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Research paper

Experimental Study for Ability to Use Plaster of Pairs Instead of Normal Concrete

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Abstract

This research investigated the possibility of using plaster of Paris instead of cement in some internal structural parts and non-exposed to moisture by casting (nine) samples divided in three group. First group was normal concrete, second was plaster of pairs concrete group and finally plaster of Paris with aggregate concrete. All of them have the same dimension (1000×150×200) mm and the same reinforcement ratio. Group one was cured with water while the rest were isolated in a place far away from the moisture. All sample designed to be failed in flexural. The process of testing was divided in two methods; for properties of material used as explain above and for samples tested under two-point load at several curing time (7,28 and 90) days. Each period consists of three samples one from each group. The result showed that the third group (plaster of Paris with aggregate concrete) approximately closer to normal concrete in applying a load by the ratio of (98%) in 7 days, (87%) in 28 days and (94%) in 90 days. While the second group (plaster of pairs concrete) was acceptable when compared with normal concrete because of missing aggregate.

Keywords normal concrete, plaster of pairs, aggregate, reinforcement ratio, curing, and moisture.

1. Introduction

Mesopotamia is the oldest in using plaster rocks and its product. Throughout the ages, with evidence of characterization of the successive civilizations, as research and studies conducted in archaeological sites are shown the best selection of materials and the most appropriate to the environment, Through the physical residues of archaeological and heritage materials since the start of rural settlements and the emergence of buildings with distinctive architectural features and distinct. Plaster is an important material as it is used as a whitish material in construction, joining the bricks, also used in (mortar, arches, domes, bonding materials, whiteness, decoration and light blocks). Plaster properties can be improved by adding some materials like tar, fiber plants, cement etc.

Plaster has been used since ancient times for many purposes, in recent decades, production has doubled globally by building factories, improving their productivity, and developing new and more sophisticated products [1]. The most important of these products can be presented as follows:

- Reinforced plaster panels as internal partitions (reducing dead loads of construction parts in multi-story buildings and consequent lower cost of foundations) and plaster panels for secondary ceilings [1].
- Fireproof plaster plates to prevent the rapid transition of heat to other parts of origin with same times safely and without damage, the plaster works naturally as a fire-resistant spraying system because the plaster contains about 21% of the water united within the crystalline structure, so delays heat transfer [2].
- Sound-proof plastered panels with plant materials with cellulose fibers such as wood saw reeds, glass fibers or mineral wool with porous or decorative facets and the resulting face with high sound absorption [3].
- Plaster blocks of different types (normal, lightweight, armed with agricultural waste, improved with Nora and additives to improve products using glue and others) [4].
- Concrete plaster (in different sizes) mixed with sand, sand and Nora, rubble (brick breaker), rubble (waste and debris of buildings) [5].
- Load and Non-load bearing walls (precast, casting site) [5].
- Exterior walls (tiling, plates, scattering) [5].

1.1 The research aim

The objective of this study is to investigate the flexural behavior (in terms of first crack load (Pcr), ultimate flexural strength (Pu), ultimate deflection (Δu) and load-deflection behavior) of simply supported singly reinforced beam having dimensions of (1000×150×200) mm under symmetrical two points loads, and the other main objective of this study is the focus on the influence of concrete constituents on the materials properties of all type concrete are used in this study.

Most of the previous researchers were partially replace Portland cement in construction products while the purpose of this research is to study the possibility of using plaster instead of concrete in some internal structural parts and non-exposed to moisture.

2. Methodology

All sample design to be the Failure as a flexural failure and the design load is (80kN) according to (ACI-318-14) [6]. as shown in (Fig. 1)

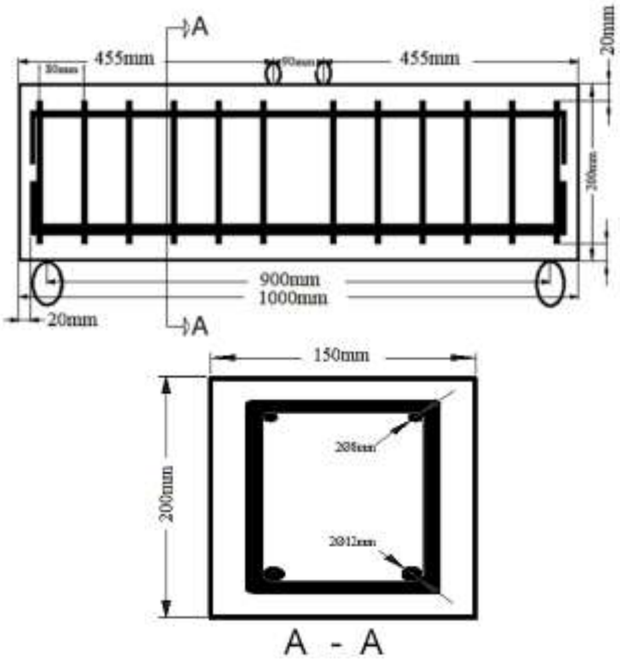


Fig. 1: Steel Reinforcement details

The Properties of Material that Used

Table 1: Chemical Composition of cement

Oxide Composition	Abbreviation	Content by weight (%)	Limit of Iraqi Specification No.5/1984
Lime	CaO	63.11	-
Silica	SiO_2	20.37	-
Alumina	Al_2O_3	5.15	-
Iron oxide	Fe_2O_3	4.39	-
Magnesia	MgO	1.68	5.0 (max)
Sulfate	SO_3	2.57	2.8 (max)
Loss on ignition	L.O.I.	2.72	4.0 (max)
Insoluble	I.R.	0.69	1.5 (max)
Lime saturation factor	L.S.F.	0.92	(0.66-1.02) %
	Main compounds (Bogue's equation)		
Tricalcium Silicate	C_3S	49.23	-
Dicalcium Silicate	C_2S	21.50	-
Tricalcium Aluminate	C_3A	6.22	-
Tetracalcium aluminoferrite	C_4AF	13.34	-

Table 2: Physical Properties of Cement

Physical Properties			
Properties	Test Results		IOS 5/1984
Specific surface area (Blaine Method), cm^2/g	4426		2300
Mortar Compressive strength (MPa) at	3 days	24	15
	7 days	32	23
Setting Time(min)	Initial	3:10	0:45
	Final	5:00	10:00
Soundness: autoclave%	0.22		0.8 max

Table 3: Chemical Composition of Plaster of Paris

Component	Test Results %	The limits of Standard No. 28 %
Free water	0.15	
Combin water	2.71	9 (max)
L.O.I		9 (max)
SiO_2	0.45	
Al_2O_3	0.51	
Fe_2O_3	Nil	
SO_3	56.96	40 (min)
CaO	39.21	2/3 from SO_3
MgO	Nil	0.25 (max)
Total	99.99	

Table 4: Physical Properties of Plaster of Paris

Physical Properties		
Properties	Test Results	IOS 5/1984
Specific surface area (Blaine Method), cm^2/g	0%	1.18-8%
Setting Time (min)	20	20
Compressive strength (kg/cm^2)	113	45 (min)

Table 5: Grading of Fine Aggregate

Sieve size (mm)	% Passing by weight	Limits of the IOS No.45/1984 (zone 2)
10	100	100
4.75	90.55	90-100
2.36	78.31	75-100
1.18	63.1	55-90
0.60	43.51	35-59
0.30	14.64	8-30
0.15	0.02	0-10

Table 6: Physical Properties of Fine Aggregate

Physical Properties	Test Results	Limits of the IOS No.45/1984
Specific gravity	2.53	-
Sulfate content	3.56%	≤0.50%
Absorption	2.25	-

Table 7: Grading of Coarse Aggregate

Sieve size (mm)	%Passing by weight	Limits of the Iraqi Specification No.45/1984
20	100	100
14	100	90-100
10	74.5	50-85
5	3.5	0-10

Table 8: Physical Properties of Coarse Aggregate

Physical properties	Test Result	Limits of Iraqi Specification No.45/1984
Specific gravity	2.60	-
Sulfate content	0.0 6%	0.1% (max)
Absorption	0.75%	-

The mix proportion for (Normal Concrete) is designed according to ACI recommended practice ACI 211.1-91[7]. The target compressive strength is (25MPa). Groups one consists of (N.C.) and material proportions which are 1:1.33:2.89 water/cement = 0.44 (this ratio has been taken after several experimental mixtures) by weight, as shown in the (Table 9) below

Table 9: Mix Proportions for Normal Concrete Strength

Groups	Cement (kg/m^3)	Sand (kg/m^3)	Gravel (kg/m^3)	Water (Liter/m^3)
One	415	552	1200	183

Then two group mixtures are used in Plaster of Paris concrete. The first mix is Plaster of Paris only with (water/powder =0.45) by weight, this mix used for the first group. The second is Plaster of Paris with Coarse Aggregate (0.5) and (water/powder =0.45) by weight, designed according to (ASTM C 317/C 317M – 00 and C 956 – 04) recommended the practice, used for group two, as shown in the (Table.10) below, all this mixture where be obtained from several laboratory mixture:

Table 10: Plaster of Paris Concrete Proportion Mixture

Groups	Plaster of Paris (kg/0.09 m^3)*	Gravel (kg/0.09 m^3)*	Water (Liter/0.09 m^3)*
Two	180	0	85

Three	180	90	85

*. These quantities are equal multiply (3× 0.2×0.15×1) m.

Nine structural specimens (reduced-scale) beam (sometimes called replica models) are prepared for experimental work purposes. These specimens are divided into three groups, each group consists of three beams of dimensions (1000 x 150 x 200) mm as shown in (Table.11) with all details:

Table 11: Complete Details of Specimens

Type of Material	Group no.	Beam Name	Aggregate ratio%*	curing times (Days)
Ordinary Concrete	Group One	BC1	2.89	7
		BC2	2.89	28
		BC3	2.89	90
Plaster of Paris	Group Two	BP1	0.0	7
		BP2	0.0	28
		BP3	0.0	90
Plaster of Paris concrete	Group Three	BP1. A	0.5	7
		BP2. A	0.5	28
		BP3. A	0.5	90

*. These quantities are ratio from cement and Plaster of Paris.

The mold used in casting the samples of research made of ply-wood lubricated with special oil to resist moisture and joint with a screw to facilitate process removal of samples as shown in (Fig. 2)

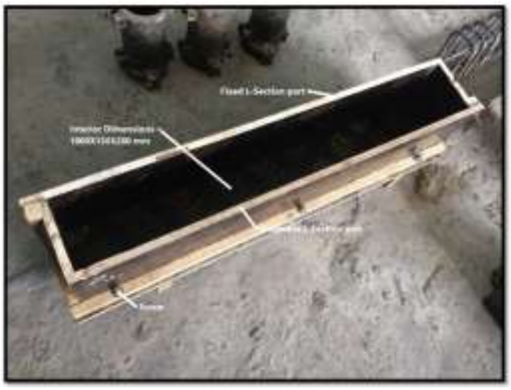


Fig. 2: The Mold used in research

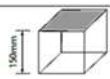
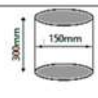
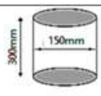
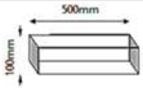
After extruding from the mold the groups, one was curing with water while the rest were isolated in a place far away from the moisture for interval time (7, 28 and 90) days as shown in (Fig. 3)

Fig. 3: The samples in the stage of curing

3. Result and Discussion

The properties of the material have been computed according to a standard that showed in the (Table.12), same mechanical properties of hardened concrete that examined its self-applied at Plaster of Pairs to be easy compare between them

Table 12: Standard Used in Test

Specimen	Number of specimens	Test	Standards of test
 150mm	3	Cube Compression Strength	B.S: 1881: part 116
 300mm, 150mm	3	Cylindrical Compression Strength	ASTM C39/C39M
 300mm, 150mm	3	Splitting Tensile Strength	ASTM C496
 500mm, 100mm	3	Modulus of Rupture	ASTM 8C7

The compressive strength result obtains in two standards (cube and cylinder) showed that cylinder samples give the best result because of uniformly distribution of stress cross-section area and amount of (F'c) are being certified in design. Plaster with two states (with and without aggregate) Give good results and asymptotic to the normal concrete, because of a manufacturing method that used to produce plaster of Paris depend on, the degree of smoothing, burning temperature with another controlled factor process. That was clearly shown in the (Table.13)

Table 13: Material Test Result in (28 Days)

Material	Cube Strength (f_{cu}) MPa	Cylinder Strength (f 'c) MPa	Splitting Tensile Strength f_{ct} (MPa)	Modulus of Rupture f_r (MPa)
Normal Concrete	30	26.6	2.6	2.3
Plaster of Paris concrete	23	20.6	1.6	1.73
Plaster of Paris concrete with aggregate	26	22	2.1	2.05

*. Both plasters of Paris and normal concrete have the same standard used in the test in (table.12).

The samples start failure (first crack) at load (from 8 to 27.5) kN, the less amount is (BP1) while the greatest (BP3, BC1) in spite of the (BP3) was without aggregate. But samples with aggregate give the highest value and asymptotic to the normal concrete in ultimate load this can be seen in the (Table.14)

Table 14: The Result of Two-Point Load Test

Group No.	Specimens	First Crack load (F.C.L) (kN)	Ultimate load (U.L) (kN)	$\frac{F.C.L}{U.L}$ (%)
1	BC1	27.5	52.5	52.4
	BC2	22.5	94.5	23.8
	BC3	18.5	102.5	17.1
	BP1	8	44	18.18

2	BP2	10	77.5	12.9
	BP3	27.5	87.5	31.43
	BP1. A	9.5	51.5	18.45
3	BP2. A	17.5	82.5	21.21
	BP3. A	20	96.5	20.73

*. Both plasters of Paris and normal concrete have the same dimension (1000×150×200) mm.

Entering the curing time effect in computed Load-Deflection curve can be observed that in (Fig. 4) as well as (Fig. 5) and (Fig. 6) all of them in increasing curing time the ultimate load increased with decreased in deflection but the (BP3.A, BC3) samples give the highest value of ultimate load:

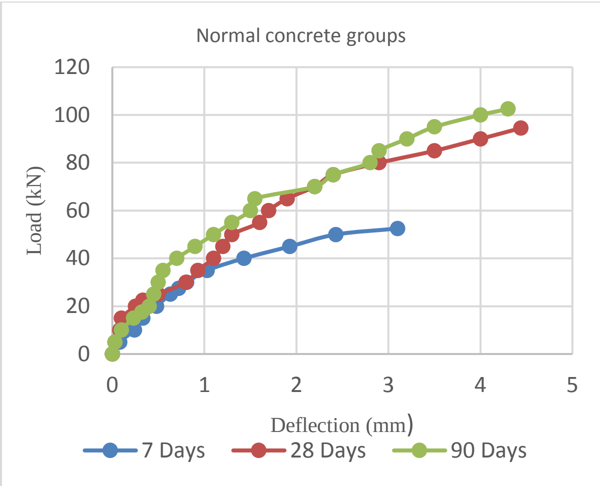


Fig. 4: Load – Deflection Curve of Specimen (BC)

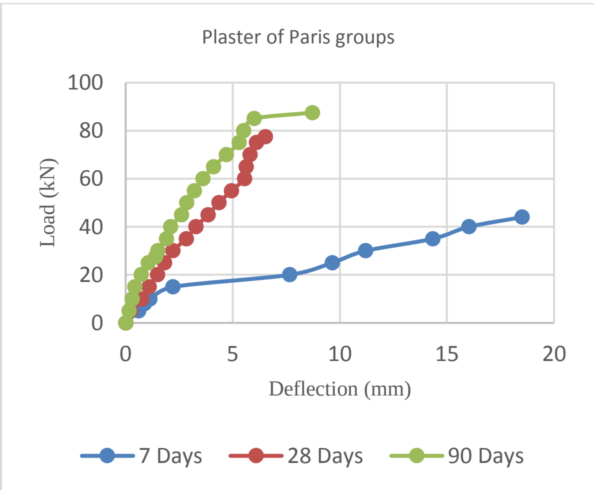


Fig. 5: Load – Deflection Curve of Specimen (BP)

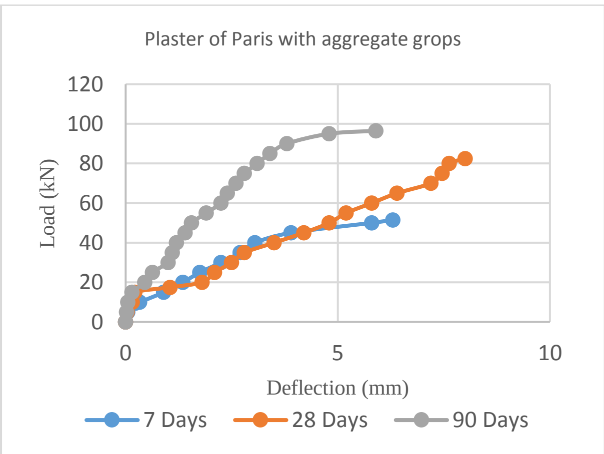


Fig. 6: Load – Deflection Curve of Specimen (BP. A)

Fig. 7: Show the crack patterns and modes of failure of each beam of (BC) group

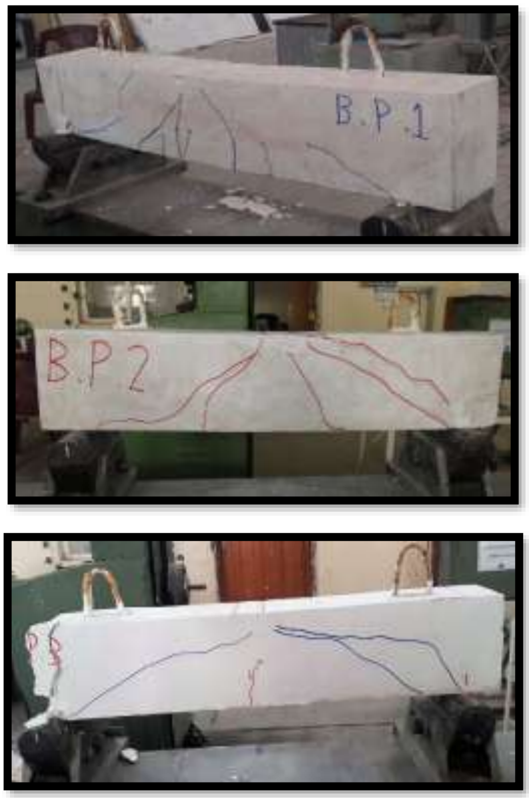


Fig. 8: Show the crack patterns and modes of failure of each beam of (BP) group

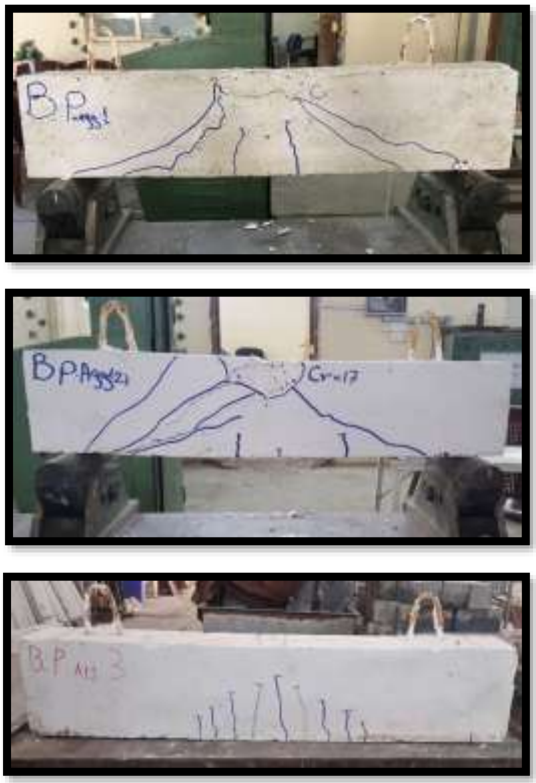


Fig. 9: Show the crack patterns and modes of failure of each beam of (BP. A) group

The hydraulic universal testing machine (MFL system) is used to test all beam specimens. The testing machine has three scale loads (0 to 600 kN, 0 to 1500 kN, 0 to 3000 kN). The machine is shown in “Fig. 8”. The high capacity, stiffness, and dimensions of the testing machine make it more adequate to test different types of specimens. All the models were tested in the construction laboratory of Al-Mustansiriyah University College of Engineering.

4. Conclusion

The result appeared that normal concrete was still the best but when used the alternatives suggested in this research (Plaster of Paris with aggregate) give construction sufficient result where the percentage of convergence in two-point load test equal to (98%) in seven days, (87%) in twenty-eight days and (94%) in ninety days ,as well as The material test in compressive strength give percent ratio of (82.71%), in splitting test (80.76%) and in modulus of rupture (89%). While plaster of Pairs without aggregate give the lowest result in all test, that indicate adding aggregate make an improvement to the properties. with increasing curing time, the strength of samples to load increased with decreased in deflection.

Acknowledgment

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