# Effect of Super Plasticizer on the Mechanical and Durable Properties of High Volume Cementitious Concrete

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## Abstract

Water reducing admixtures often called super plasticizers are used in the concrete to enhance the performance of the concrete. Design Mix of M40 grade having High volume cementitious concrete (HVCC) was prepared having cementitious content equal to that of self-compacting concrete. Mechanical, Durable properties and shear strength of concrete was calculated. Then Poly carboxylic ether (PCE) based super plasticizer (Glenium sky 8777) was added to HVCC to convert it into high volume self-compacting concrete (HVSCC). Again tests were done for mechanical, durable strength of HVSCC. Water cement ratio was kept constant for the entire study. The results showed that there is increase in the mechanical and durable properties of HVSCC when compared to HVCC.

**Keywords: Self Compacting Concrete, Cementitious Concrete, Mechanical Strength, Durability, Super Plasticizer**

## I. INTRODUCTION

Super plasticizers also referred as high range water-reducing agents, which belong to Type F and G categories of water reducers. Chemically, super plasticizers vary from other water reducers and can reduce water requirement by up to 35%. Polycarboxylates ether (PCE) composed by a methoxy - polyethylene glycol copolymer grafted with methacrylic acid copolymer. They're very strong water reducers (powerful at low dosage), with the ability to minimize water by way of 20%-35%, with much less retardation and excessive workability retention. Glenium SKY 8777 is the superplasticiser based on polycarboxylic ether polymers. The product has been primarily developed for applications in high performance ready-mix concrete. Glenium SKY 8777 is free of chloride & low alkali. It is compatible with all types of cements.

### *A. Materials used and Mix Proportions*

An Ordinary Portland Cement (OPC) 43 grade confirmed to Indian Standards (IS: 8112-1989) was used in the experimental program. Class F fly ash brought from ACC Power Plant, Gurdaspur, Ludhiana, India confirmed to Indian Standards (IS:3812-2003) was used as a mineral powder. The fly ash was used due to its additional strength contributing pozzolanic activity. The chemical properties of fly ash are presented in Table 1. Locally available coarse aggregates of size 10 and 12.5 mm of specific gravity 2.68 and fineness modulus of 7.6 was used in this study. Locally available river sand of specific gravity 2.4 and fineness modulus of 2.3 was used as fine aggregate. Polycarboxylate ether based superplasticizer complying with ASTM C 494 type F, with density 1.1 kg/l and pH 7.01 was used in the present investigation.

Table - 1
Mix proportions used in the trials

| *Cement ($kg/m^3$)* | *Fly Ash ($kg/m^3$)* | *Coarse Aggregate ($kg/m^3$)* | *Fine Aggregate ($kg/m^3$)* | *W/C* | *SP ($l/m^3$)* |
|---|---|---|---|---|---|
| *420* | *180* | *836* | *771* | *0.32* | *0* |
| *420* | *180* | *836* | *771* | *0.32* | *6* |

## II. PREPARATION OF MIXES

For the mix proportion shown in Table 2, required quantities of materials were weighed. Fine and coarse aggregate combinations were mixed for 90 sec in mixer. Cement and filler combinations were added into the aggregate mixes and remixed for 60 sec all together in dry state. The water was mixed in a flask and poured slowly into the mixer while mixing. The total mixing time was

five minutes with the rotating speed of 45+1 cycle/min of the mixer. The casting immediately followed mixing, after carrying out the tests for fresh properties. The top surface of the specimens was scraped to remove excess material and achieve smooth finish. The specimens were removed from moulds after 24 h and cured in water for 28 days till testing. The cubes of size 150 mm were cast for determination of compressive strength and resistance against acid attack, beams of 100 × 100 × 500 mm were casted for the determination of flexural strength of beam. All test measurements were taken as the average of three readings.

## III. EXPERIMENTAL STUDIES

High volume cementitious concrete (HVCC) was prepared of M40 grade with total cementitious content equal to cementitious content of self-compacting concrete. Workability test by slump cone on HVCC was performed then, mechanica, durable, shear strength of HVCC was performed. Then on the HVCC Glenium Sky 8777 (PCE) Super Plasticizer was added by 1% weight of cementitious content, and hence converted into High Volume Self Compacting Concrete (HVSCC). Slump flow, v funnel test were performed on HVSCC as recommended by EFNARC. Then again mechanical, durable, shear strength of HVSCC was calculated. Brief descriptions of these tests are given below.

### *A. Slump Cone Test*

Slump test experiment is carried out to calculate workability of fresh concrete. Slump test in keeping with the IS: 1199 – 1959 was followed on this investigation. The results of slump cone test are discussed in table 4.

### *B. Slump Flow Test and $T_{50\,cm}$ Test*

The slump flow is done to find the horizontal motion of SCC in absence of the obstructions. The process is used for deciding upon the slump flow. The diameter of concrete circle is the measure for the filling ability of the concrete. The result of slump flow test and $T_{50\,cm}$ test are discussed in below.

### *C. V Funnel Test and V Funnel Test at T 5minutes*

The apparatus is a V- shaped funnel. The V-funnel test is made to assess filling potential (flowability) of the concrete with maximum aggregate size of 20 mm. The results of V funnel test and V funnel test at T 5 minutes are discussed in table 4.

### *D. Compressive Strength Test*

The test was performed on Compression testing machine. The compressive strength test was performed as per IS 516-1959. The results of compressive strength test are discussed in table 5.

### *E. Resistance to Acid Attack*

Resistance to the Acid attack on concrete is determined in terms of % of weight loss before and after acid attack and strength loss after immersing in sulfuric acid solution (Advin et.al (2012)). Results for resistance to acid attack are discussed in table 9 and 10.

### *F. Flexure Strength Test*

Flexural Testing Machine was taken to find Flexural strength of concrete beam. Two point loading method was used. Results of flexural strength are discussed in table 11.

## IV. RESULTS AND DISCUSSIONS

Table – 2
Physical Properties of Cement

| *Characteristics* | *Experimental Observation* | *Value specified by IS: 8112-198* |
|---|---|---|
| *Standard consistency* | *33%* | - |
| *Specific Gravity* | *3.15* | |
| *Initial Setting Time* | *130 mins* | *>30 mins* |
| *Final Setting Time* | *220 mins* | *<600 mins* |

Table - 3
Workability of HVCC and HVSCC

| *Sr. No* | *Method* | *Required Value* | *Value Obtained* |
|---|---|---|---|
| *1.* | *Slump (HVCC)* | - | *28 mm* |
| *2.* | *Slump Flow (HVSCC)* | *650-800 mm* | *710 mm* |
| *3.* | *$T_{50cm}$ slump Flow (HVSCC)* | *2-5 sec* | *4 sec* |
| *4.* | *V-funnel (HVSCC)* | *6-12 sec* | *11.2 sec* |
| *5.* | *V-funnel at $T_{5minutes}$ (HVSCC)* | *6-15 sec* | *13.4 sec* |

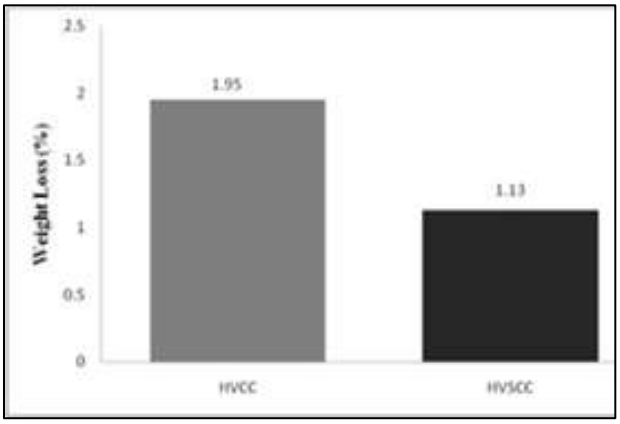


Fig. 1: Variation in Compressive Strength

Table – 4
Compressive Strength at 28 days

| *Sr. No* | *Mix* | *Mean Load (KN)* | *Mean Strength (N/mm$^2$)* |
|---|---|---|---|
| *1.* | *HVCC* | *943.33* | *41.92* |
| *2.* | *HVSCC* | *1126* | *50.03* |

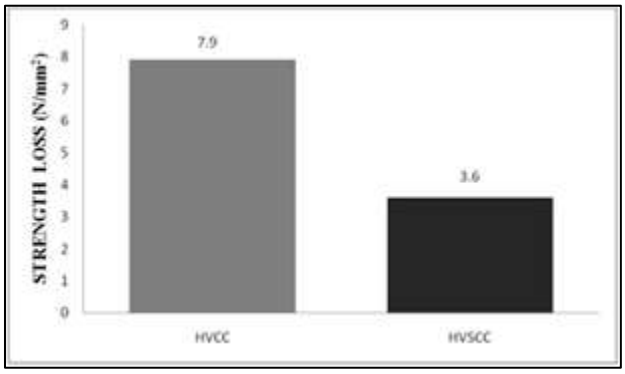


Fig. 2: Variation in Weight after Acid Attack

Table – 5
Percentage of Weight Loss in Concrete

| *Sr. No* | *Mix* | *Mean Initial Weight (kg)* | *Mean Final Weight (kg)* | *Mean Weight loss (%)* |
|---|---|---|---|---|
| *1.* | *HVCC* | *8.2* | *8.04* | *1.95* |
| *2.* | *HVSCC* | *7.95* | *7.86* | *1.13* |

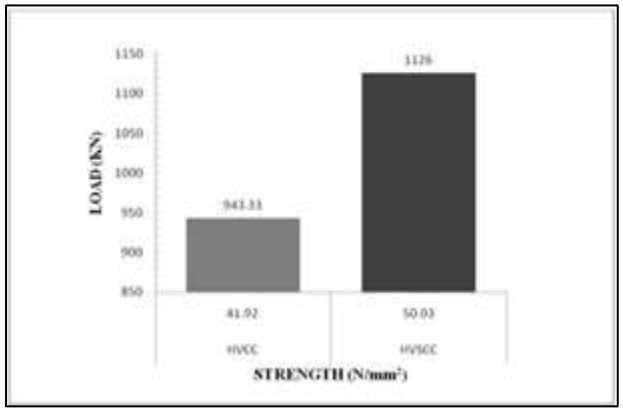


Fig. 3: Variation in Compressive Strength after Acid Attack

Table – 6
Percentage Compressive Strength

| *Sr. No* | *Mix* | *Mean Initial Strength (N/mm$^2$)* | *Mean Final Strength (N/mm$^2$)* | *Strength Loss (%)* |
|---|---|---|---|---|
| *1.* | *HVCC* | *41.92* | *38.6* | *7.9* |
| *2.* | *HVSCC* | *50.03* | *48.22* | *3.6* |

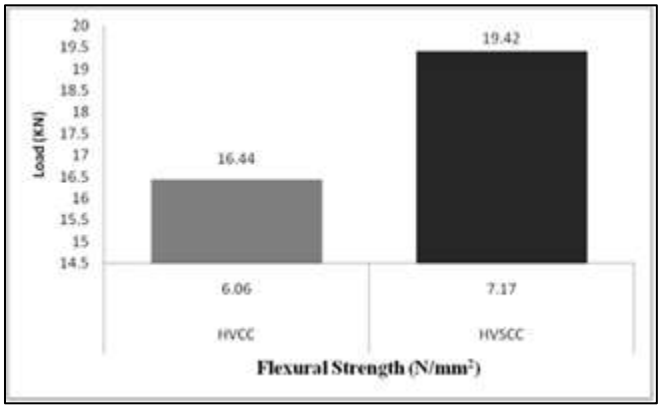


Fig. 4: Variations in Flexural Strength

Table - 7
Flexural Strength at 28 days

| *Sr. No* | *Mix* | *Mean Load (tons)* | *Strength (N/mm$^2$) Mean* |
|---|---|---|---|
| *1.* | *HVCC* | *1.6* | *6.06* |
| *2.* | *HVSCC* | *1.95* | *7.17* |

## V. CONCLUSIONS

The following conclusions were drawn from the present study:

1) After 28 days of curing, compressive strength of HVSCC increases by 19.3% than that of HVCC.
2) Resistance to acid attack is found least in case of HVSCC compared to HVCC. Weight loss for HVSCC was 1.13% whereas for HVCC was 1.95% and strength loss for HVSCC was 3.6% whereas for HVCC was 7.9%.
3) Flexural strength was increases by 18.31% by addition of SP to the HVCC.

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