# EXPERIEMENTAL INVESTIGATION ON REPLACEMENT OF CEMENT WITH MUNICIPAL SOLID WASTE ASH AND EGG SHELLS IN THE PREPARATION OF CONCRETE

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**ABSTRACT**

With increasing industrialization, the industrial by products (wastes) are being accumulated to a large extent, leading to environmental and economic concerns related to their disposal (land filling). Egg shells are the biodegradable waste obtained from chick hatcheries, bakeries, fast food restaurants. Among other biodegradable wastes, this can damage the surroundings and thus leads to ecological issues/contamination which would need appropriate treatment. In the ever-soaring tasks to change waste to wealth, the efficiency of adopting eggshells to advantageous application constitutes a concept worth-recognizing. It is systematically acknowledged that the egg shell chiefly consists of calcium compounds. It is estimated that roughly 90 million tons of hen egg are generated throughout the world every year. In India, 77.7 billion eggs are produced in the year 2010-2011. The municipal solid waste incineration ash reduces are worldwide studied topic over the last decades, so that utilize the municipal solid waste is the one of the possibilities is to use MSW ash in concrete production as it is done the bottom ash features the most convenient composition in concrete and it is available in highest amounts among the MSW ashes the bottom ash was used as partial replacement of cement in concrete strength has to find, if the prepared concrete will get sufficient strength or not. Cement is an energy extensive industrial commodity and leads to the emission of a vast amount of greenhouse gases. By reducing the demand of cement, natural reserves of limestone can be preserved, energy can be saved and pollution due to $CO_2$ can be reduced. In this project, concrete will be casted for M20 grade and the partial replacement of cement with 0 to 20% of municipal solid waste ash (MSWA) and 5% of egg shells powder (ESP) by weight of cement. The workability, compressive strength and flexural strength were conducted and results were analysed.

*Keywords: egg shell powder (ESP), municipal solid waste ash (MSWA), workability, tensile strength and compressive strength.*

## 1. INTRODUCTION

### 1.1 MSWA

The incineration of municipal solid waste has significant benefits as it can reduce the volume and the mass of the waste by about 90% and 70%, respectively. Municipal solid waste is collected and burned in an incinerator; the by-products of the combustion process are collected. Bottom ash typically accounts for 80% of the whole amount of by-products in the MSWI plants. Municipal solid waste incinerator bottom ash is the ash that is left over after waste is burnt in an incinerator. This ash contains glass, brick, rubble, sand, grit, metal, stone, concrete, ceramics and fused clinker as well as combustive products such as ash and slag. Cement and aggregate, which are the most important constituents used in concrete production, are the vital materials needed for the construction industry. This necessity led to a continuous and increasing demand for natural materials. Parallel to the need for the utilisation of the natural resources emerges a growing concern for protecting the environment and need to preserve natural resources, by using alternative materials that are either recycled or discarded as a waste. One of the possibilities is to use Municipal Solid Waste ashes in concrete production.

Cement and aggregate, which are the most important constituents used in concrete production, are the vital materials needed for the construction industry. This inevitably led to a continuous and increasing demand of natural materials used for their production. Parallel to the need for the utilization of the natural resources emerges a growing concern for protecting the environment and a need to preserve natural resources, such as aggregate, by using alternative materials that are either recycled or discarded as a waste.

Concrete has been a major construction material for centuries. Moreover, it would even be of high application with the increase in industrialization and the development of urbanization. Yet concrete construction so far is mainly based on the use of virgin natural resources. Meanwhile the conservation concepts of natural resources are worth remembering and it is very essential to have a look at the different alternatives. Among them lies the recycling mechanism. This is a two fold advantage. One is that it can prevent the depletion of the scarce natural resources and the other will be the prevention of different used materials from their severe threats to the environment.

The use of Municipal Solid Waste incinerator ash(MSWA) as a part of cement raw material was investigated. The purpose was not only to dispose of the wastes, but also to alleviate some environmental problems, by reducing resources usage, $CO_2$ emissions and energy consumption in cement manufacturing. The replacement of MSWA in raw meal was 5 and 15 percent. Chemical composition and general characteristics, as well as setting times and compressive strength, of the MSWA cements were tested and compared with conventional cement. The chemical compositions of MSWA cements were similar to the control cement, except that the SiO2 component in MSWA cements was higher than that in control cement. Setting times of cement pastes were slightly different when MSWA were used as raw materials in cement. The longer setting times of these cement pastes than those of control cement is due to lower $c_3s$ and higher $c_2s$ levels than in CC. Compressive strength of mortar produced from MSWA cements was rather smaller than the control cement mortar, especially at higher MSWA percentage.

Municipal Solid Waste (MSW) generation in India is of critical concern, especially in big cities. Hyderabad city, alone, produced approximately 4200 tons per day and per year 11550000 tons in 2018. The incineration of municipal solid waste, an effective method of volume reduction, is presently receiving wide spread attention as a final disposal method of MSW in Hyderabad. Likewise, MSW incineration process creates two general types of ash; fly ash and bottom ash. MSW ash can be used in concrete; it will not only be able to reduce the consumption of cement raw materials, but also to solve the MSW ash disposal problems simultaneously found that MSW ash has an irregular grain surface and very high specific surface area. Other properties such as high loss on ignition, highly variable in characteristics and low reactivity were also contributing problems in the reuse of MSW ash as a pozzolan. Studied the properties of concrete containing MSW incineration ash and reported that different burning conditions affected the reactivity of MSW fly ash. In addition, samples from different compositions resulted in different chemical and physical properties of the final MSW ash cement studied the use of MSW as cement replacing material. The results show that the setting time of paste was delayed significantly. Compressive strength of the concrete replaced with MSW was also greatly reduced when compared with the control concrete.

Classified the combustible MSWs into three major types; paper, leaves, and food. After preparation, leaves, paper and food were separately burned in a ferro-cement incinerator. Finally, all types of combustible MSW ashes were ground in a grinding machine fixed at 45 minutes. The weight ratio of each combustible MSW ash to total raw material was fixed at 0.05 for all of the experiments. They found that chemical composition and setting property of these cement, as well as the compressive strength of concrete, were rather close to the control cement. From the previous research, the use of MSW ash as a pozzolan or cement replacing material gave undesirable properties of the cementanous materials. Another research used MSW ash as a part of raw materials by classifying the combustible MSW in to paper, leaves and food. The results showed that the general properties were similar to Ordinary Portland Cement (OPC). However, in practice it is difficult to classify MSW.

Accordingly, this study presents the possibility of using MSWA as a part of raw materials in cement manufacturing without adjusting the proportion of raw meal. For real applications, if MSWA is replaced in raw materials, it may be necessary to adjust the proportion of raw meal. This new type of cement is expected to improve energy efficiency, to conserve raw materials and to reduce air pollution of the cement manufacturing, while the cement quality is expected to be the same as that of OPC.

From the previous work dons the compressive test results on the cement replaced municipal solid waste ash cubes did show improvement while adding 5% and 10% in the 28 days strength in comparison to the control cube, but it fall increasing the percentage of MSWA above 10%. Replacement of municipal solid waste ash up to 10% is good for using construction purposes. And also solid waste incineration powder replacing mixes are also used as base coarse. While increasing the percentage of MSWA in cement then $CaCO_3$ will reduces in it. As we maintain the more percentage of MSWA then add suitable amount of $CaCO_3$.

**1.2 Egg shells**

The eggshell has good characteristics when mixed with concrete and it has a good strength durability. Most of the eggshell waste is commonly disposed in landfills without any pre-treatment because it is traditionally useless. Eggshell has a cellulosic structure. Egg Shell Powder (ESP) is the fine-grained powder with suitable proportion which is sieved to the required size before use with concrete/mortar. An eggshell on an average is composed with 2.2 g of calcium in the form of CaCO3. An estimate of around 98.2% of dry shell constitutes CaCO3, and 0.9% of each magnesium and phosphorous are the composition of eggshell. The chemical composition of chicken eggshells has been well researched upon. Elemental and ultra-structural analysis revealed heterogeneous distribution of minerals throughout the thickness of the shell. Concentration of calcium, magnesium, and sodium were higher in inner layer of the shell before hatching. Eggshells offer wide range of applications in varied sectors such as in nutrition, art works, construction, fertilizers, and medicine It is speculated to be the better source of calcium than limestone. Eggshells have been reported has an alternative source for soil stabilizing agent. It is used as fertilizer supply for calcium. The acidity of soil can be reduced with the utilization of calcium from eggshell. The waste eggshells were reported to be a good adsorbent of humidity. CaO was produced when the eggshells were heated at 1300°C for four hours. The difference in hydration rate of CaO produced from heating of duck and chicken eggshells were investigated, where duck eggshells showed higher adsorption of humidity. Eggshell waste produced from poultry is huge in number. Traditional methods of disposal are employed such as landfill, rendering, composting, and incineration. Ground water and soil get equally polluted. The expenditure for disposal is huge setback for the industry. A limited number of studies had been conducted on the re-use of eggshell waste as an alternative material. The powdery form of eggshell powder was partially replaced in cement in this study. Eggshell powder was added to Portland cement in various amounts. The effect of replacement of eggshell powder for cement in proportion such as 2.5%, 5%, 7.5% and 10% by weight of cement was studied in detail.

The scope of the study is to determine the optimum percentage of MSWA-eggshell powder based concrete by conducting compressive strength test, bending test at the age of 7 and 28 days with the specified combinations of eggshell powder with MSWA and comparing with the control normal concrete specimen.

## 2. LITERATURE REVIEW

### 2.1 General

Population growth, booming economy, and rapid urbanization have greatly accelerated the solid waste generation all around the world. The annual global generation of solid waste has recently approached 17 billion tons and is supposed to hit 27 billion tons by 2050 (Laurent et al., 2014). This issue is of stinging concern to the nations, municipalities, and individuals, as it can cause significant damages to human health, natural resources, and ecosystems. Therefore, the concept of adopting green chemistry and technologies for environmental sustainability has been increasingly recognized and included in recent years.

Most notably, the traditional concept, in which waste is regarded as pollution, has been progressively shifting towards the new perspective that waste is treated as a resource. This undoubtedly can support societies to become more sustainable. For instance, the energy generated in certain thermal processes of waste materials can trim the energy generation services through conventional technologies. Likewise, the reuse or recycling of certain solid waste materials, such as metal, plastic, and paper can conserve the source of the corresponding virgin materials.

Against this scenario, the research of recycling solid waste materials into the production of construction materials has been carried out extensively (De Carvalho Gomes et al., 2019). These endeavors are intended to slim down the volume of solid waste, and also trim down the mounting demand for natural resources in the construction industry. Heretofore, impressive achievements relevant to this field have been attained. For example, Huang et al. (2007) reviewed the successful utilization of solid waste materials (i.e., steel slag, waste glass, tires, and plastics, etc.) for the development of asphalt pavements .

Meng et al. (2018) summarized the existing research work on recycling a range of solid waste materials in the production of concrete blocks, including crushed brick, waste glass, recycled concrete, ceramic waste, and tile waste, etc. Luhar et al. (2019b) outlined the possible use of various kinds of aquacultural and agricultural farming waste as supplementary materials in concrete. Besides that, some attracting achievements have been made in recycling solid waste materials for the manufacture of geopolymer composites. Geopolymer, namely alkali-activated material, is usually derived from the chemical reaction between aluminosilicate precursor materials and alkaline activators, being widely regarded as an alternative to ordinary Portland cement (OPC) (Provis, 2013). The past three decades have witnessed the rapid development of geopolymer through academic pursuit because of its excellent performance in various fields.

**2.2 Municipal solid waste**

Currently, incineration is commonly used practice against the context of substantial MSW. Incineration can reduce waste volume and mass by up to 90 % and 70 %, respectively (Silva et al., 2019b). Additionally, incineration allows for producing energy from waste. While after the incineration process, two types of ashes are generated, namely municipal solid waste incineration bottom ash (MIBA) and municipal solid waste incineration fly ash (MIFA). MIBA is the residue with large particles, which is found at the bed of the incinerator, whereas MIFA corresponds to the very fine particles collected by the air pollution control system (Sarmiento et al., 2019).

On the other hand, several studies have been conducted to use pretreatments such as alkaline treatment, vitrification, and wet grinding to eliminate the effect of foaming and expansion by metallic aluminate presented in MIBA (Zhu et al., 2019b). In the series of studies by Huang et al. (2019a), the alkaline treatment was employed. Specifically, MIBA was mixed with sodium hydroxide solution to form slurry and to age this slurry for 4 h, prior to preparing MIBA-based geopolymer composites. Meanwhile, several additives were incorporated during the geopolymer composite preparation for further improving the performance (Huang et al., 2018b; Huang et al., 2019a, b). The test results showed that the resulted geopolymer composites possessed satisfactory compressive strength and durability due to the high degree of geo polymerization and dense microstructure (Huang et al., 2018b; Huang et al., 2019b).

More to the point of utilizing MIBA as a precursor or gas-forming additive, researchers have evaluated the feasibility of the application of MIBA to substitute the aggregate in geopolymer composites. The study of Gao et al. (2017) was on this aspect. Here, MIBA was employed as a substitute for a maximum of 50 % fine aggregate (by volume) in geopolymer mortar. Although MIBA negatively affected the strength for its porous and fragile structure, no expansion and cracking was observed due to the metallic aluminate from MIBA. Eventually, the compressive strength of 35–56 MPa can be achieved, suggesting wide application potentials and high reuse rates of MIBA in geopolymer composites. Furthermore, the leaching behavior of formed products met the relevant legislation, confirming the advantages of using geopolymer composites again.

**2.4 Eggshells powder**

Manzoor Ahmad Allie (2018) In this paper, it is studied that quality of construction material is an important issue which enhances the stability of the structure, an attempt has been made to study the possibilities of using Eggshell powder in paver block. Cement was partially replaced by Eggshell Powder at 5% intervals from 0% to 25% by the method of replacement by weight. The paver block Curing process is done for 7 days and 28 days, after curing it is checked for its Compressive Strength and flexural strength. It was noted that 13.4% increase of compressive strength at 10% replacement of Eggshell Powder. Flexural strength was also 19.5% increased at the same 10% replacement of Eggshell

Powder. The result showed the Eggshell Powder can gives more strength if it was replaced as 10% of cement.

Pradeep Sharma (2018) In this study performed to decide the very best excellent percent of eggshell powder as partial cement replacement. The creation industries are looking for 'alternative material that may lessen the Construction cost. Over 5% of world $CO_2$ emissions can be credited to Portland cement manufacturing. Demand for cement maintains to develop different ESP concretes were established through replacing 4 to 16% of ESP for cement. Concrete performs the important thing function and a large quantity of concrete is being implemented in every introduction exercise. The egg shell commonly that are disposed, is used as an exchange for the cement for the reason that shell is manufactured from calcium. An egg shell is utilized in first rate combos to discover the feasibility of the use of the egg shells as an exchange to cement. Intention of this task is to prevent the pollution of environment with the aid of the usage of the wrong disposal of the eggshell waste, a live from eggshells domestic waste which includes schools, restaurant, bakeries, homes and rapid food accommodations, via the use of the usage of it as an additive fabric inform of ash & powder in traditional concrete with grade M35 because it's far usually utilized in manufacturing internet websites.

N. Parthasarathi (2017) In this paper, concrete is broadly used for the structures. Cement is main material in concrete but due to high demand of cement is costly. And to minimize the cost of structure, alternate material is required to manage the wastes in eco-friendly way. The intention of this research work is to apply the egg shell powder constrained extra of cement. Eggshell powder is changed by using 5%, 10% and 15% weight of cement. An experimental study proves the strength capabilities consisting of spilt tensile strength take a look at that is decreased with addition of eggshell powder, compressive strength test and flexural strength take a look at which can be increased up to 15%.

Amarnath Yerramala (2014) In this paper, it describes the usage of poultry waste in concrete thru the improvement of concrete and studied the Properties of concrete with eggshell powder (ESP) as cement alternative. Different ESP concretes had been advanced through replacing 5-15% of ESP for cement. Test are taken, compressive energy and split tensile strength take a look at turned into better than normal concrete for 5% of ESP alternative and it had lower strength than normal concrete with greater than 10% of substitute on the age of 7 & 28 days. The results proven that irrespective of ESP percentage substitute there has been proper relationship among compressive strength and split tensile strength.

## 3. OBJECTIVE AND METHODOLOGY

### 3.1 Objective

The objectives of the work are stated below:

i) To develop mix design methodology for mix 20 MPa
ii) To study the effect of adding different percentages (0% - 20%) of MSW ash and 5% Eggshells powder by the weight of cement in the preparation of concrete mix.
iii) To determine the workability of freshly prepared concrete by Slump test.
iv) To determine the compressive strength of cubes at 7, 14, 28 days.
v) To determine the Tensile strength of beams at 28 days.

### 3.2 Methodology

1. Collect the egg shells from, by blending process the egg shell powder (ESP) was obtained. The ESP and sieve with 75microns IS sieve, passed ESP used for cement replacement. Find out the fineness modulus and specific gravity tests for ESP.
2. The MSWA prepared in the month of March 2023 in a manual incineration process at Ghatkeshar Municipal Solid waste dampage area. The incinerator ash has been sieved and metal pieces has been removed manually. The generated ash from manual incineration involves a wide range of particles size; only the fraction less than 75 microns has been used in this work. The ash has been dried before experiments. Find out the fineness modulus and specific gravity tests for MSWA.
3. Find out the physical properties of Coarse aggregate, Fine aggregate, cement.
4. Design mix design of M20 grade concrete. And calculate the mix proportions for individual mix.
5. Partial replacement of cement with 5% ESP with varying percentages MSWA of (0% - 20%) in the preparation of concrete.
6. Perform the workability, compressive strength and tensile strength tests on conventional and MSWA-ESP based concrete. Compare the values and find out the optimum percentage of MSWA-ESP replacing by cement.
7. Conclusions.

### 3.3 Experimental program

To achieve the specified objectives (section 3.1) the following test program was planned and presented in the table 3.1. The number of specimens allotted for each test was included in the same table.

**Table 3.1: Experimental Program**

| Type of test to be conducted | Behavior to be identified | Specimen | Size | No |
|---|---|---|---|---|
| Slump cone test | Fresh concrete properties | - | - | |
| Compression test | Compressive strength | Cube | 150 X 150 X 150 mm | 54 |
| Flexural strength test | bending strength | Beam | 300 dia X 100 mm height | 18 |

## 4. EXPERIMENTAL INVESTIGATION

### 4.1 Materials Used

The different materials used in the investigation are:

#### 4.1.1 Cement

Cement used in the investigation was found to be Ordinary Portland Cement (53 grade) confirming to IS : 12269 – 1987.

#### 4.1.2 Fine Aggregate

The fine aggregate used was obtained from a near by river course. The fine aggregate confirming to zone – II according to Is 383-1970 was used.

#### 4.1.3 Coarse aggregate

The coarse aggregate used is from a local crushing unit having 20mm nominal size. The coarse aggregate confirming to 20mm well-graded according to IS:383-1970 is used in this investigation.

#### 4.1.4 Municipal solid waste ash

The MSWA prepared in the month of February 2023 in a manual incineration process a Ghatkeshar Municipal Solid waste dampage area. The specific gravity and fineness test is performed.

**Figure 4.4 Municipal solid waste ash (MSWA)**

#### 4.1.5 Eggshells powder

The ESP prepared in the month of February 2023 in a grinding process. The specific gravity and fineness test is performed.

**Figure 4.5 ESP**

### 4.3 Mix Design

Adopted Grade of concrete used-$M_{20}$

#### 4.3.1 Mix Design of Conventional Concrete (M20)

- In this project we are adopted M20 (1:1.5:3) grade of concrete, Assumed water cement ratio 0.5

- Density of cement = 1440 kg/$m^3$
  Density of aggregates=1800kg/$m^3$
  Density of sand=1600kg/$m^3$

- Dry volume= (1.54 to 1.57) x wet volume

- Sum of the ratio for M20 grade concrete = 1+1.5+3=5.5

- Assume volume =1$m^3$ , No. of samples =1, Wastage = 10% (10/100 = 0.1), Dry volume =1.54 x wet volume = 1.54 x 1 = 1.54
  Final Volume of the cube = 1 x 1.54 x [1+0.1] x 1 = 1.694$m^3$
  Weight of cement = [(1/5.5) x 1440 x 1.694] = 443.52 kg
  Weight of sand = [(1.5/5.5) x 1600 x 1.694] = 739.2 kg
  Weight of aggregates= [(3/5.5) x 1800 x 1.694] = 1663.2 kg
  Weight of water:
  Assume w/c = 0.5
  Weight water = 0.5 x 443.52 = 221.76 kg = 221.76 lit

- **For cube (150mm x 150mm x 150mm = 0.003375 $m^3$)**
  Weight of cement = 443.52 x 0.003375 = 1.49688kg = 1496.88 gms
  Weight of sand = 739.2 x 0.003375 = 2.4948 kg = 2494.8gms
  Weight of aggregates= = 1663.2 x 0.003375 =5.6133 kg = 5613.3gms
  Weight water = 0.5 x 1496.88 = 748.44 gms = 748.44 ml

- **For beam (100mm x 500mm x 100mm = 0.005 $m^3$)**
  Weight of cement = 443.52 x 0.005 = 2.2176kg = 2217.6 gms
  Weight of sand = 739.2 x 0.005 = 3.696kg = 3696 gms
  Weight of aggregates= = 1663.2 x 0.005 = 8.316kg = 8316gms
  Weight water = 0.5 x =2217.6 = 1108.8 gms = 1108.8 ml

**Table 4.10: Individual weight of materials M20 grade**

| **Item name** | **For 1 cube (gms)** | **For 1 beam (gms)** |
|---|---|---|
| Cement | 1496.88 | 2217.6 |
| Fine aggregates | 2494.8 | 3696 |

| | | |
|---|---|---|
| Coarse aggregates | 5613.3 | 8316 |
| water | 748.44 | 1108.8 |

### 4.3.1 Mixed design proportions for MSWA-ESP based Concrete

- In this research work 15 Standard cubic specimens of size 150mm (nine sample for each percentage of MSWA-ESP) were casted for the compressive strength of concrete and it was kept under curing for 7, 14 days & 28 days of age. Total cubes for compressive strength testing was 54 (9 cubes * 6 proportions).
- In this research work 10 standard beams of size (three sample for each percentage of MSWA-ESP) were casted for flexural strength of concrete and it was kept under curing for 28 days of age. Total cubes for flexural strength testing was 18 (3 beams * 6 proportions).
- Mass of ingredients required will be calculated for 9 no's cubes assuming 10% wastage
- Volume of the Cube = $9*1.10*(0.15)^3 = 0.0334125\ m^3$
- Mass of ingredients required will be calculated for 3 no's beams assuming 10% wastage
- Volume of the Beam = $3*1.10*((0.10)^2*(0.50)) = 0.0165\ m^3$

**Table 4.11: Material Proportions Cubes**

| ESP% - MSWA% | 0% | 5%-0% | 5%-5% | 5%-10% | 5%-15% | 5%-20% |
|---|---|---|---|---|---|---|
| Cement (Kgs) | 14.64 | 13.908 | 13.176 | 12.444 | 11.712 | 10.98 |
| ESP (kgs) | 0 | 0.732 | | | | |
| MSWA (kgs) | 0 | 0 | 0.732 | 1.464 | 2.196 | 2.928 |
| water (lit) | 6.587 | | | | | |
| fine aggregate (Kgs) | 21.574 | | | | | |
| Coarse aggregate (Kgs) | 35.88 | | | | | |

**Table 4.12: Material Proportions Beams**

| ESP% - MSWA% | 0% | 5%-0% | 5%-5% | 5%-10% | 5%-15% | 5%-20% |
|---|---|---|---|---|---|---|
| Cement (Kgs) | 7.23 | 6.8685 | 6.507 | 6.1455 | 5.784 | 5.4225 |
| MSWA (gms) | 0 | 0 | 0.3615 | 0.723 | 1.0845 | 1.446 |
| ESP (gms) | 0 | 0.3615 | | | | |
| water (lit) | 3.253 | | | | | |
| fine aggregate (Kgs) | 10.654 | | | | | |

| | |
|---|---|
| Coarse aggregate (Kgs) | 17.722 |

**4.3.2 Sample Production**

The cement, fine and coarse aggregates were weighted according to mix proportion of $M_{20}$. All are mixed together in a bay until mixed properly and water was added at a ratio of 0.45. The water was added gradually and mixed until homogeneity is achieved. Any lumping or balling found at any stage was taken out, loosened and again added to the mix.

For the second series of the mixture, the 5% ESP and MSWA was added at 5%, 10%, 15% and 20% by weight of Cement. Immediately after mixing, slump test was carried out for all the concrete series mixture. A standard 150×150×150mm cube specimens and 100×100×500mm beam specimen were casted.

The samples were then stripped after 24hours of casting and are then be ponded in a water curing. As casted, a total of (54) 150×150×150mm cubes and (18) 100×100×500mm beams specimens were produced.

**Figure 4.11 Casted Cubes**

**4.3.4 Curing**

The method of curing adopted was the ponding method of curing and produced samples were cured cubes for 7, 14, 28 days and beams for 28days.

**Figure 4.12 Water Curing of Samples**

**4.4 Test for Fresh Properties of Concrete**

**4.4.1 Slump Test**

Which can be employed either in laboratory or at site of work. It is not a suitable method for very wet or very dry concrete. It does not measure all factors contributing to workability, nor is it always representative of the placability of the concrete. It is not a suitable method for very wet or very dry concrete. It does not measure all factor contributing to workability. The slump test was carried in accordance with B.S:1882 PART2:1970.

**Figure 4.13 Slump cone test**

### 4.5 Test for Harden Properties of Concrete

### 4.5.1 Compressive Strength of Concrete

The compression test was conducted according to IS 516-1959. This test helps us in determining the compressive strength of the concrete cubes. The obtained value of compressive strength can then be used to assess whether the given batch of that concrete cube will meet the required compressive strength requirements or not. For the compression test, the specimen's cubes of 15 cm x 15 cm x 15 cm were prepared by using ESP-MSWA based concrete as explained earlier. These specimens were tested under universal testing machine after 7 days, 14 days and 28 days of curing. Load was applied gradually at the rate of 140kg/cm$^2$ per minute till the specimens failed. Load at the failure was divided by area of specimen and this gave us the compressive strength of concrete for the given sample.

**Figure 4.15 Compressive Strength testing of cube sample**

**4.5.2 Flexural Strength of Concrete**

The flexural strength test was conducted according to IS:516-1959. 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 three 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 specimen was recorded. The modulus of rupture depends on where the specimen breaks along the span. Beam dimensions are 500mm×100mm×100mm. if the specimen breaks at the middle third of the span then the modulus of rupture is given by,

$$f_{rup} = \frac{P}{bd^2}$$

Where; P = load,

d = depth of the beam,

b = width of the beam.

**Figure 4.16 Flexural Strength tests of beam samples in UTM**

**5. RESULTS AND DISCUSSIONS**

As per experimental programme results for different experiments were obtained. They are shown in table format and graph format, which is to be presented in this chapter.

**5.1 Fresh properties of concrete (Workability Test)**

**5.1.1 Slump Test**

The Slump test was performed on the ESP-MSWA based concrete to check the workability of it at different replacements viz. 5%-0%, 5%-5 %, 5%-10 %, 5%-15%, 5%-20% and the following results were obtained, according to which it can be concluded that with the increase in % of MSWA from 0 to 20 % , workability increases. The results obtained for Slump test are shown below in Table 5.1.

**Table 5.1: Results of Slump test**

| S. No | ESP%-MSWA% | Slump value (mm) |
|---|---|---|
| 1 | 0% - 0% | 120 |
| 2 | 5% - 0% | 125 |
| 3 | 5% - 5% | 132 |
| 4 | 5% - 10% | 140 |
| 5 | 5% - 15% | 146 |
| 6 | 5% - 20% | 149 |

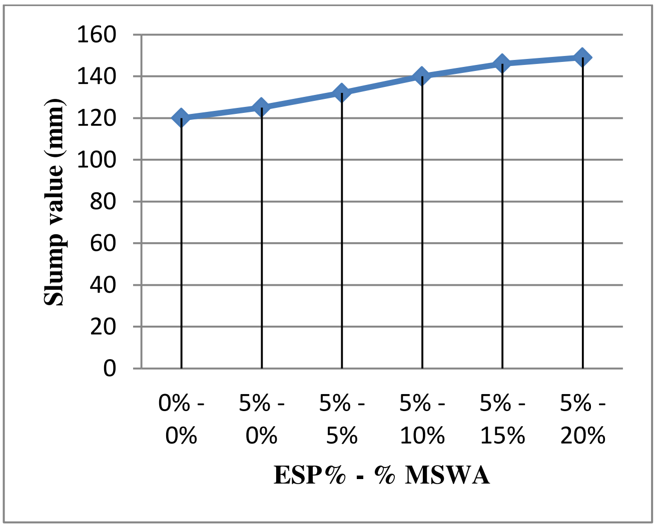


**Fig 5.1 : Slump test results**

The above figure 5.1 shows the slump results. It was observed that, the slumps increased as the MSWA content were increased in the mix. It was suitable for Medium Workability mixes.

**5.2 Harden properties of concrete**

**5.2.1 Compressive Strength Test**

The compressive strength test was performed on the cubes of size 15 cm x 15 cm x 15 cm to check the compressive strength of MSWA concrete and the results obtained are given in Table 5.2.

**Table 5.2: Results of compressive strength test**

| S. No | ESP%-MSWA% | Compressive strength of cubes ($N/mm^2$) | | |
|---|---|---|---|---|
| | | 7 days | 14 days | 28 days |
| 1 | 0% - 0% | 14 | 17.89 | 20.2 |
| 2 | 5% - 0% | 16.4 | 19.2 | 23.2 |
| 3 | 5% - 5% | 17.3 | 20.1 | 24.4 |
| 4 | 5% - 10% | 19.5 | 22 | 25.1 |
| 5 | 5% - 15% | 20.7 | 22.8 | 26 |
| 6 | 5% - 20% | 18.4 | 21.3 | 23.7 |

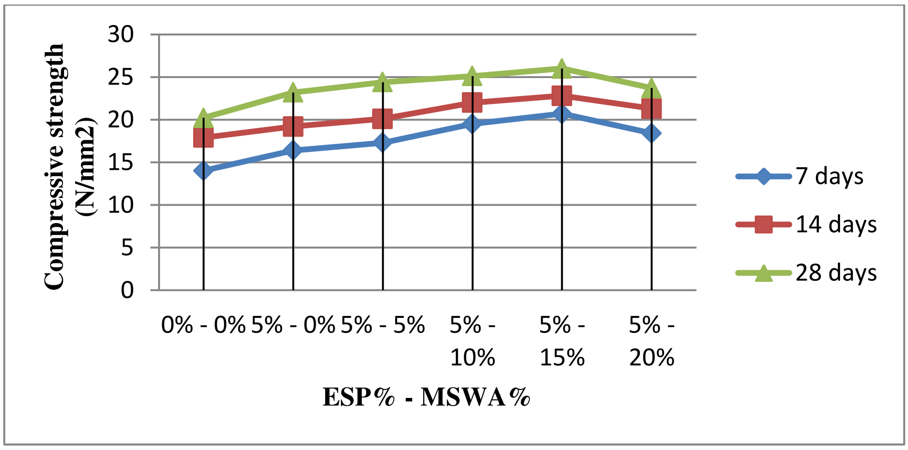


**Fig 5.2: Compressive strength**

From the above results it was observed that with the increase in percentage of ESP -MSWA from 5% - 5% to 5% - 15% in concrete the compressive strength increases after that decreases. The variation in compressive strength with respect to the given percentage of ESP - MSWA is shown in fig 5.2.

### 5.2.2 Flexural Strength Test

The Flexural test was performed on the beams of size 50 x 10 x 10 cm to check the flexural strength of the MSWA concrete and the results obtained while performing the flexural test on UTM are given in Table 5.3.

**Table 5.3: Result of flexural strength**

| S. No | ESP%-MSWA% | Flexural Strength for 28 days ($N/mm^2$) |
|---|---|---|
| 1 | 0% - 0% | 2.1 |
| 2 | 5% - 0% | 2.36 |
| 3 | 5% - 5% | 2.5 |

| | | |
|---|---|---|
| 4 | 5% - 10% | 2.62 |
| 5 | 5% - 15% | 2.74 |
| 6 | 5% - 20% | 2.42 |

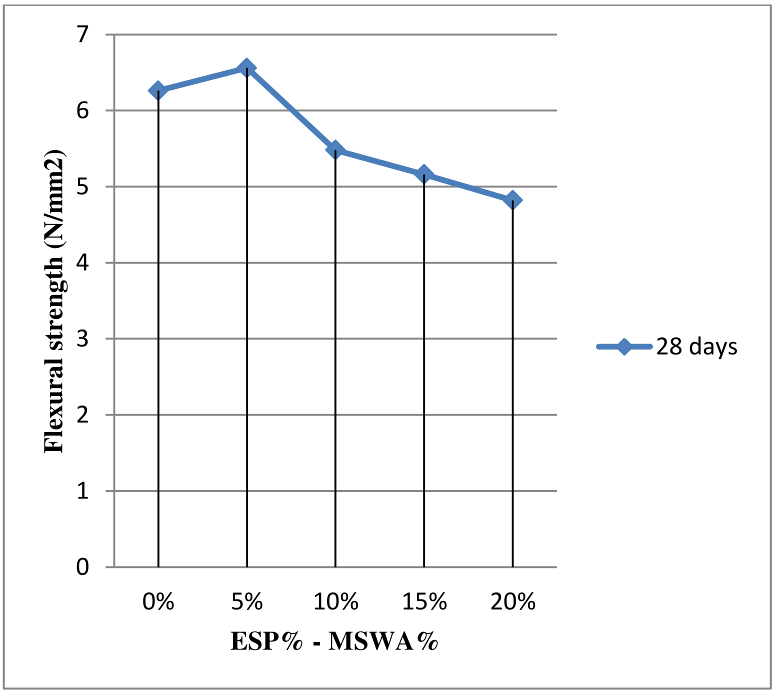


**Fig 5.3: Flexural strength**

From the above results it was observed that with the increase in percentage of ESP -MSWA from 5% - 5% to 5% - 15% in concrete the Flexural strength increases after that decreases. The variation in flexural strength with respect to the given percentage of ESP - MSWA is shown in fig 5.3.

From this study, it can be summarised that a replacement of up to 5% of ESP with 15% of MSWA can be made safely in concrete members.

**6. CONCLUSION**

1. Based on the result that has carried out here as part of this project, we concluded that the replacement of eggshells powder and municipal solid waste ash can be used for the preparation of concrete. The best advantage of this partial replacement is reducing the over dumping of solid waste to public.
2. From our investigation for M20 grade concrete by replacing 5% ESP – 15% MSWA, it attains 26Mpa. The percentage of increment in compressive and flexural strength as compare to the conventional concrete was 28.7% and 30%. So we can make it as a practice by replacing 20% (5%ESP + 15% MSWA) in all conventional buildings. It also makes it as a economical and eco-friendly building.
3. The above-mentioned work of various studies and our present experimental work, it is clear that egg shell powder and municipal solid waste ashes can be used as a partial replacement of

cement in concrete because of its increased workability, strength parameters like compressive strength and flexural strength.

4. The untreated MSWA - ESP was used as partial cement replacement in concrete. This ash, by its chemical composition, does not fulfill the standard requirements on concrete admixtures but the prepared concrete had acceptable properties. The frost resistance of MSWA - ESP containing concrete was very good. The prepared concrete contained relatively low content of MSWA; this approach represents a compromise between the ecological request on a practical utilization of MSWA – ESP and properties of the acquired product. Higher ash dosage without any accompanied loss of concrete properties would be possible only when the ash would be treated in some way (e.g. by verification) but in such case there would arise additional costs suppressing the MSWA - ESP utilization attractiveness for building industry.
5. As disposal, utilization of egg shell powder in concrete will not only provide economic, it will also help in reducing disposal problems.

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