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Innovative Use of Quartzite Rock Dust and Effect of Glass Fibers in Rigid Pavements

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Abstract— In the current investigation sand is replaced by quartzite rock dust from locally available sources. Sand is replaced by quartzite rock dust up to 70% by weight of sand in steps of 10% increments and 0.2% glass fibers by weight of cement were also included for further enhancing flexural strength of concrete. Thickness of pavement was evaluated with required parameters as per IRC-58:2002. From the results it was found that the pavement thickness can be reduced up to 25%.
Keywords— Quartzite rock dust, Glass fibers, Flexural strength, Pavement thickness, rigid pavement

I. INTRODUCTION

Currently India has taken a major initiative on developing the infrastructures such as express highways, power projects, ports and harbors, to meet the requirements of globalization, in the construction of pavements and other structures concrete plays the key role and a large quantum of concrete is being utilized in every construction practices. River sand, which is one of the constituents used in the production of conventional concrete, has become very expensive and also becoming scarce due to depletion of river bed. In view of this, there is a need to identify suitable alternative material from waste in place of river sand**.** Quarry dust is a waste obtained during quarrying process. It has very recently gained good attention to be used as an effective filler material instead of fine aggregate**.** In the recent past, good attempts have been made for the successful utilization of various industrial by products (such as fly ash, silica fume, rice husk ash, foundry waste, slag, limestone powder) in concrete and save the environmental sustainability by proper disposal of waste materials

II. LITERATURE

In previous investigations researchers used foundry sand, ceramic dust, fly ash, hypo-sludge, waste plastic and quarry dust were used as alternative materials for sand. Past experimental studies have revealed that use of glass fibers significantly enhances flexural strength of concrete, which in turn reduces the thickness of pavement. Venkata Sairam Kumar, N.B.PandurangaRao, Krishna Sai.M.L.N; et al [1] have investigated on partial replacement of cement with quarry dust for studying mechanical properties of concrete. In this experimental work, the percentages of quarry dust used as a partial replacement of cement in concrete was 0, 10%, 15%, 20%, 25%, 30%, 35%, and 40% for M20, M30, M40 grade concrete. They have concluded from the experimental studies that 25% of partial replacement of cement with quarry dust improved hardened concrete properties**.** Vipul.D.Prajapati,Nilay Joshi, Jayeshkumar Pitroda et al [2] were studied the innovative use of used foundry sand in concrete formulations as a fine aggregate. The fine aggregate was replaced by used foundry sand in the range of 0%, 10%, 30% & 50% by weight for M-20 grade concrete. They found that maximum strengths were attained at 50% replacement of foundry sand. Hence thickness of pavement is effectively reduced when compared to conventional concrete. K Vamshi krishna1 J Venkateswara Rao et al [3] have studied the influence of glass fibers on the mechanical properties of the M20 grade concrete. Glass fibers of 0.1%, 0.2%, and 0.3% by weight of cement are added to the mix. It was found that 0.2% fibers by weight of cement is the optimum dosage. Using the flexural strength values at 0.2% fiber content, pavement thickness was evaluated as per IRC : 58, it is observed that there is a reduction in the pavement thickness by 25.8%. Jayeshkumar Pitroda Dr. L. B. Zala Dr F. S. Umrigar et al [4] have studied cement replacement with hypo sludge in the range of 0%, 10%, 20%, 30% & 40% by weight of sand for M-25 and M-40 mix to improve the engineering properties. 12mm KDM glass fiber was used at rate of 0.56% by weight of cement. The use of glass fibers and hypo sludge replacement was increased the compressive strength, flexural strength of concrete compared to conventional concrete. In the current investigation sand is replaced by quartzite rock dust up to70% and 0.2% Glass fibers by weight of cement were also included. Thickness of pavement is evaluated with parameters by IRC-58:2002.

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III. MATERIALS AND MIX DESIGN

A. Materials

Ordinary portland cement (OPC) of grade 43 with a specific gravity of 3.12, quartzite rock dust is taken from locally available sources, aggregate with a maximum size of aggregate of 20mm down size, and sand were used as coarse aggregate and fine aggregate respectively. Specific gravity of coarse and fine aggregates were found to be 2.78 and 2.71 respectively. The glass fibers of 6 mm length and diameter of 0.012mm are used in the present study. A water reducing admixture, rheo build 920kk is used in concrete. Its density and pH are 1.19 and >6 respectively.

B. Physical Properties Of Aggregate

Material property	Water absorption	Aggregate Impact value	Aggregate crushing value	Flakiness Index	Elongation Index
Percentage	0.5%	26%	29%	9%	12%

Table.1

C. Mix Design

Samples are prepared for M-40 grade. For the design of mix IS: 10262-2009 recommendations are adopted. Mix proportions of M-40 are given in the following table.2.

Material	Cement	Sand	Coarse aggregate	W/C Ratio	Admixture
Weight	440.52kg/m^3	563.5kg/m^3	1135kg/m^3	0.38	2.07lit

Table 2.Mix Proportions

D. Specimens Preparation

In a mixer quartzite dust and cement are mixed thoroughly in required proportions until uniform color was achieved. Next, sand and coarse aggregates are added and mixed thoroughly again for 2 to 3 minutes. Glass fibers respective quantity of fibers are added and mixed for 1 to 2 minutes. The mix was then transferred in to cubes (150mm x 150mm x 150mm) and prisms (100mm x100mm x 500mm). During transferring the mix was compacted in three layers. Mix was then compacted on vibrator to expel the air.

E. Test Setup

The specimens were tested for 7 and 28 day compressive strength. The specimens were subjected to a compressive force at the rate of 5 KN/sec until they failure occurs. The mean value of the compressive strengths of three test cubes in a series is reported as compressive strength of a particular mix. For finding the flexural strength of prisms IS: 516-1959 guide lines are followed.

Fig4.1.Cube Testing

Fig 4.2.Prisims Testing

IV. RESULTS AND DISCUSSIONS

A. Compressive Strength Test

Compressive strength values of cube specimens were at 7&28 days testing given in below graph. From the figure 4.3 it was

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observed that rate of increment in compressive strength of the Quartzite rock dust concrete is 13.58% and 15.33% at age of 7&28 days respectively compared to conventional concrete. From the graph it was clear that there is an improvement in compressive strength of the Quartzite rock dust with glass fibers is 19.9% and 13.86% at age of 7&28 days respectively compared to quartzite rock dust concrete. It is evident that from results compressive strength of Quartzite rock dust concrete with glass fiber increases to 36.19% and 31.32% at age of 7&28 days respectively compared to Quartzite rock dust concrete.

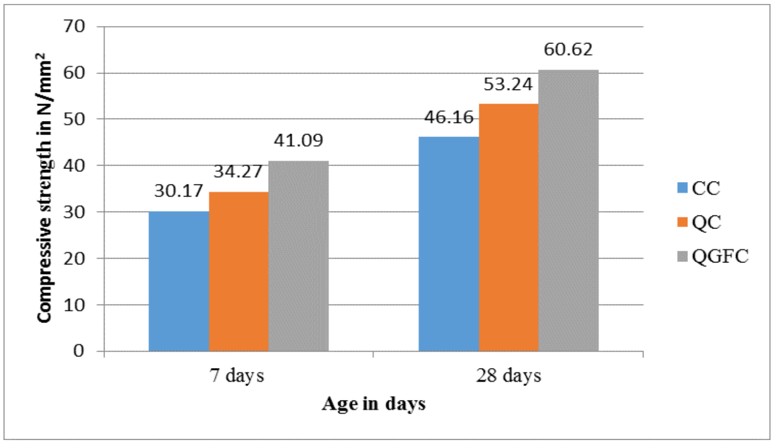

Fig 4.3 Compressive strength of CC,QC & QGFC at 7&28 days

B. Flexural Strength Test

Flexural strength of beam specimens are tested on UTM at 7&28 days .results are given below

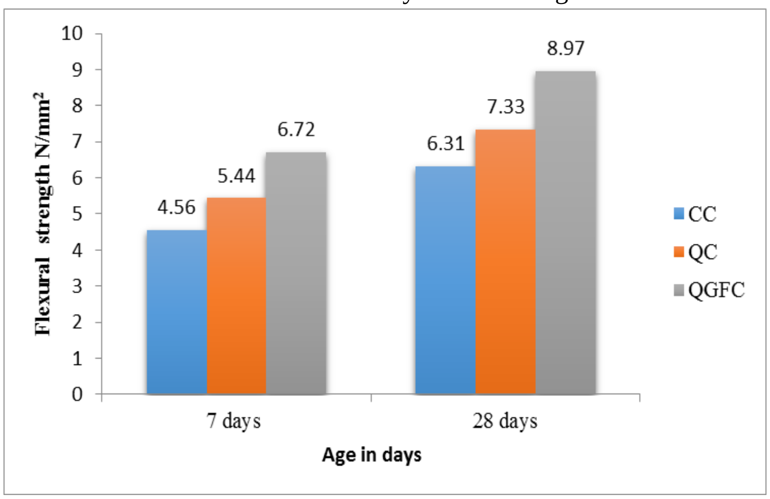

Fig 4.4 Flexural strength values of different mixes at 7&28 days

From the figure 4.4 it was observed that rate of increment in flexural strength of the Quartzite rock dust concrete is 19.29% and 16.14% at age of 7&28 days respectively compared to conventional concrete. From the graph it was clear that there was an improvement in flexural strength of the Quartzite rock dust with glass fibers was 23.52% and 23.37% at age of 7&28 days respectively compared to quartzite rock dust concrete. It was evident that from results flexural strength of Quartzite rock dust concrete with glass fiber increases to 47.36% and 42.15% at age of 7&28 days respectively compared to Quartzite rock dust concrete.

C. *Pavement Slab Design And Analysis*

Pavement slab was designed as per IRC 58:2002. The flexural strength is directly taken from the beam flexural test. The axial load spectrum is taken from IRC: 58-2002 and other data used in this design are given below. A cement concrete pavement was to be designed for a two lane two-way National Highway. The total two-way traffic is 7842 commercial vehicles per day at the end of the construction period.

The design parameters are

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Effective modulus of subgrade reaction of the DLC sub-base	=	8 kg/cm^3
Elastic modulus of concrete	=	3×10^5kg/ cm^2
Poisson's ratio	=	0.15
Coefficient of thermal expansion of concrete	=	$10\times10^{-6}/^0$C
Tyre pressure	=	8 kg/cm^2
Rate of traffic increase	=	0.075
Spacing of contrction joints	=	4.5 m
Width of slab	=	3.5 m
Design life	=	30 years
Present traffic	=	7842 cvpd

Single Axles		Tandem Axles	
Load in tones	Expected repetitions	Load in tones	Expected repetitions
20	644496	36	322248
18	1353442	32	193348
16	3158032	28	580046
14	7218361	24	1417892
12	10183045	20	7282810
10	10311945	16	94909649
Less than 10	14178924	Less than 16	4640375

Table.3 Expected repetitions for single and tandem axles

Taking the above design parameters and expected repetition values into considerations and design the slab thickness according to IRC-58:2002 for conventional, quartzite with and without glass fiber concretes.

Grade of concrete(M_{40})	Flexural strength (Kg/cm^2)	Slab thickness (cm)	Fatigue life consumed	Corner stress (Kg/cm^2)
CC	61.9	25	0.56	23.8
QC	71.9	23	0.47	28.66
QGFC	88.04	20	0.46	34.92

Table.4 Slab thickness design

D. Cost Comparison Of Pavements

Quantity and cost of each material estimated for a stretch of 1m length and 3.5wide pavement. Unit cost of materials per kg of the materials is shown in table.5. Cost of the pavement with various thicknesses for CC,QC and QGFC were determined and was compared to quartzite dust with and without glass fiber concrete to know the cost benefits of using quartzite rock dust and glass fiber. The cost of the pavement for three types of concrete is shown in table.6.

S.no.	Material	Rate per kg in Rs.
1	Cement	6.11
2	Fine aggregate	0.46
3	Coarse aggregate (20mm)	0.88
4	Coarse aggregate (10mm)	0.63
5	Super plasticizer	60
6	Fibers(glass)	150
7	Quartzite rock dust	0.13

Table.5 Cost of each material

Pavement type	Thickness (cm)	Cost (rupees)
CC	25	3714.46
QC	23	3340.48
QGFC	20	3002.92

Table.6 Cost analysis of CC,QC&QGFC pavements

From the above results we can save 711.54 /- Rs per 1m length by using combination of glass fiber and quartzite dust. The construction cost of the pavement was reduced by 23.69% by using combination of glass fiber and quartzite rock dust.

V. CONCLUSIONS

From the test results 50% replacement of sand with quartzite rock dust in concrete improves concrete mechanical properties compared to conventional concrete. Hence it is the optimum replacement of the sand by quartzite rock dust.

It is evident that from the results flexural strength of quartzite rock dust concrete with glass fiber increases to 42.15% at age of 28 days compared to conventional concrete.

Using the optimum dosage of quartzite rock dust with glass fibers in concrete reduces the pavement thickness by 25%.The construction cost of the pavement was reduced up to 23.85%,by using combination of glass fiber and quartzite rock dust.

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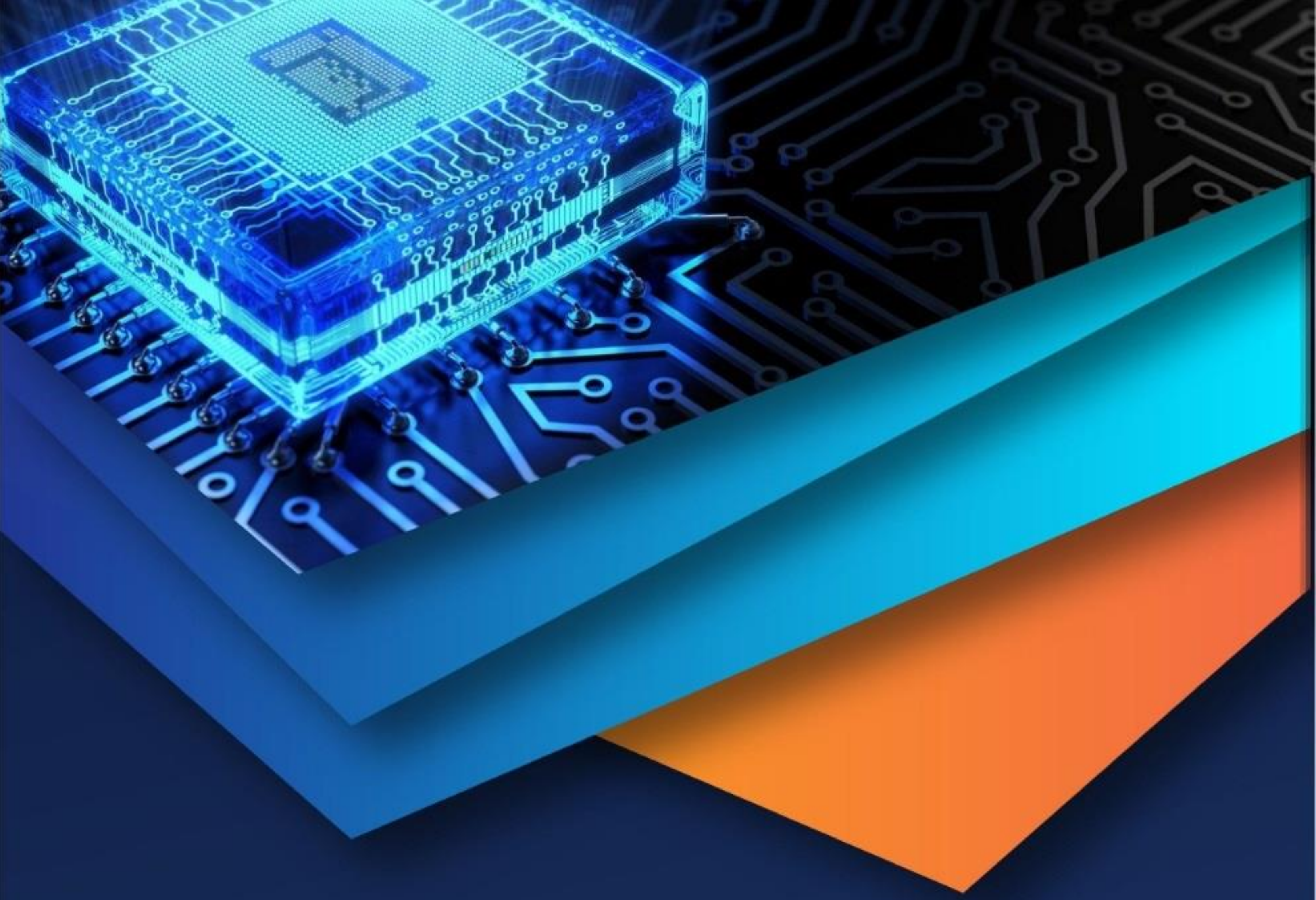

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