International Journal of Engineering Research and Science & Technology

ISSN 2319-5991 www.ijerst.com

Peer Reviewed, Referred & Indexed Journal

Research Paper

Experimental study on strength of concrete by partial replacement of fine aggregate with copper slag and cement with glass powder

Karne Anil Kumar[1], s.sekhar[2]

[1]M. Tech Student, Department of Civil Engineering, Brindavan Institute of Technology and Science, NH44, Hyderabad - Bangalore Hwy, Pedda Tekur, Chinna Tekur, Andhra Pradesh 518218

[2]Assistant Professor, Department of Civil Engineering, Brindavan Institute of Technology and Science, NH44, Hyderabad - Bangalore Hwy, Pedda Tekur, Chinna Tekur, Andhra Pradesh 518218

Abstract *Concrete is the most undisputable and indispensable material being used in infrastructure development throughout the world. Glass is commonly used in building / construction industries and large amount of glass is producing daily. The disposal of waste glass is an environmental issue as waste glass causes disposal problem. Glass powder and municipal solid waste finer than 600 μ is reported to have pozzolanic behaviour. An attempt is made to investigate the possibility of using the waste glass powder, copper slag are the partial replacement of ordinary Portland cement and fine aggregates in concrete.*

The study has been made to evaluate the effect on mechanical and durability properties of M40 grade concrete made with replacement of cement with Glass powder, (0%, 5%, 10%, 15%, 20% and 25%) and copper slag, (0%, 5%, 10%, 15%, 20% and 25%) by weight. For each set mechanical properties were studied by performing Compression test for Cubes, Flexural test for beams and Split Tensile test for cylinders and durability properties were studied by performing acid attack, alkaline attack and Sulphate attack test for cubes.

Key words: *waste glass, copper slag, mechanical, durability, acid attack, alkaline attack, Sulphate attack*

1. Introduction

Concrete is a blend of cement, sand, coarse aggregate and water. The key factor that adds value to concrete is that it can be designed to withstand harshest environments significant role. Today global warming and environmental devastation have become manifest harms in recent years, concern about environmental issues, and a changeover from the mass waste, mass consumption, and mass production society of the past to a zero emanation society is now viewed as significant. Normally glass does not harm the environment in any way because it does not give off pollutants, but it can harm humans as well as animals, if not dealt carefully and it is less friendly to environment because it is non biodegradable.

In developing countries, with the increasing population, both economy and pollution free environment in construction industry are of principal importance in order to meet the inevitable human needs of multifarious forms. Thus, use of waste aggregates in the production of new type of concrete, which plays an essential role in the construction activity, is necessary for fulfilling the demand of aggregates. Most of the waste materials are generated from industrial waste and demolishing waste. Normally the above said waste can be dumped into low laying areas but limited area is available for dumping due to land cost in urban region. Other than

the land cost, lead charges are also influencing the disposal of waste and it causes pollution to the nearby and surrounding areas.

2. Literature studies

Gautam Singh et al[4] (2014) This experiment had shown the property of concrete containing waste glass powder as a cement replacement material. The use of wastes or by-products in concrete production has advantages for improving some or all of the concrete properties. From this study it was concluded that Decrease the value of construction cost by 20% to 31% in the compare of conventional mix of M25, M30 and M35. Increase the value of compressive strength by 20.22%, 30.12%, 43.39%, 49.22% respectively.

Md. Safiuddin et al.,(2010) The main objective of this study is to investigate the potential use of various solid wastes for producing construction materials. The paper is based on the comprehensive review of available literature on the construction materials including different kinds of solid wastes. From this study it was concluded that during different industrial, mining, agricultural and domestic activities, huge quantity of solid wastes are being generated as by-products, which pose major environmental problems as well as occupy a large area of lands for their storage/disposal.

Sameer Shaikh et al (2015) In this project the attempts have been made to partially replace the cement as well as sand by waste glass powder and crushed glass particles with equal combination by 5% interval up to 20% replacement and observe its effect on the strength of concrete after 7 days and 28 days of curing. From this study it was concluded that Replacement of glass powder in cement as well as crushed glass particles in sand by 5%, 10%, 15% and 20% increases the compressive strength after 28 days by 9.25%, 38.50%, 70.80%, and 33.09% respectively.

3. Materials used

3.1 Cement

In this study Ordinary Portland cement of 53 grade (ACC cement) has been procured and has been used.

Fig 1: OPC 53 grade cement

3.2 Coarse aggregates

Coarse aggregates are particles greater that 4.75mm but generally range between 9.5mm to 37.5mm in diameter. In this study coarse aggregate of nominal sizes of 20mm, 12mm are used.

Fig 2: Coarse aggregates

3.3 Fine aggregates

Fine aggregate are basically sands won from the land or the marine environment. Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 4.75mm sieve.

The fine aggregate used in this study is river sand which is obtained from local company.

Fig 3: Fine aggregates

3.4 Water

Locally available potable fresh water which is free from concentrations of aid and organic substances has been used in this experimental program for mixing and curing.

3.5 Glass powder

Glass is an amorphous & transparent material, which is super-cooled liquid and not a solid. Glass can be made verity of forms and sizes from small fiber to

meter-sizes pieces. Primarily glass is produced by melting a mixture of materials such as silica, CaCO3, and soda ash at high temperature followed by cooling during which solidification occurs without crystallization.

Fig 4: Glass powder

3.6 Copper slag

Approximately 24.6 million tons of slag is generated from world copper production. Dumping or disposal of this slag causes wastage of metal values and leads to environmental problems. Rather than disposing, these slags can be used taking full advantage of its physico-mechanical properties. Copper slag is a by-product obtained during matte smelting and refining of copper.

Fig 5: Copper slag

4. Mix trials and mix ratio used in the study

For the experimental investigation in this paper the concrete grade of M40 is used the below specified proportions are calculated according to the materials properties.

Table 1: Mix design ratios of M40 grade concrete

MATERIAL	CEMENT	FINE AGGREGATES	COARSE AGGREGATES	WATER
Density	438 kg/m3	622 kg/m3	1044 kg/m3	197 kg/m3
Proportions	1	1.42	2.38	0.45

4.1 Mix Proportions

Mix types with percentage relative proportions and blend proportions of constituent materials are appeared in Table below

Table 2 Mix proportions of concrete

Mix Type	Cement	Fine aggregates	Coarse aggregates	Glass powder	Copper slag
0% +0% (M_0)	438	622	1044	0	0
5% +5% (M_1)	406.9	590.9	1204	21.9	31.1
10% +10% (M_2)	394.2	559.8	1204	43.8	62.2
15%+15% (M_3)	372.3	528.7	1204	65.7	93.3
20% +20% (M_4)	350.4	497.6	1204	87.6	124.4
25% +25% (M_5)	328.5	466.5	1204	109.5	155.5

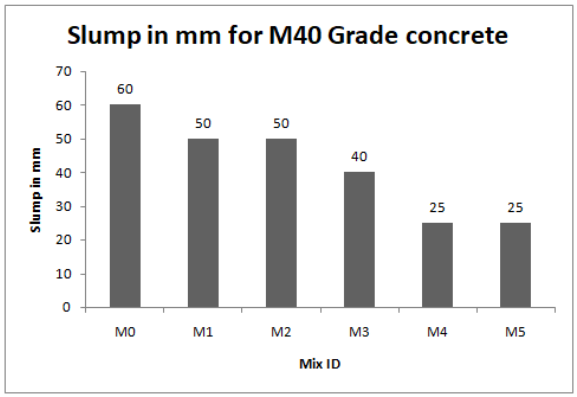
5. Experimental investigation and results

5.1 Manufacturing of concrete

Casting of cubes and cylinders as for M40 grade concrete, with a partial replacement of concrete in the mix proportions for which we are casting cubes for regular concrete. Filling the Cube Moulds and Compacting the Concrete are both part of the compaction process. Fill the cube moulds as soon as the sample has been blended and compact the concrete, either by hand or by vibration. Any trapped air in the concrete will diminish the cube's strength. As a result, the cubes must be completely compressed.

5.2 Slump cone test

The concrete slump test is utilized to decide the consistency of new concrete before it solidifies. It's utilized to test the usefulness of newly blended concrete and, thus, the straightforwardness with which it streams. It can likewise be utilized to distinguish a group that has been erroneously blended.



Graph 1: Comparison of slump cone test results

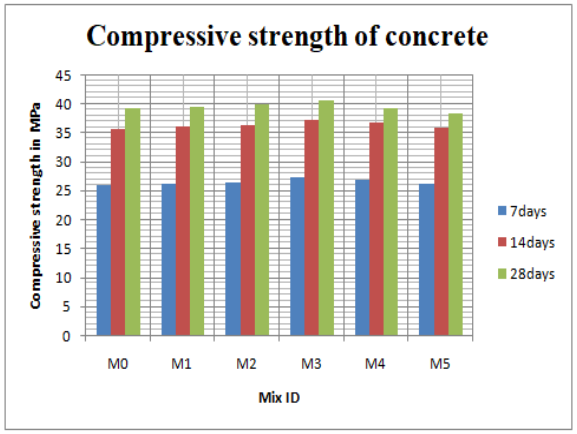
5.3 Compressive strength of concrete

The compressive strength of M40 grade is determined for different mix proportions and mix ratios of M40 grade concrete with the help of the below specified expression.

The compressive strength of cube = (P/A) N/mm2

Where,

P is load at failure in N, A is area of cube/contact in mm^2.



Graph 2: Comparison of compressive strength of concrete

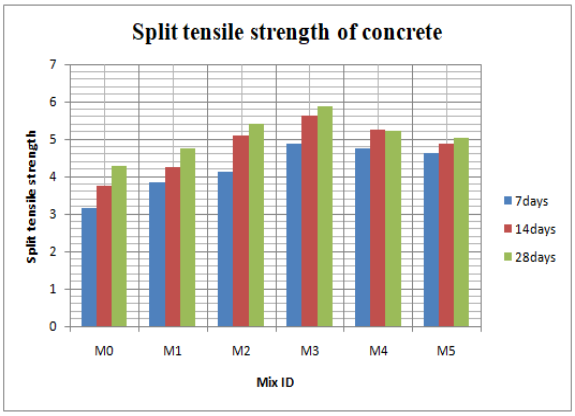
5.4 Split tensile strength of concrete

The tensile strength of M40 grade is determined for different mix proportions and mix ratios of M40 grade concrete with the help of the below specified expression

The split tensile strength = (2P/πdl) N/mm2

Where,

P= average load in N, d=diameter of cylinder in mm, l=length of cylinder in mm.



Graph3: Comparison of tensile strength of concrete

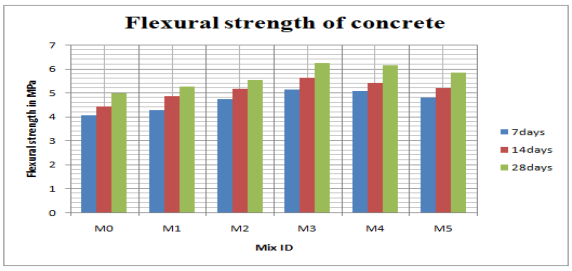
5.5 Flexural strength of concrete

The flexural strength of M40 grade is determined for different mix proportions and mix ratios of M40 grade concrete with the help of the below specified expression

$$fb = (Pl/bd^2)\ N/mm2$$

Where,

b= measured width in cm of specimen, d= measured depth in cm of specimen at a point of failure, l= length in cm of the span on which the specimen was supported, P= maximum load in kg applied to specimen.

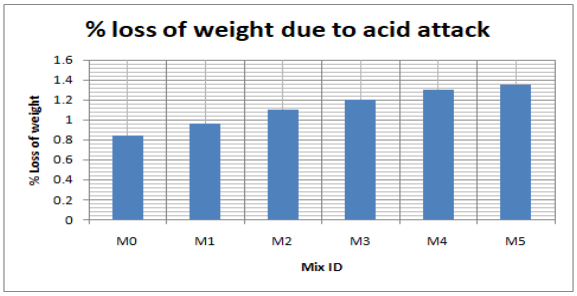


Graph 4: Comparison of flexural strength of concrete

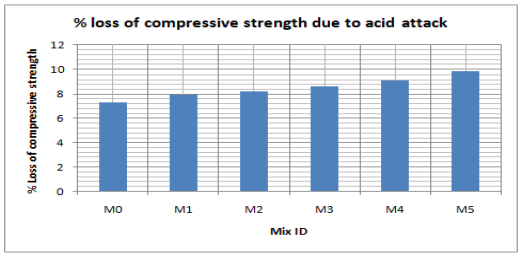
5.6 Durability of concrete

The durability of the concrete is determined by curing the test specimens in acid solutions or sulphate solutions for the period of 90 days. The percentage loss of compressive strength is determined with

various proportions of glass powder and copper slag in M40grade concrete.



Graph 5: Comparison of Percentage loss of strength due to acid attack



Graph 5: Comparison of Percentage loss of strength due to sulphate attack

6 Conclusions

From this study the following conclusions were made

1. The value of slump for the concrete decreases with increasing the percentage of Glass powder and copper slag for M40 Grade concrete.
2. Compressive strength for 7days, 14days, 28days for the concrete increases initially up to 15% Glass powder+15% copper slag waste than decreases with increasing the percentage of Glass powder and copper slag for M40 Grade concrete. The optimum value for the compressive strength was obtained at 15% Glass powder+15% copper slag.
3. Split tensile strength and flexural strength for 7days,14 days and 28days for the concrete increases initially up to 15% Glass powder+15% copper slag than decreases with increasing the percentage of Glass powder and copper slag for M40 Grade concrete.
4. The addition of Glass powder and copper significantly increased the compressive, tensile and flexural strengths of concrete with maximum strengths in each case being achieved at 15% Glass powder+15% copper slag.
5. The percentage loss of weight and percentage loss of compressive strength is increases with in increasing the percentages in all cases in durability studies in Glass powder and copper slag concrete. So, the concrete is durable up to 15% Glass powder+15% copper slag.

So the replacement of 15% Glass powder+15% copper slagis generally useful for better strength values in M40 grade of concrete.

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