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PRESTRESS LOSS OF POST-TENSIONED CLAY DIAPHRAGM AND FIN BRICKWORK

by

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ABSTRACT

Unlike calcium silicate and concrete block masonry which undergo shrinkage with time, clay brickwork has been known to expand instead. Expansion of brick units in prestressed masonry will cause an increase in the prestressing force instead of prestress loss. However, not all clay brickwork expand with time; higher strength clay units tend to undergo shrinkage with time. The main objective of this paper is to present experimental data obtained for prestress loss in post-tensioned high strength clay diaphragm and fin brickwork. The main objective of this paper is to present experimental data obtained for prestress loss in post-tensioned high strength clay diaphragm and fin brickwork. The brickwork were built from class B clay engineering brick with compressive strength of 103 MPa with designation (ii) mortar. The tests which involve monitoring prestress loss, creep and shrinkage of clay sections were carried out over a period of 120 days. Using the 120-day experimental data, the predicted long-term prestress loss is 20%.

INTRODUCTION

Even though extensive research on prestress loss of prrestressed concrete has been carried out but the same cannot be said about prestressed brickwork. Several researchers1,2,3 agreed that detailed study on prestress losses should be carried out on masonry to gain confidence amongst practicing engineers that masonry is as good as other structural materials.

In practice, long-term loss in prestressed masonry are minimised by restressing the bars either immediately or a few days later after initial prestressing and as such there is little information on loss. For design guidance, informations on such loss are really required. The mechanism of time-dependent loss caused by long term deformations of brickwork is very complicated because of the interdependent factors such as relaxation of prestressing bars, creep and shrinkage of masonry.

BS5628[4] suggested that prestress loss of masonry can be predicted by applying the ultimate values of creep and shrinkage of brickwork. The standard made no distinction on the possible influence of many factors such as the types of mortar, geometry of the brickwork wall and age at loading. Lenczner studied creep in diaphragm and fin walls constructed from Fletton brick with a 1:1/4:3 mortar. The diaphragm and fin walls were represented by I-section and solid piers, respectively. The tests were carried out in a controlled laboratory maintained at 20°C and 50% relative humidity. The walls were 2 m high and under a constant stress level of 2.01 N/mm^2. After 453 days I-section walls reached a maximum creep of 44 x 10^{-6} and showing down there after. Based on the experimental values, the creep coefficient for I-section wall is 2.08. The fin wall reached a creep of 208 x 10^{-6} after 453 days and creep of 0.96. Both I-section and fin pier walls expanded to about 125 x 10^{-6} and 146 x 10^{-6}, respectively.

EXPERIMENTAL DETAILS

The cross-sections of fin and diaphragm used in this study are shown in Figure 1. The post-tensioning system adopted in this research was high level stressing with 25 mm and 26.5 mm diameter of high yield MaCalloy bars. The height of the brickwork for both walls was approximately 2 m.

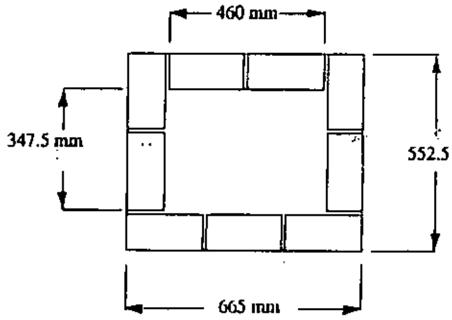

Figure 1.a : Top view of clay diaphragm wall

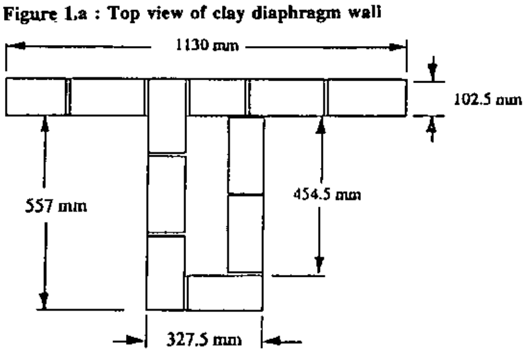

Figure 1.b : Top view of clay fin wall

The walls were built from Class B Engineering clay units with a grade (ii) mortar i.e cement:lime:sand in the mass proportion of 1:1/2:41/2. The average compressive strengths of the clay bricks and mortar cubes were 103 MPa and 11.8 MPa, respectively.

Three walls were constructed for each geometry to measure the prestress loss, creep and shrinkage separately. The walls were constructed on reinforced concrete bases with prestressing bars locked to the pocket located at the bottom of the bases. The bars were stressed up and locked to the end plates on top of the bases after which twenty-six course masonry walls were built around the bars. The walls were cured under polythene sheets for 7 days before the top of the brickwork was bedded, levelled with mortar and capped with reinforced concrete capping beam.
The bars were jacked to the required working stress, i.e 3 MPa, and locked using a nut system on the end of spreader plated on top of the capping beam 21 days after construction. The prestress loss on the bars was measured using loadcells at the anchorage point of the capping beam. The strain on the prestressing bars was measured using two sets of full bridges for high sensitivity and for compensation of temperature changes.

One of the walls in each geometry was constructed in similar manner as in the other walls but without the prestressing bar for moisture movement measurements. The strains on the brickwork walls were measure using 750mm Demec gauge. In addition to mortar control cubes. mortar prisms were cast for the measurement of creep and shrinkage, and samples of each unit type were also monitored for deformation. The main results of these tests will be reported in a future paper.

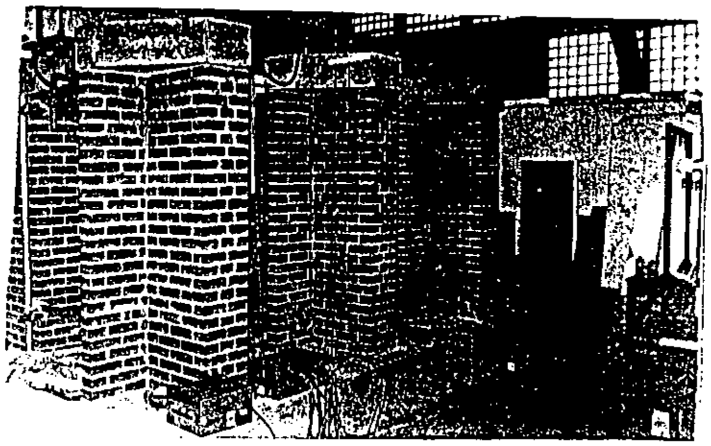

Figure 2 : Diaphragm and fin clay section under test

ANALYSIS AND DISCUSSION OF RESULTS

Figure 3 shows the measured prestress loss in the diaphragm and fin walls over a period of 120 days. The diaphragm sections have a lower prestress loss than the fin sections. In fin sections the loss is rapid initially but slows down, as in the diaphragm, after 80 days. The higher prestress loss in sections compared to the diaphragm sections is mainly due to the geometric effect on drying. Similar pattern was observed in the creep and shrinkage of the sections. Previously, it was shown that creep and shrinkage of masonry increase as the section decreases or as the volume/surface area ratio decreases (Brooks 1990). The creep of the sections was determined from the measured strain of the constant load sections, minus the initial elastic strain and shrinkage as given by the non-loaded walls.

The ultimate values of the creep and shrinkage of these sections were determined based on the short values by using the Ross (1937) hyperbolic equation:

$$c = \frac{t}{(a + bt)}$$

where = creep or shrinkage (10-6),
t = time under load (days),
a = constant
b = constant = 1/Cu,
and Cu = ultimate creep or shrinkage

The ultimate prestress loss were determined from the ultimate creep and shrinkage obtained from the regression analysis. Table 1 shows the ultimate prestress loss, creep and shrinkage of the clay sections. Based on a relaxation tests carried out on the 25 mm and 26.5 mm bars, relaxation of the prestressing bars, relaxation of the prestressing bars only contributes up to 4%. Thus it is safe to assume that long-term loss of prestress in post-tensioned class B clay Engineering bricks is 20% at the most. This value is actually quite conservative because on site the stress in post-tensioned sections reduces with time and thus creep is under reducing load. This would mean that prestress loss due to combine effect of creep, shrinkage and relaxation is less than 20%.

CONCLUSION

Based on the 120-day experimental data, the predicted long-term prestress loss of class B clay Engineering due to creep, shrinkage and relaxation is 20% at most. From the experimental observations, prestress loss, creep and shrinkage of clay brickwork is affected by geometry of the sections: diaphragm sections deform less than the fin sections.

REFERENCES

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Table 1 : Maximum and minimum prestress loss due to creep and shrinkage in diaphragm and fin walls

Geometry	Loss due to Creep (%)		Loss due to Moisture Mvt (%)		Total Loss due to Creep and Moisture Mvt (%)	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Diaphragm	8.6	9.9	4.3	5.4	12.9	15.3
Fin	8.2	10.4	5.8	7.2	14.0	17.6

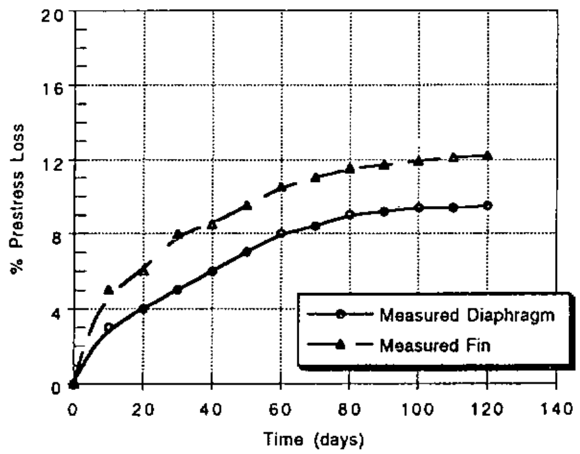

Figure 3 : Prestress loss-time curve of diaphragm and fin sections

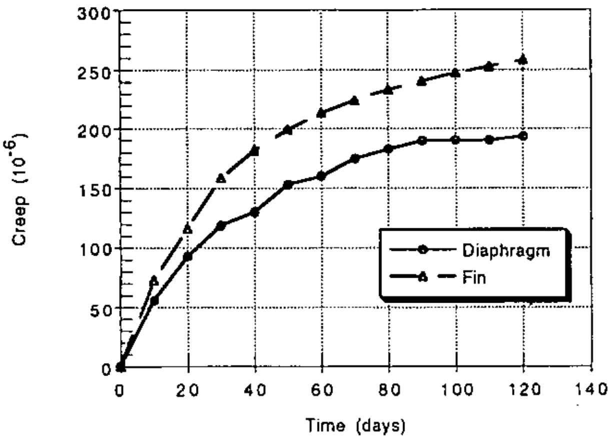

Figure 4 : Creep-time curve of diaphragm and fin sections

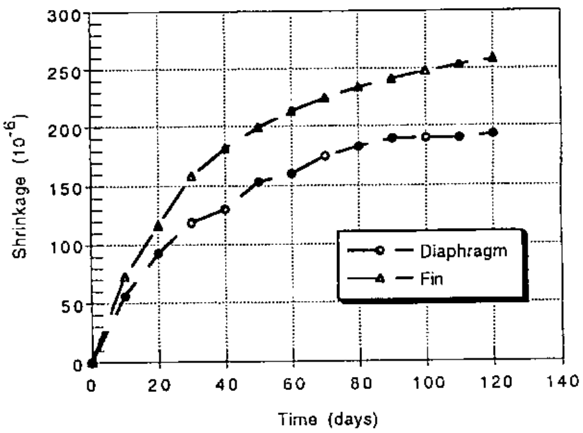

Figure 5 : Shrinkage-time curve of diaphragm and fin sections