The Impact of Using Cornstalk Ash on the Compressive Strength Concrete Mixes

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Abstract— During the past years, researchers have introduced the concept of reducing the use of cement and natural resources, energy consumption, and water absorption within the concrete industry. Cornstalk is considered one of the widely available bi-products in Egypt that produces heavy pollution for its dumping. In this context, this study investigates the feasibility of using corn stalk ash as a replacement for cement. The behavior of three different mixes with 5, 10, and 15% cement replacement were compared to a control concrete mix. The concrete assessment is addressed regarding fresh and compressive strength properties. The results showed that the concrete compressive strength at 7 and 28 days showed that increasing the CSA content lowers the compressive strength compared to the normal concrete.

Index Terms— Green concrete, sustainability, corn stalk ash, cement replacement

1 Introduction

Concrete is one of the most widely used building materials, which is considered the number one choice for many construction countries [1]. The concrete industry influences the environment through the heavy water consumption, air impact of cement manufacturing, expending energy through manufacturing the ingredients and mixing, and depletion of the natural resource. During the past years, researchers have introduced the concept of reducing the use of cement and natural resources, energy consumption, and water absorption within the concrete industry. Different researches attempted to find alternatives to reduce pollution or exploit natural resources. This environment-friendly concrete is called Green Concrete. One of the trends of producing Green Concrete is to include the depletion of bi-T products as fly ash, glass powder, wheat stalk ashes, crunched sanitary ware, thermoplastic, crushed aggregates, corn stalk ashes, and cotton stalk to reduce [2]. The green Concrete industry has been already implemented in most European countries and some Arab countries such as the UAE [3]. Vishwakarma and Ramachandran, (2018) backed the negative impact of the concrete industry on cement production [4]. Cement production produces a significant amount of carbon dioxide and leads to the depletion of a large amount of energy, and natural resources [4]. corn stalk ash (CSA) was used as a partial replacement for ordinary Portland cement in interlocking paving stone processing, at 28 days of curing; it was found that the replacement level of 10 % showed an increase in compressive strength compared to the normal concrete [5].This research aims to introduce the implementation of corn stalk ash as a replacement for cement. The behavior of three different mixes with 5, 10, and 15% cement replacement were compared to a control concrete mix.

2 Experimental Program

2 .1 Materials

Cornstalk ashes used in this study are of Egyptian origin, cornstalk samples were collected from farms in the Sharkia governorate of the Arab Republic of Egypt. Cornstalk is an agricultural waste produced from the corn crop. The samples were procured, and oven-dried until reaching reaches zero moisture content.

The coarse aggregate used were of crushed limestone with a maximum aggregate size of 20 mm. The coarse aggregate was tested according to the Egyptian standard specifications (ESS No 1109/2002 and ECP 203/2018). The fine aggregate used in mixtures was of medium sand well-graded consisting mainly of siliceous materials. All fine aggregate tests shall be carried according to ESS No 1109/2002 and ECP 203/2018. The mixing was done using Portland cement CEM I (42.5R) following the Egyptian Standard Specification (ESS) No. 4756-1/2013. The CEM I (42.5R) is a drying shrinkage cement with no ability to withstand sulfate attacks. Regarding the mixing water, pure and free from impurities water was used. The curing process is carried out following the Egyptian specification limits (203/2018).

2.2 Sample Preparation

forty samples were prepared using standard cubes with dimensions of 150 × 150 × 150 mm. The concrete was placed on three layers, each layer being compacted 25 times by a compacting rod. Furthermore, the concrete surface was levelled and left in the air for 24 hours, after which the curing process is carried out. The concrete samples resembled four different mixtures, one as a control mix, with no CSA replacement, and three CSA replacement ratios of 5, 10, and 15%. In this context, the mixtures were named after the used CSA replacement percentage. For example, CSA.10

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stands for the concrete mixture with 10% CSA/cement replacement.

3 Results and Discussions

3.1 Fresh Concrete Tests

3.1.1 Slump Test

The slump test was carried out to determine the consistency of the concrete and the workability according to the Egyptian standard specifications ASTM C143. This test is carried out on ordinary concrete mixtures and Concrete with CSA5, CSA10, and CSA15. The value of a drop of concrete for different mixtures is shown in Table 1.all samples showed a true slump failure. From the results, it is concluded that the higher the percentage of corn stalk ashes, the higher the drop in concrete. In otherworld's, adding the cornstalk ash enhanced the concrete workability. This is attributed to the larger size of the ash compared to the cement, which consequently increased the free water.

TABLE 1
THE VALUE OF THE SLUMP TEST FOR MIXES WITH DIFFERENT PROPORTION

mixes	CSA0	CSA5	CSA10	CSA15
The drop in concrete (mm)	52	60	62	65
% of the increase occurs according to CSA0 mix	-	15.40	19.23	25

3.1.2 Compaction Test

The compaction test was performed to determine the workability of the concrete mixture... This test was performed According to the Egyptian specification limits ECP 203/2018. According to the results of the coefficient of the compaction test summarized in Table 2, it can be concluded that the percentage of corn stalk ash (CSA) increased, the coefficient of compaction increased due to an increase in the percentage of fine materials, as corn stalk ash grains are considered smoother than cement grains.

TABLE 2
THE COEFFICIENT OF COMPACTION FOR DIFFERENT MIXES

mixes	CSA0	CSA5	CSA10	CSA15
Weight of the cylinder while empty(kg)	3.20	3.20	3.20	3.20
Partially compacted weight (kg)	12.10	12.30	13.10	13.69
fully compacted weight (kg)	14.20	14.32	14.90	14.86
Coefficient of compaction	0.81	0.82	0.85	0.90
% of increase	-	1.23	4.94	11.11

3.2 Results of Hardened Concrete Tests

3.2.1 Compressive Strength Test

The compressive strength test was performed on standard cubes and cylinders for the different mixtures. Twenty cubes were tested at 7 days, and the remaining twenty cubes were tested at 28 days. Cubes are divided into four groups for 7 and 28 days. The four groups at 7 days contain five standard cubes and the other four groups, at 28-day, contain five standard cubes. Each cube is assigned weight, failure load, and compressive strength. In which there is a relationship between the compressive strength values of the cubes of each group and the average compressive strength value of each group and then the ratio of the compressive strength of the cylinders to the compressive strength of the cubes for each mixture was determined. Table 3 and Figure 1 shows the results of the average compressive strength for different mixtures at 7 and 28 days.

TABLE 3
THE COMPRESSIVE STRENGTH OF DIFFERENT MIXES AT 7 AND 28 DAYS.

Mixes	Average comp. strength at 7 days for cubes (N/mm²)	Average comp.strength at 28 days (N/mm²)		Ratio
		Cubes	Cylinders	
CSA0	20.70	26.56	20.43	0.77
CSA5	17.67	21.10	10.75	0.51
CSA10	17.51	23.21	11.51	0.50
CSA15	10.66	15.13	7.98	0.52

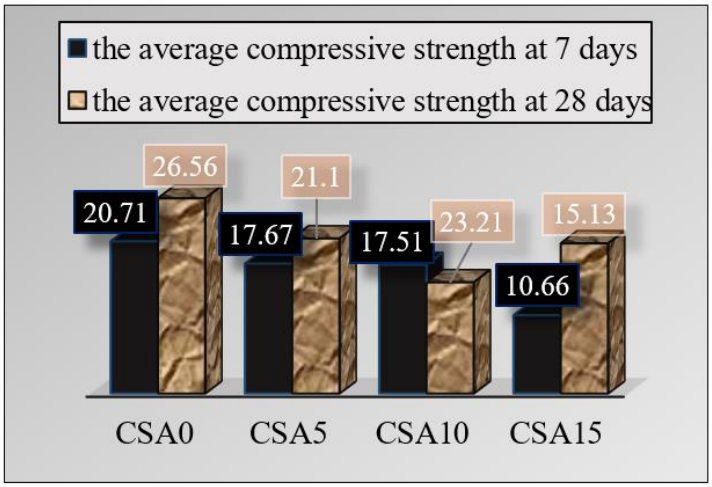

Fig.1. The comparison of the average compressive strength for different mixes at 7 and 28 days for cubes.

At seven days, the results of the compressive strength values of the fourth group of cubes showed that they are lower compared to the compressive strength values of normal

concrete due to an increase in the percentage of corn stalk ash and a decrease in the percentage of cement in the mixture. It concludes that the concrete mixture CSA10 had the highest compressive strength compared to the mixtures CSA5 and CSA15, where its compressive strength was found to be lower than the compressive strength of normal concrete. Furthermore, the compressive strength of the mixture CSA15 decreased, due to an increase in the percentage of corn stalk ashes and a decrease in the percentage of cement in the mixtures. Table 4 shows the percentage of increasing and decreasing in the compressive strength with different proportions Of CSA compared to the normal concrete.

TABLE 4
THE PERCENTAGE OF DECREASE IN COMPRESSIVE STRENGTH VALUES COMPARED TO NORMAL CONCRETE

Mixes	% of the decrease in compressive strength
CSA0 of cubes	———
CSA5 of cubes	-20.57
CSA10 of cubes	-12.60
CSA15 of cubes	-43.02

4 CONCLUSION

The following conclusions are prepared based on the experimental results:

• As a result of the addition of corn stalk ash to concrete, as a cement replacement, it was found that the higher percentage in concrete, the higher workability, and coefficient of compaction. On the contrary, adding corn stalk ash lowers its concrete density. The results of the concrete compressive strength at 7 and 28 days showed that increasing the CSA content lowers the compressive strength compared to the normal concrete.

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