

Study on the Strength and Durability of Concrete with Partial Replacement of Cement by Dolomite Powder and Coarse Aggregates by Ceramic Crushed Tiles

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ABSTRACT:The reduction in the consumption of cement will not only reduce the cost of concrete but also the emission of CO₂. Dolomite powder obtained by powdering the sedimentary rock forming mineral dolostone can be used as a replacement material for cement in concrete up to certain percentage. Extensive use of concrete leads to the scarcity of natural coarse aggregates. Ceramic tiles are lighter in weight as compared to natural aggregates. In this project control mix is casted for M30 grade and the Dolomite powder as cement replacement in range of 6%, 12% and 18% by weight of cement and the ceramic crushed tiles as coarse aggregate replacement in 10%, 20%, 30% and 40% by weight of coarse aggregate and the cubes are tested for compressive strength. The obtained results are compared with M30 grade conventional concrete. Durability properties like alkali resistance and sulphate resistance are determined.

KEYWORDS:Dolomite powder, Ceramic crushed tiles, Compressive strength, Alkali resistance and Sulphate resistance, Durability.

I. INTRODUCTION

Concrete is the civil engineering material used in most of the civil engineering structures. Many materials are used to manufacture good quality concrete. Cement, fine aggregate, coarse aggregate, mineral admixtures, chemical admixtures and water are the constituents of concrete. Cement is one of the most important constituents of concrete, since it binds the aggregates and resists the atmospheric action. Most of the properties of concrete depend on cement. Cement is manufactured by calcining argillaceous and calcareous materials at a high temperature. During this process, large amount of CO₂ is released in to the atmosphere. It is estimated that the production of one ton of cement results in the emission of 0.8 ton of CO₂. The reduction in the consumption of cement will not only reduce the cost of concrete but also the emission of CO₂.

Dolomite is a carbonate material composed of calcium magnesium carbonate CaMg(CO₃)₂. Dolomite is a rock forming mineral which is noted for its remarkable wettability and dispersibility. Dolomite has a good weathering resistance. Dolomite is a preferred for construction material due to its higher surface hardness and density. By the effective utilization of dolomite powder, the objective of reduction of cost of construction can be met.

Ceramic tiles are made from a mixture of clay, sand and other natural materials. Ceramic tiles can be used as coarse aggregate as the properties of ceramic waste coarse aggregate are within the range of the values of concrete making

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aggregate according to Indian Standards. Ceramic tiles are collected from a construction site. This paper examines the possibility of using replacement of cement with dolomite powder and coarse aggregate with crushed tiles.

II. RELATED WORK

Arulraj et al. (2015) studied the effect of replacement of cement with dolomite powder on the mechanical properties of concrete. M20 mix concrete with dolomite powder as a partial replacement material to cement. The replacement percentages tried were 0%, 5%, 10%, 15%, 20% and 25% by weight of cement. Replacement of cement with dolomite powder is found to improve the strength of concrete.

Hemanth Kumar Ch, Ananda Ramakrishna K, Sateesh Babu K, Guravaiah T, Naveen N, JaniSk (2015) studied the effect of waste ceramic tiles in partial replacement of coarse and fine aggregate of concrete. In this experimental study, different mixes are casted, waste crushed tiles are used to partially replace the coarse aggregate by 10% and 20% and tiles powder is used to partially replace the fine aggregate by 10% and 20%. Study found that there are minor increases in workability when crushed tiles are replaced in place of coarse aggregate. When crushed tiles replaced coarse aggregate up to 10% compressive strength increased.

M. Sri Lakshmi et al. (2015) studied the effect of Tile powder as partial replacement of cement in concrete. the behaviour of concrete with partial replacement of tile powder in cement accordingly in the range of 0%, 10%, 20%, 30%, 40%, and 50% by weight for M30 grade of concrete. The compression split tensile and flexural strength of M30 grade concrete increases when the cement is replaced with tile powder up to 30%. Tile powder concrete has increased durability.

Umapathy U, Mala C, SivaK (2014) did assessment of concrete strength using partial replacement of coarse aggregate for waste tiles and cement for rice husk ash in concrete. The results indicated effectiveness of tiles as coarse aggregate by partial replacement of conventional concrete by 20 %, 30%, 50% and cement as rice husk ash with 10%, 15% and 20% without affecting the design strength. Study concluded that waste tiles can be used to replace some of the aggregates in a concrete mixture. This contributes to reducing the unit weight of the concrete. This is useful in applications requiring non-bearing light weight concrete.

Olesia Mikhailovaa et al. (2015) did an effect of Dolomite Limestone Powder on the compressive Strength of concrete. The present examinations indicate that the use of dolomite limestone as component instead of limestone is a viable solution for producing Portland dolomite limestone cement, especially for quarries with dolomitic inclusions or overburden. As we can see, partial cement replacement with dolomite limestone powder results in compression strength increasing. Strength of samples containing 25% of dolomite limestone powder increased by 16.7% and 23.5% at 14 and 28 days age, respectively.

III. SCOPE

- Scope of the project is to make use of locally available waste ceramic tile material as replacement of coarse aggregates
- To provide low cost construction material.
- Provide safeguard to the environment by utilizing waste properly and by reducing the emission of carbon dioxide gas into the atmosphere.
- To improve strength and durability properties of concrete by replacement of Dolomite and Crushed tiles.

IV. METHODOLOGY

4.1 Materials used

- Cement: The ordinary Portland cement of 53 grade whose specific gravity of cement is 3.15, Standard consistency of the cement was found as 34% and the initial setting times were found as 120 min.
- Coarse aggregate: The coarse aggregate with 20 mm nominal size having specific gravity 2.74 was used and water absorption of the coarse aggregate is 0.8%.

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- Fine aggregate: Locally available river sand is used. As per IS 383:1970, sand is confirming to Zone II. Specific gravity of the sand used is 2.74 and water absorption value is 1.5%.
- Crushed Tiles: Broken tiles were collected from the solid waste of ceramic manufacturing unit. Crushed them into small pieces by manually. And separated the coarse material to use them as partial replacement to the natural coarse aggregate. Specific gravity of the crushed waste tiles is 2.56 and water absorption of the crushed tiles is 3.5%.
- Dolomite powder: Specific gravity of dolomite is 2.85

4.2 Mix design

Mix design for M30 concrete is done and amount of materials needed for casting cubes are calculated.

4.3 Mix preparation

- Preparation of control mix (M30).
- Preparation of mix by replacing cement with 6%, 12% and 18% of dolomite.
- Finding the optimum percentage dolomite.
- Preparation of mixes by replacing coarse aggregate with 10%, 20%, 30% and 40% of ceramic broken tiles by making optimum value of dolomite constant and finding the optimum value.

4.4 Specimen preparation

Cubes of size 150x150x150mm were casted for testing compressive strength of corresponding mixes. Ages of the specimens for compressive strength are 3, 7 and 28 days.

4.5 Tests on concrete

Compressive strength is conducted for Mechanical properties. Sulphate resistance test and Alkali resistance test are conducted for Durability properties

Table 1. Mix Designation

| MIX DESIGNATION | DESCRIPTION |
|-----------------|--|
| CM | Conventional Mix |
| D6 | Concrete mix with 6% replacement of cement with Dolomite powder |
| D12 | Concrete mix with 12% replacement of cement with Dolomite powder |
| D18 | Concrete mix with 18% replacement of cement with Dolomite powder |
| D12 T10 | Concrete mix with optimum replacement of cement with Dolomite and addition of 10% broken tile replacing coarse aggregate |
| D12 T20 | Concrete mix with optimum replacement of cement with Dolomite and addition of 20% broken tile replacing coarse aggregate |
| D12 T30 | Concrete mix with optimum replacement of cement with Dolomite and addition of 30% broken tile replacing coarse aggregate |
| D12 T40 | Concrete mix with optimum replacement of cement with Dolomite and addition of 40% broken tile replacing coarse aggregate |

V. RESULTS AND DISCUSSIONS

5.1 Effect on compressive strength of concrete

Compressive strength test was performed by using compression testing machine to find the 3, 7 and 28 days compressive strength of the concrete. 3 samples from each mix were tested and average of these 3 is taken as the average compressive strength of each mix.

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CM, D6, D12 and D18 indicates the mixes containing 0%, 6%, 12% and 18% replacement of cement with Dolomite and from the optimum mix D12 as constant, coarse aggregate is partially replaced with ceramic crushed tile for 10%, 20%, 30% and 40% and tests are conducted. Average values of compressive strength at 3, 7 and 28 day are shown in Table 2.

Table 2. Compressive strength of different mixes

| Mix ID | Average compressive strength | | |
|---------|------------------------------|-------------------------|------------------------|
| | 3-day | 7-day | 28-day |
| CM | 17.1 N/mm ² | 30.15 N/mm ² | 39.0 N/mm ² |
| D6 | 19.7 N/mm ² | 32.2 N/mm ² | 42.4 N/mm ² |
| D12 | 22.4 N/mm ² | 35.1 N/mm ² | 44.5 N/mm ² |
| D18 | 18.8 N/mm ² | 31.1 N/mm ² | 40.1 N/mm ² |
| D12 T10 | 23.2 N/mm ² | 35.9 N/mm ² | 45.1 N/mm ² |
| D12 T20 | 22.7 N/mm ² | 34.8 N/mm ² | 43.2 N/mm ² |
| D12 T30 | 20.9 N/mm ² | 32.5 N/mm ² | 41.8 N/mm ² |
| D12 T40 | 17.2 N/mm ² | 29.5 N/mm ² | 38.3 N/mm ² |

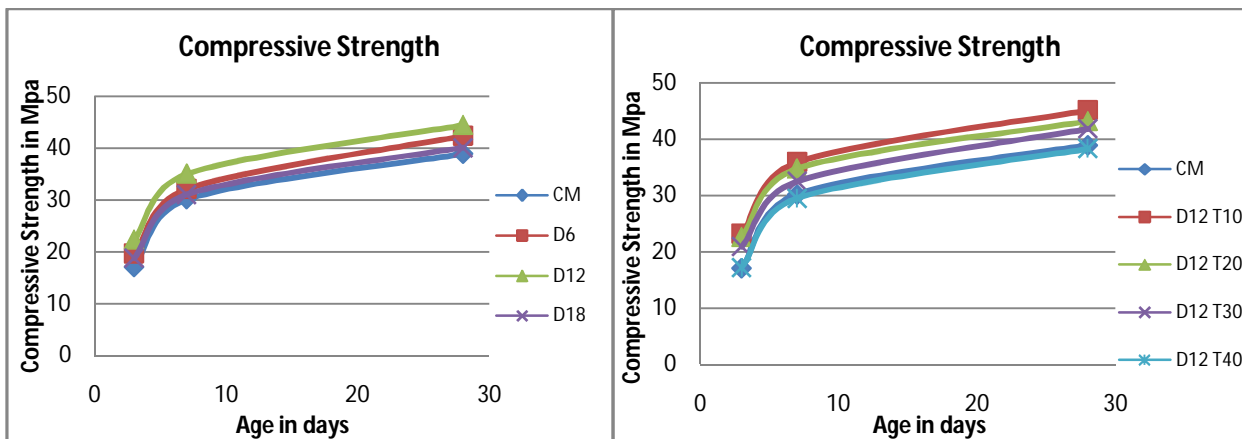


Fig. 1. Compressive strength (a) Dolomite mixes (b) Dolomite and Crushed tile mixes

From the Fig.1 (a), it can be seen that dolomite powder improves the compressive strength and reached maximum in D12 mix containing 12% dolomite powder replacing cement. As the percentage replacement of cement with dolomite powder increases, the compressive strengths increase, reach a maximum value and then decrease. The maximum compressive strength obtained at 12% replacement was found to be 44.5 N/mm². Dolomite powder is an ultra-fine powder material. By the use of Dolomite Bleeding and Segregation property was reduced by reducing porosity and increasing compactness and increasing filling & passing ability.

From the Fig.1 (b), it is clear that D12 T10 mix containing 10% tile aggregate and 12% dolomite gives greater strength as compared to other mixes. The maximum compressive strength 10% replacement of tile aggregate and 12% replacement of dolomite was found to be 45.1 N/mm² whose compressive strength has increased about 14.5% compared with conventional concrete. The obtained results for all other replacement also have increased strength compared to conventional concrete. On the contrary, the least reported strength was related to the samples including 40% replacement of tile whose strength was somehow similar to the conventional concrete. One reason for decreasing the strength of samples as a result of enhancing the amount of tile may be the increase in the flaky aggregate. The water absorption of ceramic crushed tile aggregate is higher than the natural aggregates. Ceramic tile are made from natural materials which contain a high proportion of clay minerals.

5.2 Alkali attack Test

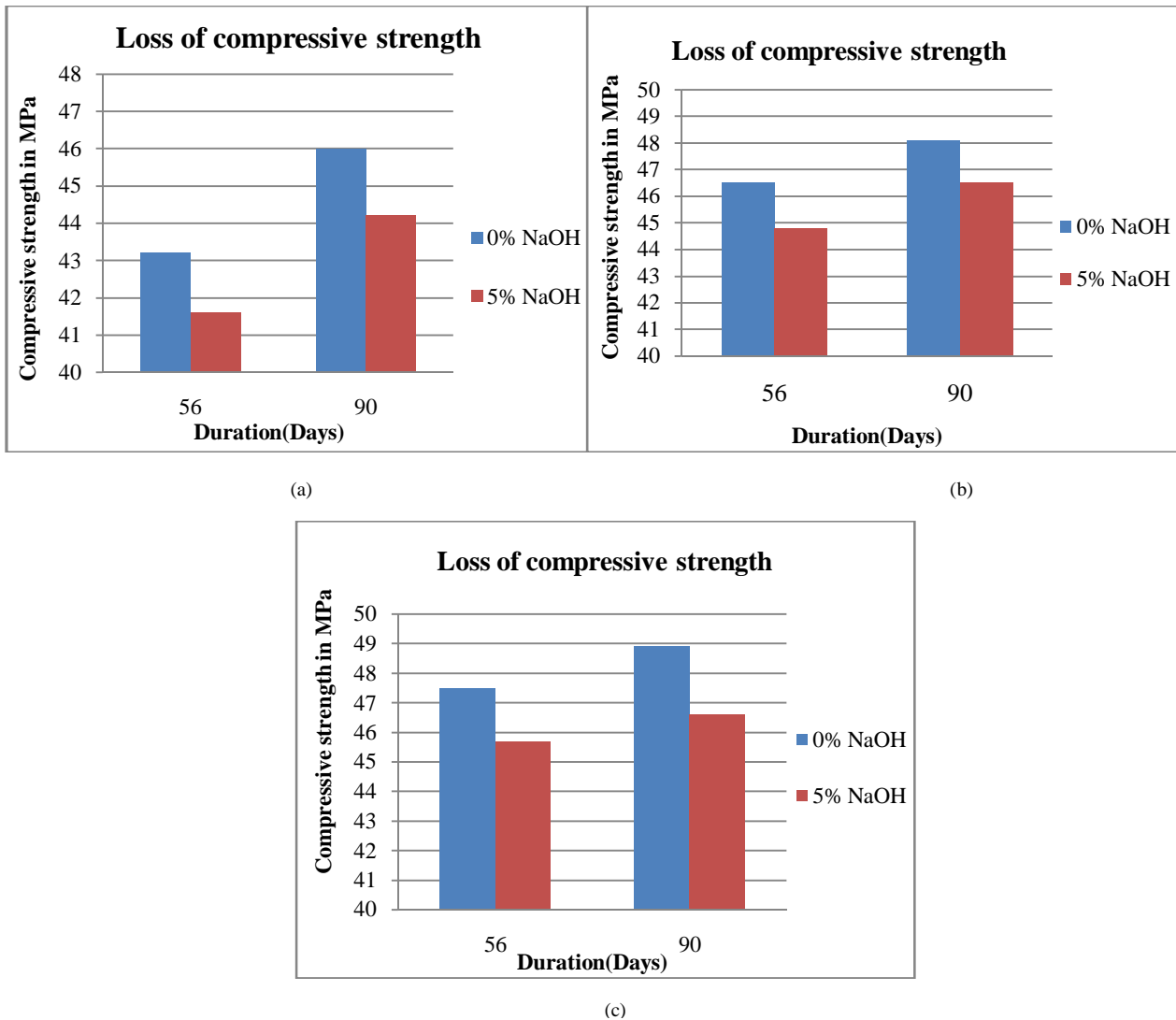


Fig. 2. Loss of compressive strength in NaOH (a) Control Mix (b) Dolomite (D12) mix (c) Dolomite and Crushed tile mix (D12 T10)

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Cubes of sizes 150 X 150 X 150 mm are casted and are cured for 28 days. After 28 days, curing cubes are taken out and allowed for drying for 24 hours and weights are taken. For Alkali Attack Test 5% dilute NaOH is used. The cubes are to be immersed in solution for a period of 56 days. The concentration is to be maintained throughout this period. After reaching the respective days the specimens are taken from sulphate solution. The surface of specimen is cleaned and weights are measured. The specimen is tested in the compression testing machine under a uniform rate of loading. The loss of strength of specimen due to Alkali Attack is determined for 56 and 90 days. This is then compared with cubes immersed in water.

5.3 Sulphate Attack Test

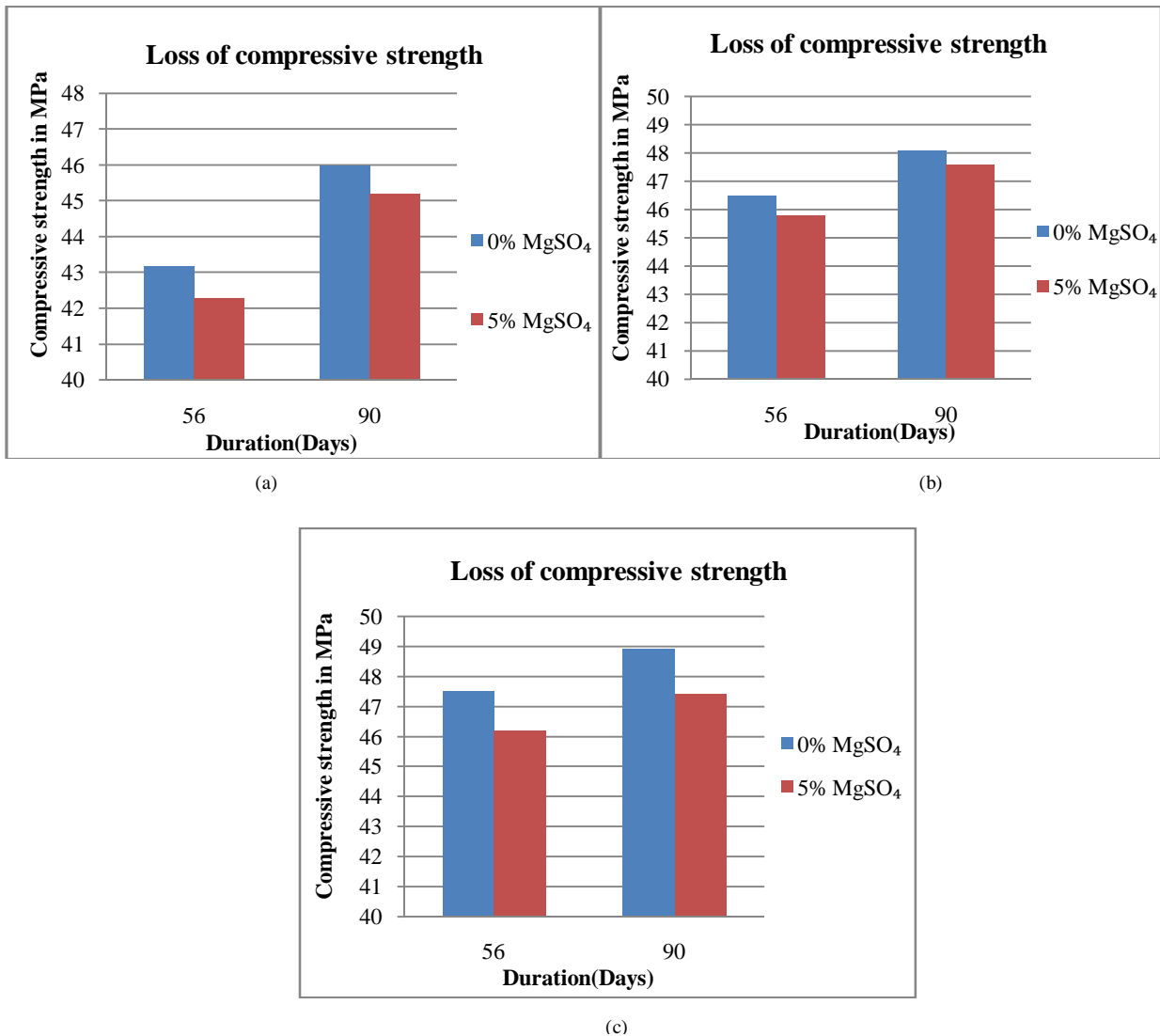


Fig. 3. Loss of compressive strength in MgSO₄ (a) Control Mix (b) Dolomite (D12) mix (c) Dolomite and Crushed tile mix (D12 T10)

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Cubes of sizes 150 X 150 X 150 mm are casted and are cured for 28 days. After 28 days, curing cubes are taken out and allowed for drying for 24 hours and weights are taken. For Sulphate Attack Test 5% dilute $MgSO_4$ is used. The cubes are to be immersed in solution for a period of 56 days. The concentration is to be maintained throughout this period. After reaching the respective days the specimens are taken from sulphate solution. The surface of specimen is cleaned and weights are measured. The specimen is tested in the compression testing machine under a uniform rate of loading. The loss of strength of specimen due to Sulphate Attack is determined for 56 and 90 days. This is then compared with cubes immersed in water.

5.4 Weight loss (%) of cube dipped in various solutions

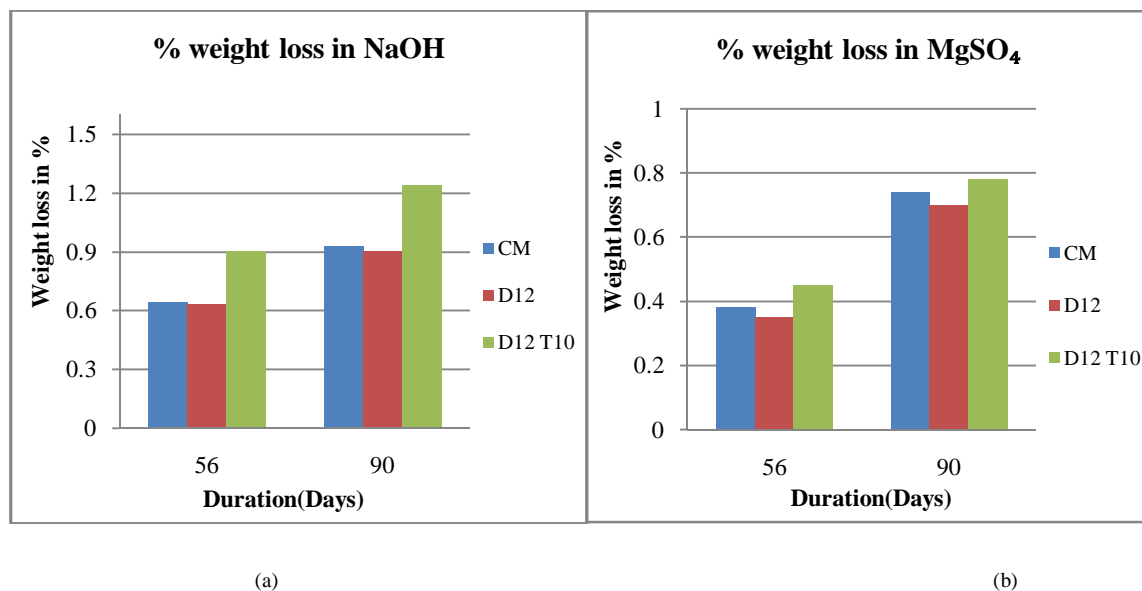


Fig. 4. Weight loss of various cubes (a) Immersed in alkali solution (b) Immersed in Magnesium sulphate solution

From the Fig.4 (a) and (b) show the percentage of weight loss of conventional concrete, concrete with Dolomite (D12) and concrete with Dolomite and ceramic crushed tile (D12 T10) with Magnesium sulphate and alkali solution. This is due to the deterioration of concrete. Weight loss is more in Sodium hydroxide solution than the Magnesium sulphate solution. Weight loss of concrete with Dolomite (D12) cube is less than that of conventional concrete. Weight loss of concrete with Dolomite and ceramic crushed tile (D12 T10) cube is more than that of conventional concrete and concrete with Dolomite (D12) cube. It is due to water absorption is more in crushed tile.

VI. CONCLUSION

The following conclusions were obtained from the studies.

- Replacement of cement with dolomite powder and coarse aggregate with crushed tiles improved the strength of concrete.

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- The compressive strength of M30 grade concrete increased with the replacement of cement with dolomite. The maximum strength is obtained with 12% dolomite (D12) replacing cement. The 28 day compressive strength is 44.5 N/mm^2
- Also the concrete mix containing by keeping optimum percentage of dolomite with cement as constant and by varying the percentage of 10%, 20%, 30%, 40% crushed tile replaced with coarse aggregate in mix.
- The mix containing 10% crushed tile replaced with coarse aggregate and 12 % dolomite replaced with cement (D12-T10) gives greater strength as compared to other mixes.
- The maximum 28 day compressive strength of 10% replacement of tile aggregate and 12% replacement of dolomite (D12-T10) was found to be 45.1 N/mm^2 .
- When coarse aggregate replaced by 40% of crushed tile and cement replaced by 12% dolomite (D12-T40) there is strength was somehow similar to the conventional concrete.
- In durability study it can be seen that the loss of strength and loss of weight of 12% Dolomite replacing cement (D12) is less compared with conventional concrete.
- In durability study it can be seen that the loss of strength and loss of weight of 12% Dolomite replacing cement and 10% ceramic crushed tile replacing coarse aggregate (D12 T10) is slightly increase compared with conventional concrete.
- Low cost concrete is developed using waste ceramic tiles (obtained free of cost) and dolomite powder, which is obtained at half the price as that of cement.
- With the reduction in the use of cement, the emission of greenhouse gas into the atmosphere from concrete can be reduced. Utilisation of waste tiles reduces environmental pollution. Scarcity of the aggregates for construction can also be met by the use of waste tiles.

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