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UTILIZATION OF LIMESTONE DUST IN BRICK MAKING

A.A.Mageed[a] and Gamal .S.AbdelHaffez [a,b]

a. Assiut Univ., Faculty of Eng. Dept. of Mining & Metall., Assiut, Egypt
b. On Secondment to king AbdulAziz Univ., Jeddah, Saudi Arabia

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In Egypt, Large amounts of limestone dust are accumulated annually during running limestone quarries. Disposal of these wastes is a rapidly growing problem, and causes certain serious environmental problems and heath hazards. Therefore, research for utilizing these disposals is urgently needed. The main aim of this study is to investigate both physical and mechanical properties of brick specimens containing combinations of limestone dust and small amount of Portland cement as a binder for producing building brick material. Limestone dust and cement were mixed, humidified and molded by two methods, hand-making method and mechanical molding method applying small compaction action. After demoulding, the produced specimens were left to dry in air at room temperature for 28 days. The obtained values of water absorption, bulk density, slake durability index, and compressive strength satisfy the Egyptian standard of fired clay building units for non-load bearing walls. The test results indicate that brick specimens contain 13% cement satisfy the requirements of building of non-load bearing walls in Egypt. The process undertaken can easily be applied in the working Egyptian brick plants using semi mechanization system. The positive use of these wastes converts them into useful products that can alleviate the disposal and environmental problems.

***KEYWORDS**: utilization of limestone wastes, Concrete mix, Environmental impact of limestone quarrying, Recycling of wastes*

INTRODUCTION

The increasing demand on building materials in the last decade, especially in the developing countries has lead to convert the industrial wastes into useful building and construction materials [1-9]. During the extraction, hauling, cutting and crushing processes for producing small limestone building blocks and coarse aggregates, large amounts of limestone fines, commonly known as quarry dust, are generated [5].

Accumulation of unmanaged wastes has resulted in an environmental concern. Because disposal and/or storage of this waste is expensive, it contaminates the air of the surrounding area with the storms in Summer and Spring and therefore causes serious health hazards including specifically asthma and lung cancer [5,6]. Recycling of such wastes as building materials appears to be a viable solution not only to solve such pollution problem but also to the problem of economic design of buildings [1].

Some authors [7,11] indicated that limestone quarrying typically produces around 20% to 25% limestone powder waste (LPW) .The estimated LPW of 21.2 million tones in the UK, 18 million tones in Greece and 30 million tones in Turkey is reported[1,4,5,7]. Many different ways for utilization of limestone dust have been proposed in literatures [1-20] such as brick and block production [1-5,8,9-11,14], concrete industry [2,6,13,15,20], filler materials [10,16] road construction and bulk fill [7,9,10,12,17], agricultural uses [10,19] , industrial waste neutralization [5], plastics and rubber industries [5] ,… etc.

Today there is an increasing interest in developing a simple and economic method to turn limestone dust into building product (artificial stone) that could be used as masonry brick or pavement block [4,10].Limited numbers of published work about the possible utilization of limestone dust in brick making are reported in literatures . Some authors [4] have undertaken evaluation tests on limited number of cylindrical samples. Limestone dust and small amounts of Portland cement were mixed, humidified and compacted in a cylindrical mold of 50 mm diameter and 80 mm height under high pressure. Water absorption values were not determined in this research [4]. The produced artificial stone exhibited acceptable quality characteristics for use as masonry unit (non– load bearing element). The combinations of limestone dust with wood sawdust, cotton wastes and glass powder wastes were successfully used to produce a light weight composite as a building material [1-3,5,8].

In Egypt, calcareous aggregates are used extensively for all construction applications such as road construction, building purposes, iron and cement industries, due to their low cost and the high availability. Considerable amounts of limestone dust are being produced as by – products of different quarrying process. Most of the limestone quarry dust are open-dumped into uncontrolled waste pits and open areas, which causes serious environmental problems and health hazards. Creating a market for common wastes will reduce volumes and provide economic advantage over disposal, as well as reducing the associated environmental and social impacts.

In the present study, laboratory trials were carried out to prepare and test molded brick specimens consisting of limestone dust and small amount of Portland cement. Physical and mechanical properties of brick specimens were tested aiming to get a suitable product for construction applications in Egypt. The key for the successful utilization of the quarry dust is its proper characterization and the development of simple and economically viable process to turn it into marketable products.

EXPERIMENTAL WORK

Material

The materials used for brick specimen's preparation were limestone dust, ordinary Portland cement, and tap water. Quarry dust sample was collected from a limestone quarry in Assiut region [Egypt] . The nominal particle size of the head sample is 1.25 mm, the sample was dried at 105 C° for 24 hours, cooled at room temperature and ground to pass 1.25 mm .The physical and chemical properties of the limestone dust used in the present work is given in Table 1. The grading of limestone dust head sample is shown in Figure1. The median size (d_{50}) of the head sample is 140 micron .

Table 1: The properties of limestone dust head sample.

Properties	Measured values
Moisture content, %	2.63
CaO , %	55.2
Density,g/cm^3	2.60
Loss on ignition , %	42.40

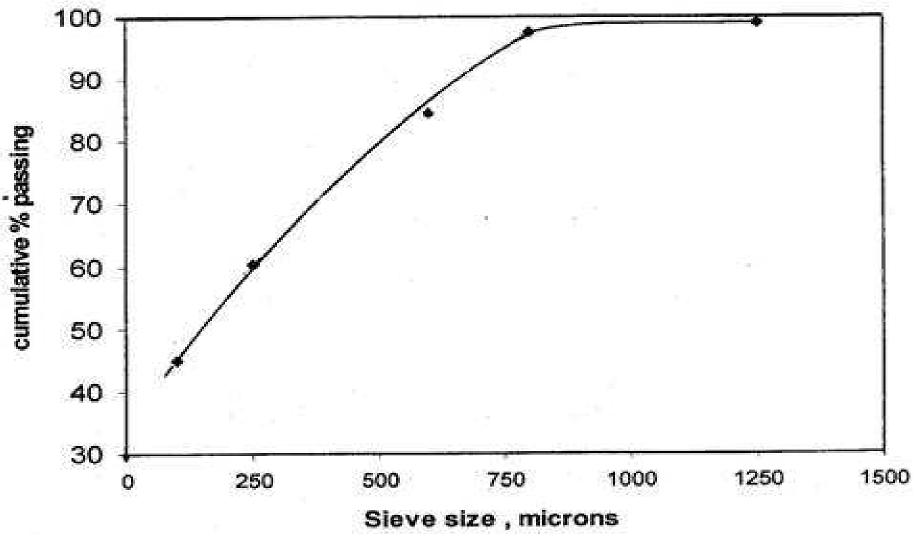

Fig.1: The sieve analysis of limestone dust head sample

PROCEDURES

Limestone dust and cement were mixed and homogenized together in a laboratory Jar mill for 5 min . The mixture was humidified by spraying an adequate amount of water to produce an workable mix. Details of mixes are given in Table 2 .

Table 2: Mixture proportions of cement – dust and water

Mix No.	Cement	Limestone dust	Water added		No. of cubes* /series
	Wt.,%	Wt.,%	Wt.,%	cm^3	
1	10	90	20	240	6
2	12	88	20	240	6
3	14	86	20	240	6
4	16	84	20	240	6
5	18	82	20	240	6

* Cubes 5x5x5 cm.

The sequence of brick making is illustrated in Fig.2. Two series of tests were fabricated using the mixture proportions given in Table 2 . In the first one , hand made brick specimens were fabricated into steel cubes of 5 x 5 x5 cm . The second series was carried out by compression moulding method , where a small compaction force of 20 KN is applied to compact the over-filled steel mould with the mixes using the same mixture proportions given in Table 2. The produced specimens of the two cases were demoulded after 24 hours and left to dry in open air at room temperature for 28 days. No damage is observed on the brick specimens while demoulding them.

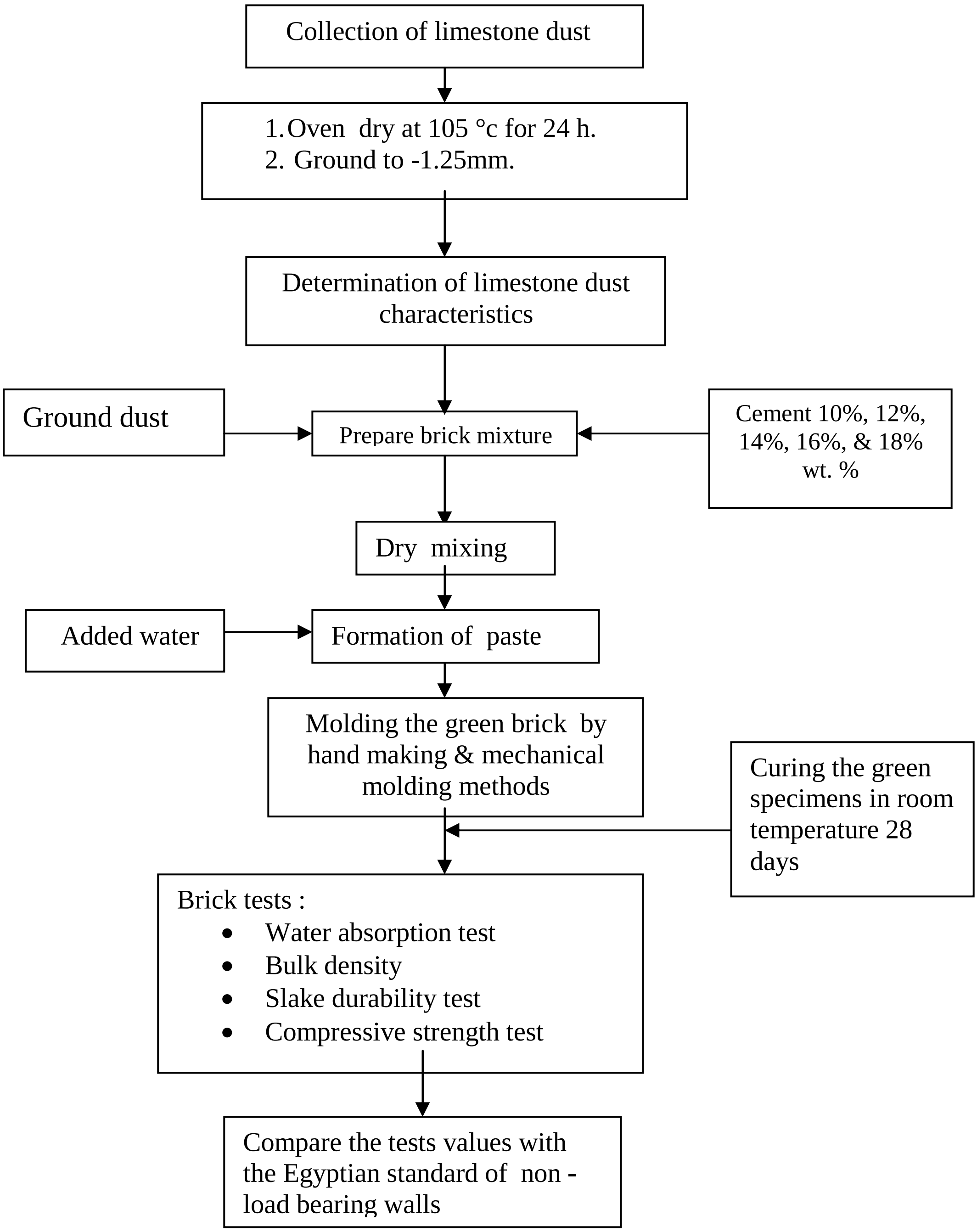

Figure 2 : Flow chart describing the sequence of brick- making

RESULTS AND DISCUSSION

The quality of the produced bricks of the two series were tested after 28 days curing for their water absorption, bulk density , slake durability , and compressive strength .

1. Water absorption

Water absorption is a key factor affecting the brick properties. The less water infiltrates into the bricks , the more durable the brick ,is the more resistance to natural environment. Thus, the internal structure of the brick is dense enough to avoid the intrusion of water . Fig.3 shows that, the water absorption in the two series tested decreases with increased cement percent from 10 % to18 %. This may be attributed to the fact that addition of cement fills the voids within the limestone particles and increases the cohesiveness and bonding ability of the mixture . Applying small compaction force in the second series reduces the values of the water absorption of tested specimens because compaction force decreases the internal voids of the specimens. The produced brick exhibited general compliance with Egyptian Standard Specifications (20 % to 30% water absorption) [21,22].

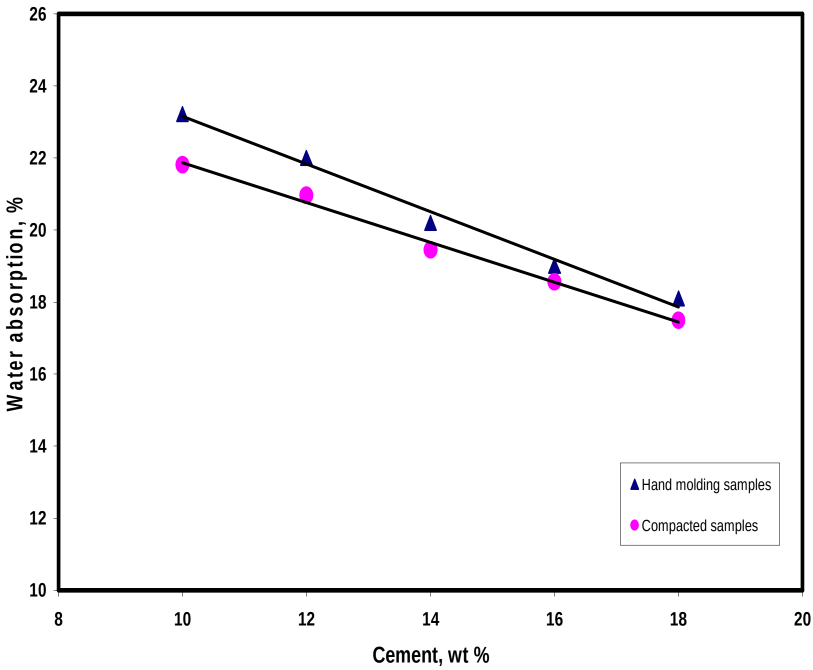

Fig. 3: Water absorption of the produced brick specimens

2- Bulk density

The summary of the obtained results of the two series tested are illustrated in Fig.4. As shown from this figure the bulk density in the two series increases with increasing the addition of cement percent . The values of the bulk density of the second series specimens slightly increased by applying small compaction force because of denser arrangement of the particulates within the brick.

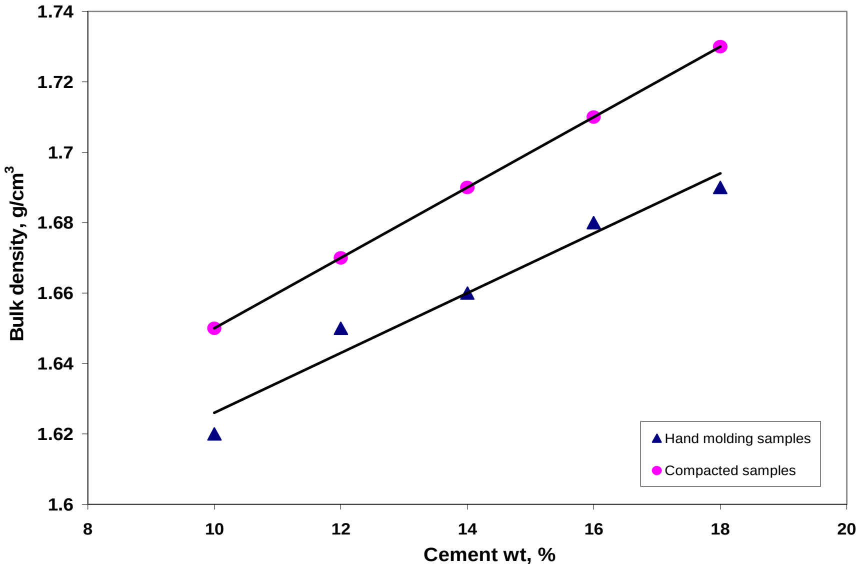

Fig.4: Bulk density of the produced brick specimens

This behavior may be contributed to the positive effect of compaction force which decreases the void volume . The bulk density of the produced specimens close enough to the bulk density of the natural limestone building blocks(1.86 g/cm^3) ,and the red brick (1.8 – 2 g/cm^3) as given in the Egyptian Standard Specifications of hand making red brick [21,22] .

3. Slake durability test

The slake durability index is defined as the resistance of a brick to wetting and drying cycles [23] . The Values of index approach zero for samples that are highly susceptible to slaking and approach 100 % for samples is hard to slake. The results of slake durability tests given in Table 3 indicate that, the index values increases as cement percent increases in the two tested series. In the first series , the minimum value is 92 % at 10 % cement and 96.05 at 18 % cement ,while in the second series , the corresponding values of index are 94.19 and 98.06 % respectively . This means that the compaction force improve the slake durability index values due to decrease in the void volume . Finally, the results of the produced specimens in the two cases are more reasonable in building purposes.

Table 3: Slake durability index values

Cement , Wt %	Slake durability index values , %	
	Hand making specimens	Compacted specimens
10	92.00	94.19
12	93.85	95.83
14	94.90	97.18
16	95.25	97.77
18	96.05	98.06

4. Compressive Strength

The compressive strength is the most important test for assuring the engineering quality of a building material . The results of measuring the compressive strength of the two tested series specimens are illustrated in Fig.5. The results indicate that the strength is greatly dependent on the amount of cement added in the mixture . The compressive strength in both series increases as the cement percent in the mixture is increased from 10% to 18%. In the case of the first series(hand making method) at 10 % cement , the compressive strength is 26 kg f/cm^2 and at 18 % cement , the value jumped to 51.2 kgf/cm^2,while in the second case (mechanical molding method) the compressive strength is about 33 kg f /cm^2 and jumped to about 66 kg f/cm^2 respectively . This indicates that applying compaction with small force improves the mechanical properties of the produced brick . The produced brick match the Egyptian standard specifications of red clay bricks(25 to 45 kgf/cm^2) [21,22] and can be used in non-load bearing walls.

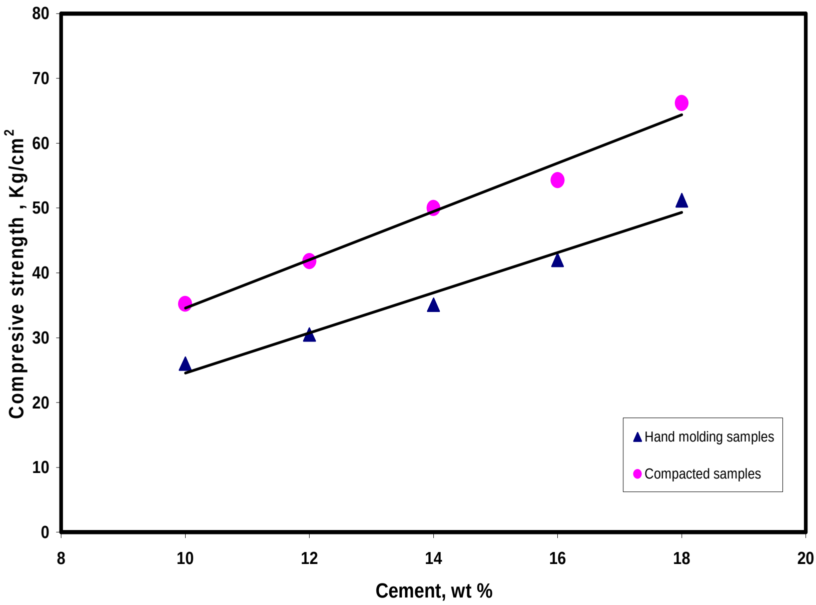

Fig. 5: Compressive strength of the produced brick specimens

CONCLUSIONS

The obtained results in this study lead to the following conclusions :

* The results show that combination of limestone dust and cement can be used in the production of masonry building bricks with acceptable mechanical properties which match the Egyptian Standard specifications of non- load bearing walls [21,22] .
* The added cement in the mixture affects positively the studied properties of the produced bricks.
* Reasonable quality brick can be produced with addition of about 13 % cement, in the mix , which attained strength of 33 kg f /cm^2 and 45 kg f /cm^2 respectively in

the two tested series. These values satisfy the requirements for buildings of non – load bearing walls (25 to 45 kg f /cm^2) [21,22] .

* The produced bricks have the following properties: 20-21 %water absorption ,bulk density of 1.65-1.68 g/cm^3 slake durability of over 95 % and compressive strength of 33-45 kgf / cm^2
* The process of mechanical moulding method can easily be applied in the existing Egyptian brick plants using semi mechanization system.
* The positive uses of these wastes produces useful profitable products and decreases environmental problems for the neighbouring society.

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استغلال ناعم الحجر الجيرى فى صناعة الطوب

تتراكم كميات كبيرة من ناعم الحجر الجيرى بالمحاجر المصرية نتيجة أعمال التحجير بهذه المواقع ، ويزداد تراكم هذه النفايات بالمحاجر بصورة مطردة مما يسبب مشاكل خطيرة للبيئة المحيطه ولصحة الانسان ، ومن ثم أصبح من الضرورى البحث عن وسائل لاستغلال هذه النفايات والاستفادة منها . ويهدف هذا البحث إلى دراسة الخواص الطبيعية والميكانكية لعينات طوب مصنعه من خليط من ناعم الحجر الجيرى مع الاسمنت البورتلندي العادى . وقد تم ذلك معمليا بخلط نسب مختلفه من ناعم الحجر الجيرى والاسمنت خلطا جيدا على الجاف ثم إضافه الماء اللازم لتشكيل العجينه ، ثم صب العجينه فى قوالب من الحديد مكعبه الشكل بابعاد 5x5x5 سم بطريقتين مختلفتين لصناعة عينات من الطوب . الاولى باستخدام الطريقه اليدوية والثانيه باستخدام الطريقه الميكانيكية بدمك العجينه فى قالب الصب بقوة ضغط 20 كيلو نيوتن . والنتائج المعملية التى تم الحصول عليها بعد تجفيف عينات الطوب فى درجة حرارة الغرفة لمدة 28 يوم وتعرضها للاختبارات الآتية : امتصاص الطوب للماء ، الكثافه الحجميه ، مقاومة الطوب للعوامل الجويه و المقاومة للضغط تعتبر مرضيه وتطابق

المواصفات القياسيه المصريه لطوب الحوائط غيرالحامله رقم (1756−1989) . ويمكن استخدام هذه الطريقه بسهوله فى مصانع طوب البناء الموجودة حاليا بمصر، والتي تعمل بالنظام نصف الميكانيكي . ولقد اوضحت النتائج ان افضل مقاومة للضغط تفى باغراض مواصفات طوب البناء بمصر يمكن الحصول عليها عند اضافة نسبة 13 % اسمنت لناعم الحجر الجيري في خلطه اعداد الطوب . والاستخدام الايجابى للتخلص من هذه النفايات يعتبر ذو فائده اقتصادية وحماية للبيئة المحيطة بالمحاجر.