Comparison of RMC and Ordinary Concrete Using Wasted Glass Material

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Abstract- Concrete is one of the most widely used construction materials in the world. However, the production of Portland cement, an essential constituent of concrete, leads to the release of significant amount of CO_2, a greenhouse gas; one ton of Portland cement clinker production is said to creates approximately one ton of CO_2 and other greenhouse gases (GHGs). Environmental issues are playing an important role in the sustainable development of the cement and concrete industry. There is a need to replace a part of cement by some pozzolanic material to reduce the consumption of cement and the environmental pollution can be checked to some extent. Some of the industrial wastes like fly ash, silica fume, blast furnace slag etc have already established their usage in concrete. Recently the research has shown that the waste glass can be effectively used in concrete either as glass aggregate or as a glass pozzolana. Waste glass when grounded to a very fine powder shows some pozzolanic properties because of silica content. Therefore the glass powder to some extent can replace the cement and contributes for the strength development and also enhances durability characteristics.Waste glass when ground to a very fine powder shows pozzolanic properties as it contains high SiO_2 and therefore to some extent can replace cement in concrete and contribute strength development. In this paper, an attempt has been made to find out the strength of concrete containing waste glass powder as pozzolana. Cement replacement by glass powder in the range of 10% to 20% increment by 5 percentages. (0%, 10%, 15%, 20%) has been studied. Replacement of 15% cement by glass powder was found to be higher strength.

Keywords – Concrete, Cement Replacement, Waste Glass Powder.

I. INTRODUCTION

In India, numbers of waste materials are produced by different manufacturing companies, thermal power plant, municipal solid wastes and other wastes. Solid as well as liquid waste management is one of the biggest issues. With the disposal of waste on the land causes serious impact on an environment. It spoils the land. To save an environment recycle of waste material is the best option.
This project is based on the utilization of the wasted glass material in powder form which would be replaced by cement and leads to reduction of quantity of cement.

READY MIX CONCRETE:
Ready Mix Concrete (RMC) is a specialized material in which the cement aggregates and other ingredients are weigh-batched at a plant in a central mixer or truck mixer, before delivery to the construction site in a condition ready for placing by the builder. The RMC supplier provides two services, firstly one of processing the materials for making fresh concrete and secondly, of transporting a product within a short time. It is delivered to the worksite, often in transit mixers capable of mixing the ingredients of the concrete just before the delivery of batch. This results in a precise mixture, allowing specialty concrete mixtures to be developed and implemented on construction sites.
The second option available is to mix the concrete at the batching plant and deliver the mixed concrete to the site in an agitator truck, which keeps the mixed concrete in correct form.
RMC is preferred to on-site concrete mixing because of the precision of the mixture and reduced worksite confusion. It facilitates speedy construction through programmed delivery at site and mechanized operation with consequent economy. It also decreases labor, site supervising cost and project time, resulting in savings. Proper control and economy in the use of raw material, results in saving of natural resources.

ORDINARY CONCRETE:

Ordinary concrete refers to the ordinary Portland cement as a cementing material, plus sand, gravel, water and admixtures (added sometimes), according to a certain percentage of preparation, after mixing, tamping shape, made of a hardened conservation man-made stone. Because of its rich resources of raw materials-

- Production process is simple.
- Good performance characteristics oflow price, and havehigher strength and durability.
- Ease of pouring into a variety of shape components or the overall structure, combined with the reinforced into the strong, anti-vibration of the reinforced concrete structure.
- It has been widely used in construction building materials.

As concrete is a combination of ingredients of non-homogeneous material, its production process also covers the preparation, mixing, vibrator and maintenance of such processes, together with cement is a kind of active materials. Concrete has relatively high compressive strength, but significantly lower tensile strength, and as such is usually reinforced with materials that are strong in tension (often steel).

The main objectives of the paper are:

- To study Ordinary Concrete and Ready Mix Concrete.
- To determine compressive strength at 7 and 28 days of Ordinary Concrete and Ready Mix Concrete.
- To determine compressive strength at 7 and 28 days of Ordinary Concrete and Ready Mix Concrete with addition of wasted glass material in different proportions like 10%, 15% & 20%.
- The comparison of Ordinary Concrete and Ready Mix Concrete using wasted glass material.

The study will highlight only difference in compressive strength of Ordinary Concrete and Ready Mix Concrete without and with addition of wasted glass material.

The rest of the paper is organized as follows. Methodology and investigations is explained in section II. Experimental results are presented in section III. Concluding remarks are given in section IV.

II. METHODOLOGY AND INVESTIGATIONS

In India, amount of glass waste material produced by different manufacturing companies and generates solid waste. Solid waste management is one of the biggest problems in the world. To find the alternative for waste disposal, this project is carried out.The experiment is performed in order to achieve the best results for optimum waste glass powder that can be replaced instead of cement. The wasted glass powder is mix with proportions of 10%, 15% and 20% in the concrete. The slump cone test and compressive strength test are carried out to analysis the optimum strength.

Figure 1 is the self-explanatory flow chart of the normal sequence of stages of the project approach that has been followed in the present work.

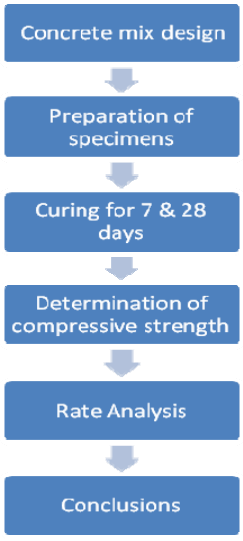

Figure 1:A Flow Chart of Project Approach

A) Glass Composition:

Over the last decade growing concern about global environmental impact is forcing the Civil Engineering and construction industry to review its conventional cement and concrete production methods with a view to replace them with sustainable alternatives. Sustainable construction is in a large part implemented by recycling secondary materials and adapting them for use in concrete and to other market needs. Waste glass is not bio-degradable and therefore rational consideration for alternative utilization dictates a diversion of waste glass away from landfill disposal sites.

Currently, the use of waste glass in the construction industry is in the form of fibre glass, abrasives, or as low-value filler, but its applications are constantly being revised in an effort to achieve most sustainable solutions. The reuse of Waste Glass in concrete has recently captured attention not only as secondary aggregate, but also as a substitute for Portland cement in concrete, A denser (less porous) and more homogeneous structure is produced when milled waste glass is used as partial replacement for cement, which benefits the resistance to moisture sorption and thus the long-term durability of cementitious materials. Partial replacement of cement with milled waste glass also benefits the stability of cementitious materials when potentially deleterious reactions between cement hydrates and the reactive aggregates is a concern. Mixed-color waste glass, when milled to about the particle size of cement and used in concrete as replacement for about 15% of cement, improves the moisture barrier qualities, durability, and mechanical performance of concrete . These improvements result from the beneficial chemical reactions of milled waste glass with cement hydrates, which yield chemically stable products capable of refining the pore system in concrete. Major environmental, energy, and cost savings can be realized by partial replacement of cement with milled mixed-color waste glass.

B) Properties of Glass:

The properties of glass are mainly governed by factor such as composition of the constitutions state of surface thermal treatment conditions, dimensions of specimen etc. following are the properties of glass which have made glass popular and useful:

- It absorbs, refracts or transmits light.
- It has no sharp melting point.
- It is affected by alkalis.
- It has no definite crystalline structure
- It is extensively brittle.
- It is not usually affected by air and water.
- It is available in beautiful colours.
- It is possible to weld glass pieces by fusion.

It can thus be easily appreciated that glass, though used for thousands of years, is just beginning to be understood and it is still possible to get a variety of glasses with certain chemical additives. Further investigations are yet in the process of preparing glass with extraordinary unusual characteristics and thus to increase the utility this unique and complex material.

C) *Concrete Mix Design:*

Concrete has been design as per I.S. 10262: 2009

Requirements:

Specified minimum strength = 25 N/mm^2
Exposure Moderate
Cement- Type OPC, Grade 43
Avg. comp. strength 28 days = 31.6 MPa
Workability: compacting factor = 0.7
Degree of quality control Good

Test Data for Material Supplied:

CEMENT
Specific gravity = 3.15
COARSE AGGREGATE
20mm Graded
Crushed stone aggregate
Specific gravity = 2.68
Water absorption = 1.46%
FINE AGGREGATE (Coarse sand)

Crushed Sand
Specific gravity = 2.6
Water absorption = 0.5%
Selection of W/C Ratio:
As required for 'Moderate' Exposure, W/C ratio of 0.4

Determination of Water & Sand Content:
For W/C = 04 & Max. Aggregate Size of 20 mm
Water content = 186 Kg/m^3
Sand as percentage of total aggregate by absolute volume = 35%
Water absorption:
Coarse Aggregates: 0.5%
Fine Aggregates: 1.46%
Thus after adjustments, Net water content = 197 Kg/m^3
Net sand percentage = 33.5 %

Determination of Cement Content:
W/c ratio = 0.5
Water content = 197 Kg/m^3
Thus, Cement content = 350 Kg/m^3

Mix Calculation:
a) Volume of concrete 1m^3
b) Volume of cement = (mass of cement)/(sp.gr of content) × (1/1000)
= (350/3.15) × (1/1000)
=0.111 m^3
c) Volume of water = (140/1) × (1/1000)
= 0.140 m^3
d) Volume chemical admixture (super plastizer)
= (7/1.145) × (1/1000)
=0.006 m^3
e) Volume of all aggregate = (a-(b+c+d))
= (1-(0.11+0.140+0.006)
= 0.743 m^3
f) Mass of coarse agg. = e × (vol. of CA × sp.gr of CA) ×1000
= 0.743 ×0.56 × 2.74 × 1000
= 1140 kg
g) Mass of fine agg. = e x (vol. of FA × sp.gr of FA) × 1000
= 0.743 ×0.44 × 2.74 × 1000
= 896 kg

Mix Proportion:
Cement = 350 Kg/m^3
Water = 140 Kg/m^3
Fine agg. = 896 Kg/m^3
Coarse agg. = 1140 Kg/m^3
Chemical admixture = 7 Kg/m^3
W/C Ratio = 0.40

Table 1: Mix proportion:

Water (Kg/m^3)	Cement (Kg/m^3)	Fine Aggregate (Kg/m^3)	Coarse Aggregate (Kg/m^3)
140	**350**	896	1140

Preparation of Replacement Material (Waste Glass Powder):

In this study, the Dark amber or brown glass (Beer bottles) wasted bottles were used. The raw material of wasted glass bottles were passed through grinding machine. Then, a glass powder have prepared from wasted glass material. This material is accurately weighed in proportions before mixed together. The mixing of these materials was carried out in mixing machines until a uniform mixture is obtained. Such a uniform mixture was used for the casting of cubes for the determination of compressive strength.



Casting of Concrete Cubes:

The cubical moulds of dimension 15 X 15 X 15 cm as per I.S. 516: 1959 were used for casting.Compaction was done by hand using the standard tamping rod and the strokes of the rod were distributed in a uniform manner over the cross-section of the mould.


Figure 1: Casting of cubes

3.8 Testing:

3.8.1 Slump Cone Test:

The **concrete slump test** is an empirical test that measures the workability of fresh concrete. More specifically, it measures the consistency of the concrete in that specific batch. This test is performed to check the consistency of freshly made concrete. Consistency is a term very closely related to workability. It is a term which describes the state of fresh concrete. It refers to the ease with which the concrete flows. It is used to indicate the degree of wetness. Workability of concrete is mainly affected by consistency i.e. wetter mixes will be more workable than dried mixes, but concrete of the same consistency may vary in workability. It is also used to determine consistency between individual batches. The test is popular due to the simplicity of apparatus used and simple procedure. Unfortunately, the simplicity of the test often allows a wide variability in the manner that the test is performed. The slump test is used to ensure uniformity for different batches of similar concrete under field conditions and to ascertain the effects of plasticizers on their introduction.

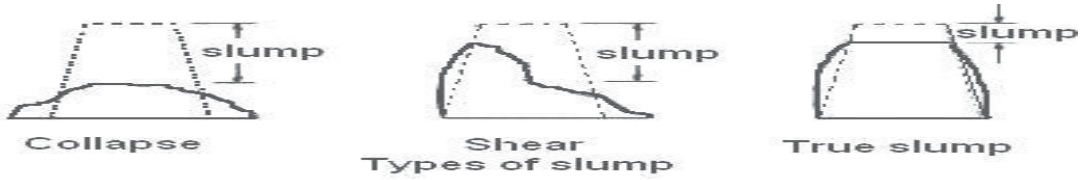

Figure 2: Slump Cone Test

3.8.2 Compressive Strength Test:

For each series five sets were casted to determine compressive strength. Each set comprises of eleven standard cubes out of which nine cubes were casted to measure the compressive strength after 7 days and 28days. The size of the cube is as per the IS code 10086 – 1982.

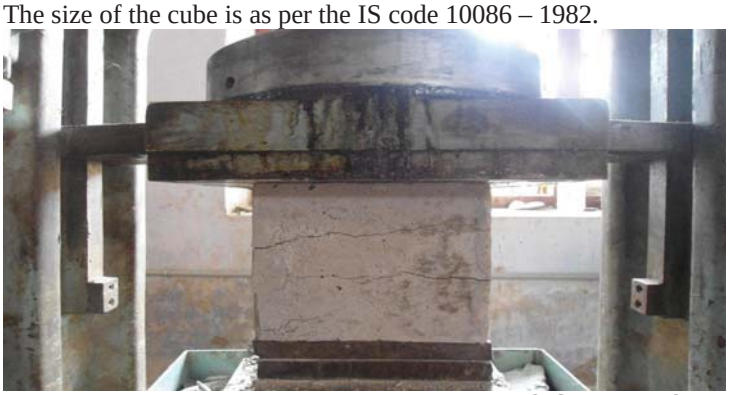

Figure 3: Compressive Strength Test

3.8.3 Testing Machine:

Specifications of the testing machine as described in I.S. 516-1959 are:

- The testing machine may be of any reliable type, of sufficient capacity for the tests and capable of applying the load at the rate 140 kg/sq. cm/min.
- The permissible error shall not be greater than ± 2 percent of the maximum load.
- The testing machine shall be equipped with two steel bearing plates with hardened faces. One of the plates preferably the one that normally will bear on the upper surface of the specimen shall be fitted with a ball seating in the form of a portion of a sphere, the Centre of which coincides with the central point of the face of the platen. The other compression platen shall be plain rigid bearing block.
- The bearing faces of both plates shall be at least as large as, and preferably larger than the nominal size of the specimen to which the load is applied.
- The College Testing machine met the above requirements. The Compressive Strength Tests werecarried out on the same.

Age at Test: Tests were done on the cubes at the age of 7 & 28 days**.**

III. EXPERIMENT AND RESULT

Slump Cone Test:

Slump test is use to determine the consistency of concrete mix of given proportions. Unsupported fresh concrete flows to the site and a sinking at height takes place. This vertical settlement is known as slump. In this test,the fresh concrete is filled into a mould of specified shape and dimensions, and the settlement or slum is measured when supporting mould is removed. Slump increases as water content is increased. The slump is measured indicating the consistency or workability of cement concrete. It keeps an idea of water content needed for concrete to be used for different work. A concrete is said to be workable if it can be easily mixed, placed, compacted and finished. From test results, it is observed that the slump is a true slump.Table 4.1 shows slump cone test results.

Table 2: Slump Cone Test Result:

Sr. No.	Type of Concrete	Slump, mm
1.	Ordinary Concrete	155
2.	Ready Mix Concrete	170

4.2 Compressive Strength Test:

Table 4.2 shows the compressive strength of casted cubes after 7 days and 28 days for ordinary concrete and RMC with 0%, 10%, 15%, and 20% cement replacement respectively. The strength values reported are the average of three test results. Graphical representation of strength development of concrete cubes of various mixes respectively.

Table 3:Compressive Strength Test:

Name of concrete	Ordinary Concrete
Grade	M 25
Date of casting	06/02/2015
Date of testing	13/02/2015
Size of cube	150x150x150 mm
Age in days	7 days

i) FOR 0% OF GLASS POWDER

Cube No.	Weight (gm)	Load (KN)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
A	8675	440	19.55	18.36
B	8680	420	18.22	
C	8785	390	17.33	

ii) FOR 10% OF GLASS POWDER

Cube No.	Weight (gm)	Load (KN)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
A	8685	480	21.33	22.07
B	8696	500	22.22	
C	8765	510	22.67	

iii) FOR 15% OF GLASS POWDER

Cube No.	Weight (gm)	Load (KN)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
A	8665	440	19.56	18.73
B	8687	400	17.78	
C	8785	420	18.67	

iv) FOR 20% OF GLASS POWDER

Cube No.	Weight (gm)	Load (KN)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
A	8694	400	17.78	16.89
B	8632	380	16.89	
C	8772	360	16.01	

Name of concrete	Ordinary Concrete
Grade	M 25
Date of casting	07/02/2015

Date of testing	07/03/2015
Size of cube	150x150x150 mm
Age in days	28 days

i) FOR 0% OF GLASS POWDER

Cube No.	Weight (gm)	Load (KN)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
A	8685	590	26.22	25.48
B	8670	550	24.44	
C	8745	580	25.77	

ii) FOR 10% OF GLASS POWDER

Cube No.	Weight (gm)	Load (KN)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
A	8655	650	28.88	29.92
B	8661	680	30.22	
C	8730	690	30.67	

iii) FOR 15% OF GLASS POWDER

Cube No.	Weight (gm)	Load (KN)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
A	8625	620	27.56	26.66
B	8654	580	25.77	
C	8689	600	26.67	

iv) FOR 20% OF GLASS POWDER

Cube No.	Weight (gm)	Load (KN)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
A	8664	550	24.44	23.55
B	8608	510	22.66	
C	8736	530	23.55	

Name of concrete	Ready mix concrete
Grade	M 25
Date of casting	13/03/2015
Date of testing	20/03/2015
Size of cube	150x150x150 mm
Age in days	7 days

i) FOR 0% OF GLASS POWDER

Cube No.	Weight (gm)	Load (KN)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
A	8675	635	28.22	28.14
B	8690	640	28.44	
C	8730	625	27.78	

ii) FOR 10% OF GLASS POWDER

Cube No.	Weight (gm)	Load (KN)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
A	8665	540	24	25.03
B	8680	560	24.88	
C	8700	590	26.22	

iii) FOR 15% OF GLASS POWDER

Cube No.	Weight (gm)	Load (KN)	Compressive Strength	Average Compressive

			(N/mm^2)	Strength (N/mm^2)
A	8660	500	22.22	21.33
B	8675	480	21.33	
C	8700	460	20.44	

iv) FOR 20% OF GLASS POWDER

Cube No.	Weight (gm)	Load (KN)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
A	8684	460	20.44	19.7
B	8625	440	19.55	
C	8750	430	19.11	

Name of concrete	Ready mix concrete
Grade	M 25
Date of casting	14/03/2015
Date of testing	11/04/2015
Size of cube	150x150x150 mm
Age in days	28 days

i) FOR 0% OF GLASS POWDER

Cube No.	Weight (gm)	Load (KN)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
A	8665	780	34.66	34.95
B	8690	795	35.33	
C	8700	785	34.88	

ii) FOR 10% OF GLASS POWDER

Cube No.	Weight (gm)	Load (KN)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
A	8650	710	31.55	32.29
B	8655	740	32.88	
C	8720	730	32.44	

iii) FOR 15% OF GLASS POWDER

Cube No.	Weight (gm)	Load (KN)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
A	8615	680	32.22	29.39
B	8635	720	27.55	
C	8670	640	28.44	

iv) FOR 20% OF GLASS POWDER

Cube No.	Weight (gm)	Load (KN)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
A	8655	590	26.22	25.47
B	8600	560	24.88	
C	8715	570	25.33	

The graphs related to 28 days strength are shown as follows

Graph 1: Percentage V/s Compressive Strength (Ordinary Concrete)

Graph 2: Percentage V/s Compressive Strength (Ready Mix Concrete)

4.3 RATE ANALYSIS:

The purpose of rate analysis is to study the cost wise comparison between ordinary and RMC.The above test results show that due to reduction in amount of cement quantity, with partial replacement of waste glass will bring significant impact on cost of the project.

The following is the rate analysis for 1 m^3 of concrete.

Rate analysis for 1m3of M25 grade of concrete (1:1:2)

Volume of dry concrete= $1m^3$

Volume of wet mortar= 42% of vol. of dry concrete

$= 1.42\ m^3$

Volume of cement = vol. of mortar / proportion

$$= \frac{1.42 \times 1}{(1+1+2)}$$

$= 0.35\ m^3$

Number of cement bag required= 0.35×30

(Volume of 50kg cement bag is 30lit)

= 10.65…..Say 11bags.

Total quantity of cement for 1 m^3 of concrete= 11×50 = 550kg.

The reduction in cement content due to addition of wasted glass is as shown in Table 4.3.

Table 4: Rate Analysis

Ordinary Concrete:

% Reduction	Amountof reduction (kg)	Rate per 50kg bag	Amount saving(Rs.)per m^3
10%	55	300	330
15%	82.5	300	495
Optimum wastedglass Content 16%	**88**	**300**	**528**

Ready Mix Concrete:

% Reduction	Amount of reduction (kg)	Rate per 50kg bag	Amount saving(Rs.)per m^3
10%	55	300	330
15%	82.5	300	495
Optimum waste glass Content 20%	**110**	**300**	**660**

From the above test results and graphs, it is observed that:

Ready Mix Concrete gives better Compressive strength than the Ordinary Concrete compared to compressive strength after addition of waste glass powder. After addition up to 20% of wasted glass powder Ready mix Concretedoes not loses its designed strength, whereas the Ordinary Concrete fails at 20% addition of wasted glass powder. The Optimum Compressive Strength for Ordinary Concrete is obtained at 16%.

From the graph for Ready Mix Concrete, it is observedthat using 20%of wasted glass powder in concrete will not reduce its designed compressive strength and would be cost effective.

It would not only reduce cost of the project but also help in minimizing the problem of global warming which is contributed by cement industry, 6.5% of the total global warming effect.

IV.CONCLUSION

- Compressive strength at 28 days Ready Mix Concrete is increased by 10% to 15% than Ordinary Concrete.
- With the addition of wasted glass powder, in ordinary concrete, 16% is permissible and for Ready Mix Concrete 20% is permissible to replace the cement content.
- If in Ordinary Concrete, wasted glass content is exceeds by 16%, it fails to achieve its designed strength and for Ready Mix Concrete, if exceeds by 20% it will fail to achieve its designed strength.
- With the partial replacement of cement content by wasted glass, overall cost of the structure can also be reduced.
- Due to replacement of cement content upto desired limit, will also reduce global warming which is caused by cement manufacturing industry.

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