PROPERTIES OF GREEN LIGHTWEIGHT AGGREGATE CONCRETE

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Abstract

With increasing concern over the excessive exploitation of natural aggregates, synthetic lightweight aggregate produced from environmental waste is a viable new source of structural aggregate material. The uses of structural grade lightweight concrete reduce considerably the self-load of a structure and permit larger precast units to be handled. In this paper, the mechanical properties of a structural grade lightweight aggregate made with fly ash and clay will be presented. The findings indicated that water absorption of the green aggregate is large but the crushing strength of the resulting concrete can be high. The 28-day cube compressive strength of the resulting lightweight aggregate concrete with density of 1590 kg/m^3 and respective strength of 34 MPa. Experience of utilizing the green lightweight aggregate concrete in prefabrication of concrete elements is also discussed.

1. Introduction

Most of normal weight aggregate of normal weight concrete is natural stone such as limestone and granite. With the amount of concrete used keeps increasing, natural environment and resources are excessively exploited. Synthetic lightweight aggregate produced from environmental waste, like fly ash, is a viable new source of structural aggregate material. The use of lightweight concrete permits greater design flexibility and substantial cost savings, reducing dead load, improved cyclic loading structural response, longer spans, better fire ratings, thinner sections, smaller size structural members, less reinforcing steel, and lower foundation costs [1-3]. Weight of lightweight concrete is typically 25% to 35% lighter but its strengths is comparable to normal weight concrete.

This paper discusses the mechanical properties of a newly developed structural lightweight aggregate which is made from expanded clay. The aggregate is reinforced with a PFA rich surface coating applied at a later stage of firing. The

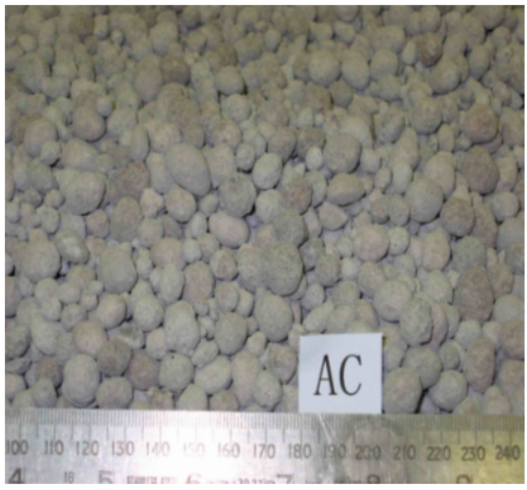
experience of utilizing this green lightweight aggregate concrete in the prefabrication of structural element is also presented.

2. Experiments and Results

2.1. Characteristics of the aggregate

The quality of the green aggregate [in terms of crushing strength] was specified by a crushing strength test based on GB2842-81 (China Standard). The strength as measured by compressing the aggregate in a steel cylinder through a prescribed distance of 20 mm is 3.8 MPa. Results of the sieve analysis and water absorption of the aggregate at different time are given in Table 1.

Table 1: Properties of the aggregate



Bulk Density	840 kg/m^3
Apparent Density (pre-wet 1 hour)	1525 kg/m^3
Crushing Strength	3.7 MPa
Sieve Ratio (mass %)	
>14mm	0
14mm~10mm	23.2
10mm~5mm	60.2
5mm~2.36mm	15.1
2.36mm~1.18mm	1.3
<1.18mm	0.2

Time (min.)	5	10	30	60
Water absorption rate (%)	9	11.2	12	13

Fig. 1 examines the topography of the aggregate specimen using an optical microscope with 200X magnification. We can see that there is a thick shell rich in PFA at the outside surface of the aggregate. The compact external shell of the aggregate contributes to the higher strength resistance than the traditional lightweight aggregate without coating. Moreover, it is critical in controlling the water absorption of aggregate during concrete mixing, reducing the slump loss of concrete with time [4].

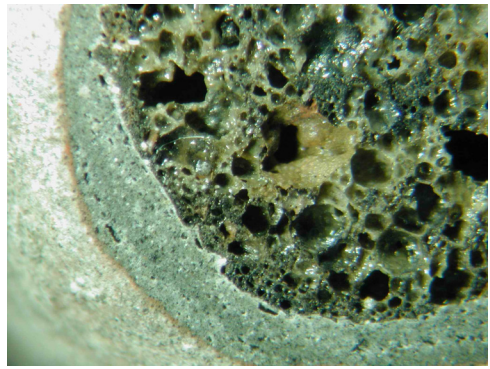


Fig. 1: Section of the lightweight aggregate

3. Prefabrication using Lightweight Aggregate Concrete

The structural lightweight aggregate was used to develop precast concrete elements for green construction. The mix proportion used is given in Table 2.

Table 2: Mix proportion of the green lightweight concrete (kg/m^3)

Cement	Water	Sand	AC agg. (pre-wetted)	Admixture
420	175	715	630	1000 ml

Fig. 2 displays that a good workable fresh concrete for concrete casting. The slump of lightweight concrete measured 30 minutes after batching was 50 mm.

Fig. 2: Highly workable fresh concrete

Fig. 3 shows the protocol of finished lightweight concrete precast façade.

Fig. 3: Protocol of finished lightweight concrete precast façade

Comparison of the design requirements with the concrete quality of the prefabricated façade are given in Table 3 below. It is seen that the gross weight of the lightweight concrete façade achieved only 70% of the density of normal weight concrete with the same compressive strength. Fig. 4 also indicated the bonding between reinforcing steel and lightweight concrete is good.

Table 3: Comparison of design requirement with actual concrete produce

	Specification	Façade quality
Unit weight	2275 kg (normal concrete)	1590 kg
1-day strength	15 MPa	14.5 MPa
28 days	30 MPa	34 MPa
Slump	75 mm	50 mm
Density	2400 kg/m^3	1750 kg/m^3

Fig. 4: Bonding between the steel bars and the lightweight concrete

The following advantages are concluded for using lightweight concrete in prefabrication in building:

- Reduce the dead weight of a façade from 5 tons to about 3.5 tons
- Reduce craneage load, allow handling, lifting flexibility with lighter weight
- Good thermal and fire resistance, sound insulation than the traditional granite rock
- Allow design and construction flexibility for larger prefabrication modules
- Allow maintenance flexibility with replaceable modules
- Factory production of module enhances quality of product
- Enhance speed of construction, shorten overall construction period
- Enhance green building construction, minimize wet trade on site
- Improve damping resistance of building
- Utilization of PFA in aggregate production resolves the waste disposal problems of ash and reduce the production cost of concrete

4. Conclusions

The successful application of structural lightweight aggregate demonstrated that lightweight used for precast structural elements can be used in building construction to increase the speed of construction, enhance green construction environment such as reducing the wet trade on site and keep dust level at construction site to the minimum.

Acknowledgments

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