Partial Replacement of Fine Aggregate with Demolished Concrete Fine Aggregate and Partial Replacement of Cement with Bentonite

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Abstract

In today’s world demolition of old structures to make way for new and modern ones is a common feature due to rapid urbanization. Very little demolished concrete is recycled or reused. Due to strict environmental laws and lack of dumping sites, demolished waste disposal is a great problem. On the other hand, production and utilization of concrete is rapidly increasing, which results in an increased consumption of natural aggregate, as it is the largest concrete component. More over the manufacturing process of cement has turned out to be a significant contributor to greenhouse gases, thereby, posing a serious threat to our environment. As a solution to these rising problems, we intend to propose an alternative for cement and natural aggregates. A possible solution to these problems is to reuse demolished concrete, thereby producing an alternate aggregate for structural concrete. By the replacement of cement by bentonite with all its added benefits, a concrete mix can be developed which is environment friendly.

The study aims to conduct experimental investigations to assess the combined effect of partial replacement of fine aggregate by demolished waste and the effect of partial replacement of cement with bentonite on all basic properties of concrete at 7 and 28 days. The potential benefits that this solution offers is not just the conservation of natural resources and the reduction of greenhouse gases in the environment. With the addition of bentonite, various benefits such as low heat of hydration, high ultimate strength, low permeability and a greater resistance to acid attack will be observed.

Keywords: Construction and Demolition(CD), Concrete replaced with Demolished Concrete waste(DC), Concrete replaced with Demolished Concrete waste and Bentonite(DCB), Portland Pozzalona Cement(PPC), Mix 25(M25), Water Cement(WC)

I. INTRODUCTION

Demolition of concrete buildings have become frequent in the present world. Deposition of these materials in landfills have become a serious threat to the human environment. Also the production and utilization of concrete is rapidly increasing with an increase in the consumption of natural aggregates. Production of cement is a significant contributor to greenhouse gases. It is important now to find an alternative for cement and natural aggregates. And thereby reduce the emission of greenhouse gases and conserve our natural resources.

A possible solution to these problems is to reuse CD waste and to produce an alternative aggregate for structural concrete. Thereby reducing the amount of cement used for construction. The use of low cost pozzolans such as bentonite, with their added benefits will provide a cost effective solution to the construction industry and also help in reducing the emission of greenhouse gases. Our aim is to produce more economic and environment friendly concrete.

Thus, this study was aimed to assess the effect of combined partial replacement of fine aggregate by CD waste and cement by bentonite on workability, compressive strength, splitting tensile strength and flexural strength of concrete for a period of 7 and 28 days.

II. COMPONENT MATERIALS

A. Cement

For this project, Portland Pozzolans Cement of Shankar has been used. It was procured from a single source and stored as per IS: 4032 – 1977.
**B. Fine aggregates**
The fine aggregate used was locally available M-sand without any organic impurities and conforming to IS: 383 – 1970 [Methods of physical tests for hydraulic cement]

**C. Coarse aggregate**
The coarse aggregate chosen for the study was typically round in shape, well graded and smaller in maximum size than that used for conventional concrete.

**D. Demolished concrete fine aggregate**
Demolished concrete aggregate was produced by crushing of old concrete cubes, cylinders and beams that were casted in our lab for experimental purposes.

**E. Water**
Water used for mixing and curing was potable water, which was free from any amounts of oils, acids, alkalies, sugar, salts and organic materials or other substances that may be deleterious to concrete or steel confirming to IS :3025 – 1964 part22, part 23 and IS : 456 – 2000

**F. Bentonite**
Bentonite is a rock formed of highly colloidal and clay particles composed mainly of hydrated aluminum silicate. This abundantly available pozzolanic material, can be effectively used as a partial replacement substance for cement in concrete.

### III. METHODOLOGY OF MIX PROPORTION DESIGN

The concrete mix design is done in accordance with IS: 10262 (1982). The cement content in the mix design is taken as 425.78 kg/m$^3$ which satisfies minimum requirement of 300 kg/ m$^3$ in order to avoid the balling effect. M-sand of zone-II was used as coarse aggregate and fine aggregate respectively. Maximum size of coarse aggregate was 20 mm. A sieve analysis conforming to IS: 383-1970 was carried out for both the fine and coarse aggregate. This study is a part of comprehensive program wherein experimental investigations have been carried out to assess the effect of replacement of regular material by a cheaper substitute i.e. demolished waste and bentonite on strength of concrete. For this study, cubes of 150 mm size and cylinders of diameter 150mm and height 300mm were cast and by replacing fine aggregates by 100%, 75%, 50% and 25% with demolished waste and cement by 5%,7.5% and 10% with bentonite for a comparative study with respect to conventional concrete. Compressive strength of this concrete were observed and compared with those of regular concrete and target strength. These specimens were tested after 7 and 28 days. To identify cube strength, a mix M25 was used during the investigation. Target strength for mix proportioning of M25 mix = 31.6 N/mm$^2$

### IV. RESULTS

**A. Control Sample**
Nominal concrete of M25 grade is casted. Specimens of cubes, cylinders and beams were casted to find the compressive strength of cubes, compressive strength of cylinders, splitting tensile strength of cylinders and flexural strength of beams. The results obtained are tabulated in Table.1

<table>
<thead>
<tr>
<th>Concrete mixture</th>
<th>7-day strength (N/mm$^2$)</th>
<th>28-day strength (N/mm$^2$)</th>
<th>Flexural Strength (N/mm$^2$)</th>
<th>Splitting Tensile Strength (N/mm$^2$)</th>
<th>Compressive strength of cylinder (N/mm$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC0</td>
<td>16.67</td>
<td>30.1</td>
<td>3.67</td>
<td>3.503</td>
<td>21.503</td>
</tr>
</tbody>
</table>

**B. Results of concrete with partial replacement of fine aggregate with demolished concrete**
Samples with 25%, 50%, 75% and 100% replacement of natural aggregates with demolished fine aggregates were casted. The compressive strength values were compared with that of conventional concrete mix of M25.
1) Compressive Strength Results

![Compressive Strength Results](image_url)

DC25 = 25% replacement of fine aggregate with demolished concrete fine aggregate  
DC50 = 50% replacement of fine aggregate with demolished concrete fine aggregate  
DC75 = 75% replacement of fine aggregate with demolished concrete fine aggregate  
DC100 = 100% replacement of fine aggregate with demolished concrete fine aggregate

From the above results obtained (Fig. 1), it can be observed that the 7-day strength of all the samples except DC100 is greater than the expected strength of 16.67 N/mm². The 28-day strength of samples DC25 and DC50 were observed to be greater than that of the control sample and target strength. Considering economy in replacement, the optimum percentage of replacement was chosen to be 50%.

C. Results of concrete with partial replacement of cement with bentonite

1) Compressive Strength of Cube Casted

![Compressive Strength of Cube Casted](image_url)

DCB5 = 5% replacement of cement with bentonite in mix DC50  
DCB7.5 = 7.5% replacement of cement with bentonite in mix DC50  
DCB10 = 10% replacement of cement with bentonite in mix DC50

From the results (Fig. 2) it is observed that the 7-day strength of all the samples was greater than the expected value of 16.67 N/mm². The 28-day strength of the samples DCB7.5 and DCB10 are lesser than the strength of control sample and target strength whereas the 28-day strength of DCB5 is greater than the strength of control sample and target strength.
2) Results for the Cylinder Casted for Testing Compressive Strength

As per the results (Fig. 3) obtained the 28-day strength of DCB5 is found to be greater than that of the control sample. The strength of the control sample was found to be 21.503 N/mm².

3) Results for the Splitting Tensile of Concrete Cylinder

From the results obtained (Fig. 4) the splitting strength value of DCB5 is found to be greater than the splitting tensile strength of conventional concrete, i.e., 3.5 N/mm². The target strength for cylinders is taken to be 0.7 times the square root of fck that is 3.5.

4) Results for the Flexural Strength of Concrete Beams

From the results obtained, the flexural strength value of DCB5 is found to be greater than the flexural strength of conventional concrete, i.e., 7 N/mm².
From the results obtained (Fig.5) the flexural strength value of DCB5 is found to be greater than the target strength. The target strength for cylinders is taken to be 0.7 times the square root of $f_{ck}$ that is 3.5.

V. Conclusion

Initially, an appropriate replacement percentage for fine aggregate considering, strength and economic factors as parameters was found. Based on the results obtained, we concluded 50% replacement provided the most favorable results. This DC50 mix was adopted and tested for partial replacements of cements with 5%, 7.5% and 10%.

The results of compressive strength of concrete with 5% replacement of bentonite in DC50 mix gave the higher strength. The splitting tensile strength and compressive strength of cylinders and flexural strength of beams also followed a similar trend as that of compressive strength of cubes.

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References


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