# EFFECT ON CHARACTERISTIC COMPRESSIVE STRENGTH OF CONCRETE BY REPLACING CEMENT PARTIALLY WITH HYPO SLUDGE

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**ABSTRACT**

Energy plays a crucial role in growth of developing countries like India. To save energy and to earn carbon credit is very much essential for the betterment of mankind. Now a day there is low availability of non-renewable energy resources, and also large requirements of Building Construction Materials like cement, etc.. The global cement industries contributes about large amount of greenhouse gases emission to earth's atmosphere and industrial waste are being produced Largely by chemical process in the India. In order to reduce cement manufacturing and disposal problem of paper waste, there is need to develop alternative binding material in construction field. Utilization of paper industry waste product as supplementary cementitious material in concrete is very important aspect in view of economical, environmental and technical reasons. This study summarizes that the research work on the behavior of concrete while adding of hypo sludge with different proportion as part replacement of cement in concrete by using test like Compression strength test, Split Tensile Strength test and Flexural Strength Test. The experimental investigation is carried on M20 and M30 grades of concrete with the replacement of cement with hypo sludge in the percentages of 0%,5%, 10%, 15% and 20 %. The experimental investigation gives results that the test results are increasing their strength values up to some initial Percentage replacement of cement by Hypo sludge and further replacement are carried out then strength results are falling down.

**Keywords :** *Cement, Hypo Sludge, Workability, Compression strength test, Split Tensile Strength test and Flexural Strength Test.*

## I. INTRODUCTION

A nations development not only depends upon the new emerging trends and technologies but also the infrastructure of that particular nation. The present situation in our country mainly focuses on the infrastructure development thus leading to a wealthy nation. Hence construction industry is the key route for the success of infrastructure development. Without concrete, the infrastructure is not a possible thing. Concrete is the combination mixture of various materials like cement, Fine Aggregate, Coarse Aggregate and water. Fine aggregate and coarse aggregate are natural resources. Cement is also a material whose raw material is found in nature. Cement production is not only expensive, but also very energy intensive. Producing one ton of conventional Portland cement releases nearly one ton of carbon dioxide into the atmosphere. As a result, the cement production process accounts for 5% of global $CO_2$ emissions. Therefore, it is necessary to substitute cement for concrete. Some of them are Fly ash, metakaolin, copper slag, quarry dust, GGBS, micro silica, egg shell powder, hypo sludge, coconut shell ash, waste glass powder, rice husk ash, saw dust, etc., can be used as partial replacement of cement. This study involves the utilization of Hypo sludge as a partial replacement of cement in concrete. Hypo sludge (paper industry waste) has a tremendous potential in this context and it is well documented that the use of hypo sludge in concrete results in a significant improvement is the rheological prosperities. During the production of paper, various wastes are generated from different processes in the paper industry. Because of its low calcium content, it is recovered from pre-waste called hyposludge for projects replacing cement use in concrete. If this low sludge contains low calcium content, it contains the highest amount of calcium chloride and the lowest amount of silica. Hyposludge

behaves like cement due to the properties of silica and magnesium. These silica and magnesium enhance the hardening of concrete.

**HYPO SLUDGE**

Pulp and paper processing includes the following processes in which Hypo sludge is produced from waste products that are pure chemical waste and do not contain biodegradable materials. Most mills use only wood products (bamboo, eucalyptus, casuarinas, poplar and other hardwoods), but some use large quantities of pulp as a raw material. Most paper mills in India use lime and chlorine to prepare bleach (calcium hypochlorite).

Six of the eight mills use CO2 as a partly substitute for chlorine or as a bleaching agent in the final stage of bleaching to achieve the highest gloss level.

Benefits of hypo sludge

• Environmentally friendly

• Hypo sludge improves the concrete surface due to the presence of silica and magnesium

• Hypo sludge is heavier than conventional concrete

• Hypo sludge improves 4 of new stones 4 Protection. Limitations

• Availability of secondary sludge

• Disposal issues

**OBJECTIVE OF WORK**

- To investigate the utilization of Hypo Sludge as Supplementary Cementitious material (SCM) and influence of this hypo sludge on the Strength of concrete.
- To study the suitability of supplementary cementitious materials (SCMs) like hypo sludge.
- To find out the optimum percentage of hypo sludge in concrete in the place of cement.
- To compare the compressive strength of conventional concrete with hypo sludge concrete.
- To compare the split tensile strength and flexural strength of conventional concrete with hypo sludge concrete.

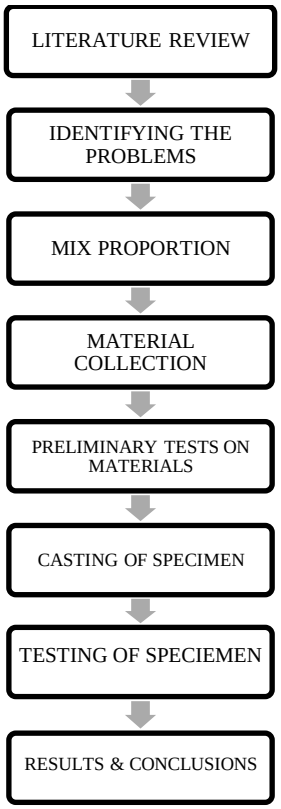
## II. LITERATURE REVIEW

There are various investigation are carried on concrete for a partial percentage replacement of cement by Hypo sludge for various grades of concrete and also taking the Workability test, concrete strength test like compression strength test ,split tensile strength test and flexural strength.

**Santosh Ahirwar et al (2018)** in this research work hypo sludge is partially replaced by OPC cement with different percentages of dry weight of cement. The experiment was conducted on M40 grade concrete as per relevant IS code of practice based on that test results are obtained. The target strength attained mix of 10% of hypo sludge in concrete. After that increasing % strength will decreases.

**Naitam and Khan (2019),** The innovative use of hypo sludge in concrete formulations as a supplementary cementation's material was tested as an alternative to traditional concrete. These tests were carried out to evaluate the mechanical properties like compressive strength up to 28 days. This research work is concerned with experimental investigation on strength of mortar and optimum percentage of the partial replacement by replacing cement via 4% to 16% of Hypo Sludge. Keeping all this view, the aim of investigation is the behavior of mortar while adding of waste with different proportions of Hypo sludge in mortar by using tests like compression strength.

## III. METHODOLOGY




**MATERIALS USED**

The materials used are cement, fine aggregate, coarse aggregate, hypo sludge ,water, and super plasticizer.

**i) Cement**

The cement used was OPC Cement. It was tested as per the Indian Standard specifications IS 12269-2013. The cement was kept in humidity-controlled room to prevent it from being exposed to moisture. and have been tested at the Concrete Laboratory of Anamacharya Institute of Technology and Science, Kadapa.

**ii) Fine Aggregate**

Sand used in this experimental program was locally procured. It was tested for various physical properties in accordance with IS 2386 (Part 3) - 1963. Fine aggregate was natural sand conforming to zone III of IS 383-2016 passing through 4.75 mm size sieve. The specific gravity and fineness modulus are found to be 2.59 and 2.64.

**iii) Coarse Aggregate**

Locally available crushed granite aggregates having the size of 20mm were used in the present work. Testing of coarse aggregates was done as per IS 2386 (Part 3) -1963. Sieve analysis was performed according to IS 383-2016

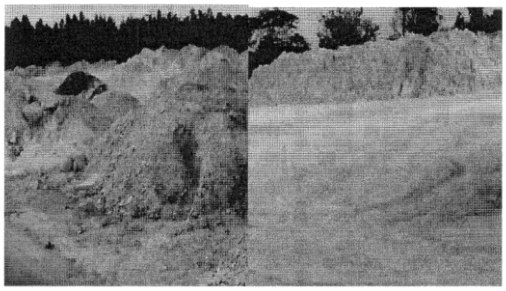
**iv) Hypo sludge**

Hypo sludge was obtained from DELTA PAPER MILLS (Bhimavaram, Andhra Pardesh, India).It was then oven dried and sieved through 90 µm Indian standard sieve. The specific gravity of the Hypo sludge was found to be 2.80. Hypo sludge contains low calcium and maximum calcium chloride and minimum amount of silica. Hypo sludge behaves like cement beause of silica and magnesium properties. This silica and magnesium improve the setting of the concrete. We replaced cement with hypo sludge by 0,5,10,15 & 20%.

**Table 1 Constituents of Hypo Sludge**

| Sl.No | Constituent | Percentage (%) |
|---|---|---|
| 1 | Acid insoluble | 11.1 |
| 2 | Silica ($SiO_2$) | 9.0 |
| 3 | Magnesium oxide(MGO) | 3.3 |
| 4 | Calcium oxide (CaO) | 46.2 |
| 5 | Moisture | 56.8 |

In the paper factories production of Hypo sludge is estimated about 35% of the daily production. These hypo sludge wastes are used as an ingredient of cement production. The various properties of raw hypo sludge are shown in Table. It indicates moisture 56.8% and MGO as 3.3% and Calcium Oxide as 46.2%.



**v) Water**

Water is an important ingredient of concrete as it actively participated in chemical reaction with cement, clean portable water which is available in our college campus is used.

Detailed description of the materials used and their physical properties has been presented. The mix design for M20 and M30 grade of concrete according to IS: 10262-1982 has been designed. The following tables 1 and 2 gives the design stipulations of grades of M20 & M30 concrete respectively.

**Table 1. Mix proportions of M20**

| Grade | M20 |
|---|---|
| Proportion | 1 : 2.06 : 3.16 |
| w/c ratio | 0.50 |
| Cement | 372 |
| Fine Aggregate | 768.834 |
| Coarse Aggregate | 1177.63 |
| Water | 186 |

**Table 2. Mix proportions of M30**

| Grade | M30 |
|---|---|
| Proportion | 1 : 1.83 : 2.95 |
| w/c ratio | 0.48 |
| Cement | 398.95 |
| Fine Aggregate | 730.340 |
| Coarse Aggregate | 1177.02 |
| Water | 191.5 |

## IV. EXPERIMENTAL INVESTIGATION

The following steps are included in this phase

1. Design of concrete mix
2. Mixing of concrete
3. Test Specimens
4. Preparation of Moulds
5. Harden properties of SCC
6. Observations and Test Results

1. Design of concrete mix

The mix design for M25 SCC mix is explained in the (Mix Design).

2. Mixing of concrete

**Fig 1. Mixing of concrete**

3. Test specimens

**Fig 2. Test specimens**

4. Preparation of moulds

**Fig 3. Preparation of moulds**

5. Hardened properties of concrete

The compressive strength, tensile strength and flexural strengths of the used samples was measured with a compressive testing machine and flexure beam apparatus.

## V. RESULTS & DISCUSSIONS

### FRESH PROPERTIES OF SCC

Following are the test result obtained from slump cone test for various grade and % replacement of Hypo sludge for various grades of concrete.

**Table 3.Slump cone results for M20 & M30**

| Grade/ %Replacement | M20 | M30 |
|---|---|---|
| 0% | 140 | 120 |
| 5% | 125 | 95 |
| 10% | 95 | 80 |
| 15% | 70 | 75 |
| 20% | 55 | 50 |

### HARDENED PROPERTIES

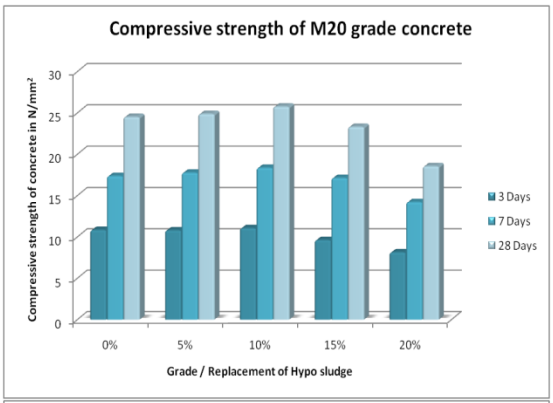
The hardened properties of concrete are compressive, tensile and flexural strength of concrete. In this work, the compressive strength is carried out and the results are discussed below.

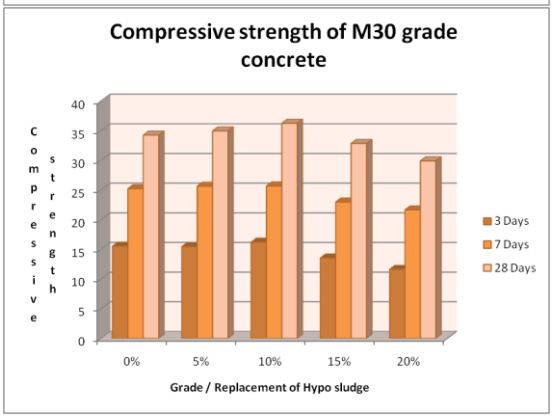
### COMPRESSIVE STRENGTH RESULTS

The compressive strength test was carried out on 150mm x150mmx150mm cubes as specified by IS 516-1959(1989). The results of the compressive strength with cement by Hypo suldge at 7 days, 14 days and 28 days for M20 & M30 grade concrete are given below.

**Table 4. Compressive strength of M20&M30 grade for 28 days**

| GRADE/% | Compressive strength($N/mm^2$) M20 | Compressive strength($N/mm^2$) M30 |
|---|---|---|
| **0%** | 29.52 | 40.25 |
| **5%** | 30.22 | 42.96 |
| **10%** | 32.77 | 45.25 |
| **15%** | 35.32 | 47.85 |
| **20%** | 25.56 | 34.91 |




**Observations :**

1. As the % of Hypo sludge increases from 5% to 10% the value of compressive strength are increases than the normal concrete strength for every grade of concrete.

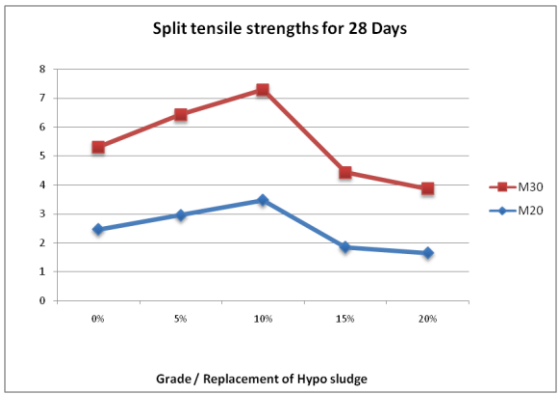
2. When the Hypo sludge % increases 15% & above 15% the values of compressive strength are goes on reducing, but for 15% replacement of hypo sludge the values of compressive strength are more than the required grade.

**SPLIT TENSILE STRENGTH**

The test result shows below are the Split Tensile Strength Test for grade M20 and M30 for 7and 28 days.

**Table 5. Split tensile strength of M20 & M30 grade**

| GRADE/% of replacement | 28 Days | 28 Days |
|---|---|---|
| **0%** | 2.456 | 2.850 |
| **5%** | 2.960 | 3.468 |
| **10%** | 3.470 | 3.820 |
| **15%** | 1.840 | 2.590 |
| **20%** | 1.650 | 2.220 |




**Observations :**

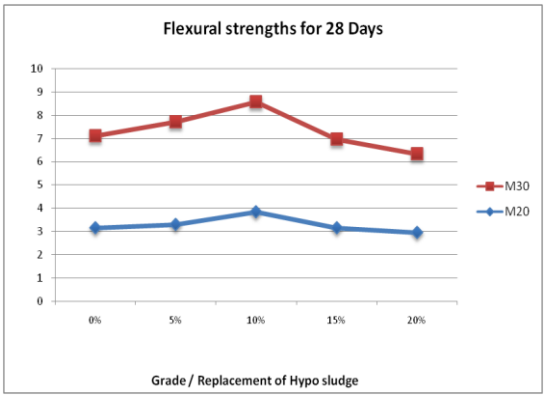
1. As the % replacement of cement by hypo sludge increases from 5% to 15% the value of Split Tensile strength test are increases than the normal concrete strength for M20 grade of concrete.
2. As the % replacement of cement by Hypo sludge increases from 5% to 10% the value of Split Tensile Strength test are to be increases than the normal concrete strength for M30 grade of concrete.
3. When the Hypo sludge % is increases up to 15% & above 15% the values of Split Tensile strength Test is to be goes on reducing.

**FLEXURAL STRENGTH**

The below test result shows the Flexural Strength Test for grade M20 and M30 for 7and 28 days.

**Table 6. Flexural strength of M20 &M30 grade**

| GRADE/% of replacement | 28 Days | 28 Days |
|---|---|---|
| **0%** | 3.160 | 3.950 |
| **5%** | 3.304 | 4.412 |
| **10%** | 3.835 | 4.739 |
| **15%** | 3.156 | 3.810 |
| **20%** | 2.950 | 3.382 |




**Observations :**

1. As the % replacement of cement by hypo sludge increases from 5% to 15% the value of Flexural strength test are increases than the normal concrete strength for M20 grade of concrete.
2. As the % replacement of cement by Hypo sludge increases from 5% to 10% the value of Flexural Strength test are to be increases than the normal concrete strength for M30 grade of concrete.
3. When the Hypo sludge % is increases up to 15% & above 15% the values of Flexural strength Test is to be goes on reducing.

## VI. CONCLUSIONS

**CONCLUSION :-**

1. The slump decreased when a higher amount of hyposludge content was included. The sludge exhibited a high water-absorption capability. Consequently, when a higher amount of hypo-sludge was included in the mixture, it required more water to achieve a given Target slump.

2. Several factors could lead to adverse effects on the workability of paper pulp concrete. The amount of hyposludge replacement, hypo sludge physical properties, and the carbon content of the hypo-sludge would be the main reasons for the reduction of concrete workability.

3. Effects of hypo sludge on hardened concrete.

I. The compressive strength value increases up to 10% replacement and above 10% replacement of

cement by hypo sludge the values of compressive strength test values are decreasing. But at 15% replacement the result for all grades are more than required grade.

II. The split tensile and flexural strength test was carried out for 7 and 28 days, respectively. The values of test result are increase up to 10% replacement and above 10% replacement of cement by hypo sludge the values of split tensile strength and Flexural strength values are goes on reducing for both strength tests.

III. The decrease in compressive strength spilt tensile test &flexural strength values with increase in hypo sludge content is due to lack of Silica &Magnesia content in the hypo sludge.

IV. Use of hypo sludge in concrete can save the paper industry disposal costs and produces a greener' concrete for construction. And also make the Structure light in weight.

V. The setting time of concrete will be increased above 15% replacement of cement by hypo sludge due to lack of alumina content.

VI. Considerably this type of concrete will be used for road works effectively with less consumption of cement, also it is used for PCC work, Making of paver blocks etc.

**FUTURE SCOPE FOR STUDY**

Through this study we have already come to the conclusion that Hypo sludge would be the best cementitious product to replace the cement in concrete mix. . Hypo sludge in near future is the best solution to produce the concrete. As the concrete forms the major component of any structure without which the structure could not be finished and also it has big financial value too. Developers now a day's looking to save the money by producing the concrete with replacement of some of its ingredient and without affecting its quality. Apartfrom this we should also look seriously towards theeffect of fire and temperature on Hypo Sludge concrete.

Hypo sludge is the waste produced by paper industry sosome research is required to be carried out in abovearea. Already we have come across these products likefly ash which is used widely in construction industry. So we shall be rest assure that our research subject possess high significance and future of concrete belongs to the Hypo sludge.

Hence, Following Point should be considered for better performance of Hypo sludge in concrete.

1. From above conclusion for better workability test result of concrete mixed with hypo sludge we can add the admixture like Plasticizer and super plasticizer in proper amount in concrete.
2. It has been noted that at15% and above 15% the test results are likely to fall due to lack of silica. content and magnesia content, hence one should add the proper amount of siliceous material like reactive powder (silica fume, quartz powder).
3. The setting time can be optimized by adding alumina content.
4. This Project work has been carried out for PCC work, therefore for R.C.C work Hypo sludge can be utilized.
5. Replacement of Natural sand with different proportion of M-sand With Hypo sludge can be carried out.
6. Improvement in the strength can be observed beyond 15%replacement with good quality of hypo sludge.
7. Replacement of fresh coarse aggregate with different proportion of recycled coarse aggregate with hypo sludge can be carried out.
8. Combination of fly ash and hypo sludge with different proportion can be utilized for plain concrete or reinforced cement concrete.

**REFERENCES**

[1] Katru Sai Teja, Koduru Uday Kumar and P. Venkata Sarath, "Hypo Sludge as a Partial Replacement of Cement in Concrete", International Journal of Civil Engineering and Technology., vol. 8, no. 4, (2017), pp.1645-1651.

[2] Mansi Rudrawar and Mr.Sangmesh Ghale, "Experimental Study of Concrete made with Hypo Sludge and Wood Ash: A Review", International Journal of Advanced Research in Science and Engineering., vol. 6, no. 4, (2017), pp. 43-47.

[3] Anand Parkash and Ar. Pardeep Kumar Yadav, "A Review Study of Egg Shell Powder as a Cement Replacing Material in Concrete", International Journal of Latest Research in Engineering and Computing., vol. 5, no. 4, (2017), pp. 6-9.

[4] Bandhavya G.B, Sandeep K and Bindhushree G.B, "An Experimental Study on Partial Replacement of Cement with Egg Shell Powder in Concrete", International Research Journal of Engineering and Technology., vol. 4, no. 6, (2017), pp. 2318-2323.

[5] Keramat khan and Dr K U Muthu, "Experimental Investigation on Concrete using Egg Shell Powder, Metakaolin and Rice Husk Ash", International Journal for Research in Applied Science & Engineering Technology., vol.5, no. 8, (2017), pp. 1713-1725.

[6] N. Parthasarathi, M. Prakash and K. S. Satyanarayanan, "Experimental Study onPartial Replacement of cement with Egg Shell Powder and Silica Fume", Rasayan J. Chem., vol. 10, no. 2, (2017), pp. 442 – 449.

[7] R. Ranjith Kumar, R. Mahendran, S. Gokul Nathan, D. Sathya and K. Thamaraikannan, "An Experimental Study on Concrete Using Coconut Shell Ash and Egg Shell Powder", South Asian

Journal of Engineering and Technology., vol. 3, no. 4, (2017), pp. 151-161.
[8] M.Nivedhitha and Dr.M.Sivaraja, "Experimental Study on Partial Replacement of Cement with Coconut Shell Powder and Egg Shell Powder", International Journal of Innovative Research in Science Engineering and Technology., vol. 6, no. 5, (2017), pp. 8505-8510.
[9] Vinayaka H Yadav and Dr H Eramma, "Experimental Studies on Concrete for the Partial Replacement of Cement by Egg Shell Powder and GGBS", International Research Journal of Engineering and Technology., vol. 4, no. 8, (2017), pp. 144-150.
[10] Anand Babu A, Ramprasanth A A and Shanmugavadivu V A, "Experimental Investigation on Partial Replacement of Eggshell Powder in Conventional Concrete", International Journal of ChemTech Research., vol. 10, no. 8, (2017), pp. 453- 457.
[11] Dr. Jayeshkumar Pitroda, "Gainfull Utilization of Hypo Sludge in Construction Industry – A Review", International Conference on Engineering Issues, opportunities and Challenges for Development., (2016), ISBN: 978-81-929339-3-1.
[12] Er. Siddharth Talsania and Dr. Jayeshkumar Pitroda, "Innovative Use of Paper Industry Waste (Hypo Sludge) in Pervious Concrete", International Journal of Constructive Research in Civil Engineering., vol. 2, no. 3, (2016), pp. 24-32.
[13] Cherian Varkey, Jefin P John, Neema V N and Namitha Joshy, "Study on Utilization of Waste Paper Sludge by Partial Replacement of Cement in Concrete", International Research Journal of Engineering and Technology., vol. 3, no. 5, (2016), pp. 589-592.
[14] Jollu Suresh and B. Harish Naik, "Effect of Characteristic Compressive Strength of Concrete by Replacing Cement Partially with Hypo Sludge", International Journal of Innovative Research in Science Engineering and Technology., vol. 5, no. 12, (2016), pp. 20372-20377.
[15] Savita Devi, Nitish Gandhi, Mahipal, Nimisha Marmat, Balveer Manda and Mahesh Vaishnav, "A Review on Cement Replacement in Construction Industry", SSRG International Journal of Civil Engineering., vol. 3, no. 5, (2016), pp. 68-71.
[16] VVS.Sarma, P.V.Rambabu and Dr.N.C.Anil, "Durability Studies on Concrete with Hypo Sludge as Partial Replacement of Cement", International Journal of Engineering Research and Application, vol. 6, no. 5, (2016), pp. 81-85.
[17] Mohamed Ansari M, Dinesh Kumar M, Milan Charles J and Dr.Vani G, "Replacement of Cement using Eggshell Powder", SSRG International Journal of Civil Engineering., vol. 3, no. 3, (2016), pp. 1-2.
[18] Lodhi Ravindra Singh, Akhtar Saleem and Batham Geeta, "Application of Paper Waste in Cement Concrete", International Journal of Engineering Research and Applications., vol. 5, no. 4, (2015), pp. 95-98.
[19] Mehtab Alam and Vebhav Berera, "An Experimental Study on use of Hypo Sludge in Cement Concrete", International Journal of Progresses in Civil Engineering., vol. 2, no. 1, (2015), ISSN: 2394-4676.
[20] Rawaa A. Al-Safy, "Experimental Investigation on Properties of Cement Mortar Incorporating Eggshell Powder", Journal of Engineering and Development., vol. 19, no. 6, (2015),pp. 198-209.
[21] S.Karthikeyan, C.Suresh, S.Manikandan, M.Divya, R.Nandhakumar. An experimental investigation of eggshell concrete. Journal of Chemical and Pharmaceutical Sciences., vol. 8, no. 4, (2015), pp. 851-852.
[22] Praveen Kumar R, Vijaya Sarathy R and Jose Ravindraraj B, "Experimental Study on Partial Replacement of Cement with Egg Shell Powder", International Journal of Innovations in Engineering and Technology., vol. 5, no. 2, (2015), pp. 334-341.

**IS CODES**

- 10262-2009, "Concrete mix proportioning-Guidelines" 1st Revision 2000, Bureau of Indian Standards, New Delhi, India.
- IS 456 - 2000, "Plain and reinforced concrete - code of practice", 4th Revision, 2000, Bureau of Indian Standards, New Delhi, India
- IS 383–2016; Specification for Coarse aggregate and fine aggregate from natural sources for concrete
- IS 12269-2013 Ordinary Portland cement 53 Grade Specification.
- IS 4031- Method of Physical Testing on Cement
- IS 2386-1963-"Method of Test for Coarse aggregate for Concrete
- IS 5816-1970 Method of test for split tensile strength of concrete.
- IS: 516 – 1959; Method of test for strength of concrete.
- IS: 9399 – 1979; Specification for apparatus for flexure testing of concrete.