

# Effect of Waste Foundry Sand as Partial Replacement of Sand on Acid Resistance of Binary Blended Concrete using Metakaolin

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**Abstract:** Metal foundries use large amounts of sand as part of the metal casting process. Waste Foundry sand is a waste material. The degradation of concrete sewer pipes by sulphuric acid attack is also a problem of global scope. The idea is to minimise this degradation while keeping it as economic as possible. In an effort to use the WFS in large volume, research has been carried out for its possible large scale utilization in making concrete as partial replacement of fine aggregate. The present work is focussed on the study of the effect of various percentages of WFS on durability (namely acid attack) of M30 grade concrete. To find the best combination of waste foundry sand and metakaolin to resist the sulphuric acid attack. Mix M10W10(Metakaolin 10%, waste foundry sand 10%) showed best resistance to acid attack. The decrease in compressive strength too was not drastic when compared to other mixes.

**Keywords:** waste foundry sand, metakaolin, sulphuric acid, compressive strength, M30 grade concrete

## I. INTRODUCTION

Foundry sand is high quality silica sand with uniform physical characteristics. It is a by-product of ferrous and nonferrous metal casting industries. Sand has been used for centuries as a moulding material because of its thermal conductivity. It is a by-product from the production of both ferrous and nonferrous metal castings. The physical and chemical characteristics of foundry sand will depend in great part on the type of casting process and the industry sector from which it originates. In modern foundry practice, sand is typically recycled and reused through many production cycles. Industry estimates that approximately 100 million tons of sand are used in production annually of that 6 - 10 million tons are discarded annually and are available to be recycled into other products and in industry. In India, approximately 2 million tons of waste foundry sand is produced yearly.

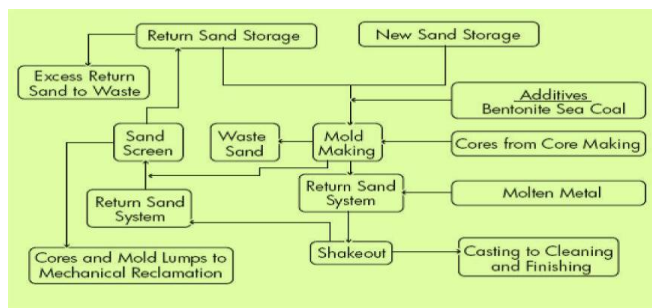


Fig. 1 How sand is reused and becomes foundry sand

Table. 1 Physical properties of waste foundry sand

Property	Results
Fineness modulus	1.66
Specific gravity	2.35
Bulk density Loose	1230 kg/m <sup>3</sup>
Bulk density Dense	1350 kg/m <sup>3</sup>

Table. 2 Mechanical properties of foundry sand

Property	Results
Micro- Devil Abrasion Loss %	< 2
Magnesium Sulphate	5- 15
Soundness Loss %	6- 47
Friction Angle (deg)	33- 40
California Bearing Ratio, %	4- 20

### 1.1 Binary Blended Concrete

It means Metakaolin or other cement replacement additives are to be used with OPC only. That is not strictly true and binary mixtures comprise efficient -systems. The primary incentive of adding limited amount Metakaolin –for example 10 percent ensures high early strength, research has however shown that binary mixtures of OPC, result in synergic action to improve the micro structure and performance of concrete. When either Metakaolin or Fly-ash or other mineral admixtures are used, the resultant enhancement of strength or pozzolanic activity was greater than super position of contributions of each, for the respective proportions. Such synergic effect results from strengthening the weak transition zone in aggregate cement interface, as well as segmentation and blocking of pores. Thus, increasing the strength as well as the durability of concrete.

### 1.2 Metakaolin

Metakaolin is obtained by calcinations of pure or refined kaolin clay at a temperature between 650°C and 850°C, followed by grinding to achieve a fineness of 700 m<sup>2</sup>/kg to 900m<sup>2</sup>/kg. The resulting material has high pozzolanicity.

Table.3 Properties of Metakaolin

Specific Gravity	2.54
Accelerated pozzolanic active index, % of control	89
Residue on 45 micron sieve, %	1.31
Loss on Ignition	0.70
Silica (SiO <sub>2</sub> )	52.24
Iron Oxide (Fe <sub>2</sub> O <sub>3</sub> )	0.60
Aluminum (Al <sub>2</sub> O <sub>3</sub> )	43.18
Calcium Oxide (CaO)	1.03
Magnesium Oxide (MgO)	0.61

### 1.3 Sulphates

Sulphuric acid reacts with the calcium hydroxide to produce gypsum. This is a white putty-like deposit, moist and flaky. It acts as a barrier to further penetration but the rougher surface area formed also provides for more places for attack to take hold. The formation of gypsum leads to an eventual loss in cohesion as the cementitious calcium compounds are broken down.

Table.4 Specifications of Sulphuric Acid

Specific Gravity	1.835
Assay (acidimetric)	Abt 98.0%
Wt.per ml at 20°c	Abt. 1.835g

## II. METHODOLOGY

An experimental study was conducted on Metakaolin mixed M30 grade of concretes with various percentages of waste foundry sand replacing sand. The inherent high pozzolanic reactivity of Metakaolin adds to the strength factor when mixed with cement concrete partially replacing cement even at higher strengths. Experimental study was carried out to investigate the strength variations in concrete as well as the attack of acid on concrete while varying the replacement percentages of waste foundry sand.

In this investigation grade of concrete M30 has been considered. The mix of concrete was designed by IS code method. Mixes were prepared with a partial replacement of fine aggregate by WFS at percentages 0, 10, 20,30,40,50,60,70,80,90 and 100 by weight of fine aggregate for cubes keeping metakaolin percentage fixed at 0% and 10%.

Table.5 Mix Proportion for grade of Concrete

Water Cement Ratio	0.46
Cement	370 Kg
Fine Aggregate	582 Kg
Course Aggregate	1230 kg
Water	170 kg

### 2.1 Curing Procedure

After the casting cubes, the moulds are kept for air curing for one day and the specimens were removed from the moulds after 24 hours period of moulding of concrete. Marking has been done on the specimens to identify the % Metakaolin and wfs. To maintain the constant moisture on the surface of the specimens, they were placed in water tank for curing. All the specimens have been cured for the desired age.



Fig. 2 Curing Tank

### 2.2 Period of Acid Attack

The prepared specimens were cured for 28 days and then exposed to sulphuric acid (3% concentration) for a period of 90 days.



Fig.3 Acid Tubs



Fig.4 Specimens before immersion in Acid



Fig.5 Specimens after Immersion in Acid for 90 days

### III. CONCLUSIONS

The results obtained from compression test of cubes of concrete containing partial/full replacement of sand with WFS are shown. It was observed that the compressive strength of the cubes increased with the dose of waste foundry sand upto 30% following which there was a decrease in the 28 day compressive strength. The 28 days cube compressive strength of OPC was found to be 37.2 Mpa where as that of binary blended was found to be 42.3 Mpa.

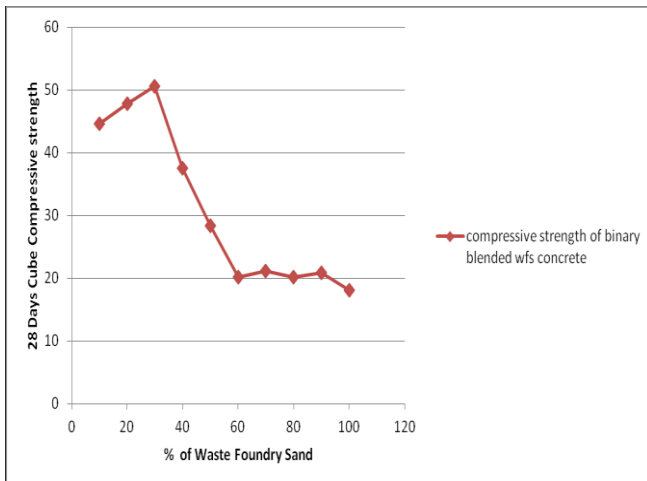


Fig.6 Variation of Cube Compressive strength of metakaolin blended concrete at 28 days in N/mm2

Table.6 Cube Compressive strength of Metakaolin Blended Concrete at 28 days in N/mm2

Designation of Mix	28 day strength (Mpa)
M10W10	44.54
M10W20	47.80
M10W30	50.52
M10W40	37.56
M10W50	28.30
M10W60	20.11
M10W70	24.32
M10W80	23.56
M10W90	23.20
M10W100	21.07

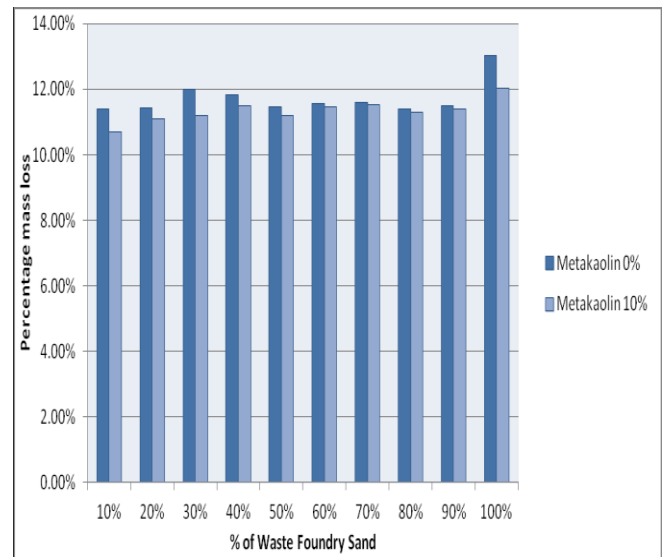


Fig.7 Mass loss comparison of specimens subjected to sulphuric acid attack (3% concentration)

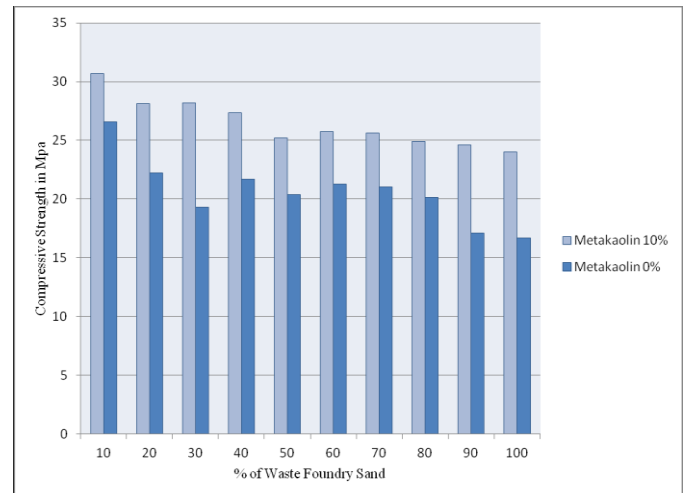


Fig.8 Comparison of compressive strength of specimens subjected to sulphuric acid attack (3% concentration) after 90 days in Mpa

## IV. CONCLUSIONS

- In this study of M30 grade, Mix M10W10(Metakaolin 10%, waste foundry sand 10%) showed best resistance to acid attack. The mass loss recorded was the least when compared to other mixes. The decrease in compressive strength too was not drastic when compared to other mixes. There was a mass loss of about 10% after 90 days in acid contact. The compressive strength obtained was 30.67Mpa.
- To be more on the economic side even mix M10W30(Metakaolin 10%, waste foundry sand 30%) can be used in places susceptible to acid attack as there is not a large difference in the mass loss and compressive strength. There was a mass loss of about 11.5% after 90 days in acid contact. The compressive strength obtained was 28.20Mpa.
- Compressive strength of concrete increased as the dosage of wfs increased up to 30%, following which there a decrease in the compressive strength of concrete.
- Addition of metakaolin increased the compressive strength of wfs concrete by about 15-20% for almost all the mixes.

## REFERENCES

- [1]. Gurpreet singh, Rafat siddique, (2012) "Effect of waste foundry sand (WFS) as partial replacement of sand on the strength, ultrasonic pulse velocity and permeability of concrete", Construction and building materials 26.
- [2]. Rafat siddique and El-Hadj Kadri, (2011) "Effect of metakaolin and foundry sand on the near surface characteristics of concrete", Construction and building materials 25.
- [3]. Rafat siddique and Gurpreet Singh, (2011) "The utilization of waste foundry sand in concrete manufacturing, , Construction and building materials 25.
- [4]. Rafat siddique, Geert de schutter and Albert noumowe, (2009) "Effect of used foundry sand on the mechanical properties of concrete", Construction and building materials 23.
- [5]. Alok khanduri, (2010) "Properties of martar containing waste foundry sand", civil engineering department, Thapar university, Patiala.
- [6]. Ishatpreet kaur, (2006) "Mechanical properties of concrete incorporating foundry sand", civil engineering department, Thapar university, Patiala.
- [7]. R.N. Kraus , T.R. Naik, B.W. Ramme and Rakesh Kumar,(2009) "Use of foundry silica-dust in manufacturing economical self-consolidating concrete", Construction and building materials 23.
- [8]. Saveria Monosi, Daniela Sani and Francesca Tittarelli, (2010) "Used Foundry Sand in Cement Mortars and Concrete Production, The open waste management journal 3, 18-25.
- [9]. J.M. Khatb, S. Baig, A Bougara, and C Booth, (2010), "Foundry sand utilization in concrete production", Sustainable construction materials and technologies June 28-June 30.
- [10]. D.Lawrence and M.Mavroulidou,(2009), "Properties of concrete containing waste foundry sand", 11th International conference on environmental science and technology, Greece 3-5 September.