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Original Article

Influence of Self-Curing Polymer PEG 400 on Physical Properties of Ordinary Portland Cement

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Abstract - *In this experimental work, the effect of Self-Curing polymer Polyethylene Glycol 400 (PEG 400) on various physical properties of Ordinary Portland Cement (OPC) of 53 grade such as standard consistency, initial setting time (IST), final setting time (FST), soundness and compressive strengths at 3, 7 and 28 days were investigated using the guidelines given in Indian Standard codes. The average molecular mass of Self-Curing polymer is 400. It was added to OPC with the rates of 1%, 1.5%, and 2% by dry cement mass. Totally, four mixes were produced; one conventional or reference mix and the remaining three with different PEG 400 contents. The outcomes of experimental work led to the findings that incorporation of PEG 400 in OPC did not significantly affect the standard consistency value. However, with the increased dosages of Self-Curing liquid, IST and FST were prolonged. The soundness of Self-Curing polymer-mixed cement paste was better than that of the reference mix, the better soundness property being for the addition of 1.5% of PEG 400. Compressive strength values of PEG 400-modified standard cement-sand mortar cubes kept in the open air in the laboratory for Self-Curing were on par with that of reference cubes immersed underwater.*

Keywords - *Polyethylene Glycol 400, curing, Ordinary Portland Cement, standard consistency, initial setting time, final setting time, soundness, etc.*

I. INTRODUCTION

The need for a large quantity of fresh water for producing and curing the concrete results in water scarcity, thereby leading to unsustainable development. As a thumb rule, 3 m^3 of water needs to be mobilized on the construction site for producing each m^3 of concrete. A substantial quantity of this water is required for the process of curing [1]. The physical properties of cement have a significant influence on the concrete properties. So, it was attempted to experimentally determine the various physical properties of the cement paste with and without PEG 400.

II. CONVENTIONAL CURING METHO

For different concrete members on the construction site like a beam, column, slab, foundation, etc., age-old curing techniques like spraying, ponding, moist burlap cover, etc., need an enormous amount of water. As per the Indian Standard, IS 6461-Part VII (1973), curing is maintaining the required humidity and temperature of freshly cast concrete in a specified time after pouring, molding, or finishing to archive a sufficient degree of hydration of cementitious components and adequate hardening of concrete. Inaccessible structures, lack of awareness about curing, paucity of good quality water, etc., impose limitations on supplying water to concrete through external curing. The depth of water penetration and its effectiveness is influenced considerably by the concrete quality. As the concrete permeability becomes low during the initial 2 to 3 days after the placement of concrete, external curing does not cater to the necessity of adequate hydration of cement particles. This is because of the accumulation of products of hydration, resulting in a network of capillary pores getting disconnected. Due to negligent attitude, the various concrete members on the site are not properly cured. Due to under-curing, the integrity of surface zone concrete gets badly affected over a depth of 30 mm to 50 mm under the normal exposure conditions [2]. Hence, concrete fails to achieve the desired strength as well as durability properties. Moreover, thick concrete elements tend to crack excessively due to the temperature gradient. There are increased possibilities of chemical shrinkage, self-desiccation, and autogenous shrinkage for concretes having water/cement ratio lower than 0.35 combined with curing by externally applying water, many times, fails to overcome these undesirable mechanisms [3]. Applying curing compounds on the surface of concrete for sufficient retention of water after the drying of bleed water can be one of the options. However, this method does not make available the extra water needed to mitigate the phenomenon of self-desiccation. It is ineffective in decreasing shrinkage at an early age for concretes with low water/cement ratios. A membrane gets formed on the surface of concrete due to the application of curing compounds. This membrane reduces the efficiency of surface finishes through an adequate bond [4].

III. SELF-CURING AND USE OF PEG 400

Sufficient curing is an essential and vital requirement of concrete for exhibiting better performance. Curing brings about a continuous hydration process, leading to an increase in strength. Cement fails to attain complete hydration if insufficient moisture conditions prevail within the concrete mass. The moment the internal relative humidity (RH) within the pores becomes less than 80%, the process of hydration stops. The water supplying method and water retaining method are the two ways of curing concrete. Self-Curing is a method of water retention. There are two ways for Self-Curing of concrete. One approach resorts to utilizing prewetted porous lightweight aggregates (LWAs) to make water available internally to compensate for the water used up in the mechanism of chemical shrinkage taking place with the hydration of cement. The other approach is to use materials that are hydrophilic in nature. Evaporation is decreased, and a sufficient amount of water is retained in the concrete due to the additions of these materials. Hydrophilic material, acting as a Self-Curing additive, reduces water loss; moreover, it has a strong affinity for atmospheric water as well. This leads to proper curing of concrete. At late, the Self-Curing method is picking up the pace and is proving its usefulness for the application on-site from the experimentalA. investigations [5-7]. As per ACI 308 committee [8], Self-Curing (Internal Curing) is a mechanism that facilitates inB. making available enough amount of water, using Self-CuringC. additive, for adequate cement hydration. Chemical shrinkage is a mechanism that drives Self-Curing. Self-Curing isD. essentially useful for the concretes having lower water/cement ratios because of chemical shrinkage prevailing owing to the hydration of OPC and materials having relatively lower permeability properties. Low water/cement ratio concretes tend to become quickly impermeable, thereby resulting in insufficient external water transfer to the inside of the concrete mass [9]. This clearly depicts how vital internal curing is. Self-Curing polymer, also acting as a Shrinkage Reducing Admixture (SRA), decreases mixing water surface tension and brings down evaporation rate [10-13]. Autogenous shrinkage and self-desiccation can be reduced to a large extent through Self-Curing [14, 15]. Apart from bringing down the shrinkage, Self-Curing facilitates a decrease in shrinkage cracking [6], plastic shrinkage cracking [16], and water absorption [17]. Accelerated evaporation of water takes place for the concrete placed in an arid region, leading to a decline in the initial water/cement ratio. It results in interrupted hydration of cement particles, thus affecting the quality of concrete to a large extent. As the evaporation occurs in the early stage, cracking due to shrinkage occurs. During the final setting stage of concrete, drying shrinkage cracking takes place because of the evaporation. When the temperatures are higher, the strength of ordinary concrete goes on decreasing due to crack formation between two materials, i.e., cement paste and aggregates, which are thermally not compatible with each other. Owing to the difference in chemical potential between the liquid and vapor phase, continuous evaporation from an exposed concrete surface prevails. The Self-Curing polymers incorporated into concrete tend to form hydrogen bonds with water molecules, leading to suppressing the chemical potential. Therefore, vapor pressure reduces, and the rate of evaporation also decreases. Thus, the hydration of cement gets enhanced. The quantity of solid phase of paste increases by the hydration rate due to the fact that hydration-related chemical reactions consume the water. This leads to maintaining enough RH of the paste, thereby reducing the self-desiccation process. If RH falls below 80%, the hydration rate gets reduced. More importantly, if the internal RH falls below 30%, the rate of hydration is negligible [18].

IV. RESEARCH SIGNIFICANCE

This experimental work had the objective of assessing the influence of PEG 400 on various physical properties of OPC. The comparative study of the results obtained from the tests conducted on reference mix and PEG 400 mixes would lead to understanding the effect of Self-Curing polymer on the various parameters under consideration.

V. MATERIALS USED

OPC 53: Cement conforming to IS-12269:1987 was used. Its specific gravity was 3.12.

Water: Potable and clean water was used for mixing and curing purposes. It was conforming to IS-456: 2000.

PEG 400: It is a condensation polymer of ethylene oxide and water, having the general formula $H(OCH_2CH_2)_nOH$, in which n is the average number of repeating ox ethylene groups ranging from 4 to about 180 [12]. It is a linear polymer that is soluble in water and is largely utilized in the pharmaceutical field. These polymers are synthesized for different applications in industrial setup by a process called polymerization, where ethylene oxides react with water, mono, or di-ethylene glycols in the presence of alkaline catalysts. The glycols are good binders, plasticizers, ointment bases, solvents, and lubricants for different applications in the pharmaceutical field. These are also utilized for oral medications and coatings of tablets. PEGs are classified into various categories, for various uses, by means of their molecular weights. They are manufactured in the molecular weight range of 200 to 8000.

PEG properties vary as their molecular weights differ. The most vital property of PEGs is their better water solubility. Their solubility in water, as well as other solvents, reduces with the increase in their molecular weight [19]. Hence, for achieving greater solubility, glycols having low molecular weight are preferred. The PEGs up to 600 molecular weight are highly water-soluble in any ratio. Even in hard water or aqueous solutions of different salts, PEGs exhibit good solubility properties. As the molecular weight goes on increasing, the hygroscopic property decreases [19]. At room temperature and in the absence of oxygen, PEG 400 is a non-volatile liquid. As the PEGs have less volatility, they are thermally stable as required for various field applications. PEGs exhibit excellent water-retention properties. PEGs having low molecular weight are more hygroscopic and hence are preferred for different field uses owing to their excellent feature of moisture retention. Table 1 shows the properties of PEG 400.

Table 1: Properties of PEG 400

Property	Details
pH	.> 6
Molecular weight (gm/mol)	400
Color	White
Hydroxyl value (mg KOH/gm)	300
Specific Gravity	1.12 at 27^0C
Appearance	Clear liquid
Density (gm/cm^3)	1.125
Nature	Water soluble

pH value of marginally more than 6 as given in the above table indicates that PEG 400 is not highly alkaline. Further, the pH value of various workability enhancing admixtures used in concrete is also around 6. However, due to the high alkalinity of cement, the resulting slurry of cement mixed with PEG 400 will be alkaline in nature, thereby posing no problem of being acidic in nature.

Sand:

Standard sand conforming to IS:650-1991 was used. The sand grains passed through 850 µm sieve, and less than 10% passed through IS 600 µm sieve.

VI. THEORETICAL BACKGROUND

A. Standard Consistency

Standard consistency of cement paste, also called normal consistency, refers to a particular consistency that allows a Vicat plunger, 50 mm long and 10 mm in diameter, to get inserted to a depth of 33 to 35 mm from the Vicat mold top [20]. The test gives the water percentage needed for making a cement paste having standard consistency.

B. Initial Setting Time and Final Setting Time

Setting time refers to the time needed for cement paste to get stiffened. It indicates a change from a fluid form to a rigid form. Selective hydration of C_3S and C_3A is the main reason for the setting of cement [21]. It is associated with the increase in temperature of cement paste; the initial setting relates to a quick temperature rise, and the final setting relates to peak temperature. An arbitrary division is created for cement setting time as initial setting time and final setting time. Exact differentiation between these two arbitrary divisions is not possible. However, for convenience, the time elapsed between an instance of water addition to cement to the time when paste starts giving up its plasticity is known as the initial setting time [20]. The final setting time is the time elapsed between an instance of mixing of water with cement and the time when the paste has fully given up plasticity and acquired adequate firmness to resist a particular minimum pressure. On civil engineering sites, while working with cement paste, cement-sand mortar, and concrete, a specific period is needed for the purpose of mixing, transportation, placement, compaction, and finish. For this duration, the material should be in a plastic state for easy molding. The duration for which the products of cement exhibit plasticity properties is the initial setting time. For the mixing and handling process, usually, a minimum of 30 minutes is required. The constituents, as well as cement fineness, are kept in such a manner that concrete is in plastic form for specifically required duration. It is desirable that concrete should lose its plasticity as early as possible once it gets placed in the final position, compacted, and finished. This ensures that the concrete is least susceptible to damage due to harmful external factors. This time must not usually exceed 10 hours, known as the final setting time.

C. Soundness

Once the cement paste sets, it should not undergo a considerable amount of change in volume. There should not be too much expansion, which with the conditions of restraint, can lead to hardened cement paste disintegration. This expansion might take place because of magnesia, free lime, and calcium sulfate (gypsum). If cement undergoes expansion, it is said to be unsound [21]. Such cement may lead to undesirable effects, thereby hampering the durability of the structures. The slow reaction of M_gO or free lime leads to unsoundness. Reactions involved are

$$M_gO + H_2O \longrightarrow M_g(OH)_2$$

$$CaO + H_2O \longrightarrow Ca(OH)_2$$

Clinker contains free lime, which is intercrystallized with other compounds. It undergoes hydration very gradually, thereby occupying a greater volume as compared to that occupied by the original free calcium oxide. The amount of free lime cannot be arrived at by resorting to chemical analysis of cement because it is impossible to differentiate between untreated C_aO and $C_a(OH)_2$ produced by partial hydration of silicates when the cement gets an exposure to the environmental effects.

Magnesia undergoes a reaction with water in the same way as that of C_aO. However, only the crystalline state is harmfully reactive, leading to unsoundness. Hence magnesia content permitted in the cement is limited to 6%. To prevent a false set of cement, gypsum is added to the clinker during the process of grinding. The amount of gypsum ranges from 3 to 5%, depending upon C_3A content. If the gypsum is added in quantity greater than that could be combined with C_3A, the excess amount remains in the cement in free form. This leads to expansion through the formation of calcium sulphoaluminate (ettringite) from excess gypsum (which is not consumed by C_3A while setting), resulting in disruption of the set cement. Cement unsoundness does not come to the surface for a long time. Hence, accelerated tests giving quick results are needed to detect the cement unsoundness.

D. Compressive Strength

The compressive strength of cement in its hardened state is of utmost importance [22]. Hence, cement is usually tested to determine compressive strength before its utilization for construction work. Due to the possibility of large shrinkage and resulting cracking of neat cement, a strength test is never conducted only on neat cement paste. It is indirectly arrived at by testing cement-sand mortar in particular proportions. The standard sand is made use of for this purpose.

VII. TESTING

A. Standard Consistency Test

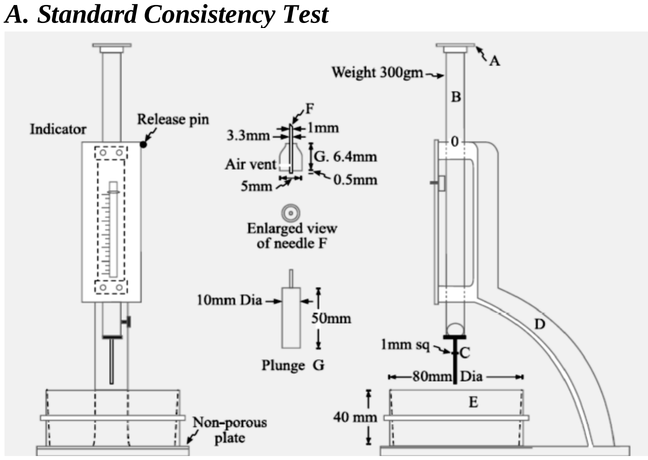

Figure 1: Vicat's Apparatus

IS:4031(Part 4) – 1988 was referred for the test. The Vicat's apparatus (figure 1) conformed to the specifications given in IS 5513-1996. The test was carried out by weighing 500 gm of OPC 53. For the first trial, 24% of water by weight of cement was mixed with the cement. The paste was made in a standard way and filled into Vicat mold of height 40 mm within 3 to 5 minutes. After the mold was fully filled, it was shaken gently in order to remove the air. A standard plunger (G) having 50 mm length; 10 mm diameter was attached and lowered down to just be in touch with the paste surface in the test block. It was released suddenly to permit it to penetrate into paste under self-weight. The penetration depth of the plunger was observed. For another trial, 25% water was mixed with the cement, and the same procedure was repeated. The various trials were conducted by increasing the water content till the plunger penetrated to a distance of 33 to 35 mm from the mould top. The water percentage which permits the plunger to sink only up to a depth of 33 to 35 mm from mould top or 5 to 7 mm from mould bottom is referred to as water percentage (P) needed to make a paste of cement having standard consistency.

B. Initial Setting Time and Final Setting Time Tests

These tests were conducted by referring to IS:4031(Part 4) – 1988. The Vicat's apparatus (figure 1) conformed to the specifications given in IS 5513-1996. A cement sample of 500 gm was taken, and it was thoroughly gauged with 0.85 times the water needed to make a paste of cement of standard consistency (0.85P). The paste was gauged and filled into Vicat mold within 3 to 5 minutes. A stopwatch was made on, the instance, the water was mixed with cement.

For determining initial setting time, the lower end of the rod of the Vicat apparatus was fitted with a thin needle of 1 mm sq. in cross-section (C). The needle was slowly lowered, and it was made to just touch the test block top surface. It was then freely released into the test block, i. e., cement paste. At the start, the needle penetrated for the full depth of 40 mm. However, as time progressed, cement paste started losing its plasticity. After a certain time, the needle could pierce into the sample block only up to a depth of 33 to 35 mm from the mould top. The time which elapsed between the instance of mixing of water with the cement and the time at which the needle pierced into the sample to a depth of 33 to 35 mm from the top was reported as the initial setting time.

For the final setting time test, circular attachment (F) was fitted. The cement paste was considered to have undergone the final set when, after attachment was slowly lowered on the top surface of the sample, and the center needle could make an impression; however, the circular edge of the attachment (F) failed to do so. The time was noted down. This showed that the paste had become hard to the extent that the center needle was unable to penetrate through the paste more than 0.5 mm. The duration which elapsed between the instance of mixing water with the cement and the time when circular attachment failed to make an impression on the paste was reported as the final setting time. As per IS: 12269-1987, the initial setting time must not be less than 30 minutes, and the final setting time must not be more than 600 minutes for OPC 53.

C. Soundness Test

IS:4031(Part 3) – 1988 was referred for the test. Le Chatelier's apparatus used for the soundness test is shown in figure 2. It detects unsoundness because of the presence of free lime only.

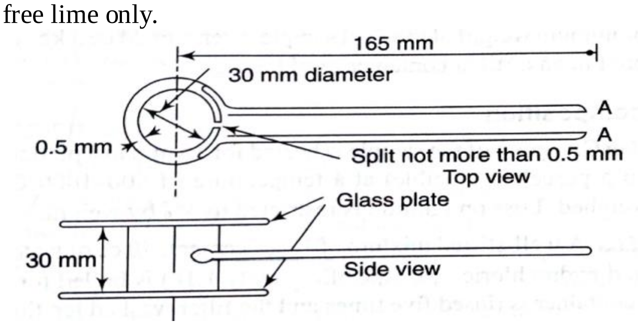

Figure 2: Le Chatelier's Apparatus

It comprises a small split cylinder, 30 mm in diameter and 30 mm high. Two indicator arms of length 165 mm with pointed ends are attached on the other side. Cement was neatly gauged with 0.78 times the water needed for standard consistency (0.78P) in a specified way and was filled into the mold kept on a glass plate. The top of the mold was also covered with a glass plate. This assembly was kept in water at a temperature of 27^0 C to 32^0 C for the duration of 24 hours. The assembly was taken out after 24 hours, and the distance between indicator points was measured. The mold was again submerged in water, and water was brought to boiling point in around 25 to 30 minutes time and kept boiling for 3 hours. The mold was then taken out of the water, and it was allowed to cool. The distance between the indicator points was measured again. The difference between the two measurements refers to the cement expansion. As per IS: 12269-1987, the distance between the indicator points should not exceed 10 mm for OPC 53.

D. Compressive Strength Test

200 gm of OPC 53 and standard sand weighing 600 gm were taken. Their proportion by mass was 1:3. The two materials were mixed thoroughly in a non-porous enamel tray using a trowel for a minute. Then water was added at the rate of (P/4 + 3%) of the combined weight of cement and sand. P is a percentage of water needed for OPC 53 to attain the standard consistency. Thorough mixing was carried out until the mixture was of uniform color. Care was taken to see that the time of mixing was neither less than 3 minutes; nor more than 4 minutes. The mortar so formed was then filled into a cube mold of size (70.6 mm X 70.6 mm X 70.6 mm). The area of the cube face was 4984.36 mm^2. The cube molds were kept on the vibrating machine for two minutes for achieving better compaction, thereby expelling the air. One set consisted of 9 cubes; 3 each for 3 days, 7 days, and 28 days testing. In all, there were 4 such sets; one for the conventional mortar and the remaining for the Self-Curing. Mortars. The cube molds were covered with wet gunny bags for 24 hours for the conventional mortar (reference mortar without PEG 400). The cubes were taken out of the molds after 24 hours, and they were kept in clean and fresh water for curing. However, no wet gunny bags were used for the mortar cubes with different dosages of PEG 400. After 24 hours, the cubes were kept in open air inside the laboratory for undergoing Self-Curing. As per IS: 12269-1987, the minimum compressive strengths of mortar cubes should be 27 N/mm^2, 37 $N/mm^{2,}$ and 53 N/mm^2 for 3, 7, and 28 days respectively.

VIII. RESULTS AND DISCUSSION

A. Standard Consistency

Table 2: Standard Consistency Values

PEG 400 (%)	Water (gm)	Number of Trials	Standard Consistency, P (%)
0	150	6	30
1	150	5	30
1.5	147	5	29.4
2	147	7	29.4

The standard consistency results are shown in table 2. It is seen that the percentage of water needed to make a cement paste of standard consistency was the same for the reference mix and mixed with 1% PEG 400. However, the requirement of water quantity for the cement pastes with 1.5% and 2% of PEG 400 to attain the standard consistency was slightly less in comparison with the first two cases. PEG 400, being hygroscopic in nature and having good water retention capacity, dosages of 1.5% and 2% resulted in the marginally low requirement of amount of water to produce the same consistency.

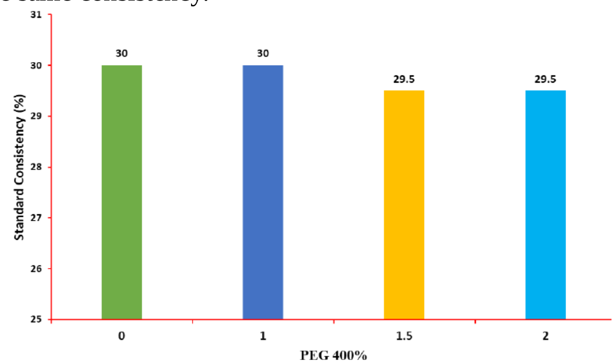

Figure 3: Standard Consistency Values

Standard consistency values for four cement paste mixes are shown in figure 3 for comparison. PEG 400 was seen to have no significant effect on consistency values. The slight reduction in water demand by cement paste with higher PEG 400 dosages shows that mixing PEG 400 in concrete would facilitate in enhancing the workability, probably with the marginal reduction in dosages of admixtures.

B. Initial Setting Time and Final Setting Time

Table 3: IST and FST Values

PEG 400 (%)	IST (Minutes)	FST (Minutes)
0	152	174
1	166	211
1.5	186	221
2	220	266

Table 3 gives values of IST and FST for the four cement paste mixes. The dosages of PEG 400 were seen to prolong both IST as well as FST. For the 1% PEG 400 mix, IST was extended by 14 minutes, and FST got prolonged by 37 minutes in comparison with that of the reference mix. For 1.5% of PEG 400 dosage, IST was prolonged by 34 minutes, whereas FST got extended by 47 minutes. IST was extended by 68 minutes, and FST got prolonged by 92 minutes for a 2% dosage of PEG 400. For all the mixes, IST was more than 30 minutes, and FST was less than 600 minutes, thereby complying with the quality standards of cement.

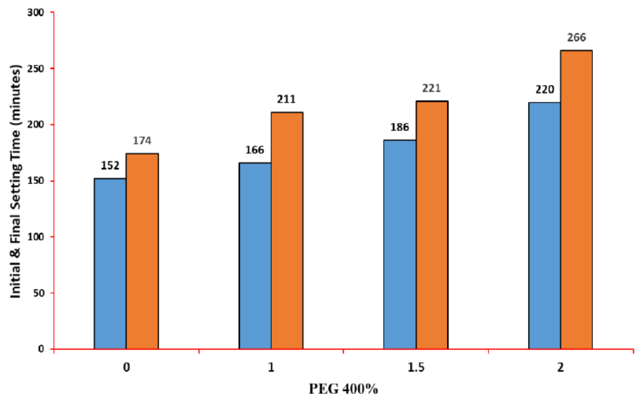

Figure 4: IST and FST Values

Figure 4 shows IST and FST for the four different cement paste mixes. For application to the concrete construction activities on-site, physical aspects such as stiffening, setting, and hardening, which are different manifestations of the process of hydration, are important. As the plastic cement paste loses its consistency, it stiffens, and this is associated with concrete slump loss. The plasticity in cement paste is caused by the presence of free water. The slow loss of free water from the system due to the formation of hydration products, surface absorption by poorly crystalline products such as calcium silicate hydrate (C-S-H), and ettringite makes the paste undergo stiffening and, ultimately, undergo setting and hardening. The tendency of PEG 400 to retain the moisture in the paste keeps it sufficiently plastic for more time. The solidification of plastic cement paste marks the setting phenomenon. The start of solidification, known as the initial setting, is the instance when the paste becomes unworkable. Hence, placement, compaction, and finishing of concrete are difficult after IST. However, the paste does not undergo solidification quickly; it needs significant time to become completely rigid. The final setting refers to the time required for the paste to solidify fully. It should not be too long to avoid delays in construction activities on the site.

In the final set, OPC exhibits very little strength because it represents only the start of C_3S hydration. As the hydration of C_3S begins, the reaction continues quickly for many weeks. The void spaces in the paste are progressively filled with the reaction products leading to a reduction in permeability and porosity and strength enhancement. This marks the hardening of concrete.

The retarding effect of PEG 400 on IST and FST is possible because of the deposition of precipitated polymer complexes on the hydrating cement grain surface. This causes a delay in the evolution of the normal setting mechanism.

C. Soundness

Table 4: Soundness Values

PEG 400 (%)	Distance Between Indicator Points After 24 hours in Water (mm)	Distance Between Indicator Points After 3 hours Boiling (mm)
0	10	10.5
1	10	10.5
1.5	10	10
2	10	10.5

Table 4 shows the distance between the two indicator points after 24 hours in water and after boiling for 3 hours.

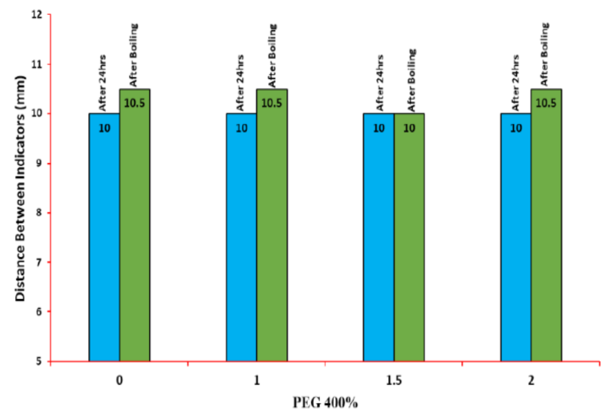

Figure 5: Soundness Values

Figure 5 represents the comparison of the distance between indicator points before boiling and after boiling. For reference mix and mixes with 1% and 2% of PEG 400, the expansion of the indicator points after the boiling was seen to be 0.5 mm. However, for the mix with 1.5% PEG 400, no expansion was observed. This indicates that all the pastes are adequately sound owing to the fact that expansion in all the cases was much less than 10 mm. No expansion in the case of paste with 1.5% PEG 400 reveals that the soundness gets enhanced at this dosage. There is no significant difference in expansion values of the four pastes indicating that PEG 400 does not influence the soundness of cement to a considerable extent. However, it can be said that the incorporation of 1.5% of Self-Curing polymer would contribute to better concrete durability in terms of keeping the soundness of OPC intact.

D. Compressive Strength

Table 4: Compressive Strength Values of OPC

PEG 400 (%)	Compressive Strength (N/mm^2)		
	3 Days	7 Days	28 Days
0	28.33	37.21	56.10
1	25.24	35.97	52.68
1.5	28.72	37.88	55.67
2	24.15	34.56	50.35

Table 4 shows the average compressive strength values of a set of 3 cubes for 3, 7, and 28 days of water curing and Self-Curing.

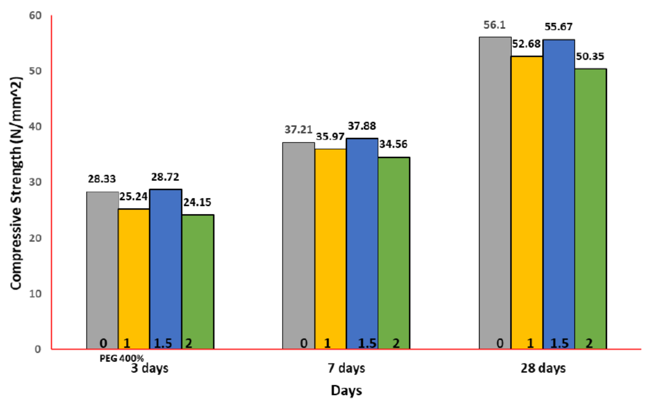

Figure 6: Compressive Strength Values of OPC

Figure 6 shows the comparison of compressive strength values of OPC after 3, 7, and 28 days of curing of cement-standard sand mortar cubes. At 3 days, the compressive strength of mortar cubes with 1.5% PEG 400 was the highest, followed by the reference cubes; with a slightly less value. The lowest compressive strength was exhibited by the mortar cubes having 2% PEG 400 dosage. An exactly similar trend was shown by the mortar cubes at 7 days as well. However, at 28 days, the compressive strength of reference cubes was maximum, followed by the cubes having a 1.5% dosage of PEG 400 with a marginally low value. The mortar cubes with 2% PEG 400 dosage exhibited the lowest value. This reveals the fact that among the Self-Curing cubes, the compressive strength increased with the increased dosage of PEG 400 up to 1.5% addition. The Self-Curing additive helps in retaining a sufficient amount of moisture inside the mortar cubes, thereby creating adequate curing conditions for the required strength gain. It acts as an effective polymer to reduce the evaporation from the cubes. The compressive strength values at 3 days and 7 days for 1.5% dosage of Self-Curing chemical, being marginally higher than that of reference cubes, reveal that the chemical is effective in the initial days. The mortar cubes with PEG 400 addition do not depend on attaining a high degree of hydration. They depend on the pore structure density to attain strength. The retention of moisture with a 1.5% dosage of PEG 400 seems to be adequate in order to achieve sufficient hydration without influencing the nature of hydration products. However, as the PEG 400 dosage was further increased to 2%, compressive strength showed a declining trend. The higher dosages may deteriorate the microstructure and may cause thinning of calcium hydroxide crystals leading to the decreased strength.

IX. CONCLUSIONS

From the experimental work carried out, the following conclusions were made.

- The addition of PEG 400 in OPC did not significantly affect the consistency of the paste. However, with increasing dosages of PEG 400, the amount of water needed to make a paste with standard consistency was marginally less.
- The IST and FST were prolonged with the increasing dosages of PEG 400.
- There was no considerable influence of the addition of PEG 400 on the soundness of cement paste. However, the soundness property exhibited at 1.5% PEG 400 was best among all the mixes.
- The compressive strength values of OPC obtained through the use of mortar cubes with the addition of 1.5% PEG 400 were observed to be on par with the results of water-cured specimens owing to the fact that PEG 400 proved itself to be an effective Self-Curing polymer.

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