# INVESTIGATION OF MOVEMENTS IN BLOCK MASONRY WALLS

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**Abstract:** One of the main concerns in block masonry is cracking, mainly due to thermal and moisture movement. There are some standards which give guidelines and recommendations to control cracking, but these cannot be directly used for local masonry due to the differences in properties of masonry units used, environmental conditions and the construction techniques. This experimental study is mainly carried out to investigate the extent of movement in block masonry and also to find the influence of mortar mix, initial condition of blocks, type of blocks used and wall thickness on movement in block masonry. Sixteen blockwork panels were constructed to study the selected test parameters on movement in block masonry. The movement was monitored for a period of one year, using dial gauges which were permanently fixed to each panel. From the results, it is found that the movement in block masonry is influenced by the initial moisture condition of the blocks. A significant influence of mortar mix and thickness of wall on movement is not seen from the experimental results. It was observed that the movements reached the maximum values within 8 ~ 9 months after construction of blockwork panels. It is found that the highest shrinkage strain of 0.02% is recorded in the masonry panel constructed with saturated solid blocks and 1: 6 mortar mix.

**Keywords:** Blockwork, movement, cracking, shrinkage strain

## 1. Introduction

### 1.1 General

Movement in buildings is one of the main concerns in the construction of modern high-rise buildings. However, in general building construction in Sri Lanka, very little attention is paid in this area due to lack of knowledge. Movements can be caused by many sources [Lenczner, (1981), Alexander and Lawson, (1981), Rainger, (1983), BS5628, Part 3, (1985)]. The main sources of movements are: applied loads on the building, changes in temperature, changes in the moisture content in the material, creep deformations in certain materials, chemical changes in the material, settlement of foundations and dynamic movements. Movements in buildings cause cracking in structural elements which greatly spoils the aesthetic appearance of the building. It is very difficult to permanently repair such cracks, and hence needs regular repairing which increases maintenance cost of the building. The main reasons reported for such movements in buildings are: the use of higher working stresses and slender elements with large spans leads to large movements, combining brickwork and blockwork in construction resulting in differential movements, taller buildings with slender elements cause greater movements, skeletal frame and infill walls cause incompatible movements, thinner sections with lower thermal capacities lead to higher temperature gradients and as large masonry units leads to greater movements at joints as the number of joints are less. Due to these reasons, special care should be taken at design stage to accommodate such movements to avoid displeasing cracks in buildings. This investigation is carried out to determine the movements in block masonry walls, which is needed for the development of specification of movement joints for local block masonry.

### 1.2 Objectives

The main objectives of this experimental study are:

(i) to evaluate the extent of movement in block masonry; and

(ii) to investigate the influence of mortar mix, initial moisture condition of blocks used, wall thickness and type of blocks used on the extent of movement in block masonry walls.

## 2. Experimental study

### 2.1 General

Recognition of the extent of movement in block masonry and the factors affecting the movement of masonry is of importance since it is essential in designing movement joints in masonry structures. Therefore, this experimental study was carried out to investigate the behaviour of block masonry panels.

### 2.2 Measurement of Movement

Even though it is possible to use available sophisticated techniques to monitor movements in masonry panels very accurately, due to some practical difficulties like high cost and non-availability of facilities to provide uninterrupted power supply over a long period of time, a simple, accurate and less expensive method reported [Nanayakkara, (2011)] was adopted to monitor movements in all block masonry panels. In this method, movements were monitored by using dial gauges which were mounted on masonry panels using steel angles and stainless steel rod. (See Figure 1).

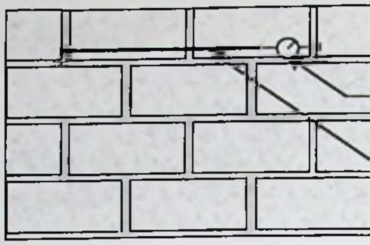


**Figure 1:** Arrangement used for Monitoring Movements is Masonry Panels

### 2.3 Main Parameters of the Test Series

Sixteen blockwork panels consisting of two identical panels for each category were constructed to investigate the influence of the test parameters on movements in block masonry. Table 1 summarises the test parameters and similarities in this test series. The four test parameters: the type of block (hollow and solid blocks), mortar mix (1cement: 6 sand and 1 cement : 8 sand), thickness of wall panel (100 mm, 150 mm, and 200 mm) and the moisture condition of blocks at construction (i.e. "Dry"- blocks dried to constant mass in a oven at 100°C, "Soaked"- blocks soaked in water for 30 minutes, and "Normal"- blocks stored in the laboratory for about four weeks were considered in this study. (It should be noted that 150 mm thick hollow blocks were purchased from a different manufacturer.)

### 2.4 Details of measurement

As described in Section 2.2, movements of blockwork panels were recorded using dial gauges. Initial measurements were taken just after construction and for the first few weeks, readings were taken at frequent intervals. After about two weeks, when the reading was relatively stabilized, readings were taken weekly. Temperature was also recorded in conjunction with the readings of panels, to make the correction for the change in length of the steel rod due to temperature variation.

**Table 1:** Details of the Panels

| Panel Number | Type of Unit | Mortar Mix | Initial Moisture Condition of Unit | Thickness of Panel (mm) |
|---|---|---|---|---|
| 1 | Hollow | 1 : 6 | Normal | 100 |
| 2 | | 1 : 8 | Normal | |
| 3 * | | 1 : 6 | Normal | 150 |
| 4 | | 1 : 6 | Normal | 200 |
| 5 | Solid | 1 : 6 | Normal | 100 |
| 6 | | 1 : 6 | Saturated | |
| 7 | | 1 : 6 | Dry | |
| 8 | | 1 : 8 | Normal | |
| * Blocks from a different manufacturer | | | | |

## 3. Results

From the dial gauge readings recorded, the horizontal strains were calculated for each blockwork panel. Figure 2 to 7 show the variation of shrinkage strains with time for different test parameters. Shrinkage strains are considered as positive in all figures.

From the results of these panels, the following general observations can be made.

- Panels constructed with nearly saturated blocks showed higher shrinkage than panels constructed with dry blocks (See Figure 2). The maximum shrinkage strain recorded was 0.02% in panels with saturated blocks and 0.01% in panels with dry blocks.

- There is no clear indication of any significant influence of mortar mix on movements in block masonry panels (Figures 3 - 4.)

- From Figure 5 it can be seen that the initial rate of drying is higher in thin walls than the 200 mm thick wall. The 150 mm thick wall showed a higher shrinkage strain than 100 mm and 200 mm thick walls. This unexpected result could be due to the influence of difference in the mix proportions used in manufacturing blocks as 150 mm blocks were purchased from a different manufacturer. When comparing 100 mm and 200 mm thick wall panels, there is no clear influence of the thickness of wall on maximum shrinkage strain.

- There is no significant influence of the type of blocks (hollow/solid) used on the movements in block masonry panels (See Figures 6 and 7).

- From the results, it can be seen that all blockwork panels start to shrink just after construction. The maximum shrinkage strains are reached about 8 to 9 months after construction of masonry panels.

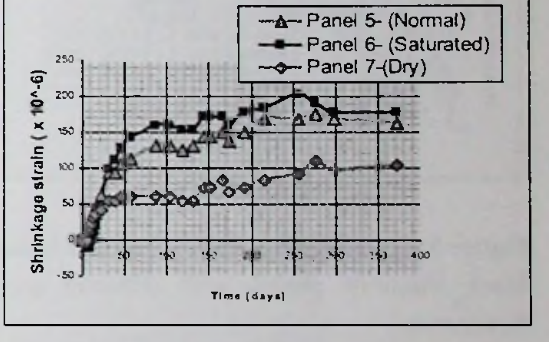


**Figure 2:** Shrinkage Strain Vs. Time for solid block masonry panels constructed with blocks having different initial moisture conditions.

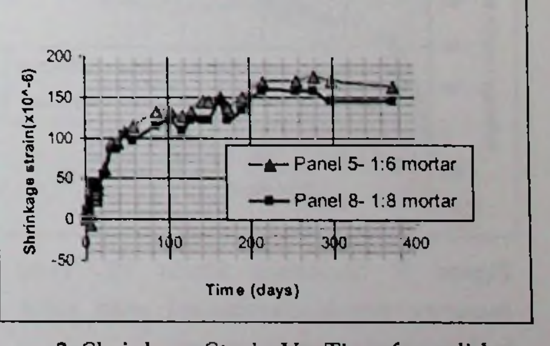


**Figure 3:** Shrinkage Strain Vs. Time for solid block masonry panels with different mortar mixes.

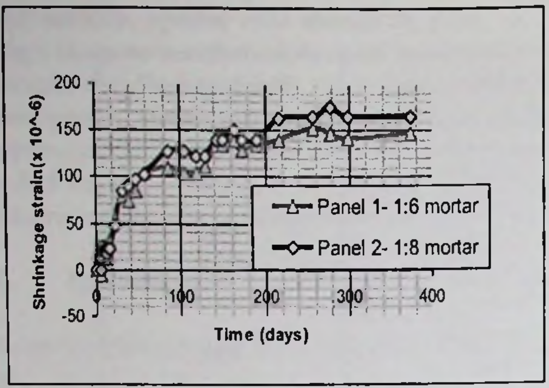


**Figure 4**: Shrinkage Strain Vs. Time for hollow block masonry panels with different mortar mixes.

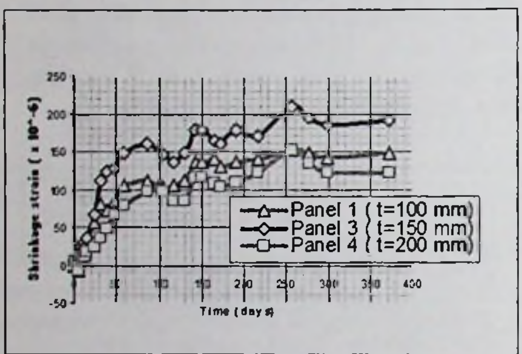


**Figure 5**: Shrinkage Strain Vs. Time for hollow block masonry panels with different panel thicknesses.

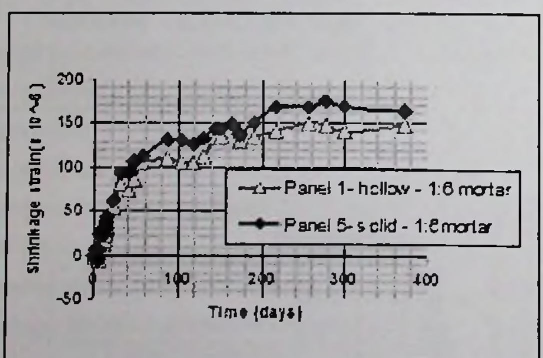


**Figure 6**: Shrinkage Strain Vs. Time for masonry panels constructed with solid and hollow blocks with 1:6 mortar.

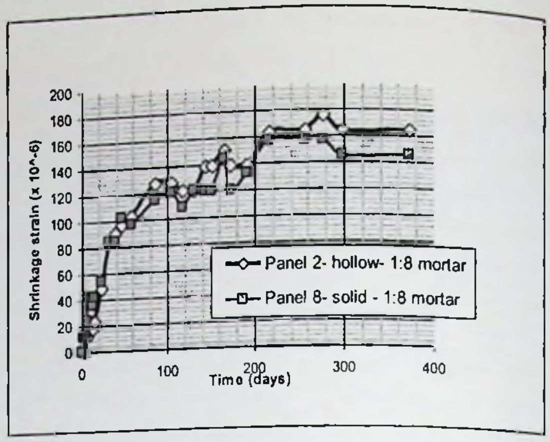


**Figure 7**: Shrinkage Strain Vs. Time for masonry panels constructed with solid and hollow blocks with 1:8 mortar.

## 4. Conclusions

- Movements in 16 block masonry panels were monitored over a long period of time till movements are stabilized.
- All block masonry panels shrink continuously, after construction.
- It is found that movements reached the maximum value within 8 - 9 months after the construction of block masonry panels.
- The highest shrinkage strain reported is 0.02% in the masonry panel constructed with saturated solid blocks and 1 : 6 mortar mix and the lowest shrinkage strain is 0.01% in the panel constructed with dry solid blocks and 1 : 6 mortar mix in this series of tests.
- Initial moisture condition of blocks at the time of construction has a greater influence on movement in block masonry.
- To minimize movements in block masonry, it can be recommended to avoid the use of saturated blocks or blocks with very high moisture content.

There is no significant influence of mortar mix, block type and the panel thickness on maximum movements in block masonry panels. However Panel No. 3 constructed with 150mm thick-normal hollow blocks and 1:6 mortar mix showed a very high shrinkage strain (0.02%). This unexpected result could be due to the influence of difference in the mix proportions used in manufacturing blocks as 150mm blocks were purchased from a different manufacturer.

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