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Evaluation of Organic Materials for Promotion of Green Buildings by Reduction of use of Carbon Emitting Materials

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Abstract

Global warming and climate change are the burning issues in the current world. In response of the same scientists and engineers have been recently working on the evaluation of construction materials for the promotion of green buildings. Green building is those buildings, which has reduced impacts on the environment during construction and operation. Several countries across the world have started rating systems for building in accordance with the sustainable features of those buildings. In green buildings, the structures are intended to be environmentally friendly producing less harmful impacts on the existing ecology. However, in most parts of the globe, the concept of green buildings is relatively new, thus the implementation of the same has its own set of obstacles. Most of the buildings and civil engineering constructions in the world consist of concrete, making concrete one of the most consumed matters in the world. Concrete uses cement as the main constituent as a binder which is one of the major causes of emission of Carbon dioxide (CO_2) in the world. Carbon dioxide production is a major reason behind global climate change and the greenhouse effect. The use of a larger amount of concrete in civil engineering work is one of the major factors works for increasing the global climatic temperature. This paper describes the use of organic materials honey, treacle, and rice husk ash in concrete to reduce the cement content without compromising the strength of concrete. The laboratory test is performed to compute the compressive strength of the cube for the M20 grade concrete. The results are obtained for the slump, density, and compressive strength, and the data are analyzed. The results show that the cement consumption can be reduced to obtain the required strength of concrete, thereby helping to build reduced emission buildings.

Keywords: Concrete; Green Building; Honey; Rice Husk Ash; Treacle

1. Introduction

Climate change has been a major topic of discussion in the world. Among the several factors affecting the change in climate, researchers in the civil engineering discipline are more concerned about the consumption of cement in construction. A huge amount of carbon dioxide is emitted during the production of cement, which enhances the problem of global warming. Thus, a method needs to be developed which can decrease the cement consumption of the structures to be constructed. One of the approaches is the partial replacement of the cement by the other constituents [1][2]. Similarly, the use of admixture will also reduce the content of cement to achieve the original strength. Different research [3][4][5][6] on the reuse of recycled aggregates has shown that cement consumption can be reduced without compromising its strength. The results of these different research aid in the reduction of the emission of carbon dioxide to the environment. This paper discusses the reduced use of cement to obtain the strength of cement concrete using organic materials to create low-emission buildings. A different study has been done in many countries about low/zero-emission buildings [7][8][9]. In this research, the organic materials used in the form of admixtures in the laboratory tests for the reduction of cement consumption are rice husk ash, honey, and treacle. The results obtained in the laboratory tests show that organic materials can be used in civil engineering concrete structures to reduce the cement content. These organic materials can be used to make reduced-emission buildings. Rice husk ash is obtained by burning the coating of the rice seed cover at higher degree temperatures. It contains pozzolanic materials and can be used as a mineral admixture in concrete. Treacle is obtained from the sugarcane and honey is harvested by bees. IS456:2000 [10] has mentioned the use of rice husk ash as an admixture to the concrete, however, there is no provision for the inclusion of treacle and honey as an admixture. This paper thus attempts to explore the use of treacle and honey as the admixture in the concrete.

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2. Experimental Works

2.1 Preparation of samples

The evaluation of the concrete is done by preparing the samples of the concrete cubes with the aggregates collected from Kotre, Nepal. The physical and mechanical test of the aggregates from the Kotre river is done by various researchers [11][12][13]. For the sake to compare the usability of the organic materials in the concrete the nominal mix is adopted, however in the case of the availability of the physical and chemical properties the mix design can also be adopted. Concrete mix with the ratio of 1:1.5:3 (nominal mix for M20 grade of concrete) is taken and a total 24 numbers of cubes with 15 cm edge length are made. The test results are obtained for the seven days and twenty-eight days of compressive strength. The curing of the samples was done in normal tap water (pH 7.0 - 7.5) at room temperature (27 ± 2^{oC}). The test of cubes for seven days and twenty-eight days strength is separated into four sets. The first set consists of the normal mix without admixtures. Similarly, the second, third and fourth set of concrete cubes consists of honey, treacle, and rice-husk ash as the admixtures respectively. The final concrete cubes with the standard M20 grade concrete are made with admixture following proportions. 1.5% of honey was added to the total weight of cement in the second set. 1.5% of treacle was added to the total weight of cement in the third set. 10% of rice husk ash was added to the total weight of cement in the fourth set.

Figure 1 shows the sample preparation of the concrete in the lab. A dry mix of the cement -aggregates are shown in Figure 2. A dry mix is done just before adding the water to the mixture of cement and aggregates. Cement and fine aggregates were mixed in the first phase of the dry mix. In the second phase of dry mixing coarse aggregates were added to the sand-cement dry mix prepared from the first phase. Figure 3 shows the slump measurement of the samples, and Figure 4 shows the final cubes with fresh concrete samples. The weight, breaking load, and compressive strength of the different mixes are shown in Table 1. The water-cement (w/c) ratio during the preparation of concrete is 0.5 for the ambient humidity and moisture condition. The results and discussion of the laboratory tests are presented in the upcoming sections.

2.2 Laboratory test data

The slump values were recorded during the preparation of the sample whereas the weight and breaking load were recorded in the seven days and twenty-eight days tests. The average slump for the normal concrete, concrete with honey as admixture, concrete with treacle as admixture, and concrete with rice husk ash as admixture was obtained as 48mm, 28mm, 11mm, and 26mm respectively. Figure 5 shows the comparative graph for the different slump values in the concrete mix.

Figure 1: Sample Weighing

Figure 2: Dry Mixing

Figure 3: Slump values

Figure 4: Final Cube Samples

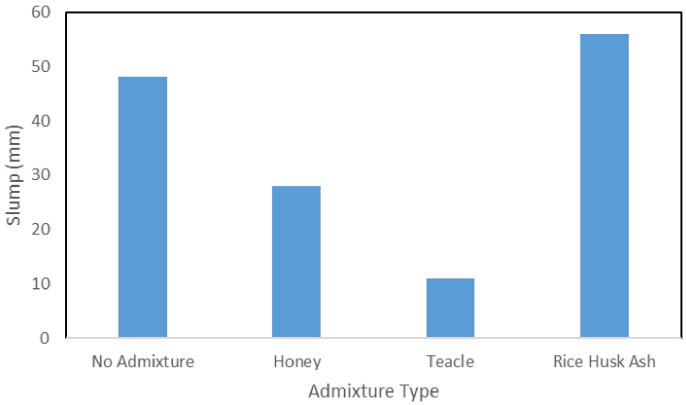

Figure 5: Concrete Slump for various admixtures

Table 1: Weight, breaking load, and compressive strength of the samples

Admix-ture type	Cube No.	Weight (kg)		Breaking Load (kN)		Compressive Strength (MPa)		Slump (mm)	Relative Setting
		28 days	7 days	28 days	7 days	28 days	7 days		
None	1A	8.045	8.098	614.32	482.25	27.30	21.43	48	Standard
	2A	8.125	8.175	612.98	485.26	27.24	21.57		
	3A	8.085	8.136	613.65	484.56	27.27	21.54		
Honey	1B	8.098	8.125	682.32	470.98	30.33	20.93	28	Extremely higher than standard
	2B	8.154	8.175	637.56	438.75	28.34	19.50		
	3B	8.129	8.148	660.19	454.98	29.34	20.22		
Treacle	1C	8.321	8.425	703.25	424.56	31.26	18.87	11	Slightly higher than standard
	2C	8.294	8.321	710.46	429.65	31.58	19.10		
	3C	8.302	8.369	706.79	427.15	31.41	18.98		
Rice Husk Ash	1D	8.321	8.425	754.32	474.56	33.53	21.09	56	Standard
	2D	8.294	8.321	748.15	479.65	33.25	21.32		
	3D	8.302	8.369	785.32	477.15	34.90	21.21		

It can be observed that the increased value of slump can be seen with the admixture of rice husk ash. There is a reduction of a slump (workability) by 41.67% and 77.08% with the use of honey and treacle as an admixture in the concrete. However, there is an increase in the workability of the concrete by 16.67% with the use of rice husk ash as the admixture.

The workability of the concrete is measured by the slump and relative setting of the concrete. The relative setting time is the degree of workability of the concrete from mixing to placing the concrete in the cube mould. For the sake of comparison setting of the concrete without the admixture i.e. for the normal concrete is considered standard. The setting time for the treacle is slightly higher than the standard setting. Similarly for treacle relative setting time is extremely higher than the standard.

The variation in the density of the concrete between seven and twenty-eight days is shown in Figure 6. The density range lies in the expected value of 24 kN/m^3 for both test days. However, it is observed that the density with treacle and rice husk ash is slighter higher than the other, thus further study is recommended for the same. Also, there is a slight decrease in the density (within the permissible range) at twenty-eight days than the density in seven days. This might be due to the increase in the size of the pores attributed due to the organic components used in concrete.

The standard compressive strength of the concrete is done on cubes of size 150 mm × 150 mm × 150 mm. The seven days and twenty-eight days average compressive strength of the concrete is 21.51 MPa and 27.27 MPa respectively. The compressive strength of the concrete with different admixture mixes is shown in Figure 7 and Figure 8 for seven days and twenty-eight days respectively. The breaking load variation of the concrete cubes is within 15% thus total all three cubes are considered for the average strength calculation. The compressive strength lies with the desired characteristic compressive strength of the M20 grade of concrete as recommended by IS 10262:2009 [14]. Thus, the laboratory results are relatively applicable to discussing the output of compressive strength of the different admixtures.

3. Results and Discussion

The density of the concrete cube is nearly 24 kN/m^3 which is in close agreement with the density of plain cement concrete (PCC). Density increases with the use of treacle and rice husk ash compared with normal concrete. The workability increases with an increase

in the use of mineral admixture i.e. rice husk ash whereas the workability decreases with the use of organic materials honey and treacle. The relative setting shows that organic materials honey and treacle sets the concrete faster than the normal concrete and the concrete with rice husk ash. The influence of the setting of the concrete by honey and treacle is due to the organic chemical properties within these materials and it needs further research which is not in the scope of this paper. It is recommended to perform chemical tests for the honey and treacle to know the influence on the concrete.

The compressive strength shows that the concrete with admixture attains the characteristic compressive strength. Whereas only normal concrete and concrete with rice husk ash meet the target strength but honey mixed concrete and treacle mixed concrete fail to do the same. Further analysis of the treacle and honey is needed to find the cause of the same. The organic properties which hinder the strength of the concrete might be the key reason for the lower compressive strength of the concrete cubes.

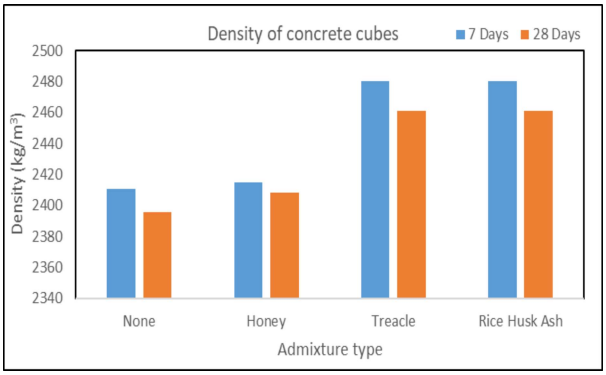

Figure 6: Density of concrete in seven days and twenty-eight days for various admixture

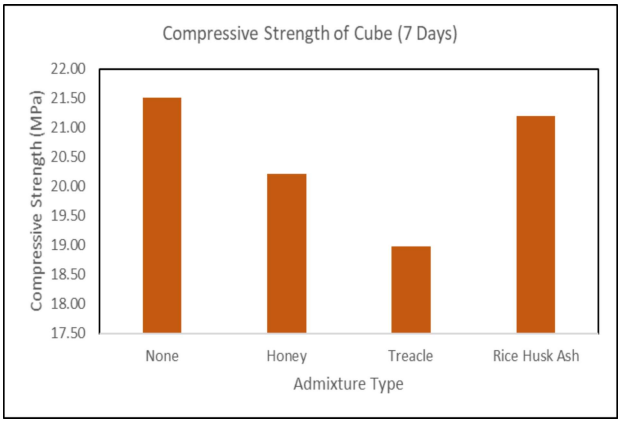

Figure 7: Compressive strength of concrete in seven days for various admixture

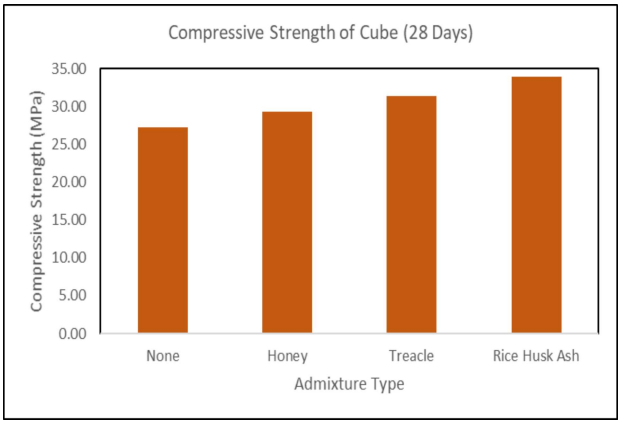

Figure 8: Compressive strength of concrete in twenty-eight days for various admixture

4. Conclusions and Recommendations

The laboratory test of the compressive strength of the plain concrete is done by using different admixtures. Treacle and honey are attempted to use as the chemical admixture whereas the rice husk ash is used as the mineral admixture. Various previous studies on rice husk ash show that it can be used as an admixture to reduce the consumption of cement in concrete. The findings in this research also contribute to the results for the use of rice husk ash as the admixture. The use of treacle and honey in the concrete influences the workability and setting time which can be useful in the concrete in extreme climatic conditions, but it does not increase the strength of the concrete. Thus, honey and treacle cannot be used to decrease the consumption of cement.

It is recommended to perform further research on the chemical and physical properties of honey and treacle to study their influence on concrete. Only the compressive strength of plain cement concrete (PCC) with organic materials is evaluated in the present article. For further research, it is recommended to perform the flexural strength test on large samples for PCC and RCC to accurately predict the influence of the honey and treacle on the concrete.

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