

# **Development & Assessment on Strength Properties of Concrete by Using Self Curing Agents**

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**ABSTRACT:** Curing is the process by which the hydraulic cement concrete matures and develops the hardened properties over time as a result of continued hydration of the cement in the presence of sufficient water and heat. Curing in which prevents the loss of moisture from the concrete. There are different methods of curing like (water, steam, self-curing).we adopt the self curing for our project. If the evaporation of moisture from concrete are not prevented properly it may results in plastic shrinkage cracks. So curing is the important process to strengthen the concrete. Curing process is carried out by the self-curing agents.

In self – curing concrete mixed proportions of concrete is similar to normal conventional concrete but in addition to that we will add self-curing agents to the concrete while mixing. Cast the (cube) shaped moulds for determining the compressive strength for 7and 28 days. For determine the workability for the fresh concrete by using the slump cone test. In the present study, strength of concrete containing self- curing agents with various percentages to cement will be investigated and compared with those of conventionally cured concrete. Finally PEG-600 (2%), PEG-4000(0.5%, 1%) and PVA (0.5%) exhibited good results than the nominal concrete strength.

**KEYWORDS:** Self Curing Concrete, PEG-600, PEG-4000, PVA, Strength Properties.

## **I. INTRODUCTION**

Concrete is the second most used material in the world after water. Ordinary Portland cement (OPC) has been used traditionally as a binding material for preparation of concrete. The world-wide consumption of concrete is believed to rise exponentially primarily driven by the infrastructural development taking place in China and India. 1 tone of carbon dioxide is estimated to be released to the atmosphere when 1 ton of ordinary Portland cement is manufactured. Also the emission by cement manufacturing process contributes 7% to the global carbon dioxide emission. It is important to find an alternate binder which has less carbon footprint than cement.

The desired properties in concrete can be obtained by proper curing if concrete is in the initial stages. Curing is the name given to the procedures used for promoting the hydration of the cement, and consists of a control of temperature and of moisture movement from and into the concrete. Curing allows continuous hydration of cement and consequently continuous gain in the strength, once curing stops strength gain of the concrete also stops. Proper curing of concrete structures is important to meet performance and durability requirements. In conventional curing this is achieved by external curing applied after mixing, placing and finishing. But, curing is not possible in all occasions because of some barriers and negligence. Water is maximum utilised commodity and because of this the day-by-day

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Vol. 7, Issue 5, May 2018

level of the water table is going down. If water has to be purchased for construction works, the cost of construction rises much higher. Also in case of concreting works done at heights, vertical members, sloped roofs and pavements, continuous curing is very difficult. Where the thickness of concreting is large, the percolation of water in the concrete is difficult, especially in the case of high strength concrete.

Self-curing or internal curing is a technique that can be used to provide additional moisture in concrete for more effective hydration of cement and reduced self-desiccation. When concrete is exposed to the environment evaporation of water takes place and loss of moisture will reduce the initial water cement ratio which will result in the incomplete hydration of the cement and hence lowering the quality of the concrete. Various factors such as wind velocity, relative humidity, atmospheric temperature, water cement ratio of the mix and type of the cement used in the mix affects the hydration process. Evaporation in the initial stage leads to plastic shrinkage cracking and at the final stage of setting it leads to drying shrinkage cracking. Curing temperature is one of the major factors that affect the strength development rate. At elevated temperature ordinary concrete losses its strength due to the formation of the cracks between two thermally incompatible ingredients, i.e., cement paste and aggregates. Self-curing agents mainly help in the retention of water in concrete by reducing evaporation during the hydration of concrete. When compared to conventional concrete self-cured concrete holds water from evaporation.

Water soluble alcohols such as Poly Ethylene Glycol (PEG), Poly Vinyl Alcohol (PVA) can be used as self curing agents in self-curing concrete. Super Absorbent Polymer is also one of the self curing agents. Most SAPs are cross linked polyelectrolyte. They absorb large quantity of water without dissolving because of their ionic nature and interconnected structure. Self curing admixtures play a vital role in today's condition where water is becoming an important asset which cannot be wasted for curing. Curing is done mainly to retain the moisture in concrete, by preventing evaporation from the concrete during the period in which it is attaining strength. Curing can be done in many other ways and the best way will be dictated at site based on conditions at site.

## II. LITERATURE REVIEW

[1] Studied the concept of several self-curing agents to reduce water evaporation from concrete. And hence increase the water retention capacity of concrete compared to conventional concrete. It was found that water soluble polymers can be used as self-curing agents in concrete. Concrete incorporating self-curing agents will represent a new trend in concrete construction in the new millennium. [2] Stated that the use of self-curing agent (Ch.) in concrete effectively improves the physical properties compared with conventional concrete. Higher cement content and/or lower water-cement ratio leads to more effective results of self-curing agents in concrete. Incorporation of silica fume into concrete mixtures enhances all physical properties.

[3] In his study, some chemical curing materials recently used in concrete production, to provide and facilitate the curing conditions of concrete, were investigated experimentally, in terms of their effects on the compressive strength values of the concrete specimens produced with more than one chemical admixture. Those results were compared with those of the specimens produced under the same conditions, but cured with water in order to determine which curing materials gave which sort of results for which kinds of concrete. And concluded that each chemical curing material used in this study presented various results, differing from each other, for concrete specimens produced with no admixture and different chemical admixtures. While curing material increases the strength of concrete produced with any type of admixture, it can reduce the strength of concrete produced with another type of chemical admixture. [4] Studied the process involves in the use of shrinkage reducing admixtures like POLYETHYLENE GLYCOL (PEG 400) as internal curing compound. This curing compound used in concrete which helps in self curing and helps in better hydration and hence good compressive strength. They trap the moisture within the structure and prevent it from evaporation which normally occurs due to the hydration process. In the present study, the affect of curing compound on workability (slump and compaction factor) and compressive strength is studied. The percentage of PEG by weight of cement from 0% to 2% as the dosage of internal curing compound was fixed. The test results were studied both for M25 and M40 mixes. It is found through this experiment study that PEG 400 help in self curing by giving strength on par with that of the conventional curing method and also improved workability.

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(A High Impact Factor, Monthly, Peer Reviewed Journal)

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Vol. 7, Issue 5, May 2018

Self curing will increase water retention capacity as compared to the conventional concrete. Proper self curing (or) internal curing increases the strength, durability and performance of concrete. Super absorbing Polymer (SAP) used as internal curing agent. [5] In this study 0.2% to 0.4% of SAP was varied in different grade of high strength concrete. In the experiment replacement of cement by silica fumes with 5%, 10% and 15% are studied. It is found that replacement of silica fumes by 10 % gives more strength and durability when compared to others.

[6] Curing is the process of maintaining the proper moisture content to promote optimum cement hydration immediately after placement and to attain desirable strength and other properties. They reported an experimental study carried out to investigate the usage of sodium lignosulphonate as self curing agent. In this particular study compressive strength and split tensile strength of self-curing concrete with varying percentages (0.5%,1%,1.5%,2%,2.5%,3%) for 7,14,28 days are analyzed, tested and compared with conventional concrete of similar mix design. Compressive and split tensile test results shows that the optimum strength of self-curing concrete attain at 0.5% mixture of sodium lignosulphonate when compared to conventional concrete. The experimental study shows that the use of water soluble sodium lignosulphonate is possible as a self curing agent. It reduces placing problems in hot weather concreting by improving workability and workability retention and allows workability to be increased without adding extra water. [7] studied involves the use of shrinkage reducing admixture polyethylene glycol (PEG 400) in concrete which helps in self curing and helps in better hydration and hence strength. In the present study, the affect of admixture (PEG 400) on compressive strength, split tensile strength and modulus of rupture by varying the percentage of PEG by weight of cement from 0% to 2% were studied both for M20 and M40 mixes. It was found that PEG 400 could help in self curing by giving strength on par with conventional curing. It was also found that 1% of PEG 400 by weight of cement was optimum for M20, while 0.5 % was optimum for M40 grade concretes for achieving maximum strength without compromising workability.

### III. MATERIALS

#### Cement:-

In this work ULTRATECH cement of 53 grade was used for all concrete mixes. The cement was of uniform colour i.e., grey with a light greenish shade and was free from any hard lumps. The various tests conducted on cement are initial and final setting time, specific gravity, fineness and compressive strength etc. Testing of cement was done as per IS:12269-1987. Various tests results conducted on the cement are reported in Table 1.

**Table 1: Physical properties of cement**

S.No	Properties	Values obtained	Standard value as per IS code 12269 -1987
1	Normal consistency	35%	-
2	Initial setting time	48 min	Not be less than 30 min
3	Final setting time	240min	Not be greater than 600 min
4	Fineness (%)	4%	Not be greater than 10
5	Specific gravity	3.1	3.1-3.15

#### Fine aggregate:-

The sand used for the experimental program was locally procured and conformed to grading zone II as per IS: 383-1970. The sand was first sieved through 4.75 mm sieve to remove any particles greater than 4.75 mm and then was washed to remove the dust. Physical properties and sieve analysis results of fine aggregates are listed in Table 2 respectively.

#### Coarse aggregate:-

Locally available coarse aggregates having the maximum size of 20 mm were used in the present work. Testing on coarse aggregates was done as per IS: 383-1970. They were then washed to remove dust and dirt and were dried to surface dry condition. The results of various tests conducted on coarse aggregate are given in Table 2 respectively.

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Vol. 7, Issue 5, May 2018

## Poly Ethylene Glycol 600, Poly Ethylene Glycol 4000, and Poly Vinyl Alcohol:-

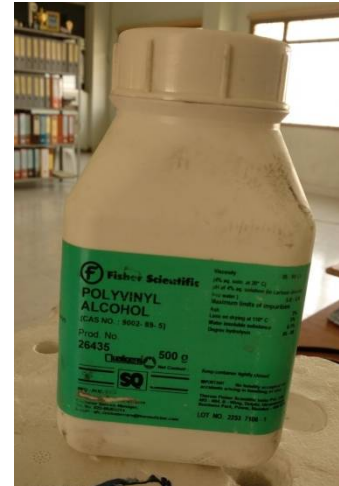
Poly Ethylene Glycol 600, PEG 4000, PVA obtained from Molychem-Manufactures and importers of laboratory reagents and fine chemicals, Mumbai are used in the present work. The physical Properties of the self curing agent PEG 600, PEG 4000, PVE are shown in Table 3. Image of the PEG 4000 is shown in Fig 1.

**Table 2: Physical properties of fine & coarse aggregate**

S.No	Properties	Fine Aggregate	Coarse Aggregate
1	Type	Crushed	Uncrushed(natural)
2	Maximum size	20 mm	4.75mm
3	Specific gravity	2.85	2.66
4	Fineness modulus	6.28	3.10

**Table 3: Physical properties of PEG 600, PEG 4000, PVA**

Properties	PEG 600	, PEG 4000	PVA
Appearance	Liquid	White Flake	White Crystalline
Specific Gravity	1.04-1.06	1.08-1.09	1.19-1.31
Molecular weight	600	4000	0.42-0.48
Hydroxyl Value	178-197	25-35	85-89
PH Value	5-7	5-7	5-8
Viscosity	11-13 cs	11-13 cs	35-50 cs



**Figure1:- PEG 600, PEG 4000, PVA**

## IV. EXPERIMENTAL PROGRAMME

### Aim of experimental programme:-

The experiment investigation has been carried out with reference to mix M20 grade concrete. 13 concrete mixes were prepared. Reference mix was prepared for M20 grade of concrete as per IS: 10262-2009. Three self curing agents such as Poly Ethylene Glycol 600 (PEG 600), Poly Ethylene Glycol 4000 (PEG 4000), Poly Vinyl Alcohol (PVA) were used in this project. Four concrete mixes were prepared, where PEG 600 was added with 0.5%, 1.0%, 1.5%, and 2.0% by

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Vol. 7, Issue 5, May 2018

weight of the cement. Four concrete mixes were prepared, where PEG 4000 was added with 0.5%, 1.0%, 1.5%, and 2.0% by weight of the cement and also where PVA was added with 0.25%, 0.5%, 0.75%, and 1.0% by weight of the cement.

### Mix design of concrete:-

Mix design can be defined as the process of selecting suitable ingredients of concrete such as cement, aggregates, water and determining their relative proportions with the object of producing concrete of required minimum strength, workability and durability as economically as possible. The mix designation of all the mixes are given in table 4 and Proportion of ingredients of all mixes was shown in table 5.

Table 4: Mix Designation

M20 Grade of concrete	
Mix Designation	Proportions (addition to cement)
M1	0%
M2	0.5% PEG 600
M3	1.0% PEG 600
M4	1.5% PEG 600
M5	2.0% PEG 600
M6	0.5% PEG 4000
M7	1.0% PEG 4000
M8	1.5% PEG 4000
M9	2.0% PEG 4000
M10	0.5% PVA
M11	1% PVA
M12	1.5% PVA
M13	2% PVA

Table 5: Various proportions of different concrete mixes in kg/m<sup>3</sup>

Mix	Cement	F.A	C.A	Water	PEG600 (%)	PEG4000 (%)	PVA (%)
M1	350.94	756	1195	186	0	0	0
M2	350.94	756	1195	186	0.5	0	0
M3	350.94	756	1195	186	1	0	0
M4	350.94	756	1195	186	1.5	0	0
M5	350.94	756	1195	186	2	0	0
M6	350.94	756	1195	186	0	0.5	0
M7	350.94	756	1195	186	0	1	0
M8	350.94	756	1195	186	0	1.5	0
M9	350.94	756	1195	186	0	2	0
M10	350.94	756	1195	186	0	0	0.5
M11	350.94	756	1195	186	0	0	1
M12	350.94	756	1195	186	0	0	1.5
M13	350.94	756	1195	186	0	0	2

### Batching, Mixing, Casting and Curing of Specimens:-

Concrete cubical moulds of size 150mm×150mm×150mm were cast for the determination of compressive strength of concrete. Care was taken during casting and table vibrator was used for proper compaction. All the specimens were prepared in accordance with Indian standard specification IS: 516-1959.

All the moulds were cleaned and oiled properly. These were securely tightened to correct dimensions before casting. Care was taken that there is no gaps left from where there is any possibility of leakage of slurry. A careful



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Vol. 7, Issue 5, May 2018

procedure was adopted in the batching, mixing and casting operations. The mixing of concrete was done by using pan mixture. OPC having 53 grades was used in casting. Fine aggregates are thoroughly mixed in mixer. After that coarse aggregates are added to it. Before adding of water the chemical admixtures were added to water and this water was added carefully so that no water was lost during mixing. All the specimens were kept on the even surface and the freshly mixed concrete was poured in to the moulds in three layers each layer being compacted thoroughly with a tamping rod to minimize voids. Extra concrete should be cleaned effectively. Finally all the specimens were vibrated on vibrating table. The specimens were allowed to remain in the steel mould for the first 24 hours at ambient condition. After 24 hrs the specimens were demoulded and were kept in ambient temperature for self curing.

After casting the specimens were put for curing. Here the curing methodology is purely different that to curing of OPC concrete. After casting the specimens with mould kept for curing in ambient temperature shown in figure 2. The compressive strength was performed on 7th day from casting. And another set of specimens were kept for ambient curing, test performed on 28<sup>th</sup> day.



Fig 2: Specimens kept for curing in ambient temperature.

### V. RESULTS & DISCUSSION

In this section, Compressive strength, of various concrete mixes using various curing compounds are discussed. All the tests conducted were in accordance with the methods described in sections three. Results were analysed with respect to slump cone test for fresh concrete and compressive strengths for hardened concrete.

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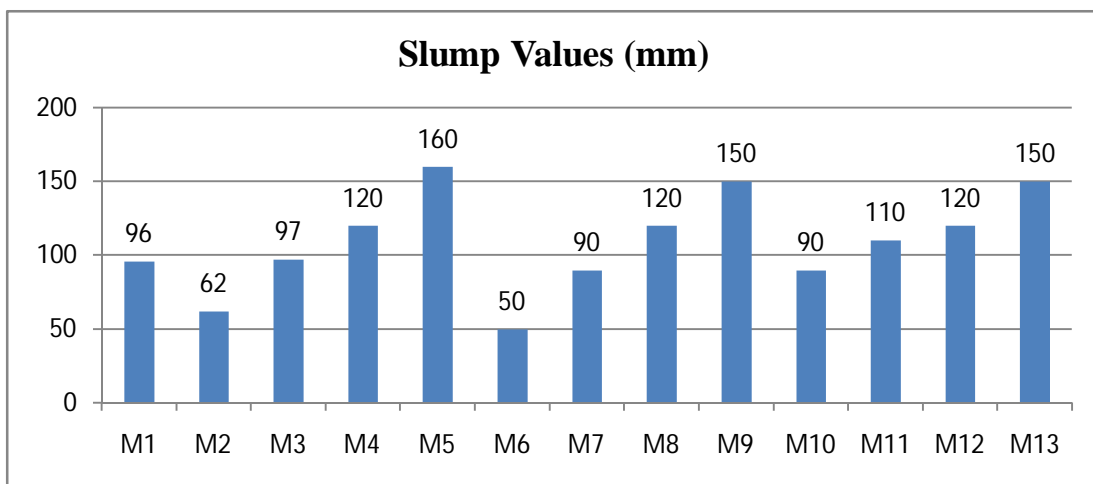
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Vol. 7, Issue 5, May 2018

### Tests on fresh concrete:-

#### Slump cone test:-

The slump cone test is the most simple workability test for concrete, involves low cost and provides immediate results. For all the various mixes, by the usage of the different curing compounds the slump cone height may vary due to the viscosity of that curing compound. The slump values are shown in table 6 and figure 3.



**Figure 3:-** Slump Cone Values

**Table 6:** Slump values for various mixes

Mix Designation	Slump Value (mm)
M1	96
M2	62
M3	97
M4	120
M5	160
M6	50
M7	90
M8	120
M9	150
M10	90
M11	110
M12	120
M13	150

### Tests on hardened concrete:-

#### Compressive Strength Test:-

The Compressive strength is one of the most important properties of hardened concrete and is considered as the characteristic material value for the classification of concrete. In the present study, three concrete specimens of

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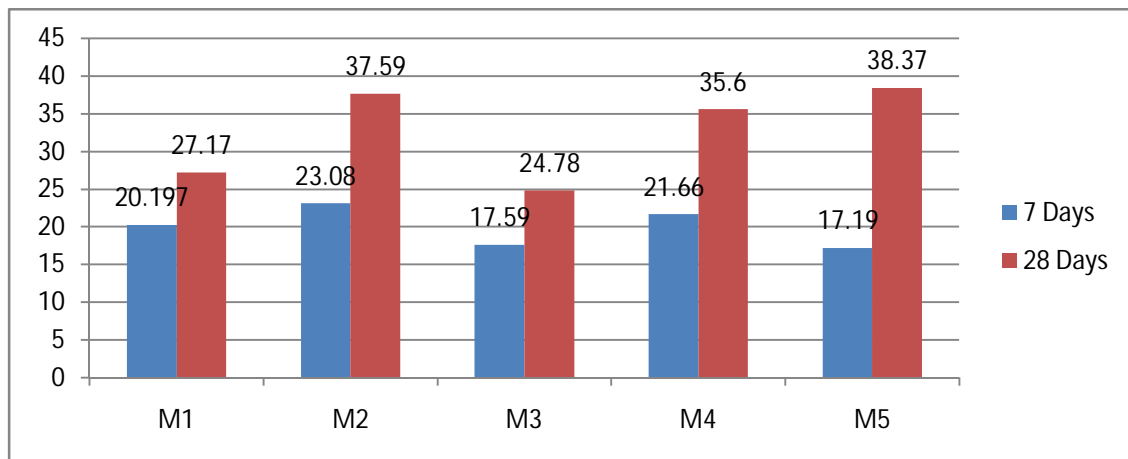
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Vol. 7, Issue 5, May 2018

15cm x 15cm x 15cm were used to determine the compressive strength. Two sets of three specimens were casted in each mix for each curing compound. Totally 78 specimens were casted and tested for strength. One set of specimens are evaluated for 7 days strength and another set of specimens are evaluated for 28 days strength. The compressive strength of specimens casted uses the curing compound PEG 600 values for 7 and 28 days shown in table 7 and graph shown in figure 4. The compressive strength of specimens casted using the curing compound PEG 4000 values for 7 and 28 days shown in table 8 and graph shown in figure 5. The compressive strength of specimens casted by using the curing compound PVA values for 7 and 28 days shown in table 9 and graph shown in figure 6.

**Table 7:** The compressive strength of specimens casted using the curing compound PEG 600 values for 7 and 28 days

Mix Designation (PEG 600)	7 DAYS	28 DAYS
M1 (PEG 600 0%)	20.197	27.17
M2 (PEG 600 0.5%)	23.08	37.59
M3 (PEG 600 1%)	17.59	24.78
M4 (PEG 600 1.5%)	21.66	35.6
M5 (PEG 600 2%)	17.19	38.37



**Fig 4:** The compressive strength of specimens casted is using the curing compound PEG 600 graph for 7 and 28 days.

For PEG 600, it was observed that the increase in compressive strength was observed gradually increases up to 1.5% to 2% of PEG 600 and then decreased. The maximum compressive strength was obtained 35.6 N/mm<sup>2</sup> at 1.5% and 38.37 N/mm<sup>2</sup> at 2% of PEG 600.



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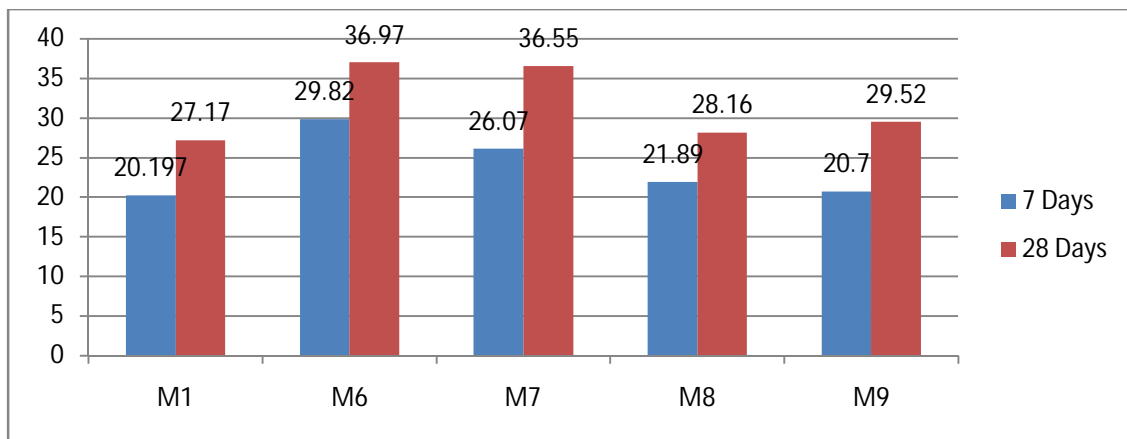
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Vol. 7, Issue 5, May 2018

**Table 8:** The compressive strength of specimens casted using the curing compound PEG 4000 values for 7 and 28 days

Mix Designation (PEG 4000)	7 DAYS	28 DAYS
M1 (PEG 4000 0%)	20.197	27.17
M6 (PEG 4000 0.5%)	29.82	36.97
M7 (PEG 4000 1%)	26.07	36.55
M8 (PEG 4000 1.5%)	21.89	28.16
M9 (PEG 4000 2%)	20.7	29.52



**Fig 5:** The compressive strength of specimens casted is using the curing compound PEG 4000 graph for 7 and 28 days.

For PEG 4000, it was observed that the increase in compressive strength was observed gradually increases up to 0.5% & 1% of PEG 4000 and then decreased. The maximum compressive strength was obtained 36.97 N/mm<sup>2</sup> at 0.5% and 36.55 N/mm<sup>2</sup> at 1% of PEG 4000.

**Table 9:** The compressive strength of specimens casted using the curing compound PVA values for 7 and 28 days

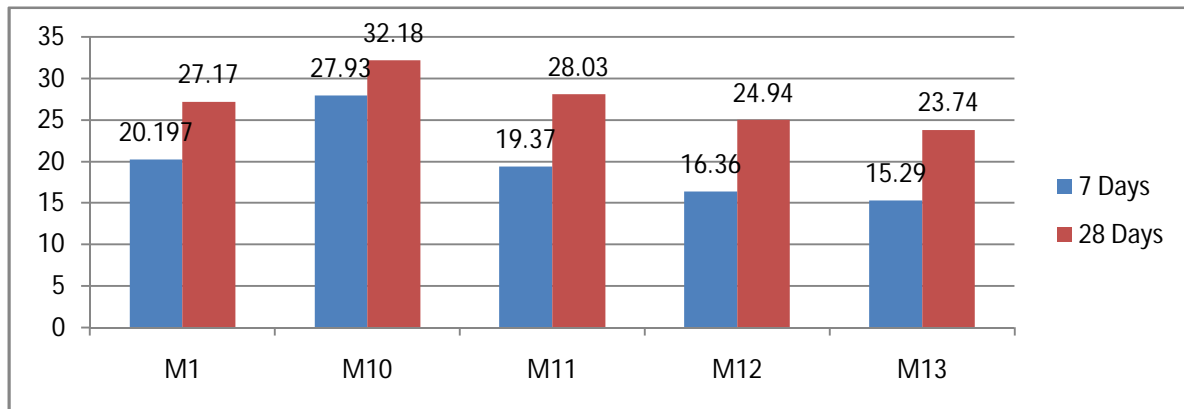
Mix Designation (PVA)	7 DAYS	28 DAYS
M1 (PVA 0%)	20.197	27.17
M10 (PVA 0.5%)	27.93	32.18
M11 (PVA 1%)	19.37	28.03
M12 (PVA 1.5%)	16.36	24.94
M13 (PVA 2%)	15.29	23.74

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Vol. 7, Issue 5, May 2018



**Fig 6:** The compressive strength of specimens casted using the curing compound PVA graph for 7 and 28 days

For PVA, it was observed that the increase in compressive strength was observed gradually increases up to 0.5% of PVA and then decreased. The maximum compressive strength was obtained 32.18 N/mm<sup>2</sup> at 0.5% and 36.55 N/mm<sup>2</sup> of PVA.

### VI. CONCLUSION

In the present study, the following are the conclusions regarding the fresh and hardened properties of concrete specimens using various self curing agents,

- The usage of water for curing of concrete specimens are reduced by using self curing agents
- As percentage of self curing agents is increased in concrete, its workability also increases.
- For PEG 600, it was observed that the increase in compressive strength was observed gradually increases up to 2% of PEG 600. The maximum compressive strength was obtained 38.37 N/mm<sup>2</sup> at 2% of PEG 4000.
- For PEG 4000, it was observed that the increase in compressive strength was observed gradually increases up to 1% & 1.5% of PEG 4000 and then decreased. The maximum compressive strength was obtained 36.97 N/mm<sup>2</sup> at 1% and 36.55 N/mm<sup>2</sup> at 1.5% of PEG 4000.
- For PVA, it was observed that the increase in compressive strength was observed gradually increases up to 0.5% of PVA and then decreased. The maximum compressive strength was obtained 32.18 N/mm<sup>2</sup> at 0.5% and 36.55 N/mm<sup>2</sup> of PVA.

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**Vol. 7, Issue 5, May 2018**

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