# AN INVESTIGATION OF THE BIO-MEDICAL WASTE ASH ON CEMENT MORTAT BRICKS

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**Abstract:** The use of Personal Protective Equipment (PPE), in particular face masks, due to COVID-19 pandemic, has become a common tool used in averting the spread of the virus. The problem of disposing and managing solid waste materials in all countries has become one of the foremost environmental, economical, and social issues. Incineration plants across the world, but the Bio-Medical Waste (BMW) has always been piled in the environment. This paper presents the influence of Bio-Medical Waste ash as fine aggregate replacement on the strength of cement mortar. A control cement mortar mix for 1:4 ratio was made and three cement mortar mixes were made with three different percentages (15%, 25% and 35%). Compressive strength of the Bio-Medical Waste ash for 15% and 25% replacement has shown good results while 35% replacement strength reduced. After paralleling all the experimental test results 15% replacement level is taken as the optimized percentage

**Key words:** Incineration, Bio-Medical Waste, Face mask, Cement, Compressive strength

## Introduction

Due to COVID-19 pandemic, individuals have started wearing surgical masks in order to take protective measures, which has radically increased the amount of waste created. While masks and other protective items have been vivacious in fight against COVID- 19, they can have incredibly detrimental impact on the environment. Single-use face masks are prepared from a variety of melt blown plastics and problematic to recycle due to both composition and risk of contamination and infection. Plastic masks can take hundreds of years to collapse. The use of Personal Protective Equipment (PPE), in particular face masks, has become a common tool used in averting the spread of the virus, with many jurisdictions instructing the wearing of masks in public. The production of PPE has expanded in an attempt to meet hit the roof demand, and PPE waste has also augmented dramatically. They enter oceans when they are littered, when waste management systems are insufficient or non-existent, or when these systems become overwhelmed due to increased volumes of waste.

The advancement of mask wearing as a way to slow the spread of corona virus has led to an extraordinary increase in the production of disposal masks: the UN trade body, UNCTAD, estimates that international sales will total some $166 billion this year, up from around $800 million in 2019. Recent media reports, screening videos and photos of divers picking up masks and gloves, littering the various waters around the French Riviera, were a wake-up call for many, refocusing minds on the plastic pollution issue, and a reminder the Government needs to address the problem of pollution. The problem of disposing and managing solid waste materials in all countries has become one of the foremost environmental, economical, and social issues. A complete waste management system counting source reduction, reuse, recycling, land-filling, and incineration needs to be implemented to control the increasing waste disposal problems. According to ministry of environment and forest about 4,05,703 Kg Bio-Medical Waste created every day in India out of which around 73% is disposed off. However more than 29% is Bio-Medical Waste is gone unattended. Most communal process of disposal of Bio-Medical Waste is incineration in precisely made for Bio-Medical Waste. Ash attained after incineration of Bio-Medical Waste is used as landfill. However, these wastes can efficiently been used in concrete creating which will result in reduce the demand of land for throwing away of Bio-Medical Waste ash on one hand and guard of environment by decreasing the consumption and fabrication of construction materials on other hand.

Figure 1 shows incineration in progress. Toxicity and probable hazards of Bio-Medical Waste is usually depending upon its source. It contains heavy toxic metals which are very detrimental for human body. At present 171 communal Bio-Medical Waste treatment facilities are presented having 145 incinerators throughout the nation. Inappropriate waste management can lead to environmental contamination and produce health hazard. The appropriate collection and disposal of hospital wastes will not only decrease the volume of contagious wastes and cost of treatment, but will also indorse healthy environment and good living. The purpose of this research to evaluate the likelihood of using Bio-Medical Waste Ash from incineration of face masks and PPE kits to partially substitute for the fine aggregate in cement mortar composites. Substantial researches and studies were carried out in some countries like USA and UK on this topic. However, there has been very some degree of studies in India on Bio-Medical Waste ash (face masks & PPE) in cement mortars and concrete. Hence an effort on the utilization of Bio-Medical Waste ash as a partial substitute of fine aggregate in cement mortar composites is done and its mechanical behavior is investigated. A toxicity and latent hazard of Bio-Medical Waste is generally depending upon its origin. It contains heavy lethal metals which are very harmful for human body.

Figure 1 Incineration in progress

At present 170 common Bio-Medical Waste treatment amenities are available having 140 incinerators throughout the country. Bio-Medical Waste can be recycled in concrete with replacement by weight for cement. The accumulation of hospital waste ash in cement matrices can be used as construction material. Incineration plants across the world, but the Bio-Medical Waste has always been piled in the environment. These waste ends up as earth fill. In these situations instead of improper and being land filling, if it was employed to prepare aggregate for cement construction composites, it will boon the construction industry as well as environmental beneficially.

**Materials and methodology**

The cement mortar mix proportions were determined for 1:4 ratio. In this research, fine aggregate has been partially replaced with different percentages of Bio-Medical Waste ash (face masks and PPE's) by 15%, 25% and 35% respectively. For study of various properties cement mortar specimens were casted and tested. The experimental investigation started with selection of materials and followed by their testing, casting of specimens and curing and finally by testing the specimen. The calculated mix proportions are given in Table 1.

Table 1 Calculated mix proportions

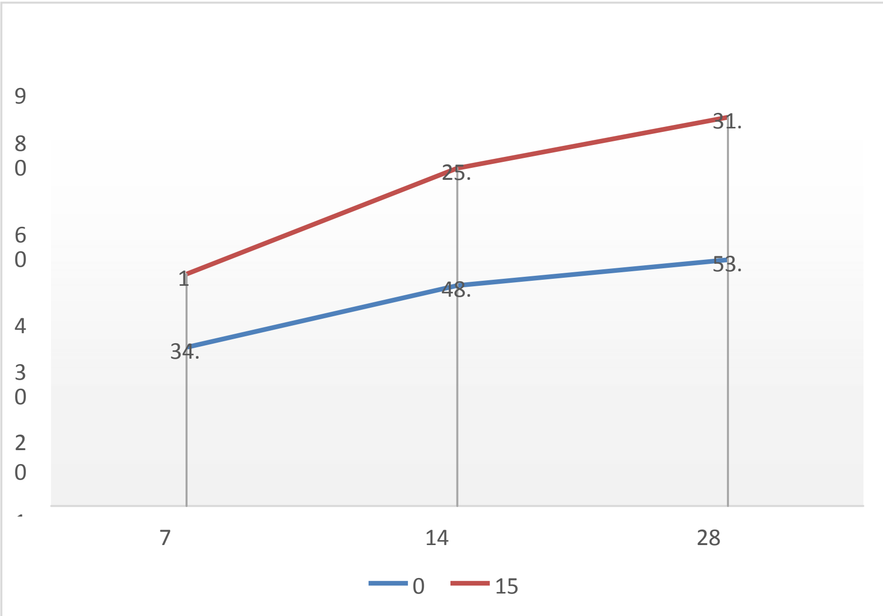
| Sl No. | BMW Ash added in % | Cement (Kg) | Fine aggregate (Kg) | BMW (Kg) |
|---|---|---|---|---|
| 1 | 0% | 0.098 | 0.392 | - |
| 2 | 15% | 0.098 | 0.333 | 0.058 |
| 3 | 25% | 0.098 | 0.294 | 0.098 |
| 4 | 35% | 0.098 | 0.254 | 0.137 |

**Results and Discussions**

Figure 2 shows that the compressive strength of 0% Vs 15%, describes the comparison between standard cubes and the cubes casted by using Bio-Medical Waste ash with 15% replacement of the fine aggregate. The graph shows the compressive strength at 7, 14, and 28 days in N/mm$^2$. The red line indicates the compressive strength of cubes manufactured by using Bio-Medical Waste ash and the blue line represents the compressive strength of standard cubes. The compressive strength of cubes by using Bio-Medical Waste ash as a partial replacement of fine aggregate obtained 10 N/mm$^2$ at 7 days of curing, 25 N/mm$^2$ at 14 days of curing and 31.1 N/mm$^2$ at 28 days of curing period. While the standard bricks/cubes shown 34.6 N/mm$^2$ at 7 days, 48.14 N/mm$^2$ at 14 days and 53.7 N/mm$^2$ at 28 days of curing. Compressive strength of Bio-Medical Waste ash replaced mixture is paralleled with the standard cement mortar mix of cement and fine aggregate. From the graph we clearly observed that compressive strength up to 70% is achieved for a mix of 15% (as replacement of fine aggregate) in the mix.

Figure 2 Compressive strength of 0% Vs 15%

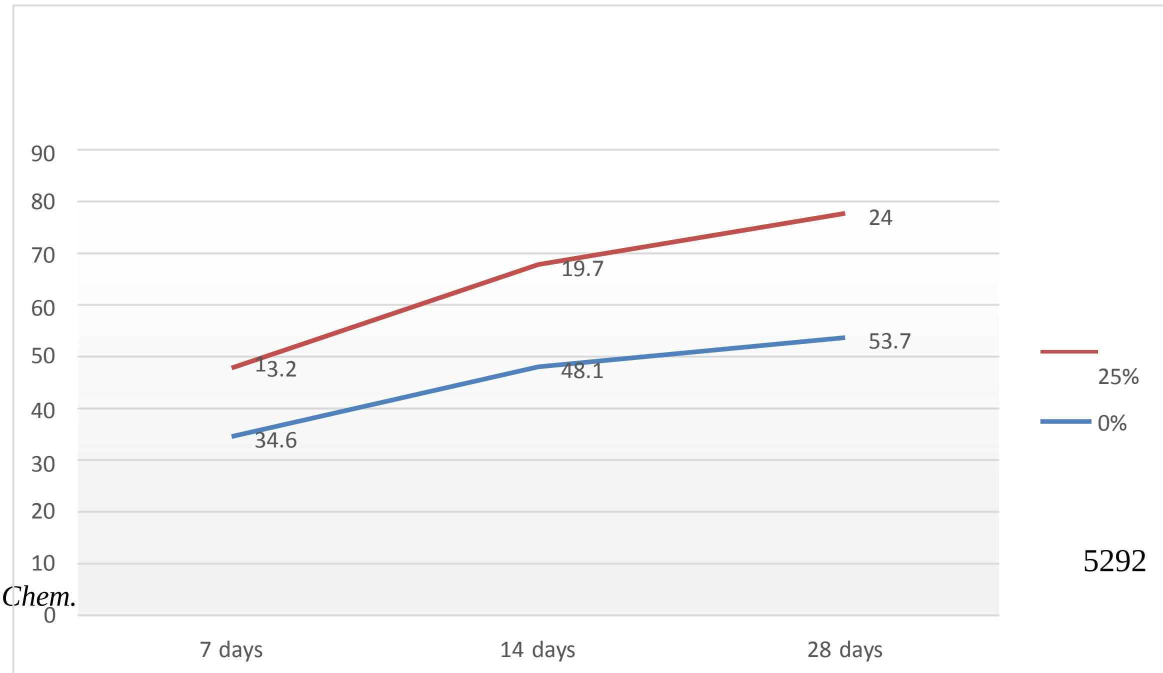
Figure 3 shows that the compressive strength of 0% Vs 25%, describes the comparison between standard cubes and the cubes casted by using Bio-Medical Waste ash with 25% replacement of the fine aggregate. The graph shows the compressive strength at 7, 14, and 28 days in N/mm$^2$. The red line indicate the compressive strength of cubes




manufactured by using Bio-Medical Waste ash and the blue line represents the compressive strength of standard cubes. The compressive strength of cubes by using Bio-Medical Waste Bio-Medical Waste ash as a partial replacement of fine aggregate obtained 13.2 N/mm$^2$ at 7 days of curing, 19.7 N/mm$^2$ at 14 days of curing and 24 N/mm$^2$ at 28 days of curing period.

While the standard bricks/cubes shown 34.6 N/mm$^2$ at 7 days, 48.14 N/mm$^2$ at14 days and 53.7 N/mm$^2$ at 28 days of curing. Compressive strength of Bio-Medical Waste ash replaced mixture is paralleled with the standard cement mortar mix of cement and fine aggregate. From the graph we clearly observed that compressive strength up to only 55% is achieved for a mix of 25% as replacement of fine aggregate in the mix. Compressive strength of Bio-Medical Waste ash replaced mixture is paralleled with the standard cement mortar mix of cement and fine aggregate.

Figure 3 Compressive strength of 0% Vs 25%



From the graph we clearly observed that compressive strength up to only 55% is achieved for a mix of 25% as replacement of fine aggregate in the mix. Figure 4 shows that the compressive strength of 0% Vs 35%, describes the comparison between standard cubes and the cubes casted by using Bio-Medical Waste ash with 35% replacement of the fine aggregate. The graph shows the compressive strength at 7, 14, and 28 days in $N/mm^2$. The red line indicates the compressive strength of cubes manufactured by using Bio-Medical Waste ash and the blue line represents the compressive strength of standard cubes.

The compressive strength of cubes by using Bio-Medical Waste ash as a partial replacement of fine aggregate obtained 8 $N/mm^2$ at 7 days of curing, 13.8 $N/mm^2$ at 14 days of curing and 19.4 $N/mm^2$ at 28 days of curing period. While the standard bricks/cubes shown 34.6 $N/mm^2$ at 7 days, 48.14 $N/mm^2$ at14 days and 53.7 $N/mm^2$ at 28 days of curing Compressive strength of Bio-Medical Waste ash replaced mixture is paralleled with the standard cement mortar mix of cement and fine aggregate. From the graph we clearly observed that compressive strength up to only 40% is achieved for a mix of 35% as replacement of fine aggregate in the mix.

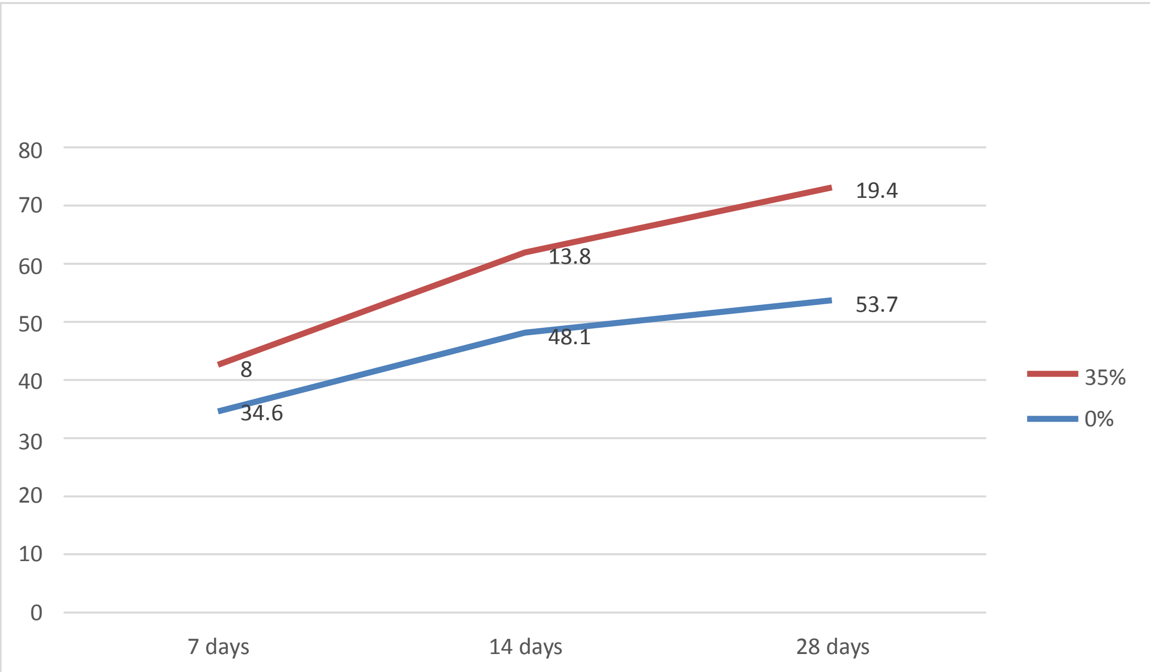



Figure 4 Compressive strength of 0% Vs 35%

Scanning Electron Microscopy (SEM) is a test practice that scans a sample with an electron beam to produce a magnified spitting image for analysis. The method is also well-known as SEM analysis and SEM microscopy, and is used very efficiently in microanalysis and failure analysis of solid inorganic materials. Electron microscopy is executed at high magnifications, generates high-resolution pictures and precisely measures very small features and objects. Scanning Electron Microscopy uses a focused beam of high-energy electrons to produce a variety of signals at the surface of solid samples. In utmost SEM microscopy applications, data is collected over a designated area of the surface of the sample and a two-dimensional image is produced that shows spatial variations in properties as well as chemical characterization, texture and orientation of materials.

The SEM is also proficient of performing analyses of designated point locations on the sample. This method is especially useful in qualitatively or semi-quantitatively decisive chemical compositions, crystalline structure and crystal orientations. The signals produced during SEM analysis produce a two- dimensional image and make known information about the sample, together with external morphology (texture), chemical composition, when used with the EDS feature, and bearings of materials making up the sample. Cement mortar generally has unique and complicated microstructure which makes it hard to observe and explore the presence of mineral. Replacement of cement mortar ingredients modifies the microstructure and mechanical properties.

However, there may be some limitation and failure due to replacement of major ingredients. Study of microstructure is the modern approach to examine the mineral composition. X-ray Diffraction Analysis, Scanning Electron Microscope and Energy Dispersive Spectroscopy analysis are some of the contemporary methods used for phase identification, micrograph and chemical characterization of the unidentified elements in the hydrated cement paste. The result from the micro structural study of cement mortar would give a clear idea about the development and distribution of hydration products in the hydrated cement paste obtained from sample. The sustainability of cement mortar was deliberate and analyzed through Scanning Electron Microscope.

The microstructure of the cement mortar mix was analyzed using Scanning Electron Microscope (SEM) which practically advantages to visualize the microstructure of the hydrated cement paste. Figure 5 shows the SEM observations in Scanning Electron Microscopy at 1500X magnification, the existence of mineral elements and their reactions with the supplementary materials are deliberate which gives an initiative to understand the microstructure of the cement mortar mixes. Based on the evaluation of the microstructure of mixes, it is clear that the hydration process in the mixes with supplementary materials was diverse from conventional cement mortar mix. In 15% replacement of fine aggregate with BMW Ash, the hydration process was quiet similar to the normal cement mortar mix.

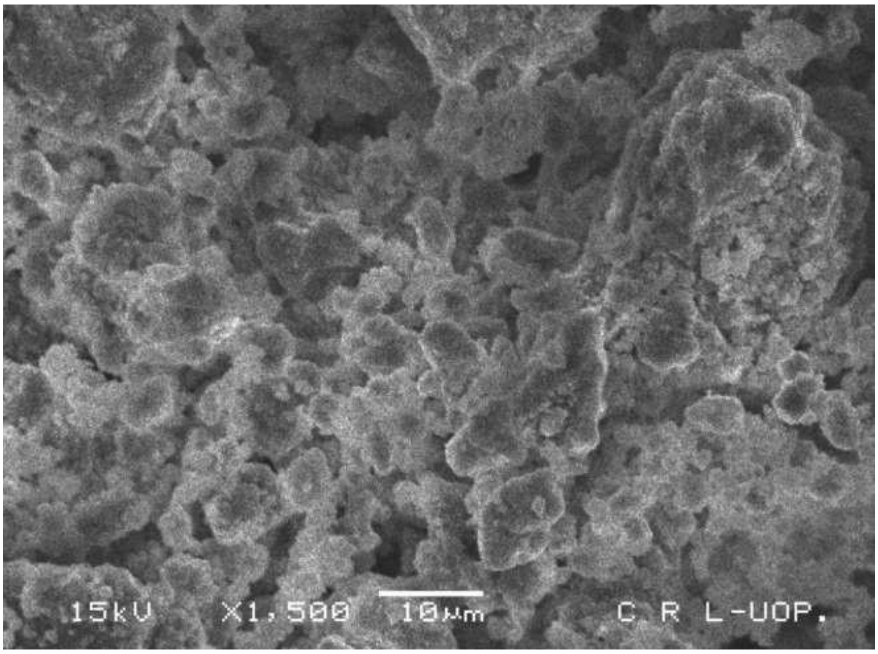



Figure 5 Scanning electron microscopy at 1500X magnification

## Conclusions

It is witnessed that density of cement mortar decreased marginally with the increase in the replacement level of Bio-Medical Waste ash. Bio-Medical Waste ash can effectively be used in cement mortar creating up to 15% or lesser percentage of replacement. The standard cement mortar cubes shown 34.6 $N/mm^2$ at 7 days, 48.14 $N/mm^2$ at 14 days and 53.7 $N/mm^2$ at 28 days of curing. The compressive strength of cubes by using Bio-Medical Waste ash as a 15% of partial replacement of fine aggregate obtained 10 $N/mm^2$ at 7 days of curing, 25 $N/mm^2$ at 14 days of curing and 31.1 $N/mm^2$ at 28 days of curing period. The compressive strength of cubes by using Bio-Medical Waste ash as a 25% partial replacement of fine aggregate obtained 13.2 $N/mm^2$ at 7 days of curing, 19.7 $N/mm^2$ at 14 days of curing and 24 $N/mm^2$ at 28 days of curing period.

The compressive strength of cubes by using Bio-Medical Waste ash as a 35% partial replacement of fine aggregate obtained 8 $N/mm^2$ at 7 days of curing, 13.8 $N/mm^2$ at 14 days of curing and 19.4 $N/mm^2$ at 28 days of curing period. Compressive strength of the Bio-Medical Waste ash for 15% and 25% replacement has shown good results while 35% replacement strength reduced when compared to 15% and 25% strength. After incorporating all the experimental test results, 15% replacement level is taken as optimized percentage. It can be used mainly for compound walls, parapet walls and temporary structures. Low cost cement mortar can be made utilizing Bio-Medical Waste ash as partial replacement of the aggregate.

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