WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Experimental Study on Strength Properties of Roller Compacted Concrete Using Admixtures

Mohammed Abdul Razzak[1], Md Shaik Shanawaz[2], K.Nanchari[3]

[1, 2] UG students, Department of Civil Engineering, ISL Engineering College, Hyderabad

[3] Assistant Professor, Department of Civil Engineering, ISL Engineering College, and Hyderabad

ABSTRACT:

Roller compacted concrete for paving is a construction technique that uses zero slump concrete. This type of concrete is transported, placed, distributed and finally compacted using heavy road construction equipments. Generally concrete pavements are widely used for heavy traffic roads and to reduce maintenance. Roller compacted concrete is placed in layers thin enough to allow complete compaction. The optimum layer thickness ranges from 20 to 30 cm. To ensure adequate bonding between the new & old layer are at cold joint, segregation must be prevented and a high plasticity bedding mix must be used at the start of the placement. A compressive strength of above 7 MPa to 30 MPa have been obtained. For effective consolidation, roller compacted concrete must be dry enough to support the mass of the vibrating equipment, but wet enough to allow the cement paste to be evenly distributed throughout the mass during mixing & consolidation process.

Present study deals with the strength properties of roller compacted concrete using admixtures. Metakaolin is used to increase the flexural strength and to reduce the rough texture to the pavements. The present study deals with the usage of Metakaolin, super plasticizer and steel fibres in Roller compacted concrete pavements. Cement is replaced with Metakaolin in varying percentages of 10,20,30,40,50,60% and the specimens are tested for compressive strength, split tensile strength and flexural strength for 3days, 7days and 28days. Super plasticizer is used to increase the workability of concrete, trial mixes are prepared in varying proportion of super plasticizer i.e 2.5, 5.0, 7.5ml per 1kg of cement and the specimens are tested for compressive strength, split tensile strength and flexural strength for 3days, 7days and 28days. Further steel fibres are used in order to improve the tensile strength. Steel fibres are added in different percentages i.e 0.25, 0.50 and 0.75% by volume of concrete. Specimens are tested for compressive, split tensile and flexural strengths for 3days, 7days and 28days. These results are compared with that of normal mix. River sand is replaced with manufacture sand in varying proportions of 0,25,50,75,100% and the tests are conducted and the strengths are compared to that of the conventional concrete.

Keywords: Metakaolin, Steel fibers, Super Plasticizers, Cement, Roller compaction,

Introduction:

Roller compacted concrete is a special blend of concrete that has essentially the same ingredients as conventional concrete but in different ratios, and increasingly with partial substitution of fly ash for Portland cement. Roller compacted concrete is a mixture of cement / fly ash, water sand aggregate or common additives, but contains much less water. The produced mix is drier and essentially has no slump. Roller compacted concrete is placed in a manner similar to paving; the material is delivered by dump trucks or conveyors, spread by small bulldozers or specially modified asphalt pavers and then compacted by vibration rollers. Roller compacted concrete is a recent development particularly in the field of dam construction. Roller compacted concrete is a lean no slump, almost dry concrete that is compacted by vibratory roller. A mixture of aggregates, cement & water are mixed in a conventional batch mixer or in other suitable mixers. Supplementary cementing material, such as fly ash can also be used. In some cases high volume fly ash to the extent of 60% by weight of cement has been used. The cement content ranges from 60 to 360 kg/cu-m

Metakaolin

Metakaolin is defined as kaolin clay that is fired under carefully controlled conditions to create an amorphous alumino silicate that is react in concrete. It is very fine and highly reactive gives fresh concrete a creamy non sticky texture that makes finishing easier. Calcium hydroxide amounts for upto 25% of the hydrated Portland cement and calcium hydroxide does not contribute to the concrete's strength or durability. Metakaolin combines with the calcium hydroxide to produce additional cementing compounds, the material responsible for holding concrete together. Less calcium hydroxide and more cementing compounds means stronger concrete. Specific Gravity of Metakoalin is 3.08. Specific gravity of Metakoalin is determined by density bottle method.

Super Plasticizer

To improve the workability of the fresh Roller Compacted concrete, a CONPLAST SP (430) Super Plasticizer was used in most of the mixtures.

Plasticizers are commonly manufactured from 16 lingo sulphonates, a by-product from the paper industry. Super plasticizers generally have been manufactured from sulphonated naphthalene condensate or sulphonated melamine formaldehyde although newer products based on Polycarboxylic Ethers are now available.

Steel Fibres

Generally, for good reinforcing effect, fibre length is greater than the maximum size of aggregate and the diameter to length ratio (aspect ratio) is more than 50. However, the aspect ratio should be less than 100 because longer fibres tend to form fibre balls. In this study, one fibre lengths with varying percentage were used. The fibre percentage, sizes, and aspect ratios are shown in Table 1. Steel fibres are used in addition to the mix to increase the tensile strength of concrete. The fibres used are of 0.50mm dia and length 3.0cm and is determined based on L/D ratio.

Table 1.1 Shape and size of steel fibres

Sym	**Gravity**	**Length (mm)**	**Diameter (mm)**	**Percentage**	**Aspect ratio**
P1	7.85	30	0.5	0.25%	60
P2		30	0.5	0.50%	60
P3		30	0.5	0.75%	60

Objective and Scope of the study

The aim of the project is to study the strength properties of roller compacted concrete by replacing cement with metakaolin, adding super plasticizer and steel fibres and replacement of river sand with manufacture sand.

Present study deals with the replacement of cement with Metakaolin in varying proportions from 10,20,30,40,50,60% and the specimens are cast, cured and tests for compressive, split tensile and flexural strengths are done and the results for the same are compared to that of the conventional concrete. Secondly super plasticizer is used to increase the workability of concrete in varying dosage of 2.5, 5.0 and 7.5 ml per kg of cement. By observing the results obtained the dosage of super plasticizer is fixed and using the same dosage further mixes are prepared. Further steel fibres are used to increase the tensile strength of the concrete, the fibres are added in varying percentage of 0.25, 0.50 and 0.75% to the volume of concrete and the specimens were cast, cured and the tests for compressive, split tensile and flexural strengths are done and the results for the same are compared to that of the conventional concrete. Apart from adding the admixtures to the roller compacted concrete the fine aggregate river sand is replaced with manufacture sand in varying percentage of 0, 25, 50, 75,100%. The specimens were casted and the strength tests are made and the study is done in strength variation compared to that of the conventional concrete

Methodology:

Study of Materials

The materials that used in the study are Cement , Fine Aggregate , Coarse Aggregate, Metakaolin, Manufacture sand Water

Cement

In the experimental investigation Ordinary Portland cement (53 grade) of 28th day compressive strength 53N/mm^2 was used. The cement procured was tested for physical properties in accordance with IS: 4031-1988.

Fine Aggregate

Fine aggregate (river sand) obtained from local market was used in this study. The physical properties of fine aggregate such as specific gravity, fineness modulus, porosity, void ratio etc were determined in accordance with IS: 2368-1963.

Coarse Aggregate

The properties of coarse aggregate like size of aggregate, shape, grading, surface texture etc play an important role in workability and strength of concrete.

Specific Gravity

The specific gravity test was performed on coarse aggregate and specific gravity was found to be 2.72.

Water Absorption

Water absorption is an important property to be considered since it affects the water cement ratio largely. The water absorption of aggregate is determined by measuring the increase in weight of an oven dry sample when in water for 24 hours

Bulk density & Void ratio

Bulk density is the weight of material in a given volume and percentage voids is the ratio of volume of voids to the total volume. To determine the bulk density, the aggregates are filled in the container and then they are compacted in a standard manner. The weight of the aggregate gives the bulk density.

Metakaolin

Metakaolin is defined as kaolin clay that is fired under carefully controlled conditions to create an amorphous alumino silicate that is react in concrete. It is very fine and highly reactive gives fresh concrete a creamy non sticky texture that makes finishing easier.

Mix Design

Materials properties are tested and calculated, In the first approach, a number of trial mortar mixtures (cement +water+ aggregates), different in W/C is selected that meets the required strength and S/C. After determining the above-mentioned ratios, the proportion of coarse and fine aggregates is adjusted to meet the specified consistency. In the second technique, the proportion of coarse aggregates is fixed according to the recommended gradation curves initially. Then, for the fixed or adjusted aggregate proportion, a number of concrete mixtures varying in their cementations material contents (cement with or without fly ash) are prepared. For each sample, the compaction process is carried out according to AASHTO-T 180 D standards. After compaction of each sample is completed, the dry density curve is determined with respect to the water content. From this curve, the compressive strength is measured using the optimum moisture content (OMC). The mixture fulfilling the compressive strength requirements with a minimum proportion of cementations material is then chosen.

Table: 2 Weights per cubic meter of concrete:

Ingredient	**Weight per m^3**
Cement	$0.371x10^{-3}$ x 3150 x 236.2= 276 kg
Sand (FA)	$1.358x10^{-3}$ x 2620 x 236.2= 850 kg
Coarse Aggregate	$1.88x10^{-3}$x 2720 x 236.2= 1274.4 kg
Water	$0.54x10^{-3}$x 1000 x 236.2= 127.55 kg
Density of Concrete	= 2528 kg/m^3

Cement = 13%

Calculation of Absolute volumes for 9 kg of aggregate

Table: 3 Unit weight and volumes for 13% cement content

Ingredient	**Sp. Gravity**	**Unit Weight (kg/m^3)**	**Volume in m^3**
Cement	3.15	3150	$0.371x10^{-3}$
Sand (FA)	2.62	2620	$1.358x10^{-3}$
Coarse Aggregate	2.72	2720	$1.88x10^{-3}$
Water	1.00	1000	$0.54x10^{-3}$
Total Volume	$4.149x10^{-3}$		

Cement = 14%

Calculation of Absolute volumes for 9 kg of aggregate

Table: 4 Unit weight and volumes for 14% cement content:

Ingredient	**Sp. Gravity**	**Unit Weight (kg/m^3)**	**Volume in m^3**
Cement	3.15	3150	$0.4x10^{-3}$
Sand (FA)	2.62	2620	$1.358x10^{-3}$
Coarse Aggregate	2.72	2720	$1.88x10^{-3}$
Water	1.00	1000	$0.54x10^{-3}$
Total Volume	$4.178x10^{-3}$		

Cement = 15%

Calculation of Absolute volumes for 9 kg of aggregate

Table: 5 Unit weight and volumes for 15% cement content:

Ingredient	**Sp. Gravity**	**Unit Weight (kg/m^3)**	**Volume in m^3**
Cement	3.15	3150	$0.428x10^{-3}$
Sand (FA)	2.62	2620	$1.358x10^{-3}$
Coarse Aggregate	2.72	2720	$1.88x10^{-3}$
Water	1.00	1000	$0.54x10^{-3}$
Total Volume	$4.2x10^{-3}$		

Cement = 16%

Calculation of Absolute volumes for 9 kg of aggregate

Table: 6 Unit weight and volumes for 16% cement content:

Ingredient	Sp. Gravity	Unit Weight (kg/m^3)	Volume in m^3
Cement	3.15	3150	$0.457x10^{-3}$
Sand (FA)	2.62	2620	$1.358x10^{-3}$
Coarse Aggregate	2.72	2720	$1.88x10^{-3}$
Water	1.00	1000	$0.54x10^{-3}$
Total Volume	$4.235x10^{-3}$		

Results

Results obtained from experimental investigations are the compressive strengths, split tensile strength, Flexural strengths of various concrete mixtures containing Ordinary Portland cement along with coarse and fine aggregates, Metakaolin, Manufacture sand respectively.

Table: 7 Results for Compressive Strength Using Metakaolin:

Percentage Of Metakaolin	Compressive Strength (N/Sqmm)		
	3 Days	7 Days	28 Days
10	16.80	20.40	33.33
20	12.00	22.20	26.67
30	4.90	13.33	17.77
40	9.70	15.50	18.66

50	15.38	27.70	33.70
60	6.66	7.77	8.88

Graph No 1 Compressive Strength Using Metakaolin:

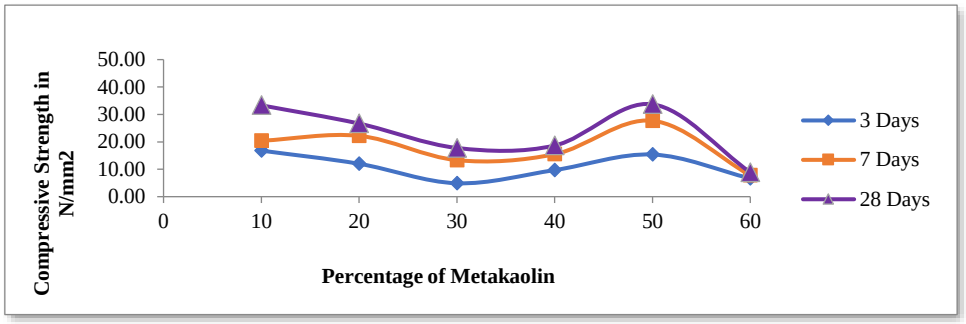


Table No 8 Results for Split Tensile Strength Using Metakaolin

Percentage Of Metakaolin	Split Tensile Strength (N/Sqmm)		
	3 Days	7 Days	28 Days
10	1.69	2.76	4.24
20	1.13	3.75	4.10
30	0.83	1.92	2.90
40	1.13	2.26	3.89
50	2.21	4.03	4.38
60	0.92	0.92	1.77

Graph No 2 Split Tensile Strength Using Metakaolin

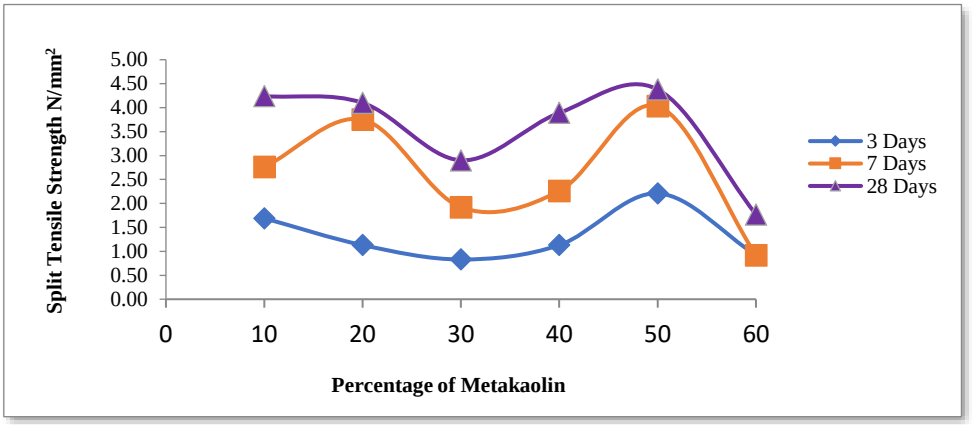


Table No 9 Results for Compressive Strength Using Super Plasticizer

Dosage Of Super Plasticizer(Ml/Kg Of Cement)	Compressive Strength (N/Sqmm)		
	3 Days	7 Days	28 Days
2.50	15.11	28.44	34.66
5.00	24.44	30.22	40.44
7.50	28.44	32.85	42.22

Graph No 3 Compressive Strength Using Super Plasticizer

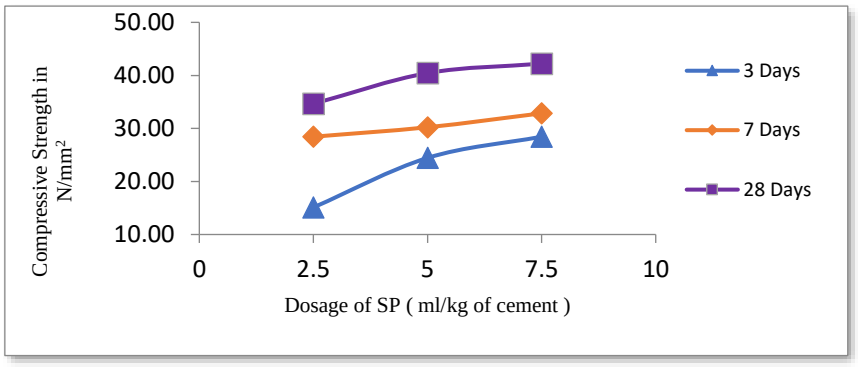
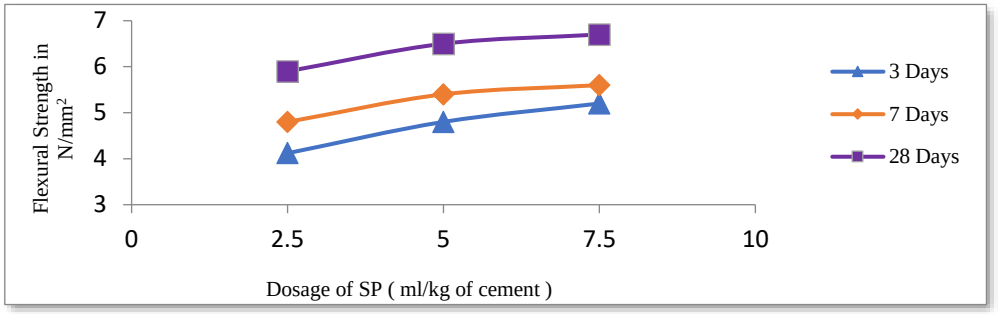


Table No 10 Results for Flexural Strength Using Super Plasticizer

dosage of super plasticizer(ml/kg of cement)	flexural strength (n/sqmm)		
	3 days	7 days	28 days
2.50	4.12	4.80	5.90
5.00	4.80	5.40	6.50
7.50	5.20	5.60	6.70

Graph No 4 flexural strength using super plasticizer



Effect of Metakaolin on different concrete mixes

variation of compressive strength for 3 days, 7 days and 28 days for various concrete mixes such as concrete in which the cement is replaced with Metakaolin. It is observed that there is increase in strength at 50% replacement of cement with Metakaolin. It is observed that there is 3.5% decrease in the strength with reference to the conventional concrete to that of replacement of cement with Metakaolin

Effect of Super Plasticizer on different concrete mixes

The results shows the variation of compressive strength for 3 days, 7 days and 28 days for various concrete mixes such as concrete in which the super plasticizers is added in different dosages. It is observed that there is increase in strength by increasing the dosage of super plasticizer. It is observed that there is 21% increase in the strength with reference to the conventional concrete for 7.5ml/kg of cement dosage of super plasticizer.

Effect of Steel Fibres on different concrete mixes

From the above results the variation of compressive strength for 3 days, 7 days and 28 days for various concrete mixes such as concrete in which the steel fibres is added in different percentages. It is observed that there is increase in strength by increasing the percentage of steel fibres. It is observed that there is 25% increase in the strength with reference to the conventional concrete for 0.75% of steel fibres to the volume of concrete.

Conclusion

1) The modified Vb value of steel fiber reinforced roller compacted concrete is greater than that of conventional roller compacted concrete, and the change in Vb value for each 1 kg/m3 change in water content is about 3 to 4 seconds, regardless of the presence of fibers. For a given unit water content, there exists a sand percentage at which the modified Vb value reaches a minimum. This sand percentage is about 40% regardless of fiber content.

2) It is observed that the VC values are increasing by the increase of super plasticizer dosage. Based on this the dosage of super plasticizer is fixed to 7.5ml/kg of cement.

3) Using of Metakaolin as cement replacement it is observed that the split tensile strength is only increasing and it is recommended replacement of cement with Metakaolin is upto 20% only.

4) Flexural strength of the samples casted by using super plasticizer is compared with the conventional concrete. It is observed that the flexural strength of the concrete is increasing by increasing the dosage of super plasticizer. By the obtained results it is observed that the flexural strength is increased by 10% to that of conventional concrete.

5) Compressive strength and split tensile strength of the concrete using super plasticizer is increasing by 21% and 32% respectively as compared to that of the conventional concrete.

6) It is observed that the split tensile strength of the concrete increases by increasing the percentage of steel fibers and it is noted that the strength increases by 35%.

7) As the steel fibers are used to increase the split tensile strength it is observed that the strength is twice the strength obtained for conventional concrete. It is recommended to use the steel fibers in 0.75% to the volume of concrete.

8) Flexural strength of the samples casted by using steel fibers along with super plasticizer is compared with the conventional concrete and it is observed that the flexural strength of the concrete is increasing by increasing the percentage of steel fibers. By the obtained results it is observed that the flexural strength increases by 20% to that of conventional concrete.

9) As the roller compacted concrete is free of reinforcement the usage of steel fibers will give the good results.

10) By using the manufacture sand as replacement to the river sand it is observed that the compressive strength and split tensile strength are increasing upto 50% replacement of river sand with manufacture sand. The percentage of increase in compressive and split tensile strength is 37% and 43% respectively with reference to the conventional concrete.

11) Flexural strength of the concrete by replacing of river sand with 50% manufacture sand is increased by 10% compared to conventional concrete. It is recommended to replace the river sand is upto 50% with manufacture sand

References:

Research Papers:

1) Benoit, F., “Fiber-Reinforced Roller-Compacted Cement Concrete (Roll fiber) for Continuous Cement Pavement”, 8th Int’l Symposium on Concrete Roads, Theme II “Progress in Concrete Road Materials and in the Construction Process”, pp.319-323, (1998)

2) Antonio, N., and Aziz, J., “RCC Pavement Reinforced with Steel Fibers”, Concrete International, pp. 64-69, March, (1989)

3) Kagaya, M., Fujita, H. and Inaba, Y. “Experimental Study on Improvement of Properties of Roller-Compacted Concrete for Pavement with Superplasticizer and Viscous Agent”, Concrete Research and Technology, JCI, Vol.10, No.1, pp.101-108,Jan. (1999)

4) Kokubu, M., “Construction Material Experiment”, pp.118-122, (1998)

5) Japan Concrete Institute, “Committee Report on Very Stiff Concrete”, JCI-TC-962, pp.10-14, (1998)

6) Noda, E., Kong, Y. and Kasahara, Y. “Basic Study on Ultra-thin White Topping”, Proc. Of the 2ndConference on Pavement Engineering, PP.45-52, (1997)

7) JSCE, “Specification on the Design and Construction of Steel Fiber Reinforced Concrete”, pp.72-73, (1983)

8) Kokubun, S., “Experimental Study on Properties and Application for Pavement of Roller-Compacted Concrete With and Without Steel Fiber”, Doctorate Thesis, Akita University, pp55-56, (1997)

9) Kobayashi, S., Morihama, K. and Nishikawa, M., “Experimental Consideration on Strength and Frost Resistance of Roller-Compacted Concrete for Pavement”, Civil Engineering Journal, Vol.33, No.7, pp.29-34, (1991)

10) Kuzu, T., Hara, J., and Kokubu, K., “Study on Resistance to Freezing and Thawing of Roller-Compacted Concrete, Proc. of JCI, Vol.12, No.1, PP.697-702, (1990)