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INVESTIGATING POTENTIAL IMPLEMENTATION OF DIFFERENT AGRO-WASTES IN CONCRETE

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Abstract: Concrete is the most widely used construction material. However, large volumes of natural resources and raw materials are being consumed in concrete production. This reduces concrete industry sustainability and increase its environmental negative impact. On the other hand, the agriculture sector is facing problems that require more efforts in agro-waste managements. To resolve this problem and benefit from agro-waste, in this study, the potential of using different types of agro-wastes in concrete as a total/partial replacement of aggregate will be evaluated. Three types of agro-wastes, which are categorized based on their fibrosity, fine and coarse, were tested. Full characterization for different agro-waste and corresponding variations in compressive strength, density and microstructure were evaluated. Results showed that the compressive strength is directly affected by the physical properties of the incorporated agro-waste and the type of the binding material. Fibrous agro-wastes exhibited the highest strength with respect to other wastes. Successful use of such agro solid wastes as whole or partial replacement of natural aggregates contributes to energy saving, conservation of natural resources, and a reduction in the cost of construction materials.

INTRODUCTION

Concrete is used in almost all farms buildings due to its strength and durability along with its compatibility with ecological practices. Concrete has many advantages: long service life; low maintenance costs; high fire resistance; reduces bacterial proliferation; easy to clean surfaces; high surface resistance to abrasion, peeling, acids and other hostile environments. Concrete can be used in building the entire farm building. With some adaptations and important follow-up, concrete can be used to fabricate the basic elements for pig production units.

On other hand, concrete is composed of aggregates, gravel and sand, agglomerated by cement paste. Furthermore, addition of several additives can enhance its strength to meet the requirement. However, concrete production emitting high carbon dioxide (CO_2) to the environment [1,2]. Carbon dioxide (CO_2) is the predominant greenhouse gas on earth and its atmospheric concentration is increasing at an exponential rate due to human activities. Cement and concrete production contributes about 7% of the total worldwide CO_2 emissions, and thus finding a practical way to reduce the greenhouse gas emission is essential [2]. Hence, the high demand of concrete in the industrial and civil construction using the normal aggregates such as gravel and granite drastically reduces the natural stone deposits and this has damaged the environment thereby causing ecological imbalance. There is a need to explore and to find out suitable replacement materials to substitute the naturel stone. In developed countries, many natural materials like pumice, scoria and volcanic debris and manmade materials like expanded blast- furnace slag and clinker are used in construction works as substitutes for naturel stone aggregate. Nevertheless, commercial use of non-conventional aggregate like the agro waste materials, like Saule–wood ,miscanthus, topinambour and vegetarian fibre in the concrete construction he is still in the research phase[3].

Recent research was performed to investigate the feasibility of the use of agro waste materials as partial replacement for naturel aggregate in concrete production [4-6]. Hence, incorporation of agro waste materials as aggregate replacement materials in concrete will be beneficial not only in environmental terms for concrete materials but also in production costs of aforesaid materials [7-9].

It is clear that materials stated above indicate high potential as an additive concrete. This paper discusses some of the physique and mechanical properties of agro waste materials including fresh and hardened properties of concrete. The feasibility to use such biomass waste as replacement of natural aggregate for the production of concrete is explored.

Experimental Program

Material

General use (GU) hydraulic cement, which conforms to CSA-3001-03 was used as binding materials. Table 1 shows the chemical composition for the used cement. Tap water was used for all mixture. The coarse aggregates that will be used is siliceous/calcareous aggregates with a maximum size of 20 mm (3/4 inch) and specific gravity of 2.697 $kg.m^{-3.}$ These aggregates will be supplied from Lafarge quarry in Montreal, Canada. The water absorption of the aggregates was 0.6%. Sand natural conforming was used as fine aggregate. The maximum particle size used was 5mm (0.19 inch). Sieve analysis for both fine and coarse aggregates meet ASTM C33 (2018) as illustrated in Fig. 1. Different agro waste materials were used as replacement to natural aggregate with different level in the conventional concrete. Figure 1 shows four types of agro wastes used in this study.

Table (1) Chemical and physical properties of cement

		OPC (1)
SiO_2	(%)	19.80
Al_2O_3	(%)	4.90
CaO	(%)	62.30
Fe_2O_3	(%)	2.30
SO_3	(%)	3.70
Na_2O	(%)	0.34
MgO	(%)	2.80
C_3S	(%)	57.00
C_2S	(%)	14.00
C_3A	(%)	9.00
C_4AF	(%)	7.00
Na_2Oeq	(%)	0.87
Loss on ignition	(%)	1.90
Specific gravity	--	3.15

(1) GU cement produced by Lafarge cement plant, Factory at St. Constant

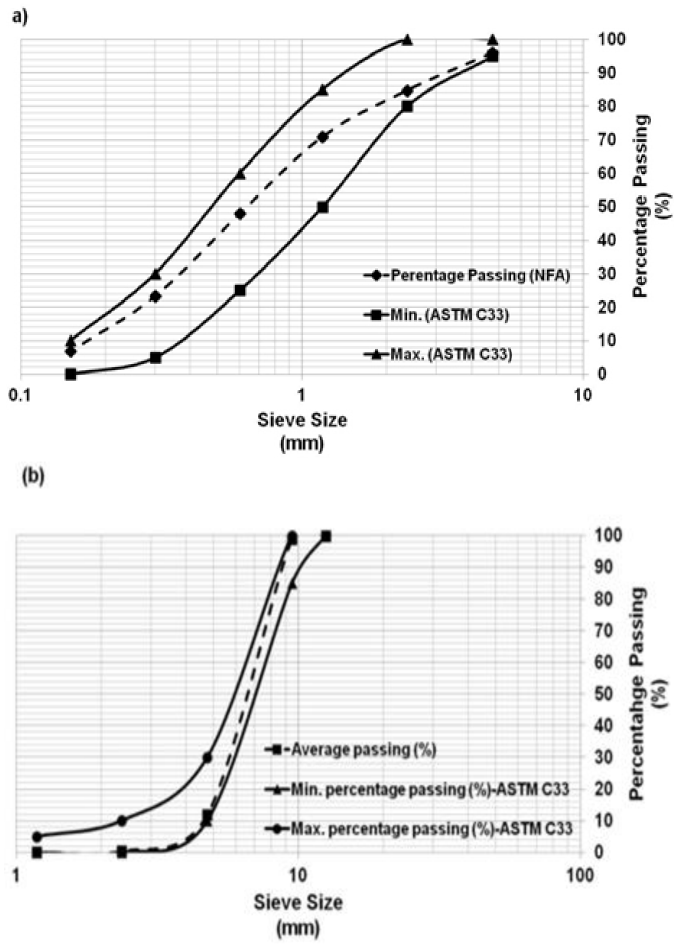

Figure 1. Sieve analysis of aggregate (a) Fine aggregate, and (b) Coarse aggregate

AWM1 AWM2 AWM3 AWM4

Figure 1 Different agro wastes used in this study

Mixtures proportions

The mixtures differentiated based on the type and the portion of partially replacement of agro-waste materials as represented in **Table 1**. The mix design concrete class was 30 MPa. The amount of high range water reducer (HRWR) ranged from (2.0% to 3.5%) of the cement weight was used. Air-entraining admixture (AEA) was added in the range of 35–65 ml/100 kg, binder targeting a fresh air content of 5 ± 1%. The mixtures prepared according to ASTM C 192 (Standard Practice for Making and Curing Concrete Test

Specimens in the Laboratory). Three mixture involving granular AWM1, AWM2 and AWM3 as substitutes for gravel in graduation of 0% 20% 30% and 40% were used in each case. The fourth one AWM4 was used as additive to reinforce the concrete with 3 % 5% and 7% by volume total of mixture. A water/cement ratio of 0.35 was used for all mixture.

Table 1 Mix design of concrete with different agro waste for 1 m3

	Mixtures			
Materials(Kg/m3)	AW0	AW20	AW30	AW40
cement	472,810	472,810	472,810	472,810
aggregate	1112,646	890,117	834,485	778,852
sand	706,452	706,452	706,452	706,452
Agro-waste content(%)	0	**20**	**30**	**40**
air entrainement agent ml/100	5,910	5,910	5,910	5,910
W/L	0,350	0,350	0,350	0,350

RESULTS AND DISCUSSION

Followability

Visual observation during mixing and compacting of all concrete suggested that the concrete with AWM1, AWM3 and AWM4 were homogenous with a small amount of water added for each mixture according to the absorption rate of this material. However, the concrete produced with AWM2 was not homogeneous due to the high absorption of this agro materials. The slump value is found to decrease with partial replacement agro waste materials AWM2 and concrete becomes unworkable when the percentage of replacement was 40% (Fig.3). It was found that the difference between the granulometry of AWM2 and the naturel aggregate and the higher absorption of water for AWM2 was a factor in reducing workability.

The flowability values of concrete were between 70 -110 mm for the three types AWM1, AWM3 and AWM4 (Fig.3 and 4). The concrete mix produced 30% aggregate naturel replaced with AWM1 and AWM3 showed similar slump to the conventional concrete. As percentages of agro waste increase, slump decreased. The reasoned that the reduction of slump value was due to the angularity of particles and the higher water absorption of agro waste materials used (AWM1and AWM3). However, for the mix AWM4, the slump value increased with the increase in AWM percentage, in which the total aggregate was replaced with 7% of AWM4 shown the highest slump value (Fig. 4).

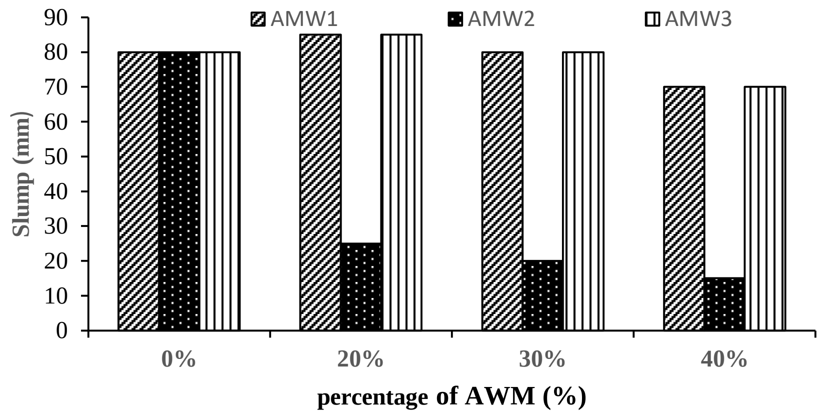

Figure 3 Slump development with A4WM

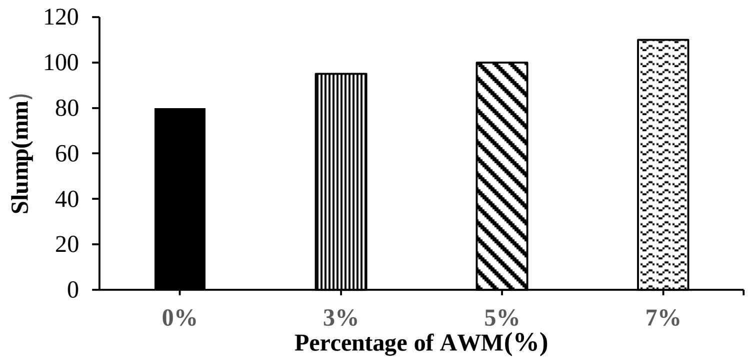

Figure 4 Slump development with different AWM4 percentage.

Compressive strength

Compressive strength test results are presented in Fig. 5. It should be mentioned that due to very low workability for concrete emixture produced by AWM2, it was execluded from th rest of the work. At early curing age of 7 days, for the AWM1 samples, the compressive strength values increased when the replacement level increased (Fig.5a) due to the higher water absorption capacity of agro waste materials (AWM1) and the rough texture of AWM1 that improved bond and interlocking characteristics between mortar and AWM1. However, at 28 days, the compressive strength of concrete produced by 40% AWM1 reduced by 8% than that of the control mixture.

Concrete produced by 40% of AWM3 present higher compressive strength than the AWM1(40%) and almost comparable than the control concrete (Fig. 5b). These results due to the fibrous property of AWM3, it's a mix between the small piece of wood and fine fiber. In contrast, coarse wood waste particles could provide bridging effect to some (resembling the role of short fiber) for the improvement of strength [10].

As seen in Fig. 5c, the rate of compressive strength loss decreases when increasing the replacement level of AMW4. The development of strength property in fiber- cement vegetarian mostly depends of the formation of fiber-matrix, matrix –matrix and fiber – fiber bond. their ability to bond to matrix and /or each other. The bonding can be affected by dimensions, surface condition, absorption, and number of fiber present in a given volume material[11]. However, the concrete produced with 3 % of AWM4 present comparable compressive strength than the control (46 Mpa) at 28 days.

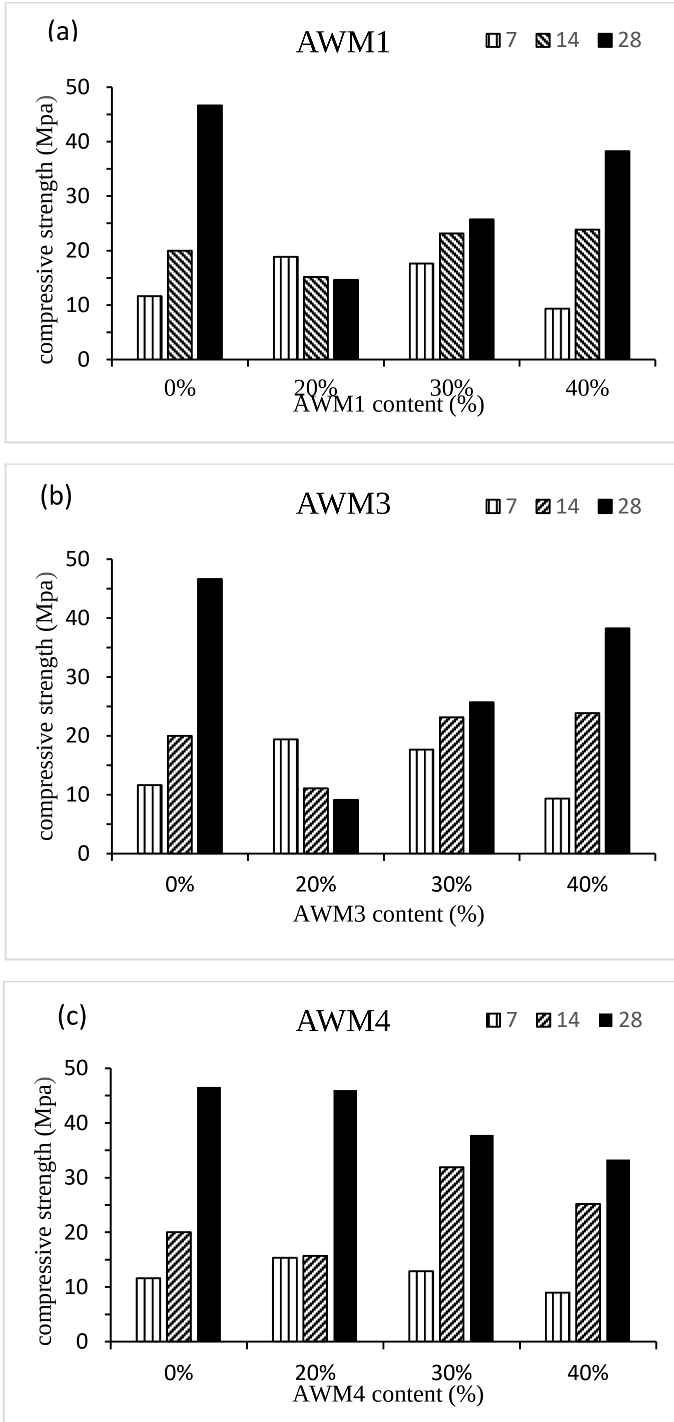

Figure 5 Compressive strength development of concrete with AWM.

Split tensile strength test

The splitting tensile strength results of the concrete mixtures are shown in Fig. 6 at 28 days. The test results indicate that inclusion of AWM1 in concrete improved the splitting tensile strength of concrete with increasing the replacement level of agro waste used. At curing age of 28 days, the splitting tensile strength of AWM3 as 20 % 30% and 40% higher than the control mix and AWM1 respectively. The improvement in splitting tensile strength of AWM3 mixtures contacting 20%,30% and 40% agro waste materials (AWM3) over of control mixture was 30%.,40 and 30%,40% and 50.5% respectively. The incorporation of AWM3 in concrete shows significant increase in splitting tensile strength due to the varied size particle of wood waste aggregate (fine and coarse) improvement stability of melange and improve the bond between fiber - cement matrix [12]. The fibrous propriety, the size and the surface morphology of agro waste effect positively to the mechanical properties of concrete and played an important role in determining the reinforcement mechanisms and reinforcing efficiency for concrete [12].

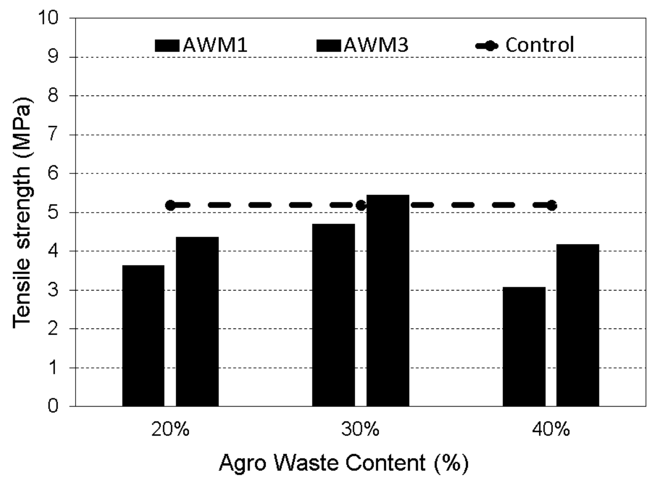

Figure 6 Tensile strength development of concrete with different AWM

Conclusions

Following conclusions are based on results of fresh and hardened tests on concrete with different agro-waste.

1. Agro waste has high potential to replace natural aggregates in concrete
2. Properties of agro waste will significantly influence the final produced concrete.
3. The higher the agro waste content, the lower the workability due to shape and water absorption ability.
4. The higher the agro content, the lower the strength achieved due lower stiffness of agro waste with respect to natural aggregate.
5. Fibrous agro waste will enhance tensile strength.

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