Use of Industrial Waste in Green Buildings

Project Report submitted in partial fulfilment of the requirement for the degree of

Bachelor of Technology

in

Civil Engineering

under the Supervision of

Mr. Chandra Pal Gautam

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to

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CERTIFICATE

This is to certify that project report entitled “Use of Industrial Waste in Green Buildings”, submitted by NISHANT BHARGAVA and ANAS M KHAN in partial fulfillment for the award of degree of Bachelor of Technology in Civil Engineering to Jaypee University of Information Technology, Waknaghat, Solan has been carried out under my supervision.

This work has not been submitted partially or fully to any other University or Institute for the award of this or any other degree or diploma.

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Abstract

In the present age the waste generated from industries is the huge concern for the environment, health, and cause for land filling. Recycling of such wastes and using them in construction materials appears to be viable solution not only to the pollution problem but also an economical option in construction. In view of utilization of industrial waste in construction material, the present paper reviews various waste materials at different levels in construction material. Compressive strength of concrete and mortar incorporating different waste materials is reviewed and recommendations are suggested at the outcome of the study. The reviewed approach for development of new construction material using industrial waste is useful to provide a potential sustainable source.

Research concerning the use of by-products to augment the properties of concrete has been going on for many years. In the recent decades, the efforts have been made to use industry by-products such as fly ash, silica fume, ground granulated blast furnace slag (GGBS), glass cullet,bagasse, metakaolin etc., in civil constructions. Many highway agencies, private organizations and individuals have completed or are in the process of completing a wide variety of studies and research projects concerning the feasibility, environmental suitability and performance of using waste materials in construction. The potential applications of industry by-products in concrete are as partial aggregate replacement or as partial cement replacement, depending on their chemical composition and grain size. The use of these materials in concrete comes from the environmental constraints in the safe disposal of these products. These studies try to match societal need for safe and economic disposal of waste materials with the help of environmental friendly industries, which needs better and cost-effective construction materials.

Keywords:

- Compressive strength of concrete
- granulated blast furnace slag (GGBS)
- glass cullet
- bagasse

CHAPTER 1

1.1) Introduction

Human activities on earth produce in considerable quantities of wastes more than 2,500 million tons per year, including industrial and agricultural wastes from rural and urban societies. This creates serious problems to the environment, health and also the land filling. Now a day the concrete is most used manmade material in the world. The Indian construction industry alone consumes approximately 400 million tons of concrete every year and the relative amount of mortar too. Therefore the demand of the concrete and the required raw materials are very high. This causes the hike in the costs of cement, fine and coarse aggregates. Quite often the shortage of these materials is also occurred. To avoid the problems like cost hike and cuts in supply of concrete and mortar, the alternate material or the partial replacements for the cement and aggregate should be developed by recycling of waste materials. This provides us the low cost, lightweight and eco-friendly construction products. Use of the waste materials also reduces the problem of land-filling, environmental and health concern.

- Since the Industrial Revolution the world has witnessed
    - Incalculable technological achievements
    - Population growth
    - Corresponding increases in resource use
- It has led to
    - Environmental and health problems
    - Cause of land filling
    - Global warming
    - Resource and ozone depletion

All these efforts are straining the limits of the Earth's "carrying capacity"— its ability to provide the resources required to sustain life while retaining the capacity to regenerate and remain viable.

Varieties of wastes are produced from industrial processes in India causing adverse environmental impact and pollution in closed vicinity of their production. The bulk of this waste remains unutilized. There is increasing shortage building materials which can be met by producing durable alternative materials from these wastes. The project describes the investigations on the characterization of industrial wastes and their recycling potential in the development of building materials such as cements, cementitious binders, bricks, tiles, precast building components etc.

Green Buildings

Green buildings (or sustainable buildings) include the involvement of sustainable development, i.e. Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It follows the following working principles: Integration of Environmental Concerns and green construction, energy efficiency, healthy structures, building longevity, waste reduction, recycled content materials and water conservation.

Application of sustainability

- Pre-design: material selection, building program, project budget, team selection, partnering, project schedule, laws, codes and standards, research and site selection.

- On-site: site analysis and assessment, site development and layout, watershed management and conservation and site material and equipment.
- Design: passive solar design, materials and specification and indoor air quality.
- Construction: environmentally conscious construction, preservation of features and vegetation, waste management and source control practices.
- O & M: maintenance plans, indoor quality, energy efficiency, resource efficiency, renovation, housekeeping and custodial practices.

Features of Green Building

Life Cycle Assessment: A life cycle assessment (LCA) can help avoid a narrow outlook on environmental, social and economic concern by assessing a full range of impacts associated with all cradle-to-grave stages of a process: from extraction of raw materials through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling. Impacts taken into account include (among others) embodied energy, global warming potential, resource use, air pollution, water pollution, and waste.

Solar and energy efficiency: Green buildings often include measures to reduce energy consumption – both the embodied energy required to extract, process, transport and install building materials and operating energy to provide services such as heating and power for equipment.

Water conservation: Reducing water consumption and protecting water quality are key objectives in sustainable building. One critical issue of water consumption is that in many areas, the demands on the supplying aquifer exceed its ability to replenish itself. To the maximum extent feasible, facilities should increase their dependence on water that is collected, used, purified, and reused on-site.

Waste reduction: Green architecture also seeks to reduce waste of energy, water and materials used during construction. During the construction phase, one goal should be to reduce the amount of material going to landfills. Well-designed buildings also help reduce the amount of waste generated by the occupants as well, by providing on-site solutions such as compost bins to reduce matter going to landfills.

Indoor environment: It includes

- Designing the HVAC system and building envelope to provide for the most optimal delivery and mixing of fresh air.
- Minimizing the number of indoor air contaminants by selecting paints and coatings, adhesives, carpets, and composite woods that emit low VOCs (volatile organic compounds).
- Establishing segregated areas for chemical-using operations.
- Maximizing natural daylight via skylights and windows, decreasing the need for artificial lighting.

Usage of green materials: Eco-friendly construction materials are those that have a lower effect on human health and the environment when compared with competing products that serve the same purpose.

Eco-friendly construction alternatives should necessarily have the following properties:

- Derived from renewable source: like agricultural waste.
- Re-use of waste product: use of fly ash, iron ore tailings etc.
- Easy availability: for material not locally available, transport costs could be significant, affecting cost effectiveness.
- Reduction in air, land and water pollution: use of materials which result in less or no VOC emission,or those which may not result in air and water pollution
- Durability and life span: Materials which are durable and require low maintainance.
- Bio-degradable: Material constructed from farm waste etc
- Reuse or recycle: products like alluminium and iron can be reused.

Green materials may include both waste generated from industries and agricultural waste.

Further industrial waste include the following types
a. Hazardous Industrial waste
b. General Industrial waste

a) **Hazardous Industrial waste:** Industrial enterprises generate hazardous industrial waste, which contain toxic or dangerous substances in a sufficient concentration or quantity to endanger human beings or pollute the environment.

b) **General Industrial Waste:** Industrial enterprises generate general industrial waste, which include wastes other than hazardous waste, which can be effectively utilized in various applications. The reported waste material which was effectively utilized world over along with its source is given in the table below.

For eg: Flyash, gypsum, PVC, cement kiln dust, lime sludge from sugar, paper and acetylene industries, blast furnace slag, leather waste, rubber waste etc.

Agricultural waste includes waste generated from agricultural activities that is of no use for the farmer. For eg: rice husk, bagasse, bamboo, coconut pith coconut stalk etc.

1.2) Literature Survey

1.2.1) Development of Mortar Using Other Materials as Partial Replacements

M. RameGowda et al. developed and studied the strength of self compacting mortar(SCM) mixes using local materials like quarry dust and rice husk ash(RHA) as the partial replacement of cement and sand. The characterization of materials has been done and various tests conducted for cement were fineness, specific gravity, normal consistency, setting time, compressive strength for 3, 7, 21, and 28 days as per EFNARC 2005 and IS 383: 1970[40- 41].

Muhammad Harunur Rashid et al. developed mortar incorporating RHA. The mortar mixes with ordinary Portland cement (OPC) and four other mixes using RHA with varying percentage by replacing OPC has been prepared. The compressive strength tests was carried out on these specimens according to ASTM C 109[42] for 7, 28, 90 days.

The reported results were average of three samples. For determining the porosity of the mortar cylindrical specimen of 100 mm diameter and 200 mm height were casted. Samples were cured for 28 days and tested at 7, 28, 90 days. Results showed that the strengths of specimens at 28 days are slightly lower. The incorporation of RHA in mortar produced filler effect due to its fine particle size. The results suggested that RHA in this work were quite reactive and pozzolanic reaction starts at the age of 28 days onwards.

WesamAmerAules used the crumb rubber as partial replacement for sand in mortar. Various mixes were prepared with crumb rubber varying percentage and compared with reference mix proportion. The tests carried out ont he mortar are compressive strength, fineness and setting time in accordance with ASTM C150-07 [43]. The strength of mixes with crumb rubber was lower than reference mix. Strength was reduced due to weak bond between crumb rubber aggregate and concrete.

Fontes et al. studied the potentiality of sewage sludge ash as mineral additive in cement mortar and high performance concrete and concluded that SSA was a prospective material to be used as cement replacement in cement based material. Mortar mixtures containing 10-30% of SSA as cement replacement presented compressive strength as per NBR 12653 [44] at 7 days higher than that of the reference mixture and about the same strength at the age of 28 days. The high performance concrete produced axial compressive strength equivalent to that of the reference mixture at the age of 28 days. The partial replacement of portland cement by SSA promoted an increase in the total porosity and a reduction in the absorption values of the OPC reference mixtures.

Gabriele Fava et al.stated that papermill sludge when combusted, converts into ash termed as paper ash (PA).All specimens were vibrated for 20 s on a vibrating table and then covered with a plastic sheet to minimize water evaporation. The dosage of super plasticizer was maintained equal to 1% by weight of the cement along with PA to reduce the water dosage. The mortar workability was similar for all the mortar mixtures and equal to 180 mm slump measured according to EN 12350- 2CEN 1999[45].

Valeria Corinaldesietal explained the experimental results of use of paper mill sludge ash as supplementary cementitious material. The mortars containing 5% PA exhibited a compressive strength higher than that of conventional mortar at 28 days. The results presented encourage the researchers to undertake further study on the use of PA in concrete, which could lead to a reduction in the cost of concrete as well as a method for disposal of PA. The compressive strengths of mortars were measured after 1, 7, 28, and 60 days after casting.

Christy and Tensing concluded that the incorporation of class F-fly ash in mixed cements feasible for making masonry mortars in brick joints. Adequate strength developments were found in mortar made of the mixed cement and fly ash as cement replacement for

1:3, 1:4.5, and 1:6 mortars Fly ash can be used in mortar to improve the long term bond strength. Partial replacement of portland cement with class F- fly ash significantly improves the masonry bond strength. The tests were conducted as per ASTM C 311, IS 1344:1968, IS 269: 1970, IS 3812: (part I) 1966[46- 49].

Alireza Naji Givietal stated that the use of supplementary cementing materials has become an integral part of high strength and high performance concrete mix design. These can be natural materials, by-products or industrial wastes, or the ones requiring less energy and time to produce. Some of the commonly used supplementary cementing materials are fly ash, Silica Fume (SF), Ground Granulated Blast Furnace Slag (GGBFS) and Rice Husk Ash (RHA) etc.

Djwantoro Hardjito et al. presented the results of study on effect of various parameters on mechanical properties of fly ash-based geo-polymer mortar with bottom ash as partial or full replacement for sand. Compressive strength of samples with 10% bottom ash (BA) was comparable to those with only sand. Further increase in bottom ash content decreased the compressive strength. However, the reverse tendency occurred after exposing the samples to 1000oC for 24 hours.

BalwaikandRaut studied the utilization of waste paper pulp by partial replacement of cement in concrete. The cement has been replaced by waste paper sludge accordingly in the range of 5% to 20% by weight for M- 20 and M-30 mix. The concrete specimens were tested in three series of test as compression test, splitting tensile test and flexural test. These tests were carried out to evaluate the mechanical properties for up to 28 days in accordance with IS 383: 1970, IS10262:1982, IS456:2000, IS 1199:1959, IS 516:1959, IS 5816:1999 [50- 56].As a result, the compressive, splitting tensile and flexural strength increased up to 10% addition of waste paper pulp and further increased in waste paper pulp reduces the strengths gradually.

Degirmenci and Yilmaz explained the use of pumice fine aggregates as an alternative for sand in the production of lightweight cement mortar. Pumice is natural material of volcanic origin produced during release of gases by solidification of lava. The purpose of this study is to evaluate the possibility of using granulated pumice as an alternative for fine aggregates in production of lightweight mortar. The compressive strength, flexural strength, freeze – thaw resistance, sulfate resistance water absorption test are determined for pumice/cement as per TS EN 197-1, TS EN 196-1, ASTM C 270-08a, ASTM 330[57-60].

ACI Committee 233 reported about the use of ground granulated blast furnace slag as a cementitious constituent in concrete. The use of iron blast-furnace slag as a constituent of concrete, either as an aggregate or as a cementing material, or both, is well known. This report primarily addresses the use of GGBF slag as a separate cementitious material added along with portland cement in the production of concrete and the specimen were tested in accordance with C 94, C109, C162, C 186, C 227, C595, C 666, C989, C1012, C1073, A 23.5, A 363[61-72].

CHAPTER 2

2.1) Objective of Project

- To study various properties of industrial waste.
- To check various properties of concrete on adding different industrial waste.
- Properties to be checked: Compressive strength, durability, water absorption, etc.
- Compare properties of concrete mix with and without adding industrial waste.
- Effect of various shapes and size of waste.
- To apply various permutation and combination to get the best mix for concrete.
- Design a green building using the optimum waste keeping environmental, economic and performance benefits in mind.

CHAPTER 3

3.1) Tests Conducted on Cement

TEST	VALUES
Normal Consistency	44%
Initial Setting Time	45 min
Final Setting Time	7 hrs 45 min
Soundness	3mm
Specific Gravity	2.99
Fineness	2%

Table 1 : Tests Conducted On Cement

3.1.1 Normal Consistency:

Standard consistency of a cement paste is defined as that consistency which will permit a vicat plunger having 10 mm dia and 50 mm length to penetrate to a depth of 33-35 mm from top of the mould.

Apparatus:

- Vicat apparatus
- Balance
- Measuring cylinder

Procedure:

1. Take 400 g of cement and place it in the enameled tray.

2. Mix about 25% water by weight of dry cement thoroughly to get a cement paste. Total time taken to obtain thoroughly mixed water cement paste i.e. “Gauging time” should not be more than 3 to 5 minutes.
3. Fill the vicat mould, resting upon a glass plate, with this cement paste.
4. After filling the mould completely, smoothen the surface of the paste, making it level with top of the mould.
5. Place the whole assembly(i.e. mould + cement paste + glass plate) under the rod bearing plunger.
6. Lower the plunger gently so as to touch the surface of the test block and quickly release the plunger allowing it to sink into the paste.
7. Measure the depth of penetration and record it.
8. Prepare trial pastes with varying percentages of water content and follow the steps (2 to 7) as described above, until the depth of penetration becomes 33 to 35 mm.

Calculation:

Calculate percentage of water (P) by weight of dry cement required to prepare cement paste of standard consistency by following formula, and express it to the first place of decimal.

$P=(W/C)X100$

Where,

W=Quantity of water added

C=Quantity of cement used

Precautions:

- Gauging time should be strictly observed
- Room temperature should be well maintained as per test requirement.
- All apparatus used should be clean.
- The experiment should be performed away from vibrations and other disturbances.

Technical Discussion:

- This test helps to determine water content for other tests like initial and final setting time, soundness & compressive strength.

3.1.2 Initial Setting Time:

Initial setting time is that time period between the time water is added to cement and time at which 1 mm square section needle fails to penetrate the cement paste, placed in the Vicat's mould 5 mm to 7 mm from the bottom of the mould.

Apparatus:

- Vicat apparatus
- Balance
- Measuring cylinder
- Stop watch

Procedure

(a) Test Block Preparation

1. Before commencing setting time test, do the consistency test to obtain the water required to give the paste normal consistency (P).
2. Take 400 g of cement and prepare a neat cement paste with 0.85P of water by weight of cement.
3. Gauge time is kept between 3 to 5 minutes. Start the stop watch at the instant when the water is added to the cement. Record this time (t_1).
4. Fill the Vicat mould, resting on a glass plate, with the cement paste gauged as above. Fill the mould completely and smooth off the surface of the paste making it level with the top of the mould. The cement block thus prepared is called test block.

(b) Initial Setting Time

1. Place the test block confined in the mould and resting on the non-porous plate, under the rod bearing the needle.
2. Lower the needle gently until it comes in contact with the surface of test block and quick release, allowing it to penetrate into the test block.
3. In the beginning the needle completely pierces the test block. Repeat this procedure i.e. quickly releasing the needle after every 2 minutes till the needle fails to pierce the block for about 5 mm measured from the bottom of the mould. Note this time (t_2).

Calculation

Initial setting time=t_2-t_1

Where,

t_1=Time at which water is first added to cement

t_2=Time when needle fails to penetrate 5 mm to 7 mm from bottom of the mould

Precautions

- Release the initial and final setting time needles gently.
- The experiment should be performed away from vibration and other disturbances.
- Needle should be cleaned every time it is used.
- Position of the mould should be shifted slightly after each penetration to avoid penetration at the same place.
- Test should be performed at the specified environmental conditions.

3.1.3 Final Setting Time:

Final setting time is that time period between the time water is added to cement and the time at which 1 mm needle makes an impression on the paste in the mould but 5 mm attachment does not make any impression.

Apparatus:

- Vicat apparatus
- Balance
- Measuring cylinder
- Stop watch

Procedure:

1. For determining the final setting time, replace the needle of the Vicat's apparatus by the needle with an annular attachment.

2. The cement is considered finally set when upon applying the final setting needle gently to the surface of the test block; the needle makes an impression thereon, while the attachment fails to do so. Record this time (t_3).

Calculation

Final setting time=t_3-t_1,

Where,

t_1=Time at which water is first added to cement

t_3=Time when the needle makes an impression but the attachment fails to do so.

3.1.4 Soundness:

In the soundness test a specimen of hardened cement paste is boiled for a fixed time so that any tendency to expand is speeded up and can be detected. Soundness means the ability to resist volume expansion.

Apparatus:

- Le-chatelier apparatus
- Water bath
- Caliper
- Measuring cylinder
- Balance

Procedure

1. Before commencing setting time test, do the consistency test to obtain the water required to give the paste normal consistency (P).

2. Prepare a paste by adding 0.78 times the water required to give a paste of standard consistency (i.e. 0.78P).
3. Lightly oil the Le-chatelier mould and place it on a lightly oiled glass sheet.
4. Fill the mould with the prepared cement paste. In the process of filling the mould keep the edge of the mould gently together.
5. Cover the mould with another piece of lightly oiled glass sheet, place a small weight on this covering glass sheet.
6. Submerge the whole assembly in water at a temperature of 27 ± 2^0 C and keep there for 24 hours.
7. Remove the whole assembly from water bath and measure the distance separating the indicator points to the nearest 0.5 mm (L_1).
8. Again submerge the whole assembly in water bath and bring the temperature of water bath to boiling temperature in 25 to 30 minutes. Keep it at boiling temperature for a period of 3 hours.
9. After completion of 3 hours, allow the temperature of the water bath to cool down to room temperature and remove the whole assembly from the water bath.
10. Measure the distance between the two indicator points to the nearest 0.5 mm (L_2).

Calculations:

Soundness/expansion of cement = L_1-L_2

L_1=Measurement taken after 24 hours of immersion in water at a temp. of 27 ± 2^0 C

L_2=Measurement taken after 3 hours of immersion in water at boiling temperature.

Calculate the mean of two values to the nearest 0.5 mm.

Precautions:

- All the measurements should be done accurately.
- Do not apply extra pressure while filling the moulds.
- During boiling water level should not fall below the height of the mould.

Technical Discussion:

- Volume expansion in cement mortar or in cement concrete is caused by the presence of unburnt lime (CaO), dead burnt MgO and also $CaSO_4$.
- By Le-chatelier method we can only find out presence of unburnt lime (CaO).
- Presence of unburnt lime may develop cracks in the cement because of increase in volume.
- Free lime (CaO) and magnesia (MgO) are known to react with water very slowly and increase in volume considerably, which result in cracking, distortion and disintegration.

3.1.5 Specific Gravity:

To determine the specific gravity is normally defined as the ratio between the weight of a given volume of material and weight of an equal volume of water. To determine the specific gravity of cement, kerosene which does not recent with cement is used.

Apparatus:

- Le-chatelier apparatus
- weighing balance
- kerosene (free from water)

Procedure

1. Dry the flask carefully and fill with kerosene or naphtha to a point on the stem between zero and 1 ml.
2. Record the level of the liquid in the flask as initial reading.
3. Put a weighted quantity of cement (about 60 gm) into the flask so that level of kerosene rise to about 22 ml mark, care being taken to avoid splashing and to see that cement does not adhere to the sides of the above the liquid.
4. After putting all the cement to the flask, roll the flask gently in an inclined position to expel air until no further air bubble rises to the surface of the liquid.
5. Note down the new liquid level as final reading.

Observations and Calaculatoins

1. Weight of cement used =W gm
2. Initial reading of flask =V1 ml
3. Final reading of flask =V2 ml
4. Volume of cement particle= V2-V1 ml
5. weight of equal of water= (V2-V1) x specific weight of water.

Specific gravity of cement = (Weight of cement/ Weight of equal volume of water)

= W/(V2-V1)

3.1.6 Fineness:

Fineness of cement is measured by sieving it on standard sieve. The proportion of cement of which the grain sizes are larger than the specified mesh size is thus determined.

Apparatus:

- Sieve
- Balance

Procedure

1. Agitate the sample of cement to be tested by shaking for 2 minutes in a stoppered jar to disperse agglomerates. Stir the resulting powder gently using a clean dry rod in order to distribute the fines throughout the cement.
2. Attach a pan under the sieve to collect the cement passing the sieve.
3. Weigh approximately 10 g of cement to the nearest 0.01 g and place it on the sieve. Fit the lid over the sieve.
4. Agitate the sieve by swirling, planetary and linear movement until no more fine material passes through it.
5. Remove and weigh the residue. Express its mass as a percentage (R_1) of the quantity first placed in the sieve.
6. Repeat the steps 3 to 5 with a fresh sample to obtain R_2.

- **Note ::** If $\mathbf{R_1}$ & $\mathbf{R_2}$ differ by more than **1%**, then carryout a third sieving and calculate $\mathbf{R_3}$.

Calculation:

Calculate the residue of cement R as the mean of R_1 & R_2 (or R_1, R_2 & R_3) in %, expressed to the nearest 0.1%.

Precaution:

- Before sieving, air set lumps of cement should be broken
- Sieving should be done by rotating the sieve and not by translation.

3.2) Design Considerations for M25 Concrete

According to IS-10262-2009:

- Maximum nominal size of aggregate = 20mm (for this water content per cubic metreof conc is 185 kg)
- Minimum Cement Content = 310 kg/m^3
- Maximum Cement Content = 540 kg/m^3
- Maximum Water Cement Ratio = 0.45

Compute Target Mean Compressive Strength:

F_{ck} = $f_{ck} + t * S$

F_{ck} = Target Mean Compressive Strength at 28 days in N/Sq.mm

f_{ck} = Characteristic Compressive Strength at 28 days in N/Sq.mm

S = Standard Deviation in N/Sq.mm

t = A Statistic, depending on accepeted proportion of low results.

= 1.65 for 1 in 20 accepted proportion of low Results

Quantity of cement = water/w-c ratio

=185/.45=411 kg

Then we find the quantities of Fine & Coarse aggregate by absolute volume method:

$V = (W+C/S_c+(1/p) * (fa/S_{fa})) * (1/1000)$ - (Eq.1) and

$V = (W + C/S_c + (1/(1-p)) * (ca/S_{ca})) * (1/1000)$ - (Eq.2)

Where

V = Absolute volume of fresh concrete = 1 m^3

W = Mass of Water (Kg) per m^3 of concrete

C = Mass of Cement (Kg) per m^3 of concrete

p = Percentage of fine aggregate.

fa = Mass of fine aggregate

ca = Mass of coarse aggregate

S_c = Specific gravity of cement.

S_{fa} = Specific gravity of fine aggregate.

S_{ca} = Specific gravity of coarse aggregate.

Substituting the values in Eq(1), we get

1000 = 185 + 411/3.0 + (1/0.36) * fa /2.6)

= 185 + 137 + fa/0.936

= 322 + fa/0.936

fa = (1000 – 322) * 0.936

= 678 * 0.936

= 635 Kg.

Substituting the values in Eq(2), we get

1000 = 185 + 411/3.0 + (1/0.64) * ca /2.65)

= 185 + 137 + ca/1.696

= 322 + ca/1.696

ca = (1000 – 322) * 1.696

= 678 * 1.696

= 1150 Kg.

For 1m^3

- Mass Of Cement(PPC) = 320kg
- Mass Of Water = 138kg
- Mass Of Fine aggregate = 751kg
- Mass Of Coarse aggregate :
  20mm = 977kg
  10mm = 380kg
- W/C ratio = 0.45

CHAPTER 4

4.1) Use of Slag in concrete

The chemical composition of a slag varies considerably depending on the composition of the raw materials in the iron production process. Silicate and aluminate impurities from the ore and coke are combined in the blast furnace with a flux which lowers the viscosity of the slag. In the case of pig iron production the flux consists mostly of a mixture of limestone and forsterite or in some cases dolomite. In the blast furnace the slag floats on top of the iron and is decanted for separation. Slow cooling of slag melts results in an unreactive crystalline material consisting of an assemblage of Ca-Al-Mg silicates. To obtain a good slag reactivity or hydraulicity, the slag melt needs to be rapidly cooled or quenched below 800 °C in order to prevent the crystallization of merwinite and melilite. To cool and fragment the slag a granulation process can be applied in which molten slag is subjected to jet streams of water or air under pressure. Alternatively, in the pelletization process the liquid slag is partially cooled with water and subsequently projected into the air by a rotating drum. In order to obtain a suitable reactivity, the obtained fragments are ground to reach the same fineness as Portland cement.

The main components of blast furnace slag are CaO (30-50%), SiO_2 (28-38%), Al_2O_3 (8-24%), and MgO (1-18%). In general increasing the CaO content of the slag results in raised slag basicity and an increase in compressive strength. The MgO and Al_2O_3 content show the same trend up to respectively 10-12% and 14%, beyond which no further improvement can be obtained. Several compositional ratios or so-called hydraulic indices have been used to correlate slag composition with hydraulic activity; the latter being mostly expressed as the binder compressive strength.

The glass content of slags suitable for blending with Portland cement typically varies between 90-100% and depends on the cooling method and the temperature at which cooling is initiated. The glass structure of the quenched glass largely depends on the proportions of network-forming elements such as Si and Al over network-modifiers such as Ca, Mg and to a lesser extent Al. Increased amounts of network-modifiers lead to higher degrees of network depolymerization and reactivity.

Different fine aggregate replacements have been studied by substituting 5%, 10%, and 15% of slag. The waste material was substituted for replacement of fine aggregates and for the preparation of concrete blocks. In this project, we have followed Indian standard methods and arrived at the mix design for M25 grade concrete. Experimental studies were conducted only on portland cement concrete. The building material specimens were analyzed for compressive strength as per IS code.

The main components of blast furnace slag are CaO (30-50%), SiO_2 (28-38%), Al_2O_3 (8-24%), and MgO (1-18%). In general increasing the CaO content of the slag results in raised slag basicity and an increase in compressive strength. The MgO and Al_2O_3 content show the same trend up to respectively 10-12% and 14%, beyond which no further improvement can be obtained. Several compositional ratios or so-called hydraulic indices have been used to correlate slag composition with hydraulic activity; the latter being mostly expressed as the binder compressive strength.

CHAPTER 5

5.1) Use of Glass in Concrete

Glass is an amorphous (non-crystalline) solid material which is often transparent and has widespread practical, technological, and decorative usage in things like window panes, tableware, and optoelectronics. The most familiar, and historically the oldest, types of glass are based on the chemical compound silica (silicon dioxide), the primary constituent of sand. The term glass, in popular usage, is often used to refer only to this type of material, which is familiar from use as window glass and in glass bottles. Of the many silica-based glasses that exist, ordinary glazing and container glass is formed from a specific type called soda-lime glass, composed of approximately 75% silicon dioxide (SiO_2), sodium oxide (Na_2O) from sodium carbonate(Na_2CO_3), calcium oxide, also called lime (CaO), and several minor additives. A very clear and durable quartz glass can be made from pure silica; the other compounds above are used to improve the temperature workability of the product.

Glass has high silica content, thus making it potentially pozzolanic when particle size is less than 75µm. Studies have shown that finely ground glass does not contribute to alkali – silica reaction. In the recent, various attempts and research have been made to use ground glass as a replacement in conventional ingredients in concrete production as a part of green house management. A major concern regarding the use of glass in concrete is the chemical reaction that takes place between the silca – rich glass particle and the alkali in pore solution of concrete, which is called Alkali – Silicate reaction can be very detrimental to the stability of concrete, unless appropriate precautions are taken to minimize its effects. ASR can be prevented or reduced by adding mineral admixtures in the concrete mixture, common mineral admixtures used to minimize ASR are pulverized fuel ash (PFA), silica fume(SF) and metkaolin (MK).A number of studies have proven the suppressing ability of these materials on ASR. A high amount of waste glass as aggregate is known to decrease the concrete unit weight. The fact that glass has a high silica content has led to laboratory studies on its feasibility as a raw material in cement manufacture. The use of finely divided glass powder as a cement replacement material has yielded positive results, Optimal dosage range of this glass powder is chosen based on cement paste studies Selected properties of the glass powder modified mixtures are compared with the properties of conventional concrete. The ultimate aim of this work is to ascertain the performance of concretes containing glass powder and compare it with the performance of conventional concretes.

Cement manufacturing industry is one of the carbon dioxide emitting sources besides deforestation and burning of fossil fuels. The global warming is caused by the emission of green house gases, such as CO2, to the atmosphere. Among the greenhouse gases,CO2 contributes about 65% of global warming. The global cement industry contributes about 7% of greenhouse gas emission to the earth's atmosphere. In order to address environmental effects associated with cement manufacturing, there is a need to develop alternative binders to make concrete.

Consequently extensive research is on going into the use of cement replacements, using many waste materials and industrial by products. Efforts have been made in the concrete industry to use waste glass as partial replacement of coarse or fine aggregates and cement. In this study, finely powdered waste glasses are used as a partial replacement of cement in concrete and compared it with conventional concrete.

This work examines the possibility of using Glass powder as a partial replacement of cement for new concrete. Glass powder was partially replaced as 10%, 15% and 20% and tested for its compressive, Tensile and flexural strength up to 60 days of age and were compared with those of conventional concrete; from the results obtained.

5.2) Benefits of use of glass in concrete

The use of recycled glass as aggregate greatly enhances the aesthetic appeal of the concrete. Recent research findings have shown that concrete made with recycled glass aggregate have shown better long term strength and better thermal insulation due to its better thermal properties of the glass aggregates. When tested for the compressive strength values at the 10 %, 40%, and 60 % aggregate replacement by waste glass with 0 – 10mm particle size were 3%, 8% and 5% above the value of conventional concrete. It has been concluded that 30% glass powder could be incorporated as cement replacement in concrete without any long-term detrimental effects. Upto 50% of both fine and coarse aggregate could also be replaced in concrete of 32 MPa strength grade with acceptable strength development properties. Better results are achieved when the waste glass powder replaced either 30 % or 70% of the sand with particles sizes ranging between 50 µm and 100 µm. Used glass waste, which is cylindrical in shape prevents crack propagation in concrete structures. From the research carried out on glass powder by the authors, it was found that glass of particle size 1.18 to 2.36 mm produced the highest expansion where as low expansion was observed at smaller particle sizes. It was observed that with a 30% replacement of cement by amber waste glass content of particle size 75µm along with flyash, the compressive strength of concrete increase 25% at 7 days and 35% when tested for 28 days strength. This effect provide ample evidence that both flyash and waste glass sand can be used together to produce concretes with relative high strength without any adverse reaction.

CHAPTER 6

6.1) Use of Bagasse in concrete

Bagasse contains mainly cellulose, hemi cellulose, pentosans, lignin, Sugars, wax, and minerals. The quantity obtained varies from 22 to 36% on Cane and is mainly due to the fibre portion in Cane and the cleanliness of Cane supplied, which, in turn, depends on harvesting practices.

The composition of Bagasse depends on the variety and maturity of Sugarcane as well as harvesting methods applied and efficiency of the Sugar processing. Bagasse is usually combusted in furnaces to produce steam for power generation. Bagasse is also emerging as an attractive feedstock for bioethanol production. It is also utilized as the raw material for production of paper and as feedstock for cattle. The value of Bagasse as a fuel depends largely on its calorific value, which in turn is affected by its composition, especially with respect to its water content and to the calorific value of the Sugarcane crop, which depends mainly on its sucrose content.

Moisture contents is the main determinant of calorific value i.e. the lower the moisture content, the higher the calorific value. A good milling process will result in low moisture of 45% whereas 52% moisture would indicate poor milling efficiency. Most mills produce Bagasse of 48% moisture content, and most boilers are designed to burn Bagasse at around 50% moisture. Bagasse also contains approximately equal proportion of fibre (cellulose), the components of which are carbon, hydrogen and oxygen, some sucrose (1-2 %), and ash originating from extraneous matter. Extraneous matter content is higher with mechanical harvesting and subsequently results in lower calorific value.

After the extraction of all economical sugar from sugarcane, about 40-45 percent fibrous residue is obtained, which is reused in the same industry as fuel in boilers for heat or power generation leaving behind 8 -10 percent ash as waste, known as sugarcane bagasse ash (SCBA)

One of the agro waste sugar cane bagasse ash (SCBA) which is a fibrous waste product obtained from sugar mills as byproduct. Juice is extracted from sugar cane then ash produced by burning bagasse in uncontrolled condition and at very high temperature. Sugarcane bagasse ash (SCBA) is one of the main byproduct can be used as mineral admixture due to its high content in silica (SiO_2) .A few studies have been carried out on the ashes obtained directly from the industries to study pozzolanic activity and their suitability as binders, partially replacing cement . The present study was carried out on SCBA obtained by controlled combustion of sugarcane bagasse, which was procured from the Maharashtra in India. Sugarcane production in India is over 300 million tons/year leaving about 10 million tons of as unutilized and, hence, wastes material.

The sugarcane bagasse consists of approximately 50% of cellulose, 25% of hemicelluloses and 25% of lignin. Each ton of sugarcane generates approximately 26% of bagasse (at a moisture content of 50%) and 0.62% of residual ash. The residue after combustion presents a chemical composition dominates by silicon dioxide (SiO_2). In spite of being a material of hard degradation and that presents few nutrients, the ash is used on the farms as a fertilizer in the sugarcane harvests.

CHAPTER 7

RESULTS

7.1) Density of concrete blocks obtained after substituting sand with slag

Table 2 : Density of concrete blocks (0.15m*0.15m*0.15m) obtained after substituting sand with slag

% slag	Weight (kg)	Density (kg/m^3)	Avg. Density (kg/m^3)
5	8.2	2429.62	2439.49
	8.3	2459.25	
	8.2	2429.62	
10	8.4	2488.8	2469.1
	8.3	2459.25	
	8.3	2459.25	
15	8.3	2459.25	2449.35
	8.1	2400	
	8.4	2488.8	

Graph showing relation between Density and % Slag replacement used

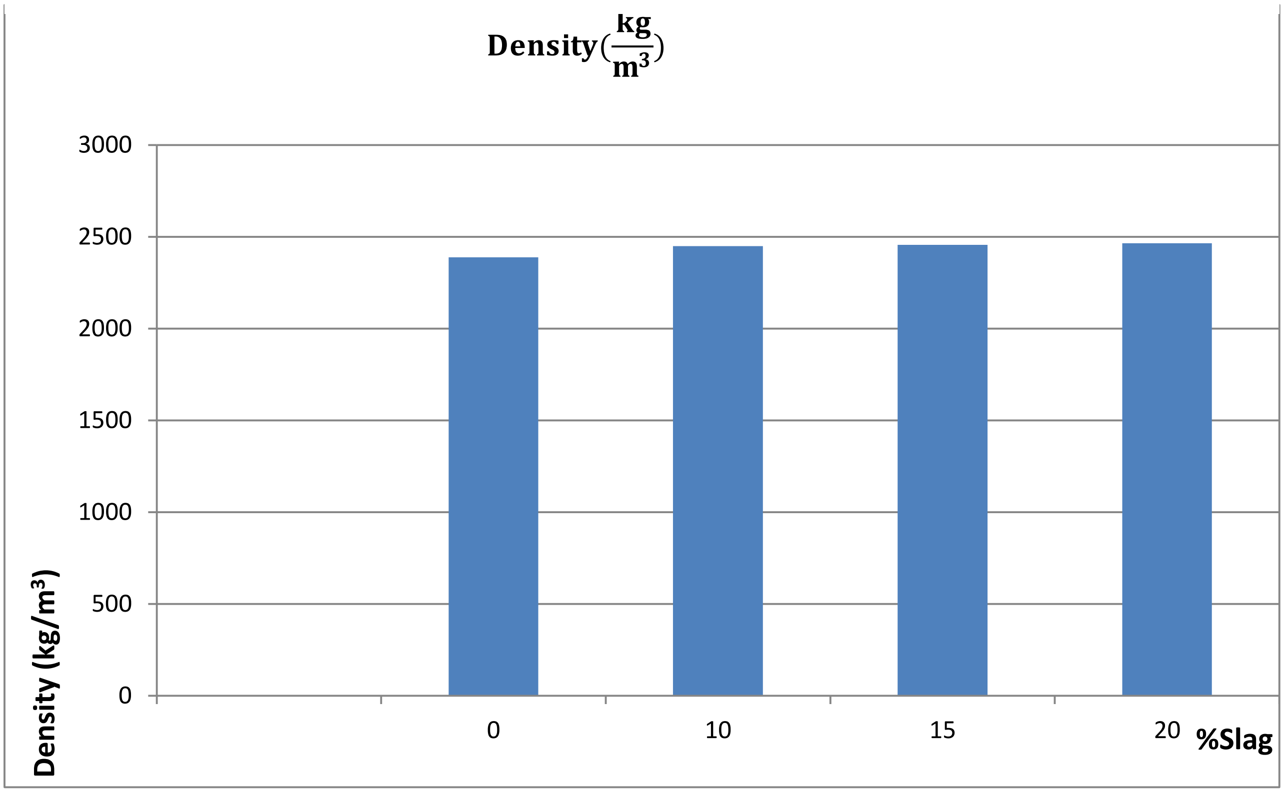

Figure 1 Graph showing relation between Density and % Slag replacement used

7.2) Relation between Compressive Strength and % Slag replacement used

Table 3: Relation between Compressive Strength and % Slag replacement used

% slag	Load (kN)	Compressive Strength (kN/m^3)	Avg. Compressive Strength (kN/m^3)
5	580	25.77	26.36
	610	27.11	
	590	26.22	
10	645	28.66	27.99
	620	27.55	
	625	27.77	
15	510	22.66	22.66
	490	21.77	
	530	23.55	

Graph showing relation between Compressive Strength and % Slag replacement used

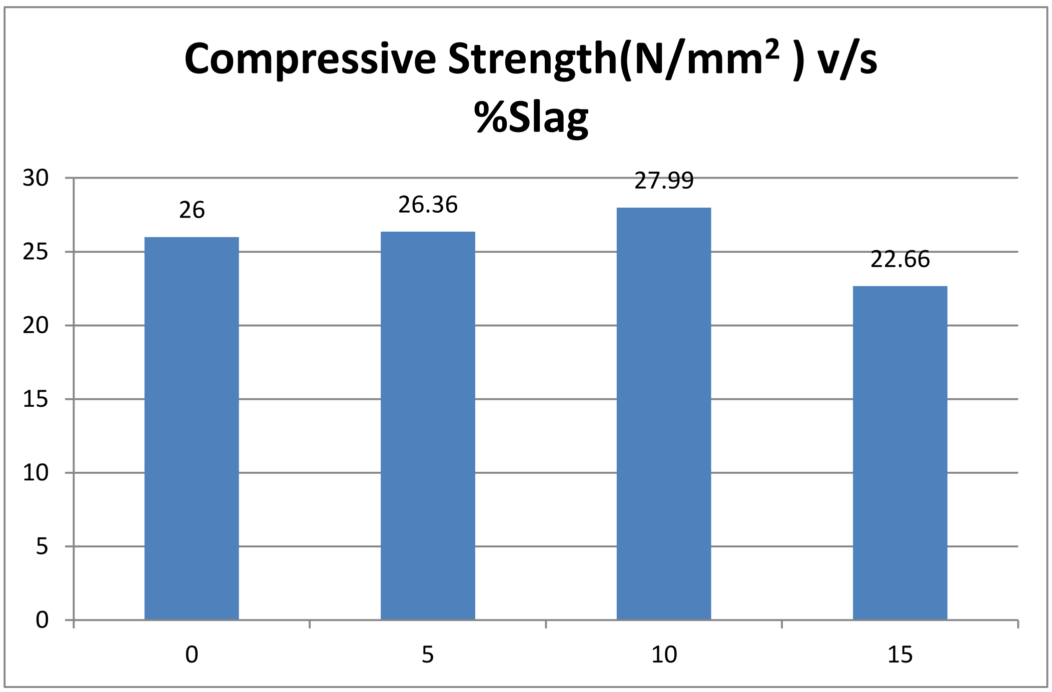

Figure 2 Graph showing relation between Compressive Strength and % Slag replacement used

• When glass (passed by 2.36mm sieve) was used as a replacement of cement average density increased from 2388.2 kg/m3 to 2465.2 kg/m3 with increase in glass content from 0 to 20% whereas the 28 day compressive strength decreased from 26.52 N/mm2 to 20 N/mm2 with increase in glass content from 0 to 20%. For 10% replacement of cement with glass, strength of 24.9 N/mm2 was observed which is very close to our desired result

7.3) Density of concrete blocks (0.15m*0.15m*0.15m) obtained after substituting cement with glass

Table 4. Density of concrete blocks obtained after substituting cement with glass

Glass %	**Weight(kg)**	**Density (kg/m³)**	**Avg. Density (kg/m³)**
Nil	8.25	2444.4	2388.2
	7.90	2340.8	
	8.04	2382.2	
	8.00	2370.4	
	8.11	2403	
10	8.27	2450.4	2449.4
	8.24	2441.5	
	8.29	2456.3	
15	8.22	2435.6	2455.2
	8.38	2482.9	
	8.36	2447.0	
20	8.15	2414.8	2465.2
	8.37	2480.0	
	8.44	2500.7	

Graph showing relation between Density and % Glass replacement used

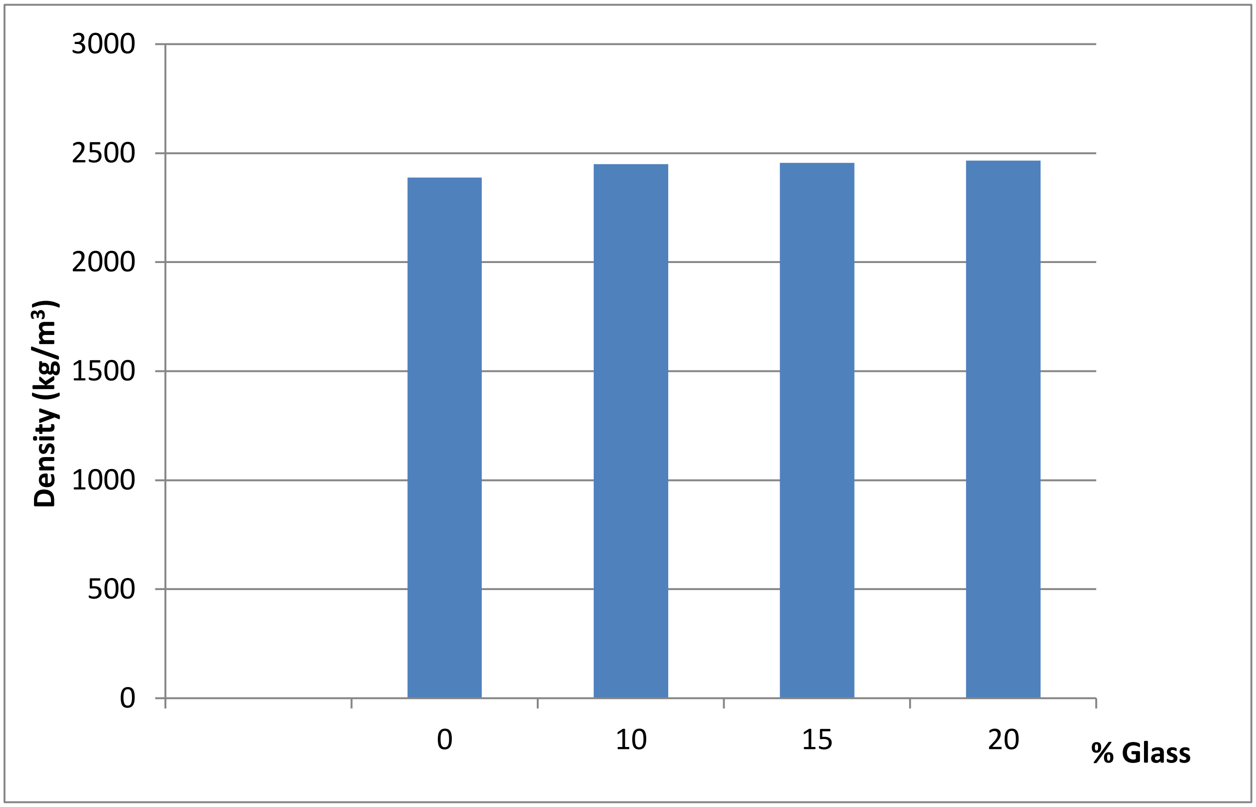

Figure 3 Graph showing relation between Density and % Glass replacement used

7.4) Compressive Strength of concrete blocks (0.15m*0.15m*0.15m) obtained after substituting cement with glass

Table 5 : Compressive Strength of concrete blocks obtained after substituting cement with glass

% Glass	Compressive load(kN)	Compressive Strength(N/mm^2)	Avg Compressive Strength(N/mm^2)
Nil	650	28.9	26.52
	550	24.5	
	600	26.7	
	580	25.8	
	600	26.7	
10	630	28	24.9
	500	22.2	
	550	24.5	
15	450	20	20.3
	480	21.3	
	440	19.6	
20	440	19.6	20
	460	20.4	
	450	20	

Graph showing relation between Compressive Strength and % Glass replacement used

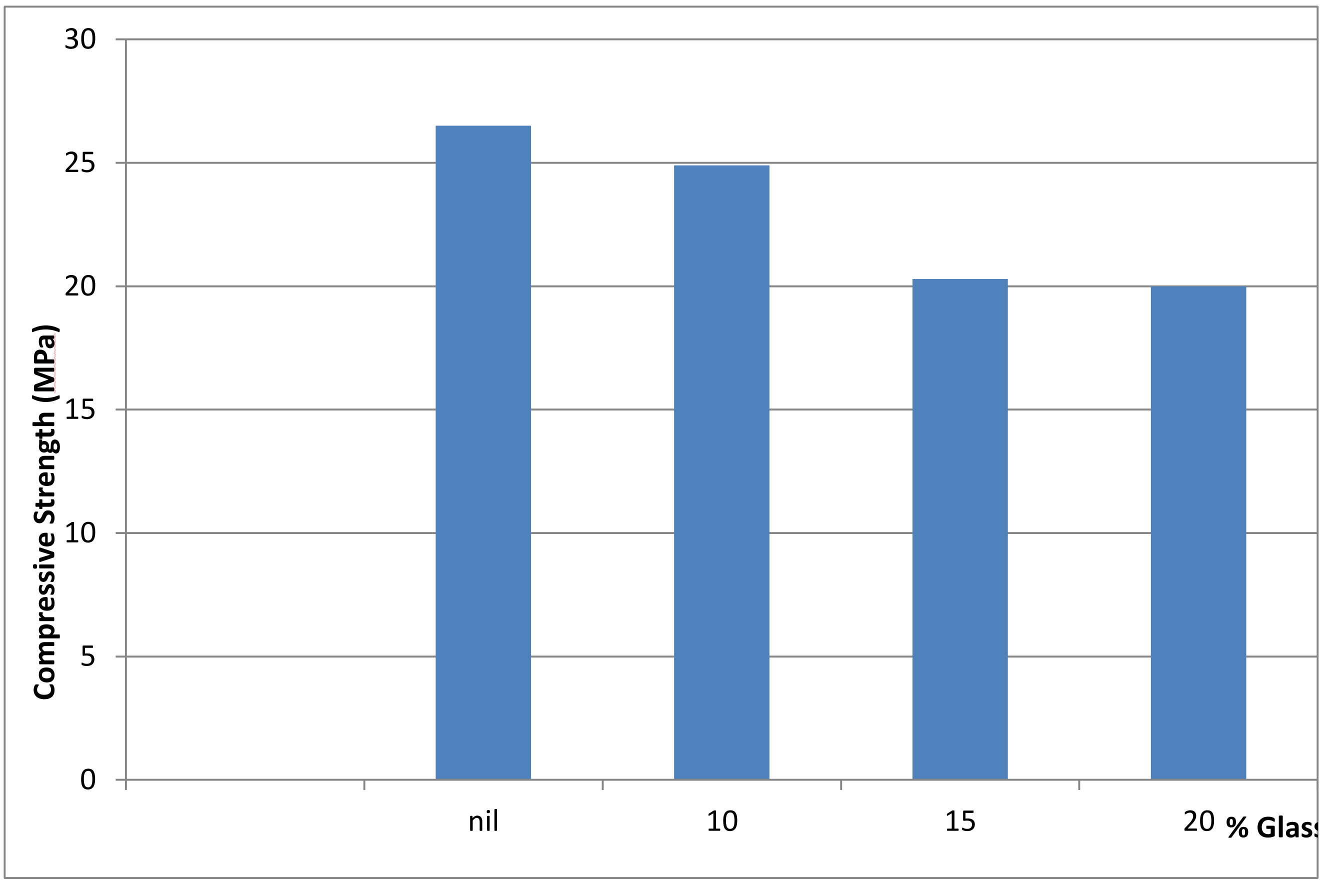

Figure 4: Graph showing relation between Compressive Strength and % Glass replacement used

• When slag (passed by 4.75mm sieve) was used as a replacement for sand average density increased from 2388.2 kg/m3 to 2449.35 kg/m3 with increase in slag content from 0 to 15% whereas the 28 day compressive strength first increased and then decreased from 26.52 N/mm2 to 27.99 N/mm2 and then to 22.66 N/mm2 with increase in slag content from 0 to 10% and then from 10% to 15% respectively. For 10% replacement of sand with slag, strength of 27.99 N/mm2 was observed.

7.5) Density of concrete blocks (0.15m*0.15m*0.15m) obtained after substituting cement with bagasse :

Table 6 : Density of concrete blocks (0.15m*0.15m*0.15m) obtained after substituting cement with bagasse

Glass %	Weight(kg)	Density (kg/m^3)	Avg. Density (kg/m^3)
Nil	8.25	2444.4	2423.7
	8.50	2518.5	
	8.04	2382.2	
	8.00	2370.4	
	8.11	2403.0	
10	8.27	2450.4	2498.7
	8.74	2589.6	
	8.29	2456.3	
15	8.22	2435.6	2467.0
	8.50	2518.5	
	8.36	2447.0	
20	8.15	2414.8	2478
	8.50	2518.5	
	8.44	2500.7	

Graph showing relation between Density VS %bagasse replacement used

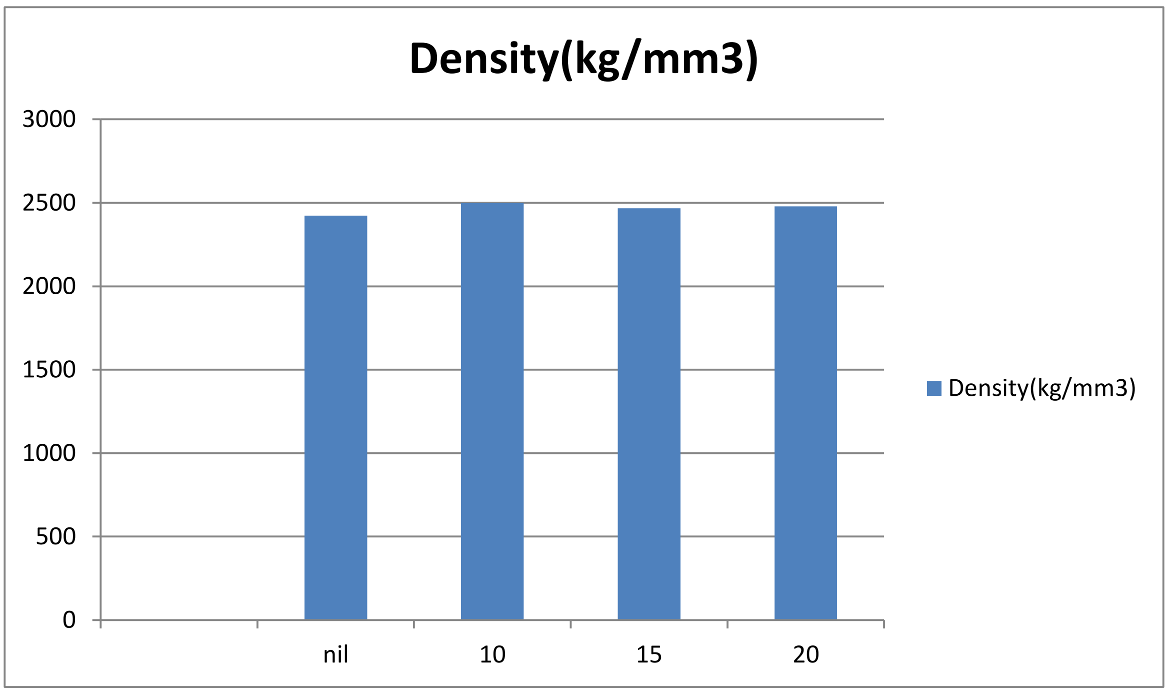

Figure 5 : Graph showing relation between Density VS %bagasse replacement used

7.6) 7 day Compressive Strength of concrete blocks (0.15m*0.15m*0.15m) obtained after substituting cement with Bagasse

Table 7: 7 day Compressive Strength of concrete blocks (0.15m*0.15m*0.15m) obtained after substituting cement with Bagasse

%Bagasse	Compressive load(kN)	Compressive Strength(N/mm^2)	Avg Compressive Strength(N/mm^2)
Nil	470.25	20.9	21.32
	483.75	21.5	
	488.25	21.7	
	468.00	20.8	
	488.25	21.7	
10	495.00	22.0	21.9
	499.50	22.2	
	483.75	21.5	
15	515.25	22.9	22.8
	517.50	23.0	
	510.75	22.7	
20	440	19.6	20
	460	20.4	
	450	20	

Graph showing relation between 7 day Compressive Strength and %Bagasse replacement used

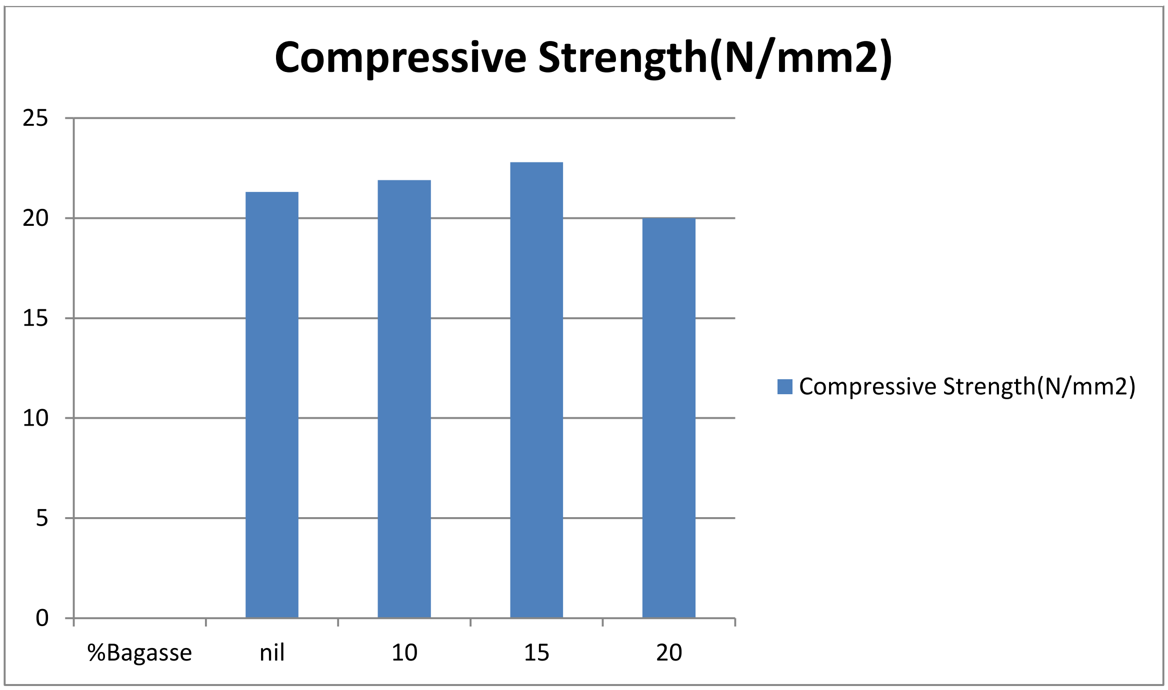

Figure 6: Graph showing relation between 7 day Compressive Strength and %Bagasse replacement used

7.7) 28 day Compressive Strength of concrete blocks (0.15m*0.15m*0.15m) obtained after substituting cement with Bagasse

Table 8: 28 day Compressive Strength of concrete blocks (0.15m*0.15m*0.15m) obtained after substituting cement with Bagasse

%Bagasse	Compressive load(kN)	Compressive Strength(N/mm^2)	Avg Compressive Strength(N/mm^2)
Nil	650	28.9	26.52
	550	24.5	
	600	26.7	
	580	25.8	
	600	26.7	
10	630	28.0	27.2
	618.75	27.5	
	585	26.0	
15	627.75	27.9	28.1
	636.75	28.3	
	630	28.0	
20	540	24	23.8
	533.25	23.7	
	537.75	23.9	

Graph showing relation between 28 day Compressive Strength and %Bagasse replacement used

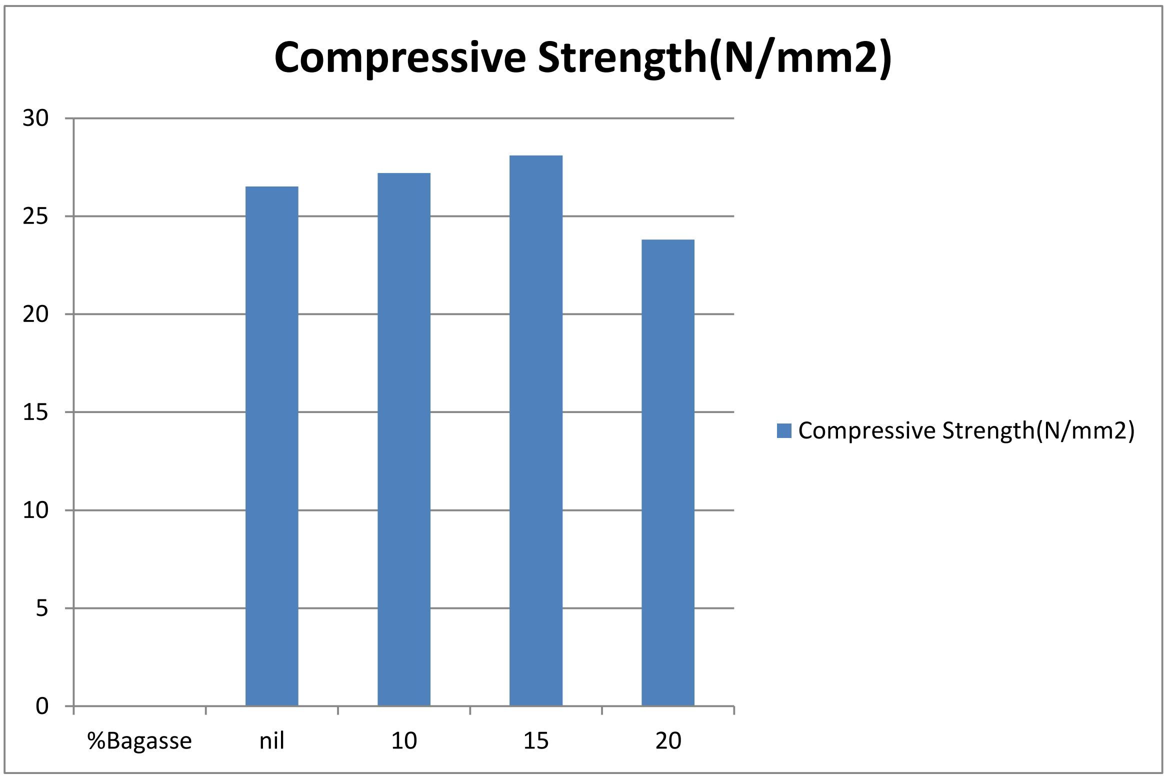

Figure 7: Graph showing relation between 28 day Compressive Strength and % Bagasse replacement used

• When bagasse (passed by 90 micron sieve)) was used as a replacement of cement average density varied between 2423.7 kg/m3 and 2498.7 kg/m3 with increase in bagasse content from 0 to 20%. Compressive strength for 7 days increased from 21.32 to 22.8 N/mm2 for 0-10% bagasse replacement whereas it decreased afterwards when the bagasse replacement was increased to 15% and the resultant compressive strength was found to be 20 N/mm2. 28 days Compressive strength increased from 26.52 to 28.1 N/mm2 for 0-10% bagasse replacement whereas it decreased afterwards when the bagasse replacement was increased to 15% and the resultant compressive strength was found to be 23.8 N/mm2 which is less than our desired result.

CHAPTER 8

8.1) Conclusion

- From this report we came to know basics of green building and the materials that could be used in the building that could be used in it to make the building more energy efficient, environmental friendly as well as economically beneficial.
- With the use of glass in concrete passing through 2.36mm sieve, the density increases by 3.22% whereas the compressive strength decreases by 24.66% with the increase in glass content due to alkali silica reaction, less bond strength and low packaging density.
- Percentage of glass that can replace cement is close to 10% as the results shows compressive strength is close to 25 MPa whereas it is not advised to use more than 5% glass as a safety precaution.
- From further studies of research paper we came to know that due to the presence of large particles of glass (>75 micron),alkali silica reaction takes place which reduces compressive strength of concrete substantially. Also packaging density plays an important factor with the size of particles. Hence, glass of size less than 75 microns should be used.
- The GGBS had been utilized in the work by using it in the building materials as addition to concrete. GGBS concrete showed better performance towards compressive strength. Density of the sample first increased by 3.39% upto 10% replacement and then decreased by 0.8% from 10-15% whereas the compressive strength first increased by 7.65% for replacement upto 10% and then decreased by 19.04% when replacement was increased to 15%. The compressive strength on 28 day of concrete cubes increases from 0% to 10% replacement of sand by GGBS than the reference materials. The optimum compressive strength of slag concretes

has been found to be 27.99 N/mm2 for 10% GGBS. The results show that 10% GGBS replacement with sand is very effective for practical purpose.

- With SCBA replacing cement, density first increased by 3.09% upto 10% replacement and then decreased by 0.83% from 10-20% whereas the compressive strength first increased by 5.96% for replacement upto 15% and then decreased by 15.3% when replacement was increased to 20%.
- It is found that the cement could be advantageously replaced with SCBA up to maximum limit of 15%. Although, the optimal level of SCBA content was achieved with 15.0% replacement. Partial replacement of cement by SCBA increases workability of fresh concrete.
- Error may be due to improper curing, moisture content in cement and human error.


COMPRESSION TESTING MACHINE


Balance(cap.100kg)


500
600
400
kN
700
300
800
200
5 kN
900
100
1000
0
RAM DIA.
SR.NO

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