COST EFFECTIVE DESIGN OF CONCRETE PAVEMENT USING USED FOUNDRY SAND

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ABSTRACT
Concrete is the most undisputable material being used in infrastructure development throughout the world. The reduction in the cost of concrete production has resulted in the increased need to find new alternative materials. The aim of the study is to minimize the cost of concrete pavement. The alternative material, Used Foundry Sand which is generated by metal casting industry is partially replaced by natural sand. The fine aggregate has been replaced by used foundry sand accordingly in the range of 10%, 20%, 30%, 40% & 50% by weight for M-20 grade concrete. Compressive and flexural strength tests are conducted for 7, 14, 28 days curing period, and compared with the conventional concrete. Maximum compressive and flexural strength are found for 20% replacement of used foundry sand (FA_2) with respect to the conventional concrete (A_0). The pavement slab thickness and construction cost reduced to 6 cm and 22% respectively in case of concrete FA_2.

Keywords: Pavement; used foundry sand; compressive and flexural Strength; cost effective

INTRODUCTION

The maintenance cost of flexible pavement is more than concrete pavement but it is more stable, durable than flexible pavement. Sand is a major material used for preparation of concrete and plays an important role in mix design. In general consumption of natural sand is high, due to the large use of concrete and mortar. Hence the demand of natural sand is very high in developing countries to satisfy the rapid infrastructure growth. The developing country like Bangladesh facing shortage of good quality natural sand and particularly in Bangladesh, natural sand deposits are being used up and causing serious threat to environment as well as the society. Rapid extraction of sand from river bed causing so many problems like losing water retaining soil strata, deepening of the river beds and causing bank slides, loss of vegetation on the bank of rivers, disturbs the aquatic life as well as disturbs agriculture due to lowering the water table in the well etc. are some of the examples. For the reduction in the sources of natural sand and in the cost of concrete production has resulted in the increased need to find new alternative materials to replace river sand, so that excess river erosion is prevented and high strength concrete is obtained at lower cost. Used foundry sand can be the good replacement of river sand.

Metal foundries use large amounts of sand in the metal casting process. Foundries successfully recycle and reuse the sand many times in a foundry and the remaining sand that is termed as foundry sand is removed from foundry. To reduce disposal and pollution problems emanating from these industrial wastes, it is most essential to develop profitable building materials from them and use of foundry sand in various engineering applications can solve the problem of disposal of foundry sand and other purposes. This study presents the information about the civil engineering applications of foundry sand which is technically sound, cost effective and is environmentally safe. Foundry sand consists primarily of silica sand, coated with a thin film of burnt carbon, residual binder and dust. Foundry sand can be used in concrete to improve its strength and other durability factors. Foundry sand can be used as a partial replacement of fine aggregates to achieve characteristic properties of concrete.

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METHODOLOGY

Foundry sand

Metal foundries use large amounts of sand in the metal casting process. Foundries successfully recycle and reuse the sand many times in a foundry and the remaining sand that is termed as foundry sand is removed from foundry. Foundry sand consists primarily of silica sand, coated with a thin film of burnt carbon, residual binder and dust. Foundry sand can be used in concrete to improve its strength and other durability factors. Foundry Sand can be used as a partial replacement of fine aggregates to achieve characteristic properties of concrete. The Physical appearance of used foundry sand and chemical compositions of used foundry sand is represented in Fig. 1 and Table 1 respectively.

Fig. 1: Physical appearance of used foundry sand

Table 1: Chemical compositions of used foundry sand

Constituents	Value (%)
SiO_2	87.91
Al_2O_3	4.70
Fe_2O_3	0.94
Cao	0.14
MgO	0.30
SO_3	0.09
Na_2O_3	0.19
K_2O	0.25
TiO_2	0.15
SrO	0.03
LOI	5.15

Design Mix

A mix of M-20 grade is designed as per IS: 10262-1982 and the same is used to prepare the test samples. The design mix proportion is 1:1.50:3.20 and w/c ratio is 0.50. The evaluation of Used Foundry Sand to use as a replacement of fine aggregate begins with the concrete testing. The fine aggregate has been replaced by Used Foundry Sand accordingly in the range of 10% (FA_1), 20% (FA_2), 30% (FA_3), 40% (FA_4) & 50% (FA_5) by weight for M-20 grade concrete. The (6 in × 6 in × 6 in) cube for compressive strength test and (4 in × 4 in × 20 in) beam for flexural strength test are made, tested and compared in terms of compressive and flexural strength with the conventional concrete. Samples are tested after 7, 14 and 28 days for compressive strength and 28 days for flexural strength tests.

Compressive Strength and Flexural Strength

Compressive strength tests are performed on compression testing machine using cube samples. Three samples per batch are tested with the average strength values reported in this paper. The loading rate on the cube is 35 N/mm^2 per min. The comparative studies are made on their characteristics for concrete mix with partial replacement of fine aggregate by used foundry sand as 10%, 20%, 30%, 40% and 50% respectively.

The flexural strength is determined by the central point method. Standard metallic beam molds (4 in × 4 in × 20 in) are cast for the preparation of concrete specimens for flexural strength. A table vibrator is used for compaction of hand filled concrete beams. The specimens are de molded after 24 hours and subsequently immersed in water for different age of testing. For each age three specimens are used for the determination of average flexural strength. The test is performed on Universal Testing Machine (UTM) having capacity of 50 BT.

The variation of compressive strength and flexural strength at 28 days curing period is represented in Fig. 2 and Fig. 3.

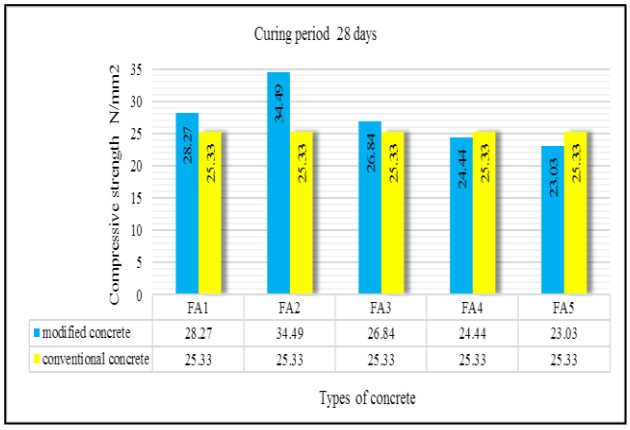


Fig. 2: Compressive strength at 28 days curing period

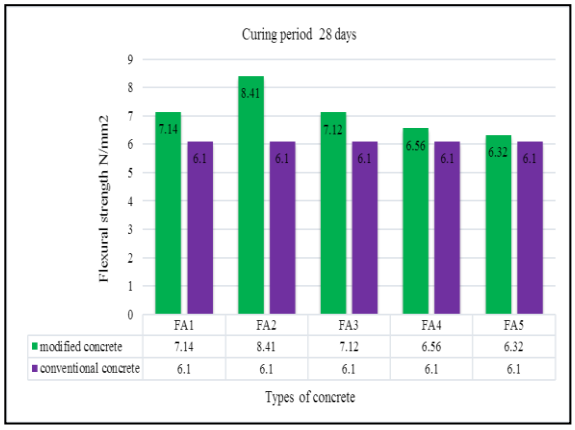
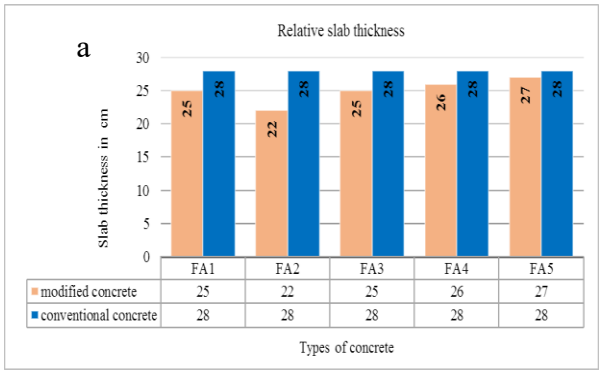


Fig. 3: Flexural strength at 28 days curing period

RESULTS AND DISCUSSIONS

Economic feasibility

A cement concrete pavement has been designed for a four-lane two-way National Highway in Rajshahi city from Talaimari MOR to Kalpona Cinema Hall. The total two-way traffic is 4500 commercial vehicles per day at the end of the construction period. (Source: Rajshahi City Corporation). The relative thickness and cost for different types of concrete modified by Used Foundry Sand is represented in Fig. 4 (a & b).



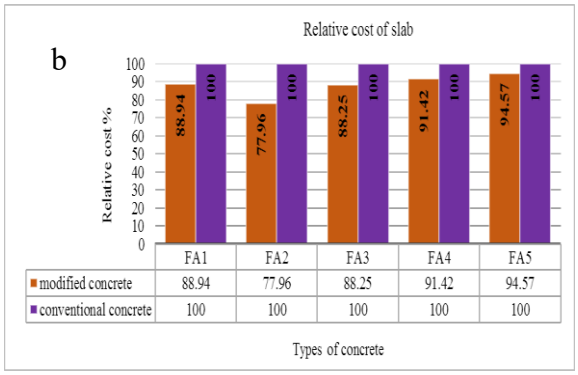


Fig. 4: The relative slab thickness (a) and relative cost of slab (b) for different types of concrete

CONCLUSIONS

After conducting compressive and flexural strength test of specimen made by partially replacing the river sand with Used Foundry Sand for different percentages, then a concrete pavement has been designed. The thickness of pavement slab is reduced and the relative cost of pavement construction is reduced almost 22% for concrete FA_2.