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Study Of Characteristics Strength of Concrete with Admixtures by Flexural and Disc Bending Test

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ABSTRACT
Concrete is widely used in structural engineering with its high compressive strength, low cost and abandoned raw material, but common concrete has some deficiency, such as shrinkage and cracking, low tensile strength and flexural strength, high brittleness, that restrict its applications. To overcome these deficiencies' additional materials are added to improve the performance of the concrete. Super plasticizer is a chemical added to conventional concrete mix that makes the concrete more workable and it can be placed easily. The aim of this project work to study the characteristics strengths of concrete such as compressive strength, flexural strength, split tensile strength, diametric strength and tensile strength by disc bending test. For the experimental work normal concrete M 40 has to be prepared and characteristics strength such as compressive strength, tensile strength, and flexural strength have to be achieved. This strength has to be performed after 7 days and 28 days curing. After that in addition of super plasticizer the study of the strength have to be performed with various % of plasticizer such as 0.60% to 1.2 % by the weight of cement and study of strength of concrete have to be performed at 7 days and 28 days. A relative comparison of the strength of the concrete with addition of admixtures with normal concrete can be study.
KEYWORDS: compressive strength, flexural strength, disc bending test, M 40, Super plasticizer.

I. INTRODUCTION

Concrete is most widely used construction materials because of its specialty of being cast in any desirable shape. It has replaced stone and brick masonry. In spite of all this, it has some serious deficiency for its remarkable qualities of resilience, flexibility and ability to redistribute stress, would have prevented its use as a building material Plane concrete is weak in tension and has limited ductility and little resistance to cracking. Micro cracks are present in concrete and because of its poor tensile strength; the crack propagates with the application of loads, leading to brittle fracture of concrete. Micro cracks in concrete are formed during the hardening stage. A discontinuous heterogeneous system exists even before application of any external load. When the load is applied, micro cracks start developing along the planes which may experience relatively low tensile strains at about 20 -25 % of the ultimate strength in compression. Further application of load leads to uncontrolled growth of micro cracks. The low tensile strength of concrete being compensated for in several ways, and this has been achieved by the use of reinforcing bars and also by applying prestressing method. Though these methods provide tensile strength to concrete member, they do not increase the inherent tensile strength of concrete itself. Further conventionally reinforce concrete is not a two phase material in true sense. These deficiencies have laid researchers to investigate and develop a material which could perform in area where conventional concrete has several limitations. One such development has been two phase composite material i.e. Admixture and concrete. Preventing these from enlarging under load into cracks which eventually cause failure. Prevention of propagation of cracks originating from internal flaws can result in improvement in static and dynamic properties of the matrix. There is currently a great deal of interest in developing the technology for using admixture in cement composites. With change in time, demands are also changing but the inherent properties of material remains same. So for the solution of existing problems, new materials are ought to be developed. The challenged behind such material is that it should be easily available. Admixtures possess all the property be need hence it has become the most important construction materials. These days concrete are being used for different purpose. In these conditions ordinary concrete may fail to exhibit the required quality performance. In such case to modify the properties of concrete so as to make its suitable for different conditions admixtures are used.

II. LITERATURE REVIEW

Rosenhaupt, Van Real and Wijler, 1957 Proposed a new indirect method of deterring the tensile strength of concrete. In this test a compressive load is applied along the middle of two opposite faces of a concrete cube. The tensile stress thus setup result in a rupture of the specimen along the plain containing the load. As in the case of split test applied to cylinders, the same moulds and loading apparatus can be used for both tension and compression tests. Moreover the test is even simpler as the problem of alignment does not arise. Nevertheless a detailed experimental and theoretical investigation is required to make the test generally acceptable and to define all the conditions and limitations that may be necessary. For example no optimum relation between the width of loading strip and the cube size has been given.

B.R. Sen. and A.L. Bharara,1961 Proposed a new indirect tensile test for concrete. In this test a compressive load is applied in a vertical plane on two opposite faces of a concrete prism obtained by breaking a specimen by the flexure test. The split along the plane containing the load due to tensile stresses setup. An advantage of this method which may be called the " prism split test" is that the bending , compression and tensile strengths of concrete can all be obtained from one specimen.

III. EXPERIMENTAL PROGRAM

3.1 Materials

The material used in present investigation were locally available in Sindri, Dist-Dhanbad(Jharkhand) and physical properties were found through various laboratory tests conducted in Concrete and Road material lab, B.I.T Sindri.

3.1.1 Fine aggregate

Ordinary sand available in Sindri, Dhanbad (Damodar river sand) having following properties has been used :

Fineness modulus : 2.77
Unit weight : 1.674 gm/cc
Water absorption : 0.44%
Bulking : 26%
Sand after sieve analysis confirm to zone-II as per IS 383-1970.

3.1.2 Coarse aggregate

Locally available black crushed stone (Pakur stone) in Sindri with maximum nominal size of 20 mm and 10 mm have been used as coarse aggregate. The physical properties for the coarse aggregate as found through laboratory test according to IS 2386-1963 is resulted as

Aggregate crushing value =24%
Aggregate impact value = 29%
Specific gravity = 2.64
Water absorption = 0.94%
Unit weight = 1.60gm/cc
Fineness Modulus = 6.15

3.1.3 Cement

Commercially available Portland slag cement confirming to IS 455: 1989[5]with brand name (ACC CEMENT) was used M-40 grade of concrete.
The physical properties of the cement are given as

Initial setting time (minute) : 145
Final setting time (minute): 230
Specific surface (m^2/Kg) : 325
Specific gravity: 3.15
Residue on 200 µm (%) : 1.00
Normalconsistency (%) : 28
28 days compressive strength (MPa) : 49
Le-Chatelier expansion (mm) : 0.5

3.1.4 Water

Tap water was used throughout the test procedure which is available in concrete laboratory

3.2 Mix design of concrete

Using Indian Standard recommended guidelines for mix design of concrete of grade M-40 as per IS 10262-2009. The mix proportion is calculated and the value of different ingradients for one cubic meter concrete by mass is given as

Water (kg/m3)	Cement (kg/m3)	Fine aggregate (kg/m3)	Coarse aggregate (kg/m3)
148.50	450.0	663.0	1258.0
0.33	1	1.473	2.8

3.3 Mixing and casting procedure

The specimen were prepared according to IS 516-1959. Mixing of all the material were done manually in the laboratory at room temperature.

The coarse aggregates, fine aggregates and cement were weighed and placed on the mixing floor, moistened in advance and mixed homogeneously. After mixing these ingradient, weight the water and placed on the dry mix. The mixing of total mass was continued until the binding paste covered all the aggregates and mixture become homogeneous and uniform in colour. Fresh concrete was castin steel mould and each cube specimen was cast in three layers by compacting manually(as shown in fig 2.2) as well as by using vibration table as shown in fig.(2.3). Each layer received 35 strokes of compaction by standard compaction rod for concrete, followed by further compaction on the vibration table.The cube specimens of size 150×150×150 mm size were used for compressive strength determination after demoulding at one day, the specification were cured in water at 20^{o}c until 28 days age and then cured in air with a temperature of 20^{o}c and 50% relative humidity.

After the feeding operation, each of the specimen was allowed to stand for 24 hours before demoulding, stored in fresh tap water at 20 ± 2^{o}c for 28 days and the removed and kept at room temperature until the time of the experiment.

Figure- 1 Compaction on vibrating table.

IV. TESTING METODOLOGY

Three cubes each was tested for different strength at 7 days and 28 days of curing using testing machines.

4.1 Compressive strength test:- For this it is proposed that 6 (six) cubes of the size 150mm×150mm×150mm have to be cast for each set (i.e. for nominal concrete and with variation of different % of admixtures(0.6% to 1.2%) or super plasticizers),which will be tested after 7 days and 28 days curing separately.

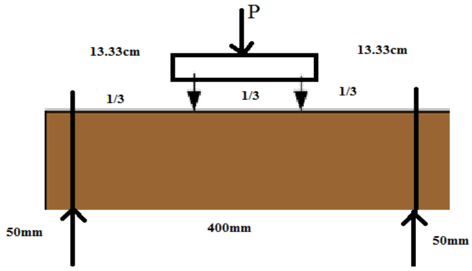
4.2 Determination of tensile strength: - two methods are available for determination of tensile strength (a) direct pull test. (b)Indirect test.

4.2.2 Direct pull test: - The direct pull test is difficult to conduct free of eccentricity and is further complicated by secondary stresses induced by the gripping devices (Davies and boss-1968 and Neville-1977)

4.2.3 Indirect test: - these difficulties gave rise to the use of indirect tensile tests. Two methods are widely used for indirect test namely (I) Modulus of rupture test (ii) Splitting test.

4.3 Modulus of rupture test (ASTMC-78):- In the modulus of rupture test, concrete beams of size of 500mm×100mm×100mm, are subjected to centre point loading or symmetrically two point loading with clear span of 400mm.the tensile stress in the bottom face of the beam at failure (none as modulus of rupture), is calculated by assuming that the stresses across the section is proportional to the distance from the modulus of rupture test is higher than that determined from the direct from the direct tensile test made on concrete from the same batch. The explanation for this was given by

(Neville-1977)



The modulus of rupture is determined by the formula,

$f_r = \frac{M}{bd^2} = \frac{PL}{bd^2}$

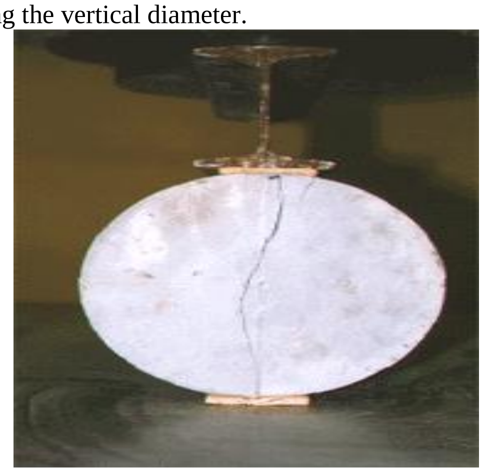
Where, p=applied load.

L=length (clear span of beam).

d=depth of beam. b=width of beam.

4.4 Splitting test (ASTMC-496)-(IS-5816-99):- Another indirect tensile test method i.e. the splitting test method was proposed by (carneiro and barecllos-1953) in Brazil and developed independently by Akazawa (1953) in Japan.

In this test commonly called Brazilian test. A concrete cylinder specimen of size 30 cm in length and15 cm in dia. is led horizontally between the loading platens of the testing machine and is compressed along a vertical diameter as shown in fig. (2), strips of comparatively soft packing material are placed between the specimen and plates of the machine load are applied until the specimen splits along the vertical diameter.



The Brazilians test namely gives consistent results that lie between those based on other two methods (wrigh-1955). In this method the split tensile strength,

$\sigma_t = \frac{2P}{\pi LD}$

Where, p=applied load.
L= length of cylinder.
D=Dia. of cylinder.

4.5 Disc bending test: - The direct tensile strength is quite difficult to measure with direct axial tension loads because of the problems in gripping test specimen so as to avoid stress concentrations and because of difficulty in aligning the loads. As results of these problems two indirect tests are available to measure concrete tensile strength namely flexural test and split cylinder test.

Some practical difficulties like gripping of specimens, Application of loads, Handling of specimens during the tests, stress concentration of tensile strength of concrete can be minimized up to a great extent utilizing the principle of disc bending test given by (seely and smith-1952) as expressed below.

$$\sigma_t = \frac{3(1+\mu)P}{2\pi t^2}\left[\frac{1}{1+\mu} + \log_e\frac{r_0}{r_d} - \frac{1-\mu}{1+\mu}\frac{r_o^2}{4r_d^2}\right]$$

Where,
σ_t = maximum tensile stress
μ = Poisson's ratio of the material
P = applied load
t = thickness of the disc
r_d = radius of the disc.
r_o = radius of the area under uniform force.
The relationship is valid under the following conditions.

(1) The deflection of plate is relatively small(less than t/2).
(2) The material is ideally elastic
(3) The plates remain flat.

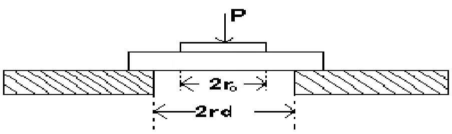


Figure-2 Bending of Disc

4.6 Experimental investigation

The experimental set-up employed for testing the concrete disc comprises of the following components:

1) Mild steel hollow cylinder with required arrangement to provide free circumferential support to concrete disc specimen.
2) Circular splittable mould of mild steel for making of concrete disc specimen.
3) Motorized load frame- strain controlled.
4) Dial gauges and device to hold them.

4.6.1 Mild steel hollow cylinder

To provide free circumferential support to the concrete disc specimen a mild steel hollow cylinder with appropriate edge bearing was fabricated. The clear span i.e., $2r_d$ is kept at 152.4 mm whereas the dimension 177.8mm with circumferential edge bearing of 12.7mm has was provided as the inner diameter of cylinder to accommodate the concrete disc of 177.8mm diameter in order to meet the requirement of free support condition.

4.7 Circular split table mild steel mould

In case of diametral compression test the specimen of 6" diameter and 12"length is used. Keeping this in view concrete disc of 178mm (7") diameter of various thickness ranging from 25.4mm (1") to 50.8mm (2") are proposed for bending test. In order to prepare the sample of the diameter split table mould as shown in plate 3.1 was made. The split table mould was used to get the sample with least disturbances. The mould was fabricated using mild steel plate which consists clamp with nuts and bolts to tie the two halves of the mould firmly.

4.8 Motorized load frame:-

Strain controlled motorized load frame manufactured by AIMIL (as available in lab) is shown in the plate 3.2 and is used to apply the load with a choice of ten constant rate of strain ranging from a maximum of 1.25 mm/minute.

4.8.1 Operation

Specimen to be tested for bending is placed on the bottom of loading plate in the cylindrical mild steel mould. A proving ring of desired capacity is fixed to the adopter for measuring the load. Loading platen is raised or lowering by operating the hand wheel with the strain rate lever kept at neutral. The proving ring devise to measure the load is brought in to the contact with test specimen with the help of a circular steel ball kept on a circular mild steel plate on the specimen. Being ensure that the proving ring is in contact with the test specimen, loading system is operated by switching on the main supply.

4.8.2 Dial gauges and devices

In order to measure the central deflection of the disc, the arrangement was made to fixed up the dial gauges through clamp to the loading frame and to rest the needle of the dial gauges on mild steel strips attached to the circular mild steel plate which is placed at the centre of the specimen to provide the uniformly distributed load as shown in plate 3.3, the least count of the dial gauge was 0.01 mm.

4.9 Mild steel rectangular, cylindrical and cubical split table mould for beam bending split cylinder and cube test

For beam bending test, mild steel rectangular splittable mould of internal dimension 500mm × 100mm × 100mm, for split cylinder test mild steel splittable mould of internal diameter 150mm and length 300mm and to know the characteristic compressive strength of concrete cube, mould of internal dimension 150mm × 150mm × 150mm were used for casting the specimens.

4.9.1 Universal compression testing machine

For split cylinder and cube test the standard universal testing machine of capacity 1500 KN and constant rate strain loading was used.

4.9.2 Loading frame for flexure test

A standard well established loading frame system consisting of jack for loading and proving ring attached to the jack was used for beam bending test.

4.9.3 Sample preparations and curing of sample

In order to prepare the concrete specimens for test, cement, sand and stone chips were taken by weight in proportion of 1:1.47:2.79.

For preparation of concrete samples for disc bending test, disc of 152.4 mm diameter and 38mm thickness, were prepared with constituent of cement, sand and stone chips were taken by weight in proportion of 1:1.47:2.79. Twelve numbers of samples were prepared in split table mould for each test such as disc bending and diametral test at water cement ratio 0.33 and with compacting effort of 25 nos. of temping by temping rod of 1” diameter. The samples were also prepared of varying thickness 30mm and 25mm at varying % of admixture (0.6 to 1.2 %) keeping water cement ratio constant for the same test disc bending and diametral test.

In flexural test, beams of 500mm × 100mm × 100mm in 6 numbers for split tensile test of 6 cylinders of 150mm diameter and 300mm length and compressive strength 6 cube of 150mm × 150mm × 150mm size were also prepared from the same batch of mix for the sake of comparison of tensile strength of disc bending test with flexural strength and diametral compression strength and cube strength wherever required. The same process was adopted for different % of admixture.

The specimens of concrete discs, beams, cylinders and cubes after preparation were kept for 7 days and 28 days under water in tank before testing.

4.9.4 Testing Procedure:-

To study the effect of tensile strength in bending, the test set-up as shown in fig. was eused for testing the compacted concrete disc specimens. Before application of load the center of specimen was marked and it the mild steel hollow cylinder in such a way that the free support condition exists.

4.10 Mode of Failure:-

By Visualization of the concrete sample tested in disc bending method, it is found that the samples had failure with the development of cracks at the bottom face of the sample near the centre. The photographic views of some specimen failed are shown in plate. The mode of failure is because of tension.

Most of the failures have taken place due to normal bending of disc which usually occurs inside the ring 2 rd with the development of radial cracks.

The failure pattern of the concrete disc in the present study is similar to a great extent as earlier reported by jaeger (1967) in case of rocks.

V. RESULTS AND DISCUSSION

The experimental results are presented and discussed in appendix. Each of the strength test data plotted in Table no 1-3, corresponds to the mean value of the strengths.

V. CONCLUSIONS

In the present study, application of theoretical approach namely Grashof's theory of bending of the plate has been considered. It is based on the similar application as used by Protodyakonov (1961) and Sharma (1997) as an indirect method for obtaining tensile strength of rocks and soil. This method gives the best possible representation of tensile behavior of materials and very useful also in determining their anisotropic strength. In spite of the fact that bending tests usually gives higher values than the direct tensile test, this method may still be useful to determine the tensile strength of concrete an should be termed as the modulus of rupture or flexural strength of concrete. The analysis of results indicate that the sensitivity of experiments depends entirely on certain elemental variation and hence tensile behavior of concrete for any concrete structure covers a broad and extensive field of study because the factors involved are numerous and to a large extent unpredictable analysis even on the most simplified basis under such circumstances. Therefore, it is not possible to make generalized conclusions.

The work presented in this thesis is therefore concluded as follows:-

I. The concrete, which is prepared in proportion of 1:1.47:2.79 by weight having fairly good tensile strength.
II. The tensile strength of the concrete increases with an increase in % of admixture up to in the range of 0% to 1.0% and at 1.2% of admixture its value decreases. It is valid for all the cases like compressive strength and the diametral stress and fracture strength too. The tensile strength obtained from bending test (disc bending and beam bending) is higher than the compression test (disc diameteral compression test, split cylinder test and cube test).
III. The tensile strength obtained from disc bending test is higher than the beam bending test.
IV. The tensile strength obtained from disc diameteral compression test is higher than the split cylinder compression test and cube compression test.
V. The value of tensile strength obtained from cube test is lower than the Flexural Strength, Diametral Stress and tensile strength from Disc bending test but it is slightly greater than the tensile strength from split cylindrical test.
VI. It is observed from the test data that % of admixture increase upto 1.0 %. The value of all types of strength of concrete is going to be increased. At the same time flow ability of concrete increases even at 1.2% of addition of admixture.

Further scope of studies:-

As discussed earlier, there are several factors which affect the tensile behavior of the concrete and it is not possible to include all of them in analysis even on the most simplified basis. However, an effort has been made in the present study to include, major factors and their influence on the tensile behavior of the concrete.

For further work, the effect of the following factors on tensile strength by disc bending method may be studied:

1. Effect of the other methods of compaction.
2. Effect of creep.
3. Effect of stress concentration at surface cracks and flaws.
4. Effect of frictional forces between loading surface and specimen surface.
5. Effect of % of admixtures by considering the various thickness of the disc plate.
6. Effect of the size of aggregates on characteristic strength of M-40 Grades of concrete with various % of Admixture can be studies.
7. Studies of characteristic strength of M-40 Grade of concrete with different % of Admixture with different types of cement.

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APENDIX

Table no: 1 Comparative results of % increments' of all data with 0% Admixture for 28 days

Sr.No	% of Admixture	% increments' in compressive strength	% increments' in Split tensile	% increments' in Flexural strength	% increments' in Diametral stress	% increments' in Disc Bending
01	0	------	------	------	-----	-----
02	0.6	3.88	3.43	1.94	1.53	3.32
03	0.8	8.53	7.47	6.79	6.32	7.75
04	1.0	12.49	11.11	12.03	7.85	12.36
05	1.2	5.42	0.80	0.00	3.256 (Decreases)	0.92

Table no: 2 Comparative Results of Deflection in flexural test and disc bending test of different % of admixture at 28 days.

Sr. No.	% of Admixture	In Flexural		In Disc Bending	
		Load in N	Deflection in mm	Load in N	Deflection in mm
01	0%	1.13	0.85	6500	0.69
02	0.6%	1.17	0.75	7250	0.64
03	0.8%	1.38	0.68	8000	0.58
04	1.0%	1.42	0.61	8750	0.50
05	1.2%	1.185	0.92	8133.33	0.77

Table 3. COMPARATIVE RESULTS OF OBSERVATION DATA FOR 28 DAYS

Sr. No	Compressive Strength N/mm2	Split Tensile Strength N/mm2	Flexural Strength N/mm2	Diametral Stress N/mm2	Fracture Strength Fr. $0.7\times\sqrt{fck}$	Disc Bending Test(Tensile Strength) N/mm2
M0	43	4.95	5.15	5.22	4.58	5.42
M1	44.67	5.12	5.25	5.30	4.67	5.60
M2	46.67	5.32	5.50	5.55	4.78	5.84
M3	48.33	5.50	5.77	5.65	4.86	6.09
M4	45.33	4.99	5.15	5.05	4.71	5.5