKA

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ABSTRACT

Concrete slabs exposed to direct sunlight experience temperature related horizontal movements. In addition, temperatures on the top surface will be higher than those on the underside of the slab, causing an upward deflection of the slab during heating. In a typical building, masonry and concrete elements are connected to each other at their common interfaces. Therefore, significant movements may be generated on the masonry walls due to the movement of the roof slab. These movements can result in overstressing and cracking in masonry. These cracks may not be structurally serious, but may lead to ingress of moisture and in any case are not acceptable especially where good finish is desired.

In this study, the behaviour of these cracks was studied based on surveys of buildings where such cracks have formed. Also typical structural arrangements were numerically modelled to investigate the stresses developing in walls due to the movement of the overlying slab and consequent cracking. Using these numerical models, the effect of the aspect ratio of the wall, structural form of the wall and presence of other structural features such as openings and lintels on the formation of these cracks was studied. These results were compared with the information obtained from the field survey and also with a few physical models which were constructed to the scale of 1/3 of the prototype. The formation of cracks was observed and the strains generated on walls and the temperature variations of the assemblies were monitored. These observations enabled qualitative validation of the numerical models.

Numerical modelling was initially done as a linear elastic un-coupled analysis. A commercially available structural analysis software SAP2000 was used for the study. Locations and directions where cracking would occur were identified using the principal stresses developed in the finite element model and a failure criterion developed based on modified Von-Mises theory. Using detailed numerical modelling (i.e. non-linear structural-thermal coupled analysis), the development of cracks in walls under the time varying thermal load was studied. Modelling was done using a



commercially available finite element code ANSYS 11.0. The model was also used to study the effectiveness of various remedial measures for the problem of thermal cracks in concrete framed walls.

It was found that concrete framed walls could exhibit horizontal cracking under the beam and inclined cracking (at 45° to the horizontal) near the ends of walls. For load bearing walls the inclined cracking at wall ends had an inclination to the horizontal of around 60° , while vertical cracking near the wall mid length was also a possibility.

Linear elastic analysis will give a reasonably good idea of crack locations in solid walls. However non-linear analysis would be required for predicting crack locations in walls with openings.

The results of detailed numerical modelling illustrate that the use of a lintel in a concrete framed wall is not an effective solution to the problem of thermal cracking in walls. However, separating the wall from the concrete frame at the wall-beam interface and wall-column interface (for a depth of $1/3$ of the wall height from the beam soffit level) seems to be an effective solution.

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Finally my warm gratitude is for my husband who always stood by me during difficult moments and for nourishing my mind with hope and courage.

DECLARATION

This thesis is a report of research carried out in the Department of Civil Engineering, University of Moratuwa, between February 2004 and May 2008. Except where references are made to other work, the contents of this thesis are original and have been carried out by the undersigned. The work has not been submitted in part or whole to any other university.

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Supervisor

Prof. W P S Dias

Department of Civil Engineering

University of Moratuwa

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CONTENTS

Abstract	ii
Acknowledgements	iv
Declaration	v
Dedication	vi
Contents	x
List of Figures	
List of Tables	
CHAPTER 1: INTRODUCTION	1
1.1 Background	1
1.2 Objective of the study	4
1.3 Methodology	5
1.4 Structure of the thesis	6
CHAPTER 2: LITERATURE REVIEW	8
2.1 Introduction	8
2.2 Strength of masonry	9
2.2.1 Masonry in compression, tension and shear	9
2.2.2 Softening of masonry	12
2.3 Overview of Strategies for numerical modelling of masonry structures	13
2.4 Modelling interfaces of discontinuous materials	16
2.4.1 Interface discontinuous materials	16
2.4.2 Finite element modelling of interfaces	16
2.5 Modelling of cracking in masonry	19
2.6 Models developed for defining failure of masonry	23
2.7 Overview of physical modelling of masonry	33
2.8 Studies about existing structures using numerical and physical models	36

2.9	Summary	38
CHAPTER 3: SURVEY OF BUILDINGS		40
3.1	Introduction	40
3.2	Methodology	41
3.3	Observations and discussion	45
3.4	Summary	52
CHAPTER 4: PRELIMINARY NUMERICAL MODELLING – UNCOUPLED LINEAR ELASTIC ANALYSIS		53
1.1	Introduction	53
1.2	Numerical modelling of the assemblies	54
4.2.1	The assemblies used	54
4.2.2	Modelling of structural elements	55
4.3	Loading and material properties	59
4.4	Numerical analysis	61
4.5	Failure evaluation	61
4.5.1	Cracking in the masonry	61
4.5.2	Cracking at the interface	64
4.6	Results and discussion	64
4.7	Modelling of walls with openings and lintels	72
4.8	Summary	82
CHAPTER 5: DETAILED NUMERICAL MODELLING – COUPLED NON-LINEAR ANALYSIS		84
5.1	Introduction	84
5.2	Thermal history analysis	85
5.2.1	Description of model	85
5.2.2	Data for heat flow analysis	85
5.2.2.1	Temperature boundary conditions	85
5.2.2.2	Thermal properties of materials	87
5.2.3	Heat flow analysis	87
5.2.4	Results and discussion	88

5.3	Crack modelling in masonry Walls – background and approach	90
5.3.1	Model description	90
5.3.2	SOLID65 concrete material model	92
5.3.3	Modelling of cracking	98
5.3.4	Loading and material properties	102
5.3.5	Analysis	103
5.4	Results and observations of crack modelling	103
5.4.1	Analysis of displacements	103
5.4.2	Analysis of cracking	107
5.4.2.1	Overview of crack initiation	107
5.4.2.2	Solid walls	108
5.4.2.3	Walls with openings	116
5.4.2.4	Remedial measures for thermal cracking in walls	123
5.5	Modelling the effect of a masonry-concrete interface	132
5.5.1	Modelling of interface	132
5.5.2	Results and discussion	134
5.6	Summary	137
 CHAPTER 6: PHYSICAL MODELLING		138
6.1	Introduction	138
6.2	Description of models	139
6.2.1	Selection of scale	139
6.2.2	Selection of models	140
6.2.3	Loading	141
6.2.4	Materials	142
6.3	Construction of models	143
6.4	Instrumentation and monitoring	146
6.4.1	Strain measurements	146
6.4.2	Temperature measurements	149
6.5	Observations and discussion	150
6.5.1	Temperature variation	150
6.5.2	Crack observations	152



6.5.2.1 Concrete framed wall model	152
6.5.2.2 Load bearing wall model	153
6.5.3 Strain measurements	154
6.6 Summary	163
CHAPTER 7: COMPARISON OF RESULTS	165
7.1 Introduction	165
7.2 Comparison	166
7.2.1 Solid walls	166
7.2.2 Walls with openings and lintels	171
7.3 Validation issues	176
7.3.1 Quantitative validation of SAP2000 model	176
7.3.2 Validation of ANSYS model	177
7.3.2.1 Quantitative validation	177
7.3.2.2 Qualitative validation	185
7.4 Note on failure criteria	186
7.5 Summary	188
CHAPTER 8: CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE STUDY	190
1.1 Introduction	190
1.2 Conclusions	190
1.3 Recommendations for future study	193
REFERENCES	199
ANNEX A	200
ANNEX B	228
ANNEX C	237



LIST OF FIGURES

Figure	Description	Page No.
Fig. 1.1	Movement of slab during heating: (a) In simply supported slab; (b) Continuous slab	3
Fig. 2.1	Typical load-deformation response of a quasi-brittle material in tension/flexure (Bhushan 1995)	12
Fig. 2.2	Softening curves of crack opening of masonry due to (a) Tension and (b) Shear (Rots 1997)	13
Fig. 2.3	Modelling strategies for masonry. (a) Detailed micro-modelling; (b) Simplified micro-modelling; (c) Macro modelling (Lourenco 1999)	14
Fig. 2.4	Possible joint – unit (two phase) modeling (Rots 1997)	18
Fig. 2.5	Thin layer interface element ; a) Details of the modelled connection between the masonry wall and the concrete roof slab, b) Geometry of the Joint element (Ibrahim and Suter 1990)	19
Fig. 2.6	Idealisation of cracks in discrete crack modelling (Ali and Page 1989)	22
Fig. 2.7	Idealisation of single crack in smeared crack modelling (Ali and Page 1989)	22
Fig. 2.8	Bond failure surface of masonry (Page 1980)	24
Fig. 2.9	Biaxial strength curves for brick work (Samarasinghe 1980)	25
Fig. 2.10	Biaxial failure criterion for masonry in terms of two principal stresses (Chong et al. 1991)	26
Fig. 2.11	Failure stress of masonry in normal stress terms (Syrmakeziz and Asteris 2001)	27
Fig. 2.12	Continuum failure surface for masonry: plane stress representation (Lourenco et al. 1997)	28
Fig. 2.13	Behaviour of the model for a) Tension and b) Compression (Lourenco, Rots and Johan 1998)	29
Fig. 2.14	Interface cap model (Lourenco and Rots 1997)	29

Fig. 2.15	Behaviour of model for (a) Uniaxial tension, (b) Shear and (c) Uniaxial compression (Lourenco and Rots 1997)	30
Fig. 2.16	Failure surface for bond failure of at interface of brick and mortar (Ali and Page 1989)	31
Fig. 2.17	Failure surface for, (a) Cracking of bricks, (b) Crushing of bricks (Ali and Page 1989)	31
Fig. 2.18	Hyperbolic yield criterion for masonry (Hamid and Benson 1994)	32
Fig. 2.19	Failure criterion for masonry (Ayala 1994)	32
Fig. 3.1	Shrinkage crack on concrete framed masonry wall	42
Fig. 3.2	Shrinkage crack on load bearing masonry wall	43
Fig. 3.3	Typical plan with the details of cracks	44
Fig. 3.4	Horizontal cracking under beam (crack has reappeared after repairing)	49
Fig. 3.5	Vertical crack at the centre part of a load bearing wall	49
Fig. 3.6	Diagonal crack inclined downward near column	50
Fig. 3.7	Diagonal crack at the outer edges of concrete framed wall	50
Fig. 3.8	Diagonal crack at the outer edges of load bearing wall	51
Fig. 3.9	Crack at the top corner of an opening	51
Fig. 3.10	Crack at a bottom corner of an opening	52
Fig. 4.1	Idealised section of a building considered for the analysis	54
Fig. 4.2	Definition of positive stress in a solid element	56
Fig. 4.3	Simulation of the concrete-masonry joint	58
Fig. 4.4	Temperature variation on roof slab	60
Fig. 4.5	Modified Von-Mises failure criterion for masonry (Symakesis, Antonopoulos and Mavruli 2005)	62
Fig. 4.6	Mohr-Coulomb yield criterion combined with tension cut off criterion (Rots 1997)	64

Fig. 4.7	Failure stresses of masonry walls in the bi-axial failure envelope	66
Fig. 4.8	Interface cracking stress in the failure envelope	67
Fig. 4.9	Mohr circle representation of stresses of a load bearing masonry element	68
Fig. 4.10	Mohr circle representation of stresses of a masonry element in concrete framed wall	69
Fig. 5.1	Thermal Boundary Conditions	86
Fig. 5.2	Temperature variation across the roof slab	89
Fig. 5.3	Temperature variation across the roof slab in used as thermal load in detailed coupled analysis (ANSYS) and preliminary analysis (SAP 2000)	89
Fig. 5.4	Typical arrangement of an assembly	92
Fig. 5.5	The failure surface described in three dimensional principal stress space	94
Fig. 5.6	Strength of cracked condition	100
Fig. 5.7	Deformation at the wall-slab interface of load bearing wall	105
Fig. 5.8	Deformations at the wall-beam interface of the concrete framed wall	105
Fig. 5.9	Maximum horizontal and vertical deformation of load bearing wall	106
Fig. 5.10	Maximum horizontal and vertical deformation of concrete framed wall	106
Fig. 5.11	Cracking in the 6 m load bearing wall (MA1)	109
Fig. 5.12	Vector plot of total strains in 6 m load bearing wall (MA1)	110
Fig. 5.13	Cracking at 6 m concrete framed wall (MA2)	111
Fig. 5.14	Vector plot of total strains in 6 m concrete framed wall (MA2)	112
Fig. 5.15	Cracking of 6 m two bay framed wall (MA3)	114

Fig. 5.16	Cracking of 6 m two bay framed wall with lintel from the left column to the right column at 0.875 m bellow the wall-beam interface (MA4)	115
Fig. 5.17	Cracking of 6 m two bay framed wall with opening and short lintel (MA5)	117
Fig. 5.18	Cracking of 6 m two bay framed wall with opening and lintel from the left column to the central column (MA6)	119
Fig. 5.19	Cracking of 6 m two bay framed wall with opening and lintel from the left column to the right column (MA7)	120
Fig. 5.20	Cracking of 6 m two bay framed wall with opening extend up to the beam soffit (MA8)	122
Fig. 5.21	Cracking of 6 m two bay framed wall with separation at wall – beam interface	124
Fig. 5.22	Cracking of 6 m two bay framed wall with separation of 1/3 of wall length at wall column interface (MA9)	125
Fig. 5.23	Cracking of 6 m two bay framed wall with separation of 1/4 of wall length at wall column interface (MA10)	126
Fig. 5.24	Cracking of 6 m two bay framed wall with separation of 1/5 of wall length at wall column interface (MA11)	127
Fig. 5.25	Cracking of 6 m two bay framed wall with opening extending up to beam and separation (MA12)	129
Fig. 5.26	Cracking of 6 m two bay framed wall with opening, short lintel and separation (MA13)	130
Fig. 5.27	Cracking of 6 m two bay framed wall with opening, lintel (left column to right column) and separation (MA14)	131
Fig. 5.28	Stress contours, deformation and separation of one bay framed wall with interface elements	135
Fig. 5.29	Horizontal separation at wall-beam interface	136
Fig. 5.30	Vertical separation at wall-beam interface	136
Fig. 6.1	Details of simplification of the model	141

Fig 6.2	Materials used for construction of models: (a) Brick cutting by diamond cutter; (b) Bricks employed in the project (size 75 x 36 x 24 mm); (c) Sieving of sand by 1.4 mm sieve	142
Fig. 6.3	Construction of model walls: (a) Foundation in foreground; (b) 4 mm thick joint between bricks; (c) Construction of wall according to English bond pattern; (d) 5 mm thick plaster	145
Fig. 6.4	Strain measuring locations	146
Fig. 6.5	Strain measurements using mechanical strain gauge: (a) Datum discs (b) Mechanical strain gauge	147
Fig. 6.6	Details of strain measuring and data logging: (a) Strain gauge pasted on the prepared surface; (b) Digital data logger; (c) Horizontal and vertical strain gauges at the centre of walls; (d) Diagonal strain gauges on wall	148
Fig. 6.7	(a) Multi-meter with surface probe; (b) Measuring temperature using surface probe	149
Fig. 6.8	Temperature variation in model representing 6 m load bearing wall	151
Fig. 6.9	Temperature variation in model representing 6 m concrete frame wall	151
Fig. 6.10	Cracks in 6m concrete frame model: (a) Horizontal crack immediately under the beam (the right hand side of the wall, Face 2); (b) Horizontal crack below the beam level (the left hand side of wall, Face 2); (c) Diagonal crack at the edge of the left hand side, Face 1; (d) Diagonal crack at the edge of the right hand side, Face 2.	153
Fig. 6.11	Strain variation across the horizontal crack under the beam of concrete framed model	154
Fig. 6.12	Strain variation across the diagonal crack of concrete framed model	154
Fig. 6.13	Cracks in wall representing 6 m load bearing wall	155
Fig. 6.14	Cracks in wall representing 6 m concrete framed wall	156
Fig. 6.15	Average maximum expansion of the model representing 3 m load bearing wall	156

Fig. 6.16	Average maximum expansion of the model representing 6 m load bearing wall	158
Fig. 6.17	Average maximum expansion of the model representing 6 m concrete framed wall	159
Fig. 6.18	Strain measurements in model representing 6 m concrete framed wall – Face 1	160
Fig. 6.19	Strain measurements in model representing 6 m concrete framed wall – Face 2	161
Fig.7.1:	Possibility of cracking identified by uncoupled linear elastic analysis using SAP2000	172
Fig.7.2:	Possibility of cracking identified by coupled non-linear analysis using ANSYS	172
Fig.7.3:	Crack observations at the shopping complex of West Bus Park Awissawella	173
Fig.7.4:	Principal stress contours - uncoupled linear elastic analysis and locations of possibility of cracking identified (kN/m ²)	174
Fig.7.5:	Stress contours before formation of cracking – Detailed numerical modelling (stress in kN/m ²)	175
Fig.7.6:	Stress contours after formation of the first crack – Detailed numerical modelling (stress in N/m ²)	175
Fig. 7.7	6 m load bearing wall analysis with SAP2000: Reference temperature equal to wall temperature (stress in N/m ²)	178
Fig. 7.8	6 m load bearing wall analysis with SAP2000: Reference temperature 23 ⁰ C (stress in kN/m ²)	178
Fig. 7.9	6 m load bearing wall analysis with ANSYS: Contour pattern just before cracking (stress in N/m ²)	179
Fig. 7.10	6 m one bay concrete framed wall analysis with SAP2000: Reference temperature equal to wall temperature (stress in kN/m ²)	179
Fig. 7.11	6 m one bay concrete framed wall analysis with SAP2000: Reference temperature 23 ⁰ C (stress in kN/m ²)	180



Fig. 7.12	6 m one bay concrete framed wall analysis with ANSYS: Contour pattern just before cracking (stress in N/m^2)	180
Fig. 7.13	6 m two bay concrete framed wall with opening and short lintel analysis with SAP2000: Reference temperature equal to wall temperature (stress in kN/m^2) (stress in kN/m^2)	181
Fig. 7.14	6 m two bay concrete framed wall with opening and short lintel analysis with SAP2000: Reference temperature $23^{\circ}C$ (stress in kN/m^2)	181
Fig. 7.15	6 m load bearing wall analysis with SAP2000: Higher load on roof slab and reference temperature equal to wall temperature (stress in kN/m^2)	184
Fig. 7.16	6 m one bay concrete framed wall analysis with SAP2000: Higher load on roof slab and reference temperature equal to wall temperature (stress in kN/m^2)	184
Fig. 7.17	6 m two bay concrete framed wall with opening and short lintel analysis with SAP2000: Higher load on roof slab and reference temperature equal to wall temperature (stress in kN/m^2)	185
Fig. 7.18	Failure surface used in ANSYS in principal stress space with bi-axial stress	187


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LIST OF TABLES

Table	Description	Page No.
Table 2.1	Factors affecting to bond between mortar and masonry units	11
Table 3.1	Summery of the building survey	47
Table 4.1	Details of assemblies considered for the study	55
Table 4.2	Material Properties	60
Table 4.3	Summary of results of numerical modelling	71
Table 4.4	Locations of possible cracks identified in 3m one bay concrete framed wall	74
Table 4.5	Locations of possible cracks identified in 6m concrete framed walls	75
Table 4.6	Locations of possible cracks identified in 6m two bay concrete framed walls	76
Table 4.7	Locations of possible cracks identified in 9m load bearing walls	78
Table 4.8	Locations of possible cracks identified in 9m three bay concrete framed walls	79
Table 5.1	Thermal boundary conditions	86
Table 5.2	Thermal properties of materials	87
Table 5.3	Description of Assemblies	91
Table 5.4	SOLID 65 Concrete material data	93
Table 5.5	Details about the first crack initiation	107
Table 5.6	Material constants for defining interface behaviour	134
Table 6.1	Description of physical models used in the study	140
Table 6.2	Details of strain measuring locations	147
Table 6.3	Temperature values at top of the slab and the wall as the top surface reaches its peak	150
Table 7.1	Possibility of cracking identified by each approach	169

Table 7.2	Approaches used for validation of Numerical Models	176
Table 7.3	Comparison of strains of 1/3 scale load bearing model	177
Table 7.4	Contour value range of the models in critical locations	183



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