RESEARCH PAPER | Engineering | Volume : 4 | Issue : 7 | July 2014 | ISSN - 2249-555X

Workability Characteristic Properties of Concrete with Varying Percentages of Steel Fibre

KEYWORDS: steel fibres, microcracks, workability

Dr. Deepa A Sinha

Ph.D. Structural Engg., Associate Professor, Structural Engineering Dept, BVM Engineering College, Vallabh Vidyanagar, Anand, Gujarat, India.PIN 388120.

ABSTRACT *Civil infrastructure around the world is in a state of utter disrepair and significant effort are needed on the part of all stake holders to render are failing infrastructure back to a serviceable and safe state. fibre reinforced concrete is an ideal material for controlling shrinkage, cracking, abat micro cracks from widening and provide concrete with high ductility but by adding fibres the workability of concrete reduces and this seams a handicap for onsite application. In this work the workability characteristics of concrete with varying percentages of fibres is found. M30 grade concrete as per IS: 10262-2009 was designed which yielded a proportion of 1:1.86: 2.41 with a w/c ratio of 0.45. 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. Workability of concrete is seriously affected as the percentage of steel fibres in it increases.*

Compared to other building materials such as metals and polymers, concrete is significantly more brittle and exhibits a poor tensile strength. Concrete carries flaws and micro-cracks both in the material and at the interfaces even before an external load is applied. These defects and microcracks emante from excess water, bleeding, plastic settlement, thermal and shrinkage strains and stress concentrations imposed by external restraints. Under an applied load, distriuted microcracks propagate, coalesce and align themselves to produce macrocracks. When loads are futher increased, conditions of critical crack growth are attained at tips of the macro- cracks and unstable and catastrophic failure is precipitated. Under fatigue loads, concrete cracks easily and cracks create easy access routes for deleterious agents leading to early saturation, frees thaw damage, scalling, discoloration and steel corrosion. The micro and macro fracturing processes described above can be favourably modified by adding short randomly distributed fibres of various suitable materials. Fibres not only suppress the formation of cracks, but also abate their propogation and growth. The resulting material termed fibre reinforced concrete (FRC) is rapidly becoming a well accepted main stream construction material. There are currently 200,000 metric tone of fibre used for concrete reinforcement.

Workability is one of the physical parameters of concrete which affects the strength and durability as well as the cost of labor and appearance of the finished product. Concrete is said to be workable when it is easily placed and compacted homogeneously i.e without bleeding or Segregation. Unworkable concrete needs more work or effort to be compacted in place, also honeycombs &/or pockets may also be visible in finished concrete.

Definition of Workability

The property of fresh concrete which is indicated by the amount of useful internal work required to fully compact the concrete without bleeding or segregation in the finished product. The Factors affecting workability are Water content in the concrete mix , Amount of cement & its Properties, Aggregate Grading (Size Distribution) , Nature of Aggregate Particles (Shape, Surface Texture, Porosity etc.), Temperature of the concrete mix , Humidity of the environment, Mode of compaction, Method of placement of concrete, & Method of transmission of concrete. The workability is measured in the laboratory by Slump test, compaction factor test, flow table test and veebee test.

Objective of study

Main objective of this study is to how the workability characteristics of concrete is affected with varying percentages of fibres

Materials used

- **Cement:**

53 Grade Ordinary Portland Cement (OPC), with specific gravity 3.15, initial setting time 120 minutes and final setting time 220 minutes, and 7 day compressive strength of 29N/mm^2 and 28 day compressive strength of 54N/mm^2, complying with IS: 12269 – 1987 was used.

- **Fine aggregates:**

Locally available sand with specific gravity of 2.67, falling under the zone-II, complying with IS: 383 – 1970 was used.

- **Coarse aggregates:**

Locally available coarse aggregates of 12mm and down size having a specific gravity of 2.74, complying with IS: 383 – 1970 was used.

- **Steel fibres:**

Steel fibers of 30 mm length and 0.7 mm thickness with corrugated shape which gave an aspect ratio of 42 were used. The steel fiber was added by 1% of volume fraction. Crimped steel fibres were used, since it helps in improper bonding.

- **Superplasticizer:**

Conplast SP 430, complying with IS: 9103 – 1979 was used, to impart workability. It was based on sulphonated naphthalene formaldehyde. Super plasticizer was used at the rate of 0.78% by weight of cement as found by Marsh cone test.

Procedure

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 superplasticizer was now added and mixed thoroughly. After this, different percentage of steel fibers (0.5% upto 2%) by volume was added to the mix and the entire concrete was agitated thoroughly to get a homogeneous mix and workability test were carried.

Volume : 4 | Issue : 7 | July 2014 | ISSN - 2249-555X

Methodology

Slump test:- Slump test is the most commonly used method of measuring consistency of concrete. It is not a suitable method for very wet or very dry concrete. The apparatus for conducting the slump test essentially consist of a metallic mould in the form of a frustum of a cone having the internal dimensions as under:

P1- Slump Apparatus

Bottom diameter :- 20 cm
Top diameter :- 10 cm
Height :- 30 cm

The thickness of the metallic sheet for the mould should not be thinner than 1.6 mm. the mould is provided with suitable guides for lifting vertically up. For tamping the concrete, a steel tamping rod 16 mm diameter, 0.6 meter along with bullet end is used. The internal surface of the mould is thoroughly cleaned and freed from excessive moisture and adherence of any old set concrete before commencing the test. The mould is placed on a smooth, horizontal, rigid and non-absorbent surface. The mould is then filled in four layers, each approximately ¼ of the height of the mould. Each layer is tamped 25 times by the tamping rod taking care to distribute the strokes evenly over the cross-section. After the top layer has been rodded, the concrete is struck off level with a trowel and tamping rod. The mould is removed from the concrete immediately by raising it slowly and carefully in a vertical direction. This allows the concrete to subside. This subsidence is referred as SLUMP of concrete.

Compacting factor test

It is more precise and sensitive than slump test and is particularly useful for concrete mixes of very low workability as are normally used when concrete is to be compacted by vibration.The compacting factor test has been developed at the road research laboratory U.K. and it is claimed that it is one of the most efficient tests for measuring the workability of concrete. This test works on the principal of determining the degree of compaction achieved by a standard amount of work done by allowing the concrete o fall through a standard height. The degree of compaction, called the compacting factor is measured by the density ratio. The sample of concrete to be tested is placed in the upper hopper up to the brim. The trap-door is opened so that the concrete falls into the lower hopper. Then the trap-door of the lower hopper is opened and the concrete allowed falling into the cylinder. The excess concrete remaining above the top level of the cylinder is then cut-off with the help of the plane blades supplied with the apparatus. The concrete is filled up exactly up to the top level of the cylinder. It is weighed to the nearest 10 grams. This weight is known as “weight of partially compacted concrete”. The cylinder is emptied and then refilled with the concrete from same sample in layers approximately 5 cm in deep. The layers are heavily rammed so as to obtain full compaction. The top surface of the fully compacted concrete is then carefully struck off level with the top of the cylinder and weighed to the nearest 10 grams. This weight is known as “weight of fully compacted concrete”.

The compacting factor = Weight of partially compacted concrete / Weight of fully compacted concrete

P2- compacting factor

Table-1. Essential dimensions of the compacting factor apparatus

Upper Hopper A	Dimension cm
Top internal diameter	25.4
Bottom internal diameter	12.7
Internal height	27.9
Lower Hopper B	
Top internal diameter	22.9
Bottom internal diameter	12.7
Internal height	22.9
Cylinder C	
Internal diameter	15.2
Internal height	22.9
Distance between bottom of upper hopper and top of lower hopper	20.3
Distance between bottom of lower hopper and top of cylinder	20.3

Flow test

This is the test, which gives an indication of the quality of concrete with respect to consistency, cohesiveness and the proneness to segregation. In this test, a standard mass of concrete is subjected to jolting. The spread or the flow of the concrete is measured and this flow is related to workability.

The apparatus consists of flow table, about 76 cm. in diameter over which concentric circle are marked. A mould made from smooth metal casting in the form of frustum of a cone is used with the following internal dimensions. The base is 25 cm. in diameter, upper surface 17 cm. in diameter, and height of the cone is 12 cm.The table top is gritty material and is wetted. The mould is kept on the center of the table, firmly held and is filled in two layers. Each layer is rodded with 25 times with a tamping rod 1.6 in diameter and 61 cm long rounded at the lower tamping end. After the top layer rodded evenly, the excess of concrete which has overflowed the mould is removed. The mould lifted vertically upward and the concrete stand on its own without support. The table is then raised and dropped 12.5 mm 15 times in about 15 seconds. The diameter of the spread concrete is measured in about 6 directions to the nearest 5 mm and the avg. spread is noted. The flow of concrete is the percentage increase in the average diameter of the spread concrete over the base diameter of the mould.

Volume : 4 | Issue : 7 | July 2014 | ISSN - 2249-555X

$$\text{Flow, percent} = \frac{\text{spread diameter in cm} - 25}{25} \times 100$$

The value could range anything from 0 to 150 percent.

P3- Flow Table

Vee-bee consistometer test

This is the good test to measure to measure indirectly the workability of concrete. This test consists of a vibrating TN, a metal pot, a sheet metal cone, a standard iron rod.In this test, placing the slump cone inside the sheet metal cylindrical pot of the consistometer. The glass disk attached to the swivel arm is turned and placed on the top of the concrete in the pot. The electrical vibrator is then switched on and simultaneously a stop watch started. The vibration is continued till such a time as the conical shape of the concrete disappears and the concrete assumes a cylindrical shape. This can be judged by observing the glass disk from the top for disappearance of transparency. Immediately when the concrete fully assumes a cylindrically shape, the top watch is switched off. The time required for the shape of concrete to change from slump cone shape to cylindrical shape in seconds is known as vee-bee degree .this method is very suitable for very dry concrete whose slump value cannot be measured by slump test, but the vibration is too strong for concrete with a slump greater than about 50 mm.

P4- Vee Bee Cosistometer

Test results

Different test results such as workability are tabulated as shown :

Workability test results

Following table 2 gives the workability test results as measured from slump, compaction factor, % flow and vee bee degrees.

Table 2 Workability test results.

Percentage of steel fibres added	Slump (mm)	Compaction factor	Flow %	Vee bee (sec)
0%	70	0.90	70	6
0.5%	60	0.88	68	7
0.75%	55	0.85	66	8
1.0%	50	0.84	64	9
1.25%	48	0.82	63	10
1.50%	45	0.80	60	13
1.75%	40	0.78	57	15
2.0%	38	0.74	55	16

The variation in slump, compaction factor, flow value and veebee degree can be depicted in the form of graphs as shown in figure 1, 2,3 and 4 respectively.

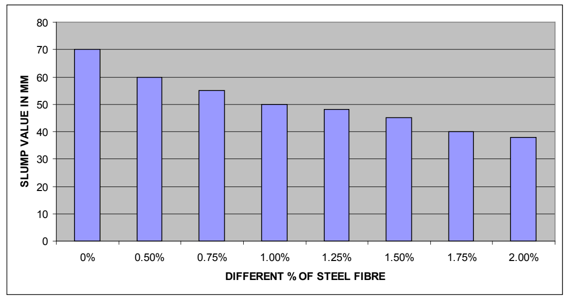

Figure .1. Variation of slump with different % of steel fibre

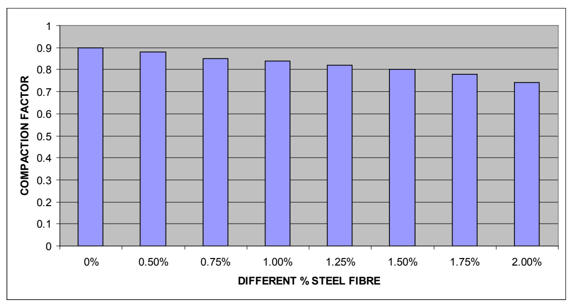

Figure 2 Variation of compaction factor with different % of steel fibre

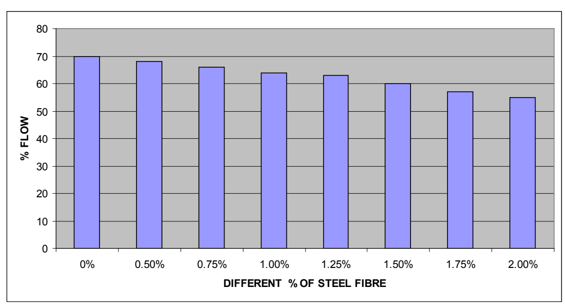

Figure 3 Variation of % flow with different % of steel fibre

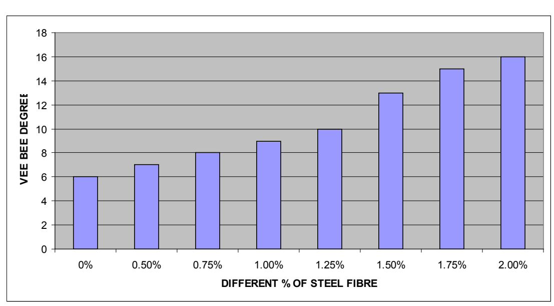

Figure 4 Variation of Veebee degree with different % of

Volume : 4 | Issue : 7 | July 2014 | ISSN - 2249-555X

steel fibre

Observations and discussions

Fig. 1, fig. 2, fig. 3 and fig. 4 show variations in slump value, compactions factor, percentage flow and veebee degree. It is observed that as the percentage of fibre increases the workability of concrete decreases. This is obviously due to the fact that the added fibres will obstruct the flow and hence affect the workability of concrete. Thus it can be concluded that as the percentage of fibres go on increasing workability goes on decreasing.

Conclusions:

Workability of concrete is seriously affected as the percentage of steel fibres in it increases.