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Waste Management and Cost Decreasing for High Cost Concrete using Alternative Waste Materials and Polymer : case study in Iraq

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Abstract

Waste management and its use in concrete, as well as searching for alternatives to materials to reduce project costs, are important matters for maintaining a clean environment and economic projects. This research aims to reduce the high cost of reactive powder concrete by using polymers and fine glass powder resulting from glass waste, with the aim of reducing the final cost of high-priced concrete like reactive powder concrete and ensuring greater economic efficiency for engineering projects, in addition to reducing environmental pollution resulting from waste. The study shows that the use of polymers and glass powder can be used instead of steel fibers and silica fume powder. The study showed that the new concrete gave tensile and compressive strength as efficiently as high-cost concrete, with a significant decrease in economic cost. locally reactive powder concrete costs about 950 dollars for each 1 cubic meter concrete while it reduced in this study to 314 dollars per one cubic meter with slight increment in compressive strength compared with reactive powder concrete ,study include tensile strength, compressive strength and modulus of elasticity tests by using new concrete contains polymers and waste glass and comparing results with previous research deals with reactive powder concrete in iraq to ensure efficiency of new concrete .

Keywords
Waste Management, Reactive Powder Concrete, Polymers, Environmental Pollution, Economic Projects.

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Introduction

Industrial and construction waste materials need good management to get rid of these wastes, and construction projects require studying costs and alternatives to reduce project costs to the lowest possible extent. For these considerations, construction projects are more economical and ensure a clean environment. Many researchers have studied the use of waste in the concrete industry to reduce the total costs of projects and ensure a reduction in environmental pollution [1,2]. Researcher Amiya,A. [3] studied the management of plastic waste and its use as aggregate in concrete and obtained good results in terms of obtaining less dense and more ductile concrete. This study investigates the enhancement of mechanical properties of polymer modified concrete (PMC) by partially replacing fine aggregates with waste iron filings and chips. The results show significant improvements in compressive strength (up to 30%), tensile strength

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(about 50%), flexural strength (approximately 93%), and modulus of elasticity by using up to 40% replacement. The improved performance is attributed to the strong bond between iron particles and the cement-polymer matrix, as well as the inherent strength of the iron waste material [4]. Waste plastics also studied by Mohd and Mohammed [5,6,19] and the obtained higher compressive strength by 10% waste plastics as aggregate in concrete and achieving lightweight concrete. This study investigates the use of waste concrete and waste granite as coarse aggregates in concrete to promote environmental sustainability and reduce costs. Results showed that waste granite aggregate significantly improved compressive strength from 33.6 to 43.9 MPa and tensile strength, while waste concrete aggregate also enhanced compressive strength from 33.6 to 36.9 MPa with full replacement. Additionally, waste granite contributed to lower absorption rates, indicating higher durability [7,15]. construction and demolition waste management studied by several researchers such as Wong,B and Siti,N [8,16,18] in Malaysia and use of concrete waste in concrete industry to minimize concrete waste and decreasing cost of construction ,other researchers studied the waste glass powder [9,10] and use it in concrete as fine aggregate or use it as replacement from cement in concrete and they gain over 20% increment in mechanical properties of new concrete and that can reduce the cost of concrete and achieve les environmental pollution . Rocks , plastic wastes and also Heat resistance glass wastes also used by some researchers to achieve lower cost concrete and higher durability against fire exposure especially when pyrex glass waste is used [11,12,14] . this study aims to decrease the total cost of reactive powder concrete and decreasing environment pollution by using waste materials and polymers . This study evaluates the suitability of using office paper waste as a partial replacement for sand in cement mortar to promote sustainability and reduce environmental impact. The results indicate that while workability and compressive strength decrease with higher paper content, flexural strength improves, and absorption and density show minor changes. The optimum paper content balances mechanical properties and environmental benefits [13,17,20].

Experimental Program:

the production of alternative concrete in this study is simply by using waste glass and grinding it to fine powder in order to use it instead of silica fume which is very costly , and using styrene butadiene rubber SBR which is very effective to increase tensile strength so it can use it instead of steel fibers in reactive powder concrete , so this mixes can highly decrease cost of production of reactive powder.The new reactive powder concrete is polymer reactive powder concrete (PRPC) as reference mix which contains cement , fine sand which passing from sieve 850 micron , 10% SBR liquid polymer and Flocrete super-plasticizer used with ratio of 1.5 % from weight of cement , mix proportions used as 1:1 (cement :sand) with water/cement ratio equal to 0.23 . waste glass fine powder used as replacement from sand with ratio ranged from 10% to 40 % ,fine waste glass used after passing it from sieve with dimension of 850 micron . sulfate resisting cement used in all mixes . Table 1 show the mix proportions for reference mix.

Table 1 : PRPC ingredients for 1 cubic meter concrete

Cement, kg	Fine sand, kg	Water, kg	SBR , kg	flocrete , kg
1000	1000	230	100	15

Figure 1 show some specimens after compressive and tensile tests .

specimens and tests : PRPC mixes contains cylinders and cubic specimens , the cubic specimens with dimensions of 7*7*7 cm are used to be tested for compressive strength , AND also 2 other types of cubes with 5*5 cm and 10*10 cm are used to see the difference between them and to match all specifications for compressive strength tests . cylinders with 10*20 cm are used for splitting tensile test .

modulus of elasticity done by using 150*300 mm cylinders and the test done according to ASTM C-469 [14] , using mechanical dial gauge fixed on specimens to read the strain and loading the specimen under uniaxial compressive load , the modulus of elasticity of concrete can be obtained from stress-strain diagram .

Figure 1 : some concrete specimens (PRPC) during and after test

Results and Discussion

1- Quality of Concrete : table 2 shows the results of the compressive strength tests for concrete specimens that contain waste glass and also the reference mixes which not contain waste glass , the compressive strength increased by using wastes until 30% which is the optimum ratio in this study , the compressive strength increased from 66.4 MPa for mix without waste glass to 76.12 MPa for mixes with 30% waste glass . Larger samples gave a slight decrease in compressive strength values but the concrete remained among the high strength concrete .table 3 shows tensile and modulus of elasticity tests for all mixes in this study , good results in tensile and modulus of elasticity obtained by using polymers and waste glass .

Table 2 : Compressive strength tests for different mixes of RPC and different sizes specimens

Mix type	Compressive strength ,MPa(for 5*5cm cubes)	Compressive strength ,MPa(for 7*7cm cubes)	Compressive strength ,MPa(for 10*10cm cubes)
PRPC without waste glass M1	66.40	63.39	61.02
PRPC 10% WASTE GLASS ,M2	69.63	66.08	62.87
PRPC 20% WASTE GLASS,M3	73.29	71.31	68.44
PRPC 30% WASTE GLASS,M4	76.12	74.89	70.58
PRPC 40% WASTE GLASS,M5	75.04	72.54	69.11

Table 3 : Tensile strength and modulus of elasticity for different mixes .

Mix type	Tensile strength ,MPa	Modulus of elasticity,MPa
PRPC without waste glass MIX 1	6.23	38181
PRPC 10% WASTE GLASS	7.10	40829

PRPC 20% WASTE GLASS	7.97	41628
PRPC 30% WASTE GLASS	8.90	42322
PRPC 40% WASTE GLASS	7.87	42110

2- cost study and comparison for previous studies : table 4 shows cost study (as costs in iraq) for this study and comparing it with previous study for RPC in the research of Eyad,K.[15] , this previous study chosen because that the results obtained in this research is close to Eyad study as shown in table , the compressive and tensile strength is too close to this study so it can be appropriate to compare costs between the two works . the PRPC in this study shows very lower costs compared to Eyad research and that is very good for less construction cost . it should be noted that replacement 30 % of sand with waste glass powder does not highly effected the cost , but it is necessary to increase the values of mechanical properties of PRPC and reduce the environmental pollution . table 4 show also the cost of new reactive powder concrete is 314 dollars for one cubic meter concrete while ordinary reactive powder concrete costs 950dollars for 1 cubic meter and that give lower cost of construction .

Conclusion

several points achieved by using waste materials in this case study :
1- using glass waste in reactive powder concrete can improve mechanical properties and and decrease the total cost of this expensive type of concrete .
2- not using silica fume in this research has not affected the properties of reactive powder concrete because of using polymers and glass wastes which are lower in cost compares with silica fume .
3- the total cost of concrete obtained in this study was found 314 dollars for one cubic meter concrete , and by comparing this cost with previous study , which used silica fume and about 950 dollars cost , the reduction in cost is perfect .

Table 4 : costs study comparison (case study in Iraq)

Ingredient for this study	Costs in Iraq for ingredient	Cost for 1 cubic meter concrete	Ingredient for previous study Eyad ,K. [15]	Cost for 1 cubic meter concrete
Cement 1000 kg	4 dollars for 50 kg	80 dollars	Cement 900 kg	72 dollars
Sand ,1000 kg	4.4 dollars for 1000 kg cement	4.4 dollars	Sand 990 kg	4.36 dollars
SBR 10% (100 kg)	2 dollar for 1 kg	200 dollars	Silica fume 20%(180 kg)	450 dollars
Flocrete super-plasticizer 1.5% (15 kg)	2 dollars for 1 kg	30 dollars	Steel fibers 1% (79 kg) and 4.0 dollars for each 1 kg steel fibers	316 dollars
Silica fume (not used)	2.5 dollars for 1 kg	------	Super plasticizer ,6% (54 kg) 2 dollars for 1 kg	108 dollars
Total cost		314.4 dollars	Total cost	950.36 dollars
Mechanical properties comparison with Eyad,K. [15]				
Compressive strength	For this study	74.89 MPa	For Eyad,K.[15] ,Mixes	73.2 MPa
Tensile strength		8.9 MPa		9.6 MPa
Modulus of elasticity		42322 MPa		41287 MPa

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