

Synthesis of Expanded clay aggregate pellets by using local raw materials

Elham Abid Almajeed

College of Materials Engineering ,Babylon University
Drelham_2003@yahoo.com

Samer Karim Turki

i.astm1987@gmail.com

Abstract

This study assesses the possible use of local raw materials (clays) for producing expanded clay pellets and test the product with American standard for test materials (ASTM) and according to ASTM C 330. For using them as lightweight aggregate in different construction applications, like thermal insulation, lightweight structural concrete, decoration pieces, etc. The clay was collected from Al-Anbar province. The clay was bloated at 1150 C° without adding any impurities, just mechanical treatment and perfect firing program, in order to obtain good bloating coefficient that is related with firing parameters (access time, temperature, soaking time).

We got the results of the match determined by the American specification (ASTM C330) and in which is considered lightweight aggregate. We got density about (280 kg / m³) which is much less than that determined by ASTM where the aggregate lightly if the density is less than (880 kg / m³).

Key words: Lightweight Aggregate, Expanded Clay Aggregate.

الخلاصة

هذه الدراسة تقييم إمكانية استخدام مواد أولية محلية لإنتاج كرات من الطين المتمدّد بالحرق وفحص المنتج باستخدام المواصفات الأمريكية ASTM C330، لغرض استخدامه في عدة تطبيقات إنشائية مثل إنتاج خرسانة عازلة للحرارة وخرسانة إنشائية وقطع ديكوريه وغيرها. الأطيان تم جمعها من محافظة الأنبار عن طريق الشركة العامة للصناعات التعدينية. بعد إجراء تجارب متعددة انتفخ الطين عند حرق بدرجة حراره تصل الى 1150 درجة مئوية وبدون أي مضافات مع الطين باستثناء معالجات ميكانيكيه وباستخدام برنامج حرق ملائم، لذلك وللحصول على انتفاخ جيد يجب الأخذ بعين الاعتبار عوامل الحرق (درجة حرارة الحرق، زمن الوصول لهذه الدرجة، وكذلك زمن مكوث الطين عند هذه الدرجة). لقد حصلنا على نتائج تطابق ما تحدده المواصفات الأمريكية والتي من خلالها يعتبر الركام خفيف فلقد حصلنا على كثافة تصل إلى (280 كغم / م³) وهي اقل بكثير من مما تحدده المواصفات الأمريكية حيث تعتبر الركام خفيفا في حال كانت كثافة اقل من (880 كغم / م³).

الكلمات المفتاحية: ركام خفيف، ركام الطين المتمدّد.

1. Introduction

The expanded clay pellets as a lightweight aggregates are an important and versatile materials, used in concrete mixtures to make lightweight concrete (LWA), which used in different applications such as curtain walls, shell roof floors, pre-cast and pre-stressed concrete (Satish and Leif, 2004).

Today, lightweight aggregates are available in wide range of densities, size and strength. This makes designers capable to design concrete with more options of densities and strengths for different applications (Mahmood, 2008).

Expanded clay is a powdery building material with good thermal insulation properties and resistance to the external impacts. It is obtained by feeding clay in a rotary kiln at a temperature of (1150C°). In this temperature raw materials start bloat turning into light pellets with a porous and firm structure. Properties of the

obtained product depend not only on the properties of the start materials , but also on its additives and production technology (Giedrius and Aras, 2011).

2. Study objective

The objective of this research is to produce the lightweight expanded clay pellets from the local raw materials and compare to the specifications(ASTM C330, 2004).

3. Materials and Methods

3.1 Materials

Clay sample supplied by " state company for mining industries – Department of materials extraction" the clay was collected from Al-Anbar province. Table (1) show the chemical composition of this study. Then clay was prepared through several processes in order to produce expanded clay pellets

3.2- preparation of start materials

3.2.1 Crushing and milling

The raw materials was supplied as rock form . The mechanical treatment was applied to produce clay powder with an average surface area (SSA= 0.4-0.7 m²/kg),by using crushing and milling machine that shown in Figure (1) at university of Babylon/college of materials engineering – department of ceramic and building materials.

3.2.2 XRD diffraction

Table (2) shows the XRD results for the sample, that contain quartz, calcite, dolomite and small amount of feldspar. Behind that the figure (2) show the phases of XRD test for clay. X-ray diffraction (XRD) type (Shimadzu 6000, Japan) shown in Figure (3) at the Babylon University / Collage of Materials Engineering – Department of Ceramics and Building materials was used to characterize the structure of clay samples .

3.2.3 DTA

Figure (4) of clay curve shows that there are different reactions, the first reaction is endothermic at 110.7 C° because of the evaporation of water . The second one is more less reaction exothermic, it's remove adsorbed water. The third peck is exothermic reaction at 590.8 C° for crystallizations. And the last peck is also exothermic reactions at 823.2 C°, it is for TG transformation.

3.2.4 Plastic and liquid limit

This test measured the plastic and liquid limits of the clay samples used in this study. The liquid limit (LL) is arbitrarily defined as the water content, in percent. By using Liquid Limit Device (mechanical device) show in figure (5).Amount of clay mixed with water and put in a standard cup, then cut by a groove of standard dimensions after this the clay subjected to 25 shocks from the cup being dropped 10 mm with a rate of one shock per second, to find the liquid limit of the clay samples, this test according to(ASTM D 4318,2004) .

The plastic limit (PL) is the water content, in percent, at which a soil can no longer be deformed by rolling into 3.2 mm, diameter threads without crumbling , according to (ASTM D 4318,2004) .

The plasticity index (PI) of a soil is the numerical difference between its liquid limit and its plastic limit, and is a dimensionless number. Both of the liquid and plastic limits are moisture contents. Table (3) shows the results of clay.

The next equations used to calculate LL, PL and PI.

$$LL=W (N/25)^{0.12}$$

$$PL = (\text{Weight of water/ Weight of oven - dry soil}) * 100\%$$

$$\text{Plasticity Index} = \text{Liquid Limit} - \text{Plastic Limit}$$

$$PI=LL- PL$$

Where,

N : number of shocks

W : weight percentage of water

3.3 Molding

Mechanical treatment, milling and mixing with water and finally molding by using extruder. The shape of sample shows in the figure (6) , the mixer shows in figure (7) and the extruder shows in the figure (8).

3.4 Drying and firing program

The next steps of producing expanded clay pellets are drying and firing, the figure (9) show the electrical furnace that used for this process, we used many programs for drying and firing clay samples but the best program is shown in Table (4).

4. Results of test expanded clay pellets

4.1 coefficient of bloating

In this study clay formed, 8 mm in diameter using a laboratory piston press and cut into specimens, 10 mm long. The specimens, dried at a temperature of 105 °C,

Afterward, the dry specimens were heated at a temperature of 200 °C for 20 min and fired at high firing rate by using a laboratory electrical furnace to a temperature of 1050 °C –1150 °C and stay in the furnace for 25 min. Bloating tests were performed at temperatures differing between (20-50 °C) until the semi-melt temperature of the specimens was attained. After heating , the specimens are taken out of the furnace , cooled at the room temperature, then weighted and submersed into a water for 24 hours by flooded them.

The specimens are removed from water, wiped with a cloth then weighted, the volume (V_2) is measured. According to the obtained data, bloating coefficients K_p are measured by using equation below. Table (4) shows the coefficient of bloating of clay pellets.

$$K_p= V_2/V_1 \dots\dots\dots(1).$$

4.2 Bulk density

The bulk density of expanded clay pellets that was produced from clay was measured according to American standard (ASTM C 29/C 29M – 97, 2004) , the results shown in the table (6). The clay has big amounts of calcite that produce more gases during firing that refer to low density .

4.3 Porosity measurements

Table (7) shows the results of porosity for expanded clay as lightweight aggregate that produced in this study by using rich calcite clay. The results show that the structure of expanded clay have high porosity, that means the weight will be decreased and thermal conductivity will be also decreased. The porosity of clay caused by the structure of clay contain amounts of calcite, that release gases during firing that make the structure more porous (ASTM C 29/C 29M – 97, 2004).

4.4 Specific Gravity

The results of specific gravity are very important because of identifying the expanded clay whether it is lightweight or not, after compare the results with ASTM C330, it is found that the expanded clay is lightweight aggregate. Table (8) shows the results of specific gravity.

4.5 Water absorption

Absorption calculations shown in the following, as well as comparing the results with the specification and find out the validity of the product in the table (9). Note that the test was conducted according to standard (ASTM C 127, 2004). These value show that clay pellets has low water absorption percentage because of the shield that covers the surface of pellets such as glass that prevents water from enters inside pellets.

4.6 Sieving

Table (10) shows the grading of expanded clay pellets as lightweight aggregate according to (ASTM C 136, 2004), the results refer to the aggregates that have the grading (4.75-19 mm)

Conclusions

In this study for the first time , the expanded clay pellets has been produced equal in quality with the expanded clay pellets that manufactured outside the country, by using the available local raw materials and by simple technology . During the study of mechanical properties , the expanded clay as lightweight aggregate has been according to (ASTM C 330, 2004) .Through laboratory tests, it is considered successful by all standards and can be used to produce lightweight concrete.

References

Satish Chandra and Leif Berntsson, 2002," *Lightweight aggregate concrete*" Chalmers University of Technology Göteborg, Sweden by Noyes Publications .

- Mahmood. F. Abed, 2008. *"Preparing Lightweight Aggregate for Production Lightweight nsulating Concrete"* Geology Dept., College of Science, Tikrit University, Tikrit, Iraq.
- Giedrius Vaickelionis and Aras Kantautas, 2011," Production of Expanded Clay Pellets by Using Non-selfbloating Clay" Department of Silicate Technology, Kaunas University of Technology, Radvilenu pl. 19, LT-50254 Kaunas, Lithuania.
- ASTM D 4318 – 00, 2004, *"Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils"*.
- New Russian standard GOST 32026", 2012, "Clay raw materials for manufacturing of clay gravel, rubble and sand. Specifications.
- ASTM (C 29/C 29M – 97) ,2004 , *" Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate "*.
- ASTM C 330 , 2004 , *" Standard Specification for Lightweight Aggregates for Structural Concrete"*.
- ASTM C127 , 2004, *" Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate1"* (2004).
- ASTM C 136 , 2004, *" Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates1 "*.

List of tables

- Table (1) shows the chemical composition of clay sample.*
- Table (2)XRD results for the sample*
- Table (3) Shows the results of PL, LL, PI clay.*
- Table (4) drying and firing program*
- Table (5) shows the coefficient of bloating of clay pellets.*
- Table (6) shown in the bulk density*
- Table (7) shows the results of porosity*
- Table (8) shows the results of specific gravity.*
- Table (9) shows the results of water absorption.*
- Table (10) shows the grading of expanded clay pellets.*

List of figures

- Figure (1)shows the crushing and milling machine.*
- Figure (2) shows the phases of clay sample by XRD test.*
- Figure (3) show the XRD device .*
- Figure (4) show the DTA curve of clay sample.*
- Figure (5) show the mechanical device used to calculate LL.*
- Figure (6) show the shape of sample.*
- Figure (7) show the mixer.*
- Figure (8) show the extruder.*
- Figure (9) show the electric furnace.*

Table (1) shows the chemical composition of clay sample.

Clay	SiO ₂ %	Al ₂ O ₃ %	CaO%	K ₂ O%	L.O.I%
	44.28	8.62	13.86	1.46	17.51

Table (2) XRD results of the sample.

<i>2θ</i>	<i>Phase</i>	<i>2θ</i>	<i>Phase</i>
20.80	Quartz	42.61	Calcite
23.05	Calcite	43.15	Quartz
26.63	Quartz	45.79	Quartz
27.95	Feldspar	47.50	Calcite
29.39	Calcite	48.50	Calcite
30.98	Dolomite	50.07	Quartz
20.80	Calcite	55.29	Quartz
35.95	Quartz	59.95	Quartz
36.50	Quartz .Calcite	67.74	Quartz
39.31	Quartz	68.14	Quartz

Table (3) Shows the results of PL, LL, PI clay.

<i>Clay type</i>	<i>LL</i>	<i>PL</i>	<i>PI</i>
Clay	0.942	0.5	0.442

Table (4) drying and firing program

NO.	Firing program	Access Time (min)	Stay Time (min)
1	Room Temp → 105 C°	10	10
2	105 C° → 200 C°	10	10
3	200 C° → 1150 C°	25	25

Table (5) shows the coefficient of bloating of clay pellets.

<i>Clay type</i>	<i>Average of Coefficient of bloating</i>
Clay	4.26

Table (6) shows the bulk density

<i>Clay</i>	<i>Averaged density Kg/m³</i>
Clay pellets	280

Table (7) shows the porosity

<i>Clay</i>	<i>Averaged Porosity %</i>
Clay pellets	46

Table (8) shows the results of specific gravity.

<i>Expanded clay pellets</i>	<i>Average specific gravity measurements kg/m³</i>
Clay	448

Table (9) shows the results of water absorption

<i>Clay Pellets</i>	<i>Average water absorption %</i>
Clay	6

Table (10) shows the grading of expanded clay pellets

<i>Sieve size mm</i>	<i>Passing %</i>	<i>Limits of America specifications ASTM (C 136)</i>
25	100	100
19	100	90-100
9.5	30	10-50
4.75	3	0-15



Figure (1) shows the crushing and milling machine

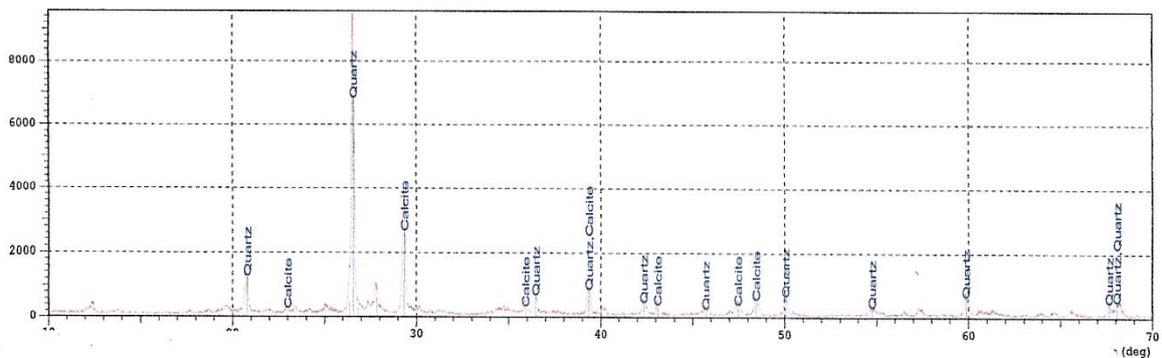


Figure (2) shows the phases of clay sample by XRD test.



Figure (3) show the XRD device .

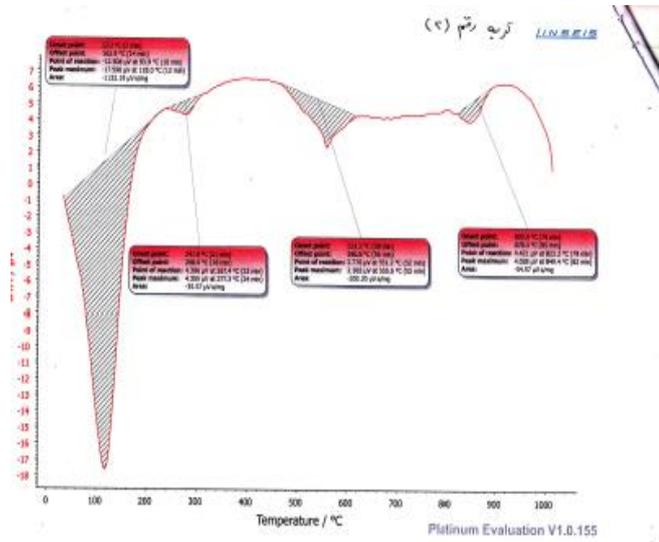


Figure (4) show the DTA curve of clay sample.



Figure (5) show the mechanical device used to calculate LL.

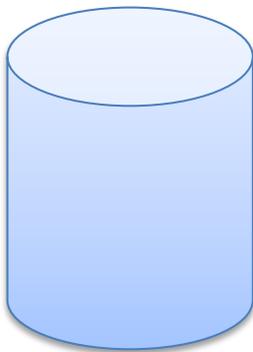


Figure (6) show the shape of sample.



Figure (7) show the mixer.

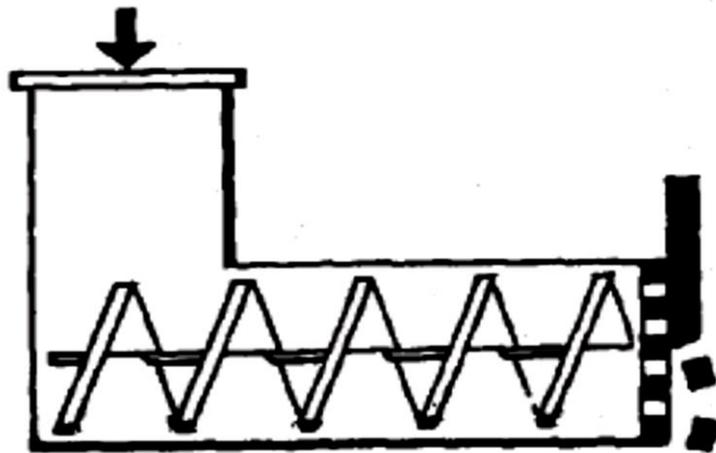


Figure (8) show the extruder.



Figure (9) show the electric furnace.