Experimental study of partial replacement of cement by waste marble powder in a concrete prepared with artificial sand

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Abstract. Marble is the most common building material having a huge amount of waste. This waste causes dust pollution also it makes soil infertile etc. Day by day marble waste goes on increasing. Another problem is regarding no availability of natural sand as resources of natural sand exhausting very rapidly also it contains a lot of deleterious materials to overcome this issue we can make partial replacement of cement by waste marble powder and natural sand by artificial sand. The concrete is made with heterogeneous material therefore compressive strength of concrete depends upon various materials with various trials so the process is simplified in a mathematical technique called the regression method, which gives predicted compressive strength, if we get regression equation, it reduces the trials of concrete mix.

1. Introduction

Manpreet Singh [1-2, 6-7, 12] gives result up to 10-15% use of marble powder increases strength of concrete. Valeria Corinaldesi et. al [3] shows 10% substitution of sand by marble powder with plasticizer gives maximum strength with workability. A. S. E. Belaidi [4] study shows up to 40% (natural pozzolona + marble powder) improve workability with suitable strength. Rajendra Kumar Khayaliya [5] study concluded marble waste could be harmless used in aggressive and non-aggressive environment by replacing river sand by 25% and 50%. Ali khodabakhshian [8, 10] study concluded 20% waste marble powder and 10% silica fumes partially replacement of cement decreases detrimental effect of cement industry on environment. Deepankar Kumar Ashish [10] noticed optimal replacement with 10% cement and 10% sand by 20% marble powder. V. Nezerka [11] indicates that elimination of the interfacial transition zone (ITZ) and minimization of porosity would increase the strength of cement-based materials carrying waste marble powder.

Present study focuses on experimental investigation of compressive strength and workability of concrete with substitute of cement by waste marble powder and sand by artificial sand, from this study we will come to know effect of waste marble powder with artificial sand on compressive strength and workability of concrete.

2. Why Waste M. P as alternative for cement

There is basic reason to select waste M. P as alternative for cement because both cement and waste marble powder having same chemical composition.
Table 1. Chemical properties of both cement and waste M.P

| Chemical constituents | Cement  | Waste M.P |
|----------------------|---------|-----------|
| Alumina(A12O3)       | 4.6%    | 0.7%      |
| Iron oxide(Fe2O3)    | 3%      | 0.33%     |
| Calcium oxide(CaO)   | 61.40%  | 51.49%    |
| magnesium oxides(MgO) | 2.3%    | 0.36%     |
| Sodium oxide(Na2O)   | 0.19%   | 0.19%     |
| Potassium oxide(K2O) | 0.83%   | 0.25%     |
| Sulphur trioxide(SO3)| 3.8%    | 0.1%      |
| Loss on ignition     | 2.7%    | 44.6%     |

Table 2. State wise marble production in tonnes

| State               | Year     |
|---------------------|----------|
|                     | 2015-16  | 2016-17 | 2017-18 |
| Rajasthan           | 15676902 | 13523759| 13199265|
| Gujarat             | -        | 983401  | 829711  |
| Madhya Pradesh      | 104301   | -       | -       |
| Andhra Pradesh      | -        | 357     | -       |

3. Methodology

3.1 Materials
O.P.C confirming to I.S.269-1989 the specific gravity of O.P.C was 3.15, artificial sand confirming to I.S.383-1970 is used as fine aggregate. Waste marble powder make available from Pandharpur located in Maharashtra. The waste was generated from cutting the marble into pieces; obtained waste was dried and then used. Coarse aggregate having size 20mm is used.

3.2 Mix proportion
The research was carried out on concrete mixes in which some amount of cement was substitute with waste marble powder and natural sand by artificial sand. The substitute of waste marble powder was 0%, 5%, 10%, 15%, 20%, 25% and 30% by weight of cement. The concrete mix was designed as per I.S.10262-2009 with target 28 compressive strength of 20 MPa. The W/C ratio was kept as 0.5; further subsequent trials are prepared with substituting cement with M.P.

3.3 Testing details
The tests was conducted for examining the properties, as workability was measured through slump test and actual strength was measured at different ages after casting.

4. Result and discussion

4.1 Workability
The different values of slump are presented in figure 1. It was concluded that workability decreases as amount of M.P increases. The workability also decreases due to artificial sand.

The workability was decrease due to two major facts:
1. Artificial sand having rough surface texture that requires maximum amount of water
2. Waste marble powder containing large amount of fine particles requires more water to wet.

Due to these combined effects, more water is required for workability.
Figure 1. Workability with increase in waste marble powder

4.2 Compressive Strength
The major strength of concrete at different phases are determined and are shown in table no 3. from fig compressive strength goes on increasing with up to 10%, thereafter compressive strength goes on decreasing as amount of waste marble powder increases. The 28 days compressive strength of mixes are 28.29,31.22,32.35,27.32,26.97,25.13and21.24N/mm² respectively for 0%,5%,10%,15%,20%,25% and 30% from the observation the optimum compressive strength of concrete at 10% substitute of waste marble powder against cement.

The compressive strength of concrete added on due to fine marble powder, which increases binding property of concrete. The artificial sand distinctly make impact on compressive strength.

Table 3. Compressive strength at varying % of M.P

| Sr. No | % of Marble Powder | W/C Ratio | Water lit/m³ | Cement kg/m³ | Fine aggregates /kg/m³ | Coarse aggregates kg/m³ | Marble Dust Powder kg/m³ | Compressive strength in (N/mm²) | Expt./Obs | Predicted |
|--------|---------------------|-----------|--------------|---------------|------------------------|------------------------|---------------------------|---------------------------------|----------|-----------|
| 1      | 0%                  | 0.5       | 191.58       | 368.42        | 690.93                 | 1147.1                 | 0                         | 28.29                          | 31.83    |           |
| 2      | 5%                  | 0.5       | 191.58       | 350           | 690.93                 | 1147.1                 | 18.42                     | 31.22                          | 30.34    |           |
| 3      | 10%                 | 0.5       | 191.58       | 331.58        | 690.93                 | 1147.1                 | 36.84                     | 32.35                          | 28.85    |           |
| 4      | 15%                 | 0.5       | 191.58       | 313.16        | 690.93                 | 1147.1                 | 55.26                     | 27.32                          | 27.36    |           |
| 5      | 20%                 | 0.5       | 191.58       | 294.74        | 690.93                 | 1147.1                 | 73.68                     | 26.97                          | 25.87    |           |
| 6      | 25%                 | 0.5       | 191.58       | 276.32        | 690.93                 | 1147.1                 | 92.1                      | 25.13                          | 24.39    |           |
| 7      | 30%                 | 0.5       | 191.58       | 257.89        | 690.93                 | 1147.1                 | 110.53                    | 21.34                          | 22.9     |           |

4.3 Regression method
Now a day’s construction work is growing rapidly as concrete is made up of different materials. The important parameter in construction most probably is compressive strength. Compressive strength depends upon different parameters like cement, W/C ratio, F.A, C.A, surface structure etc. In this fast growing industry, there is lot of time waste for trial mix of concrete and checking of compressive...
strength at different ages. So to overcome this some mathematical model is established to check predicted compressive strength called as regression techniques. Multi-linear regression resolves the interrelationship between different independent variables and dependent variable with providing a linear equation with actual data. The correlation between dependent and independent variable is expressed in equation.

\[ P = a_0 + a_1 w + a_2 M.P \]  

multi-linear regression

Where,  
\[ P \] = Predicted strength of concrete
\[ w \] = amount of cement
\[ M.P \] = Waste Marble Powder

From multilinear regression, methods following (Table 4) coefficients are determined to calculate predicted compressive strength

| Specifications                | coefficients | values |
|------------------------------|--------------|--------|
| Constant                     | \( a_0 \)    | 3.095  |
| Cement                       | \( a_1 \)    | 0.078  |
| Waste Marble Powder          | \( a_2 \)    | -0.0028|

5. Conclusion

With the available research, we conclude:

- The strength of concrete with waste marble powder with artificial sand gives higher strength in comparison to natural sand.
- Workability do affect due to artificial sand.
- 20% waste marble powder gives optimum strength.
- Regression technique gives standard equation to infer the strength of concrete with waste marble powder.
- It is observed the infer values of compressive strength achieved by suggested regression equation are in good compatibility with the actual results.

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