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USING ICON SUPER CONCRETE IN UNREINFORCED FLOORS

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Abstract— *A New polymer is introduced to concrete ingredients which are nontoxic and soluble in water. Currently, this polymer is used in roads manufacture. This paper seeks to expand its use in unreinforced concrete floors. Thus, experimental work was carried including, 19 cubes and 15 cylinders to determine the compressive strength. Five different mixtures were prepared and tested after curing for 7 days, 14 days and 28 days. The studied parameter was the quantity of the polymer in the mixture. Increasing the quantity of the polymer increases the compressive strength by up to 1.5 times at age 28 days.*

Index Terms— *Polymer, Concrete, Experimental Work, Compressive Strength, Nontoxic*

A. Introduction

Concrete is the most used construction material all over the world. Concrete floors are used in industrial floors, warehouse floors, decorative floors, and resin floors. The essential characteristic is compressive strength. Recently using nontoxic constituents has become a necessity. As for concrete to become sustainable, cement made from limestone associated with using fly ash, silica fume and slag is used. Also, the durability of concrete is associated with using excellent ingredients. Polymers are materials consisting of many small molecules (called monomers) that can be linked together to form long chains. A typical polymer may include tens of thousands of monomers. Because of their large size, polymers are classified as macromolecules. Polymer concrete is a composite material in which the binder consists entirely of a synthetic polymer. There exist three principal classes of polymer concrete materials: Polymer-Portland Cement Concrete (PPCC), Polymer impregnated Concrete (PIC) and Polymer Concrete (PC). PPCC refers to polymer being incorporated into a Portland cement mix and a polymer network formed in situ during curing of the concrete. PIC is concrete that is impregnated with a monomer which is subsequently polymerized in situ. Finally, PC is resin concrete where the resin binds aggregate together. Several researchers studied polymer concrete for instance, Raman Bedi [1] mentioned in his research that high compressive strength, fast curing, high specific strength, resistance to chemical attack are the advantages of polymer concrete which has found application in very specialized domains. Applications of polymer concrete are repair, thin overlays and floors and precast components. Bedi et al. discussed the effect of several parameters on polymer concrete such as: e resin type and content, fiber reinforcements, microfillers, curing conditions, aggregate type and grading, and silane coupling agents. Shadab et al. [2] focused in their research on recycling of waste and industrial byproducts as components of concrete. The reduction of co_2 emission by 30% was one of the main results.

Recently, green concrete has been the focus of several researches. Kumar et al. [3] discussed preparing green concrete by partial replacement of ingredients by using waste materials and admixtures that showed better compressive and tensile strength, improved sulphate resistance, decreased permeability and improved workability. Also, the cost per unit volume of concrete with waste materials like quarry dust is lower than the corresponding control concrete mixes. Bambang Suhendro [4] discussed several solutions to reduce energy and impact of global warming. Nanoengineering showed that concrete strength and durability depend upon calcium silicate hydrates spherical nanoparticles. The concrete hardening process is similar to human bone formulations. Accordingly, the goal was to copy the process of bone formation and accelerate it to form a new building material. The result would be improved different properties such as: strength, ductility, creep and shrinkage, fracture behavior, and durability of cementitious construction materials greatly. A crack free concrete could be attained through enhancing the bond between different particles. In addition to that, the research showed that better concrete durability occurred with the substitution of cement by fly ash. Finally, greener concrete using recycled materials was discussed.

M. E. Allam et al. [5] tried to use granite waste powder in concrete as partial replacement to cement and sand with various percentages. Slump test, indirect fire resistance, water absorption, and permeability experimental work were conducted on the concrete samples as indicators for durability. Experimental results showed that adding the granite waste powder whether as a cement or sand replacement, showed a positive response in terms of enhancement of strength of concrete under elevated temperatures. Karsan et al. [6] conducted an investigation on the benefits of green concrete in construction processes. The research was based on the reviews of concrete professionals. Compressive strength properties of concrete made out with slag, glass, rubber was investigated and compared with ordinary concrete. Also, experimental work was performed to study the mechanical and physical properties of recycled aggregate concrete. Portland cement was replaced with silica fume by rates of 0%, 5% and 10%. It was found that fly ash concrete gained the strength after 28 days. The benefits of fly ash were that it decreased both water absorption and sorptivity of concrete by up to 50%. Concrete containing rubber had an increase in tensile strength. However, a higher percentage of rubber was not recommended as it would decrease the compressive strength. Finally, it was concluded that green concrete would contribute the sustainable environment.

Antti Ruuska et al. [7] discussed material efficiency of buildings and assessed the significance of different building materials on the material efficiency. The research showed that using better construction materials in the European Union would influence 42% of final energy consumption. It was expected that about 35% of greenhouse gas emissions would be decreased. It was also predicted that up to 30% of water consumption would be saved. A case-study was assessed to highlight the effect of land use, energy use and/or harmful emissions on the environment or sustainability assessment of buildings. Finally, the paper suggested that greenhouse gas emissions could be used as an indicator for material efficiency in buildings. GARG et al. [8] covered the aspect on how to choose a green material for concrete. Materials like fly ash, query dust, marble powder/granules, plastic waste and recycled concrete and masonry were investigated as aggregates in concrete. The use of fly ash in concrete contributes to the reduction of greenhouse emissions with negative impacts on the economy. The main aim was to use green concrete to reduce the CO_2 emission in atmosphere towards eco-friendly construction technique. So, green concrete is an excellent substituent of cement as it is cheaper, because it uses waste products also, green concrete has greater strength and durability than the normal concrete.

M. Glavind et al. [9] studied green concrete in Denmark where, he suggested three different ways to produce this type of concrete. First, use minimal clinker content, second, green types of cements and binders and third, use inorganic, residual products. The research focused on a recently started large Danish research project, where the most important goal was to develop the technology necessary to produce and use resource-saving concrete structures, i.e. green concrete

This paper discusses the effect of using a new type of polymers in concrete i.e. Icon super concrete (ISC) which contains no toxic substance. World Wide Investment Company in Egypt under supervision of Chairman Dr. Alladin Eid provided the authors with tested polymer. This polymer can be safely disposed because it is completely soluble in water. Thus better impact on the environment more than the usual types will prevail. It is worth to mention that the authors used the tested polymer only for scientific purposes in this research without any commercial profits.

Objectives

This paper aims to promote the use ISC in order to widen its application in unreinforced floors through experimental work that identifies the compressive strength.

B. Details of Concrete Specimens

Nineteen cubes 15x15x15 cm in addition to fifteen cylinders 15x30 cm were cast. The research focused on studying the compressive strength of ISC. The studied properties were compressive strength and volume of voids. Each specimen was weighted as an indication to the present air voids. Five different mixtures were tested and each mix was casted in three cubes. Testing of specimens was carried out after curing for 7 days, 14 days and 28 days. Curing took place after twenty four hours with spraying mode where specimens were covered with burlap. Mix proportions are shown in table (1). Mix (1) contained no icon additives. It was meant to be compared with other mixes to emphasis the effect of the amount of icon. Mix (2), (3), (4) and (5) contains icon by the following quantities 2 cm, 4 cm, 8 cm and 16 cm. Also, four additional cubes were casted: cube (A) contained ISC without cement, cube (B) contained ISC without cement in addition to 20% of volume foam. Meanwhile, cube (C) was like cube (B) but with 40% of volume foam. Finally, cube (D) contained only icon and water without aggregates or cement. Tests were carried out according to Egyptian Standards. The following mix design in table (1) was used in the research. Chemical composition of Icon polymer was conducted by química medio arabiente “Cesmec” in spain as shown in table (2).

Table (1): Mix Proportions for Concrete

Proportion of Mixes	Typical Proportion for cubes	Typical Proportio n for cylinders
Cementitious Material	1.18 kg/m^3	1.86 kg/m^3
Coarse Aggregate	4.33 kg/m^3	6.8 kg/m^3
Water Content	0.65 kg/m^3	1 kg/m^3
Fine Aggregate	2.035 kg/m^3	3.2 kg/m^3

Table 2: Chemical Composition of Icon Polymer

Element	Abbreviation	%
Aluminum	Al_2O_3	1-2
Barium Oxide	BaO	0-0.1
Calcium Oxide	CaO	0.1-0.4
Chrome	Chro	0-0.1
Copper	Cuo	0-0.1
Ferro	Fe_2O_3	0.5-0.9

Potassium	K_2O	0-0.1
Magnesium	MgO	0-0.1
Manganese Oxide	MnO	0-0.1
Nitrous Oxide	N_2O	0-0.1
Phosphorus Pentoxide	P_2O_5	0-0.1
Sulfur Dioxide	SO_2	0-0.2
Silicon Dioxide	SiO_2	0-0.2
Titanium oxide	TiO_3	0-0.1
Vanadium Trioxide	V_2O_3	0-0.1
Zinc	ZnO	0-0.1
Zirconium	ZnO_2	0-0.1

C. Manufacturing Procedures of Specimens

Thin layer of oil was applied to cover cube molds to easily fabricate required concrete specimens. The mixing process took place by using concrete mixer. Concrete was mixed with water then poured in molds. Finally, specimens were leveled from top to get smooth concrete surface. As shown in Figure (1) the specimens were ready for testing and the testing machine contained data acquisition system that recorded the results.

Fig. (1) Specimens prepared for testing

D. Results and Discussions

First crack that occurred in specimens is shown in Fig. (2 a) where different amounts of ISC did not affect failure mode. Other cracks happened afterwards during the test on the other walls of the specimen along with inclined craks as shown in Fig. (2 b).

Test results are summarized in Table (3) that showed the results for specimens (cubes, and cylinders) after seven, fourteen and twenty eight days with different mixtures. It is clear from the table that the density of traditional concrete is higher than ISC by 6%. From table (3) at curing age 28 days only 10 % was added to compressive strength as shown from the results in Fig. (3). When the results of mix 5 are compared with the results of mix 1, an increase by up to 1.5 times can be noticed. Based on that, increasing the quantity of ISC improved the compressive strength. The results of the cylinders showed slight increase by up to 6% in compressive strength when comparing mix 1 with the other mixes as shown from the results in Fig. (4).

Based on the test results of table (4), failure of cube A the sides of the cube cracked from the top at compressive strength 80 Kg/cm^2. The test results of cube B indicate that absence of cement gave higher compressive strength than traditional mix because the polymer was used instead of cement. The effect of using foam in cube C decreased the compressive strength by 90% when compared with cube B due to its low compressive strength. Failure cracks of cube D are shown in Fig. (5) where lower side cracks are obvious. Surprisingly, compressive strength of cube D was about 40% of cube B although it contained neither aggregate nor cement. This decrease in the compressive strength is due to the absence of aggregate in the cube.

a) Fig. (2) First cracks

b) Fig. (2) Failure cracks

Table (3): Compressive Strength for Concrete Cube/Cylinder

Specimen number	Curing days	Cube compressive strength (Kg/cm^2)	Weight of cube (gm)	Cylinder compressive strength (Kg/cm^2)	Weight of cylinder (gm)
Mix 1	7 days	405	7952	250	12210
	14 days	405	7990	300	12350
	28 days	450	8095	315	12350
Mix 2	7 days	545	8251	250	12290
	14 days	545	8649	260	12540
	28 days	545	8562	320	12610
Mix 3	7 days	560	8325	295	12360
	14 days	560	8564	295	12540
	28 days	575	8575	300	12700
Mix 4	7 days	605	8425	305	12440
	14 days	610	8334	335	12460
	28 days	645	8412	350	12480
Mix 5	7 days	549	8509	260	12530
	14 days	665	8407	320	12510
	28 days	700	8631	340	12690

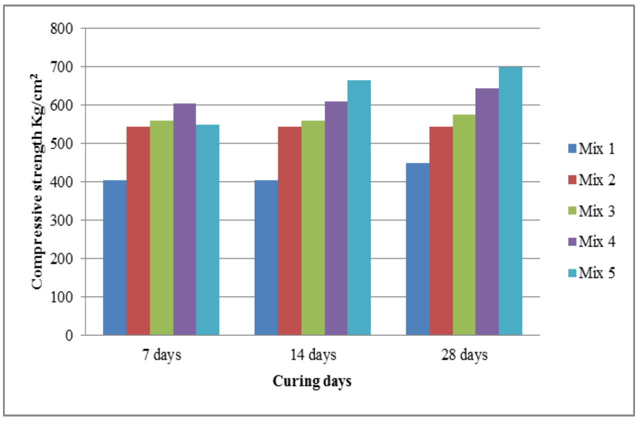

Fig. (3) Cube compressive strength versus curing time

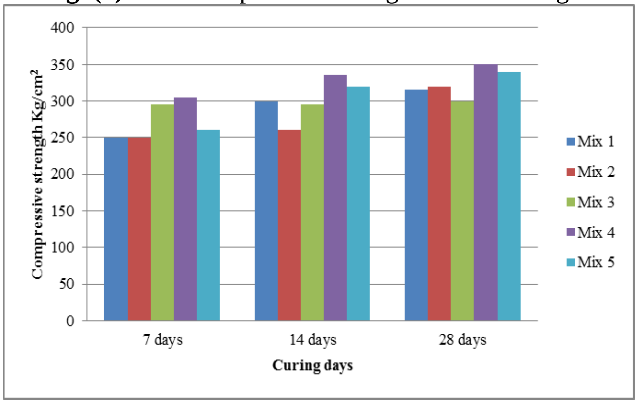

Fig. (4) Cylinder compressive strength versus curing time

Table (4): Compressive strength for additional cubes after curing 28 days

Cube name	Weight of cube (gm)	Cube compressive strength (Kg/cm^2)
Cube A	7432	80
Cube B	6477	595
Cube C	6500	59
Cube D	6800	237

Fig. (5) Failure of cube D

Conclusions

A new nontoxic polymer is introduced in concrete industry and it reaches the desired compressive strength in 7 to 14 days. ISC increased the compressive strength by 1.5 times more than the usual concrete mix. Increasing quantity of ISC will increase the compressive strength with no change in the failure mode of the specimens. Absence of cement in the mix and using the polymer instead gave higher compressive strength than traditional mix by 30%. The authors recommend more experimental work in order to determine the optimum quantity of polymer. Also, flexural strength of the polymer needs further experimental work.

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