International Journal of Latest Engineering and Management Research (IJLEMR)
ISSN: 2455-4847
www.ijlemr.com || Volume 03 - Issue 02(S) || PP.60-67

Experimental Study on Light Weight Concrete by Ceramic Waste

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Abstract: This paper investigate the prospect of utilization of the ceramic wastes (CW) such as coarse and fine aggregate in lightweight aggregate concrete (LAC) that is consequence of coarse aggregate material (CAM) substitute with CW and consequence of biscuit substitute fine aggregate material (FAM) on properties of LAC. The composition of ordinary Portland cement (PC): FAM: CAM are 1: 2.21: 3.03 and substituted CAM with CW and FAM with biscuit at the levels of 0, 25, 50, 75 and 100 wt.%. All conditions of LAC was subjected to tested water absorption, thermal conductivity and unit weight at the age of 28 day. The compressive strength at 7, 14, 28 and 56 days was also conducted. The results show that when proportion of CW is increased then density and compressive strength decreased but the water adsorption and thermal conductivity increased. After 28 days, the sample with 100% CW compressive strength and bulk density has reduced from 55.4 to 11.4 MPa and 2394 to 1362 kg/m3. On the other hand 50 wt. % gave the compressive strength and density of 38.1 MPa and 1803 kg/m3 respectively. 50% mix was collected for study with biscuit replaced FAM on mechanical properties. The compressive strength improved when levels of biscuit increased for 50 wt. % were as decreased with excess 50 wt. %. The bulk density and thermal conductivity dropped from 1803 to 1584 kg/m3 and 0.689 to 0.592 W/m°K. The optimum configuration that meet the ASTM C330: standard range for structural lightweight aggregate concrete has t contain 50 wt. % of CW and 100 wt. % of biscuit.

Keywords: lightweight aggregate concrete (LAC), ceramic wastes (CW). Coarse aggregate material (CAM)

I. Introduction

Lightweight concrete (LWC) outlined as a sort of concrete that contains of AN increasing agent that will increase the degree of the mixture that is lighter than the standard concrete.. USA, uk, Sweden, etc has been wide exploitation LWC. The LWC has denseness and thermal conduction. Reduction of load, quicker building rates in construction and lower transport and handling prices square measure blessings of LWC. Light-weight mixture concrete may be shaped employing a vary of light-weight aggregates from natural materials, thermal treatment of natural raw materials, by-products from industrial. Volcanic rock, clay, slate, shale, fly ash, feather palm shell ash, biscuit ceramics, bottom ash etc. were used be light-weight mixture in concrete [1]-[6]. the specified engineering properties of LWC can have a sway on the most effective style of light-weight mixture to use. it's a touch structural, however high thermal insulation properties, square measure required a light-weight, weak mixture may be used. The LAC have AN air dry density not exceptional 2000 kg/m3, however may be as low as four hundred kg/m3 reckoning on the materials used and therefore the compressive strength will vary between one and sixty five MPa [7]. The LAC was usually being designed in accordance with ACI 213R-04 [8].

The environmental problems square measure important and anxious in industrial sector. The small, medium and huge industrials turn out pollution akin to water, air, solid, risky and noise. In ceramic industries, they're the one in all industries that generates solid wastes from method akin to biscuit, deteriorated operating mould etc. The biscuit is defected final product akin to ceramic ware, or unglazed ceramic ware, typically known as terracotta, or, most typically, A negotiator stage in a very glazed final product. The operating moulds square measure drop before expiration or deterioration. From the ministry of business (Thailand) found that the number of deteriorated operating mould is quite 38,000 tons/year [9]. Generally, the management of operating mould waste will utilized in varied manufacture business akin to cement business, the mineral is additional into a clinker concerning 3-5 wt.% of cement weight and created the ceiling that it's utilized in little quantities. Additionally, the ceramic production has broken ceramic wastes concerning five-hitter of ceramic product. Each most operating mould and biscuit square measure drop or land crammed that square measure inappropriate strategies.

It increasing the chance of chemical element compound gas and Causes the worldwide warming. From the property of CW and biscuit that have a lower density than traditional coarse and fine mixture. it's presumably replacement of CAM and FAM This analysis study the optimum quantitative relation of light-

weight mixture concrete with deteriorated operating mould (CW) and biscuit as mixture The compressive strength, bulk density, water absorption and thermal conduction of LAC were investigated. LWC outlined as a sort of concrete which has AN increasing agent therein it will increase the degree of the mixture. it's lighter than the standard concrete that was under 800 kg/m3. The utilization of LWC has been wide unfold across countries akin to USA, uk, Sweden, etc. The LWC square measure denseness and thermal conduction. Therefore its blessings square measure that there's a discount of load, quicker building rates in construction and lower transport and handling prices.

LWC maintains its massive voids and not forming laitance layers or cement films once placed on the wall. LWCs will either be light-weight combination concrete, foamed concrete or autoclaved aerated concrete (AAC). LWC blocks square measure usually utilized in house construction. Light-weight combination concrete will be made victimisation kind of light-weight aggregates. Light-weight aggregates originate from either natural material, thermal treatment of natural raw materials, by-products from industrial. Volcanic rock, clay, slate, shale, fly ash, feather palm shell ash, biscuit ceramics, bottom ash etc. were used be light-weight combination in concrete [1]-[6]. The desired engineering properties of LWC can have an impression on the most effective sort of light- weight combination to use. It's a touch structural, however high thermal insulation properties, square measure required a light-weight, weak combination will be used. The LAC have associate air dry density not prodigious 2000 kg/m3, however will be as low as400 kg/m3 reckoning on the materials used and also the compressive strength will vary between one and sixty five MPa [7].The LAC was typically being designed in accordance with ACI 213R-04 [8].The environmental problems square measure necessary and curious about industrial sector. The small, medium and huge industrials generate pollution resembling water, air, solid, risky and noise. In ceramic industries, they're the one among industries that generates solid wastes from method resembling biscuit, deteriorated operating mould etc. The biscuit is defected final product resembling ceramic ware, or unglazed ceramic ware, usually referred to as terracotta, or, most ordinarily, associate treater stage in an exceedingly glazed final product. The operating moulds square measure drop before termination or deterioration. From the ministry of business (Thailand) found that the number of deteriorated operating mould is quite thirty eight, 000 tons/year [9]. Generally, the management of operating mould waste will utilized in numerous manufacture business resembling cement business, the mineral is accessorial into a clinker concerning 3-5 wt.% of cement weight and created the ceiling that it's utilized in tiny quantities. Additionally, the ceramic production have broken ceramic wastes about5% of ceramic product. each most operating mould and biscuit square measure drop or land crammed that square measure inappropriate strategies. It increasing the danger of atomic number 1 chemical compound gas and CAM uses the worldwide warming. From the property of CW and biscuit that have a lower density than traditional coarse and fine combination. it's probably replacement of CAM and FAM in animal product. This analysis study the optimum quantitative relation of light-weight combination concrete with deteriorated operating mould (CW) and biscuit as combination the compressive strength, bulk density, water absorption and thermal physical phenomenon of LAC were investigated.

Chemical content	CW (% by dry mass)	Biscuit (% by dry mass)
SO3	54.5	–
CaO	45.0	0.23
SiO2	0.162	67.90
SrO	0.112	–
Fe2O3	0.055	0.49
Al2O3	0.047	27.92
MgO	0.044	0.16
Na2O	0.033	0.40
Cl	0.031	–
K2O	0.010	2.81
CuO	0.008	-

The CW and biscuit during this analysis were obtained from ceramics production method and grounded into tiny items of concerning 4.75 to nineteen metric linear unit for CW as CAM and 0.075 to 4.75 mm. for biscuit as FAM. Fig. one showed each ceramic wastes compared with crushed stone and watercourse sand. The chemical properties of the CW and biscuit shown in Table I. The operating mould consisted primarily of SO3 and fabric since its matter of calcium sulphate hydrate or mineral that created the operating mould. Major chemical composition of biscuit is SiO2 and Al2O3. The physical properties of wastes

ceramics showed in Table II. each CW and biscuit have the precise gravity, bulk density and fine modulus less than compared with CAM and FAM. The crushed stone and watercourse sand as coarse and fine combination. The physical properties of each combination showed in Table II. Additionally, standard cement (PC) was used as binder that has relative density of three.

Physical Properties	Coarse Aggregates		Fine Aggregates	
	CW	Crushed stone	Biscuit	River Sand
Specific gravity	1.78	2.58	2.16	2.4
Apparent density(kg/m3)	1772	2572	2236	2542
Bulk density (kg/m3)	1016	2542	2156	2402
Water absorption, 24 hr. (%)	41.27	0.5	5.79	3.68
Fine modulus	2.44	2.17	2.77	2.83

A. Combine Proportions

This paper investigated the results of replacement of operating mould and biscuit as coarse and fine combination on the engineering properties of product. Combine proportion of LAC was 1: 2.21: 3 that is meant in according the yank Concrete Institute (ACI211.1). The primary half study the result of levels of CW so as to interchange the coarse combination at the degree of zero, 25, 50, 75 and 100 wt. % of gravel and investigated the compressive strength, bulk density and water surface assimilation. The second half study collect the optimum magnitude relation of LAC and studied the substitution of biscuit at levels of zero, 25, 50, 75and 100 wt.% of sand on the engineering properties. All combine proportions are showed in Table III.

MIX (GRAVEL:CW)	OPC:FA(BISCUIT:):CA W/C
Control	1: 2.21: 3.03(100:0) 0.62
WM-25	1: 2.21: 3.03(75:25) 0.68
WM-50	1: 2.21: 3.03(50:50) 0.73
WM-75	1: 2.21: 3.03(25:75) 0.75
WM-100	1: 2.21: 3.03(0:100) 0.78
WM-525	1: 2.21(25:75): 3.03 (50:50) 0.73
WM-550	1: 2.21(50:50): 3.03 (50:50) 0.77
WM-575	1: 2.21(75:25): 3.03 (50:50) 0.79
WM-510	1: 2.21(0:100): 3.03 (50:50) 0.80

The water content of all mixed used slump take a look at that was performed to evaluated the workability of the contemporary concrete in accordance with ASTM C143M-05 [10]. The controlled slump for all samples was eight to ten cm. The all specimens were solid in commonplace steel moulds with the dimensions of 150x150x150 metric linear unit of cubes. When 1st day, all samples were aloof from moulds and cured within the water.

The engineering properties corresponding to compressive strength, bulk density, water absorption and thermal physical phenomenon were investigated. Compressive strengths of LAC at seven, 14, twenty eight and fifty six days were tested in according with ASTM C39-15 [11] and ACI 213R-04 [12]. a group of 5 samples was used for compression testing at e ach natural action length and also the arithmetic average was taken. Bulk densities and water absorptions of LAC at twenty eight days were tested in according with ASTM C642-13 [13]. Additionally, the optimums of LAC were collected to research the thermal physical phenomenon exploitation start up methodology following ASTM C1113-04 [14].

II. Results and Discussion

Fig. 1 show the compressive strength of LAC substitution the gravel with CW. Increasing level of replacement of CW resulted in reduction of compressive strength. At 28-day compressive strength of the traditional concrete was 55.4 MPa and faded to 11.4 MPa, once CW was side one hundred wt.% of gravel. The compressive strength of all LAC the concrete incontestable a decreasing tendency with increasing the proportion of CW content. Compared to the traditional concrete, replacement of CW in concrete reduced the compressive strength concerning twenty three to seventy nine compared with traditional concrete. This was reason for surface assimilation of CW combination (about forty-one wt.%) that's ready to absorb mix water over crushed stone (about zero.5 wt.%) and resulted in water to cement quantitative relation of LAC[15]. when mix, some water was wont to react with normal hydraulic cement to supply association product whereas remained water in pore was gaseous that resulted in pore in matrix. it absolutely was reason for reduction of compressive strength of animal product. At 100 wt.% of CW replaced in LAC get the compressive strength was under seventeen MPa that failed to still within the commonplace vary for structural light-weight combination concrete (ASTM C330)[16].

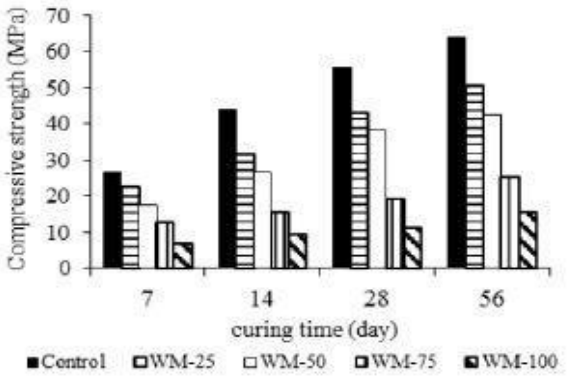

Fig. 1. Compressive strength.

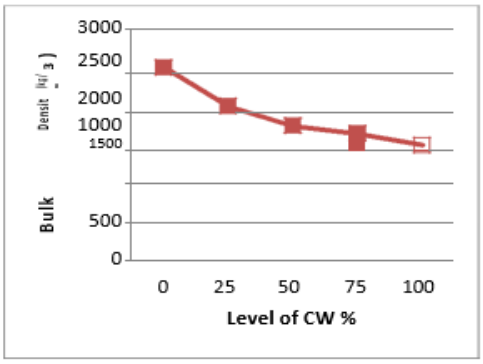

Fig. 2. Bulk density and share of reduction of LAC at twenty eight days.

In addition, increasing of the extent of replacement of CW in LAC accomplished to reduction of density (Fig. 2). This was caused of skyrocketing of water to cement quantitative relation that leaded to high body in LAC matrix. The W/C of traditional concrete was 0.62 and exaggerated to 0.78 with one hundred wt.% of DMW were replaced in combine. it absolutely was reason for a diluted cement concentration in paste that was reason for cracking and shrinkage when cement paste set. The high shrinkage and high exceed water of concrete ends up in micro-cracks, that ar zones of weakness [15]. Additionally, increase of substitution of CW resulted within the reduced the majority density of LAC attributable to density of CW is under a crushed stone that concerning (2.58 to 1.78) that show Table II. At 28 days, the majority density of traditional concrete was 2394 kg/m3 and faded to 2030, 1803, 1757 and 1362 kg/m3 once the extent of replacement of CW exaggerated from twenty five to one hundred wt.%. Compared to the traditional concrete and WM-100, the majority density faded forty three you make sure that showed in Fig. 3. The many researches [5], [17]-[20] reportable that use of lighter materials replaced traditional combination will cut back the density of concrete. It absolutely was Cause from the foremost of light- weight combination is high porous materials that increase the degree of pore in LAC [15]. In step with Bakri et al. [6] reportable that level of replacement of ceramic wastes in concrete reduced the density and exaggerated w/c quantitative relation. the rise of water absorption of all LAC trusted levels of CW that were showed in Fig. 3. The water absorption of LAC exaggerated from 2.49% to 16.33% once the CW loading exaggerated from zero to one hundred wt.%. The water absorption of LAC with one hundred wt. % of CW was more than and controls concrete concerning half dozen.5 times. it absolutely was reason for high water surface assimilation of CW (41.21%). Lo et al. [20] reportable that the water absorption of concrete exaggerated once the extent of light-weight combination exaggerated. the rise of the light-weight combination loading exaggerated the void and also the share of pore space within the LAC that was CAM used of reduction of strength and density however increase of waster surface assimilation. The high water surface assimilation of LAC influenced to surface zone of light-weight combination concrete. This was reason for reduction of the cohesion between CW and cement paste as a result of the surplus water coated the surface of combination that protected the cement paste. It created the gap between combination and cement paste.

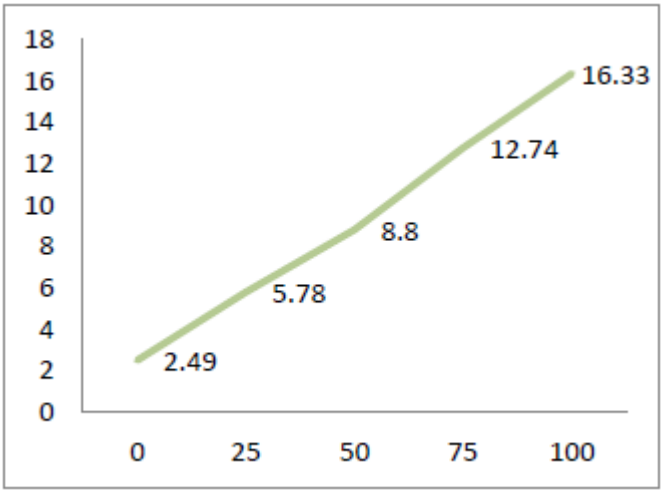

Fig. 3. Water adsorption of LAC at 28 days. X axis level of CW% y axis water absorption%

B. Impact Biscuit as Fine mixture on Engineering Properties of LAC

The optimum quantitative relation of LAC was discovered in fifty wt. % of DWC that have the compressive strength bulk density and water absorption meet the ASTM C330-14. Therefore this analysis studied the impact of levels of biscuit substitution the fine mixture on mechanical properties. The extent of biscuit replaced fine mixture at zero, 25, 50, 75 and 100 wt. % were studied during this topic. The compressive strength of the LAC with varies levels of biscuit are conferred in Fig. 4. This compressive strength enhanced from 38.1 to 43.9 MPa with increasing of biscuit from zero to fifty wt. %. Attributable to biscuit is one in all ceramic kind and have high strength. Once it absolutely was crammed in pore of LAC and cause increase of compressive strength. Additionally, biscuit have quantity of little size (less than three millimeter concerning forty nine wt.%) that was over sand. It will fill in pore of LAC that enhanced the compressive strength. At levels of biscuit of seventy five and one hundred wt. % were adscititious in concrete reduced the compressive strength from 43.9 to 23.4 MPa. it's potential that the high levels of biscuit enhanced the water to cement quantitative relation that enhanced from 0.73 to 0.80 and cause reduction of strength [18], [19]. Fig. five

shows the link between levels of biscuit and also the bulk density of LAC containing 50wt.% CW. The reduction of bulk density of LAC was found once the amount of biscuit replacement increase. At twenty five and fifty wt.% of biscuit, the majority density of LAC very little bated from one803 to 1784 and 1776 kg/m3 that reduced concerning 1.1 and 1.15% compared LAC while not biscuit. the limited reduction of bulk density results from the particular gravity of biscuit (2.16) was under sand (2.4) concerning ten. This results connected with the rise of compressive strength of LAC with CW containing twenty five and fifty wt. % of biscuit. Additionally, the water to cement quantitative relation of each mixed (0.73 and 0.77) were under LAC containing seventy five and one hundred wt. % of biscuit (0.79 and 0.80). the majority density of LAC with fifty wt.% CW containing seventy five and one hundred wt.% of biscuit have 1698 and 1585 kg/m3 that bated concerning 5.9 and 12.1% compared with sample no biscuit. The proportion of reduction of bulk density enhanced because of the number of biscuit and water to cement quantitative relation in mixes enhanced. This cause reduction of compressive strength. The water absorption of the LAC with fifty wt. % CW containing distinction levels of biscuit are showed in Fig. 6. Poon and Lam [21] reported that the number of water absorption enhanced because the levels of mixture replacement enhanced. The water absorption on LAC enhanced from 8.08 to 8.84, 10.2, 11.59 and 13.22 % when the amount of biscuit loading enhanced from zero to one hundred wt.%. the rise of a bit water absorption results from addition of biscuit to substitute realize mixture. It had water absorption at twenty four hour. of biscuit concerning five.79% that was over sand (3.68%).

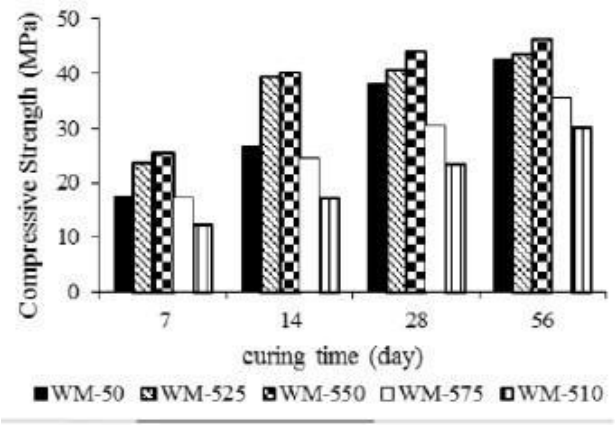

Fig. 4. Compressive strength of LAC containing fifty wt. % of CW with distinction levels of biscuit replaced FAM.

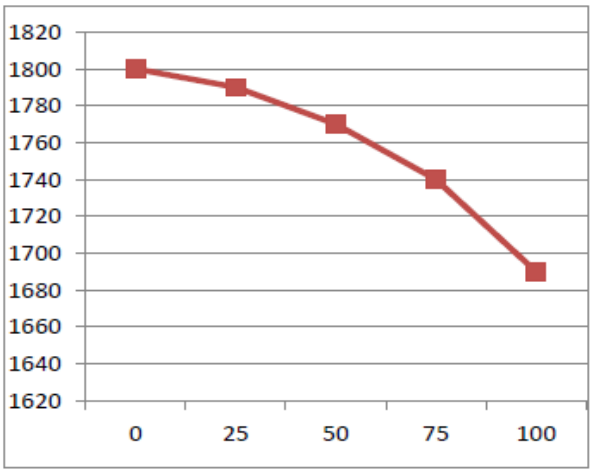

Fig. 5. Impact of levels of biscuit on bulk density of LAC containing fifty wt. % of CW with distinction levels of biscuit replaced FAM. X axis levels of biscuit% y axis Bulk density kg/m3

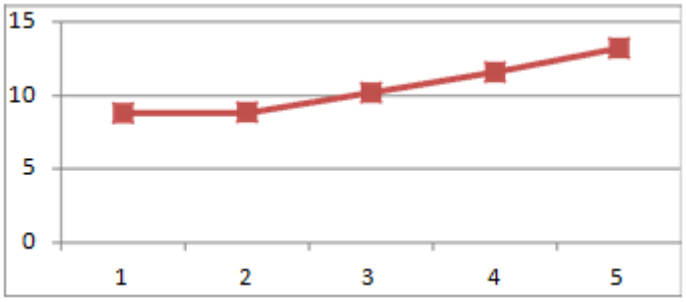

Fig. 6. Impact of biscuit loading on water sorption of LAC with fifty wt. % CW. X axis levels of biscuit% Y axis absorption %

C. Thermal physical phenomenon

The normal concrete, LAC with fifty wt.% of CW containing zero and one hundred wt.% of biscuit were collected to review thermal physical phenomenon properties that showed in Table four. The results of the thermal physical phenomenon and density at 28-days of traditional concrete was 1.201 W/m°K and a pair of, 395 kg/m3. When 50 wt.% of CW was adscititious into animal product, the thermal physical phenomenon bated to 0.689 W/m°K. it absolutely was reason behind the properties of CW that have mineral as major composition and porous material. CW at fifty wt.% into LAC bated the thermal physical phenomenon concerning forty two compared with traditional concrete. Additionally, thermal physical phenomenon and density bated to 0.592 W/m°K and 1,584 kg/m3 once one hundred wt.% of biscuit was adscititious in LAC containing fifty wt.% CW. The reduction of thermal physical phenomenon of LAC resulted from properties CW and biscuit as light-weight mixture.

III. Conclusion

The experimental results showed that the compressive strength, bulk density and thermal physical phenomenon bated however water absorption bated once the extent of CW and biscuit loading enhanced. The optimum quantitative relation of LAC with ceramic wastes that meet the ASTM C330 was concrete replaced coarse mixture with fifty wt.% of CW and fine mixture with one hundred wt.% of biscuit. it absolutely was compressive strength, bulk density, water absorption and thermal physical phenomenon of 23.4 MPa, 1584 kg/m3, 13.22% and 0.592 W/m° that meet to the ASTM C330 normal for structural light-weight mixture concrete.

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