AN EXPERIMENTAL STUDY ON INTERNALLY CURED CONCRETE OF DIFFERENT GRADES INCORPORATING RECYCLED AGGREGATE AND M-SAND

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ABSTRACT

Concrete most importantly has an edge over other construction materials because of its unique ability to take any shape in various applications whether it is produce on the site or whether it is made in a factory as a pre-cast product. During the last two decades, concrete technology has been undergoing rapid improvement. The imagination of world without concrete is impossible. Concrete is a soul of infrastructures. Concrete is necessary to gain strength in structures. Conventional concrete, which is the mixture of cement, fine aggregate, coarse aggregate and water needs curing to achieve required strength. So it is required to cure for a minimum of 28 days for good hydration and to achieve target strength. Because after mixing cement with water the process of hydration takes place which required water for cooling purpose. If water is not provided then shrinkage of concrete occurs which results cracking. Internally cured concrete can be achieved by adding SELF CURING AGENTS. The concept of internally cured agents is to reduce the water evaporation from the concrete and hence increasing the water retention capacity of the concrete.

KEYWORDS: Concrete, M-Sand, Recycled aggregates, Self Curing Agents, Internally Cured Concrete.

1. INTRODUCTION

Concrete has been and will be, for a considerable number of years the most versatile materials used in construction. Concrete most importantly has an edge over other construction materials because of its unique ability to take any shape in various applications whether it is produce on the site or whether it is made in a factory as a pre-cast product. During the last two decades, concrete technology has been undergoing rapid improvement. The imagination of world without concrete is impossible. Concrete is a soul of infrastructures. Concrete is necessary to gain strength in structures So it is required to cure for a minimum of 28 days for good hydration and to achieve target strength. Lack of proper curing can badly affect modern concrete, self-curing concrete is concrete which cure itself by retaining water.

The concept of internally cured agents is to reduce the water evaporation from the concrete and hence increasing the water retention capacity of the concrete. But it is necessary to give some brief explanation about different water retaining methods which are as follows.

1.1 Types of Curing

1.1.1 Water Retaining Techniques: Water retaining techniques include Membrane forming curing compound, plastic sheeting.

1.1.1.1 Curing compound: Various types of curing compound are available in the market, mainly includes water based,

1.1.1.2 Plastic Sheet: polyethylene film are used to cure concrete. Polyethylene films are lightweight, impervious hence prevent the moisture movement from the concrete and can be applied to simple as well as on complex shapes

1.1.2 Water adding techniques: Water adding techniques include Pounding or immersion, spraying or fogging and saturated wet covering

1.1.2.1 Ponding or immersion: curing method wherein the flat concrete surfaces such as slabs and pavements are cured by Ponding of water around the perimeter of the surface with the help of sand dikes.

1.1.2.2 Fogging or Sprinkling: is a curing method wherein a fine fog mist is frequently applied on the surface of the concrete through a system of sprayers or nozzles.

1.1.2.3 Saturated Wet Curing: is most often used curing method in the construction industry. In this method moisture retaining fabrics such as burlap cotton mats and rugs are used as wet covering to keep the concrete in a wet condition during the curing period.

1.2 Scope of The Work: Curing is the important Process as far as concrete structure is concern it requires 28 days of watering under congenial atmosphere.

●This issue leads to research on curing process which requires less or no water for curing without compromising with its compressive strength.

●The aim and objective is to study the effect of polyethylene glycol (PEG 400) on strength characteristics of concrete.

●The objective is to study the mechanical characteristic of concrete i.e. compressive strength by varying the percentage of PEG400 and SAP from 0% to 2% by weight of cement for M20 and M30 grade of concrete**.**

1.3 Internally Cured Concrete: Primary requirement of fast-track construction is high early strength in concrete. Early age concrete strength without costly heat treatment is of greater significance in the construction industry. This reduces the rate of evaporation from the surface. Internal-Curing concrete is the newly emerging trend in the construction industry. Water soluble alcohols are general used as self-curing agents. With conventional ingredients it is possible to design reasonably good fast track concrete mixture using admixture.

1.3.1 Advantages of Internally Cured Concrete:

• Internally cured concrete is a good solution for the water scarcity region.

• As there is no requirement of labour for curing so it reduces the cost of labour required for curing.

• It is a good solution for the high rise buildings and complicated structure where curing is difficult.

• It is good solution for the external curing deficiencies generated due to many practical difficulties or by human during the initial hours when curing is required the most. As it achieves strength of 28 Days in 7 Days only so it can be used for highways Construction

1.3.2 Limitation of Internally Cured Concrete.

• Proper and Accurate supervision is needed while adding self-curing agent.

• Adding excess amount of Self-Curing agent may decrease the strength of concrete.

1.4 Significance of Self Curing Concrete.

The self-curing concrete is more significant in water lacked areas or low water resources areas. It is mainly used to reduce the water evaporation from concrete structures and also retaining the water internally in concrete structures. When mineral admixtures are react completely in a blended system of concrete, then demand for curing water externally or internally. To control the water evaporation we use SAP as self-curing agent in concrete. In this self-curing technique we get a good result with significant chemical mix, if chemical mix proportion was not properly mixed early-age cracking and shrinkage may occurs.

1.5 Mechanism of Internally Curing: The mechanism of internal curing is holding the preserved water content of concrete structures within it. So concrete structures are not required any additional water for curing purpose. The concrete structures are exposed to atmosphere evaporation is continuously takes place. The shrinkage admixtures like sap is used to retention of water content internally.

1.6 Advantages of Self Curing

➢Internal curing maintains sufficient moisture to hydrate the cement particle, manage moisture with mixing water alone

➢Maintains high relative humidity and reduces the self-drying of concrete structures.

➢It eliminates the autogenously shrinkage.

➢It maintains concrete strengths at the early ages above this level cracking occurs due to strains.

➢It reduces the difficulties and lacking of supervision in external curing due to human intelligence and hydration processes.

1.7 Objective of The Project:

➢Internally cured concrete with admixture

➢SAP and PEG 400 is added in the concrete mix design

➢Mix grades of M20 and M30 was done

➢Cubes, Cylinders and Beams were casted with mix design by adding 0, 0.5, 1, 1.5, 2% of SAP and PEG individually

➢Finally, strength was calculated for each of the specimens

2. LITERATURE REVIEWS

There are numerous studies that have been reported in the literature in respect of internally cured concrete. Some of the significant contributions are briefly mentioned in the literature.

➢**Swamy et. al.** presented a simple method to obtain a 50MPa 28-day strength concrete having 50 and 65 percent by weight cement replacement with slag having a relatively low specific surface. The compressive and flexural strengths and the elastic modulus of these two concretes as affected by curing conditions are then presented.

➢**Roland Tak Yong Liang, Robert Keith Sun** carried work on internal curing composition for concrete which includes a glycol and a wax. The invention provides for the first time an internal curing composition which, when added to concrete or other cementitious mixes meets the required standards of curing as per Australian Standard AS 3799.

➢**PietroLura,** The main aim of his study was to reach a better conception of autogenous shrinkage in order to be able to model it and possibly reduce it. Once the important role of self-desiccation shrinkage in autogenous shrinkage is shown, the benefits of avoiding self-desiccation through internal curing become apparent

2.2. Self-Curing Using Lightweight Aggregates

Lightweight aggregate are natural or synthetic aggregates which weighs less than or equal to 1100 kg/m3. The most important characteristic of lightweight aggregate is its void fraction. The high absorption values of LWA make concrete proportioning quite difficult. Expanded clay, shale and slate are the most frequently used materials of lightweight aggregate used in structural concrete. Internal curing is achieved by substituting a percentage of coarse aggregate.

2.3. Self Curing Using Super-Absorbent Polymer:

A superabsorbent polymer is a new method for prevention of self-desiccation. Most SAPs are cross-linked polyelectrolytes. Due to its ionic nature and interconnected structure, an SAP is able to absorb a significant amount of liquid from its surroundings and will retain the liquid within its structure without dissolving.

Commonly SAPs are added at rate of 0– 0.6 wt % of cement. They are covalently cross-linked and are Acrylamide/acrylic acid copolymers. One type of SAPs are suspension polymerized, spherical

particles with an average particle size of approximately 200 mm, another type of SAP is solution polymerized and then crushed and sieved to particle sizes in the range of 125–250 mm. The size of the swollen SAP particles in the cement pastes and mortars is about three times larger due to pore fluid absorption.

3. MATERIALS AND METHODOLOGY

The following materials are being used and are listed below.

➢Cement
➢Fine aggregate (M-Sand)
➢Recycled aggregates (replacement of coarse aggregate)
➢Water
➢Sap
➢Peg 400

3.2.1. CEMENT

The most common cement used is an Ordinary Portland Cement (OPC). The Ordinary Portland Cement of 53 grade (OPC) conforming to IS: 8112-1989 is used. A cement is a binder, a substance used in construction that sets, hardens and adheres to other materials, binding them together. Cement is used with fine aggregate to produce mortar for masonry, or with sand and gravel aggregates to produce concrete. It is a powered adhesive and cohesive substance which when mixed with fine aggregate, coarse aggregate and water form a paste which on curing for certain period turns in to mass of hard stone.

Fig No.: 3.1 Cement

Table: 3.1. Properties of Cement

S.No.	CHARACTERISTICS	VALUE
1	Specific Gravity	3.12
2	Normal Consistency	28%
3	Bulk Density	1190kg/m^3
4	Fineness	225kg/m^2
5	Initial Setting Time	35 min
6	Final Setting Time	132 min

3.4. AGGREGATES

Aggregates are inert granular materials such as sand, gravel or crushed stone that are an end product in their own right. They are also the raw materials that are an essential ingredient in concrete. For a good concrete mix, aggregates need to be clean, hard, strong particles free of absorbed chemicals or coatings of clay and other fine materials that could cause the deterioration of concrete.

Depending upon the size the aggregates are classified into two types

1) Coarse Aggregate, 2) Fine Aggregate M-Sand

3.4.1. Fine Aggregate

M Sand is nothing but artificial sand made from crushing of rock or granite for construction purposes in cement or concrete. M sand differs from natural river sand in its physical and mineralogical properties. Nowadays, sources of natural sand such as river sand, pit sand, stream sand, sea sand and other sands. Another cause for the use of M sand is its active availability, reducing transport distances and minimizing pollution.

Table: 3.2. Properties of Fine Aggregate

S.No.	Physical Properties	Fine Aggregate
1	Size and Zone	4.75 mm down
2	Specific gravity	2.65
3	Water Absorption	1.4%
4	Moisture Adsorption	2%
5	Fineness modulus	3.95

3.5. Recycled Aggregates

The waste from the demolition of concrete structures are collected, aggregates are separated as recycled aggregates.

The proposed recycled aggregates are used in the concrete mix for this project. The recycled aggregates are conformed by means of grading. As per specification 20 mm angular recycled aggregates are selected for partial replacement.

3.6. Properties of Recycled Aggregate:

The use of recycled aggregate obtained from the waste concrete, as a component of the new concrete mixture, implies a thorough understanding of its basic properties, considering that some of them may significantly differ from the properties of aggregates obtained from natural resources. In addition, their differences primarily depend on the quantity and quality of cement mortar, which is attached to the grains of recycled aggregate

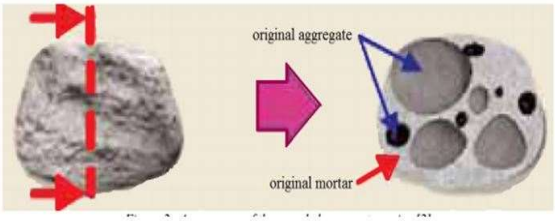


Fig 3.6. Appearance of the recycled aggregate grains

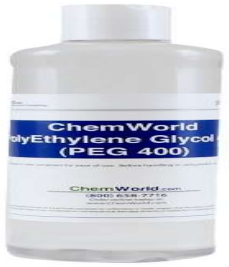
NA RCA

Table: 3.3. Physical Properties

S.No.	Physical Properties	RCA
1	Water absorption (%)	1.56
2	Specific gravity	2.63
3	Bulk Density (kg/ m^3)	1469.8

3.8. SELF-CURING AGENTS (PEG-400):

The polymers added in the mix mainly form hydrogen bonds with water molecules and reduce the chemical potential of the molecules of water which in turn reduces the vapour pressure, thus reducing the rate of evaporation from the surface. The physical and chemical properties of PEG-400 are shown in Table 3.4. Polyethylene Glycol (PEG), also known as Polyethylene Oxide (PEO) or Polyoxyethylene (POE), is the most commercially important polyether used as self-curing agent.



3.9. Super Absorbent Polymer (Sap):

The common SAPs are added at rate of 0–0.6 wt % of cement. The SAPs are covalently cross-linked. They are Acryl amide/acrylic acid copolymers. One type of SAPs are suspension polymerized, spherical particles with an average particle size of approximately 200 mm; another type of SAP is solution polymerized and then crushed and sieved to particle sizes in the range of 125–250 mm.

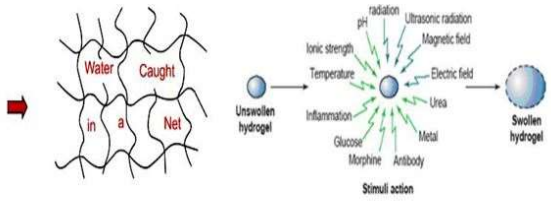


Fig 3.10: Swelling Behaviours of Intelligent Hydrogels

3.10. Water:

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it helps to from the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully, having PH value 7.

MIX DESIGN-(M20 and M30 Mix Design)

Specified minimum strength = 20 N/Sq mm,

Minimum Cement Content = 300 Kgs/cum

TARGET MEAN STRENGTH (TMS)

Statistical constant K = 1.65, b) Standard deviation S = 4.6 Thus, TMS = 27.59 N/Sq mm

Table: 4.4 Mix Proportions for M30 with SAP

Mix	SAP % of cement	SAP (Kg/m³)	Cement (Kg/m³)	Fine aggregate (Kg/m³)	Coarse aggregate (Kg/m³)	Water (lit/m³)
CC	**0%**	0	394	732	1139	197
Mix-1	**0.5%**	1.97	394	732	1139	197
Mix-2	**1.0%**	3.94	394	732	1139	197
Mix-3	**1.5%**	5.91	394	732	1139	197
Mix-4	**2.0%**	7.88	394	732	1139	197

4.3. Batching and Mixing

Batching is process of measuring the quantities of concrete either by volume or by mass for preparation of concrete mix. In this weight batching method is adopted to measure the quantities of fine aggregate, cement, coarse aggregate, and Recycled aggregate. For mix proportion material quantities were measured by using weighing balance. The ingredients of concrete in the required quantities were enhanced into the capacity laboratory concrete mixer.

FIG: 4.1 BATCHING AND MIXING OF CONCRETE

4.4 Casting and Curing Of Specimens

IS standard 150mm×150mm×150mm for cubes, 150mm×300mm for cylinders, and 700mm×150mm×150mm for beams for casting specimens the concrete has been placed in the standard metallic moulds in three layers and compacted with tamping rod by giving 25 blows. Before placing the concrete in moulds, a thin coat of oil was applied for the walls of the mould inside for easy removal. The concrete specimens were air dried for 24-hour and then the specimens are remoulded and then kept for ambient curing.

5. EXPERIMENTAL INVESTIGATION

5.1 Tests on Fresh concrete:

5.1.1 Workability

Slump test is used to determine the workability of fresh concrete. Slump test as per IS: 1199 – 1959 is followed. The apparatus used for doing slump test are Slump cone and Tamping rod.

The difference in level between the height of the mould and that of the highest point of the subsided concrete is measured. This difference in height in mm is the slump of the concrete.

Table: 6.2. Slump test for self-curing concrete (SAP)

S.No.	SAP	M20	M30	M40
1	0%	65	50	40
2	0.5%	93	80	69
3	1%	108	86	80
4	1.5%	116	95	92
5	2%	165	150	125

5.2 Tests on Fresh concrete:

Casting of Concrete Cubes, Cylinders and Beams is done. The test moulds are kept ready before preparing the mix. Tighten the bolts of the moulds carefully because if bolts of the moulds are not kept tight the concrete slurry coming out of the mould when vibration takes place. Then moulds are cleaned and oiled on all contact surfaces of the moulds and initially the constituent materials were weighed and dry mixing was carried out for cement, sand and coarse aggregate and admixtures.

The cubes are demoulded after 1 day of casting and then kept in room for curing at room temperature with a relative humidity of 85% the cubes are taken out from curing after 7 days, 14 days, 28 days and 56 days for testing.

The following are the strength tests which was conducted in the project:

- Compressive strength test
- Split tensile strength test
- Flexural strength test

5.2.1 Compressive Strength Test

Concrete cubes of sizes 150mm×150mm×150mm were tested for crushing strength. Compressive strength depends on loads of factor such as w/c ratio, cement strength, excellence of concrete material and excellence control during manufacture of concrete. These cubes are tested by compression testing machine after 7 days, 14 days, 28 days, 53 days curing. The sample is placed centrally on the base plate of machine and the load have to be apply gradually at the rate of 140 kg/cm2 per minute till the specimen fails.

The cube compressive strength, then **fc=P/A N/mm2**

5.2.2 Split Tensile Strength Test

The tensile strength of concrete is one of the basic and important properties. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. Split tensile strength test was conducted by using the method prescribed by IS5816-1999. Cylinders of 150mm×300mm were used for this test. The specimens was tested for 7, 14, 28, 56 days the cylinder specimen was placed in horizontal direction on the testing machine.

The following relation is used to find out the spilt tensile strength of cylinder

$$Ft = 2P/\pi DL$$

P= Ultimate load in KN, L = Length of the cylinder in mm, D = Diameter of the cylinder in mm.

5.2.3 Flexure Strength Test

Flexural strength test on concrete beam to determine the strength of concrete. Flexural strength test was conducted by using the method prescribed by IS 516 –1959.Beams of dimension 700mm×150mm×150mm were used for this test, the test specimen is placed in the machine at the bearing surfaces of the supporting and loading rollers So that the load shall be applied without shock and increasing continuously at a stress increases at approximately 7 kg/sq mm that is at a rate of loading 400 kg/min for the 150 mm specimens. The load shall be increased until the specimen fails, and the maximum load applied to the specimen during the test shall be recorded.

Where, Modulus of rupture f = PL/BD2

Fig.:5.5 Flexural Strength Testing Machine

6. RESULTS & DISCUSSION

6.1 INTRODUCTION

This chapter explains the mechanical strength properties like compressive strength, split tensile strength, and flexural strength.

The results completed in the present investigation are reported in the form of Tables and Graphs for various percentage of recycled aggregate as a replacement to coarse aggregate. The following are the percentages replacement of cement i.e. 0 to 2% with SAP, PEG and 100% replacement of coarse aggregate with recycled aggregate Fine aggregate with M-Sand

6.1.1 Slump Cone Test

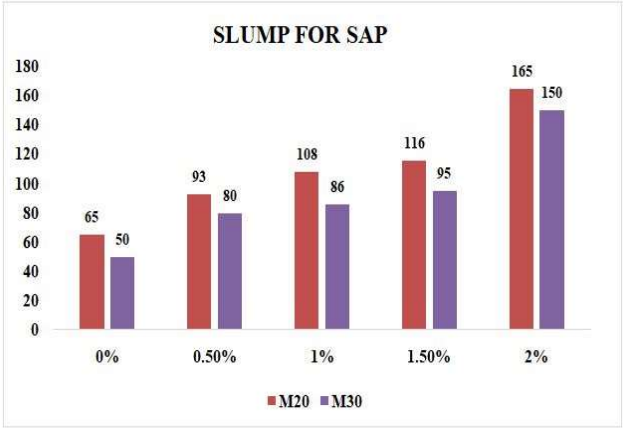


Fig.: 6.3. Slump cone test results SAP

6.1.2 Compressive Strength Test.

Table: 6.6. Compressive strength of concrete with mix design of M30 (SAP)

Mix id	7 DAYS	14 DAYS	28 DAYS	56 DAYS
CC	23.92	30.8	37.9	40.8
S-MIX-1	25.4	29.8	38.4	41.34
S-MIX-2	27.2	30.1	39.9	47.28
S-MIX-3	29.5	32.4	41.2	49.2
S-MIX-4	25.2	29.81	38.2	46.2

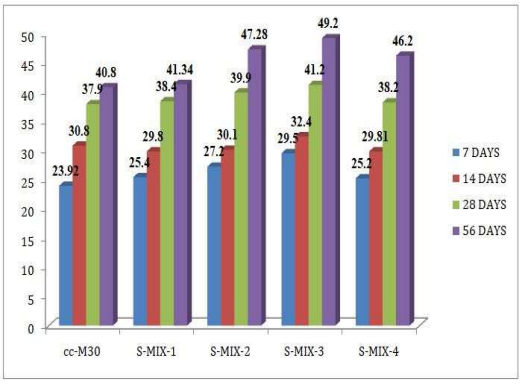


Fig.: 6.7. Compressive strength of concrete with mix design of M30 (SAP)

6.1.3 Split Tensile Strength Test Results

Table: 6.10. Split tensile strength of concrete with mix design of M30 (SAP)

Mix id	7 DAYS	14 DAYS	28 DAYS	56 DAYS
CC	2.2	3.18	3.7	4.2
S-MIX-1	2.7	3.32	4.01	4.8
S-MIX-2	2.92	3.92	4.23	5.21
S-MIX-3	3.18	4.02	4.68	5.6
S-MIX-4	3.01	3.82	4.32	5.23

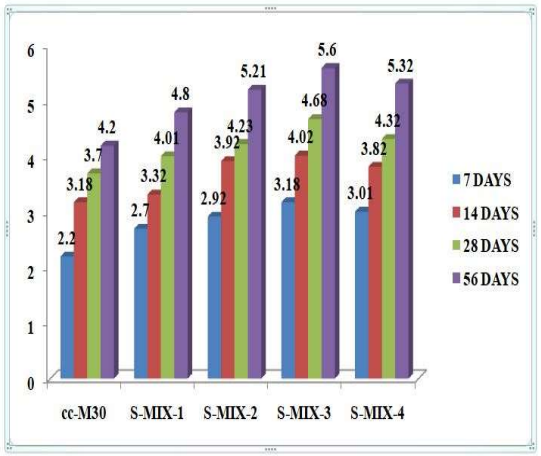


Fig.: 6.11. Split tensile strength of concrete with mix design of M30 (SAP)

6.1.4 Flexural Strength Test Results

Table: 6.13. Flexural strength of concrete with mix design of M30 (PEG)

Mix id	7 DAYS	14 DAYS	28 DAYS	56 DAYS
CC	2.8	3.2	3.9	4.2
P-MIX-1	2.98	3.42	4.02	5.02
P-MIX-2	3.01	3.54	4.8	5.42
P-MIX-3	3.28	3.98	4.92	5.68
P-MIX-4	3.14	3.45	4.58	5.38

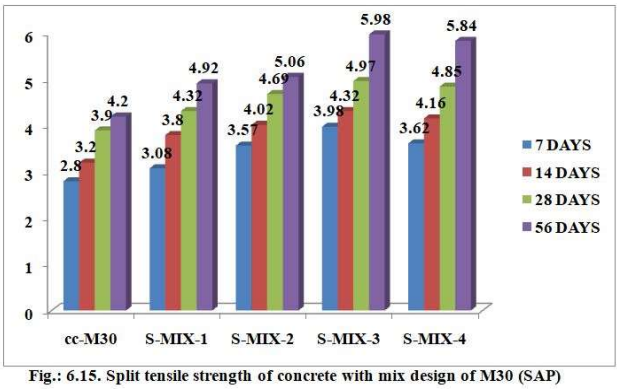


Fig.: 6.15. Split tensile strength of concrete with mix design of M30 (SAP)

CONCLUSION & FUTURE SCOPE

7.1 CONCLUSION

➢It was found that PEG at an optimum dosage gives some better results whereas adding it in excess may decrease the strength of concrete

➢Also, it was found that the optimum dosage for M20 was 1.5% which is similar to remaining M30 grade specimens further increment in dosage will results in decrease in strength i.e., 2% so with this we can conclude that with the increase in dosage of PEG or SAP in concrete decrease in strength results.

➢Compressive strength of concrete with 0.5% to 2% PEG-400 dosage gives higher compressive strength as compared to conventionally cured concrete.

➢In compression with PEG and SAP in the present investigation it is clear that PEG400 gives better strength compare to SAP

7.2 FUTURE SCOPE

➢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**.**

➢Taking present scenario, saving water should be given more priority than money so with the same economic factors of concrete of both conventional and internally cured concrete, we should start adopting internally cured concrete technique in construction field.

➢In further studies we can replace cement with some cementious materials (by products) by adding PEG400 and SAP i.e. self-curing concrete.

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