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DEVELOPMENT OF DISASTER RESISTANT BUILT ENVIRONMENTS WITH COMMONLY USED BUILDING MATERIALS IN SRI LANKA

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by

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This thesis was submitted to the Department of Civil Engineering of the University of Moratuwa for the fulfillment of the requirements for the Degree of Doctor of Philosophy



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ABSTRACT

At present, sustainable building construction practices are actively promoted. One of the key strategies that can enhance the degree of sustainability is creating built environments that can last a very long time when very high level of disaster resistance is achieved with commonly available building materials in a very cost effective way. These strength enhancement methods should cover multitudes of disasters like cyclones, floods and earthquake tremors.

Masonry is a very good material for carrying compressive stresses due to gravity loads consisting of self weight and live loads. However, alternative building materials such as Compressed Stabilized Earth (CSE) bricks and blocks and rammed earth can also demonstrate a behaviour comparable to conventional masonry such as burnt clay bricks and cement sand blocks.

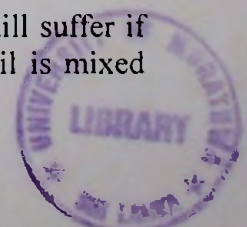
Lateral loads are the dominant of all forces acting in a disastrous situation. Therefore, flexural strengths of the building materials are of very importance. These lateral forces are static or dynamic in nature. In most instances, it may be possible to find equivalent quasi-static forces for dynamic forces. This means, an accurate assessment of the lateral load carrying capacity of masonry walls and also strategies available for improving the lateral load carrying capacities will be of importance.

It is shown that for experimental determination of flexural strength parallel and perpendicular to bed joints, testing of panels with low degree of pre-compression can give reasonable results with acceptable level of scatter. This method has been used to determine the flexural strength parameters for both conventional and alternative materials.

It is also shown that the presence of continuous tie beams at plinth level, window sill level and lintel level can create a situation where wall panels behave almost as vertically spanning. Since tie beams can control the deflection in lateral direction while applying some pre-compression, it was possible to present a theoretical concept for determining the lateral load resistance with the enhancements possible with tie beams. This method relies on the compressive strength of masonry. Once this theoretical method is used with adequate partial factors of safety, a reasonable estimate of lateral load resistance can be obtained. This method can be used even with masonry having very low flexural tensile strength parallel to bed joints.

The above method has to rely on the restraint offered by the continuous tie beam. This means that the tie beam should be adequately restrained. The ideal restraint can be the return walls that would generally occur at 3.0 - 4.0 m intervals in houses. It would also be advisable to have the tie beam extended at least 300 to 600 mm into the partition walls since it can provide better load transfer. This means that some of the plan layout may need some adjustments. Such an integrated approach could provide a house where the masonry walls are adequately tied at various levels and hence capable of transferring loads from one element to the other thus mobilizing various load resisting systems like that can be possible with shear walls.

Even a well constructed house with these disaster resistant features can still suffer if the foundation fails. Thus, adequate soil improvements where sandy soil is mixed



with laterite soil and re-compacted in both foundation and also around the house would be essential.

Three-dimensional finite element modelling with commercial software became a reality only recently. The use of such software like SAP 2000 to identify the likely behaviour under lateral loads was presented. A similar attempt was made to obtain the influence of the nearby houses under wind conditions using ANSYS software.

With all these disaster resistant features, it would now be possible to create a robust single storey house with potential to last as long as possible. The same techniques can be adopted for multi-storey houses as well. Therefore it can be stated with confidence that the research presented in this thesis led to a development of an integrated approach for creating disaster resistant houses. Once such robust built environments are coupled with passive techniques already successfully used for adequate indoor thermal comfort, it would be possible to have robust houses that will need very low energy for day to day operations.

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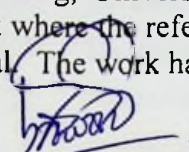
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DECLARATION

This thesis is a report of research work carried out in the department of Civil Engineering, University of Moratuwa, between September 2005 and August 2009. Except where the references are made to the other work, the contents of this thesis are original. The work has not been submitted in part or in whole to any other university.


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TABLE OF CONTENT

1	Introduction.....	1
1.1	General.....	1
1.2	The objectives	4
1.3	The methodology	5
1.4	The arrangement of the thesis.....	6
2	Literature review.....	8
2.1	General.....	8
2.2	Types of disasters.....	8
2.2.1	Floods.....	8
2.2.1.1	Riverine floods.....	9
2.2.1.2	Causal phenomena	9
2.2.1.3	Impacts.....	10
2.2.2	Coastal flooding- Tsunami.....	12
2.2.2.1	Causal phenomena	12
2.2.3	Cyclones.....	15
2.2.3.1	Causal phenomena	20
2.2.3.2	Impacts.....	21
2.2.4	Earthquakes.....	23
2.2.4.1	Causal phenomena	25
2.2.5	Impacts.....	26
2.2.6	Landslides	28
2.2.6.1	Causal phenomena	29
2.2.6.2	Impacts.....	32
2.2.7	Droughts.....	33
2.2.7.1	Causal phenomena	33
2.2.7.2	Impacts.....	35
2.2.8	Lightning strikes	36
2.2.8.1	Causal phenomena	37
2.2.8.2	Impacts.....	38
2.2.9	Summary on natural hazards.....	39
2.3	The commonly used building materials.....	39
2.3.1	Burnt clay bricks.....	39

2.3.2	Cement sand blocks	42
2.3.3	Compressed stabilized earth bricks (CSE Bricks)	42
2.3.4	CSE plain solid blocks	43
2.3.5	CSE interlocking solid blocks	43
2.3.6	CSE interlocking hollow blocks	44
2.3.7	Rammed earth	45
2.4	The techniques for enhanced disaster resistance	46
2.4.1	The use of tie beams in walls for enhanced lateral resistance	46
2.5	Summary	47
3	Performance in recent disasters	50
3.1	General	50
3.2	Evidences from floods	51
3.2.1	Evidence from riverine floods	51
3.2.2	Evidence from coastal flooding due to Tsunami	52
3.2.2.1	Non-engineered masonry brickwork structures	52
3.2.2.2	Typical foundations of single storey houses	53
3.2.2.3	Foundations of reinforced concrete structures	54
3.2.2.4	Window and door openings in wall panels	55
3.2.2.5	Damage due to floating debris	56
3.2.2.6	Damage to infrastructure	56
3.3	Evidences from cyclones	58
3.4	Evidences from earthquakes	60
3.5	The structural forms and typical weaknesses	63
3.6	Lessons from evidences	64
3.7	The remedial actions	66
3.7.1	Remedial actions for floods	66
3.7.1.1	Lateral pressure exerted by filled up water	66
3.7.1.2	Uplift caused by filled up water	68
3.7.1.3	Floor slab failure due to erosion of foundation	69
3.7.1.4	Unprotected slope failures	70
3.7.1.5	Liquefaction of granular foundations	72
3.7.2	Remedial actions for cyclones	73
3.7.2.1	Remedial actions for the roof structure	73
3.7.2.2	Use of reinforced concrete columns	75

3.7.2.3	Proper selection and orientation of openings	76
3.7.3	Remedial actions for earthquakes	78
3.8	Summary	80
4	Experimental investigation for CSE bricks and blocks	82
4.1	General	82
4.2	Objectives of experimental programme and methodology	85
4.3	Compressed Stabilized Earth (CSE)	85
4.4	Experimental programme	86
4.4.1	The test method in BS 5628: Part 1: 1992	87
4.5	Results and analysis	90
4.6	Enhancement of lateral load carrying capacity	95
4.7	Conclusion	96
5	An assessment on remedial measures	97
5.1	General	97
5.2	The objectives and methodology	98
5.3	The types and properties of masonry	98
5.4	The preferred locations for tie beams	99
5.4.1	Tie beams at plinth level	99
5.4.2	Tie beams at window sill level	99
5.4.3	Tie beams at lintel level	100
5.5	Quantification of lateral strength	100
5.6	Quantification of strength enhancement	103
5.7	The conditions for tie beams and reinforcement	106
5.8	Summary	110
6	Computer modelling	111
6.1	General	111
6.2	Applicability of finite element analysis	112
6.2.1	Case studies	112
6.2.2	Load cases and combinations	114
6.2.3	Use of FEM to identify weaknesses	114
6.2.4	Use of FEM in modified layouts	117
6.2.5	Analysis of results	119
6.3	Applicability of computational fluid dynamics	120
6.3.1	Analysis cases	121

6.3.2	The results.....	125
6.3.3	Application.....	126
6.4	Summary.....	127
7	Conclusions and future work.....	128
7.1	General conclusion.....	128
7.2	Future work.....	132
	List of references.....	134
	Appendix A.....	147
	Determination of the flexural strength of masonry wall panels from laboratory test results.....	147
	Appendix B.....	149
	Appendix C.....	155

LIST OF FIGURES

Figure 1.1: The yearly increase of natural catastrophes in the world (Munich group, 2008)	2
Figure 1.2: Trends in number of reported events- Climatic hazards vs. earthquakes (Wikipedia, the free encyclopaedia)	3
Figure 2.1: The Hydrologic cycle constantly circulates water throughout the earth's environment (FEMA 15, 1981).....	9
Figure 2.2: Lateral hydro-static forces acting on structures due to flood water (FEMA 577, 2007)	10
Figure 2.3: Lateral hydro-dynamic forces acting on structures (FEMA 577, 2007) ...	11
Figure 2.4: Probability and Magnitude of floods (FEMA 577, 2007)	11
Figure 2.5: Tsunami: the relationship with the submarine earthquake eruption and consequent Tsunami wave propagation (UNESCO-IOC, 2006b)	14
Figure 2.6: Tsunami speed reduces in shallow water as wave height increases (UNESCO-IOC, 2006b).....	14
Figure 2.7: Seasonal frequency of cyclonic storms (Zubair, 2006).....	16
Figure 2.8: Typical cyclonic tracks of the world (Cook, 1985).....	17
Figure 2.9: Landfall of the Tropical cyclone TC 21-78 on November 24 th 1978 (JTWC, 1978)	18
Figure 2.10: Landfall of the Tropical cyclone TC-04B on 26 th December 2000 (JTWC, 2000)	18
Figure 2.11: Wind loading zones in Sri Lanka (Clarke et al., 1979)	19
Figure 2.12: Schematic drawing through a hurricane. Low-altitude trade winds feed moisture and heat to the eye. Updrafts rise rapidly up the core (eye) wall and are helped away by high altitude winds (Abbott, 1996)	21
Figure 2.13: Cyclone classification scales and their inter-relationships (Disaster Management Centre).....	22
Figure 2.14: Sri Lanka is located about 1500 km away from the epicentre of the December 26 th , 2004 earthquake (Dias et al., 2006).....	24
Figure 2.15: Elastic rebound theory (Murthy, 2002)	26
Figure 2.16: Watawala landslide on 3 rd June 1992 in Nuwara-Eliya District due to reactivation of a dormant ancient landslide, engine of a goods train were also taken down the slope (National Building Research Organization)	29

Figure 2.17: Beragala landslide in 19 th November 1997 in Badulla district (National Building Research Organization).....	29
Figure 2.18: Padiyapalalla in 13 th January, 2006 (National Building Research Organization), houses have been completely damaged and roads were blocked interrupting rescue activities	29
Figure 2.19: Mass movement speed Vs moisture content (Abbott, 1996).....	31
Figure 2.20: Varnes landslide velocity scale and probable destructive significance (Australian Geomechanics Society, March, 2007b)	31
Figure 2.21: Classification of mass movements in a land slide (Australian Geomechanics Society, March, 2007b)	32
Figure 2.22: Drought in 2001 (Government of Sri Lanka).....	34
Figure 2.23: Drought in 2004 (Disaster Management Centre)	34
Figure 2.24: Impacts on agriculture. (Disaster Management Centre).....	34
Figure 2.25: A reservoir completely dried out in Hambantota. In Hambantota itself, out of the 11 reservoirs, 8 were completely dried out during the drought in year 2001 (Disaster Management Centre)	35
Figure 2.26: Peaks in lightning strikes in Sri Lanka (Department of Meteorology, Sri Lanka)	36
Figure 2.27: Phenomena of lightning strikes	37
Figure 2.28: An ancient seven storied brick masonry structure of 800 years old (Polonnaruwa, Sri Lanka).....	40
Figure 2.29: Royal palace- an ancient seven storied palace constructed with brick masonry (Polonnaruwa, Sri Lanka)	40
Figure 2.30: CSE Brick of 230 mm of length x 110 mm of width x 75 mm of height	41
Figure 2.31: CSE Plain Solid Block of 225 mm of length x 225 mm of width x 115 mm of height.....	41
Figure 2.324: CSE Interlocking Solid Block of 235 mm of length x 225 mm of width x 115 mm of height.....	41
Figure 2.33: CSE Interlocking Hollow Block of 300 mm of length x 145 mm of width x 100 mm of height	41
Figure 2.34: Rammed earth panel of 600 mm of length x 900 mm of height x 150 mm of thickness used for testing.....	41
Figure 2.35: Load-bearing brickwork structure	42
Figure 2.36: Cement sand block work structure	42

Figure 2.37: Ground floor of a two storey house constructed with CSE plain solid blocks	43
Figure 2.38: Test panel of 840 mm of length x 400 mm of height x 145 mm of thickness constructed with CSE Inter-locking hollow blocks	44
Figure 2.39: Single storey house constructed with CSE Interlocking hollow blocks..	44
Figure 2.40: Steel moulds used for casting of rammed earth wall panels	45
Figure 2.41: A house being constructed with rammed earth walls.....	45
Figure 2.42: A model house completed with rammed earth walls (picture courtesy, CHPB, Battaramulla)	45
Figure 2.43: Rubble foundation with tie beams at DPC and window sill levels	48
Figure 3.1: Low rise masonry house completely washed away during the massive flood in 2006 in Chilaw	51
Figure 3.2: House closer to the river completely washed away during the floods in 2008 in Kalutara.....	51
Figure 3.3: Complete inundation of the area up to about 15 ft above ground level, in Palindanuwara, Matugama in 2008.....	51
Figure 3.4: Partly damaged house in Palindanuwara, Matugama in 2008.....	51
Figure 3.5: Yala Safari Beach hotel before Tsunami impact.....	52
Figure 3.6: Yala Safari Beach hotel-completely destroyed from Tsunami impact.....	52
Figure 3.7: Excessive lateral loads on un-reinforced masonry walls- Yala Safari beach hotel.....	53
Figure 3.8: Completely damaged masonry walls in the 2 nd floor of a two storey structure.....	53
Figure 3.9: Partially collapsed brickwork structure due to Tsunami tidal waves.....	53
Figure 3.10: A reinforced concrete building survived with damage being concentrated to the infill partition walls.....	53
Figure 3.11: Complete failure of masonry low rise buildings in Yala-Safari beach hotel due to Tsunami waves.....	54
Figure 3.12: Under-scouring of foundation at a corner of a school building from Tsunami waves.....	54
Figure 3.13: A house closer to the shoreline exposing its long weaker side towards sea	56
Figure 3.14: A house closer to the shoreline exposing its short and stiffer edge towards sea.....	56

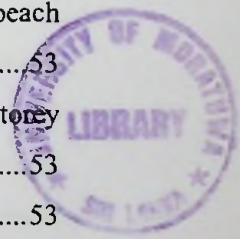


Figure 3.15: Damage by impact of debris-A boat being taken by Tsunami waves	57
Figure 3.16: Static and dynamic impact of water and debris failed a concrete column	57
Figure 3.17: Damage to access roads due to collapsed bridges	57
Figure 3.18: Partly damage bridge deck due to wave impact during Tsunami.....	57
Figure 3.19: Part of the railway road has washed away from Tsunami waves making its inaccessible	57
Figure 3.20: Collapsed transmission tower during Tsunami. Failure may be due to impact of debris on critical elements or due to excessive lateral loads on legs.....	57
Figure 3.21: A house with a clay tile roof. The roof covering material has completely blown away and some of the roof members have failed during the 24 th November, 1978 Cyclone (Datum International)	58
Figure 3.22: An uprooted coconut tree has fallen over a house damaging the roof and some of the walls during the 24 th November, 1978 Cyclone (Datum International)...	58
Figure 3.23: Damage mechanism of different roof arrangements in strong wind situations (Arya, 2000).....	59
Figure 3.24: Effect of roof overhangs (Arya, 2000).....	59
Figure 3.25: Roof overhangs and Veranda can suffer from heavy winds. (a) : Roof overhang build as an extension of the main roof structure, (b) : Uplift forces can easily exceeds the dead weight, hence the whole roof blown away, (c) : An open Veranda build as a separate structure, (d) : Can blow off without damaging the rest (Ankush, 2007)	60
Figure 3.26: (a) to (h) are some typical damages observed in Beralihela in Thissamaharama on 9 th , 20 th and 21 st July, 2007 after few minor earthquake tremors	62
Figure 3.27: Construction of a typical single storey house with two continuous tie beams at lintel and plinth levels (Beralihela, Thissamaharama).....	64
Figure 3.28: Sudden variations and discontinuities in load paths can trigger damages to the structural elements; (a) : Soft storey type construction, (b) : Discontinuity of structural elements, (c) : Irregularities in structural shapes (one side open in the ground storey) can make the structure rotate (Murthy, 2002).....	65
Figure 3.29: Lateral pressure exerted by filled up water	67
Figure 3.30: Uplift caused by filled up water	69
Figure 3.31: Impacts form erosion under the foundations.....	70
Figure 3.32: Slope failure and effect of vegetation	71

Figure 3.33: Structural collapses due to liquefaction of foundation soil	72
Figure 3.34: Relative roof uplift pressures as a function of roof geometry, roof slope, and location on roof, and relative positive and negative wall pressures as a function of location along the wall (FEMA 424, 2004)	74
Figure 3.35: Additional steel members can be used to connect the timber frame work	75
Figure 3.36: Details of proper roof anchoring mechanism	75
Figure 3.37: Provision of tie beams at three different locations to improve the disaster resistance	76
Figure 3.38: Schematic of internal pressure condition when the dominant opening is in the windward wall (FEMA 424, 2004)	77
Figure 3.39: Schematic of internal pressure condition when the dominant opening is in the leeward wall (FEMA 424, 2004)	77
Figure 3.40: Relationship between limiting epicentral distance of sites at which liquefaction has been observed and moment magnitude for shallow earthquakes	80
Figure 4.1: A three storey house constructed with CSE Interlocking blocks with a rammed earth boundary wall	83
Figure 4.2: Standard dimensions of brick ((a) and (b)) and block ((c) and (d)) wallets to determine the flexural strengths according to BS 5628: Part 1:1992 Appendix A.3.1	88
Figure 4.3: Details of the three bond patterns used (a) Flemish bond, (b) English bond, (c) Rat-trap bond	88
Figure 4.4: Rammed earth panel being tested for f_{kx} perpendicular to the compacted layers of soil	89
Figure 4.5: CSE Plain solid block panel being tested for f_{kx} parallel to bed joints	89
Figure 4.6: CSE Interlocking solid Figure 4.7: CSE Brick panel being	90
Figure 4.8: CSE Brick panel being tested for f_{kx} parallel to bed joints- Flemish Bond	90
Figure 4.9: The typical bending moment diagram and the resultant stress diagram for a masonry wall panel	92
Figure 4.10: Sudden and brittle block- mortar interface failure of a CSE interlocking solid block wall panel loaded parallel to its bed joints	93
Figure 4.11: Sudden and brittle brick- mortar interface failure of a CSE brick wall panel loaded parallel to its bed joints	93

Figure 4.12: Failure of a rammed earth panel tested for f_{kx} perpendicular to the compacted layers of soil..... 93

Figure 4.13: Failure of a rammed earth panel tested for f_{kx} parallel to the compacted layers of soil..... 93

Figure 5.1: Resultant bending moment diagram of a free standing wall and the location of the crack..... 102

Figure 5.2: Resultant bending moment diagram of a free standing wall propped at top 102

Figure 5.3: Resultant bending moment diagram of a wall spanning between two tie beams 102

Figure 5.4: The limiting condition at Figure 5.5: Resultant bending moment 103

Figure 6.2: House with modified plan layout6.1 113

Figure B.0.1: A free standing wall subjected to lateral load..... 149

Figure B.0.2: Details of the wall used for the case study 151

LIST OF TABLES

Table 1.1: Natural Disasters in Sri Lanka and their impacts in Year 2007 (National Disaster Management Centre).....	4
Table 2.1: Tsunami classification (Horikawa, 1988).....	13
Table 2.2: Normal and post disaster wind speeds for three wind loading zones in Sri Lanka (Macks et al, 1979).....	19
Table 2.3: Global occurrence of earthquakes (United States Geological Society).....	25
Table 2.4: Major types of landslides (Australian Geomechanics Society, March 2007b).....	30
Table 3.1: Preferable roof angles with roof covering materials (Clarke et al, 1979).....	74
Table 4.1: Flexural strength of different walling materials in two orthogonal directions.....	91
Table 5.1: Summary of results obtained for different locations in a masonry wall ...	104