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CONTROL LOW STRENGTH AGRO-CONCRETE

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Abstract: Agriculture farms produce a massive amount of wastes annually which represents one of the main challenges facing the agriculture industry. This study attempt to link agriculture and construction industries through reusing such as agriculture waste (Agro waste) in construction materials. Control low strength material (CLSM) was selected as a potential construction material that can accommodate a high percentage of agro waste. This is attributed to the fact that the CLSM performance requirement is low enough to be achieved while incorporating Agro waste. Standard low strength material mixtures according to ASTM were used as reference mixtures. These mixtures were also modified by the incorporation of a fine agro waste at rates 5%,10% and 20% as a volume replacement for sand. Fresh and mechanical properties including mini-slump, water absorption, spread flow, compressive and tensile strengths, modulus of elasticity and shrinkage were evaluated for all mixtures. Results showed a reduction in mechanical properties. However, it was still within the targeted strength. Also, the reduction in compressive strength and shrinkage has an indirect proportional to the increase in rate.

INTRODUCTION

Wastes of the whole period of agriculture industries process are known as Agriculture waste. This waste includes herbal such as vegetables, fruits and crops and animals such as dairy products, meat, and fertilizers. Wastes from different activities of the agriculture industry, based on the system and activity, can be liquid, solid or slurries. Annually, agricultural industries produce a significant amount of agro wastes that can have undesirable effects on global health (Agamuthu, 2009; Obi, Ugwuishiwu, & Nwakaire, 2016). Using these agro wastes in construction materials is one of the solutions with an excellent environmental effect along with reducing the disposal cost of these wastes (Ramezanianpour, Mahdikhani, & Ahmadibeni, 2009).

Availability of agro wastes in various shapes makes them a suitable replacement of nonrecyclable resources in different applications, especially in construction materials. For example, sawdust, giant reed ash, rice husk ash can be used a fine aggregate or filler in concrete (Sargın, Saltan, Morova, Serin, & Terzi, 2013), coconut shell can be used as coarse aggregate (Shafigh, Mahmud, Jumaat, & Zargar, 2014). Hence, using agro-wastes in concrete have financial and environmental benefits (Shafigh et al., 2014).

Control low strength materials (CLSM), are non-structural cementitious material that is self-compacted, unshrinkable, flowable filler and self-control density. It has a low in-place cost and high production rate (Du, Folliard, & Trejo, 2002). Higher amount of water to cement, less coarse aggregate and a significant amount of fly ash make CLSM different from other cementitious materials. The non-structural nature of this material with a controlled specified strength of 8.3 MPa or less in 28 days cured condition is feasible. Usually, 2.1 MPa is the lower limit in case of some application with a lower value (Siddique, 2009). The availability, cost, and specific application are the three main things that address to correct selection of materials.

In this paper, experiments designed to evaluate the CLSM mixture and to replace the sand in this mixture with agricultural waste and to study different angles such as usage of this material as a filler and its chemical and physical properties.

Experimental Program

Materials

GU hydraulic cement according to the CSA-3001-03 and Class F fly ash according to ASTM C618 were used as binding materials for all tested CLSM mixtures. The chemical composition and the physical properties of the cement and fly ash (FA) are shown in Table 1. The used fine aggregate was natural riverside sand with a fineness modulus was 2.70 according to ASTM C136 (2014), specific gravity and water absorption of 2.51 and 2.73% determined by ASTM C 128 (2015), respectively. Sieve analysis for fine aggregate meets ASTM C33 (2018) as illustrated in Fig. 1.

Table 1. Chemical and physical properties of cement

		GU	FA
SiO_2	(%)	19.80	43.39
Al_2O_3	(%)	4.90	22.08
CaO	(%)	62.30	15.63
Fe_2O_3	(%)	2.30	7.74
SO_3	(%)	3.70	1.72
Na_2O	(%)	0.34	1.01
MgO	(%)	2.80	------
Na_2Oeq	(%)	0.87	------
Loss on ignition	(%)	1.90	0.58
Specific gravity	--	3.15	2.50

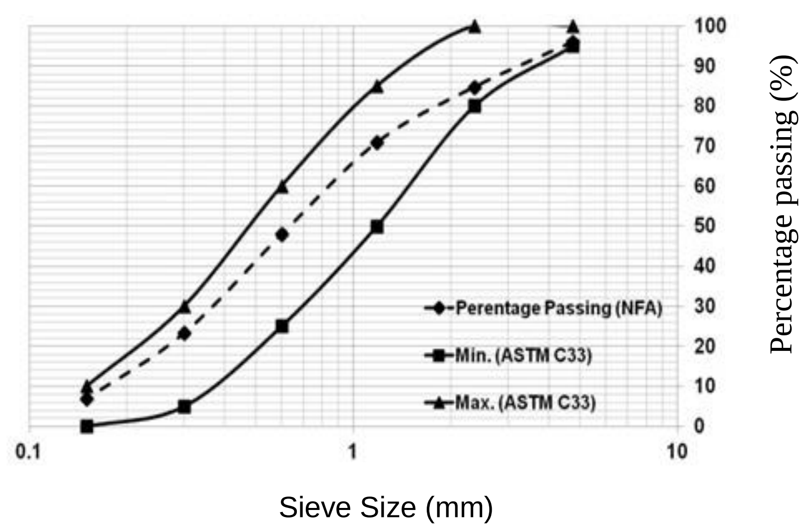

Figure 1 Sieve analysis of fine aggregate

Mixtures proportions

Table 2 shows the composition for all tested mixtures. Control mixtures were prepared based on proportion guidelines reported by ACI committee 229. Agro-waste was incorporated as partial replacement of sand by volume at rates of 5%, 10%, and 20%. The water was adjusted to achieve adequate flowability.

Table 2. Mixture compositions for CLSM mixtures with agro waste

	Materials (kg/m^3)				
Mix Code	Cement	Fly ash	Sand	Agro Waste	Water
G30	30	148	1725	----	297
G30W5	30	148	1640	10	302
G30W10	30	148	1555	20	303
G30W20	30	148	1380	40	306

Mixing procedure

The mixing process is divided into two stages, dry and with water. The first part begins with a dry mixture of cement, fly ash, sand, and agro-waste for one minute. The second step is to add half the water and mix for 1 minute more. Then add the rest of the water for 1 minute.

Testing

In this study, the experiments are divided into two sections, fresh and hardened. According to ASTM standards, fresh samples are tested, including followability and bleeding. Compressive strength was conducted to evaluate the mechanical properties. For each mixture, three 50 × 50 × 50 (mm) cube samples were prepared for testing at ages 3,7, 14 and 28 days.

RESULTS AND DISCUSSION

Followability

For CLSM, the water content must be adjusted to achieve am adequate flowability within the range of 150–200 mm. Figure 2 shows the results of the flowability for all tested CLSM mixtures. The flow values were in the range from 182 to 189 mm, which falls within the normal flowability category according to the ACI committee 229R report. On the other hand, replacing sand with the powder agro waste reduced the amount of required water slightly to achieve the same flowability range of control mixtures as shown in Fig.2. Adding such fine agro waste will increase the surface area of the particles leading to higher water demand. However, it will fill the voids between binder particles and release the entrapped water compensating the other effect.

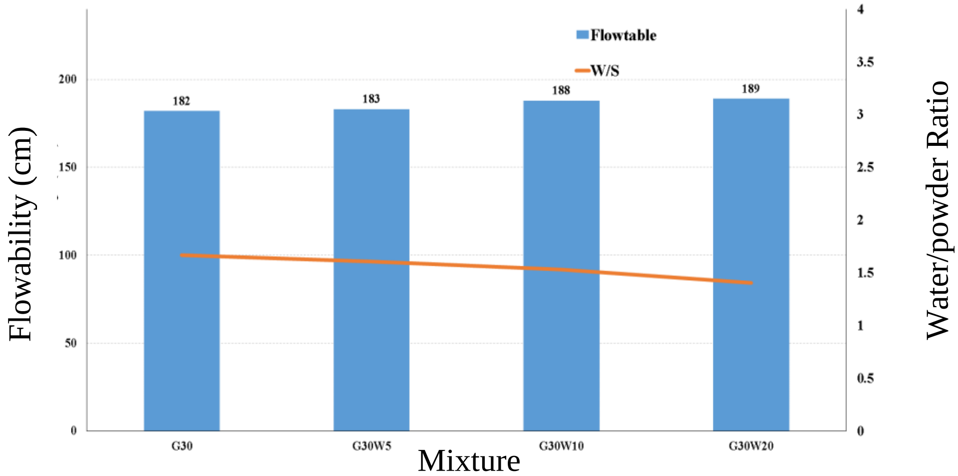

Figure 2. Flowability and water/powder ratio for all CLSM mixtures

Bleeding

Figure 3 shows the bleeding measured for all tested CLSM mixtures. It is clear that all mixtures were stable and did not exceed the bleeding limit (maximum of 5% for stable CLSM. Mixtures incorporating agro waste exhibited lower bleeding than that for mixtures without agro-waste. On interesting point, increasing the waste content fro 5% to 20% did not affect the bleeding for mixtures incorporating 30 kg/m^3. This can be attributed to the high water content of these mixtures.

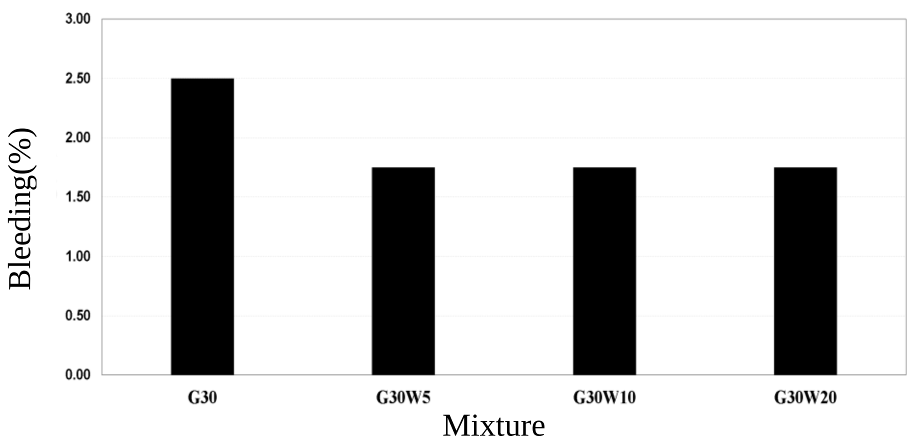

Figure 3. Bleeding for all CLSM mixtures

Compressive strength

Figure 4 summarizes the compressive strength results for tested CLSM at ages 3,7 14 and 28 days. Control mixtures with a cement content of 30 kg/m3 and without agro waste exhibited strength around 550 kPa. This is expected as class F fly ash used in these mixtures has no cementitious properties and needs cement in order to react with calcium hydroxide (CH), released during the hydration process of the cement, to form calcium silicate hydrated (CSH) which is the binding materials. For mixtures incorporating agro waste, it is clear that strength decreased as the amount of agro waste increased. However, at such lean mixtures the variations in strength due to agro waste addition was insignificant (Fig. 4). Hence, the higher the cement content, the higher the reduction in strength induced by agro waste addition. Two reasons can be attributed: the high water/powder ratio and low CH in lean mixtures. The ACI committee 229 recommends if future excavation is anticipated a compressive strength lower than 2.1 (MPa) .

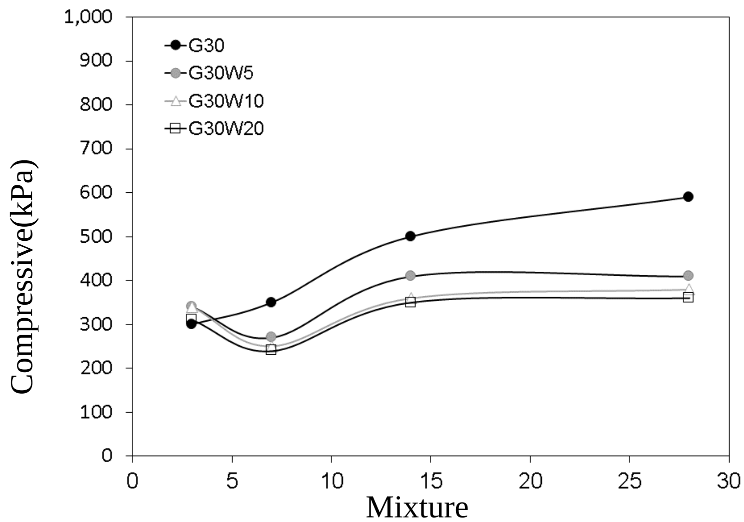

Figure 4. Compressive strength for all CLSM mixtures

Removability Modulus

The removability modulus (RE) used to assess the excavatability of a CLSM mixture based on its strength and dry density (Eq. (1)).

$$RE = \frac{W^{1.5} \times 0.619 \times C^{0.5}}{10^6}$$

The density after 28 days of the mixture in (kg/m3) in dry shown by “W.” the 28 days compressive strength .in (kPa) shown by “C.” If RE is less than 1,then CLSM mixture considered as easily removable. Figure 5 shows the calculated RE for all mixtures. It is clear that all CLSM produced by the fine agro waste can excavate easily.

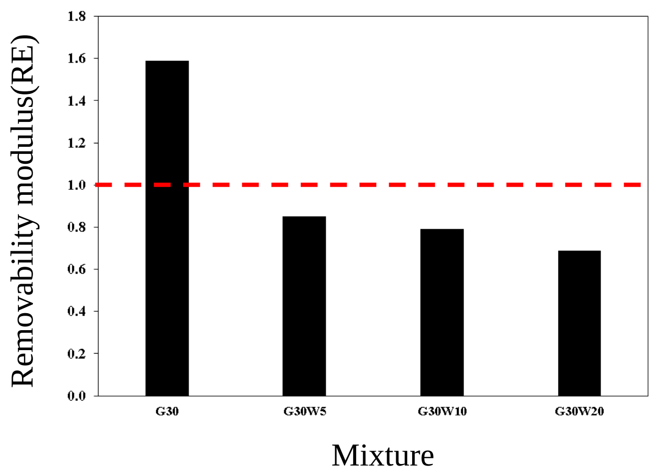

Figure 5. Removability modulus for all CLSM mixtures

Conclusions

Following conclusions are based on results of Fresh and hardened tests on CLSM with agro-waste.

1. CLSM with agro waste achieve flowability within the normal flowability of CLSM
2. Bleeding of CLSM decreased with the addition of agro waste
3. Addition of agro wastes did not significantly affect the compressive strength.
4. Adding agro waste make CSLM excavation easier.

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