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# ENHANCING DURABILITY AND SUSTAINABILITY OF CONCRETE BY EXPERIMENTING ON M40 GRADE WITH GLASS POWDER (GP), MUNICIPAL SOLID WASTE (MSW) AND STONE DUST.

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**Abstract -** *Concrete is highly versatile and extensively used material in construction due to its notable strength, durability, and adaptability. Traditional concrete composed of aggregates, cement and water, can be molded into various shapes and sizes, making it suitable for a wide range of construction applications, from buildings and bridges to roads and sidewalks.*

*Glass is a prevalent material utilized in the building and construction sectors, with a substantial volume being pulverized on a daily basis. However, the disposal of glass waste poses environmental challenges, necessitating effective management strategies.*

*Presently, the construction industry seeks economically viable materials to augment the structural integrity of concrete infrastructure. In recent decades, there has been extensive global research into the effective utilization of Municipal Solid Waste Incineration (MSWI) residues. One promising avenue involves incorporating MSWI ashes into concrete production, akin to utilization of coal combustion products. Additionally, glass powder and municipal solid waste with particle sizes smaller than 600µm exhibit pozzolanic properties, further enhancing their potential for application in concrete formulations.*

*As seen in recent years the availability of the sand is also decreasing. Stone dust, a by-product of stone crushing processes has emerged as a promising additive in concrete production.*

*This project investigates methods to enhance the durability and sustainability of concrete through experimental analysis on M40 grade concrete. The study explores the effects of replacing traditional constituents with alternative materials such as glass powder, municipal solid waste incineration by-products, and stone dust. Through systematic experimentation and analysis, the project aims to identify optimal combinations that improve concrete's durability while promoting sustainability in construction practices.*

***Key Words***: Concrete, Durability, Sustainability, Glass waste, Structural integrity, MSWI residues, Pozzolanic properties, Stone dust, Alternative materials.

## 1. INTRODUCTION

Over the past 50 years, high-strength concrete has seen significant evolution. Initially defined by strengths over 40 MPa, modern high-strength concrete often exceeds 60 MPa. It features a denser cement paste matrix with fewer capillary voids, resulting in less micro-cracking. Achieving these properties requires a higher binder content, superplasticizers, and a low water-to-binder ratio (below 0.30 by weight), which ensures low permeability and a discontinuous capillary pore structure shortly after hydration.

Mix design is crucial to balancing strength, durability, and cost. Historically, strengths between 35 MPa to 45 MPa were common in prestressed structures, but higher strengths became widespread in the 1990s, especially in projects like the Konkan Railway. Today, high-strength concrete is common in high-rise buildings in major Indian cities, with strengths ranging from 45 MPa to 60 MPa.

We are exploring alternative industrial materials as partial replacements for fine aggregate in concrete, including manufactured sand (M sand). Produced through crushing suitable source materials, M sand addresses environmental concerns related to natural quarry overexploitation. This is particularly important in developing countries with high concrete demand due to rapid infrastructure development. In this project, M sand is sourced from Swathi Precast Constructions in Adoni.

Additionally, we are investigating the partial replacement of cement with alternative waste materials like municipal solid waste (MSW) and glass powder. These materials can serve as supplementary cementitious materials, reducing environmental impact, managing waste efficiently, and lowering costs. Properly processed, these materials enhance concrete properties such as strength, durability, and workability. By optimizing the use of MSW and glass powder in concrete, this research aims to develop sustainable, resource-efficient construction practices that meet structural requirements and mitigate environmental impact.

## 2. Objective of this study:

To assess the workability, overall strength, and the rate of strength development across different water-cement ratios in concrete compositions featuring glass powder, municipal solid waste, and a 10% substitution of sand with stone dust.

Analyze and contrast the outcomes obtained from concrete compositions containing glass powder, municipal solid waste, and stone dust with those of a traditional concrete mix.

To examine the compressive, split tensile, and flexural strengths of concrete utilizing glass powder, municipal solid waste (MSW), and stone dust.

Assessing concrete durability with glass powder, MSW, and 10% stone dust enhances strength, sustainability, and chemical resistance via Supplementary Cementitious Materials.

## 3. Accumulation of materials

The project requires several key materials: Cement, Fine Aggregate, Coarse Aggregate, Water, Manufactured Sand (M sand), glass powder, Municipal Solid Waste Incineration Ash (MSWI), and Admixtures, all sourced locally.

Ordinary Portland Cement (OPC) of 53 grade (IS 1489-1-1991) was used for its binding efficacy. Fine aggregate was natural river sand (IS 383-1970), air-dried and sieved for optimal grading. Coarse aggregate consisted of crushed natural granite (IS 383-1987) in a 60:40 ratio, passing through a 25 mm sieve and retained on a 12.5 mm sieve.

Potable water, compliant with IS: 456-2000, was used for mixing and curing. M sand from Swathi Precast Constructions was sieved (4.75 mm) and used to partially replace natural fine aggregate. Glass powder, procured online from IndiaMART, enhances the concrete's density and reduces permeability due to its fine particle size.

MSWI ash, when processed, serves as a supplementary cementitious material, improving strength, durability, and chemical resistance, while reducing the demand for traditional cement and landfill waste. Superplasticizers, such as CONPLAST SP430, were incorporated to achieve self-leveling, self-compacting concrete with enhanced strength and workability.

**Figure: 1 M sand from Swathi Precast Constructions**

**Figure: 2 Glass powder, procured online from IndiaMART**

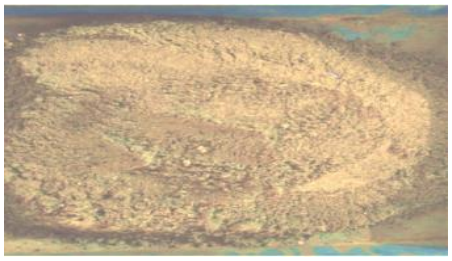


**Figure: 3 MSWI ash**

## 4. Actual Proportion of the Mix

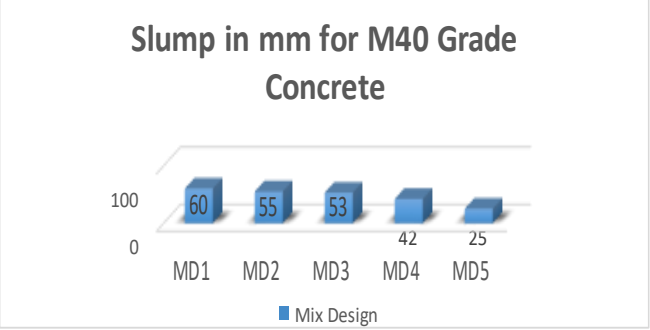
Final trial mix for M40 grade concrete is

1: 1.4413: 2.8935: 0.45 at W/C of 0.40.

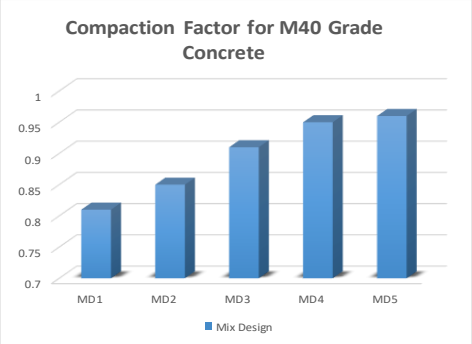
## 5. Result and Analysis

### 5.1 Workability

#### 5.1.1 Slump cone test:

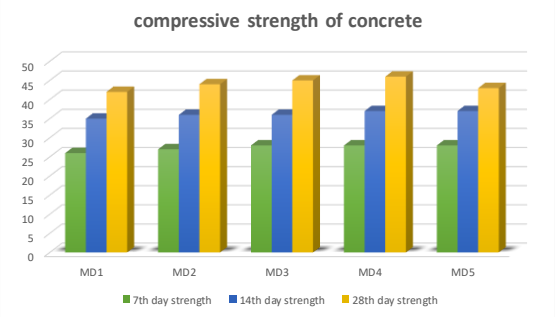


### 5.1.2 Compaction Factor Test

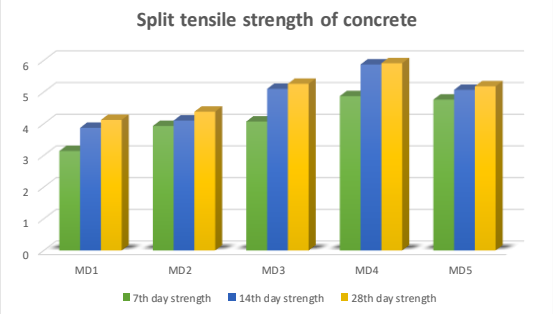



## 5.2 Strength of Concrete

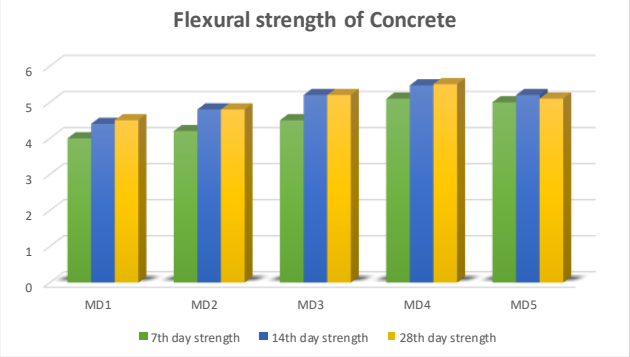
### 5.2.1 Compressive strength of concrete




### 5.2.2 Split tensile strength of Concrete

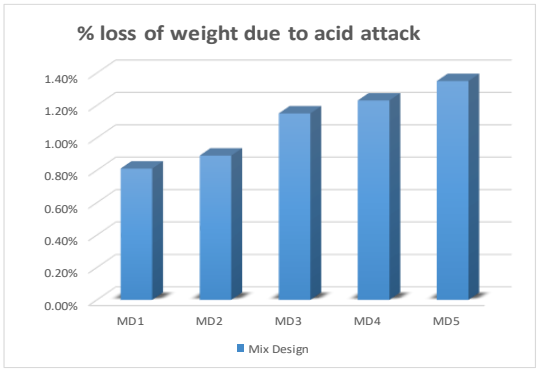


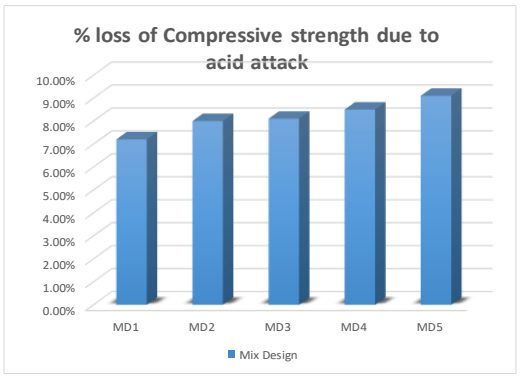

### 5.2.3 Flexural strength of Concrete



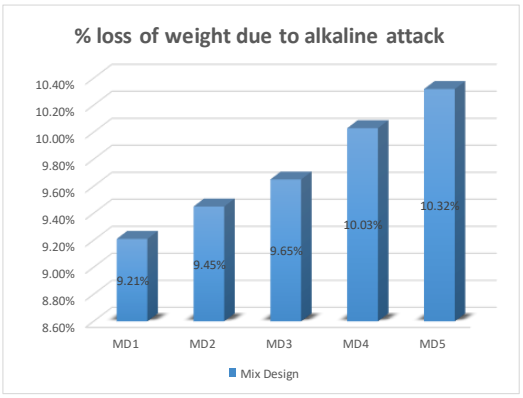

## 5.3 Durability of Concrete

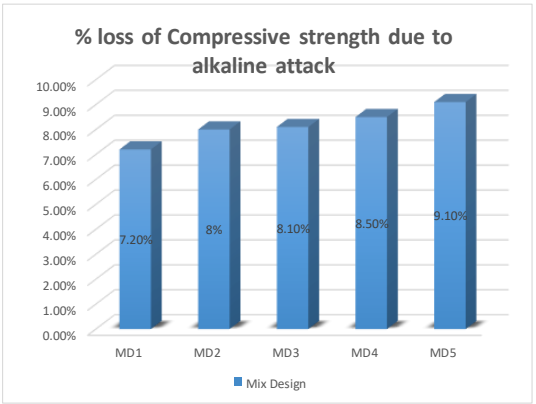
### 5.3.1 Acid Attack




### 5.3.2 Alkaline Attack



## 6. Conclusion

1. Optimal Material Replacement for M40 Concrete**: Experiments indicate that replacing up to 15% of cement with MSWI, 15% with GPW, and 10% of sand with stone dust is beneficial for M40 grade concrete, balancing performance and cost.

2. Impact on Workability and Strength**: Increasing replacement percentages decreases workability, as shown by slump cone and compaction factor tests. However, compressive strength tests show that the MD4 mix has the best load-bearing capacity over time, and MD4 also exhibited the highest split tensile and flexural strengths.

3. Durability Under Chemical Attacks**: Durability tests revealed varying susceptibility to acid, alkaline, and sulphate attacks. MD5 mix showed the highest weight and compressive strength losses across these tests, indicating poor resistance to chemical degradation.

4. Need for Material Optimization**: The findings emphasize the importance of selecting appropriate materials and construction practices to enhance concrete durability. Incorporating supplementary cementitious materials or chemical-resistant additives could mitigate vulnerability to chemical attacks.

5. Guidance for Future Research and Development**: These experiments provide valuable insights into concrete performance, guiding the development of more resilient construction materials. Further research is needed to create concrete mixes with enhanced durability for diverse environmental conditions.

## References

Syam Prakash. V (2007) "READY MIXED CONCRETE USING MANUFACTURED SAND AS FINE AGGREGATE" Article Online Id: 100032053 The online version of this article can be found at: http://cipremier.com/100032053

Nimitha Vijayaraghavan. Et al (2013) "Effects of Manufactured Sand on compressive Strength and Workability of Concrete" IJSCER ISSN 2319 – 6009 www.ijscer.com, Vol. 2, No. 4, November 2013

Zbysek Pavlik, Et al (2010)"Use of municipal solid waste incineration waste materials as admixtures in Concrete" - https://www.researchgate.net/publication/282256798

K Tarun Kumar, Et al (2020) "Study on strength and durability of concrete by using glass powder (GP) and municipal solid waste (MSW)" - ISSN NO: 0886-9367, The International journal of analytical and experimental modal analysis, Volume XII, Issue VII, July/ 2020

Veena V. Bhat, N. Bhavanishankar Rao, et al (2014) "Influence of Glass Powder on the Properties of Concrete ", International Journal of Engineering Trends and Technology (IJETT), V16 (5), 196-199 Oct 2014. ISSN: 2231-5381. https://www.ijettjournal.org./ published by seventh sense research group

M. H. Maher, et al Transportation Research Record 1295 "Properties of Municipal Solid Waste Ash-Cement Composite", Rutgers, the State University of New Jersey, Piscataway, N.J. 08855

Utpal Singh, et al (2018) "STUDY ON PROPERTIES OF CONCRETE (M40) USING STONE DUST AND DEMOLISHED CONCRETE WASTE AS PARTIAL REPLACEMENT OF FINE AND COARSE AGGREGATE: A REVIEW" - International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 05 Issue: 05 | May-2018 www.irjet.net p-ISSN: 2395-0072

Murali Krishnan.S. (2015) "Investigation on Durability Properties of Concrete Using Manufactured Sand and Admixtures" IJMCCE, Vol.1, Issue.4, September 2015 ISSN (Online): 2394-8868

Md. Safiuddin, Mohd Zamin Jumaat, M. A. Salam, M. S. Islam, R. Hashim, "Utilization of solid wastes in construction materials", International Journal of the Physical Sciences Vol.5 (13), pp. 1952-1963, 18 October 2010.

Chevula Surender, K. Anand Goud, Shruthi Kaviti, "Behavior of Geopolymer Concrete by using Steel Fibers", International Journal of Innovative Technology and Exploring Engineering', Volume-9 Issue-4, pp.2422-2429, February 2022