RESEARCH PAPER | Engineering | Volume : 4 | Issue : 8 | August 2014 | ISSN - 2249-555X

Comparison of Normal Concrete Pavement with Steel Fiber Reinforced Concrete Pavement

KEYWORDS: Steel fibres, strength, radius of relative stiffness, slab thickness, temperature stresses.

Dr. Deepa Sinha	Prof. C.B. Mishra	Ravindra V. Solanki
Associate. Professor, Dept. of Civil Engg., BVM Engineering College, Gujarat, India	Associate. Professor, Dept. of Civil Engg., BVM Engineering College, Gujarat, India	Assistant Professor, Engg College, Rajkot, Gujarat, India

ABSTRACT *In India, owing to rapid engines of growth in infrastructure and tremendous rise in highly laden vehicles on limited road space demands road to withstand high stresses with minimum maintenance. Pavements made of concrete provide durable service life and has remarkable application under heavy traffic loading. In this paper an attempt is made to evaluate the compressive strength and flexural strength with and without steel fibers. Also the stresses are worked out. The test results shows that steel fiber reinforced concrete is an excellent new type of composite material compared with ordinary concrete as thickness of road is reduced without affecting the load carrying capacity and is a cost effective technology. Considerable changes in temperature stress values are noted too.*

Introduction

Concrete pavement has superior durability and longer structural life than asphalt pavement. Use of the concrete pavement has been grown over the past decade in developing countries. In Indian road network 98% of roads are flexible pavement and only 2% of roads are rigid pavement [1]. Plain concrete is an inherently brittle material with low tensile strength and strain capacity. The use of steel fibers considerably improves its structural characteristics such as static flexural strength, impact strength, tensile strength, ductility and flexural toughness, the cracking performance of concrete pavements and reduces the required slab thickness [2]. These factors lead to the development of Fiber Reinforced Concrete. Fiber reinforced concrete is a composite material comprised of Portland cement, aggregate, and fibres. Normal unreinforced concrete is brittle with a low tensile strength and strain capacity. Fibers are generally utilized in concrete to manage the plastic shrink cracking and drying shrink cracking. They also lessen the permeability of concrete and therefore reduce the flow of water. Some types of fibers create greater impact; Steel fiber reinforced concrete is concrete made of cements containing fine or fine and coarse aggregate and discontinuous discrete steel fibers. In tension, SFRC fails only after the steel fiber breaks or is pulled out of the cement matrix [3].

Objectives of Work

(1) To find out effect of variation in percentage of steel fiber on properties of FRC i.e. Workability, Compressive Strength, Flexural strength for pavement construction. (2) To find out optimum dosage of steel fiber for economic construction of pavement with compare to normal concrete pavement.

EXPERIMENTAL WORK

Experimental work was done on M30 grade concrete and mix design as per IRC: 44-2008 [4]. In the experimentation 53 grade OPC was used in the experimentation. Coarse aggregates of 12mm and down size having a specific gravity of 2.74 and locally available sand with a specific gravity of 2.67 and falling in Zone-II were used. Steel fibers of 30 mm length and 0.7 thicknesses with corrugated shape which gave an aspect ratio of 42 were used. The mix design was carried out for M30 grade concrete as per IS: 10262-2009 which yielded a proportion of 1:1.86: 2.41 with a w/c ratio of 0.45. The dosage of super plasticizer used was 0.78% (by weight of cement). The steel fibres were added at the rate of 0.5%, 0.75%, 1.0%, 1.25%, 1.50%, 1.75%, and 2.0% by volume fraction. The cement, sand and coarse aggregates were weighed according to the proportion of 1:1.86: 2.41 and dry mixed. The required amount of water was added to this dry mix and intimately mixed. The calculated quantity of super plasticizer was now added and mixed thoroughly. After this, different percentage of steel fibers (0.5% up to 2%) by volume was added to the mix and the entire concrete was agitated thoroughly to get a homogeneous mix. Then the mix was placed layer by layer in the moulds to cast the specimens. The specimens were prepared both by hand compaction as well by imparting vibrations through vibrating table. The specimens were finished smooth and kept under wet gunny bags for 24 hours after which they were cured for 28 days by immersing them in water [5].

Strength parameters were checked on Plain concrete and steel fiber reinforced concrete and Comparison of design parameters of Normal concrete pavement and SFRC pavement was done.

Pavement Design and Analysis

Pavement slab is designed as per IRC 58:2002 [6]. The flexural strength is directly taken from the beam flexural test. The traffic is taken as 3020 cvpd, The design life is taken as 30 years. The Axle load spectrum is taken from IRC: 58 -2002 and other data used in this design is given below:

Design of CC Pavement at Dhrol Jamnagar Road as per IRC 58

(a) Grade of Concrete in Pavement 35 Mpa = 350 kg/cm^2
(b) Flexural Strength of Concrete 0.7 * fck 0.5
= 4.141256 Mpa
= 41.41256 kg/cm²
(c) Effective Modulus of subgrade Reaction Of DLC Subbase kg/cm²/cm = 7.36 kg/cm³
(d) K - value of Subgrade kg/cm²/cm
From Table -2 of IRC -58 Corresponding to a CBR Value = 2.4 kg/cm³
(e) Poisson's Ratio = 0.15
(f) Coefficient of Thermal Expansion of Concrete

= 1.00E-05/degree Centigrade
(g) Tyre Pressure = 0.8 Mpa = 8 kg/cm²
(h) Rate of Traffic increase = 10 %
(I) Spacing of Contraction joints = 4.5 m
(j) Width of Slab = 3.75 m

Table: Comparison of design parameters of Normal concrete pavement and SFRC pavement

sr no	% of fiber in various mix	Slump mm (5)	compressive strength Kg/cm² (5)	flexural strength Kg/cm²(5)	Radius of relative stiffness (cm)	slab thickness (cm)	temperature stresses (kg/cm²)	corner stress
1	R0 Mix 0%	70	40.3	51.4	114.4	37	32.46	15.38
2	R1 Mix 0.50%	60	40.8	54.06	109.91	35	34.4	16.88
3	R2 Mix 0.75%	55	41.5	56	107.77	34	35.71	17.75
4	R3 Mix 1.00%	50	45.8	61.36	107.9	33.5	36.51	18.28
5	R4 Mix 1.25%	48	45	67.05	110.06	34.5	34.97	17.37
6	R5 Mix 1.50%	45	44.2	68.68	111.01	35	34	15.53
7	R6 Mix 1.75%	40	44	69.1	112.13	35.5	32.7	15.14
8	R7 Mix 2%	38	43.5	71.12	113.15	36.5	33.43	14.78

Results & Discussion

The following are the outcomes of various investigations carried out in the laboratory and are discussed as follows:

1. It is noted that inclusion of fibers in concrete mix affects the properties of fresh concrete such as slump value, compressive strength & flexural strength. Results shown in table shows decrease in slump value with increase in % of steel fibre in concrete mixes.
2. The table reveals that the inclusion of steel fibre affects the hardened properties such as 28 days compressive strength of concrete mix. It is evident that there is an increase in compressive strength of concrete mix up to addition 1% of steel fibers and then there is decrease in compressive strength slowly though the compressive strength of 2% mix is more than normal mix concrete but from the economic point of view it is very costlier than the mix having 1% steel fibers.
3. The inclusion of steel fibre shows a constant increase in flexural strength with increase in % of steel fibers. It is maximum at 2% but from economic point of view the cost of 2 % mix is more than that of 1% mix.
4. It is observed that radius of relative stiffness increases with increase in fibre content in concrete mix up to 1% because as the fiber content goes on increasing the modulus of elasticity of the particular mix is increasing and it is 338378.48 kg/cm^2 for R3 mix which is more than the value of R0 mix which is just 317411.4 kg/cm^2. This increase is mainly due to higher compressive strength and strong bond in matrix, which makes the bond to experience less strain for a given stress.
5. The slab thickness is decreasing up to optimum level i.e 1% of fiber as mechanical properties of fiber depend on parameters like fiber shape, fiber amount and aspect ratio. The aspect ratio is associated with fiber efficiency which is obtained as 42 and this is depending on the ratio of length of corrugated fiber (30 mm) to thickness (0.7 mm).The result shows that at 1% the thickness obtained is optimum i.e. 33.5 cm compared to the normal concrete (37 cm).
6. From the experiment it is seen that ability to carry temperature stress of the concrete section is getting increase with increase in percentage of fibers. As temperature stress is mainly depend upon coefficient of temperature differential, Modulus of elasticity of concrete, coefficient of thermal expansion and the temperature differential for the area. Here in this practical coefficient of thermal expansion and temperature differential is constant and there is change in modulus of elasticity and of concrete mix and change in value of coefficient of temperature differential as it depends on value of radius of relative stiffness which decreased up to 1 % and it changes the value of coefficient of temperature differential. So there is a variation in the change of temperature stress.
7. From the experiment it is seen that the maximum stress is induced in the corner region as the corner is discontinuous in two directions. Corner stress is mainly depending upon the wheel load, slab thickness, radius of contact area and radius of relative stiffness. For this experimental work the design of various sections for different mixes are showing the decrease in value of slab thickness as well as in the value of radius of relative stiffness up to 1% than it goes on increasing. From the above figure it is clearly shown that the change in slab thickness and radius of relative stiffness makes the considerable change in temperature stress values.

Calculation of cost saving

- **Cost of construction for R0 Mix i.e Normal mix**

Length of road = 75 mt
Width of road = 7.5 mt
Slab thickness = 37 cm

The total concreting work to be done in m^3 = 75*7.5*0.37

= 208.13 m^3

As per the SOR rates cost of construction of 1 m^3 of cement concrete road is Rs.755

So the cost of construction of this road is = 208.13 * 755 = 1,57,138 Rs.

- **Cost of construction of R3 Mix i.e 1% steel fibers mix**

L = 75 mt
W = 7.5 mt
H = 33.5 cm

So total concreting work to be done in m^3 = 75*7.5*0.335 = 188.13 m^3

As per above mention rate from SOR for 1 m^3

Cost of construction for this section = 188.13 * 755

Volume : 4 | Issue : 8 | August 2014 | ISSN - 2249-555X

= 1,42,038 Rs.

Now,

Difference in cost of construction = 1,57,138 -1,42,038 Rs.
= 15,100 Rs.

So the saving in cost of construction by adding 1% steel fiber in concrete mix is 9.6%.

Conclusion…

In this study, it can be concluded that increased strength of SFRC suggests that thinner SFRC slabs on the ground can be designed compared to plain concrete slabs also it is seen that the change in slab thickness and radius of relative stiffness makes the considerable change in temperature stress values.

Here, optimum dosage of steel fiber is 1%, which can withstand over the traffic passing over the section of road by giving considerable amount of reduction in thickness i.e. 3.5 cm than normal concrete which is 37 cm and it also gives 9.6% of cost saving in construction. Also it takes care of temperature stresses and corner stresses. Hence one can say that SFRC can become an option in future.

REFERENCE

1. Elsaigh A. W., Kearsley P. E., and Robberts M. J "Steel fiber reinforced concrete for road pavement application" proceeding of 24th southern African transport conference pp.191-200 july-2005 | 2. K. Sankar, 'A Study on the Effect of Fiber Reinforcement in Concrete Pavements,' M. Tech Thesis, Department of Civil Engineering, National Institute of Technology, Tiruchirappalli –620-015. | 3. IRC: SP: 46-1997, 'Steel Fibre Reinforced Concrete for Pavements'. | 4. IRC 44 : 2008 "Guidelines for Cement Concrete Mix design For road pavements", Indian Road Congress, New Delhi | 5. Dr Deepa A Sinha, Characteristic Properties Of Steel Fibre Reinforced Concrete With Varying Percentages Of Fibre, Indian Journal of Applied Research, Vol. 4 , , Issue 7,July 2014,pp218-230 | 6. IRC-58:2002, 'Guidelines for the Design of Rigid Pavements |