PREPARATION OF PAVER BLOCKS BY ADDING GLASS WASTE

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ABSTRACT

In the past few decades, the rapid process of industrialization and urbanization has increased the generation of waste material at huge rates and landfills are filling up faster than the exploration of new sites. Disposal of industrial waste is one of the serious problems faced worldwide. There is now a significant interest to solve the environmental problem caused by industrial waste and other similar materials by adding such material in manufacture of concrete. The use of paver block technique has been introduced in construction a decade ago, for specific purpose namely footpath, parking area etc. but now being adopted extensively for different units where the conventional concrete of pavement using bituminous mix or cement concrete technique is not feasible or desirable. This study looked at the feasibility of Fly ash inclusion as partial cement and glass waste as fine aggregates replacement system. Properties of M30 grade concrete paver blocks replacing glass waste as fine aggregate partial substitution around of 2.5%, 5%, 7.5% and 10% were investigated. Also the concrete replacing fly ash as partial substitution for cement amounts of 25% were investigated.

1. INTRODUCTION

1.1 General

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 Paver blocks 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 Paver blocks. 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

S.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	M30	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	45	Heavy traffic	100	Bus terminals, industrial complexes, mandi houses, roads on expansive soils, factory floor, service stations, industrial pavements, etc
5	M55	50	Very Heavy traffic	120	docks yards, mine access roads, bulk cargo handling areas, airport pavements, etc.

1.2 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 &

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.

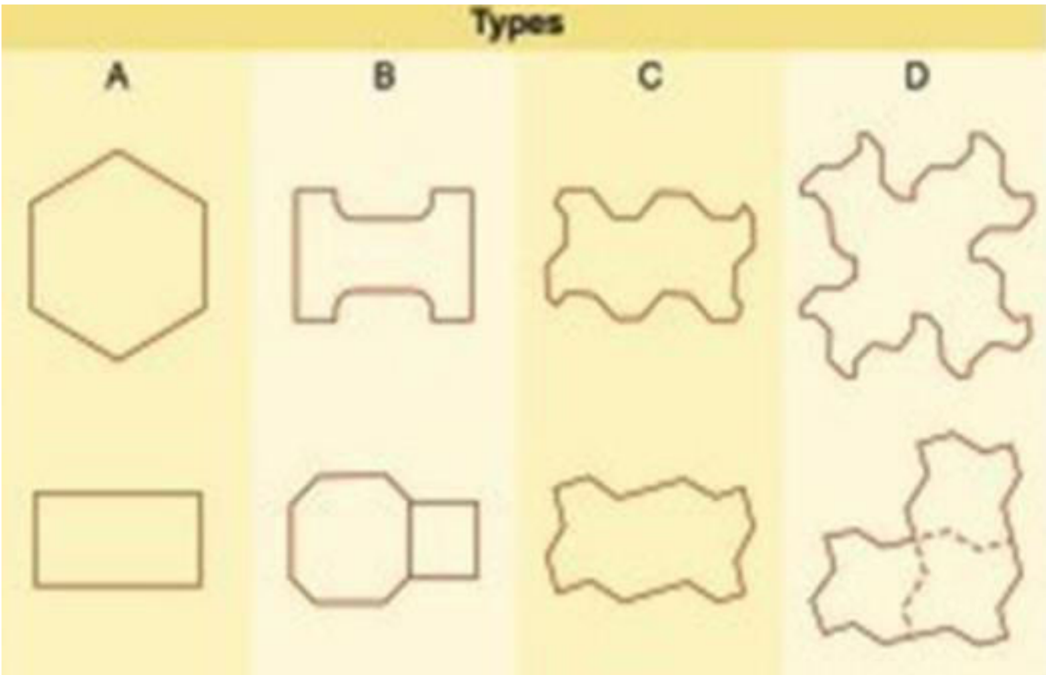

Figure: 1.1 Different Shapes Paving blocks

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 Paver blocks are a porous form of Paver block 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 Paver blocks 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.

1.3 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.

Solid Waste from 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. In this project fly ash and glass waste using as preparation of paver blocks.

2. LITERATURE REVIEW

Ritesh Mall et al, In this Compressive Strength analysis of Paver Block with 0%, 5%, 10%, 15%, 20%, 25%, 30%, fly ash are tested and graph shown that at 25% fly ash is partially replaced with OPC 43 grade give higher strength as compared to conventional mix i.e., is 0%. Then at 25% fly ash give economic value as compared to conventional mix i.e., is 0%. Replacement of cement by Fly Ash up to 25% by weight has a negligible effect on the reduction of any physical and mechanical properties like compressive strength, flexural strength etc. There is limitation in addition of Fly Ash in concrete to maintain the workability of concrete. There are 10-20% reductions in cost with the addition of 25% fly ash in concrete. Use of Fly Ash in Paver block can solve the disposal problem, reduce cost and produce a greener Eco friendly Paver Blocks for pavement.

Patel Vivek V and Et Al (2016) had studied that concrete paving blocks are supreme materials on the roads and footpaths for better look, easy laying and finish. Paver block has small maintenance cost and replace easily with a newer one at the time of fracture. There are various types of Industrial Waste available in local markets, and certain of it in the building industry can be used for deployment of waste material and eco-friendly condition, which would lessen both the discovery cost and environmental effects of paver block works in the construction industry are vitalmainly as it is not only accountable for natural resources consumption and energy but also its absorb capacity waste of the other industry. The objective of this investigation is mainly to increase the compressive strength of paver blocks rubber mould and the cost decrease of rubber mould paver blocks by replacing aggregates with the Kota stone chips.

Dinesh W. Gawatre et al (2015) have been studied on manufacture of paver block using partial replacement of construction and demolished concrete waste. In order to achieve the same conventional results they trying to replace the course aggregate and fine aggregate completely and partially up to 50% in bottom layer because of environmental considerations and growing trend in reusing waste products. Impact value and crushing value obtained for aggregates obtained from concrete waste were 14.6% and 13.25% respectively which are way better than requirements as per IS recommendations. They conclude the characteristic compression strength of interlocking paver blocks obtained was 35.63MPa which is more than design standards for M35. Minimum breaking load for a single sample out of eight samples was 6.420KN, which is still more than that required for Regularly Trafficked Roads. Average tensile splitting strength was obtained as 1.5MPa which is not satisfactory. Finally they concluded that the paver blocks prepared using M35 grade of concrete and 50% replacement of aggregates can be used for pedestrian plazas, car parks, rural roads, office complexes, with short volume traffic, residential roads, housing colonies etc.

Ronaldo L.S.Izzo (2015) construction and debris from demolition and manufacture lime waste. They check the physical and chemical characteristics of the waste lime and mechanical also. To study about the chemical, mineralogy composition of finishing products and earlypart and also axial resistance strength, and absorption of water etc. Extra studies about growth after adding of calcium carbonate and carbonate of magnesium.

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

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

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

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

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

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

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

3. OBJECTIVE AND METHODOLOGY

3.1 Objective of study

The objective of this Project is given below

1. Here Paver Block is manufactured by using design mix M30 and makes the paver block more durable and effective.
2. Study on strength characteristics of M30 grade concrete paver blocks with replacement of 25% cement by fly ash and replacement of 2.5%, 5%, 7.5% and 10% fine aggregate by glass waste(4.75mm – 75microns).
3. Study the Compressive Strength of Paver Block in 7 days, 14 days and 28 days respectively.
4. To determine the Shape and size test, water absorption test, fire ignition, Colour test and Structure test for concrete.

3.2 Methodology

During this experimental study we are going to perform various test on fine aggregate, coarse aggregate, glass waste, Fly ash and various strength test on Interlocking paver blocks designed by decided mixes of M30. We are perform following tests on materials:

a) On Coarse Aggregate: Specific Gravity, Sieve analysis, Water Absorption Test

b) On Fine Aggregate & glass waste: Specific Gravity, Sieve analysis and Water Absorption Test

c) On Fly Ash: Specific Gravity, Fineness Module

d) On Cement: Specific Gravity, Finesse Test, Consistency, Initial and Final Setting Time

We are going to perform following procedure on modified mixed concrete Paver Block:

1. We have to use dry waste material (fly ash and glass waste).
2. Then, we crush the rubber waste in small particles, the small particles crush into fine size particles (10mm-4.75mm).
3. Mix I : 25% of cement replacing with fly ash, coarse aggregate, cement and fine aggregates, w/c ration kept constant.
4. Mix II : Fine particles of glass waste partially replacing with coarse aggregates, 25% of cement replacing with fly ash and fine aggregates, w/c ration kept constant.
5. We can mix it properly and make a uniform mixes I & II.

6. We poured the mix into moulds.
7. Keep it the moulds for dry upto 24hrs.
8. And compare the compressive strength for mix I & II, and conclusions.

4. EXPERIMENTAL INVESTIGATION

4.1 Materials Used

For the preparation of paver blocks by using concrete, we are used Cement, fly ash, glass waste, Coarse aggregates, Fine aggregates and water.

4.2 Mix design

Adopted Grade was **M30** for preparion of concrete Paver blocks

Table 4.1: Quantities of materials in cement concrete.

Material	Quantity
Cement (grade 53)	425.73Kg/m^3
Water	191.58 liters
Fine aggregate	649.63 kg/m^3
Coarse aggregate	1199.92 Kg/m^3
Water: cement	0.45

The final mix proportions are:

cement: fine aggregate: coarse aggregate = **1: 1.526: 2.818: 0.45**

4.2.1 Fly ash and Glass waste replacement in concrete Paver blocks

For 1 Paver block making (25% Replacement of cement with Fly ash and 0% to 35% replacement of fine aggregates with glass waste).

Volume of block = 1.1 X (0.2 x 0.1 x 0.1) = 2.2 x 10^{-3} m^3

Table 4.2: Quantities of materials for 1 Block

Mix	Fly ash – Glass waste(%)	Cement (kg)	Fly ash (kg)	FA (kg)	Glass waste(kg)	CA (kg)	Water (lit)
1	0-0	0.936	0	1.43	0	2.64	0.421
2	25 - 0	0.702	0.234	1.43	0		
3	25 – 5			1.358	0.0715		
4	25 – 10			1.287	0.143		
5	25 – 15			1.215	0.2145		
6	25 – 20			1.144	0.286		
7	25 -25			1.0725	0.3575		

8	25 - 30			1	0.43		
9	25 - 35			0.93	0.5		

4.3 Sample Production

Control mix: The cement, fine and coarse aggregates were weighted according to mix proportion of M_{30}. All are mixed together in a bay until mixed properly and water was added at a ratio of 0.45. The water was added gradually and mixed until homogeneity is achieved. Any lumping or balling found at any stage was taken out, loosened and again added to the mix.

Fly ash based Concrete paver block: The cement, fly ash (25% of cement weight replacement), fine and coarse aggregates were weighted according to mix proportion of M_{30}. All are mixed together in a bay until mixed properly and water was added at a ratio of 0.45. The water was added gradually and mixed until homogeneity is achieved. Any lumping or balling found at any stage was taken out, loosened and again added to the mix.

Fly ash & Glass waste based concrete paver block: The cement, cement (25% of cement weight replacement), coarse aggregates, fine aggregates, and glass waste(0% - 35% with interval of 5% replacement of fine aggregates) were weighted according to mix proportion of M_{30}. All are mixed together in a bay until mixed properly and water was added at a ratio of 0.45. The water was added gradually and mixed until homogeneity is achieved. Any lumping or balling found at any stage was taken out, loosened and again added to the mix.

A 100×100×100 mm paver block specimens were casted for all above various types of concrete mixes. The samples were then stripped after 24hours of casting and are then be water for curing 7days, 14days, 28days. As casted, a total of (90) 100x 100 × 100mm paver block specimens were produced.

4.3.1 Curing

The next stage is curing of the specimens. It is an important phase as the water for hydration is to be maintained in the specimens. Proper curing gives good strength to the concrete. So, after removing from the moulds the specimens are transferred to the curing tank containing water free from impurities and cured for 28 days.

4.4 Experimental Procedure

In this section, the test setup and experimental procedure for conducting various tests are discussed.

4.4.1 Compressive strength test (IS 516-1989)

Compressive strength of concrete is the most important characteristic and it is an indexing property as concrete is designed to carry compressive loads.

This test is conducted to determine the variation of strength of the specimens with varying ratios of fine aggregate and cement with glass waste& fly ash. Compressive strength test machine (CTM) with 2000KN capacity is used to conduct the test on block. After placing the cube between the plates in the CTM, load is applied until the crack is observed on the specimen. The load at the point of cracking is considered as failure load and it is noted. The compressive strength is calculated by

Compressive Strength (σ) = Failure load / Cross sectional area of specimen

4.4.2 Water Resistance Test

In this the paver block first weighted in dry condition and they are immersed in water for 24 hours. After that they are taken out from water and they are wipe out with cloth. Then the difference between the dry and wet Paver blocks percentage are calculated. The less water absorbed by paver block the greater its quality. Good quality paver blocks don't absorb more than **20%** water of its own weight.

4.4.3 Efflorescence test

The presence of alkalies in Paver blocks is harmful and they form a grey or white layer on the Paver block surface by absorbing moisture. To find out the presence of alkalis in Paver blocks this test is performed. In this test, a Paver block is immersed in fresh water for 24 hours and then it's taken out of the water and allowed to dry in shade. If the whitish layer is not visible on the surface it proofs that absence of alkalis in Paver block.

If the whitish layer visible about 10% area of the Paver block surface then the presence of alkalis is in the acceptable range. If that is about 50% of surface area then it is moderate. If the alkali's presence is over 50% of the Paver block surface area then the Paver block is severely affected by alkalies**.**

4.4.4 Shape and Size Test

Shape and size of Paver blocks are very important consideration. All Paver blocks used for construction should be of same size. The shape of Paver blocks should be purely rectangular with sharp edges. Standard Paver block size consists length x breadth x height as 100mm x 100mm x 100mm.

4.4.5 Colour Test

A good Paver block should possess bright and uniform color throughout its body.

4.4.6 Fire Resistance Test

The external fire, applied on Paver block to test the fire resistance test. Concrete Paver blocks all materials are act like insulation. If there is no change in the structural properties of Paver blocks up to 180^0 above which visible cracks are seen and the Paver blocks deteriorate with increase in temperature.

4.4.7 Soundness test

Soundness test of Paver blocks shows the nature of Paver blocks against sudden impact. In this test, 2 Paver blocks are chosen randomly and struck with one another. Then sound produced should be clear bell ringing sound and Paver block should not break. Then it is said to be good Paver block.

4.4.8 Hardness test

A good Paver block should resist scratches against sharp things. So, for this test a sharp tool or finger nail is used to make scratch on Paver block. If there is no scratch impression on Paver block then it is said to be hard Paver block.

4.4.9 Drop test

When Paver blocks are dropped from the height of 1 to 1.2m (4 feet), it should not crack or break. This ensures the durability and quality of Paver blocks.

4.4.10 Structure of Paver blocks

To know the structure of Paver block, pick one Paver block randomly from the group and break it. Observe the inner portion of Paver block clearly. If there are any flaws, cracks or holes present on that broken face then that isn't a good quality Paver block.

5.RESULTS AND DISCUSSIONS

As per experimental programmed results for different experiments were obtained. They are shown in table format or graph, which is to be presented in this chapter.

5.1 Paver block Test Results

5.1.1 Compression Test

Table 5.1 Compression test results

Mix	Fly ash – glass waste(%)	Compressive strength (Mpa)		
		7 days	14 days	28 days
M1	0-0	17.5	25.1	28.9
M2	25 - 0	18	26.4	30
M3	25 – 5	18.4	27.45	30.5
M4	25 – 10	18.9	28	30.8
M5	25 – 15	19	28.23	31
M6	25 – 20	19.2	28.4	31.2
M7	25 -25	19.32	28.7	31.5
M8	25 - 30	18.8	27.75	30.5
M9	25 - 35	18.5	26.75	29.4

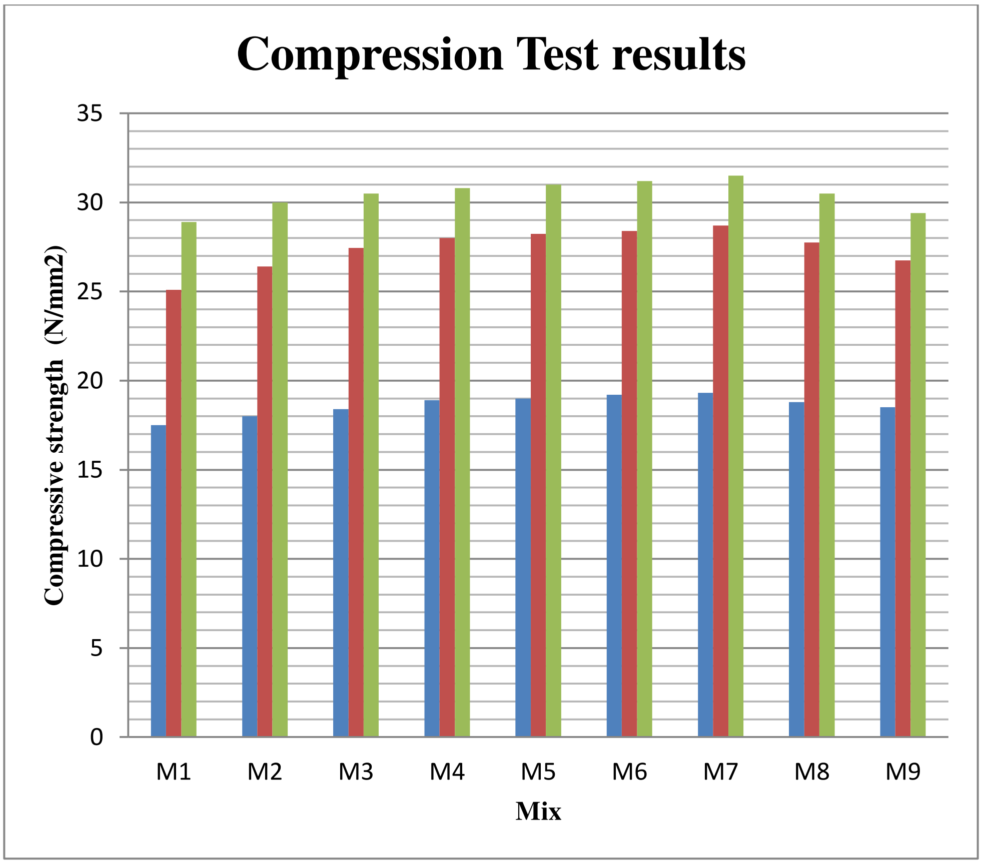

Fig 5.1 Compressive strength test results graph

The compressive strength is increasing with increasing in the glass waste as coarse aggregate replacement in the concrete Paver blocks preparation. The replacement of cement with fly ash (25%) and fine aggregate with glass waste(Up-to 25%), the incremental concrete compressive strength comparison is mentioned below:

Mix	Fly ash – glass waste(%)	28 days Compressive strength (Mpa)	Increment (%)
M1	0-0	28.9	-
M2	25 - 0	30	+3.8
M3	25 – 5	30.5	+5.53
M4	25 – 10	30.8	+6.57
M5	25 – 15	31	+7.26
M6	25 – 20	31.2	+7.96
M7	25 -25	31.5	+8.9
M8	25 - 30	30.5	+5.53
M9	25 - 35	29.4	+1.73

Table 5.2 Compression test results comparison

The compressive strength is higher for all different mixes as compare to the control mix of M1. The optimum dosage of Fly ash – glass waste(%) is 25 – 25 (%).

5.1.2 Efflorescence test

No efflorescence visible on all Paver blocks. All the Paver blocks are good quality Paver blocks.

5.1.3 Shape and Size Test

For all Paver blocks are rectangular shape and size 10 cm x 10 cm x 10 cm. Proper shaped or uniformly shaped all the casted and cured concrete Paver blocks. Then this Paver blocks are good quality Paver blocks.

5.1.4 Fire Resistance Test

There is no change in the structural properties of Paver blocks up to 200°C above which visible cracks are seen and the Paver blocks deteriorate with increase in temperature

5.1.5 Water Resistance Test

Table 5.3 Water Resistance Test results

Mix	Fly ash – glass waste(%)	Water absorption (%)
M1	0-0	2.2
M2	25 - 0	2.0
M3	25 – 5	1.9
M4	25 – 10	1.7
M5	25 – 15	1.6

M6	25 – 20	1.4
M7	25 -25	1.2
M8	25 - 30	1.0
M9	25 - 35	0.6

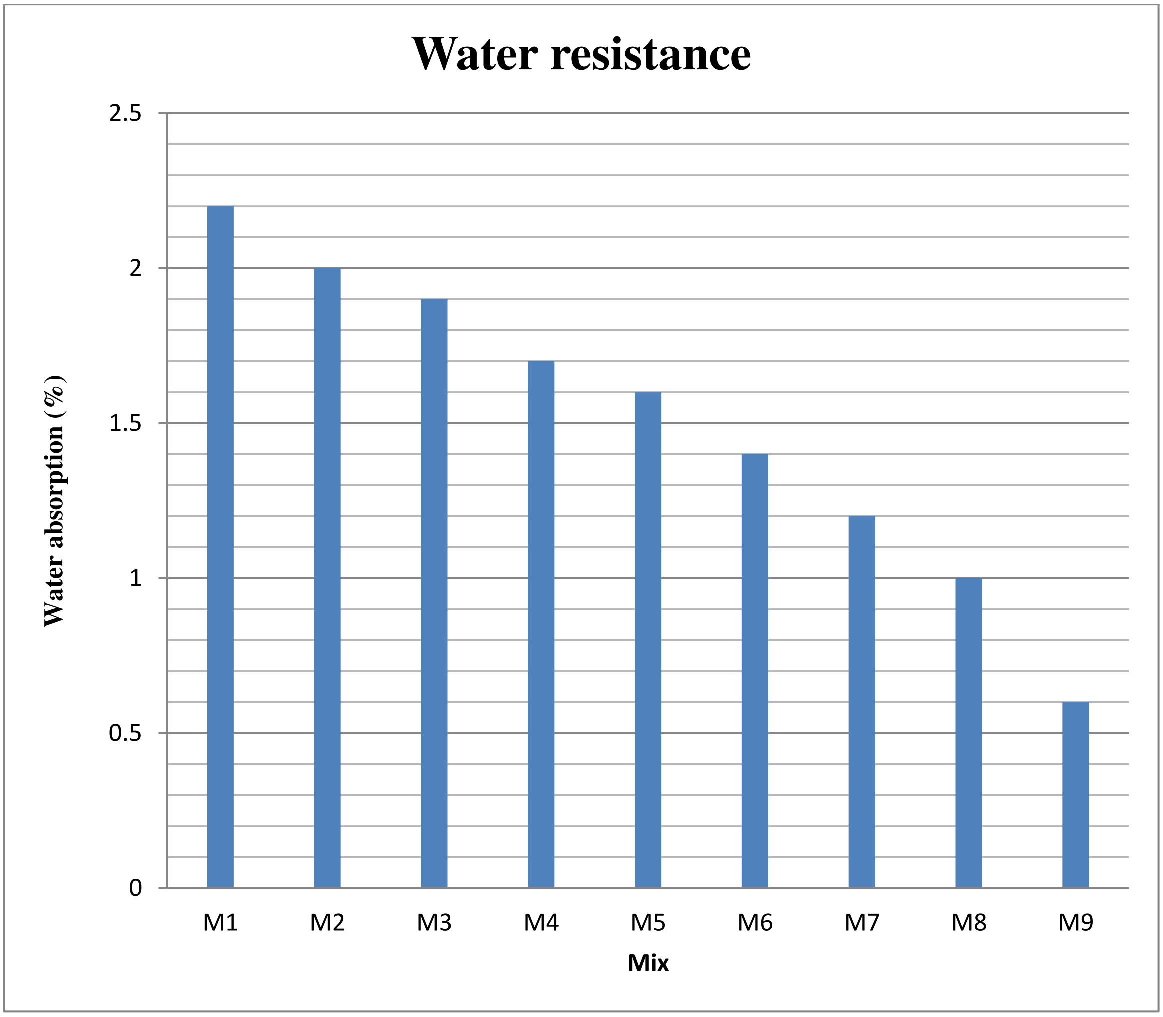

Fig 5.2 Water absorption test results graph

The water absorption value is going to decreases with increasing the tile waste content in the preparation of concrete Paver blocks**.**

5.1.6 Colour Test

All the Paver blocks having the uniform color for entire structure. Then this concrete Paver blocks are good quality Paver blocks.

5.1.7 Soundness test

For all the Paver blocks ringing sound produced and Paver blocks are un-broken. Then the Paver blocks are good quality Paver blocks.

5.1.8 Drop test

For all the Paver blocks un-broken while performed drop test, then the Paver blocks are good quality Paver blocks.

5.1.9 Structure of Paver blocks

There are no flaws, cracks or holes present on that broken face then that is a good quality Paver block.

5.1.10 Hardness test

Little bit scratch visible on all Paver blocks concrete Paver blocks

6. CONCLUSIONS

6.1 Summary

6.1.1 Study on paver blocks

Comparative study on Glass waste aggregate concrete and normal aggregate concrete has thrown the lights on following results :

1. Many private enterprises picks up waste from designated sites segregates and processes Constructional and demolished waste in to various aggregates which are then used to make building products such as paver blocks, kerb stones etc.
2. Acceptability of glass waste& fly ash was found amongst the paver blocks manufacturers only if uninterrupted supply is guaranteed at lower rates than that of virgin aggregates.
3. There are many paver block manufacturing clusters in Hyderabad which can use aggregates processed from Constructional and demolished waste, industrial wastes. A survey of manufacturers in two such clusters revealed that there is acceptability of recycled industrial waste aggregates if there is regular supply at rates lower than natural aggregates. It was also found that price of natural aggregates is directly proportional to distance of glass waste or fly ash from paver block manufacturers.
4. Paver block manufacturers situated close to the glass waste are paying less for per unit of aggregate than those situated far from them. The opportunity thus lies for an industrial waste mobile processing unit or standalone processing unit of small capacity in dump sites near to the paver block manufacturers.
5. The study identified two clusters of designated dump sites where such units can be set up. Recommendations discussed on this work include effective utilization of industrial waste collected from dumping site through decentralized approach, increasing the sanctioned capacity of the existing plant, providing logistics support to existing processing plant through differential tipping fees, enhancing awareness among entrepreneurs in Pune towards the use of industrial waste to be a secondary raw material and its potential to generate income. Other recommendations on improving product quality made out of Constructional and demolished

waste such as introduction of preferential procurement, green labelling and other certification provided by National level 2 organizations and the need for more research and development activities focused on use of fine particles (silt and clay) were also discussed.

6. Waste is unavoidable by product which is in various forms such as demolished building materials. Reducing and reuse of building materials like concrete waste, debris and old demolished structure and convert it into new usable product is the need in metropolitan cities due to rapid urbanization, development of elegance structure and also natural disaster like earthquakes, floods, wars etc.
7. Thus to reduce stresses of natural resources, recycling is need of hour for country like India. As the price of building material goes on increasing continuously due to development in rural and urban areas, a partial replacement material reduces the cost of construction.

6.1.2 Production of concrete paver block

Meticulous care, good rules of production was made for production of good concrete paver block. Quality control was done at every stage of production. Initially the dry materials Cement, Aggregates & Sand are mixed. The liquid component of the mixture was then added to the dry materials and the mixing continued for further about 4 minutes to manufacture the fresh concrete paver block. The fresh concrete was cast into the moulds immediately after mixing, in three layers for cube specimens. For compaction of the specimens, each layer was given 60 to 80 manual strokes using a rodding bar, and then vibrated for 12 to 15 seconds on a vibrating table. Addition of 10 % extra cements to cater the quality of concrete. Hand mixing is done. Hand mixing was done in a tray. The maximum size of bag in hand mixing was one.

6.1.3 Cost Optimization:

1. Cost optimization is achieved by using glass waste as sand and cement as fly ash partial replacement.
2. Cost of virgin aggregates is directly proportional to distance of glass waste or fly ash from the building material manufacturers.
3. Opportunity exist for decentralized management of industrial waste if there is a viable business cases for mobile crushing units or standalone industrial waste processing facilities of small capacities.
4. For making normal fine aggregate it required 650 per one meter cube. And for making one meter cube concrete from glass waste aggregate it required rupees 487.Thus rupees 163 per meter cube was saved due to use of processed aggregate in concrete partially, but as it uses waste and saves environmental pollution and other problems, recommended good use.
5. For making normal cement it required 430 per one meter cube. And for making one meter cube concrete from fly ash it required rupees 323.Thus rupees 107 per meter cube was saved due to use of processed cement in concrete partially, but as it uses waste and saves environmental pollution and other problems, recommended good use.

6.1.3 Safeguard to Environment

1. Lack of awareness about Constructional and industrial waste glass waste and fly ash and products amongst building material manufacturers.
2. Constructional and demolished waste can be reused in construction to reduce environment degradations and weight on ground.
3. Small steps in Hyderabad have been taken to reuse the in Ready Mix Concrete of recycled aggregates, concrete Paver blocks, blocks of footpath and kerb stones.
4. Process done Industrial waste can be used for parking and constructional embankment.
5. The study provides an analysis and evaluation of waste of construction and industrial management situation in Hyderabad and proposes suitable strategies to industrial enhance the processing and utilization of waste.

6.2 Conclusions

1. The aggregates are vital elements in concrete Paver blocks. The usage of enormous quantities of fine aggregates results in excavation of rivers causing geological and environmental imbalance. The environmental impacts of extracting river sand and crushed stone aggregates become a source of increasing concern in most parts of the Country. Pollution hazards, noise, dust, blasting vibrations, loss of forests and spoiling of natural environment are the bad impacts caused due to extraction of aggregates. Landslides of weak and steep hill slopes are induced due to unplanned exploitation of rocks.
2. Considering the depletion of natural sources and the effect on environment, the disposal problems involved in disposing glass waste and fly ash. This waste used in concrete Paver blocks manufacturing gives good mechanical properties.
3. Trying to replace fine aggregate by glass waste partially to make concrete structure more economic along with good strength criteria. This can be useful for construction of low-cost housing society. Solves problems of disposal of industrial waste of glass waste and fly ash.
4. Up to 35% of fine aggregate replaced by glass waste and 25% of cement replaced by fly ash is good according to strength and cost wise.
5. Up to 25% of fine aggregate replaced by glass waste and 25% of cement replaced by fly ash gives higher compressive strength compare to control mix.
6. The water resistance value is decreasing by increasing glass waste replacement by coarse aggregates. The structure test, soundness test, drop test, Colour test, Size and shape test the properties are similar to good quality Paver blocks. And this Paver blocks are very lesser cost compare to normal concrete and fly ash – glass waste based Paver blocks.

Future scope

1. This study limited for glass waste as fine aggregate and fly ash as cement replacement, it will extended for glass waste as coarse aggregate and fine aggregate replacement in the preparation of paver blocks and other supplementary cementitious materials as cement replacement (like GGBS, MSWA, coal dust, metakaolin, SCBA etc.)
2. The cost of glass waste somewhat higher than other industrial waste materials, try to use other industrial waste material as replacement with ingredients in the pave blocks preparation.