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Original Paper

Using Different Types of Concrete to Produce Lightweight Bricks

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Abstract

The usage of Light Weight Concrete Bricks(LWCB) gives a prospective solution to building construction industry. efforts has been made to study the behavior of concrete bricks by taking different proportions of fly ash, cement, Rubber, Addipor, Dolomite, lime, gypsum, sand and aluminum powder. This research was conducted to find out the physical and the mechanical properties of the mixes which included different percentages of the different constituents. The aim of experimental work carried out in this paper was to investigate the following items,Effect of using waste rubber as a replacement of aggregate on the physical and mechanical properties of concrete.
Study effect of using fly ash as a replacement of aggregate on the physical and mechanical properties of concrete. The sulfate resistance, fire effect for Lightweight Concrete Bricks (LCB). This paper includes the details of the experimental work carried out on the material used, design of concrete mixes, mixing procedures, preparation of concrete test specimens and used test devices.

Keywords: Lightweight concrete bricks, Rubber, Addipor, Fly ash.

1. Introduction

Manufacturing of commercial brick produce a lot of air pollution. The technology adopted for making. The lightweight concrete bricks are eco-friendly. It is no need fire operation in production unlike the conventional bricks Among the traditional fossil fuel sources, coal exists in quantities capable of supplying a large portion of nations energy need. Light Weight Concrete Bricks has become more popular in recent years owing to the tremendous advantages it over the conventional concrete. Many architects, engineers, and contractors recognize the inherent economies and advantages offered by these materials, as evidenced by the many impressive light weight concrete structures found today throughout the world [1]. Lightweight concrete bricks are made of fly ash, Rubber, Addipor, Dolomite, lime, gypsum cement, sand and aluminum powder. These can be extensively used in all building constructional activities similar to that of common burnt clay bricks [2]. Using Lightweight Concrete Bricks as a building material has assumed great significance like never before. Several investigations have been carried out throughout the world to make an attempted to use Lightweight Concrete Bricks in many civil engineering projects by virtue of its good properties as an ingredient of concrete[3]. Lightweight Concrete Bricks are comparatively lighter in weight and stronger than common clay bricks. Using Lightweight Concrete Bricks as a building material has assumed great significance like never before. The size and the amount of pores in the cellular concrete bricks depend upon the amount of the aluminum powder used [4-5]. The low density of cellular concrete is accompanied with reduced compression strength. It can sustain stresses up to 8 N/mm^2 [6].

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Cellular concrete has been shown to provide better sound insulation than conventional concrete and clay bricks under comparable conditions [7]. Extensive researches have been carried out regarding the physical and mechanical properties of lightweight concrete bricks with special attention to cellular concrete bricks as well as their applications [8-9].

2. Experimental Program

2.1 Materials Used

The materials used were obtained from local sources. These materials are described as follows:
Coarse Aggregates: Natural gravel from Suez Zone was used as coarse aggregate. The gravel has a nominal maximum size of 3/4 inch (19mm). The particles were smooth in texture with 70 percent of them cubical in shape and the rest were of angular shape. The grading curve of the gravel used is shown in Table (1).
Fine Aggregate (Sand): Natural siliceous sand from El-Khatatba, Menoufia governorate, was used as fine aggregates. Its characteristics satisfy the Egyptian Code E.C.P. 203/2007. The grading of the sand used is shown in fine aggregate are given in Table (2).the physical and mechanical properties of fine aggregate are given in Table (3).

Table 1. Grading for sand according to E.C.P.(203/2007) and grading of natural sand used

Sieve size(mm)	9.5	4.75	2.36	1.18	0.61	0.31	0.16
%Passing used sand	100	100	94	80	50	15	0
%Passing (ASTM C33)	100	95-100	80-100	50-85	25-60	5-30	0-10

Table 2. Physical and mechanical properties of used sand

Description	Value
Volume weight	1.73 t/m^3
Specific gravity	2.64
Fineness modulus	2.61
Voids ratio	33.81
Absorption%	0.78

Cement: The cement used was the ordinary Portland cement, which was provided from the Suez factory. Its chemical and physical characteristics satisfy the Egyptian Standard Specification E.S 373/2007. The properties of the cement used were illustrated in Table (2).

Table 3. Mechanical, physical and chemical properties of the cement used

Test description	E.S. 373/2007 Specification limits	Test results
Specific gravity	---------------	3.15
Setting time (Vicat test) * Initial * Final	Not less than 45 min. Not more than 10hr.	hr : min 1 :20 5 :30
Percentage of water to give a paste of standard consistency W/C %	-----------------	27%
Fineness of cement, percentage retained on the standard 0.09mm sieve by weight,	Not more than 10%	7%

Lime: It is Locally Commercially produced.
Fly Ash: Fly ash (produced from bituminous coal) provided by Duquesne Light-Cheswick. Power station, conforming to ASTM specification C618 [10].
Aluminum Powder: Meeting the requirement of ASTM specification D 692 [11].
Water: Tap water without taste, smell, color, or turbidity was used for mixing and curing the cellular concrete bricks product.
Clay Bricks: Varying colour as per soil, Uneven shape as handmade, Heaving in weight, Compressive strength is around 35 kg/Cm^2 and water absorption 25%.

2.2 Procedure of Mixing

For Rubberized Concrete Bricks : Charging sequence was coarse aggregate, fine aggregate, and rubber, the size of the rubber shown in Fig.(1). After 5 minutes from starting time, the cement was added while the mixer was still rotating, and after 2 minutes from the placing of cement, mixing water is added to the mix gradually. The mixer is still rotate after adding water for 5 minutes to insure the full mixing of the rubberized concrete. The concrete was charged out from the mixer bowl, the unite weight, the slump test and compaction factor are measured. The concrete was then placed in molds and compacted as shown in Fig.(2).

Figure 1. The shape and the size of rubber particles

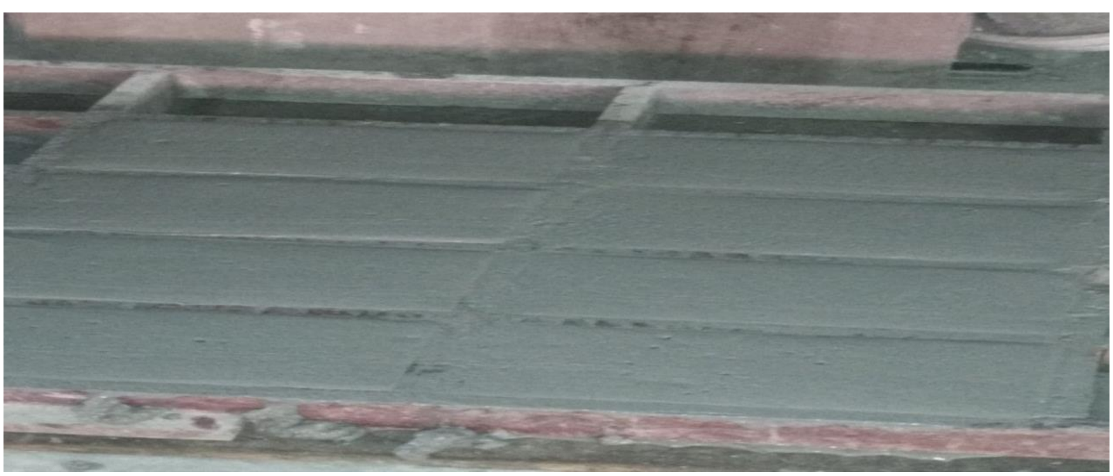

Figure 2. Rubberized concrete bricks when casting in molds

For Cellular Lightweight Concrete: Bricks The mixing process consisted of steps. First, the aluminum powder was mixed with cement using a stir bar. In order for the aluminum powder to disperse into the water quickly, a liquid dish soap (used as a surfactant) was added to the aluminum slurry during mixing. In the second step, fly ash was fed into the mixer where it was mixed with water, cement and lime where added to the mixer next and the slurry was mixed with a high mixing speed. Thirdly, the dispersed aluminum slurry was added to the mixer and the CLCB slurry was mixed approximately one minute in order to make a homogeneous slurry as shown in Fig. (3). The Cellular Lightweight Concrete Bricks (CLCB) slurry was then ready to cast into the wood mold and Fig. (4) show the shape of Aluminum Powder.

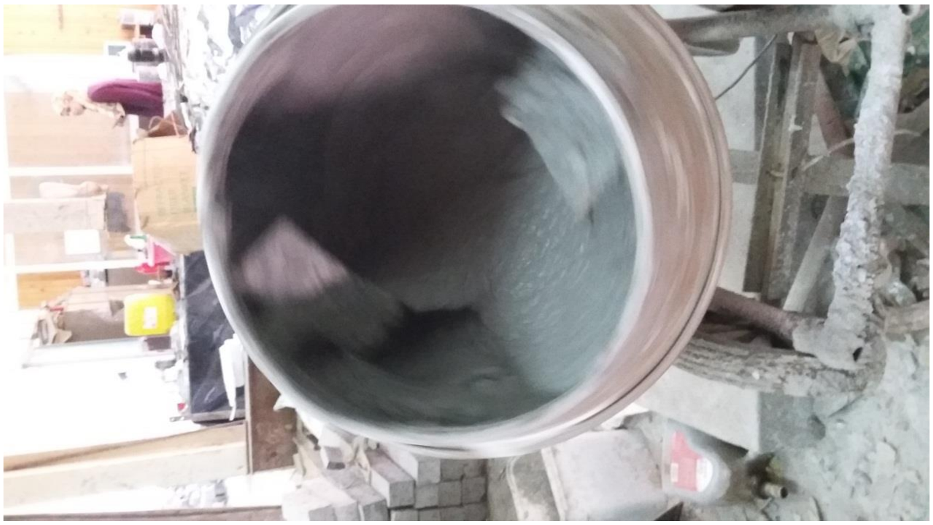

Figure 3. Show mixing mixtures

Figure 4. The shape of aluminum powder

Before casting the Cellular Lightweight Concrete Bricks (CLCB) mixture, the wood molds were cleaned and oiled with an appropriate mold releasing oil in order to ensure easy demanding. The CLCB mixed slurry was then poured into wood molds. The height of the slurry within the molds was kept constant the height of the mold. As a result, the slurry rose and filled up the mold. The slurry was completely raisin within 30 minutes. The Bricks when casting in molds shown in Figure (5).

Figure 5. The bricks when casting in the molds

For Lightweight concrete Bricks by Using Addipor: Charging sequence was coarse aggregate, fine aggregate, and Addipor. After 5 minutes from starting time, the cement was added while the mixer was still rotating, and after 2 minutes from the placing of cement, mixing water is added to the mix gradually. The mixer is still rotate after adding water for 5 minutes to insure the full mixing of the Addipor concrete. The concrete was charged out from the mixer bowl, the unite weight, the slump test and compaction factor are measured. The concrete was then placed in molds and compacted.

2.3 Concrete Mixes

Trial mixes were designed and prepared in order to establish the basic range of mixes for this study As shown in Groups (1,2,3,4 and5).

Group (1):Cellular concrete bricks

Mix. Code	Cement	Fly ash	Lime	Gypsum	Aluminum powder/Cement%	Water
CF1	250	200	250	7.5	3%	125
CF2		300			3%	256
CF3		400			3%	370
CF4		500			3%	560
CF5		500			6%	1160
CF6		500			3%	605
CF7		500			6%	605

CF=Cement and Fly ash

Group (2):Cellular concrete bricks

Mix. Code	Cement	Fly ash	Sand	Lime	Gypsum	Aluminum powder/cement%	Water
CFS1	250	250	250	415	26	2%	270
CFS2		250	250			3%	590

CFS=Cement, Fly ash and Sand

Group (3): Cellular concrete bricks

Mix. Code	Cement	Sand	Lime	Gypsum	Aluminum powder/cement%	Water
CS1	250	500	415	26	2%	196
CS2		500			3%	285

CS=Cement and Sand

Group(4): Lightweight concrete bricks using rubber

Mix. Code	Cement	Sand	Rubber	Dolomite	Water	Replacement of Rubber
CRD1	400	600	50	1350	200	20%
CRD2			145	835	200	40%
CRD3			290	506	200	60%
CRD4			450	450	200	80%
CRD5			540	Zero	200	100%

CRD=Cement, Rubber and Dolomite

Group (5): Lightweight concrete bricks using addipor

Mix. Code	Cement	Sand	Addipor	Dolomite	Water
CDA1	450	900	20	910	205
CDA2		900	40	250	245

CAD=Cement, Dolomite and Addipor

3. Testing and Testing Results

3.1 Physical Properties

3.1.1 Unit Weight

The red and lightweight concrete bricks were dried and weight. These were then immersed in water for 24 hours and then weighted again as shown in table(4).

The unit weight of Lightweight concrete bricks was measured for the fresh concrete directly after mixing. In group (1), The unit weight of cellular concrete bricks investigated for the different proportion of aluminum powder. The unit weight reaches its minimum value when 6% of aluminum powder was used in Mix. (CF5) comparing with conventional bricks (CB). The unit weight of cellular concrete bricks is assumed an advantage for the concrete application to reduce the dead loads, the strength of the cellular concrete decreases with the reduction in the unit weight. The Mix (CFS2) gives acceptable value in group (2) .The Mix.(CS2) gives minimum and acceptable value of unite weight in group(3).The Mix. (CRD5) gives best value of unite weight in group (4).The Mix (CDA2) gives the minimum value in group(5) comparing with(CB). In general the Mixes.(CF3,CF5,CF7,CRD5,CDA2)give the best value of unite weight comparing with conventional bricks.

Table 4. Relation between cellular concrete bricks mixes and unites weight

Groups	Mix. Code	Unite Weight (Kg/m^3)
Group1	CF1	480
	CF2	530
	CF3	560
	CF4	590
	CF5	440
	CF6	540
	CF7	490
Group2	CFS1	790
	CFS2	750
Group3	CS1	1000
	CS2	920
Group4	CRD1	1140
	CRD2	1060
	CRD3	880
	CRD4	750
	CRD5	620
Group5	CDA1	1020
	CDA2	620

3.1.2 The Slump Test

Tests were carried out using a metal mold in the shape of a conical frustum known as a slump cone. Cone is placed on a hard non- absorbent surface. This cone is filled with fresh concrete in three stages. The mold is carefully lifted vertically up wards with twisting motion, so as not to disturb the concrete cone. The concrete then subsides as shown in Fig, (6). This subsidence is temed as slump and the results are shown in Table (5). It is shown from the table that the Mix.(CF5 and CF7) gives minimum value of slump in group(1), The Mix.(CFS2) gives acceptable value of slump in group(2), The Mix.(CS2) gives minimum value in group(3),The Mix.(CDR5) gives the best value of slump in group(4) and in group(5) the Mix.(CDA2) gives the minimum value of slump. In general the mixes.(CF5,CF7,CDA5 and CDA2)give the best value of Slump comparing with (CB).

Figure 6. The slump test

Table 5. The value of the slump test

Groups	Mix. Code	Slump(cm)
Group1	CF1	6.8
	CF2	7.0
	CF3	7.8
	CF4	8.5
	CF5	8.5
	CF6	5.0
	CF7	3.0
Group2	CFS1	7.0
	CFS2	6.0
Group3	CS1	9.0
	CS2	7.0
Group4	CRD1	9.0
	CRD2	7.0
	CRD3	8.0
	CRD4	8.5
	CRD5	6.0
Group5	CDA1	7.0
	CDA2	4.0

3.1.3 Water Absorption

The water absorption of the different samples under investigation is given in Table (6). The test procedure was carried out according to ASTM C-127[10]. The table shows that, the water absorption increases with the increasing of the percentage of the fly-ash and aluminum powder increased, in group (1) the minimum value of absorption was in Mix.(CF1 andCF3) comparing with (CB), The Mixes.(CFS1 and CFS2) gives un acceptable value of absorption in group(2), the Mix.(CS1) gives acceptable value of absorption in group(3) comparing with (CB), Mix.(CRD5) in group (4) was the best in the water absorption and give acceptable unite weight according to light weight concrete standard B),). In general the Mixes.(CF1, CRD5, CDA1) give the best value comparing with conventional bricks.

Table 6. Value of water absorption

Groups	Mix. Code	Absorption%
Conventional Bricks		25%
Group1	CF1	29%
	CF2	30%
	Cf3	29%
	CF4	33%
	CF5	35%
	CF6	32%
	CF7	34%
Group2	CFS1	38%

	CFS2	33%
Group3	CS1	28%
	CS2	32%
Group4	CRD1	24%
	CRD2	30%
	CRD3	29%
	CRD4	24%
	CRD5	23%
Group5	CDA1	22%
	CDA2	23%

3.2 Mechanical Properties

3.2.1 Compressive Strength

Eighteen different lightweight concrete mixes were investigated to study the compressive strength of lightweight concrete bricks at 28 and 90 days. The tests were carried out on 6*12.5*25 cm according to ASTM C39-86 [11] as shown in Fig.(7). Table (7) shows the compressive strength of the investigated mixes at different ages comparing with conventional bricks (CB). In group (1) Mixes (CF1, CF2, CF3, and CF5) give bigger value of compressive strength and acceptable unite weight comparing with conventional bricks, the compressive strength increasing by (28.5%, 22.8%, 11.5%, and43.5%) respectively, comparing with the conventional bricks(CB). Mix.(CFS1) in group(2) gives acceptable value comparing with (CB) and the compressive strength increasing by(14.3%) comparing with (CB), all mixes in Group (3) give acceptable value of compressive strength but the weight were un acceptable, Mix.(CRD5) in group (4) was the best in the compressive strength and give acceptable unite weight according to light weight concrete standard. Mix.(CDA2) in group(5) gives compressive strength increasing by (8.6%) comparing with conventional bricks

Figure 7. Compressive strength test

Table 7. The compressive strength of the investigated mixes at different ages

Groups	Mix. Code	Compressive Strength(Kg/Cm^2)	
		28days	90days
Conventional Brick		35	35
Group1	CF1	40	45
	CF2	35	43
	CF3	32	39
	CF4	27	34
	CF5	44	50
	CF6	26	35
	CF7	20	31
Group2	CFS1	33	40
	CFS2	28	36
Group3	CS1	46	50
	CS2	48	62
Group4	CRD1	262	340
	CRD2	121	145
	CRD3	81	106
	CRD4	70	95
	CRD5	56	80
Group5	CDA1	48	55
	CDA2	39	38

3.3 Sulfate Resistance

Tests were carried out on (6*12.5*25) cm concrete bricks .The molds were kept in the laboratory conditions for 24 hours after casting and then dried in an oven at 100°C for the 48hrs until a constant mass was achieved. At the age of 28 days, the specimens were immersed completely in 20% magnesium sulfate solutions till the age of testing. The compressive strength at the ages of 3 months after exposure to a sulfate solution was compared with that of the specimens immersed in water until testing as shown in Fig.(8) and the results are shown in table. (8). the compressive strength of lightweight concrete bricks mixes increased after 3 months. The highest compressive strength was developed by Mixes. (CF1, CF2,CF3, CF4, CF5, CF6 and CF7) in group(1) and acceptable unite weight comparing with conventional bricks, the compressive strength increasing by (62.8%, 57%, 34.3%, 8.5%, 77%, 31.4%, and17%) respectively, , Mix. (CFS1) gives acceptable value in group(2) comparing with (CB) and compressive strength increasing by(57%) Comparing with (CB). The compressive strength of all Mixes in group (3) were acceptable but unit weight were un acceptable. Mix.(CRD5) in group (4) was the best in the compressive strength and give acceptable unite weight according to light weight concrete standard, and Mix.(CDA2) in group(5) gives compressive strength increasing by (40%) comparing with conventional bricks .

Figure 8. Lightweight concrete bricks mixes immersed in sulfate after 3 months

Table 8. Compressive strength of cellular lightweight concrete bricks mixes immersed in sulfate after 3 months

Groups	Mix. No	Compressive Strength(Kg/Cm2) Before exposure to sulfate	After exposure to sulfate
Group1	CF1	45	57
	CF2	43	50
	CF3	39	42
	CF4	34	38
	CF5	50	62
	CF6	35	46
	CF7	31	41
Group2	CFS1	40	60
	CFS2	36	40
Group3	CS1	50	55
	CS2	62	68
Group4	CRD1	340	360
	CRD2	145	200
	CRD3	106	160
	CRD4	95	140
	CRD5	80	115
Group5	CDA1	55	64
	CDA2	38	49

3.4 Effect of High Temperature

Nine specimens (6*12.5*25) cm cubes were prepared in order to study the effect of high temperature on the light weight concrete bricks. An electrical oven providing up to 1000°C is used for this purpose. The specimens were dried at a temperature of 100°C, for 24 hours, then the sample were kept for 2 hours in the furnace and exposed to gradually increasing temperature up to 600°C as shown in Fig.(9).The effect of high temperature on the compressive strength of lightweight concrete bricks is illustrated in table(10), The highest compressive strength was developed by Mixes.(CF1,CF2,CF3,CF4,CF5, CF6 and CF7) in group(1) comparing with conventional bricks, the compressive strength increasing by(57%, 37%, 31%, 29%, 71%, 29% and 14%) respectively. Mixes. (CFS1 and CFS2) give acceptable value in group(2) comparing with (CB) and compressive strength increasing by(40% and 29%) respectively Comparing with (CB), the highest compressive strength was developed by Mix. (CS2) in group(3) the compressive strength increasing by(94%), But Group(4) and group(5) were exposed to fired at 600^{0}c the rubber and addipor were burned, the smoke have bad smell, it's not recommended to be used in ovens contractures, or any other building exposed to high temperatures.

Figure 9. Effect of exposure to high temperature (600C°)

Table 9. Effect of exposure to high temperature(600c)for 2hr.on the concrete compressive strength of the tested mixes

Groups	Mix. No	Compressive Strength(Kg/Cm^2) Before exposure to high temperature	Compressive Strength(Kg/Cm^2) After exposure to high temperature
Group1	CF1	45	55
	CF2	43	48
	CF3	39	46
	CF4	34	45
	CF5	50	60
	CF6	35	45
	CF7	31	40
Group2	CFS1	40	49
	CFS2	36	45
Group3	CS1	50	56
	CS2	62	68
Group4	CRD1	340	-
	CRD2	145	-
	CRD3	106	-
	CRD4	95	-
	CRD5	80	-
Group5	CDA1	55	-
	CDA2	38	-

4. Conclusions

Out of this research study the following conclusion could be driven:

Cellular Concrete Bricks could be manufactured using a mixture of cement, lime, fly ash, sand, aluminum powder and water. Concrete density in the rang of 0.92 to 1.33 Kg/m^3 could have been achieved.

The density of Cellular Concrete Bricks is 68% less than that of standard clay bricks. This reduction in the weight of bricks results in a great deal of savings amongst which are saving in the raw materials and transportation costs and saving to the consumer, that result from increased number of units and reduction in the loads on structural element.

The unit weight of cellular lightweight concrete bricks less than of the ordinary concrete bricks4.

A study of the mixing shows that the highest compressive strength is in the Mix. (CF1) and the Mix. (CF5) in group1 when we increased ratio of fly ash and increased percentage of aluminum powder.

A study of mixing shows that the Mix (CF5) can used in buildings which exposed to sulfates.

A study of mixing shows that The Mix. (CRD5) in group 4 gives acceptable value of unite weight and compressive strength.

lightweight concrete bricks produced in this study seem to be suitable for use as construction material. The production of this type of bricks will certainly contribute to the recycling of the fly ash and hence minimize the negative impact of the fly ash land fills on the environment. On the other hand, the reduction in clay usage for the production of conventional clay bricks will help to protect the environment. Furthermore, the hazardous emissions from the clay brick burning kilns will be reduced. The considerably low volume weight and low thermal conductivity of the fly ash bricks will reduce the construction and heating/cooling costs of the buildings.

light weight concrete bricks are eco friendly as it protects environment through conservation of top soil and utilization of waste products of coal or lignite used in thermal power plants. It is three times stronger than the conventional burnt clay bricks. It plays a vital role in the abatement of carbon dioxide a harmful green house gas mass emission of which is threatening to throw the earth's atmosphere out of balance. Being lighter in weight as compared to conventional bricks, dead load on the structure is reduced and hence saving is overall coast of construction.

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