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Strength Performance of Concrete Containing Date Seeds as Partial Replacement of Coarse Aggregates under the Exposure of NaCl and Na_2SO_4

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ABSTRACT

This study aimed to investigate the strength performance of concrete containing Date Seeds (DS) exposed to Sodium Chloride (NaCl) and Sodium Sulphate Na_2SO_4. In this study, we have replaced the Coarse Aggregates with Date Seeds (DS) by different percentages of weight i.e. (CA:DS)%, (100:0)%, (98:2)%, (97:3)% and (96:4)%. The constant water-cement ratio was used in all mixes i.e. 0.5. Workability, Density, and compressive strength were examined by casting 48 standard cubes of 100mm size, and exposure to the NaCl and Na_2SO_4 Solution for curing at 7 and 28 days. Test results demonstrated that workability first increases at 2% replacement but then decreases as replacement increases. The results of Density and Compressive Strength of Cubes cured in plain water and in mixed solution of NaCl and Na_2SO_4 were compared. It was observed that the replacement of coarse aggregate with date seeds was increases the workability of concrete. The density and compressive strength of cubes cured in plain water decreases to a small extent. For Compressive Strength, it was observed at 28 days, that the Compressive Strength of cubes placed in normal water for curing have greater values as compare to the cubes placed in the salt solution.

INTRODUCTION

Concrete is the most prevalent and artificially made construction material all over the world. Its high production is due to the widespread availability of its constituents. Each year more than ten billion tons of concrete are manufactured worldwide. In the US, over 500 million tons of annual production means around two tons per head (Tantawi, 2015). These quantities need large amounts of natural resources to manufacture aggregates and cement. Concrete is defined as "The mixture of fine and coarse aggregates that are held together by a binder of cementitious paste that is largely made of Portland cement and water (Tantawi, 2015). Concrete is the most prevalent and artificially made construction material all over the world. Its high production is due to the widespread availability of its constituents. Each year more than ten billion tons of concrete are manufactured worldwide. In the US, over 500 million tons of annual production means around two tons per head. This study is based upon the partial replacement of coarse aggregates with Date Seeds (DS). For the curing purpose 2 methods were adopted: (i) curing in Plain Water, (ii) curing in Salt Solution of 5%NaCl +5%Na_2SO_4.

In this modern world, engineers are trying to develop new technologies for recycling and reuse of waste materials as construction materials. As Population is increasing day by day the world has been trying to make new infrastructure, buildings, roads, bridges, etc. These things require a lot of materials and we have also lack of natural resources day by day (Prusty and Patro, 2015). So, engineers are now getting their work on research for use of waste materials in addition to other construction materials and checking results. The natural materials of the world significantly decline because of the rising demand of natural aggregate for the construction sector. This has also dis-integrated the environment and has provided a compelling to studies and researches for sustainable development by using various waste products like the substitution

of coarse aggregates in the construction sector (Prusty and Patro, 2015).

The usage of Date Seeds (DS) in concrete manufacturing will not just reduce the issue of Farming waste away in the societies although will significantly decrease the cost of concrete manufacturing. This is in the light of this study to investigate the appropriateness of Date Seed when used as coarse aggregate in concrete production (Karthikeyan, *et al*., 2017).

Researchers have already been expanding innovative technologies to achieve sustainable raw material in the building industry. One of such tools is to make use of discarded materials as building materials. Date Seeds (DS) is a renewable source and hence, has considerable potential in the building industry where Date Seeds (DS) are in plenty. This is especially the case in Libya. Presently, the large amount of DPS waste has resulted in concentrating on the potential use of this waste as aggregates in unique structural lightweight concrete. It has been stated that the concrete industry worldwide was going to consume all-around 8 to 12 billion tones on an annual basis of natural aggregates after the year 2010 (Mangi, *et al*., 2019).

Though, the expense of concrete is in direct proportion to the expense of broken stone or regional gravels. The cost of coarse aggregates could be reduced by substituting them with additional waste materials like Date Seeds (DS). Though there is also the issue of durability of concrete to withstand the exposure of Salts under marine or hydraulic structures (Akib, *et al*., 2018).

Concrete is the principal material of building for infrastructure advancement around the globe. Still, concrete structures constructed with Ordinary Portland Cement (OPC) tend to deteriorate significantly faster under aggressive environmental conditions such as underground constructions, sea structures, and the structure of sewage treatment plants (Yohanna, *et al*., 2019). Hence, the concrete is required to have durability against the different salts present in water like the Sodium Chloride (NaCl) and Sodium Sulphate ($NaSO_4$).

MATERIALS AND METHODS

Materials

In this study the Date Seeds replaced were collected from orchard's of Date Palm trees of Khairpur Mir's, Pakistan. These were washed and made clean before use as shown in Figure 1. First trials have been made on using dry Date Seed for preparing concrete mix and cubes were casted which showed less strength and cracks appeared during demolding. Then again Date Seeds were kept in water for 48 hours so that they may absorb water as much as it need. The OPC Cement of Lucky Brand was used. Coarse aggregate was also taken from the local Construction Material Agency in Khairpur Mir's as shown in Figure 2. Sodium Chloride (NaCl) and Sodium Sulphate were purchased from Chemical Store in Karachi. The physical characteristics of materials were determined such as specific gravity, water absorption, and particle size distribution.

Figure 1. Date Seeds used in Experimental Work

Figure 2. Coarse Aggregates

Mix Proportions

The four kinds of mixes have been prepared with different percentage replacement of Coarse Aggregates with Date Seeds (DS) i.e. (CA:DS)%, (100:0)%, (98:2)%, (97:3)% and (96:4)%. The fine aggregate (sand) has been passed through 4.75 mm sieve and coarse aggregate of nominal maximum size passing through 10mm and retaining on 4.75mm were used. The Sieve analysis of Date Seeds was performed, which were also passing from 10mm sieve and retained on 4.75mm sieve.

Casting and Curing

Concrete cubes of size 100mm have been prepared with and without Date Seeds (DS) replacement for the testing of Density and Resistance to compression. Total 48 samples were prepared as shown in Figure 3, 12 of the control mix and 36 of the different mixes. Out of 48, 24 specimens were cured in plain water and the other 24 were exposed to water containing salts (5% NaCl + 5% Na_2SO_4) Solution for 7 and 28 Days.

Figure 3. Casting Cubes

Testing

Fresh mix concrete was firstly evaluated for workability test with the help of the slump cone method. Next, the hardened concrete cubes were evaluated for density as per the given equation (1). Then the compressive strength was evaluated under a universal load testing machine according to BS 1881: Part 116: (British Standards, 1990). However, the density of any material is well-defined to be the ratio of mass of the substance to the volume dominated by that substance. Its unit is kg/m^3.

$$\text{Density} = \frac{\text{Mass in kg}}{\text{Volume in m}} = \frac{m}{V} \qquad (1)$$

RESULTS AND DISCUSSION

Slump Test

The workability of concrete was assessed with the slump cone method by the requirements of ASTM C143-148 (Standards Catalog, 2016). The gap between the top of the slump cone and the top of the concrete cone was assessed as the workability of concrete. The comprehensive results of the workability of concrete mixes are provided in Table 1 and presented in Figure 4.

Table 1. Slump Test Values

S.No	Percentage Replacement	Slump Values (cm)
1	0%	3.8
2	2%	6
3	3%	5.5
4	4%	4.9

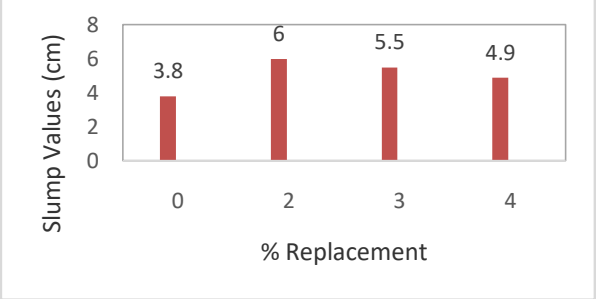

Figure 4. Workability Slump Values Chart

Density of Cubes

The density of concrete cubes was evaluated at 7 and 28 days. However, after curing of cubes at 7 Days, the density was determined by calculating their weight and volume. The density of cubes has been determined before and after curing in plain water and Salt Solution. It shows a variation as shown in table 2 and graphically presented in Figure 5. It was observed that the density of concrete was found to be decreased with the addition of date seed in concrete. It indicates that the incorporation of date seeds in concrete could produce lightweight concrete.

Table 2. Density of Concrete at different curing periods

S.No	% Replacement	Density of Cubes cured in Plain Water (A)		Density of Cubes cured in Salt Solution (B)	
		7 Days	28 Days	7 Days	28 Days
1	0%	2647	2646	2647	2642
2	2%	2528	2527	2528	2522
3	3%	2472	2471	2472	2468
4	4%	2446	2445	2446	2440

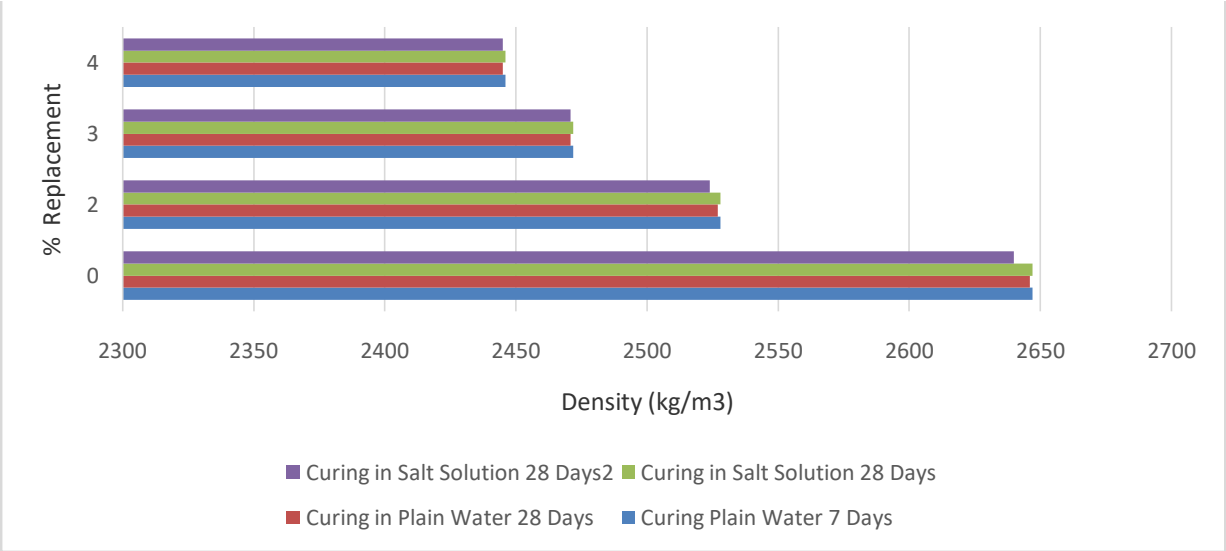

Figure 5. Density of Concrete at Different Curing Periods

Compressive Strength

Compressive strength is the capacity of concrete cubes to withstand compressive loads or the resistance of the material to breaking under compression. The test approach involves the determination of compressive strength of concrete specimens BS 1881: Part 116 (British Standards, 1990). It involves applying a compressing axial load to molded cubes at a level that is within a specified range until failure occurs (Mangi, *et al*., 2019). The compressive strength shall be calculated by dividing the highest possible load attained throughout the test by the cross-section area of the sample. The Compressive Strength of Concrete is provided in Table 3 and Figure 6. It was observed that the compressive strength was found to be decreased with the addition of date seeds in concrete because date seed is lighter than the coarse aggregate and results in the reduction in compressive strength. It was also previously noticed by Mangi *et al*. (2018) that the materials having lower specific gravity could influence the compressive strength of concrete.

Compressive Strength Test for cubes cured in Normal Water

Table 3. Compressive Strength of Concrete cured in Normal Water Curing

S. No	Percentage Replacement	Average Compressive Strength (MPa) at 7 days	Average Compressive Strength (MPa) at 28 days
1	0%	14.2	14.5
2	2%	13.01	13.83
3	3%	11.8	13.12
4	4%	10.6	11.76

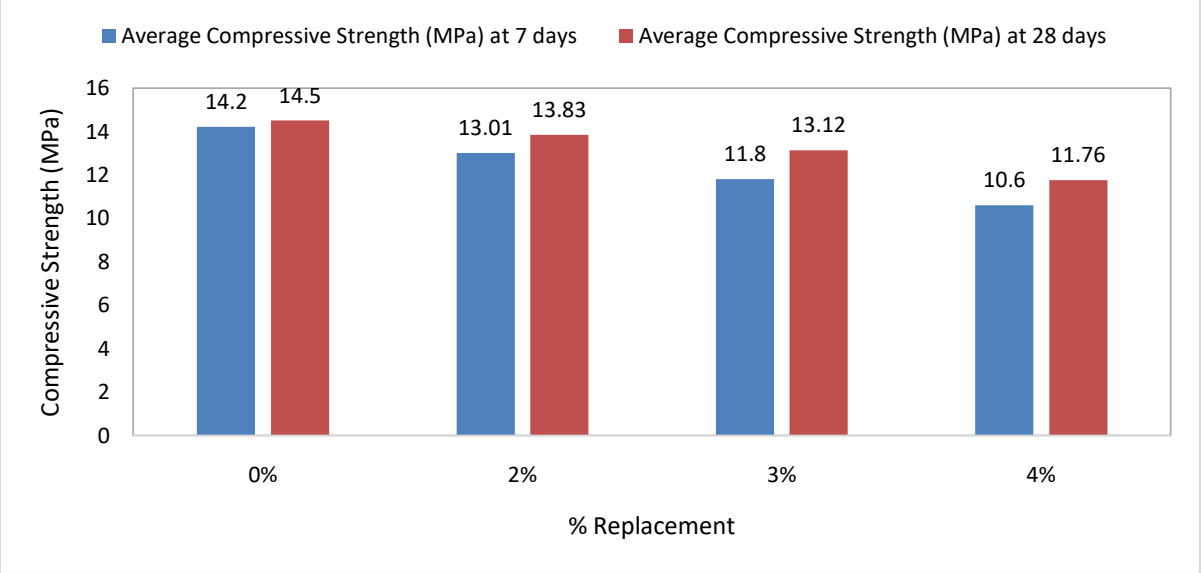

Figure 6. Compressive Strength Performance Under Normal Water

Compressive Strength Test for cubes cured in Saltwater

Compressive Strength of Concrete at 7 and 28 Days (Saltwater Curing) as shown in Table 4. It was observed that 7 days test on the compressive strength of cubes placed in salt for curing have greater values of compressive strength as compare to the cubes placed in normal water for curing. However, at 28 Days test, it was noted that the Compression Strength of cubes placed in normal water for curing has greater values as compare to the cubes placed in the salt solution.

Table 4. Compressive Strength of Concrete cured in Saltwater

S.No	% Replacement	Average Compressive Strength (MPa) at 7 days	Average Compressive Strength (MPa) at 28 days
1	0%	19.62	18.56
2	2%	18.56	17.03
3	3%	17.31	16.03
4	4%	14.92	15.21

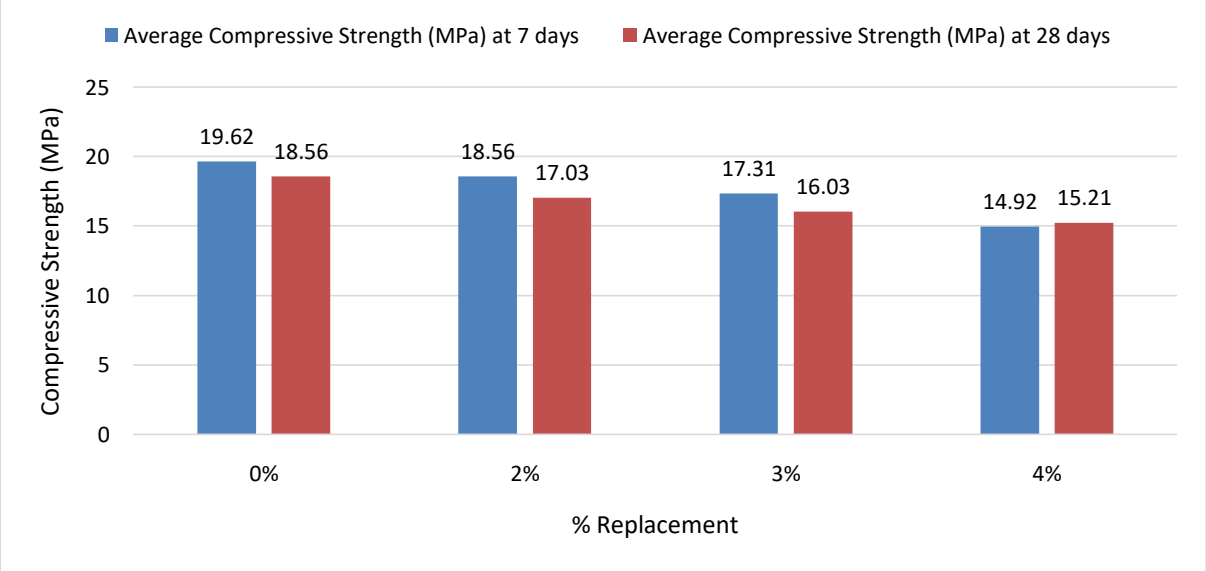

Figure 7. Compressive Strength Performance Under Saltwater

It was observed from the experimental findings as that concrete performance under salt water was found to be higher than the normal water as shown in figure 8. It is indicated that saltwater is less hazardous for normal concrete as well as concrete containing date seeds as a coarse aggregate replacement.

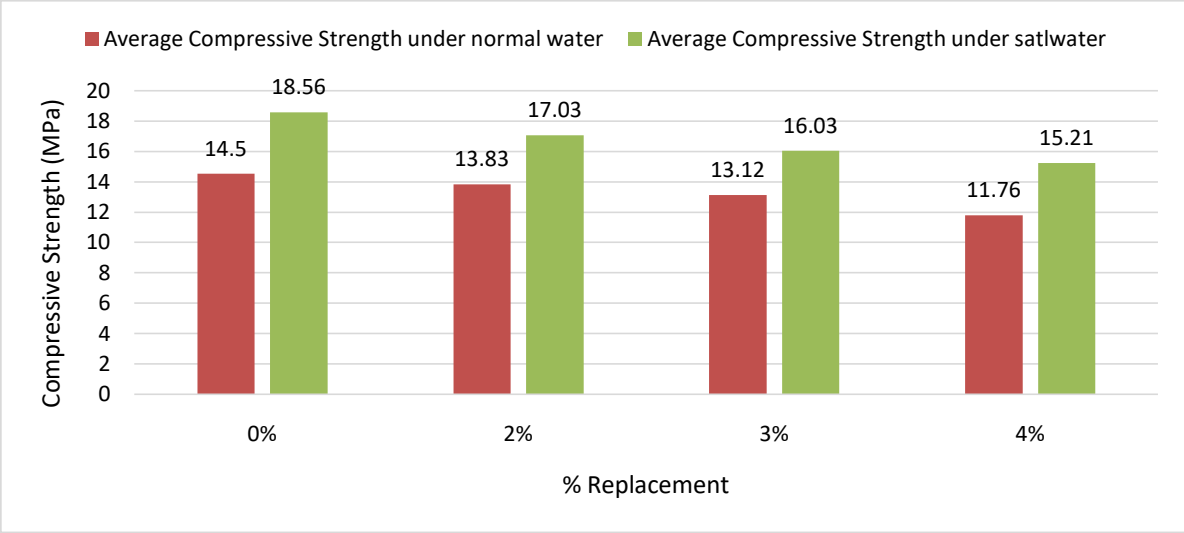

Figure 8. Compressive Strength Performance Under Normal Water and Saltwater

CONCLUSION

The additional things added to concrete in research work are the waste product which have no use except disposal. Hence, their usage in concrete will reduce the waste product and ensure the conversation of natural sources of concrete as coarse aggregate for the future. The Date Seeds are easily available in such countries where Date palm trees are in abundance and are the best replacement for the coarse aggregates, which may provide the lightweight concrete and also can withstand the impacts of aggressive environment to some extent.

1. Workability decreases to a small extent with increasing content of Date Seeds.
2. To maintain the water-cement ratio of concrete, use the wet date seeds, otherwise it will absorb almost all water required for proper mixing of concrete.
3. Date Seed proved to be a good substitute for the replacement of coarse aggregate, as it provides lightweight concrete.
4. It was found that at 7 days compressive strength of cubes placed in salt for curing has greater values of compressive strength as compared to the cubes placed in normal water for curing.
5. At 28 Days test, it was found that the Compressive Strength of cubes placed in normal water for curing has greater values as compare to the cubes placed in the salt solution.

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