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A Review on Study of Cement and Aggregate Replacement in Concrete using Glass Powder and Recycled Aggregate

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ABSTRACT

In a growing country like India a huge amount of industrial waste is polluting the environment. With a view of the above, this study aims at utilization of such industrial by product for value added application. In addition the waste can improve the properties of construction materials. The recycled glass has been used in the form of powder. The glass powder was tested with concrete and mortar. Cement was replaced by the glass powder in some proportion. The flexural strength was conducted for the above replacements. The result showed glass powder improves the mechanical properties. The advantages of this project are that the replacement of glass powder is economically cheap as well as a superior concrete can be made.

Concrete is the most widely used man made construction material in the world. The popularity of concrete is due to the fact that from the common ingredients the properties of concrete are tailored to meet the demand of any particular application and then most widely used in all types of civil engineering works including infrastructures, low and high rise buildings, defense developments. It is obtained by mixing cementing materials, water and aggregate. However, in recent years the wisdom of own continued wholesale extraction and use of aggregate from natural resources has been questioned at on an international level. This is mainly because of the depletion of quality primary aggregate and greater awareness of environmental protection. In light of this the availability of natural resource for future generations has also been realized. In fact, many governments throughout the world have now introduced various measures aimed at reducing the use of primary aggregates and increasing reuse and recycling where it is technically, economically or environmentally acceptable.

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KEYWORDS: *Glass powder, Recycled aggregate, Concrete Mix, Compressive Strength, flexural strength*

1. INTRODUCTION

Concrete is a most widely used construction material today. Flexibility, molding ability of concrete material, its high compressive strength and the steel reinforcing and pre-stressing technique in concrete facilitates to improve its strength as against its low tensile strength propertyand contributed largely to its widespread use.

The concrete is the most important construction material which is manufactured at the site, it is a composite product obtained by mixing cement, water and an inert matrix of sand and gravel or crushed stone, it undergoes a number of operations such as transportation, placing, compacting and curing. The distinguishing property of the concrete is its ability to harden under water. The ingredients of the concrete can be classified into two groups, namely active and inactive. The active group consists of cement and water, whereas inactive group comprises of fine and coarse aggregates, the inactive group is sometimes called as inert matrix. Good concrete, whether plain, reinforced or pre-stressed, should be strong enough to carry superimposed loads during its anticipated life and should have all other essential properties include durability, impermeability, minimum amount of shrinkage and cracking.

The following factors contribute to the production of good quality of concrete.

- Type and quality of its component materials
- Based on exposure of concrete to atmosphere, temperature, rain, sea water selects w/cratio

- Water content in the mix.
- Curing time and placing time of concrete
- Method of compaction of concrete
- Ratio of cement :sand: coarse aggregate: water as per design of the mix
- Temperature maintained during pouring and compaction
- Competent direction and supervision.

Over the last decade, growing concern about the global environmental impact is forcing the Civil Engineering and construction industry to review its conventional cement and concrete productionmethods with a view to replace them with sustainable alternatives. Sustainable construction is ina large part implemented by recycling secondary materials and adapting them for use in concrete.

Use of Industrial Waste and by-products in concrete will lead to green environment and such concrete can be called as "Green Concrete". The most commonly used Industrial waste materials to replace sand and cement in concrete are Fly Ash, Rice Husk Ash, Sugar Cane Bassage Ash, Foundry Sand, Blast Furnace Slag, Hypo Sludge, Red Mud and Phosphor, Gypsum, Silica Fume, Crushed glass and Pond Ash.

Use of recycled waste glass in Portland cement and concrete has attracted a lot of interest worldwide due the increased disposal costs and environmental concerns. The glass used for containers, jars and bottles are soda lime silica counts for 80% of the recycled glass The glass being mainly a silica-based material in amorphous form can be used in cement-based applications.Due to its silica content, ground glass is considered a pozzolanicmaterial and as such can exhibit properties similar to other pozzolanic materials such as fly ash, metakaolin, slag and wheat husk ash.

Work carried out on Glass concrete by Anderson, J. E. (2007), suggest that for every ton of cement clinker produced, 579 kg of CO2 gas is emitted solely from a chemical reaction, regardless of the process used or the fuel efficiency. Replacement of Portland cement with powdered glass in concrete would substantially reduce carbon dioxide emissions.

Since this study is preliminary based upon the experimental investigation on the use of glass powder to partially replace of cement and use of Recycled Aggregate as partial replacement of Aggregate with some adjustable percentage to achieve high strength of concrete.

1.1. CONSTITUENTS OF CONCRETE

1.1.1. Cement

Cement is a most important constituent in concrete and well known binding material has occupied an indispensable place in the construction work. There is a variety of cements available in the market and each type is used under certain conditions due to its special properties.

In the early period, cement was used for making mortar only. Later the use of cement was extended for making concrete.

The term cement is derived from the Latin word Caementun, which is meant stone chippings such as used in Roman mortar not the binding material itself. Cement word described as a material with adhesive and cohesive properties which make it capable of bonding mineral fragments into a compact whole. The first factory in India, Portland cement was first manufactured in 1904 near Madras, by the South India Industrial Ltd. but this venture failed. The Indian Cement Co. Ltd., was established between 1912 and 1913 at Porbander and delivered about 1000 tons of Portland cement in the year 1914.

Ordinary Portland cement is the most commonly used in the form of binding material in the cement concrete. It essentially consists of a mixture of various ailments and silicates of calcium produced by the interaction of various oxides during fusion. The standard requires that it is made from 95 to 100% of Portland cement clinker and 0 to5% of minor additional constituents. Minor additional constituents are one or more of the other cementitious materials. The OPC wasclassified into three grades, namely 33 grade, 43 grade and 53 grade depending upon the strength of the cement at 28 days. If the 28 days strength is not less than 33 N/mm^2, it is called 33 grade cement, if the 28 days strength is not less than 43 N/mm^2, it is called 43 grade cement and if the 28 days strength this not less than 53 N/mm^2, it is called 53 grade cement.

1.1.2. Aggregates

Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. Aggregates were considered to simply be filler for concrete to reduce the amount of cement required. Aggregates occupy 70-80 percent of the volume of concrete

1.1.3. Water

Water is very actively participates in the chemical reaction with cement. Since it helps to form the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully and secondly, it acts as a lubricant of all other materials and makethe concrete workable. In practice, very often great control on the properties of cement and aggregate is

exercised, but the control of the quality of water is often neglected. Since quality of water affects the strength, it is necessary for us to go into the purity and quality of water. One of the most common causes of the poor-quality concrete is the use of too much mixing water. Fundamentally "the strength of concrete is governed by the nature of the weight of the water to the weight of the cement in a mix, provided that it is plastic and workable, fully compacted and adequately cured". It has been said that there is a much more bad concrete mad through using too much better quality of water than there is using the right amount of poor-quality water. The rule of thumb for water quality is "if you can drink it, you can work concrete with it". A large friction of concreteis made using municipal water supplies. However, good quality concrete can be made with water that would not pass the normal standard for drinking water.

1.1.4. Admixtures

Admixtures are added to the concrete mix immediately before or during mixing to modify one or more of the specific properties of concrete in fresh or hardened state. The use of mixture to offer an improvement not economically attainable by adjusting the proportion of cements and aggregate and should not affect adversely any properties of the concrete. The properties commonly modified are the rate of hydration or setting time, workability, depression, and air entrainment.

These days, a mix without admixture is exceptional. The admixture is a chemical product whichis added to the concrete mix in quantities not larger than 5% by mass of cement during mixing or during an additional mixing operation prior to the placing of concrete, for the purpose ofachieving a specific modification to the normal properties of concrete. Admixtures are capable of imparting considerable physical and economic benefits with respect to concrete production. It is established fact that the use of admixture results in commencement improving durability without the use of additional measures.

The effectiveness of any admixture may vary depending on its dosage in the concrete and also onthe constituents of the mix, especially the properties of the cement.

1.1.5. Glass powder

Glass is one of the most versatile substances on earth which is used in many applications and in a wide variety of forms. Glass occurs naturally when rock high in silicates melt at high temperature and cool before they can form a crystalline structure. Obsidian or volcanic glass is a well-known example of naturally occurring glass. When manufactured by humans the glass is a mixture of silica, sand, lime and other materials. Glass Powder is the waste product which can be obtained after cutting of glass product or also derived from grounding the waste glass material to fine powder. The glass powder from glass manufacturing industries can also be obtained in bulk amount.

1.1.5.1. Environmental impact of glass powder

Normally glass does not harm the environment in any way because it does not give off pollutants,but it can be harm humans as well as animals. However, the land filling of waste glasses is undesirable because they are not biodegradable. Which makes them environment less friendly and also it requires a large amount of land to discharge of glass powder. There is now a significant worldwide interest to solve the disposal problems caused by these waste glasses. The typical glass contains 70% silica approximately. Past study shows pozzolanic properties of glassare noticeable on particle sizes below approximately 100µm. Size of glass powder less than 75µm possessed cementitious capability and improves resistance to sulfate attack and chlorideion penetration. The peasants of alkali in glass may cause alkali-silica reaction and change the volume, but it has been found that finely ground glass does not contribute to alkali-silicareaction. In this project used size of glass powder is passing by 90 micron sieve.

Figure 1.1: Glass powder

1.1.5.2. Advantages of Glass Powder in concrete:-

1. Glass powder has been widely used in cement concrete as a porcelain.
2. It also helps in bricks and ceramic manufacture and it preserves raw materials.
3. Decreases energy consumption and volume of waste sent to landfill.
4. As useful recycled materials, glasses and glass powder are mainly used in fields related to civil engineering, for example, in cement, as porcelain, and coarse aggregate.
5. Utilization of waste also enhances performance of the concrete when used in optimum amounts.
6. Either way, their use in concrete would substantially reduce carbon dioxide emissions

generated during the production process of Ordinary Portland cement.

1.1.6. Recycled Aggregate

Recycled Aggregate will be used in these experiments contain 25 mm maximum size of aggregate

Figure no.:-1.2: Recycled aggregate

1.2. CONCRETE MIX SELECTION

Concrete mix design is the procedure of obtaining a suitable proportion of various ingredients like Cement, Fine aggregate, coarse aggregate, water and Admixture if used in the most optimal manner so as to produce concrete of most economically as far as possible having specified properties of workability, homogeneity in green concrete and strength and durability in hardened concrete.

Concrete mix is designed following the stipulation laid down in IS 456:2000 with respect to minimum cement content and maximum water-cement ratio for various exposure conditions and guidelines. The mix is designed according to IS 10262:2009 – ISI method.

2. LITERATURE REVIEW

OVERVIEW OF PAPERS:-

1. Mahmoud Elsayed, Samar R. Abd-Allah(2023)

The main goal of this paper is to evaluate the flexural and shear performance of reinforced concrete (RC) beams containing recycled coarse aggregate (RCA), waste aluminum fiber (WAF) and waste glass powder (WGP). Five concrete mixes contained different percentages of (0% and 100%) RCA, (0, 1%, 2%, and 3%) WAF with a fixed percentage of 20% of WGP as cement substitution were investigated. Ten RC beams (two beams for each) were tested, five beams were designed to fail in flexure and the last five beams were designed to fail in shear. Results showed that using a combination of RCA and WAF has an adverse influence on the slump of concrete mixes. The compressive strength decreased by full substitution of natural coarse aggregate (NCA) with RCA. Conversely, adding WAF resulted in an improvement in mechanical characteristics of recycled coarse aggregate concrete (RCAC) mixes. The results revealed that the full substitution of NCA with RCA results in an adverse impact on the capacity, toughness, initial stiffness and ductility of tested beams. The load carrying capacity of tested RCAC beams was increased with the addition of WAF. The optimum percentage of WAF that can be added to RCAC to give optimistic responses to the overall behavior of tested beams is 1%.

2. Nafisa Tamanna1,* and Rabin Tuladhar (2022)

Mechanical strength and durability properties of concrete with 10%, 20% and 30% of RGP as a partial cement replacement were tested and compared with typical concrete and fly ash blend concrete. The relative strength test of mortar was conducted to assess the reactivity of glass powder with the cement. RGP concrete showed an improvement in strength over time like fly ash. Using RGP significantly improved the resistance against chloride penetration with increasing glass powder content. Furthermore, RGP also met the relative strength requirement as per Australian Standard requirement to be considered as a supplementary cementitious material.

3. Mr. Tushar R Sonawane1, Prof. Dr. Sunil S. Pimplikar(2021)

Experimental results show that:-

1. Use of recycled aggregate up to 30% does not affect the functional requirements of thestructure as per the findings of the test results.
2. Various tests conducted on recycled aggregates and results compared with naturalaggregates are satisfactory as per IS 2386.
3. Due to use of recycled aggregate in construction, energy & cost of transportation of natural resources & excavation is significantly saved. This in turn directly reduces the impact of waste material on the environment.

4. Dhanrajmohan patil[9] (2013),

Experimental results show that**:-**

glass powder takes some part of reaction at the time of hydration and also it is act as a filler material the term glass include several chemical varieties like binary alkali-silicate glass, boro-silicate glass and ternary soda-lime glass. Partial replacement of cement with waste glass benefits the microstructure and stability of cementitiousmaterials. Mixed colour waste glass when milled to about the particle size of cement and used in concrete as replacement for about 20% of cement, improves the moisture barrier qualities, durability and mechanical performance of concrete. This paper conclude that the particlesize less than 90micron get higher strength than that of particle size ranges from 90 to 150micron

5. Dr. G.Vijaykumar[13] (2013),

Experimental results show that**:-**

the glass powder can be used as cement replacement material up to particle size less than 75micron to prevent alkali silica reaction. Glass is an inert material which could be recycled and use many times without changing its chemical properties. Glass is an amorphous material with high silica content, thus making it potentially pozzolanic when particle size is less than 75mcicron.According to the study it is observed that with a 30% replacement of cement by the amber waste glass content of particle size 75micron along with fly ash, the compressive strength of concrete increases 25% at 7 days and 35% when tested 28 days strength.

6. Dr. B. R. Patagundi[8] (2012),

Experimental results show that**:-**

several million tons of waste glasses are generated annually worldwide. The research hasshown that the waste glass can be effectively used in concrete either as glass powder (as fine aggregate or coarse aggregate) or as a glass pozzolana. Post-consumer and other waste glass type are a major component of the solid waste stream in many countries & most is currently landfill. Expansive alkali-silica reaction (ASR) can occur between glass particles and cement paste, particularly in moist condition & with high alkali cement. The paper is conclude that, higher strengths can be achieved when 20% cement is replaced byglass powder in concrete.20% replacement of cement by glass powder in concrete inducebetter resistance to high temperature of 500˚C for 12 hours.

7. Ismail Abdul Rahman Hasrudin Hamdam Ahmad Mujahid Ahmad Zaidi(Corresponding author)

Experimental results show that:-

1. The 28-day target compressive strength for all six mixes was achieved to 25 MPa even though the RAC strength is lower than NAC. The compressive strength for RAC is withinthe same range compared to NAC and reaching up to 25MPa at day 28 of curing.
2. The size of RA was affected the strength in compressive strength, the results shows the10mm and 14mm size of RA is better than 20mm size.
3. The workability (slump test) of the RAC is lower than NAC because the absorptionrate of RA is higher than NA.
4. The general properties of RA, including AIV, ACV and specific gravity show hardly any noticeable difference from NA, and thus it is proven that RA size affected the workability and strength of concrete and can be seen especially in water absorption.
5. Gives a manual guideline for Malaysian construction industry to reuse a recycled aggregate in the future.

8. Krishnakumar S. *1, Anju Sam2a, Jayasree S.2c and Job Thomas1c

Experimental results show that**:-**

The reduction in the strength of concrete containing 40 percent (CCA) was found to be less than 10 percent. The bond strength of concrete is directly proportional to the grade of concrete. Based on the experimental study, it may be concluded that a 40 percent replacement of natural coarse aggregate with crushed concrete aggregate (CCA) can be recommended.

9. Prof. Chetna M Vyas Prof. (Dr.) Darshana R Bhatt

experimental results show that**:-**

the early compressive strength of concrete made of natural coarse aggregate and recycled coarse aggregate is approximately same. • The slump test indicates a decreasing trend of workability when the percentage of recycled aggregate is increased. According to the result, the highest slump obtained was 130mm and the lowest slump was 102mm for M20grade concrete. Slump obtained was 110mm and the lowest slump was 90mm for M25 grade concrete and Slump obtained was 99mm and the lowest slump was 80mm for M30 grade concrete Therefore; target slump had been achieved, where the range is from 75mmto 150mm. The workability was good and can be satisfactorily handled for 0% recycled aggregate to 100% recycled aggregate. The slump observed is less with more percentages of recycled aggregate concrete mixes. • It is found that the rebound number which gives the surface hardness of the concrete is higher at the replacement of 40% recycled aggregate for all types of concrete grade. The rebound number is observed more or less same for all the concrete, i.e. M20, M25 and M30 grade of concrete.

The compression test result indicates an increasing trend of compressive strength in the early age of the concrete specimens with 60% recycled aggregates. However, it show

that the strength of recycled aggregate specimens was gradually increased up to 40% replacement of recycled aggregate & then it decreases at the 100% replacement of re- cycled aggregate after 28 days. The target strength for M20, M25, and M30 grade is respectively 26.6Mpa, 31.6MPa and 38.25MPa that are achieved for all the specimens tested in the study. The results also show that the concrete specimens with 40% replacement of recycled aggregate get the highest strength when compared to the concrete specimens with different percentage of recycled aggregate. From the obtained result, it is possible to use 40% recycled aggregate for a higher strength of concretes. Hence the recycled aggregate can be used in concrete with 40.

CRITIQUE

With reference to the papers studied It is found that till now work has been only carried out on the replacement of Aggregate by Recycled Aggregate and cement by Glass Powder their combination is not used in concrete making, since in this study we"ll replace both Aggregate and cement by Recycled Aggregate and Glass Powder respectively at some suitable percentage. For mixes will be prepared by reducing Aggregate and cement content and varying the Recycled Aggregate and Glass Powder accordingly to achieve highest strength

3. PROBLEM FORMULATION

It is estimated that several million tons of waste glasses are generated annually worldwide. Onlya part of this waste glass can be used in recycling. The remaining waste glass cannot be used for any purposes and it is also seen that the process of manufacturing of cement consume more quantity of fuel and the process of fuel burning emitted CO_2.

The huge demand for concrete has made this natural resource to get reduced. On one side extraction of natural stone in excess has noticeable environmental impacts.

So it is of prime importance to carry out research works on the feasibility of us in these alternative materials like Recycled Aggregate and Glass Powder, which are wasted by product and find out its suitability for potential utilization in concrete constructions. Therefore, in this study, we are replacing both Aggregate and cement with varying percentage of Recycled Aggregate and Glass Powder in concrete.

OBJECT OF THE WORK

The objectives of the work for the study under consideration will include the following.

- To determine the best combination of recycled Aggregate and glass Powder by replacing Aggregate from recycled Aggregate and cement from glass Powder content at which concrete shows its high Flexural strength.
- Utilization of Industrial waste in a useful manner.
- To provide economical construction material.
- Protect the environment by the use of industrial waste.

REFERENCES

[1] **Dr. G. Vijayakumar, Ms H. Vishaliny, Dr. D. Govindarajulu**, "Studies on Glass Powder as Partial Replacement of Cement in Concrete Production", International Journal of Emerging Technology and Advanced Engineering, Volume 3, Issue 2, February 2013.

[2] **Sunny O. Nwaubani and Konstantinos** I. Photos, The Influence of Waste Glass Powder Fineness on the Properties of Cement Mortars" International Journal of Applied or Innovation in Engineering & Management (IJAIEM), Volume 2, Issue 2, February 2013.

[3] **Dr. G. Vijayakumar, Ms H. Vishaliny, Dr. D. Govindarajulu,** "Studies on Glass Powder as Partial Replacement of Cement in Concrete Production", International Journal of Emerging Technology and Advanced Engineering, Volume 3, Issue 2, February 2013.

[4] **Dhanraj Mohan Patil, Dr. Keshav K. Senegal**, "Experimental Investigation of WasteGlass Powder As Partial Replacement of Cement in Concrete", International Journal of Advanced Technology in Civil Engineering, ISSN: 2231 –5721, Volume-2, Issue-1, 2013

[5] **R. Vandhiyan, K. Ramkumar, R. Ramya**, "Experimental Study on Replacement Of Cement By Glass Powder", International Journal of Engineering Research & Technology (IJERT), Vol. 2 Issue 5, May – 2013.

[6] **Dhanraj Mohan Patil, Dr.KeshavK. Senegal,** "Experimental Investigation of Waste Glass Powder As Partial Replacement of Cement in Concrete", International Journal of Advanced Technology in Civil Engineering, ISSN: 2231 – 5721, Volume-2, Issue-1, 2013

[7] **Dr. B. R. Patagundi, Dr.K. B. Prakash**, "Effect of Temperature On The Properties Of Concrete Containing Glass Powder As Pozzolana", International Journal of Engineering Research & Technology (IJERT), Vol. 1 Issue 8, October – 2012.

[8] **J. M. Khatib, E. M. Negim, H. S. Sohl, N. Chiles**, "Glass Powder Utilization in Concrete Production", Europ. J. Apple. Sci., 4 (4): 173-176, 2012

[9] **Dr. B. R. Patagundi, Dr. K. B. Prakash,** "Effect of Temperature On The Properties Of Concrete Containing Glass Powder As Pozzolana", International Journal of Engineering Research & Technology (IJERT), Vol. 1 Issue 8, October – 2012.

[10] **AHMAD SHAYAN**, "Value-added Utilization of Waste Glass in Concrete", IABSE Symposium, Melbourne, 2002.

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