AN EXPERIMENTAL STUDY ON MECHANICAL PROPERTIES OF CONCRETE WITH PARTIAL REPLACEMENT OF CEMENT BY EGG SHELL POWDER AND COARSE AGGREGATE BY CERAMIC TILES WASTE

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Abstract - *In this developing world, many countries are going to urbanization due to population growth. As India is one of developing countries, the construction will grow in the future. The development of a country or a country depends not only on technology, but also on infrastructure. Concrete is called the pillar of infrastructure. Cement production ranges from 8% to 10% of the world's total carbon dioxide. Consequently, cement production is not environmentally friendly, and cement is the most expensive material in the composition of concrete and, therefore, uneconomical. Therefore, it is necessary to find alternative materials to make the construction industry environmentally friendly and sustainable. In this work, fresh and hardened properties of the concrete mix are determined like fresh concrete property i.e. workability of mix using slump cone test whereas the hardened properties of the mix like compressive strength test, split tensile strength test and flexural strength values are calculated after 7 and 28 days of curing. The findings suggested that the suitability of eggshell powder and ceramic tiles with different proportions are applicable in the structural system of the buildings*.

Key Words: **Egg Shell Powder (ESP), Ceramic Tiles Waste (CWT), Compressive Strength, Split Strength, Flexural Strength, Workability, Concrete mix.**

1. INTRODUCTION

Portland cement clinker is the dominant binder used in concrete because of an abundance of raw materials, its relatively low cost and its excellent mechanical and durability properties. However, as reported by Meyer (2009), its production process is energy intensive (850 kcal per kilogramme of clinker) and emits a high level of carbon dioxide emissions to the atmosphere (about a tonne of carbon dioxide per tonne of cement). It has also been estimated that cement companies are responsible for the emission of about two billion tonnes of carbon dioxide per year, which is 6–7% of the planet's total carbon dioxide emissions (Meyer, 2009). The cement industry is looking for alternatives to overcome these problems and to comply with protocol obligations by making more sustainable binders and reusing wastes from other industries. Cement is a very expensive construction material which is used as a binding agent in concrete. Due to high process of cement construction costs are quite high. On the other hand wastes produced by different industries like coconut husk, Egg Shell and bricks waste are getting useless and are a threat for the environment. If these wastes are not properly disposed they may cause serious environmental pollution and health hazards. So, to reduce the construction cost and to protect our environment it is necessary to use the wastes from different industries in construction. Egg Shell is one of such wastes which is produced in large quantities by the food processing industry and can be used as a partial replacement of cement. And Ceramic Tiles wastes are used to partially replace the aggregates in the mix. So, this research will aim on using Egg Shell powder and ceramic waste as a partial replacement of cement and coarse aggregates, respectively and also to determine the various strength parameters of concrete.

2. LITERATURE REVIEW

Amarnath Yerramala (2014) describes research into the use of poultry manure in concrete through the development of concrete containing eggshell powder (ESP). Various ESP concretes have been developed by replacing 5-15% of the ESP with cement. The results showed that the 5% ESP substitute exhibited higher strength than the control concrete, with 5% ESP being the optimum level for maximum strength. Moreover, the performance of the ESP concrete up to 10% of his ESP substitution was comparable to the control concrete in terms of transport properties. The results further indicate that adding fly ash along with ESP is beneficial in improving concrete performance.

Doh Shu Ing And Chin Siew Choo Et Al., (2014) conducted an investigation on egg shell powder as potential additive to concrete, showed conclusion of eggshell powder in concrete has improved the compressive strength of concrete and with addition of 10% egg shell powder in M25 Grade of concrete.

Arun Kumar C et al. (2018) studied that part of the eggshell powder could be replaced with a mixture that could be used as an alternative cement source. According to statistics, large amounts of eggshells were discarded as garbage in India and sent to landfills. Therefore, due to its chemical properties and its presence in nature, it can be replaced with cement. In this work, experiments were conducted using eggshells as a partial substitute for cement. The concrete mix considered is M40 with a ratio of 1:1.5:2.3. Samples were prepared by replacing cement with 5%, 10%, 15%, 20%, and 25%. Mechanical properties such as compressive strength, split strength and flexural strength of eggshell powdered concrete were measured at curing times of 7, 14 and 28 days, and the results were compared with conventional concrete.

Sherin Khan et.al.(2019) researched to determine the strength .properties of concrete by somewhat partial replacement of natural coarse aggregate by the wastes from ceramic collection. Results may sustain the environment and also enhance the concrete strength parameters. M30 grade concrete mix was designed with variation of CWT as 0%, 10%, 20%, 30%, 40% & 50% to evaluate concrete strength parameters..

R. Johnson Daniel et al. (2020) This research paper details an experimental study to replace waste recovered from ceramic manufacturing plants with natural fine aggregate for reuse in concrete. Due to this ceramic waste, natural fine aggregate extraction can be reduced and the nominal cost of river sand is higher. compared to all other alternative fine aggregate materials. Ground and granulated waste powder ceramic tiles vary from 0%, 5%, 10%, 15% and 20% as a fine aggregate replacement material. Mixed designs were prepared by replacing fine aggregate with ceramic (crushed tiles) at various percentages from 0% to 20% and substituting M30 grade concrete. An experimental study on workability was carried out on fresh concrete. Various tests have been carried out on hardened concrete. B. Compression tests, modulus and flexural strength of concrete beams with different proportions of ground ceramic tiles at different stages of curing time from 7 to 28 days.

Pramodini Sahu et al. (2020) worked on the strength effects of Jute Fiber Reinforced Cement Concrete while performing experimental work on concrete with addition of Jute Fiber at various proportions. Mainly modulus of rupture and compressive strength reading are generally noted.

3. MATERIALS

3.1 Cement

Ordinary Portland Cement, conforming to specifications for 43 – grade ordinary portland cement, as per the IS code 8112-1989 was used in this study.

3.2 Water

Water available in the laboratory with pH value of 7.0 corresponding to values of IS 456-2000 is used for making concrete and curing the specimen as well.

3.3 Natural Fine Aggregates

Material fractions ranges from 4.75 mm to 150 micron are considered as fine aggregates. River Sand which is locally available was used as per Indian Standard 383-1970.

3.4 Natural Coarse Aggregates

In this study, locally available crushed coarse aggregate conforming to Indian Standard 383-1970 was used. Particle size distribution confirm to requirements of as per IS (2386 part I). Nominal size passing through size 20mm and retain on 10 mm is sieve used.

3.5 Egg Shell Powder (ESP)

Eggshells are agricultural dump objects produced from poultries, bakeries, fast food restaurants among others. Its damping on the open land can damage the surroundings and as a result comprising ecological issues/contamination which would need an appropriate diffusion into atmosphere. This created different environmental and health problems.

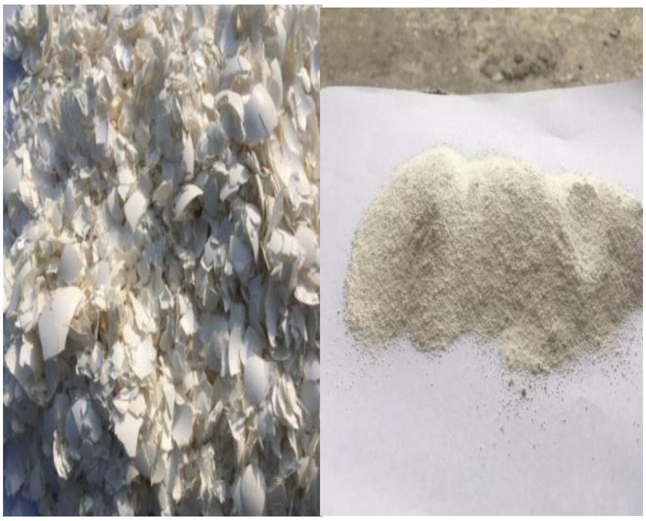

Figure 3.1 Egg Shell Powder (ESP)

Table 3.1: Chemical Properties of ESP

S.No.	Composition	Percentage (%)
1.	CaO	53%
2.	MgO	1%
3.	SiO_2	1.5%
4.	Al_2O_3	0.28%
5.	Fe_2O_3	0.36%
6.	Cl_2	0.011%

3.7 Ceramic Tiles Waste

Ceramic products are mostly produced using a natural material that contains high content of clay minerals. Broken tiles will be collected from the solid waste of ceramic manufacturing unit and from demolished building sites.

Figure 3.3: Ceramic Tiles Waste (CWT)

Table 3.2: Chemical Composition of CWT

Sr. No.	Characterstics	Value (%age)
1	Silica(SiO_2)	64.56
2	Alumina(Al_2O_3)	15.07
3	Lime(CaO)	6.01
4	Potassium(K_2O)	2.13
5	Magnesia(MgO)	2.04

4. METHODOLOGY

In this study, Egg shell powder and ceramic waste will be used as replacement of cement and natural coarse aggregates respectively, and then various concrete strength properties can be determined. In this study, the mix proportions were prepared according to Indian standard code IS 10262. Following tests are adopted to precede the work.

4.1 Workability Test

Slump cone test is most commonly used test for determination of consistency of concrete. The slump test indicates the behaviour of compacted concrete mix under action of gravitational force. The apparatus consists of a frustum of cone dimensions of 10 cm diameter at top, 20 cm diameter at bottom and 30 cm height of cone. A 16mm diameter with bullet end rod is used in this test for tamping. This test is suitable for medium to high workability concrete i.e. slump values 25mm to 125mm. And this test is limited to concrete with maximum size of aggregate less than 38mm.

4.2 Compression Strength Test

Compressive strength of cubes of size (15×15×15)cm was computed using Compression Testing Machine. Compressive strength for any material is the load applied at the point of failure to the cross-section area of the face on which load was applied.

Compressive Strength= Load / Cross-sectional Area

4.3 Split Tensile Strength Test

Tensile strength of concrete mix is measured by the units of Force per Cross-Sectional area (N/mm^2 or MPa). The cylinder of size 15 cm diameter and 30 cm height was cast to check the splitting tensile strength of concrete.

The splitting tensile strength, $T_{sp} = 2P / \pi DL$

4.4 Flexural Strength Test

Flexural strength is essential to estimate the load at which the concrete member may crack. The specimen cast for this test was of size (70×15×15) cm. Flexural strength is calculated using the equation:

$F = PL/ (bd^2)$

5. RESULTS AND DISCUSSIONS

5.1 Workability Test

Slump cone test of concrete made with Egg Shell Powder as replacement of cement at varying percentage of 0%, 3%, 6%, 9% & 12% and Ceramic tiles waste as replacement of coarse aggregates at varying percentage of 0%, 12%, 24%, 36% & 48% was determined. The results of Slump cone test are given below in figure 5.1

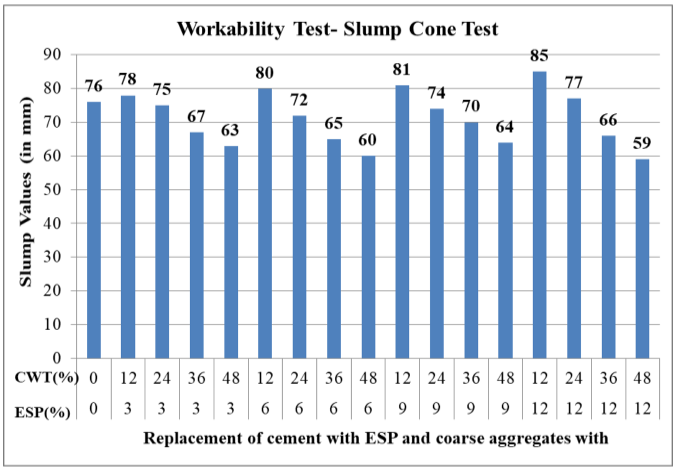

Figure 5.1: Slump Values of Concrete Mix Using ESP and Ceramic Tiles Waste.

5.2 Compressive Strength Test

The compressive strength test is performed by testing a cube of size (150 x 150 x 150) mm. The compressive strength of concrete mixtures prepared using eggshell powder as a substitute for cement and ceramic tile waste as a substitute for coarse aggregate was measured after 7 and 28 days. A graphical representation of the compressive strength of the cubes at 7 and 28 days is shown in Figures 5.2 and 5.3

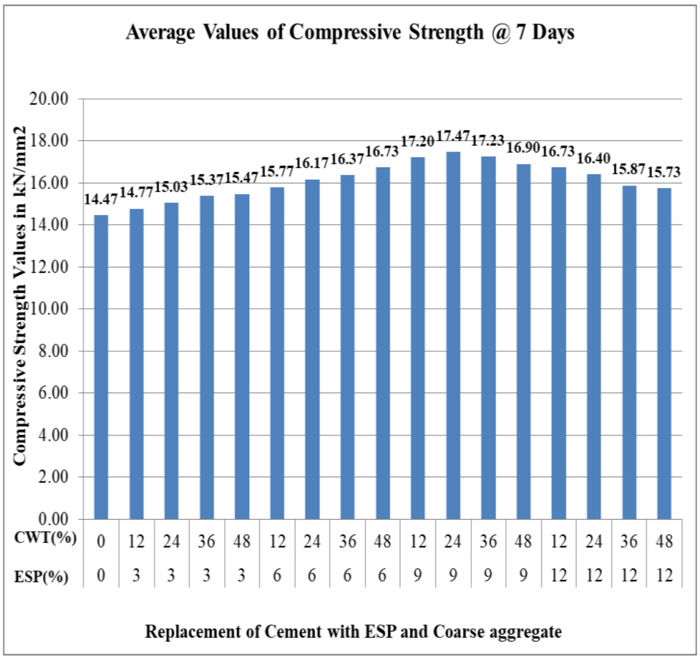

Figure 5.2: Compressive Strength of Concrete Mix using ESP and Ceramic Tiles Waste after 7 days of curing.

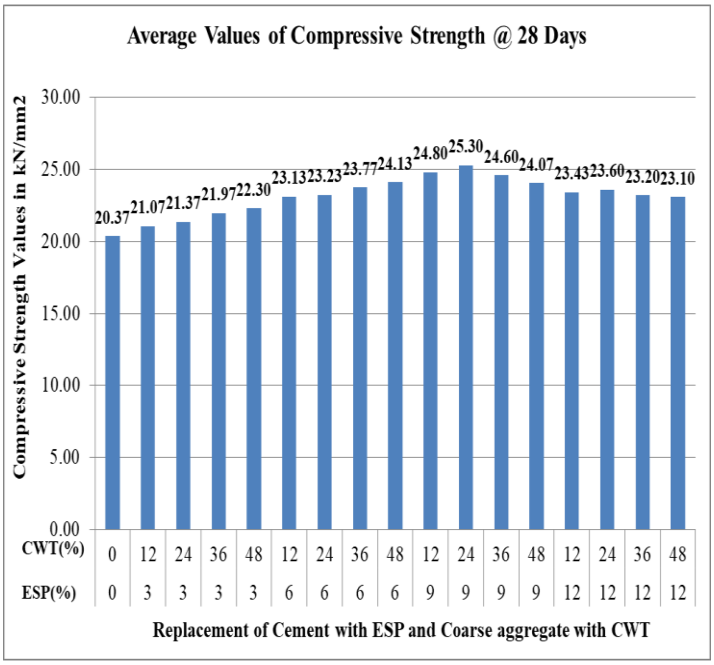

Figure 5.3: Compressive Strength of Concrete Mix using ESP and Ceramic Tiles Waste after 28 days of curing.

5.3 Split Tensile Strength

The results of Split Tensile Strength are determined on cylindrical specimen using UTM. The results for 7 days and 28 days are shown in figure 5.4 and 5.5

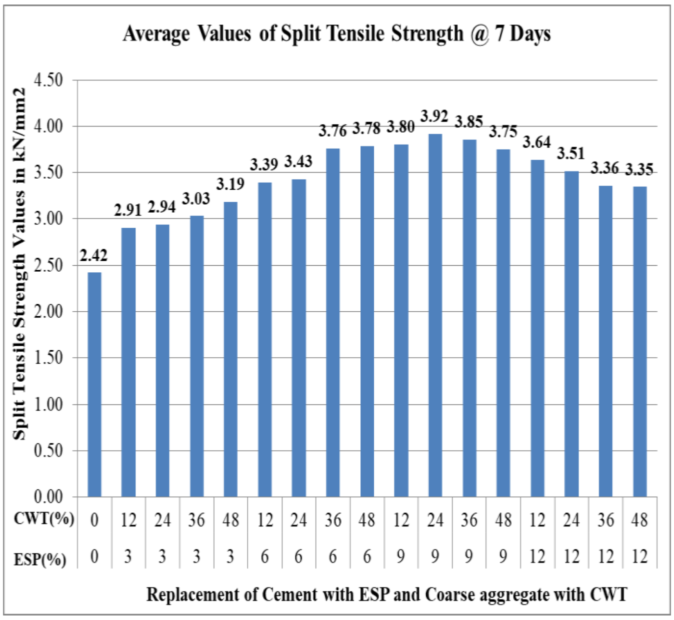

Figure 5.4: Split Tensile Strength of Concrete mix using ESP and Ceramic Tiles Waste after 7 days of curing.

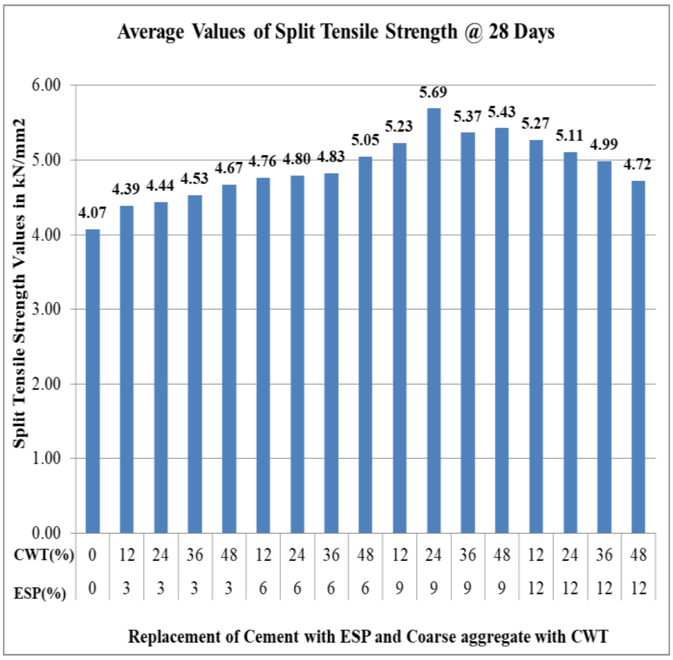

Figure 5.5: Split Tensile Strength of Concrete mix using ESP and Ceramic Tiles Waste after 28 days of curing.

5.4 Flexural Strength Test

The results of flexural Strength are determined on beam specimen using UTM. The results for 7 days and 28 days are shown in figure 5.6 and figure 5.7

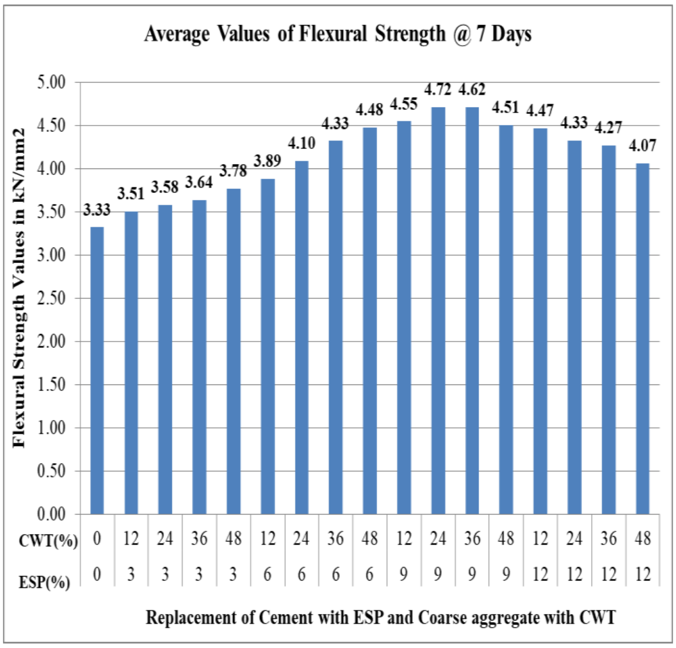

Figure 5.6: Flexural Strength of Concrete mix using ESP and Ceramic Tiles Waste after 7 days of curing.

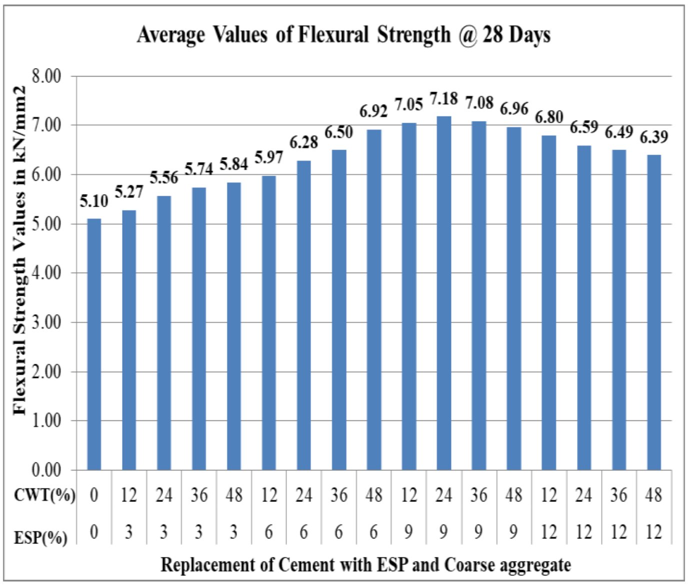

Figure 5.7: Flexural Strength of Concrete mix using ESP and Ceramic Tiles Waste after 28 days of curing.

6. CONCLUSIONS

Present study concludes the following:

1. The results of obtained by Slump test method concluded that workability of mix increases with the increase in the ESP content. This may be attributed to the extended setting time property of ESP. But increase in workability of concrete by ESP is limited to 9% replacement.

2. The strength results concludes that compressive strength, Split Tensile strength and Flexural Strength of concrete containing ESP and CWT aggregates increases upto 9% ESP and 24% CWT. The increase in strength may be contributed due to its fineness and better binding property with other ingredients.

3. The results concluded that the maximum value of compressive strength obtained at ESP9%CWT24% are 17.47Mpa and 25.30Mpa at 7 and 28 days of curing.

4. The maximum value of split tensile strength obtained at ESP9%CWT24% are 3.92Mpa and 5.69Mpa at 7 and 28 days of curing.

5. The maximum value of flexural strength obtained at ESP9%CWT24% are 4.72Mpa and 7.18Mpa at 7 and 28 days of curing.

6. Concrete mix ESP9%CWT24% can be considered as optimum mix in terms of strength and economy. Thus it can be used as structural concrete without compromising its strength properties.

REFERENCES

1. Batriti Monhun R. Marwein (2016), **"A REVIEW PAPER ON UTILISATION OF CERAMIC WASTE IN CONCRETE"**, *International Journal of Scientific & Engineering Research,* Volume 7, Issue 4, April-2016 ISSN 2229-5518.

2. E.H.Wadie (2017), **"The Use of Ceramic Tile Waste as Aggregate in Concrete"**, *International Journal of Scientific & Engineering Research*, Volume 8, Issue 11, November-2017 ISSN 2229-5518.

3. Ambikesh Singh (2018), **"Ceramic waste in concrete - A Review"**, *Recent Advances on Engineering, Technology and Computational Sciences (RAETCS),* 78-1-5386-1686-4/18/2018 IEEE.

4. ARUN KUMAR C (2018), **"A PARTIAL REPLACEMENT OF EGG SHELL POWDER FOR CEMENT IN CONCRETE"**, *International Journal of Creative Research Thoughts (IJCRT),* Volume 6, Issue 1 February 2018 | ISSN: 2320-2882.

5. Sathvik S, Edwin. A (2019), **"Experiment of Partial Replacement of Egg Shell Powder and Coconut Fibre in Concrete"**, *International Journal of Innovative Technology and Exploring Engineering (IJITEE)* ISSN: 2278-3075, Volume-8, Issue- 6S4, April 2019.

6. Sherin Khan (2019), **"USE OF CERAMIC TILE WASTE IN CONCRETE MIX BY PARTIAL REPLACEMENT OF COARSE AGGREGATE: AN EXPERIMENTAL STUDY"**, *Journal of Emerging Technologies and Innovative Research (JETIR),* March 2019, Volume 6, Issue 3, (ISSN-2349-5162).

7. POORNIMA K (2019), **"A Review Study of Egg Shell Powder as a Cement Replacing Material in Concrete"**, *International Research Journal of Engineering and Technology (IRJET)*, Volume: 06 Issue: 05 | May 2019.

8. Vaibhav R. Shirodkar (2020), **"The Effects of Nano Materials and Egg Shell Waste Material on the Physical and Strength Properties of Floor Tiles"**, *International Journal of Creative Research Thoughts (IJCRT),* Volume 8, Issue 6 June 2020 | ISSN: 2320-2882.