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EVALUATION OF WATER RETAINING CONCRETE PROPERTIES WITH VARIOUS POLYMERS

Sapan Gupta[1], R S Mishra[2] & R C Singh[3]

[1]M-Tech Scholar, Dept. of Civil Engineering, RSR-RCET Bhilai, India
[2]Asst. Professor, Dept. of Civil Engineering, SSITM, Bhilai, India
[3]Professor, Dept. of Civil Engineering, RSR-RCET, Bhilai, India

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Abstract - Normal concrete produced by conventional method is less durable and requires certain fix amount of water based on water cement ratio calculated. This is helpful in reducing water cement ratio and enhancing concrete properties in matrix. This is carried out by impregnating polymer compound during the concrete mixing phase.

Here in this research study it is tried to evaluate the water requirement and retentivity behavior of concrete properties using different types of polymers such as SBR-Latex, Polycarboxylate Ether and PolyEthylene Glycol are used. For this study M30 grade of concrete mix is prepared and carried; with different types of polymers and complete study on workability, flexural strength and Water retentivity has been studied.

Key Words - Polymer, Impregnating, Water Retentivity, SBR-Latex, PolyEthylene Glycol and Polycarboxylate Ether.

1. INTRODUCTION

Polymer concrete is set of concretes that uses polymers to/or supplement or replace cement as a binding material. Polymer concretes are elevated performing substitute element that has been developed since the early 1960's. Polymer concrete consists of aggregates bonded together by a strong resin chain instead or along with water and cement, which are alone typically used in cement-based materials. Polymer concretes are very strong, anticipated to be durable, and cures very rapidly, which is a significant deliberation in many civil engineering applications. This rock like material is a brittle material which is strong in compression but very weak in tension due to which cracks get developed and concrete fails simultaneously. With the increasing demand being made on concrete technology to serve the needs of society, experts are responding positively by proposing new formulations using other materials.

Some polymers are water-soluble and their low solubility causes problems in respect to the use as a concrete modifier. One of the major advantages for water soluble polymers is the nonexistence of surfactants to maintain the polymers in solution. The polymer molecules are supplied on a molecular scale, recuperating the move towards the relative large cement grains (up till 80 μm) by the polymers.

1.1. Classification of Polymer-Concrete Materials.

Significant progress has been made recently in both fundamental and applied research on all kinds of polymer/concrete system. There exist three principal classes of polymer concrete materials viz., (a) Polymer-Portland Cement Concrete (PPCC), (b) Polymer impregnated Concrete (PIC) and (c) Polymer Concrete (PC).

a) Polymer Portland Cement Concrete (PPCC) - A monomer, pre-polymer of dispersed polymer is incorporated into a Portland cement mix and a polymer network formed in situ during curing of the concrete.
b) Polymer-Impregnated Concrete (PIC) - Previously formed concrete is impregnated with a monomer which is subsequently polymerized insitu. A polymer enhances the Strength Characteristics of the original concrete.
c) Polymer Concrete (PC) - It is also known as Resin Concrete. A polymer is used to bind an aggregate together.

Investigation showed that the influence of aggregate grading and w/c ratio on the workability and compressive strength of cement aggregate matrix. It has been also observed that the increase in water/cement ratio has reduced the value of mechanical properties and increased the workability. In another study by Schulze [10], the influence of w/c ratio and cement content on the properties of 68 polymer-modified mortars has been of acute interest. Y. Y. Kim et al. [9] observed that for increase in w/c ratio of cement mortar from 0.45 to 0.60, porosity went upto 150% and compressive strength has reduced to 75.6 %. Zhou et al. [10] observed that the dynamic compressive strength of cement mortar increased with decrease in water content. The dynamic compressive strength of saturated specimen was 23% lower than that of totally dry specimen. Zivica [13] studied the effect of low w/c on the pore structure and compressive strength of the cement paste. Fineness modulus of sand also influences the w/c ratio of the mortar. Lim et al. [14] observed that the mortar with coarse sand has obtained higher compressive strength than those of the finer sand when the w/c ratio is less, and finer sand grading specimen required a higher w/c ratio to achieve an equivalent workability.

Polymeric admixtures added in concrete mix during mixing can manage slump value, such as to allow concrete producers to maintain slump until discharge without reducing concrete quality.

i. It is a water-reducing admixture capable of producing large water reduction or immense flow ability without causing undue set retardation or entrainment of air in mortar or concrete.
ii. Further increase the water requirement for concrete mixtures, increasing the strength & durability of concrete.
iii. Can reduce the need for water by 25 - 30%

1.2. Different types of polymers and their specifications.

a. Natural Polymers

i. SBR-LATEX is a Carboxylated – Styrene Butadiene copolymer latex admixture that is formed as an integral adhesive for cement bond coats, mortars and concrete to improve bond strength and chemical resistance.
ii. Linin Ligno Sulphate is a Sulphonated compound admixture that is designed as an integral adhesive for cement bond coats, mortars and concrete to improve bond chemical resistance and as dispersing agent.

b. Artificial Polymers

i. Polyvalent alcohol
ii. Polyethylene glycol (PEG)
iii. Poly-acrylic acid
iv. Xvlitol, sorbitol
v. Glycerine
vi. Phytosterols
vii. Hyaluronic acid
viii. Polyxyelhylene (poe)
ix. Sodium pyrrolidone carboxylate (PCA-Na),
x. Stearyl alcohol
xi. Cetyl alcohol
xii. Thermosetting polymers

1.3. Functions of polymers in concrete.

Polymer admixtures are classed according to function. There are five defined classes of chemical admixtures: air-entraining, water-reducing, retarding, accelerating, and plasticizers (super-plasticizers). All other varieties of admixtures fall into the subject class whose function includes corrosion inhibition, shrinkage reduction, alkali-silica reactivity reduction, workability enhancement, bonding, damp proofing, and coloring.

i. Water-reducing admixtures usually reduce the required water content for a concrete mixture by about 5 to 10 percent.
ii. Retarding admixtures, which slow the setting rate of concrete, are used to counteract the accelerating effect of hot weather on concrete setting.
iii. Accelerating admixtures increase the rate of early strength development; reduce the time required for proper curing and protection, and speed up the start of finishing operations.
iv. Super-plasticizers - also known as plasticizers of high-range water reducers reduce water content by 12 to 30 percent and can be added to concrete with a low-to-normal slump and water-cement ratio to make high-slump flowing concrete.
v. Corrosion - inhibiting admixtures - fall into the special admixture category and are used to slow corrosion of reinforcing steel in concrete. The shrinkage reducers are used to control drying shrinkage and minimize cracking, while inhibitors control durability problems associated with alkali-silica reactivity.

1.4. Objective of Study.

The objective of this research work is to evaluate effect of different polymer used in concrete matrix mass on w/c ratio and water retentivity. Also to find out the effect, of implementation of polymers admixture in concrete, whether it enhances its basic properties or affects its. The selected polymers like; SBR latex, PCE & PEG having different chemical formulation, what be their effects on plasticity, curing, strength is to be studied. For this purpose OPC has been selected with above mentioned polymers to produce concrete of M30 grade.

Advantages of polymer concrete:

a. Rapid curing at ambient temperatures makes durability with respect to freeze and thaw cycles
b. Low permeability to water and aggressive solutions induces resistance against corrosion

Advantages of polymer concrete:

It tends to be brittle in nature i.e. if fiber reinforcement is not provided in some polymer concrete cases they tend to develop cracks. Among the disadvantages also is their high cost.

2. LITERATURE REVIEW

A.S. El Dieb et. Al. [1] **"Self Curing Concrete: Water Retention, Hydration and Moisture Transfer"** The research find out is the water retention capacity and degree of hydration and moisture transport by using self-curing agent and compare to conventional curing of concrete. The self-curing agent used in this study was water soluble polymer polyethylene glycol. Self-curing concrete suffered less self-desiccation under sealed conditions also resulted in better hydration with time under drying condition compared to conventional concrete.

J Bala Krishna et. Al. [2] **"Comparative and Experimental Study on Self Curing Concrete"** Durable concrete Specifying a high-strength concrete does not ensure that a durability will be achieved. The pozzolanic materials can be used in concrete as partial replacement of cement, which are very essential ingredients to produce high performance concrete. In this study water retention, compressive strength compacting factor and flexural strength of concrete containing self-curing agent is investigated and compared with conventional curing. Concrete weight loss with time was carried out in order to evaluate the water retention ability for different dosages of self-curing agent and for different conditions. The water retention, compressive strength compacting factor and flexural strength of concrete is increased by 0.5% to 2%.

Jingjing Xiao et. Al. [3] **"Effect of styrene–butadiene rubber latex on the properties of modified porous cement stabilized aggregate"** A laboratory experiment was conducted to improve the cracking properties of PCSA through the incorporation of styrene butadiene rubber (SBR) latex. The effects of SBR latex usage on permeability, compressive strength, flexural strength and anti-freezing ability of PCSA were investigated. Test results indicate that the air voids and permeability coefficient decreased with the increase of SBR latex dosages.

Amel Kamoun et. Al. [4] **"Evaluation of the performance of sulfonated esparto grass lignin as a plasticizer–water reducer for cement"** The objective of the work is an investigation of the preparation of a sulfonated esparto grass lignin and its behavior as a plasticizing–water-reducing agent for cement–water systems. Conclusion from the results obtained in this study is SEL has a good plasticizing effect on mortars. It also permits a reduction of the water content in a given mortar mix without affecting the workability. SEL, as all LS-based plasticizers, leads to a moderate delay of the initial and final times of set Along with it allows an increase of the compressive strength after 28 days of age.

Haoliang Huang et. Al. [5] **"Improvement on microstructure of concrete by Polycarboxylate superplasticizer and its influence on durability of concrete"** In this study, the influence of polycarboxylate superplasticizers (PCE) on durability of concrete were investigated. Carbonation, water impermeability and rapid chloride permeability of concrete with different types of polycarboxylate superplasticizer and polynaphthalene superplasticizer (PNS) were tested.. Smaller carbonation depth, water penetration depth and chloride permeability of concretes show that concretes with PCE have better durability performances also PCE best optimizes pore structure of concrete. Cement pastes with PCE have more hydration products, i.e. C–S–H and CH than in the cement pastes with PNS and, therefore, denser microstructures.

F. Puertas et. Al. [6] **"Polycarboxylate superplasticiser admixtures: effect on hydration, microstructure and rheological behaviour in cement pastes"** study was conducted on the effect of a polycarboxylate (PC) admixture on the mechanical, mineralogical, micro structural and rheological behavior of Portland cement pastes. PC admixture on cement hydration shows that at very early ages an initial retardation of cement hydration is produced.

S. R. Thiru Chelve et. Al. [7] **"Effect of Polyethylene Glycol as Internal Curing Agent in Concrete"** Proper curing of concrete structures is important to ensure that they meet their intended performance and durability requirements. Therefore an effective in situ curing is necessary to maximize the degree of hydration and to minimize the cracking problems due to drying shrinkage. A higher and earlier heat production rate due to hydration is found for higher amounts of PEG added to the reference concrete. The effectiveness of internal curing by means of PEG applied to concrete is the highest if 0.5% of PEG is added.

S. K. Gupta et. Al. [8] **"Use of polymer concrete in construction"** Polymer concrete is a composite material in which the binder consists entirely of a synthetic/organic polymer. Strength of concrete in compression, tension and shear can be greatly improved by polymer modified concrete. The most remarkable increment is obtained in the tensile strength.

3. EXPERIMENTAL BACKGROUND AND ANALYSIS

Investigational efforts have been conceded by mixing natural and synthetic polymers in different proportions to the M30 grade concrete while mixing as per mix design data. The M30 grade concrete is prepared by using mix designing procedural guidelines as per IS: 10262 - 2009. The detailed concrete mix designing process erstwhile explained afterward. The various proportions of polymers like SBR-Latex, PEG and PCA are used within the proportioning of M30 grade concrete in following percentage of 5%.

These matrix mix masses were used to prepare specimens of cube and prism which are earlier examined for workability and further placed to testing for the determination of their mechanical strength via; compressive strength & split tensile strength. For workability tests is performed by slump cone test.

Table No. 1 - Properties of Aggregates used in the study conforming to IS: 383 -1970 and IS: 2386 - 1963.

Physical Properties of Coarse and Fine Aggregates Physical tests	Coarse Aggregates	Fine Aggregates
Specific gravity	2.71	2.68
Fineness modulus	6.86	2.64
Bulk density (kg/m^3)	1540	1780

Type of Cement (confirming to IS-8113-1989) Used is OPC 43 grade. Exposure Condition from (IS 456: 2000) is assumed to be severe. Concrete is pump able with slump control value of 80 mm.

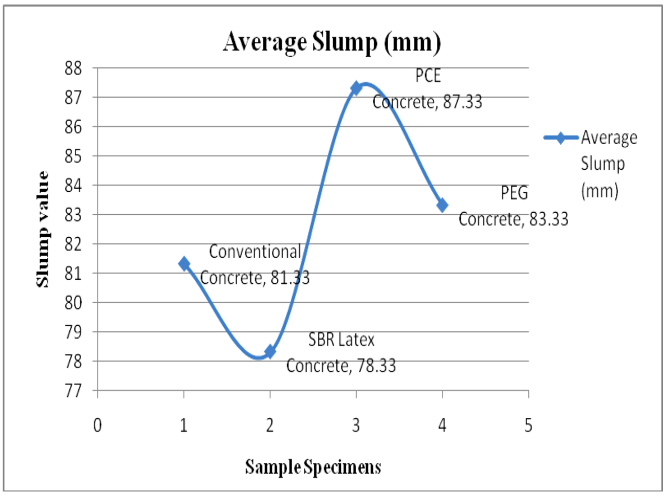
Table No. 2 –Proportion used in different types of concrete M30 Mix.

Type of Concrete	Cement (m^3)	Coarse Aggregate (kg/ m^3)	Fine Aggregate (kg/ m^3)	Water (litre)
0% polymer Concrete	0.131	1153.452	669.925	193.44
5% PCE Concrete	0.14	1214.08	675.36	139.54
5% SBR Concrete	0.14	1214.08	675.36	156.59
5% PEG Concrete	0.14	1214.08	675.36	139.04

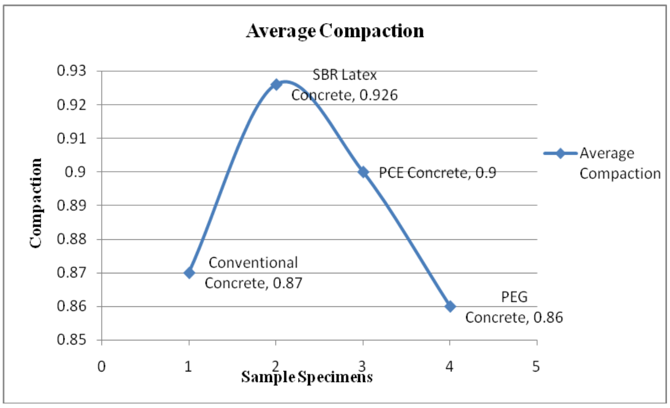
4. RESULT ANALYSIS

Table No. 3. Test Results obtained via various test conducted.

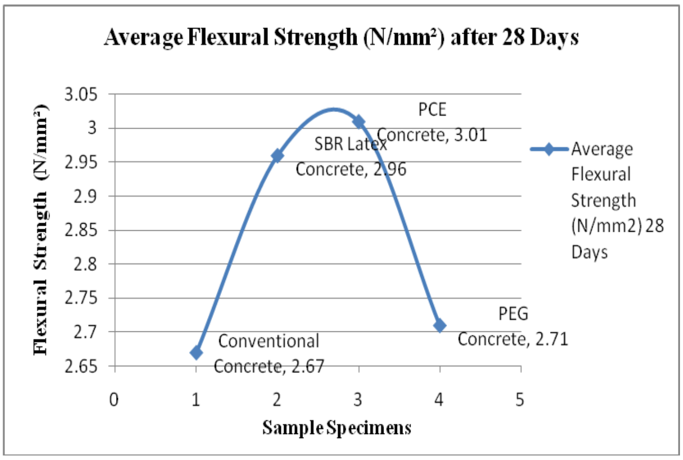
Sample Specimen	Sample Specimen Name	Average Slump (mm)	Average Compaction	Flexural Strength (N/mm^2)	Average Flexural Strength (N/mm^2)	`w/c	Weight of sample (Kg)	Water Retentivity (Kg)		Average Retentivity (Kg)	
				28 Days	28 Days		1st Day	7 Days	28 Days	7 Days	28 Days
Conventional Concrete	S1	81.33	0.87	2.63	2.67	0.45	7.546	7.242	7.195	7.24	7.195
	S2			2.72			7.548	7.241	7.191		
	S3			2.67			7.562	7.238	7.198		
SBR Latex Concrete	S4	78.33	0.926	2.90	2.96	0.42	8.446	8.256	8.129	8.258	8.124
	S5			2.99			8.436	8.267	8.121		
	S6			2.99			8.441	8.25	8.124		
PCE Concrete	S7	87.33	0.9	3.01	3.01	0.42	8.446	8.201	8.111	8.199	8.1
	S8			2.97			8.436	8.197	8.11		
	S9			3.05			8.441	8.199	8.108		
PEG Concrete	S10	83.33	0.86	2.67	2.71	0.42	8.446	8.236	8.112	8.243	8.115
	S11			2.71			8.436	8.216	8.114		
	S12			2.74			8.441	8.279	8.118		



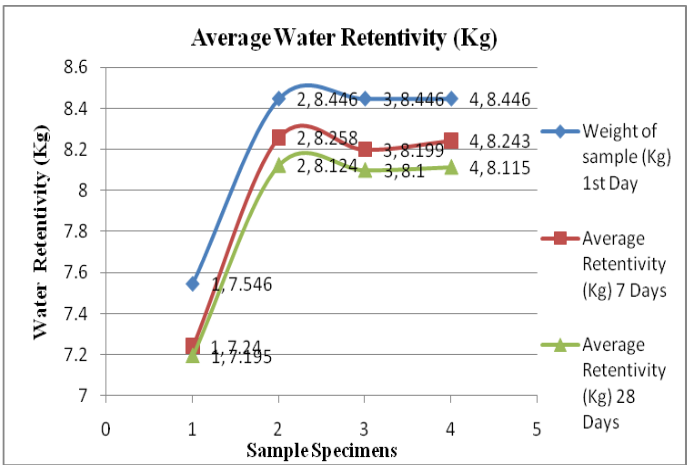
Graph 1: Results of Average Slump values as observed in test results



Graph 2: Results of Average Compaction values as observed in test results



Graph 3: Results of Average Flexural strength (28 days) as observed in test results



Graph 4: Results of Average water retentivity (28 days) as observed in test results

5. RESULT DISCUSSION

i. From the graph 1: it could be easily concluded that the observed Average slump values are best for PCE polymer, it has best workability attainment i.e. greater than 80mm as compared to others.

ii. From the graph 2: it could be easily concluded that the average compaction values are best for SBR than that of others which is probably presence of adhesive latex mass which produces affinity for matrix materials to be compacted or be in contact.

iii. From the graph 3: it could be easily concluded that the observed average values are best for PCE polymer. This is purely due to hardening of ether molecule after 14 days whereas; SBR, PEG are lacking such lateral bonding.

iv. From the graph 4: it could be easily concluded that the observed average values are best for SBR polymer. This is purely due to hardening and adhesive nature of latex after 28 days whereas; PCE, also shows good retenivity; whereas PEG imparts self curing with bonding mass.

6. CONCLUSIONS

I. Polymers impart better workability and hence; induce greater usability of concrete due to increase in plasticity.

II. Water Cement Ratio reduces considerably with the impregnation of polymers. It is observed that introduction of polymer upto 5% reduces water upto 14 -18%. of matrix mass.

III. Higher compaction is achieved by use of polymer; but conventional concrete compaction is higher in case of PCE & PEG.

IV. The series for compressive strength at later age is SBR > PCE > PEG > Conventional Concrete, which shows that polymer impregnation increases compressive strength of concrete considerably.

V. Flexural strength at 7 day is higher for conventional concrete then polymer based concretes, whereas after 28 days it is higher for polymer based concretes.

VI. The series for flexural strength at later age is PCE>SBR> PEG > Conventional Concrete.

VII. Modulus of elasticity is also increased after introduction of polymer concrete but it is higher for SBR concrete as compared to other polymer concrete.

VIII. Water retentively is best for polymer induced concrete as compared to conventional concrete as polymer forms voids which is filled by water as pore water and used afterwards as internal curing support.

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