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An Experimental Study On Physical Properties Of Self Curing Concrete By Using Polyethylene Glycol

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ABSTRACT

The existence of a world without concrete is impossible. Concrete is a soul of infrastructure & constitutions. Concrete is necessary to gain strength in structures. Conventional concrete, which is the mixture of cement, fine aggregate, coarse aggregate, water, needs curing to achieve strength. So it is required to cure for a minimum period of 28 days for good hydration and to achieve target strength. Lack of proper curing can badly affect the strength and durability Criteria's. Self curing concrete is the one modern type concrete, type concrete, which cure itself by retaining water (moisture content) in it. The use of admixture POLYETHYLENE GLYCOL in conventional concrete as an admixture helps better hydration process and hence to achieve better strength of the concrete. In this present research work individual effect of admixture PEG400 & PEG1500 on compressive strength by varying the percentage of PEG400 and PEG1500 by weight of cement 0.5%, 1.0%, 1.5% and 2% were studied. The study shows that PEG400 and PEG1500 could help in gaining the strength of conventional concrete by reducing the conventional curing period. It was founded that 1.5%of both PEG400 and PEG1500 by weight of cement was optimum for M30 grade concrete for achieving maximum strength without compromising workability. The test results indicate that use of water soluble polymer like PEG400 and PEG1500 in conventional concrete has improved performance.

INTRODUCTION

Concrete is the basic engineering material used in most of the civil engineering structures. Curing of concrete structures is important to meet the performance and durability requirements. In conventional curing this is achieved by external curing applied after mixing, placing and finishing. 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. Its popularity as basic building material in construction is because of its economy of use, good durability and self-curing ease with which it can be manufactured at site. Concrete like other engineering materials needs to be designed for properties like strength, durability, workability. With advent of new generation admixtures, it is possible to achieve higher grades of concrete with high workability levels economically.

The concept of self-curing agents is to reduce the water evaporation from concrete, and hence increase the water retention capacity of the concrete compared to conventional curing concrete. It was found that water soluble polymers

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(polyethylene glycol*)* can be used as self-curing agents in concrete.

WHAT IS SELF CURING CONCRETE:

- It has been pointed out earlier that curing does not mean application of water; it means also creation of condition for promotion of **Uninterrupted** and **Progressive hydration**.
- It is also pointed out that the quantity of water, normally mixed for making concrete is sufficient to hydrate the cement content.
- Concrete in which the mixing water is restricted by means of some chemical compounds, to go out from the concrete body is known as "**self curing concrete**."

1.3 METHODS OF SELF CURING:

Currently, there are two major methods available for internal curing of concrete. The first method uses saturated porous lightweight aggregate (LWA) in order to supply an internal source of water, which can replace the water consumed by chemical shrinkage during cement hydration. The second method uses poly-ethylene glycol (PEG) which reduces the evaporation of water from the surface of concrete and also helps in water retention.

1.4 WHAT IS THE NEED OF SELF CURING CONCRETE :

➢ Sometimes works are carried out in place where there is acute shortage of water and the application of water curing is not possible for reasons of economy.

Fig 1.4-: scarcity of water

➢ Prevention of moisture loss from the surface of flat concrete works such as highways and airports have been challenging task for construction managers.

Fig 1.4.1 – self curing concrete pavements

➢ If the evaporation of moisture from concrete are not prevented properly it may results in plastic shrinkage cracks, poorly formed hydrated products, finishing problems and other surface defects.

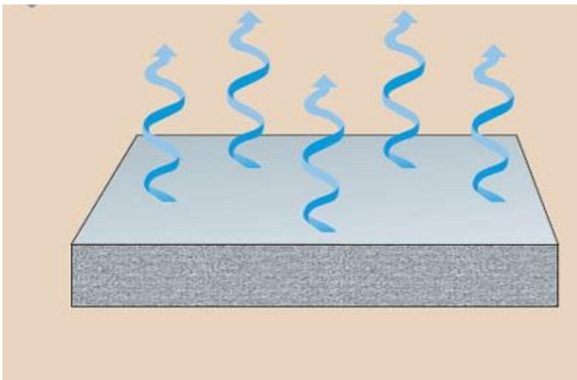

Fig1.4.2- phenomenon of self curing in concrete

➢ Sometimes concrete is placed in some inaccessible, difficult or far places. Where curing cannot be properly done or supervised.

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Fig 1.4.3- self curing concrete

Advantages of self curing concrete :

1. Reduces autogenously cracking.
2. self-curing
3. Reduce the permeability.
4. Increases mortar strength and early age strength sufficient to withstand strain.
5. Greater utilization of cement.
6. Lower Maintenances

MATERIAL PROPERTIES

MATERIALS :

1. Cement.
2. Course aggregate.
3. Sand.
4. Polyethylene glycol.
5. Water.

3.1 TEST ON CEMENT :

Portland cement has been invented by Joseph Asphdin which is a fine grey powder. Among the various types of cement, it is the most commonly used as binding material. It is a mixture of chalk or limestone together with clay. In India are manufactured the three grades of OPC, namely 33grade, 43 grade and 53 grade. As per the standard testing procedure compressive strength of cement will be obtained after 28 days.

Apart from OPC, there are several other types of cement, e.g. sulphate resistant cement, colored cement, oil well cement, expansive cement, etc. Ordinary Portland cement of 53 grade Zuari Cement brand confirming to IS 12269:1987 standard has been used in the present investigations. General OPC cement constitutes proportions like:

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Ingredient	%content
Lime	60-67
Silica	17-25
Alumina	3-8
Iron oxide	0.47-6
Magnesia	0.1-4
Sulphur	1.3
Alkali's	0.4-1.3

Table3.1: Proportions of ingredients in cement

Tested to determine the following properties:

- Specific gravity
- Normal (standard)Consistency of cement
- Initial and final setting time
- Compressive strength
- Fineness of cement (by Le -Chatelier Method)
- Soundness of cement

3.1.1 Specific gravity of cement :

Specific gravity of cement is general the cement was grey in colour and free of hard lumps. The cement is tested for its various properties as per IS 4031:1988 and found to be conforming to the requirements as per IS 12269:1987. Cement ally determined by Le

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chartelier flask. Specific gravity is determined by measuring the weight of a cement sample and its volume by measuring the liquid displaced by the cement sample. The liquid, which is to be used, should be such that it does not have any chemical reaction with cement otherwise the volume would include that of products the reactions. Also the liquid, which is to be used, should be such that it does not have any physical reaction such as absorption with the cement. If polar liquids are used their density in the regions very close to the cement, particle surface will be more than of the free Liquid away from the surface of particles. Generally kerosene is used as liquid in flask to know the volume of cement. Whenever cement is poured into the flask without any obstructions, the liquid level in the flask rises from the initial point. The final level of liquid point indicates the volume of cement. So from that one specific gravity of cement will found as follows:

Table 3.1.1: Specific gravity of cement

S.No.	Initial reading	Final reading	Volume of cement	Specific gravity
1	0	20.5	20.5	3.13

Result: Specific gravity of the given cement at room Temperature = 3.13

Normal (standard) consistency of cement :

Normal or standard consistency of any given cement sample is that water content which will produce a cement paste of standard consistence. Consistence is determined by the vicat's apparatus, which measures the depth of penetration in paste of a 10 mm diameter plunger under its own weight. Normal or standard consistency is expressed as that percentage of water, by mass of dry cement, corresponding to which a specified depth of penetration in paste is achieved. For ordinary Portland cement, the normal consistency varies from 20 to 35%.

Normal consistency of cement is determined for the purpose of determining the water to cement ratios for preparing the specimens to be used for other quality tests such as; times of set, compressive and tensile strengths, and soundness tests, on the same cement. For finding out initial setting time, final setting time and soundness of cement and strength a parameter known as standard consistency has to be used.

The objective of conducting this test is to find out the amount of water to be added to the cement to get a paste of normal consistency i.e., the paste of a certain standard solidity which is used to fix the quality of water to be mixed in cement before performing tests for setting time, soundness and compressive strength. The test is required to be conducted in a constant temperature (27^0C).

% of water content	Initial reading (mm)	Final reading (mm)	Depth of penetration (mm)
28	50	13	13
30	50	8	8
32	50	5	5

Table 3.1.2: standard consistency of cement

Result: standard consistency of cement= 31.5 %

Fineness of cement :

The fineness of cement is an important factor in determining the rate of gain of strength and uniformity of quality. It is measured in terms of specific surface of the cement and can be calculated from the particle size distribution are determined by one of the air permeability. IS sieve No.9 (90 microns), as for Indian standard (IS: 264-1975), the percentage of residue left after sieving a good Ordinary Portland cement through IS sieve no 9, should not exceed 10%.

Table 3.1.3: Fineness of cement

Trail no.	1	2	3
Weight in cement (g)	100	100	100
Quantity of cementretained (%)	3	2.4	2.4

Result: fineness of the given cement= 2.6%.

Initial and final setting times of cement :

Initial and final setting time are find out by vicat's apparatus.In order that the concrete may be placed in position conveniently, it is necessary that the initial setting time is not too quick and after it has been laid, hardening should be rapid so that the structure can be made use of as early as possible. The initial set is a stage in the process of hardening after which any crack that may appear will not re-unite. The concrete is said to be finally set when it has obtained sufficient strength and hardness. For ordinary Portland cement, the initial setting time should not less than 30 minutes and finial setting time should not be more than 600minutes. For quick cement, initial setting time should not less than 5 minutes and final setting time should not exceed 30 minutes. The setting time is influenced by temperature, humidity fair and quantity of gypsum in the cement.

Soundness of cement (by le-chatelier method) :

Soundness of cement indicate the liability of cement to expand to sometimes after setting and causes severe cracking of failure of concrete. The chief test for soundness is the Le-chatelier test the suitability of given cement sample.

The cement is said o be sound when the percentage of free lime and magnesia is within specified limits.These materials expand in the structure and thus the concrete or mortars also expand, causing unequal expansion of pate. Disintegration of cement compound is determined by Le-chatelier apparatus.

Type of cement
= Zuari cement
Normal consistency: P
= 31.5%

Water required for soundness test
= 0.78 X 31.5 = 24.57 ml
Initial distance = 10mm
Final distance = 11.3mm
Expansion of cement = 1.3mm

Result: Soundness of the cement = 1.3mm.

Compressive strength of cement :

The compressive strength of cement is found by preparing 50 sq.cm size cubes. The compressive strength of hardened cement is one of the main important property than all the other properties. Strength tests are not done on neat cement paste because of the difficulties like too much shrinkage and happening after something cracking of neat cement. Strength of cement is found indirectly on cement sand mortar in specific proportions. The standard sand to be used in the test shall conform to IS: 650:1966.

Specific gravity	3.13
Standard consistency	31.5%
Fineness property	2.6%
Initial setting time	50 min
Final setting time	600 min
Soundness	1.2mm
Compressive strength	56 MPa

Table 3.1.6: standard consistency of cement

TESTS ON COURSE AGGREGATES (C.A):

Tests are conducted to check the quality of aggregates. Aggregates are very important components of concrete, so the quality really matter when it comes to aggregates.

Various tests which are done on aggregates are listed below.

1. Specific gravities of course aggregate
2. Sieve analysis for course aggregate
3. Sieve analysis for coarse aggregate

Specific gravity :

Specificgravity of aggregates are found by using a 50-cc density bottle or a

500-cc Pycnometer. Specific gravity value of aggregates is useful in the preparation of mix design. The basic procedure to find specific gravity as follows:

Empty bottle weight = W_1

Bottle weight + aggregate in bottle = W_2

Bottle weight + aggregate + water= W_3

Bottle Weight + only water = W_4

So the specific gravity (G) calculated from the formula

$$= \frac{(W_2 - W_1)}{(W_2 - W_1) - (W_3 - W_4)} .$$

The calculated specific gravities of aggregate values are tabulated:

Table 3.2.1: specific gravities of aggregates

Fine aggregate	2.57
Coarse aggregate	2.75

Grain size distribution of course aggregate:

To study the particle size distribution of the given fine aggregate by conducting sieve analysis, to draw the grading curve and to determine the fineness modulus of the given fine aggregate sample. A set of sieves consisting of the sizes of .5 mm,2.3 mm, 1.18 mm, 600 µ, 300 µ,150 µ and pan. Sample should be taken for which the sample is thoroughly mixed and spread over a clean surface. If any further reduction of quantity is required the process may be repeated. Weight retained on each sieve shall not exceed the limits specifies IS code.

Table 3.2.2: Fineness modulus of Fine Aggregate

s.no	Sieve size	Weight retained(GM's)	%(retained)	%cumulative retained (F)	%cumulative passing (100-F)
1	4.75mm	0	0	0	100
2	2.36mm	36	3.6	3.6	96.4
3	1.18mm	113	11.3	14.9	85.1
4	600µm	438	43.8	58.7	41.3
5	300µm	340	34.0	92.7	7.3
6	150µm	53	5.3	98	2

Calculation:Fineness Modulus=$\sum F/100$ = (267.9/100)= 2.679

Result: Fine aggregate passes through grading Zone II

Grain size distribution of coarse aggregate:

To study the particle size distribution of the given coarse aggregate by conducting sieve analysis, to draw the grading curve and to determine the fineness modulus of the given coarse aggregate sample. We have used a set of sieves consists the sizes of 40mm, 20 mm, 12.5 mm, 4.75 mm, 2.3 mm and pan. Sample should be taken for which the sample is thoroughly mixed and spread over a clean surface. If any further reduction of quantity is required the process may be repeated. Weight retained on each sieve shall not exceed the limits specifies IS code.

Table 3.2.3: Fineness Modulus of Coarse aggregate

s.no	Sieve size	Weight retained (gms)	%age wt retained	Cumulative % wt retained (F)	%age passing (100-F)
1	20mm	0	0	0	100
2	16mm	1800	18.0	18.0	82.0
3	12.5mm	1920	19.2	37.2	62.8
4	10mm	2200	22.0	59.2	40.8
5	6.3mm	3100	31.0	90.2	9.8
6	4.75mm	980	9.8	100	0

Calculation: Fineness Modulus=∑F/100 = (304.6/100)=3.04

Test results on Coarse aggregate (IS: 383-1970)

Property		Results Obtained	Range
Specific gravity		2.76	2.7-2.8
Impact value		12%	<35
Crushing value		16%	<45
Shape Test	Flakiness Index	22.45%	<35%
	Elongation Index	30.82%	<40%

TEST ON FINE AGGREGATE:

Use of all normal sands i.e., both crushed and rounded sands is suitable for SCC. Siliceous or calcareous sands are also used. The amount of fines less than 0.125 mm is to be considered as powder and is very important for theology of the SCC. A minimum amount of fines is achieved to avoid segregation. Aggregate should be of uniform quality with respect to shape and grading. The grading must be uniform throughout the work.

It is formed by the decomposition of sand stones due to various effects of weather. The shape and surface structure of fine aggregate has a greater influence on water demand of concrete than because fine aggregate contain a much higher surface area for a given weight. Smooth and rounded aggregate particles are better for workability than shape and rough particles.

Locally available physical properties of fine aggregate conforming as per IS: 383-1970 and the results are shown in table

Table 3.3: Test results on Fine aggregate (IS: 383-1970)

Properties	Results	Range
Specific gravity	2.658	2.6-2.7
Fineness modulus	2.730	Fine 2.2-2.6 Medium 2.6-2.9 Coarse 2.9-3.2

POLYETHYLENE GLYCOL :

Polyethylene-glycol is a liquid state polymer of ethylene oxide and water, having general formula H(OCH2CH2)nOH, here n refers average number of repeated oxyethelene groups, it ranges from 4 to 180. The abbreviation of poly ethylene glycol is a combination with a numeric suffix which represents the average molecular weights. Main feature of polyethylene glycol is water-soluble nature. These are two types

1. POLYETHYLENE GLYCOL-400
2. POLYETHYLENE GLYCOL-1500

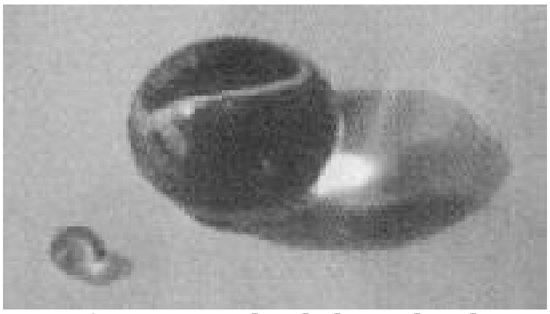
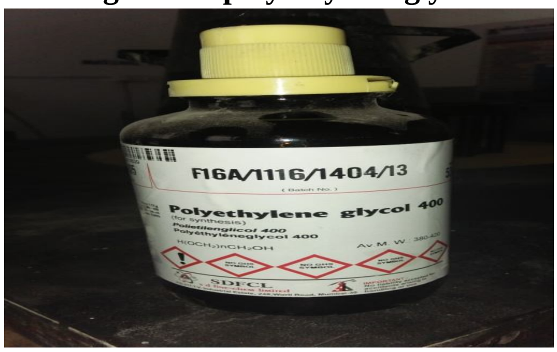
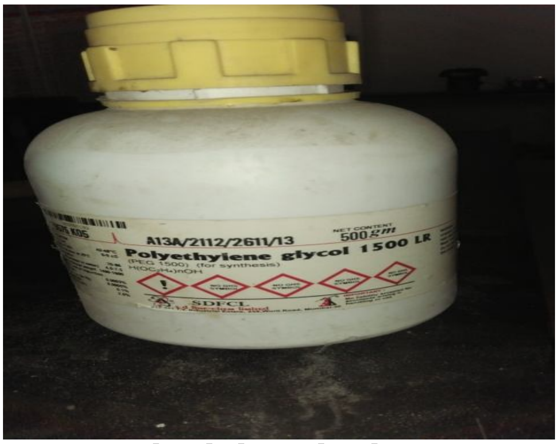


Figure 3.4 polyethylene glycol





Polyethylene glycol 400
Polyethylene glycol 1500

Chemical properties of PEG: PEG 400 is strongly hydrophilic. The partition coefficient of PEG 400 between hexane and water is 0.000015 (log P = -4.8), it indicates that when PEG is mixed with water and hexane, it divided into 15 parts of polyethylene glycol in hexane layer for 1 million parts of polyethylene glycol in water layer. PEG 400 is soluble in water, acetone, alcohols, benzene, glycerine, glycols, and aromatic hydrocarbons, and is slightly soluble in aliphatic hydrocarbons. These are main chemical properties.

3.5 WATER :

Table water is used in the experimental work for both mixing and curing purposes of concrete

MIX DESIGN

DESIGN STIPULATION OF M30 GRADE:

Step1. Design specifications :

Grade selection =M30
Type of cement = O.P.C - 43 grade
Brand of cement =Dalmia
Admixture = POLYETHYLENE GLYCOL-400; POLYETHYLENE GLYCOL-1500
Fine aggregate =Confirming Zone-II
Specific gravity of cement=3.125
Max size of coarse aggregate = 20mm
Minimum and maximum cement content =400 kg/m^3
Maximum water-cement ratio =0.45
Exposure condition according to IS 456-2000 =Severe
Workability =100mm slump

This method of concrete mix design consist of following 11 steps :

1. Design specification
2. Testing of materials
3. Calculating target strength for mix proportioning
4. Selecting water/cement ratio
5. Calculating water content
6. Calculating cement content
7. Finding out volume proportions for Coarse aggregate & fine aggregate
8. Mix calculations
9. Trial mixing and
10. Workability measurement (using slump cone method)
11. Repeating step 9 & 10 until all requirements is fulfilled.

Let us discuss all of the above steps in detail

Step 1. Design specification:

This is the step where we gather all the required information for designing a concrete mix from the client. The data required for mix proportioning is as follows.

- Grade designation (whether M10, M15, M20 ,M30 etc)
- Type of cement to be used
- Maximum nominal size of aggregates
- Minimum & maximum cement content
- Maximum water-cement ratio
- Workability
- Exposure conditions (As per IS-456)
- Maximum temperature of concrete at the time of placing
- Method of transporting & placing
- Early age strength requirement (if any)
- Type of aggregate (angular, sub angular, rounded etc)
- Type of admixture to be used (if any)

Step 2. Testing of materials :

The table given below shows the list of most necessary tests to be done on cement, coarse aggregate, fine aggregate and admixture. After doing the test, store the test data for further calculation.

Concrete Ingredients	Tests to be done			
Cement	Specific gravity	–	–	–
Coarse aggregate	Specific gravity	Water absorption	Free surface moisture	Sieve analysis
Fine aggregate	Specific gravity	Water absorption	Free surface moisture	Sieve analysis
Admixture (if any)	Specific gravity	–	–	–

Step 3. Target strength calculation :

Calculate the target compressive strength of concrete using the formula given below.

$f_{ck}' = f_{ck} + 1.65s$

Where,

f_{ck}' = Target compressive strength at 28 days in N/mm^2.

f_{ck} = Characteristic compressive strength at 28 days in N/mm^2. (same as grade of concrete, see table below)

s = Standard deviation

The value of standard deviation, given in the table below, can be taken for initial calculation.

Therefore, target strength =30 + 1.65 x 5 =38.25 N/mm² for M0

Sl.No	Grade of Concrete	Characteristic compressive strength (N/mm^2)	Assumed standard deviation (N/mm^2)
1.	M10	10	3.5
2.	M15	15	
3.	M20	20	4.0
4.	M25	25	
5.	M30	30	6.0
6.	M35	35	
7.	M40	40	
8.	M45	45	
9.	M50	50	
10.	M55	55	

Step 4. Selection of water-cement ratio :

For preliminary calculation, water cement ratio as given is IS-456 Table4.1.4 (also given below) for different environmental exposure condition, may used.

Note: Use Table-1 for finding out water-cement ratio of **Plain Concrete** an use Table-2 for finding out water-cement ratio of **Reinforced Concrete**.

Sl.No.	Environmental Exposure Condition	Plain Concrete		
		Minimum Cement Content (kg/m3)	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete
1	Mild	220	0.60	–
2	Moderate	240	0.60	M15
3	Severe	250	0.50	M20
4	Very Severe	260	0.45	M20
5	Extreme	280	0.40	M25

Refer the table given below (As per IS-456) to choose right type of environment depending upon different exposure conditions to concrete.

From Table 4.1.4 of IS 456, maximum water-cement ratio = 0.45.

Based on experience, adopt water-cement ratio as 0.40.

0.40 < 0.45, hence O.K.

4.1.5: Step 5. Selection of water content :

Selection of water content depends upon a number of factors such as

- Aggregate size, shape & texture

- Workability
- Water cement ratio
- Type of cement and its amount
- Type of admixture and environmental conditions.

Factors that can reduce water demand are as follows

- Using increased aggregate size
- Reducing water cement ratio
- Reducing the slump requirement
- Using rounded aggregate
- Using water reducing admixture

Factors that can increase water demand are as follows

- Increased temp. at site
- Increased cement content
- Increased slump
- Increased water cement ratio
- Increased aggregate angularity
- Decrease in proportion of the coarse aggregate to fine aggregate

The quantity of maximum mixing water per unit volume of concrete may be selected from the table given below.

Maximum water content per cubic meter of concrete for nominal maximum size of aggregate		
Sl.No.	Nominal maximum size of aggregate	Maximum water content
1	10	208
2	20	186
3	40	165

The values given in the table shown above is applicable only for angular coarse aggregate and for a slump value in between 25 to 50mm.

Do the following adjustments if the material used differs from the specified condition.

Type of material/condition	Adjustment required
For sub angular aggregate	Reduce the selected value by 10kg
For gravel with crushed stone	Reduce the selected value by 20kg
For rounded gravel	Reduce the selected value by 25kg
For every addition of 25mm slump	Increase the selected value by 3%
If using plasticizer	Decrease the selected value by 5-10%
If using super plasticizer	Decrease the selected value by 20-30%

Note: Aggregates should be used in saturated surface dry condition. While computing the requirement of mixing water, allowance shall be made for the free surface moisture contributed by the fine and coarse aggregates. On the other hand, if the aggregate are completely dry, the amount of mixing water should be increased by an amount equal to moisture likely to be absorbed by the aggregate

- From Table , maximum water content =186 litre (for 25 to 50 mm slump range) for 20 mm aggregate
- Estimated water content for 175 mm slump =186+(3/100)186

=191.58 litre/m^3

Step 6. Calculating cementious material content :

From the water cement ratio and the quantity of water per unit volume of cement, calculate the amount of cementious material. After calculating the quantity of cementious material, compare it with the values given in the table shown in Step-4. The greater of the two values is then adopted.

If any mineral admixture (such as fly ash) is to be used, then decide the percentage of mineral admixture to be used based on project requirement and quality of material.

From the above considerations the W/c =0.40

Cement =191.158/0.40= 478.95 kg/m^3

from table 5 IS 456, min cement content for severe exposure condition =320 kg/m³
478.95 kg/m³> 320 kg/m³,
henece safe.

Step 7. Finding out volume propotions for coarse aggregate & fine aggregate :

Volume of coarse aggregate corresponding to unit volume of total aggregate for different zones of fine aggregate is given in the following table.

Sl.No.	Nominal Maximum Size of Aggregate (mm)	Volume of coarse aggregate per unit volume of total aggregate for different zones of fine aggregate			
		Zone IV	Zone III	Zone II	Zone I
1	10	0.50	0.48	0.46	0.44
2	20	0.66	0.64	0.62	0.60
3	40	0.75	0.73	0.71	0.69

The values given in the table shown above is applicable only for a water-cement ratio of 0.5 and based on aggregates in saturated surface dry condition.

If water-cement ratio other than 0.5 is to be used then apply correction using the rule given below.

Rule: For every **increase or decrease** by **0.05** in **water-cement ratio**, the **above values** will be **decreased or increased** by **0.01,** respectively.

If the placement of concrete is done by a pump or where is required to be worked around congested reinforcing steel, it may be desirable to reduce the estimated coarse aggregate content determined as above, upto 10 percent.After calculating volume of coarse aggregate, subtract it from 1, to find out the volume of fine aggregate.

Step 8. Mix calculations :

The mix calculations per unit volume of concrete shall be done as follows.

A	Volume of concrete=	1m³
B	Volume of cement=	(Mass of cement/specific gravity of cement)*(1/1000)
C	Volume of water=	(Mass of water/specific gravity of water)*(1/1000)
D	Volume of admixture=	(Mass of admixture/specific gravity of admixture)*(1/1000)
E	Volume of total aggregate (C.A+F.A)=	[a-(b+c+d)]
F	Mass of coarse aggregate=	e*Volume of coarse aggregate*specific gravity of coarse aggregate*1000
G	Mass of fine aggregate=	e*Volume of fine aggregate*specific gravity of fine aggregate*1000

Volume of concrete =1000lit/m³
Volume of cement = 478.95/3.15
= 152.04 lit/m³
Volume of water = 191.58/1
= 191.58 lit/m³
Volume of all aggregate = volume of concrete –volume of (cement+ water)
= 1000-(152.04+191.58) = 656.38 lit/m³
Volume of CA = 656.38*0.62
= 406.95 lit/m³
Volume of FA= volume of all aggregate – Vol CA
=656.38-40695 =249.42 lit/m³
Mass of CA = volume of CA *specific gravity of CA
= 406.95 *2.76
n = 1123.18 kg/m³
Mass of FA = volume of FA *specific gravity of FA
= 249.42*2.678 = 667.94 kg/m³
Mix proportion : cement: 472.95
FA : 596.94 W/C=0.40
CA : 1201.18
Admixture = 0.5% by weight of cement =2.4 Kg
The proportion for M30 is **1: 1 : 3**

Step 9. Trial mix :

Conduct a trial mix as per the amount of material calculated above.

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Step 10. Measurement of workability (By slump cone method):

The workability of the trial mix no.1 shall be measured. The mix shall be carefully observed for freedom from segregation and bleeding and its finishing properties.

The workability by slump cone method =110 mm

Step 11. Repeating trial mixes :

If the measured workability of trial mix no.1 is different from stipulated value, the water and/or admixture content shall be adjusted suitably. With this adjustment, the mix proportion shall be recalculated keeping the free water-cement ratio at pre-selected value.

Trial-2 – increase water or admixture, keeping water-cement ratio constant

Trial-3 – Keep water content same as trial-2, but increase water-cement ratio by 10%.

Trial-4 – Keep water content same as trial-2, but decrease water-cement ratio by 10%

Trial mix no 2 to 4 normally provides sufficient information, including the relationship between compressive strength and water-cement ratio.

OBSERVATION :

A. Mix was cohesive and homogeneous.

B. Slump =110mm

C. No. of cubes casted =12Nos.

7 days average compressive strength = 51.26 MPa.

28 days average compressive strength = 62.96 MPa which is greater than

Grade of concrete	Weight ratios	Water/cement ratios
M30	1:1.45:2.91	0.45

48.25MPa Hence the mix is accepted.

EXPERIMENTAL ANALYSIS

5.1 GENERAL :

The experimental program was designed to investigate the strength of self-curing concrete by adding poly ethylene glycol PEG400 and PEG1500 at percentage changes 0.5%, 1%, 1.5% and 2% by weight of cement to the concrete of each. The experimental program was aimed to study the compressive strength, flexural strength. To study the above properties mix M30 is considered. The scheme of experimental program is given below

Stage 1:

Cubes having size 150 x 150 x 150mm and beam having size 100 x 100 x 500mm were casted for the determination of the strength of nominal concrete.

Stage 2:

Cubes having size 150 x 150 x150mm and beam having size 100 x 100 x 500mm were casted for the determination of the strength of self curing concrete by adding poly ethylene glycol PEG400.

Stage 3:

Experimental works were conducted on conventional concrete mixes by using different binder mix modified with different proportions polyethylene glycol. This experimental investigation was carried out for three different proportions of PEG-400 and PEG1500 at percentage changes 0.5%, 1%, 1.5% and 2% by weight of cement to the concrete. Then the optimum percentage of chemical mix was found. Similarly experimental work is conducted for different proportions of chemical mix. Hence analyze concrete mixed with PEG-400 and PEG1500 results were tabulated.

Stage 4:

Here cubes and beams are prepared with four different dosages of PEG-400 and PEG1500 with concrete.

CONCRETE MIXING AND CASTING

MIXING:

Mixing is place an important role in concrete structures. Proper mixing gives uniform and high quality concrete. The proper mixing gives better strength results.

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The concrete mix is obtained by combination of Portland cement, specified fine and coarse aggregate. The proper mixing of these materials gives uniformity.

In this we required normal conventional mixing and chemical mixing. First we make the mixing for M30 and M40 grade conventional concrete with water/cement ratio of0.40 and 0.45. Another mixing is self-curing concrete mix. In this we are adding self-curing agent PEG-400 and PEG-1500 to the conventional concrete mix. In these we are adding polyethylene glycol at different dosages @ 0.5%, 1%, 1.5% and 2%. For each dosage mixing is takes place having water/cement ratio of 0.40 and 0.45.

5.3 CASTING :

Casting of the specimens placed as per IS: 10086-1982, material preparation, requirement of materials and casting of cubes and beam. The mixing, compacting and curing of concrete are done according to IS 516: 1959. After casting, cube and beam specimens were placed in water for 7days and 28 days and the specimens casting with self-curing compound were placed in dark place for curing at room temperature. Chemically made specimens are not exposed to sunlight. The casting details are given below

CASTING DETAILS:

The casting details of conventional concrete and self-curing concrete cube and beam specimens are given below:

1. Compressive strength after 7 days, 28 days.
2. Flexural strength after 7 days, 28 days.

Fig5.3:mixing

Fig 5.3: casting of specimens

SLUMP CONE TEST :

To find the consistency of concrete, slump test is the best method for it. Slump test can be performed in laboratory as well as at work-site also. All factors contributing to workability are not possible to measure by slump test. However, it is used conveniently as a control test and gives an indication of the uniformity of concrete from batch to batch.

COMPRESIVE STRENTH TEST :

The cube specimens were tested on compression testing machine of capacity

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3000KN. The bearing surface of the machine was wiped off clean and sand or other material removed from the surface of the specimen. The specimen was placed in machine in such a manner that the load was applied to opposite sides of the cubes as a cast that is, not top and bottom. The axis of the specimen was carefully aligned at the center of loading frame. The load applied was increased continuously at a constant rate until the resistance of the specimen to the increasing load breaks down and no longer can be sustained. The maximum load applied on specimen was recorded. The cube specimen size is 150 mm x 150 mm x 150 mm

$$Fc = P/A,$$

Where, P is applied load

A is area of the specimen.

Fig 5.5– compressive test

FLEXURE TEST ON CONCRETE :

The machine consists of a motorized load frame. The lower platen has two rollers, the distance between which is adjustable. For 100 mm x 100 mm x 500 mm beam, the centre distance between the rollers is 400 mm, while it is 400 mm for beams of size 100 mm x 100 mm x 400 mm. The upper platen has also a pair of rollers whose distance adjustable. It is 100 mm x 100 mm x 500 mm size beam. Total capacity of the machine is 100 KN. 150mm dia pressure gauge of 0-100 KN x 1 KN least count to indicate load is fixed on the load frame. A separate electrically cum hand operated pumping unit housed in a cabinet is supplied. On/Off switch and a slow/fast lever to control rate of loading are fitted on the front panel of the pumping unit. A facility for hand operation is provided. A micro switch and relay fitted inside the pressure gauge protect the unit from overloading.

The test method essentially involves applying a load at the centre of a beam of concrete 100 mm x 100 mm x 500 mm supported at its ends.. The specimens were supported on a pair of rollers, a rocker and a bearing plate at each support. A two-point-loading scheme was used to apply loading to the specimens. The distance separating the two loading points was constant for al1 the specimens at 400 mm. The shear span separating the loading points from the supports was equal on both ends of the specimens creating a zero shear region between the two loading points.

The loading was applied monotonically and the load required to break the specimen is then recorded.

Fig5.6: Flexure test

5.7 REBOUND HAMMER :

Procedure for rebound hammer test on concrete structure starts with calibration of the rebound hammer. For this, the rebound hammer is tested against the test anvil made of steel having Brinell hardness number of about 5000 N/mm^2.

After the rebound hammer is tested for accuracy on the test anvil, the rebound hammer is held at right angles to the surface of the concrete structure for taking the readings. The test thus can be conducted horizontally on vertical surface and vertically upwards or downwards on horizontal surfaces as shown in figure below:

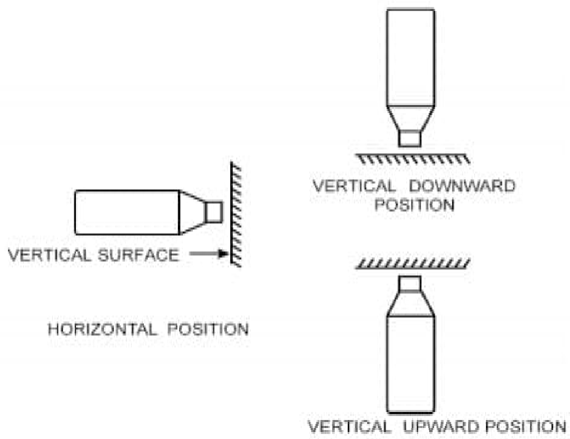


Fig 5.7: Rebound Hammer Positions for Testing Concrete Structure

If the rebound hammer is held at intermediate angle, the rebound number will be different for the same concrete.

The following points should be observed during testing.

(a) The concrete surface should be smooth, clean and dry.

(b) Ant loose particles should be rubbed off from the concrete surface with a grinding wheel or stone, before hammer testing.

(c) Rebound hammer test should not be conducted on rough surfaces as a result of incomplete compaction, loss of grout, spalled or tooled concrete surface.

(d) The point of impact of rebound hammer on concrete surface should be at least 20mm away from edge or shape discontinuity.

Six readings of rebound number is taken at each point of testing and an average of value of the readings is taken as rebound index for the corresponding point of observation on concrete surface.

How the correlation between compressive strength of concrete and rebound number is obtained:

The most suitable method of obtaining the correlation between compressive strength of concrete and rebound number is to test the concrete cubes using compression testing machine as well as using rebound hammer simultaneously. First the rebound number of concrete cube is taken and then the compressive strength is tested on compression testing machine. The fixed load required is of the order of 7 N/ mm^2 when the impact energy of the hammer is about 2.2 Nm. The load should be increased for calibrating rebound hammers of greater impact energy and decreased for calibrating rebound hammers of lesser impact energy. The test specimens should be as large a mass as possible in order to minimize the size effect on the test result of a full scale structure. 150mm cube specimens are preferred for calibrating rebound hammers of lower impact energy (2.2Nm), whereas for rebound hammers of higher impact energy, for example 30 Nm, the test cubes should not be smaller than 300mm.

The concrete cube specimens should be kept at room temperature for about 24 hours after taking it out from the curing pond, before testing it with the rebound hammer. To obtain a correlation between rebound numbers and strength of wet cured and wet tested cubes, it is necessary to establish a correlation between the strength of wet tested cubes and the strength of dry tested cubes on which rebound readings are taken. A direct correlation between rebound numbers on wet cubes and the strength of wet cubes is not recommended. Only the vertical faces of the cubes as cast should be tested. At least nine readings should be taken on each of the two vertical faces accessible in the compression testing machine when using the rebound hammers. The points of impact on the specimen must not be nearer an edge than 20mm and should be not less than 20mm from each other. The same points must not be impacted more than once.

Interpretation of Rebound Hammer Test Results :

After obtaining the correlation between compressive strength and rebound number, the strength of structure can be assessed. In general, the rebound number increases as the strength increases and is also affected by a number of parameters i.e. type of cement, type of aggregate, surface condition and moisture content of the concrete, curing and age of concrete, carbonation of concrete surface etc. Moreover the rebound index is indicative of compressive strength of concrete up to a limited depth from the surface. The internal cracks, flaws etc. or heterogeneity across the cross section will not be indicated by rebound numbers.

Average Rebound Number	Quality of Concrete
>40	Very good hard layer
30 to 40	Good layer
20 to 30	Fair
<20	Poor concrete

As such the estimation of strength of concrete by rebound hammer method cannot be held to be very accurate and probable accuracy of prediction of concrete strength in a structure is ± 25 percent. If the relationship between rebound index and compressive strength can be found by tests on core samples obtained from the structure or standard specimens made with the same concrete materials and mix proportion, then the accuracy of results and confidence thereon gets greatly increased.

RESULTS AND DISCUSSIONS

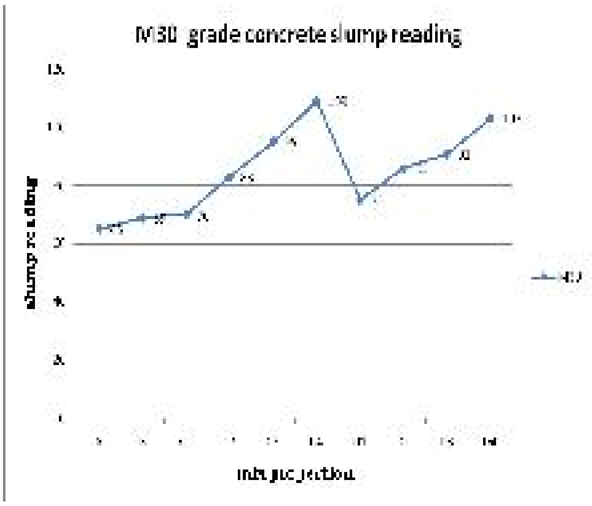
The strength parameters of self-cured concrete were compared with cured concrete at 7days and 28 days

The slump test results are represented in following table and graphical representation is also shown in figure. As the % of PEGs (PEG400&PEG1500) are increased the slump is found to increase respectively.

SLUMPCONE TEST:

M30 Grade of concrete slump test values :

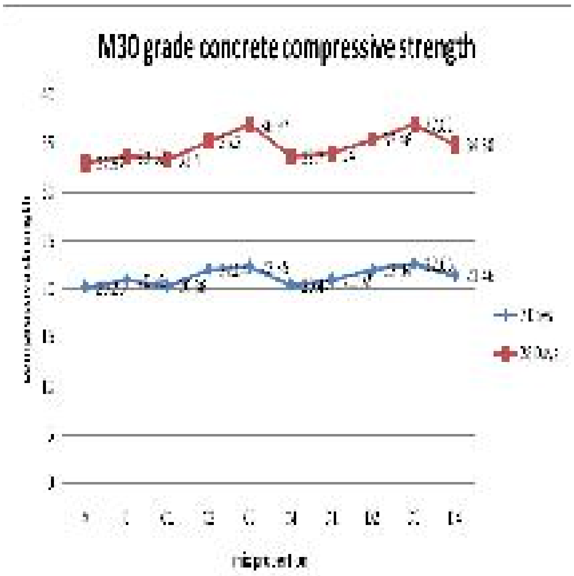
	MIX PROPORTIONS	SLUMP value(mm)
		M30
A	Without curing and without admixture (A)	65
B	With general curing and without admixture (B)	69
C1	With admixture PEG400 0.50% weight of cement(C1)	70
C2	With admixture PEG400 1% weight of cement(C2)	83
C3	With admixture PEG400 1.5% weight of cement (C3)	95
C4	With admixture PEG400 2% weight of cement (C4)	109
D1	With admixture PEG1500 0.50% weight of cement (D1)	75
D2	With admixture PEG1500 1% weight of cement (D2)	86
D3	With admixture PEG15001.5% weight of cement(D3)	91
D4	With admixture PEG1500 2% weight of cement(D4)	103



COMPRESSIVE STRENTH :

The results of the compressive strength are represented in Table and the graphical representation is shown in Fig. The compressive strength was found to increase up to 1.5% PEG400 and PEG1500 then decreased for M30 grade. In this we are adding self-curing agent PEG-400 and PEG-1500 to the conventional concrete mix. In these we are adding polyethylene glycol at different dosages @ 0.5%, 1%, 1.5% and 2%. For each dosage mixing is takes place having water/cement ratio of 0.45

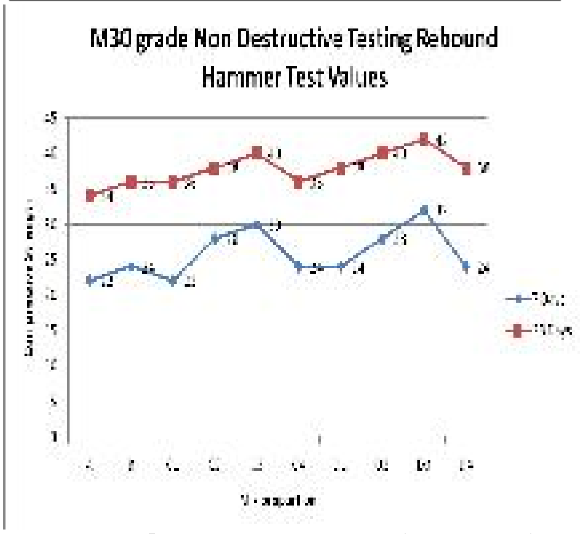
Mix proportion	M30 Compressive Strength (N/mm^2)	
	7 Days	28 Days
A	20.26	32.97
B	20.96	33.67
C1	20.36	33.40
C2	22.04	35.20
C3	22.35	36.97
C4	20.44	33.70
D1	21.02	34.00
D2	22.04	35.46
D3	22.66	37.02
D4	21.46	34.88



M30 grade concrete compressive strength

a. REBOUND HAMMER TEST:

Mix Proportion	Non Destructive Testing Rebound Hammer Test Values	
	7 Days	28 Days
A	22	34
B	24	36
C1	22	36
C2	28	38
C3	30	40
C4	24	36
D1	24	38
D2	28	40
D3	32	42
D4	24	38



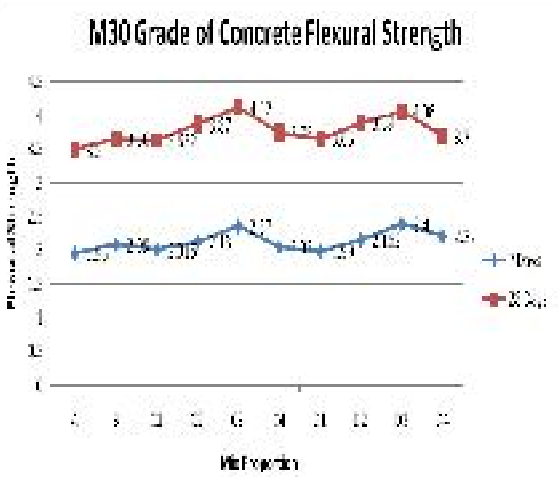
M30 grade Non Destructive Testing Rebound Hammer Test Values

FLEXURAL STRENGTH :

The results of the compressive strength are represented in Table and the graphical representation is shown in Fig. The flexural strength was found to increase up to 1.5% PEG400 andPEG1500 then decreased for M30 grade. In this we are adding self-curing agent PEG-400 and PEG-1500 to the conventional concrete mix. In these we are adding polyethylene glycol at different dosages @ 0.5%, 1% and 1.5% . For each dosage mixing is takes place having water/cement ratio of 0.45

Mix Proportion	M30 Grade of Concrete Flexural Strength	
	7 Days	28 Days
A	1.96	3.5
B	2.09	3.66
C1	2.016	3.632
C2	2.13	3.87
C3	2.37	4.12
C4	2.05	3.75
D1	1.99	3.66
D2	2.162	3.89
D3	2.40	4.06
D4	2.22	3.70

M30 Grade of Concrete Flexural Strength



M30 Grade of Concrete Flexural Strength

The results of the compressive strength are represented in Table and the graphical representation is shown in Fig. The compressive strength was found to increase up to 1% PEG400 andPEG1500 then decreased for M40 grade. In this we are adding self-curing agent PEG-400 and PEG-1500 to the conventional concrete mix. In these we are adding polyethylene glycol at different dosages @ 0.5%, 1%, 1.5% and 2%. For each dosage mixing is takes place having water/cement ratio of 0.40

CONCLUSION

1. As per the results compiled in the tables, compressive strength of various mixes for M30 Grade concrete we conclude that the compressive strength mixes using self curing compounds (PEG-400 and PEG1500) are equal with that of the concrete with conventional curing.
2. The optimum dosage of PEG400 for maximum strength was found to be 1.5% weight of cement for M30 grade.
3. The optimum dosage of PEG1500 for maximum strength was found to be 1.5% weight of cement for M30 grade.
4. From the slump test results the workability is increased and compressive strength for self -curing concrete gets decreased
5. From these research work, we conclude that (1.5%) weight of cement for M30 grade.

SCOPE OF FUTURE WORK :

1. From these research work, is to compare physical properties by adding by varying the percentages of PEG 400 and PEG1500 from 0%to 2% by weight of cement for M30 grade of concrete
2. The Future Work is self curing concrete different types of mix design (M20, M25, M30 and M40) grad of concrete.
3. The Future Work is self curing concrete different types of admixture (PEG200, PEG400, PEG600 and PEG1500) are used.

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