"A STUDY ON PROPERTIES OF SELF-CURING CONCRETE USING POLYETHYLENE GLYCOL-400"

Dr. U. B. Choubey[1], Gajendra Raghuvanshi[2]

[1]*Professor, Dept. of Civil Engineering, SGSITS, Indore*
[2]*PG Scholar, Dept. of Civil Engineering, SGSITS, Indore*

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Abstract: *As water is becoming a scarce material day-by-day, there is an urgent need to do research work pertaining to saving of water in making concrete and in constructions. Curing of concrete is maintaining satisfactory moisture content in concrete during its early stages in order to develop the desired properties. Curing of concrete plays a major role in developing the concrete microstructure and pore structure and hence improves its durability and performance. The use of self-curing admixtures is very important from the point of view that saving of water is a necessity everyday (each 1m^3 of concrete requires 3m^3 of water in a construction, most of which is used for curing). Keeping importance to this, an attempt has been made to develop self-curing concrete by using water-soluble Polyethylene Glycol as self-curing agent. The function of self-curing agent is to reduce the water evaporation from concrete, and hence they increase the water retention capacity of concrete compared to the conventionally cured concrete.*

The present investigation involves the use of self-curing agent viz., polyethylene glycol (PEG) of molecular weight 400 (PEG-400) for dosages of 0%, 0.5%,1% and 2% by weight of cement added to mixing water in the concrete. Comparative studies were carried out for compressive strength for conventional and self-cured concrete mixture of M20, M30 and M40 grades at standard ages (7, 14 and 28 days). It was also found that 1% dosage of PEG-400 by weight of cement was optimum for M20, and M30 grade of concrete while 0.5 %dosage of PEG-400 was optimum for M40 grade concrete for achieving maximum strength without compromising workability.

Keywords: **Self-curing concrete, Self-curing agent, Polyethylene Glycol (PEG-400), Water retention, Compressive strength, Workability, Saving of water.**

1.INTRODUCTION

For the few decades, Concrete has been the most versatile material used in the construction industry. It is the second most consumed material in the world due to its high compressive strength and durability. Conventional concrete, which is the mixture of cement, fine aggregate, coarse aggregate and water needs curing to achieve required strength. When cement is added to water, hydration reaction takes place and this hydration process is necessary for hardening of concrete. Curing is the process to avoid moisture content deficiency from concrete during the hydration process. Effect from curing has a strong influence on the properties of hardened concrete such as it will increase the durability, strength, volume stability, abrasion resistance, impermeability and resistance to freezing and thawing. If water is not provided then shrinkage of concrete takes place which results in cracking. Furthermore, unexpected shrinkage and temperature cracks can reduce the strength, durability, and serviceability of the concrete.

Practically good curing of concrete is not achievable in many cases due to unavailability of suitable quality of water and many other practical difficulties. During the last two decades, concrete technology has been undergoing rapid Improvements. With conventional ingredients it is possible to design reasonably good fast track concrete mixture using admixtures. Internally cured concrete can be achieved by adding Self Curing Agents. Water soluble polyethers are generally used as self-curing agents. The goal of internal curing is to provide water in the proper amount with a proper spatial distribution so that the entire three-dimensional microstructure of hydrating cementitious paste remains saturated and autogenous stress free.

1.1Materials and Their Properties

Following are the materials required:

1) Cement (OPC 43 grade)
2) Fine Aggregate (Sand): Fine Aggregates used was obtained from a nearby source. The fine aggregate confirming to zone 3 according to IS: 383-1970.

Table -1: Physical Properties of Fine Aggregate

Physical Properties	Observed Values
Specific Gravity	2.64
Bulk Density (Loose), Kg/m^3	1585
Bulk Density (Compacted),Kg/m^3	1610

3) Natural Coarse Aggregate: Crushed stone was used as Coarse Aggregate confirming to IS: 383-1970. Maximum coarse aggregate size used is 20mm.

Table -2: Physical Properties of Coarse Aggregate

Physical Properties	Observed Values
Specific Gravity	2.81
Bulk Density (Loose), Kg/m^3	1435
Bulk Density (Compacted),Kg/m^3	1620

4) PEG-400: Polyethylene Glycol (PEG), also known as Poly-oxy-ethylene (POE) or Polyethylene Oxide (PEO), is a condensation polymer of ethylene oxide and water having a general formula H-(OCH2CH2)n-OH, where n is the average number of repeating oxy ethylene groups typically ranging from 4 to 180 approx. The abbreviation (PEG) is defined in combination with a numeric suffix which indicates the average molecular weights. One common feature of PEG appears to be the water-soluble substance. PEG is non-toxic, odourless, lubricating, neutral, non-volatile and non-irritating and is used in a variety of Pharmaceutical works.
5) Admixture: In this experimental study a super plasticizer of BASF chemical company has been used to increase the strength of M40 grade of concrete by reducing water-cement ratio.
6) Water: Water used was fresh, colourless, odourless, and tasteless potable water that was free from organic matter of any type.

1.2 Scope of the work

The scope of the work or research is to study the mechanical characteristics of concrete such as compressive strength, by varying the dosages of 0.5%, 1.0% and 2% of PEG-400 by weight of cement for M20, M30 and M40 grade of concrete.

1.3 Objective of study

The objective is to study the mechanical characteristic of concrete i.e. compressive strength by varying the percentage of PEG-400 from 0% to 2% by weight of cement for M20, M30 and M40 grade of concrete assumes greater importance to learn usefulness of PEG-400 in the early and later strength gain of concrete mixtures typically for draught prone areas.

2. RESEARCH METHODOLOGY

The systematic approach to study the gaps identified in the literature survey will be followed. Step by step methodology of the proposed work is as follows.

a) Design of Concrete Mix as per IS: 10262-2009
b) Addition of different percentages dosages of Chemical PEG-400
c) Casting of Concrete Cubes
d) Testing the Cube specimens

2.1 Details of Test Specimens:

Cubes of size 150x150x150 mm will be used and total 108 cube specimens will be prepared with and without Polyethylene glycol (PEG-400). Total twenty-seven (27) number of cube specimens will be prepared for concrete mixes of M20, M30 and M40 grades without using PEG-400. Total eighty-one (81) number of cube specimens will be prepared for concrete mixes of grades M20, M30 and M40 using PEG-400.

3. CONCRETE MIX DESIGN

In this study concrete of grades M20, M30 and M40 has been prepared as per design mix IS 10262:2009 which are as shown in table-3.

Table -3: Mix Proportion of M20, M30, M40

Grade of Concrete	Unit of Batch	Water (Liters)	Cement (Kg)	F.A. (Kg)	C.A. (Kg)
M20	Content	186	372	580	1283
	Ratio	0.50	1	1.56	3.45
M30	Content	186	413.33	586.17	1238.50
	Ratio	0.45	1	1.42	3.0
M40	Content	153	425	612	1293.2
	Ratio	0.36	1	1.44	3.04

4. RESULTS & DISCUSSION

4.1 Workability Test

4.1.1 Slump and compaction factor test

As the % of PEG-400 is increased the slump and compaction factor is found to be increased. But, the rate of

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increase of slump and compaction factor for M40, M30 concrete is less than that of M20 concrete. The results of the cube specimens are as shown in table 4, figure1 and figure 2.

Table-4: Slump cone and Compaction factor test results

PEG 400(%)	Slump (mm)			Compaction factor		
	M20	M30	M40	M20	M30	M40
0	65	50	40	0.87	0.84	0.83
0.5	90	70	60	0.90	0.86	0.85
1.0	110	90	85	0.93	0.89	0.88
2.0	160	140	135	0.96	0.92	0.90

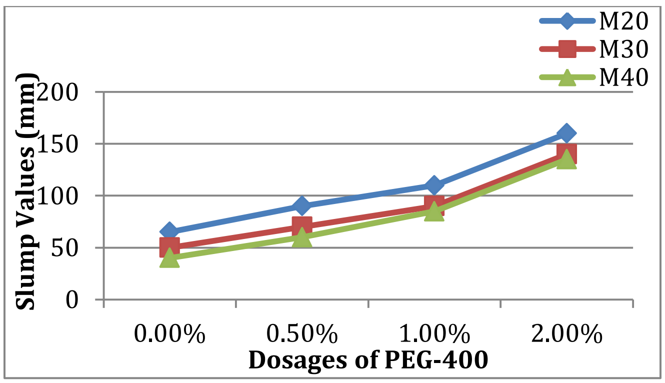


Fig- 1: Slump Cone Test Results

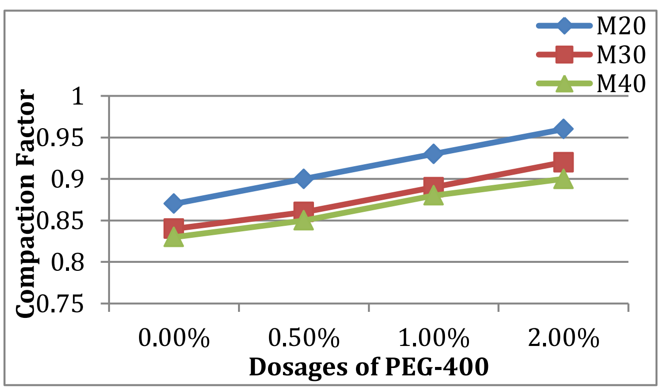


Fig-2: Compaction factor Test Results

4.2 Non Destructive Testing

Rebound Hammer Test and Ultrasonic Pulse Velocity Test: In order to evaluate the compressive strength of concrete, 3 cube specimens provided were analyzed for each grade and each dosage of PEG- 400 by the rebound hammer and the ultrasonic pulse velocity test apparatus at 28 days of casting of cubes in the laboratory. The results for specimens are shown in table 5, figure 3 and figure 4.

Table-5: Rebound hammer and ultrasonic pulse velocity test results

PEG 400 (%)	Rebound Hammer Values (N/mm²)			Ultrasonic Pulse Velocity Values (m/seconds)		
	M20	M30	M40	M20	M30	M40
0.0	26.94	38.31	48.13	4139	4351	4387
0.5	27.06	38.50	48.79	4293	4412	4564
1.0	28.86	38.61	48.35	4363	4460	4515
2.0	27.50	38.15	47.74	4290	4446	4454

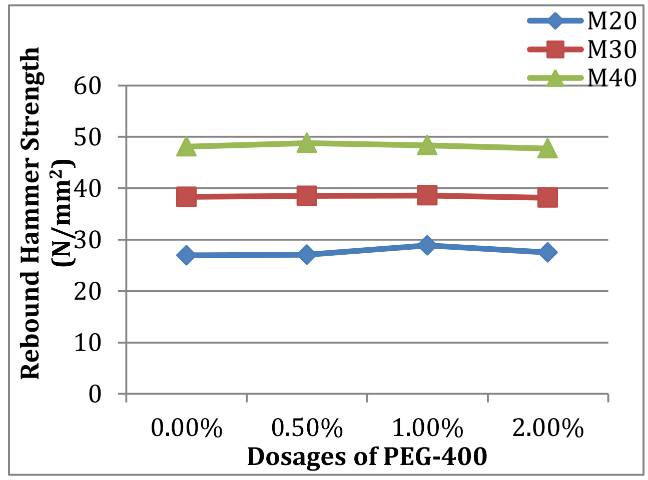


Fig-3: Rebound hammer test results at 28 days

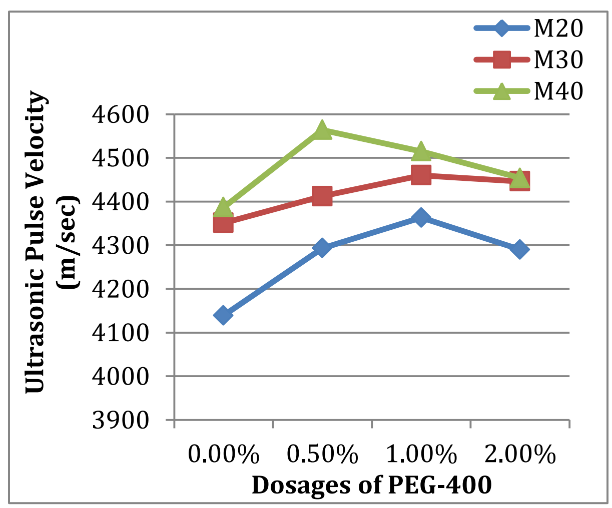


Fig-4: Ultrasonic pulse velocity test results at 28 days

4.3 Destructive Testing

Compressive Strength:

Table-6: Compressive Strength of M20 Grade of Concrete

Mix	Percentage of PEG-400 by weight of cement	Compressive Strength (N/mm^2)		
		7 days	14 days	28 days
M20	0.0	16.86	20.97	26.84
	0.5	18.31	22..12	28.39
	1.0	19.56	23.42	29.26
	2.0	17.08	21.73	27.19

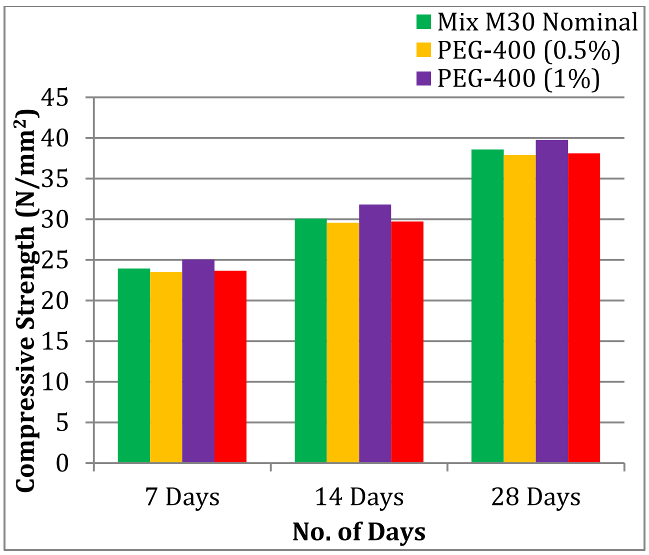


Fig-5: Bar chart of compressive strength of M20 concrete

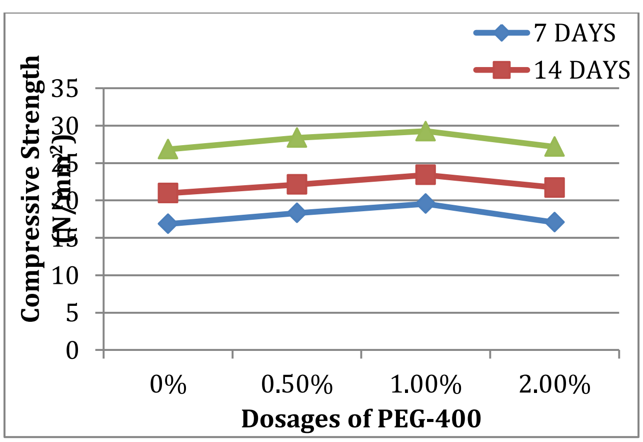


Fig-6: Line chart of compressive strength of M20 concrete

Table-7: Compressive Strength of M30 Grade of Concrete

Mix	Percentage of PEG-400 by weight of cement	Compressive Strength (N/mm^2)		
		7 days	14 days	28 days
M30	0.0	23.92	30.08	38.57
	0.5	23.51	29.57	37.92
	1.0	25.04	31.81	39.76
	2.0	23.63	29.72	38.11

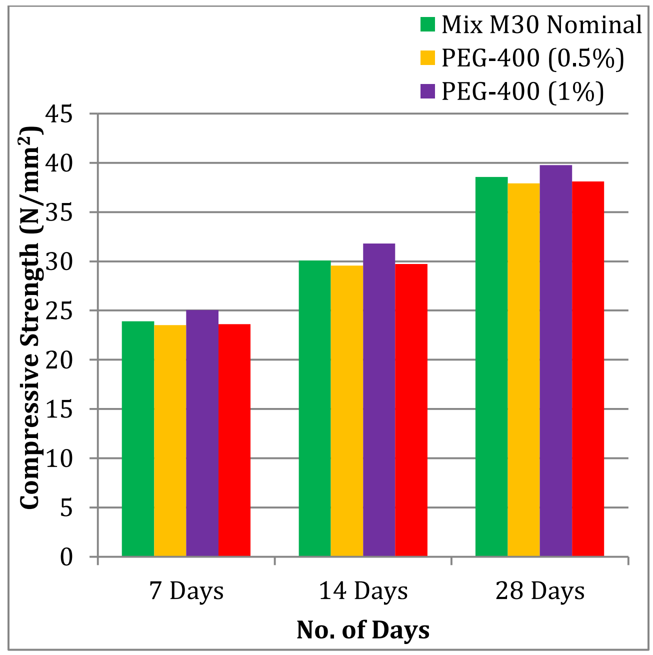


Fig-7: Bar chart of compressive strength of M30 concrete

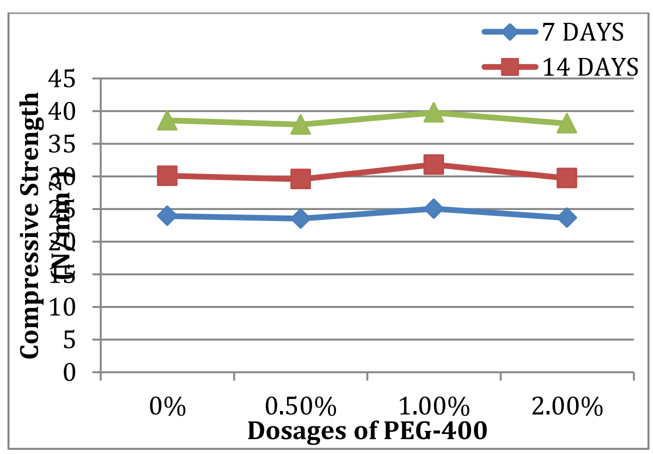


Fig-8: Line chart of compressive strength of M30 concrete

Table-8: Compressive Strength of M40 Grade of Concrete

Mix	Percentage of PEG-400 by weight of cement	Compressive Strength (N/mm²)		
		7 days	14 days	28 days
M40	0.0	29.41	36.53	46.83
	0.5	30.52	38.15	47.69
	1.0	29.79	36.24	46.32
	2.0	29.64	35.65	45.13

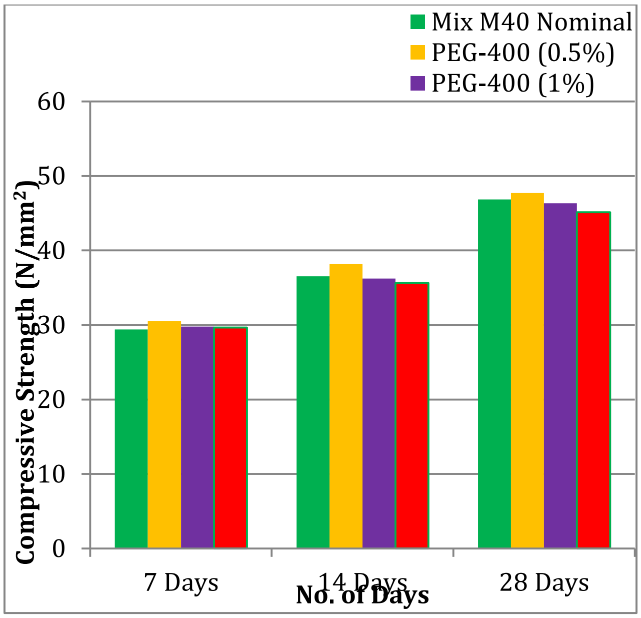
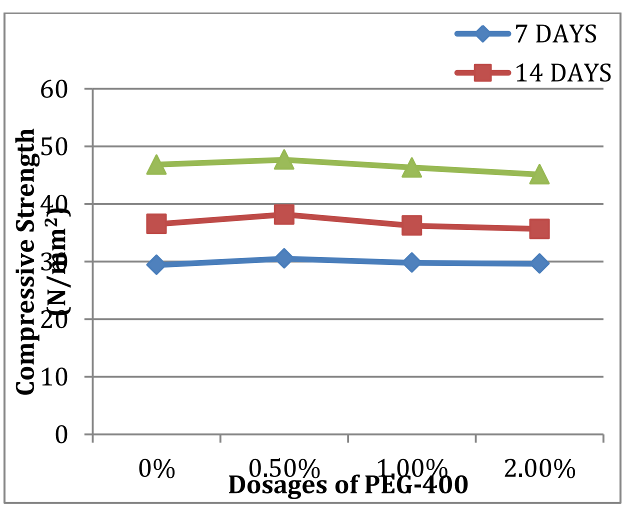


Fig-9: Bar chart of compressive strength of M40 concrete

Fig-10: Line chart of compressive strength of M40 concrete



4.4 Rate Analysis & Cost Comparison

The attempt was made to find out the rates and comparison of cost between the conventional concrete and internal curing concrete having different percentages dosages of PEG-400 including the cost of water required for curing and an labor that is needed in case of conventional concrete as shown in table 8,9,10 and 11 respectively.

Table-9: Cost of Conventional Concrete

Grade	Requirements	Quantity (m³)	Analysis (Rs.)	Amount (Rs.)
M20	Concrete	0.0915	7454	682
	Water	0.2745	160	44
	Labour	8hrs/day	400*7	2800
				TOTAL=3526
M30	Concrete	0.0915	7640	699
	Water	0.2745	160	44
	Labour	8hrs/day	400*7	2800
				TOTAL=3543
M40	Concrete	0.0915	7867	720
	Water	0.2745	160	44
	Labour	8hrs/day	400*7	2800
				TOTAL=3564

Table-10: Cost of Internal Cured Concrete 0.5% PEG-400

Grade	Requirements	Quantity (m³)	Analysis (Rs.)	Amount (Rs.)
M20	Concrete	0.0915	7454	682
	PEG-400	0.397	1148	456
				TOTAL=1138
M30	Concrete	0.0915	7640	699
	PEG-400	0.397	1148	456
				TOTAL=1155
M40	Concrete	0.0915	7867	720
	PEG-400	0.397	1148	456
				TOTAL=1176

Table-11: Cost of Internal Cured Concrete 1% PEG-400

Grade	Requirements	Quantity (m^3)	Analysis (Rs.)	Amount (Rs.)
M20	Concrete	0.0915	7454	682
	PEG-400	0.441	1148	507
				TOTAL=1189
M30	Concrete	0.0915	7640	699
	PEG-400	0.441	1148	507
				TOTAL=1206
M40	Concrete	0.0915	7867	720
	PEG-400	0.441	1148	507
				TOTAL=1227

Table-12: Cost of Internal Cured Concrete 2% PEG-400

Grade	Requirements	Quantity (m^3)	Analysis (Rs.)	Amount (Rs.)
M20	Concrete	0.0915	7454	682
	PEG-400	0.453	1148	521
				TOTAL=1203
M30	Concrete	0.0915	7640	699
	PEG-400	0.453	1148	521
				TOTAL=1220
M40	Concrete	0.0915	7867	720
	PEG-400	0.453	1148	521
				TOTAL=1241

5 CONCLUSIONS

On the basis of the results obtained from the present study, following conclusions can be drawn:

1) PEG-400 was found to be effective as a self-curing agent. It was found that every grade of concrete has one optimum percentage of dosage which it requires to give the maximum strength. It was found that the optimum dosage of PEG-400 for M20 was 1%, for M30 it was 1% and for M40 it was 0.5%.

2) Compressive strength of concrete with an optimum dosage of PEG-400 gives higher compressive strength as compared to conventionally cured concrete. By the use of PEG-400 it is observed that the workability of concrete also increases and concrete becomes flow able.

3) It is concluded that use of PEG-400 is a better option to form an internally cured concrete which does not compromise with its strength. 100% curing water can be saved as there is no need of curing process required for internally cured concrete.

4) The cost of internally cured concrete is less as compared to conventional concrete.

5.1 Future Scope of Internally Cured Concrete with PEG-400:

It can become a new practice in construction field of replacing conventional concrete with internally cured concrete to skip curing process. It can be used for normal as well as high strength concrete. More of research can be done such as self-compacted internally cured concrete. Research on internally cured concrete in hot and cold weather condition can be done. Many other properties of concrete can also be studied such as chemical and physical properties.

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