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EFFECT ON PROPERTIES OF CONCRETE PAVERS USING DAM SILT AS PARTIAL REPLACEMENT OF FINE AGGREGATE

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Abstract — *Siltation is continuously affecting our drinking water and water storage facilities. The settlement of silt, over the years, has resulted in a decrease in the storage capacities of dams. Removal of silt from such facilities involves huge cost and environmental issues and a real challenge for developing countries such as Pakistan. However fruitful utilization of such silt after its removal can help to recover such costs and minimize environmental concerns. Concrete paver block is one of the possible options for the utilization of silt as a replacement of fine aggregate. Initially, such paver blocks were developed in 1950,s as a substitute for paver bricks. However, the effect of such replacement has not been studied yet. This research is an effort to cover that gap. The research is based on the experimental study which was carried out to utilize dam silt in concrete pavers as partial replacement of fine aggregate from 0%- 40% by volume of fine aggregate in high strength concrete (M55 Grade). A total of 180 concrete paver blocks were casted with different proportions of dam silts from three different dams of Pakistan, in the province situated in Khyber Pakhtunkhwa, namely, Tarbela Dam, Warsak Dam & Tanda Dam. The compressive strength values of these blocks were evaluated. The highest compressive strength of 8000 psi $\geq$ was obtained at 10% replacement of F.A with Tarbela Dam silt, 30% for Warsak dam silt, and at 20% on Tanda Dam silt. The difference in the values of compressive strength also depends upon the chemical composition of the silts. It was concluded that dam silt can be replaced with fine aggregate in concrete pavers as their results were found satisfactory and were according to ASTM Standards.*

Keywords- *Paving blocks, Dam Silt, High Strength concrete, Nominal Concrete, Replacement Ratio*

I. INTRODUCTION

Silting in dams from eroded rivers is a major problem which is reducing the dam storage capacity. For that, desilting is required to restore the capacity of dams. The extracted silt from dams and canals is dumped into open spaces, landfills etc. Apart from it is utilized by the farmers in fields and the remaining is dumped in open areas.
The storage capacity of three major dams in Pakistan is reducing gradually due to silting in the reservoir. Tarbela, the largest earth filled dam in Pakistan which is located in Khyber Pakhtunhwa province, was constructed in 1976. Design storage capacity of reservoir was 9.67 million-acre feet (MAF) and is reduced to 6.77 MAF due to sedimentation [1].
Mangla dam is located in Mir Pur, Azad Kashmir, Pakistan and was constructed in 1965. Initially the design storage capacity was 5.83 (MAF) which reduced to 4.73 (MAF) because of silting [2].
Warsak dam was constructed in 1960 located at Warsak in District Peshawar, Khyber Paktunkhwa Pakistan. Design storage capacity was 62,022-acre feet but now it is reduced to around 12,000-acre feet [3].
Researchers and scientists are trying to find a way out to utilize the waste material/end products that are harmful to the environment in cement, sand and aggregate in concrete. Keeping in view the environmental and economic concerns waste products and solid end products can be utilized in concrete as a replacement of aggregate. Therefore, it is very important to find the properties of waste products/ end products so that we can further utilize them in civil engineering applications.

Concrete pavers blocks are hard, non- reinforced, readymade, part of concrete mostly used for external flooring. The shape of concrete pavers blocks has gradually urbanized in different styles from non-interconnected to partially connected to fully interconnected i.e brick shape, H shape, and zig-zag shape. They turn out to be an ideal way out for approximately any function due to their superior qualities in comparison to asphalt and concrete. Concrete paver blocks look eye-catching, purposeful and need very slight or no preservation if perfectly made and fixed in contrast with concrete and asphalt. They are mostly used in flooring of gas stations, toll plazas, footpaths and walkways in parks.

II. Literature Review

The main focus of this study is to examine the mechanical properties of concrete pavers using dam silt as partial replacement of fine aggregate. Some work has already been done earlier by utilizing different waste as partial replacement of fine aggregates. Few of the work is as under.

Ling et.al, (2014) investigated the properties of rubberized concrete paving blocks RCPB. Compressive test, flexural test, splitting tensile test and three curing conditions were examined during their study. Four mixes of RCPB were made by replacing fine aggregate volume with crumb rubber at 0%, 10%, 20% and 30% were prepared in a commercial plant.

Their results showed that by replacing crumb rubber at 10% with sand didn't show any noteworthy change in compressive strength but with a slight improvement in flexural strength. But as the crumb rubber content increases to 20 % the compressive strength reduces by a great extent however; ductility of the concrete paver increases. Their research recommended using RCPB in pavements that are subjected to traffic [4].

Santos et al, (2013) explained the utilization of coal waste to produce concrete paving blocks. They examined compressive strength, abrasion resistance and water absorption of concrete paving blocks. Coal waste was replaced with fine aggregate by volume from (0%-100%) in five mixes with different w/c ratio. From their test result it was observed that coal waste can be replaced by sand from (25% - 50%) in concrete paving blocks as their results were acceptable. This utilization can help in cleaning the environment [5].

Nishikant et al, (2016) studied the properties of concrete paving blocks in which fine aggregate was replaced by waste glass collected from waste collectors. Waste glass was added in concrete as a partial replacement of fine aggregate at 15%, 30% and 45% by weight. It was noticed from their results that paving blocks containing 15 % and 30% waste glass shows higher compressive strength than the normal blocks. They concluded from their research that waste glass can be replaced up to 45% as a replacement of fine aggregate. An increase in the compressive strength of the paving blocks was noted with the increase in waste glass content. They suggested using these paving blocks in pavements having lighter traffic [6].

Shanmugavalli et al, (2017) studied that concrete paving blocks can be made by replacing cement with plastic waste in order to lessen the cost of concrete paver and to use plastic waste in concrete paver which will help in reduction of pollution as the decaying process of plastic waste is extremely slow so they can be utilized in something. With plastic waste they also used coarse aggregate, stone dust from quarry and waste from ceramic industry. After casting the paver block with these materials, they found that their results were satisfactory with good heat resistance although compressive strength was less as in comparison with normal concrete paver but can be used in parks, bicycle route, non-traffic, low traffic and in walkways [7].

Nguyen et al, (2013) explained the utilization of seashell waste in concrete pavers which are pervious and less quantity of fine aggregate was used to increase high void content which would help in reducing the runoff and water would infiltrate through these pavers. They replaced coarse aggregate with seashell waste by 20%, 40%, and 60% by weight. After casting and testing these pervious concrete pavers, they found that concrete pavers with 40% seashell waste had a substantial decrease in their compressive strength. While permeability and void content increase which was the main focus of their research work. Moreover, they also suggested replacement of coarse aggregate with seashell waste up to 40% keeping in view the compressive strength, permeability and void content of the pervious concrete pavers [8].

Kashiyani et al, (2013) in their research investigated that properties of concrete paver block can be enhanced by adding polypropylene fibers in concrete pavers block up to some extent. For this purpose, they cast the concrete paver blocks with different mixes with two layers. The upper layer consisted of cement and dolomite powder in the ratio (1:3) and bottom layer with cement, fine aggregate, coarse aggregate and quarry dust in the ratio (1:1:2:3.75) with the addition of polypropylene fibers by 0.1% to 0.5% in both the layers by weight of paver block. After testing these concrete pavers they found that at 0.4% of polypropylene fibers, their water absorption was minimum while the compressive strength was maximum. Furthermore, they enlightened that the addition of polypropylene fibers would also reduce the wear and tear cost of the blocks. They also performed the cost comparison for concrete pavers of each mix [9].

Barthel et al, (2013) studied the performance of self-cooling concrete pavers to lessen the urban heat transferred to the surrounding environment. They cast the concrete pavers in two layers, the bottom layer was made from mass concrete which stores the water and the upper layer was from permeable concrete paver which will help to infiltrate water to mass concrete layer. They focused on the compressive strength and water absorption properties of concrete pavers. Four mixes were made using viscose fibers in the upper layer and recycled concrete granulate in the bottom layer. From the test results they concluded that concrete pavers with viscose fibers and concrete recycled granulate, their compressive strength was less but water absorption was maximum. They found that mass concrete (bottom layer) is mainly responsible for the cooling effect of concrete pavers and also noticed that compressive strength and water absorption values were found satisfactory in self-cooling concrete pavers [10].

The above-mentioned research works were in context of replacement of the materials to achieve environmentally friendly concrete for concrete pavers. However, no study is available in the published literature which deals with the replacement of fine aggregate with dam silt in concrete pavers and its impacts on the properties of high strength concrete pavers.

III. Materials for Testing

Dam Silt (DS):
Three sources of silt were selected i-e Tarbela Dam (TD), Warsak Dam (WD) & Tanda Dam (TND), then the chemical composition of all the three silt samples were examined by using Energy Dispersive X Ray Spectroscopy and surface morphology by Scanning Electron Microscopy (SEM).

Grain size distribution of each sample was also determined using hydrometer analysis.

Cement:
Cherat cement was used in preparation of samples with fineness of 299 m^2/kg

Fine and Coarse Aggregate:
Sand was obtained from Lawrencpur with F.M of 1.2. Similarly, coarse aggregate was obtained from local quarries of Peshawar with specific gravity of 2.71.

IV. Sample Casting and Testing

In factory, trail mixes were done with paving block machine to make sure proper material proportions and water amounts using pressure and vibration till the desired strength of M_{55} grade concrete was achieved. The materials (cement, fine aggregate, and coarse aggregate) were added in mixer machine in dry form and then water was added till the desired moisture content achieved. The concrete pavers were casted using pressure and vibration until thorough compaction was achieved from the compacting machine.

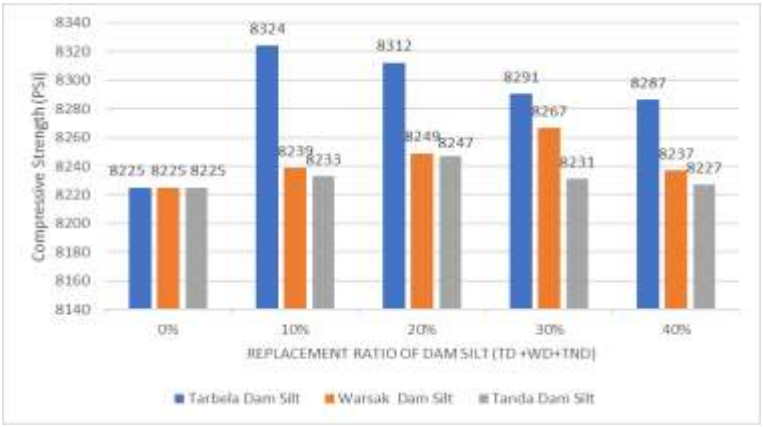
Proper tagging and marking of paving blocks after casting

S.No	Composition groups	Replacement of cement (%)	Number of samples
1	TD00, WD00, TND00	0	3x12 = 36
2	TD10, WD10, TND10	10	3x12 = 36
3	TD20, WD20, TND20	20	3x12 = 36
4	TD30, WD30, TND30	30	3x12 = 36
5	TD40, WD40, TND40	40	3x12 = 36
		Total:	**180**

Compression Test 28 Days (ASTM C 936/C 936M):

Compressive strength of concrete pavers was found according to ASTM- C 936. Pavers was tested in UTM with a capacity of 200 Tons. In each type, three samples were tested and their average compressive strength was calculated by using the formula:

Compressive strength = Load / Area (Psi or MPa)



Compressive strength at 28 days in comparison

V. Conclusions and Recommendations

Experimental study was carried out to conclude compressive strength of concrete paving blocks in comparison using dam silt from three distinct sources as fine aggregate replacement. Concrete paver samples with varying proportions of dam silt were cast and tested to find the property like compressive strength 28 days. Based on the results of tested samples, the following conclusions have drawn:

1. It was noticed that compressive strength (28 days) of concrete pavers with 10% replacement of TD silt with fine aggregate gives the maximum strength which is 1.2 % greater than the control mix. Among all the three sources of silt maximum strength were achieved using TD silt. The compressive strength of concrete paver block made with WD silt goes on increasing till 30% of replacement with F.A and gives the maximum strength which is 0.51 % more than the normal control mix. Similarly, compressive strength of pavers utilizing TND silt goes on increasing till 20% and gives the maximum compressive strength which is 0.26% more than the control mix. Increase in compressive strength is due to presence of pozzolanic properties in all the three silts which helps to give strength to concrete. As silt size is small so it fills all the voids in concrete which also improves the strength.

2. In future, more research work will be carried out by fully replacing dam silt with F.A and also partial replacement of dam silt with cement. Abrasion test, permeability test will also be conducted to find porosity and durability.

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