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EFFECT OF POLYMER LATEX ON PHYSICAL AND MECHANICAL PROPERTIES OF COMPOSITE CONCRETE

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Abstract: The presented study examines the effect of SBR polymer latex on the performance of concrete composite containing (1%MgO powder + 0.75%polyolefin fibers). In this study, the amount of added latex to concrete composite was varied. Density, compressive strength, and flexural strength were measured. The results showed that SBR addition caused a reduction in compressive strength with increase the dosage of adding. Flexural strength at 28 days improved with increase of SBR dosage (2%, 4% and 6%) and the results recorded.

Keywords: *SBR, MgO, polyolefin fibers, compressive strength, latex.*

1. Introduction

Its well-known basic constituents of building material are concrete because it was fairly inexpensive and its ingredients were simply available, also the concrete is available a lot of infrastructure works and civil constructions. Even though that the concrete have some of demerits as weak in tension, brittleness and lower resistance to crack restoration. For there a behavior of Concrete brittleness and possess low tensile strength but as we add fibers, decrease its brittle behavior and the increases tensile strength. With the respect of time many specimen are in experiments that were conducted for increasing the properties of concrete in the hardened or initial state. Also, the significant properties such as workability, decreasing or increasing the setting time and the high compressive strength were depend also by super plasticizers, admixtures, micro fillers and basic constituents remain the same. For structural concretes Fibers, that have classification based on their materials as pitch and polyacrylonitrile (PAN) fibers, steel fibers, alkali-resistant glass fibers (AR), and synthetic fibers and carbon [2].

The fiber reinforced concretes (FRCs) are defined as the concretes which contain or was reinforced with randomly oriented dispersed. un-connected fibers. In addition, concrete was intrinsically brittle, yet such brittleness is rectified if it was reinforced with the fibers in structure; the ductility was enhanced via suppressions regarding the crack's growth via reinforcing fibers. Pavement made from fiber-reinforced precast concrete has a high resistance to cracking and to fracturing that can occur during transportation and installation[3].

Admixtures might be specified as chemical products that, excluding some conditions, were added to the mix of concrete by mass of the

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cement throughout mixing or throughout more operation of mixing before placing the concrete, to achieve certain modifications, or changes, to concrete's normal properties. Also, the admixtures might be utilized in liquid or solid states [4].

In addition, the magnesium oxide based shrinkage compensating concretes (MgO concretes) were concretes with MgO powder admixture. The shrinkage compensation is majorly because of volume expansion resulting from hydration regarding the expansion additives. Therefore, the expansion related to the MgO concretes might be matching the mass concrete shrinkage as it cools, while the concrete was of high importance in dams constructions for minimizing the development of cracks, simplifying the temperature control measures, as well as speeding up the constructions [5][6]. The polymeric admixtures were specified as polymers utilized as major ingredient used to modify or improve the cement-based materials. Latex addition to the concrete mix has been explored as a way to use high early-strength concrete in pavement formulations because of the ability of latex to improve the concrete's permeability resistance. Adding latex improves the fluidity of the concrete mix, even at low water-to-cement ratios. This is because of interactions of cement materials with the surfactant present in the latex. Latex film creation enhances the mechanical properties and bond strength of the concrete, and increasing the resistance of concrete to water permeability[3].

W. Ibrahim et al.(2014)[7] examines the impact of polyolefin fiber at fairly low-volume fraction (0, 0.2, 0.4 and 0.6) % on flexural and compressive properties of foamed concretes. Also, the results of the tests are showing that the polyolefin fibers just insignificantly enhanced the flexural and compressive strengths of the foamed concrete by 9.3% and 4.3%. **A. Sedaghatdoost and M. Amini (2017)**[8] indicated the mechanical characteristics related to the polyolefin fiber reinforced light-weight concretes (LWCs). Splitting, flexural and compressive tensile strengths related to the sample have been measured. In addition, the polyolefin fibers are added to the reinforced composites in different amounts (0-2%), while the test results are showing that the maximum compressive strength is acquired in LWC that contain fiber (1%) result in an increase of approximately 8%. Yet, a decrease in the compressive strength has been indicated in the case when increasing the amount of fiber, while to increase the amount of fibers led to a growth in splitting tensile strength and rupture modulus.

Zainb. H. M. (2018) [9] studied the impact of adding the MgO powder to mixtures with ratios (1, 2, 3 and 4) % by weight of cement. In addition, the investigated parameters involved absorption tests, ultrasonic pulse velocity tests and compressive strength. The test results indicated an optimum ratio in the case when adding MgO powder of 2% by weight of cement, in which the increase rate in compressive strength as well as the ultrasonic pulse velocity at age of twenty-eight days have been (59.57 and 148.76) % in comparison to reference mixture.

Kaijian H. et al. (2019) [10] investigated behavior of concrete with MgO expansion agent (MEA) jointed reinforced slabs. In addition, concrete mixtures with various contents of MEA have been tested in the lab for evaluating the impact of MEA on the mechanical properties of concrete (flexural and compressive strengths), change in volume, and the existence of micro cracking. Also, the field data included the concrete slab stain and the steel reinforcement stress in concrete pavements without and with MEA. The test results indicated that adding MEA will be decreasing the compressive strength of concrete (up to 27%), yet insignificant enhancement (up to 12%) in the flexural strength was reached in the case when the content of MEA was limited to 8%. Furthermore, the field study is showing that the volume expansions resulting from the hydration of MEA might efficiently compensate concrete shrinkage. **T. Gonçalves et al. (2019)**[11] evaluated the effect of adding 2 distinctive commercially-available reactive MgO samples as partial replacements of cement (at 10, 15, and 20) % by weight in mortar's production. Also, all the specimens have been assessed with regard to their mechanical as well as durability-related performances (shrinkage, carbonation, compressive and flexural strengths, water absorption through capillary action). The results are indicated that, despite the reduced, performances with increased incorporation regarding MgO as partial replacement of cement, a considerable reduction was indicated in the shrinkage strains related to the cementitious materials showing compressive and flexural strengths, of all mixes at (3, 7, 14, 28, and 56) days. As the MgO content is increased, the strength will be reduced.

2. Experimental Program

The materials utilized to prepare latex modified FRC mixes are:

1. Cement: Iraqi ordinary Portland cement conforming to ASTM C204 – 05 3914 is utilized in this work.
2. Fine Aggregate: Manufacturer's sand has been used for the present investigation. It conforms to Zone-II with 4.75mm as a maximum size. according to the requirements of IQS 45/1984[12].
3. Coarse Aggregates: The coarse aggregates were with maximum size of 20mm.The physical and chemical properties test conforming to IQS 45/198[12] .
4. Water: Ordinary tap water is utilized for all the concrete mixes and also for curing. It has added in several stages to facilitate the mixing and homogeneity of materials (OPC, sand, gravel). For all mixtures the water to binder ratio is set at 0.34.
5. Superplasticizer: The superplasticizer used in this work was Master Glenium 51.
6. Polyolefin Fibers: Fibers of length 60 mm as show in figure (1) and of specific gravity 0.91 was used. The fibers used in this work with volume fraction (0.75%).

Figure 1. Polyolefin fiber.

7. Magnesium oxide powder (MgO) used in this study is light white magnesia. Figure (2) shows MgO powder. Its added to mixes with (1%) ratio of cement weight.

Figure 2. Magnesium oxide powder

8. The polymer used in this study is SBR Latex is a synthetic rubber white emulsion. SBR Emulsion is consist of (25%) styrene and (75%) Butadiene copolymer [13]. SBR Latex is simply added to the mixing water.

The SBR used in this work are (2, 4, and 6%) of cement weight. Table (10) shows the product data according to manufacturing company.

Table 1. Technical Data of SBR Emulsion.

Type	Synthetic Rubber Latex
Form	White liquid
Density	Approximately 1.00 kg/lt.
Chloride content	Nil (EN 934-2)

3. Mix Proportions

The mix design for all mixes agrees with the British Standard Method B.S 1881:PART2[14]. The material's mix proportions utilized in the presented study are showed in table (4.10).Concrete mixes with varying percentages of MgO (1,3,and 5%) and SBR (2,4,and 6%) by weight of cement and different volume fraction of polyolefin fibers(0.5,0.75,and 1%).There were three basic mixes; fiber reinforced concrete , fiber reinforced concrete with MgO powder , and latex modified fiber with MgO powder. The control mix in this research is designated as 'CM'. Mix proportioning specifications are detailed in Table (2).

4. Testing Program

In this experimental study, following properties of concrete were tested as per relevant standards.
1) Hardened Density Test: 100*100*100 mm concrete cubes have been utilized for the density test. In addition, the specimens are immersed in tap water for not less than 24 hours, the specimens were dried for not less than 24 hours, and then the dried mass was specified**.** The test is conducted based on ASTM C 642-13[15].

Density of specimens determined through dividing the unit weight of the specimen by the unit volume.

Density $\rho = W / V$ (1)

In which: ρ representing the concrete specimen density (kg/m³), m representing the specimen mass (kg), and representing the specimen volume (m³).

Mass will be measured with a sensitive digital balance, in (kg), and volume will be measured by multiplying its length, height, and width of specimen.

$V= l \times w \times h$ (2)

Where l : is length (m), h s height (m) , w is width (m).
Density can indicates defects in product, like bubble or crack in cast parts (voids) in concrete specimen [16].
2) Compressive Strength Test: This test was conducted on cube of 100 mm and measured according to BS 1881 Part1 16:1983 C109.
3) Flexural Strength Test: This test was carried out as flexural strength related to concrete and estimated on (10×10×50) mm prism specimens based on ASTM **C78/C78M**[17]**.** The prisms have been subjected to 2-point loading.
Span length, calculating the modulus of rupture in the following way:

$R=PL/bd^2$ (3)

Where:
R representing the modulus of rupture, MPa,
L representing the span length, mm
P representing the maximum applied load specified via testing machine, N
d representing the specimen's average depth, mm [in.], at fracture.
b representing the specimen's average width, mm, at fracture, and

Table 2. Mix proportions of material used in this work

Mixes	Samples	Cement	Sand	Aggregate	Water L/m^3	Super plasticizer By weight of cement %	MgO By weight of cement %	Fiber content VF%	SBR By weight of cement %
		Kg/m^3							
MgO .PO. SBR	MI	565	777	1225	192	1.7	1	0.75	2
	MII	565	777	1225	192	1.7	1	0.75	4
	MIII	565	777	1225	192	1.7	1	0.75	6

5. Results and Discussions

1) Dried density

Figures (3) show the density test of each group of concrete mixes composite. It was seen that mix of group (MI) with 2% SBR have the best density over all mixes due to combined effect of MgO powder effect in filling the capillary pores due to expansion effect of MgO, and SBR effect in increasing the bonding between the concrete constituents and the super plasticizer effect of SBR.

2) Compressive Strength

The results obtained for cubes with (100*1000*100) mm dimensions. Compressive strengths for the different mixes at 28 day are shown in Fig. (5). Figure shows the compressive strength test results for concrete mixes containing varying amounts of added latex to concrete containing (1%MgO+0.75%Polyolefin fibers) . For plain concrete, for mix (MI) as the latex content 2% the compressive strength increased due to bonding effect of SBR, with increasing the SBR content from 4 to 6% the compressive strength begin to decrease due to increase of air entrapped which effect adversely to concrete compressive strength.

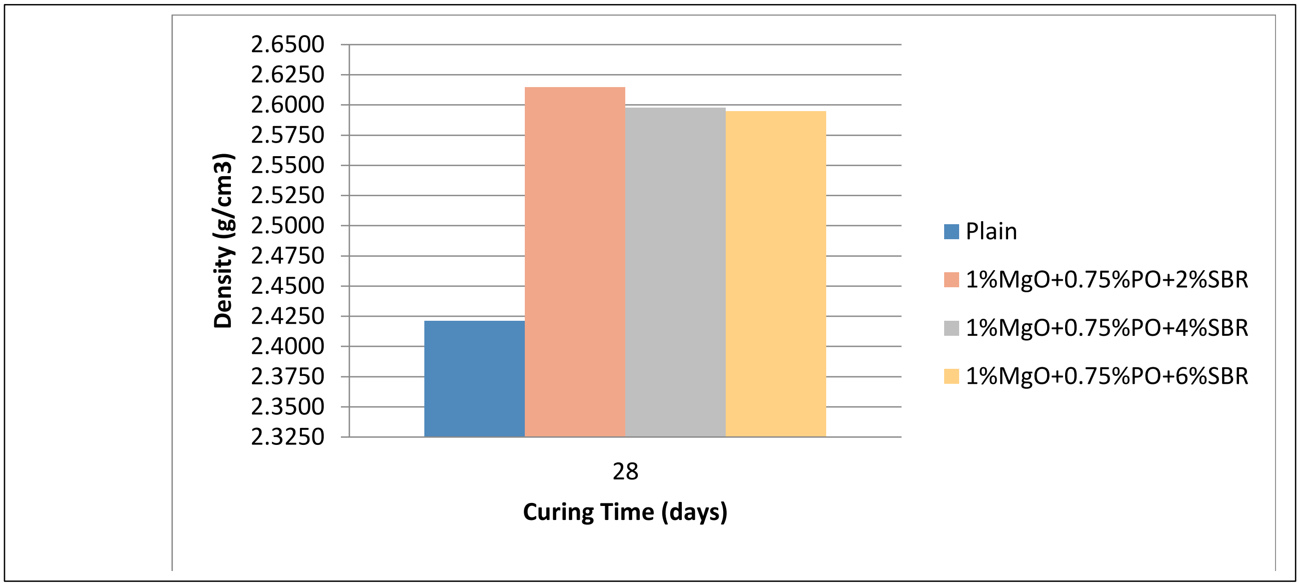

Figure 3. Comparison of 28th day concrete density.

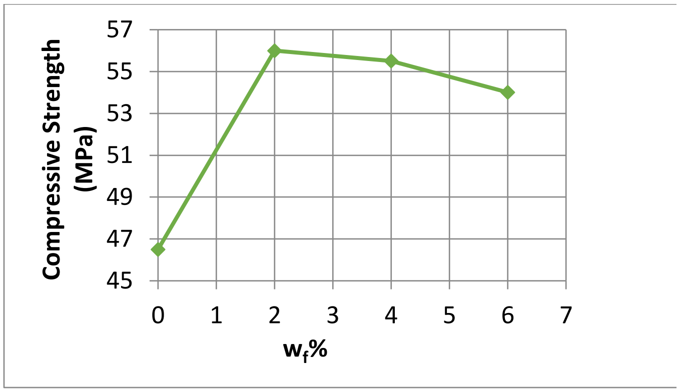

Figure 4. Compressive strength of concrete mixes.

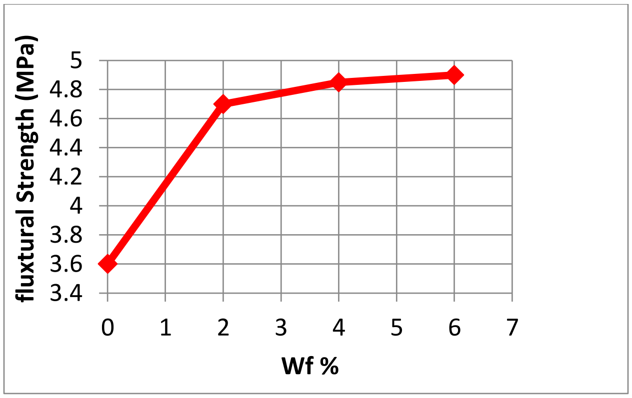

Figure 5. Flexural strength of concrete mixes.

3) Flexural Strength

The effects of varying latex percentage are illustrated in Fig.(5). For plain concrete, as the latex level increased from 0 to 2, 4, and 6% the flexural strength steadily increased compared to the other mixes due combined effect of (MgO and fibers and SBR) .where the polymers themselves provide improvement in cement hydrate-aggregate bond.

2. Conclusions

In this study, the polyolefin fibers volume fraction (0.75%) and the amount of added MgO powder (1%) and latex (2, 4, and 6%) by cement weight were varied for concrete mixes. According to experimental results, the next conclusion can be stated:

1. The optimum density was obtained with (1%MgO-cement ratio +0.75 vol. % Polyolefin fiber+2%SBR).
2. With the addition of 2 % SBR -cement ratio to group (MI) of concrete mixes , the compressive strength showed a certain extent increase.

3. By increasing the SBR content to the concrete the compressive strength tend to decrease.
4. The flexural increase with increasing SBR content in due to SBR effect in bonding the concrete component that work compatibility with fibers and expansion effect of powder to increase the flexural strength.

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