Production of Building Blocks Buffer lightweight Concrete

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Abstract

More recently there has been Great interest in the production of lightweight building components which can be used for the purpose of thermal insulation.

The use of such components and buildings have a great advantage and cause great reduction in the energy required for heating and cooling consequently results cost reduction to a great extent , especially prevailing hot dry climatic condition of Iraq. Its thus aimed in this research to study properties of polystyrene concrete insulation which can be used for thermal insulation construction unit.

This research presents and experimental research work. It includes preparation of several concrete mixes using extra lightweight aggregate (polystyrene) To obtain lightweight concrete of two densities ranging from (350 to 625) Kg/ m3, which provides a good thermal insulation. The physical properties of polystyrene concrete have been found which include density, compressive strength, modules of rupture. Several relationships have been found relating one property to others.

Key word: lightweight building, thermal insulation, polystyrene, lightweight concrete, density

Introduction

In the present days, lightweight aggregates are varied and the interest in it has been increased on account of its economical advantages regarding heat insulation and reducing dead Load especially in tall buildings. One of the most significant examples of lightweight aggregates current uses in Iraq is packing "Nassib Al-Shahid" Dome in Baghdad where expanded clay aggregates, that its density is less than (1000 kg/m^3), was used as connective lightweight concrete layer below the Ceramic blocks. Another example is the secondary roofs in the Conference Hall where fly ash aggregates, which is commercially known as Lytage, was used in producing the lightweight concrete used in the construction of these roof(1)(2)

The most advantages of the concrete made of lightweight aggregates and used in constructing and building sector can be summed up as following(3)

1. Reducing dead Load in the foundation parts resulted in reducing all foundations or identifying the establishing parts dimensions as well as reducing vertical and intervenes pressure on casting blocks.
2. Providing high quality of heat insulation in comparison to traditional concrete.
3. Increasing fire resistance of - flammable inorganic types- as a result, the risks and fire damages will be reduced.
4. Chipping and drilling will be very easy as well as fixity and wiring.

The most disadvantages of the concrete made of lightweight aggregates can be summarized as following:

1. High cost: as the cost of digging out and manufacturing of these aggregates are high.
2. The decrease of the modulus of elasticity in the lightweight aggregates concrete and the shear strength in comparison to traditional concrete, which leads to taking into consideration some precaution during designing buildings, when using such kind of lightweight concrete.
3. Increasing the amount of aridity shrinking, creeping and water absorption in general.
4. Deficiency of fire resistance in the types that contain organic aggregates such as polystyrene.

The purpose of the research:

The use of the polystyrene aggregates is limited and the existing studies about this type of lightweight aggregates is not covering the required knowledge about this material. Moreover, there is an urgent need to discover its thermal, properties, as using heat insulation in buildings becomes one of the essential means to ensure the residential denouement.

Polystyrene granules used in lightweight concrete in finite zone point out the idea of the possibility of using these granules in the insulated concrete used in walls and roofs. This research aims to study the potential of such kind of lightweight concrete in providing heat insulation when used as adjunct floors over electrical potencies.

The research also aims to find the effect of several parameters such as water-cement ratio, the ratio of cement content and aggregates content to the mechanical, thermal properties of such lightweight concrete.

lightweight concrete

There is no an agreement among the best researchers definition for lightweight concrete and its categorization. Lightweight concrete is defined as being the kind of concrete that has density of lower than (800 kg/m^3) [4] that is according to the 1985 adjusted report done by the committee 116 that is related to the American Institution of concrete. The same report defined the lightweight construction as being that kind of concrete which is made of light aggregate that have density between (1440-1800 kg/m^3)

lightweight aggregate

There are different types of aggregates whose properties covered wide range [(5)] that polystyrene aggregate (topic of this research) is classified as low insulated density concrete between (300-800 kg/m^3) and polystyrene beads are new type of added to the type mentioned above , such as perlite and vermiculite, as a result reviewing the studies will be restricted to insulated lightweight concrete.

polystyrene aggregate

Polystyrene particles known commercially as styropore are made of styrene resin, when adding a small amount of volatile monstrous materials to styrene resin and apply steam heating this material is expanded by 10 to 60 times of its actual size and the density of these particles that has a density is about (16.5 kg/m^3), while its water absorption ratio is about (0.2%). This polystyrene has been used as a good heat insulation for over 30 years after formation in a specific molds. But, this material has some features as thermosetting and inflammable.

Polystyrene Concrete*:*

There is no many research on this topic , since 1959 , Kohling[(6)] conducted a study about the possibility of using Polystyrene aggregate in producing high heat insulation concrete. But, the high density of Polystyrene at that time not widely speared.

Popovic[(7)] mentioned this kind of concrete as high heat insulation materials, but it has very light fine aggregate and homogeneity in size and higher price . which, caused possibility in manufacturing. .

Neville[(3)] mentioned the difficulty of mixing it with cement and proposed that the Polystyrene aggregate need to be added at least (15%) of Entrained air materials to get the required workability .

The physical properties of Polystyrene have been studied by a number of researchers like Parton[(8)], Baum[(9)]and Kohling [(6)],they all noticed that the physical properties of Polystyrene concrete such as density, compression strength , rapture modulus, elasticity coefficient and heat insulation, all the mentioned properties depend mainly on the Polystyrene-Cement ratio.

In 2007, Kan and Demierboga[(10)] studied the properties of modified lightweight concrete mixtures by adding the Polystyrene aggregate with different sizes (1:1, 1:2, 1:3, 1:4) and performance was evaluated by using compressive strength. The result showed that the compressive strength increase by (4 times). These result, also showed

Laukaitis et.al (2005)[11] Lightweight polystyrene concrete of density ranging from 150 to 300 kg/m3 made of a foam matrix and polystyrene beads of diameters ranging from 2.5-10 mm. In fact, for the same concrete density, compressive tests results showed an increase of 40% in the compressive strength given by2.5-5mm polystyrene beads concrete in comparison with the one given by 5-10mm polystyrene beads concrete.

Thermal conductive coefficient

This coefficient depends on the followings:

1. The material: as metal is a good transformer of heat while wood is a bad one.
2. Density: the thermal coefficient increases when the density increases.
3. Humidity: the thermal coefficient increases as the humidity increases.
4. The temperature: in high temperature degrees the thermal coefficient changes according to the degree but it is considered as stable in moderate degrees.

XU et.al (2015) [12] study the polystyrene (EPS) inclusions on thermal conductivity of lightweight concrete is studied. Various mixtures are produced by incorporating EPS aggregate at different volumes (0%, 10%, 20%, 30% and 40%) in concrete with three water/cement ratios (0.55, 0.50 and 0.45). The apparent density and thermal conductivity values of expanded polystyrene concrete decrease as the volume of EPS increases. The thermal conductivity increases with an exponential function of the apparent density whatever the water/cement ratios. The general thermal conductivity models can not well predict the present experimental results. Based on experimental results and composite approach, a new simplified model is proposed to evaluate the effective thermal conductivity with an equation of the plain concrete thermal conductivity, the EPS thermal conductivity, the density and the percentage of EPS particles. The model is applicable to the EPS lightweight concretes with different water and cement ratios.

Abd, Suhad M., Dhamya Gh(2016)[13] With the increase in demand for construction materials there is a strong need to utilize alternative materials for sustainable development. The main objective of this investigation is to study the properties, such as compressive strength and tensile strengths of light weight concrete containing Expanded Polystyrene (EPS) beads. Its properties are compared with those of the normal concrete, i.e., without EPS beads. EPS beads are used as partial replacement to fine aggregates. The results showed that the amount of polystyrene beads incorporated in concrete influences the properties of hardened concrete. Since the compressive strength less than a certain percentage depending on the amount of replacement. At 28 days, it was found that compressive strength of 5%, 15%, 20%, EPS based concretes compared to control concrete were 41%, 38 %, 25%, respectively.

Dawood (2015)[14] was conducted to investigate the properties of lightweight concrete produced by the inclusions of polystyrene beads and perlite that can be used for production of Canoe. Different percentages of polystyrene (20, 35, 50 and 65%) were used. Besides, the 50% of polystyrene beds with different percentages of perlite (10, 20, 30, 40, 50 and 60%) as partial replacement of sand were used. The fresh density, compressive strength, flexural strength and absorption capacity of the mixes were tested. The results show that the uses of 50% of polystyrene with 50% of perlite as partial replacement of sand exhibit suitable ranges of density, compressive and flexural strengths of lightweight concrete used for canoe production. Thus, the Canoe produced from these inclusions of polystyrene and perlite show a clear success in terms of floating. Some conclusions can be drawn from this study:

1- The density of lightweight concrete decreased by the inclusion of polystyrene beads in the mix. The use of 65% of polystyrene reduced the density of the concrete by about 50%.

2-The compressive strength of lightweight concrete was influenced due to polystyrene beads inclusion. The addition of 65% polystyrene reduced the compressive strength from 27.6 MPa to 6.9 MPa.

Characteristics of materials used and methods of test

Materials used

Cement

The ordinary Portland cement produced was used for all concrete mixtures. the results of the chemical analysis and physical properties of the cement used show that the cement is identical to the Iraqi specifications m. IQS. No. 5/1984.

Water

Use tap water for the city of Baghdad in all concrete mixtures used in this research.

Polystyrene granules

Polystyrene is classified as a type of Thermoplastic which is produced from petroleum products or natural gas and its resistance to acid is weak and water absorption is very low at 0.2% and its density is 16.5 kg / m3 [15].

Design of experimental concrete mixtures

There is no standard method for designing concrete mixtures made of very light aggregates used for thermal insulation purposes. The design of the very light concrete mixtures in this research is designed to achieve low density and provide a certain thermal insulation (measured by thermal conductivity). Design determinants can be summarized as follows

1. The density shall not exceed 800 kg / m3 in order for the concrete to be within the specifications of the concrete heat-insulating materials [5]

2. The compression strength shall be within the range (0.7 - 7) MPa

Molds used

Two types of iron molds were used: - The first type, in the shape of a dimension (70 x 70 x 280) mm, was prepared for concrete models used in nondestructive tests. And the second type in parallel to rectangles dimensions (100 × 200 × 50) mm were prepared to find the coefficient of thermal conductivity according to the requirements of the inspection device.

Formation of concrete models

Method of mixing concrete

One of the main problems in the production of polystyrene concrete is the difficulty of obtaining a homogeneous mixture in which the polystyrene is homogeneous with cement because of the light weight of the polystyrene. It was manually mixed according to ASTM C-192 [(16)] and for the following reasons:

1.The required quantities of mixtures are slow that the mixing of the hand is sufficient to obtain a homogeneous mixture with good operating capacity.

2. To avoid segregation between cement and polystyrene in the mixer ban.

3. Manual mixing ensures that the used polystyrene particles are not crushed in the concrete mix which can be crushed when using the mechanical mixer.

The proportions used for mixing are volumetric because of the lightness of the polystyrene because, when using the weight ratios, a larger line is generated due to the large difference between the density of polystyrene and the rest of the compounds in the mixture.

Method of Mixing The production of a homogeneous concrete mixture and a good workability are as follows:

The weight of cement required is first prepared, then the aggregate (polystyrene) / mixed aggregate is mixed thoroughly with metal crystals until it becomes a homogeneous

Dry mixture and almost all the polystyrene granules are enclosed in the cement to prevent separation when adding water. Then add half the water and mix well for up to 6 Minutes. Then add the other half of the specified amount of water and mix thoroughly until a homogeneous mixture is obtained. The aggregates are distributed regularly to each mixture.

Casting and compaction concrete

The concrete was poured after the mixing process was done directly in the steel molds whose inner faces were applied with a thin layer of oil. The concrete was poured in two equal forms in the thickness and according to the shape of the mold. According to ASTM C (53) A wooden square sawdust in view of the fact that the vibrator can not be used in the plaster to prevent the separation of the polystyrene granules used in concrete mixtures

Curing

After completion of casting process, the molds were covered with polyethylene foil to prevent water evaporation from soft concrete and left for 24 hours. The molds were then removed and sealed in polyethylene bags for 28 days. This method was followed by ASTM C-192 (16)

Test the Modulus of Rupture

The fraction of the light concrete for this research was found using the three-point loading method Three - Loading Point, shown in US Standard ASTM C-78 (17) where the pirated models used in the previous non - destructive tests were broken by three axes for each test. The load was mounted on these models with a 50-ton Naruto machine.

Compressive strength Test

The strength of the concrete was extracted using three point loading was examined for the extraction of the fracture calibrators. The parts of the prism remained intact after the examination, and since the square section is obtained, it is possible to obtain an equivalent cube by laying the load accurately and vertically. Day with three samples per test using an Olsen Tinius device with a capacity of (90 ton). The test was conducted under ASTM C-116 (18)

Test thermal conductivity coefficient

There are two ways to measure the thermal conductivity of construction materials under the British Standard B.S 874 (19) the first method depends on the steady state of heat transfer and the second method depends on the unstable state of heat transfer.

Each method has its own instrument. In the first method, the hotplate is used to connect the face of each model to one side of the plate while the other faces of the two models are confined to the two cooling sheets, which are of dimensions equal to the dimensions of the heating plate and all of which are stored in a thermally insulated cabin.

Thermal conductivity is calculated by measuring the amount of heat transferred through the mass of the model space in the unit of time, and measuring the difference in temperature between the two faces of the model when reaching the state of heat balance.

In recent years, the second method began to evolve because of the speed in finding thermal conductivity of structural materials (20) .This method was used to find thermal conductivity in this research.

The method of measurement depends on the heating of the model for a short period and record the rise in temperature over time and from these readings can find the coefficient of thermal conductivity by using the relationship between temperature and time calculated under special laboratory arrangements.

In this paper, the thermal conductivity of concrete models was measured in parallel to rectangles and dimensions (200 * 100 * 50) mm using the thermal conductivity measurement type 31 - model TC made by KYOTO ELECTRONICS [21] The method used in the inspection is the method of delivery in a non- Unsteady State Conduction Within the measurement range (0.5-5) W / m. K.

Thermal conductivity is measured by measuring the temperature increase of a high wire metal before reaching the thermal balance and the heat of the wire between the two models is obtained from the heat generated by the generated thermal energy when an electric current passes through it.

The thermal conductivity required depends on the fact that the heat in the thermal wire changes depending on the thermal conductivity of the model, indicating that the maximum thermal conductivity of the model is the fastest movement and dispersion of heat, and the lower and lower heat rise in the thermal wire.

After placing the two models in the specified position, the thermal wire temperature rises and is calculated by the device. Then, a number representing the thermal conductivity value is shown in units (W / m). Each types has three readings.

Results and its discussion

This chapter discusses the results obtained from the destructive and non-destructive tests. And compare them with those of other researchers. The results will be presented in the form of relationships whenever possible. The values are listed in the tables (1)(2)

Table (1)

results for compressive strength and Modulus of the Rupture of the polystyrene concrete (Group I)

Series number	Volume mixing ratios C: P	Cement content kg / m 2	Percentage of water to cement%	Density kg / m3	Compressive Strength MPa	Modulus Of Rupture MPa
1	1:2	200	0.45	550	1.6	0.5
	1:3	200	0.45	531	1.34	0.46
	1:4	200	0.45	388	0.89	0.30
	1:5	200	0.45	354	0.625	0.20
2	1:3	200	0.35	568	1.8	0.54
	1:3	200	0.40	545	1.5	0.49
	1:3	200	0.45	531	1.34	0.46
	1:3	200	0.45	524	1.16	0.43
3	1:3	150	0.45	515	1.10	0.36
	1:3	200	0.45	531	1.34	0.46
	1:3	250	0.45	568	1.80	0.50
	1:3	300	0.45	585	1.96	0.61

Table (2)

Thermal conductivity coefficient of polystyrene concrete (group 1)

Series number	Volume mixing ratios C: P	Cement content kg / m 2	Percentage of water to cement**%**	Density kg / m3	Thermal conductivity coefficient Watt / m.k
1	1:2	200	0.45	550	0.18
	1:3	200	0.45	531	0.14
	1:4	200	0.45	388	0.12
	1:5	200	0.45	354	0.11
2	1:3	200	0.35	568	0.23
	1:3	200	0.40	545	0.18
	1:3	200	0.45	531	0.14
	1:3	200	0.45	524	0.14
3	1:3	150	0.45	515	0.13
	1:3	200	0.45	531	0.14
	1:3	250	0.45	568	0.23
	1:3	300	0.45	585	0.25

Compression Strength

The relationship between compressive strength and water-cement ratio for the concrete mix models used in this search, where compressive strength is reduced by increasing the ratio of water to cement. It is generally similar to the known exponential relationship of ordinary concrete. This trend is also consistent with the results of many previous works of other types of lightweight aggregate [22][23]. It also supports the fact of not depending on the compressive strength of low-weight aggregate and depending on the type of aggregate used.

the relationship between compressive strength and dry density of polystyrene concrete. The compressive density relationship is a positive indicator for obtaining specific compressive strength within the specified density limits.

Thermal conductivity factor

Thermal conductivity is one of the most important characteristics of insulating concrete because it is closely related to the use of this type of concrete as heat insulation. In this part of the chapter, the relationship between the conductivity and other physical properties such as density and others will be established.

Table (1) (2) present the results of the thermal conductivity test of the concrete models used in this study. The results showed that the concrete is a good thermal insulation that can be used for thermal insulation purposes.

Figure (1) shows the relationship between the thermal conductivity coefficient and the ratio of aggregate to cement. When increasing this ratio within the range (2-5), the thermal conductivity is reduced. The above figure shows that the thermal conductivity of the second group is higher than the first. Figure (2) shows Relationship between dry density and thermal conductivity of polystyrene concrete

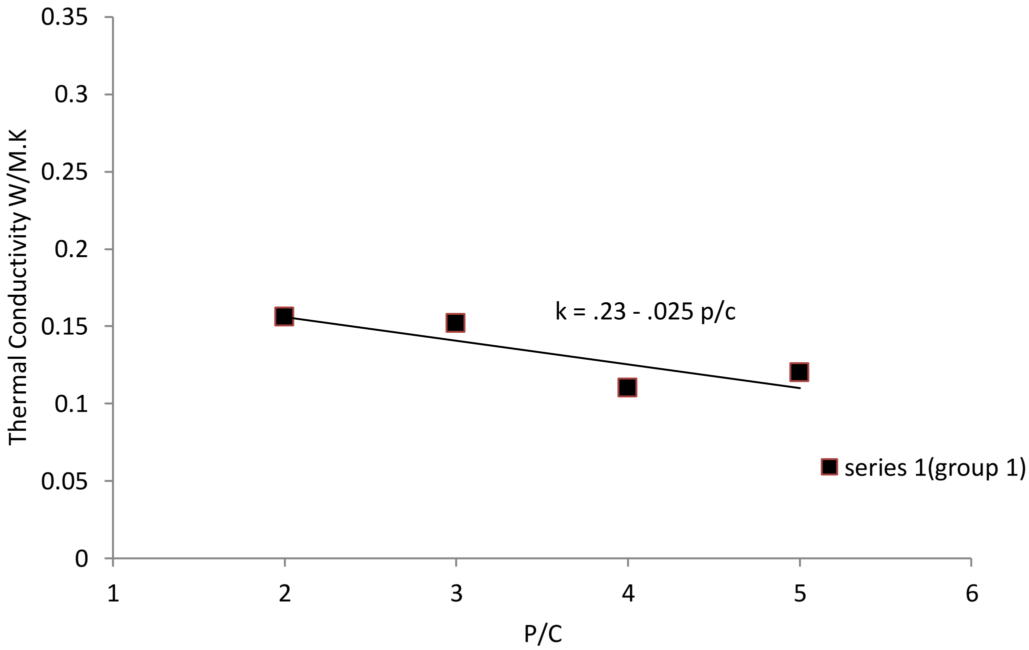

Figure (1) The relationship between P / C and thermal conductivity of the polystyrene concrete

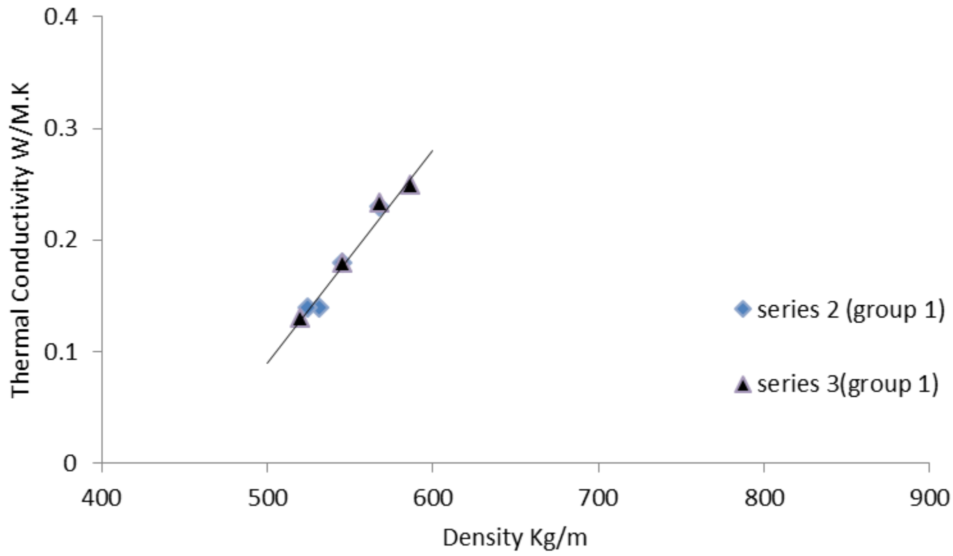

Figure (2) Relationship between dry density and thermal conductivity of polystyrene concrete

Conclusions

Through this research, a lab experiments have been made to find the physical features for a new type of thermal insulation concrete made of polystyrene as aggregates. Through the tests' results and within the limitations of the experiments that have been made we can reach the following conclusions:

1- Compression strength and Rapture:

Compression strength value for the polystyrene used in this research varies between (0.62-3.34). It increases with increasing the density and the percent of cement to water. Was depend on the type of aggregate, while the rapture modulus is related with a linear relationship with Compression strength .

2- Thermal conductivity coefficient:

The thermal conductive coefficient of the polystyrene concrete is vary between (0.11-0.34) and related to polystyrene density and the thermal conductive coefficient as shown in the figure (1)(2)where the coefficient increases with the density and depends on the aggregates. There is also a relation between the dynamic elasticity coefficient and connectivity coefficient as shown in the figure (4-15).

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