Webology (ISSN: 1735-188X)
Volume 18, Number 6, 2021

# Experimental Investigation On Compressive Strength Of High Strength Concrete Using Fly Ash And Silica Fume

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**Abstract:**

The world is facing a huge amount of pollution in the environment and its increasing day by day. Concrete is most suitable material for constructing the sustainable structures which leads to rapid increase in demand of concrete structures. On one hand where the concrete structures are strong, durable and consistent where as on the other hand the concrete has its own disadvantages. High cost of construction is one disadvantage. But the cement production process being the contributor in world's 5% of environmental pollution is cause of concern. On the other hand industrial wastes which are causing the huge environmental pollution and also industries are facing the difficulty in their disposal. Having the cementing properties the industrial wastes can be successfully replaced to cement up to certain percentages. Reducing the environmental pollution as the principal goal of the current research work. The industrial wastes such as fly ash(F.A) and silica fume(S.F) are replaced with the cement in certain percentages and tried to evaluate the high strength concrete of M40 grade. The study is focused on only compressive strength. The results showed that silica fume has shown better strength compare to fly ash when they are added individually. When these materials are added in combination have shown the more better results compare to when they are added in place of cement individually.

**keywords:** High strength concrete, industrial wastes, pollution, fly ash, silica fume.

**Introduction:**

Increasing population and technology is resulting in increase of construction of structures day by day. It is also a fact that as constructional works are increasing day by day the natural resources are also decreasing which are used in the concrete(Pappu et al., 2007). it is very clear that the wastes is increasing every year across the world and it's not being recycled as per the requirement of the atmosphere's climate(Kishore & Gupta, 2019). About 5% of worlds pollution is caused by the cement production and this needed to be stopped by bringing the best alternatives of cement in the constructional field. As per the research studies conducted it is evaluated that about 960 million tones of solid wastes is generated every year this is the solid wastes that has been generated as a byproduct from the industrial, mining, agricultural and other sectors. Though the technology is increasing day by day in the process of finding a way to dispose these wastes we came across the best solution that can be taken to dispose these wastes and that is use of this wastes in the constructional field(Pappu et al., 2007).There are many natural and industrial wastes available which are causing difficulty in disposing them such as 15% replacement of coconut shell in the place of the coarse aggregates have shown the best results in improving the properties of the concrete weather it is strength wise or the other properties of the concrete(Uzni & Hanapi, 2021). Not only in concrete but also in other constructional activities such as in making bricks industrial wastes such as industrial sludge can be used effectively(Arsenovic et al., 2012). The countries which produces copper in abundant amounts are facing problems in disposal of copper. This copper which is a industrial by product can be used in place of cement up to 5% apart from increasing the strength good resistance to chloride and acid is also seen. (Onuaguluchi & Eren, 2012). Steel slag and copper slag are stated to be increasing the density where as the foundry sand and bottom are doing the opposite of it. Foundry sand can be replaced up to 20% in place of the fine aggregates. Steel slag can be stated to be replaced up to 30% in place of fine aggregates but among all these copper is stated to be replaceable up to 40% in place of fine aggregates which is highest among the these above mentioned (Dash et al., 2016). 10% replacement of metakaolin has shown the best results in place of cement in the concrete(Dubey et al., 2015).where as many other research works suggested metakaolin gives maximum strength at 15% replacement(CH Jyothi Nikjila and Chaitanya Kumar, 2015). Fly ash (FA) is one of the most suited cement replacements which is also a by product fly ash not only increases the mechanical strength of the concrete however it also improves the other properties such as heat evaluation at the setting time, workability properties etc are improved compare to the normal concrete. fly ash has shown the best results when it comes to be a partial replacement to the cement. Being a by product of thermal power stations it is produced at a huge quantities every year and the thermal plants lack behind in disposing it and number of penalties have been put off on many thermal plants. By using the fly ash as the cement replacement will not only increase the mechanical and durability property of the concrete but it will also help to remove or reduce the pollution that is being produced in the environment by the cement and the air pollution which is being produced by the small particles of fly ash when it is disposed(Sear, 2010)(Flyash_2019-20-Converted, n.d.). When the industrial wastes such as fly ash, metakaolin, silica fume are added at combination has shown the better results when compare to the results when these materials are added individually not just normal concrete but we can achieve the high strength and ultra high strength from these combinations. the sitting times of the concrete retardates as we add the industrial wastes(Brooks et al., 2000).Silica fume(SF) come under chemically active mineral admixtures and FA, GGBS come under the micro filler mineral admixtures category.10% SF and 30% quarry dust replacement has shown the best results when it comes to derive the maximum results as a replacement s to cement and sand in the concrete(Kumar et al., 2017).It's our duty to safe guard the environment and we are taking steps in this process trying to recycle the wastes in their own way so that they can be helpful in making the environment more green(Pappu et al., 2007). It's getting very difficult to accommodate the huge areas of disposal and apart from this the industrial wastes also creates the air pollution. These industrial wastes have the binding properties which can be good replacement to the cement in concrete(Pappu et al., 2007). Especially industrial wastes can be used in the concrete at a good amounts(Dash et al., 2016). When the industrial wastes have the capacity to be added in the place of cement then it is mandatory to encourage the industrial wastes which have the capability to be replaced to the cement in order to reduce the pollution which is being caused by both the cement and the industrial wastes. It is mandatory to find the best replacements to the cement from among the available industrial wastes that has been proven its worth to be replaced to the cement.

**Procedure:**

In the present study the industrial wastes silica fume and fly ash is taken. The silica fume is added as a partial replacement to the cement in percentages of 0%, 5%, 10%, 15% and fly ash is added on the percentages of 0%,10%,20%,30%. The M40 mix is taken in the study as per the IS-2019 standard code book. The concrete specimens that is cubes are casted for 7 and 28days. The average value of 3 specimens will tabulated ad the final value for each day that is for 7 and 28days. The specimens are cured in normal water for 7 and 28days for compressive strength tests and for durability tests specimens are cured in for 28 and 90days in the water with 5% solution of HCL and $HNO_3$.

M40 mix design the quantities of material is as follows:

Grade of concrete = M 40

Cement = 412 kg/m$^3$

Water = 160 kg/m$^3$

Sand = 642 kg/m$^3$

Coarse aggregates = 1228 kg/$m^3$

**Research Objective:**

To evaluate the strength characteristics of the M40 grade concrete when S.F and F.A are partially added in place of Cement.
To investigate the durability capacity of the S.F and F.A when they are partially used in place of cement in concrete.
To investigate mechanical and durability properties of the concrete when the S.F and F.A are added in concrete individually and in combinations.

**Research significance :**
The research is carried out with an aim to know more about the industrial wastes as partial replacements to the cement. Through this research we would be getting an idea about the which among the selected industrial wastes that is fly ash and silica fume are better when compare to one another and when we will also be getting a clear idea which mixture provides more strength weather when they are added individually or when they are added in combination.

**Materials:**

**Cement:**
The cement taken in the study is from the Bharathi cement company with the cement grade of Opc 53 as per IS 8112-1939.
Specific gravity of cement obtained is 2.88.

**Coarse Aggregates:**
The coarse aggregates taken in the study are 20mm crushed coarse aggregates.
Specific gravity of sand obtained is 2.74 with water absorption value about 0.18% for 24hours.

**Fine Aggregates:**
The natural river sand is taken in the study.
The sand falls under the zone - II as per the IS 383-1978
Specific gravity of sand obtained is 2.65 with water absorption value about 1.8% for 24hours.

**Fly ash:**
The class C fly ash from the Madhavi industries Pvt, Ltd, YSR district, kadapa in Andhra Pradesh.

| S.No | Properties | Value |
|---|---|---|
| 1. | Specific gravity | 2.07 |
| 2. | Colour | Light Grey |

**Silica Fume:**

The silica fume is taken from the Madhavi industries Pvt, Ltd, YSR district, kadapa in Andhra Pradesh.

**Properties of Silica Fume:**

| S. No | Properties | Value |
|---|---|---|
| 1. | Specific gravity | 2.2 |
| 2. | Particle Size | < μ |
| 3. | Colour | Grey |

**Result:**

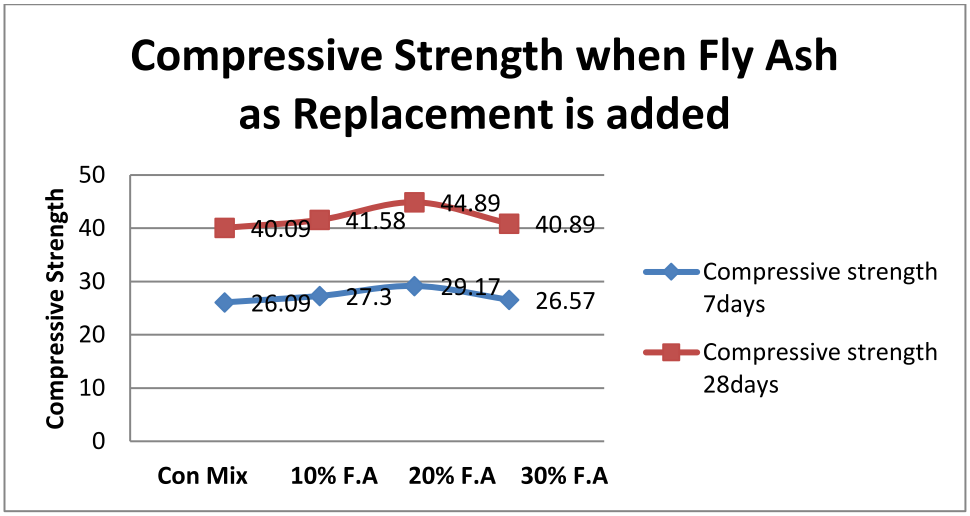
**Compressive Strength:**

In the present research work about 54 cube specimens are casted for 7 and 28days. The specimens are tested and average of 3specimens values are taken as final value for each day. The cube specimen of size 150mm × 150mm × 150mm are casted and cured for 7 and 28days and these specimens are tested in compressive testing machine. The results are as follows.

**M40 grade concrete compressive strength with fly ash as replacement:**

| S.No | Specimen | Compressive strength | |
|---|---|---|---|
| | | 7days | 28days |
| 1. | Convectional concrete | 26.09 | 40.09 |
| 2. | 10% Of fly ash | 27.3 | 41.58 |
| 3. | 20% fly ash | 29.17 | 44.89 |
| 4. | 30% fly ash | 26.57 | 40.89 |

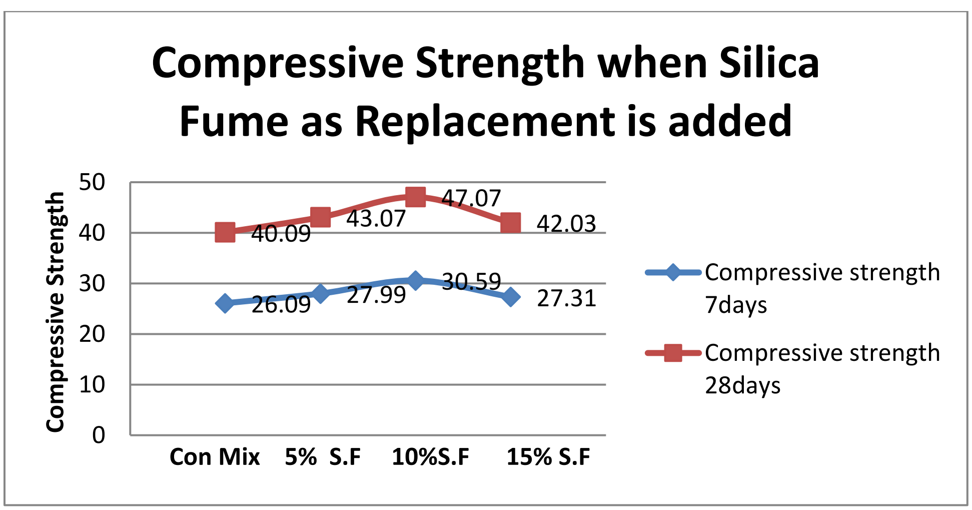
**Graphical representation of the compressive strength with fly ash as replacement:**




**M40 grade concrete compressive strength with silica fume as replacement:**

| S. No | Specimen | Compressive strength | |
|---|---|---|---|
| | | 7days | 28days |
| 1. | Convectional concrete | 26.09 | 40.09 |
| 2. | 5% silica fume | 27.99 | 43.07 |
| 3. | 10% silica fume | 30.59 | 47.07 |
| 4. | 15% silica fume | 27.31 | 42.03 |

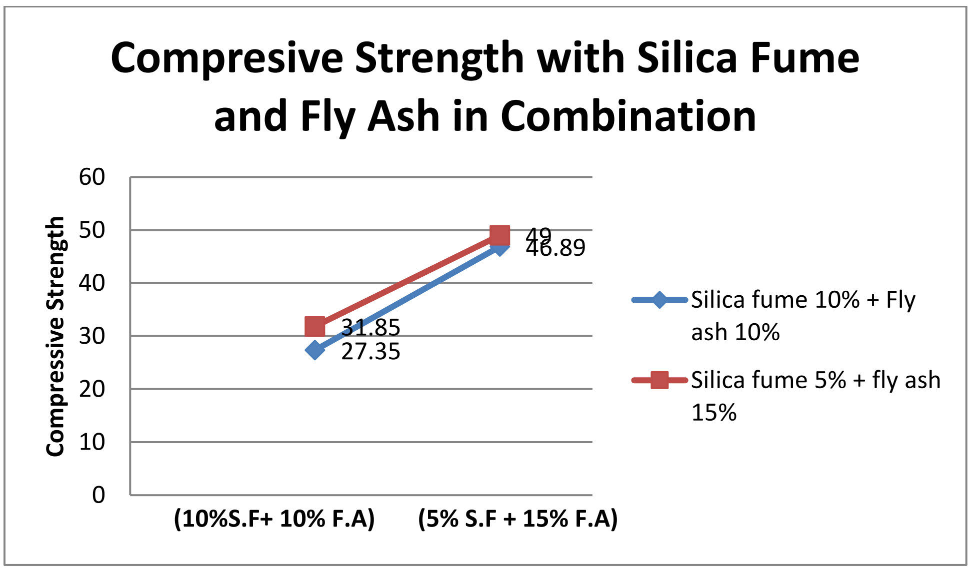
**Graphical Representation of compressive strength with silica fume as replacement:**




**M40 grade concrete compressive strength incorporated with combination of silica fume and fly ash as replacement:**

| S. No | Specimen | Compressive strength | |
|---|---|---|---|
| | | 7days | 28days |
| 1. | Silica fume 10% + Fly ash 10% | 27.35 | 51.79 |
| 2. | Silica fume 5% + fly ash 15% | 31.85 | 48.30 |

**Graphical Representation of compressive strength incorporated with combination of silica fume and fly ash as replacement:**




**M40 grade concrete compressive strength incorporated with combination of silica fume and fly ash as replacement under HCL attack:**

| S. No | Specimen | Compressive strength | |
|---|---|---|---|
| | | 28days | 90days |
| 1. | Convectional Concrete | 39.09 | 38.19 |
| 2. | Silica fume 10% + Fly ash 10% | 40.97 | 49.19 |
| 3. | Silica fume 5% + fly ash 15% | 47.88 | 47.1 |

**M40 grade concrete compressive strength incorporated with combination of silica fume and fly ash as replacement under $HNO_3$ attack:**

| S. No | Specimen | Compressive strength | |
|---|---|---|---|
| | | 28days | 90days |
| 1. | Convectional Concrete | 38.09 | 39.03 |
| 2. | Silica fume 10% + Fly ash 10% | 50.03 | 49.03 |
| 3. | Silica fume 5% + fly ash 15% | 47.98 | 48.70 |

**Conclusion:**

The study has shown that when the fly ash and silica fume are individually added to the concrete as a partial replacement to the cement it is seen that the silica fume has shown better compressive strength when compare to the fly ash. The study has shown that silica fume has shown the maximum strength at addition up to 10% increasing the silica fume content more than the 10% may reduce the strength. The fly ash has shown the maximum strength at addition up to 20% further increase in percentage of fly ash has shown the reduction in strength. It is evaluated that when the silica fume and fly ash are added in combination have shown the better strength when compare to the mixes where the industrial wastes are added individually. In the present research work high strength concrete Of M40 grade is been produce using the industrial wastes. This is the proof that we can not only produce the normal strength concrete we can also produce the high strength concrete using the industrial wastes such as fly ash, silica fume. The world is facing the crises with day by day increase in the pollution. The sudden climatic changes is the proof for it. Cement production process being the 5% world's pollution contributor. It is the duty of us engineers we build but we should also maintain the green environment. The industrial wastes are the effective solution to reduce the pollution which is caused due to cement production.

**Future Scope:**

The present research work which is done on M40 grade concrete but the study is limited only up to compressive strength. Further research on flexural strength, tensile strength is and other durability properties is needed is needed to be done to get more clearer picture on this materials.

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