Study and Evaluation of the low (LWC) Density Production Characteristics

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Abstract

This paper presents the study and evaluation of low lightweight concrete (LWC) density production under multi stage casting process. The lightweight aggregate type and associated volume fraction mix is determined by the lightweight concrete density. In traditional mixing process of concrete, the minimization of the density clearly required high volume fraction which will causes aggregate segregation. The multi stage casting procedure occupy inserting lightweight (LW) aggregates in casing following satisfying in residual interstitial void by means of cementations grout with a low density. Consequently, these methods produce low compressive strength and enhanced weak point. Thus, the suggested casting technique could have a practical for developed non-structural rudiments and structural compound that require minimum density. The results show promising methods to support many projects that required strength more than 20 MPa for house slabs, driveways and footpaths.

Keywords- LWC, Lightweight, Low density**,** LWC Aggregate **.**

5. Introduction

The fast growth of building structure requires enough attention in current and future research to develop the traditional techniques [1, 2]. Nowadays, the widely used of structural lightweight concrete is subsequence advance in production methods for aggregate of lightweight [3, 4]. To reduce the dead load of structure, the lightweight concrete should be used [5, 6].Also, the LWC is suitable for low cost building [7, 8]. By using sintered fly ash, one could expand soil and shale to produce lightweight aggregate [9, 10]. Inherently, they has large amount of pores which produce minimum strength and high deformability [11, 12]. Therefore, any weak in lightweight aggregate will affect the strength and the concrete will fail [13, 14]. Though, a high strength aggregate has reported by [15, 16] which conclude that not necessary lead to high strength concrete. In same time, the demonstration of volume fraction of LW aggregate is opposite amount to compressive potency is introduce by [17, 18]. For that reason, the strength of LWC restricted with the properties, volume fraction of LW aggregate and the ration of water to cement [19, 20]. Many researchers have investigated the physical and mechanical possessions of LWC under lightweight coarse aggregate and conventional weight fine aggregate. The potency and modulus of normal vibrate LWC has been studied by [21]. The density and aggregate volume fraction of 1.650 kg/m3 and 24% for normal LWC has reported by [22]. In normal pulsate concrete, the volume fraction of LW aggregate up to 45% and the self compacting concrete was decreased by 25% to 35% is introduced by [23]. The aggregate contents could reduce to minimize the viscosity in order to provide enough flow for self consolidation [24]. The combine proportion technique is suitable for usual heaviness [25]. The dry density of vibrated LWC has reduced up to 1.750 kg/m3 in accordance with combine quantity due to its light weight structure has been introduce by [26, 27]. The coarse aggregate volume fraction of 30-34% is recommended by [28, 29] with range provides resistance of segregation. To maximizing the volume fraction of lightweight aggregate in a mixture, the reduction of density is become more important [31, 32, 33]. This work introduces multi phase casting technique to maximize the volume fraction of LW aggregate with minimum density by using identical density. The suggested technique provides much lighter concrete than the traditional mix methods. In this proposal, the cast include the following steps:

a.The lightweight coarse aggregate is first putting in the mold

b.Then, the cement grout is injected into interstitial voids among the removed aggregate

The proposed method was tested under 4 kinds of LW aggregate to illustrate the probability of this technique. A property of mechanical and physical samples was examined to evaluate their performance. The characteristics effect of LWC aggregate such us size distribution, shape and packing density are discussed as well.

1. Preparation of Samples

Firstly, the Portland cement has been used to make the LWC with specific gravity of about 3.150kg/m3 and Blaine surface area of about 335m2/kg in this experiment. The measurement was done according to ASTMC 188 and ASTMC204. Table 1 shows the oxide composition of the cement used in this work. The LWC aggregate used in this work with physical properties shown in

Table 2.

Table 1: Cement Composition properties [19]

Oxide	Na2O	TiO_2	K_2O	Fe_2O_3	SO_3	MgO	$Al2O_2$	SiO_2	CaO
Percent (%)	0.1	0.2	1.0	3.3	3.3	3.1	4.3	17.5	65.7

Table 2: properties of different type LWC aggregate [21]

Parameters	S1	S2	S3	S4
Material	Polystyrene	Clay	Shale	Slate
Size	10	11	14	18
Max. Size	10	10	11	11
Oven dry density	34.8	11700	1270	1357
SSD density	34.7	1380	1450	1435
Dry bulk density	15.7	770	774	870
Absorption of water	0%	16%	3%	13%
Shape	Spherical	Spherical	Irregular	Irregular

The Spherical shape of S1 and S2 with their production which involves sintering development and compressed into elected mass resulting in many size allocation up to 19 mm as illustrated in Figure 1. The denote size of these types shows nearly the same as S1, 9.8 mm and 10.1 mm correspondingly. The supposed size thickness tag was obvious 700 kg/m3 and the capacity in the lab are upper than 770 kg/m3 and 771 kg/m3 correspondingly. Thus, the two taster has sufficiently same as mean size and dry size density within S1 while their allocation and form is completely different. Inherently, it is collected of congested cell arrangement with low density. The structure of closed cell is then prevent water from absorbed inside the material. The bulk density in this work was chosen to be 34.9 kg/m3 and 15.8 kg/m3.

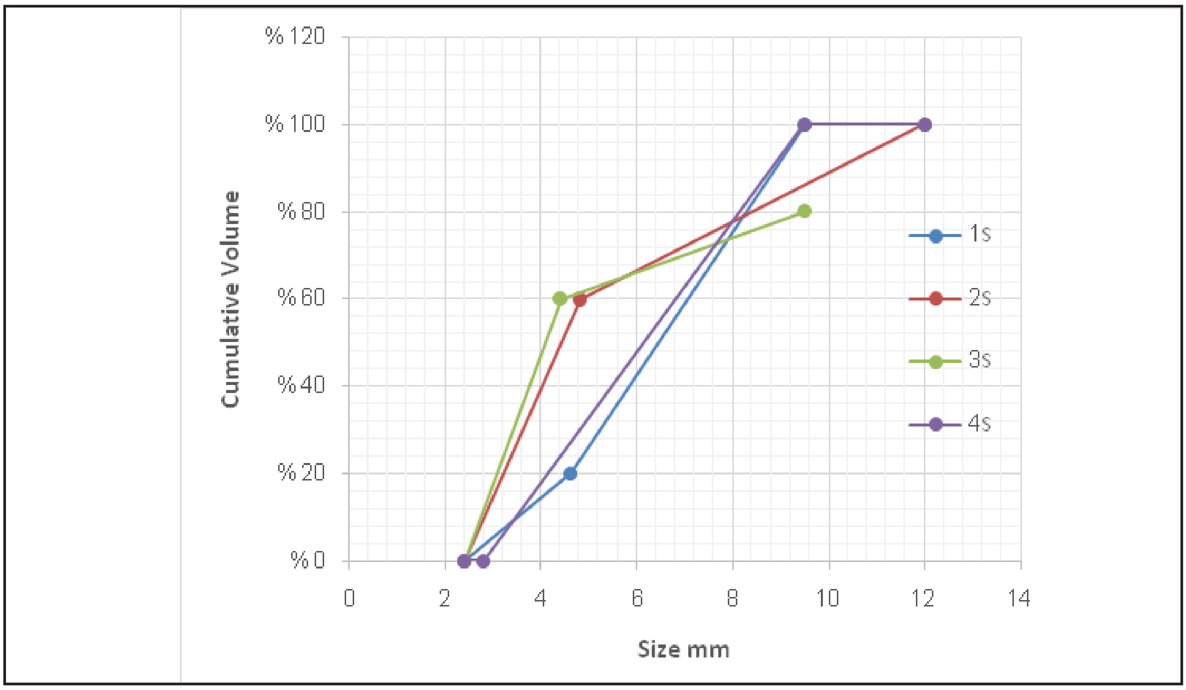

Figure 1. degree of LW aggregates.

The LW aggregate density and strength are administrated by raw material and the condition of production which has a sparse microstructure. The large pores numbers exist inside to produce lower density and strength with high absorption of water. The deep investigation inside LW aggregate and scanning electron to get microstructure images of aggregates cross section is achieved. From this investigation, a lot of macro and micro annulled in S1 were coarse consider which reduce the weight of this category and increase the quantity of irrigate absorption. The casing of S2, the indoors is diverse from other cases due to no macro pores with composed of circular comb cells. With large numeral of pores and fabric property create S2 low weight. In the case of S3 and S4, they contain lesser and low micro pores. Therefore, together cases have moderately large density. Table 3 illustrate the mix proportion of every sample be prepared in cylinder of height of 200 mm and 100 mm diameter. The relative humidity has maintained around 95%. The sample A1 is vibrated LWC viewing a slouch of 155 mm to 220 mm. The LWC type SCC is represented by S6 with slouch stream of 625 mm. These two tasters are controlled a mix formed by traditional integration methods. This method is made by composed the cement and aggregates for dry mixing and adding the water to the mixture. By mixing material for 2 minute, the fine aggregate was combinative of washed sea sand with crushed sand is produced. The modulus of fineness, density and water absorption of fine aggregate is 2.5, 2.6 kg/m3 and 1.4% correspondingly. The coarse LW aggregate that used is drenched plane dehydrated for integration. The HRWRA (high range water reducing admixture) has been used for SCC taster S6 as poly carboxyl solid content was 20%. In addition, sample S1, S2, S3, and S4 be created by apply the multi stage casting techniques. No fine aggregate was used in all sample but an oven dried LW coarse aggregate has used.

Table 3: LWC mix proportion and water to cement ratio

Label	Water/cement	Water Kg/m^3	Cement Kg/m^3	Aggregate Kg/m^3	HRWRA Kg/m^3
A1	0.4	270	600	410	0000
S6	0.33	290	850	350	3.5
S1	0.4	230	560	690	1.7
S2	0.4	240	580	619	1.8
S3	0.4	250	580	770	1.8
S4	0.4	220	530	775	1.7

6. Multi Stage Casting Technique

To provide low density of LWC, a high volume fraction of LW aggregate should be maximized. This idea could **be achieved by multi stage casting technique as follow:**

a.Insertion the LW aggregate in the cast to create complete packing

b. Fill the interstitial annulled seats in the pattern grout

From Table 3, the mixing sequence of the samples is explained below:

a. The cast is overflowing with dehydrated LW aggregate

b. The cement grout was organized by five minutes distribution is dispense into cast pending totally fill the annulled absent among aggregate

c. The cement and water included in Table 3 correspond to cement grout to create 1m3 LWC.

d. Assume the oven dried LW aggregate is S1ample

e. Let the mix absorb water of about 16%

f. Decrease the water content as absorption correspond to Table2

7. Results and Discussion

Figure 2 shows the volume fraction factor of samples elements under test. As illustrated from this curve, the normal vibrate concrete A1 and S6 included similar aggregate of S1 sample. The LW aggregate consist of many pores within a minimum density and the volume fraction in this case could used to determine the unit weight of hardened concrete. In same time, the mixture S6 contain high fluidity and LW aggregate than the traditional mixture A1. The self compacting capability and fluidity of the mix is produced by using fine elements and

g. Make the water to cement ratio of sample S1 within 0.21 rather that initial value.

h. Hence, noted that, the Table 3 contents for weighting element materials based on the oven dried aggregate form and no effect were indicated of water per cement ratio in binding material

i. No fine aggregate for grout used in this work

j. Due to the internal gaps among LW aggregate, the fine aggregate in grout is limited and fine fillers will be more necessary in future study such as silica powder.

incorporating chemical admixture HRWR which increase the cement content and decrease the volume fraction in coarse aggregate. The resulting mixing design to produce LW contains low volume fraction and high unit weight of LW aggregate confirming that the LWC incorporate high quantity of LW aggregate. Hence, to decrease the unit weight of concrete, the volume fraction should be increase in the mixing process. The mixture of S1, S2, S3 and S4 in this study is produced by use suggested technique to maximize the volume fraction.

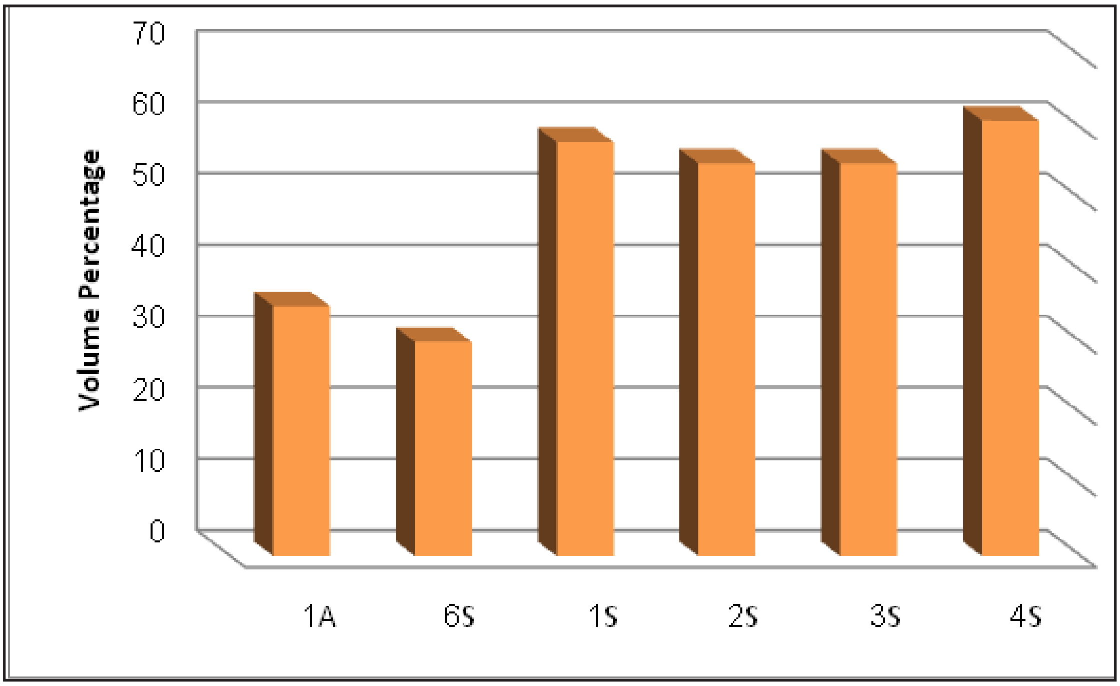

Figure 2: LW aggregate volume fraction in every sample

In the taster S1, the LW aggregate used packing density of 100 mm diameter by 200 mm height cylinder mold is 60% with same volume fraction. Additionally, the hardened density is 1.5 kg/m3 which are much less than that in A1. In the sample S2, much lighter concrete is used to produce lower density of LWC. In sample S3 and S4, the production used irregularly shape aggregate with graded size and packing density higher than mono size. Hence, S3 show same packing density of S4. The irregular form is used to avoid any decreasing of void gaps inside the cast. Hence, rating size decrease the void dimension among aggregate less than S3.

The density and compressive strength of concrete tasters with proportional trend between them of each material is investigated and examined. The concrete with low density had low strength also as showed by many other studies. The same LW aggregate has used in all samples of A1, S6 and S1. Within 30 days, the strength of all samples was found higher than S2 and the improvement in S3 and S4 is caused due to use of aggregate. From the other hand, the link aggregate of S3 and S4 could contribute to high strength with same irregular shape and size distribution in these samples. Within 28 day, the density and compressive strength were found less than 30 days test. The dynamic modules of S1, S3 and S4 according to ASTM are illustrated in Table 4 and Figure 3. To calculate the frequency of longitudinal and tensional resonance, a sum of 100 mm diameter and 200 mm height cylinders have been used. The elastic and active modulus of flexibility are

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Table 4: LWC dynamic modulus

Samples	Dynamic modulus GPa		Resonance Frequency kHz	
	Young	Shear	Longitudinal	Tensional
S1	13	5	7.5	5
S3	18	8	9	5.5
S4	15	6	8	15

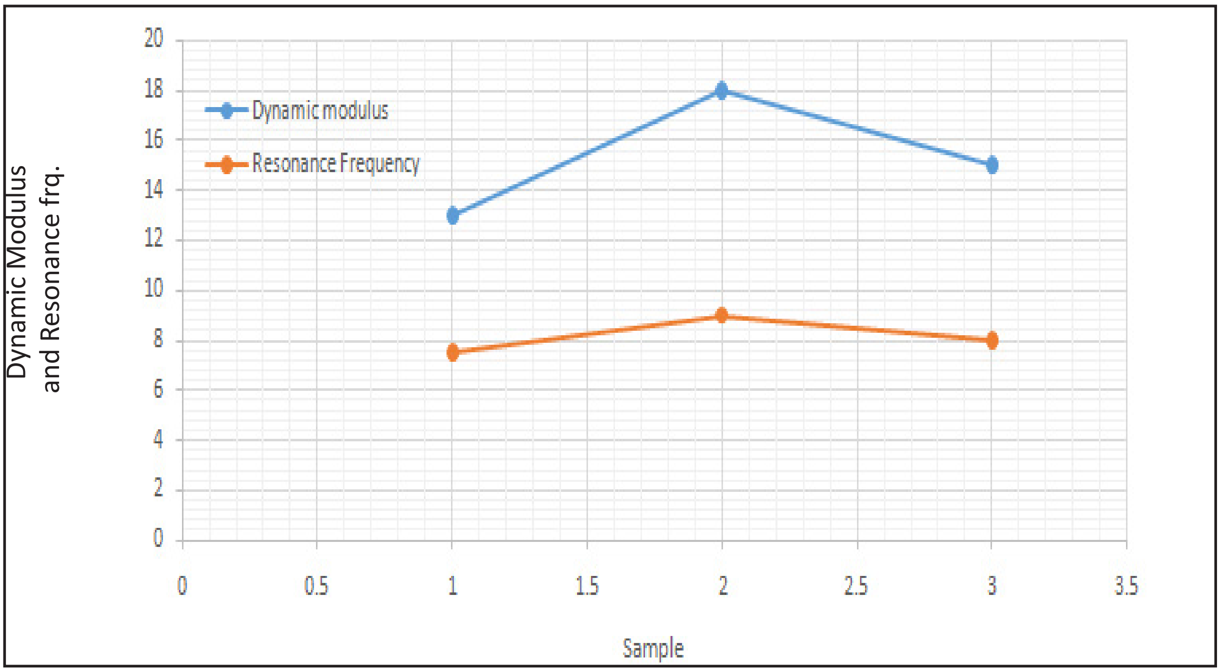

Figure 3: Dynamic Modulus and resonance frequency of each sample

1. Conclusion

In any production of LWC by traditional methods, one should take into account the work ability and aggregate separation of the new mixture. Hence, traditional mix techniques are restricted by retainable volume fraction of LW aggregate and as a result, the attainable lowest density of LWC is restricted also.

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