Enhancing Concrete Strength with Sustainable Alternatives: Partial Replacement of Fine Aggregate with Glass Waste and Coarse Aggregate with Marble Waste

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ABSTRACT

With increasing environmental awareness and stricter regulations on industrial waste management, the need for sustainable construction materials is more critical than ever. This study explores the potential of industrial waste as an alternative aggregate in concrete, aiming to enhance both environmental sustainability and structural performance. M40 grade concrete was selected as the reference mix, with fine aggregate partially replaced by waste glass powder at varying proportions (0%, 10%, 20%, 30%, 40%, and 50%) and coarse aggregate partially replaced by 30% marble waste. The fresh and hardened properties of concrete were analyzed to determine the optimal replacement levels. The findings contribute to sustainable construction practices by promoting the use of industrial by-products in concrete, reducing waste, and minimizing environmental impact while maintaining or enhancing concrete strength and durability.

Key words: M40 grade concrete, Sustainable concrete, waste glass powder, marble waste, fine aggregate replacement.

1.INTRODUCTION

The increasing demand for natural resources in concrete production has raised concerns about environmental sustainability and resource depletion. River sand, a key component in concrete mix, contributes to ecological imbalance by depleting groundwater levels, causing riverbank erosion, and escalating costs due to scarcity. As a result, the construction industry is actively seeking sustainable alternatives to traditional aggregates. One promising solution is the partial replacement of fine and coarse aggregates with industrial by-products such as crushed waste glass and marble waste.

Crushed glass, when incorporated into concrete, offers a viable alternative to natural sand, contributing to enhanced durability and structural integrity. The crystalline nature of waste glass makes it a robust and environmentally friendly material for concrete production. Additionally, its use in mix design reduces water absorption, shrinkage, and enhances resistance to abrasion. The effectiveness of glass aggregate in mitigating Alkali-Silica Reaction (ASR) expansion depends on particle size, with finer glass particles reducing ASR-related deterioration. Furthermore, incorporating waste glass in concrete helps in managing municipal solid waste by diverting it from landfills.

Modern technology has led to an exponential increase in glass-based products, such as LCD panels in televisions, computers, smartphones, and cameras. However, the remanufacturing of waste glass poses significant challenges due to contamination and the complexity of glass sorting. Utilizing crushed waste glass in concrete not only transforms discarded materials into valuable resources but also reduces transportation costs and environmental impact. Research has shown that concrete with waste crushed glass exhibits improved resistance to chloride ion penetration, making it particularly suitable for coastal infrastructure exposed to seawater and de-icing salts.

Similarly, marble waste, a by-product of the stone-cutting industry, remains largely underutilized despite its availability. Traditional construction relies on granite aggregates, but alternative materials like marble waste can serve as effective substitutes without compromising strength and durability. By incorporating 30% marble waste as a replacement for coarse aggregates and varying proportions (0% to 50%) of crushed glass as a fine aggregate substitute, this study investigates the fresh and hardened properties of M40 grade concrete.

The integration of waste glass and marble waste into concrete enhances its compressive, tensile, and flexural strengths while improving durability through pozzolanic activity. A microstructural analysis using Scanning Electron Microscopy (SEM) further examines the particle distribution and its impact on concrete performance. This research not only contributes to sustainable construction practices but also provides an eco-friendly solution for industrial waste management, promoting the use of alternative materials in the construction industry.

2. LITERATURE SURVEY

V. Gokulnath , B. Ramesh, K. Priyadharsan (2019) They have concluded that usage of unused Glass Powder and additional fibers are like steel yarns, glass filaments, polypropylene, Industrial wastes like fly ash and silica fume getting as increasing strengths. They concentrated on mechanical characteristics and fresh characteristics with respect to own-consolidated concrete with altered grades concrete by addition of fibers of various percentage. They did workability and hardened tests on mix of SCC. By adding fibers in concrete strength gained slightly when comparing to conventional concrete. Concrete is effective with Machine-sand and adding of glass powder in SCC and cured 7, 28, 56 & 90 days in enhance the strength. The comparison for manufacturing-sand and river-sand was also done. By addition cutglass powder and other fibers in self-compacting concrete with cumulative percentage the Bending, compressive and ductile strength enhancement was observed. It evades fissures bounces performance and upsurges fresh properties of mix.

Aman Roy Patil, Tushar saxena (2019) :This investigational study essential to recognize the effects of unused glass powder as a fractional fine aggregate substitute in concrete.Because of the angular shape of the glass particles, the workability of fresh concrete decreases as the cumulative fraction of waste glass powder in the concrete mix increases.. Slump values reduced with upsurge in glass proportion. Compaction factor values reduced with upsurge in glass fraction strength in Compression was shown escalation by adding of unused cut-glass to the proportions till it reaches the ideal level of replacement. For both the water cement ratios i.e. 0.45 and 0.50 up to 10% fraction of fine aggregates by waste glass exhibited ideal upsurge in strength in compression at 7 and 28 days. By utilizing glass waste powder as fractional replacement of fine aggregate, compressive strength increases up to 10% by 7.18% for 0.45 w/c ratio and 13.19% for 0.50 w/c ratio, but after that, it starts decreasing for 12% & 20%.W/C ratio of 0.50 shows better result for M-25 grade of concrete mix and it is also higher workable than 0.45 w/c ratio. Using unused cutglass in mix showing cost-effective by means of usage of unused one in concrete preparation. Using of glass in concrete eliminates discarding difficulty of unused glass and shown to be ecological approachable hence leading to economical friendly concrete. By using in mix will protect usual material essentially normal sand and thus make infrastructure business supportable.

T O Ogundairo, D Adegoke, I Akinwumi and O M Olofinnade (2019) Protecting earth is worldwide subject and many researchers are see kinging ways to limit towards energy consumption and decrease influence on the environment, in this research they detected that cut-glass is a maintainable construction material. Development of whole strength properties of mix that reprocessed with unused cutglass was improved compared than conventional mix. Structural building construction is possible, also money-spinning medium to use reprocessed unused glass. Unused cut-glass is superior since total requirement of adhesive not supportable while its production releases more Carbon. However, Codal provisions require to be maintained for reference to usage of reprocessed unwanted cut-glass for construction efforts to drive unused cut-glass to construction need unceasing study and expansion. Research to study cost effectiveness with unused cut-glass usage to be done for confirming or contradict the economic worries of using unwanted cut-glass in constructions must be led. Government must also pass an ordinance that endorses and support the use of reprocessed ingredients in construction. Lot of problems touches the durability of constructions having reprocessed unused glass. The requirements for employing reprocessed unused cut-glass must be numerous and clearly stated (1). Mix proportion, constituent all combination require different engineering effects on aggregates. (2) Cut-glass form, dimensions of element how we are swapping glass content (3) Ingredients, color and manner of handling the reprocessed surplus cutglass. Reprocessed unwanted cut-glass either be used as in place of aggregate or Adhesive. Furthermore, in the perception of the main practical anxiety of recycled waste cut-glass in construction as regards to the influence of Alkali-Aggregate Reaction (AAR) in structures.

Mohammed Seddik Meddah (2019) From the outcomes of this study, on the physical parameters of the crumpled glass aggregate resulting from the unused glass are appropriate as a fine aggregate for concrete manufacture in terms of profile, dimension, gradation and relative density. While flaky grain form of crumpled glass may have effect on the fresh properties of concrete but it was extremely beneficial in strength enhancement. The presence of powdered glass as a fractional substitute for ordinary sand has resulted in a small reduction in strength in compression, tension, and flexure. Concrete's Permeability and water absorption with varying glass aggregate quantities have somewhat augmented as equated to the standard mix.

M.K. Sharbatdar, A. Kavyani , H. Dabiri , M. Baghdadi (2018) In this studyto assess result by substituting filler material with unused cut-glass element in concrete, 27 samples were primed and verified, compressive strength and weight of samples were studied. Inference from this study is that with unused glass element in its place of sand in concrete combination containing Micro silica, upsurge the compressive strength of concrete. The strength in compression increases as the fraction of glass element increases.The optimal fraction of glass element used in this research was 50%. As stated earlier, the only worry of concretewith waste glass is ASR taht might be prohibited by addition Micro silica in concrete. Furthermore on the basis of outcomes addition of Micro silica in concrete combination upsurge the strength of concrete in compression. Substituting sand with unused glass particle does not affect the mass of concrete. The dead load due to concrete construction does not alter by using waste glass particle.

Jagriti Gupta, Nandeshwar Lata& Bharat Nagar (2018)] In this studythe workability of concrete displays as slump of the concrete mixture upsurge up to 20% substitute in control mix. With rise in unused glass content, fraction of water absorption drops. For attainment the good practicable concrete a super plasticizer was added up to 0.8% of Cement fraction by weight of cement. Fine waste glass bottle crumpled fine substantial shows pozzolanic behaviour. Compressive strength in concrete was noticed to rise and with 10% fraction shows higher strength achievement. Density of concrete mixture with WGB is declining with upsurge in glass content. Utilizing unused glass in concrete decreases the dumping difficulties of unused glass also an environment welcoming hence paving approach for greener concrete. Usage of unused glass in concrete will reserve normal resources mainly river sand and consequently shall make concrete manufacturing sustainable.

Oluwarotimi M. Olofinnade, Anthony N. Ede, Julius M. Ndambuki, Ben U. Ngene, Isaac I. Akinwumi & Olatokunbo Ofuyatan (2018) they observedthe workability of newly formed concrete reductions in strength properties by means of fraction of unused glass sand rises. The decrease illustrates a robust relationship assessment of $r = 0.97$ which propose that new concrete displays declining in fresh properties as the amount of crimppled glassupsurges,the grain form of glass crystal sand elements is thought to be the cause. Reduction in Strengths towards compression and tension of the concrete with unused glass was detected as the quantity of unused glass enriched from 50% to 100% substitution of normal sand.Following the findings of the experiment, it is clear that environmentally friendly concrete may be prepared using waste glass incorporated with natural sand in concrete till 50% natural sand substitution for structural activities..

Rahman Khaleel AL-Bawi, Ihsan Taha Kadhim, Osamah AL-Kerttani (2017) The compressive strength results were depressingly impacted when WG cullet was combined and its proportion increased. The decrease in strength between the 3 series of concretes, however, did not surpass developments in Materials Science and Engineering. In comparison to the respective reference mixes, series II yielded 26 and 29 percentages for the 1st and 2nd series, respectively. With the exception of series III, the drop in strength grew more extreme, reaching a maximum of 43 percent. The least strength in compression was 46.6 MPa which has considered satisfactory for several customs of structural concrete applications. Strength in tension, flexure, and modulus of elasticity results shadowed the like pattern witnessed in outcomes of strength in compression, While at high rates of WG substitution in series III, in which the glass was employed as fine and coarse graded, the decrease in these constraints was more significant. Irrespective of the extent of WG cullet substitution,◌̇ max, area under the load-displacement curve and fracture energy values discovered negligible results when glass aggregate was existing and incremented. Equally, characteristic properties noted greater results for concrete with WG representing low inelastic behavior than standard concrete.As a function of compressive strength, an exceptional correlation between splitting tensile strength, modulus of elasticity, fracture energy, and characteristic strength can be established.For strength and fracture properties, these correlations resembled linear and power equations.

A. W. Otunyo,and B. N. Okechukwu (2017) The authors observed Strength of the concrete in compression at 7 and 28 days improved as the WG standby rate amplified to extreme readings at 15% additional. This indicates that best proportion of fine aggregate containing WG happened at 15% standby rate. The strength of concrete in flexure varied as fraction additional of WG augmented. The authors suggested that more research be should done in this area. Beyond 15% WG substitution level, WG as fine aggregate had negative effect on the growth of strength of concrete in compression. As the proportion of WG increased up to 15% standby rate, the initial and final setting times reduced. This approves that fine WG aggregate can be used as a concrete retarder up to a 15% substitution rate. The water captivation reduced as the WG fraction amplified. The study's outcomes normally indicated that fractional fine aggregate standby with WG is cost-effective. Because the amount of costly sand may be decreased to a 15% spare rate, and because WG is commonly discarded and could be found for less or no price in contrast to sand, the cost of producing concrete could be comparatively cheap employing this waste. Since WG (non-biodegradable) is often a problem to dispose of, using it in concrete will result in long-term environmental protection.

R Ramasubramani, S Divya and Vijay (2016) Following main inferences are haggard from the current study by the authors. Extreme compressive strength was attained at 50% substitution. When 50% of the sand in concrete was substituted with glass powder, the strength of concrete in compression improved by 7.5%. Tensile strength attained its peak value when sand was replaced by glass powder at 10% replacement level. Strength of concrete in tension was amplified by 6.2%. At a 10% additional rate, the strength of concrete in flexure achieved its maximum value and the upsurge was by 13.8%. The chloride ion diffusion was studied using the Rapid Chloride Penetration Test.The chloride ion penetrability was confirmed to be in permissible limts during the study. The concrete was subjected to acid and alkalinity attacks, which resulted in a loss in weight and strength in compression. Acid attack demonstrated a weight reduction, where weight oftraditional concrete reduced by 6.8% and weight of glass powder concrete reduced by 7.24%. The strength of both conventional concrete and glass powder concrete was reduced by 5.66 %. For conventional concrete, sulphate attack resulted in a weight loss of 1.49% and 1.13% percent for glass powder concrete.The reduction in compressive strength for normal concrete was by 3.3% and that for glass powder concrete was by 3.13%.

B.V. Kavyateja, P. Narasimha Reddy , U.Vamsi Mohan (2016) Based on the study and investigational outcomes, the subsequent inferences have been made. There exist high potential for the use of crumpled glass in concrete as fine aggregate for saving of natural aggregate. With growing of crumpled glass elements into the concrete the workability would be amplified gradually as associated to normal concrete. Crushed glass substituted as fine aggregate in the strength of concrete compression should be augmented till 20% additional rate and after 30% and 40% substitution rate it drives to declining. The split tensile strength should be reduced slowly at cumulative of crumpled glass substituted as sand into the concrete.

K.Rubini, Liya Sara Joy, Sanjana (2016) Results for normal and designed concrete were associated in order to acquire the strength phase of concrete. The denouements are tabulated by testing of cubes and cylinders for 7, 14 and 28 days. The outcomes designates that the highest strength in compression and tension were attained for normal sand by 10% replacement of crumpled glass material. For 10% standby, the compressive strength was augmented about 15% and also the split ductile strength shows an increase of about 17% than that of conventional concrete. Further it depicts that the strength was decreased for less than 8% and between 10% and 40% standby, the concrete's strength decreases and was lesser than that of the standard mix.By using low-cost and ecological welcoming building ingredients from industrial discarded, a sustainable concrete can be produced. It is an additional choice for groups directing glass for crushing, and to possibly reduce the costs of glass removal and concrete manufacture. Glass waste is a good left-over material, that could be utilized as a fractional standby of fine aggregate in the concrete. Fractional standby of sand by crushed glass material is cost-effective.

Sameer Shaikh ,S.S.Bachha ,D.Y. Kshirsagar (2015)Inference of their research is as follows, from the control sample, concrete made from unused powdered cutglass and crushed glass particles had a very good workability.. The use of unused glass powder enhanced the workability of concrete, according to the results of the slump test. In tenure of strength, concrete by waste glass powder typically have developed strength at 28 days. Normal concrete displays strength in compression as 14.51 N/mm2 , strength in tension of 1.55 N/mm2 and strength in flexure of 1.97 N/mm2 at 7 days.Normal concrete displays strength in compression as 19.25 N/mm2 , strength in tension of 1.88 N/mm2 and strength in flexure of 2.72 N/mm2 at 28 days. The strength in compression of cement and crumpled glass elements in sand increases by 9.25%, 38.50%, 70.80%, and 33.09 percent after 28 days, respectively, when glass powder and crumpled glass elements are added by 5%, 10%, 15%, and 20%, respectively. The addition of 15% glass powder to cement and crumpled glass particles to sand increases the strength in tension by 4.25 % after 28 days.Standby of glass powder in cement by 5%, 10% 15% and 20% upsurges the flexural strength after 28 days by 5.88%, 30% and 44.85%, and 13.97% correspondingly. When compared to standard concrete, glass powder concrete increases strength in compression, tension and flexure at a 15% combined standby. Extremely fine grinded glass has been revealed to become an excellent filler with sufficient pozzolanic properties to function as a fractional cement substitute. Crumpled glass pieces remaining on the 3.36 mm and 1.18 mm IS sieves also proven to be a good filler substantial.

M. Adaway & Y. Wang (2015) In this research work it was found out that the flow ability of concrete has reduced trend with surge in fraction of fine aggregate since the glass particles have angular nature. Even there is a decreasing trend the concrete is workable. Optimum percentage was found out to be at 30% of fine total is substituted by fine glass. There is gain in resistance towards compression at optimal substitute of standby. There's a improved bond with the cement adhesive. By using beyond 30% it was found out that there was a negative effect on compressive strength. If in larger quantities are used, voids will be formed in the microscopic level in the concrete since cement paste will be reduced due to the angular shape of the glass total used.

Bhupendra Singh Shekhawat & Vanita Aggarwal (2014) It is proved that cut-glass powder can be used as fractional standby of cement in concrete owing to amplified workability, durability evaluated by water absorption and sorpitivity test, strength characteristics like compressive strength, flexural strength, tensile strength. There is a problem we are facing regarding disposal of by-products as there is an increased landfills, increased price for disposing. So, usage of glass can reduce disposing problems.

M.N.N.Khan,M.F.M.Zain, T.S.Serniabat (2014) The need for sustainable concrete in the world along with possibilities of recycling waste glass into concrete is gone through this paper. Glass is used as coarse aggregate instead of stone aggregate. Chipped brick and stones are expensive and need to be collected from natural source. Waste glass may open a productive and concrete production without pollution can be achieved. From this research, max of 3889 psi compressive strengths was shown after numerous combinations and is satisfactory even however uneven surfaces have provided better bond and strength. As glass do not absorb water, decent amount of strength is obtained with low water cement ratio.

Vikas Srivastava, S.P.Gautam, V.C.Agarwal, P.K.Mehta (2014) By using cutglass scrap by way of replacement for granular aggregate , 28 day strength was shown increment up to 20% and decrement from 30-40% replacement . Glass scrap is beneficial when used as an alternate to coarse aggregate. 10% replacement is said to be optimal percentage.

SadoonAbdallah & MiziFan (2014) In this experimental work ,workability has been reduced with growing replacement of the unused cut-glass content. Even if the Slump has been decreased it has shown the good work ability. The strength towards compression is shown out to be 5.28 % more at 20% standby when associated to the control mix which shows the pozzolanic response of the concrete. With upsurge in the waste class aggregate ratio there is a decrease in the water absorption. At 20% replacement of fine aggregate by cut-glass the highest reduction was found out to be 14.68% when compared to control mix. When equated to the normal mix the ultrasonic pulse velocity of several combinations covering different fraction of aggregate standby shows the lesser values and the pulse velocity at 28 days for all the mixes was higher than 4 km/s which shows that it is a good concrete which indicates that the dense structure is formed. At 14 days of curing when equated to the normal mixture with 20% of glass aggregate there is a reduction in reduction in expansion about 70% which infers that ASR in concrete took place between the silica's of unused glass and alkali current in the cement paste.

T.F.Vieira, J.deBrito, J.R.Correia, V.Alves (2014) In present work experimental work has been done on usage of recycled ceramic fine aggregates by way of additional material for fine aggregates in mix. From this research we can say that by incorporating the fine aggregate in concrete can form as a structural concrete. By using the fine aggregate in concrete, the strength in compression and strength in tension is not changed when compared to control mix of concrete. But we can also see that these properties can be decreased if reprocessed sanitary element aggregates are used. From this research, we can observe reduction in elastic modulus by surge with the substitute ratio of both fine reprocessed sanitary element aggregate also with the brick aggregates. By using the fine recycle sanitary ware aggregates there is an improvement in the mechanical performance incorporating the usage of super plasticizer in the mixes.

Yasser Sharifi, Mahmoud Houshiar, BehnamAghebati (2013) The recent examination treats the usage of glass to produce SCC. Fine aggregate is replaced with recycled glass up to 50%. Concluded that the flow of slump increases by increasing reprocessed cut-glass content. L-box ,V funnel values are reduced by more addition of sand by reprocessed cut-glass. It is seen that the fresh properties like flow ability is amplified and creates the concrete appropriate for building of structures like walls and pillars. The V funnel test explanations show the separation resistance or viscosity of recycled glass self-consolidated concrete- have been decreased. For this type of concrete, segregation parameter is said to be dominant. Passing ability, strength of RG-SCC's in compression, flexure and tension have reduced and considered insignificant. Quantity of reprocessed glass in mix 10% of fine total gives more flexural and split tensile strength associated with conventional mix. Replacement from 5-15% by glass shows extra adhesion between cement and glass leading to flexural and tensile strengths. All RG-SCC s are found to be good for building structural components. Density reduced by cumulative amount of waste glass. Relying on results, glass can be replaced by sand in SCC without significant decrease in strengths. Fresh properties should be observed for segregation and viscosity.

ZubaidahAbdullateef, Bayati (2013) The tests completed in this examination were fundamentally intended to give a sign of relative favorable circumstances and drawbacks of the utilization of ground glass elements in mix blend. Which gives a review of the usage of unused materials in the building industry. Decrease of strength found around 23.75% in compression, 3.38% in tensile, and 10.0% in terms of flexural correspondingly when substitute fraction of 10% is utilized, considering little drop in strength.50% usage of crushed glass when used in concrete exhibits lesser strength in compression, tensile and being compared to normal concrete. The decrease is about compression 34.53, tensile 27.73, and bending 35.47% respectively. Therefore, it is said that concrete by reprocessed cut-glass of lesser strength through further substitute fraction be used for civil engineering approaches, mainly in nonstructural applications, wherever fewer strength is essential. This will subsidize to the cost decrease by consuming non-structural concrete.

3. PROPOSED SYSTEM

The proposed system explores the partial replacement of fine aggregate with waste glass and coarse aggregate with marble waste to enhance the strength and sustainability of concrete. This approach aims to optimize mechanical performance while minimizing environmental impact by incorporating industrial waste materials into concrete production.

1. Materials and Mix Design

- **Cement:** Ordinary Portland Cement (OPC) is used as the primary binder.
- **Fine Aggregate Replacement:** Waste glass powder is used as a partial replacement for fine aggregate at varying percentages (0%, 10%, 20%, 30%, 40%, and 50%).
- **Coarse Aggregate Replacement:** Marble waste replaces 30% of coarse aggregate in all mix designs.
- **Water-to-Cement Ratio:** A fixed water-to-cement (w/c) ratio is maintained to ensure consistency in mix design.
- **Admixtures:** Superplasticizers may be used to improve workability, especially at higher glass waste replacement levels.

2. Workability Assessment (Slump Test)

The slump test is conducted to evaluate the workability of concrete with different percentages of glass waste and marble waste.

- **Expected Trends:**
  - Increasing glass waste content may reduce workability due to the angular shape of crushed glass particles.
  - Marble waste is expected to improve cohesiveness but may slightly impact flowability.
  - Adjustments in water content or superplasticizer dosage may be required to maintain a balance between workability and strength.

3. Hardened Properties Evaluation

- **Compressive Strength Test:**
  - Standard concrete cubes (15 cm × 15 cm × 15 cm) are cast and tested at 7, 14, and 28 days.
  - Strength variations are analyzed to determine the optimal replacement levels for glass and marble waste.
- **Split Tensile Strength & Flexural Strength Tests:**
  - Cylindrical specimens are tested for tensile strength, while beam specimens are used for flexural strength evaluation.
  - These tests assess the structural integrity of the modified concrete under tensile and bending loads.
- **Durability Assessment:**
  - Chloride penetration and water absorption tests are conducted to determine the resistance of concrete to environmental degradation.
  - Alkali-Silica Reaction (ASR) expansion is monitored to ensure long-term stability.

4. Key Findings (Expected Outcomes)

- **Optimal Replacement Levels:**
  - The highest compressive strength is anticipated at an optimal glass waste replacement level, likely around 20-30%, combined with 30% marble waste.
- **Workability Adjustments:**
  - As glass waste content increases, slump values may decrease, requiring modifications in mix proportions.
- **Sustainability Benefits:**
  - The proposed system promotes eco-friendly construction by reducing reliance on natural sand and coarse aggregates.
  - Waste utilization helps mitigate environmental pollution and lowers CO_2 emissions associated with conventional concrete production.

This study aims to provide a sustainable alternative for conventional concrete by incorporating glass and marble waste, offering a practical solution for enhancing strength, durability, and environmental sustainability in construction.

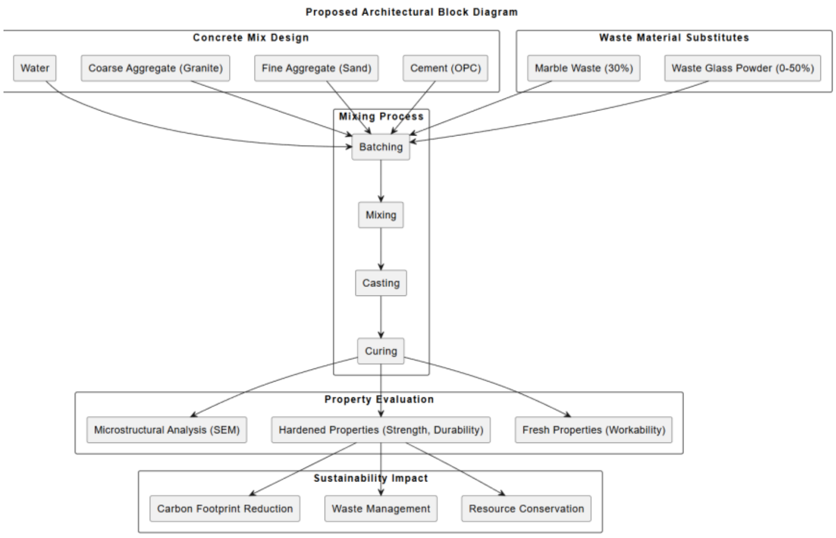

Figure 1 Presents the Block Diagram of Proposed System.

4. RESULTS AND DISCUSSIONS

4.1 Fresh properties of concrete (Workability Test)

4.1.1 Slump Test

The Slump test was performed on the Glass powder – marble waste based concrete to check the workability of it at different replacements. According to which it can be concluded that with the increase in % of Glass powder – marble waste from M0 to M6, workability increases. The results obtained for Slump test are shown below in Table 4.1.

Table 4.1: Results of Slump test

Mix No.	MW - GW	Slump (mm)
M0	0 – 0	102
M1	30 - 0	104
M2	30 – 10	107
M3	30 – 20	109
M4	30 – 30	112
M5	30 - 40	116
M6	30 - 50	120

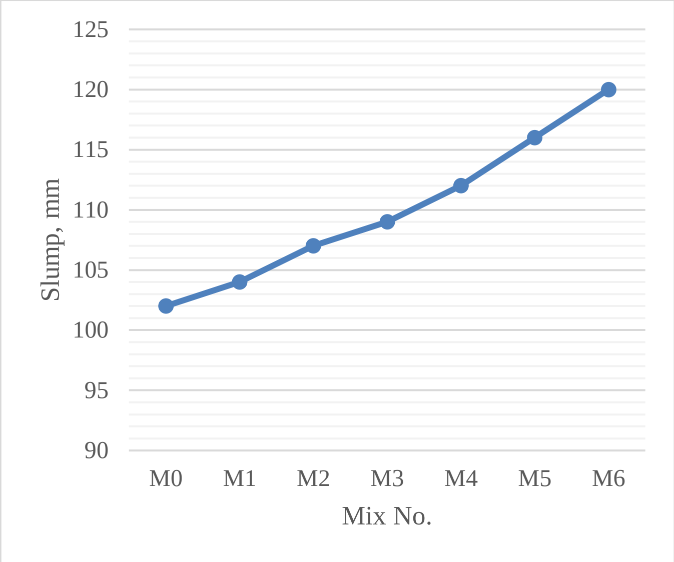

Fig 4.1 : Slump test results

The above figure 4.1 shows the slump results. It was observed that, the slumps increased from M0 to M6 mix with increased GW – MW in the mix. It was varied from Medium Workability to High workability.

4.2 Harden properties of concrete

4.2.1 Compressive Strength Test

The compressive strength test was performed on the cubes of size 15 cm x 15 cm x 15 cm to check the compressive strength of GW – MW based concrete and the results obtained are given in Table 4.2.

Table 4.2: Results of compressive strength test

Mix No	MW - GW	Compressive strength of cubes (N/mm^2)		
		7 days	14 days	28 days
M0	0 – 0	26	38	41.9
M1	30 - 0	27.28	40	44
M2	30 – 10	28	41.2	45.3
M3	30 – 20	29.16	42.7	47
M4	30 – 30	31	43.8	49.2
M5	30 - 40	27.4	40.2	44.2

M6	30 - 50	26.5	38.5	42.4

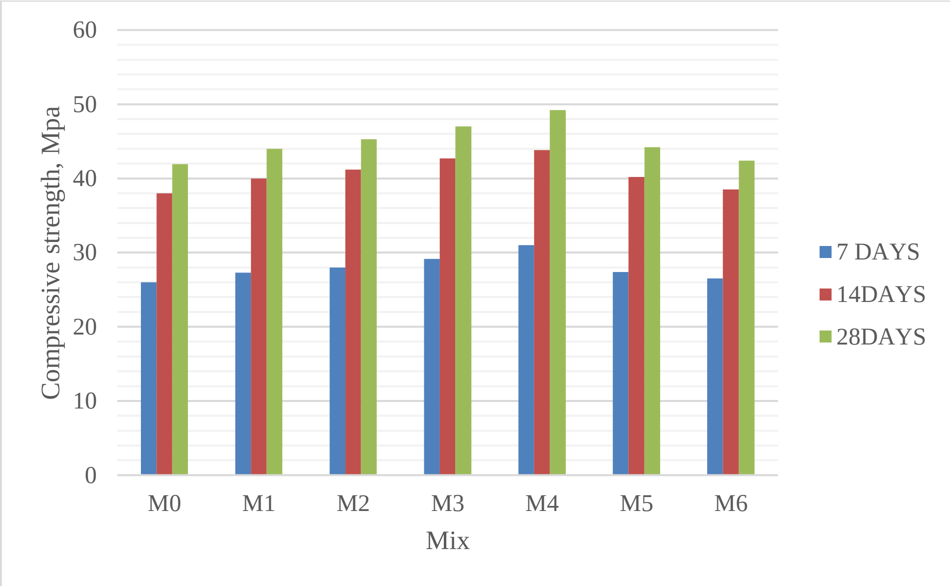

Fig 4.2: 7days Compressive strength test result graph

From the above results it was observed that with the increase in percentage of GW – MW from M1 to M6 in concrete the compressive strength more than control mix M0. The maximum compressive strength gained for 30% marble waste replacing with coarse aggregate and 30% glass waste replacing with fine aggregate of concrete. The optimum dosage suggested from this study was 30% GW – 30% MW.

5.CONCLUSIONS

The study demonstrates the potential of incorporating waste glass as a partial replacement for fine aggregate and marble waste as a substitute for coarse aggregate in concrete. The experimental results indicate that an optimal replacement level of glass waste (around 20-30%) combined with 30% marble waste enhances the mechanical properties of concrete, particularly in terms of compressive, tensile, and flexural strength. The findings also highlight that while workability decreases with increasing glass waste content, appropriate mix adjustments can balance both flowability and strength. Moreover, the utilization of waste glass and marble waste contributes to sustainable construction by reducing reliance on natural resources such as river sand and granite, which are becoming increasingly scarce. Additionally, incorporating these industrial by-products minimizes environmental pollution, promotes waste recycling, and lowers the overall carbon footprint of concrete production. The study confirms that concrete modified with glass and marble waste not only meets structural performance requirements but also offers an eco-friendly alternative to conventional concrete. These results pave the way for broader adoption of sustainable materials in the construction industry, encouraging responsible waste management and greener building practices for the future.

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