DEVELOPMENT OF MODIFIED CONCRETE INTERLOCKING BLOCKS FOR PAVEMENT CONSTRUCTION IN SRI LANKA.

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INTRODUCTION

Concrete interlocking block (CIB) pavements were introduced to Sri Lanka in late 2000 and the use of CIB has increased remarkably after that. The construction pattern in concrete interlocking block pavement is an important factor, as maintenance cost can be controlled by the counteraction pattern. The herringbone laying pattern is the most effective arrangement for the carrying traffic (Soutsos, 2011)**.** For herringbone laying pattern, the direction of the traffic relative to the alignment of the pattern has little effect on pavement performance (Korean Industrial Standards Committee, 1995, Gonzalo,1990)

Though concrete interlocking blocks provide many advantages both during the construction and during the functional stage it has been noticed that some of interlocking blocks get damaged due to poor tensile capacity (Karunarathna, 2012). This is one of the major disadvantages of the interlocking block pavements. This problem can be avoided by upgrading the tensile strength of the blocks. The improvement of the tensile strength can be carried out in many ways (Neville, 1999, Shetty, 2010). One simplest approach is improving the compressive strength and the other approach is by the addition of steel fiber types material to the concrete mix. In this study, we try to upgrade the tensile property of concrete interlocking blocks by altering the traditional mix with steel fiber type materials.

METHODOLOGY

PRODUCTION OF MODIFIED INTERLOCKING BLOCKS

Our work can be divided into two parts. The first part was aimed at the determination of the effects of modified mixtures, with less cement content (Non-reinforced interlocking blocks). The second part was aimed to evaluate the influence of binding wires on the properties of the CIBs. The mixture is selected here with randomly oriented small binding wires.

i. Non-reinforced interlocking blocks

Two different cement contents 300 kg/m^3 and 350 kg/m^3 were selected based on the practices in the other countries (Gencel, 2012, Uygunoglu2012). The rest of the material was determined using the standard mix design method. These mixtures are named *A* and *B*. The Water cement ratio (W/C) of each mix was changed approximately from 0.34 to 0.6 for the study of compressive strength and tensile strengths. Mix proportions are summarized in Table 1.

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Table 1 – Mix proportion for mix A and mix B with water cement ratios

W/C	Material							
	Mix A				Mix B			
	OPC (kg/m^3)	Water content (kg/m^3)	Fine aggregate (kg/m^3)	Coarse aggregate (kg/m^3)	OPC (kg/m^3)	Water content (kg/m^3	Fine aggregate (kg/m^3	Coarse aggregate (kg/m^3)
0.34	300	102	1224.40	1249.13				
0.35					350	122.50	971.06	1002.84
0.38	300	114	1022.00	1022.00				
0.40					350	140.00	976.37	957.03
0.42	300	126	1026.12	985.88				
0.425					350	148.75	977.10	938.76
0.45	300	135	1028.63	968.72	350	157.50	976.00	919.13
0.475					350	166.25	975.00	900.07
0.50	300	150	1014.23	917.64	350	175.00	974.85	882.02
0.55					350	192.50	975.07	840.71
0.60					350	210.00	975.33	801.26

*OPC-Ordinary Portland Cement

ii. Reinforced interlocking concrete blocks

Reinforced interlocking concrete blocks were produced by using small binding wires in random orientation (mix D). In preparing these samples the small binding wire pieces were mixed with the normal concrete mix in the mould. The samples were cured for 7 days as in the sites.

The comparison of mix D against steel fiber reinforced concrete and the mix proportion of mix D are tabulated in Table 2.The properties of steel fiber reinforced concrete was obtained from Xu, 2009.

Table 2 - Comparison of Database information of the mechanical properties for Steel fiber reinforced concrete and reinforced mixes

	Steel Fiber Reinforced Concrete	Mix D
W/C Ratio	0.25-0.50	0.50
Fraction %	0.50-1.50	0.40
Aspect Ratio	50-80	50
Cement Content (Kg/m3)	320 (minimum)	350
Sand Content (Kg/m3)	750-850 (reasonable)	974.85
Aggregate Size (mm)	19 (maximum)	≤ 10

RESULTS AND DISCUSSION

Figure 1 presents the variation of compressive strength against the water cement ratio for mix A and B. The results of mix A show that the optimum W/C ratio has not been achieved as the strength is still increasing against the W/C ratio. In the mix B, it can be observed from our results that the compressive strength increases up to W/C ratio 0.5. Therefore the optimum W/C ratio can be determined as 0.5. The relationship between the W/C and strength is well established (Neville, 1999, Shetty, 2010). We believe that the strength gain is due the difference in W/C.

We prepare samples with binding wires with the optimum water cement ratio of 0.50. Comparisons of compressive strength of different mixtures are presented in Figure 2a. All mixtures show higher strength development.

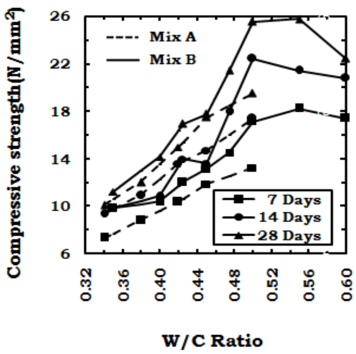

Fig.1-Variation of Avg compressive strength for Mix A and B.

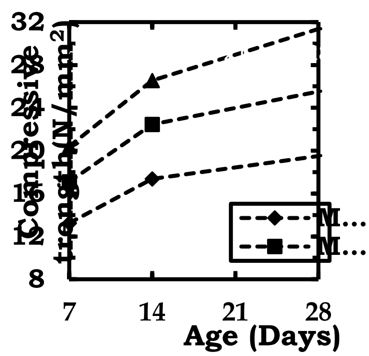

Fig.2a-Comparison of compressive of different mixtures

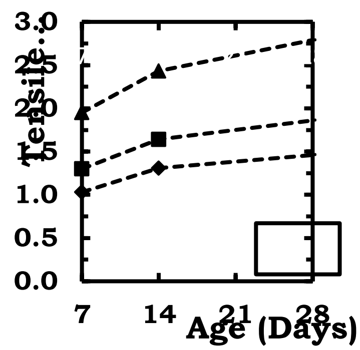

Fig.2b. Comparison of tensile strengths of different mixtures

However the arbitrary oriented binding wires sample has significantly improved the compressive strength. This is probably due to the control of micro cracks that are taking place inside the samples during the compression test. Several numerical softwares are available today to produce such micro cracks using synthetic material in numerical simulation (Potyondy, 2009). It can be reasonably assumed that these small binding wires control the growth of micro cracks during the experiment. When small pieces of binding wires are randomly placed in the mix, the growth of micro cracks are controlled by bonded binding wires. Hence significant improvement of strength can be observed.

The tensile strength of mix A and B can be determined directly from the SANS 1058:2009 (Cairns, 2009) as they are unreinforced. Analysis of the material quantities of mix D shows that it can be considered as a polymer concrete. Therefore the resutls provided by (Xu, 2009)are exploited in the present study to determine the tensile stength of mix D. The tensile stength of different mixtures are given in Figure 2b. Samples of mix D show higher tensile strength gain. This agrees with the improvement of compressive strength in different mixtures.

Although, one might think that this mix with binding wires is more expensive than that of the traditional mixtures, it can be explicitly illustrated that the modified mixtures are in fact cheaper than the traditional mixtures (Karunarathna, 2012). Use of the modified mix provides 4% cost saving for 1000 bricks even if we use higher labour cost for the modified blocks. Cost values were determined based on the market values of the material cost in 2011, February. This may vary according the present values**.**

CONCLUSIONS

We have modified the existing mix proportions used for the production of concrete interlocking blocks. Binding wires are used to upgrade tensile strength of the interlocking concrete blocks.

The compressive strength of each mix was determined at 7, 14 and 28 days. The tensile strength of non reinforced mix was determined by incorporating Cairns approach (Cairns, 2009) where as the tensile strength of reinforced mixtures was determined using tensile strength of polymer concrete. The resulting values show greater improvement in the tensile strength. Our methodology therefore offers a promising and simple approach to enhance the tensile strength of concrete interlocking blocks. The increment of tensile strength in the modified CIBs is about 50%. Use of the modified mix provides 4% cost saving for 1000 bricks of modified blocks

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