INVESTIGATION ON THE SUITABILITY OF PAPER PULP IN THE PRODUCTION OF LIGHTWEIGHT, NON-LOAD-BEARING CEMENT BLOCKS

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INTRODUCTION

Cement blocks are widely used currently in the construction of walls. The main ingredients used in the production of conventional cement blocks are Ordinary Portland Cement (OPC) and fine aggregate in the form of M-sand (graded quarry dust). If these cement blocks can be made lighter while maintaining the required engineering properties, it would reduce the dead load applied to the structures resulting in a reduction in the size of the structural components which is cost-effective. Moreover, lightweight cement blocks make handling and transport much easier.

This research study was conducted to explore the feasibility of producing a lightweight cement block by partially replacing fine aggregate with paper pulp obtained from wastepaper which is abundant and cheap. An additional advantage of using paper pulp is its outstanding heat insulation and soundproofing properties. The use of paper pulp in cement block manufacture reduces the amount of paper that ends up in landfills, making it a sustainable technique.

Sri Lanka Standards Institution has published standards applicable to the requirements and test methods for cement blocks (SLS 855: Parts 1 & 2, 1989). This research study explores the effects of using different percentages of paper pulp in cement blocks to achieve the optimal mix proportions in cement blocks.

Rame-gowda and Prasanna (2014) investigated the mechanical properties of papercrete cubes made with various proportions of cement, sand, paper, and fly ash. They claimed that papercrete can easily be moulded into any desired shape, is lightweight when compared to conventional concrete, and has an excellent surface finish.

Yun et al. (2007) investigated the mechanical properties of papercrete by taking various samples and conducting experiments on them. According to them, when the replacement ratio of waste paper in papercrete is increased, the density of the papercrete decreases. By including a higher replacement ratio of waste paper, the splitting tensile strength was also reduced.

METHODOLOGY

Manufacturers of typical cement blocks use cement: sand ratio up to 1: 14 and there is a doubt about satisfying the compressive strength requirement specified in SLS 855. Due to the expected reduction in compressive strength when paper pulp is added, a few preliminary studies were carried out to determine the optimum cement: sand ratio, the optimum water: cement ratio, and the appropriate paper pulp replacement range. Based on the outcome of these preliminary studies it was concluded that the paper pulp replacement should be done within the range of 28% and 34% of fine aggregate, with an optimum cement: sand ratio of 1: 8 and water: cement ratio of 0.7. After removing any hard objects present waste paper was torn into small pieces and soaked for five days. Soaked paper pieces were mechanically blended till they were transformed into pulp. The pulp was then squeezed to drain the water and kept under direct sunlight for 3 to 5 days for complete drying. The dried pulp was then broken into small pieces and were used for sample preparation. Table 1 shows the composition of materials used in this study. The paper pulp percentage indicated in Table 1 is

the percentage of M-sand replaced by paper pulp. The blocks, 305 x 152 x 102mm in size, were cast in a block yard that manufactures cement blocks for commercial purposes.

Table 1 – Designation of test specimens

Mix no.	Cement : Sand	Paper pulp %	Water : Cement
Control Mix	1:8	0	0.7
1		28	
2		30	
3		32	
4		34	

Figure 1 – Block making machine

RESULTS AND DISCUSSION

Compressive Strength Test

The blocks were tested for compressive strength according to SLS 855: Part 2: 1989. Individual blocks were cured for 3 and 7 days, respectively, before being taken for testing. The compressive strength was tested with a compressive strength testing machine. According to SLS 855 Part 1 (1989), the minimum strength of a non-loadbearing cement block should be 1.2 N/mm^2. However, it does not specify an exact curing period. Figure 2 shows the compressive strength test results of samples obtained after 3 and 7 days.

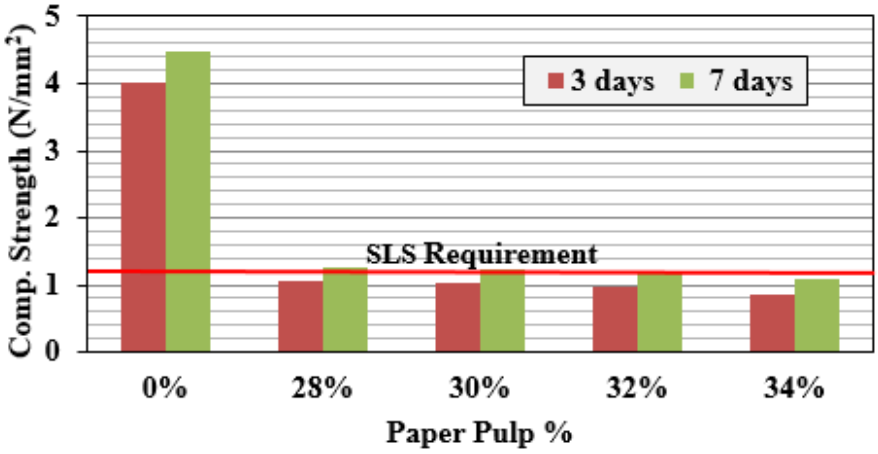

Figure 2: Compressive strength test results

Water Absorption and Moisture Content

Water absorption and moisture content tests were carried out conforming to the SLS 855: Part 2: 1989. The upper limit recommended in SLS 855: Part 1 for moisture content of cement blocks is 40%. Variation of moisture content with paper pulp percentage is shown in Figure 3 and it is evident that all the values lie below the 40% upper limit.

Water absorption test results are plotted in Figure 4. The peak value of water absorption, 227.6 kg/m^3, was observed for 34% paper pulp percentage and lies below the SLS 855 recommended maximum acceptable limit of 240 kg/m^3.

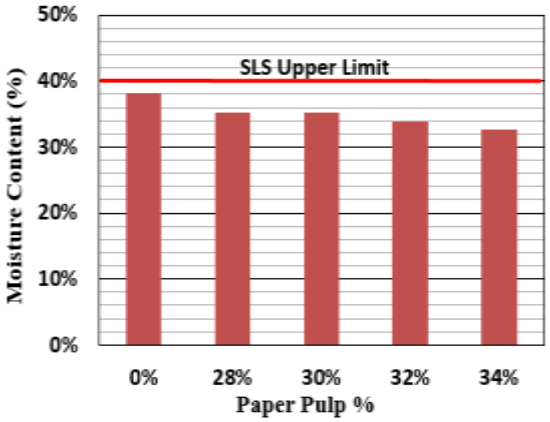

Figure 3: Moisture content test results

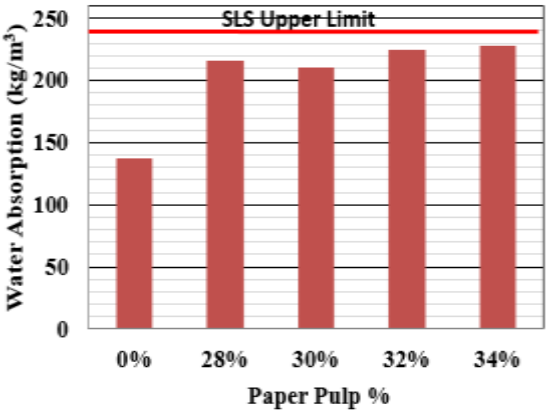

Figure 4: Water absorption test results

Block Density

Wet and dry densities of cement blocks were tested by obtaining the wet and dry masses of cement blocks selected from each set of blocks cast from each mix. The test was conducted according to SLS 855 PART 2 (1989). Figure 5 shows the graphical representation of the wet density and dry density test results. The results of block density values fall between the maximum value of 2800 kg/m^3 and the minimum value of 1000 kg/m^3 respectively as recommended in SLS 855 PART 2:1989.

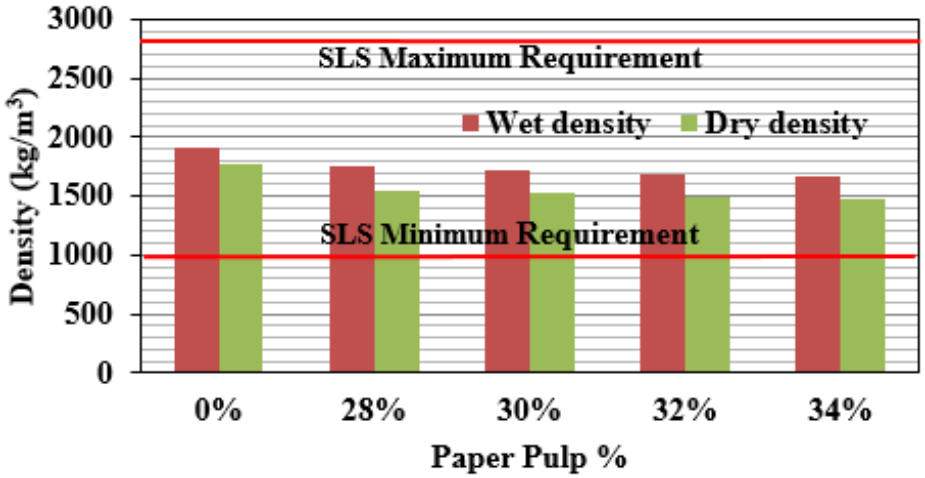

Figure 5: Wet density and dry density test results

CONCLUSIONS/RECOMMENDATIONS

The primary aim of this research was to produce a lightweight cement block satisfying all the requirements specified in SLS 855: 1989 applicable to cement blocks partially replacing fine aggregate utilizing paper pulp obtained from waste paper. Results of the compressive strength, moisture content, water absorption, and block density tests, recommended in SLS 855 for cement blocks, indicated that cement blocks made with 30% replacement of fine aggregate with paper pulp have achieved this after 7 days of curing. 30% replacement can be considered as the optimum percentage replacement since any further increase in the amount

of pulp fails to achieve the required compressive strength of blocks, 1.2 N/mm^2, recommended for non-load bearing walls.

SLS 855: 1989 does not specify any curing period to achieve the specified compressive strength. It only says that this strength needs to be achieved the day blocks are taken out of the casting yard. Since the compressive strength results of cement blocks tested after three days of curing failed to achieve this, it is a requirement to cure cement blocks for seven days in the casting yard.

It also gives around a 14% reduction in dry density and a 10% reduction in wet density when compared to the control block. This reduction in self-weight leads to substantial savings in the construction cost of structural elements. Further, even without any test results from this study, it can be concluded that savings are possible in energy costs due to the expected heat insulation property of added paper pulp.

The durability aspect of these blocks could not be studied since there is no such test recommended in SLS 855 due to the fact that conventional blocks are made with cement and aggregates and have no durability issues. However, it is advisable to conduct a suitable test to study the durability.

REFERENCES

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