UTILIZATION OF WASTE MATERIAL IN CONCRETE FOR THE CONSTRUCTION OF RIGID PAVEMENT

A Thesis

Submitted in partial fulfillment of the requirements for the award of the degree of

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CONSTRUCTION MANAGEMENT

Under the supervision of

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by

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to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

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MAY - 2019

STUDENT'S DECLARATION

I hereby declare that the work presented in the project report entitled **"UTILIZATION OF WASTE MATERIALS IN CONCRETE FOR THE CONSTRUCTION OF RIGID PAVEMENT"** submitted for partial fulfilment of the requirements for the degree of Master of Technology in Civil Engineering at **Jaypee University of Information Technology, Waknaghat** is an authentic record of my work carried out under the supervision of **Dr. Amardeep Boora** (Asst. Professor). This work has not been submitted elsewhere for the reward of any other degree/diploma. I am fully responsible for the contents of my project report.

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CERTIFICATE

This is certify that the work which is being presented in the project entitled **Utilization of waste materials in concrete for the construction of rigid pavement** in partial fulfillment of the requirement for the thesis progress of Master of technology in Construction Management and submitted to Department of Civil Engineering of Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by **Ankit Dharma** under the supervision of **Dr Amardeep** (Assistant Professor**),** Department of Civil Engineering , Jaypee University of Information Technology, Waknagath .

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Ankit Dharma

(172606)

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LIST OF ACRONYMS AND ABBREVATIONS

GGBS	Ground granulated blast furnace slag
LFS	Ladle Furnace Slag
OPC	Ordinary Portland Cement
SCBA	Sugarcane Bagasse Ash
RCBW	Red clay brick waste
RCA	Recycled concrete aggregate

ABSTRACT

The present study aims to identify the most suitable way to utilize the waste materials produced from different industries as the replacement of cement for highway construction purposes. Several studies have been conducted across the world which identified the adverse effects of different waste materials on environment as well as on human health also. The basis of different studies, it was revealed that the production of cement on large scale is also responsible for causing several diseases to the human and the water pollution. Therefore, it is the need of the situation to utilize the different waste material as an alternative of cement. For the same purpose several studies were conducted across the world. Consequently, different waste materials were found to be appropriate ranging from 5% to 50% for the highway construction purposes. But, still there is a need to replace the cement completely by introducing another material by considering the chemical composition of cement (i.e. to achieve the same binding property as cement has). In the present study, an attempt has been made to aware the researchers and engineers to manufacture inexperienced concrete in order to attain the balance between environment, economical and technical aspects by highlighting different methods of utilizing the discarded materials (i.e. waste).

Keywords: Cement, Waste material, Highway pavement, Environment

CHAPTER-1

INTRODUCTION

1.1 GENERAL

The economy of any country depend upon a good infrastructure which covers roads, bridges, buildings, warehouses, airports, harbors, instrumentality terminals etc. In today's life, a good infrastructure is a major requirement for the growth of a country which seems impossible to attain without using cement. Cement is a powdery substance which is made up of calcining lime and clay. Mainly cement is used as a binding material which is mixed with water, sand and aggregates for the construction purposes (i.e. highways or building). Though, it is an environmental concern because of the emission of several hazardous gases at various stages of cement manufacturing process. In a previous study (Mehraj et al 2014), it was mentioned that consumption of cement in India is increasing with the rate of 10% per year. It is to note that the cement is the second most consumable material after water across the world.

1.2 INTRODUCTION

The global cement industry produces over four billion tonnes of cement annually. As per the latest report of Indian Bureau of mines (2015), production of cement in India in various companies is ranging from 0.83 to 43.8 million tons per year as shown in table1. 1. Therefore, production of cement in so much quantity has become the point of interest for the researchers across the world as the waste produced (i.e. cement dust) from these cement plants is very harmful to the environment and human health also. Fly ash, steel slag, E-plastic and recycled concrete aggregate are the few examples waste materials which can be recycled and used as a polymer concrete mix which will decrease the consumption of Ordinary Portland cement (OPC) and also help in utilization of energy without causing any environmental pollution. To preserve the natural resources some waste material should be used to maintain the sustainability of the environment. However, some guidelines have been provided regarding the use of fly ash in road construction. Therefore, it is the need to propose an alternative of the cement for the construction work when the people are getting affected by several serious diseases while working in these plants or residing nears these plants. Ministry of Environment and Forests (2016) has notified the emission standards for cement plants. Here, one point is to note that the permissible stack dust emissions limit in India is set to 50 mg/Nm which shows the seriousness of the situation in the country. Table1.2 is exhibiting the main constituents of cement. Table1.3 is showing different bogus compounds of cement which are formed by mixing of cement with water.

Table 1.1 Production of cement by different companies in India

Company	Production (million tones/Year)	Company	Production (million tones/Year)
ACC Ltd	23.84	Orient Paper Industries	4.12
Birla Corp. Ltd	7.62	Penna Cement Industries	3.91
CCI Ltd	0.83	Prism Cement	4.78
J.K. Group	6.3	Lafarge India (P) Ltd	6.85
J.K. Lakshmi Cement	4.21	Malabar Cements	0.53
Century Textiles	7.65	Binani Cement	4.50
India Cements	9.80	Rain Cements Ltd	2.25
Century Textiles	7.65	KCP Ltd	1.55
India Cements	9.80	OCL India Ltd	4.21
Tamil Nadu Cement(e)	0.59	Dalmia Cement	6.6
Ramco Cement	7.69	Cement Manu. Co. Ltd	1.10
Gujarat Sidhee Cement	2.59	Chettinad Cement	5.55
Ultra Tech Cement Ltd	43.88	Zuari Cement Ltd	3.65
Ambuja Cements Ltd	21.54	Heidelberg Cement (I) Ltd	2.84
Jaypee Cement Ltd	13.52	Shree Cement	14.2
Kesoram Industries	5.16	Others*	8.21

Table 1.2 Main constituents of cement

Constituents	%age
Lime (CaO)	60 to 67 %
Silica (SiO_2)	17 to 25%
Alumina (Al_2O_3)	3 to 8**%**
Iron oxide (Fe_2O_3)	.5 to 6%
Magnesia (MgO)	.1 to 4%
Sulphur trioxide (SO_3)	1 to 3%
Soda and/or Potash (Na_2O+K_2O)	.5 to 1.3%

Table 1.3 Different bogus compounds of cement

Compounds	Chemical composition	Abbreviation	Normal %
Tricalcium silicate	$3CaO.SiO_2$	C_3S	40
Dicalcium silicate	$2CaO.SiO_2$	C_2S	30
Tricalcium aluminate	$3CaO.Al_2O_3$	C_3A	11
Tetracalcium aluminoferrite	$4CaO.Al_2O_3.Fe_2O_3$	C_4AF	12

As the natural resources aren't perennial, so we want to seek out an alternative of cement while not compromising with the standard and effective parameters of the final product. In India, waste produced from different construction work and companies was found ranging from 0.10 to 5.14 million tons per year (Shrivastava and Chini 2012) as shown in Table1.4 and Figure 1.1. It was concluded from (Mindess & Young et al 1981) that some changes can be done in the constituents of the cement but it will affect some property of concrete. Among all the bogus compounds, C_3S (Tri calcium Silicate) is responsible for achieving the early strength and the initial setting time of concrete. C_2S (Dia calcium silicate) is used to increase Latter strength of Cement and used as a Low heat cement, used for Mass concreting like bridge, piers, abutments, foundation, water retaining structures, retaining walls etc.C_3A(Tri calcium aluminate) doesn't contribute to Strength but it control the Setting time of Cement and Shrinkage.C_4AF(Tetra calcium Alumino Ferrate) Very low contribution to Strength, Control setting time and Impart colour to cement.

Table 1.4 Waste production by India in construction site

Constituent	**Million tones/year**
Soil, Sand and gravel	4.20 to 5.14
Bricks and masonry	3.60 to 4.40
Concrete	2.40 to 3.67
Metals	0.60 to 0.73
Bitumen	0.25 to 0.30
Wood	0.25 to 0.30
Others	0.10 to 0.15

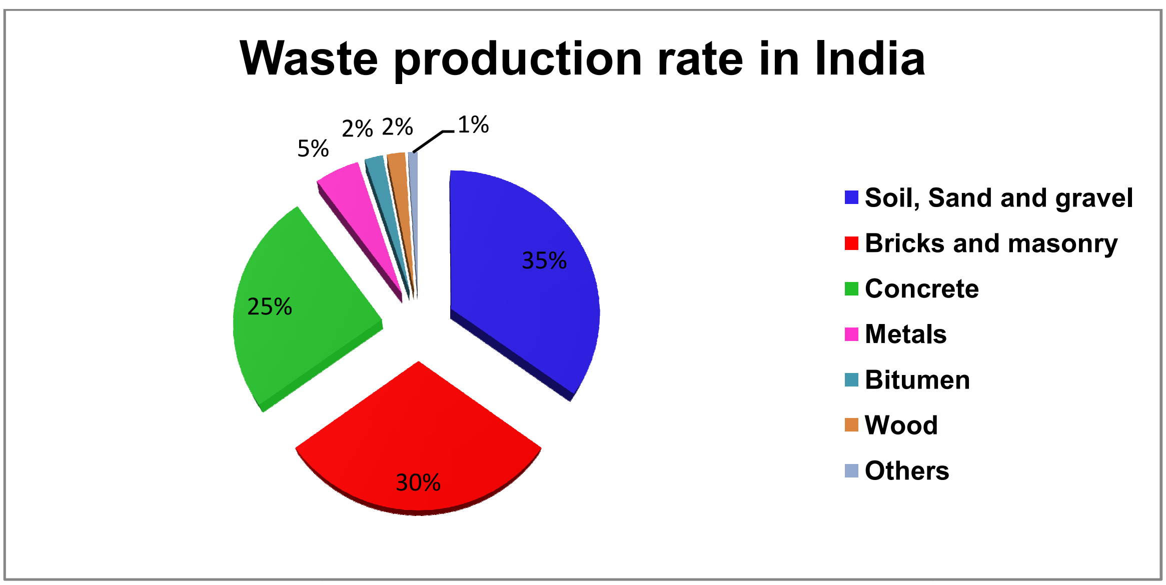

Fig1.1. Waste production rate in India

1.2 .1 Hazardous effects of cement waste

Cement dust produced during the preparation of cement which is considered as waste material. This waste material affects the human as well as other species (i.e. animals and plants) upto a large extent. Both (animals and human) are badly tormented due to the pollution which was occurred by cement manufacturing plants and other waste materials. A brief discussion has been made regarding the consequences of cement waste on the atmosphere, human and other living beings. Mishra et al. (2014) studied the effect of cement manufacturing emissions on surroundings and living beings. In a survey, International Energy Agency (IEA), production of cement in India will manufacture will be reached upto or more than 2000 million tons up to 2050 which will result into global warming, ozone depletion, acid rain, biodiversity loss, reduced crop production, etc. Various diseases like tuberculosis, chest discomfort, chronic bronchitis, asthma attacks, and cardiovascular diseases will be caused by cement production in huge amount as the gases that emit while production of cement is NO_2, SO_2, CO, CO_2, H_2S, VOCs, etc very harmful for the health.

1.2.2 Effects on human health

The most important result of the cement production is human health effects in the 2012 World Health Organization (WHO) reported that worldwide non-communicable diseases are the leading cause of mortality which accounts for 82 % of deaths and among those non-communicable diseases chronic respiratory diseases, asthma, and chronic obstructive pulmonary diseases accounted for 4 million or 10.7 % deaths (Gizaw et al. 2016). Peoples who work in the cement factories or residing near to the cement plants are found largely affected from cement dust which causes lung cancer in the respiratory system, chest tightness, impairment of lung function, obstructive and restrictive lung diseases (Mehraj 2014) which are tabulated in table 1.5. It causes stomach ache and cancer also. Asthma is the most common deceases that found in the worker of cement factory.

Mehraj (2014) conducted a study about the consequence of cement factory. Different consequences that are caused due to cement production are asthma, emphysema, lung cancer, pneumonia, tuberculosis, and cough etc. Employers working in the cement industries also get affected adversely due to the presence of cement dust particles in the air (i.e. as an adult breathe an average of 20000liter of air in a day).

Table 1.5 Respiratory Diseases to cement factory workers

Disease	**Exposed (%)**	**Unexposed (%)**
Allergic reactions that interfere with breathing	96	3
Chronic bronchitis	57	0
Asthma	49	1
Emphysema	9	0
Lung cancer	1	0
Pneumonia	21	1
Tuberculosis	19	1
Shortness of breath	96	10
Cough	96	15
Wheezing	96	21
Seizures	7	1
Chest pain	49	11
Irregular heart beat	51	13
Swelling in legs and feet (not caused by walking)	43	0
High B.P	85	14
Eye irritation	97	12
Skin allergies	95	11
Anxiety	89	12
Fatigue	91	17
Heart burn/ indigestion not related to eating	58	11
Neck and back disorders	59	10

1.2.3 Effect on air and water bodies

Cement plant are the most polluting industries which emits: 5% of the world's total greenhouse gasses. Cement contain huge amount of suspended solid and Chemical oxygen demand (COD) substances which contaminated all the water resources situated nearby to the cement plant resulting in the death of water species due to the presence of nitrate and the phosphors. Cement production causes air pollution which is the worst influence from the past 20 years. Acid rain is also an example of the side effect of cement waste (i.e. due to the emission of very fine dust particle which enters in the atmosphere and causes acid rain). Siddiqui et al. (2011) discussed the impact of the cement industry on groundwater quality. Groundwater which can be extracted by different sort of means like hand pumps dug wells and bore wells etc is the pure form of water which is available on the ground surface. In this study, four samples were collected from a different source of water from different locations. The various test was conducted in the laboratory to measure the turbidity, total hardness, total dissolved solids (TDS), fluorides, nitrates, manganese, chlorides, and Iron, etc. Later, all the results were compared with the guidelines provided by the world health organization (WHO) regarding the portable groundwater. The quality of groundwater was found to be decreasing due to excess of mining and the presence of total solids, alkalinity, total hardness and iron more than their specified limits.

1.2.4 Effect on vegetation and wildlife

As the cement dust covers the whole leaf then due to low chlorophyll content and ovaries of crop plants not fertilized with pollen, cannot grow properly which results in the low production of the crop (Sai et al 1987). On the other hand, an increment in the production of the wheat crop was observed in those fields that were situated far away from the cement plants. Establishment of a cement plant near to wildlife area also affects their population. Loss in the population of the animals causes by eating the leaf of a tree or fruit which get contaminated from the toxic substance (i.e. due to the settlement of dust on leaf etc.). Due to these hazardous consequences, there is a need to propose an alternative to reduce the usage of high carbon cement. Regarding the same, different studies have been conducted around the worlds which are tabulated in table1.6 Fig 1.2 is depicted the different locations affect from cement dust.

(a) (b) (c)

Fig1.2 (a) Cement dust on leaves (b) Animals eating grass near cement factory (c) Water resources polluted by cement dust.

Table 1.6 Different type of waste to be used in construction in past

SNo.	Waste Material	Author (Year)	Remarks
1	Fly ash	Mohammadinia et al. (2017)	Cementinous property of fly ash was examined in order t use with the reclaimed asphalt pavement and crushed bricks. Stability and strength of the pavement was found increased with an addition of 15% of fly ash.
2	Steel slag	Shen et al. (2008)	Steel slag mix with solid waste and used into base layer of pavement. Binding property of steel slag is also compared with cement and found to me more superior all other base material
3	Silica fume	Maddalena et al. (2018)	Low carbon material can be replaced instead of using OPC. 80% of strength can attain by using Silica fumes in concrete.
4	E- Waste	Krishna and Rao (2014)	15% of E-waste can be replaced instead of course aggregate. Optimum compressive and tensile

			strength are provided by using E-waste.
5	Wood waste	Wang et al. (2017)	Magnesium phosphate cement (MPC) mixed with wood waste to check reinforcing efficiency. PVA (polyvinyl alcohol) fiber reinforced also increases flexural strength of MPC.
6	Ground granulated blast furnace slag (GGBS)	Manjunatha et al.(2014)	Addition of GGBS up to 50 % as the replacement of cement in M20 grade of concrete resulted in increment of the compressive strength due to extra fine which reduces the void in the mixture.
7	Recycled course aggregate (RCA)	Wagih et al. (2012)	Replacement of RCA with natural aggregate up to 50% exhibiting the same strength as shown by fresh aggregate. However, a reduction in strength upto 18 % was observed if natural aggregate get replace completely (i.e. 100%).
8	Plastic waste	Jassim (2017)	Cement was replaced successfully with 35% of plastic waste.
9	Marble waste	Ashish (2017)	Cement and sand both of 10%replaced by 20% of marble waste .
10	Rice husk	Sathiparan et al. (2018)	Grinded husk can be replaced instead of using sand only in ratio of 1:5:1 (cement, sand, waste)
11	Bagasse ash	Amin (2011)	20% of cement can be replaced by bagasse ash optimally.
12	Paper waste	Rajput et al. (2012)	Waste concrete brick made up of 85% of paper waste gives highest strength.
13	Ladle furnace slag (LFS)	Marinho et al. (2017)	Huge amount of CaO approx 88% was found so best suitable for replacement of cement.

1.3 OBJECTIVE

1. To study the physical and chemical properties of waste materials and sustainable utilization of waste.
2. To purpose an alternative of cement without compromising with its properties.
3. To optimize the Cost effectiveness of concrete by using different waste materials.
4. To purpose guidelines regarding the use of waste material in pavement construction and make new concrete mix design.

CHAPTER 2
LITERATURE REVIEW

2. 1 GENERAL

To gain some knowledge about the work done and the project work of the waste material and the factors which are related to the attain work objective, various literature writings on research papers which are on this topic were collected and evaluated. This involves collecting the data and materials on the topic, along with research papers, journal articles, outlines and technical details which were already exist in research organizations and government department. After analyzing different research papers, some review was made on the base of personal understanding. It gives a review regarding the use of solid waste and nano particles as alternatives to make green concrete mix. Main motive of this paper was to discuss all the waste material that can be used instead of using cement and aggregate to reduce CO_2 emission which is responsible for the environment pollution. Different waste resources were highlighted in the study that come from agriculture side, industries side and many more In the study it was reported that the addition of nano particle of SiO_2 in concrete mix will increase the strength and durability of structure.

2.2 LITERATURE REVIEWOF DIFFERENT WASTE MATERIAL

2.2.1 Recycled concrete aggregate (RCA)

Wagih et al. (2012) studied the aspect regarding the use of reused concrete and demolished concrete waste as the replacement of natural aggregate (NA). Approx 50 sample were made by replacing of NA with RCA of 0%, 25%, 50%, 75%, 100% and by adding super plasticizer from 0% to 1.3%. Silica fume in very small size were added to 10% of cement. By performing various test different properties of concrete like compressive strength etc, were measured. From the study it was concluded that use of RCA will result in the reduction in the workability of concrete mix and in the compressive strength also. Huda et al. (2014) investigated the property of recycled course aggregate up to 3 generation of usage by replacing 100% of them. Small sample of 100 X 200mm of cylinder and 150 X 150 X 500 mm were casted and randomly tests were examined to know the physical and mechanical properties of aggregates. Compressive and splitting tensile strength was getting reduced a little when RA was used as the substitution of aggregate. Usage of recycled aggregate was showing the similar maximum stress and axial strain value (i.e. 50 MPa and 0.0027 respectively) as shown by the normal mix (i.e. using natural aggregate). Test for Modulus of elasticity and Poisson's ratio showed that recycled aggregate can be reused thrice. Kuo et al. (2012) used the recycled concrete ready with limestone pieces in the subbase layer of flexible pavement. RCA composed up to size of 45mm for subbase layer by crushers etc. Mechanical property like compressive, tensile, shear strengths and modulus of elasticity of RCA was found 40% lesser than fresh aggregate. For conducting various tests like lime rock bearing ratio (LBR), LA abrasion, soundness of concrete, modified Proctor compaction and hydraulic conductivity, two tracks of RCA and one of lime rock were constructed. Ebrahim et al. (2013) provide different factors like gradation, angularity, soundness, and solubility of aggregate were kept in mind to use the recycled concrete as subbase layer of the pavement. On the basis of the findings it was observed that only 70% of required strength can be achieved by mixing of 5% cement with recycle concrete aggregate. However, this value can be increased up to 77%. Courard et al. (2010) examined the suitability of recycled aggregates for the construction of roller compacted concrete (RCC). It is special types of polymer concrete that do not contain reinforcement while the construction of structure. It has high compressive strength and durability and very less sensitive to shrinkage also. Different test like Los Angeles test, specific gravity test and durability test were conducted in the study. Findings of the study revealed that the recycled aggregates can be used as RCC as overall performance was good. Cuttell et al. (1997) check the performance of rigid pavement made up of recycled concrete aggregate. It was concluded that 25% of fine aggregate can be replaced by recycled aggregate by considering the minimum requirement of strength and workability. The recycled portland cement concrete (PCC) mixture has low water cement ratio. RCA had compressive strength of 40kpa which is sufficient for rigid pavement. Other factor like split tensile strength, modulus of elasticity, coefficient of thermal expansion and volumetric surface texture shows average result. Load transfer property is one of the areas where some improvement is required. All over good performance is attended when good amount of PCC is added to RCA. Malešev et al. (2010) replaced the fresh aggregate with recycled aggregate to be used in construction of structural concrete. Three type of mixtures were prepared by replacing aggregate by 0%, 50%, 100%. Later, 99 samples were made to conduct the various tests like slump test, workability, bulk density, air content, water absorption and wear resistance. Among all the samples, a sample made with the 50% replacement of natural aggregate with recycled concrete was showing better result. Wan et al. (2018) examined the usage of waste materials in definite proportion to make light weight self compacting concrete. Different samples were made by using perlite, scoria, and polystyrene lightweight aggregates in varying proportion. After conducting different tests of compressive and tensile strength it was concluded that more waste is added to mix will result in the lesser compressive strength of concrete. Rao et al. (2006) recommended the utilization of aggregate obtained from C & D waste in concrete. Aggregate used in concrete should be free from salts and other rubbish materials which destroyed during demolish building. Workability of RAC in concrete was found to be decreased when the 50% of natural aggregate get replaced with RA (Topcu and Sengel 2004).Silva et al. (2014) measure the properties of recycled aggregates obtained from C & D waste. After demolition four forms of concrete were identified namely first is recycled concrete aggregates (RCA), second is recycled masonry aggregate (RMA), third is mixed recycled aggregates (MRA) and last one is construction and demolition recycled aggregates (CDRA). The density of RMA was found lower than the RCA due to high porosity value. It was also conclude that these materials can be utilized in the construction of subbase layer of roads. Park (2003) gives some guidelines regarding the application in construction material and se of building elastic waste in the subbase layer of the rigid pavement. On the basis of the findings a comparison was made in between recycled concrete aggregate (RCA), crushed stone aggregate (CSA), and gravel. Different properties like specific gravity, water absorption rate, loss angles abrasion value and optimum moisture content were showing the same value as found in case of CSA and gravels. RCA was showing higher shear resistance comparatively gravel and CSA. Xiao et al. (2005) examined the bond strength between recycled concrete and steel bars. The ratio of replacement of recycled concrete was kept in different proportion like 0%, 50%and 100%. After 28 days of curing it was concluded that 100% replacement of RCA will give 20% less compressive strength then natural one. When plane bar was used bond strength was found to decrease from 50% to 100% but in case of deformed bar it remain constant. Singh et al. (2005) examined the suitability of recycled aggregate as a road pavement material. For the same purpose a comparison was made between natural aggregate and recycled aggregate (RA). Virgin aggregate (VA) and RA was mixed with several blend mixture in a ratio of 20% to 80%. Later, CBR and resilient modulus test were conducted. It was observed that 100% of RCA was depicting lesser resilient modulus value then the 100% VA but RAP was having higher value of resilient modulus then VA. So, it was concluded that RAP is better than RAC for the subbase layer of pavement.

2.2.2 Red clay brick waste (RCBW)

Few yew year before Robayo et al. (2016) investigated the behavior of RCBW as alkaline and admixture of Na_2SiO_3 and OPC. Five samples were made during the study. Out of which one sample consisting 100% RCBW and remaining samples were contained OPC in different proportion i.e. 5%, 10%, 15%, 20%. It was observed that 10 % of OPC sample mixture shows utmost compressive strength of 41.39 MPa. It was also found that addition of corroborates increase the compressive strength of the mix. The whole combination of NaOH + Na_2SiO_3 and 20% of OPC gives strength of 102.6 MPa at 25°C. Poon et al. (2005) found the sufficient use of RCA and crushed RCBW as sub-base layer of pavement. Three mixtures were made of recycled concrete aggregate and crushed clay brick in different ratios. The percentage of clay bricks was kept in different proportion like 0%, 25% and 50% respectively. During the study subbase made up of crushed clay was found less susceptible to moisture. After analyzing results it was concluded that the use of 100% recycled concrete aggregates instead of natural aggregate will result in the increment in the optimum moisture content and while maximum dry density will be decreased. Subbase consisting of crushed clay brick was exhibiting a lower CBR value in comparison to the subbase consisting of recycled concrete aggregate. Balbo et al. (2015) conducted a study to examine the effect of crushed stone used in high quality cement for concrete pavement. To make the samples, aggregate were mixed in various proportion i.e. 0/0.5 mm, 5/2 mm, 2/4 mm, 4/8 mm, 8/16 mm and 16/32 mm. It was concluded that the crushed stone treated cement can be used for subbase layer of rigid pavement. Jaroslav et al. (2017) studied the effect on mechanical properties of cement paste by adding concrete powder in it. Different 5 samples were made by varying the percentage of RCP from 0% to 50%. Beside this, one sample of Portland cement was also made to make the comparison. All the results obtained from different tests were based on 28 days curing time period. Impact resonance test was conducted to calculate Young's modulus for each sample. Use of RCP up to 30% showed higher porosity and lower modulus of elasticity. The uniaxial compressive test concluded that compressive strength decrease with increase amount of RCP more than 20%. Flexural strength was found to be higher than cement paste with the use of 20 % of RCP. The bulk density was found to be decreased with the increment in the percentage of RCP.

2.2.3 Fly ash

Mohammadinia et al. (2017) studied the effect when fly ash is mixed with crushed brick (CB) and reclaimed asphalt (RAP) in the subbase layer of flexible pavement. Aggregates of CB and RAP having size of 20 mm were accumulated from factory where recycling is done. Fly ash (FA) is added in different proportions. A number of compaction tests were conducted on CB and RAP to determine the OMC and MDD. To calculate the unconfined compression strength (UCS) test, dry aggregate were combined with relative moisture content for 2 hours before addition of FA. CB and RAP aggregates were blended with the range of 5%, to 30% of FA then tested for the maximum strength con achieved for which %. When 10% of FA is added then pores of RAP is filled and up to 20% it will get its maximum strength. All the tests were conducted by curing the samples in a humidity restricted box for 7 days. It was concluded that the 15% fly ash can be utilized for pavement bases as well as a cementitious material for the pavement.Wang et al. (2017) examined the effect on concrete when fly ash is added to mix. Fly ash was added to mix in replacement of cementitious material like cement. While preparing sample for testing w/c ratio have to kept .35 and .25 and replacement of cement from 8% to 15% can be done. Test to find compressive strength, chloride permeability and shrinkage of new concrete mix. After analyzing result it was found that 15% substitution give the optimum result. Shaikh and Supit (2015) calculate that by using 8% of ultrafine fly ash (UFFA) in the concrete, compressive strength porosity and durability get increased by forming extra C-S-H gel. Jerath and Hanson (2007) conducted the study to check the durability of concrete by increasing the gradation of aggregate with fly ash content. The usage of high quantity of fly ash decreases the water content of mix which gives high compressive and flexural strength. Dense graded aggregate with 45% of fly ash in place of cement reduces the specific gravity, permeability, absorption and voids in concrete mix which increase the durability of the rigid pavement in every climate conditions. Anupam et al. (2017) conducted the study by utilizing industrial waste in roads. Fly ash was mixed with soil to increase the bearing capacity of lower surface layer of pavement. Adding waste in ranging from 0 to 35% by weight of soil sample are made. Various test like California bearing ratio test, unconfined compressive strength test, triaxial test and micro structural investigation were performed. Results concluded that 25% mix sample increases the property of soil for the pavement.

2.2.4 Sugarcane Bagasse Ash (SCBA)

Amin (2011) conducted a study to examine the impact on strength or chloride resistivity by using bagasse ash in concrete. Ranging from 5% to 30% different proportion of bagasse ash was replaced in place of cement. Surface area of bagasse ash was higher than cement but density, specific gravity and mean grain size were low. It contain large amount of silica content and Al_2O_3, Fe_2O_3, and CaO also. While conducted various test for compressive strength, splitting tensile strength, chloride permeability and chloride diffusion it was found that 20% of OPC can be replaced by bagasse ash. Without compromising its quality, strength, workability, water permeability and durability bagasse ash is suitable for replacement. Deepika et al. (2017) examine the property of bagasse ash as a construction product. Bagasse ash when added to concrete alkaline byproduct was formed which will increase the durability of mix. Up to 20 % of bagasse ash was replaced and various tests were performed to know the compressive strength, abrasion resistance, water absorption, water permeability and sorptivity. Results concluded that possibility of replacement 20% had no harmful effect on concrete. Cordeiro et al. (2007) conducted a study to define the fineness of bagasse ash to be used in concrete. For the 20% replacement of cement, fineness of the bagasse ash was less than 60 μm particle size which does not allow compromising its compressive strength.

Bahurudeen et al. (2015) examine the performance of bagasse ash as a alternative supplementary cementitious material in concrete. Due to high composition of silica (SiO_2) in bagasse ash, formation of CSH gel was more by reacting with calcium hydroxide in cement. By performing different test for compressive strength, heat of hydration, drying shrinkage and durability it was concluded that 25% of replacement can be done. Mangi et al. (2017) conducted a study to replace cement partially by using sugarcane bagasse ash. Fine aggregate which was less than 4.75mm and bagasse ash passing from 300µm sieve was selected to made M20 and M15 grade of concrete. Replacement of bagasse ash was done in range of 0% to 10%. Result concluded that 5% will increase the compressive strength up to 12% from conventional concrete. Slump value will be more which increase the workability of concrete without adding superplastizer.

2.2.5. Steel slag

Shen et al. (2009) studied the application of steel slag, fly ash and phosphogypsum as the road base course materials. Due to the presence of C_3S, C_2S, C_3A and C_4AF elements steel slag can be used as the replacement of cement. Use of steel slag and fly ash in the ratio of 1:1 with 2.5% of phosphogypsum exhibiting 28 days strength around 8.36 Mpa which is much higher than other base material of the pavement. The splitting strength and resilience modulus of steel slag and fly ash was found higher than lime fly ash soil which makes it superior to be used as a base material.Liu and Guo (2018) check the performance of high strength concrete which was made up of steel slag powder. When the 10% replacement of cement was done with pores less than 50nm their will be no change in the strength of concrete. Steel slag was reacting like admixture, which improve the workability and fluidity of mixed concrete. Liu and Wang (2017) studied the influence on plain concrete by adding steel slag silica fume in it. Silica fume and steel slag were used in a ratio of 92:8 and 84:16 after mixing for 10 min in mixture. Sample was tested for compressive strength, splitting tensile strength, chloride ion permeability, carbonation and drying shrinkage. Examine the results it was concluded all the property was better than the plain concrete.

2.2.6 Ground granulated blast furnace slag (GGBS)

Manjunatha et al. (2014) studied about the usage of GGBS as the partial replacement of OPC cement. A comparison was made in the durability and permeability of GGBS based concrete with fly ash based concrete. Composition of GGBS is found analogous to the conventional cement. Compressive test and durability test for each grade of concrete was conducted. Up to 50% of replacement of GGBS to OPC gives same strength after 28 days. By conducting Rapid chloride penetration test (RCPT) it was analyzed that continuous substitution of cement with GGBS decreases the voids in the mix and increase the strength of structure after long time period. Some factor like good quality, availability, energy effective, low cost makes GGBS more sustainable material for future generation. From many years GGBS is treating like a waste material of steel making industry but from now onward it was so useful for protecting our environment from polluting. Das et al. (2015) conducted a study to use GGBS contain concrete to marine environment. Cylindrical 16 sample were made and some are exposed to water contain NaCl and $CaCl_2$and some to normal water. Result concluded that by adding GGBS to concrete permeability of concrete get decreased so that possibility of chloride penetration will decrease to 36%. Which decrease the deterioration of concrete under sea water. Kuo et al. (2013) after late stage of curing the compressive strength of GGBFS get increased due to the pozzolanic reaction with mix. Mehta and Siddique (2018) conducted study to examine the strength and permeability of concrete which was made by using GGBS and rice husk ash (RHA). Globally 300MT of GGBS was produced from steel industries. RHA has large amount of silica oxide because of that both were most suitable to replace the conventional cement as an alternative of binder. The specific gravity of GGBS and RHA which was used in mix were calculated to be 2.68 and 2.23, respectively. GGBS were used in ranging of 70% to 100% and RHA was in range of 0% to 30%. Various tests are performed to measure the strength of concrete after 90 days of curing. Also different tests were also performed to observe the microstructure property of the waste specimen. After examine the results it was concluded that sample of 15% RHA was optimum for the replacement of cement with 85% of GGBS.

2.2.7 Ladle Furnace Slag (LFS)

Marinho et al. (2017) conducted study to use ladle furnace slag (LFS) as a binder in cement concrete mix. Ladle furnace slag (LFS) is a by-product of low carbon steel production, obtained from the process of secondary refining in ladle furnaces The main components of the LFS are calcium, silicon, magnesium, aluminum oxides, and calcium silicates under various allotropic forms. LFS is obtained in a slow cooling process and presents a large content of fine particles, with 20–35% below 75 μm. Calcium oxide and calcium magnesium silicates are the 88% of total mix. After lots of tests it was concluded that utilization of LFS instead of lime for cement composite based material. It is the best suitable material for the partial alternate of cement. Razenovic et al. (2011) conducted chemical analysis which represented that the main compounds are calcium, silicon magnesium, and aluminium oxides are more than 92% of the whole mass. Manso et al. (2005) conducted a study of utilization of LFS in construction. Test was conducted to find that it will be suitable for paving roads in place of cement. It was concluded that LFS appears appropriate for paving roads as a soil–cement mixture. The cheap cost and time dependent properties, i.e., bearing to load and resilience, also donate to its potential use.

2.2.8 Rice husk Ash

Sathiparan et al. (2018) measures the effect on cement block by partially replacement of sand by some agricultural waste. Open dumping of agriculture waste causes various health hazards and also pollute the environment. Cement block were made up of agricultural waste like rice husk. Cement, sand and waste materials were mixed in different proportion like (1:5:1), (1:4:2), (1:3:3) to make 400 sample. Test was conducted to determine the compressive strength and flexural tensile strength ”density, water absorption rate,” acid attack resistance and alkaline attack resistance of sample after done the curing of 28 days at room temperature. It was concluded that cement block of 1:5:1 gives equal strength of normal mix of block as all the properties were found similar the normal one. Zabihi et al. (2018) investigated that rice husk ash mix with geopolymer concrete assure 100% replacement of cement unless property like Water absorption, flexural strength and splitting tensile strength get compromise to some extent.

2.2.9 Plastic waste

Jassim (2017) conducted a study to introduce the plastic cement based on the recycling of polyethylene waste. In now days, polyethylene is the most dangerous material that is harmful for our environment due to its low biodegradability. This problem can be resolved by using polyethylene in replacement of sand in mix. The partially replacement of high density polyethylene waste (HDPW) with portland cement was used in different ratio like 15%, 20%, 25%, 30%, 35%, 40% 50%, 60% and 80% by volume. Cube sample were made and allow them to dry and put them into water for 3-4 days for curing. Different characteristics like density, moisture, workability, durability and compressive strength of each sample were examined. Utilize of the plastic waste from 25 to 35 % showed the increment in the density and compressive strength in comparison to the conventional concrete mix. However, workability was found to be decreased with the increase in the amount of plastic waste. Kumar and Baskar (2014) utilized the recycled plastic as a construction material in India. From 10 to 50 % of volume ranging, the coarse aggregate was partially replaced by E-plastic with dissimilar percentages. M25 grade of concrete mix was formed by keeping w/c ratio of 0.49. Different tests were performed to calculate the different type strengths and surface dry density. On the basis of the results it was concluded that the plastic waste can be utilized upto 30% without compromising with the property of mix (i.e. exhibiting the same compressive strength as of conventional mix). Appiah et al. (2017) uses the plastic waste in the construction of pavement. Main focus was to reduce the creation of potholes on roads due to extreme traffic and axle weight. This study was conducted to check the effect of unification waste like thermoplastic polymers in bituminous pavement. The result concluded that utilization can be done up to some extent.

2.2.10 Silica fumes

Maddalena et al. (2018) examined the suitability of low carbon waste material as the replacement of Portland cement. A comparison was made with the properties of OPC by investigating physical, thermal and mechanical properties of silica fume and in small form nano-silica in order to remove some elements and to add some green binders. Different test namely compressive strength, X-Ray diffraction and scanning electron microscopy (SEM) were conducted during the study. From the study it was concluded that the different low carbon material proposed in the study can be used for the construction purpose without compromising with the required strength. Along with this, harmful impact on environment by these new composites of cement was examined by considering the carbon emissions factor (i.e. during manufacturing and production process). For all the samples, carbon footprint value was found 23-55% lower than Portland cement. Kurup and Kumar (2017) conducted a study to check the shear strength of concrete by adding silica powder and recycled PVC waste. 10% of silica was replaced by cement and 21% of shear strength get reduced when compared with normal mix.

2.2.11 Marble powder

Ashish (2018) conducted the study to attain sustainable growth check the feasibility of waste marble powder in concrete as a replacement of cement and sand. Waste that was generated by marble was about 3Mt per year and the country which producers largest of marble waste is India. After studying some past studies it was found that 10% of diatomite and 5% marble powder mix is the perfect replacement of concrete. Cube of (150 X, 150 X 150) and (100 X 100 X 100) and cylindrical specimen of (150 X 300) were made by using some variable in cement type, marble power, aggregate, sand and water cement ratio etc. various test were conducted to measure the workability, compressive strength, tensile strength and carbonation in mix. The optimum result is found when 10% of sand and 10% of cement is replaced by 20% of marble powder. Durability of marble powder was improving which indicate that it was most suitable additive to the concrete. Singh et al. (2017) determine the long term effect when marble powder slurry is used in place of cement in concrete. By weight 0 to 25% of cement was replace. Samples were tested for 7, 28, 56, 90, 180 and 360 days to know its Compressive strength, split tensile strength, flexural strength, water permeability, abrasion resistance and sorptivity. Results concluded that 15% replacement of cement by marble slurry was optimum for all conditions.

2.2.12 Palm oil waste and ceramic waste

Mazenan et al. (2017) analyzed a review study regarding the partial replacement of cement in place of palm oil fuel and ceramic waste. By reviewing past studies it was identified that the replacement of cement can be done by incorporating 20% of palm oil and 30 % of ceramic waste. Furthermore increment in the percentage of palm oil and ceramic waste, there must be reduction in the potency of concrete. Siddique et al. (2018) conducted a study by using bone china ceramic waste as a fine aggregate for the green concrete mix. It was concluded that 60% replaceable sample shows the maximum compressive strength due to similar composition to cement.

2.2.13 Volcanic ash

Patil et al. (2018) investigated a study by replacing some percentage ratio of cement by adding volcanic ash into the concrete mixture. Different sample were casted in different ratio of 10 to 50%. It was examined that up to 40% OPC can be partially replaced by volcanic ash. After that reduction in strength and rusting of the reinforcement will take place due to the presence of various chlorides in volcanic ash which decreases the durability of concrete.

2.2.14 Wood waste

Wang et al. (2017) utilized wood waste with magnesia-phosphate cement (MPC) into fiber reinforcement. To deal with wood particles MPC is the most suitable binders with fast setting property (i.e. 5 min). While using MPC some properties have to be kept in mind are their high brittleness, low strain capacity, and low water resistance. To achieve the required strength dosage of polyvinyl alcohol (PVA) in different proportion was added into MPC. It was evident on the basis of the results that the use of 12mm of fiber length, 2% dosage of PVA and 35 um diameter of wood fiber reinforcement will give the maximum flexural strength and tensile strength.

2.2.15 Paper waste and cotton

Rajput et al. (2012) conducted a study on Waste crete bricks by using recycled paper waste and cotton. Sixty sample were made by using paper waste (PW), cotton waste (CW) and Portland cement in different proportion of 85-89% PW + 10% Cement + 1-3% CW. By performing various test compressive strength, specific weight, equilibrium moisture content, water absorption and thermal conductivity was measured for each sample. It was concluded by examine the results that 85% PW–5% CW–10% cement was the optimum composition. Gree et al. (2018) conducted study to replace cement by paper sludge fly ash; however, its huge water requirement limits the replacement level to 10%. By substitution up to 60% in boards make it mechanical, thermal-insulating, and sound-absorbing suitable for sustainable material

CHAPTER 3

METHODOLOGY

3.1 GENERAL

This chapter gives details about the experimental setup and different methods that are to be done and helps to achieve objectives followed in this project work. After studying various research papers it comes to know that cement can be replaced by using that type of waste material which contains a high amount of CaO. To increase the strength silica content have to increase so that a large quantity of C-S-H gel will be formed that increases the durability and workability.

3.2 Material and Methods

After comparing the composition of various waste materials with OPC cement it was concluded that waste material like GGBS, LFS and Bagasse ash will be suitable for the partial replacement of cement as shown in table 3.1. In place of sand, stone dust will be used and for aggregate recycled aggregate will be used to some percentage. Different test that will be conducted is shown in table 3.3 to know the best suitable percentage of replacement of cement. In the end, the cost of conventional concrete will be compared with new green concrete.

Table 3.1 Sample to be made of different proportion

Cement %	GGBS %	Ladle furnace slag %	Bagasse ash %
100	0	0	0
95	5	5	5
90	10	10	10
85	15	15	15
80	20	20	20
75	25	25	25
70	30	30	30
65	35	35	35

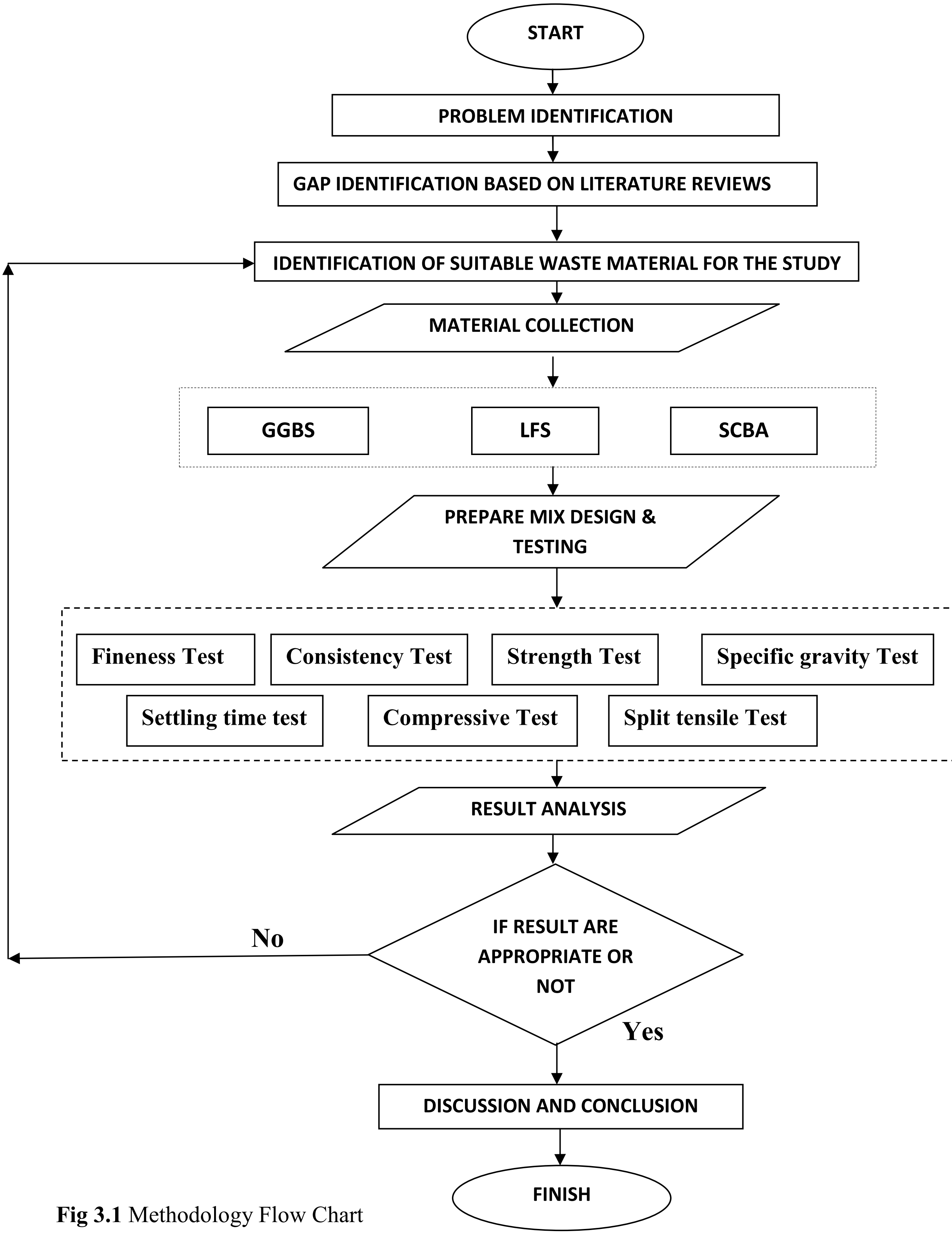

Fig 3.1 Methodology Flow Chart

Table 3.2 Difference in chemical composition of cement and different waste materials. (Siddiqui et al. 1970)

Waste type	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2	MnO
OPC	20.27	5.32	3.56	60.41	2.46				
GGBS	35.00	13.00		40.00	8.00				
Bagasse Ash	78.34	8.55	3.61	2.15	1.65	3.46	0.12	0.50	0.13
Ladle furnace slag	15.00	14.30	1.54	48.37	15.25	0.36	0.43	0.20	

3.2.1 DIFFERENT TYPE OF TEST

1) Normal Consistency test

The consistency of the cement test follows the IS 4031 (4) - 1988. The test for determining the consistency of cement was performed using Vicat's apparatus and consistency plunger. The water paste of cement was prepared using the water mix and was filled in the Vicat's mould. The water-cement ratio was taken as 25%. The gauging time should not be more than 5 minutes and should not be less than 3 minutes. The penetration value should lie between 7 to 5 mm and that water percentage is considered as the consistency of cement.

2) Initial & Final setting time

The initial & final setting time test for cement follows IS 4031 (5) - 1988. The test for determining the initial and final setting time of cement was performed using Vicat's apparatus and setting time needles. The water must be added, "0.85P" by weight of cement, where "P" is the standard consistency of cement. The initial setting time of cement was measured using 1mm penetration needle failed to penetrate at 5 -7"mm from the bottom of the mould. And, the final setting time of cement is the time at which"1mm penetration needle makes an impression on the mould 5 mm assembly failed to make any impression on the mould.

3) Specific gravity of cement

Fill the empty specific gravity bottle with cement and measure weight of it. After that remove half of the cement from bottle and measure its weight. Now fill the half empty bottle with kerosene and note down the weight of it. At last empty the density bottle and take weight. By some standard formula specific gravity was calculated.

4) Tensile strength of cement

Take 300g of cement, 900gm of sand and water (P/5 + 2.5) of water, then mix them properly. Put mix into briquette mould. After 24hr open the sample and put in curing tank for 3 and 7 days.

5) Compressive strength of cement

The cube of size of 7cm x 7cm x 7cm was constructed with the help of cement motor. This test was conducted after measuring the consistence of cement so that that much amount of water is used while making sample and standard vibration machine is used for compaction. After constructing cube they were tested in CTM for 7, 14 and 28 days respectively.

6) Specific gravity of sand

Pycnometer method is used to determining the specific gravity of sand. Take weight of empty pycnometer. Fill pycnometer with sand and take weight of it, after that fill that bottle with half sand and half water and measure the weight of it. After taking readings fill pycnometer with water. Now with the help of formulas calculate the specific gravity.

7) Specific gravity of coarse aggregate

The test for determining the specific gravity of coarse aggregate follows IS 2386 (3) – 1963. Using the wire bucket, the specific gravity test for coarse aggregate was performed.

8) Compressive strength of concrete

The test for the compressive strength of concrete blocks can be checked by compression testing machine after 28 days curing. The concrete cubes are of dimension 150 mm x 150 mm x 150 mm were prepared using mix of grade M40. Before casting the cubes, the cubes mould should be cleaned properly and coat inside with oil and use fresh water for curing process. Mould should also subjected to vibration so that minimum number of void remain in sample.

9) Split tensile strength of concrete.

Split tensile test was performed with the help of UTM on cylindrical sample. Load was applied on the horizontal surface at height of cylinder. Two wood strips will applies at top and bottom surface where load was applied so that crushing of concrete does not take place where plane surface of UTM and surface of specimen meets. Size of cylinder sample will be 150 mm dia and 300mm height.

Table 3.3 Different tests that has to be performed

Cement	**Concrete**
Fineness Test	Compressive Strength Test
Consistency Test	Split Tensile Test
Strength Test	
Specific Gravity Test	
Settling Time test	

3.3 DESIGN MIX PROCEDURE

This study aims to make use of the waste material for replacing the cement and using in construction of roads. Therefore, mix design of M40 grade concrete was done by following the guidelines of the Indian standards which is namely; IS: 465-2000 and IS 10262 -1982**.** With help of these codes the quantity of concrete required for 1 cubic meter can be estimated and at which water cement ratio concrete going to be mixed is also selected from these codes as shown in Fig 3.4.

Table 3.4 Mix proportioning of concrete for $1m^3$

S.No.	Materials as per (IS 456-2000)	Calculated Value (IS 10262:2009)
1	Cement	350 kg/m^3
2	Water	1140 kg/m^3
3	Fine Aggregates	896 kg/m^3
4	Coarse Aggregates	1140 kg/m^3
5	Chemical Admixture	7 kg/m^3

3.4 ESTIMATION OF THE QUANTITY OF CONCRETE MIX

The calculations of concrete as per unit volume shall be measured as follows:

The volume of cubes = 0.15 X 0.15 X 0.15X 3 = $.01012m^3$

Cement = 350 X .01012 = 3.54 kg

Sand = 896 X .01012 = 9.97 kg

Aggregate = 1140X.01012 = 11.53kg

Water = 140 X .01012 = 1.41kg

Admixture = 7 X .01012= 0.0708kg

After calculating the quantity some sample were made of some specific size and shapes. Cubes are made for to test the compressive strength of concrete and cylinders are made to measure the tensile strength of concrete. Step by step all the procedure is shown below with the help of different diagrams.fig 3.2 shows the casting of cubes and fig 3.3 shows cylinder moulds filled with concrete. After remolding then sample has to be kept in curing tank for 28 days. Before testing sample should be in dry condition, then with the help of CTM strength was measured.

Fig 3.2 Casting Cube sample

(a) (b)

Fig 3.3 (a) Cylinder mould, (b) Casting cylinder sample

Fig 3.4 Curing tank

Fig 3.5 Sample after curing

Fig 3.6 Compressive testing machine

Fig 3.7 Universal testing machine

(a) (b)

Fig 3.8 (a) Tested cube sample, (b) Tested cylinder sample

CHAPTER 4
RESULTS ANALYSIS

4.1 GENERAL

Different test of materials are conducted to check the suitability of available material. Test of sand, aggregate and cement was performed. According to mix design every material should posses the same property and same values. Test like Normal Consistency test, Initial & Final setting time, specific gravity of sand cement and aggregate, water absorption. And compressive strength was performed. Quantity required for making sample was also estimated.

Different tests were performed for testing OPC and the results obtained from these tests were compared.

Table 4.1 Values of different test results

S.No.	Experiments	Results
1	Normal consistency of cement	27%
2	Initial setting time of cement	27 min
3	Final setting time of cement	7 hours
4	Compressive strength of cement 3 days 7 days 28 days	$21 N/mm^2$ $30 N/mm^2$ $42 N/mm^2$
5	Tensile strength of cement 3 days 7 days	$22 kg/cm^2$ $27 kg/cm^2$
6	Specific gravity of cement	3.12
7	Specific gravity of fine aggregate	2.74
8	Specific gravity of coarse aggregate	2.67

The cube with standard size of 150 X 150 X 150 mm was used to find the compressive strength of concrete by using waste material in them. Place cubes inside the plates of CTM and apply a constant rate of loading until failure of cube will occur. The ultimate load was measured as shown below in table 4.2.

Table 4.2 Compressive strength by using GGBS for 7 days

% Replacement of GGBS	Casting –I (MPa)	Casting – II (MPa)	Casting – III (MPa)	Average (MPa)
0%	26.42	27.41	27.21	27.01
5%	30.08	28.22	29.64	29.31
10%	30.22	30.66	31.02	30.63
15%	27.77	28.00	28.17	27.98
20%	26.53	26.35	25.91	26.26
25%	23.77	24.71	24.22	24.23
30%	21.33	20.57	20.84	20.91
35%	18.66	19.22	19.73	19.20

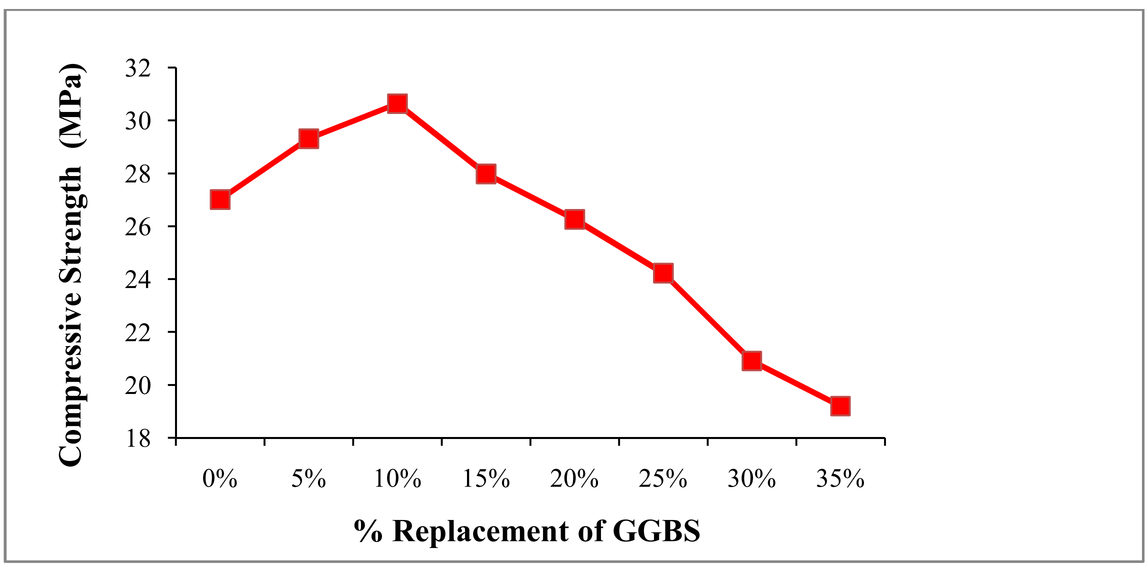

Fig 4.1 Fluctuation in compressive strength with the % of GGBS for 7 days

Table 4.3 Average Compressive strength by using GGBS for 28 days

% Replacement by GGBS	Casting –I (MPa)	Casting – II (MPa)	Casting – II (MPa)	Average (MPa)
0%	40.65	42.17	41.87	41.56
5%	42.77	44.09	46.52	44.46
10%	43.12	45.90	46.86	45.29
15%	42.57	40.66	40.73	41.32
20%	39.17	40.34	40.18	39.89
25%	38.97	38.15	38.74	38.62
30%	37.41	35.80	36.85	36.68
35%	34.00	35.80	30.50	33.43
40%	31.67	33.39	32.80	32.62
45%	32.45	30.22	30.54	31.07
50%	29.41	28.32	26.19	27.97

In fig 4.2 Compressive strength for 28 days by using GGBS gives optimum results, when cement was replaced up to 15%. At 10 % replacement there was an increment of 12% compressive strength.

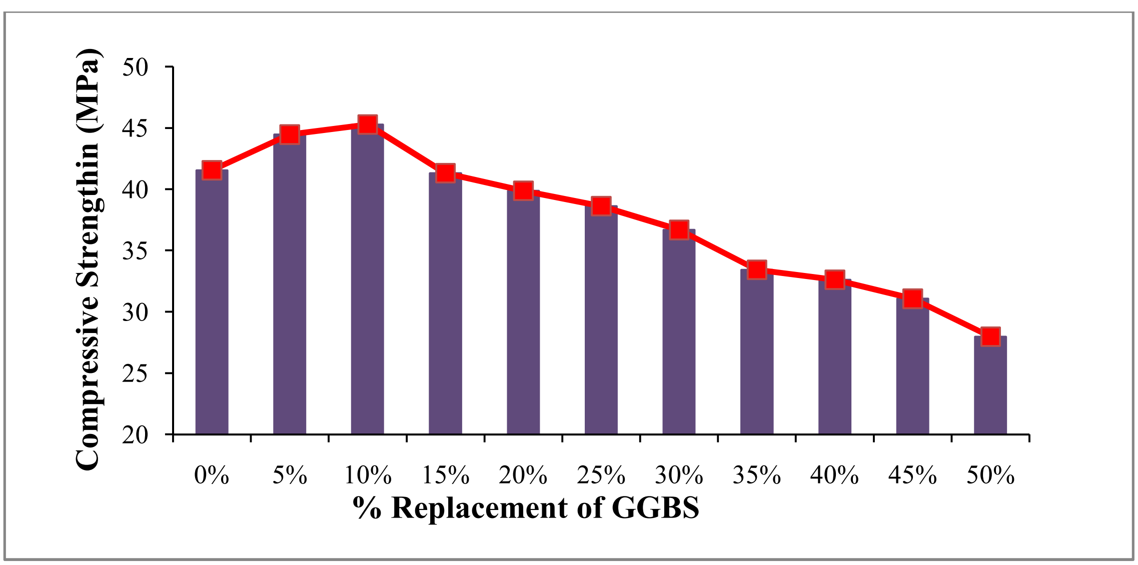

Fig 4.2 Fluctuation in compressive strength with the % of GGBS for 28 days

Table 4.4 Compressive strength by using LFS for 7 days

% Replacement by LFS	Casting –I (MPa)	Casting – II (MPa)	Casting – III (MPa)	Average (MPa)
0%	26.42	27.41	27.21	27.01
5%	28.66	26.22	27.73	27.53
10%	29. 57	31. 84	30. 33	30.58
15%	29.85	28.73	29.12	29.23
20%	26.56	27.80	26.95	27.01
25%	25.17	24.15	23.80	24.37
30%	21.28	22.37	21.65	21.76
35%	20.22	19.02	19.66	19.63

In fig 4.3 showed that LFS 20% replacement was observed without compromising with its strength. After 7 days rate of increasing strength is ideal to get better strength.

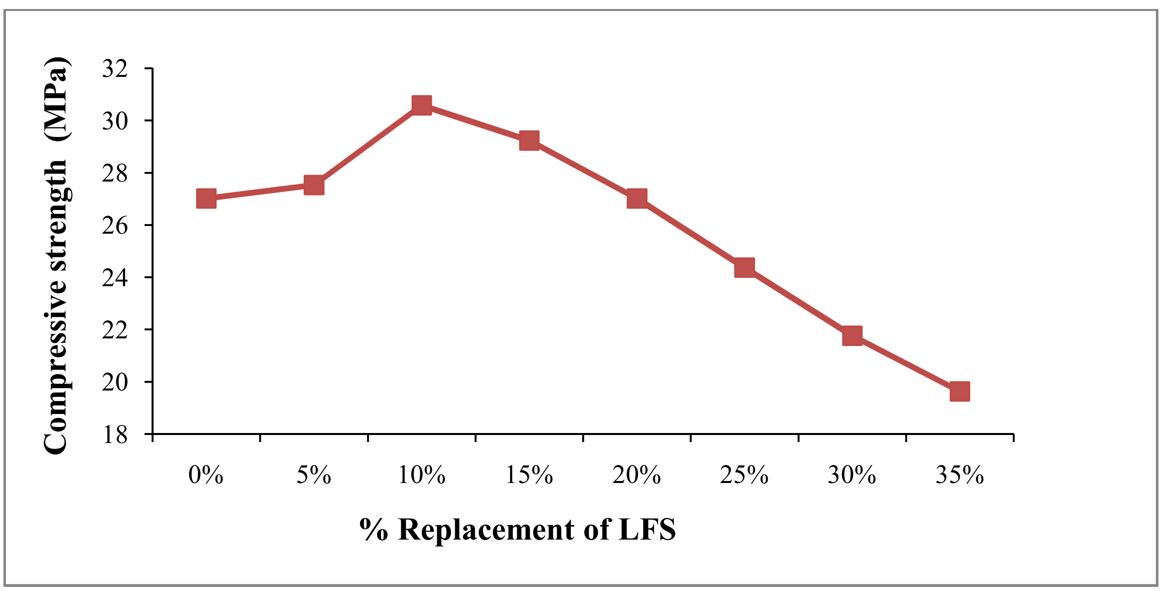

Fig 4.3 Fluctuation in compressive strength with the % of LFS for 7 days

Table 4.5 Average Compressive strength by using LFS for 28 days

% Replacement by LFS	Casting –I (MPa)	Casting –II (MPa)	Casting –III (MPa)	Average (MPa)
0%	40.65	42.17	41.87	41.56
5%	43.15	40.97	42.65	42.25
10%	42.55	44.73	45.34	44.20
15%	46.87	44.17	43.65	44.89
20%	42.96	40.19	40.74	41.29
25%	39.18	39.52	38.15	38.95
30%	37.50	37.70	36.24	37.14
35%	35.14	33.46	32.71	33.77
40%	31.74	34.83	30.27	32.28
45%	29.85	28.21	26.91	28.32
50%	27.77	25.34	26.69	26.60

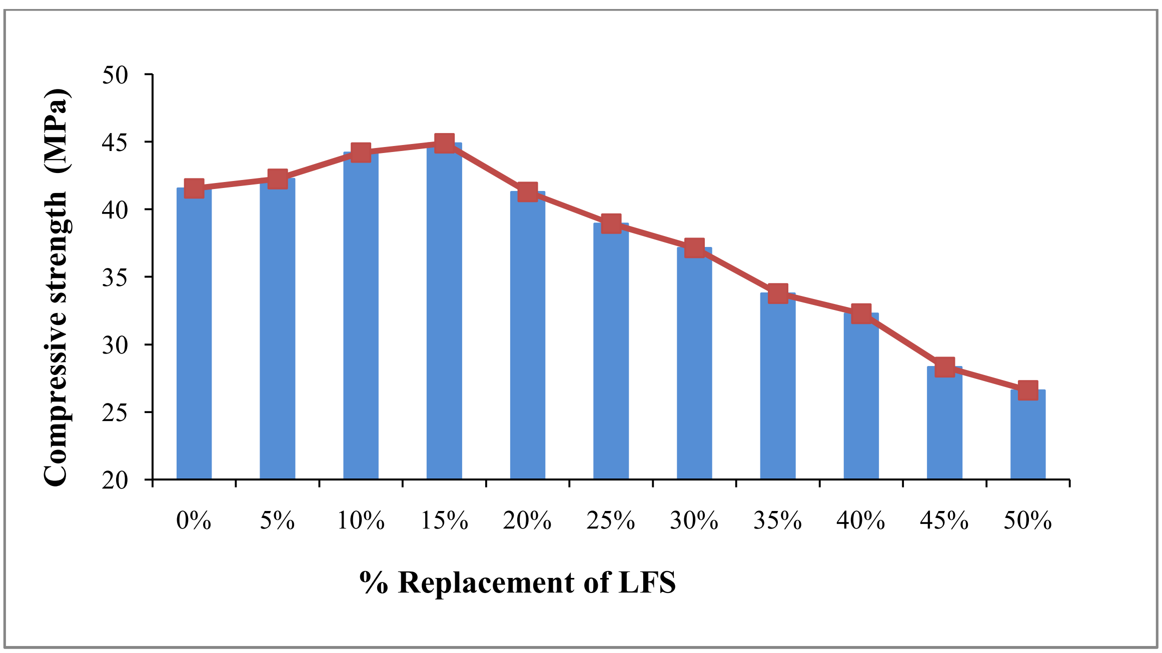

Fig 4.4 Fluctuation in compressive strength with the percentage of LFS for 28 days

Table 4.6 Compressive strength by using SCBA for 7 days

% Replacement by SCBA	Casting – I (MPa)	Casting – II (MPa)	Casting – III (MPa)	Average (MPa)
0%	26.42	27.41	27.21	27.01
5%	26.43	27.77	28.83	27.67
10%	29.23	29.48	30.59	29.76
15%	30.18	29.11	28.57	29.28
20%	28.59	27.85	26.74	27.72
25%	25.48	25.49	24.79	25.25
30%	23.83	24.83	24.28	24.31
35%	22.85	22.28	21.92	22.35

After that in Fig4.5 and 4.6 SCBA was partially replaced upto 50% and it was concluded that 15 % gives the maximum strength after 7 days and 28 days of curing.

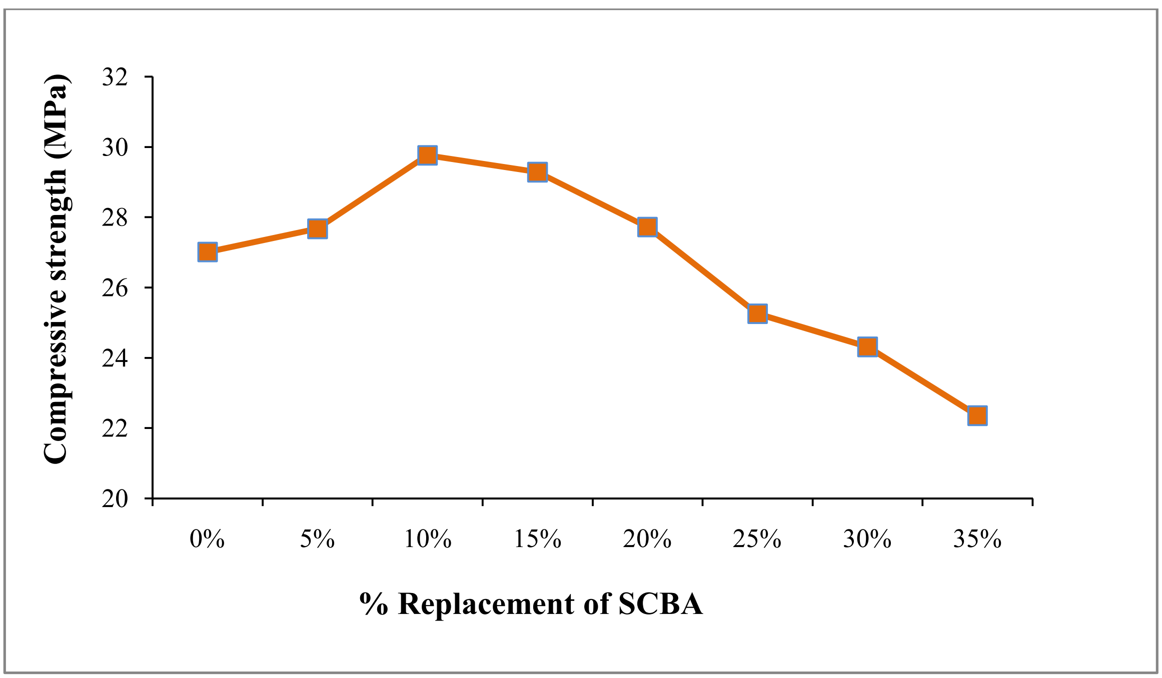

Fig 4.5 Variation in compressive strength with the percentage of SCBA for 7 days

Table 4.7 Average Compressive strength by using Bagasse ash (SCBA) for 28 days

% Replacement by SCBA	Casting –I (MPa)	Casting – II (MPa)	Casting – III (MPa)	Average (MPa)
0%	40.65	42.17	41.87	41.56
5%	45.91	43.56	45.44	44.97
10%	47.61	46.43	46.59	46.87
15%	48.43	49.77	47.83	48.67
20%	43.23	42.48	40.59	42.10
25%	38.18	39.11	38.57	38.62
30%	36.59	37.85	36.74	37.06
35%	35.48	35.49	34.79	35.08
40%	33.83	34.83	34.28	34.31
45%	30.85	32.28	31.92	31.68
50%	30.65	30.11	30.44	30.40

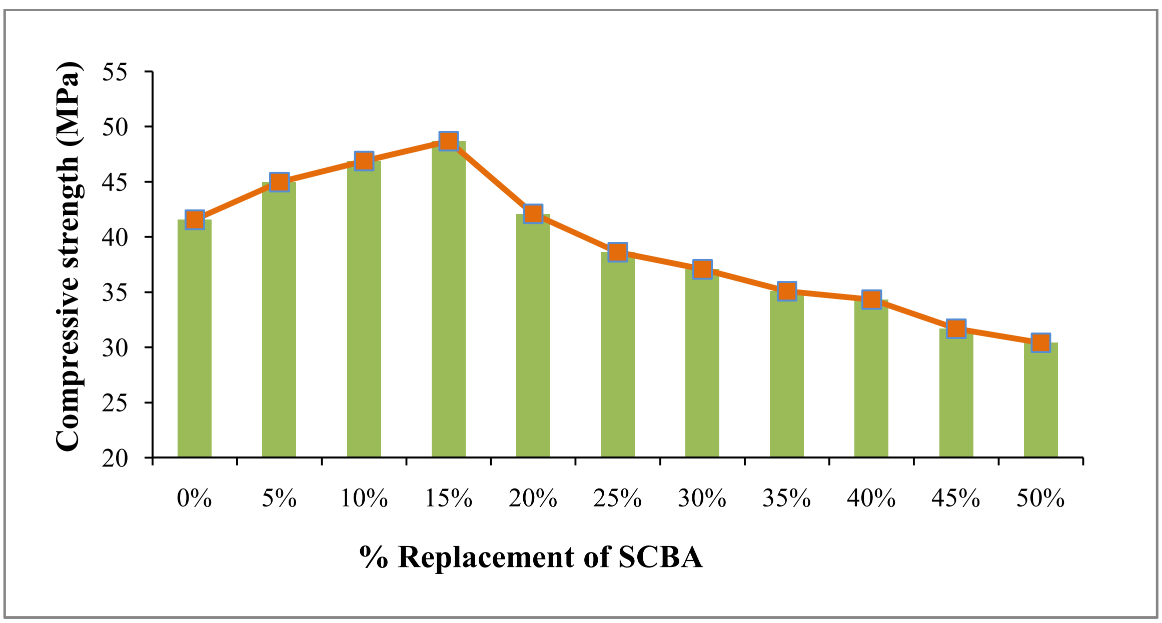

Fig 4.6 Fluctuation in compressive strength with the percentage of SCBA for 28 days

Split tensile test was performed with the help of UTM on cylindrical sample. Load was applied on the horizontal surface at height of cylinder. Two wood strips will applies at top and bottom surface where load was applied so that crushing of concrete does not take place where plane surface of UTM and surface of specimen meets. Size of cylinder sample will be 150 mm dia and 300mm height. In table 4.8, 4.9 and 4.10 split tensile strength of various materials was calculated.

Table 4.8 Split tensile strength of GGBS after 28 days

% Replacement by GGBS	**Casting –I (MPa)**	**Casting – II (MPa)**	**Casting – III (MPa)**	**(Average) (MPa)**
0%	3.05	2.99	3.02	3.02
5%	3.18	3.24	3.22	3.21
10%	3.25	3.30	3.34	3.29
15%	3.35	3.40	3.38	3.37
20%	3.31	3.28	3.30	3.29
25%	3.25	3.18	3.24	3.22
30%	3.18	3.11	3.15	3.14
35%	3.13	3.07	3.05	3.08

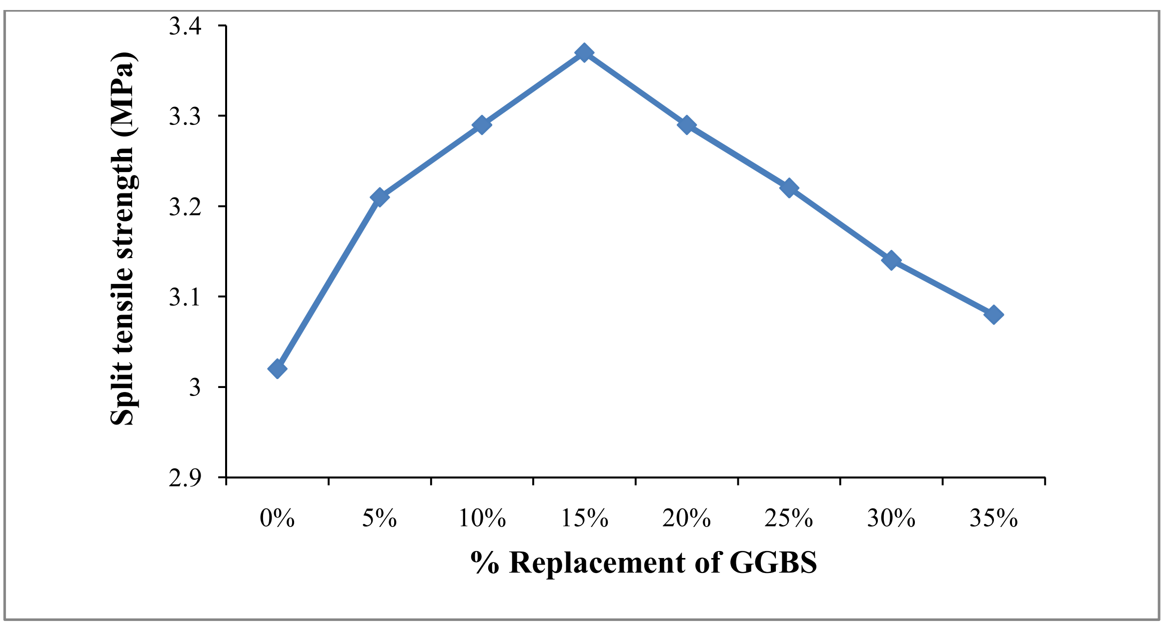

Fig 4.7 Deviation in Split tensile strength with the percentage of GGBS for 28 days

Table 4.9 Split tensile strength of LFS after 28 days.

% Replacement by LFS	Casting –I (MPa)	Casting – II (MPa)	Casting – III (MPa)	Average (MPa)
0%	3.05	2.99	3.02	3.02
5%	3.35	3.46	3.50	3.43
10%	3.70	3.84	3.89	3.81
15%	3.96	4.03	4.19	4.06
20%	4.10	3.95	3.91	3.98
25%	3.86	3.82	3.81	3.83
30%	3.63	3.81	3.73	3.72
35%	3.52	3.71	3.64	3.62

In fig 4.8 the deviation in split tensile strength from 0% to 35% was shown below and at 15 % reaches the maximum limit.

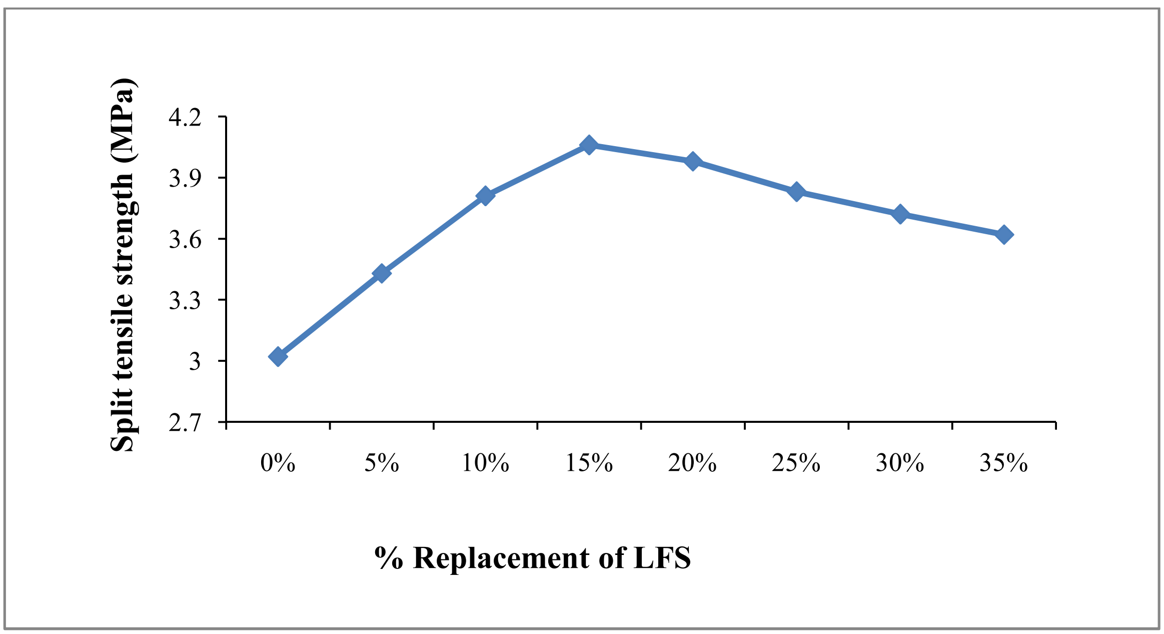

Fig 4.8 Deviation in Split tensile strength with the percentage of LFS for 28 days

Fig 4.10 Split tensile strength of SCBA after 28 days.

% Replacement by SCBA	Casting –I (MPa)	Casting – II (MPa)	Casting – III (MPa)	Average (MPa)
0%	3.05	2.99	3.02	3.02
5%	3.15	3.16	3.19	3.16
10%	3.35	3.40	3.48	3.41
15%	3.42	3.39	3.34	3.38
20%	3.29	3.32	3.27	3.29
25%	3.28	3.25	3.26	3.26
30%	3.24	3.21	3.18	3.21
35%	3.15	3.11	3.06	3.10

In fig 4.9 shows the average split tensile strength for 28 days by using SCBA. At 10 % there must be an increment of 5% strength.

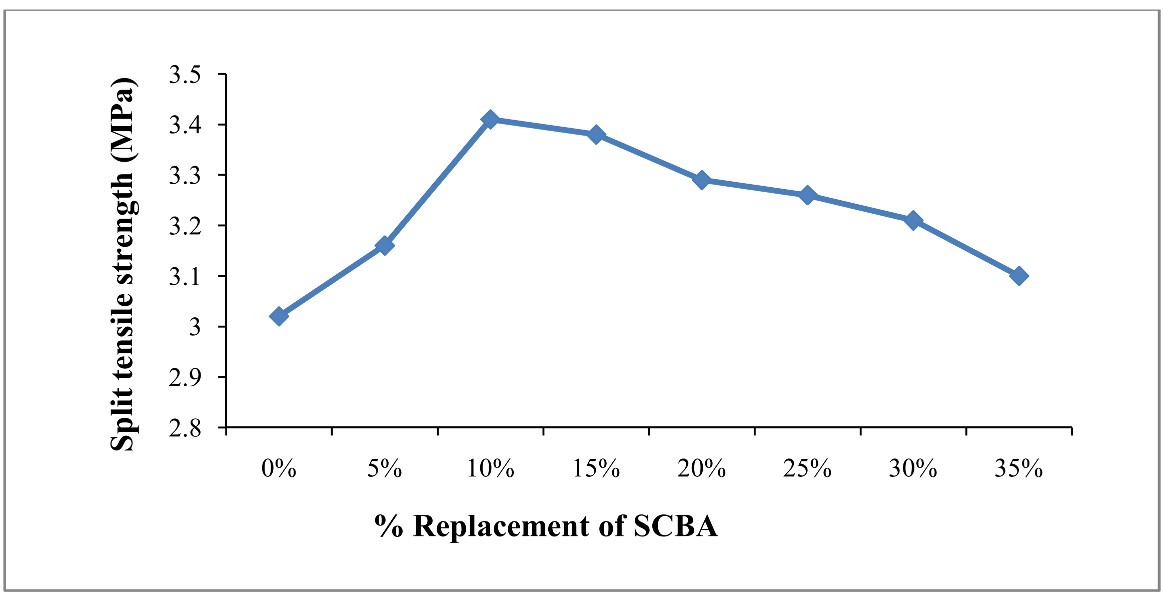

Fig 4.9 Fluctuation in Split tensile strength with the percentage of SCBA for 28 days

The Combination of different waste material was used to replace the cement upto maximum percentage so that in table 4.11 compressive strength of combination was represented in a form of 5G5L5S, which mean 5% of GGBS, 5% of LFS and 5% of SCBA were used to make cubes. From fig 4.10 it can be clearly seen that upto 30% replacement does not make such difference.

Table 4.11 Variation in compressive strength of combinations of waste materials

Combination %	**Casting – I**	**Casting – II**	**Casting – III**	**Average MPa**
5G5L5S	42.65	46.87	44.62	44.71
5G5L10S	45.58	43.80	47.90	45.76
5G5L15S	41.77	42.63	40.25	41.55
5G5L20S	39.72	41.62	40.01	40.45
5G10L5S	40.90	45.15	43.42	43.15
5G10L10S	42.56	45.37	46.32	44.75
5G10L15S	46.31	45.23	47.98	46.50
5G15L5S	43.91	44.52	45.31	44.58
5G15L10S	40.20	41.12	39.90	40.40
5G20L5S	46.20	42.18	43.34	43.96
10G5L5S	43.80	42.34	45.80	43.98
10G5L10S	38.48	40.37	42.36	40.40
10G5L15S	39.59	41.73	40.28	40.53
10G10L5S	43.59	40.79	41.37	41.96
10G10L10S	43.72	43.59	42.89	43.40
10G15L5S	44.72	42.51	41.53	42.92
15G5L5S	41.64	40.96	42.65	41.75
15G5L10S	42.74	43.01	41.77	42.50
15G10L5S	39.90	38.62	40.15	39.55
20G5L5S	40.77	38.91	37.65	39.11

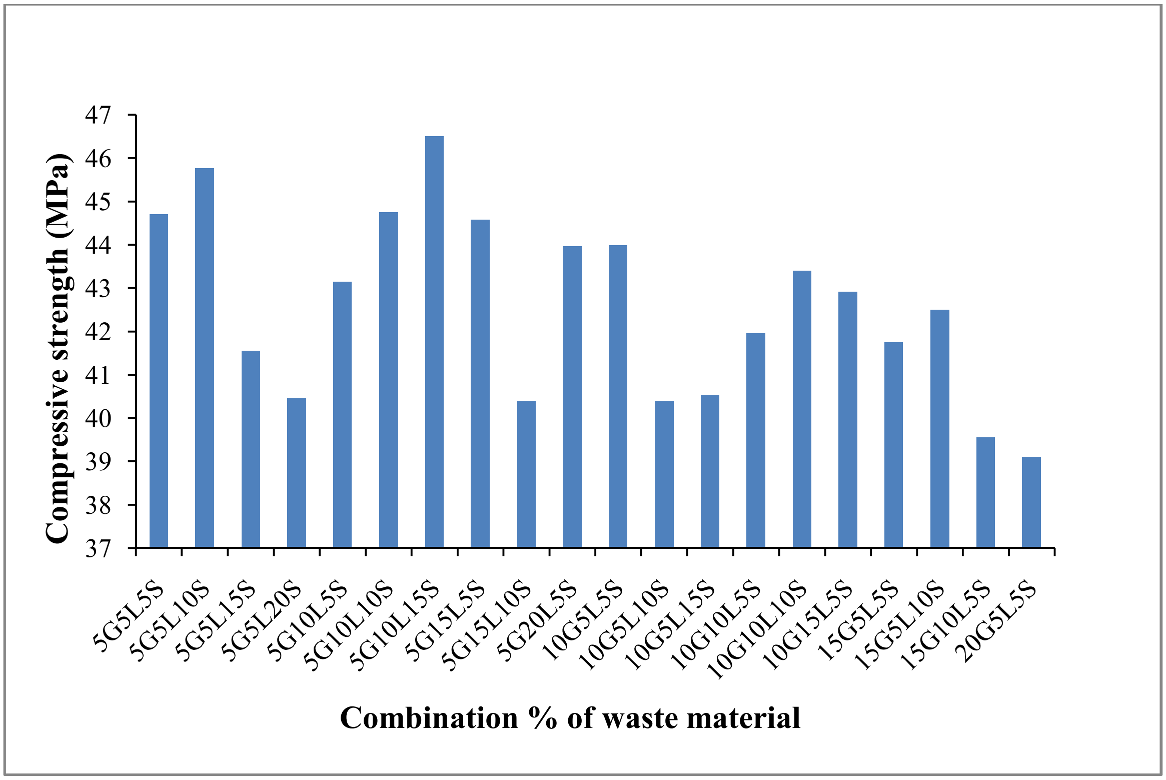

Fig 4.10 Graph between compressive strength and combination % of waste material

Number of cement bags in 1000m^3 concrete = 350 X 1000\50 =7000 bags
Cost of stone dust per tonnes = 778 Rs
Cost of aggregate per tonnes = 1223 Rs

Table 4.12 Comparison of costs for conventional and green concrete

Materials	Cost of Conventional concrete	Cost of Green concrete
Cement	2870000	2009000
Stone dust	696889	696889
Aggregate	1393334	1393334
Waste materials		
GGBS	0	0
LFS	0	0
Bagasse ash	0	0
Total cost	**4960223**	**4099223**

Amount saved = 861000 Rs

CHAPTER 5
DISCUSSION AND CONCLUSIONS

5.1 GENERAL

This report emphasis upon the information and knowledge about the utilization of waste materials for the construction of main road. Dubai is the only one country which produces approximately 27.7MT of concrete waste. For make a sustainable environment it is necessary to recycle and reuse the demolished concrete and other waste material also. The material that comes during demolishing building like concrete, asphalt, wood, metals, gypsum, plastics and salvaged building components should be recycled. It also reduces the cost of landfill. If some serious steps will be not taken right now then the production of C&D waste will increase up to 300 million tonnes per year. The knowledge was obtained after reviewing various literatures supplemented by recent p ublished reports, analysis updated by professors at completely dissimilar forums, and priv ate conferences which was conducted by different consultants. Different types of waste material were used in highway construction but the definite ratio can't be explained until nowadays. However, lots of researches have been take place across the world but none was succeeded in introducing an alternative of cement (i.e. 100% replacement) for the construction purposes. Reviewing of literature revealed that maximum utilization of the waste material was upto 50% (i.e. for GBBS) now till date. Consequently, present study is recommended to utilize the waste materials completely in rigid pavement instead of cement (i.e. 100% replacement of cement) which will be an aid to the environment, human health and construction field also.

5.2 DISCUSSIONS

In fig 4.1 and 4.2 graph shows the variation in compressive strength with the percentage of GGBS for 7 and 28 days, which results 15% replacement of cement by GGBS optimally. At 10 % replacement there was an increment of 12% compressive strength.

In fig 4.3 and 4.4 graph represented the variation in compressive strength with the percentage of LFS for 7 and 28 days in which 20% replacement was observed without compromising with its strength.

In fig 4.5 and 4.6 graph gives the variation in compressive strength with the percentage of SCBA for 7 and 28 days. While replacing cement upto 50%, it was concluded that 15 % gives the maximum strength after 28 days of curing.

In fig 4.7, 4.8 and 4.9 graph represented the calculated deviation in Split tensile strength with the percentage of GGBS, LFS and SCBA for 28 days which was higher than the normal concrete. There will be not lots of improvement but also not decrement in split tensile strength. After that we can say that replacement of waste material partially has no adverse effect in tensile strength.

In fig 4.10 graph shows the combination results of compressive strength and by analysing then it come to know that 30% of cement can be replaced. Cost of construction will be reduced to 18% of the total cost.

5.3 CONCLUSION

1. Compressive strength for 28 days by using GGBS gives optimum results, when cement was replaced up to 15%. At 10 % replacement there was an increment of 12% compressive strength.

2. In case of LFS 20% replacement was observed without compromising with its strength.

3. After that SCBA was partially replaced upto 50% and it was concluded that 15 % gives the maximum strength after 28days of curing.

4. Different combinations of these three waste materials were prepared during the study. On the basis of the results it was observed that 5% of GGBS, 10% of LFS and 15% of SCBA in the mix exhibit maximum compressive strength.

5. Split tensile strength of GGBS, LFS and SCBA are slightly higher than the conventional concrete.

6. Cost of construction will be reduced upto 18% of the total cost of the project.

5.4 FUTURE SCOPE

These waste materials improve the chemical, mechanical and physical properties of concrete. The proposed guidelines of the present study can be implementing in the field in the construction of rigid pavement with the application of reinforcement. Study can be extended by examining the behavior of the green concrete (i.e. made with the waste material) under different loadings and different climatic condition (i.e. to examine different stresses which will take place on green concrete). Beside this, the percent utilization of the waste material proposed in the present study can be increased (i.e. upto 80 or 100 %) by proposing different mix design (i.e. in varying proportion). Furthermore, some other waste materials can also be introduced by analyzing their chemical and physical properties in order to make the green concrete and sustainable environment.

REFERENCES

[1] Anupam, A.K., Kumar, P., Ransinchung, G.D. and Shah, Y.U., 2017. Study on Performance and Efficacy of Industrial Waste Materials in Road Construction: Fly Ash and Bagasse Ash. *Airfield and Highway Pavements 2017*, p.45.

[2] Amin NU., 2010. Use of bagasse ash in concrete and its impact on the strength and chloride resistivity. Journal of materials in civil engineering. Nov 8;23(5):717-20.

[3] Appiah, J.K., Berko-Boateng, V.N. and Tagbor, T.A., 2017. Use of waste plastic materials for road construction in Ghana. *Case studies in construction materials*, *6*, pp.1-7.

[4] Ashish DK., 2018. Feasibility of waste marble powder in concrete as partial substitution of cement and sand amalgam for sustainable growth. Journal of Building Engineering. Jan 31;15:236-42.

[5] Bahurudeen A, Kanraj D, Dev VG, Santhanam M., 2015. Performance evaluation of sugarcane bagasse ash blended cement in concrete. Cement and Concrete Composites. May 1;59:77-88.

[6] Bourtsalas, A.T., Zhang, J., Castaldi, M.J. and Themelis, N.J., 2018. Use of non-recycled plastics and paper as alternative fuel in cement production. *Journal of Cleaner Production*, *181*, pp.8-16.

[7] Behiry, Ahmed Ebrahim Abu El-Maaty., 2013."Utilization of cement treated recycled concrete aggregates as base or subbase layer in Egypt." *Ain Shams Engineering Journal* 4, no.

[8] Bujang M, Hainin MR, Majid MZ, Satar MK, Azahar WN., 2018. Assessment framework for pavement material and technology elements in green highway index. Journal of Cleaner Production. Feb 10;174:1240-6.

[9] Courard L, Michel F, Delhez P. ,2010. Use of concrete road recycled aggregates for roller compacted concrete. Construction and building Materials. Mar 1;24(3):390-5.

[10] Cordeiro, G.C., Toledo Filho, R.D., Tavares, L.M. and Fairbairn, E.D.M.R., 2009. Ultrafine grinding of sugar cane bagasse ash for application as pozzolanic admixture in concrete. *Cement and concrete research*, *39*(2), pp.110-115.

[11] Cuttell G, Snyder M, Vandenbossche J, Wade M. ,1997. Performance of rigid pavements containing recycled concrete aggregates. Transportation Research Record: Journal of the Transportation Research Board. Jan 1(1574):89-98.

[12] Das S, Singh G, Ahmed AA, Saha S, Karmakar S., 2015. Ground Granulated Blast Furnace Slag (GGBS) based Concrete Exposed to Artificial Marine Environment (AME) and Sustainable Retrofitting using Glass Fiber Reinforced Polymer (GFRP) sheets. Procedia-Social and Behavioral Sciences. Jul 3;195:2804-12.

[13] Deepika S, Anand G, Bahurudeen A, Santhanam M. ,2017. Construction Products with Sugarcane Bagasse Ash Binder. Journal of Materials in Civil Engineering. Jul 21;29(10):04017189.

[14] Huda SB, Alam MS. 2014, Mechanical behavior of three generations of 100% repeated recycled coarse aggregate concrete. Construction and building materials. Aug 29;65:574-82.

[15] Jerath, S. and Hanson, N., 2007. Effect of fly ash content and aggregate gradation on the durability of concrete pavements. *Journal of materials in civil engineering*, *19*(5), pp.367-375.

[16] Kumar KS, Baskar K. ,2015. Recycling of E-plastic waste as a construction material in developing countries. Journal of Material Cycles and Waste Management. Oct 1;17(4):718-24.

[17] Kupwade-Patil K, Chin SH, Johnston ML, Maragh J, Masic A, Büyüköztürk O., 2018. Particle size effect of volcanic ash towards developing engineered portland cements. Journal of Materials in Civil Engineering. Jun 5;30(8):04018190.

[18] Kuo WT, Chen SH, Wang HY, Lin JC., 2013.A study on the mechanical and electricity properties of cement mortar added with GGBFS and piezoelectric powder. Construction and Building Materials. Dec 1;49:251-6.

[19] Kurup AR, Senthil Kumar K., 2017. Effect of recycled PVC fibers from electronic waste and silica powder on shear strength of concrete. Journal of Hazardous, Toxic, and Radioactive Waste. Feb 9;21(3):06017001.

[20] Law Yim Wan DS, Aslani F, Ma G., 2018.Lightweight Self-Compacting Concrete Incorporating Perlite, Scoria, and Polystyrene Aggregates. Journal of Materials in Civil Engineering. May 31;30(8):04018178.

[21] Liu J, Guo R. ,2018. Applications of Steel Slag Powder and Steel Slag Aggregate in Ultra-High Performance Concrete. Advances in Civil Engineering.;2018.

[22] Liu J, Wang D., 2017. Influence of steel slag-silica fume composite mineral admixture on the properties of concrete. Powder Technology. Oct 1;320:230-8.

[23] Malešev, Mirjana, Vlastimir Radonjanin, and Snežana Marinković., 2010. "Recycled concrete as aggregate for structural concrete production." *Sustainability* 2.5 : 1204-1225.

[24] Maddalena R, Roberts JJ, Hamilton A., 2018. Can Portland cement be replaced by low-carbon alternative materials? A study on the thermal properties and carbon emissions of innovative cements. Journal of Cleaner Production. Jun 10;186:933-42.

[25] Marinho AL, Santos CM, Carvalho JM, Mendes JC, Brigolini GJ, Peixoto RA. , 2005.Ladle furnace slag as binder for cement-based composites.

[26] Mazenan PN, Khalid FS, Shahidan S, Shamsuddin SM. 2017, Review of palm oil fuel ash and ceramic waste in the production of concrete. InIOP Conference Series: Materials Science and Engineering Nov (Vol. 271, No. 1, p. 012051). IOP Publishing.

[27] Manso JM, Losañez M, Polanco JA, Gonzalez JJ. ,2005.Ladle furnace slag in construction. Journal of materials in civil engineering. Oct;17(5):513-8.

[28] Mehta, A. and Siddique, R., 2018. Sustainable Geopolymer Concrete using Ground Granulated Blast Furnace Slag and Rice Husk Ash: Strength and Permeability Properties. *Journal of Cleaner Production*.

[29] Mehraj SS, Bhat GA., 2014. Cement factories, air pollution and consequences. Jammu and Kashmir, India.:30-6

[30] Mishra S, Siddiqui NA., 2014. A review on environmental and health impacts of cement manufacturing emissions. International Journal of Geology, agriculture and environmental sciences. Jun;2(3):26-31.

[31] Park T., 2003.Application of construction and building debris as base and subbase materials in rigid pavement. Journal of Transportation Engineering. Sep;129(5):558-63.

[32] Poon CS, Chan D., 2006. Feasible use of recycled concrete aggregates and crushed clay brick as unbound road sub-base. Construction and building materials. Oct 1;20(8):578-85.

[33] Rajput D, Bhagade SS, Raut SP, Ralegaonkar RV, Mandavgane SA., 2012.Reuse of cotton and recycle paper mill waste as building material. Construction and Building Materials. Sep 1;34:470-5.

[34] Rao A, Jha KN, Misra S. ,2007. Use of aggregates from recycled construction and demolition waste in concrete. Resources, conservation and Recycling. Mar 1;50(1):71-81.

[35] Rađenović A, Malina J, Sofilić T., 2013. Characterization of ladle furnace slag from carbon steel production as a potential adsorbent. Advances in Materials Science and Engineering. doi.org/10.1155/2013/198240

[36] Robayo RA, Mulford A, Munera J, de Gutiérrez RM., 2016. Alternative cements based on alkali-activated red clay brick waste. Construction and Building Materials. Dec 15;128:163-9.

[37] Sathiparan N, De Zoysa HT. ,2018. The effects of using agricultural waste as partial substitute for sand in cement blocks. Journal of Building Engineering. Sep 1;19:216-27.

[38] Siddique S, Shrivastava S, Chaudhary S., 2018. Influence of Ceramic Waste as Fine Aggregate in Concrete: Pozzolanic, XRD, FT-IR, and NMR Investigations. Journal of Materials in Civil Engineering. Jul 2;30(9):04018227.

[39] Singh M, Lamba P, Srivastava A, Bhunia D., 2017. Long Term Effect of Partially Replacing Cement by Waste Marble Slurry in Concrete. In Congress on Technical Advancement 2017 (pp. 65-76).

[40] Silva RV, De Brito J, Dhir RK., 2014. Properties and composition of recycled aggregates from construction and demolition waste suitable for concrete production. Construction and Building Materials. Aug 29;65:201-17.

[41] Siddiqui N, Shukla R, Ziauddin A. ,1970. Impact of Cement Industry on the Ground Water Quality-A Case Study. I Control Pollution. Jan 1;27(2):1-5.

[42] Singh P., 2015. Resilient modulus of recycled aggregates as road pavement materials. Southern Illinois University at Carbondale.

[43] Shaikh FU, Supit SW., 2015. Compressive strength and durability properties of high volume fly ash (HVFA) concretes containing ultrafine fly ash (UFFA). Construction and building materials. May 1;82:192-205.

[44] Shen W, Zhou M, Ma W, Hu J, Cai Z., 2009. Investigation on the application of steel slag–fly ash–phosphogypsum solidified material as road base material. Journal of Hazardous Materials. May 15;164(1):99-104.

[45] Shrivastava S, Chini A. 2009. Construction Materials and C&D waste in India. Lifecycle Design of Buildings, Systems and Materials.:72.

[46] Topcu, I.B. and Şengel, S., 2004. Properties of concretes produced with waste concrete aggregate. *Cement and concrete research*, *34*(8), pp.1307-1312.

[47] Topič, Jaroslav, Zdeněk Prošek, and Tomáš Plachý. 2017. "Influence of increasing amount of recycled concrete powder on mechanical properties of cement paste." *IOP Conference Series: Materials Science and Engineering*. Vol. 236. No. 1. IOP Publishing,.

[48] Van de Ven MFC. 2005. Material recycling-general report. In: 2nd International symposium of treatment and recycling of materials for transport infrastructure, Paris, France, October 24–26,.

[49] Vishwakarma V, Ramachandran D., 2018. Green Concrete mix using solid waste and nanoparticles as alternatives–A review. Construction and Building Materials. Feb 20;162:96-103.

[50] Wang L, Iris KM, Tsang DC, Yu K, Li S, Poon CS, Dai JG., 2018.Upcycling wood waste into fibre-reinforced magnesium phosphate cement particleboards. Construction and Building Materials. Jan 20;159:54-63.

[51] Wang Q, Wang D, Chen H., 2017.The role of fly ash microsphere in the microstructure and macroscopic properties of high-strength concrete. Cement and Concrete Composites. Oct 1;83:125-37

[52] Wagih, Ashraf M., et al. "Recycled construction and demolition concrete waste as aggregate for structural concrete." *HBRC journal* 9.3 (2013): 193-200.

[53] Xiao J, Falkner H., 2007. Bond behavior between recycled aggregate concrete and steel rebars. Construction and Building Materials. Feb 1;21(2):395-401.

[54] Mindess, S., Young, J.F. and Darwin, D., 1981. Concrete Prentice-Hall. *Englewood Cliffs, NJ*, *481*.

[55] Indian Bureau of Mines "Indian Minerals Yearbook 2015, (Part- III : Mineral Reviews) ,54th Edition", Ministry of Mines. https://ibm.gov.in/writereaddata/files/08092017095128Cement2015(Final).pdf.

[56] "Annual report on Environment and air pollution India 2017" Industrial pollution control http://envfor.nic.in/sites/default/files/Environment%20AR%20English%202016-2017.pdf.

[57] IS: 10262-1982 "Indian code for recommended guidelines for concrete mix design", Bureau of Indian Standards, New Delhi, India.

[58] IS: 465-2000 "Indian code of practice for reinforced and plain concrete", Bureau of Indian Standards, New Delhi, India.

[59] Zabihi SM, Tavakoli H, Mohseni E., 2018. Engineering and Microstructural Properties of Fiber-Reinforced Rice Husk–Ash Based Geopolymer Concrete. Journal of Materials in Civil Engineering. May 31; 30(8):04018183.