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Utilisation of Power Plant Coal Bottom Ash as Coarse and Fine Aggregate to Produce Eco-Friendly Lightweight-Self Compacting Concrete

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ABSTRACT

Sustainable solid waste management and recycling are progressively significant challenges in all industries. Coal bottom ash (CBA) is a by-product generated from the coal fired thermal power plants. Reusing such solid wastes as a construction material in civil engineering has the potential to improve environmental benefits and partially solves the problems associated with waste disposal of coal bottom ash. In light of this, the objective of this study investigates the possibility of using coal bottom ash (by-product from abounded Algerian thermal power plant) as coarse and fine aggregates to produce lightweight-self compacting concrete (LWSCC). The fresh and mechanical properties of LWSCC incorporating CBA in full replacement of fine and coarse aggregate were evaluated and compared it with that manufactured with natural aggregates. The test results revealed that the flowability, passing ability, and segregation resistance of mixtures made with (CBA) as coarse aggregates increase with the full replacement (100%) of natural coarse aggregates (NCA) by (CCBA), and decrease with the full replacement (100%) of natural fine aggregates (NFA) by (FCBA). The results satisfied the self-compacting concrete's criteria. However, compressive strength was slightly decreased when the CBA was used as coarse and fine aggregates. Also, the results show that the density of mixtures made by (CCBA) and (FCBA) reduced noticeably ($<2000 \text{ Kg/m}^3$). In addition, the results showed that the porous nature of CBA aggregates contribute to increase the water absorption of LWSCC.

Keywords: Coal bottom ash, Fine and coarse aggregates, Lightweight-self compacting concrete, Fresh and mechanical properties, environment.

1. Introduction

In the Bechar region southwest of Algeria Slag heaps from 50 years of coal mine exploitation have accumulated. Coal was discovered in Bechar in 1907. That exploitation produced a significant amount of waste were abandoned in the environment. These wastes are disposed of as heaps contains coal bottom ash (CBA) which is a by-product generated from the coal fired thermal power plants. These by-products have a detrimental impact on population health and poses an ecological issue. Therefore, utilizing these large quantities of CBA as building materials coarse and fine aggregates in various types of concrete mixtures opens a pathway to efficiently dealing with these wastes. Many studies have been conducted on the use of CBA in concrete. According to Singh and Siddique, coal bottom ash has the potential to be a useful material for fine aggregate in concrete. [1]. Also, Park et al [2], concluded that using CBA coarse aggregate leads to reduce the compressive and flexural strength as the coal bottom ash mixing ratio increased in porous concrete. In an investigation reported by Kim and Lee [3] on the influence of coars and fine CBA on the density, authors found that as coarse and fine CBA replacement levels increased, the densities of hardened concrete decreased linearly. Therefore to reduce the density of self-compacting concrete (SCC) the use of industrial wastes and by-products as lightweight aggregate is the main solution for such problem and to produce Lightweight self-compacting concrete (LWSCC) which can reduce the self-weight of the structure and increase workability. The objective of this study was to investigate the potential use of bottom ash collected from an Algerian coal-fired power plant to produce LWSCC. This study concentrated on the fresh



properties, strength behavior, and rate of water absorption of the LWSCC incorporating CBA aggregates and then compared with those of self-compacting concrete.

2. Materials and methods

In this study, a portland cement CEM II/B 42.5 N is conform to EN 197-1 manufactured was used. Rolled sand with maximum size of 3 mm and crushed limestone were used as the natural fine and coarse aggregate come from the quarry (Bechar). Coal bottom ash collected from Algerian (Bechar region) coal-fired power plant was crushed and sieved to produce fine and coarse aggregates with same gradation of that of normal aggregates Mixing water and chemical admixture. Following the recommendations for self-compacting concrete [AFGC 2008], three self-compacting concrete (SCC) mixtures were produced. A reference mix, (RSCC) prepared with natural aggregates was designed first. The sand were replaced totally by the coal bottom ash fine aggregates (FCBA) and coarse coal bottom ash aggregates (CCBA) to produce FSCC and CSCC mix respectively. The principal properties of SCC in the fresh state (slump flow, segregation resistance, L-box tests) were performed. The dry density, water absorption and compressive strength of the concrete were determined.

3. Results and Discussion

From the experimental results presented in Table I all concretes have an acceptable fluidity according to AFGC standard (Slump-flow 680-800 mm). For L-Box test the passing ability of all mixtures was ranging from (0.78-0.90) . Apparently, the use of FCBA aggregates decreased the value of passing ability and as observed the full replacement of natural aggregate by CBA aggregate decrease the value of segregation ratio however all the mixes present a good stability (Stability in sieve 6.44-9.24% less than 15%). the measured dry density of the produced concrete after 28 curing days is presented in figure 1. It can be shown that using CBA as aggregate in producing LWSCC reduces the dry density from 2133.96 to 1920.6 kg/m³, lower than 2000 kg/m³ which can be considered as lightweight-self compacting concrete, this is because of the low density of CBA aggregate compared to normal-weight aggregate. The water absorption rate increase when using CBA as aggregates in SCC this increased was due to the porous structure of CBA.

Table I: experimental results

Mix	Slump flow (mm)	L-box test	Stability in sieve (%)	Dry density(kg/m ³)	Water absorption(%)
RSCC	727	0.94	9.24	2133.96	4.2
FSCC	680	0.78	6.44	1952.63	6.43
CSCC	800	0.90	8.5	1920.60	5.48

The strength development of concrete at 7 and 28 days are presented in figure 1. The results demonstrated that the replacement of natural aggregate by CBA aggregates in SCC led to a decrease in the compressive strength. This may be due to the lower strength of the CBA aggregates.

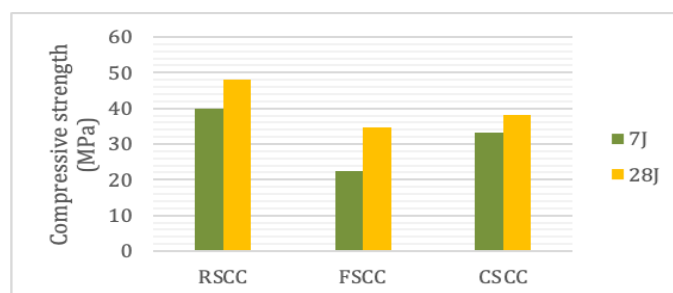


Figure 1: Compressive strength at 7 and 28 days

4. Conclusions

From this study, the following conclusions can be drawn:

- The results of the present investigation demonstrate that CBA aggregates can be used to produce LWSCC having good rheological and mechanical characteristics.
- The use of CBA wastes as aggregates contribute to produce eco-friendly lightweight-self compacting concrete, to protect the environment and mitigate their negative impact.

References

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