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Effect of Marble Waste Powder as Cement Replacement on The Concrete Mixes

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Abstract Leaving the waste materials to the environment directly can cause environmental problem. Waste reuse was therefore emphasized. Waste can be used to produce new products or can be used as additives so that natural resources are used more efficiently and protect the environment from waste deposits. The marble stone industry generates both solid waste and stone slurry which will adversely affect the environment. This study focuses on the use of local marble powder waste in concrete and enhance the concrete compressive strength more economically, by partial replacement of the weight of cement by marble powder with 0, 2.5, 5, 7.5 and 10% of cement weight.The concrete mixture was designed at a compression strength of 50MPa after 28 days. The water/cement ratio (0.48) remained constant. Concrete samples (cubes) were tested for compressive strength after 3, 7, 14 and 28 days after proper curing. Fineness of hydraulic, Normal consistency and initial and final setting time of cement by marble powder of 0, 2.5, 5, 7.5 and 10% of cement weight were tested.The study which was carried out under controlled laboratory condition indicates that high level of marble powder in the concretes decrease the early and later ages strength development of marble powder significantly. Only concrete with 2.5 % marble powder which gives compressive strength very close to the 0% marble powder concrete. The use of this type of marble powder resulting from the process of cutting marble as partial replacement of cement in concrete will not benefit cement industrial unless find another source of good marble waste powder.
Keywords: Concrete, compression strength, Marble Powder, waste material.

تأثير بودرة نفايات الرخام المحلي كبديل للأسمنت على الخلطات الخرسانية الطازجة والصلبة

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الملخص إن ترك النفايات في البيئة مباشرة يمكن أن يسبب مشكلة بيئية. لذلك تم التأكيد على إعادة استخدام النفايات. يمكن استخدام النفايات لإنتاج منتجات جديدة أو يمكن استخدامها كمضافات بحيث يتم استخدام الموارد الطبيعية بشكل أكثر كفاءة وحماية البيئة من ترسبات النفايات. صناعة الرخام تنتج كلاً من النفايات الصلبة وبودرة الحجر مما سيؤثر سلباً على البيئة. تركز هذه الدراسة على استخدام نفايات بودرة الرخام المحلي في الخرسانة وتعزيز قوة ضغط الخرسانة بشكل اقتصادي أكثر، عن طريق الاستبدال الجزئي لوزن الأسمنت بمسحوق الرخام مع 2.5 و 5 و 7.5 و 10٪ من وزن الأسمنت. تم تصميم خليط الخرسانة بقوة ضغط تبلغ 50 ميجا باسكال بعد 28 يوماً. ظلت نسبة الماء / الأسمنت (0.48) ثابتة. تم اختبار عينات الخرسانة (المكعبات) لمقاومة الانضغاط بعد 3 و 7 و 14 و 28 يوماً بعد المعالجة المناسبة. تم اختبار صفاء الهيدروليكي ، والاتساق العادي ووقت الإعداد الأولي والنهائي للأسمنت بمسحوق الرخام من 0 ، 2.5 ، 5 ، 7.5 و 10 ٪ من وزن الأسمنت. تشير الدراسة التي أجريت تحت ظروف معملية خاضعة للرقابة إلى أن المستوى العالي من مسحوق الرخام في الخرسانة يقلل من قوة تطور بودرة الرخام في العصور المبكرة واللاحقة بشكل ملحوظ. فقط الخرسانة ببودرة الرخام 2.5٪ مما يعطي قوة ضغط قريبة جداً من الخرسانة الرخامية المسطحة بنسبة 0٪.

الكلمات المفتاحية: الخرسانة ، قوة الضغط ،بودرة الرخام .

Introduction

In the world of construction, concrete like other materials is playing an important role in development. Concrete is a composite material which is a mixture of cement, fine aggregates, coarse aggregates and water. The Cement among which plays an important role in strength of concrete. Other Pozzolanic materials such as marble dust, Silica Fume, Fly ash can also be used. It possesses many advantages including low cost, general availability, adaptability, no extra energy consumption, enhancement of concrete properties and utilization under different environmental conditions[1]. The goal of sustainable construction is to reduce the environmental impact of a constructed facility over its lifetime. Concrete is the main material used in the construction world. With the rapid

development in the industrialization numerous industries are established and their rate is increasing day by day. Various industries such as Marble industry, steel mills etc uses such materials that results in the production of various by-products such as silica fume, marble dust, fly ash and many others. In some countries these materials are dumped in open as of no use without knowing about their cementitious properties. Thus by doing so they are polluting the environment and also reducing the natural resources by cutting mountains. These by-products have cementitious properties, so they can be used as replacement with cement. In the future it may be useful to find new source of binding material for the production of concrete due to increase in demand for and decrease in supply of cement. Partial replacement of cement is a viable option to decrease the demand on high quality natural resources and to limit the amount of waste excreted by industries. Partial replacement of cement with by-products has shown successful results in improving the strength of concrete and also helpful in producing low strength concrete at low cost than cement. The by-products contribute to material sustainability, reduce environmental impacts of by-products and can have positive financial implication for certain projects. The cost of project could decrease if cement replacement is done for gaining the high strength.

Marble has been used as an important building material, especially for decorative purposes for centuries. In processing marble such as cutting to size and polishing etc. for decorative purposes, marble dust and aggregate are created as by-products. During sawing, shaping, and polishing process, about 25% of the processed marble turns into dust or powder form. Disposal and re-using of the waste materials of the marble industry is one of the environmental problems all over the world. Marble factories remnants considered one of the most dangerous industrial pollutants to the environment and health, as the absence of engineering methods of environmental disposal the proper ones and throw it randomly cause a lot of environmental problems and health.

Libyans have been interested in the marble industry since ancient times, and there are marble in Libya abundantly in the old cities and palaces as well as the old and modern Libyan House. In Libya use of Marble waste powder in not very usual and there has been little research work done on it.

Therefore, the study of the effect of partial replacement of marble powder with cement ratio 0, 2.5, 5, 7.5 and 10% in order to preserve the environment from the impact of raw waste damage and make use of marble waste to reduce the cost of concrete[2-7].

Materials Used

The same materials were use throughout this study. All the materials were in accordance with relevant BS and ASTM standards and considered suitable for the scope of this study.

1. Aggregate

Fine and coarse aggregate was used in this study, it was obtained from Sawawa area, about 5 km east of Sirte.

2. Cement

Zliten cement was used in this study which can be classified as normal Portland cement type 42.5N and the results of the tests of fineness, specific gravity, normal consistency and setting time were confirm to the specifications. Table 1 shows the chemical and physical properties of cement.

Table 1: Cement Chemical & Physical Properties

Physical properties		Chemical properties	
Laboratory Tests	Results	Chemical Composition	Percentage(%)
Standard water ratio	0.3	Loss when burning	0.3
Primary doubt time (minutes)	205	SiO_2	20.14
Time of final doubt (minutes)	330	Fe_2O_3	2.99
Size stability(mm)	1.00	Al_2O_3	5.91
Pressure resistance after 3 days (MPa)	26	CaO	62.9
Pressure resistance after 28 days (MPa)	44	Mgo	1.59
Specific weight	3.15	SO_3	2.13
Surface Area (g / cm2)	2977	Na_2O	0.19
-------	-------	K_2O	0.97

3. Water:-

The quality of concrete mixing water should not contain undesirable organic substances or inorganic constituents in excessive proportion. Therefore, tap water used throughout the mixing and curing procedures of concrete in this study.

4. Marble Waste powder

Marble Waste (powder) were collected from three marble workshop in Sirte, the Marble originally from Egypt. Marble Waste were brought into a state of indivisible mass and in total form in large quantities and their size was about 40 mm to 80 mm as shown in Figure 1.

Fig. 1: Solid marble waste

In this case, it is not suitable for use as a substitute for cement. It was necessary to find a way to convert this masses to a state close to the case of cement and degree of smoothness near the degree of smoothness of cement, These steps have been taken to obtain the desired degree of smoothness:-

1- The marble waste dried in the oven for 24 hours To get rid of water contents.

2- The marble waste crashed in the Los Angeles machine with iron balls to grind the sample and obtain the required smoothness as shown in Figure 2.

Fig 2: The marble waste after grinding in loss Angeles machine

3- Collect the sample after extracting it from the Los Angeles apparatus and place it in the oven to protect it from moisture.

4- Pass the sample on a sieve to see the smoothness obtained

5- For samples did not achieve the required degree of softness, they are place again in a Los Angeles Machine to be grinding.

Chemical Analysis of Marble Waste powder

Table 3 shows the results of chemical analysis of the three sample collected.

Table 3: Marble Waste Chemical Properties

Chemical Composition	Sample 1	Sample 2	Sample 3	Device type
Ca	28%	30%	30%	Titratium
Sio2	0.2ppm	8.0ppm	0.52ppn	Device U.V
Fe2o3	0.02ppm	0.02ppm	0.02ppn	Device U.V
Cao	39 %	42%	42%	Calculation

From the chemical analysis of marble powder and chemical analysis attached to cement, it is notice the presence of calcium oxide (Cao) in the sample 2 is higher than the other sample, Due to these results sample 2 studied to determine it is effect as substitute of cement in concrete.

Fineness of hydraulic cement by No.200 sieve (ASTM C 184-83)[8]

This test method covers determination of the fineness of hydraulic cement by means of the (No.200) sieve. Smoothness test was carried out by replacing marble powder with a percentage of 0, 2.5, 5, 7.5, 10% of the weight of the cement and the results were in conformity with the specifications as shown in the following tables 4.

Tables 4: Fineness of cement with marble powder by no.200 sieve

Percentage of Marble powder (%)	Percentage of retaining on (NO.200) sieve (%)	Specifications (%)
0	5.6	<22
2.5	4.6	
5	4.4	
7.5	4.4	
10	4.4	

Normal consistency of cement (ASTM C 187-86)[9]

This test method cover, the determination of the normal consistency of hydraulic cement. That is by determining the amount of water required to prepare cement pastes for initial and final time of setting test.

It was found that the optimum water content that gives a penetration of 10 mm is 28% of the weight of cement, where 28% was fixed when replacing marble powder by 2.5, 5, 7.5, 10% of the weight of cement and the penetration as shown in the following table 5.

Table 5: Normal consistency of the cement and marble powder

Percentage of Marble powder (%)	Water amount (%)	Penetration (mm)
0	28	10
2.5		13
5		13
7.5		13.5
10		15.5

Initial and final time of setting of cement (ASTM C191-82) [10]

This test covers determination of time of setting of cement by means of the Vicat needle. The effect of the marble residues on the initial and final time of setting of the cement has been studied, the same steps were used to determine the initial and final time of setting of the cement.

Figure 4 showing that the relationship between initial, final time and penetration rate of each percentage of marble powder.

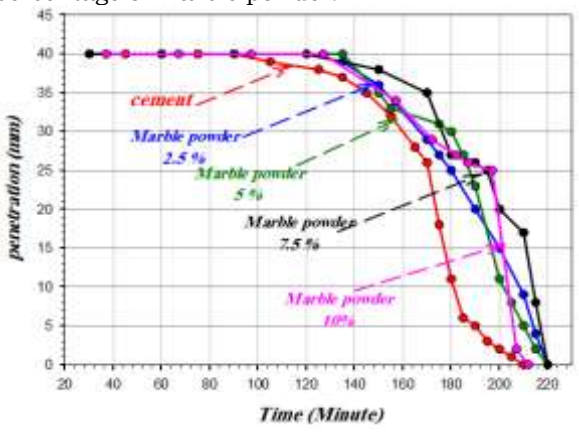

Fig. 4: Relationship between initial time and penetration rate of each percentage of Marble powder

Table 6 show the relationship between the percentage of marble powder and initial and final setting time for each percentage.

Table 6: Initial and final setting time of cement and marble powder

Percentage of Marble powder (%)	Initial setting time (Minute)	Final setting time (Minute)
0	173	210

2.5	180	220
5	186	220
7.5	195	220
10	197	221

Mix design of Portland cement and Marble Waste concrete

In this study, the BRE method (Mix design of normal concrete)[14] has been used to design the concrete mixes.

Target mean strength = 50 MPa.

Free-water/cement ratio = 0.48

In order to obtain concrete with the elegant Portland cement mixture (control) and replace the cement partial cement with marble residue levels of 2.5, 5, 7.5 and 10% the values obtained from the mixing ratios listed in Table 7.

Table 7:Weights of concrete constituents for cubic meter

Materials	Weight (Kg/ m^3) for each % of Marble powder				
	0	2.5	5	7.5	10
Cement	469	457	445	434	422
marble waste	0	12	23	35	47
Water	225	225	225	225	225
Fine aggregate	560	560	560	560	560
Coarse aggregate(10mm)	326	326	326	326	326
Coarse aggregate(20mm)	760	760	760	760	760

The strength development results of the investigated concretes at 0, 2.5, 5,7.5 and 10% levels of marble waste powder studied in order to quantify the strength that maybe expected in structural elements, results used to estimate the contribution of marble dust to the strength development of concrete at different ages is investigating. Standard concrete cubes size (100*100*100) mm^3 has been used at different ages of 3, 7, 14 and 28days to determine the effect of marble waste powder on early age strength and long-term strength of ordinary concrete, note that both concretes subjected to the same conditions of mixing, molding, compaction, curing and testing.

Effect of marble powder concrete mixes on Properties of fresh concrete:-

The slump test was carried out on fresh concrete. This test was done to find out the effect of replacing cement with marble powder on the workability of fresh concrete. Figure 5 shows the result obtained from The test, it shows as percentage of marble powder increase the slump increase.

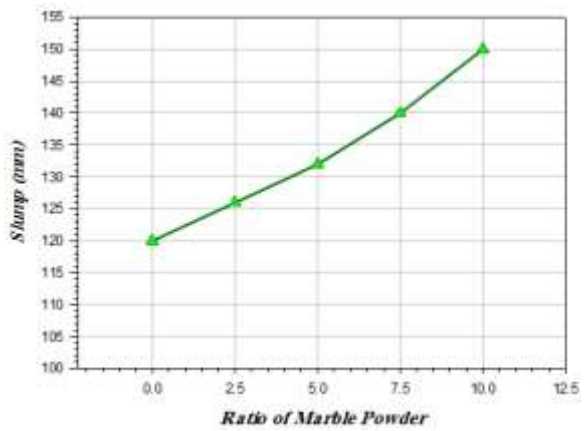

Fig. 5: Slump result

Effect of marble waste powder concrete mixes on compressive strength

The strength development for Portland cement and Portland cement with 2.5, 5, 7.5and 10% replacement level of marble waste powder are showing in figure 6.

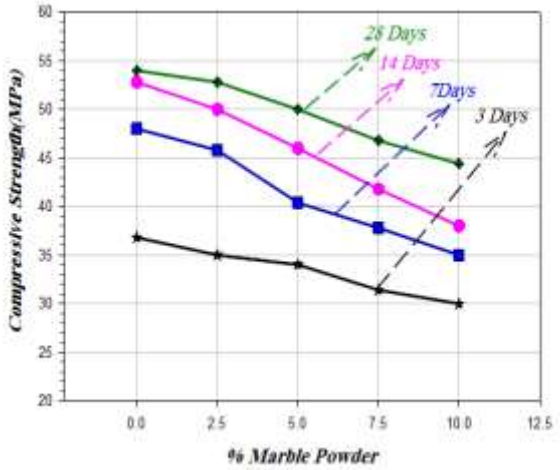

Fig. 6: Compressive strength of concretes

At all ages, the strength development of Portland cement concrete is greater than Portland cement with percentage of marble powder concrete, it is had been notice that when the percentage of marble powder in cement increase the strength development decrease. This attributed to the fact that the marble powder which had had been replacement by cement could be reacting as filler material such as sand , the water cement ratio of concrete mix is largely responsible for the strength development. For 2.5% marble powder concrete, the strength development appears to be similar to Portland cement concrete strength at all ages.

Figure 7 shows the ratio of the strength development of Portland cement and marble powder concretes. The ratio strength development of 2.5, 5,7.5 and 10% was lower than strength of Portland cement for early age to later age. For concrete that contain 2.5% marble powder the strength development was about 98% of strength of Portland without marble powder at early age and later age, the ratio of strength development in the first 3 days was around 97.7% of Portland cement concrete strength development, after that the strength ranging between (94.7 – 97.7)% of Portland cement concrete strength development.

This Figure clearly shows no much positive effect appears after the replacement.

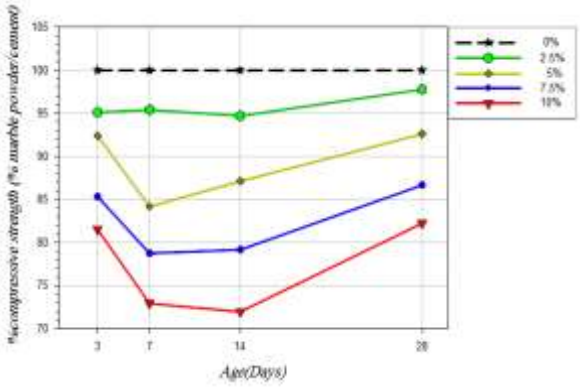

Fig. 7: Ratio of Portland cement to marble powder compressive strength

Conclusion

The result of the partial replacement of cement with marble powder and the study of its effect on fresh and hardened concrete can be summarized as follows:

1- The initial setting time Increased as the percentage of marble powder increased, as well as increasing the value of the final setting time by 10 minutes consistently at all ratios

2- The slump of all concrete mixes Increased as the percentage of marble powder increased.

3- The concrete compressive strength decreased as the percentage of marble powder increased

4- The 2.5% replacement of cement by marble powder in concrete give Approximate strength by 97% of cement concrete.

5- The use of this type of marble powder resulting from the process of cutting marble as partial replacement of cement in concrete will not benefit cement industrial unless find another source of good marble waste powder.

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