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# A comparative study on compressive strength of cement mortar cubes with fly ash and GGBS produced using different fine aggregates

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**Abstract**

River sand is the most commonly used Fine Aggregate for construction throughout India. Excessive use of river sand leads to lowering of ground water table, sand degradation and also threat to bridges, river banks and nearby structures and in the same way Cement is a major constituent material of the concrete which produced by natural raw material like lime and silica. Ordinary Portland cement is one of the main ingredients used for the production of cement mortar. But, the production of each tonne of cement involves emission of large amounts of carbon-dioxide gas into the atmosphere, a major contributor for greenhouse effect and global warming. To overcome the above backdrops, we have to go for alternatives for satisfying the requirements. The Research focused on comparing the compressive strength of cement mortar cubes produced using fine aggregates from different sources. This project involves, preparation of cement mortar cubes of CM(1:2) proportion and also cement is replaced with 25% of Fly ash and 50% of GGBS for different grades of cement (33,43 and 53) at Constant water cement ratio and tested to determine the compressive strength of cement mortar cubes for 7, 14, 28 and 54 days under normal curing conditions. Finally, preparation of graphs from obtained results for comparative analysis.



***Keywords:***

Fine aggregates; River sand; Ennore sand; Stone dust; Quartz dust; Compressivestrength; Cement mortar

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## I. Introduction

River sand is most commonly used fine aggregate for construction throughout India has become highly expensive and also scarce. Natural sand is excavated from river bed impacts on environment in many ways. Due to digging of the sand from river bed reduces the water head, so less percolation of rain water in ground, which result in lower ground water level. There is erosion of nearby land due to excess sand lifting as well as it destroys the floraFauna in surrounding areas. Since it is utmost important ingredient for cement mortar and its immersive use in construction leads to rise in economy and the requirement of material in non-availability area is also costly process. To overcome the above backdrops, we have to go for alternatives for satisfying the requirements. The most commonly used fine aggregates are river sand, Ennore sand, stone dust, quartz dust etc.,

Concrete is the most widely used construction material in civil engineering industry because of its high strength and stability. Cement is a major constituent material of the concrete which produced by natural raw material like lime and silica. Ordinary Portland cement is one of the main ingredients used for the production of cement mortar. But, the production of each tonne of cement involves emission of large amounts of carbon-dioxide gas into the atmosphere, a major contributor for greenhouse effect and global warming. This situation leads to think all people working in construction industry to do research work on cement replacing material and use of it. The construction industry is constantly looking for supplementary cementations material with the objective of reducing the solid waste disposal problem. Ground granulated blast furnace slag (GGBS) and Fly ash (FA) are the solid wastes generated by industry. To overcome from this crisis, partial replacement of cement with GGBS and fly ash can be an economic alternative.

## II. Observations and results

Compressive Strength Test Results

The test performed on the cubes of size 70.6mm X 70.6 mm X 70.6 mm in the compressive strength testing machine for the 3, 7, 28 and 54 days gives the compressive strength. Compressive Strength = Failure load (KN)/ Area of the cube($mm^2$)

### A. Physical properties of different grades of cement

### i. Physical Properties of Ordinary Portland cement (33 grade)

| S.No | Characteristics | Values | | |
|---|---|---|---|---|
| | | cement | Cement+ 25 % flyash | Cement + 50%GGBS |
| 1 | Fineness of cement % | 7 | 5.2 | 3 |
| 2 | Standard Consistency, percent | 29 | 29.5 | 31 |
| 3 | Specific gravity | 3.12 | 3.3 | 4.0 |

**Table 1 Physical properties of OPC (33 grade)**

**ii. Physical Properties of Ordinary Portland cement (43 grade)**

| S.No | Characteristics | Values | | |
|---|---|---|---|---|
| | | cement | Cement+ 25 % fly ash | Cement + 50% GGBS |
| 1 | Fineness of cement % | 5 | 4 | 3 |
| 2 | Specific Gravity | 3.17 | 3.4 | 4.11 |
| 3 | Standard Consistency, percent | 29.8 | 30 | 31 |

**Table 2 Physical properties of OPC (43 grade)**

**iii. Physical Properties of Ordinary Portland cement (53 grade)**

| S.No | Characteristics | | | Values | |
|---|---|---|---|---|---|
| | | | cement | Cement+ | Cement + |
| | | | | 25 % fly | 50% |
| | | | | ash | GGBS |
| 1 | Fineness of cement % | | 5 | 3.8 | 2.7 |
| 2 | Specific Gravity | | 3.18 | 3.42 | 4.13 |
| 3 | Standard | Consistency, | 30 | 30.5 | 31.2 |
| | percent | | | | |

**Table 3 Physical properties of OPC (53 grade)**

**B. Physical properties of different types of sands**

**i. Physical properties of Ennore sand**

| S.No | Physical Properties | values |
|---|---|---|
| 1 | Specific gravity | 2.64 |
| 2 | Absorption in 24 hours | 0.90% |

**Table 4 Physical properties of Ennore sand**

**ii. Physical properties of river sand**

| S.No | Physical Properties | values |
|---|---|---|
| 1 | Specific gravity | 2.65 |
| 2 | Absorption in 24 hours | 1.15% |

**Table 5 Physical properties of river sand**

**iii. Physical properties of stone dust**

| S.No | Physical Properties | values |
|---|---|---|
| 2 | Specific gravity | 2.52 |
| 3 | Absorption in 24 hours | 1.6% |

**Table 6 Physical properties of stone dust**

**iv. Physical properties of quartz dust**

| S.No | Physical Properties | values |
|---|---|---|
| 1 | Specific gravity | 2.75 |
| 2 | Absorption in 24 hours | 0.8% |

**Table 7 Physical properties of Ennore sand**

**C. Compressive strength values for different types of fine aggregates**

**ii. Compressive strength values for Ennore sand:**

| Type of Sand | Days | 33 grade | 43 grade | 53 grade | 33 grade + 25% Flyash | 43 grade + 25% Flyash | 53 grade + 25% Flyash | 33 grade + 50% GGBS | 43 grade + 50% GGBS | 53 grade + 50% GGBS |
|---|---|---|---|---|---|---|---|---|---|---|
| Ennore Sand | 7 | 25.67 | 32.32 | 37.30 | 21.02 | 31.25 | 36.98 | 24.72 | 32.16 | 36.41 |
| | 14 | 30.62 | 39.20 | 45.74 | 27.15 | 31.83 | 37.28 | 28.55 | 38.25 | 44.98 |
| | 28 | 36.30 | 45.39 | 53.76 | 30.25 | 35.75 | 40.54 | 34.37 | 44.49 | 52.11 |
| | 56 | 38.12 | 48.28 | 54.97 | 31.25 | 40.07 | 47.64 | 39.09 | 48.90 | 56.47 |

**Table 8 Compressive strength values for Ennore sand**

**ii. Compressive strength values for river sand:**

| Type of Sand | Days | 33 grade | 43 grade | 53 grade | 33 grade + 25% Flyash | 43 grade + 25% Flyash | 53 grade + 25% Flyash | 33 grade + 50% GGBS | 43 grade + 50% GGBS | 53 grade + 50% GGBS |
|---|---|---|---|---|---|---|---|---|---|---|
| River Sand | 7 | 23.71 | 28.74 | 34.92 | 18.15 | 27.51 | 33.17 | 22.12 | 27.95 | 34.23 |
| | 14 | 32.54 | 39.18 | 42.18 | 22.28 | 35.75 | 35.82 | 29.27 | 35.14 | 41.28 |
| | 28 | 36.74 | 43.57 | 53.19 | 23.15 | 34.14 | 40.28 | 31.98 | 38.15 | 48.27 |
| | 56 | 37.63 | 44.85 | 54.89 | 25.18 | 37.33 | 42.20 | 33.09 | 43.17 | 53.11 |

**Table 9 Compressive strength values for river sand**

**iii. Compressive strength values for stone dust:**

| Type of Sand | Days | 33 grade | 43 grade | 53 grade | 33 grade + 25% Flyash | 43 grade + 25% Flyash | 53 grade + 25% Flyash | 33 grade + 50% GGBS | 43 grade + 50% GGBS | 53 grade + 50% GGBS |
|---|---|---|---|---|---|---|---|---|---|---|
| Stone dust | 7 | 22.16 | 26.03 | 32.75 | 17.15 | 25.87 | 31.86 | 23.75 | 29.75 | 33.98 |
| | 14 | 26.61 | 33.04 | 38.67 | 21.64 | 27.79 | 34.16 | 27.25 | 34.18 | 40.18 |
| | 28 | 29.99 | 40.01 | 44.98 | 22.79 | 31.26 | 36.75 | 31.01 | 40.11 | 47.58 |
| | 56 | 32.16 | 41.71 | 48.78 | 27.44 | 33.76 | 39.41 | 32.57 | 42.19 | 50.89 |

**Table 10 Compressive strength values for stone dust**

**iv. Compressive strength values for quartz dust:**

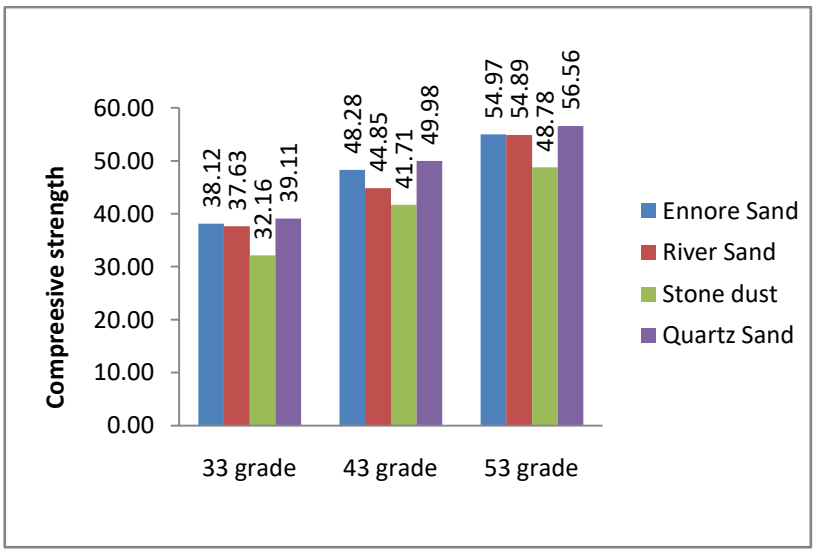
| Type of Sand | Days | 33 grade | 43 grade | 53 grade | 33 grade + 25% Flyash | 43 grade + 25% Flyash | 53 grade + 25% Flyash | 33 grade + 50% GGBS | 43 grade + 50% GGBS | 53 grade + 50% GGBS |
|---|---|---|---|---|---|---|---|---|---|---|
| Quartz Sand | 7 | 27.79 | 35.22 | 39.94 | 21.48 | 28.55 | 32.25 | 26.47 | 33.14 | 37.91 |
| | 14 | 31.57 | 41.13 | 49.07 | 24.66 | 31.28 | 34.88 | 29.81 | 38.25 | 46.73 |
| | 28 | 37.94 | 48.12 | 56.33 | 29.02 | 35.15 | 36.25 | 36.14 | 45.37 | 53.41 |
| | 56 | 39.11 | 49.98 | 56.56 | 33.24 | 43.25 | 51.25 | 41.48 | 52.51 | 59.48 |

**Table 11 Compressive strength values for stone dust**

## IV. Graphs and Discussions

### i. Compressive strength Vs Different grades of cement

Compressive strength of cement mortar with different grades of cement and different types of sands at 56 days




**Graph 1 Compressive strength Vs Different grades of cement**

**Discussions:**

i. From graph 1, it is observed that the cement mortar with 53 grade cement has more compressive strength compared to the cement mortar cubes produced with 33 and 43 grade cement.

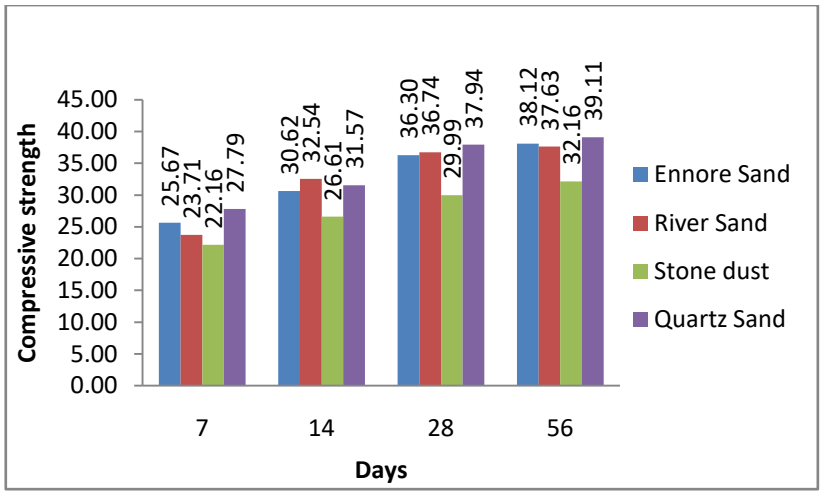
ii. It is also observed that the cement mortar with quartz sand has highest compressive strength compared to cement mortar with Ennore sand, river sand and stone dust by 2.53%, 3.78% and 17.77% for 33 grade cement respectively.

iii. It is observed that the cement mortar with quartz sand has highest compressive strength compared to cement mortar with Ennore sand, river sand and stone dust by 3.40%, 10.26% and 16.54% for 43 grade cement respectively.

iv. It is observed that the cement mortar with quartz sand has highest compressive strength compared to cement mortar with Ennore sand, river sand and stone dust by 2.81%, 2.95% and13.755% for 53 grade cement respectively.

**ii. Compressive strength VsNo. of days**

Compressive strength of cement mortar with 33 grade cement for different fine aggregates.




**Graph 2 Compressive strength VsNo.of days**

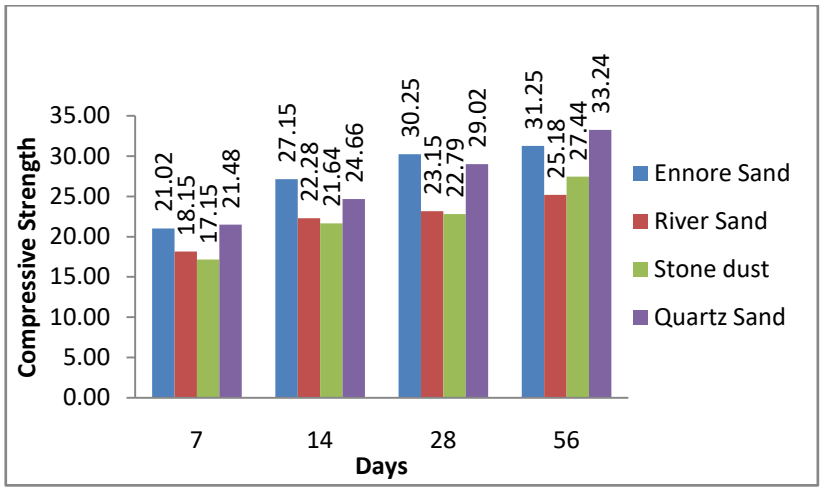
**Discussions:**

i. From graph 2, it is also observed that the cement mortar containing river sand has high strength for 14 days but for 56 days there is decrease in strength compared to Ennore sand and quartz sand by 1.30% and 3.93% respectively. This means that the cement mortar with river sand gains early strength compared to all other fine aggregates.

ii. It is also observed that the cement mortar with Ennore sand and river sand has almost same compressive strength at 28 days.

**iii. Compressive strength VsNo. of days (fly ash)**

Compressive strength of cement mortar with 33 grade cement contains 25% fly ash for different fine aggregates.




**Graph 3Compressive strength Vs No.of days (fly ash)**

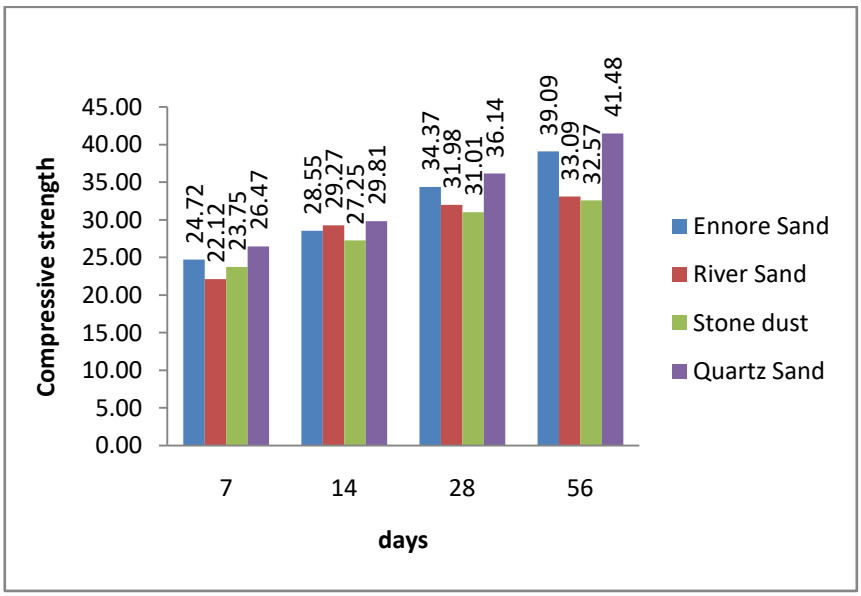
**Discussions:**

i. From graph 2, it is observed that the cement mortar containing stone dust has less strength compared to cement mortar containing Ennore sand, river sand and quartz sand but from graph 3, it is observed cement mortar containing stone dust has high strength compared to river sand at 56 days when cement is replaced with 25% of fly ash.

ii. From graph 2, it is also observed that the cement mortar containing Ennore sand and river sand has almost same compressive strength but from graph 3, there is a large variation in compressive strength for cement mortar containing Ennore sand and river sand when cement is replaced with 25% fly ash.

**iv. Compressive strength VsNo. of days (GGBS)**

Compressive strength of cement mortar with 33 grade cement contains 50% GGBS for different fine aggregates.




**Graph 4Compressive strength Vs No.of days (GGBS)**

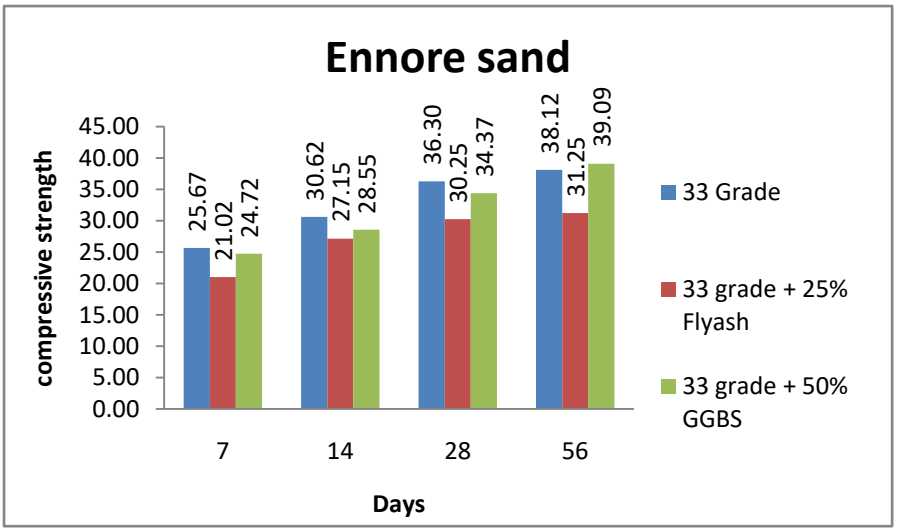
**Discussions:**

i. From graph4, it is observed that the cement mortar containing stone dust has greater strength compared to river sand at 7 days but decreases from 14 days onwards.

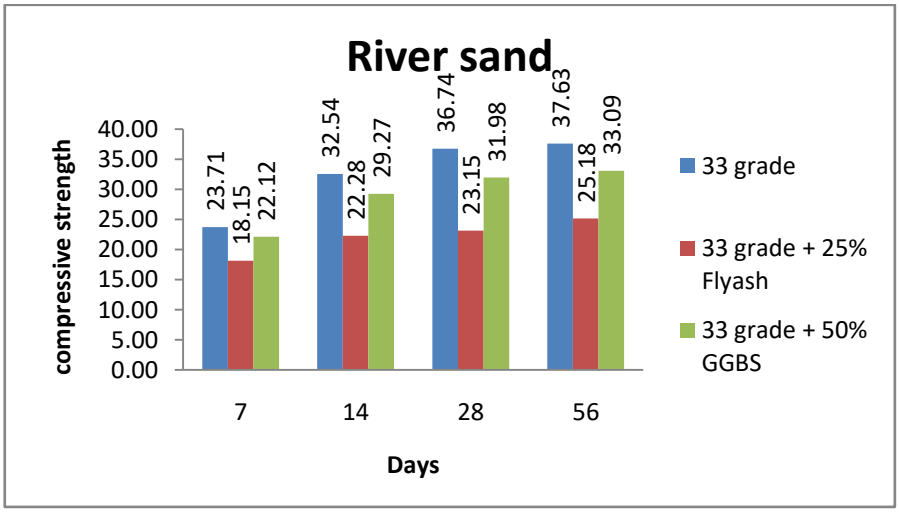
ii. It is also observed that the cement mortar with river sand and stone dust has almost have same compressive strength at 28 and 56 days when cement is replaced with 50% GGBS.

**v. Compressive strength VsNo. of days for different FA**

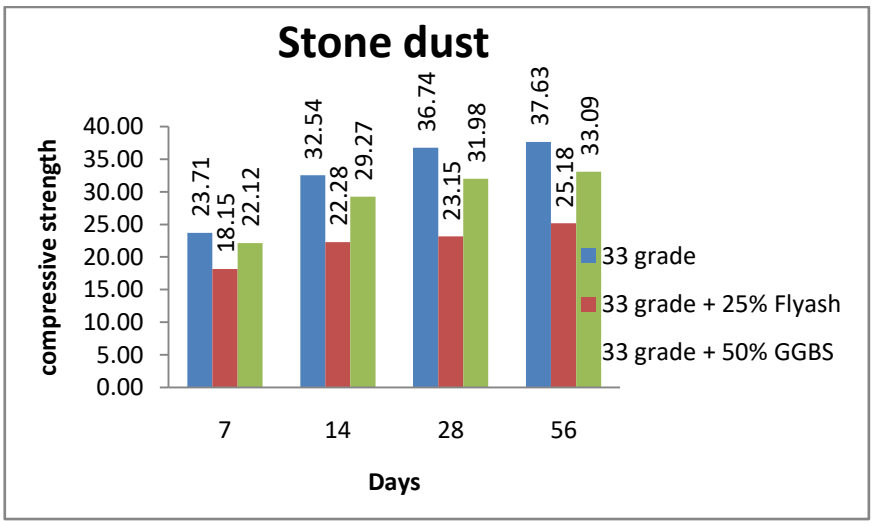
Compressive strength of cement mortar with 33 grade cement contains 25% fly ash and 50% GGBS for Ennore sand, river sand, stone dust and quartz dust.



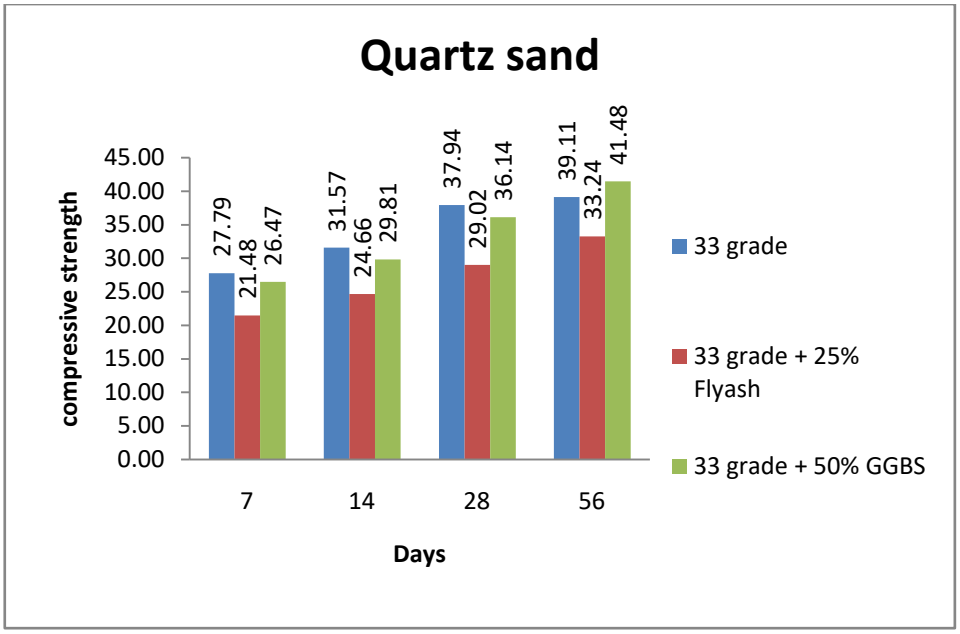

**Graph 5Compressive strength Vs No.of days Ennore sand**




**Graph 6Compressive strength Vs No.of days for river sand**




**Graph 7Compressive strength Vs No.of days for stone sand**




**Graph 8 Compressive strength VsNo.of days for quartz sand**

**Discussions:**

i. From graph 5 and graph 8, it is observed that the cement mortar cube containing Ennore sand and quartz sand has more strength when cement is replaced with 50% GGBS but has low strength when cement is replaced with 25% fly ash.

ii. In the same way it is observed that the cement mortar cubes containing Ennore sand and quartz sand has more strength up to 28 days but it decreases at 56 days. This means there is a gradual increase in strength when cement is replaced with 50% GGBS.

iii. From graph 6 and graph 7, it shows that the cement mortar cube containing river sand and stone dust has less strength when the cement is replaced with fly ash and GGBS.

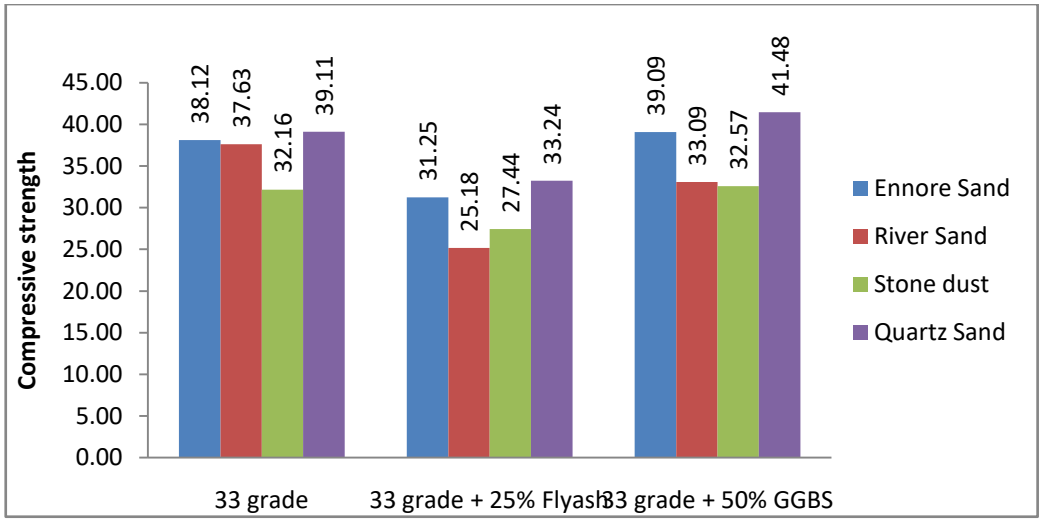
**vi. Compressive strength VsNo.of days (fly ash & GGBS)**

Compressive strength of cement mortar with 33 grade cement contains 25% fly ash and 50% GGBS for different types of sands.

**Discussions:**

a. From graph 9, it is observed that the cement mortar cube produced with quartz sand has high compressive strength, cement mortar with stone dust has low compressive strength and the cement mortar with Ennore sand and river sand has almost have same strength for 33 grade cement at 56 days.

b. It is also observed that the cement mortar with Ennore sand and quartz sand has more strength compared with the cement mortar with river sand and stone dust when cement is replaced with 25% of fly ash and 50% of GGBS.




**Graph 9Compressive strength Vs No.of days (fly ash & GGBS)**

## V. Conclusions

The following specific conclusions can be arrived based on the study conducted on cement mortar

a. The cement mortar contains 53 grade cement has more compressive strength compared to the cement mortar with 33 and 43 grade cement.

b. It is also observed that the cement mortar with quartz sand has highest compressive strength compared to cement mortar with Ennore sand, river sand and stone dust by 2.53%, 3.78% and 17.77% for 33 grade cement respectively.

c. It is observed that the cement mortar with quartz sand has highest compressive strength compared to cement mortar with Ennore sand, river sand and stone dust by 3.40%, 10.26% and 16.54% for 43 grade cement respectively.

d. It is observed that the cement mortar with quartz sand has highest compressive strength compared to cement mortar with Ennore sand, river sand and stone dust by 2.81%, 2.95% and13.755% for 53 grade cement respectively.

e. The cement mortar containing Ennore sand and quartz sand has more strength when cement is replaced with 50% GGBS but has low strength when cement is replaced with 25% fly ash.

f. The cement mortar containing river sand has high strength for 14 days but for 56 days there is decrease in strength compared to Ennore sand and quartz sand by 1.30% and 3.93% respectively. The cement mortar with river sand gains high strength in early days compared to Ennore sand, stone dust and quartz dust.

g. The cement mortar containing stone dust has least strength compared to cement mortar containing Ennore sand, river sand and quartz sand but it is increased at 56 days when cement is replaced with 25% of fly ash.

h. If 100% cement is used, then cement mortar containing Ennore sand and river sand has almost have same compressive strength But there is a large variation in compressive strength of cement mortar containing Ennore sand and river sand when cement is replaced with 25% fly ash and 50% GGBS.

i. The cement mortar with river sand and stone dust has almost have same compressive strength when cement is replaced with 50% GGBS.

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