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Evaluation of Strength Characteristics of Pavement Quality Concrete Mixes using Ekosoil

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Abstract - *The concrete used for the construction of rigid pavements, runways etc. is known as pavement quality concrete (PQC). Formation of cracks in PQC leads to decrease in both compressive and flexural strength characteristics thus PQC layer deteriorates rapidly. In previous years materials like flyash, manufacturing sand (MS), marble dust, GGBS, superplasticizers etc have been used to increase the properties of PQC. In the present study utilization of EKOSOIL in PQC mixes and the effect of varying percentages of EKOSOIL on workability, compressive strength and flexural strength characteristics of EKO-PQC mixes has been done. The PQC mixes were prepared by adding 1%, 2% and 3% of EKOSOIL. The ultra-sonic pulse velocity test assessment was also done as a part on non- destructive technique which can assess the quality of concrete with respect to homogeneity of the concrete, presence of cracks, voids, changes in the structure of the concrete which may occur with time, the quality of the concrete in relation to standard requirements. According to the results observed for compressive strength and flexural strength of EKO-PQC there is a slight increase in the values from 1% to 2% addition of Ekosoil and decrease in the values from 2% to 3% addition of Ekosoil. But the results obtained are less than as compared to values for conventional PQC mix. This might be because the EKO-PQC mix is porous in nature as compared to conventional mix. It also appears that the over dosage of Ekosoil, in normal concrete may affect the cohesiveness between the particle of concrete and this results in degrading of compressive strength and flexural strength.*

Key Words: PQC, EKOSOIL, Compressive Strength, Flexure Strength.

1. INTRODUCTION

Transportation contributes to the economic, industrial, social and cultural development of any country (Khanna & Justo). Among various modes of transportation road transport is considered to be one of the cost-effective and preferred modes of transport for passengers as well as for freight. It is estimated that more than 60 percent of freight and 85 percent of passenger traffic in the country is being handled by roads (web.worldbank.org). India has a road network of over 5,603,293 km, the second largest road network in the world as per Basic Road Statistic of India.
The concrete used for the construction of rigid pavements, runways etc. is known as pavement quality concrete (PQC). In highway pavements, due to variation in the traffic condition, the formation of micro cracks in the PQC layer takes place under the combined effect of stresses due to wheel load and temperature. Formation of such type of cracks in PQC leads to decrease in both compressive and flexural strength characteristics thus PQC layer deteriorates rapidly. Rigid pavements suffer from deterioration therefore various alternatives have been adopted to increase the quality and strength of PQC. In previous years materials like flyash, manufacturing sand (MS), marble dust, GGBS, superplasticizers etc have been used to increase the properties of PQC.

In this research study EKOSOIL is used in different percentages by volume of water in PQC mixes and the physical properties such as workability, compressive strength and flexural strength of EKO-PQC is utilized and the optimum mix proportion was taken as the mix proportion that exhibited the highest compressive and flexural strength at 7 and 28 days.

1.1 EKO-SOIL

EKO SOIL is a cost effective multiple enzyme based product fermented from organic materials. It is environmentally safe and has been used to create stabilized road bases using existing road construction techniques in countries such as the United States, Mexico, Canada and many South American and Asian countries.

EKO SOIL reduces the amount of water that soaks into the road base materials. Observations have shown that because of the increased density obtained with the use of EKO SOIL (if properly mixed and compacted) permeability is reduced. EKOSOIIL works by reducing the amount of water held in the soil, thus eliminating voids and air spaces between the soil particles. Maximum density is more easily attainable by reducing the friction resistance between and the swelling capacity of the soil particles. EKOSOIL enhances tensile strength and density by fusing the clay fraction together with the other particles into a tight solid mass. Through the force of compaction EKOSOIL is able to achieve a strong fusing throughout the soil (Ekosoil Technical Manual, July 2015).

Table 1: Properties of EKOSOIL

S.N.	Properties	Value
1	Specific gravity	1.05
2	Boiling Point	212ºF
3	Evaporation rate	Same as water
4	Vapour pressure	Same as water
5	Melting Point	N/A
6	Appearance	Brown colour
7	Odour	Slight Ferment odour

(Source- Ekosoil Technical Manual, July 2015)

2. PROPOSED METHODOLOGY

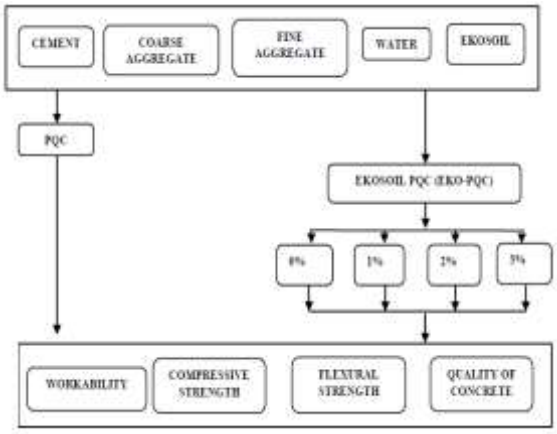

Fig 1: Proposed Methodology

3. EXPERIMENTAL PROGRAM

3.1 Design Mix Proportioning

In the investigation, M40 grade was considered and designed as per guidelines given by IRC: 44- 2008. Three different mixes with water-cement ratio 0.40 were designed as control mixes. In the design of EKO-PQC, Ekosoil was added as 1%, 2% and 3% of volume of water.

3.2 Preparation of Concrete Mix

For casting of specimen, the materials were taken according to the desired specifications. Hand mixing is adopted for the whole experimental program. The mixing of concrete is done in such a way that the mix obtain will be having minimum voids. Ekosoil is mixed with water as it is soluble in water so that it can be uniformly distributed to the mix.

Fig 2: Preparation of concrete mix

3.3 Casting and Curing of Test Specimens

For each mix 9 cubes, and 6 beams were casted. It is to note that the concreting operation should be completed within 25 to 30 minutes from the instance of adding water to the dry mix. Then the specimens were allowed to cure in a cool and humid place at a temperature of 27± 2ºC for about 24 hours and then demolded carefully. The curing of the casted specimens was done by immersing the specimens in a tank containing water. The concrete specimens were cured for 7 days and 28 days and later specimens were taken out of water for testing.

3.4 Testing of Specimens

3.4.1 Workability Test

Slump test is adopted as the primary measure of concrete workability confirming to IS: 1199-1959, and was performed to evaluate the influence of EKOSOIL on workability. The apparatus for conducting the slump test consist of metallic mould in the form of frustum of cone having internal dimensions, bottom diameter 20 cm, top diameter 10 cm and height 30 cm. Figure 3 shows the slump test apparatus test used in the laboratory and the process of tests being conducted. The workability tests are conducted immediately after mixing the concrete. For the concrete used for Pavement Quality Concrete, a slump value between 25mm to 50mm is desirable. The Slump test was conducted for mixes with required slump value and then, those mixes were used for casting of specimen.

Fig 3: Slump Test

3.4.2 Compressive Strength Test

The cube specimens are tested for compression and the ultimate compressive strength is determined with the help of compressive testing machine (CTM). The average value of compressive strength of three specimen for each percentage replacement at the age of 7, 14 28 days were studied.

$$f'c = Pc / A$$

Where,
Pc = Compressive Failure load, (kN)
A = Loaded area of cube, (mm^2)

Fig 4: Compressive Strength Test

3.4.3 Flexural Strength Test

Flexural strength tests are conducted on universal testing machine (UTM) of 600 KN capability. Generally three beams of 700*150*150 mm from each batch are subjected to this test. The flexural strength of concrete beam specimen was calculated as

$$F_b = PL/bd^2$$

Fig 5: Flexural Strength Test

Where,
F_b=flexural stress, MPa,
b=measured width in cm of the specimen d=depth in mm of the specimen.
l=length in mm of the span on which the specimen was supported
p=maximum load in kg applied to the specimen.

3.4.4 UPV Test

The ultrasonic pulse velocity method can be used to evaluate the homogeneity of the concrete, presence of cracks, voids and other inadequacies, changes in the structure of the concrete which may occur with time, the quality of the concrete in relation to standard requirements, the quality of one element of concrete as compare to others. The ultra-sonic pulse velocity non-destructive test conforming to IS: 13311- 1992 (Part 1), was conducted on EKO-PQC Mixes. The pulse velocity can be used to assess the quality and uniformity of the material. The path length for the UPV through the concrete specimen is of 150 mm.

$$V = L/T$$

Where;

V = Pulse velocity
L = Path length
T = Transit time

Fig 6: UPV Test

4. TEST RESULTS AND ANALYSIS

4.1 Effect of Ekosoil on Workability Characteris-tics of PQC

It can be seen that slump demonstrates an increased trend with addition of ekosoil. The slump value of unmodified PQC was obtained as 27 mm. On 1%, 2% and 3% addition, a gradual increase of slump value is seen. On 1%, 2% and 3% addition we are getting 28mm, 31mm and 34 mm slump value respectively.

Hence it is observed that adding 1%, 2%, 3% Ekosoil there is an increment of 3.70%, 14.81%, 25.93% in slump value with respect to conventional PQC.

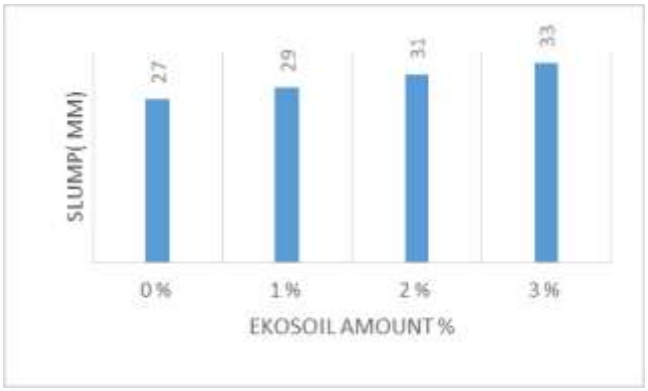

Fig 7: Results of Slump Test on EKO-PQC Mixes

4.2 Effect of Ekosoil on Compressive Strength Characteristics of PQC

The results indicate that when EKO-PQC included 1% EKOSOIL, the compressive strength at 7 days decreased by 27.52% than the conventional PQC. Similarly, for 14 days and 28 days these value decreased by 24.06 % and 23.06% than the conventional PQC. On the other hand, when EKO-PQC comprised 2% EKOSOIL, the compressive strength at 7 days decreased by 25.35%, whereas for 14 days and 28 days these value decreased by 20.84% and 20.16% than the conventional PQC. The decrement in compressive strength was 53.36%, 51.52% and 51.77% in EKO-PQC consisting of 3% EKOSOIL after 7, 14 and 28 days respectively as compared to conventional PQC. It was observed that, with the addition of EKOSOIL, the compressive strength of EKO-PQC showed decreasing trend from 0% to 1%, then it shows increment from 1% to 2% and after that more decrement is observed from 2 % to 3% in the present study. After these experimental program we can say that EKOSOIL gives optimum results with 2%.

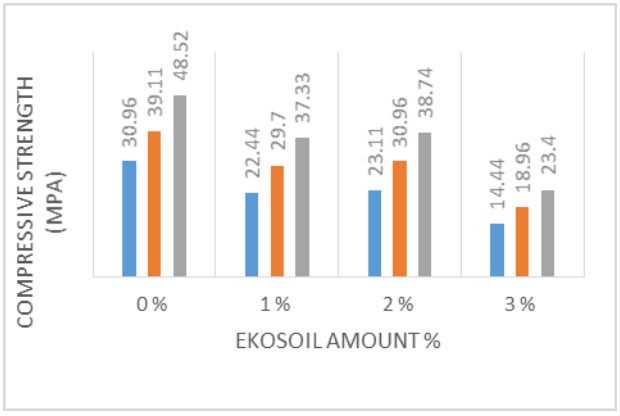

Fig 8: Results of Compressive Strength Test on EKO-PQC mixes

4.3 Effect of Ekosoil on Flexural Strength Characteristics of PQC

This section deals with the results of flexure strength tests of EKO-PQC mixes with various Ekosoil contents after 14 and 28 days curing. The 14 and 28 days Results obtained from flexure strength tests of EKO-PQC mixes are shown in Figure 5.3.

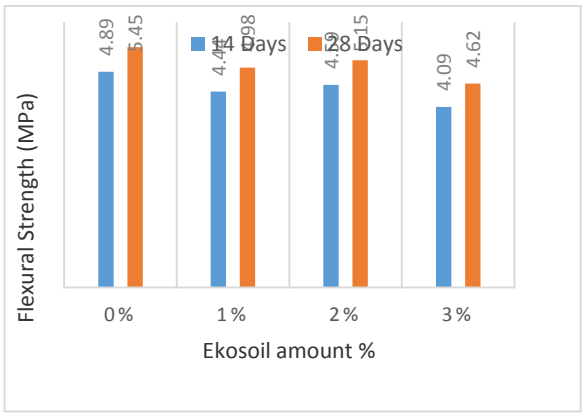

Fig 9: Results of Flexural Strength Test on EKO-PQC Mixes

A decreasing trend in flexural strength with slight increase at 2% of Ekosoil can be seen along with the addition of Ekosoil. The optimum value for compressive strength of EKO-PQC mixes was found corresponding to 2%. The maximum flexural strength at 14 days obtained was 4.44 N/mm² with optimum 2% EKOSOIL, while it was 5.15 N/mm² at 28days which is 5.55% lower than the Conventional PQC mix. While with 1% the 28-days flexural strength was 4.98 N/mm² and with 3% the 28 days flexural strength was 4.62 N/mm² which is 8.62%, 15.23% lower than conventional PQC.

4.4 UPV Test

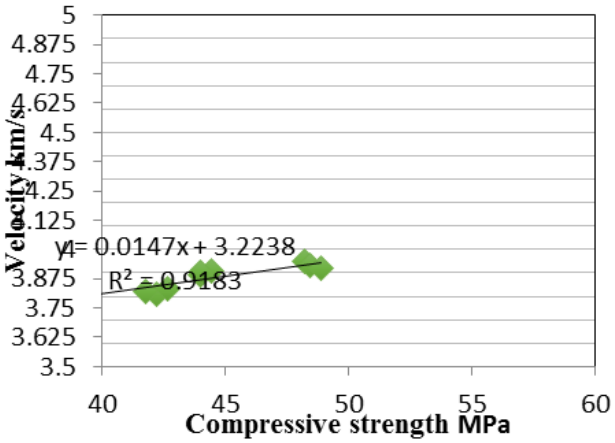

Fig 10: UPV vs Compressive Strength Graph

It is observed that with addition of a small amount of EKOSOIL in PQC resulted in a decrease in UPV, which may indicate less compact or consistent structure of EKOSOIL concretes. However, small increase in the velocity has been observed from 1% to 2% of EKOSOIL but after that from 2% to 3% of EKOSOIL decrease in velocity has been observed. This may be attributed to the porous structure of concrete.

In this section the results of ultra-sonic pulse velocity is presented which is conducted on the specimens of EKO-PQC Mixes.

5. CONCLUSIONS

The present study focuses on the usage of Ekosoil in PQC mixes and its effect on workability, compressive strength and flexural strength characteristics of EKO-PQC. The ultra-sonic pulse velocity test was conducted on EKO-PQC for the assessment of dispute settlement (quality and uniformity in quality) and post damage investigation of concrete. The result obtained showed that EKO-PQC mixes are having average quality. Decrease in compressive strength and flexural strength was observed with using Ekosoil. Further following points are concluded from the present study:

1) Addition of Ekosoil to the PQC mixes has been found to increase slump of EKO-PQC mixes. It was observed that adding 1%, 2%, 3% Ekosoil there is an increment of 3.70%, 14.81%, 25.93% in slump value with respect to conventional PQC.

2) The optimum percentage of Ekosoil for maximum compressive strength of EKO-PQC mixes was 2%. Addition of Ekosoil to PQC mixes up to the optimum value has shown an increasing trend in compressive strength. The maximum compressive strength 38.74 MPa, at 28 days was obtained at optimum Ekosoil content. With further increase of Ekosoil content, compressive strength has shown decreasing trend. Reduction in compressive strength may be due to the porous structure.

3) The optimum percentage of Ekosoil for maximum flexural strength was 2%. Flexural strength of EKO-PQC mixes has shown an increasing trend up to the optimum content of Ekosoil and the maximum value obtained after 28 days was 5.15 MPa. The flexural strength of concrete mixes containing Ekosoil generally followed the compressive strength trend and the reduction in flexural strength may be due to the porous structure.

4) According to the results observed for compressive strength and flexural strength of EKO-PQC there is a slight increase in the values from 1% to 2% addition of Ekosoil and decrease in the values from 2% to 3% addition of Ekosoil. But the results obtained are less than as compared to values for conventional PQC mix. This might be because the EKO-PQC mix is porous in nature as compared to conventional mix. It also appears that the over dosage of Ekosoil, in normal concrete may affect the cohesiveness between the particle of concrete and this results in degrading of compressive strength and flexural strength.

6) The results of ultra-sonic pulse velocity tests for EKO-PQC mixes obtained are between 3.5 and 4.5 km/sec which according to IS: 13311- 1992 (Part 1), means that in relation to standard requirements, concrete quality is good with respect to homogeneity of the concrete, presence of cracks, voids and changes in the structure of the concrete which may occur with time.

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