SPECIFICATION OF MOVEMENT JOINTS FOR MASONRY STRUCTURES IN SRI LANKA

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PhD/C/01/94

Degree of Doctor of Philosophy

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Declaration

I declare that this is my own work and this thesis 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.

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Abstract

Masonry is the most commonly used building material for construction of low rise buildings and even for infill-walls of some high-rise buildings in Sri Lanka. Propagation of cracks in masonry walls is one of the main problems in masonry structures as it affects aesthetics and serviceability greatly. Movement in masonry is the prime cause for such cracks. Especially when movements are restrained, stresses will be set up which may lead to cracking. Even though these cracks may not be of structural significance, due to the difficulties in concealing them permanently and due to increase in maintenance costs of buildings, it has become one of the main concerns in the construction industry.

In a few Codes of Practice and Standards, various guidelines are stipulated to control cracking in masonry, but still there are no hard and fast rules for predicting movements accurately at the design stage, due to its complexity. The guidelines specified for design of movement joints for masonry in other countries cannot be directly used in Sri Lanka for local masonry, due to differences in environmental conditions and material properties. Therefore, there is a strong need to develop a methodology for movement joint design and a specification of movement joints for masonry structures in Sri Lanka. To achieve this goal, a comprehensive research study was carried out. It consisted of a literature survey, a field study, an experimental study, a theoretical study and a finite element study.

The literature survey was carried out to identify the important parameters to be studied, to assess the current state of knowledge, and to gather necessary information on the design of movement joints.

A field study was carried out by conducting a detailed questionnaire survey to collect information on cracking of local masonry walls. Most of the houses had at least one or more cracked walls and majority of the cracks was present only in the superstructure. Wall thickness, exposure to direct sunlight /rain, wall length/height ratio, existence of openings, cross sectional variations in walls, and existence of wall junctions or wall returns were found to be influential parameters on movements.

The experimental study included an extensive investigation of movements in different types of masonry wall panels, where 34 wall panels were tested for movements over long period of time till movements stabilized. As brickwork is the most widely used masonry material in Sri Lanka, greater emphasis was given to it. With these tests, long-term movements in different types of masonry were investigated. Numerous tests were also carried out to determine the required properties of brickwork and constituents of brickwork, needed for the theoretical study and the finite element study. The experimental study also resulted in the development of a simple, accurate and inexpensive method for measurement of long term movements in masonry.

A theoretical model accounting for elastic, creep, shrinkage and thermal deformations of bricks and mortar was developed with an accuracy of 96% to predict the long-term movements in masonry, which can be used to investigate various aspects which influence design of movement joints for masonry walls. Parametric study highlighted its usefulness.

A finite element analysis, using SAP 2000 with thin shell elements, was carried out to study the behaviour of masonry walls subjected to restrained shrinkage, using varying sizes and varying end conditions of a rectangular wall. Significant influence of L/H ratios of walls on stresses

developed in masonry walls was seen. Influence of openings, wall returns, and restraints were also studied.

Finally a methodology for design of movement joints was developed and presented. Further, simplified guidelines for design of movement joints with minimum calculations, were also proposed. Some important conclusions of the study were that moisture expansion of local bricks is insignificant in comparison to that reported for high strength bricks in other countries; movement of local masonry can be described by three parameters maximum shrinkage (ε_0), maximum expansion (ε_{ex}) and critical shrinkage (ε_{cr}) of which last is the most decisive parameter; and first year after construction is the critical period as regards movement of local masonry.

To my father, mother, husband, sister, brother and son whose love and understanding have brought me happiness in my life

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