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# "A Study of Performance of Concrete with Mineral and Chemical Admixtures"

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***Abstract* - Fly ash and mineral powder are used for composite preparation of high strength lightweight aggregate concrete in this paper. The results shows, when we increase the percentage of the ground fly ash from 30% to 40% with 10% of Silica Fume the strength of concrete are increased. There is a decrease in the strength when 40% of Fly Ash is added with 5 & 15% of Silica Fume. Excellent composite effect is shown when fly ash and mineral powder are combined together, the pozzolanic reaction more fully and the interface transition region between the lightweight aggregate and the cement paste solidifies further, which makes the structure of the lightweight aggregate concrete more compact.**

***Keywords- Lightweight Aggregate Concrete; Fly Ash; Admixtures; Combined Admixture; Pozzolanic Reaction***

## 1. INTRODUCTION

### *1.1 GENERAL*

Concrete is the most widely used building material which is a mixture of cement, sand, coarse aggregate and water. It can be used for construction of multi-story buildings, dams, road pavement, tanks, offshore structures, canal lining etc. The process of selecting suitable ingredients of concrete and determining their relative amount with the objective of producing a concrete of the required strength, durability and workability as economically as possible is termed as "concrete mix design". The compressive strength of hardened concrete is generally considered to be an index of its other properties depends upon many factors e.g. quality and quantity of cement water and aggregates batching and mixing placing compaction and curing. The cost of concrete made up of the cost of materials plant and labour the variation in the cost of material arise from the fact that the cement is several times costly than the aggregates thus the aim is to produce a mix as possible from the technical point of view.

The rich mixes may lead to high shrinkage and cracking in the structural concrete and to evolution of high heat of hydration in mass concrete which may cause cracking. The actual cost of concrete is related to cost of materials required for producing a minimum mean strength called "characteristic strength" that is specified by designer of the structures. This depends on the quality control measures but there is no doubt that quality control adds to the cost of concrete. The extent of quality control is often an economical compromise and depends on the size and type of job nowadays engineers and scientists are trying to increase the strength of concrete by adding the some other cheap and waste material as a partial replacement of cement or as a admixture fly ash, micro silica, steel slag etc. are the few examples of these types of materials. These materials are generally by-products from other industries for example fly ash is a waste product from power plants and silica fume is a by-product resulting from reduction of high purity quartz with coal or coke and wood chips in an electric arc furnace during production of silicon metal or ferrosilicon alloys. Nowadays whole world is facing a major problem of environmental pollution these materials fly ash, micro silica, steel slag may become a major pollution materials.

### *1.2 Role of Admixtures in Concrete*

It has been demonstrated that the best pozzolans in optimum proportion mixed with Portland cement improves many qualities of concrete, such as:

- Lower the heat of hydration and thermal shrinkage
- Increase the water tightness
- Reduce the alkali-aggregate reaction
- Improve resistance to attack by sulphate soils and sea water
- Improve extensibility
- Lower susceptibility to dissolution and leaching
- Improve work ability
- Lower cost

In addition to these advantages, contrary to the general opinion good pozzolans will not unduly increase water requirement or drying shrinkage.

Mineral addictive are in organic material both natural and industrial by products that are added in small quantities in cements. Such additives may be blended or inter grounded with OPC or added directly to concrete before or during mixing of concrete. It has been observed that incorporation of certain artificial or natural mineral additives such as Fly Ash & Silica Fume can have beneficial impact on quality of cement. By adding such addictive the performance characteristics like workability, water tightness, mechanical properties, and resistance under aggressive environment have shown much improvement.

### *1.3 Fly Ash and Its Properties*

Fly ash is an industrial waste and a material of pozzolanic characteristic occurring due to burning the pulverized coal in the thermal power plants. In the

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construction sector, the fly ash is used in the production of cement as an additive-material, in production of concrete instead of some of the cement or instead of some of the fine aggregate, as a base and sub-base material in high- way construction, as a filling material in dams, in retaining walls, and for production of light construction materials.

The fly ash, is similar to other pozzolans, affects the technical properties of the concretes and mortars by its pozzolanic characteristics and filler effect. It is known that the filler effect of the fly ash is more effective than the pozzolanic characteristics when affecting the properties of concrete. The fly ash have pozzolanic activity because they contain surplus amount of silica, alumina and iron oxide; they have a structure with very fine particles and amorphous. Materials with silica and alumina in the structure of fly ashes make additional calcium silicate hydrate (C-S-H) by reacting with calcium hydroxide occurring as a consequence of hydration of the cement. The resultant C-S-H gels cause increase in strength of the concrete. Furthermore, the fact that fly ash contains very fine particle increases compactness in the concrete or mortar and causes filling of the spaces. Using the fly ash in the concrete generally increases the workability of the fresh concrete, increases resistance of the concrete to the chemical effects, decreases the bleeding, hydration temperature, permeability of the hardened concrete, and costs. The physical and chemical properties of Fly Ash are shown in table 1.1 given below:

*1.4 Micro Silica and Its Properties*

Micro silica is a by-product of Electric Arc furnace used in the production of ferrosilicon and silicon industries. The average grain size of micro silica is less than 0.1 microns. It is a very fine active artificial pozzolanic and cementious material. The main field of application is as pozzolanic material for high performance concrete. The physical and chemical properties of Silica Fume are shown in table 1.2 given below:

Table 1.1 Properties of Fly ash

| Physical properties | |
|---|---|
| Colour | Whitish grey |
| Specific gravity | 2.2 |
| Avg. particle size | 6.92 microns |
| Chemical Properties | |
| Composition | Percentage |
| Silica | 59% |
| Alumina | 21% |
| Ferric Oxide | 3.70% |
| Calcium Oxide | 6.90% |
| Magnesium Oxide | 1.40% |
| Potassium Oxide | 0.90% |
| Sulphur Oxide | 1.00% |

Table 1.2 Properties of Micro silica

| Physical properties | |
|---|---|
| | |
| Odour | Odourless |
| Colour | White colour powder |
| Specific gravity | 2.3 |
| pH of 5% solution | 6.90 |
| ` Chemical properties | |
| Composition | Percentage |
| Silica | 99.886% |
| Alumina | 0.043% |
| Ferric oxide | 0.040% |
| Calcium oxide | 0.001% |
| Titanium oxide | 0.001% |
| Potassium oxide | 0.001% |
| Sodium oxide | 0.003% |

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*1.5 SUPERPLASTICIZER*

Superplasticizers, also known as high range water reducers, are chemical admixtures used where well-dispersed particle suspension is required. These polymers are used as dispersants to avoid particle aggregation (gravel, coarse and fine sands), and to improve the flow characteristics (rheology) of suspensions such as in concrete applications. Their addition to concrete or mortar allows the reduction of the water to cement ratio, not affecting the workability of the mixture, and enables the production of concrete and high performance concrete. This effect drastically improves the performance of the hardening fresh paste.

It is the use of super plasticizer which has made it possible to use w/c as low as 0.25 or even lower and yet to make flowing concrete to obtain strength of the order 120 MPa or more. It is the use of super plasticizer which has made it possible to use fly ash, slag and particularly silica fume to make high performance concrete. The main benefits of super plasticizers can be summarized as follows:

Increased fluidity:

- Flowing
- Self-leveling
- Self-compacting concrete
- Penetration and compaction round dense reinforcement

Super plasticizers can produce:

- At the same w/c ratio much more workable concrete than the plain ones,
- For the same workability, it permits the use of lower w/c ratio,
- As a consequence of increased strength with lower w/c ratio, it also permits a reduction of cement content.
- The super plasticizers also produce a homogeneous, cohesive concrete generally without any tendency for segregation and bleeding.

Effects of super plasticizers on fresh concrete

It is to be noted that dramatic improvement in workability is not showing up when plasticizers or super plasticizers are added to very stiff or what is called zero slump concrete at nominal dosages. A mix with an initial slump of about 2 to 3 cm can only be fluidized by plasticizers or super plasticizers at nominal dosages. A high dosage is required to fluidity no slump concrete. An improvement in slump value can be obtained to the extent of 25 cm or more depending upon the initial slump of the mix, the dosage and cement content. It is often noticed that slump increases with increase in dosage. But there is no appreciable increase in slump beyond certain limit of dosage. As a matter of fact, the over dosage may sometime harm the concrete.

## 2. LITERATURE REVIEW

*2.1 Literature Review*

Arel (2011) studied the "Effects of Fly Ash Fineness on the Mechanical Properties of Concrete" in which he confirms the pozzolanic characteristics and filler effect of fly ash on concrete. It is known that the filler effect of the fly ash is more effective than the pozzolanic characteristics when affecting the properties of concrete.

The fly ashes have pozzolanic activity because they contain surplus amount of silica, alumina and iron oxide; they have a structure with very fine particles and amorphous

Behera J P et al.,(2005) investigation has been made to develop fly ash in activated form. Fly ash mixed in the ratio of 20%, 30%, 40% and 50 percent by replacing Portland cement. The cement has been prepared by grinding in ball mill with 30% of gypsum. Different physical properties of the cement thus prepared have been examined .It has been found that up to 40% fly ash in an activated form can be used for manufacturing blended cement as per Indian standard.

Francois De Larrard and Pierre-Claude Aitcin., (2000)investigated that the drying behavior of two silica fume concretes and one that does not contain silica fume. Experimental results show that these three concretes dry in different ways. After a certain period of time, one can exhibit a strong moisture gradient, while others do not. An explanation of the apparent strength loss of the silica fume concrete is proposed. If this explanation is accepted, it is shown that the apparent strength loss can never be more than two times the tensile strength of concrete. This theoretical maximum strength retrogression fits well with the published data.

Christy, et., al (2009), studied the "Effect of Class – F Fly Ash as Partial Replacement with Cement and Fine Aggregate in Mortar" They found that fly ash has a pozzolanic effect on the concrete and can be used as a partial replacement for cement up to a certain percentage. They replaced cement by fly ash in the percentages of 10%, 20%, 25% and 30% by weight of cement. Due to its pozzolanic effect the microstructure of cement has improved in its properties and the voids were reduced. They also found that the compressive strength of concrete was higher with 10% replacement of cement with fly ash when compared with the normal mortar mix.

*2.2 Summary of Literature*

Literature review indicates that the partial replacement of cement by fly ash and micro silica in concrete not only solves the problem of their disposal but also improves the basic properties of concrete like decreases permeability to water, compressive strength with higher strength to weight ratio of material, workability, reduction in self-weight etc.

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## 3. SCOPE OF THE STUDY

### *3.1 Scope Of The Study*

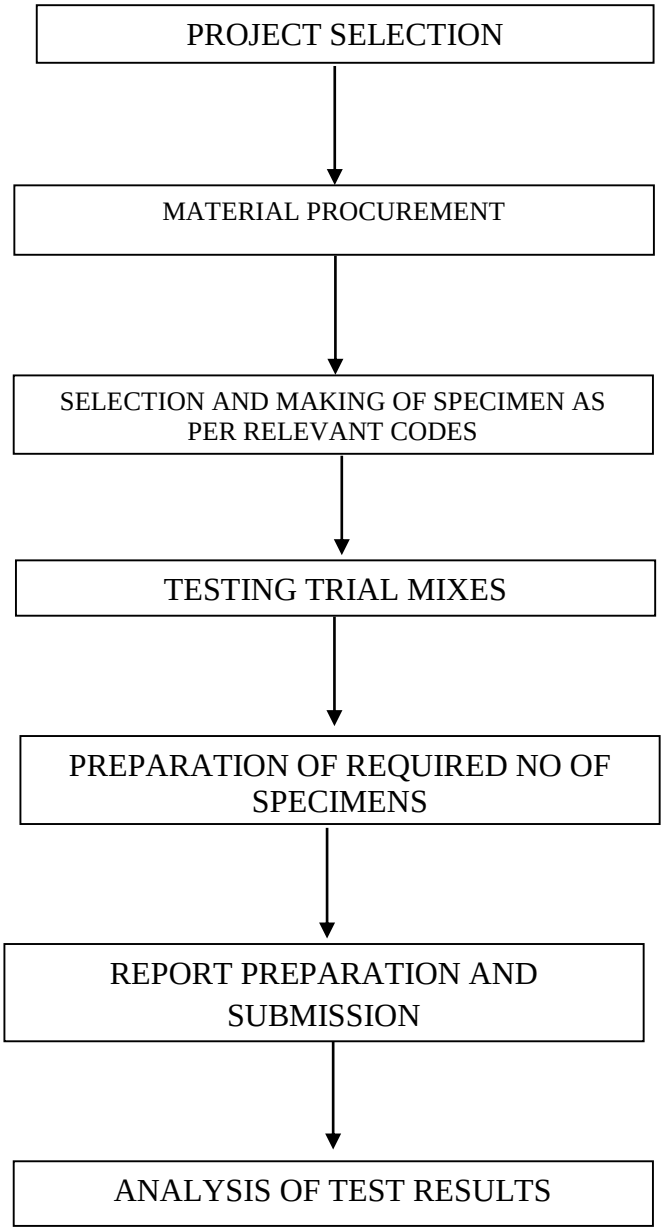
The conventional concrete has several drawbacks like very low tensile strength, low workability. These deficiencies may be overcome by introducing mineral and chemical admixtures.

This project work is an attempt to improve the strength and high workability of concrete by including various combinations of mineral and chemical admixtures.

## 4. METHODOLOGY

For any successful investigation, numerous tests have to be performed and the trend of results should be carefully studied before arriving at the conclusion. To have reliable result from the test proper experimental setup testing procedure are required.

METHODOLOGY FOR PROJECT




## 5. EXPERIMENTAL INVESTIGATION

### *5.1 General*

The main aim of this experimental work is to study the effect of Fly Ash & Silica Fume on the Compressive Strength of Concrete.

### 5.2 Materials Used in the Present Work

The materials used in the present investigation are;

- Cement – OPC 43 grade conforming to IS 8112 – 1989

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- Fine aggregate – natural sand – IS383 – 1970
- Coarse aggregate – crushed 20mm maximum size – IS383 – 1970
- Fly ash
- Micro silica
- Portable water
- Super plasticizer (Chryso)

*5.3 Tests on Materials*

The various types of tests conducted on cement, fine aggregate and coarse aggregate and the results are tabulated in table 5.1, table 5.2 and table 5.3 respectively.

The Table 5.1 below shows the different types of tests carried out on cement.

Table 5.1 Test on Cement

| **Test** | **Values** |
|---|---|
| Specific Gravity | 3.15 |
| Fineness | 96.33% |
| Consistency | 31% |
| Initial Setting Time | 34 min |

The Table 5.2 below shows the different types of tests carried out on fine aggregate.

Table 5.2 Test on Fine aggregates

| **Test** | **Values** |
|---|---|
| Specific Gravity | 2.70 |
| Free Surface Moisture | 2% |
| Gradation | Zone II |

The Table 5.3 below shows the different types of tests carried out on coarse aggregate.

Table 5.3 Test on Coarse Aggregates

| Test | Values |
|---|---|
| Specific Gravity | 2.70 |
| Aggregate Impact Value | 31.98% |
| Aggregate Crushing Values | 18.70% |

*5.4 Tests on Fresh Concrete*

The tests conducted on fresh concrete are shown below in Table 7.4

Table 5.4 Test on fresh concrete

| Test | Value |
|---|---|
| Slump | 85 M |

*5.5 Compressive Strength Test*

The compression test on hardened concrete was conducted as shown in Figures 5.1 and 5.2; the results are tabulated in Table 7.5

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Figure 5.1 Compression Test on Cube
(After Application of Load)

The Compressive Strength of Cubes for Mix 1 to Mix 10 for 3 days, 7 days and 28 days is shown in the Table 5.5 given below.

Table 5.5 Compression test on Concrete Cubes

| Design Id | Compressive Strength ($N/mm^2$) | | |
|---|---|---|---|
| | 3 days | 7 days | 28 days |
| M1 | 18.34 | 22.91 | 31.40 |
| M2 | 17.23 | 21.22 | 32.97 |
| M3 | 18.92 | 23.31 | 31.68 |
| M4 | 17.61 | 21.86 | 33.82 |
| M5 | 16.28 | 23.44 | 32.60 |
| M6 | 19.82 | 24.72 | 35.12 |
| M7 | 17.98 | 22.66 | 33.78 |
| M8 | 16.81 | 20.72 | 29.89 |
| M9 | 19.62 | 23.88 | 34.18 |
| M10 | 15.95 | 21.28 | 30.12 |

- The compressive strength of concrete cubes after 3 days of moisture curing is shown in the Figure 5.2 below:

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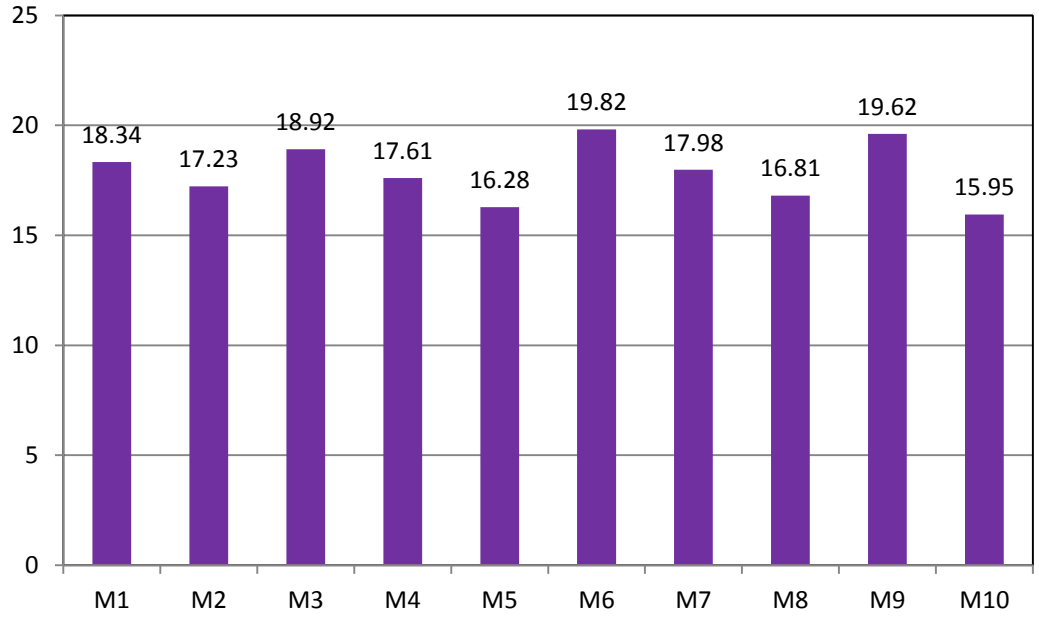


Figure 5.2 Compressive Strength of Concrete Cubes after 3 days of Moisture Curing.

- The compressive strength of concrete cubes after 7 days of moisture curing is shown in the Figure 5.3 below:

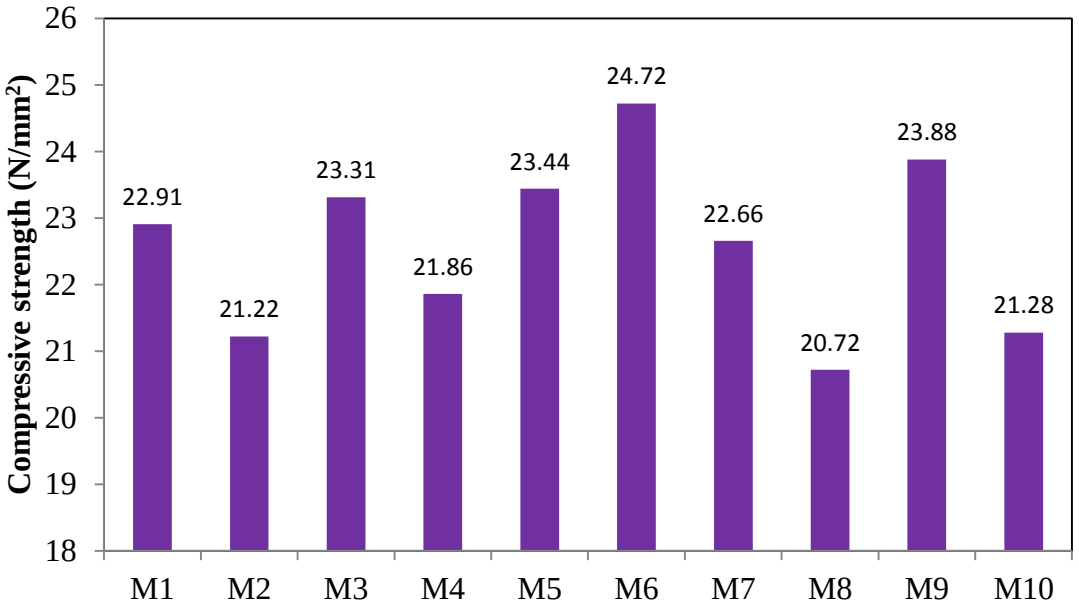


Figure 7.3 Compressive Strength of Concrete Cubes after 7 days of Moisture Curing.

- The compressive strength of concrete cubes after 28 days of moisture curing is shown in the Figure 5.4 below:

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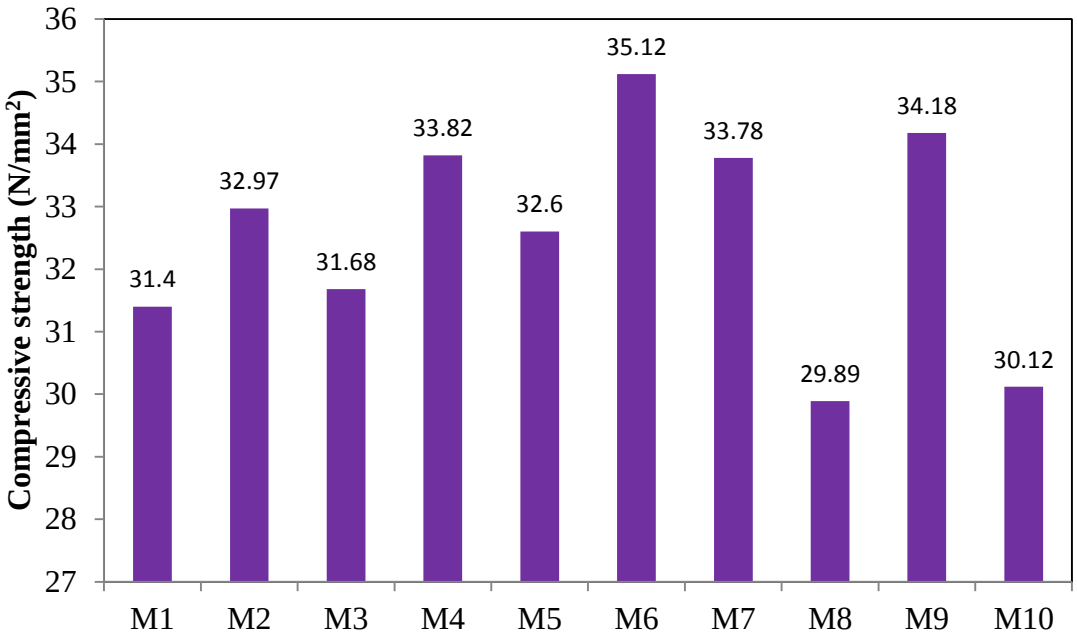


Figure 5.4 Compressive Strength of Concrete cubes after 28 days of Moisture Curing.

## 6. RESULTS AND DISCUSSIONS

### *6.1 Comparison of Compressive Strength*

The overall Compressive Strength of Concrete Cubes of Mixes 1 – 10, for 3 days, 7 days and 28 days is shown in the Table 6.1 below:

Table 6.1 Overall Compressive Strength of Concrete Cubes

| Design Id | Compressive Strength (N/mm²) | | |
|---|---|---|---|
| | 3 days | 7 days | 28 days |
| M1 | 18.34 | 22.91 | 31.40 |
| M2 | 17.23 | 21.22 | 32.97 |
| M3 | 18.92 | 23.31 | 31.68 |
| M4 | 17.61 | 21.86 | 33.82 |
| M5 | 16.28 | 23.44 | 32.60 |
| M6 | 19.82 | 24.72 | 35.12 |
| M7 | 17.98 | 22.66 | 33.78 |
| M8 | 16.81 | 20.72 | 29.89 |
| M9 | 19.62 | 23.88 | 34.18 |
| M10 | 15.95 | 21.28 | 30.12 |

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The overall compressive strength of concrete cubes for 3 days, 7 days and 28 days is shown in the Figure 6.1 below:

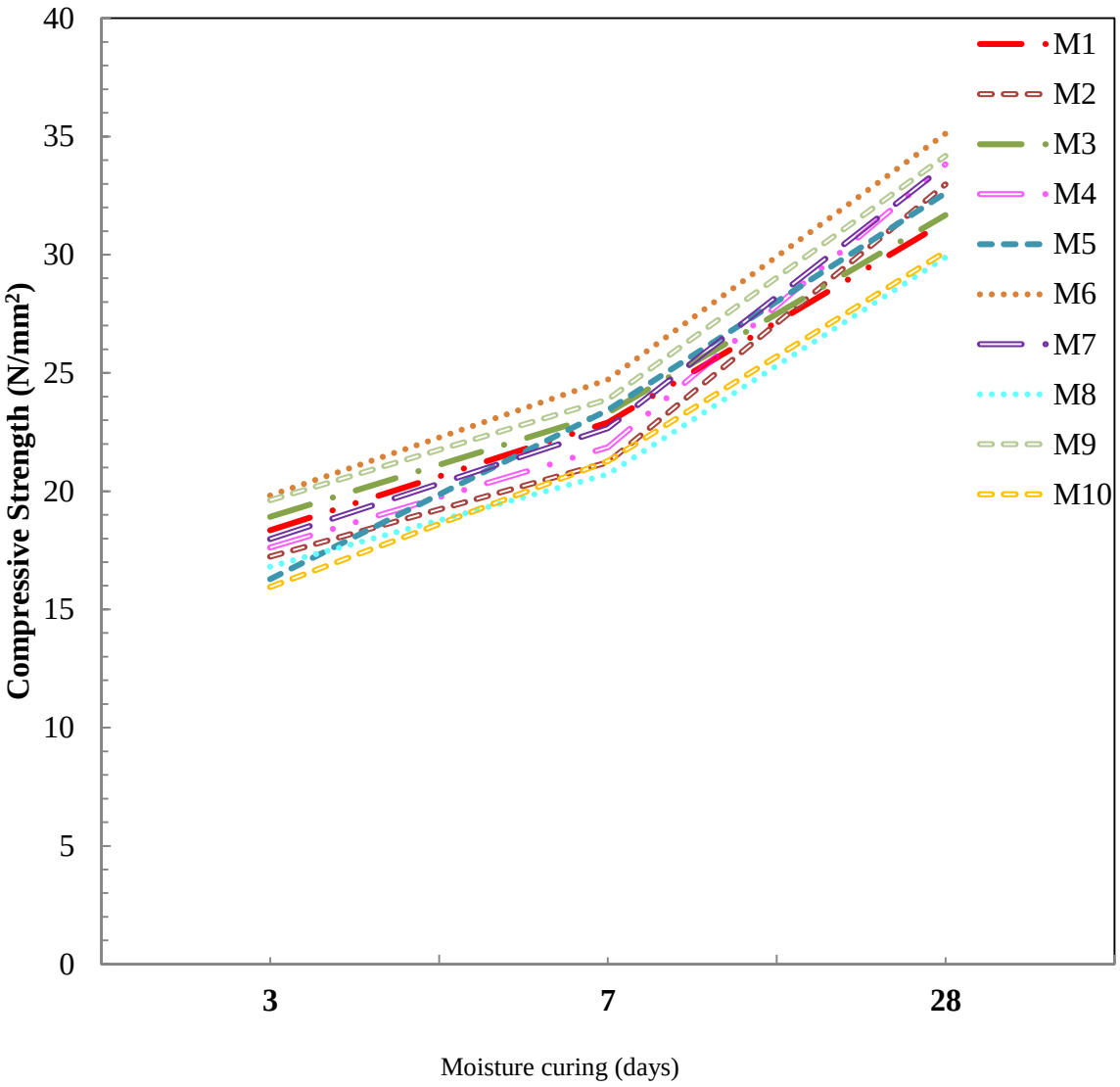


Figure 6.1 Overall Compressive Strength of Concrete Cubes

From the graph it is clear that the mix 8 & 10 have compressive strength below the normal mix.

Table 6.2 summarizes the result of Compressive strength of concrete in 28 days of moisture curing, with different proportions of cementious materials (Fly Ash & Silica Fume).

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Table 6.2 Percentage Increase or Decrease in Compressive Strength of Concrete Cubes

| Normal Mix | Other Mix | Increase or Decrease in Strength (%) |
|---|---|---|
| M1 (31.40 N/mm$^2$) | M2 | 5.00 |
| | M3 | 0.89 |
| | M4 | 7.70 |
| | M5 | 3.80 |
| | M6 | 11.84 |
| | M7 | 7.50 |
| | M8 | -9.50 |
| | M9 | 8.85 |
| | M10 | -9.70 |

From table 6.2, it is seen that M6 has got more than 11 percentage of the strength than the normal concrete; this is because the M8 has sufficient amount of silica fume percentage (10%) when added with 35 percentage of fly ash as compared to other mixes.

It is also seen that M10 has got least strength (-9.70%) than compared to normal concrete.

It is also seen that when we increase the percentage of fly ash from 30% to 40% with 10% of silica fume, the compressive strength of concrete cube increases. Also the compressive strength of concrete cube decreases when we keep the percentage of silica fume 5% when added with fly ash.

## 7. CONCLUSION

### *7.1 General*

The performance of concrete with different proportions of admixtures and was studied in depth. The compressive strength test was carried out and the results were produced.

### *7.2 Conclusions*

1. When we increase the percentage of the ground fly ash from 30% to 40% with 10% of Silica Fume the strength of concrete is increased.
2. There is a decrease in the strength when 40% of Fly Ash is added with 5 & 15% of Silica Fume.
3. Study shows that this deficiency could be overcome by using silica fume upto 10% only when added with fly ash.
4. From table 8.2, it can be seen that M6 shows higher strength (11.84 N/mm$^2$) as compared to normal mix.
5. According to our study, from strength & conomical point of view M6 has best proportion of mix percentage to use.

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