VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"Jnana Sangama", Belgaum-590 014

A Project Report on

"PERFORMANCE OF CRUSHED LAMINATED WASTE SHEET MODIFIED MORTAR AND CONCRETE"

Submitted in partial fulfilment for the award of the degree of

BACHELOR OF ENGINEERING IN

CIVIL ENGINEERING

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C.M.R. INSTITUTE OF TECHNOLOGY

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Department of civil engineering

Certificate

This is to certify that the project work entitled ***"PERFORMANCE OF CRUSHED LAMINATED WASTE SHEET MODIFIED MORTAR AND CONCRETE"*** *has been successfully completed by Mr.Gaurav Anand (1CR16CV018),Mr.Gautam Anand (1CR16CV019),Ms.Juhi Kumari(1CR16CV025), Mr.Pankaj Yadav(1CR16CV040), bonafide students of CMR Institute of technology in partial fulfilment of the requirement for the award of degree of Bachelor of Engineering in Civil Engineering of the* ***"VISVESVARYA TECHNOLOGICALUNIVERSITY",*** *Belgaum during the academic year 2019-20. It is certified that all corrections indicated for internal assessment has been incorporated in the Report. The project report has been approved as it satisfies the academic requirements in respect of project work prescribed for the said Degree.*

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DECLARATION

We, **Mr.Gautam Anand, Ms. Juhi Kumari , Mr. Gaurav Anand, Mr, Pankaj Yadav**, bonafide students of CMR Institute of Technology, Bangalore, hereby declare that dissertation entitled **"Performance of crushed laminated waste sheet modified mortar and concrete"** has been carried out by us under the guidance of **Dr. Asha M Nair (HOD),** Department of Civil Engineering, CMR Institute of Technology, Bangalore, in partial fulfilment of the requirement for the award of degree of Bachelor of Engineering in **Civil Engineering** of the Visvesvaraya Technological University, Belgaum during the academic year 2019-2020. The work done in this dissertation report is original and it has not been submitted for any other degree in any university.

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PEFORMANCE OF CRUSHED LAMINATED WASTE SHEET MODIFIED MORTAR AND CONCRETE

CHAPTER 1: INTRODUCTION

Cement mortar along with the concrete is an irreplaceable material in today's construction industry. Conventional concrete is made of cement, sand and mortar. Cement is a binder material which is manufactured through controlled chemical combination of calcium, silicon, aluminium, iron and other ingredients, which are mainly finite in nature and are derived from the mineral resources of our planet. Sand, wildly used as fine aggregates is also derived mainly from the natural sand reserves on our planet. However, scarcity of raw materials and the need for high performance concrete has motivated the researchers for identifying innovative materials for modifying conventional concrete.

The concrete structures often must face modification and improvement in their vital characteristics such as the compressive strength, to have a better performance in their service life. Nowadays, materials such as rice husk, manufactured sand, slag sand, flyash, quarry dust, processed crushed rocks, etc. are introduced within the concrete to get the required modification and improvement in the properties of concrete. The desirable properties of concrete includes, high compressive strength , better durability, better workability, proper porosity and density, resistance to weathering , high impact resistance , lesser creep and shrinkage of concrete etc. This project is an attempt to determine the feasibility of waste laminated sheets as a concrete constituent and study the various properties of modified mortar or concrete composite. Accordingly the following objectives are set for the proposed work.

- Crushing and screening the waste laminated sheets to desirable sizes.
- Investigate the compressive strength of mortar and concrete wherein a portion of sand is replaced with crushed waste.
- Compare the results of modified mortar and concrete with the controlled specimens. (prepared using conventional materials)
- Investigate the morphological characteristics of modified mix and the controlled specimens

CHAPTER 2: LITERATURE SURVEY

A wide variety of alternatives/replacement materials for cement, fine aggregates and coarse aggregates are available today. Research have been going on for decades to find alternative materials for cement and sand specially. The researches and the alternatives available as of today have been compiled in the following sections.

2.1 REPLACEMENT (Partial) OF CEMENT –

The commonly used materials for replacement of variety of alternatives/replacement materials for cement, fine aggregates and coarse aggregates are available today. However, by virtue of pozzolanic action, different alternatives are used and are described in the below sub-sections.

2.1.1 PULVERISED FUEL ASH (PFA)/ FLYASH AS CEMENT SUBSTITUTE-

PFA is a by-product of coal-burning power stations. As part of the combustion process, coal is pulverised into a powder before being burned. About 18% of the fuel forms fine glass spheres, about 75% of which rise with the flue gases from the combustion. The ‘ash’ is recovered from the gases and used, amongst other functions, as a cement substitute.

2.1.2 GROUND GRANULATED BLAST FURNACE SLAG (GGBS)-

GGBS is a by-product of the iron and steel industry). In the blast furnace, slag floats to the top of the iron and removed. GGBS is produced through quenching the molten slag in water and then grinding it into a fine powder. Chemically it is similar to, but less reactive than, Portland cement (Pc).When mixed with water it will hydrate in a similar way to Portland cement. It is always used in combination with Portland cement.

2.1.3 SILICA FUMES –

Silica fume is a by-product from the manufacture of silicon. It is an extremely fine powder (as fine as smoke) and therefore it is used in concrete production in either a densified or slurry form. Due to economic considerations, the use of silica fume is generally limited to high strength concretes or concretes in aggressive environmental conditions.

2.2 REPLACEMENT TO FINE AGGREGATES-

2.2.1 MANUFACTURED SAND-

Manufactured sand (M-Sand) is a substitute of river sand for concrete construction. Manufactured sand is produced from hard granite stone by crushing. The crushed sand is of cubical shape with grounded edges, washed and graded to as a construction material. The size of manufactured sand (M-Sand) is less than 4.75mm.

2.2.2 COPPER SLAG –

Copper slag is a by-product of copper extraction by smelting. During smelting, impurities become slag which floats on the molten metal. Slag that is quenched in water produces angular granules which can be used as a fine aggregate substitute.

2.2.3 GRANULATED BLAST FURNACE SLAG (GBFS)- Ground-granulated blast-furnace slag (*GBFS* or *GGBFS*) is obtained by quenching molten iron slag (a by-product of iron and steel-making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder.

2.2.4 QUARRY DUST – Quarry dust is a by-product of the crushing process which is a concentrated material to use as aggregates for concreting purpose, especially as fine aggregates. In quarrying activities, the rock has been crushed into various sizes; during the process the dust generated is called quarry dust and it is formed as waste.

2.2.5 FOUNDRY SAND- Foundry sand (FS) is high quality silica sand with uniform physical characteristics. It is a by-product of the ferrous and nonferrous metal casting industry, where sand has been used for centuries as a moulding material because of its unique engineering properties. India ranks fourth in terms of total foundry production (7.8 million tonnes) according to the 42nd Census of World Casting Production of 2007. Foundry sand which is very high in silica is regularly discarded by the metal industry. Currently, there is no mechanism for its disposal, but international studies say that up to 50 per cent foundry sand can be utilized for economical and sustainable development of concrete.

2.2.6 BOTTOM ASH- Bottom ash is part of the non-combustible residue of combustion in a power plant, boiler, furnace or incinerator. In an industrial context, it has traditionally referred to coal combustion and comprises traces of combustibles embedded in forming clinkers and sticking to hot side walls of a coal-burning furnace during its operation. The portion of the ash that escapes up the chimney or stack is, however, referred to as flyash. The clinkers fall by themselves into the bottom hopper of a coal-burning furnace and are cooled. The above portion of the ash is also referred to as bottom ash.

2.2.7 CONSTRUCTION AND DEMOLITION WASTE – The raw materials from the construction and demolition waste can be reused in certain applications. Recycled sand and aggregate from C&D waste is said to have 10-15 per cent lesser strength then normal concrete and can be safely used in non-structural applications like flooring and filling.

2.2.8 SPENT FIRE BRICKS (SFB) AGGREGATES-Spent Fire Bricks are waste material from foundry bed and walls; and lining of chimney which is adopted in many industries) and can be used for partial replacement of fine aggregate in concrete. It has been observed that the compressive strength of partial replacement of Crushed Spent Fire Bricks aggregate concrete is marginally higher than that of the river sand aggregate concrete at age of 7 days, 14 days, and 28 days, respectively.

2.3 RESEARCHES ON ALTERNATIVES / PARTIAL REPLACEMENT OF CEMENT, FINE AGGREGATES AND COARSE AGGREGATES-

2.3.1 Padole, D., Patil, U., & Padade, A. (2019). – The use of rice husk ash as a by-product in the production of concrete can be considered as important for India since India is one of the leading rice cultivating country in the world. It also provides social aids related to problems associated with ash dumping in the environment. The main purpose of the investigation is to obtain the optimum mix design and to examine the physical properties– density, strength (bending and compression), water absorption and moisture content. From the experimental studies, it was observed that compressive strength and flexural strength increases with increases in rice husk ash percentage for a replacement upto 7.5%. As the rice husk is burned out at 600º to 800º C. It is observed that the around 79 % of silica was produced due to this it provides excellent thermal insulation. It is observed that Rice Husk Ash and Quarry sand concrete will be durable and impervious as compared to control concrete.

2.3.2 Rantung, D., Supit, S. W., & Nicolaas, S. (2019)

This paper aims to investigate experimentally the influence of replacing cement with different fineness of fly ash based on flowability, passing ability, compressive strength, tensile strength (splitting). Concretes with 15% fly ash (passed a number 100 sieve) and fine fly ash (passed a number 200 sieve) as cement replacement were cast and tested at 7, 14, 28 days after water curing. A superplasticizer in the form of viscocrete 3115 N was constantly used for each concrete mixtures as much as 1% by weight of cement. The results show that the use of fly ash does not significantly increased the compressive strength and tensile strength of SCC mixtures. However, concrete with 15% fine fly ash its self and combined 7.5% fly ash with 7.5% fine fly ash show better flowability and passing ability when compared to concrete with cement only indicating the performance of using smaller particle sizes of fly ash could lead better properties of SCC that can be potentially used for building construction application.

2.3.3 Elaqra, Hossam A., Mohamed A. Abou Haloub, and Rifat N. Rustom. (2019)

This study investigates the effects of using local wastes of Glass Powder (produced from crushing the glass waste) as replacement of cement in fresh and hardened concrete. Four percentages of Glass Powder (GP) were used: 0%, 10%, 20%, and 30%. Two mixing methods were used in the study. First, the conventional mixing method, where the glass powder was added with the cement and aggregates. Second, the glass powder was dissolved in water before adding it to cement and aggregates. The slump increased as the glass powder replacement increased in the concrete due to the presence of more free water in the structure, which leaded to have lower density and higher water absorption. As a result, the compressive strength of conventional mixes method decreased as the glass powder increased at early age. Later, after 90 days, the highest compressive strength was obtained for the 20% GP. The new mixing method showed higher compressive strength than the conventional mixing method. Using 10% GP in the new mixing method gave a significant increase, around 130% of the compressive strength of the control mix. This increase can be related to the hydrolysis of the glass powder into free ions of SiO_2, CaO and Na_2O in the water which formed more CSH. The relative index proves the rise of the glass powder reactivity as the amount of glass powder increases.

2.3.4 Yassin, Mohammed Maher, Akram Shakir Mahmoud, and Sheelan M. Hama (2019)-

This paper present glass waste material reusing in concrete as partial replacement of cement. Some hardened properties like compressive and flexural strengths, modulus of elasticity and % absorption was made. The effect of glass powder on these properties was examined compared to reference specimens without glass powder. Five percentage was tested: 0%(reference), 10%, 15%, 20% and 25%. From tests results one can conclude that replacing cement partially by glass powder enhanced strengths of concrete (compression and flexural) up to 20% replacing level Using glass powder as partial replacement of cement improved strengths and modulus of elasticity of concrete. The %absorption decrease with increasing of glass powder content. The results show that utilization of waste glass as powder in concrete can reduce amount of cement which save cost besides its environmental benefits.

2.3.5 Kiran M. Mane · D. K. Kulkarni · K. B. Prakash (2019)

The overuse level of cement and natural sand for civil industry has several undesirable social and ecological consequences. As an answer for this, industrial wastes called as by-products (pozzolanic materials) such as fy ash, GGBFS, silica fume and metakaolin can be used to interchange partially cement and natural sand by manufacturing sand (M-sand). In this paper, the detailed experimental investigation was done to study the efect of partial replacement of, natural sand by M-sand in various percentages (0%,10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100%), with water–cement ratio of 0.45 and cement was partially substituted by 20% of pozzolanic materials. M30 grade of concrete mix proportions were designed as per IS 10262:2009 guidelines. The fresh concrete properties and tensile strength results, were checked for the diferent concrete mix proportions and compared with conventional concrete. The tests on hardened concrete were destructive in nature which includes tensile test on cylinder as per IS: 5816-1999 at 28 days of curing. From this research work, it can be concluded that for replacement of 60% natural sand by M-sand and 20% cement by silica fume yields maximum tensile strength and improves the microstructure than conventional concrete.

2.3.6 Christy, C. Freeda, and D. Tensing (2010)-

Fly ash is investigated for its use as a replacement for cement and fine aggregate in cement mortar. This paper presents the results of the cement mortar of mix proportion 1:3, 1:4.5 and 1:6 cement mortar in which cement is partially replaced with Class-F fly ash as 0%, 10%, 20%, 25% and 30% by weight of cement. Richer the mix, higher the compressive strength has been obtained even with partial replacement of fly ash with cement. Test results indicate the significant improvement in the strength properties of mortar with fly ash as partial replacement with fine aggregate and with the cement in the cement mortar 1:6. It can be effectively used in masonry with the compressive strength of the brick unit ranges between 3-20 N/mm^2.

2.3.7 Al-Jabri, K. S., Al-Saidy, A. H., & Taha, R. (2011).

An experimental investigation was conducted to study the effect of using copper slag as a fine aggregate on the properties of cement mortars and concrete. Various mortar and concrete mixtures were prepared with different proportions of copper slag ranging from 0% (for the control mixture) to 100% as fine aggregates replacement. Cement mortar mixtures were evaluated for compressive strength, whereas concrete mixtures were evaluated for workability, density, compressive strength, tensile strength, flexural strength and durability. The results obtained for cement mortars revealed that all mixtures with different copper slag proportions yielded comparable or higher compressive strength than that of the control mixture. Also, there was more than 70% improvement in the compressive strength of mortars with 50% copper slag substitution in comparison with the control mixture. The results obtained for concrete indicated that there is a slight increase in density of nearly 5% as copper slag content increases, whereas the workability increased significantly as copper slag percentage increased compared with the control mixture. A substitution of up to 40–50% copper slag as a sand replacement yielded comparable strength to that of the control mixture. However, addition of more copper slag resulted in strength reduction due to the increase in the free water content in the mix. Also, the results demonstrated that surface water absorption decreased as copper slag content increases up to 50% replacement. Beyond that, the absorption rate increased rapidly and the percentage volume of the permeable voids was comparable to the control mixture. Therefore, it is recommended that up to 40–50% (by weight of sand) of copper slag can be used as a replacement for fine aggregates in order to obtain a concrete with good strength and durability requirements.

2.3.8 Patil, Yogendra O., P. N. Patil, and D. Arun Kumar

The production of cement results in emission of many greenhouse gases in atmosphere, which are responsible for global warming. Hence, the researchers are currently focussed on use of waste material having cementing properties, which can be added in cement concrete as partial replacement of cement, without compromising on its strength and durability, which will result in decrease of cement production thus reduction in emission in greenhouse gases, in addition to sustainable management of the waste. The ground granulated blast furnace slag is a waste product from the iron manufacturing industry, which may be used as partial replacement of cement in concrete due to its inherent cementing properties. This paper presents an experimental study of compressive and flexural strength of concrete prepared with Ordinary Portland Cement, partially replaced by ground granulated blast furnace slag in different proportions varying from 0% to 40%. It is observed from the investigation that the strength of concrete is inversely proportional to the % of replacement of cement with ground granulated blast furnace slag. It is concluded that the 20% replacement of cement is possible without compromising the strength with 90 days curing.

2.4 INTRODUCTION OF ADMIXTURES IN MORTAR / CONCRETE

Admixtures are materials other than cement, aggregate and water that are added to concrete either before or during its mixing to alter its properties, such as workability, curing temperature range, set time or colour. Addition of fibre to concrete makes it tough and fatigue resistant. Such type of admixtures are used extensively in important engineering projects.

2.4.1 USE OF MINERAL ADMIXTURES - Availability of mineral admixtures marked the opening of a new era for designing concrete mix of higher and higher strengths. However, it was experienced, and hence realized, over a period of time, that it was not only the strength that was important, but also other properties like durability and workability were also vital performance parameters. This has led to research on high performance concrete (HPC). HPC mix is designed with mineral and chemical admixtures along with normal ingredients of concrete, having low water-cementitious ratio.

Mineral admixtures are added to concrete in relatively varying quantities, generally 5% to 40% by weight of cement. Addition of mineral admixtures to concrete reduces heat of hydration due to reduced cement content and increases durability by contributing to pore refinement. Mineral admixtures include fly ash (FA), silica fume (SF), ground granulated blast furnace slag (GGBS), Metakaolin (MK), and rice husk ash (RHA) which possess certain characteristics through which they influence the properties of concrete differently.

2.4.2 USE OF CHEMICAL ADMIXTURES- Chemical admixtures are the ingredients in concrete other than Portland cement, water, and aggregate that are added to the mix immediately before or during mixing. Producers use admixtures primarily to reduce the cost of concrete construction; to modify the properties of hardened concrete; to ensure the quality of concrete during mixing, transporting, placing, and curing; and to overcome certain emergencies during concrete operations. Water reducing admixtures, retarding admixtures, accelerating admixtures, superplasticizers, corrosion inhibiting admixtures, air entraining admixtures etc. are some of the examples of the chemical admixtures used today.

2.5 RESEARCHES ON ADMIXTURES-

2.5.1 Combrinck, R., et al (2019) –

Plastic shrinkage cracking (PSC) is one of the earliest possible defects that can potentially ruin the performance of concrete structures with large exposed surfaces. PSC is mainly attributed to tensile stresses arising in concrete due to a combination of capillary pressure, and restraints provided by reinforcement and formwork. The adoption and use of several admixtures in modern-day concrete has been known to alter properties of both the fresh and hardened concrete. In this research, the adopted admixtures include a minimum and maximum dosage of a glucose-based retarder, calcium chloride-based accelerator, chloride free air entraining agent, lignosulphonate plasticiser, shrinkage-reducing admixture (SRA), poly carboxylate ether (PCE) based super-plasticiser, and a sulphonated melamine formaldehyde (SMF) based superplasticiser. The experimental tests were conducted in a climate chamber with an ambient temperature of 40 C, relative humidity of 10% and a wind speed of 20.2 km/h. By understanding the phenomenological and fundamental relationships of PSC when various admixtures are used in conventional and high-flow concretes, it was found that admixtures cause a substantial reduction in PSC severity. The respective admixtures led to a reduction in measured crack areas, capillary pressures, evaporation amount/rate, as well as settlement/shrinkage behaviours in both types of concrete. Compared to conventional concrete, high-flow mixes showed a greater reduction in the severity of PSC. The underlying working mechanism of these admixtures largely relates to the surface tension reduction ability.

2.5.2 Yordakul, E., Boyer, D., Rieder, K. A., & Lemma, Y. K. (2019) –

The present invention provides an admixture composition comprising a liquid suspension of colloidal silica, siloxane, and polycarboxylate polymer cement dispersant for enhancing early age strength, finishability, and other properties in hydratable cementitious compositions such as concrete (e.g., shotcrete). An inventive method involves mixing the components together in a specific sequence, thereby to obtain a stable liquid suspension. This attainment of a stable liquid suspension is surprising and unexpected because (i) the polycarboxylate polymer cement dispersant and siloxane components are incompatible and immiscible with one another; and (ii) that colloidal silica and siloxane compound are incompatible and immiscible with one another. Yet, the present inventors achieved an additive in the form of a stable liquid suspension which can be conveniently dosed into concretes and shotcrete mixtures, to enhance early age strength, and to improve workability and rheology in terms of finishability of concrete surfaces and improved rebound performance in shotcrete applications.

2.5.3 Pereira, P., Luís Evangelista, and Jorge De Brito-

It is considered that using crushed recycled concrete as aggregate for concrete production is a viable alternative to dumping and would help to conserve abiotic resources. This use has fundamentally been based on the coarse fraction because the fine fraction is likely to degrade the performance of the resulting concrete. This paper presents results from a research work undertaken at Instituto Superior Técnico (IST), Lisbon, Portugal, in which the effects of incorporating two types of superplasticizer on the mechanical performance of concrete containing fine recycled aggregate were evaluated. The purpose was to see if the addition of superplasticizer would offset the detrimental effects associated with the use of fine recycled concrete aggregate. The experimental programme is described and the results of tests for splitting tensile strength, modulus of elasticity and abrasion resistance are presented. The relative performance of concrete made with recycled aggregate was found to decrease. However, the same concrete with admixtures in general exhibited a better mechanical performance than the reference mixes without admixtures or with a less active superplasticizer. Therefore, it is argued that the mechanical performance of concrete made with fine recycled concrete aggregates can be as good as that of conventional concrete, if superplasticizers are used to reduce the water–cement ratio of the former concrete.

2.6 USE OF FIBRES IN CONCRETE/ MORTAR-

Fibre reinforcement of cement and concrete is not really a new concept since we have been using reinforcements like straw in bricks and hair in mortar for a long time. However, there has been a lot of research and development in this area during the last two decades. Addition of fibre to concrete is a convenient and practical method of improving several properties of the material, for example, toughness, fatigue resistance, impact resistance and flexural strength. It also assists in changing the flow characteristics of the material. Concrete with fibre reinforcement differs from conventional concrete in several respects. It has higher cement content, lower coarse aggregate and a smaller size of aggregate. Generally, the fibre content varies from 0.2% to 2%.

2.7 USE OF WASTE MATERIALS IN CONCRETE –

There are variety of waste materials that can be utilised effectively as an ingredient of concrete. Examples of such materials include –

- Glass
- Tile and Sanitary Ceramics
- Clay Bricks
- Tyres and Rubber
- Metal waste and discards
- Agricultural Waste
- Silica fume
- Fly Ash etc. …

The management of the wastes mentioned above is an important aspect in solid waste management. When such wastes are utilised in construction industry, there is room for sustainable construction. The focus of the study being laminated glass fibre, let us have a look at glass as a construction material.

2.7.1 GLASS AS A CONSTRUCTION MATERIAL – Researchers have shown that glass particle size has an obvious effect on concrete performance .Smaller particles increase activity with lime, improve compressive strength and reduce shrinkage. Another result showed that the size of the glass does not lead to alkali-silica reaction but the high potential of high alkali glass powder particles leads to destructive expansion. The experimental tests showed that the compressive strength of concrete samples with 10% glass powder was higher than the samples using fly ash. However, with 90 days' curing, the compressive strength and water absorption of fly ash concrete was higher than that of the glass powder samples. Also, increasing the curing time and adding fly ash to glass powder decreased the chloride diffusion and expansion of the alkali-silica reaction. In high performance concrete, if glass powder is shattered into micro scale, it will establish useful reactions with cement over time helping in the formation of calcium silicate hydrate (C-S-H), which is very important for the structural characteristics of high performance concrete.

2.8 RESEARCHES ON USE OF GLASS AND OTHER WASTE MATERIALS IN CONSTRUCTION –

2.8.1 Soroushian, Parviz. (2012) - Milled waste glass was used as secondary cementitious material towards production of recycled aggregate concrete with improved strength and durability attributes. Experimental investigation of the novel concept of using milled waste glass, as partial replacement for cement, to overcome the drawbacks of recycled aggregate and the resulting concrete showed that waste glass, when milled to micro-scale particle size, is estimated to undergo pozzolanic reactions with cement hydrates, forming secondary calcium silicate hydrate (C–S–H). These reactions bring about favorable changes in the structure of the hydrated cement paste and the interfacial transition zones in recycled aggregate concrete.

Use of milled waste glass, as partial replacement of cement, is estimated to produce significant gains in strength and durability of recycled aggregate concrete. Milled waste glass was also found to suppress alkali-silica reactions. The encouraging test results are viewed to facilitate broad-based use of recycled aggregate and diversion of large quantities of landfill-bound mixed-colour waste glass for a value-added use to produce recycled aggregate concrete incorporating milled waste glass.

2.8.2 Islam, GM Sadiqul, M. H. Rahman, and Nayem Kazi. (2017)-

Million tons of waste glass is being generated annually all over the world. Once the glass becomes a waste it is disposed as landfills, which is unsustainable as this does not decompose in the environment. Glass is principally composed of silica. Use of milled (ground) waste glass in concrete as partial replacement of cement could be an important step toward development of sustainable (environmentally friendly, energy-efficient and economical) infrastructure systems. When waste glass is milled down to micro size particles, it is expected to undergo pozzolanic reactions with cement hydrates, forming secondary Calcium Silicate Hydrate (C–S–H). In this research chemical properties of both clear and colored glass were evaluated. Chemical analysis of glass and cement samples was determined using X-ray fluorescence (XRF) technique and found minor differences in composition between clear and colored glasses. Flow and compressive strength tests on mortar and concrete were carried out by adding 0–25% ground glass in which water to binder (cement + glass) ratio is kept the same for all replacement levels. With increase in glass addition mortar flow was slightly increased while a minor effect on concrete workability was noted. To evaluate the packing and pozzolanic effects, further tests were also conducted with same mix details and 1% super plasticizing admixture dose (by weight of cement) and generally found an increase in compressive strength of mortars with admixture. As with mortar, concrete cube samples were prepared and tested for strength (until 1 year curing). The compressive strength test results indicated that recycled glass mortar and concrete gave better strength compared to control samples. A 20% replacement of cement with waste glass was found convincing considering cost and the environment.

2.8.3 Kim, Jihwan, Chongku Yi, and Goangseup Zi (2015)-

This paper presents the results of a study conducted to evaluate the possibility of utilizing the waste glass sludge (WGS) from the cutting and polishing process of glass plates, as a partial replacement of cement. A total of seven mortar mix proportions were prepared, by replacing ordinary Portland cement with WGS and/or fly ash (FA). The influences of WGS and FA on the compressive strength of mortars and ASR expansion of mortars were investigated. In addition, X-ray diffraction analysis was performed, to evaluate the pozzolanic activity. The results show that the incorporation of the WGS yields mortars with improved strengths at the later age (28 days), in comparison with that of a control mortar (ordinary Portland cement only); while the WGS caused a lower early strength than that of control, but higher than that of mortars containing FA. The ASR expansion of the mortars can be reduced by incorporating WGS as effectively as by fly ash. It is found that the consumption rate of calcium hydroxide for the paste with the WGS was faster than that of paste with FA, up to 28 days. These results indicate that the WGS has a higher reactivity than FA; and therefore, the WGS can be used as a pozzolanic admixture in cement composites.

CHAPTER 3 – METHODOLOGY

- Procurement of the test materials – cement, fine aggregates, coarse aggregates, laminated sheets.
- Crushing the laminated fibre sheets into smaller pieces of varying sizes.
- Achieving variable concrete mixes by using different quantities of crushed waste sheets in the concrete.
- Testing these concrete mixes for workability.
- Compression tests on mortar cubes.
- Compression test on composite concrete cubes with waste sheets and its comparison with normal concrete cubes.
- Water absorption test on the concrete-glass composite.
- Study of the morphological characteristics of the concrete-glass composite and its comparison with normal concrete morphology using tests such as FTIR (Fourier Transform Infrared Spectroscopy) and SEM (Scanning Electron Microscopy) analysis.
- Arriving at a conclusion after detailed study to know the feasibility of laminated glass sheets as a constituent of concrete.
- The morphological characteristics of the modified mortar and concrete will be studied using SEM and FTIR.

3.1 SEM ANALYSIS -

A **scanning electron microscope** (**SEM**) is a type of electron microscope that produces images of a sample by scanning the surface with a focused beam of electrons. The electrons interact with atoms in the sample, producing various signals that contain information about the surface topography and composition of the sample.

3.2 FTIR ANALYSIS-

Fourier Transform Infrared Spectroscopy, also known as FTIR Analysis or FTIR Spectroscopy, is an analytical technique used to identify organic, polymeric, and, in some cases, inorganic materials. The FTIR analysis method uses infrared light to scan test samples and observe chemical properties.

The FTIR instrument sends infrared radiation of about 10,000 to 100 cm^{-1} through a sample, with some radiation absorbed and some passed through. The absorbed radiation is converted into rotational and/or vibrational energy by the sample molecules. The resulting signal at the detector presents as a spectrum, typically from 4000 cm^{-1} to 400cm^{-1}, representing a molecular fingerprint of the sample. Each molecule or chemical structure will produce a unique spectral fingerprint, making FTIR analysis a great tool for chemical identification.

CHAPTER 4 – TESTS AND RESULT

- SPECIFIC GRAVITY OF FINE AGRREGATES –
- It is the ratio of weight of given volume of fine aggregate to the equal volume of water displaced.
- Sg of fine aggregate can be determined by using pycnometer method as per IS 2386 (part 3) -1963

The acceptable range of specific gravity of fine aggregates are from 2.5 – 3.0

- SPECIFIC GRAVITY OF COARSE AGRREGATES –
- It is the ratio of weight of given volume of coarse aggregate to the equal volume of water displaced.
- Sg of fine aggregate can be determined by using wire basket method as per IS 2386 (part 3) -1963

- The acceptable range of specific gravity of fine aggregates are from 2.5 – 3.0 , with an average value of around 2.63 .
- SPECIFIC GRAVITY OF CEMENT –
  - Sg of cement can be determined by using Le Chatleirs flask, As per IS 2720 - part 3
  - here, in this method kerosene is used instead of water.
- The sg of cement ranges 2.90 – 3.16 and averages around 3.15 .

- WATER ABSORPTION TEST ON CA –
- Water absorption test of CA is carried out usin wire mesh bucket method.
- The water absorption value for CA should not be more than 2 % .
- WATER ABSORPTION TEST ON FA –
- Water absorption test on FA is carried out using pycnometer method.
- The water absorption values for FA ranges from 0.3% - 2.5% . The maximum permissible limit is 3%.

EXPERIMENTS	MATERIALS	RESULTS
1. Specific gravity	Fine aggregates	2.62
	Coarse aggregates	2.64
	Cement (OPC 53)	3.16
2. Water absorption	Fine aggregates	0.90%
	Coarse aggreagates	0.76%
3. Fineness test	cement	5.6%
4. Normal consistency and setting time test.	Cement (OPC 53)	Normal consistency = 31% Initial setting time = 50 min Final setting time = 220 min

MIX DESIGN CALCULATIONS

- As per IS 10262:2009 , Mix design is calculated for M20 grade of concrete.
- Slump test and vee be consistometer tests are conducted to find out the workability of concrete. As per IS 456:2000.

Mix design	
Grade designation	M20
Type of cement	OPC 53 grade
Nominal size of aggregate	20mm
Min Cement Content	320 kg/m³
Max W/C Ratio	0.45
Workability	100 mm slump
Exposure condition	severe
Method of concrete placing	pumping
Type of Aggregate	crushed angular aggregate
Test data for material	
Specific Gravity of Cement	3.16
Specific Gravity of CA	2.64
Specific Gravity of FA	2.62

Size of mould = 150*150*150mm		
Mix proportioning for M20 grade		
Cement	400Kg/m³	
Water	186Kg/m³	
Coarse aggregate	1110 Kg/m³	
Fine aggregate	675 Kg/m³	
Volume of materials required		
Volume Of Concrete	24*(150*150*150)	
	0.081 m³	
add 20% wasteage	0.0972	
Volume Of Concrete	0.0972m³	
Cement	38.88	40 Kg
Water	18.07	19 Kg
Coarse Aggregate	107.89	108 Kg
Fine Aggregate	65.61	67 Kg

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