Utilization of Industrial By-Products as Sand Replacement on Properties of concrete

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Abstract – *The Solid waste management is big problem with quantities of waste material that is being generated in cities and in industrial areas. The major contributors are of industrial solid waste disposal are Thermal Power plant, Iron and steel mills which produces blast furnace slag etc. And Disposal of this by-products produced from this industries is major problem. Also landfill operating cost is high and availability of land for landfill is also problem. Recently research showed that, it is possible to utilize industrial by-products as sand replacement of normal concrete.*

Key Words: Pond Ash, SEM analysis, compressive strength, C–S–H gel, Microstructural.

1. INTRODUCTION

Disposing the industrial by-products is major problem of big industries as due to large quantity generation of waste by-product generated requires increased costs for maintaining the landfills and also there is problem scarcity of landfill grounds. Due to the potential hazardous effects of industrial by-products, it's consumption for the various purposes is becoming trend instead of dumping it, in view of grown environmental awareness relating. Some of these waste materials could possibly be used in constructional materials for the production of concrete. So in this research I have tried one of the by-product Pond ash which is located near Eklahare Thermal power plant. And Pond ash is available in tons outside the power plant. So I have used pond ash as partial sand replacement on concrete. And find out how strength is affected.

1.1 Objective

The Objective of paper is,

a. To study the feasibility of Industrial By-Product Pond ash as Sand Replacement in concrete

b. To check Compression strength and durability of concrete with Industrial By-Product Pond ash as sand replacement

c. To find out Microstructural Analysis of Concrete specimen which are casted. And to check strength of specimen is how increased and decreased

1.2 Methodology

This research follows a step-by-step methodology which started with finding the project topic identifying the factors affecting to achieve objective, as per the guide lines provided and standard IS code specification the casting of cubes by applying various technics is done. The casted cubes further merge for curing and then testing should be done. Also, SEM analysis is done on specimens.

Materials

a. Cement: - ACC Ordinary Portland Cement 53 Grade was used as per BIS:269-19789 R1998

b. Coarse and Fine Aggregate: - Coarse aggregate 10, 20 mm were collected from Vilholi-Nashik region, Maharashtra. And Fine aggregate natural sand of riverbed from Tapi river, Nandurbar, Maharashtra India According to grading zone 1 and as per BIS:383-1970 R-1997.

c. Industrial By-Product (Pond Ash): – Industrial By-product Pond Ash is obtained from Eklahare Thermal power plant. Nashik, Maharashtra, India.

Fig -1: Industrial By-Product Pond Ash

d. Plasticizer: - Emceplast BV Plasticizers were used as directed by the manufacture to improve the workability of the fresh concrete mix according to BIS:2645-2003.

e. Water: - Potable (drinking) Water was used for casting and curing process of concrete specimens.

1.3 Physical and Chemical Properties

1.3.1 Specific Gravity

The specific gravity of coarse aggregate (20mm &10mm), sand and pond ash is determined by using Pycnometer and are found to be 2.81, 2.68,2.59 & 1.68 respectively. It is observed that the specific gravity of pond ash is less as compared to sand

Table -1: Specific Gravity of Materials used

Specific gravity			
C.A. (20mm)	C.A. (10mm)	sand	Pond Ash
2.81	2.68	2.59	1.684

1.3.2 Fineness Modulus

To determine the fineness modulus of sand, pond ash and coarse aggregates of 10mm&20mm detailed sieve analysis is performed. The fineness modulus of coarse aggregate (10mm and 20mm), sand and pond ash are 7.0, 7.29, 3.5 and 2.04 respectively.

Table -2: Fineness Modulus of Materials used

Fineness Modulus			
C.A. (20mm)	C.A. (10mm)	Sand	Pond Ash
7.0	7.29	3.5	2.04

Fig -2: Sieve analysis of pond ash

1.3.3 Water Absorption

The water absorption of coarse aggregate (10mm &20mm), sand &pond ash are determined by conventional method.

Table -3: Water Absorption of Materials

Particulates (gm)	Aggregate (10 mm)	Aggregate (20 mm)	Sand	Pond Ash
Wet wt. of aggregate (W_1)	167	155	144	92
Dry wt. of aggregate (W_2)	171	157	160	116
Water absorption = $[(W_1 - W_2)/W_2] \times 100$	1.02%	1.01%	1.11%	26.08%

Water absorption of pond ash found more so we used plasticizer to increase workability.

2.0 Laboratory Testing Program

For laboratory testing program, the M-40 Grade mix design was selected and Concrete mixture with different proportions of Industrial By-Product Pond Ash was selected for w/c ratio 0.40. For this work 36 Cubes specimens were casted and tested for 7, 28 days.

Cube: - Cube of size 150 mm × 150 mm × 150 mm were used. The cubes were cleaned thoroughly with a waste cloth and then oil was properly applied along its faces. Concrete was then filled in mould in three layers, while filling the mould concrete is compacted using tamping road of 600 mm having a cross sectional area of 25 mm2 then the mould is kept on the vibrating table for 60 seconds to achieve proper compaction and then the mould are kept on plane and level surface in the laboratory for 24 hours and then cubes are removed from the mould and kept for curing. For this report 36 cube specimen are casted and tested.

$$\text{Compressive strength } (N/mm^2) = \frac{\text{Ultimate load in N}}{\text{Area of cross section } (mm^2)}$$

Fig -3: Cube casting testing and Failure pattern of cube

Table -4: Type of Samples Prepared

Type	Description
M0	Controlled Concrete
M1	10 % sand replaced with by product pond ash
M2	20 % sand replaced with by product pond ash
M3	30 % sand replaced with by product pond ash
M4	40 % sand replaced with by product pond ash
M5	50 % sand replaced with by product pond ash

Table -5: Type of Samples and compressive strength

Mix	7 Days in N/mm²	28 Days in N/mm²
M0	32.40	47.50
M1	32.60	48.24
M2	33.20	49.10
M3	24.68	43.84
M4	22.71	43.16
M5	21.58	41.84

It was observed that for 10%and 20% sand replacement the compressive strength was increased and for 30%, 40%, 50% sand replacement is was decreased, when compared with control concrete.

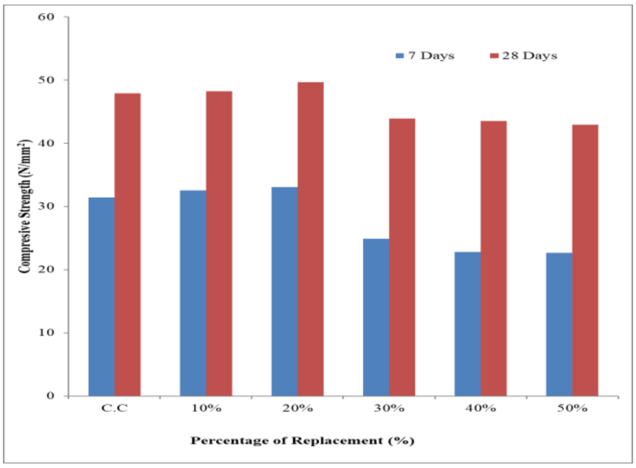


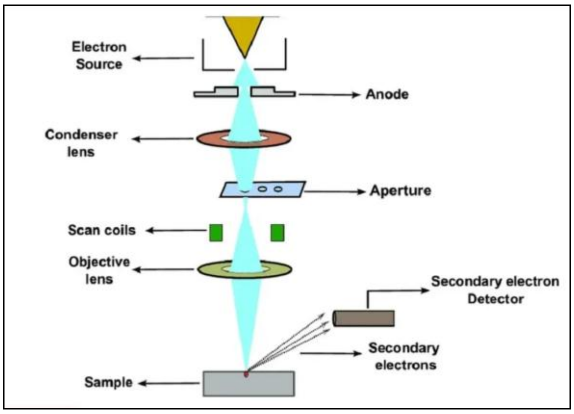
Chart -1: Compressive Strength Vs Variation in pond ash

3. Microstructural Analysis on Specimen using SEM

A scanning electron microscope is that kind of electron microscope which prepares images of a sample by scanning the top surface with a focused beam of electrons. A scanning electron microscope (SEM) scans a focused electron beam over a surface to create an image. The electrons in the beam interact with the sample, producing various signals that can be used to obtain information about the surface topography and composition. [7]

Working of SEM:-

- The SEM uses electrons instead of light to form an image.
- A beam of electrons is produced at the top of the microscope by heating of a metallic filament.
- The electron beam follows a vertical path through the column of the microscope. It makes its way through electromagnetic lenses which focus and direct the beam down towards the sample.
- Once it hits the sample, other electrons are expelled from the sample.
- Detectors collect the secondary or backscattered electrons and convert them to a signal that is sent to a viewing screen similar to the one in an ordinary television, producing an image. [7]



(Source: www.informationpalace.com)

Fig -4: Schematic Representation of SEM[7]

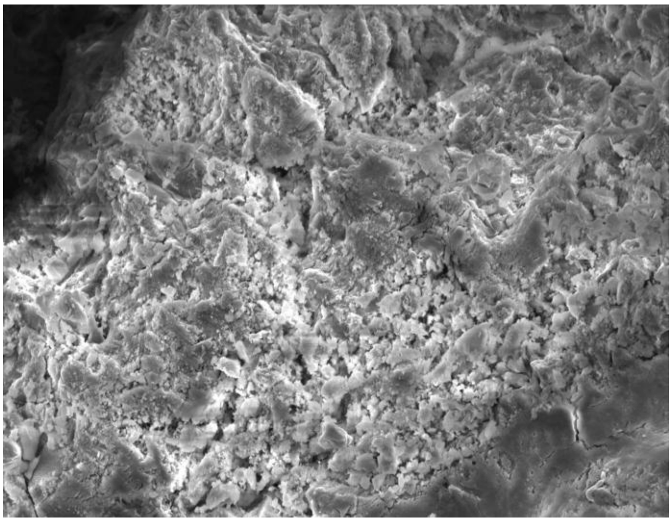
3.1 Sample Preparation for SEM Analysis

The formation and distribution of hydration products of hydrated cement paste of Six different mix proportions are pictured below. The microstructure of the seven mixes were examined and compared with the nominal mix. The microstructure and strength properties of all the seven mixes were correlated based on the hydration products formed after 28 days. The reason behind the strength of the concrete was analysed and explained based on the growth of hydration products in the microstructure of concrete mixes.

Fig -5: Sample preparation for SEM

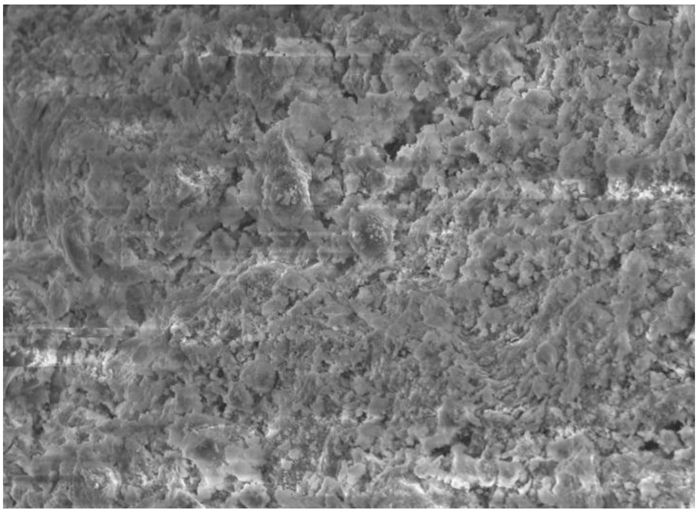
3.2 SEM Micrograph Images

Mix -0 Normal Concrete



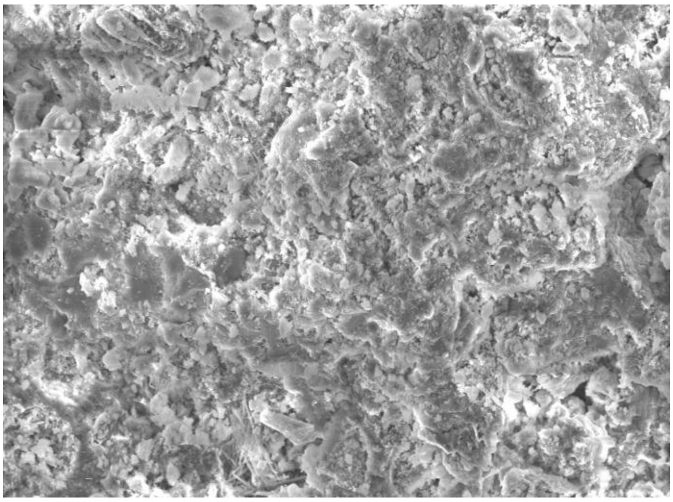
From Micrograph Figure, it shows the formation of proper and clear C–S–H gel in various stages. The important point to be noted in the micrograph is that the C–S–H gel i.e., the bright masses with nodules and big chalky gel parts are spread over the entire micro- graph, as it is evident from various literatures, the C–S–H gel gets spread over the aggregates thus acting as binders for the paste.

Mix – 1 10 % sand replaced with by product



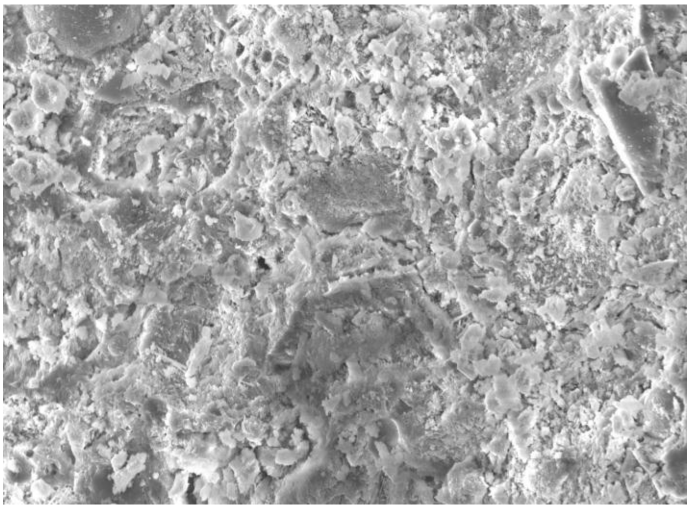
From Micrograph Figure, it shows two major features. Firstly, the number of voids in the mix has significantly reduced and secondly, the C–S–H gel paste is widely spread as it was in the reference mix, secondly showing some aversion to the binder paste but more importantly, the effect of by product adds strength to concrete mix.

Mix – 2 20 % sand replaced with by product



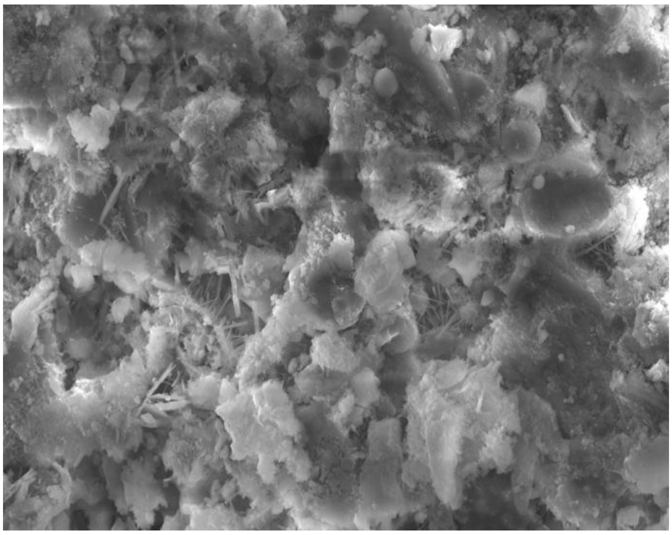
From Micrograph Figure, it shows again two major features. Firstly, the number of voids in the mix has significantly reduced than above figure and secondly, the C–S–H gel formation is better, and which adds strength.

Mix -3 30 % sand replaced with by product



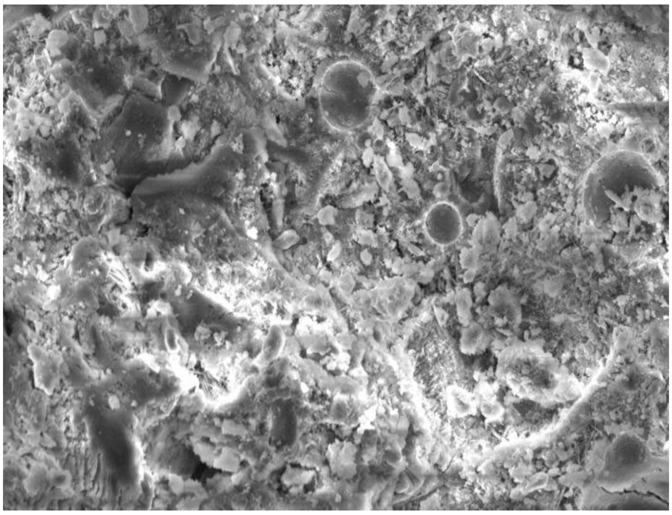
From Micrograph Figure, it shows again two major features. Firstly, the number of voids in the mix has significantly reduced than above figure and secondly, the C–S–H gel formation is better, and which adds strength. Some voids are developed.

Mix -4 40 % sand replaced with by product



From Micrograph Figure , shows that voids in mix are more than above figure. also secondly C–S–H gel formation is low comparatively. also the mix has crumbled and strength goes down.

Mix -5 50 % sand replaced with by product



From Micrograph Figure, shows that voids in mix are clearly visible in the micrograph. The C–S–H gel could not be seen at many places in the micrograph. The most important inference from the image is that the paste is crumbling, as the amount of replacement goes so high in this sample that the equilibrium falls and leads to lower strength.

3. CONCLUSION

It was observed that for 10%and 20% sand replacement the compressive strength was increased when compared with control concrete. Also, the microstructural observation shows how strength is increased and decreased. From overall study, we can use this industrial by-product in concrete as partial replacement to sand.

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