A STUDY ON PRODUCING NEW MORTAR CONTAINING MIXTURE OF WASTE LIMESTONE AND GLASS[+]

دراسة لإنتاج مونة جديدة حاوية على مزيج من مخلفات الحجر الجيري والزجاج

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Abstract:

Large amounts of glass and limestone wastes are accumulating every year. Disposal of wastes of limestone factories , recycled container glass (battles) and wastes of industrial glass is a rapidly growing problem for environment, so research for alternative utilization of these disposals is needed. In this respect, the objectives of this study are to investigate the possibility of producing new mortar containing crushed limestone and glass combinations instead of natural sand . In the present research program, in which mortar has been produced with different ratios of substitution (25%, 50%, 75% and 100%) of natural sand with new mixture of waste limestone and glass. The mechanical properties of the mortars including compressive strength, tensile strength and density were tested. Results show the increasing of compressive strength with an increase of replacement ratios of limestone and glass, at level 25% and 50 %, the highest compressive strength after 3and 7 days was achieved by specimens 50% of crushed limestone and fine glass. The difference is however significant and equals about (21%) in relation to conventional mortar ,while there is an increase of (11%) in the tensile strength of mortar . Hence it is concluded that combined usage of limestone and glass, will be suitable instead of using natural sand in mortar of cement at specified replacement level.

Keywords: Waste glass; Limestone ; New mortar; Mechanical Properties; Replacement.

المستخلص:

كميات هائلة من مخلفات معامل الحجر والمخلفات الصناعية للزجاج تتراكم سنويا وللتخلص من هذه المخلفات دعت الحاجة إلى إجراء بحث وإعادة تدوير هذه المخلفات. إن هدف الدراسة الحالية هو انتاج مونة سمنت جديدة وذلك باستخدام مزيج من مسحوق مخلفات معامل الأحجار الجيرية ومسحوق الزجاج الناتج من سحق القناني الزجاجية والمخلفات الصناعية كبديل عن الرمل الطبيعي وبنسب وزنية مختلفة (٢٥، ٥٠، ٧٥، ١٠٠%) . الفحوصات أجريت لحساب الخواص الميكانيكية لمونة السمنت (مقاومة الانضغاط ومقاومة الشد) بالإضافة إلى قياس الكثافة لمكعبات المونة الجديدة وأثبتت النتائج أن مقاومة الانضغاط تزداد بزيادة نسبة استبدال الرمل بمزيج من مسحوق مخلفات الحجر الجيري ومسحوق الزجاج إلى حد ٢٥ % و٥٠ %. النسبة ٥٠% أعطت أعلى زيادة في مقاومة الانضغاط في عمر ٣ و٧ أيام. وكانت الزيادة في مقاومة الانضغاط حوالي (٢١%) مقارنة مع المونة العادية بينما كانت الزيادة في مقاومة الشد حوالي (١١%) ، وهكذا يمكن استنتاج أن استعمال مزيج مسحوق الحجر الجيري ومسحوق الزجاج سيكون مناسبا كبديل عن الرمل الطبيعي في مونة السمنت في حدود النسبة المعطاة.

الكلمات المفتاحية: مخلفات الزجاج ،مخلفات الحجر الجيري ، مونة جديدة،الخصائص الميكانيكية، استبدال

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Introduction:

A s the construction industry grows rapidly together with economic growth, the demand for aggregate is rapidly increasing . river sand ,and even ocean sand are currently being exhausted and the natural environment of the land is being destroyed.

Because the demand for aggregate steadily increases while the supply is limited, the use of recycled aggregates obtained by crushing limestone or glass or waste concrete, is inevitable when attempting to balance demand and supply [1,2].

Glass has been used as fine aggregate in road construction ,building and masonry materials [3], recent studies have shown that reuse of very finely ground waste glass in concrete has economical and technical advantages [4-6] . Partial replacement of fine aggregate in concrete by crushed glass was already attempted and strength loss due to the sand substitution by the crushed glass was reported to be between 5 to 10 % [7].

Many efforts have been made to use industrial by products such as fly ash, silica fume, ground granulate blast furnace slag, glass cullet, etc. in civil constructions for many years [8,9].

Turgut and Yahlizade [10] have shown feasibility of paving blocks with the fine and coarse waste glass technically . The test results show that the replacement of (FG) by (FA) at level of 20% by weight has a significant effect on compressive strength, splitting tensile strength of paving blocks as compared with the control sample because of pozzolanic nature of FG .

This study investigates the possibility of producing fine aggregate to make new cement mortar by replacement of waste limestone and glass in various ratios (25%, 50%,75% and 100%) of natural sand, and study the density, mechanical properties of new mortar compressive and tensile strength.

Material and Experimental procedure:

1- Materials

Cement: Ordinary Portland Cement (O.P.C) was used in accordance with Iraqi Specifications No. 5, (1984) [11].The physical properties of cement are shown in the Table (1).

Natural sand (fine aggregates) *:* sand from (Al-Kazer) region was used as fine aggregates, graded as shown in the Table (2), according with Iraqi Specifications No.40, (1985) [12].

Crushed limestone *:*In this study wastes of limestone factories was crushed and grade as natural sand .

Crushed glass*:* recycled container glass(battles) was crushed and graded as natural sand and used in this study .

Table (1): Physical properties of cement.

Physical property	result	Limit of I.S. No.5
Vicat initial setting time (minutes)	80	Not less than 45 minuet
Vicat final setting time (minutes)	165	Not less than 10 hours
Fineness	280	Not less than 230 kg/ cm2
Normal consistency	0.285	----------
Compressive strength 3-days (MPa)	19.7	Not less than 15 MPa
Compressive strength 7-days (MPa)	30.9	Not less than 23 MPa

Table (2): Grading of fine aggregate.

Nominal sieve size (mm)	Percentage passing by weight (%)	Limits of Iraqi standard Specification
9.5	١٠٠	١٠٠
٤	٩٤	١٠٠ _٩٠
٨	٧٧	٩٥_٦٠
١٦	٤٩	٧٠ _٣٠
٣٠	٢٤	٣٤_١٥
٥٠	31	٢٠_٥٠
١٠٠	٣	٠_١٠`
٢٠٠	٠	Add to specification according to new update

2- Preparation of specimens

The proportion of materials which is used in the present study was 1:3 by weight one part of cement to 3 parts of sand . Batch the following , which is sufficient for six samples , 500 gm of cement, 1375 gm of sand 142 ml of water according to ASTM C 109 [13].
Table 3 illustrates the mix proportion of mortars prepared by replacement of natural sand with combined mixture of crushed limestone and crushed glass at the same ratio then replaced natural sand at variable amount (25%, 50%,75% and 100%) of sand , compositions of mortars were:

- MLG1 – mortar prepared with 25% of mixture limestone and glass.
- MLG2 – mortar prepared with 50% of mixture limestone and glass.
- MLG3 – mortar prepared with 75% of mixture limestone and glass.
- MLG4 – mortar prepared with 100% of mixture limestone and glass.
- Control – mortar were prepared by using only natural fine aggregates.

The existence of water is important for the mixture to complete the chemical reaction of cement and provide required workability. In this study trials were made to evaluate the required water quantity to gain good workability and the amounts of water added to each mix are shown in Table (3).

Table (3): Mix proportions of mortars studied for one cube.

Mix notation	Mixed sands (g)			Cement (g)	Water (ml)
	Waste Limestone	Waste Glass	Natural sand		
Control	٠	0	٢٢٩	٨٣	23.6
MLG 1	29	29	171	٨٣	25
MLG 2	57	57	115	٨٣	29
MLG 3	86	86	57	٨٣	30
MLG 4	114.5	114.5	0	83	32

3. Tests program

Tests were conducted to determine , the density , compressive strength and tensile strength.

Compressive strength : The cubes used were (5 x 5 x 5) cm^3 in accordance with BS (1881 part 111 1981) [14]. The mortar samples were tested after 3 and 7-days casting and curing. The compressive strength of each group of mortar was carried out according to BS (1881 part 111 and 116, 1983) [15]. By using universal compression testing machine at 3 and 7- days, compressive strength results were calculated as the average value of three specimens. Results of the tested specimens are summarized in Table (4).

Tensile strength In this study tensile test was used to evaluate the effect of using a mixture of crushed limestone and glass in mortar instead of sand. This test was done according to BS part 1 1998[16].

Density : the density of the specimens was determined using water displacement method

Results and Discussion:

As one can see from Figure 1, compressive strength increases with an increase of replacement ratios of limestone and glass, at level of 25% and 50 % ,but the compressive strength decreased at the ratio 75% and 100%. Results presented in Table 4 show that the highest compressive strength after 3 and 7 days was achieved by specimens with 50% of crushed limestone and glass. The difference is however significant and equals about (21%) in relation to control mortar .

Table (4): Test results of compressive , tensile strength and density.

Mix notation	Compressive strength (MPa) at 3-days	Compressive strength (MPa) at 7-days	Tensile strength (MPa)	Density kg/cm3
Control	20.3	28.7	2.21	2.275
M-LG-٢٥ %	24.4	32.8	2.27	2.256
M-LG- 50 %	26	34.8	2.45	2.197
M-LG-75 %	19.6	25.6	2.31	2.189
M-LG-100 %	16.4	24	2.28	2.175

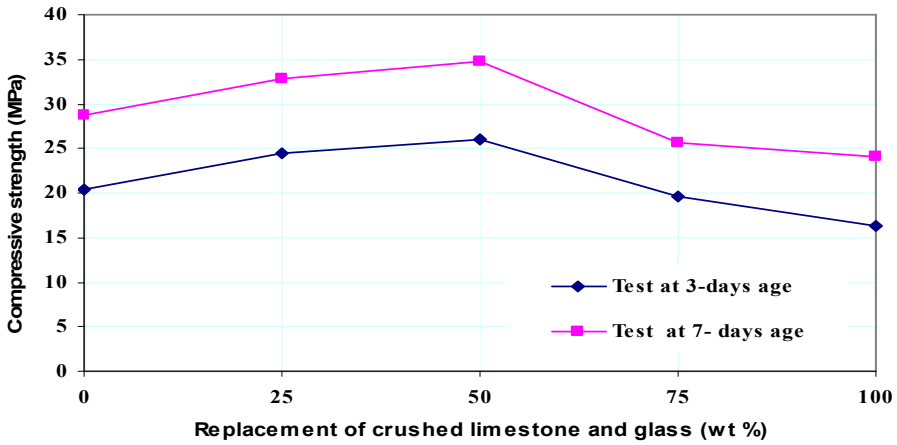

Figure (1): Mortar compressive strength with Replacement ratios of crushed limestone and glass.

In general, crushed limestone particles are angular and have a rougher surface texture and high surface area as compared with natural sand, this leads to an increased bond with cement and to increased compressive strength.

Figure 2 shows the effect of replacement ratios of crushed limestone and glass on density of mortar. As the replacement ratio of the waste limestone and glass increases , the density decreases significantly, according to the results presented in Table 4.

Figure 3 illustrates the effect of the replacements of limestone and glass instead of natural sand on tensile strength . As the replacement ratio of the waste limestone and glass increases , the tensile strength increases as compared with the control sample, The recorded increase was up to (11%) for tensile strength.

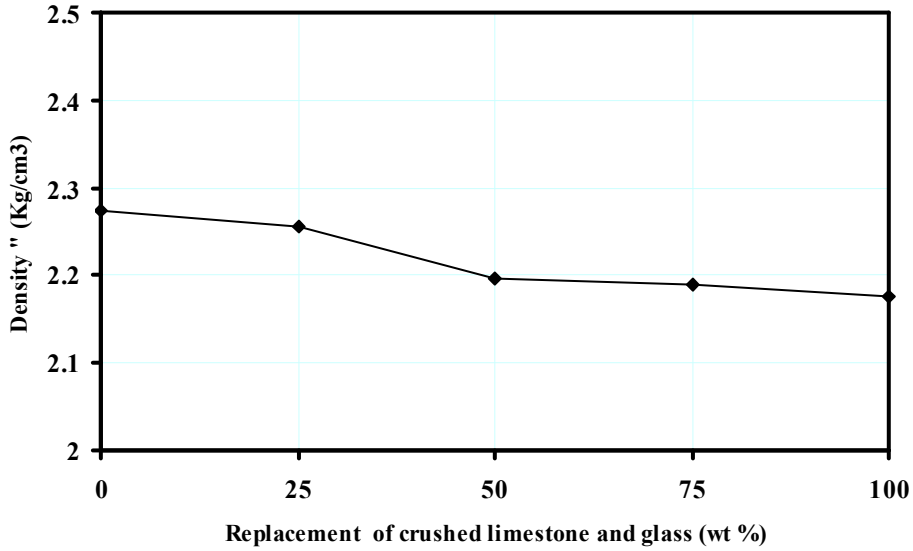

Figure (2): Mortar Density with Replacement ratios of crushed limestone and glass.

Figure (3): Mortar Tensile strength with Replacement ratios of crushed limestone and glass.

Conclusions:

The paper proposes application of mixture contains the same ratio of crushed limestone and glass which after proper processing can be used as a substitute of natural sand in the production of cement mortar.On the basis of analysis of experimental results it can be concluded:

1. The procedure of preparing mortar containing crushed limestone and glass resembles the one with natural fine aggregate , it is necessary however to adjust the amount of water in order to obtain the required mix.
2. Test results allow stating that there is a possibility to produce new mortar containing the crushed limestone and fine glass as partial replacement instead of natural sand.
3. Compressive strength increases with an increase of replacement ratios of limestone and glass, at ratios of 25% and 50 % , the highest compressive strength after 3and 7 days was achieved by specimens with 50% of crushed limestone and glass. The difference is however significant and equals about (21%) in relation to control mortar as shown in Figure 4.
4. As the replacement ratio of the waste limestone and glass increases , the tensile strength increases as compared with the control sample, The recorded increase due to 50 % was (11%) for tensile strength at 50 % replacement as shown in Figure 4.
5. As the replacement ratio of the waste limestone and glass increases , the density decreases .

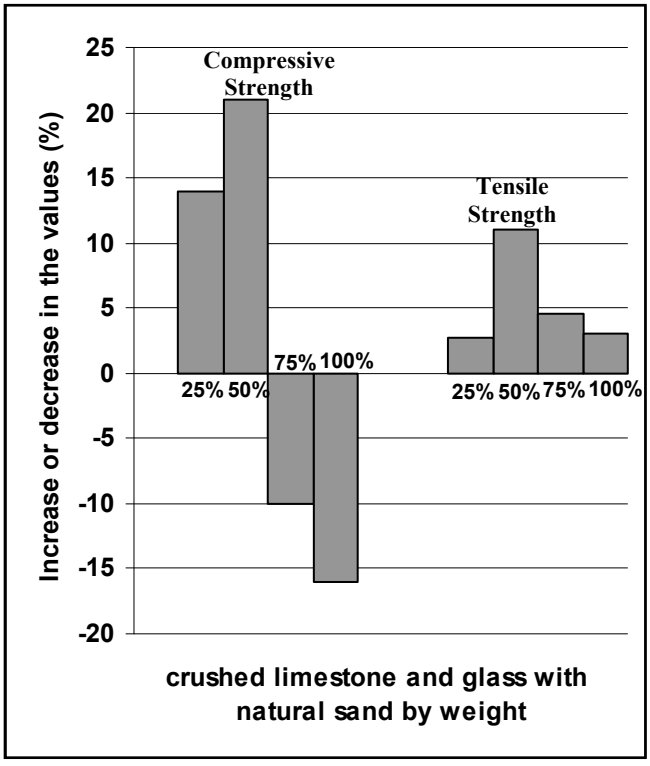

Figure (4): The variation (%) of test results in crushed limestone and glass replacement with natural sand

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