# STUDY ON SELF COMPACTING CONCRETE AND ITS PROPERTIES BY PARTIAL REPLACEMENT OF CEMENT WITH FLY ASH AND SILICA FUME

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## 1 INTRODUCTION

Starting from 1983, the risk of durability of concrete constructions was a most important subject of experiment in Japan. The establishment of strong concrete constructions needs the efficient compaction by skilled technicians. The plans of reinforced concrete constructions were much advanced, but the planed models of structures were much difficult and having heavy weight reinforcements seems to be uneconomical. Further, the slow decrease in the number of trained labours in Japan manufacturing companies lead to reduction in the durability of construction works. The only one solution for achieving the long life of concrete structures without depending on the qualities of labours work is the implementation of self compacting concrete. The SCC can be settled into each part of the formwork by purely on its self weight and with no utilization of artificial compaction. Okamura suggested the requirement of this variety of concrete in the year of 1986

The first SCC mix was completed in the year of 1988 by utilizing the locally available materials. This mix provides the acceptable values of heat of hydration, compaction after harden and shrinkage.

Professor Aitcin has defined the high performance concrete; it is the concrete having higher durability due to less water cement proportion. From after, the high performance concrete was utilized throughout the universe to refer the high durable concrete. The authors M Ouchi and H Okamura were published an experiments on SCC for JACT 2003.These authors renamed the term for this particular concrete to self compacting high performance concrete.

## 2. ADVANTAGES OF SCC

The benefits of SCC over the ordinary concrete are as follows;

- Improvement in the properties of concrete and reduced maintenance cost
- Quicker construction
- Lower construction cost
- Utilization of automation in concrete construction
- Improved safety and health due to elimination of vibrators
- Reduction in the noise pollution
- The utilization of industrial wastes and dusts can be possible in SCC
- Good surface finishing
- Easier placing of concrete
- Thinner structural elements
- Higher flexibility in design
- Increased durability
- Reduction in equipment costs and labor costs

## 3 LIMITATIONS OF SCC

The some of the limitations of SCC are stated below;

- A slight alteration in the composition of SCC could be a warning sign on concrete quality
- The alteration of even 1% moisture quantity in fine ingredients will cause the larger impact on qualities of SCC
- For developing the SCC, it requires the large number of trial mixes

- The SCC cost is greater than that of conventional concrete
- The formworks should be manufactured to resist the fluid pressure of concrete
- The SCC may be fixed in elevators in taller structures

## 4 LITERATURE REVIEW

These literature reviews explores the various method and applications employed to examine the self consolidating concrete by utilizing the variety of binding ingredients and also utilizing the admixture. This literature review enumerates the projects finished from the various scientists on the self consolidating concrete.

### 4.1 LITERATURE ON THE WORKABILITY OF CONCRETE

**1) Xie et al (2002)**

He published the project report that include the high quality mix and high strength self consolidating concrete by utilizing the fly ash. This work is carried out by utilizing the locally available materials. In the present research work, the cement content is replaced by the 30 % of the total cement quantity by fly ash and also the sand were modified by the pieces of gravels. The admixture such as super plasticizer of about 1.0 to 1.6% is utilized of total quantity of cement and 175 l/$m^3$ of water quantity. At the time when the admixture proportion is greater than the 1.6 %, the compressive reduces due to bleeding. The final outcome of this research gives that the workability of fresh concrete is increases and the compressive strength variation reduces with the enhance in the fine ingredient proportions of SCC. The fine aggregates proportion should not be below than 40% of total volume.

**2) Felekoglu et al [2005]**

This scientist was conducted the experiment on the affect of w/c proportions upon the hardened as well as fresh qualities of SCC. As per the experiment it shows that, the alteration of w/c proportion along with the super plasticizer ratio is one of the significant qualities in preparing the SCC mixes. Finally, this project concludes the maximum dosage of the w/c proportion is needed to obtain the self consolidating concrete is 0.84 to 1.07 by volume of cement. The little variation of this proportion above or below might result in segregation of the ingredients.

### 4.2 LITARATURE ON THE COMPRESSIVE STRENTH OF CONCTRETE

**1) Venkatesh babu D L [2003]**

In this study, the author conducted experiments on the qualities of the self consolidating concrete. Many tests were performed by utilizing variety of cement combinations, water binder proportion, water reducing admixture and retarder admixture were utilized in the mix proportions to increase the compressive strength and workability of SCC. The final analysis result indicates the workability of concrete was in between the acceptable limits for SCC. The greater compressive strength of self compacting concrete mix at exactly 28 days is 71.33 Mpa is obtained. The test outcomes and the qualities such as passing ability, flowing capacity and segregate resistance were within the limit

**2) Kung Chung Hsub,Nan sua,His Wen Chai [2001]**

These scientist were create the new mix proportions for the self consolidating concrete with satisfying the self compacting qualities like flow ability, passing ability, flow ability and other. The quantity of the ingredients was taken and the pores in the concrete paste packed by these ingredients. Therefore, the quantities of aggregates, binders, water quantity and amount of super plasticizer to be employing are found out carefully. The fresh qualities of SCC such as slump flow, V funnel, L box, U box and the compression strength experiments were conducted to determine the qualities of self consolidating concrete. This way is much better than the Japanese ready mix concrete technology due to easy implementation of this concrete, less construction period, much economical and with consuming less quantity of cement content.

## 5. MATERIALS UTILIZED IN THE PROJECT

1] Ordinary Portland cement
2] Fine aggregates

3] Coarse aggregates
4] Fly ash
5] Silica fume
6] Conplast sp 430 admixture

Fig 5.1 Fly ash powder


Fig 5.2 Silica fume bag

Fig 5.3 Conflast sp 430

## 6. DEFFERENT TESTS ON SELF COMPACTING CONCRETE

### 6.1 Slump flow test method

The slump flow test is the much familiarly using SCC test in the modern times. The test includes the utilize of slump cone which is utilizing for ordinary concrete as illustrated in ASTM-C 143 [2002].The major distinction among the ASTM-C 143 and slump flow test is that, the slump flow test determines the spreading of concrete when the cone is raised rather than the usual concrete slump height. The $T_{50}$ test is calculated at the time of slump flow test. It is determined as the duration, the concrete take to spread to a distance of 50 centimeter. Normally, slump flow readings of 24 to 30 inch are considered as satisfactory reading. The satisfactory $T_{50}$ time period is 2 – 5 seconds.

Fig 6.1 Slump flow testing

Fig 6.2 Slump flow testing

### 6.2 L Box test

An L-box test is the proportion of height of concrete at every point of the container after the testing is over. The L-box apparatus comprises of chimney, trough and section. The height of the concrete in chimney is mentioned as $H_1$ and also the height of concrete at trough is writes as $H_2$. Finally, the L-box test values are concluded by the ratio $H_2/H_1$, this relation is known as L box ratio. The acceptable reading of L box test is 0.8 to 1. When the height of the concrete at every point is level then the L box reading is noted as 1.0. And the other end, if the concrete unable to flow through the trough its reading is noted as zero.

Fig 6.3 L Box tasting

Fig 6.4 L Box testing

### 6.3 V Funnel and T 5 minute test

The V-funnel test is utilized to find out the flow capacity of the concrete. The highest size of the ingredients is 20 mm. This test requires the 12 liter of concrete. The time duration for the flow of the concrete through the funnel is recorded. After this, the concrete is again filled up in the funnel and left for 5 minute to settle down, this will cause the segregation then the flow time will increases.

Fig 6.5 V Funnel testing

Fig 6.6 V Funnel testing

### 6.4 J Ring test

This experiment is conducted to find the passing abilities of concrete. The instruments including the rectangular shaped open iron ring. The holes are drilled vertically to accept threaded reinforced bars. These bars may be of varying diameters and placed at varying distances. The size of the aggregates must be appropriate to pass through the bars.

After the experiment, the variation between the inner and the outer side of J-ring concrete height is calculated. This measure is the indicator of passing ability.

6.7 Fig J Ring Testing

Fig 6.8 J Ring Testing

### 6.5 U Box test

This experiment is utilized to find out the filling ability of the SCC. The instrument has the vessel that is sub divided into two sections. One sliding gate is fixed in the middle of two compartments. The 13 mm diameter bars are fixed at the gate and 50 mm center to center spacing. The left sided compartment is filled by 20 liters of concrete. When the gates lifts, the concrete moves to the other compartment. The concrete height in the both the sections are noted

**Fig 6.9 U Box testing**

**Fig 6.10 U Box testing**

## 7. EFFECT OF SILICA FUME AND FLY ASH UPON FRESH CONCRETE PROPERTIES;-

According to the ENARC, the time period from 6 to 12 second is approved as good for SCC. The V-funnel flowing duration is in between 4 to 10 seconds. The all the mixes of SCC reach the required flow time. The 12 mm size of ingredients was utilized in the SCC to eliminate the blocking. The variation in height of SCC in the U-box sections was in range of 5 to 40 mm. all the test values satisfy the European standards.

**Table 7.1 Properties of Fresh SCC for w/c relation 0.45. Sp = 1.6**

| Mix proportion | Slump flow | | V - funnel | | L – box $H_2/H_1$ | J – Ring In MM | U – box $H_2$-$H_1$ in mm |
|---|---|---|---|---|---|---|---|
| | In MM | $T_{50\ sec}$ | Sec | 5 min in mm | | | |
| 0% F A + 0% S F | 670 | 5 | 10 | 13 | 0.8 | 9 | 20 |
| 15% F A + 3% S F | 675 | 4.5 | 10 | 12 | 0.82 | 8 | 20 |
| 20% F A + 6% S F | 684 | 4 | 8 | 9 | 0.84 | 8 | 25 |
| 25% F A + 9% S F | 687 | 4 | 9 | 11 | 0.86 | 8 | 20 |

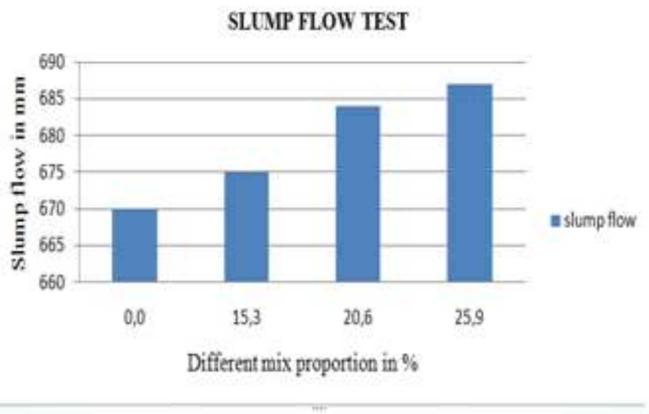



Fig 7.1 Graph of slump flow against different mix proportions for w/c ratio 0.45 and SP 1.6

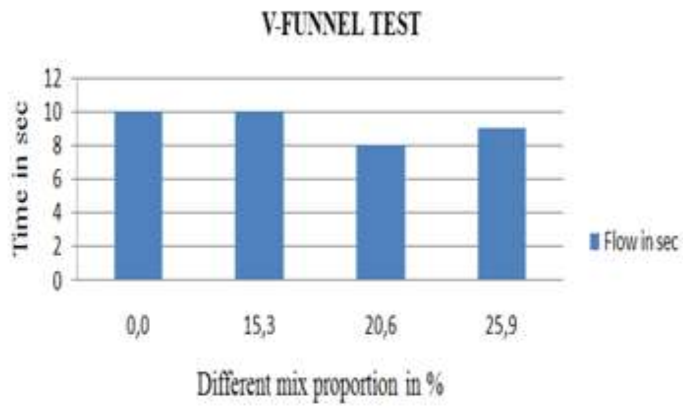



Fig 7.2 Graph of V funnel test against different mix proportions for w/c ratio 0.45 and SP 1.6

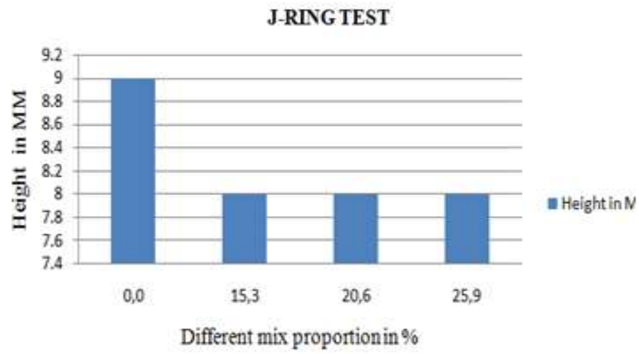



Fig 7.3 Graph of J ring test against different mix proportions for w/c ratio 0.45 and SP 1.6

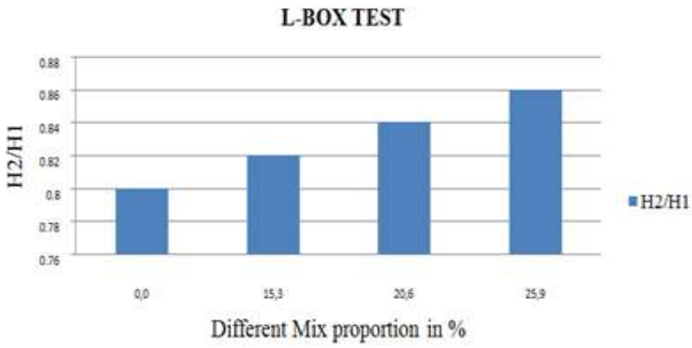



Fig 7.4 Graph of L box test against different mix proportions for w/c ratio 0.45 and SP 1.6

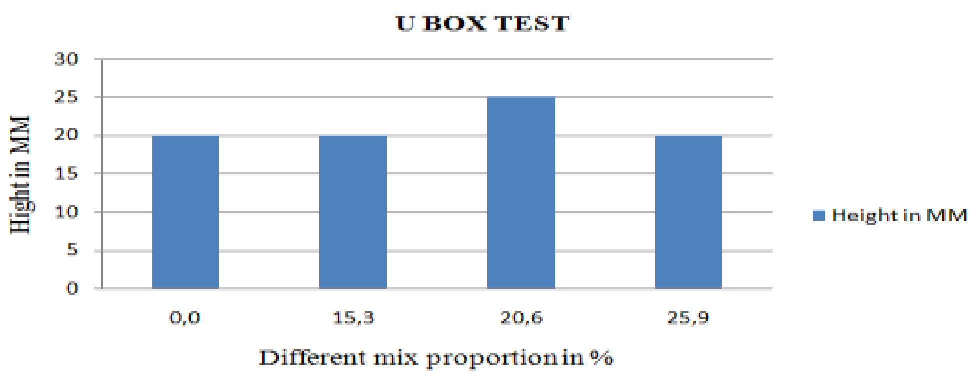
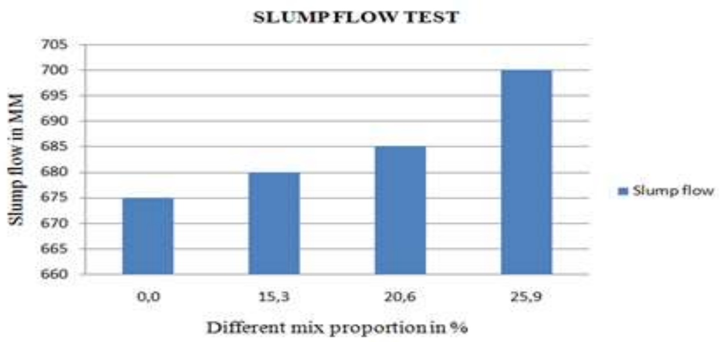



Fig 7.5 Graph of U-box test against different mix proportion for w/c ratio 0.45 and SP 1.6

**Table 7.2 Properties of Fresh SCC for w/c relation 0.46. Sp = 1.62**

| Mix proportion | Slump flow | | V - funnel | | L Box ($H_2/H_1$) | J Ring in mm | U Box ($H_2/H_1$) in mm |
|---|---|---|---|---|---|---|---|
| | In MM | $T_{50\ sec}$ | Sec | 5 min in mm | | | |
| 0% F A + 0% S F | 675 | 4 | 9 | 12 | 0.8 | 7 | 17 |
| 15% F A + 3% S F | 680 | 4 | 8 | 12 | 0.81 | 8 | 20 |
| 20% F A + 6% S F | 685 | 4.5 | 8 | 11 | 0.81 | 7 | 25 |
| 25% F A + 9% S F | 700 | 4 | 8 | 10 | 0.8 | 7 | 20 |



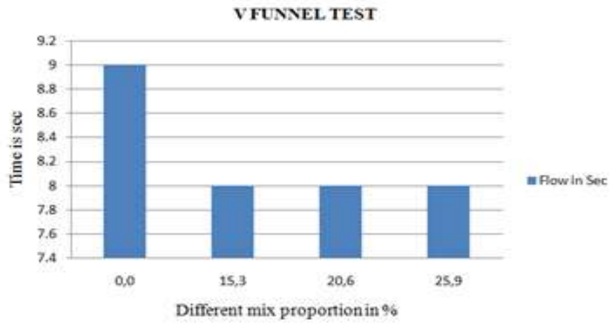
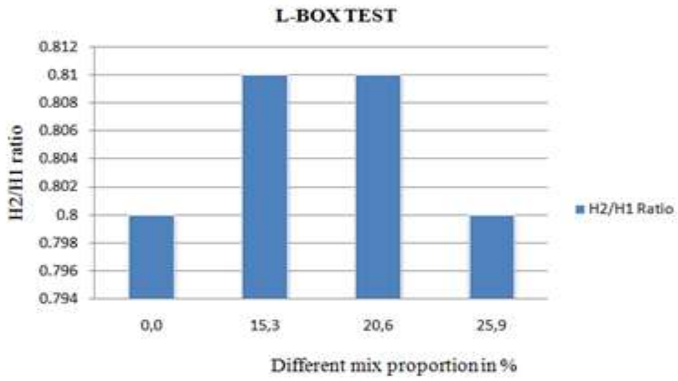




**Fig 7.6 Graph of slump flow against different mix proportions for w/c ratio 0.45 and SP 1.6**

**Fig 7.7 Graph of V funnel test against different mix proportions for w/c ratio 0.45 and SP 1.6**



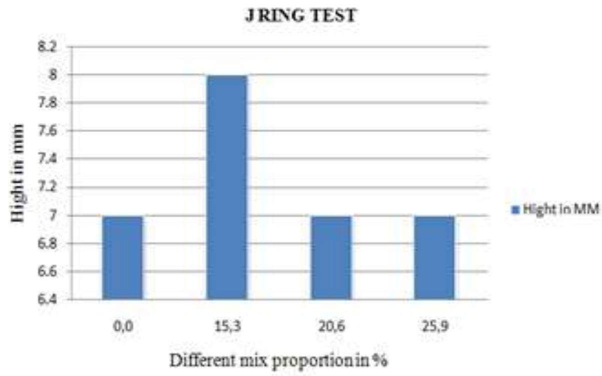




**Fig 7.8 Graph of slump flow against different mix proportions for w/c ratio 0.45 and SP 1.6**

**Fig 7.9 Graph of V funnel test against different mix proportions for w/c ratio 0.45 and SP 1.6**

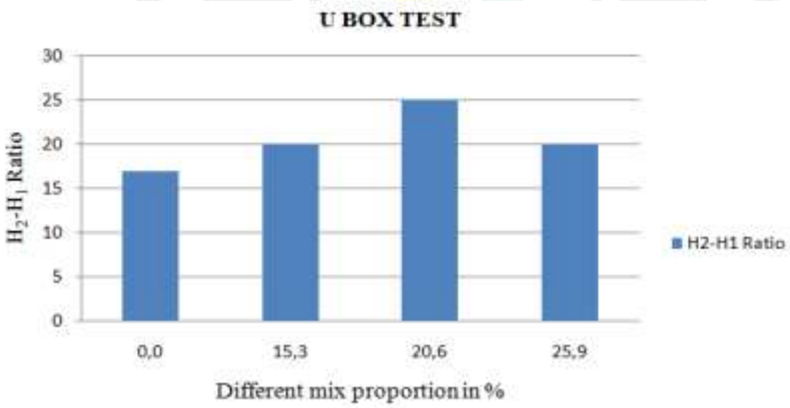



**Fig 7.10 Graph of U-box test against different mix proportion for w/c ratio 0.45 and SP 1.6**

# 8. HARDENED CONCRETE PROPERTIES

## 8.1 Compressive strength of hardened concrete

The load which results in failure of concrete specimens, where the specimens are subjected to uniaxial compression within the given range of loading is known as compressive strength. The compressive strength is the most important quality of the SCC. The unit of compressive strength is $N/mm^2$.The compressive strength is depend on the features like degree of compaction, material to water proportion, type and quality of aggregates, size and texture of aggregates and curing heat.

The samples after 7 days, 28days cured are examined for the compressive strength. As per IS 516-1959. Insert the SCC cubes in the compressive testing apparatus in such a manner that the load can be applied in the reverse directions. And start the electric motor of the machine. The pressure application starts gradually on the SCC specimens without shocks at the rate of 300 KN/minute. Finally, note down the breaking load of the each specimen and do calculations. Finally, release the valve and allow the lower piston to go down and remove the broken cubes.

Compressive strength is determined as below

Compressive strength = FC = P/A N/mm$^2$

When P = Applied load

A = Surface area of cube

Fig 8.1 Compression testing


Fig 8.2 Compression testing

**Table 8.1 Properties of Hardened SCC with w/c proportion 0.45, Sp = 1.6**

| Mix proportion | Compressive strength in N/mm$^2$ | | | | | |
|---|---|---|---|---|---|---|
| | 7 days | | | 28 days | | |
| | N1 | N2 | N3 | N4 | N5 | N6 |
| 0% F A + 0% S F | 24.88 | 24.11 | 24.44 | 38.33 | 38 | 39 |
| 15% F A + 3% S F | 23.88 | 22.88 | 22.88 | 37.55 | 36.33 | 37.44 |
| 20% F A + 6% S F | 22.11 | 22 | 21.55 | 35.88 | 36.11 | 34.50 |
| 25% F A + 9% S F | 20.88 | 21.50 | 20 | 34 | 31.11 | 31.55 |
| Final mix | 22.59 | | | 35.81 | | |

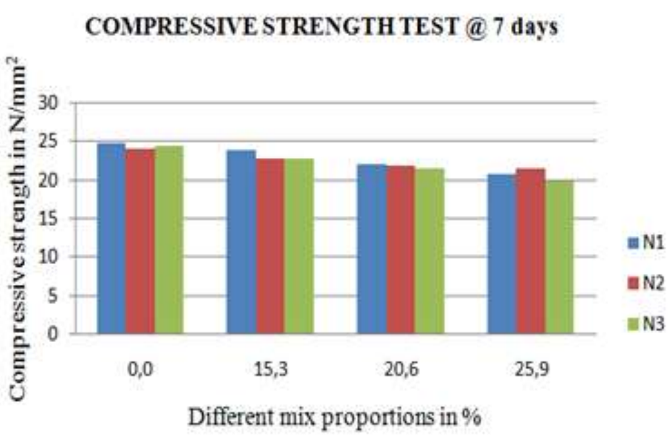



Fig 8.3 Graph of compressive strength for w/c ratio 0.45 0and SP 1.6 at 7 days

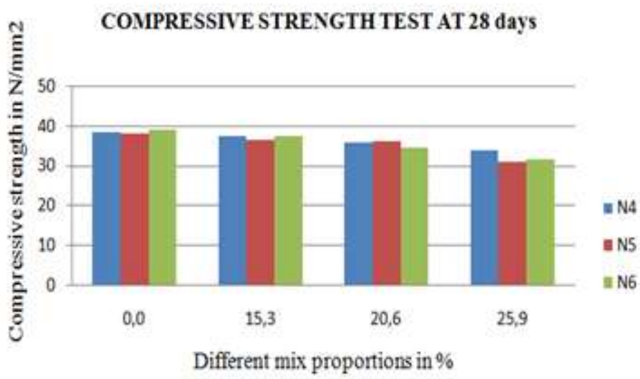



Fig 8.4 Graph of compressive strength for w/c ratio 0.45 0and SP 1.6 at 28 days

**Table 8.2 Property of the hardened SCC for W/C ratio 0.46 Sp = 1.62**

| Mix proportion | Compressive strength in N/mm² | | | | | |
|---|---|---|---|---|---|---|
| | 7 days | | | 28 days | | |
| | N1 | N2 | N3 | N4 | N5 | N6 |
| 0% F A + 0% S F | 25.40 | 24.10 | 24.50 | 37.88 | 36.88 | 36.11 |
| 15% F A + 3% S F | 23.44 | 24.55 | 23.11 | 36.11 | 35.50 | 35.88 |
| 20% F A + 6% S F | 22.50 | 22.88 | 22.10 | 35.11 | 35.88 | 35.44 |
| 25% F A + 9% S F | 21.88 | 20.50 | 21.88 | 34.11 | 34.44 | 34.88 |
| Final mix | 23.07 | | | 35.51 | | |

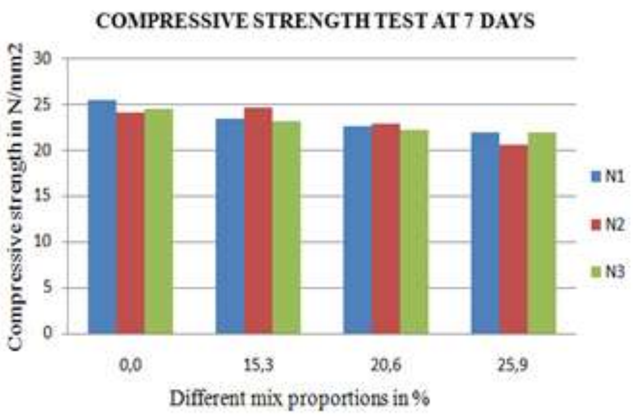



**Fig 8.5 Graph of compressive strength for w/c ratio 0.46 and SP 1.62 at 7 days**

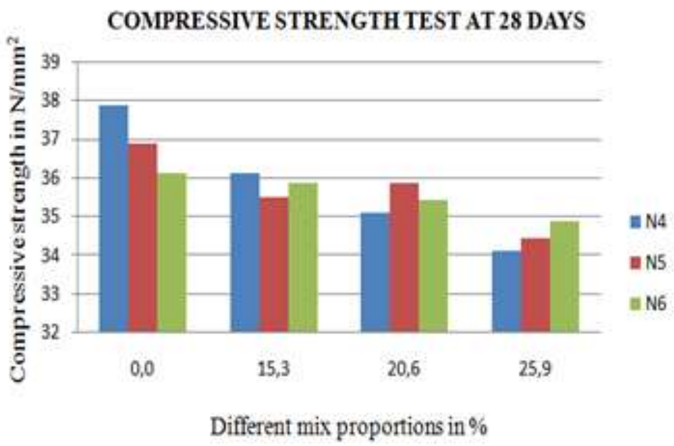



**Fig 8.6 Graph of compressive strength for w/c ratio 0.46 0and SP 1.62 at 28 days**

## 9. EFFECT OF FLY ASH AND SILICA FUME ON COMPRESSIVE STRENGTH

The test outcomes of compressive strength of SCC blends are indicated in the above tables and figurs. For the w/c ratio 4.5 and sp 1.6, the compressive strength of SCC mixes develop in between 20 to 24.88 N/mm$^2$ at 7 day of watering and 31.11 N/mm$^2$ to 39 N/mm$^2$ at 28 day of watering. The silica fume and fly ash quantities were varied in the range of 0 to 25% and 0 to 9% respectively. It is detected that the increase of about 4.88 N/mm$^2$ of compressive strength at 7 days curing and 7.89 N/mm$^2$ at 28 days curing with the reduction of fly ash and silica fume quantity from 25 % to 0% and 9% to 0% respectively.

For w/c ratio 4.9 and sp 1.62, the compressive strength of SCC mixes develop in between 20.50 to 25.40 N/mm$^2$ at 7 day of watering and 34.11 N/mm$^2$ to 37.88 N/mm$^2$ at 28 day of watering. The silica fume and fly ash quantities were varied in the range of 0 to 25% and 0 to 9% respectively.

## 10. CONCLUSION

1. It is concluded from the above test that, as the silica fume and fly ash quantity decreases, the compressive strength values increases respectively
2. It is observed that the increase of about 4.88 N/mm$^2$ of compressive strength at 7 days curing and 7.89 N/mm$^2$ at 28 days curing with the reduction of fly ash quantity from 25 % to 0% and 9% to 0% respectively for w/b 0.45
3. The workability of concrete raises with alteration of concrete by the silica fume and fly ash.
4. It is observed that the increase of about 4.9 N/mm$^2$ of compressive strength at 7days curing and 3.77 N/mm2 at 28 days curing with the decrease of fly ash and silica fume quantity from 25% to 0% and 9% to 0% respectively for w/b 0.46.
5. The tested values of passing ability, filling ability and flowing ability satisfies the EFNARC guidelines

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