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# A Study On the Effect of Enhancing High Performance Concrete with Supplementary Material

Saurabh Suman[1], Ravikant Sharma[2]
[1]*M.Tech. Scholar, Department of Civil Engineering, R.P.E.T. Bastara, Karnal, India*
[2]*Assistant Professor, Department of Civil Engineering, R.P.E.T. Bastara, Karnal, India*

***Abstract*: This paper presents an experimental study comparing the properties of traditional concrete and concrete made up of other supplementary materials. To have an environmental and consistent way of disposal in this study, natural sand and cement have been partially replaced by marble/stone dust and fly ash respectively. Multiple scenarios have been studied where 20%, 22.5%, 25% & 35% of cement was replaced by fly ash. Similarly, 30% & 40% of fine aggregate is replaced with marble dust and stone dust. The experiments were performed with these replacements.**

***Keywords*: Ordinary Portland Cement (OPC), Waste Materials Fly Ash, Marble Dust, Stone Dust.**

## 1. Introduction

The costliest component of concrete is cement. Replacement of cement by fly ash helps reduce unit cost of concrete. Even partial replacement can result in considerable reduction and same has been confirmed in recent studies as well where researchers have proclaimed that use of additional cement-like materials, for example fly-ash in concrete is economical and reliable. Using natural stone waste in mortar and concrete has been promoted in studies done in different countries. Marble, granite and lime stone waste was used by the researchers to replace cement or sand in concrete mix. This was done to analyze their effect on the physical and mechanical properties of concrete.

In his study of 2007, Berryman et al presented that for concrete containing class C fly ash a replacement percentage of 35% can result in maximum compressive strength. The mean value of compressive strength for 35% class C fly ash was slightly above 41.5 N/mm². For class F fly ash replacement of 25% resulted in maximum compressive strength which was approximately 36.0 N/mm².

As per Ashle and Quadori (2013) the compressive strength of concrete of grade M25 & M30 made with stone dust is increased at each replacement level between 30-60% at an interval of 10%, however, maximum increased strength is observed at a replacement level of 40%.

## 2. Material and methodology

1) *Cement*

The cement used was ordinary Portland cement (43 grades). The properties of cement based on various test results conducted are as following:

Normal consistency = 31
Specific Gravity = 3.12
Initial setting time= 30 min.
Final setting time= 430 min.

2) *Fly ash*

Fly ash is one of the residues generated in the combustion of coal. Fly ash is generally captured from the chimneys of coal – fired power plants. Fly ash was used obtained from parichha thermal power plant Jhansi (U.P.) India. The specific gravity of fly ash is 2.11.

- Stone dust: Stone dust was obtained Mahalakhmi group of stone crushers(Haryana). The specific gravity of stone dust is 2.64 and fineness modulus is 2.76.
- Marble dust: Marble stone industry generates marble dust. Whereas marble dust results from the rejects at the mine sites or at the processing units The fineness modulus of marble stone used in the study is 1.55 and specific gravity of marble stone is 2.25.

3) *Aggregates*

a) Fine aggregate
Specific gravity = 2.02, fineness modulus=3.1

b) Coarse aggregate
Specific gravity=2.70, Fineness modulus=5.0

## 3. Experimental investigation

The experimental investigation was done for the comparative study of compressive strength of concrete mix with addition of fly ash, stone dust and marble dust. Fifteen types of concrete mixes were prepared. The various mix proportions and their compressive strength are shown in the table 2. The concrete of grade M30 was designed as per IS standards.

Table 1
Control concrete mix (M30)

| Water | Cement | Fine Aggregate | Coarse Aggregate |
|---|---|---|---|
| 0.45 | 1 | 1.41 | 2.90 |
| 182.7ltrs | 406kg | 576kg | 1178kg |

Table 2
Preparation of material with FLY ASH, MD & SD and compressive strength

| S. No. | Mix | Cement | Fly Ash | Fine Agg. | | | Coarse Agg. | | W/C | Compressive Strength | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | SAND | MD | SD | 10MM | 20MM | | 7Days (N/mm²) | 28Days (N/mm²) |
| 1 | CC | 100% | 0% | 100% | 0% | 0% | 40% | 60% | 0.45 | 25.78 | 38.66 |
| 2 | M1 | 65% | 35% | 70% | 20% | 10% | 40% | 60% | 0.45 | 19.55 | 28 |
| 3 | M2 | 65% | 35% | 70% | 15% | 15% | 40% | 60% | 0.45 | 20.44 | 28.90 |
| 4 | M3 | 65% | 35% | 70% | 10% | 20% | 40% | 60% | 0.45 | 21.33 | 30.22 |
| 5 | M4 | 65% | 35% | 60% | 30% | 10% | 40% | 60% | 0.45 | 19.55 | 27.55 |
| 6 | M5 | 65% | 35% | 60% | 20% | 20% | 40% | 60% | 0.45 | 17.77 | 25.80 |
| 7 | M6 | 65% | 35% | 60% | 10% | 30% | 40% | 60% | 0.45 | 18.66 | 26.70 |
| 8 | M7 | 75% | 25% | 70% | 20% | 10% | 40% | 60% | 0.45 | 20.88 | 29.80 |
| 9 | M8 | 75% | 25% | 70% | 15% | 15% | 40% | 60% | 0.45 | 22.22 | 32 |
| 10 | M9 | 75% | 25% | 70% | 10% | 20% | 40% | 60% | 0.45 | 23.11 | 35.55 |
| 11 | M10 | 75% | 25% | 60% | 30% | 10% | 40% | 60% | 0.45 | 21.33 | 30.25 |
| 12 | M11 | 75% | 25% | 60% | 20% | 20% | 40% | 60% | 0.45 | 22.22 | 31.55 |
| 13 | M12 | 75% | 25% | 60% | 10% | 30% | 40% | 60% | 0.45 | 20.88 | 29.80 |
| 14 | M13 | 77.5% | 22.5 | 70% | 10% | 20% | 40% | 60% | 0.45 | 24.29 | 35.55 |
| 15 | M14 | 80% | 20% | 70% | 10% | 0% | 40% | 60% | 0.45 | 25.03 | 38.81 |

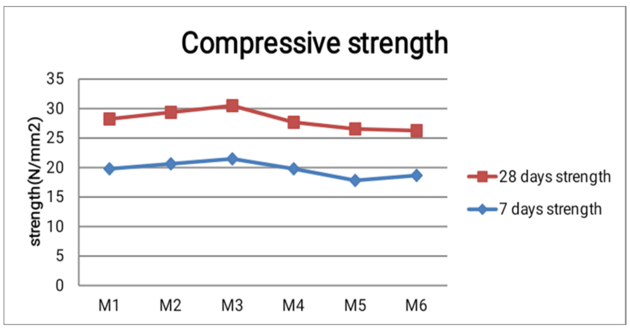


Fig. 1. Variation in compressive strength with 35% fly ash

Figure 1 indicates the 7 and 28 days' compressive strength of 6 concrete mixes. The highest value is 30.22 N/mm² for 35% of cement replacement and 30% of sand replacement.

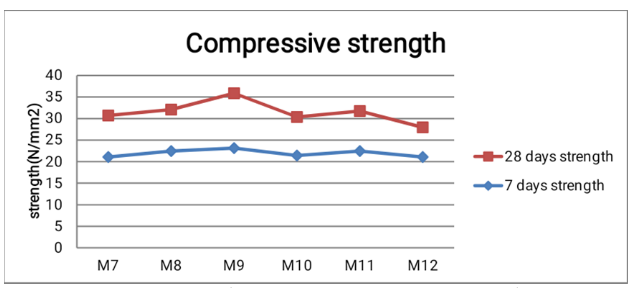


Fig. 2. Variation of compressive strength with 25% fly ash

Figure 2 indicate the 7 and 28 days' compressive strength of 6 samples. The highest value is 32N/mm² for 25% of cement and 30% of sand replacement.

The curve in fig. 3 shows the rate of compressive strength development of M13 and M14 mix over a span of 7 and 28 days. It can be seen that concrete with 25% of cement and 30% of sand replacement has the highest rate of increase in compressive strength.

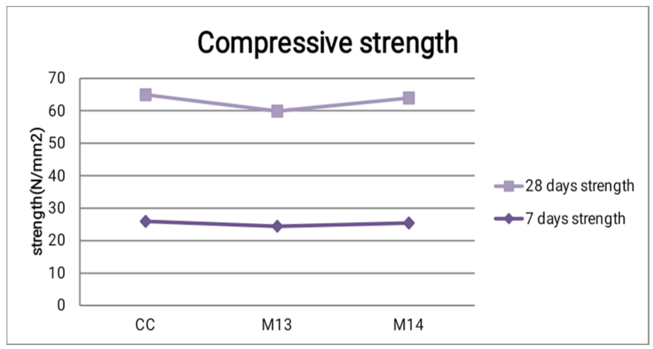


Fig. 3. Variation in compressive strength with 22.5% and 20% fly ash

## 4. Conclusion

After the experiments to compare the strength of concrete with conventional and supplementary materials were conducted, several observations were made which are produced below:

1. Percentage replacement of cement and fine aggregate upto 20% and 30% results in increased compressive strength.
2. The possibility of safely disposing fly ash, stone dust and marble dust can be achieved by using supplementary materials in preparation of concrete. These alternatives also resulted in solving environmental problems. In addition, use of fly ash, stone dust & marble dust minimizes the requirement of cement in large quantity. Therefore, in order to move towards sustainable development in construction industry, it is recommended to re-use these wastes in concrete.
3. Use of fly ash and stone waste materials in concrete leads is economical and results in cost saving.
4. The mix M14 had high value of compressive strength, remaining mix (M1-M13) were comparatively less. But

the workability value of mix M4, M5 and M6 had good values as compare to other mixes.

5. This experiment and investigation throws light on compressive strength between modified concrete and control concrete. Strength of modified concrete (with alternative materials) is at comparable range with control concrete at 28 days. This indicates that fly ash, stone dust and marble dust can be introduced as functional construction materials.

## 5. Scope for future work

As per this study, characteristic compressive strength of concrete improves considerably when all three waste products, fly ash, stone dust and marble dust are used together for making a concrete mix. This comparison of change in compressive strength for both control and alternative mixes can be determined at 60, 90 and 120 days.

There needs to be further study of use of marble dust and stone dust in order to have these waste materials contribute to be large constituents of concrete mixes thereby optimizing the cost of project and at the same time not compromising with strength and other properties of the concrete for sustainable development.

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