

Early Stage Compressive Strength of Self Curing Concrete Enhanced with Polyethylene Glycol

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Abstract—Curing is the process of wetting concrete in order to get required strength and durability in concrete. However, satisfactory curing is not possible at everywhere. Therefore, Self curing method was adopted in order to complete water demand of concrete and many researchers attracted to work on self curing agents such as Lightweight Aggregate (LWA) (natural and synthetic, expanded shale), Super-absorbent Polymers (SAP), and shrinkage reducing agent i.e., PEG (polyethylene glycol), polyvinyl alcohol, Paraffin Wax, Acrylic acid. The object of this research was to investigate the effect polyethylene glycol peg-400 as self curing agent. In order to check the effect of Polyethylene Glycol PEG-400 on concrete, a mix of 21 MPa was designed using Doe Mix designed method. Therefore, 8 mixes were prepared with varying percentage of PEG-400 (0.25%,0.5%,0.75, 1%, 1.25%, 1.5%,1.75%, 2%)by weight of cement) and there compressive strength tested at time interval of 3 days. It was found that the optimum dosage for achieving maximum strength for 21 MPa was 1.5% of PEG-400 (by weight of cement).Compressive strength of concrete using PEG-400 increased by 12.5 % as compared to conventional concrete.

Keywords: PEG (Polyethylene Glycol), Polyvinyl Alcohol, Paraffin Wax, Acrylic Acid

I. INTRODUCTION

In the construction industry, concrete is a widely used material by its high compressive strength and less viable to weathering action. For generating durable and high strength concrete, we need to mix it properly and cure it for 28 days for the complete hydration of binding material. If there is no proper curing, it results in a decrease in the strength and low resistance to weather action (1). Due to human negligence and lack of supervision, there is a problem in the proper curing of concrete. Self-curing referred to as Internal-Curing is a process of controlling the moisture loss during the hydration process of binding material from the concrete. Curing of concrete can be done in two different methods, which are mainly, number one is

Water adding method and another is Water retaining method (2). The technique of internal-curing is placed in the water-retaining method. For internal curing, there are two main approaches presented for internal curing of concrete. In the first method, we use saturated permeable lightweight aggregate to provide an internal birthplace of water, which can substitute the water disbursed by chemical shrinkage throughout hydration of cement in concrete (2). The second method is to use hydrophilic materials for reducing the evaporation process from the surface of the concrete cover and helps in the attachment of water in concrete. In this paper, the second method is implemented. For the control of evaporation of water, the use of hydrophilic materials in concrete becomes adorable which controls the evaporation of water due to external temperature and also fascinates moisture from the atmosphere which provides unremitting

curing to concrete (2). Some different kinds of resources used in the inner curing method are Lightweight Aggregate (LWA) (natural and synthetic, expanded shale), Super-absorbent Polymers (SAP), and shrinkage reducing agent i.e., PEG (polyethylene glycol), polyvinyl alcohol, Paraffin Wax, Acrylic acid (3). Water that will be mixed in concrete is insufficient to complete the hydration process of cement completely in concrete therefore internal curing agent provides a sufficient amount of water. Mixing water itself cannot help in complete hydration of cement paste whereas inside curing can provide the required amount of water for its complete hydration of cement after placing in a structural member of concrete and to preserve the high relative humidity which inhibits self-dehydration. This process of using the self-curing agent in concrete yields hard, dense concrete and decreases shrinkage cracking, thermal cracking (4).it was estimated in one of the the researches that for preparing 1 m3 of concrete we need 3 m3 of water (5). As in arid areas it is not possible to bring huge of water. Therefore, self curing agents plays great role for completion of hydration process.

II. MATERIALS AND METHODS

A. Material Used In Mixed Proportion:

To perform experimental work, the following ingredients were used for producing concrete. Material availability and source are given as below.

MATERIAL	Source of all materials
Cement	PAKLAND (OPC)
Fine Aggregate(Sand)	Sand(Petaro near Jamshoro)
Coarse Aggregate	Petaro, Jamshoro, Sindh Pakistan.
Water	Portable water
Polyethylene Glycol PEG400	QINGDAO ASPIRIT CHEMICAL CO, LTD. Karachi Pakistan

Table 1: Materials used in concrete mix

1) Cement

To produce concrete the cement used was belonging to PAKLAND Company and the type of cement was OPC. Before the usage of OPC cement, all tests were performed such as specific gravity, fineness, normal consistency, soundness, initial and final setting time, and compressive strength at 28 days were 3.12, 96%, 0.34, 2.5mm, 74 minutes and 180 minutes, and 42 MPa.

2) Fine Aggregate

Aggregate used for producing concrete was locally available in the market. All the properties of aggregate such as fineness modulus, water absorption, and specific gravity were determined according to the code ASTM C128 – 04. All properties are given in following table no:02

Characteristics of Fine Aggregate	Values
Water absorption	1.52
Fineness modulus	2.42
Specific Gravity	2.65

Table 2: Characteristics of Fine aggregate

3) Coarse Aggregates

Aggregates are called inert material. Coarse aggregate is another ingredient of concrete production. Coarse aggregate is the material which retains on No#04 Sieve. This aggregate plays the main role in the strength of concrete and its characteristics should be determined such as fineness modulus, water absorption, and specific gravity and sieve analysis (6) (7). In my research work, the coarse aggregate of size 20 mm was selected and it was available at site petaro, jamshoro, Pakistan.

Characteristics of Fine Aggregate	Values
Water absorption	0.54%
Fineness modulus	2.74
Specific Gravity	2.86

Table 3: Characteristics of coarse aggregate

4) Potable Water

Concrete main constituents are fine aggregate, fine aggregate cement, and water. In which water is the main constituent to form homogeneous concrete. Since the water affects the hardened properties e.g. compression strength, tensile strength, durability, etc., and fresh properties such as workability. Therefore, it is important to check the water before it to be used in concrete because it may consist of dissolved salts such as sodium chloride, calcium carbonates, and different alkalis. The water that we used in this research was pure and free from alkalis and it was available at the civil engineering laboratory.

5) Polyethylene Glycol PEG-400

Polyethylene (PEG) is a condensation polymer of ethylene oxide (C₂H₄O) and water (H₂O) and the chemical nomenclature for polyethylene glycol is H(OCH₂CH₂)_nOH, in which n represents repeating ox ethylene groups typically from 4 to about 180. The main feature of Polyethylene Glycol is its solubility in water and its physical characteristic are odorless, non-reactive, lubricating, non-volatile, and non-irritating, etc (5). In this research, PEG-400 was used as it has high hygroscopic property as compared to the higher molecular weight polyethylene glycol. It was brought from a certified shop named QINGDAO ASPIRIT CHEMICAL CO, LTD. Karachi Pakistan. All physical properties of PEG-400 are given in table:04.

SR.NO	PROPERTIES OF PEG-400	UNIT OF MEASURE	VALUES
1	Molecular Weight	-	400
2	Colour	APHA COLOR	6
3	Specific Gravity	-	1.035
4	Water	Weight %	0.06
5	Acidity(ml 0.1 NaOH/10ml)	-	0.02
6	Reflective index@25C	-	1.4310

Table 4: Properties Of Polyethylene Glycol

B. Mix Design:

To produce concrete we need proper proportion for homogeneous mix and to reach our desired strength and make the concrete impervious and durable concrete. Since the concrete is made of cement, fine aggregate, coarse aggregate, and water. Therefore, there are two codes by which concrete are design mix proportion is obtained which are ACI (American concrete institute) and another one is DOE (Department of Environment) (8). However, in this research work, the DOE mix design was followed for producing 21MPa compression strength concrete. In the following table no.5, the proportion of concrete ingredients is given. However, in form of a ratio, it is 1:1.96:3.06 having a w/c ratio of 0.6. Proportion is given in following table.

Cement (kg/m ³)	Fine Aggregate (kg/m ³)	Coarse aggregate (kg/m ³)	Water (kg/m ³)	w/c ratio	Compressive strength of conventional concrete at 3 days in MPa
350	685	1070	210	0.6	16.34

Table 5: 21 MPa DOE mix design proportion

C. Strength test:

After completing the casting, 3 days compressive strength of concrete specimens were tested. The specimens were tested in concrete laboratory using UTM (UNIVERSAL TESTING MACHINE). Load was applied over specimen under uniform rate. Load was applied until the signs of failure appeared at cube as shown in figure below. And the compressive strength values of 3 days are given in table no 02:



Fig. 2: UTM (Universal Testing Machine)

SR. No	Concrete With Varying Percentage Of PEG -400	compressive strength in MPa 3 days
1	conventional concrete without curing	15.51
2	conventional concrete with curing	16.34
3	0.25 %	15
4	0.5 %	14.91
5	0.75 %	16.07
6	1 %	16.4
7	1.25 %	17.3
9	1.5%	18.38
10	1.75%	17.23
	2 %	17.59

Table 07: Compressive strength of Concrete

III. RESULT AND DISCUSSION

A. Compressive strength of concrete with PEG-400

Compressive Strength test of concrete was conducted in Concrete laboratory of MUET, Jamshoro in order to find the strength of concrete cubes. Cubes were tested under uniform loading by using UTM (Universal testing Machine) having capacity of 1000KN. Cube was placed at uniform surface where constant rate loading was applied until the failure of Cube. Reading was noted in tables then recoded force was divided with area in order to find its compressive strength. Compressive strength with varying percentage of PEG-400 of 3days are given in following figure.

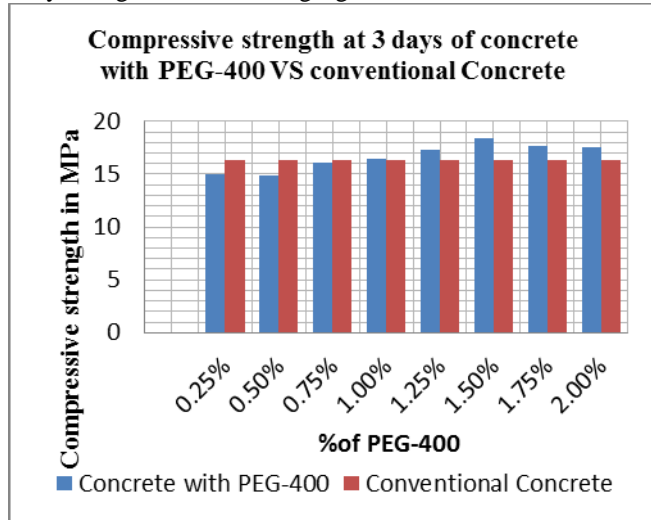


Fig. 3: Comparison Of Compressive Strength of Conventional Concrete with conventional curing Vs Concrete Mix with PEG-400

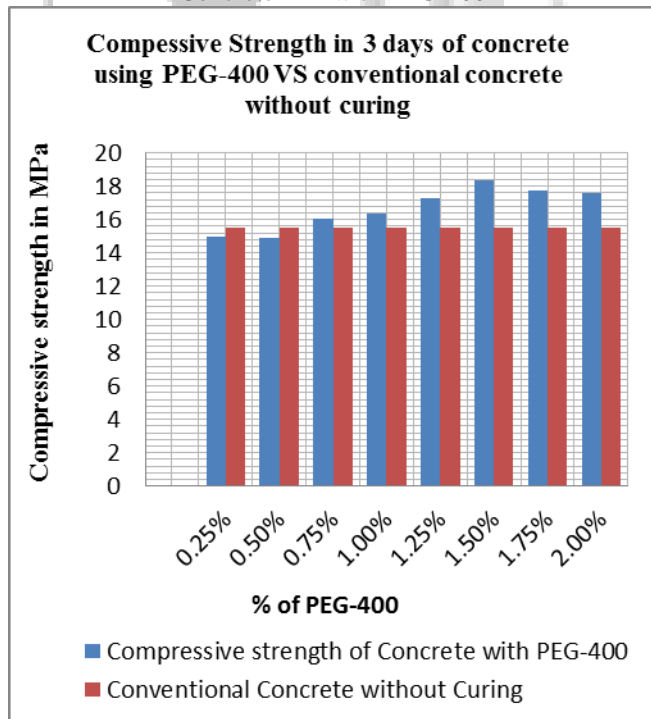


Fig. 4: Comparison of Compressive Strength of Conventional Concrete without Curing Vs Concrete Mix with PEG-400

IV. CONCLUSION

- 1) It was observed that at 0.25%, 0.5 % of PEG-400 compressive strength of 21 MPa concrete decreases.
- 2) Optimum dosage of PEG-400 for maximum compressive strength is found to be 1.5% at 3 days.
- 3) At 1.5% Dosage of PEG-400, the compressive strength of concrete increased by 12.5 % as compared to conventional concrete with conventional curing at 3 days.
- 4) At 1.5% Dosage of PEG-400, the compressive strength of concrete increased by 18.5 % as compared to conventional concrete without conventional curing at 3 days.
- 5) Strength of conventional concrete is relatively less than concrete containing PEG-400 except 0.25% and 0.5 %.

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