Manufacturing of Concrete Paving Block by Using Waste Glass Material

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Abstract- There is now a significant world-wide interest to solve the environmental problems caused by industrial waste and other materials by including such materials in the manufacture of concrete.This technology has been introduced in India in construction, a decade ago, for specific requirement namely footpaths, parking areas etc. but now being adopted extensively in different uses where the conventional construction of pavement using bituminous mix or cement concrete technology is not feasible or desirable. The characteristics of concrete containing fine crushed glass during its process, the best ratio of fine crushed glass which leads to higher strength of concrete in order to produce concrete blocks, and the effect of waste glass replacement on the expansion caused by Alkali-silica reaction (ASR). This study looked at the feasibility of waste glass inclusion as partial FA replacement systems. Properties of concrete incorporating waste glass as partial substitution for FA amounts of 15%, 30% and 45% were investigated. The waste glass material used was obtained waste collectors. The results obtained show clearly that glass enhances the compressive strength properties of the final concrete product. The study indicated that waste glass can effectively be used as fine aggregate replacement (up to 45%) without substantial change in strength.

Index Terms- Waste Glass, recycling,cement, concrete, construction field, fine aggregate.

I. INTRODUCTION

Concrete paving blocks has been extensively used in many countries for quite some time as a specialized problem-solving technique for providing pavement in areas where conventional types of construction are less durable due to many operational and environmental constraints. This technology has been introduced in India in construction, a decade ago, for specific requirement namely footpaths, parking areas etc. but now being adopted extensively in different uses where the conventional construction of pavement using bituminous mix or cement concrete technology is not feasible or desirable. Concrete paver blocks were first introduced in Holland in the fifties as replacement of paver bricks which had become scarce due to the post-war building construction boom. These blocks were rectangular in shape and had more or less the same size as the bricks. During the past five decades, the block shape has steadily evolved from non-interlocking to partially interlocking to fully interlocking to multiply interlocking shapes.

The main challenge before the Indian concrete industry now is to meet the demand of economical and efficient construction materials required by large infrastructure needs due to rapid industrialization and urbanization. All these call for use of good quality concrete with use of minimum resources (eg. Limestone, energy &money) and achieving maximization of strength, durability and other intended concrete properties. In recent years there has been an increasing worldwide demand of concrete paving blocks for the footpaths, roads and airfields which has led to a local depletion of aggregates. In some urban areas, the enormous quantities of aggregate that have already been used means that local materials are no longer available and the deficit has to be made up by importing materials from other locations. Most cities have areas of land covered by spoil heaps which are unsightly and prevent large areas of land being used for anything else.

Concrete paving block is a versatile, aesthetically attractive, functional, and cost effective and requires little or no maintenance if correctly manufactured and placed. Paver blocks can be used for different traffic categories are as follows:

Table: 1. 1 Recommended Grades of Paver Blocks for Different Traffic Categories

Sr. **No.**	**Grade. Designation of-Paver Blocks**	**Specified Compressive Category Strength of Paver Blocks at 28 Days** N/mm	**Traffic Category**	**Recommended Minimum Paver Block Thickness mm**	**Traffic Examples of Application**
1.	M-30	30	Non- traffic	50	Building premises, monument premises, landscapes, public gsrdendparks,domestic

					drives, paths and patios ,embankment slopes, sand stabilization area, etc.
2.	M35	35	Light-traffic	60	Pedestrian plazas, shopping complexes ramps, car parks, driveways, farmhouses, beach sites, tourist resorts local authority footways, residential roads, etc
3.	M40	40	Medium-traffic	80	City streets, small and medium market roads, low volume roads, utility cuts on arterial roads, etc
4.	M50	50	Heavy traffic	100	Bus terminals, industrial complexes, mandi houses, roads on expansive soils, factory floor, service stations, industrial pavements, etc
5.	M55	55	Very Heavy traffic	120	Container terminals, ports, docks yards, mine access roads, bulk cargo handling areas, airport pavements, etc.

II. SHAPES AND CLASSIFICATIONS

There are four generic shapes of paver blocks corresponding to the four types of blocks as below and figure 1.1 shows the different shapes of paving blocks:

a. **Type A:** Paver blocks with plain vertical faces, which do not key into each other when paved in any pattern,
b. **Type B:** Paver blocks with alternating plain and curved/corrugated vertical faces, which key into each other along the curve/corrugated faces, when paved in any pattern,
c. **Type C:** Paver blocks having all faces curved or corrugated, which key into each other along all the vertical faces when paved in any pattern and
d. **Type D:** 'L' and 'X' shaped paver blocks which have all faces curved or corrugated and which key into each other along all the vertical faces when paved in any pattern.

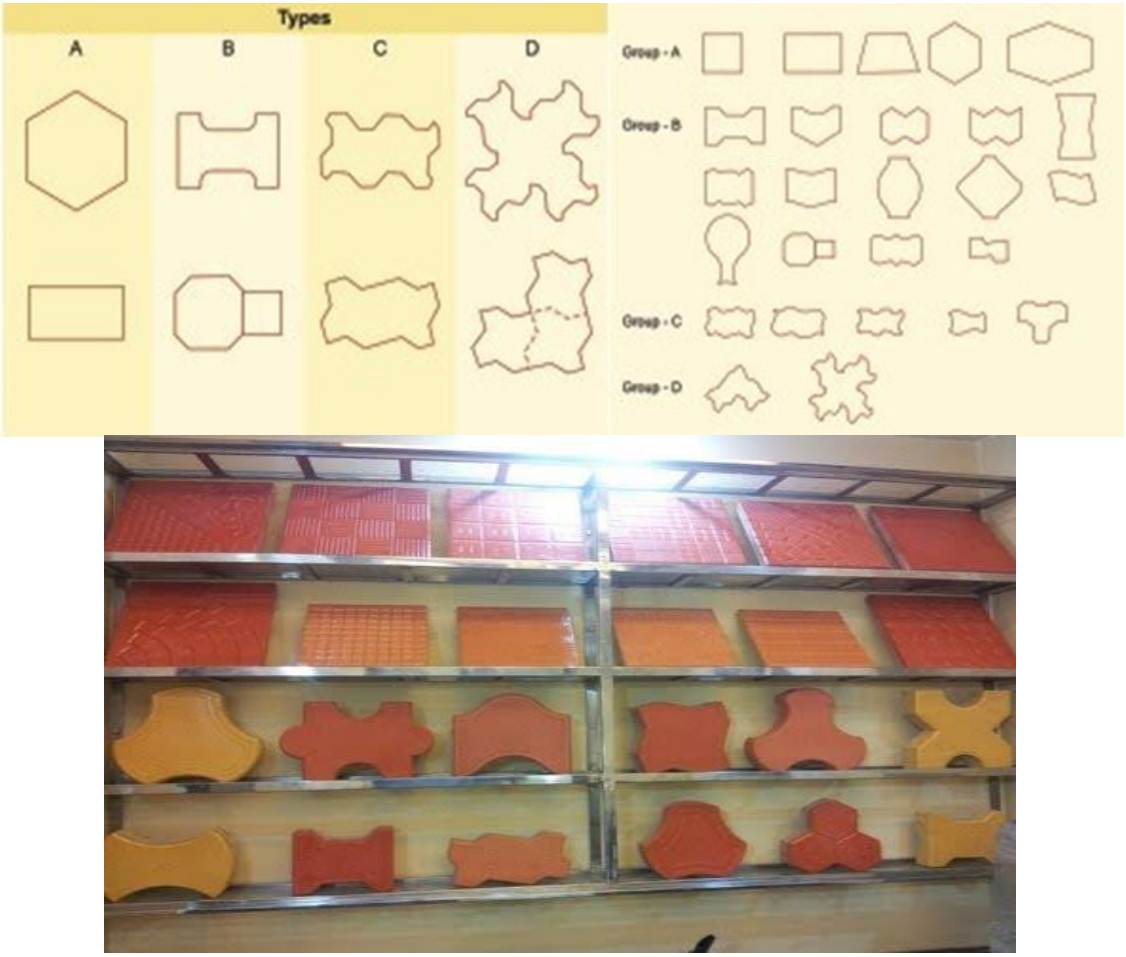

Figure: 1.1 Different Shapes Paving blocks

Concrete blocks are mass manufactured to standard sizes. This makes them interchangeable. Typical concrete paving blocks have one smooth face and one rough, although some paving blocks so come with reversible surfaces (can be used both sides). The performance characteristics of concrete paving blocks make it suitable for the heaviest duty applications, able to support substantial loads and resist shearing and braking forces. The concrete paving bricks are a porous form of brick formed by mixing small stone hardcore, dyes, cement and sand and other materials in various amounts:-

Various advantages of paving block

- Capability of being moulded in different sizes, shapes, and colours
- Good stability and durability, if properly manufactured and installed.
- Easy to produce ,Easy laying
- Good indoor climate (balanced humidity; cool)
- Various attractive patterns can be formed
- Equipment to produce tiles can be easily made by local workshop

Many block paving manufacturing methods are now allowing the use of recycled materials in the construction of the paving bricks such as crushed glass and crushed old building rubble. Several researchers have studied the use of waste materials in concrete such as coal, fly ash, plastic waste, Industrial waste fiber, rubber pads, marbles etc., for making the concrete products. The advantages of using such type of concrete products are these products having low cost as well as they conserve natural resources.

1.2 Waste Materials

Definition of waste: "Wastes materials are substance or objects, which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law"

Solid waste is the unwanted or useless solid materials generated from combined residential, industrial and commercial activities in a given area. It may be categorized according to its origin (domestic, industrial, commercial, construction or institutional); according to its contents (organic material, glass, metal, plastic paper etc. or according to hazard potential (toxic, non-toxin, flammable, radioactive, infectious etc.

Waste is any substance which is discarded after primary use, or it is worthless, defective and of no use. If the large amount of waste materials generated were used instead of natural materials in the construction industry there would be three benefits:

- Conserving natural resources.
- Disposing of waste materials (which are often unsightly).

- Freeing up valuable land for other uses.

1.2.1 Solid type waste

Solid Waste from our homes and Industries is generally collected by our local authorities through regular waste collection, or by special collections for recycling. Within hot climates such as that of the Caribbean the waste should be collected at least twice a week to control fly breeding, and the harboring of other pests in the community. Other factors to consider when deciding on frequency of collection are the odors caused by decomposition and the accumulated quantities. The following are the various waste materials used as ingredient in concrete are;-

➢ ***Fly ash-***

- The beneficial use of fly ash in concrete is the preferable option for safe and economical utilization of millions tons of fly ash. There is a critical need to find new methods for using fly ash for its highest and best use. The major obstacle in use of bottom ash in a concrete is that the chemical properties of coal bottom ash are different from place to place and are depends upon the origin of the raw material.

➢ ***Steel Aggregates and Rubber Pad-***

- Rubber products are everywhere to be found, though few people recognize rubber in all of its applications. Rubber is used in radio and T.V sets and in telephones. Electric wires are made safe by rubber insulation. Rubber forms a part of many mechanical devices in the kitchen. It helps to exclude draughts and to insulate against noise. Sofas and chairs may be upholstered with foam rubber cushions, and beds may have natural rubber pillows and mattresses.

➢ ***Waste marble:-***

- Marble processing industry generates around 7 million tons of wastes mainly in the form of powder during sawing and polishing processes. These are dumped in the open which pollute and damage the environment

➢ ***Plastic Waste;-***

- The distribution of plastic debris is highly variable as a result of certain factors such as wind and ocean currents, coastline geography, urban areas, and trade routes. Human population in certain areas also plays a large role in this. Plastics are more likely to be found in enclosed regions such as the Caribbean. Plastic pollution, more so in the forms of macro- and mega-plastics, potentially serves as a means of distribution of organisms to remote coasts that are not their native environments.

➢ ***E- waste:-***

- E waste describes loosely discarded, surplus, obsolete, broken, electrical or electronic devices. Rapid technology change, low initial cost have resulted in a fast growing surplus of electronic waste around the globe. Generation of e-waste is a very serious issue in world. In year 2014 produce near about 650000MT of e-waste in India that includes all waste electronics and electrical equipment(TVs, computers, sound systems, refrigerators etc.) .This waste not dispose properly finally they affect environment and human health and also create storage proble

➢ ***Paper:-***

- Plantation timber, not native forests, is the source of most paper-making pulp. Stronger, better quality paper is made from hardwoods. Softwoods produce shorter fibres suitable for paper such as newsprint. Good quality paper is in demand with recyclers to produce a variety of recycled paper products such as printing and writing paper, office supplies such as envelopes, toilet paper and tissues. Lower grade paper is usually used to make products such as cardboard and insulation. Demand for old newspapers can fluctuate. The short fibres in newsprint make it unsuitable for recycling uses other than packaging material, insulation material or being recycled back into newsprint.

➢ ***Glass waste:-***

- Glass makes up a large component of household and industrial waste due to its weight and density. The glass component in municipal waste is usually made up of bottles, broken glassware, light bulbs and other items. Adding to this waste is the fact that many manual methods of creating glass objects have a defect rate of around forty percent. Glass recycling uses less energy than manufacturing glass from sand, lime and soda.
- Glass makes up a large component of household and industrial waste due to its weight and density. The glass component in municipal waste is usually made up of bottles, broken glassware, light bulbs and other items. In many cases it is not only easy to recycle, glass it can be recycled indefinitely with no loss in quality or purity. Making new glass from old glass saves energy because recycled glass is processed at a lower temperature than glass made from raw materials.
- In glass products all glass materials are not recyclable some glass products such as light bulbs, window panes, glassware and mirrors Ovenware (including Pyrex glass) Opaque white rum, black wine, and green beer bottles with ceramic tops , Pottery , Vases ,Crystal ,Dishes ,Drinking glasses etc. such type of glass waste Disposed in a landfill involves burying the waste and this remains a common practice in most countries. Landfills were often established in abandoned or unused quarries, mining voids or borrow pits. A properly designed and well-managed landfill can be a hygienic and relatively inexpensive method of disposing of waste materials. Older, poorly designed or poorly managed landfills and open dumps can create a number of adverse environmental impacts such as wind-blown litter, attraction of vermin, and generation of liquid leachate.
- For avoiding this use of the recycled glass as aggregate in concrete has become popular in modern times, with large scale research being carried out at Columbia University in New York as well as The use of waste glass as a substitute for fine aggregates in mortar mix is one option that can alleviate waste glass disposal problem and has been studied widely in recent years. Due to the limited landfill space available and stringent

environmental regulations, many waste glasses are attempting to develop efficient, economic and environmental sound alternatives for utilizing this waste glass. Therefore, the civil engineers have been challenged to convert this waste glass, in general, to useful building and construction materials. This greatly enhances the aesthetic appeal of the concrete. Recent research findings have shown that concrete made with recycled glass aggregates have shown better long term strength and better thermal insulation due to its better thermal properties of the glass aggregates.

Waste Glass in concrete offer several advantages:

1. It is one of the most durable materials known because it has basically zero water absorption.
2. The excellent hardness of glass may give the concrete improved abrasion resistance that can be reached only with few natural stone aggregates.
3. Glass aggregates may enhance the flow properties of fresh concrete so that very high strengths can be obtained even without the use of admixture (plasticizer's, superplasticisers etc.
4. The aesthetic potential of colour-sorted, post-consumer glass has barely been explored at all and offers numerous novel applications for architectural purposes.
5. Very finely ground glass has pozzolanic properties and therefore, can serve both as partial cement replacement and filler.

In this project we are using non-recyclable type waste i.e. Glass products (window panes) for replacing some percentage of fine aggregate in concrete paving blocks.

III. EXPERIMENTAL WORK

3.1 MATERIAL and TESTING

3.1.1 Cement-

- In this work, Ordinary Portland cement (OPC) of Altratech (53 grade) brand obtained from a single batches was used. The physical properties of OPC as determined are given in following Table. The cement satisfies the requirement of IS: 8112-1989. The specific gravity was 3.15 and fineness was 2800 cm2/g.
    - Following figure 3.1shows 53 grade of Cement :-

Figure 3.1 53 grade OPC Cement

- This table shows typical composition of ordinary Portland cement and table no.is 3.1 is given below

Table 3.1 Typical composition of ordinary Portland cement.

Name of compound	Oxide compassion	Abbreviation	Weight
Tricalcium Silicate	3CaOSiO2	C3S	55%
Dicalcium Silicate	2CaO. SiO2	C2S	18%
Tricalcium aluminate	3 CaO. A1203	C3A	10%
Tetra-calcium alumino ferrite	4 CaO. A 1203 F 203	C4AF	8%
Calcium sulphatedehydrate	CaO.Na	CSH2	6%

- The cement grade 53 is known for its rich quality and is highly durable. Hence it is used for constructing bigger structures like building foundations, bridges, tall buildings, and structures designed to withstand heavy pressure. With a good distribution network this cement is available most abundantly. The chemical and physical properties of this material were shown in following Table.
- This table properties of ordinary Portland cement and table no. is 3.2 shows given below-

Table 3.2 Properties of Cement

Sr no.	Chemical Ingredients	Range %	Common Proportion
1	Lime	60-70	63
2	Silica	17-25	22
3	Alumina	3-8	6
4	Iron Oxide	0.5-6	3
5	Magnesium Oxide	0.4-4	2.5
6	Sulphur Trioxide	1-3	1.75
7	Alkalies such as soda & potash	0.2-1	0.25
8	Loss on ignition	1-2	1.5

- *Physical properties of Portland cement:-*
- The cement used should satisfy the IS specification before to be used as construction material. The important physical properties of cement and there is specification are as follows.

- Fineness -The residue of cement should not exceed 10% when sieved 90-micron I.S. sieve.
- Setting time-The time at which the cement paste looses its plasticity is termed as initial setting time. The initial setting time should not be less than 30 minutes.
- Soundness -The expansion carried out in the manner described in IS 269-1976 should not be more than 10 mm in the Leghatelievs test and 0.8% in Autoclave test.
- Compressive -For ordinary Portland cement the compound Strength -strength at 3 and 7 days curing should not be less than 16 N/mm2 and 22N/mm2 respectively. The graded standard sand used for preparing the cubes should conform to I.S. 650-1966.
- Heat of hydration- For law heat Portland cement should not be more than 66 and 75 cal/g for 7 and 28 days respectively. For OPC it varies from 37 cal/g at 50^0 C – 80cal/g at 40^0 C.

3.1.2 Aggregate –

Aggregate are the important constituents in concrete. They give body to the concrete, reduce shrinkage and affect economy. Aggregate occupy is to assist in producing workability and uniformity in mixture. The fine aggregate is also assists the cement paste to hold the coarse aggregate in suspension. This concrete 70-80%of the volume of concrete. To increase the density of resulting mix the aggregates are frequently used in two or more sizes. The most important function of the fine aggregate action promotes plasticity and segregation. The aggregate provides about 75% of body of. The size of aggregate bigger than 4.75 mm is considered as course aggregate and less as fine aggregate or sand. The nominal sizes of course aggregate are 10 mm, 20 mm and 25 mm etc. where have used. In our project we are using fine aggregate as well as coarse aggregate are as follows:-

3.1.2.1 Fine aggregate (Sand)-

In this project we are using (Natural Sand) Fine aggregate resulting from the natural disintegration of rock and which has been deposited by streams or glacial agencies. The river sand was used as natural river sand. It is distinguished from gravel only by the size of grain or particle, but is distinct from clays which contain organic minerals. Sands that have been sorted out and separated from the organic material by the action of currents of water or by winds across arid lands are generally quite uniform in size of grains. Usually commercial sand is obtained from river beds or from sand dunes originally formed by the action of winds. Much of the earth's surface is sandy, and the sand is usually quartz and other siliceous materials. Sand is used to make mortar and concrete and for making moulds in foundries.Size of sand used which passing from 4.75mm.
The specific gravity of sand used was 2.605. Specific gravity of sand is found out by the Pycnometer test.

- Following figure no 3.2 shows River sand :-

Figure 3.2 River Sand

➢ ***Characteristics of aggregates –***

- In general an aggregate to be used in concrete must be clean, hard, strong, properly shaped and well graded. The aggregate must process chemical, resistance to abrasion, and to freezing and thawing. They should not contain feletarious material, which may cause physical or chemical changes such as cracking, stability swelling, softening or leaching.

➢ ***Strength of aggregate –***

- IS 383-1970 prescribes a 45% limit for the crushing value determined as per IS 2386 (Part IV) – 1963 for the aggregate used for concrete other than for wearing surface such as runways, roads and pavements.

➢ ***Porosity, Absorption And Moisture Content Of Aggregate –***

- The porosity, permeability and absorption of aggregate influence the resistance of a concrete freezing the thawing, its chemical stability, resistance to abrasion and the bond between the aggregate and the cement paste

3.1.2.2 Coarse Aggregates-

Coarse aggregate are the crushed stone used for making concrete. The commercial stone isquarried, crushed and graded. Much of the crushed stone used is granite, limestone and trap rock. Crushed angular granite metal of 10 mm size from a local source was used as coarse aggregate. The specific gravity of2.6 and fineness modulus 6.05 was used. Size of aggregates used Aggregates passing through 12.5 mm size sieve and retained on 10 mm size sieve are used. Specific Gravity of aggregates used were 2.884.

Following figure no 3.3 shows 10 mm coarse aggregate :-

Figure 3.3 10 mm Coarse Aggregate

3.1.3 Admixture-

Superplasticisers recommended by IS-9103

3.1.4 WATER

The water used for mixing and curing of concrete should be free from harmful materials and objectionable strain on surface. A part of mixing water is utilized in the hydration of cement and the remaining water serves as lubricant between the fine and course aggregates and make concrete workable. Generally minimum 0.3 to 0. 8 w/c ratios are required for hydration. But for good workable concrete additional water is required to lubricant the mix. The extra water results in formation of bleeding effects of effective water in concrete are as below.

- ❖ Less effective bond formation
- ❖ Leakage through formwork
- ❖ Honey comb formation

3.1.5 Glass-

For this project the non-recyclable glass is used. Basically waste glass material that cannot be reused due to the high cost of manufacturing. Therefore the manufacture will disposed in the waste landfill. Due to environmental problem, researcher tries to use the waste glass in to concrete, to create a new material to use in construction field. Researcher found that, the main material composition of glass is silica that also contain in cement production and other compound that also similarly contain in cement production.

It is crushed by using los angles abrasion testing machine up to 4.75 mm passing and 90 micron retaining glass taking for project work.

- The following table no 3.3 shows Chemical composition of clear glass is as follows:

Table 3.3 Chemical Composition of Glass

Composition	**Clear Glass**
Sio2	72.42
Al2O3	1.44
Tio2	0..35
Cr2O3	0.002
Fe2O3	0.07
CaO	11.50
MgO	0.32
Na2O	13.64
K2O	0.35
SO3	0.21

- Following figure no 3.4 and 3.5 shows crushed waste Glass material:-

Figure 3.4 Crushed Glass

Figure 3.5 Crushed Glass

3.1.5.1 Test carried on crushed Glass

- A.Specific Gravity

Apparatus

- 1.A balance of capacity not less than 3kg ,readable and accurate to 0.5 gm and of such a type as to permit the weighing of the vessel containing the aggregate and water .
- 2. A well ventilated oven to maintain a temperature of 100ºC to 110ºC
- 3 .Pycnometer of about 1 Littre capacity having a metal conical screw top with a 6mm hole at its apex. The screw top shall be water tight.
- 4. A means supplying a current warm air.
- 5. A tray of area not less than 32cm².
- 6. An air tight container large enough to take the sample.
- 7. Filter papers and funnel.

Procedure

(I) Take about 500g of sample and place it in the pycnometer.

(II) Pour distilled water into it until it is full.

(III) Eliminate the entrapped air by rotating the pycnometer on its side, the hole in the apex of the cone being covered with a finger.

(IV) Wipe out the outer surface of pycnometer and weigh it (W)

(V) Transfer the contents of the pycnometer into a tray, care being taken to ensure that all the aggregate is transferred.

(VI) Refill the pycnometer with distilled water to the same level.
(VII) Find out the weight (W1)
(VIII) Drink water from the sample through a filter paper.
(IX) Place the sample in oven in a tray at a temperature of 100ºC to 110º C for 24±0.5 hours, during which period, it is stirred occasionally to facilitate drying.
(X) Cool the sample and weigh it (W2).

The following table shows Specific gravity test
Observation-

Table 3.4 Specific Gravity Test

Density bottle number	1	2	3
Mass of empty bottle W_1gm	680	702	685
Mass of bottle + crushed glass W_2gm	780	802	785
Mass of bottle + crushed glass + water W_3gm	1538	1650	1590
Mass of bottle full of water W_4gm	1480	1590	1535
Mass of soil $(W_2 – W_1)$ gm	100	100	100
Mass of water in full bottle (W_4-W_1) gm	800	888	850
Mass of water used $(W_3 – W_2)$ gm	758	848	805
Volume of soil particle $(W_4 – W_1) – (W_3- W_2)$ gm	42	40	45
Average specific gravity	2.36		

Calculation:-

$$G = \frac{(W_2 – W_1)}{(W_4 – W_1) – (W_3- W_2)}$$

$= 2.36$

Result:-
Specific gravity of fine aggregate = 2.36

3.1.6 Moulds –

The rubber mould are used for casting paving block of Type C: Paver blocks having all faces curved or corrugated, which key into each other along all the vertical faces when paved in any pattern. They were made in such a manner as to facilitate the removal of the moulded specimen without damage.

- Following figure 3.6 shows C- type rubber mould :-

Figure 3.6 C-Type Rubber Mould.

Metal moulds are used for casting of concrete cube, preferably steel or cast iron of size 15 cm x 15 cm x 15 cm were used for practical analysis. They were made in such a manner as to facilitate the removal of the moulded specimen without damage. The joints between the sections of the mould are thinly coated with mould oil and a similar coating of mould oil is applied between the contact surface of the bottom of the mould and the base plate in order to ensure easy removal of specimen from mould. The mould nuts and bolts were tightened so that no water escapes during the filling.

- Following figure 3.7 shows concrete cube mould:-

Figure 3.7 Concrete Cube Mould

3.1.7 Weighing –

The proportions or the materials are taken by weight or by volume. The procedure we adopted was by weighting of the material this is more accurate method than volumetric method hence we preferred this method.

3.1.8 Mixing-

After taking weights of all the ingredients there was the next procedure of mixing. First take the coarse aggregate than fine aggregate sand and then cement with fly ash in hump manner. Then first mixing was carried out in dry mixing for 3 times. Then again the material hump was created. Then small pond was created and the calculated quantity or specified water was poured in the pond. Then the materials was wet mixed from out to in. The wet mixing was carried for 3 times. The mixing was done manually. To get good result the mixing can be done by small mechanical mixes.

3.1.9. Compacting-

Compacting of concrete was done after placing the mixed concrete in the mould of 15 cm x 15 cm x 15 cm as well as paving rubber mould. The compaction was carried out manually with tamping steel rods and vibrating concrete externally. The

concrete was filled in 3 layers. Each layer was tamped 25 times for cube casting and for the paving blocks 10 mm thickness of doramite and colour mixture after that concrete mixture. The filling of concrete in mould was done in such a way that the materials were equally distributed in the mould. The compaction by tamping rod for was done vertically for cube and table vibrator for paving block. The compaction must be carried very carefully so that no voids are left and concrete becomes denser.

3.2 CURING OF PAVING BLOCK AND CONCRETE CUBES-

Curing is the process in which the concrete is protected from loss of moisture and kept within a reasonable temperature range. This process results in concrete with increased strength and decreased permeability. Curing is also a key player in mitigating cracks. Traditionally, quality of concrete in construction works is calculated in terms of its 28 days compressive strength. . If after 28 days, the quality of concrete is found to be dubious, it would have considerably hardened by that time and also might have been buried by subsequent construction.

For paving blocks Air curing is used. Because of The necessity for curing arises from the fact that hydration of cement can take place only in water-filled capillaries. This is why loss water must be prevented. Furthermore, water lost internally by self-dedication has to be replaced by water from outside Thus, for complete and proper strength developments, the loss of water in concrete from evaporation should be prevented, and the water consumed in hydration should be replenished. This the concrete continues gaining strength with time provided sufficient moisture is available for the hydration of cement which can be assured only by creation of favorable conditions of temperature and humidity. This process of creation of an environment during a relatively short period immediately after the placing and compaction of the concrete, favorable to the setting and the hardening of concrete is termed curing (The paving blocks are kept under shadow for curing. The curing is done for 7 and 28 days.

Following figure 3.14 shows Air curing of paving block :

Figure: 3.14 Curing Of Paving Block

For paving blocks & concrete cubes of size 0.15X0.15X0.15 m Air curing method is used. The paving blocks and concrete cubes are kept under shadow for curing. The curing is done for 7 and 28 days. In case of dry-air curing, the specimens were weighed and exposed to dry air.

3.3 TESTING OF PAVING BLOCKS-

- The number of paving blocks tested is given in Table shows 3.3

Table 2.6 Samples tested as per IS: 15658:2006

Property	Reference Clause No.	Testing method	Number of paver blocks for each test
Compressive strength	6.2.5	Annex D	
Flexural strength	6.3.2	Annex F	

Compressive Strength:-

Paving block were tested for compressive strength. Compressive strength of paver blocks shall be specified in terms of 28 days compressive strength. The average 28 days compressive strength of paver blocks shall meet the specific requirement. Compression testing machine was used for the testing of paving blocks.

- Following Table no. 3.7 shows Compressive Testing for Result for Ordinary Paving Block respectively :-

Table 3.7 Compressive Testing Result for Ordinary Paving Blocks

PERIOD	LOAD (TN)	LOAD (N)	COMPRESSIVE STRENGTH (N/MM^2)	AVG. COMPRESSIVE STRENGTH(N/MM^2)
AT 7 DAYS	185	$1850X10^3$	44.39	43.51
	180	$1800X10^3$	43.19	
	179	$1790X10^3$	42.95	
AT 28 DAYS	246	$2460X10^3$	59.04	58.40
	240	$2400X10^3$	57.60	
	244	$2440X10^3$	58.56	

Following Table no. 3.8,3.9 and 3.10 shows Compressive Testing for Result for 15%,30% and 45% replacement of glass Paving Block respectively :-

Table 3.8 Compressive Testing Result For 15% Replacement Paving Block

PERIOD	LOAD (TN)	LOAD (N)	COMPRESSIVE STRENGTH (N/MM^2)	AVG. COMPRESSIVE STRENGTH(N/MM^2)
AT 7 DAYS	223	$2230X10^3$	53.51	54.55
	232	$2320X10^3$	55.67	
	227	$2270X10^3$	54.47	
AT 28 DAYS	OVER 300	$3000X10^3$	71.99	71.99
	OVER 300	$3000X10^3$	71.99	
	OVER 300	$3000X10^3$	71.99	

Table 3.9 Compressive Testing Result For 30% Replacement Paving Blocks

PERIOD	LOAD (TN)	LOAD (N)	COMPRESSIVE STRENGTH (N/MM^2)	AVG. COMPRESSIVE STRENGTH(N/MM^2)
AT 7 DAYS	248	$2480X10^3$	59.51	58.31
	242	$2420X10^3$	58.07	
	239	$2390X10^3$	57.35	
AT	OVER	$3000X10^3$	71.99	

	300			
• 28	OVER 300	$3000X10^3$	• 71.99	• 71.99
• DAYS	• OVER 300	• $3000X10^3$	• 71.99	•

Table 3.10 Compressive Testing Results For 45% Replacement Paving Blocks

• PERIOD	• LOAD (TN)	• LOAD (N)	• COMPRESSIVE STRENGTH (N/MM^2)	• AVG. COMPRESSIVE STRENGTH(N/MM^2)
• AT	• 227	• $2270X10^3$	• 54.57	•
• 7	• 217	• $2170X10^3$	• 52.07	• 53.99
• DAYS	• 231	• $2310X10^3$	• 55.43	•
• AT	• OVER 300	• $3000X10^3$	• 71.99	•
• 28	OVER 300	$3000X10^3$	• 71.99	• 71.99
• DAYS	• OVER 300	• $3000X10^3$	• 71.99	•

- Following figure 3.15 shows Compression Testing on paving block:-

Figure: 3.15 Compressions Testing On Paving Block

casting

Following figure 3.16 shows graph compressive strength v/s method of paving block :-

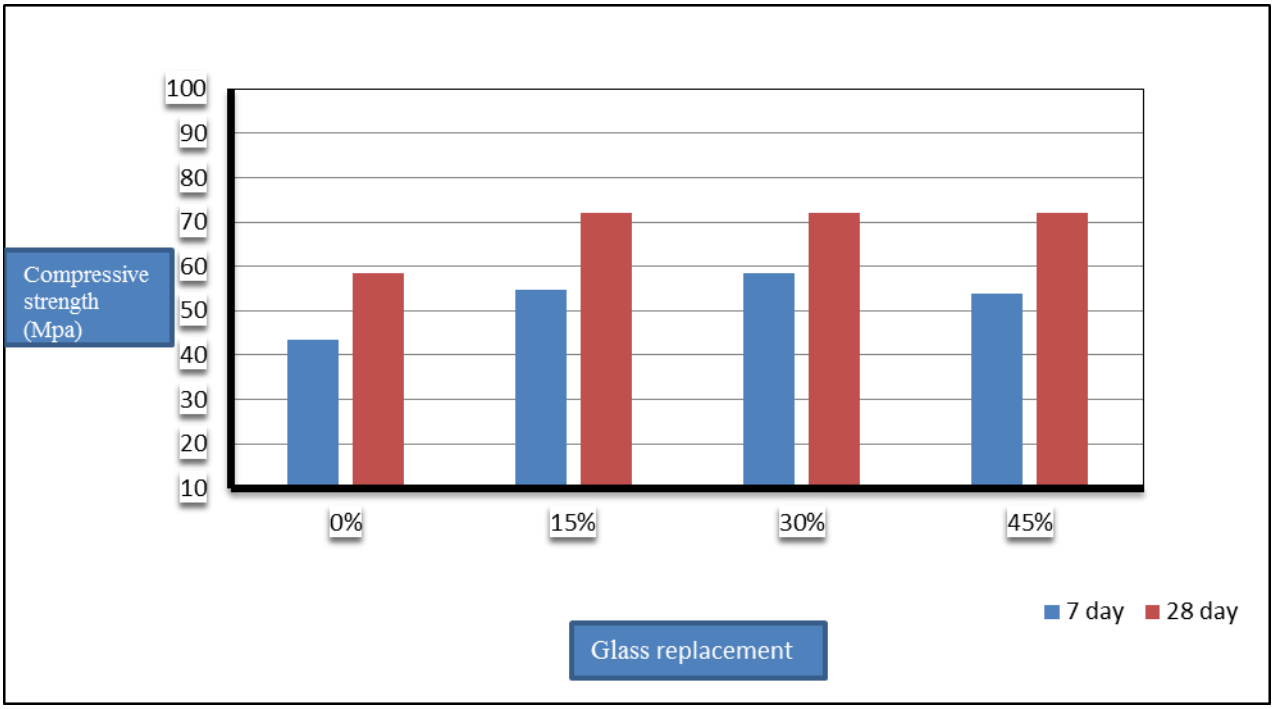

Figure: 3.16 Compressive strength vs % of glass replacement

Compressive strength on concrete cubes-

- Following Table no. 3.11 shows Compressive Testing for Result for Ordinary Concrete Block respectively :-Table 3.11 Compression test on concrete cubes (Ordinary)

PERIOD	LOAD (TN)	LOAD (N)	COMPRESSIVE STRENGTH (Mpa)	AVG. COMPRESSIVE STRENGTH(Mpa)
AT 7 DAYS	43.9	$439.0X10^3$	19.51	19.50
	43.0	$430.0X10^3$	19.11	
	44.7	$447.0X10^3$	19.87	
AT 28 DAYS	73.5	$735.0X10^3$	32.67	32.55
	71.8	$718X10^3$	31.91	
	74.4	$744X10^3$	33.06	

Following Table no. 3.12,3.13 and 3.14 shows Compressive Testing for Result for 15%,30% and 45% replacement of glass Concrete Block respectively :-

Following Table no. 3.12,3.13 and 3.14 shows Compressive Testing for Result for 15%,30% and 45% replacement of glass Concrete Block respectively :-

Table3.12Compression test on concrete cubes (15 % replacement)

PERIOD	LOAD (TN)	LOAD (N)	COMPRESSIVE STRENGTH (Mpa)	AVG. COMPRESSIVE STRENGTH(Mpa)
AT	45.5	$455X10^3$	20.22	
7	46.1	$461X10^3$	20.48	20.63
DAYS	47.7	$477X10^3$	21.20	
AT	76.1	$761X10^3$	33.82	
28	76.9	$769X10^3$	34.17	34.46
DAYS	79.7	$797X10^3$	35.38	

Table 3.13 Compression test on concrete cubes (30 % replacement)

PERIOD	LOAD (TN)	LOAD (N)	COMPRESSIVE STRENGTH (Mpa)	AVG. COMPRESSIVE STRENGTH(Mpa)
AT	48.307	$483.07X10^3$	21.47	
7	47.490	$474.90X10^3$	21.11	21.86
DAYS	46.9	$469X10^3$	20.87	
AT	80.257	$802.57X10^3$	35.67	
28	78.6	$786X10^3$	34.91	35.27
DAYS	78.9	$789X10^3$	35.06	

Table3.14Compression test on concrete cubes (45 % replacement)

PERIOD	LOAD (TN)	LOAD (N)	COMPRESSIVE STRENGTH (Mpa)	AVG. COMPRESSIVE STRENGTH(Mpa)
AT	43.9	$439X10^3$	19.51	
7	42.7	$427X10^3$	18.97	19.64
DAYS	46.0	$460X10^3$	20.44	
AT	73.6	$736X10^3$	32.67	
28	75.7	$757X10^3$	33.60	33.11
DAYS	74.4	$744X10^3$	33.06	

- Followig figure 3.17 shows compressive strength v/s method of casting cube :-

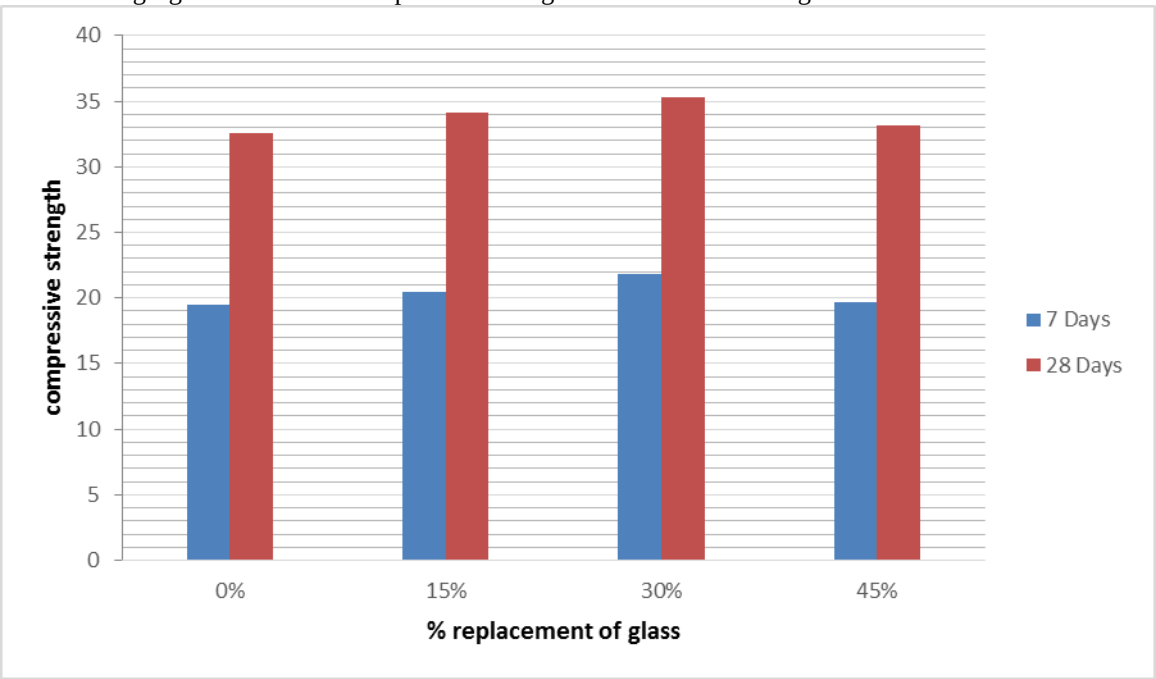

Figure 3.17 compression strength vs. % of glass replacement in cubes

FlexureTest:-

- The flexural strength of the paving block shall be calculated as follows;

$Fb = 3Pl/2bd2$

Following Table no. 3.15 Shows Flexure Test Result for Ordinary Paving Block respectively :-

Table 3.15 Flexure Test Result for Ordinary Paving Blocks

PERIOD	LOAD (KN)	LOAD (N)	COMPRESSIVE STRENGTH (N/MM^2)	AVG. COMPRESSIVE STRENGTH(N/MM^2)
AT	8.152	$8.152X10^3$	2.36	
7	7.958	$7.958X10^3$	2.30	2.38
DAYS	8.557	$8.557X10^3$	2.48	
AT	9.532	$9.532X10^3$	2.76	
28	9.263	$9.263X10^3$	2.68	2.76
DAYS	9.897	$9.897X10^3$	2.86	

Following Table no. 3.16 Shows Flexure Test Result for 15% Replacement of Paving Block respectively :-

Table 3.16 Flexure Testing Result for 15% Replacement of Paving Block

PERIOD	LOAD (TN)	LOAD (N)	COMPRESSIVE STRENGTH (N/MM^2)	AVG. COMPRESSIVE STRENGTH(N/MM^2)
AT	6.38	$6.38X10^3$	1.84	
7	6.89	$6.89X10^3$	1.99	1.96
DAYS	7.11	$7.11X10^3$	2.06	
AT	8.12	$8.12X10^3$	2.35	
28	8.45	$8.45X10^3$	2.45	2.40
DAYS	8.27	$8.27X10^3$	2.39	

Following figure 3.18 shows flexural Testing on paving block:-

Figure 3.18 Flexural Testing on Paving Block.

- Following figure 3.19 shows paving block Before tseting:-

Figure 3.19 Paving block before flexure Testing

- Following figure 3.20 shows Paving Block After Testing:-

Figure 3.20 paving block after flexure testing

IV. RESULTS AND DISCUSSION

4.1 Result-

To observe the effect on compressive strength of paver blocks and concrete cube of waste glass used as replacement with fine aggregate at 15, 30 and 45% of replacement in paver blocks as well as concrete cube of 15* 15* 15 cm were used. Paver blocks and concrete cube are cast without glass also and the waste glass replacement paving block are compared with the paver blocks made without replacement of glass (Ordinary paving block).The results of compression test and flexure test are obtained that are shown below.

- Following Table no.4.1 shows result of compressive strength on paving block.

Table 4.1 Compressive strength on paving block

	After 7 days(Mpa)	After 28 days(Mpa)
Ordinary paving blocks	43.41	58.40
15% glass replaced paving blocks	54.55	71.99

30% glass replaced paving blocks	58.31	71.99
45% glass replaced paving blocks	53.99	71.99

- Following Table no.4.2 shows result of compressive strength on concrete block:-

Table 4.2 Compressive strength on concrete block

	After 7 days(Mpa)	After 28 days(Mpa)
Ordinary paving blocks	19.50	32.55
15% glass replaced paving blocks	20.46	34.12
30% glass replaced paving blocks	21.86	35.27
45% glass replaced paving blocks	19.64	33.11

- Following Table no.4.2 shows result of flexural strength on paving block:-

Table 3.3 Flexural strength on paving block

	After 7 days(Mpa)	After 28 days(Mpa)
Ordinary paving blocks	2.38	2.76
15% glass replaced paving blocks	1.96	2.40

- Following figure no.4.1 shows result of flexural strength on paving block:-

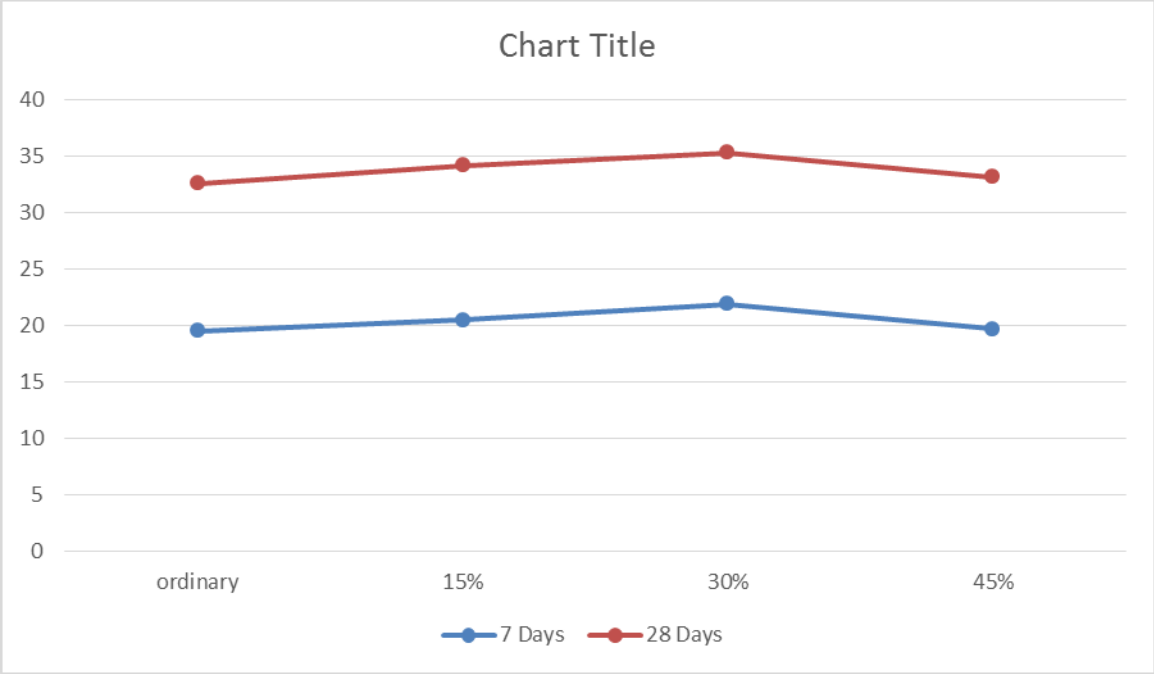

Figure 4.1 Compressive strength vs % of glass replacement in cube

An analysis made on strenghth characteristic by conducting test on non-recyled glass concrete. The 7 days and 28 days compressive strength result of M30 grade concrete shown in table and analysis by graphically shown in chart.

We replace waste glass as a fine aggregate in concrete with different percentage such as 15%, 30%, and 45%. The tests carried on the fine aggregate such as specific gravity,sieve analysis are also conducted on waste glass.

We casted overall 36 paving blocks and 12 cubes . In that we cast normal blocks (Ordinary paving block and cube) of M30 grade concrete and compressive test conducted on paving block as well as concrete cube and the flexural test are conducted on only the paving block that after curing of 7 days and 28 days. By replacing waste galss to fine aggregate in different percentage 15%, 30%,and 45% casting is done. After curing of 7 days and 28 days the compressive test and flexural test are conducted on that. By observing results of waste glass blocks that is concrete cube the srength of bolck is increases from 15% to 30% repalcement of glass and after 45% waste glass replacement and onwards the srength is decreases. Strength reduce because of internal voids of waste galss increases. We compairing strength of waste glass bolcks with normal blocks. Upto 15% and 30% is compaerly more than normal block but upto 45% srength is nearly same to normal block.So from above chart we got the optimized value as 30% repalcement of waste glass as well we

found that 45% replacement of waste galss is suitable for casting the paving block for light traffic.

V. CONCLUSION

The feasibility of concrete blocks with the Fine Glass was shown technically in the present study. Based on the experimental investigation, the following conclusions-

- Density of concrete decreased with increase in waste glass content thus making concrete light weight in nature.
- The use of waste glass as fine aggregate decreases the unit weight of concrete.
- With increase in waste glass content, percentage water absorption decreases.
- Workability of concrete mix increases as well as durability of concrete also increases with waste glass content.
- Flexural strength decreases with increase in waste glass content.
- Compressive strength increases with increasing the glass parentage from 15% to 30% repalcement of glass and after 45% waste glass replacement onwards the srength is decreases. Strength reduce because of internal voids of waste galss increases.
- Cost of paving blocks is decreases with increase in glass content.
- Crushed waste glass aggregate have irregular shapes than river sand.
- Reduction in bleeding is observed by addition of glass in the concrete mixes.
- Fluidity of the fresh concrete is inhibited.

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