A study on strength properties of roller compacted concrete with 30% replacement of OPC 53 grade cement by flyash.

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Abstract
Roller compacted concrete is a zero-slump concrete, low water content, dense mix consisting of coarse aggregate, sand, cementitious materials, and water. By using conventional vibrators, it is very difficult to compact for larger thicknesses. There is a chance of getting honey combing and inconsistency with respect to laboratory values. To rectify this, roller compacted concrete technique is proposed by preparation of samples. In this an attempt is made to prepare M15 and M20 mixes at their optimum moisture content and tested for compressive and split tensile strengths for various time periods (i.e., 3days, 7days, 14 days and 28 days). From these results, it is observed that higher strengths at early periods are obtained. When cylinders were tested, the compressive strength for M15 and M20 mixes at 28 days are 25Mpa and 31Mpa respectively. Similarly, for M15 and M20 mixes at 28 days, the split tensile strengths are 1.7Mpa and 1.9Mpa respectively. Since high strengths are obtained in compression and tension, it can be used as base course and sub-base course for flexible and rigid pavements.

Keywords: Roller compacted concrete, Compressive strength, Split tensile strength, Grade of concrete and water cement ratio

Introduction
Roller compacted concrete is a zero-slump concrete consisting of dense-graded aggregate and sand, cementations' materials, and water. Because it contains a relatively small amount of water, it cannot be placed by the same methods used for conventional (slump) concrete. Roller compacted concrete has the same basic ingredient as conventional concrete: cement, water, and aggregates. The basic difference is that roller compacted concrete is a much drier mix with practically zero slumps. It is drier, and looks and feels like damp gravel. It does not require any forms, dowels, reinforcing steel & finishing. Also, the method of compaction is different than the conventional compacted concrete and it is compacted by vibratory or pneumatic-tired rollers. The objective of mix design is to produce a roller compacted concrete mix that has sufficient paste volume to coat the aggregates in the mix and to fill in the voids between them. Any of the basic roller compacted concrete proportioning methods like those based on concrete consistency testing, the solid suspension model, the optimal paste volume method, and soil compaction testing may be used for mix design. Roller-Compacted Concrete uses aggregate sizes often found in conventional concrete. However, the blending of aggregates will be different than that done in case of conventional concrete. Crushed aggregates are preferable in roller compacted concrete mixes due to the sharp interlocking edges of the particles, which help to reduce segregation, provide higher strengths, and better aggregate interlock at joints and cracks. The use of roller compacted concrete for pavements at industrial facilities such as port and intermodal container terminals is particularly appropriate because of the ability to construct low-cost concrete pavements over large areas. Roller compacted concrete is also used in Bulk material storage, General cargo storage, Container terminals, Road / rail transfer facilities, Truck parks, Tank roads and parking, Sewage sludge stacking, Composting slabs and Pre-casting yards.

Objective and scope
To carryout soil compaction procedure for M15 and M20 grades for find out optimum moisture content. Casting of cubes and cylinders of M15 and M20 grades with 30% fly ash replacement to know compressive and split tensile strengths.

Materials and Methods

Cement

Ordinary Portland Cement of 53 Grade conforming to Bureau of Indian Standards (I.S. 12269: 1987) was used in the present investigation. The cement was tested for various properties as per I.S. 4031: 1981.

Test name		**Result**
Consistency		30%
Specific gravity		3.12
Setting time	Initial	45 minutes
	final	375 minutes

Flyash

Flyash used in this experimental work was obtained from National Thermal Power Corporation (NTPC), Visakhapatnam. Flyash is finely grained residue resulting from the combustion of ground or powdered coal. Mean particle size is about 0.1 to 0.2 µm and finer than cement and consist mainly of glassy spherical particles as well as residues of hematite and magnetite. The specific gravity, specific surface area and density of flyash are 2.84, 310 m^2/kg and 1.4 kg/m^3 respectively.

Fine Aggregate

Locally available river sand passing through 4.75 mm sieve and retained on 75 micron sieve were used.

Coarse aggregate

Crushed blue granite of coarse aggregate passing through 24mm sieve and retained on 20mm sieve were used.

Water

Potable water was used for the concrete. The pH value was 7.25. The same water was used for mixing and curing of concrete cubes and cylinder.

Experimental Procedure

Mix design

Mix proportion of 1:2:4 and 1:1.5:3 were assumed on nominal basis for M15 and M20 grades respectively.

Testing methodology

Optimum moisture content by Modified Proctors test for both the grades (M15 and M20) of concrete, 2% of water (i.e. 140ml for M15 and 110ml for M20) is added to its weight of mix proportion and mixed thoroughly in a basin. Empty weight of CBR mould (Height 17.5cm and Diameter 15cm) is taken. Now the mould is placed on proctor test apparatus and filled with the concrete in five layers. After placing of each layer, 56 blows were applied on mix with a free drop of 4.89 kg rammer from a height of 450mm and then the top surface leveled by trowel. Now the weight of the mould with mix is determined. Density of sample is determined by the ratio of compacted mix weight by volume. By this dry density of sample is calculated. This procedure was repeated by increasing the water percentage by 2% up to 10%. A graph is drawn between the moisture content verses dry density. By this optimum moisture content (OMC) and maximum dry density are determined. Using this optimum moisture content cubes and cylinders are prepared.

Slump cone test

The cement and fine aggregate are mixed thoroughly until uniform color on a rigid and non absorbent surface. Then coarse aggregate is added and mixed it thoroughly and then water is added and mixed it until the concrete appeared to be homogenous. Slump cone mould is thoroughly cleaned and oil is applied inside of it. Now the mixed sample is placed in three layers. After placing of every layer in mould, 25 blows were applied on it by using tamping rod taking care to distribute the strokes evenly over the cross section. After complete filling of three layers, the top surface is leveled with trowel. Now slowly lift the slump cone mould vertically without disturbance of placed sample. Height of the sample specimen is noted. The difference between the initial and final height of the sample gives the slump value in mm.

Casting

Cube moulds of 150mm in size were cast in conventional method to know the compressive strengths of grade of concrete. The cylindrical moulds of diameter 150mm X height 300mm were cast to know the split tensile strength test. These moulds were cleaned and applied oil inside surface. Now the moulds were placed on vibration machine and filled with green concrete in five layers by giving vibration to each layer for a period of 2 minutes.

Curing:

The test specimens are stored in moist air for twenty four hours and then specimens are de-mould and submerged in clear fresh water for 28 days.

Procedure (testing):

Specimens are removed from water after curing, wiped out the excess water and the surface is dried. The specimens are placed in CTM and then tested for compressive strength as per IS: 516-1959 and the results were tabulated.

Methodology and Experimental Investigation

M15 Grade concrete cubes of 150mm were used to determine the compressive strength. In total 24 cubes were cast, among which 12 cubes were without flyash and the rest were with flyash as replacement of cement by 30%, and cured in water for a period of 28 days. The compressive strength was carried out after 3, 7, 14 and 28days.

M15 Grade concrete cylinders of diameter 150mm X height 300mm of 48 numbers were cast to study compressive strength and split tensile strength. Out of 48 cylinders 24 numbers were without flyash and the remaining was with flyash. The cylinders of 24 numbers were divided in to 2 sets, as 12 in each set. 1st set is for compressive strength test and the 2nd set is for split tensile strength test. These specimens were tested under CTM as per IS 516: 1959 and strengths were calculated for 3, 7, 14 and 28 days, and the results were tabled.

Similar procedure was carried out for the M20 grade concrete also and the results were tabled.

Mix notation	Shape of specimen	3 day Strength in MPa	7 day Strength in MPa	14 day Strength in MPa	28 day Strength in MPa
M15 C	Cube	15.22	22.44	25.11	30.88
M15 C	Cylinder	10.11	18.22	20.55	24.66
M15 S	Cylinder	1.10	1.20	1.50	1.60
M15 FR30C	Cube	14.55	22.88	25.66	31.44
M15 FR30C	Cylinder	12.33	18.77	21.88	25.56
M15 FR30S	Cylinder	1.10	1.30	1.50	1.70
M20 C	Cube	18.66	24.55	32.00	36.22
M20 C	Cylinder	15.22	20.11	24.99	29.33
M20 S	Cylinder	1.20	1.50	1.60	1.9
M20 FR30C	Cube	18.00	24.22	33.44	37.11
M20 FR30C	Cylinder	15.66	20.66	26.22	31.33
M20 FR30S	Cylinder	1.20	1.50	1.70	1.90

*C: Compressive strength; S: Split tensile strength; FR30: Flyash replacement by 30%

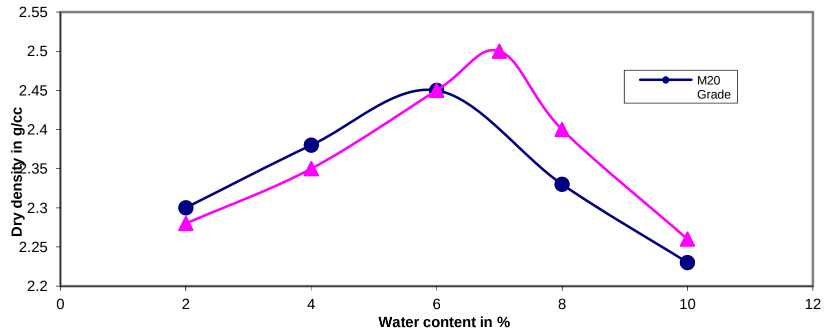
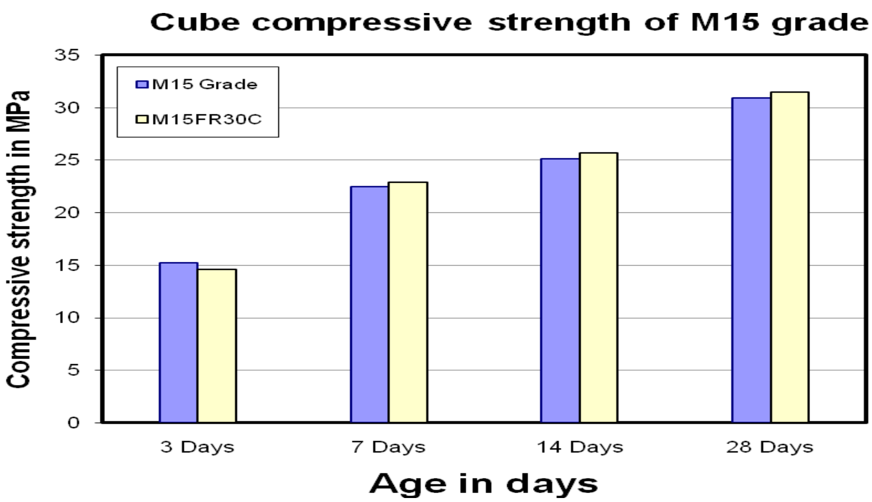
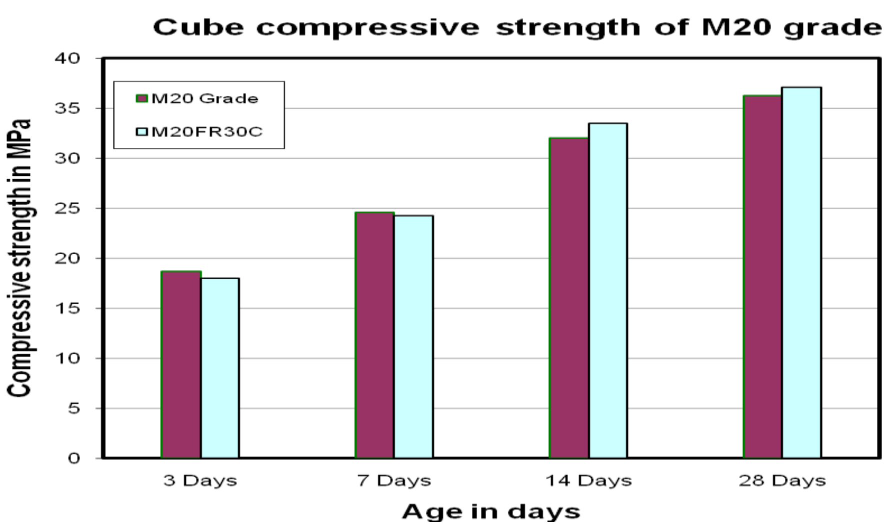
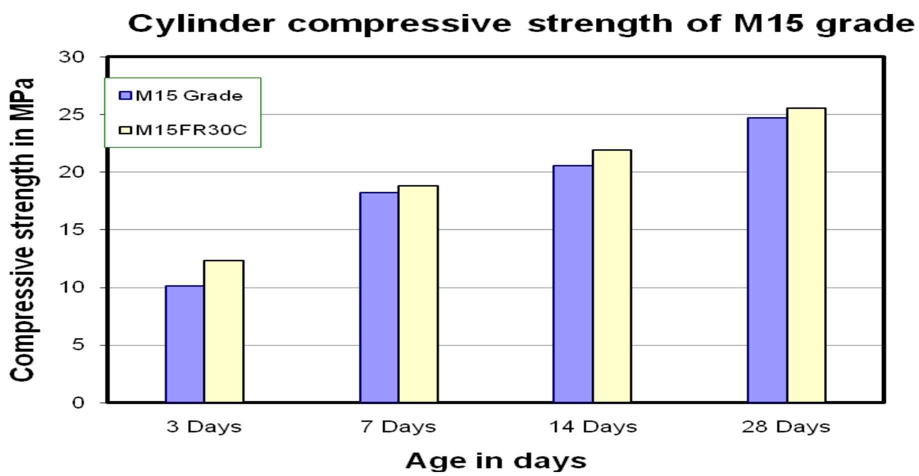
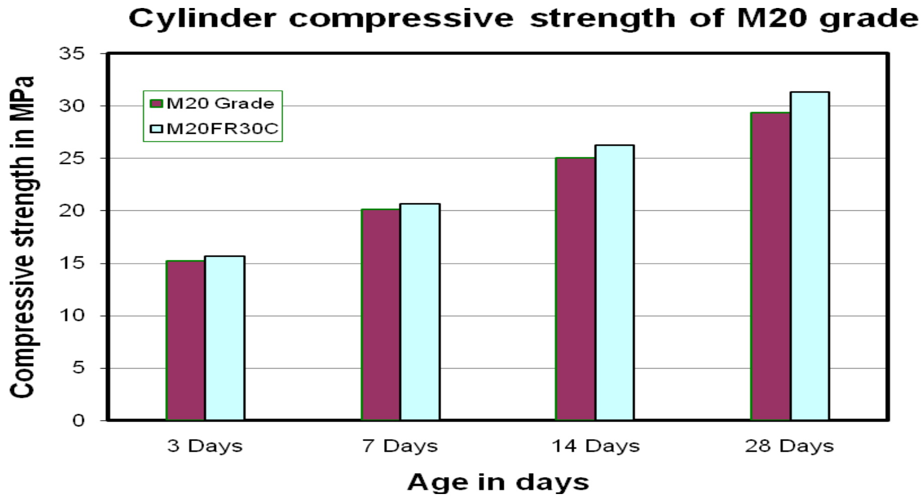


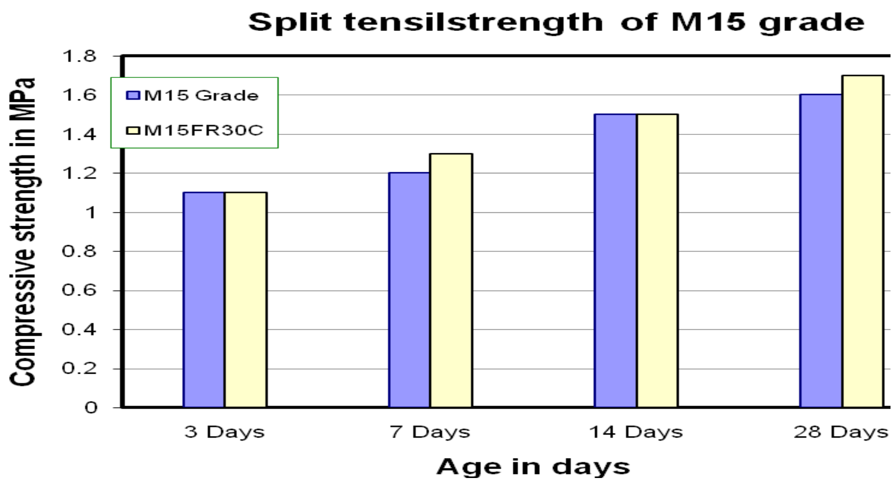
Figure 1 Optimum moisture contents for M15 and M20

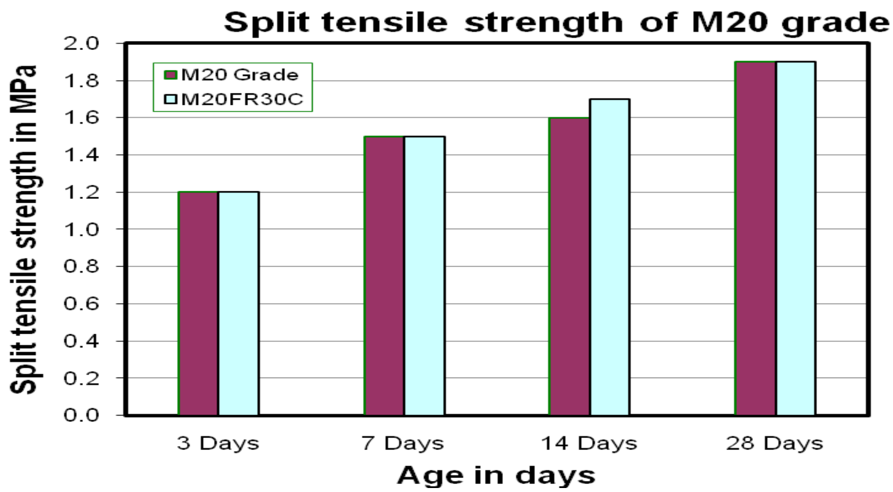





Cylinder compressive strength of M15 grade
M15 Grade
M15FR30C
Compressive strength in MPa
30
25
20
15
10
5
0
3 Days
7 Days
14 Days
28 Days
Age in days


Cylinder compressive strength of M20 grade
M20 Grade
M20FR30C
Compressive strength in MPa
35
30
25
20
15
10
5
0
3 Days
7 Days
14 Days
28 Days
Age in days


Split tensilstrength of M15 grade
M15 Grade
M15FR30C
Compressive strength in MPa
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
3 Days
7 Days
14 Days
28 Days
Age in days



Results and Inferences

For M15 and M20 grade mixes, the maximum dry density was observed as 6% and 7% respectively by weight of their proportions and zero slump were noted. The figure 1 represents the same.

The compressive strengths of concrete cubes of M15 and M20 grades of 30% replacement of cement by flyash was performed almost same strengths M15 and M20 grades of concrete mixes without any replacement of cement.

The compressive strengths of roller compacted concrete cylinder specimens of M15 and M20 grades of 30% replacement of cement by flyash was performed almost same strengths M15 and M20 grades of roller compacted concrete mixes without any replacement of cement.

The split tensile strengths of roller compacted concrete cylinders of M15 and M20 grades of 30% replacement of cement by flyash was performed almost equal strengths M15 and M20 grades of roller compacted concrete mixes without any replacement of cement.

From the above investigations it was observed that the compressive strength of cube and cylinder specimens of M15 and M20 grades with and without replacement of 30% flyash was showed same performance with a marginal difference. The same trend was observed in split tensile strength of cylindrical specimens also. This experimental results conclude that roller compacted concrete of M15 and M20 grades with 30% fly ash replacement can be used for both base and sub base course. Because flyash was an industrial waste by product and disposal of it is a great problem.

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