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# Strength Behaviour of High Performance Concrete using Fibres and Industrial by Products

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***ABSTRACT:-*** **A High performance concrete is something which demands much higher performance from concrete as compared to performance expected from routing concrete. Use of chemical admixtures reduces the water content, thereby reducing the porosity within the hydrated cement paste. Mineral admixtures also called as cement replacement material (CRM) such as fly ash, rice husk ash, Metakaolin, silica fume and additives such as metallic and non-metallic fibres are more commonly used in the development of High performance mixes, act as pozzolanic materials as well as fine fillers, thereby the microstructure of hardened cement matrix becomes denser and stronger. In this study, to replace the constituent materials by mineral admixtures, chemical admixtures and additives also, it is proposed to use high performance concrete. Also High Performance concrete specimens with fiber and without fiber in size 150mmx150mmx150mm, cylinder of 150mmx300mm and prism of 100mmx100mmx500mm were cast and the strength tests were observed. Finally mechanical properties of concrete were carried out by ANN modeling.**

***KEYWORDS: HPC, Admixtures, Fibres, Strength properties, ANN, Prediction***.

## INTRODUCTION

Concrete is most widely used construction material. 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 deficiencies which, but for its remarkable qualities of resilience, flexibility and ability to redistribute stress, world have prevented its use as a building material. A high performance concrete is something which demands much higher performance from concrete as compared to performance expected from routine concrete. Use of chemical admixtures reduces the water content, thereby reducing the porosity within the hydrated cement paste. Mineral admixtures, also called as cement replacement materials (CRM), act as pozzolanic materials as well as fine fillers, thereby the microstructure of hardened cement matrix becomes denser and stronger. Materials selection will play a large part in the improved concrete of the new century. The choice of w/cm will be eliminated from concrete specification. The judicious selection and use of chemical admixtures will continue to enhance the durability of concrete. These benefits will in turn protect the concrete from aggressive chemical elements, reduce the rate of carbonation, improve corrosion resistance and extend the life of transportation infrastructure. Chemical admixtures that inhibit corrosion, reduce the formation of ASR products inhibit water penetration and reduce shrinkage will provide important benefits as well.

## LITERATURE COLLECTION

P.L.Domone, and M.N.Soutsos, ( 1995 ) "The results show broadly similar effects to those in lower strength concrete, although of differing magnitude in some cases. Some potential advantages of ternary blends for optimization of properties have been demonstrated. Long- term strength of PFA and GGBS mixes may not reach those of 100% Portland cement mixes when the water-binder ratio is reduced to 0-26 and below, but micro silica can increase the strength of all mixes". R.Duval and E.H.Kadri (1998) " The results show that partial cement replacement up to 10% silica fume does not reduce the concrete workability and propose a model to evaluate the compressive strength of silica fume concrete at any time. The increase of the compressive strength of SF concretes depends much more on the decrease of the water/cementitious materials ratio than on the replacement of silica fume with cement'. ShreetiS.Mavinkurve, et al., (2003) " Present paper discusses the approach adopted to develop HPC mix by means of laboratory trials using HRM. The various properties of concrete, both in the fresh and hardened states are also highlighted .It can be concluded the high strength concrete up to compressive strength of 82.75 M pa, having quite low permeability and with reasonably high slump can be developed using Indian HRM and cement". Marta Kasior-Kazberuk and MalgorzataLelusz (2006) " Strength of concrete with different types of cement have been analyzed to evaluate the effect of addition content, the time of curing and the type of cement on the compressive strength changes. The pozzolanic and hydraulic activity of fly ash have mainly been pointed out as well as the possibility to use this addition as a concrete component".

## EXPERIMENTAL INVESTIGATION

In the experimental study, generally a good quality of cement like 43 grade cement is preferred but it may vary according to the grade of HPC needed. Natural sands crushed and rounded sands and manufactured sands are suitable for HPC. River sand of specific gravity 2.65 and conforming to zone II of IS 363 was used for the present study. The shape and particle size distribution of the aggregate is very important as it affects the packing and voids content. The moisture content, water absorption, grading and variations in fines content of all aggregate should be closely and continuously monitored and must be taken into account in order to produce HPC of constant quality. Coarse aggregate used in this study had a maximum size of 10mm. Specific gravity of coarse aggregate used was 2.75 as per IS 363. Ordinary potable water was used. The pH value is not less than 8.0. Super plasticizers are high range water reducing admixtures an essential component of HPC. Conplast SP 430 was used as super plasticizer. Silica fume imparts very good improvement to rheological, mechanical and chemical properties. It improves the durability of the concrete by reinforcing the microstructure through filler effect and thus reduces segregation and bleeding. It is also helps in achieving high early strength. Fly ash produced from the burning of younger lignite or sub bituminous coal, in assertion to having pozzolanic properties, also has some self-cementing properties. Class C fly ash generally contains more than 20% lime (CaO). Glass fiber also called fiberglass. It is material made from extremely fine fibers of glass. Fiber glass is a lightweight, extremely strong and robust material. Glass is the oldest, and most familiar, performance fiber. Generally glass consists of quartz sand, soda, sodium sulphate, potash feldspar and a number of refining and dying additives. Steel fiber products are available in a variety of types and sizes from various manufacturers. A plasticizer or super plasticizer is often used to enhance mix workability. About two decades back, steel fiber reinforced concrete (SFRC) was considered a new technology for the construction industry. However today this technology has found wider acceptance among the construction industry. The objective of the study is to evaluate the effectiveness of various percentages of mineral and chemical admixtures in producing high performance concrete.

The experimental programme was planned to study the following properties:

Cement: Ordinary Portland cement of 43 grades conforming to IS-12269 having specific gravity of 3.08.

Fine aggregate: Natural river sand conforming to IS-383, Zone-II has specific gravity 2.65.

Coarse aggregate: Crushed granite angular aggregate of size 20mm passing confirming to IS-383 having specific gravity 2.75.

Mineral admixtures: fly ash and silica fume.

Additives: Steel fiber and Glass fiber

Chemical admixture: Conplast Sp-430

Water: Ordinary portable water conforming to IS 456.

Material replacement:

- Fly ash - 20% replacement of cement.
- Silica fume – 10 % replacement of cement
- Steel fibre – 1% in volume of concrete
- Glass fibre – 1% in volume of concrete

Super plasticizer Conplast SP430 is high range water reducing admixtures. The details of the specimens were shown in Table 1.

Table 1 Detail of Specimens

| Sl.no | Name of testing | No of specimens | | |
|---|---|---|---|---|
| | | **Cube** | **Cylinder** | **Prism** |
| 1 | Compressive strength | 27 | 27 | - |
| 2 | Split tensile strength | 27 | 27 | - |
| 3 | E for concrete | - | 27 | - |
| 4 | Flexural strength | - | - | 27 |

The specimens of having dimensions Cube 150mmx150mm, Cylinder 150mmx300mm, Prism 100mmx100mmx500mm could be used to determine all the above mentioned properties.

## COMPRESSIVE STRENGTH TEST

The compression testing machine is of any reliable type, of sufficient capacity for the tests and capable of applying the loads. The permissible error shall not be greater than the 2% of the maximum load. The testing machine shall be equipped with 2 steel bearing plates with hardened faces. One of the plates( preferably the one that normally with bear on the upper surface of the specimens) is fitted with a ball seating in the form of the portion of a sphere, the center of which coincides with the central point of the face of the plate. The other compression plate shall be plain rigid bearing block. The bearing faces of both plates are at least as largest, and preferably larger than the normal size of the specimen to which the load is applied. After 28 days of continuous curing the specimens are taken out and they are exposed to atmosphere for six hours. Surface water and grit shall be wiped off the specimens and any projecting fins are removed. After visual confirming that the specimens are dry it is then taken for testing.

Figure 1 Compressive test set up

Table 2 compressive strength of cube 28 days

| SL.NO | TYPE OF SPECIMEN | AVERAGE COMPRESSIVE STRENGTH N/mm² | AVERAGE TENSILE STRENGTH N/mm² |
|---|---|---|---|
| 1 | Conventional | 35.99 | 5.78 |
| 2 | HPC | 36.23 | 6.12 |
| 3 | HPC & Glass fibre | 37.18 | 7.16 |
| 4 | HPC & Steel fibre | 38.47 | 8.08 |
| 5 | HPC & Hybrid fibre | 39.66 | 9.09 |

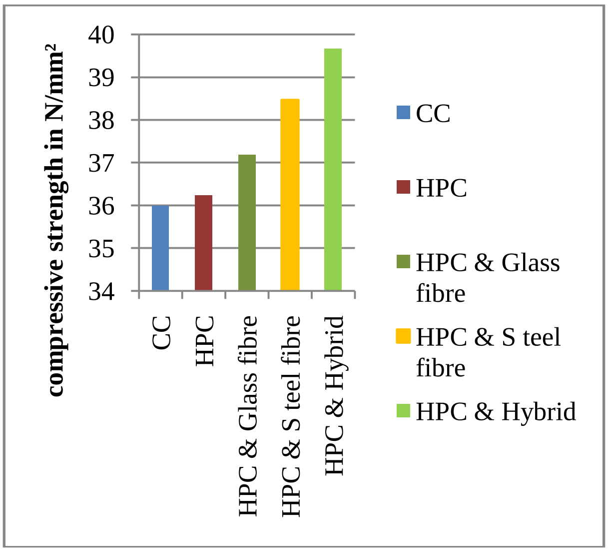


Figure 2Compressive strength of cube 28 days

Table 4 compressive strength of cylinder 28 days

| SL.NO | TYPE OF SPECIMEN | AVERAGE COMPRESSIVE STRENGTH N/mm² | AVERAGE TENSILE STRENGTH N/mm² |
|---|---|---|---|
| 1 | Conventional | 27.70 | 2.87 |
| 2 | HPC | 27.90 | 3.15 |
| 3 | Glass fibre | 31.49 | 3.91 |
| 4 | Steel fibre | 33.19 | 4.28 |
| 5 | Hybrid fibre | 34.89 | 5.04 |

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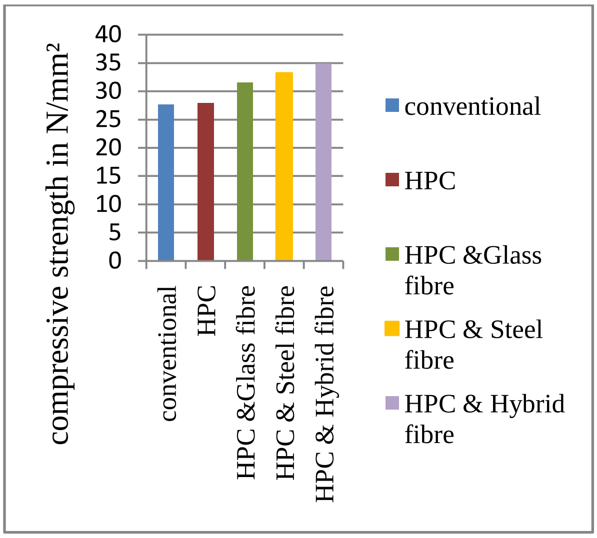



Figure 4 Compressive strength of cylinder 28 days

SPLIT TENSILE TEST

Since there is no direct method for finding the tensile strength of concrete indirect method is adopted in this method the same compression testing machine as used for finding the compressive strength is used. The cube specimens of size 150*150*150 mm were cast in steel mould. Casting was conducted in three layers with each layer compacted by using ramping rods up to sufficient levels. The specimens remained in the steel mould for 24 hours and then it is de-molded and then placed in curing tank. After 28 days specimen were taken out and exposed to atmospheric condition so as to obtain dry surface. The specimen is placed diagonally in the standard compression testing machine. The concrete cubes were placed in the machine in such a manner that the load was applied on the diagonally edge surface of the cube as cast. The load was applied gradually till the specimens to the increasing loads breaks down and no greater load was sustained. The maximum load applied is the specimen was recorded and the appearance of any unusual cracks was noted. The ultimate load value was recorded. Results are compared with the reference specimen and their details are shown



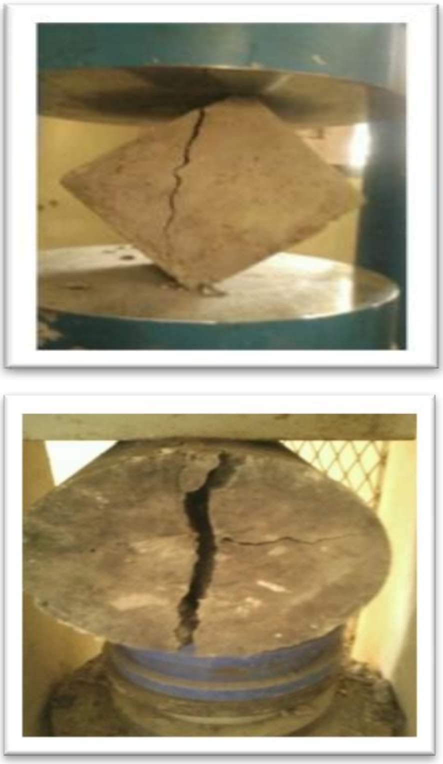


Figure 4 Tensile Test set up

FLEXURAL STRENGTH TEST

The Prism specimens of size (100* 100*500) were cast in steel mould. Casting was conducted in three layers with each layer compacted by using ramping rod up to sufficient levels. The specimens remained in the steel mould for 24 hours and then it is de-u and then placed in curing tank.

After 28 days prisms were taken out and exposed to atmospheric condition so as to obtain dry surface. Two points loading was used to determine the flexural strength of the prism.

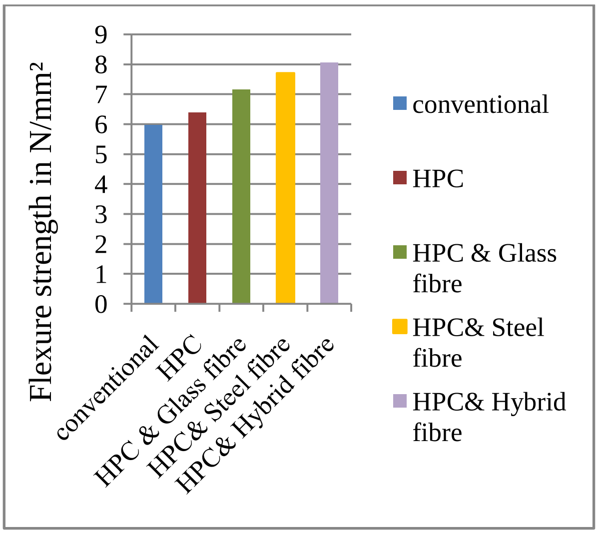
The bearing surface of the supporting and loading rollers are wiped clean, and any loose sand are other material removed from the surface of the specimen where they are to make contact with rollers.

The permissible errors shall be not greater than +0.5 or -0.5 percent of the applied load where, a high degree of accuracy is required and not greater than +1.5 or -1.5 percent of the applied load for commercial type of use.

The bed of the testing machine was provided with two steel rollers, 38mm in diameter, on which the specimen is to be supported, and these rollers were mounted that the distance from center to center is 60cm, for 15cm specimens or 40cm for 10cm specimens.


Figure 3 Flexure Test set up

| SL.NO | TYPE OF SPECIMEN | AVERAGE FLEXURAL STRENGTH N/mm² |
|---|---|---|
| 1 | Conventional | 5.972 |
| 2 | HPC | 6.388 |
| 3 | Glass fibre | 7.152 |
| 4 | Steel fibre | 7.708 |
| 5 | Hybrid fibre | 8.05 |






## CONCLUSION

HPC was designed with various replacements of constituent materials and addition of mineral and chemical admixture was casted. HPC mixture were designed having a constant W/C ratio is 0.40. The mechanical strength conclusions were listed below.

- In HPC Compressive strength of Cube and cylinder was increased 0.66% and 0.71%, Split tensile strength of cube and cylinder was increased 5.55% and 8.88%, Flexural test of prism was increased 6.5% as compared with conventional concrete at 28 days.
- In HPC & Glass fibre Compressive strength Of Cube and cylinder was increased 3.2% and 12%, Split tensile strength of cube and cylinder was increased 19.2% and 26.59%, Flexural test of prism was increased 16.4% and modulus of elasticity was increased 2.1% as compared to conventional concrete at 28 days.
- In HPC & Steel fibre Compressive strength Of Cube and cylinder was increased 6.44% and 16.54%, Split tensile strength of cube and cylinder was increased 28.5% and 32.94%, Flexural test of prism was increased 22.5% and modulus of elasticity was increased 4.3% as compared to conventional concrete at 28 days.
- In HPC with fibre and without fibre of Hybrid fibre of Compressive strength Of Cube and cylinder was increased 9.25% and 20.6%, Split tensile strength of cube and cylinder was increased 36.4% and 43.05%, Flexural test of prism was increased 25.8% and modulus of elasticity was increased 5.3% as compared to conventional concrete at 28 days.

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