

# Utilization of Egg Shell Powder (ESP) and M-Sand for Sustainable Construction

Anitha J

Assistant Professor,  
Department of Civil Engineering, Sir. MVIT,  
Bangalore, India

H. Ravi Kumar

Associate Professor,  
Department of Civil Engineering, Sir. MVIT,  
Bangalore, India

Pradeepa. S

Assistant Professor,  
Department of Civil Engineering, Sir. MVIT,  
Bangalore, India

Pranav. P

Undergraduate Student,  
Department of Civil Engineering, Sir. MVIT,  
Bangalore, India

**Abstract**— This paper aims to deal with utilization of M-SAND and waste egg shell in concrete. Due to rapid growth construction industry, the demand for materials like sand has increased drastically, causing deficiency of suitable river sand in most part of the world. Therefore, comprehensive utilization of M-SAND and waste egg shell is important in saving resources, improving surroundings and for sustainable development. The quality of lime in eggshell waste is influenced greatly by the extent of exposure to sunlight, raw water and weather conditions. In this study, attempts were made to investigate the suitability and reliability of M-SAND and Egg shell waste in manufacture of concrete.

**Keywords**—M-SAND, Egg shell, Compressive Strength, Tensile Strength.

## I. INTRODUCTION

Concrete is widely used to construct both small and large structures because of its structural versatility, its ability to be moulded or cast into almost any desired shape and attractive appearance. Concrete is generally made of OPC, sand, crushed rock and water. Concrete is a highly durable material, however, the materials used, quality of the mortar, workmanship and the pattern in which the units are assembled can significantly affect the durability of the overall concrete construction. Economy and stability are the primary requisites of any structures. The production of cement, as per reports from about 150 countries, reached 3.7 billion tonnes in 2012. For every part of cement, we require about six to seven parts of sand and gravel, thus causing deficiency of suitable river sand. Sand has by now become the most widely consumed natural resource on the planet after fresh water. Due to the depletion of good quality river sand for the use of construction, the use of manufactured sand has increased. Another reason for use of M-Sand is its availability and transportation cost, it can be crushed from hard granite rocks and are readily available at the nearby place, reducing the cost of transportation from far-off river sand bed. Thus, the cost of construction can be controlled by the use of manufactured sand as an alternative material for construction.

Furthermore, M-Sand can be dust free, the sizes can be controlled easily so that it meets the desired grading for the given construction. Furthermore, the entire construction industry is in search of a suitable and effective the waste product that would considerably minimize the use of cement and ultimately reduce the construction cost. Few of such products have already been identified like Rice Husk Ash (RHA), Fly Ash, Silica Fumes, Egg shell etc. Amongst these Egg shells are known to have good prospects in minimizing the usage of cement. This work intends to study the effects on compressive strength and tensile strength of concrete after the partial replacement of cement and river sand by egg shell powder and manufactured sand respectively.

## II. LITERATURE REVIEW

Earlier, a study of compressive strength, split tensile strength, and Flexural strength was undertaken to use egg shell powder and admixtures as partial replacement for cement in concrete(IJETT-2014, D.Gowsika, S.Sarankokila, K.Sargunan). It was found that replacement of 5% Egg shell powder + 20 % Microsilica can be added without any reduction in compressive strength properties of conventional cement, replacement of 5% Egg shell powder + 10% Microsilica replacement in cement yields similar flexural strength as in conventional concrete and replacement of 5% Egg shell powder + 10% Microsilica replacement in cement yields higher Split Tensile strength as compared to other compositions. From another study on Properties of concrete with egg shell powder as cement replacement (ICJ-2014, Amarnath Yerramala), it was found that 5% ESP replacement the strengths were higher than control concrete and indicate that 5% ESP is an optimum content for maximum strength. In addition, the performance of ESP concretes was comparable up to 10% ESP replacement in terms of transport properties with control concrete. The results further show that addition of fly ash along with ESP is beneficial for improved performance of concretes. According to the study on Egg Shell Concrete with Partial Replacement of Cement by Fly Ash (IJERT-2015), it was found that Compressive strength, density and workability decreased with addition of ESP to concrete. While workability and density increased with addition of fly ash to optimum egg shell powder concrete, no change was found in Compressive strength.

Also the study on suitability of M-Sand as fine aggregate in mortars and concrete (CSIC Project, 2011, Prof. B.V.Venkatarama Reddy) concluded that Compressive Strength of M20 and M30 concretes with M-sand as fine aggregate is 6% - 9% higher when compared with the results using river sand as fine aggregates. Further it was found that the flexure strength of concrete using M-sand as fine aggregate is 12% - 15% higher when compared with the results using river sand as fine aggregates.

### III. EXPERIMENTAL WORK

#### A. Materials

The properties of various materials used in making the concrete (M20) are discussed in the following sections:

##### 1) Cement

Cement used was ordinary Portland cement of Grade 43 meeting the requirement of Indian Standard (IS 8112- 1989). Ordinary Portland cement of 43 Grade was used in the concrete mixture, which was stored in a cool dry place during the course of the experimentation. It should be free from lumps and fresh. Specific gravity of cement was 3.25.

##### 2) Egg Shell Powder

Egg shell powder is used as partial replacement of cement in concrete's as it is rich in calcium oxide. ESP can be replaced up to 15% without considerable decrease in various chemical properties of concrete. The Egg Shell Powder used should pass 90 $\mu$  IS sieve. The shells cleaned in normal water and sun dried for four to six hours approximately at a temperature range of 25 – 30°C. The shells then hand crushed, grinded and sieved through 90 $\mu$  sieve. Material passed through 90 $\mu$  sieve was used for cement replacement and the retained material was discarded.

##### 3) Natural Sand

Locally available river sand conforming to zone II as per IS: 383-1970 is used.

##### 4) M-Sand

The use of crushed rock sand as a partial replacement of river sand in concrete production was investigated. Common tests such as specific gravity, water absorption and fineness are to be carried out.

##### 5) Aggregates

Aggregate is the term used to describe the material used in concrete and masonry blocks other than paste, which is bonded to each other by the paste medium. The coarse aggregate must be free from dust, deleterious materials and soft particles. The coarse aggregate must be well graded. Aggregate should not contain oversize of flaky materials. Shall be angular, hard and of required grade size and shall be blackish or grey in colour. The coarse aggregate used in the present project is of passing 20mm IS sieve and retaining 16mm IS sieve.

##### 6) Water

The water used was clean and free from deleterious matter. pH value should be well within 5.5 to 8.3 and Normal turbidity limit is 2000-2500.

### IV. TESTING

#### A. Material Properties

##### 1) Cement

- i). Specific Gravity: 2.985
- ii). Normal Consistency: 30%
- iii). Initial Setting time: 30 minutes

##### 2) Egg Shell Powder

- i). Specific Gravity: 1.865

##### 3) River Sand

- i). Specific Gravity: 2.85
- ii). Water Absorption: 25.64%

##### 4) M-Sand:

- i). Specific Gravity: 2.41
- ii). Water Absorption: 30%
- iii). Fineness Modulus: 3.98

#### B. Proportioning

Three combinations of mixes were used viz., mix 1, mix 2 and mix 3 with different percentages of cement and sand replaced using egg shell powder and M-Sand respectively.

TABLE I. REPLACEMENT % FOR DIFFERENT MIXES

MIX/REPLACEMENT PERCENTAGE	CEMENT	SAND
MIX 1	5 %	20 %
MIX 2	10 %	40 %
MIX 3	15 %	60 %

#### C. Casting

Cubes of 150mm x 150mm x 150mm and cylinders of diameter 150mm and height 300mm are casted. The coarse and fine aggregates are spread out in layers after collecting the calculated quantity. Pour the cement on the top of it and mix them dry by shovel, turning the mixture over and over again until uniformity of colour is achieved. This uniform mixture is spread out in thickness of about 20 cms. Considering water cement ratio as 0.55 based on workability test, water is taken in a measuring cylinder and added to the dry mix. This operation is continued till such a good and homogenous concrete is obtained. The mix is poured in respective mould and compacted.

#### D. Curing

The test specimen is stored in a place free from vibration. Blocks are stored at a temperature within the range of 22 degrees to 32 degree Celsius. The specimens are marked for easy identification during testing. The clear water 24 – 32 degrees Celsius should be used. The blocks are covered with wet gunny bags for 28 days and water spraying on the blocks should be two times in a day. The blocks are kept in wet and not to be allowed to become dry at any time until they have been tested.

**E. Fresh Concrete**

Slump tests were carried out to determine the workability of the concrete mix. The test method used is to determine the slump of freshly mixed concrete, which is an approximate measure of consistency or workability. The test may be done in the laboratory and in field.

**F. Hardened Concrete**

Tests for compression and split tensile were carried out on hardened concrete specimens cured for a period of 7 and 28 days. Compressive strength of concrete cubes is determined by testing cubes under compression testing machine. It consists of applying a compressive axial load to moulded cubes at a rate which is within a prescribed range until failure occurs. The compressive strength is calculated by dividing the maximum load attained during the test by the cross sectional area of the specimen. The split tensile test method covers the determination of the splitting tensile strength of cylindrical concrete specimens.

**V. RESULTS AND DISCUSSION**

**A) Cement Properties**

Various tests were carried on properties of cement and the observed results are tabulated below. The values obtained for different tests are well within standards.

TABLE II. PROPERTIES OF CEMENT

Sl no.	Property	Observation	Standard for OPC
1.	Fineness (%)	1.70	Not > 10
2.	Specific gravity	2.985	2.95 – 3.15
3.	Consistency (%)	30	-
4.	Initial setting time	30 min	>30
5.	Final setting time	190 min	<600
6.	Slump	80 mm	-

**B) Egg Shell Powder Properties**

The egg shell powder prepared for the partial replacement of cement was tested for its property of specific gravity and the result obtained is tabulated in the below table. The value obtained for the specific gravity of ESP is well within range when compared to the specific gravity of the ordinary Portland cement.

TABLE III. PROPERTIES OF EGG SHELL POWDER

Sl no.	Property	Observation	Standard for OPC
1.	Specific gravity	1.865	2.95 – 3.15

**C) Sand Properties**

The tests for water absorption and specific gravity were carried out and the values obtained are tabulated below.

TABLE IV. PROPERTIES OF SAND

Sl no.	Property	Observation
1.	Water absorption	25.64 %
2.	Specific gravity	2.85

**D) Manufactured Sand Properties**

Water absorption, specific gravity and fineness tests were carried out on the manufactured sand and the results obtained are tabulated. The results are satisfactory.

TABLE V. PROPERTIES OF M-SAND

Sl no.	Property	Observation	Comparison
1.	Water absorption	30 %	25.64 %
2.	Specific gravity	2.41	2.85
3.	Fineness	3.98	-

**E) Hardened Concrete**

**1) Compressive Strength Test of concrete**

The compressive strength of concrete blocks were carried out based on the standard procedure and the results obtained are tabulated below.

TABLE VI. 7 DAYS COMPRESSIVE STRENGTH RESULTS

Sl no.	Mix proportion	Compressive strength observed (N/mm <sup>2</sup> )	Min. compressive strength of M20 grade concrete (N/mm <sup>2</sup> )
1.	Mix 1	19.48	13.5
2.	Mix 2	18.12	13.5
3.	Mix 3	16.76	13.5

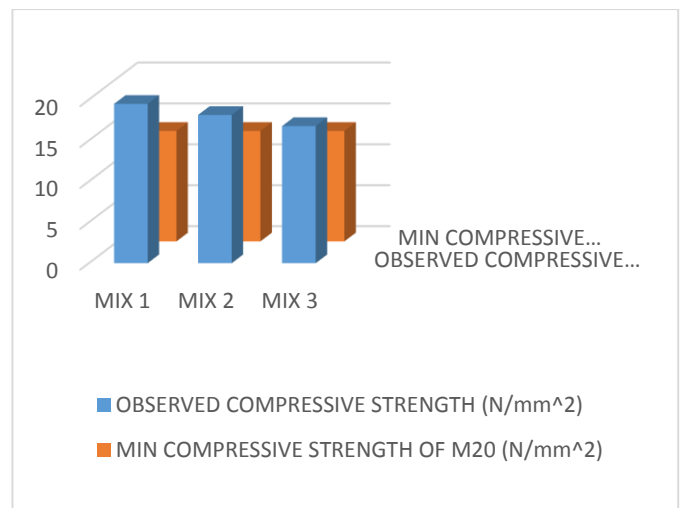


Fig.1. 7 day's compressive strength results

TABLE VII. 28 DAYS COMPRESSIVE STRENGTH RESULTS

Sl no.	Mix proportion	Compressive strength observed (N/mm <sup>2</sup> )	Minimum compressive strength of M20 grade concrete (N/mm <sup>2</sup> )
1.	Mix 1	27.1	20
2.	Mix 2	25.8	20
3.	Mix 3	24.9	20

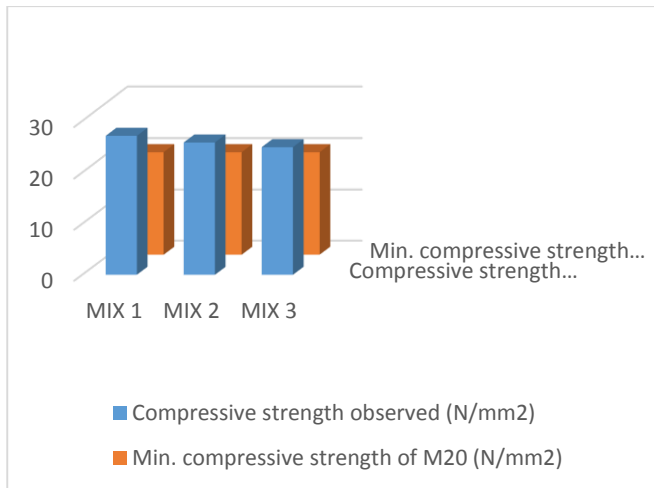


Fig.2. 28 day's compressive strength results

TABLE IX. 28 DAYS SPLIT TENSILE STRENGTH RESULTS

Sl no.	Mix proportion	Split tensile strength observed (N/mm <sup>2</sup> )	Standard split tensile strength of M20 concrete(N/mm <sup>2</sup> )
1.	Mix 1	2.63	2.137
2.	Mix 2	2.08	2.137
3.	Mix 3	1.94	2.137

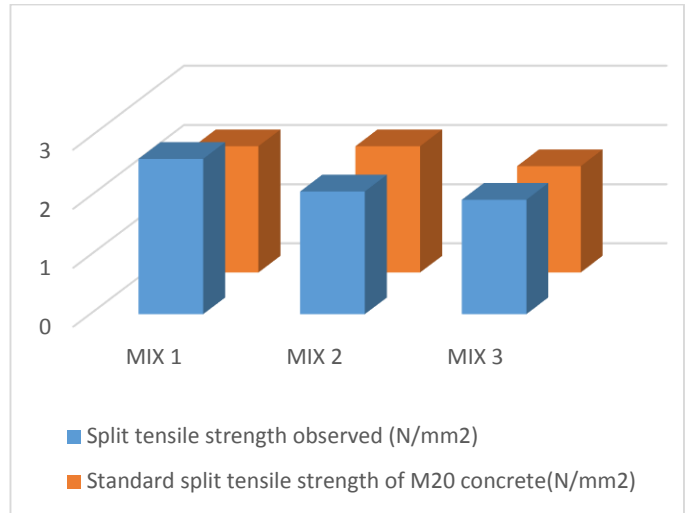


Fig.4. 28 day's split tensile strength results

2) Split Tensile Strength Test of concrete

The split tensile strength of concrete blocks were carried out based on the standard procedure and the results obtained are tabulated below.

TABLE VIII. 7 DAYS SPLIT TENSILE STRENGTH RESULTS

Sl no.	Mix proportion	Observed split strength value (N/mm <sup>2</sup> )	Average split tensile strength value (N/mm <sup>2</sup> )
1.	Mix 1	1.8	1.708

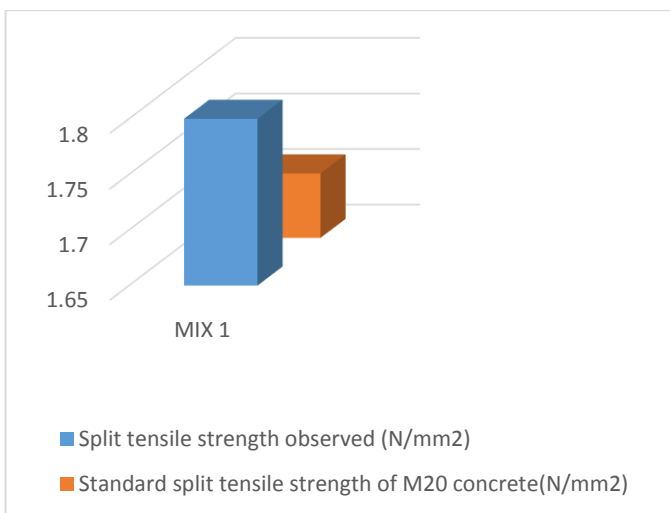


Fig.3. 7 day's split tensile strength results

VI. CONCLUSION

Energy plays a crucial role in growth of developing countries like India. Due to low availability of non-renewable energy resources along with requirements of large quantities of energy for building materials like cement, importance of using organic waste or industrial waste cannot be underestimated. In the current study substitution of egg shell and M-sand shows better compressive strength which can be further studied. By using the waste materials instead of conventional material, we would not only be preserving the natural precious resources, but also solving the problems of disposal of waste, which has become a national problem. Since the need of building materials is growing at an alarming rate, in order to meet the demand of new ways and techniques must be evolved. Manufacturing of building materials like brick, cement, steel, aggregates etc. which are consumed in bulk quantities, puts great pressure on natural resources (raw materials) and are highly energy demanding. There is an abundant waste of egg shell & wastage after crushing of rocks which can be used for partial replacement of cement & fine aggregate respectively in concrete. However some of these waste materials possess potential characteristics, which can be tapped for various uses. Therefore, the use of alternatives materials for constructions should be encouraged. The effect on the use of manufactured cement on early age and long term volumetric properties, such as shrinkage and creep respectively, are not available and should be studied. Their particles size distribution helps in higher packing density which enhance the durability of the concrete. Due to the use of the above alternatives there is an

increase in strength characteristics of concrete due to denser particle packing in silt free nature of M-sand as compared to river sand. The percentage of replacement should be such that the concrete is of adequate workability for the placing condition of the concrete and we can properly be compacted with the means available.

#### ACKNOWLEDGMENT

We would like to express our deep sense of gratitude to the HOD of Department of Civil Engineering, Sir M.Visvesvaraya Institute of Technology, Bangalore for his support and guidance throughout the course of work. We would also like to thank the lab technician and non-teaching staff for helping us in successfully carrying out the experimental work.

#### REFERENCES

- [1] Sathish Kumar.R, "Experimental Study on the Properties of Concrete Material", International Journal of Modern Engineering Research (IJMER), Vol.2, Issue. 5, Sept.-Oct. 2012, pp-3006-3012.
- [2] Dr. Amarnath Yerramal, Associate Professor at Madanapalle Institute of Technology (MITS), Madanapalle, Andhra Pradesh.
- [3] D.Gowsika, S.Sarankokila, K.Sargunan, PG Student, Dept of Civil Engineering, KSR College of Engineering, Tiruchengode, TamilNadu, India. Asst. Professor, Dept of Civil Engineering, KSR College of Engineering, Tiruchengode, TamilNadu, India.
- [4] B.C.Punmia, *Building Materials*.
- [5] Sushil Kumar, standard publisher distributor, 1988, *Building Construction*.
- [6] Jayashankar.R, Post graduate student, Department of Civil Engineering, AUT, Tiruchirapalli.
- [7] W.O.Abuodha, Department of Civil and Construction Engineering, University of Nairobi P.O.Box 30197-00100, Nairobi, Kenya
- [8] M.S.Shetty from S.Chand & company Ltd. 2012, *Concrete Technology*
- [9] A. R.Santhakumar, Oxford university press 2011, *Concrete Technology*
- [10] K. S Manjunatha, sanguine technical publisher 2008, *Materials of construction*
- [11] M. L Gambhir, Neha Jamwal TATA McGraw hill education Pvt Ltd.2011, *Building materials*.
- [12] P. Kumar Mehta, Paulo J.M. Monterio, TATA McGraw Hill Education Pvt. Ltd., *Concrete*.
- [13] UNEP Global Environmental Alert Service – Sand, rarer than one thinks (2014)
- [14] Zhang G., Song J., Yang J., Liu X., "Performance of mortar and concrete made with a fine aggregate of desert sand. *Building and Environment* 41", (2006) ,1478–1481
- [15] Global Witness report–Shifting sand (2010)