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Study of The Mechanical and Absorbent Properties of Lightweight Concrete (Foam Concrete) Reinforced with Waste Fillers

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ABSTRACT

This research included the production and study of the mechanical properties (compression resistance), absorption and density of lightweight concrete (foam concrete), where different proportions of the raw materials used in the production of this type of concrete. The obtained results showed that the addition of waste paper filling powder reduces the spaces between the concrete chains, which reflects the high concrete ability to withstand the pressure imposed on it, and that the degree of homogeneity between both concrete and waste paper is high, and that this increases the compressive strength of the prepared models by an increase of (44.6 %), while the addition of waste iron wire fillers reduces the compressive strength of the samples prepared for light concrete. Several engineering and physical tests were conducted on lightweight concrete models in this research, where it was reached to produce light concrete with a compressive strength ranging between (1.18 - 2.43) MPa, and the density was measured and the recorded values ranged between (718-917) kg / m 3, the water absorbency of the models was recorded, and the recorded values ranged between (18.6-56.6)%. The research aims to produce lightweight concrete with good physico-mechanical properties that can be used in the manufacture of building units, with a focus on the economic aspect of producing this type of concrete from available materials and at the lowest possible cost. Various fillers and foam were used as a percentage of cement weight for the purpose of improving the properties properties mechanical.

Keywords: lightweight aerated concrete; fillers; mechanical properties; cement; foam; foam concrete

INTRODUCTION

Lightweight concrete is defined as concrete with a density that is less than (2000) kg/m3, compared to ordinary concrete with a density that is higher than (2350) kg/m3, meaning that aerated lightweight concrete is much lighter than conventional concrete. This does not affect its strength, but rather provides strength almost comparable to normal strength concrete of lower grades. [1]. A lot of waste was used as fillers to be added to foam concrete, which is recycled to reduce the density of concrete. Examples of these materials are fly ash from silica fume, lime chalk, crushed concrete, incinerator bottom ash, recycled glass, foundry sand, expanded polystyrene, And oil palm rind and other materials [2-3]. The real concept behind manufacturing lightweight concrete (foam concrete) is to create a microscopic porous structure by trapping air bubbles in the concrete mixture. This work can be done by adding preformed foam or a chemical surfactant that reacts during mixing to form air bubbles in mix. The air bubbles continue in their size and shape and remain stable during the period of the concrete mixture preparation process, and the diameter of the air bubbles ranges between (0.1 and 1) mm. Light weight of concrete as there is no coarse aggregate in this process [4]. The researchers worked on using different types of foam to form foam concrete. Two types of foam were used: chemical and mechanical foam. In chemical foaming, a foaming agent such as aluminum powder, CaH_2, TiH_2, or MgH_2 is mixed with the basic mixture components, and during the mixing process, foam is produced from chemical reactions that form the cellular structure in concrete. Or when using mechanical foam, the foam is prepared in advance using a special device, a foam generator, where water and chemical (foaming agent) are mixed in a certain proportion and the previously manufactured foam is mixed (mechanically) with the concrete mixture, and after pouring the mixture, the concrete is hardened in the conditions Normal air [5-6]. The category of foam concrete (Foam Concarate) belongs to a broader category in applications than aerated concrete, where the foam concrete has several characteristics. It is light in weight, resistant to moisture and fire, and has good sound and heat insulation, so it has been successfully applied in oil well cementing projects, and is also used as a backfill material in drilling projects, and is used for sound and heat insulation in building panels, and also as a firewall. Also as energy absorbing platforms in roads, structural fills, foundations, and mine filling applications [7-10]. As for this practical study, the aim is to produce a new type of lightweight foam concrete with added waste fillings that can be recycled. This concrete can be used as a new building material to conserve energy and protect the environment, and is also used in particular for thermal and acoustic insulation of building walls and also in Yemen. Use as fire retardant walls.

EXPERIMENTAL PROGRAMS, MATERIALS

Materials and fillers used in the research

Cement: The cement used in this study is the main material, which is Portland cement, produced by Saqr Al-Kitan Company for Cement Production Ltd., it was produced according to the Iraqi Standard (No. 5 of 2019), (IQS 5 CEM I 42.5 R). Table 1 shows some of the chemical properties of the cement used in this research.

TABLE 1: Chemical properties of the cement that were used

Name of material	CaO	Al2O3	Fe2O3	SO3
Cement	65.23	5.23	3.30	0.98
Name of material	K2O +Na2O	Loss on ignition	Soluble residue	MgO
Cement	1.6	1.5	0.19	2.76

Fillers: Two types of fillers were used in this research to be added to the mixture (cement with foam), which are waste paper and iron wire fillers. Waste paper is cut into small pieces and then added to the mixture after dissolving it with the solvent, while the other fillings are iron wires that are used Cut it and put it in cubes to be added in three layers with the mixture.

Foam: There are two types of foam, chemical foam and mechanical foam. In this research, mechanical foam was used with the mixture. The foam is prepared in advance using a special device, a foam generator, where water and chemical (foaming agent) are mixed in a certain proportion and the previously manufactured foam (mechanically) is mixed with the concrete mixture. Its self-made white powder is formed by confining gas pockets within a liquid or solid.

SAMPLE PREPARATION:

prepare lightweight concrete with additives of different concentrations from waste fillers, the following steps were followed:

(1) A mold was made of iron with thickness (mm5), and the sides are movable and can be fixed to each other by iron nails. Where the mold used to form the foam concrete samples is in a cubic shape and its dimensions are (length 115 mm, width 115 mm, height 115 mm).

(2) Using the manual method (Hand-lay-out) and at laboratory temperature, the base material (portal cement) was mixed with the fillers (waste paper and iron wire) for reinforcement in different weight ratios, and then the previously prepared foam is added to the mixture. Where six samples of foam concrete cubes were poured, four of them without fillings and two with fillings. The proportions of water and fillings were changed while the proportion of cement and foam remained constant in all samples. The process of mixing materials to form samples continuously and slowly for (5 minutes) until the mixture is well homogeneous. Figure (1) (A) shows a photograph of the sample prepared with the iron mold, and (B) the concrete model with paper waste, and (C) Concrete sample with iron wires, and table paper (2) shows the weight ratios of the wade used in the research, with the percentages of cement and foam remaining constant in all samples.

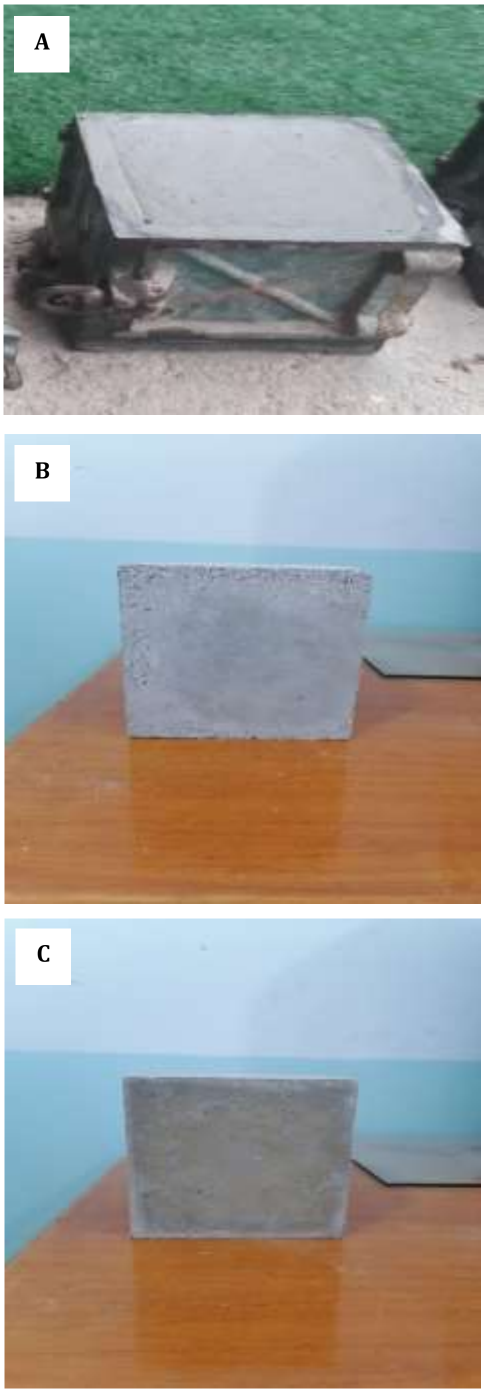

FIGURE 1: (A) photograph of the sample prepared with the iron mold, (B) the sample of concrete with waste paper without the mold, and (C) the sample image of concrete with iron wires.

TABLE 2: Weight ratios of materials used in lightweight foam concrete

Sample Number	Water Amount (Ml)	Amount of Cement (Gm)	Fillers	Foam (Gm)
A	980	2500		20
B	1040	2500		20
C	1105	2500		20
D	1170	2500		20
E	1175	2500	waste paper	20
F	1180	2500	iron wire	20

TEST EQUIPMENT

A device was used to measure the mechanical properties (compressive strength) of the lightweight foam concrete samples with the name (Digital indictor for compression machines) and type (HUMBOLDT (650 BAR). 220V 50/60 HZ), with an average rotating speed of (psi/sec.564.07), and stress strength of (1598.11 psi) to examine the models by measuring the compressive strength, and the readings were recorded for all samples of lightweight concrete cubes without addition and concrete with fillings (Waste paper and iron wires), and Figure (2) shows a device for measuring mechanical properties (compressive strength) of concrete cubes.

FIGURE 3: a photograph showing a mechanical measuring device

RESULTS AND DISCUSSION

Figure 3 shows the relationship between the weight ratios of the lightweight concrete samples with the compressive strength. Where we notice from the figure that the behavior of the compressive strength begins at the sample (A), where the ratio of water to cement is (980 ml), and the compressive strength is (Mpa1.75), then the compressive strength decreases when the percentage of water to cement is increased by 190 ml, which is (1.68 Mpa) for sample (D) with the proportions of cement and foam remaining constant in all samples and therefore the percentage of water negatively affects the compressive strength, and then when adding fillers (waste paper) to the mixture with an increase in the proportion of water to cement (1175 ml) The compressive strength increases and is (2.43 Mpa) for the sample (E). Where there is a high homogeneity between the fillings with the cells and thus fills the spaces between the cement particles, and this enhances the strength of the sample bearing the weight and increases the compressive strength. As the internal structure weakens, the compressive strength increases. But for the use of fillers (iron wire), the compressive strength decreases with the increase in the ratio of the amount of water to cement to the sample (F), where the amount of compressive strength of concrete with fillers (iron wire) is (1.18 Mpa), where the iron wire weakens the internal structure of the mixture and therefore the mixture cannot bear the high pressures and thus the compressive resistance decreases, and the iron wires also make the mixture not completely homogeneous, thus leaving many voids, and these voids weaken the sample.

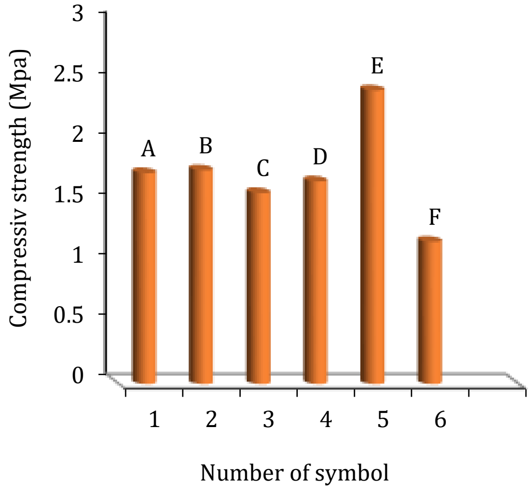

FIGURE 3: The relationship between the weight ratios of lightweight concrete and the compressive strength

Figure 4 shows the relationship between the weight ratios of lightweight concrete with density. Where we notice from the figure that the maximum density recorded for the models was (917 Kg/m3) for the sample (E), i.e. concrete with waste paper, and this matter is attributed to the presence of waste paper that increased the mass of the sample, and the absence of spaces between the internal structure as a result of high homogeneity between waste paper and concrete, and thus the sample is not well absorbent of water, in contrast to concrete with iron wires, which absorb a high amount of water as a result of the presence of large voids that led to the lowest density recorded was (718.8 Kg/m3) for the sample (F) and the reason This is that the iron wires work on the heterogeneity of the concrete mixture well, but it created many gaps between the particles of the mixture, which led to the weight of the sample before wetting was low and increased the absorption of water.

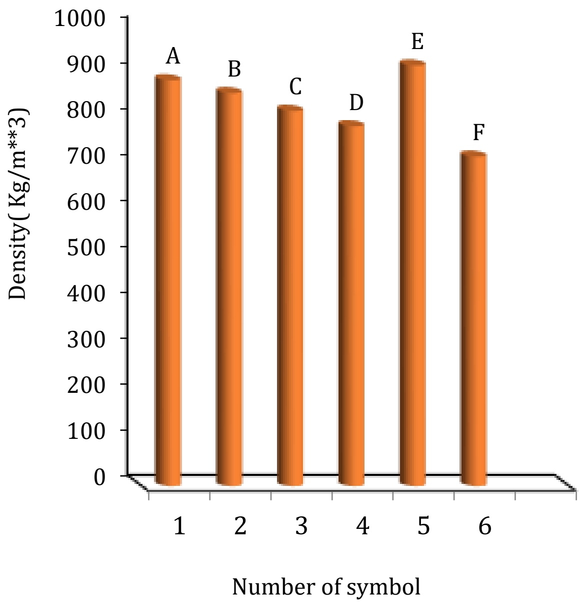

FIGURE 4: The relationship between the weight ratios of lightweight concrete with density.

We note from Figure 5, which represents the percentages of water for cement added with samples of lightweight concrete without fillings and with fillings (waste paper and iron wire) with the percentages of cement and foam remaining constant in all concrete samples. Where we started with the amount of water percentage, which is (980 ml) with the sample (A), then we increased the percentages of the amount of water in proportion to the cement to form concrete samples to reach the highest percentage of adding the amount of water, which is (1175 ml) with the sample (F). Adding the amount of water to a mixture Concrete in varying proportions has an effect on the absorption values of concrete samples, and this leads us to a change in the compressive strength of samples.

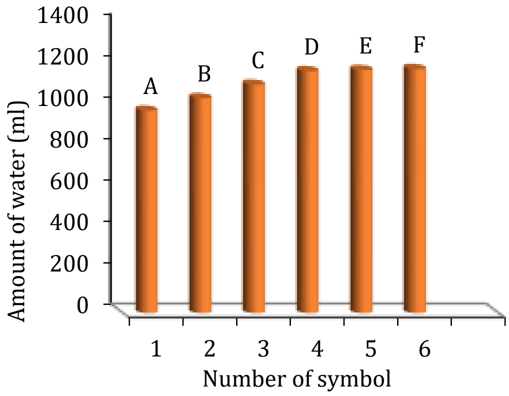

FIGURE 5: The relationship between the weight ratios of lightweight concrete with the water-cement ratios

Figure 6 shows the relationship between the weight ratios of lightweight concrete with absorption, where the absorption values were calculated through the difference between the weight of concrete samples before and after hydration divided by the weight of the sample before hydration, which can be represented by relationship No. (1).

Absorption Ratio = (A-B)/B*100%.

Whereas: -
A: Weight of concrete sample after hydration (kg)
B: Weight of the concrete sample before wetting (kg).

Where we notice from Figure (6) that the highest value of absorption was recorded with the sample (F), which represents the concrete sample with iron wires, and the reason for this is that the iron wires create many voids between the internal structure of the mixture, and this makes the mixture able to absorb the largest amount of water Which is estimated at (56.6%), while the sample (E) and sample (A) represent the lowest value for water absorption and it is estimated at (20%), where the waste paper powder prevents the presence of voids between the internal structure of the concrete as a result of the great homogeneity with the mixture and thus the percentage of the amount of absorption Water is a very small percentage, and this is a relief from the figure below.

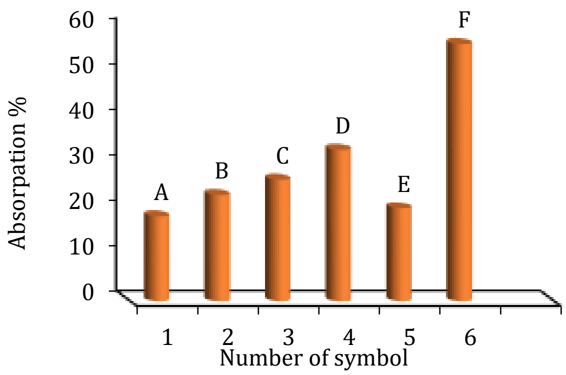

FIGURE 6: The relationship between the weight ratios of lightweight concrete with the absorption values

For the purpose of calculating the difference in cost when using light concrete instead of bricks and thermos tone for the section on building walls for a house building area (10 km^3), it is done according to the following steps:
- Calculating the size of the building with bricks, and calculating the size of the building with light concrete for the complex as well. Calculating the cost of building with bricks for the house by multiplying the building volume by the bricks x the cost (1 m3) of building by the bricks. Calculating the cost of building with light concrete by multiplying the volume of the building with light concrete x the cost (1 m3) of building with light concrete. Calculate the cost of building in thermostone by multiplying the volume of construction in thermostone x cost (1 m3) of building in thermostone. The difference between the costs represents the amount of cost savings, and Table No. (3) shows the calculation of the difference in costs between the materials bricks, light concrete and thermostone, according to the researchers' estimation and based on the calculations that were mentioned without the cost of the cat, damage and work.

TABLE 3: Calculation of the difference in costs between light concrete, brick and thermostone materials.

Paragraph details	Quantity	Building Unit Price (Iraqi dinar)	Quantity price without labor and damage costs (thousand dinars)
with bricks	4340	250	1085
light concrete	416.6	2000	833
thermiston	416.6	2500	1041

From the above table it is noted the cost of paragraphs (1 and 2) above, and the difference between the two costs is = 252 thousand dinars. From the above table it is noted the cost of paragraphs (1 and 3) above, and the difference between the two costs is = 208 thousand dinars.

That is, the cost savings is by using light concrete instead of bricks for the construction section of the external and internal walls. To build an area (10 km3) is (252) two hundred and fifty-two thousand dinars, and cost savings by using concrete. The light instead of thermiston is (208) two hundred and eight thousand dinars.

CONCLUSIONS

We conclude from this practical study that the addition of waste paper filler powder reduces the spaces between the concrete chains, which reflects the high concrete ability to withstand the pressure imposed on it, and that the degree of homogeneity between both concrete and waste paper is high, and therefore the maximum compressive strength was recorded (2.4Mpa), While the addition of waste iron wire fillers reduces the compressive strength, the lowest compressive strength was recorded (Mpa 1.18), and the highest compressive strength was recorded for the concrete model without any addition of (Mpa 1.7), and we conclude that the recorded density values for lightweight concrete samples range from (718). -917) kg/m3, the water absorbency of the models was recorded, and the recorded values ranged between (18.6-56.6) %. We conclude from this research that the addition of waste paper fillers was the best in terms of compressive strength as well as absorbency and density, and it can be considered the best sample than the rest of the samples due to the high homogeneity between concrete and waste paper and it can be used in the manufacture of building units with a focus on the economic aspect in the production of this type of concrete from materials Available and at the lowest possible cost, and we also conclude that waste iron wire is useless and not useful to add with concrete because it weakens the compressive strength. To compare between the economic costs of building materials, the cost of one cubic meter of light concrete was calculated, as it amounted to (86,670) dinars / m^3, and the cost of one cubic meter of bricks was calculated, which amounted to (119,358) dinars / m3, and the cost of one cubic meter of thermiston was calculated, which amounted to (115500) dinars / m^3.

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