# Comparison of Flexural, Split Tensile & Compressive Strength of HP-SCC using Magnetized Water

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**Abstract – The objective of the report is to plot an effective trend between the strengths of concrete viz. Flexural, Split Tensile & Compressive Strength of HP – SCC Concrete. This will help us understand the exact relation between the three different strengths of the material thereby forecasting & modifying the design phenomenon. Systematic testing of the raw materials, the fresh concrete and the hardened concrete is an inseparable part of any quality control programme for concrete which helps to achieve higher efficiency of the materials used and greater assurance of the performance of the concrete in regard to both strength and durability. Concrete has relatively high compressive strength,but significantly lower tensile strength,and as such is usually reinforced with materials that are in tension(often steel).The elasticity of concrete is relatively constant at low stress levels but starts decreasing at higher stress levels as matrix cracking develops. Concrete would almost always fail from tensile stresses,even when loaded in compression .the practical implication of this is concrete elements subjected to tensile stresses must be reinforced with material that are strong in tension. Reinforced concrete is the most common form of concrete.**

**Index Terms – Strength Comparisons, Construction Materials, Flexural Strength, Split Tensile Strength, Compressive Strength, Magnetized Water, Lab Trials.**

## 1. INTRODUCTION

High Performance Self Compacting Concrete: Self-compacting concrete (SCC) is a flowing concrete mixture that is able to consolidate under its own weight. The highly fluid nature of SCC makes it suitable for placing in difficult conditions and in sections with congested reinforcement. Use of SCC can also help minimize hearing-related damages on the worksite that are induced by vibration of concrete. Another advantage of SCC is that the time required to place large sections is considerably reduced.

On the other hand ,testing plays an important role in controlling the quality of cement concrete work. Systematic testing of the raw materials, the fresh concrete and the hardened concrete is an inseparable part of any quality control programme for concrete which helps to achieve higher efficiency of the materials used and greater assurance of the performance of the concrete in regard to both strength and durability. The test methods used should be simple, direct and convenient to apply. To judge the quality of concrete, compressive strength is convenient than flexural strength evaluation. Concrete has relatively high compressive strength, but significantly lower tensile strength, and as such is usually reinforced with materials that are in tension(often steel).The elasticity of concrete is relatively constant at low stress levels but starts decreasing at higher stress levels as matrix cracking develops. Concrete would almost always fail from tensile stresses, even when loaded in compression .the practical implication of this is concrete elements subjected to tensile stresses must be reinforced with material that are strong in tension. Reinforced concrete is the most common form of concrete. It has been recognized that reproducible and repeatable test results can be obtained only with standard testing equipment capable of giving the desired level of accuracy.Hence the apparatus and equipments should also be given due importance while testing.

### Flexural Strength

Flexural Strength is one measure of tensile strength of concrete. It is a measure of an unreinforced concrete beam or slab to resist failure in BENDING. Flexural Strength is expressed as Modulus of Rupture(MR) and measured in Mpa. It is measured by loading 150X150X700 mm or 100X100X500 mm concrete beams with a span length at least three times the depth. It is determined by standard test methods ASTM C 78 (third-point-loading) or ASTM C 293 (centre-point loading).

### Split-tensile strength

Tensile strength is one of the basic and important properties of concrete. A knowledge of its value is required for the design of concrete structural elements subject to transverse shear, torsion, shrinkage and temperature effects. Its value is also used in the design of prestressed concrete structures, liquid retaining structures, roadways. and runway slabs. Direct tensile strength of concrete is difficult to determine; recourse is often taken to the determination of flexural strength or the splitting tensile strength and computing the direct tensile. The cylindrical specimen for routine testing and comparison of results, shall be 150 mm in diameter and 300 mm in length

**Compressive Strength**

Compressive strength is the capacity of a material or structure to withstand axially directed pushing forces. When the limit of compressive strength is reached, materials are crushed. Concrete can be made to have high compressive strength. By definition, the compressive strength of a material is that value of uniaxial compressive stress reached when the material fails completely. The compressive strength is usually obtained experimentally by means of a compressive test. The apparatus used for this experiment is the same as that used in a tensile test. However, rather than applying a uniaxial tensile load, a uniaxial compressive load is applied. Test specimens cubical in shape shall be $15 \times 15 \times 15$ cm. Cylindrical test specimens shall have a length equal to twice the diameter. They shall be 15 cm in diameter and 30 cm long.

## 2. RELATED WORK

The objective of the study is to plot an effective trend between the strengths of concrete viz. Flexural, Split Tensile & Compressive Strength of HP – SCC Concrete. This will help us understand the exact relation between the three different strengths of the material thereby forecasting & modifying the design phenomenon. Systematic testing of the raw materials, the fresh concrete and the hardened concrete is an inseparable part of any quality control programme for concrete which helps to achieve higher efficiency of the materials used and greater assurance of the performance of the concrete in regard to both strength and durability. Concrete has relatively high compressive strength, but significantly lower tensile strength, and as such is usually reinforced with materials that are in tension(often steel).The elasticity of concrete is relatively constant at low stress levels but starts decreasing at higher stress levels as matrix cracking develops. Concrete would almost always fail from tensile stresses, even when loaded in compression .the practical implication of this is concrete elements subjected to tensile stresses must be reinforced with material that are strong in tension. Reinforced concrete is the most common form of concrete.

1. In this study we will plot an effective trend between the strengths of concrete viz. Flexural, Split Tensile & Compressive Strength of HP – SCC Concrete. This will help us understand the exact relation between the three different strengths of the material thereby forecasting & modifying the design phenomenon.
2. However our final conclusion for the entire project lies with the use of MAGNETIZED WATER for preparation of HP – SCC. The final part will be to compare the 3 strengths of material with MAGNETIZED WATER & Without MAGNETIZED WATER.
3. It is generally anticipated that use of MAGNETIZED WATER for manufacturing concrete will effect in enhancement in Strengths & WORKABILITY of the mixture. And our Lab Trials have proved it right.
4. Hence our main focus for the project will be to compare & Analysed the trends of trial results for HP-SCC with MAGNETIZED WATER & Without MAGNETIZED WATER and to find out the % Enhancement in the above said properties of concrete viz. Strengths & WORKABILITY.

## 3. LITERATURE REVIEW

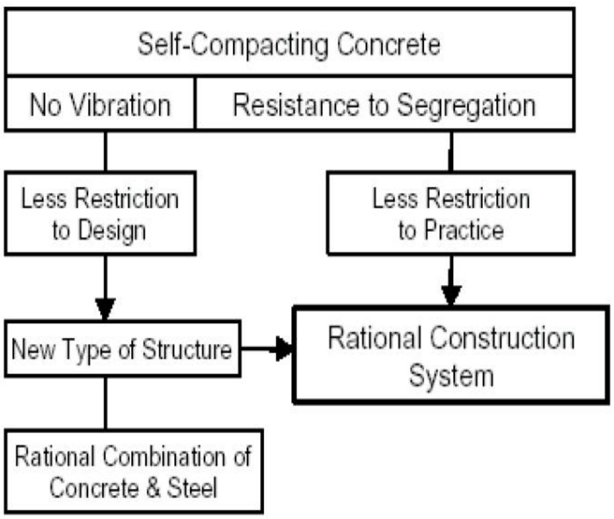
Testing plays an important role in controlling the quality of cement concrete work. Systematic testing of the raw materials, the fresh concrete and the hardened concrete is an inseparable part of any quality control programme for concrete which helps to achieve higher efficiency of the materials used and greater assurance of the performance of the concrete in regard to both strength and durability. The test methods used should be simple, direct and convenient to apply. To judge the quality of concrete, compressive strength is convenient than flexural strength evaluation. Concrete has relatively high compressive strength, but significantly lower tensile strength, and as such is usually reinforced with materials that are in tension(often steel).The elasticity of concrete is relatively constant at low stress levels but starts decreasing at higher stress levels as matrix cracking develops. Concrete would almost always fail from tensile stresses, even when loaded in compression .the practical implication of this is concrete elements subjected to tensile stresses must be reinforced with material that are strong in tension. Reinforced concrete is the most common form of concrete. It has been recognized that reproducible and repeatable test results can be obtained only with standard testing equipment capable of giving the desired level of accuracy. Hence the apparatus and equipments should also be given due importance while testing.

**High Performance Self Compacting Concrete**

Self-compacting concrete (SCC) has been described as "the most revolutionary development in concrete construction for several decades". Originally developed to offset a growing shortage of skilled labour, it has proved beneficial economically because of a number of factors, including:

- Faster construction
- Reduction in site manpower
- Better surface finishes

- Easier placing
- Improved durability
- Greater freedom in design
- Thinner concrete sections
- Reduced noise levels, absence of vibration
- Safer working environment




Originally developed in Japan, SCC technology was made possible by the much earlier development of superplasticisers for concrete. SCC has now been taken up with enthusiasm across Europe, for both site and precast concrete work. Practical application has been accompanied by much research into the physical and mechanical characteristics of SCC.

**Materials for SCC**

Mixture proportions for SCC differ from those of ordinary concrete, in that the former has more powder content and less coarse aggregate. Moreover, SCC incorporates high range water reducers (HRWR, superplasticisers) in larger amounts and frequently a viscosity modifying agent (VMA) in small doses. The questions that dominate the selection of materials for SCC are:

(i) Limits on the amount of marginally unsuitable aggregates, that is, those deviating from ideal shapes and sizes

(ii) Choice of High Range Water Reducers (HRWR).

(iii) Choice of Viscosity Modifying Agents (VMA).

(iv) Interaction and compatibility between cement, HRWR, and VMA.

| SCC Applications | SCC Advantage |
|---|---|
| 1.Walls with large openings<br>2.Aesthetic concrete or architectural concrete<br>3.Highly reinforced concrete<br>4.Slab-on-grade<br>5.Complex shapes where usage of vibrators is difficult<br>6.Elevated slabs<br>7.Difficult formwork designs<br>8.Congested steel reinforcement | 1.Self compacting concrete – no vibrations required<br>2.High fluidity<br>3.No segregation<br>4.No bleeding<br>5.No honeycombing<br>6.Labor greatly reduced<br>7.Better filling of gaps in complex designs<br>8.Quick unloading and placement<br>9.Increased productivity<br>10.Better adhesion to rebar<br>11.Good finish |

**Magnetized Water**

The magnetic water has been used in different fields like agriculture, health care, constructions,dairy production, and oil industries. Concrete mixes designed were prepared using tap water (TW) and another set of concrete mixes designed of the same proportions were also prepared using magnetized water (MW) in the laboratory to prepare the testing specimens. Assessment of the Concrete strength was performed to determine the effect of using magnetized water. The compression parameters included the mechanical properties and the consistency of fresh concrete. The change in water surface tension and the positive results of the concrete evaluation is evidence of the positive effect of using magnetized water in preparing concrete. Recently, magnetized water (MW) has been used in several applications including health, environment, agriculture, construction industry. The main target of this project is to study and evaluate concrete produced using MW. An experimental laboratory plan has been established to investigate the physical and mechanical properties of this concrete. Magnetized water is obtained by passing tap water through a magnetic field. Special apparatus to generate the magnetic field has been purchased and assembled with immerse-able water pump, for the laboratory study.

**Background of Magnetized Water :**

Magnetic water is the water that results when it is passes through a magnetic field with the purpose of changing its structure. After water passes through a magnetic field of a certain strength, it is called magnetic field treated water (MFTW). Or magnetic water (MW). The estimated improvement to the concrete strength is 10 %, saving 5 % of the cement dosage in addition to improving other characteristics. Where the structure of any substance appreciably determines its physical, chemical and thermo-physical properties. Workability plays an important role in the concrete quality in the short and long term. It is anticipated that the use of MW would have an effect on the fresh concrete quality that will lead to better quality of the hardened concrete, due to a change in the surface tension (viscosity) of the water used in the mix. moreover, more water is required for the concrete to be mixed well. Adding more water in concrete will make it workable, but unfortunately adding water will scarify the concrete density. The reduction in water surface tension causes the water molecules to be more dynamic and fluid. This in turn allows much better bonding between the other materials added to the water.

**Magnetic Device :**

The type of magnet which is used in many household appliances, automobiles, and industrial machines. This type of magnet can be used to produce a magnetic field and has the advantage control of the magnetic field strength by controlling the voltage of the electric current passed through the coil wire This study aims to investigate the affect of using magnetized water on concrete properties. Therefore, prior to the proportion of each mix, water will be prepared for that specific concrete mix. The water will simply be treated by passing it through magnetic field (magnetizer). MW will be prepared by passing it through magnetic field, using an im-merseable pump to circulate the water through the magnetic field for 45 min with a velocity of 9 m3/h. As a result the surface tension of water will get decreased by 7.4 mN/m.

## 4. RESULTS & DISCUSSION

**Evaluation of Flexural Strength: (As per IS 516-1959)**

The flexural strength of the specimen shall be expressed as the modulus of rupture *f*b, which, if '*a*' equals the distance between the line of fracture and the nearer support, measured on the centre line of the tensile side of the specimen, in cm, shall be calculated to the nearest 0.5 kg/sq cm as follows:

$$Fb = p \times l / bd^2$$

when '*a*' is greater than 20.0 cm for 15.0 cm specimen, or greater than 13.3 cm for a 10.0 cm specimen.

$$Fb = 3p \times a / bd^2$$

when '*a*' is less than 20.0 cm but greater than 17.0 cm for 15.0 cm specimen, or less than 13.3 cm but greater than 11.0 cm for a 10.0 cm specimen.

Where, *b* = measured width in cm of the specimen,

*d* = measured depth in cm of the specimen at the point of failure,

*l* = length in cm of the span on which the specimen was supported ,and

*p* = maximum load in kg applied to the specimen.

If '*a*' is less than 17.0 cm for a 15.0 cm specimen, or less than 11.0 cm for a 10.0 cm specimen, the results of the test shall be discarded.

**For M40 Grade:-**

| Sr.no | Casting Date | Age Days | Weight (kg) | Load (KN) | Failure Distanc (cm) | Fb=P xl / bd² (kg/cm²) |
|---|---|---|---|---|---|---|
| 1 | 19/1/2016 | 07 | 39.760 | 20 | 23 | 3.488 |
| 2 | 19/1/2016 | 07 | 40.075 | 25 | 26 | 4.360 |
| 3 | 19/1/2016 | 07 | 38.890 | 23 | 20.50 | 4.011 |
| 4 | 19/1/2016 | 28 | 40.860 | 29 | 23 | 5.057 |
| 5 | 19/1/2016 | 28 | 39.390 | 26 | 27 | 4.534 |
| 6 | 19/1/2016 | 28 | 39.865 | 29 | 28 | 5.057 |

**For M30 Grade:-**

| Sr.no | Casting Date | Age Days | Weight (kg) | Load (KN) | Failur Distan (cm) | Fb=P xl / bd² (kg/cm²) |
|---|---|---|---|---|---|---|
| 1 | 19/1/2016 | 07 | 38.870 | 18 | 28 | 3.139 |
| 2 | 19/1/2016 | 07 | 39.825 | 19 | 26 | 3.313 |
| 3 | 19/1/2016 | 07 | 39.775 | 18 | 24 | 3.139 |
| 4 | 19/1/2016 | 28 | 40.175 | 22 | 23.50 | 3.836 |
| 5 | 19/1/2016 | 28 | 39.875 | 23 | 24 | 4.011 |
| 6 | 19/1/2016 | 28 | 40.660 | 20 | 26 | 3.488 |

**Evaluation of Split Tensile Strength :-(As per IS 5816-1999)**

The measured splitting tensile strength Fct, of the specimen shall be calculated to the nearest 0.05 N/mm² using the following formula :

$$Fct = 2P / (3.14 \times l \times d)$$

*P* = maximum load applied to the specimen(in N)

I = length of the specimen (in mm)

d = cross sectional dimension of the specimen (in mm).

**For M40 Grade:-**

| Sr.no | Casting Date | Age (Days) | Weight (kg) | Load (KN) | Fct (N/mm²) |
|---|---|---|---|---|---|
| 1 | 19/1/2016 | 07 | 13.086 | 134.80 | 1.910 |
| 2 | 19/1/2016 | 07 | 13.166 | 150.00 | 2.120 |
| 3 | 19/1/2016 | 07 | 13.298 | 149.30 | 2.110 |
| 4 | 19/1/2016 | 28 | 13.180 | 218.50 | 3.090 |
| 5 | 19/1/2016 | 28 | 13.446 | 260.30 | 3.680 |
| 6 | 19/1/2016 | 28 | 13.440 | 244.80 | 3.460 |

**For M30 Grade:-**

| Sr.no | Casting Date | Age (Days) | Weight (kg) | Load (KN) | Fct (N/mm²) |
|---|---|---|---|---|---|
| 1 | 19/1/2016 | 07 | 13.195 | 119.40 | 1.680 |
| 2 | 19/1/2016 | 07 | 13.274 | 124.80 | 1.760 |
| 3 | 19/1/2016 | 07 | 13.213 | 125.60 | 1.770 |

| | | | | | |
|---|---|---|---|---|---|
| 4 | 19/1/2016 | 28 | 13.248 | 174.50 | 2.470 |
| 5 | 19/1/2016 | 28 | 13.533 | 192.10 | 2.710 |
| 6 | 19/1/2016 | 28 | 13.360 | 188.70 | 2.660 |

**Evaluation of Compression Strength:-(As per IS 516-1959)**

Tests shall be made at recognized ages of the test specimens, the most usual being 7 and 28 days. Ages of 13 weeks and one year are recommended if tests at greater ages are required. Where it may be necessary to obtain the early strengths, tests may be made at the ages of 24 hours ± ½ hour and 72 hours ± 2 hours. The ages shall be calculated from the time of the addition of water to the dry ingredients. At least three specimens, preferably from different batches, shall be made for testing at each selected age. Specimens stored in water shall be tested immediately on removal from the water and while they are still in the wet condition. Surface water and grit shall be wiped off the specimens and any projecting fins removed. Specimens when received dry shall be kept in water for 24 hours before they are taken for testing.

The measured compressive strength of the specimen shall be calculated by dividing the maximum load applied to the specimen during the test by the cross-sectional area, from the mean dimensions of the section and shall be expressed to the nearest kg per sq cm. Average of three values shall be taken as the representative of the batch provided the individual variation is not more than ± 15 percent of the average. Otherwise repeat tests shall be made.

***Compressive Strength=Fck= Applied Load / c/s Area***

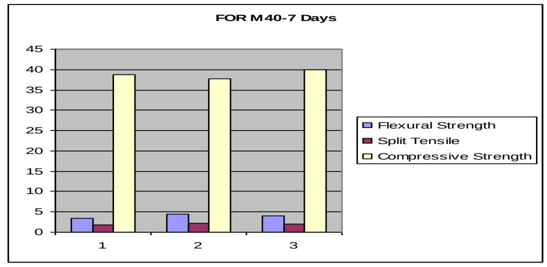
**For M40 Grade:-**

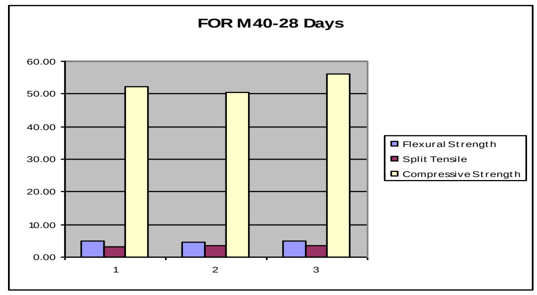
| Sr.no | Casting Date | Age (Days) | Weight (kg) | Load (KN) | Fck (N/mm²) |
|---|---|---|---|---|---|
| 1 | 19/1/2016 | 07 | 8.50 | 871 | 38.71 |
| 2 | 19/1/2016 | 07 | 8.40 | 847 | 37.64 |
| 3 | 19/1/2016 | 07 | 8.45 | 898 | 39.91 |
| 4 | 19/1/2016 | 28 | 8.50 | 1179 | 52.40 |
| 5 | 19/1/2016 | 28 | 8.65 | 1132 | 50.31 |
| 6 | 19/1/2016 | 28 | 8.70 | 1262 | 56.08 |

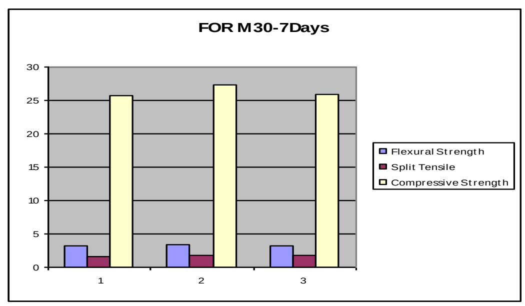
**For M30 Grade:-**

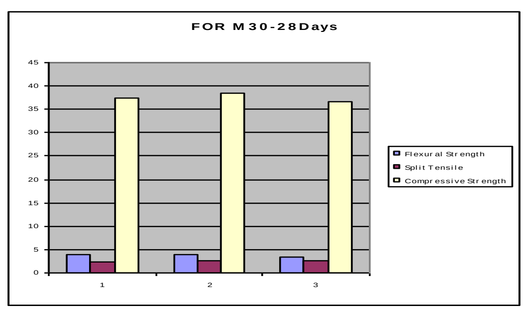
| Sr.no | Casting Date | Age (Days) | Weight (kg) | Load (KN) | Fck (N/mm²) |
|---|---|---|---|---|---|
| 1 | 19/1/2016 | 07 | 8.65 | 580 | 25.77 |
| 2 | 19/1/2016 | 07 | 8.45 | 615 | 27.33 |
| 3 | 19/1/2016 | 07 | 8.30 | 584 | 25.95 |
| 4 | 19/1/2016 | 28 | 8.55 | 840 | 37.33 |
| 5 | 19/1/2016 | 28 | 8.75 | 865 | 38.44 |
| 6 | 19/1/2016 | 28 | 8.50 | 824 | 36.62 |

## 5. INVESTIGATION & OBSERVATIONS




## 6. CONCLUSIONS

1. Concrete has relatively high compressive strength, but significantly lower tensile strength.
2. The elasticity of concrete is relatively constant at low stress levels but starts decreasing at higher stress levels as matrix cracking develops.
3. Concrete would almost always fail from tensile stresses, even when loaded in compression .the practical implication of this is concrete elements subjected to tensile stresses must be reinforced with material that are strong in tension.

4. Though flexural strength test is a useful tool in research and in laboratory evaluation of concrete ingredients and proportions ,it is too sensitive to testing variation to be usable as a basis for the acceptance or rejection of concrete in the field.
5. The concrete industry and inspection and testing agencies are much more familiar with the traditional compressive tests for control and acceptance of concrete.
6. Flexural strength can be used for design purpose, but the corresponding compressive strength should be used to order and accept the concrete.

REFERENCES

[1] ASTM. (2006). “Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.” C136-06, West Conshohocken, PA.
[2] ASTM. (2007a). “Standard test method for density, relative density (specific gravity), and absorption of fine aggregate.” C128-07, West\Conshohocken, PA.
[3] ASTM. (2007b). “Standard test method for density, relative density(specific gravity), and absorption of coarse aggregate.” C127-07, West Conshohocken, PA.
[4] ASTM. (2008a). “Standard test method for air content of hydraulic cement mortar.” C185-08, West Conshohocken, PA.
[5] ACI Committee 363, 1984. State-of-the-Art Report on High Strength Concrete, ACI
Journal. 81 (4): 364-411.
[6] Malhotra VM. Introduction: sustainable development and concrete technology. ACI Concr Int. 2002; 24(7):