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# Strength Characterstics Of Self Cured Concrete

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**Abstract** *The strength and durability of concrete depends on the curing of concrete. As per The ACI-308 Code guidelines "internal curing is the process in which the hydration of cement occurs because of the availability of additional internal water that is not part of the mixing Water." Conventionally, curing concrete means creating conditions in which water is not lost from the surface i.e., curing happens 'from the outside to inside'. In contrast, 'internal curing' is allowing for curing 'from the inside to outside' through the internal reservoirs (in the form of saturated lightweight fine aggregates, superabsorbent polymers, or saturated wood fibers) Created. 'Internal curing' many times also referred as 'Self– curing.' Any avoidance in curing will interfere in the strength and durability of concrete. Shrinkage reducing agents and lightweight aggregates such as Polyethylene-glycol and Leca, Silica fume and stone chips are used respectively to achieve effective curing results.*

***Key Words*: Self-curing concrete; Water retention; Relative humidity; Hydration; Absorption; Leca Polyethylene-glycol; Silica fume; Permeability.**

## 1.INTRODUCTION

Concrete is made up of two components, aggregates and paste. Aggregates generally classified into two groups, fine and coarse, and occupy about 60 to 80 percent of the volume of concrete. The paste is composed of cement, water, and entrained air and ordinarily constitutes 20 to 40 percent of the total volume.

In properly made concrete, the aggregate should consist of particles having adequate strength and weather resistance and should not contain materials having injurious effects. A well graded aggregate with a low void content is needed for effectively use of paste. Each aggregate particle is completely coated with paste, and aggregate particles space is completely filled with paste. The concrete quality is greatly dependent upon the quality of paste, which in turn, is dependent upon the ratio of water to cement content used, and the extent of curing. The cement and water combine chemically in a reaction, called hydration, hydration takes place very rapidly at first and then more and more slowly for a long period of time in favorable moisture conditions. More water is used in mixing concrete than is required for complete hydration of the cement. This is required to make the concrete plastic and more workable; however, as the paste is thinned with water, its quality is lowered, it has less strength, and it is less resistant to weather. For quality concrete, a proper proportion of water to cement is essential.

### 1.1 OBJECTIVE OF THE STUDY

- To study the effect of different curing methods on the strength properties of concrete
- To compare the strength and quality of concrete at hardened state using destructive techniques.

## Concrete mixes are prepared based on different curing methods

- Internal curing using PEG-400
- External(membrane) curing method using CUREFREE-C
- Conventional curing method (ponding)

### 1.2 OVERVIEW OF RELATED TESTS

Concrete mixture proportions should always be developed in such a way that the finished hardened concrete will attain the required physical properties and be able to withstand exposure to the anticipated environmental conditions. Equally important is that the freshly mixed concrete should always possess the workability and other characteristics that permit it to be mixed, transported, placed, consolidated, and finished in a timely fashion without hardship under prevailing conditions. After mixtures have been developed and the necessary characteristics that affect workability are determined, it is essential that the may be quantities of ingredients be kept relatively uniform. Non-uniformity evident in freshly mixed and hardened concrete.

### 1.2.1 STRENGTH TEST OF HARDENED CONCRETE

The most common concrete property measured by testing is strength. There are three main reasons for this. First, the strength of concrete gives a direct indication of its capacity to resist loads in structural applications, whether they are tensile, compressive, shear, or combinations of these. Second, strength tests are relatively easy to conduct. Finally, correlation can be developed relating concrete strength to other concrete properties that are measured by more complicated tests.

Strength tests of concrete specimens for three main purposes:

- For research
- For quality control and quality assurance
- For determining in-place concrete strength

### 1.2.2 COMPRESSIVE STRENGTH TEST

The cubes were tested on compression testing machine of capacity 2000KN. The bearing surface of 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 casted i.e. 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.

$$\text{Compressive Strength} = \frac{P}{A}$$

Where,

P= load in KN

A= area

### 1.2.3 TENSILE STRENGTH TEST

There are currently no standardized test procedures for determining the direct tensile strength of concrete, that is, the strength under uniaxial tension. This is due to the difficulty involved in inducing pure axial tension within a specimen without introducing localized stress concentrations. Knowledge of the tensile strength of concrete is important because it determines resistance to cracking. Therefore, several test procedures have been developed to indicate indirectly the tensile strength of concrete. These include: -

- Split Tensile Strength of Cylindrical Concrete Specimens.
- Using Simple Beam with Third-Point Loading.
- Using Simple Beam with Centre-Point
- Loading.

### 1.2.4 MODULUS OF RUPTURE

The beam specimens were tested on universal testing machine for two-point loading to create a pure bending. The bearing surface of machine was wiped off clean and sand or other material is removed from the surface of the specimen. The two-point bending load the beam specimens were tested on universal testing machine for two-point loading to create a pure bending. The bearing surface of machine was wiped off clean and sand or other material is removed from the surface of the specimen. The two-point bending load applied was increased continuously at a constant rate until the specimen breaks down and no longer can be sustained. The maximum load applied on the specimen was recorded. The modulus of rupture depends on where the specimen breaks along the span. If the specimen breaks at the middle third of the span then the modulus of rupture is given by

$$\text{Flexural Strength} = \frac{WL}{bd^2}$$

If the specimen breaks at a distant of 'a' from any of the supports then the modulus of rupture is given by

$$\text{Flexural strength} = 3wa/bd^2$$

where

W= load at failure

L=length of specimen(500mm)

a= distance from one support in mm

b=width of specimen(100mm)

d=depth of specimen(100mm)

## 2. LITERATURE REVIEW

In order to study closely and sparsely related studies in the field of curing techniques adopted in the construction of concrete structures or the use of self/ internal curing compound literature review was carried out. The various journals like Science Direct, ACI Journals as well as various text books on concrete and bundles of material from internet were referred for the analysis of the above problem. Self Cured concrete is still not conventionally used in construction industry but still continuous improvements are being made to optimize them. Some of the research studies on the properties, uses, shortcomings and behaviour of internal curing methods have been highlighted in the following paragraphs.

**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.

**Patel Manishkumar Dahyabhai, Prof. Jayeshkumar Pitroda** studied on "introducing the self-curing concrete in construction industry". Compressive strength of self-curing concrete is increased by applying self-curing admixtures. The compressive strength of concrete mix increased by 37% by adding 1.0% of PEG600 and 33.9by adding 1.0% of PEG1500 as compared to the conventional concrete. The optimum dosage of PEG600 for maximum compressive strength was found to be 1% of weight of cement for M25 grade of concrete. The optimum dosage of PEG1500 of maximum compressive strength was found to be 1% of weight of cement for M25 grade of concrete. Self-curing concrete is the best solution to the problem faced in the desert region and faced due to lack of proper curing.

**Basil M Joseph** Studied on self-curing concrete and PEG400 were used as a self-curing agent in concrete. M20 grade of concrete is adopted for investigation. He added 0-1.5% of PEG400 by weight of cement for M20 grade concrete from that he found 1% of PEG400 by weight of cement was optimum for M20 grade of concrete for achieve maximum strength. He also found that if percentage of PEG400 gets increased slump as well as compaction factor also increased.

**Shikha Tyagi** Studied on self-curing concrete and had use PEG400 as a self-curing agent in concrete. M25 and M40 grade of concrete are adopted for investigation. She added 1-2% of PEG400 by weight of cement for M25 and M40 grade concrete. She was concluded that the optimum dosage of PEG400 for maximum Compressive strength was to be 1% for M25 and 0.5% for M4O grades of concrete.

**Dayalan J** had used super absorbent polymers as a self-curing agent in concrete. He was added 0.0-0.48% of super absorbent polymer by weight of cement for M25 grade concrete. He was found that super absorbent polymer 0.48% by the weight of cement provides higher compressive, tensile as well as flexural strength than the strength of conventional mix.

## 3. 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

- two grades of concrete has been selected for the research work **M25, and M30**
- Mix design of concrete to be done as per IS: 10262-2009
- testing of ingredients of concrete mix

**Cement:**

OPC (43 grade) conforming to IS: 8112-1989

**Fine Aggregate:**

Conforming to IS: 383-1970

**Coarse Aggregate:** Conforming to IS: 383-1970

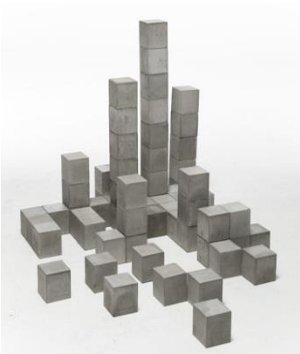
**Water:** Potable water available in the laboratory for mixing and curing. (IS 456- 2000)

- All tests related to the ingredients of concrete and the entire study to be performed at the Civil Engineering Department, KIET, Ghaziabad.
- Preparation of concrete mix for production of concrete as per Is 10262-2009
- Preparation of test samples using OPC (43 grade) cement with following combinations

| S. No. | Type of Concrete Mix for one grade |
|---|---|
| 1 | Conventional concrete mix |
| 2 | Concrete mix with PEG-400 as internal curing compound |
| 3 | Concrete mix with CUREFREE-C as external curing compound |

### 3.1 Combination of various mixes

- Preparation of cubes and beams from the different grades as stated above.
- From each mix the specimens are to be cast and tested at 7and 28 days.
- 3 Nos. of Cubes for each grade for the determination of 7 and 28 days characteristic compressive strength.
- 3 Nos. of Beams for each grade for determining of 7 and 28 days flexural strength.



### 3.2 Specimens to be casted for testing purpose

| S.No. | NATURE OF CURING | M25 | | M30 | |
|---|---|---|---|---|---|
| | | CUBE | BEAM | CUBE | BEAM |
| 1. | CONVENTIONAL(PONDING) | 6 | 6 | 6 | 6 |
| 2. | EXTERNAL CURING | 6 | 6 | 6 | 6 |
| 3. | INTERNAL CURING (PEG-400 having quantity (0.5%) | 6 | 6 | 6 | 6 |
| 4. | INTERNAL CURING (PEG-400 having quantity (1%) | 6 | 6 | 6 | 6 |
| 5. | INTERNAL CURING (PEG-400 having quantity (1.5%) | 6 | 6 | 6 | 6 |
| 6. | INTERNAL CURING (PEG-400 having quantity (2%) | 6 | 6 | 6 | 6 |
| | | | | | |

## 4. EXPERIMENTAL WORK CONDUCTED

Various test was done on the ingredients of concrete to collect data require for mix design as well as to study their physical properties. The proportions of ingredients for M25 and M30 for all the three types of mixes were determined by mix design and same proportions were used for casting the concrete specimens (cubes and beams).

- Mix designs were done as per IS: 10262-2009.
- Materials were weighed by weigh batching.
- Each set consists of 3 specimens (cubes and beams) and the test strength of the sample has been taken as the average strength of the specimens.
- 36 numbers of cubes 150mm x 150mm x 150mm were casted to determine the compressive strength of various mixes of concrete at the end of 7 and 28 days.
- 36 numbers of beams 100mm x 100mm x 500mm were casted to determine the flexural strength of various mixes of concrete at the end of 7 and 28 days.
- The details of all the mix design are shown in the table below.

## 5. RESULT AND DISCUSSION

**Table 6.1 Strength test results of various mixes for M25 Grade of Concre**

| MIX | AVG. COMPRESSIVE STRENGTH(N/mm²) | | AVG. FLEXURAL STRENGTH (N/mm²) | |
|---|---|---|---|---|
| | 7 days | 28 days | 7 days | 28 days |
| CONVENTIONAL | 26.66 | 48 | 6.25 | 8.5 |
| PEG-400 (0.5%) | 21.11 | 32.33 | 3.75 | 3.85 |
| PEG 400 (1%) | 25.11 | 33.77 | 3.625 | 4 |
| PEG 400 (1.5%) | 27.55 | 34.4 | 3.8 | 4.25 |
| PEG 400 (2%) | 17.33 | 26.67 | 3.25 | 3.5 |
| CUREFREE-C | 28.44 | 31.11 | 5.0 | 5.25 |

Average Compressive and Flexural strength for 7 and 28 days obtained by taking average of 3 specimens for each day are compiled below.

### Analysis and Comparative study of various mixes for M25 grades of concrete

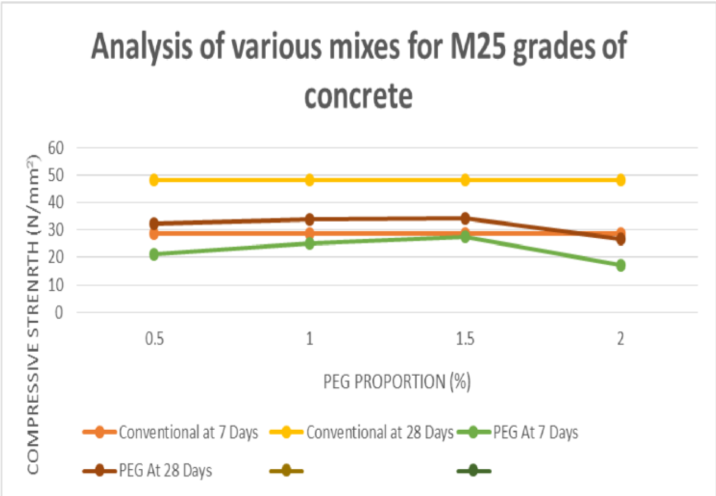
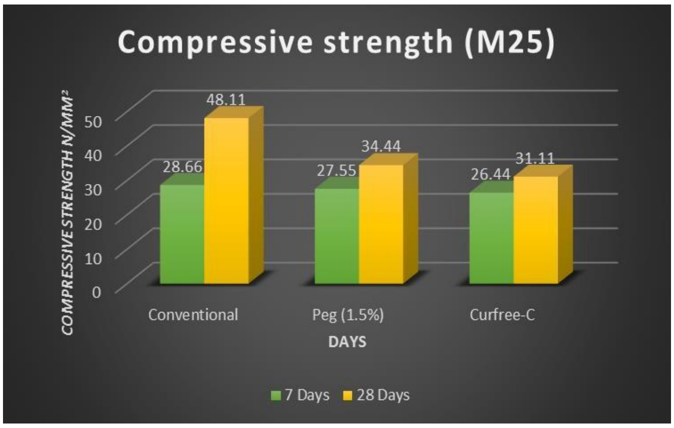
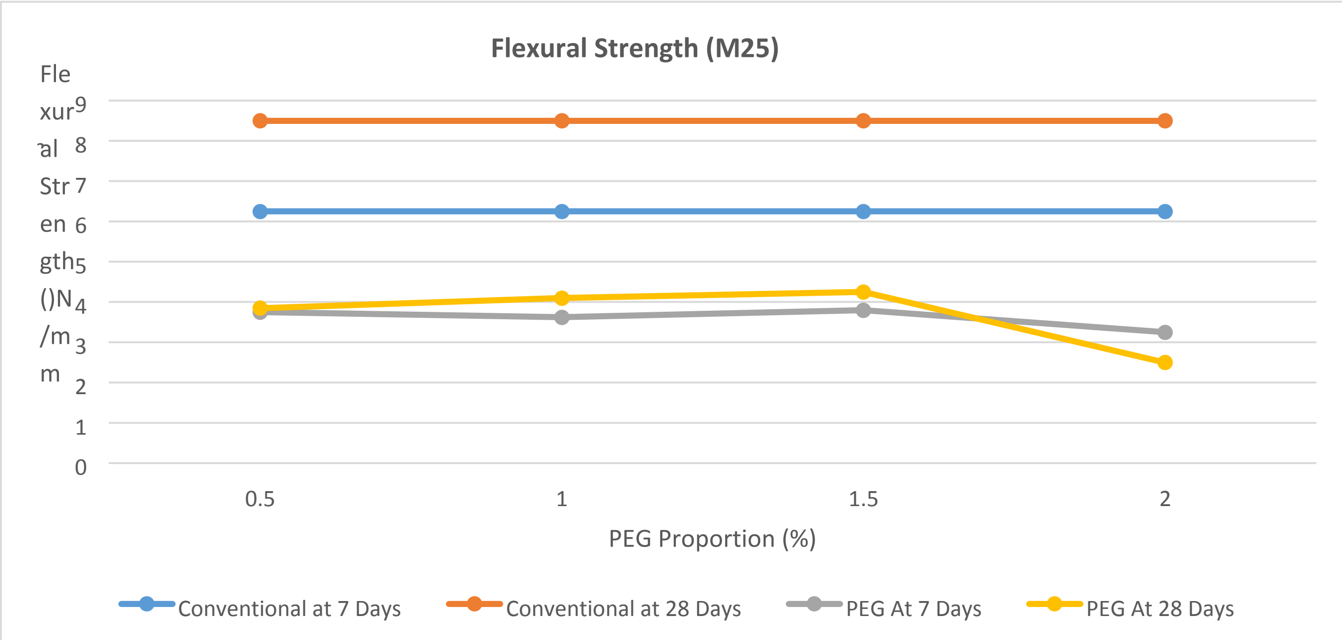



*Figure 6.1: Compressive Strength of M25 grade concrete for various mixes*





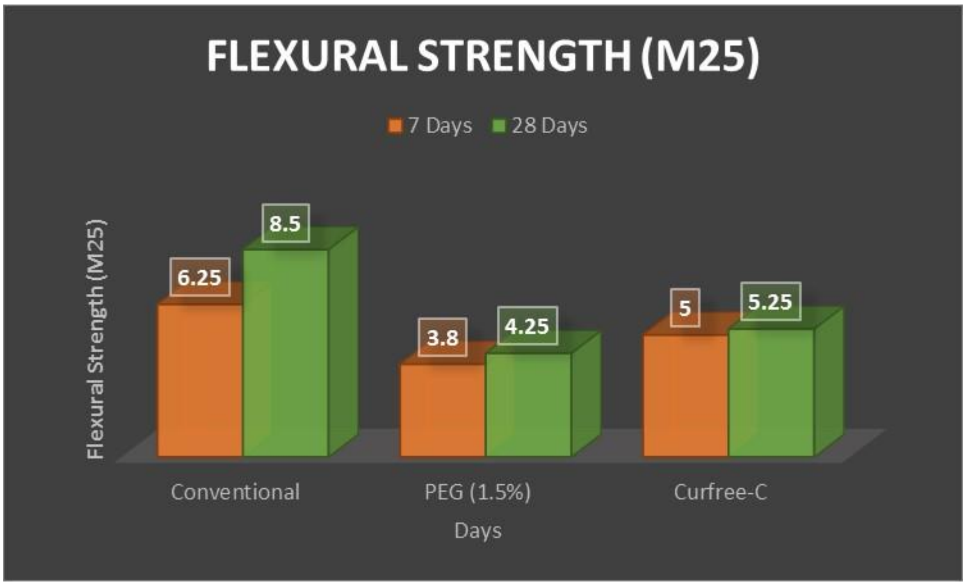
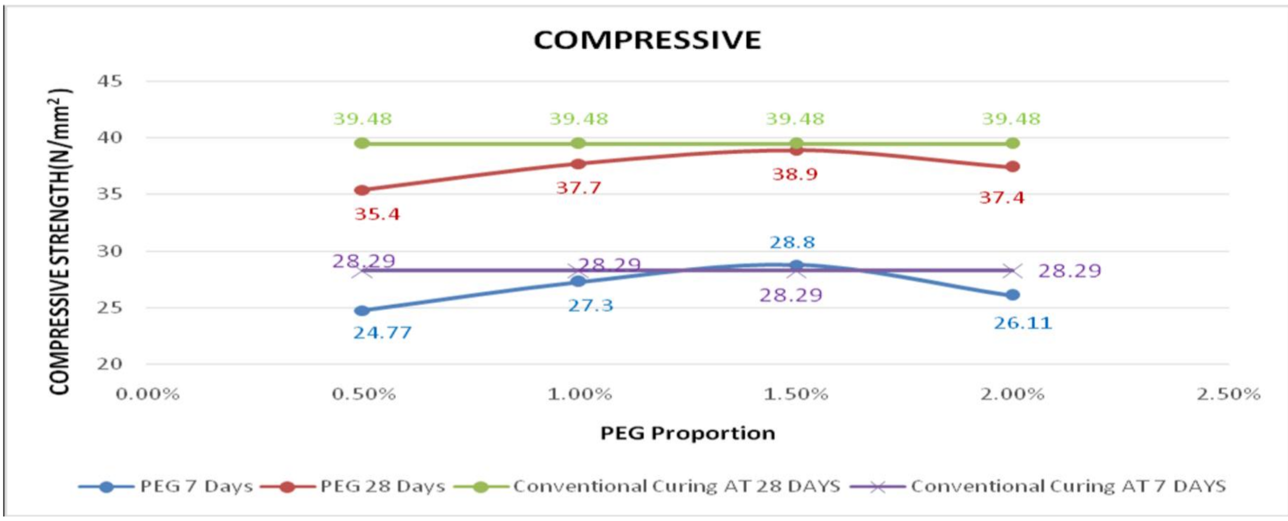




**Figure 6.2:** ***Flexural Strength of M25 grade concrete for various mixes***

Analysis an d Comparative study of various mixes for M30 grades of concrete



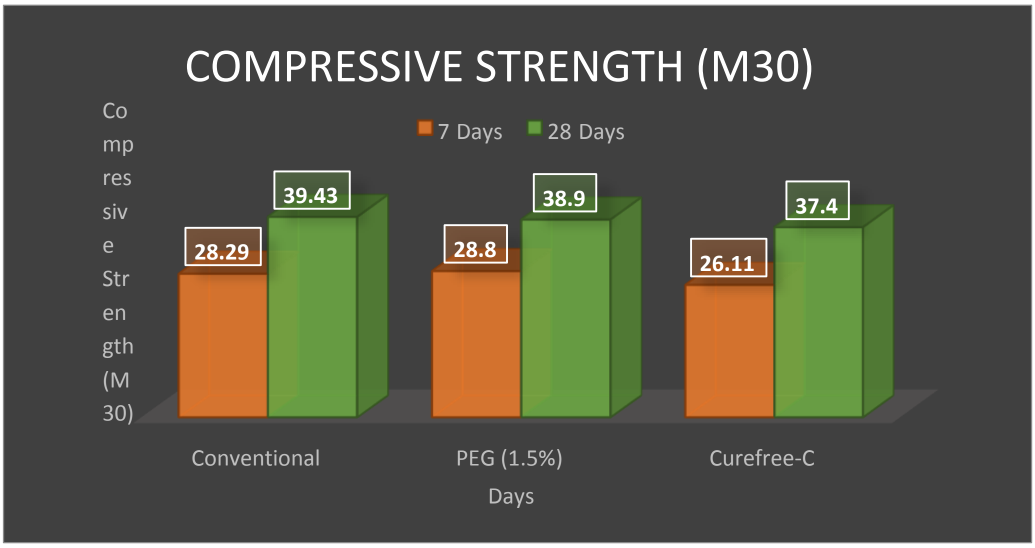
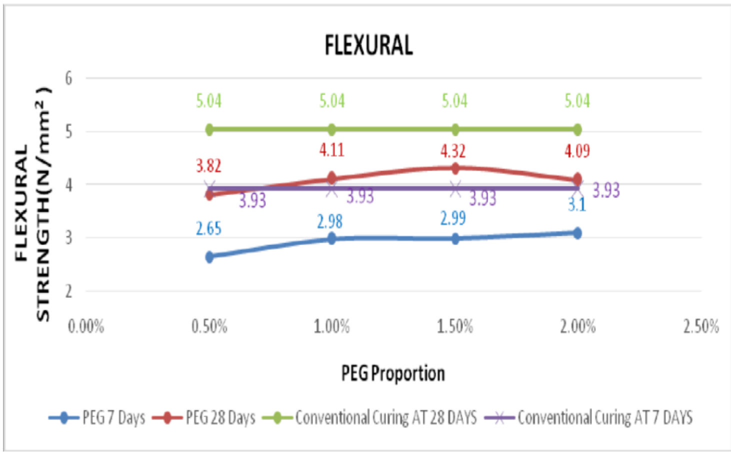




**Figure 6.3:** ***Compressive Strength of M30 grade concrete for various mixes***



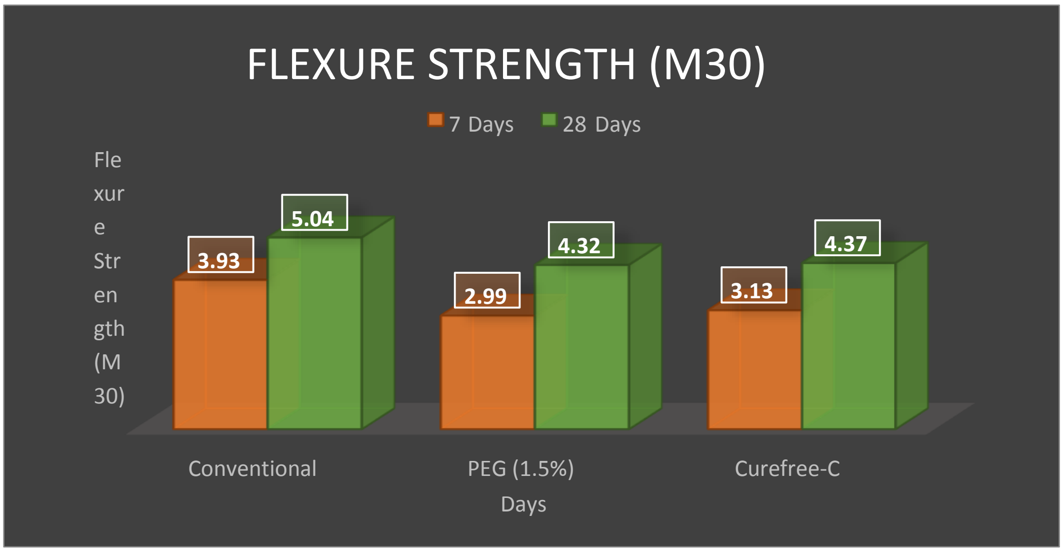



**Figure 6.4:** ***Flexural Strength of M30 grade concrete for various mixes***

The test results are obtained by keeping the mix proportions constant without any inclusion of plasticizers and super-plasticizers. Only curing compounds are additionally added in the mix as a substitute of curing water.

The strength of concrete achieved by conventional curing is higher as compared to internal and external curing methods. The results obtained from conventional curing method (ponding) are under ideal conditions when the specimens are kept completely submerged in water for 7 days and 28 days. Such long and ideal curing conditions may not be possible under actual site conditions. Thus, these results do not give a true picture of conditions existing at construction sites.

Concrete mixes prepared using curing compounds did not reach specified target strength values calculated during design mix for both M25 and M30 grade of concrete. But it can be seemed that the minimum strength as per the codal provisions has been achieved by the specimens cured through curing compounds. The strength achieved by PEG-400 and CUREFREE-C is comparable for both types of mix i.e. M25 and M30.The results obtained after the use of curing compounds show a better picture of the actual site Site conditions in comparison to those obtained from conventional curing techniques. Only the environmental conditions existing at site and laboratory may vary. Rest all parameters are more or less the same.

The strength achieved by cubes and beams cured through curing compound (both PEG-400 and CUREFREE-C) is nearly 85.66% of that achieved through conventional curing method for both M25 and M30 grade of concrete.

Approximate strength analysis can be taken up using non-destructive analysis techniques provided the test results are properly interpreted.

The extra cost of procuring water from deep underground or far off sources especially in developing areas can be saved by the use of curing compounds. Also continuous supervision by labor to ensure good moisture and temperature conditions for maintaining satisfactory curing conditions is avoided. Thus any fault or delay in curing would not affect the structural strength in the long run.

## 5. CONCLUSIONS

- Plain concrete needs congenial atmosphere for a minimum period of 28 days for good hydration and to attain desired strength. Any laxity in curing badly affects the strength and durability of concrete. India has predominantly hot climate for most of the year. Within 2 or 3 hours, high ambient temperature and evaporation causes rapid shrinkage on freshly completed concrete structures, resulting in shrinkage cracks. Here pond curing cannot be executed since concrete has not attained hardened state. Also, additional labor is required to ensure proper curing at least 3-4 times a day for a minimum seven days. Depletion of water resources at a very fast rate is a very big concern these days. Water resources needs to be conserved specially in arid regions where there is a lot of water scarcity. It is said that around 1 $m^3$ of concrete requires nearly 3 $m^3$ of water for construction most of which is for curing.

- All this led to the need to develop self-curing agents. 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 concrete. These compounds will rise to the finished concrete surface and effectively seal the surface against evaporation.

- The aim of the project was to compare the test results based on curing conditions only. No changes have been done in the mix design for the three types of mix. The results achieved from the tests conducted on specimen casted using curing compounds are very satisfactory. Though they are not able to achieve the target strength as per mix design but the minimum strength as per codal provisions has been achieved. Results show that there is continuous increase in the strength of specimens for a period of 28 days. Higher strength results can be easily achieved by the use of plasticizers and super-plasticizers, reduction of water cement ratio and the addition of external cementitious compounds. Curing compound has the advantage of being used and left with no further maintenance. The strength results of conventionally cured specimens have been obtained after 28 days of proper curing which may not be possible at site as continuous vigilance is required to see that the surface moisture is not lost. In this regard, the strength results obtained by the use of curing compound are very near to that of site conditions.

- Thus, our experimental study has been successfully completed. We have been able to achieved good concrete quality with sufficient strength. The results show that curing compounds have the potential of replacing water as the curing agent. Further study is required to check the durability of self cured concrete structures. With research work going on in this field, self-cured concrete structured will become very common and curing compounds will gain a lot of importance in the upcoming years.

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