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# Somewhat increasing the strength and durability of M30 and M40 concrete by using eggshell powder in lieu of cement and copper slag

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***Abstract:***

***Because of its low cost and high efficiency, concrete is expected to be both stronger and more long-lasting than it has ever been. Furthermore, the essential advantages that concrete gives over other building materials must be preserved. There is a great deal of flexibility in terms of where and how it may be made, as well as a low cost of components and manufacture. Concrete performance advancements have been spurred by these variables for years and will continue to do so. The increasing demand for concrete, coupled with concerns about environmental effect, has led to the increased usage of alternative material components. Copper slag will be used as a partial substitute for fine particles in the concrete mix design in an experimental study to investigate the properties of the concrete. Compressive strength, split tensile strength, and other durability tests will be carried out on concrete of M30 and M40 grades using varying percentages of copper slag (CS) with fine aggregates (0, 5, 10, 15, 20, and 25 percent by weight) and egg shell powder (ESP) as cement (0, 5, 10, 15, 20, and 25 percent by weight). The results of this study will be compared to those of ordinary concrete in order to determine how copper slag, used to replace some of the tiny particles in concrete, alters its properties.Key words: Copper Slag,EggshellPowder,Compressive Strength, Split Tensile Strength***

## I. Introduction

Cement and concrete may be made from industrial waste or secondary resources in the building sector. Many enterprises generate new garbage and by-products. When garbage is handled or disposed of, there are environmental and safety considerations. Construction and demolition waste may be used and recycled to provide a lucrative business opportunity. There has been a long-held belief that these materials should be thrown away. Because this concrete had superior workability and durability than regular concrete, it was used for fuel, chemical facilities, and submerged structural parts. In recent decades, experts have worked tirelessly to investigate every possible way of recycling. Alternative aggregates, such as building waste and slag from explosive furnaces, have been accepted as raw materials for conventional Portland cement production, according to the study of Teikthyeluin et al (2006).

The copper process generates a by-product known as copper slag. Each tonne of copper produced generates around 2.2 tonnes of copper slag. Slag from The global copper sector is expected to produce 24.6 million metric tonnes this year (Gorai et al 2003). The copper layer is typically used in sandblasting and the production of abrasive tools, while the rest is discarded without further recycling or reusing. The copper layer is mechanically and chemically described as a component replacement for Portland cement or an aggregate substitute for the material to be utilised in concrete. An ideal candidate for mixed use is Slag, because to its soundness and resistance to abrasion. In addition, it has a lengthy record of reliability (Gorai et al 2003). Copper slag contains a low concentration of calcium oxide (CaO) in addition to its pozzolanic capabilities. It may be used to replace Portland cement, either in part or in whole, when NaOH is used to activate it. Copper slag has the additional benefit of cutting the cost of concrete while also reducing waste disposal costs since it may be used to replace Portland cement or serve as a key element.

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## II .Literature review

Researchers Gowsika and colleagues (2014) conducted experiments using powdered eggshell (ESP) as a partial substitute for cemented concrete. Cured for 28 days, 5 to 30 percent of the weight of cement was replaced with ESP at a 1:3 mixing ratio and chemical composition and strength qualities of ESP were used in the mortar. Admixtures such as sawdust ash, fly ash, and microsilica have been used to boost the compression beyond and above 5% of ESP replacement. Replacement of 5 percent ESP with 10 percent micro silica results in high-strength hard concrete, in contrast to ordinary concrete. Amaranth Yerramala et al. studied the qualities of eggshell concrete powder as a cement alternative (2014). Concrete hardens to a certain set of qualities throughout the 7th and 28th day curing periods when 5, 10, and 15 percent of ESP for cement were tested. According to the study's findings, flyash and ESP may provide a 15% edge. The absorption property of vacuum-permeable vacuum has been reduced. Water absorption has increased whereas absorption has decreased as a result of increased exertion. After 28 days, the paper's strength and weight increased by up to 30%. replaces a portion of cement with powder from the fused form of cement. As a result, mineral Silicate and sawdust admixtures must be substituted to accomplish the force reduction of over five percent. As much as 10 percent of the micro silica, fly and dust are substituted in the concrete mix to increase its strength by 5 percent. In studies on well-healed specimens after a period of seventy four and twenty-eight days, the ESP replaced 10 percent, 20 percent, and 30 percent of the ESP in ESP replacements. [3] Experimentally, Praveene Kumar et al. attempted to use eggshells as a partial cement substitute (2015). Because silica fume only increases strength by 15%, ESP is necessary to get higher strengths economically. Dhanalakshmi and her colleagues did a comparative research on eggshell cement and fly ash as a partial substitute for cement in concrete (2015). As a consequence of the substitution of cement with two wastes, new products have emerged. Fly ash has improved the workability and density of concrete with the greatest possible ESP. [5] [5] Using eggshell powder as an alternative to cement was researched by Mohamed Ansari et al ( 2016). The properties were replaced with ESP cement replacements ranging from 10% to 20%. To a 10 to 15 percent reduction in intensity, results show that ESP substitution works. Monisha et al. conducted experiments on eggshell powder and polypropylene fibre concrete (2016). Fine aggregates of ESP (20%) and polypropylene fibre (0, 0, 2, and 4 percent) are suggested as alternatives in the research that goes along with it. Strength characteristics are comparable to standard concrete after 7-14 and 28 days of cure. Resilience of fine particles substituted by ESP is shown, and polypropylene fibre content of 0.2% by weight of concrete at grade M20 was obtained. There has been research exploring the use of eggs and rice as partial cement replacements to enhance concrete's mechanical characteristics.

## III .Objective of the study

Because copper and eggshell power slag is a waste product, we use There to dispose of it in order to minimise environmental damage. In the construction, there is copper slag There are several applications for copper slag outside of building, although it only accounts for a small percentage of the total.

It is the major objective of this research to use copper slag as fine aggregate in concrete. Concrete's strength measures, including as compressive strength, tensile strength, and flexural strength, which fine contributes to, are essential to understanding how the material behaves. As an alternative to using copper slag and egg shell powder, we may use a range of percentages such as 0% (5% + 5%), 15% + 10% (also known as 15% + 15%), 20% (+20%) (also known as 25% + 20%), and 30% (+30%)

## IV .Methodology

The development of a concrete technologist capable of formulating concrete and hardened-concrete mixes with accurate strengths and durability is an essential objective of this research. Developing a concrete mix is not an easy task because of the wide range of material qualities, the site conditions (particularly exposure conditions), and the specific activity for which the mix is produced. A thorough understanding of the interactions between concrete's many constituents, both on site and after hardening, is required for this task. All of these aspects make designing a blend considerably more complex. Designing and constructing the concrete mix requires additional knowledge and expertise in the field of concrete building. It is possible to alter and vary the amount of concrete components in the lab depending on the individual conditions of the field.

Mix design is the process of selecting and specifying the optimum proportions of different concrete materials in order to generate a product with minimum strength and endurance. By definition To begin, only high-strength and dependable materials should be used. A second goal is to make concrete the most cost-effective choice. Price and cost are the two most essential factors in calculating the total cost of the project. Cement is used in the smallest quantity feasible while yet being strong and long-lasting in order to save money.

4.1 **Mix Design of Conventional Concrete (M30)**

In the following phase, the concrete will be designed.

**Step 1 :Target Mean Strength**

$$f'_{ck} = f_{ck} + 1.65 \times \sigma = 30 + 8.25$$

$$= 38.25$$

**Table 1 Assumed Standard Deviation**
(*Clauses* 3.2.1.2, A-3 *and* B-3)

| Sl No. (1) | Grade of Concrete (2) | Assumed Standard Deviation N/mm² (3) |
|---|---|---|
| i) ii) | M 10, M 15 | 3.5 |
| iii) iv) | M 20, M 25 | 4.0 |
| v) vi) vii) viii) ix) x) | M 30, M 35, M 40, M 45, M 50, M 55 | 5.0 |

NOTE — The above values correspond to the site control having proper storage of cement; weigh batching of all materials; controlled addition of water; regular checking of all materials, aggregate grading and moisture content; and periodical checking of workability and strength. Where there is deviation from the above, values given in the above table shall be increased by 1 N/mm².

**Phase 2: Ratio of W / C**
It is recommended that the graph described in IS10262,w/c be considered as 0.46 for a compressive strength of 25 N / mm2.
Hence, the w/c ratio is 0,45 for at least two different conditions, as shown in Table 5 of Is 456 for a mild condition.

**Stage 3: Water's worth to society**
As may be seen in Table 2 of IS10262, only 20 mm of the entire capacity is really being used. According to this, the maximum water content is 186 kg.

$$\text{Water content} = 186 \times 1.06 = 197.16$$

**Table 4.2: Water Content**

**Table 2 Maximum Water Content per Cubic Metre of Concrete for Nominal Maximum Size of Aggregate**
(*Clauses* 4.2, A-5 *and* B-5)

| Sl No. (1) | Nominal Maximum Size of Aggregate mm (2) | Maximum Water Content [1] kg (3) |
|---|---|---|
| i) | 10 | 208 |
| ii) | 20 | 186 |
| iii) | 40 | 165 |

NOTE — These quantities of mixing water are for use in computing cementitious material contents for trial batches.

[1] Water content corresponding to saturated surface dry aggregate.

## 4.2 Calculation Of Coarse Aggregate And Fine Aggregate

Our w / c is 0,46, and our coarse aggregate volume is 0,6; the coarse aggregate volume of 20 mm is 0,62, and the volume of fine aggregate is 0,608 for the coarse aggregate volume of w / c 0,42, according to IS10262.

and hence volume of fine aggregate is 1 - 0.608 = 0.392

**Table 4.2: Zone classification**

**Table 3 Volume of Coarse Aggregate per Unit Volume of Total Aggregate for Different Zones of Fine Aggregate**
(*Clauses* 4.4, A-7 *and* B-7)

| Sl No. | Nominal Maximum Size of Aggregate | Volume of Coarse Aggregate [1] per Unit Volume of Total Aggregate for Different Zones of Fine Aggregate | | | |
|---|---|---|---|---|---|
| | mm | Zone IV | Zone III | Zone II | Zone I |
| (1) | (2) | (3) | (4) | (5) | (6) |
| i) | 10 | 0.50 | 0.48 | 0.46 | 0.44 |
| ii) | 20 | 0.66 | 0.64 | 0.62 | 0.60 |
| iii) | 40 | 0.75 | 0.73 | 0.71 | 0.69 |

[1] Volumes are based on aggregates in saturated surface dry condition.

## Step 6 : Mix Proportion

volume of concrete = $1m^3$

$$\text{volume of cement} = \frac{438.13}{(3.2\times1000)}$$

$$= 0.136m^3$$

volume of water = 197.16

$$= 0.197m^3$$

Absolute weight of all materials except total aggregates = 1 - (0.136 + 0.197)

$$= 0.667$$

volume of coarse aggregate = $0.667\times0.61\times2.68\times1000$

$$= 1090.41\ m^3$$

volume of fine aggregate = $0.667\times0.39\times2.52\times1000$

$$= 655.52\ m^3$$

**438.13:655.52;1090.41 1:1.49; 2.48 is the mix ratio for step 7.**

## V.The materials that were put to use.

## 5.1 Cement:

In order to create concrete, it is necessary to have a supply of cement. In the construction industry, cement is a well-known and essential building material. A variety of cements are available on the market, each with its own unique features, such as colour and cement arrangement.
Tables 1 and 2 demonstrate the cement's physical qualities and chemical composition, respectively.


***Figure 5.1- Ordinary Portland cement 53 grade***

**Table 5.1 Physical Properties of cement**

| Sl.no | Properties | Test value |
|---|---|---|
| 1 | Standard Consistency | 34% |
| 2 | Initial Setting Time | 35min |
| 3 | Specific Gravity | 3.14 |
| 4 | Fineness | 3% |

**Table 5.2 Chemical Properties of Cement**

| Sl.no | Oxide Contents | Percentage (%) |
|---|---|---|
| 1 | CaO | 60.67 |
| 2 | SiO2 | 17.25 |
| 3 | Al2O3 | 3-8 |
| 4 | Fe2O3 | 0.5-6.0 |
| 5 | MgO | 0.1-4.0 |
| 6 | K2O, Na2O | 0.4-1.3 |
| 7 | SO3 | 1.3-3.0 |

**5.3 Coarse Aggregate:**

Almost all concrete is made out of a coarse material. With this approach, moisture movement-induced shrinkage and other dimensional changes are minimised since the materials utilised are chemically inert. The Rigid broken granite stones are found in the coarse aggregate of the concrete mixture. This is how they were hired. A adjacent quarry provides 20 mm-sized material. Materials greater than 20 mm are segregated in silos. Statistical tests are used to examine the overall features of a sample population.

***Figure 5.3- Coarse aggregate***

**Table 5.3 Physical properties of Coarse aggregate**

| Sl.no | Properties | Test Value |
|---|---|---|
| 1 | Specific gravity | 2.67 |
| 2 | Fineness modulus | 4.75 |
| 3 | Aggregate impact value | 24.48% |
| 4 | Flakiness Index | 12.56% |
| 5 | Elongation Index | 42.24% |

**5.4 Fine aggregate**

The aggregate's primary role is to aid in the creation of workability and consistency in the mixture. In addition, the fine mixture aids the cement paste in suspending the coarse aggregate particle. To prevent any segregation between the paste and the coarse aggregate, do this operation.

*Figure 5.4-Fine aggregates*

**Table 5.4 Physical Properties of Fine aggregate**

| Sl.no | Properties | Test value |
|---|---|---|
| 1 | Specific gravity | 2.7 |
| 2 | Fineness Modulus | 4.72 |
| 3 | Bulking of fine aggregate | 52% |

**5.5Copper slag**

Almost all concrete is made out of a coarse material. With this approach, moisture movement-induced shrinkage and other dimensional changes are minimised since the materials utilised are chemically inert. The Rigid broken granite stones are found in the coarse aggregate of the concrete mixture. This is how they were hired. A adjacent quarry provides 20 mm-sized material. Materials greater than 20 mm are segregated in silos. Statistical tests are used to examine the overall features of a sample population.

*Figure5.5-Copper slag*

**5.6 Egg shell powder**

The egg shell wastelands have received particular attention in the poultry sector due to the possibility for recovery that they represent. Eggshell trash is plentiful and easily available from the food processing, egg cracking, and shading industries. The food enjoyment industry should look at more ecologically friendly methods of processing and using egg shell waste. We need a low-cost answer. Eggshell waste removal is often not a source of income, but rather a cost. When it comes to getting rid of anything, the least expensive technique should always be used..

*Figure 5.6- Egg shell powder*

**Table 5.6 Physical Properties of Egg shell powder**

| Sl.no | Properties | Test value |
|---|---|---|
| 1 | Specific gravity | 2.44 |
| 2 | Standard Consistency | 39% |
| 3 | Initial setting time | 38 min |

## VI .Results and Discussion

**6.1 Introduction**

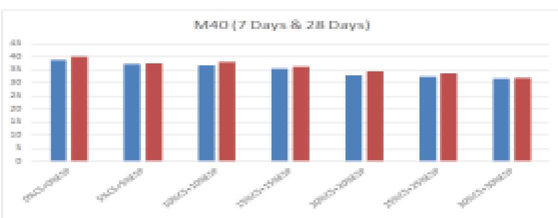
As previously noted, six cubes were made from each of the mixes listed, enabling compression testing on two cubes to be undertaken on seven days, 14 days and 28 days, while the average compression value was utilised as a compressive power in the next chapter of the study.

**Test results**

**Table 6.1 Compressive strength results**

| Sl.no | Type of concrete | M30(7 Days) | M30(28 Days) | M40(7 Days) | M40(28 Days) |
|---|---|---|---|---|---|
| 1 | 0%CS+0%ESP | 28.84 | 29.60 | 38.60 | 39.86 |
| 2 | 5%CS+5%ESP | 28.60 | 29.20 | 37.24 | 37.44 |
| 3 | 10%CS+10%ESP | 27.40 | 29.80 | 36.60 | 37.90 |
| 4 | 15%CS+15%ESP | 26.40 | 27.00 | 35.40 | 36.20 |
| 5 | 20%CS+20%ESP | 25.60 | 26.40 | 32.80 | 34.22 |
| 6 | 25%CS+25%ESP | 22.20 | 24.20 | 32.20 | 33.45 |
| 7 | 30%CS+30%ESP | 21.00 | 23.60 | 31.60 | 31.62 |


**Graph 6.2 – 7 & 28 Days strength of different proportions of M30 grade concrete**

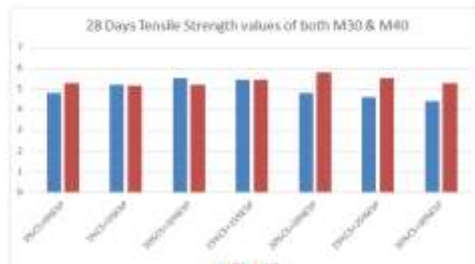



**Graph 6.3 – 7&28 Days strength of different proportions of M40 grade concrete**

## 6.3 Tensile Strength

**Table 6.2 Tensile Strengths**

| Sl.no | Type of concrete | 28 Days Tensile strength of M30 | 28 Days Tensile strength of M40 |
|---|---|---|---|
| 1 | 0%CS+0%ESP | 4.82 | 5.28 |
| 2 | 5%CS+5%ESP | 5.21 | 5.16 |
| 3 | 10%CS+10%ESP | 5.53 | 5.20 |
| 4 | 15%CS+15%ESP | 5.45 | 5.46 |
| 5 | 20%CS+20%ESP | 4.80 | 5.80 |
| 6 | 25%CS+25%ESP | 4.60 | 5.53 |
| 7 | 30%CS+30%ESP | 4.40 | 5.30 |

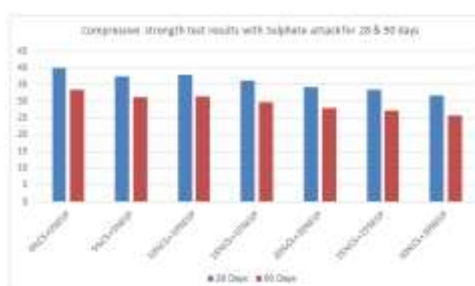



**Graph 6.4-28 Days Tensile strength of different proportions of M30 & M40 grade concrete**

## 6.4 Compressive strength test with Sulphate attack

**Table 6.3 Compressive strength test with Sulphate attack**

| Sl.no | % replacement | Compressive strength of cube after 28 Days | Compressive strength of cube after 90 Days | %loss of compressive strength due to sulphate attack |
|---|---|---|---|---|
| 1 | 0%CS+0%ESP | 39.86 | 33.40 | 16.22 |
| 2 | 5%CS+5%ESP | 37.44 | 31.13 | 16.84 |
| 3 | 10%CS+10%ESP | 37.90 | 31.37 | 17.22 |
| 4 | 15%CS+15%ESP | 36.20 | 29.82 | 17.60 |
| 5 | 20%CS+20%ESP | 34.22 | 28 | 18.20 |
| 6 | 25%CS+25%ESP | 33.45 | 27.30 | 18.40 |
| 7 | 30%CS+30%ESP | 31.62 | 25.73 | 18.60 |



**Graph 6.5- Compressive strength test results with Sulphate attack for 28 & 90 days**

# VI .Conclusion

The cement, fine aggregates, and gross aggregates may be used for testing since they fulfil IS code standards within acceptable limits.

Because copper slag concentration has decreased, concrete built with it has a lower drop cone value.

Copper slag concrete's compaction factor decreases with increasing copper slag content.

Concrete compressive force resulted in a 20% copper layer replacement over the 7-day and 28-day treatment periods.

Copper slag replenishment of 20% for cylindrical specimens is most effective after 28 days.

Coating the surface of the mixture with egg coating powder may increase carbonation and minimise permeability. The carbonation cycle in the mixture must thus be thoroughly studied.
The workability of concrete was shown to be adversely affected by the presence of ESP and Copper Slag at concentrations ranging from 14 percent to 20 percent.

It takes 28 days for maximal bending strength to be achieved at a concentration of ESP (14%) and Copper Slag (20%).

A 28-day period and a 40% coffee slag duration resulted in the highest split tensile strength.
Increasing the tensile strength of concrete grade M30 is as simple as adding 20 percent copper slack to the mix.10. Copper slag substitution of 20% to 40% in M30 grade concrete typically improves the concrete's tensile strength.

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