

# Experimental Investigation on Reduction of Initial Cracks in Beams

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**ABSTRACT:** The presence of cracking does not necessarily indicate deficiency in strength or serviceability of concrete structures. While currently available design code provisions lead to reasonable control of cracking, additional control can be achieved by understanding the basic causes and mechanisms of cracking in concrete structures. Concrete can crack due to a number of causes. Cracking occurs when tensile stresses exceed the tensile strength of the concrete. Concrete cracking can develop during the first days after placing and before any loads are applied to the structure. Stresses develop due to differential temperatures within the concrete. Tensile stresses due to dead load and live load cause cracking. Normal reinforcement or pre-stressing should be designed to provide required strength and keep crack widths within permissible limits. Tensile stresses due to service loads can be controlled by pre-stressing. Cracks at the initial stage can be reduced by different methods. Initial cracks on the beams may lead to the widening of the crack due to moisture content. Improper treating of the crack may lead to the failure of the beam. It is important to identify the primary concern in regard to initial cracking. The main concerns are whether the cracks are affecting structural integrity as a result of reduced durability. The type of cracking provides useful information to help a crack's effects on structural stability. In this study, we are observing the crack patterns formed and analysing the results.

**KEYWORDS:** Serviceability, tensile strength, reinforcement, Crack pattern, prestressing.

## I. INTRODUCTION

The presence of cracking does not necessarily indicate deficiency in strength or serviceability of concrete structures. While currently available design code provisions lead to reasonable control of cracking, additional control can be achieved by understanding the basic causes and mechanisms of cracking in concrete structures. Concrete can crack due to a number of causes. The tensile strength of concrete is a widely scattering quantity. Cracking occurs when tensile stresses exceed the tensile strength of concrete. Therefore, to control concrete cracking, the tensile strength of concrete is of primary importance. Concrete cracking can develop during the first days after placing and before any loads are applied to the structure. Stresses develop due to differential temperatures within the concrete.

If concrete members are allowed to cool quickly, tensile stresses may reach values higher than the developing tensile strength of the concrete. Even if this process results only in micro cracking, the effective tensile strength of the hardened concrete is reduced. However, very often wide cracks appear even when reinforcement is provided. In addition, the reinforcement may not be fully effective since bond strength is also developing and is yet too low. It is necessary to minimize such early cracks by keeping temperature differentials within the concrete as low as possible.

In massive concrete structures or in moderately prestressed concrete structures subjected to tensile stresses due to temperature, cracks that occur often remain as fine cracks. Optimal crack control is obtained by choosing small bar diameters and a small spacing. Cracking can be due to applied loads or restraint forces.

## II. RELATED WORK

H.S. Alajmani & (2019) investigates experimentally the shear strength behavior of reinforced concrete (RC) beams cast with Lava lightweight aggregates as a replacement of normal coarse aggregates. A total of 24 shear deficient RC beams were fabricated and cast with normal (NWC) and lightweight (LWC) concrete and tested under three-point bending after 28 and 56 days. The variables of the experimental program include type of aggregate, concrete compressive strength, and beam size. The experimental results include load-deflection response curves along with failure mode for each beam specimen. The experimental result showed that all beams failed in a similar fashion, due to diagonal tension shear crack. However, a larger number of cracks with less spacing occurred in the LWC beams as compared to NWC specimens.

A.R. Dar (2019) proved that novel CFS composite beams have shown better performance considerably. Local buckling instability under compressive stresses is common in cold-formed steel (CFS) members and generally occurs well before the material has reached its yield strength. This results in under-utilization of the cross-section, compared to its full capacity governed by strength failure. Under flexural loading these CFS members possess sufficient inelastic reserve strength up to the ultimate stage.

### III. ADDITIONAL MATERIALS USED

#### STEEL FIBRES

Steel fiber for reinforcing concrete is defined as short, discrete lengths of steel fibres with an aspect ratio (ratio of length to diameter) from about 20 to 100, with different cross-sections and that are sufficiently small to be randomly dispersed in an unhardened concrete mixture using the usual mixing procedures.



(a) Steel Fibres

#### WIRE MESH

Plain steel wire mesh, in the wire mesh industry, plain steel- or carbon steel, as it sometimes referred to- is a very popular metal that commonly manufactured in both woven and welded wire mesh specifications. It is primarily composed of iron(Fe) with a small amount of carbon(C).



(b) Wire Mesh

### IV. MATERIAL REQUIREMENTS

#### CEMENT

The cement water paste has its characteristic properties of adhesion and cohesion by which it can bond well with aggregate to form a strong rock like mass called concrete as a consequence of the chemical reaction between cement and water. Cement is the most widely used material in existence and is only behind water as the planet's most consumed resource.

##### Physical properties of cement

- The colour of cement should be uniform.
- Cement should be free from lumps.
- Cement should be cool when felt with hand.
- If a small quantity of cement is thrown into bucket of water it should sink.
- Average compressive strength of cement mortar cube of size 7.06 cm should not be less than  $11.6 \text{ N/mm}^2$  at the age of 7 days.
- Heat of hydration should not be more than  $65 \text{ cal/gm}$  at 7 days and  $75 \text{ cal/gm}$  at 28 days.
- Initial setting time of cement should not be more than 30 minutes and final setting time should not be less than 10 hours.
- Fineness of cement should be less than 10% in sieve test.

##### Chemical properties of cement

IS 263-1989 specifies the following chemical requirements of cement:

- The ratio of percentage of lime to percentage of silica, alumina and iron oxide.

- Ratio of percentage of alumina to that of iron oxide present in the cement should be more than 0.6%.
- The total sulphur content should be less than 4%.
- The total weight of insoluble residue should be less than 1.5%.
- The total loss of ignition should be less than 4%.
- The weight of magnesia should be less than 5%.

### Aggregates

Aggregates are inert granular materials such as sand, gravel, crushed stone that along with water and Portland cement are an essential ingredient in concrete.

For a good concrete mix, aggregate needs to be clean, hard strong particles free of absorbed chemicals or coatings of clay and other fine materials that could cause the deterioration of concrete. Fine aggregates generally consist of natural sand or crushed stone with most particles greater than 0.19 inch. Aggregates strongly influence concrete's freshly mixed and hardened properties. Selection of aggregates is an important process. Although some variation in aggregate properties is expected, characteristics that are considered include: grading, durability, particle shape and surface texture, abrasion, unit weight and voids, absorption and surface moisture.

As per IS 383-1970, ideal aggregates should satisfy the following characteristics:

1. It should be strong and durable, free from anything.
2. It should not react with cement or steel.
3. It should consist of natural stones, gravel, and sand or in various combinations of these materials.
4. Porosity should be limited.
5. It should be angular in shape having rough surface.

### Fine Aggregate

Fine aggregates are basically sand won from the land or the marine environment. Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 9.5 mm sieve. As with coarse aggregates these can be from primary, secondary or recycled source.

## V. CASTING AND CURING OF TEST SPECIMEN

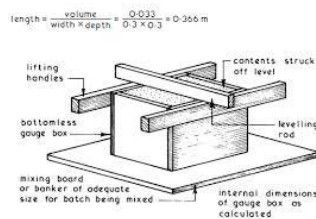
### BATCHING

The measurement of materials for making concrete is known as batching. There are two methods of batching:

1. Volume batching
2. Weigh batching

### Volume batching

Volume batching is not a good method of proportioning the material because of the difficulty it offers to measure granular materials in terms of volume. Volume of moist sand in loose condition weighs much less than the same volume of dry compacted sands the amount solid granular material in a cubic meter is an indefinite quantity. Because of this the ingredients are measured by weight, not by volume. But water is measured either in kilogram or in liter as may be convenient. In this case the two units are same, as density of water is one kg/liter. The quantity of water required is a product of water cement ratio and the weight of cement.



(c) Volume Batching

### Weigh batching

Weigh batching is the correct method for measuring the materials. For important concrete invariably, weigh batching system is adopted. Use the weigh system in batching. Facilities accuracy, flexibility and simplicity. Different types of weigh batches are available, in smaller works, the weigh arrangement consist of two buckets, each connected through a

system of levers to a spring-loaded dials which indicated the load. A simple spring balance or the common platform weighing machines also can be used for small works.

Automatic batch plants are available in small or large capacity. In this the operator has only to press one or two buttons to put into motion and weighing of all the different materials and the flow of each being cut off when the correct weigh is reached.



(d) Weigh Batching

### MIXING

Thorough mixing of material is essential for the production of uniform concrete. The mixing should ensure that the mass becomes homogeneous, uniform in colour and consistency. There are two methods for mixing concrete:

1. Hand mixing
2. Machine mixing

#### Hand mixing

Hand mixing is practiced for a small unimportant concrete works. As the mix cannot be thorough and efficient, it is desirable to add 10% more cement to cater for the inferior concrete produced by this method.

Hand mixing should be done over an impervious concrete or brick floor of sufficiently large size to take one bag of cement. Spread out the measured quantity of coarse aggregate and fine aggregate in alternate layers. Pour cement on the top of it, and mix them dry by shovel, turning the mixture over an again until uniformity of colour is achieved. This uniform mix is spread out in thickness of about 20 cm water is taken in water-can fitted with a rose-head and sprinkled over the mixture and simultaneously tamped over. This operation is continued till such time is good uniform, homogeneous concrete is obtained.

#### Machine mixing

Mixing of concrete is most invariably carried out by machine, for reinforced concrete work. Machine mixing is not only efficient, but also commercial, when the quantity of concrete is to be produced is large.

Many types of mixture are available for mixing concrete. They can be classified as batch mixers and continuous mixers produce concrete continuously without stoppage till such time the plant is working. In this, materials are fed continuously by screw feeders and the materials are continuously mixed and continuously discharged. This types of mixers is used in large works such as dams. In normal concrete work, it is the batch mixer that are used. Batch mixer may be of pan type drum type and the drum type may be further classified as tilting, non-tilting, reversing or forced action type.

### COMPACTION OF CONCRETE

Compaction of concrete is the process adopted for expelling entrapped air from the concrete. The test specimens are made as soon as practicable after mixing and in such a way as to produce full compaction of concrete with neither segregation nor excessive laitance. Each layer is compacted by hand or by vibration. When compacting by hand the standard tamping bar is used and the strokes of bar are distributed in a uniform manner over the cross section of the mould. The number of strokes per layer required to produce the specified conditions vary according to the type of the concrete.

For the cubical specimens, in no case should the concrete be subjected to less than 35 strokes per layer for 15 cm or 25 strokes per layer for 10 cm cubes. For cylindrical specimens, the number of strokes is not less than 30 per layer. Strokes penetrate into the underlying layer and the bottom layer is rodded throughout its depth. Where voids are left by the tamping bar, the sides of the mould are tapped to close the voids.

When compacting by vibration each layer is vibrated by means of an electric or pneumatic hammer or vibrator by means of a suitable vibrating table until the specified condition is attained. The mode of quantum of vibration of the laboratory specimen shall be nearly the same as those adopted in actual concreting operations. If care is not taken



severe segregation takes place in the mould, which results in the low strength when cubes are crushed. The cube crushing strength does not represent the strength of the concrete.

**CASTING OF SPECIMEN**

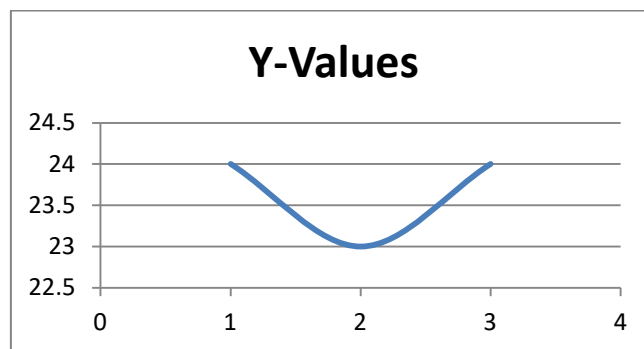
Moulds were properly fixed with screws and oil is applied on the surface for easy de moulding. Concrete is prepared in the mixture and put in a tray. In this tray required quantity of bottle cap fibres are added and mixed properly. Fresh properties of concrete are determined. The specimens are cast. In the next day, specimens were de moulded and put in a curing tank.

**VI. EXPERIMENTAL RESULTS**

**COMPRESSIVE STRENGTH TEST**

Table1. 7<sup>th</sup> day compressive strength test results

SPECIMEN NUMBER	COMPRESSIVE STRENGTH (N/mm2)
1	24
2	23
3	24

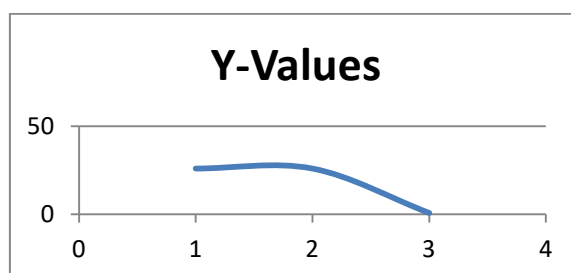


(e) Graph showing 7<sup>th</sup> day compressive strength

X axis = specimen number  
Y axis = compressive strength

Table 2. 14<sup>th</sup> day compressive strength test results

SPECIMEN NUMBER	COMPRESSIVE STRENGTH
1	26
2	26
3	25



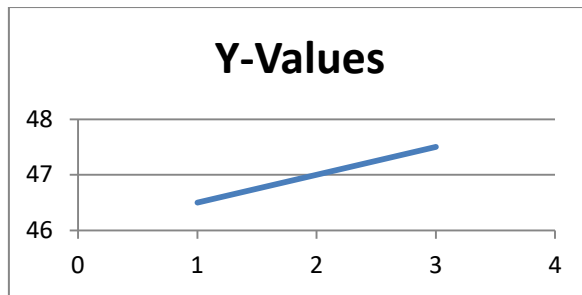
(f) Figure showing 14<sup>th</sup> day compressive strength

X axis = specimen number  
Y axis = compressive strength



Table 3 28<sup>th</sup> day compressive strength test results

SPECIMEN NUMBER	COMPRESSIVE STRENGTH
1	46.5
2	47
3	47.5



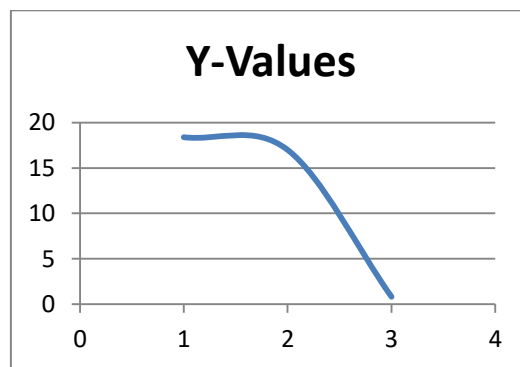
(g) Graph showing 28<sup>th</sup> day compressive strength

X axis = specimen number  
Y axis = compressive strength

**TWO POINT LOAD TEST**

Table 4 normal beam specimen test

SPECIMEN	LOAD
1	18.4
2	17
3	19.5

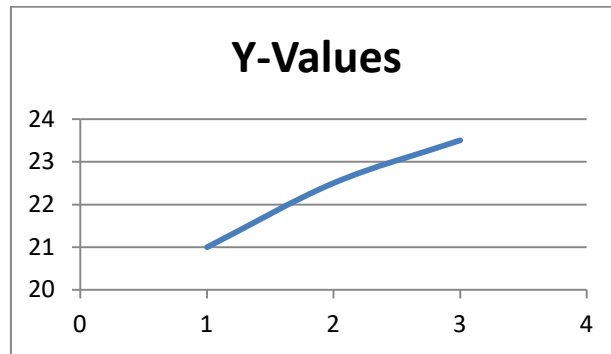


(h) graph showing maximum load on normal beam

X axis= specimen number  
Y axis = maximum load applied

Table 5 beam specimen with steel fibre

SPECIMEN NUMBER	LOAD
1	21
2	22.5
3	23.5



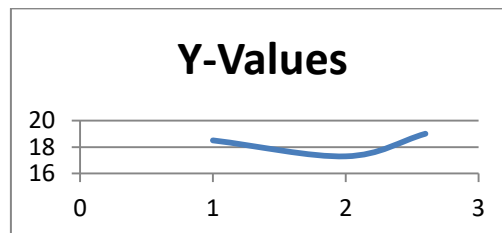
(i) Graph showing maximum load on beam with steel fibre

X axis= specimen number

Y axis = maximum load applied

Table 6 beam specimen with wire mesh

SPECIMEN NUMBER	LOAD
1	18.5
2	17.3
3	19



(j) Graph showing maximum load on beam with wire mesh

X axis= specimen number

Y axis = maximum load applied

## VII. CONCLUSION

The test result shows that the normal beam shows the signs of initial cracking when a load of 18 KN is applied. So the initial crack may enlarge with moisture content and result in the cracking of the beam. In order to reduce the initial crack in beams, add steel fibres and wire mesh on top and bottom portion of the RCC beams. This reduces the initial cracking to a great extent. Addition of steel fibres shows more reduction of initial cracks than that of the wire mesh. The test results shows that when the steel fibres are applied on top and bottom portion of the beam, the crack appeared when a load of 22KN is applied. In case of wire mesh the crack occurred when a load of 19KN is applied. So from the test results it can be concluded that steel fibres can be added to the beam to reduce the initial cracks to some extent more than the addition of any other material.

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