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A Study on Rigid Pavement Strength using Glass Fibre as a Reinforcing Agent

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Abstract

India's Ministry of Road Transport and Highway has decided to move towards making rigid pavement the default mode of construction on national highways. The decision, taken after considering factors related to service life, fuel consumption, weather conditions, maintenance cost and natural resources, primarily aims to promote environment friendly construction practices in execution of road projects. Only 2% to 3% road length in the country that is composed of concrete roads and the remaining are made of unbound aggregates surfaced with bitumen or asphalt based surface courses. The main reason behind that, the initial cost of rigid pavement is much more than the flexible pavement. The cost is not the single parameter for such less construction but also the main failure such as mud pumping, sagging of slabs due to less flexural strength, concrete is brittle etc. is liable. But the concrete roads construction shows to be better as compared to flexible pavement in long term maintenance, design life, riding quality etc. Rigid pavements mostly fail in bending, that result the cracks are developed in rigid pavements. There is also a problem of corrosion of steel reinforcement in rigid pavement which also boosts more thickness of slab and raises the material requirement. So in this project work we are using glass fibres as reinforcing agent in concrete. Randomly spread glass fibres in concrete grasps the concrete and improves its ductility features. Owing the glass fibre in concrete, the thickness of concrete wedge becomes less as the glass fibre rises the strength characteristics of concrete is increases, due to which material requirement in construction on rigid path also decreases. Glass fibre reinforced concrete is a complex material consists of sand, cement, coarse aggregate and arbitrarily distributed fibres. These arbitrarily distributed glass fibre increases the strength of concrete and increases its ductility properties. In this experimental investigations, strength properties in compression, flexural strength and split tensile strength the different percent (%) of glass fibre by volume of concrete fraction are studied. From the different laboratory test conducted on concrete with different % of glass fibre by volume of concrete results are: The slump value (workability of concrete) of concrete decreases with increase in % of glass fibre. The compressive strength at 7 days and 28 days increases with increase in % of glass fibre by volume of concrete fraction. The maximum increase in compressive strength is 32% and 13% at 7days and 28 days respectively.

Keywords: *Pavement Strength, Glass Fibre, Reinforcing Agent.*

1. Introduction

India´s road system is the third largest road network in the world. Only 2% road length in the country that is composed of concrete roads and the remaining are made of unbound aggregates surfaced with bitumen or asphalt based surface courses. The main reason behind that, the initial cost of rigid pavement is much more than the flexible pavement. The cost is not the single parameter for such less construction but also the main failure such as mud pumping, sagging of slabs due to less flexural strength, concrete is brittle etc. is liable.

But the concrete roads construction shows to be better as compared to flexible pavement in long term maintenance, design life, riding quality etc. An example of such benefits is that, the concrete roads in some sites of Kanpur or Gujarat which are built at the time British rule are still in use (source: Wikipedia).

As the concrete is hard in nature it wants some supporting agent like steel bars. Steel bars reinforcement to increase its ductility. But the conventional steel reinforcement boosts more thickness which in turn becomes uneconomical. In order to make concrete capable of carrying tension at better strain, at which the cracks starts to develop, we

have raised the tensile strength. To increase the tensile and flexural strength, glass fibres are added in concrete. The adding of fibre will result in complexes material which has the properties altered from un-reinforced concrete. The amount of variation in strength will depend upon the type of fibres and on the amount of fibre.

2. Methodology

General

In this study the subsequent steps have been adopted:

Collection of different material: Different material such as coarse aggregate, fine aggregate, cement (OPC) was collected from local market. Glass fibre was purchased from a Delhi based industry.

Experimental investigation of materials: Different experiments were performed on the ingredients to evaluate their properties.

Design mix of concrete: M30 design mix was prepared according to the standards put down by IS: 10262-2009 and IS: 456-2000

Experimental investigation on concrete: Different experiment was done on plain concrete and concrete with different percent such as 0.1% 0.2 %, 0.3 % etc. of glass fibre by volume of concrete fraction was which are as follows:

i. Workability or slump test (IS:516-1959)
ii. Flexural strength test (ASTM c293)
iii. Compressive strength test (IS:516-1959)
iv. Split tensile test (IS 5816:1999)
v. Ultra sonic pulse velocity (IS:13311 part 1 1989)
vi. Modulus of elasticity(IS 516:1959)
vii. Water absorption test(IS:1558:2006)

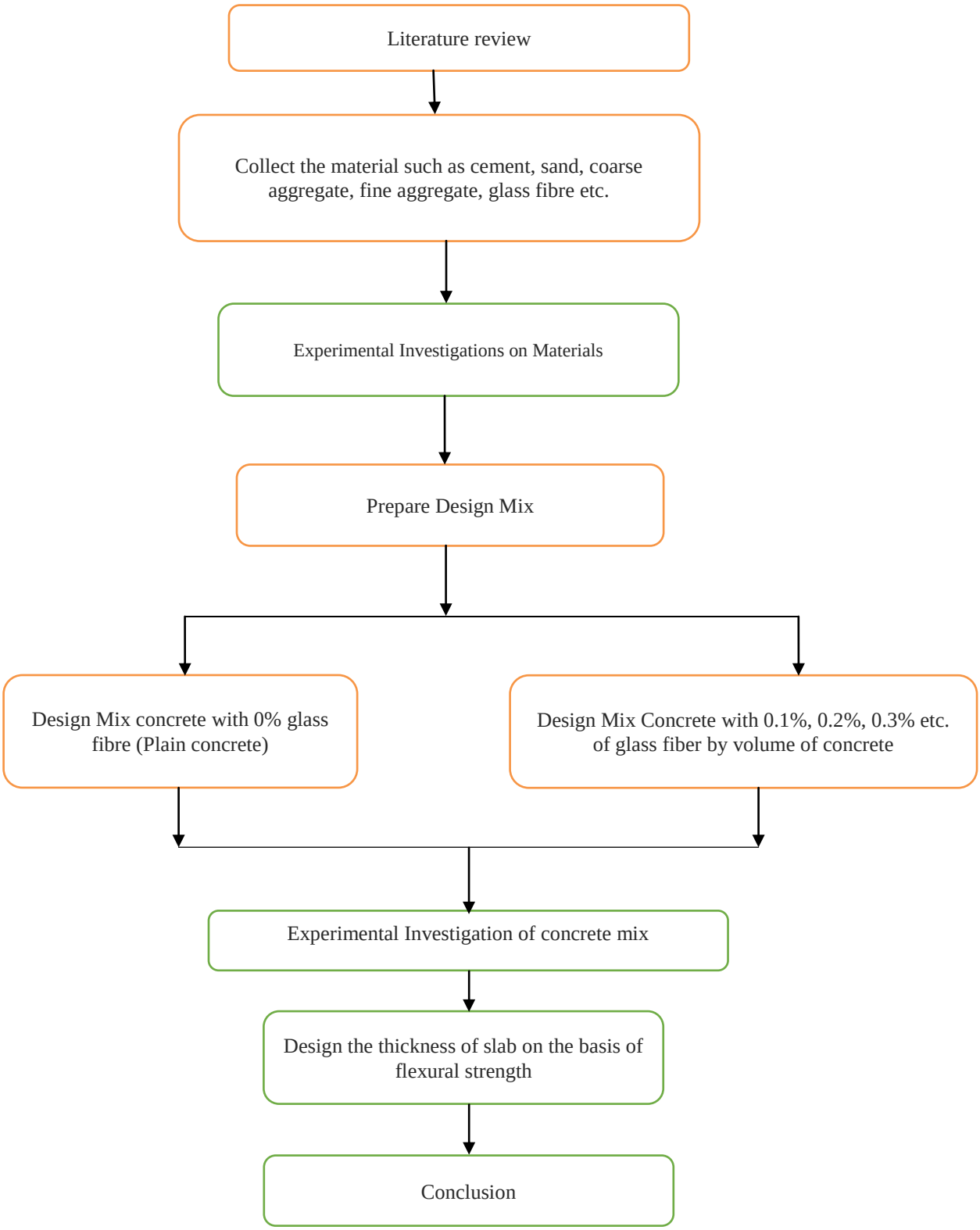

Figure 1: Flow chart of work

3. Materials used and Test procedure

Different materials which are used in this project work are described as follows:

3.1 Coarse Aggregates

Crushed angular, passing through 20 mm sieve aggregate is used in this study. The aggregate is free from powder and impurities. Explanation of different test on aggregates is described below:

3.1.1 Aggregate Impact Test

This experiment is done in according to IS: 2386 (part 4) -1963 .This test measures the toughness of aggregate which indicate capacity of material to resist impact. For the period of the traffic operation the pavement layers is subjected to heavy wheel load due to which the road aggregates are subjected to impact load, so this test is execute to evaluate the resistance of aggregates to impact.

The following apparatus were required in this test:

i. Impact testing machine
ii. IS test sieves viz. 12.5 mm ,10 mm & 2.36 mm
iii. A cylindrical mould of internal diameter 75mm and depth 50 mm
iv. A tamping rod

Figure 2: Aggregate Impact Apparatus

In this experiment the aggregate passing through 12.5 mm sieves and retained on 10mm sieve. Retained material was taken as the test sample which was weighed as W_1 g. And then the aggregate were dried in an oven at 100 c to 110 c for four hours and then cooled in air. Aggregates were then filled in cylindrical mould up to one third and it is tamped for 25 times and then residual quantity of aggregates were filled in two steps in same way and were given 25 strokes by tamping rod. Then the aggregates of cylindrical mould was transferred to cup (internal diameter 102 mm and depth 50 mm) which is definitely fixed to the aggregate impact machine (shown in fig. 2). After placing aggregates in cup the hammer was raised to a height of 380 mm and was allowed to free fall on aggregates for 15 times. The crushed aggregate was removed from the cup and whole aggregate was sieved through 2.36 mm sieve. The aggregate passed through 2.36 mm sieve was weighed as W_2 g.

The aggregate impact value was conveyed as the percentage of weight passed through 2.36 mm sieve (W_2) to the total weight of test sample (W_1).

$$\text{Aggregate impact value} = \frac{100 \times W_2}{W_1}$$

Where

W_1 = Weight of aggregate sample
W_2= Weight of aggregate passing through 2.36 mm sieve

4. Conclusion and Recommendations

From the different laboratory test conducted on concrete with different % of glass fibre by volume of concrete following conclusions are drawn:

1. The slump value (workability of concrete) of concrete decreases with increase in % of glass fibre. With increasing % of glass fibre concrete is becoming more and harsh. To improve its workability super plasticizer can be used.
2. The compressive strength at 7 days and 28 days increases with increase in % of glass fibre by volume of concrete fraction. The maximum increase in compressive strength is 32% and 13% at 7days and 28 days respectively.
3. The flexural strength increases with increase in percent of glass fibre up to 0.5 % glass fibre but the rate of increment of flexural strength was found more when glass fibre mix in concrete is 0.3% to 0.4% and less in 0.4% to 0.5%.
4. Split tensile strength increase with percent of glass fibre increases. Split tensile strength at 0% and 0.5% of glass fibre is 3.24 and 4.30 respectively.
5. Water absorption test was performed on hardened concrete at 28 days and found percent of water absorption increase with increase in percent of glass fibre but the maximum water absorption found at 0.5% glass fibre mix concrete and minimum rate of increment of water absorption is at 0.4% glass fibre concrete.
6. Modulus of elasticity increases with increase in glass fibre. The value modulus of elasticity of concrete mix at 0% glass fibre is 3.04*10^5 kg/cm^2 and 0.5% glass fibre concrete mix is 3.40*10^5, which is nearly equal to 0.4% of GFCM. But the graph represents 0.4% GFCM having maximum strain compare with 0.5% GFCM.
7. Ultrasonic pulse velocity test for 0% and 0.5% glass fibre concrete gives good and medium quality of concrete respectively and 0.1% , 0.2%, 0.3%,0.4% glass fibre concrete have excellent quality.

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