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Investigating Compressive and Flexural Strength of Concrete with Varying Levels of Glass Powder and Fly Ash Substitution for Cement: A Review

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ABSTRACT:

Waste glass, being non-biodegradable and abundant, poses significant environmental challenges in landfill disposal. However, its high silica content and amorphous nature make it a potential pozzolanic material suitable for enhancing concrete properties. Fly ash, a by-product of coal combustion, is rich in silica and contributes to the pozzolanic reaction, improving concrete durability and workability.

This research investigates the effects of incorporating waste glass powder and fly ash at varying proportions (10%, 20%, 30%, 40%) as partial replacements for cement in concrete. The study evaluates the compressive strength of cubes and flexural strength of beams at 7-day and 28-day intervals, comparing them with conventional concrete mixes. Special attention is given to the alkali-silica reaction, a potential concern when using silica-rich materials like glass powder.

Preliminary findings indicate promising results in terms of concrete durability and mechanical properties with the addition of waste glass powder and fly ash. The research emphasizes the environmental benefits of reducing cement consumption and utilizing industrial by-products, thereby contributing to sustainable construction practices and minimizing environmental impact.

Keywords: Sustainable construction, Waste glass powder, Fly ash, Cement substitution, Concrete durability, Environmental impact

INTODUCTION:

Million tonnes of glass cullet are used for land filled throughout the world in every year. In 2005, around 12.8 millions tonne of glass cullet was used in land filled in United States. When unwanted glass is collecting and various colour glasses is frequently added. Then Mixed colour glasses couldn't be recycled since of mixing colouring agent result in an changeable and uncontrollable colour in the new glass. Large glass pieces can be effectively sorted by colour using optical sensors; however, sorting small glass pieces is not cost effective, and much of this non-recyclable glass cullet is land filled. In the United Kingdom for example, 1.65 million tonnes of unwanted glasses are discarded per year due to their inability to be recycled. As far as the economic and environmental effects of landfills are concerned. One of the possible ways of reusing millions of tonnes of glass cullet each year as aggregate or supplementary cementitious material is in the concrete industry. The majority of crushed glass research has concentrated on its use as fine aggregates in concrete. However, the use of glass as a fine aggregate substitute in concrete has been restricted due to concerns about alkali-silica reaction (ASR). Several studies shows that if ground finely enough, glass acts pozzolanically with a surface area of more than 300 m2/kg [4-9]. The pozzolanic reaction occurs when amorphous silica in the SCM reacts with calcium hydroxide (CH), which is produced as a by-product of the cement reaction, and water to form more calcium silicate hydrate. The majority of research on the impact of glass cullet on cementitious mixtures as SCM based on mechanical and chemical properties. Increases Long- term compressive strength, flexural strength, resistance to ASR and sulphate attack, and a reduction in water sorptivity of concrete containing finely ground glass powder have all been observed in concrete containing finely ground glass powder. Furthermore, some research found that finely ground glass powder had mechanical properties comparable to or slightly better than fly ash and slag at later ages, but much less than silica fume. Despite the aforementioned findings, few studies have attempted to link the microstructural properties of cementitious mixtures containing glass powder to the glass mixtures' performance characteristics. Federico investigated the effect of glass powder on the kinetic and performance properties of cementitious mixtures in depth. However, however, the impact of curing temperatures on various types of glass cullet reaction kinetics and efficiency has not been investigated. Temperature is one of the most important factors affecting the hydration of cement or cementitious materials. Weather, heat curing, and hydration heat can all affect the temperature of concrete.. Elevated temperatures will accelerate pozzolanic activity activation by increasing the rate of hydration, early strength gain, changing the hydration products produced, changing the density of the formed products, and changing the hydration products formed [15-16]. High temperatures, on the other hand, may reduce ultimate strength, increase permeability and drying shrinkage, and even cause delayed ettringite formation in some cases (DEF) and Concrete is a mixture of cement, sand, and water. Concrete's importance is enhanced by the fact that it can be built to withstand the harshest conditions. In recent years, concern about environmental issues has grown, and a shift from the past's mass-waste, mass-consumption, mass-production society to a zero-emanation society is now regarded as important. Glass does not normally damage the environment because it does not emit toxins, but it can harm humans and animals if not handled properly, and it is less environmentally friendly because it is non- biodegradable. As a result, new technology development has been needed. Glass refers to a variety of chemical compounds, including soda-lime silicate glass and alkali-silicate glass.. Until now, these types of glass powder have been commonly used as pozzolana in cement and aggregate mixtures for civil works. The addition of waste glass to cement raises the alkali content of the material. It also aids in the production of bricks and ceramics, protects raw materials, and reduces energy consumption and waste sent to landfills. Glass and glass powder are mostly used in civil engineering fields as useful recycled materials, such as cement, as pozzolana (supplementary cementitious materials), and coarse aggregate. Their recycling rate is close to 100%, and they can be used in concrete without compromising its toughness. As a result, it is thought to be suitable for recycling.

HISTORY OF CONCRETE:

The Indian cement industry is today, nearly 93 ages previous. The first plant was built in 1913 with an annual capacity of 0.01×106 t/a. The increase of cement manufacture in India has witnessed. The increase of cement manufacture in India has witnessed lots of boom and floppy period. The cement and concrete business viewed both quantitative in addition to qualitative expansion in the free system, which carries on till date.

The foundation of cement producing industries in India was placed by Indian cement company Ltd. In the time 1912-13 at Porbandar (Gujarat State) and commenced construction in 1914. No of researchers those exercise with or study of India build environment, the city of Chandigarh dates from the mid-1950s is often believed to be the beginning point for the employ of toughened concrete in India. By that stage Europe and North America had been made with reinforced concrete for over fifty years and so this work investigates the utilization of this material in India throughout the ½ of the twentieth century. The structures planned by Lutyens and Baker in New Delhi there have been smallest attention in India's construct surroundings from the 1/2 of the twentieth century. There are numerous motives for this situation. The structures of this phase started to get on a additional international form, substitute the exoticism of the Indo-Saracenic method of the late nineteenth and early twentieth century that was, and residues, so appealing to many writers of Indian architectural history. The legal age of buildings, where a designer is acknowledged, was by architects who are almost unknown inside and outside India and therefore has not drawn the attention of western architectural historians. Journals and publications written at the time there was no mention of the engineers and contractors, or details of the structure of the buildings. The investigation completed in 1947 through the finish of the British ~ lie in India, a stage of conversion for India and close to the "pause" in the building industry. though Anglo-Indian designers persistent to perform after the battle, they were concealat first by Le Corbusier and Louis Khan - high-profile names brought in to assist encourage a modern India - and after that by Indian designers for example Charles Correa, Balkrishna Doshi, and Raj Rewal.

MATERIALS:

The materials used in concrete mix projects are cement, fine aggregate, coarse aggregate, Fly ash, Glass Powder as described in detail below:

1. Concrete Composition: The most important purpose of this research is to calculate the effect on the mechanical properties of concrete when OPC is partially replaced by 10%, 20%, 30% and 40% of glass powder, fly-ash and their combinations. Different material and experimental tests are performed to check the quality of concrete. The materials should be appropriate for future use in concrete or doesn't hold harmful ingredients in some amounts that can damage the quality or durability of the concrete.

2. Cement: its one of the main imprtant component of concrete, since the binding medium for the distinct ingredients is created. Produced from naturally occurring raw materials and then mixing with toxic waste or underground. For the analysis, OPC 53 grades of Ordinary Portland Cement (OPC) conforming to IS12269-1987 were used. The mix configuration is made with ordinary Portland cement of grade 43. Concrete's most essential component is cement. The ability of cement to create improved microstructure in concrete is one of the most important criteria for cement selection. The hard Cement of Grade 43 was used in this analysis. Since it is an essential ingredient of concrete, mortar, stucco, and most non-specialty grout, Portland cement (often referred to as OPC, from ordinary Portland cement) is the most common form of cement in general use around the world.

3. Fine Aggregate: Aggregates that cover almost 70 to 75 % concrete volume are often used in more than one way as inert ingredients. This is well known now a day, however, that the (i) physical (ii) chemical (iii) thermal properties of aggregates drastically affect the property of 23 mm and concrete results. To extract all pebbles, fine aggregates (sand) use as fresh dry sand sewn in a 4.75 mm sieve. Clean river sand of maximum size 4.75 mm used such as fine aggregate.

4. Coarse Aggregate: For making concrete, coarse aggregate is used. They are generally in form of irregular broken stone, or gravel that naturally occurs. Coarse aggregates are called material that is wide to be held at 4.75 mm sieve size. Up to 20 mm may be its maximum span. And angular aggregate of size between 4.75mm to 20 mm is used as coarse aggregate.

5. Water: water plays an important role as it engages in a heat of hydration with cement. In concreting water is present in the form of gel which help to increase the concrete's strength. For mixing, portable water is usually considered satisfactory. The pH value of water shall not be lower than the maximum allowable values expressed in the following concentrations.

a) Limits of acidity: Not more than 5 ml of 0.02 NaOH should be needed to neutralize a 100 ml solution of water using phenolphthalein as an indicator. The test details are as stated in IS 3025.

b) Limits of alkalinity: Using a mixed indicator, neutralizing a 100 ml solution of water does not need more than 25 ml of 0.02 natural H2SO4. The specifics of the tests are as stated in IS 3025.

c) Percentage of solids: When measured in compliance with IS 3025, the maximum allowable limits of solids are as set out in IS 3025.

6. Fly ash: Fly ash is finely divided residue consequential from the combustion of pulverized coal and transported by the flue gases of boilers by pulverized coal. It was obtained from thermal power station, dried and used. In this experiment fly ash having particle sizes not more than 90 μ is used. Mineral admixtures like fly ash are generally adding in much more quantity in concrete to improve the workability of freshen concrete and also improving fire resistance in concrete by which thermal cracking doesn't occur, alkali-aggregate expansion, and sulphate attack; or to permit a reduction in cement content. F class fly ah is the highest classification. In this analysis, fly ash was obtained from the Century pulp and paper mill in Lalkuan, Uttarakhand. The specific gravity and fineness modulus of the fly ash were both poor, at 1.975 and 1.195, respectively.. Fly ash, otherwise called flue-ash, it may be noticeable among the residues created under combustion, and comprises those fine particles that rise with flue gases. Ash that doesn't rise is called bottom ash. In mechanical context, fly ash typically alludes with burning of coal. Fly ash is obtained by electrostatic precipitators and suction pumps before the gasses goes through coal-fired power plant's chimneys. Since, its depending on the source of the coal burning continuously and the contents for fly ash particles.

7. Glass Powder: Locally available glass is collected and converted into powder form. This material replace the cement in different % . Before adding glass powder in the concrete, it has to be powdered to required size. In this experiment glass powder particle sizes not more than 90 μ is used. Glass being transparent material produced by melting a mixture of silica, soda ash, and CaCO3 at temperature emulated by cooling during which hardening happens without crystallization. Glass products are normally used in our daily fabricated items. Since the increase of waste glass leads over the recent years and these waste glass pieces have been dumped and occasionally not in use. The waste glass fill areas are not in use since glass is less eco-friendly and is not biodegradable. The glass powder which is used in this analysis was purchased from a market in Kolkata. In the mix, this substance takes the place of cement. Glass is a completely recyclable material in theory; it can be recycled without losing its consistency. There are numerous examples of waste glass being successfully recycled: as cullet in glass making, as a raw material for the manufacture of abrasives, and so on, in sandblasting, as a pozzolanic additive, in road beds, pavement, and parking lots, as raw materials for making glass pellets or beads for highway reflective paint, to make fibre glass, and as fractionators for lighting matches and shooting ammunition

- Glass is an amorphous (non-crystalline) substance that is essentially a supercooled liquid rather than a solid.
- Glass can be manufactured in a range of shapes and sizes, from small fibres to meter-sized parts, with excellent homogeneity.
- Glass is primarily composed of sand, soda ash, limestone, and other additives (Iron, Chromium, Alumina, Lead and Cobalt).
- Glass has been used as an aggregate in road, house, and masonry construction.

Source of Glass–

• Sand is circulated into three different size screens of various sizes.

• The best sand produces the best glass. The toughest glass is made from the largest sand.

• Glass is made by melting sand in a crucible.

Sources of waste glass

- Glass food and beverage containers are a common source of waste glass, as are window repair shops.
    - Decorative glass pieces
    - Electric bulbs and old tube lights
    - Glass polishing and manufacturing shop for glass windows and doors
- Application and properties of glass
    - Glass is a uniform amorphous solid material that forms when a viscous molten material cools rapidly below its glass transition temperature without allowing enough time for a normal crystal attice to form.
    - The most common type of glass is silica-based glass, which is used for windows, containers, and decorative items.
- Glass falls in the category of biologically inactive material that can be formed with very smooth and impervious surfaces.

OBJECTIVES:

Comparison of different property like compressive strength, density of modified concrete, with partial replacement of standard concrete with Fly ash & waste glass powder.

- To analyze the effect on the strengthening of Fly ash & glass powder waste materials in concrete.
- Analysis the property of fresh concrete prepared by Fly ash & waste glass powder particle material replacement
- Using knowledge of the various parameters to work out the best result and secure concrete output.
- To safeguard the optimization natural resource, prices.

LITERATURE SURVEY

M.D.A. Thomas, M.H. Shehata et al. have discovered that cementations blending of Portland cement, silica fume, and fly ash provide major benefits over binary cementitious blends, and even greater benefits than pure Portland cement.

Sandor Popovics et al. have investigated the Portland cement-fly ash-silica fumes system in concreting and over that adding silica fumes to fly ash cement mortar has many beneficial effects in conditions of strengthening, workability, and ultrasonic velocity test performance.

Jan Bijen et al. have investigated the benefits of adding copper slag or fly ash to OPC concrete in provisions of alkali-silica reaction and sulphate attack.

L. Lam, Y.L. Wong, and C.S. Poon et al. concluded in their study various Effects of fly ash and silica fumes on compressive and rupture behaviours of concrete that adding different percentages of fly ash and silica fumes to improving strength properties of concrete.

Tahir Gonen and Salih Yazicioglu et al. The impact of primary and secondary minerals admixture on small and large term performance of concrete was investigated, and lots of enhanced concreting property in freshen and hardened state were discovered.

Mateusz Radlinski, Jan Olek and Tommy Nantung. The causes of various proportions of ingredient in primary blending of mixing on scaling resistance of concrete in very least temperature was discovered in this investigational work and allowed causes of mix components and initial curing situation on the scaling resistance of primary concrete**..**

S.A. Barbhuiya, J.K. Gbagbo, M.I. Russeli, P.A.M. Basheer The properties of fly ash concrete customized with hydrated lime and silica fume were investigated, and it was discovered that adding some quantity of lime and silica fume improving concrete's early compressive strength as well as its long-term strength growth and durability.

Susan Bernal, Ruby De Gutierrez, Silvio Delvasto, Erich Rodriguez Research based on performance of an alkali-activated slag concrete reinforced with steel fibres was carried out. The established AASC has high compressive strengthening than Ordinary Portland cement concretes, according to their findings. The addition of fibres increases the splitting tensile strengthening of both OPCC and AASC concretes after 28th days of curing period.

Hisham Qasrawi , Faisal Shalabi, Ibrahim Asi Done research on the use of unprocessed steel slag with a low CaO content as a fine aggregate in concrete. Their final result is that steel slag is most beneficial for lower strength concretes in condition of compressive and tensile strengthening.

M. Maslehuddin, Alfarabi M. Sharif, M. Shameem, M. Ibrahim and.S M Barry Done investigational work comparing the properties of steel slag and crushed limestone aggregate concretes, and came to the conclusion that the steel slag cement concrete had greater toughness characteristics than the crushed limestone aggregate concrete. Any of the physical property of concrete were superior than the crushed lime stones.

J. G. Cabrera and P. A. Claisse Experiments on oxygen and water vapours transfer to the paste were carried out, and it was concluded that although oxygen flow is defined by the Darcy equation, water vapour flow is not. Because of the various mechanisms of transport, oxygen transmission rates are much more variable than water vapour transmission rates, with some SF samples nearly impermeable to oxygen.

O. Boukendakdji, S. Kenai, E.H. Kadri, F. Rouis Effects of copper slag on the rheology of freshen self-compacted concrete was the subject of research. Slag, they conclude, will generate strong self-compacting concrete.

Tahir Gonen,Salih Yazicioglu carried The impact of different admixtures on small and large term performance of concrete was investigated, and this was establish that silica fume contributing to both small and large term properties of concrete, while fly ash have beneficial effect over a longer period of time. In terms of compressive strength, the addition of both silica fume and fly ash improved compressive strength significantly, but contributed more to the development of concrete's transport properties.

Houssam A. Toutanji and Tahar El-Korchi when increasing the compressive strengthening of cement mortar 6 contains silica fumes as half substitution for cement significantly contributing the strength of bonds among the cement paste or aggregate, according to investigational work on oxygen and water vapour transfer in cement pastes.. It was also discovered that combining a superplasticizer with silica fume is more efficient in mortar mixes than in paste mixes. It could be credited to most effective use of super plasticizer in mortar mix suitable to improved silica fume dispersion.

Jigar p. patel Done investigational work on the wider use of steel slag aggregate in concrete, and thus concluded that the main aim of this research was to determine the toughness of steel slag aggregates concrete in a freeze-thaw setting, as there was a perception that steel slag aggregates have expansive properties and would cause cracking in concrete.

R. D. Padhye et al (2016) Their findings revealed that fly ash may be replacing up to 40% of the time, and that replacements greater than 40% might not be safe for various concrete mixes. The compressive strengthening of concreting mix decreases as the quantity of fly ash in the mix increases.

Veena V. Bhat et al (2014) This study, they rendered concrete with different percentages of unwanted glass powder replacing cement, such as 5%, 10%, 15%, and 20%, and compared the freshen or hardened property of concrete to traditional concrete. When 20% of the cement in concrete is substituted with glass powder or water/cement ratio is kept stable, then strengthening of concrete increasing by 27%. Even with 20% substitution, the slump was 70 to 72mm. Glass powder wills substitution of cement up to 20% of the time, depending on the strength requirements.

Dr. G.Vijayakumar et al (2013) Experiments on concrete prepared by partially replacing cement with unwanted glass powder by 10%, 20%, 30%, and 40% of the binder were carried out as part of their study. The compressive strengthening of cement is increased by 19.6%, 25.3 percent, and 33.7 percent, respectively, when glass powder is replaced by 20%, 30%, and 40%. The split tensile strengthening of cement is increased by 4.4 percent when glass powder is replaced by 40%. The flexural strengthening of cement is increased by 83.07 percent, 99.07 percent, and 100 percent, respectively, when glass powder is replaced by 20%, 30%, and 40%.

Y. S. Tai et. al. [2016] they mechanical examined the actions of high working steel fiber rounded in UHPC at different pullout speeds the experiment variables were steel fiber style matrix ingredients, and addition rates. In exacting, five variety of high strengthening steel fiber were used and five pullout rates from quasi-static to impact rates were applied. In addition, the effect of decreased quantity of glass fine particles, as key matrix constituent, on pullout behavior was explored. Investigational outcome explain that the addition reply of all of the fiber types exhibit increasingly rate sensitivity as the addition speed enlarges and turn into important through impact loading. It is mainly important in the soft and warped fibers and smallest amount in the hooked fibers. Also, examines electron microscope analyses are offered and used to make clear the machinery of rate augmentation from a microscopic perspective.

Anju Ramesan et. al. [2015] they studied about suitability of functions concrete of light weight with plastic aggregate. the weight appropriateness of recycled fibers a C.A. in concreting by performing different experiments similar to workability by slump test, compressive force of cube and cylinder, splitting tensile power analysis of cylinder, flexural strengthening of Reinforced cement concrete Beams, to find out the function and performance in concrete. Cause of substitute of C.A. with various percentages (0% to 40%) of plastic aggregate on behavior of concrete was investigational analysis and the finest particle replaced with of coarse aggregate was achieved. The outcome explained that adding of plastic aggregate to the concrete combination enhanced the material goods of the resulting mixture.

Sahil Verma et. al. [2015] they investigated about the use the waste fiber crushed bottles of suitable volume in concreting with half-done substitution of F.A.or it have the potential of dumping of massive quantity of catastrophic waste in a beneficial way. The ecological belongings could be significantly reducing by proper encaptsulaion of this unuseful plastic bottle. The analysis also provides the similarity of compressive strengthening of conventional concrete with the concrete made from the partial substitution of aggregates with Polyethylene Terephthalate bottles. Therefore concrete with waste polymers could be utilized as an efficient plastic waste organization performance in future.

B. Patnaik et .al. [2015] they learned about the power and durability elements of cement having copper waste as a half-done substitution of sand and results have been introduced in this paper. Two various types of Concrete Grade (M20 and M30) were utilized with various extents of copper slag substitution (0 to half) in the solid concrete. Strength and Durability properties, for example, sulfate resistivity, compressive strengthening, flexural strengthening, were assessed for both blends of cement concrete. test results clarifies that the strength elements of cement concrete having copper slag as a halfway replacement of Sand (up to 40%) in cement concrete however as far as of stability the solid concrete discovered to be low impervious to corrosive assault and better opposition against sulfate attack.

CONCLUSION

In this chapter will present a conclusion outlining the main findings as well as possible recommendation for additional research. This research has helps to identify factor causes of Fly ash & Glass Powder waste replacing with cement in concrete.

Following assumptions are to be taken for this analysis is as follows:

1. A Fly ash & Glass Powder waste is such type of waste used as a substitute to Cement in concrete.
2. From this analysis, fly ash & Glass Powder waste particles are used because it is low cost material which would help to resolve solid waste disposal problem or save atmosphere from pollution.
3. Concrete manufacturing cost reduces when in concreting cement replaced by Fly ash & Glass Powder waste.
4. More Amount of Fly ash & Glass Powder waste increasing the density of mix so its directly increase the Self-weight of mix.
5. The Compressive Strengthening of mix with half substitute of cement with Fly ash & Glass Powder waste up to 20% can be comparable with conventional Concrete.

6. Partial substitution of Fly ash & Glass Powder waste in mix shows good resistance against sulphate attack.

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