Fresh and Hardened Properties of Self-Curing Concrete and its Comparison with Conventional Concrete

Usama Sharafat[1], Ashar Aftab[1], Samar Hussain Rizvi[1], Muhammad Saleem Raza[1], Fida Hussain[1] and Abdul Raqeeb Memon[1]

[1]*Department of Civil Engineering, Mehran UET, Jamshoro*

***Abstract*: Concrete technology is a rapidly advancing field. Over the passage of time numerous innovations in concrete have led to the alleviation of its users. Water is a chief constituent of concrete. It bears paramount importance even after the placing of concrete; as it requires water to carry its strength developing reactions. Due to its exposure to atmosphere, the water in concrete is evaporated, which causes shrinkage cracks and compromises strength. To prevent this, 'Curing' is performed. Curing is the maintaining of suitable moisture content and temperature in concrete. The time required for curing is a stagnation for building time, increasing both the cost and efforts. The idea of Self-curing concrete proved to be a promising solution. The purpose of Self-curing agents is to minimize the water evaporation from concrete, thereby increasing the ability of concrete to retain water, as compared to conventional concrete. Over decades, these agents have become a growing demand in the field of concrete technology. These 'Self-curing' agents affect properties of concrete like; Strength, Workability and durability-both indulgently and drastically. This study includes the examination of the effect of Polyethylene glycol (PEG-400) in ratios of 0%, 0.5%, 1%, 1.5%, 2% on compressive strength, split tensile strength and workability of concrete. It has been observed that ratios 1% and 1.5% have yielded satisfying results.**

***Keywords: Curing*, Self-curing concrete, Hydration, Polyethylene glycol (PEG), Strength and Workability,**

I. INTRODUCTION

Concrete is most widely used construction material in the world. Many researches have been carried out to make it most suitable for the users. The properties like; strength, durability and economy make concrete, a preferred material for construction. Water is a chief constituent in the production of concrete. It bears paramount importance even after the placing of concrete; as it requires water to carry its strength developing reactions. It is a matter of fact that concrete is open to the atmosphere, hence the process of hydration is affected immensely by the evaporation of water; which verdantly causes the occurrence of shrinkage cracks and lack of development of strength [1]. To prevent such circumstances 'Curing' is performed. Curing is the preservation of the enough moisture and temperature in the concrete during its nascent stages in order to produce the appropriate structural concrete. The curing process must be carried out properly in order to gain the adequate performance and durability [2]. Conventional curing requires the external application of water curing after the concrete is mixed, set and finished. It is a well-known fact that, curing most of the times proves to be a hurdle in a quick scheduled construction, as well as its immense consumption of water makes it a hard-to-execute process for maintaining the moisture in the concrete. Modern construction looks for modern techniques, therefore innovations are being made to replace the tedious process of curing with a far better time saving and economical alternative.

The idea of Self-curing concrete proved to be a far-lasting heed to such a call. Various researches have been and are being carried out for the introduction and advancement of Self-curing abilities of concrete. The aim of self-curing agents is to minimize the evaporation of water from concrete, thereby increasing the retention of water by the concrete compared to conventional concrete types [3]. Over decades, these agents have become a growing demand in the field of concrete technology. These 'Self-curing' agents affect properties of concrete like; Strength, Workability and durability-both indulgently and drastically. Self-curing concrete can be made either using light weight aggregates or by using chemical compounds [4]. Saturated light weight aggregates can reduce the appearance of shrinkage cracks, by providing additional moisture to fight the effects of drying and self-desiccation [4-5]. The following study includes the examination of the effect of Polyethylene glycol (PEG) on the Self-curing properties of concrete, as well as its Strength and Workability. PEG is a chemical agent which reduces the loss of water from concrete, it also attracts moisture from the atmosphere. Self-curing concrete not only excludes the extensive consumption of fresh water but also minimizes field labor for curing and the overall time of construction. Thus, Self-curing concrete is an essential requirement for construction nowadays.

Apart from its numerous uses, Polyethylene glycol is added to concrete to introduce self-curing properties. Such a phenomenon occurs due to the hydrophilic nature and water locking properties of PEG [6]. Polyethylene glycol is clear that it cannot grant truly self-curing properties and yield full results without affecting the overall characteristics of fresh and hardened concrete. For the research the Fresh and Hardened properties of concrete will examined at 0%, 0.5%, 1%, 1.5% and 2% of Polyethylene glycol (PEG-400) and their comparison with conventional concrete.

II. LITERATURE REVIEW

Magda Mohamed I. Musa. (2015) discussed the effect of poly-ethylene glycol on water retention and strengths of concrete in his research. The results he concluded are: The compressive and split Tensile Strengths of all concrete mixes are gradually increased with time. Self-curing agents increase the water retaining properties, hence create a less porous concrete than conventional [7].

M. Coleperdi, A. Bersoi, S. Coleperdi. (2006) stated in their research that There was no noteworthy change in compressive strength of five concrete mixtures, except at day-1 when there was retardation in cement hydration. The shrinkage is observed to be reduced by approximately up to 50% due to presence of polyethylene in chemical structure [8].

Ali A. Bashindi. (2015) used silica fume along with the poly-ethylene glycol and found the results as Self-curing concrete behaved nearly identical to the same CC concrete but the self-curing SC concrete with chemical curing agent gives less strength values by about 8-10% comparing to conventional curing CC concrete. The durability is not affected much by using chemical curing agents for self-curing. He also found out that Self-curing concrete losses strengths (compressive and split tensile) with increase in elevated temperature and exposed period [9].

Patel Manish Kumar Dayabhai and Prof. Jayesh kumar R. (2014) used poly-ethylene glycol of different molecular masses (PEG600 and PEG1500) and found out that The Workability (Slump) of concrete increases as the percentage of PEG is increased. With the addition of self-curing agents, the strength is improvised. The compressive strength of concrete mix improved overall by 37% by adding 1.0% of PEG-600 and 33.9% by adding 1.0% of PEG-1500 as compared to the conventional concrete [10].

Ryan Henkersien, Tomy Natung and Jason Weisse (2008) introduced lightweight aggregate for the internal curing or self-curing and determined that Mixtures with a larger volume of Lightweight aggregates showed a reduction in shrinkage and absolute shrinkage. The ability is imparted by the addition of light weight aggregates [11].

III. MATERIALS & METHODS

A. CEMENT

For the research, Ordinary Portland Cement is used.

B. FINE AGGREGATES

The granular material passing from 4.75mm sieve is referred as ‘Fine aggregates. Fine aggregates used in this research has Specific Gravity of 2.62 and water absorption 0.6%.

C. COARSE AGGREGATES

In experimental work, the molds used are smaller in size, therefore the size of coarse aggregates is restricted to some extent. Hence, aggregates that pass from 19.5mm sieve and retained on 4.75mm are used in the production of concrete, having Specific Gravity of 2.67 and water absorption 0.88%.

D. POLY-ETHYLENE GLYCOL(PEG-400)

Polyethylene glycol is a polymer of ether. It has a vast range of applications including industrial, chemical and biological usages. By nature, Polyethylene glycol is hydrophilic. Its molecular structure is shown as $H\text{-}(O\text{-}CH_2\text{-}CH_2)_n\text{-}OH$. Whereas 400 is Molecular Weight of the compound. Polyethylene glycol is found to have been exhibiting water locking properties. Therefore, in the following research, PEG is used as an admixture to impart self-curing ability in concrete.

The materials for concrete: Ordinary Portland Cement (OPC), fine aggregates, coarse aggregates and water are collected. Several tests are run to ensure that all the materials of concrete production are best suited for their purpose. Controlled mix design of concrete is prepared for appropriate target mean strength. Five controlled mixes are prepared with proportion of 0%, 0.5%, 1%, 1.5% and 2% of Poly-ethylene glycol (PEG-400) For checking out fresh property, slump test is conducted to check the workability of concrete. Six cubes, each with dimensions 0.1m x 0.1m x 0.1m and six cylinders of 0.2m height and 0.1m diameter are prepared each with proportions of Poly-ethylene glycol. Cubic compressive strength and cylinders’ split tensile strength are determined. All the results are compared with the conventional concrete.

Fig. 1. Schematic Diagram of Methodology

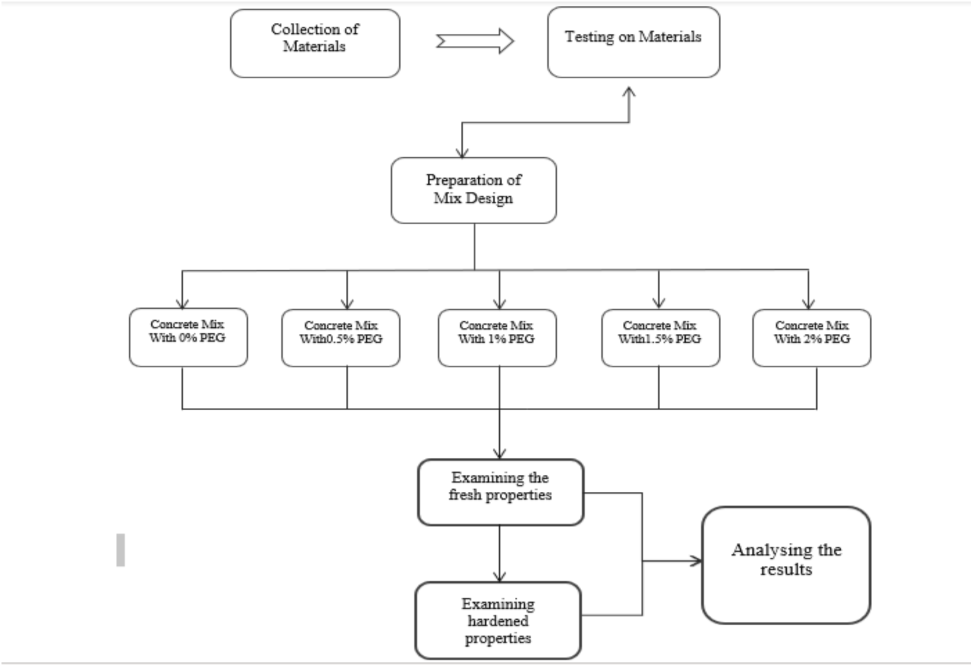

Fig. 1

IV. RESULTS

The ratio of constituents will be kept constant throughout all the mixes of the research, while varying the proportions of Polyethylene glycol at 0%, 0.5%, 1%, 1.5%, 2% of the weight of cement. The comparison is drawn between concrete mixes with these proportions and conventional concrete, with reference to the Workability, Compressive strength and Split tensile strength of concrete. Controlled mix proportions of concrete constituents are given as follows:

Table. 1

Controlled Mix of 4000 psi					
S.NO.	Cement (Kg/m³)	Fine Aggregates (Kg/m³)	Coarse Aggregates (Kg/m³)	Water (Kg/m³)	Mix Proportions by weight
1.	415	725	1030	225	1:1.75:2.48

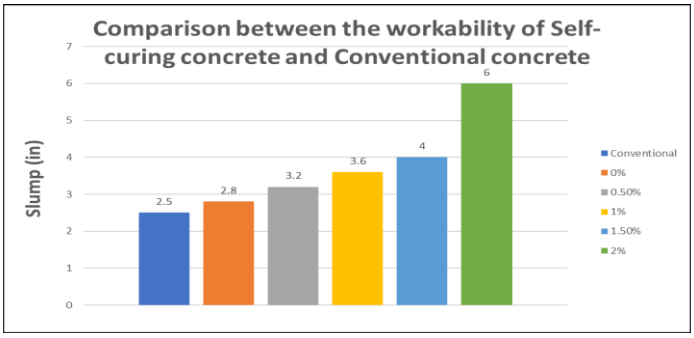

Fig. 3

A. WORKABILITY

Workability adversely affects the quality of the concrete. Below are the results of the tests performed to assess the workability of concrete in different ratios of polyethylene glycol.

Table 1. Workability of Concrete

S.NO.	PEG-400	Water Cement	Slump (in)

		Ratio	
1	-	0.54	2.5
2	0%	0.54	2.8
3	0.5%	0.54	3.2
4	1%	0.54	3.6
5	1.5%	0.54	4
6	2%	0.54	6

B. COMPRESSIVE STRENGTH

All the prepared cubes at varying proportions of 0%, 0.5%, 1%, 1.5% and 2% are tested for their compressive strength at third, seventh and twenty eighth day. With the help of graphs, the strength is compared and analyzed. The compressive strength of conventional concrete and self-curing concrete are explained below:

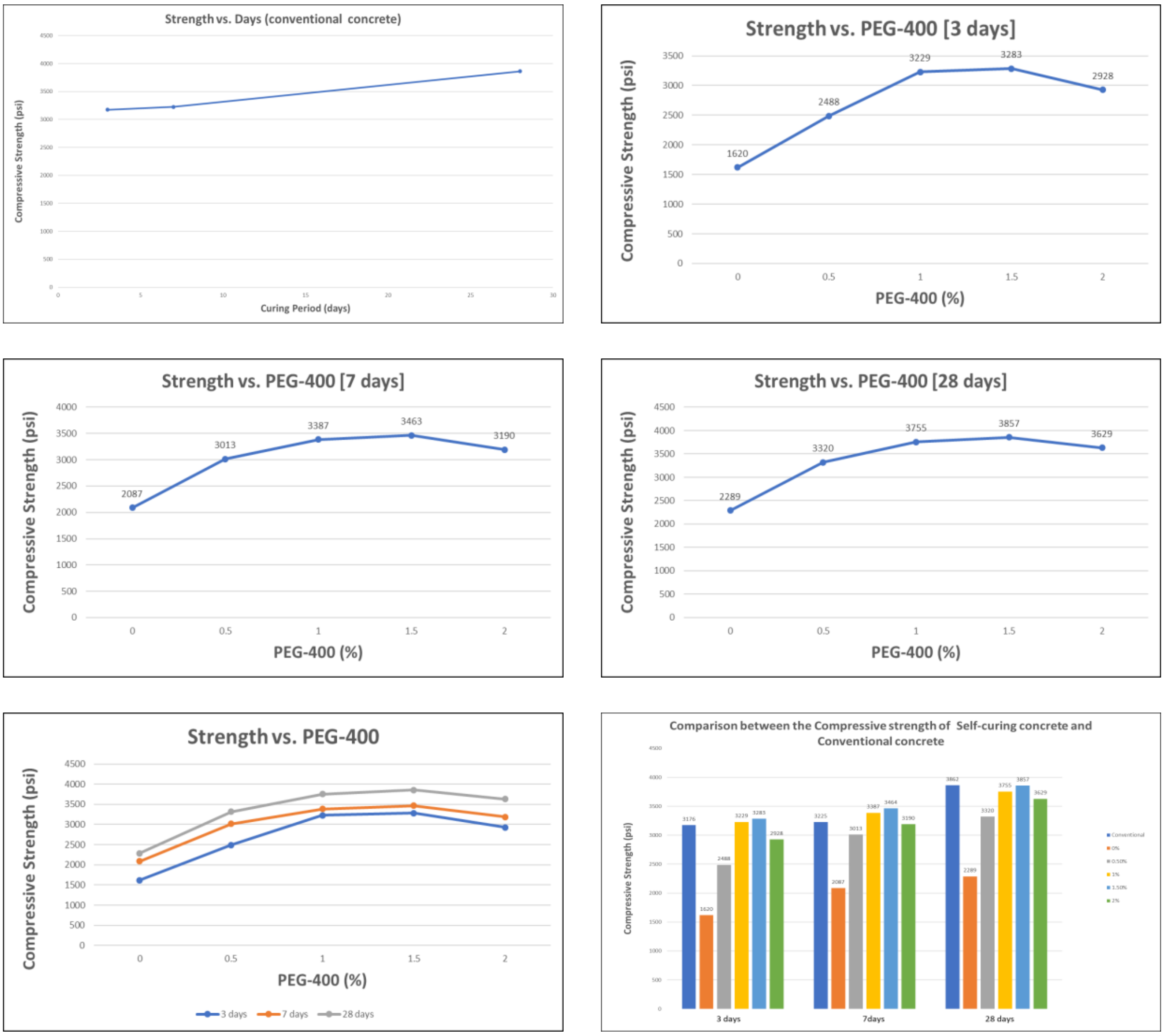

Fig. 4

C. TENSILE STRENGTH

As with its compressive strength, the self-curing concrete must be checked and compared to conventional concrete with its 'Tensile strength'. To carry out this operation concrete cylinders of 200mm length and 100mm diameter were cast at the varying proportions of Polyethylene-glycol i.e. 0%, 0.5%, 1%, 1.5% and 2% of weight of cement. The cylinders are put laterally into the Universal Testing Machine (UTM) and the load is applied. Upon reaching their maximum strength the cylinders crack and split open, the load is then noted. This test is generally called "Split Tensile strength test" because of its working mechanism. The results of Split tensile strength test are as follows:

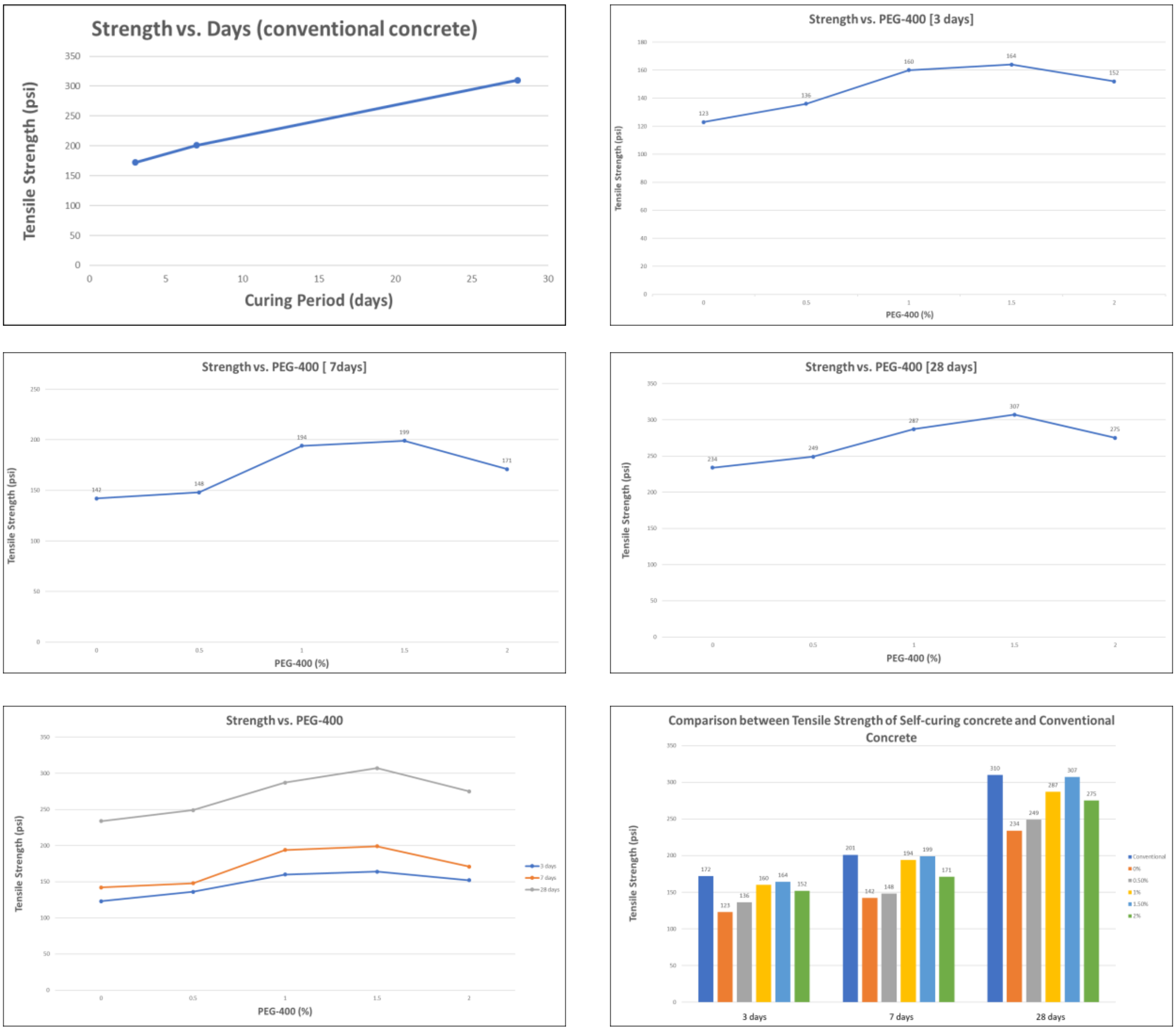

Fig. 5

V. CONCLUSIONS

Following conclusions are drawn after analyzing the experimental results.

1. It has been noted that workability of concrete increases as the ratio of PEG-400 increases.
2. With the introduction of PEG-400 at 0.5% the strength of concrete at 3 days decreases by 21.6%, at 7 days decrease by 6.5% and 28 days decrease by 14%.
3. With the introduction of PEG-400 at 1.0% the strength of concrete at 3 days increases by 1.66%, at 7 days increase by 5% and 28 days decrease by 2.77%.
4. With the introduction of PEG-400 at 1.5% the strength of concrete at 3 days increase by 3.4%, at 7 days by increase by 7.4% and 28 days decrease by 0.13%.
5. With the introduction of PEG-400 at 2.0% the strength of concrete at 3 days decreases by 7.8%, at 7 days decrease by 1% and 28 days decrease by 6%.
6. A decrease of 19.6% in split tensile strength was observed at 0.5% of PEG-400, decrease of 7.4% in split tensile strength at 1.0% of PEG-400, decrease of 0.97% in split tensile strength at 1.5% of PEG-400 and decrease of 11.29% in split tensile strength at 2.0% of PEG-400 was observed at 28 days.
7. It is advised that the ratios 1.0% and 1.5% of PEG-400 should be used as optimum value of self-curing agent.

8. It has been concluded that self-curing concrete can overcome the many problems faced by proper curing of concrete.

VI. RECOMMENDATIONS

Studying the results and conclusions, the following recommendations are presented for the future works:

1. Although the Poly-Ethylene Glycol imparts satisfactory self-curing properties in concrete, but further study must be carried to find out the compounds that may be able to serve this purpose.
2. Certain admixtures must be tested with PEG-400 content equal to and greater than 2.0% to obtain improvised self-curing properties without compromising the strength.
3. Other forms of poly-ethylene Glycol (PEG600, PEG1500) should be tested to determine the self-curing properties that they can impart in concrete, in future researches.

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