Experimental Studies on Rubber Mould Paver Block with Granite Chips

Ravi Goutam[1], Dr. Vihangraj V. Kulkarni[2], Dr. Jayeshkumar R. Pitroda[3]

[1]Final year Student, M. Tech Construction Engineering and Management, BVM Engineering College, Vallabh Vidyanagar, Gujarat, India

[2]Assistant Professor, Department of Civil Engineering, Government Engineering College, Banswara, Rajasthan

[3]Associate Professor, PG Coordinator Construction Engineering and Management, Civil Engineering Department, BVM Engineering College, Vallabh Vidyanagar, Gujarat, India

Abstract: *Interlocking Concrete Block has been existing in India in development, 10 years prior, for exacting requirement to be specific footpaths and parking areas and so on. currently Interlocking Concrete Block Pavement is being received broadly in various uses where the traditional development of pavement utilizing hot bituminous blend (for flexible pavement) or cement concrete (for rigid pavement) is not desirable or attractive. India is artistic with one of the best granite deposits in the world and accounts for over 20% of world's resource in granite. Granite chips are waste produced in granite factories while cutting granite rocks to the desired shapes and also in polishing granite slabs. Disposal of this granite waste has become a major problem. Random disposal of the granite waste would lead to health hazard and disposal in landfill will decrease the life of landfill. This experimental work was conducted on Paver Blocks containing granite waste as a partial and fully replacement of coarse aggregate by granite waste chips at 25% 50%, 75% and 100% by weight. The standard paver block measure the compressive strength, flexural strength, abrasion resistance after 28 days and 56 days and water absorption test and cost compared this to that of control mixes of M45 grade.*

Keywords: Coarse Aggregate, Concrete, Fine Aggregate, Industrial waste, Manufacturing process, Sustainable material, Paver Blocks , granite chips, aggregates replacement , Environment.

I. INTRODUCTION

Granite industry is one of the leading industries in RAJASTHAN. Disposal of these granite waste is one of the environmental hazards (Allam M. E.,et al, 2014) and is a major problem in RAJASTHAN. Granite waste are produced during various process of cutting and polishing of granite slabs. Concrete paving blocks were first introduced in Holland in the fifties as replacement of paver bricks. Concrete paving block is widely used in India. Granite is well-known for combination of beauty and strength. It is formed when bits of quartz and feldspar are shot out of volcanoes, so it's one kind of igneous rock. The word "granite" comes from the Latin word "granum", a grain, because granite is made of lots of smaller bits of quartz and feldspar stuck together or can be defined as they are the most abundant plutonic rocks of mountain belts and continental shield areas.

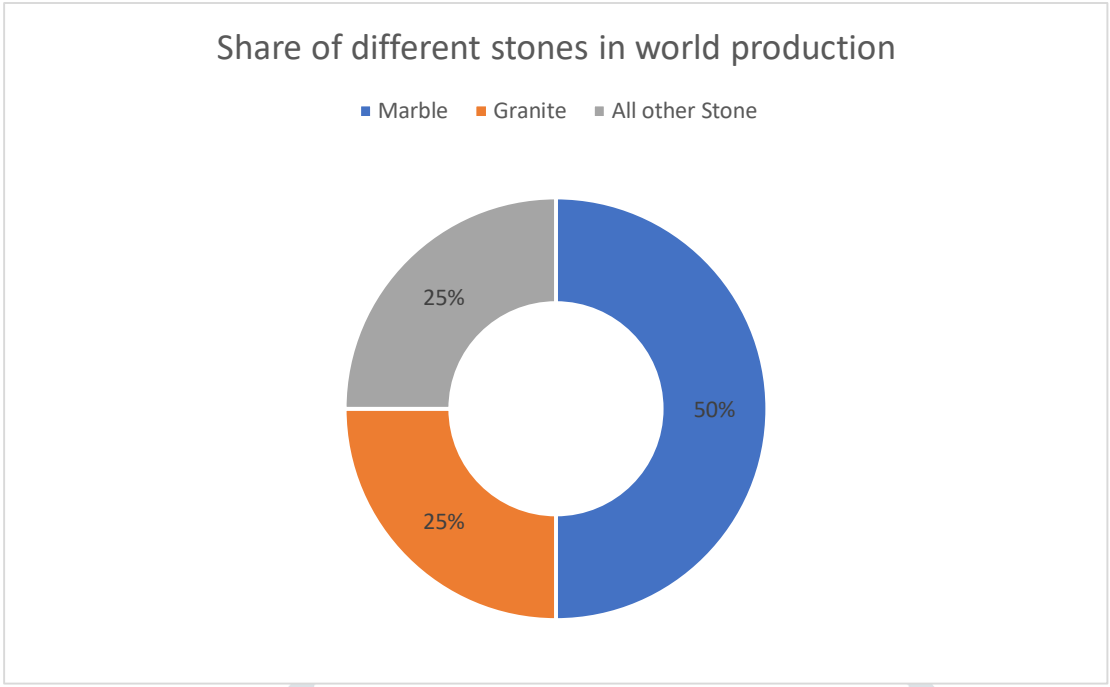

Fig. 1: Share of different stones in world production

Source: MSME-Development Institute Govt. of India, Ministry of Micro, Small & Medium Enterprises, Rajasthan

As per the Government of India, ministry of mines, Indian bureau of mines the waste generation of granite and marble during the extraction of block is 30% to 40% of the production in mechanized mines by the method such as wire saws and 60% to 70% in mines by using conventional blasting techniques. The quarry waste are generated in different process like direct waste from mining, waste generated during initial development of quarry, waste generated during actual extraction. The waste include the various sizes and shapes of blocks and unwanted rock fragments. The huge quantity of waste generated, are create problem for mining industry as dump area are required. It also leads to land degradation, water pollution, and also affect the animals and society.

II. EXPERIMENTAL MATERIALS

In this systematic study cement, fine aggregates, coarse aggregates, water and granite slurry waste were used to produce concrete mixes. Suitability of these materials were checked at laboratory by the performing various tests. The properties of materials obtained in the laboratory are as follows.

a) Granite waste:

The marble and granite has more strength so by using marble and granite waste in Paver block as a partially or fully replace by the course aggregates gives better strength to paver block. The marble and granite waste are collected from the locally available source UDAIPUR.

The following figure 1 shows the Granit waste.

Figure 1 Granite waste

Following table 1 show the physical properties of Granite waste and table 2 shows chemical properties of Granit waste.

Table 1 Physical Properties of Granite waste

S.No.	Characteristics	Results
1.	Compressive strength	200MPa
2.	Specific Gravity	2.6-2.7
3.	Water Absorption%	0.7
4.	Density (Kg/m^3)	2650

Table 2 Chemical composition of Granit waste

SiO2	71.22%
Fe2O3	0.56%
Fe2O3	12.48%
TiO2	0.16%
CaO	1.40%
MgO	0.81%
LOI	1.20%
Na2O	6.16%
K20	4.56%

b) Cement:

The ordinary Portland cement of 53 grade are used which is as per the IS 269: 2013 for making all cement brick mixture. For making Paver block cement are mixed with sand, aggregate, granite waste and water.

Following table 3 shows the physical properties of cement and table 4 shows chemical properties of cement.

Table 3 Physical Properties of Cement

S.No.	Physical properties	Requirement as per IS 8112: 2013
1.	Initial setting time	30 minutes (min.)
2.	Final setting time	600 minutes (max.)
3.	7 day compressive strength	33MPa
4.	28 day compressive strength	43MPa

Table 4 Chemical composition of Cement

Sr No.	Particular	Requirements of IS 12269-1987	Criteria
1	[Cao-0.7SO_3]/ [2.8SiO_2+1.2Al_2O_3+0.65Fe_2O_3]	0.8	Min
2	Al_2O_3/Fe_2O_3	0.66	Min
3	Insoluble residue(Weigh)	3.00	Max
4	Magnesia(% by mass)	6.00	Max
5	Sulphuric anhydride(percent)	3.00	Max
6	Total Loss of Ignition(%by mass)	4.00	Max
7	Total chloride9%by mass)	0.10	Max

c) Fine aggregate:

Those fractions from 4.75 mm to 150 micron are termed as fine aggregate. Locally available sand, free from silt and organic matters was used. The river sand is be used in combination as fine aggregate conforming to the requirements of IS 383- 1970.

Table 5 Properties of Fine Aggregate

Property	Fine Aggregate
Specific Gravity	2.65

d) Coarse aggregate:

There are three types of aggregates used in the concrete mix that is 6mm, 10mm and 12mm in size. The coarse aggregates are partially and fully replaced by Granite waste in the percentage of 25%, 50%, 75% and 100%.

III. EXPERIMENTAL METHODOLOGY

The following mix design was used in proposed research work.

a) Design Mix Properties

The following table 6 shows design mix properties in 1 m3 concrete.

Table 6 Design Mix Properties in 1m3 concrete (kg)

Mixture No.	% Replacement	Cement (kg/m^3)	Coarse Aggregate (12 & 10 mm) (kg/m^3)	Granite Chips (kg/m^3)	Fine Aggregate (Dust and 6mm) (kg/m^3)	W/C ratio
A	0	409	687.43	0	883.84	0.4
A1	25	409	515.57	171.86	883.84	0.4
A2	50	409	343.71	343.71	883.84	0.4
A3	75	409	171.86	515.57	883.84	0.4
A4	100	409	0	687.43	883.84	0.4

b) Compressive Strength Test (As per IS: 15658:2006)

Concrete Paver Blocks are casted by using M45 grade concrete. The compression strength test is carried out on the specimens at the end of 28 days and 56 days of curing.

Compressive Strength = Load / Cross-sectional Area.

The following figure 3 shows setup of compressive strength testing machine

Figure 2 Setup of Compressive Strength Testing Machine

c) Water Absorption Test (As per IS: 15658:2006)

Standard size Paver blocks shall be completely immersed in clean water at room temperature for 24 hours. All paver blocks shall be dried in a ventilated oven at 100 to 1150C for not less than 24 hours.

Absorption, percent = (W1-W2)/W2 * 100

Where, w1=wet mass of unit (kg)

w2= dry mass of unit in (kg)

d) Flexural Strength Test (As per IS: 15658:2006)

Concrete Paver Blocks are casted by using M45 grade concrete. The flexural strength test is carried out on the specimens at the end of 28 days of curing.

Figure 3 Flexural strength Testing machine

e) Abrasion Resistance Test (As per IS: 15658:2006)

Concrete Paver Blocks are casted by using M45 grade concrete. The Abrasion Resistance test is carried out on the specimens at the end of 28 days of curing. For testing dry specimens, the specimens shall be dried to constant mass at a temperature of 105+ 5"C. For testing wet/saturated specimens; the specimens shall be immersed in water for 7 days and wiped with a damp artificial sponge prior to each weighing (see E-3) so that all specimens appear equally damp.

$$\Delta V = \Delta m / PR$$

Where:

AV = loss in volume after 16 cycle, in mm3;

Am = loss in mass after 16 cycles, in g; and

PR = density of the specimen, or in the case of two-layer specimens, the density of the wearing layer, in g/mm3.

IV. EXPERIMENTAL RESULT AND DISCUSSION

From following different test result shown below:

a) Compressive strength test results:

Following table 7 shows compressive strength at 28 and 56 days.

Table 7 Compressive Strength at 28 and 56 days

Samples	W/C Ratio	Granite replacement level (%)	Compressive (MPa) (28 days)	Compressive (MPa) (56 days)
A	0.40	0	47.50	48.87
A 1	0.40	25	48.42	49.86
A 2	0.40	50	48.18	49.15
A 3	0.40	75	47.84	48.82
A 4	0.40	100	47.53	48.55

Following figure 4 shows the compressive strength for M45 mixes: Control mix concrete and concrete with replacement of Granite waste in different proportions at 28 and 56 days.

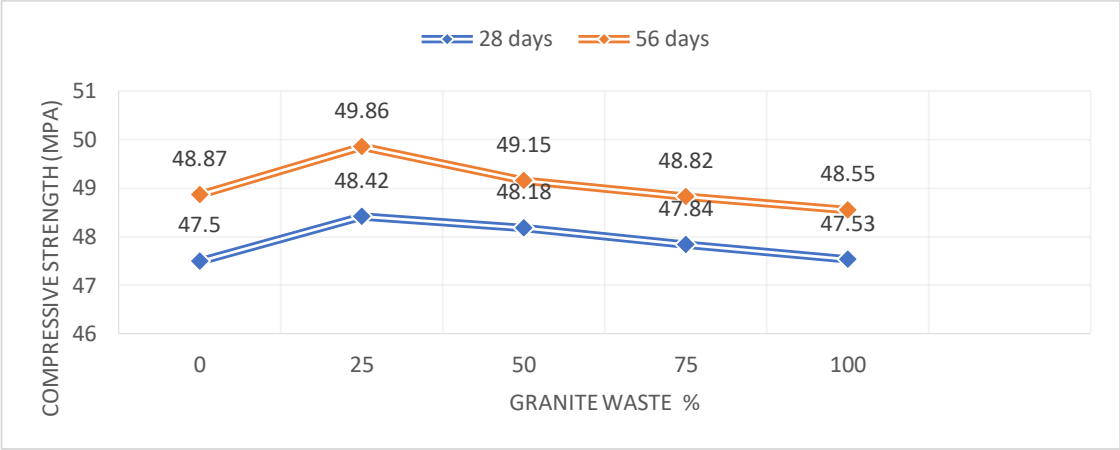

Figure 4 Compressive Strength Results for M45 Concrete Mixes: Standard Concrete and Concrete with replacement of Granite waste in Different Proportions at 28 and 56 days.

b) Water Absorption Test Results:

Following table 8 shows the results of percentage water content immersed in blocks for the water absorption test done on concrete blocks at 28 days for M45 concrete mixes control mix concrete and concrete with replacement with Granite waste in different proportions.

Table 8 Water Absorption Test Results for M45 Concrete Mix: Normal Concrete with Different Proportions at 28 days

Samples	W/C Ratio	Granite replacement level (%)	Water absorption %
A	0.40	0	2.63
A 1	0.40	25	2.13
A 2	0.40	50	2.38
A 3	0.40	75	2.20
A 3	0.40	100	2.12

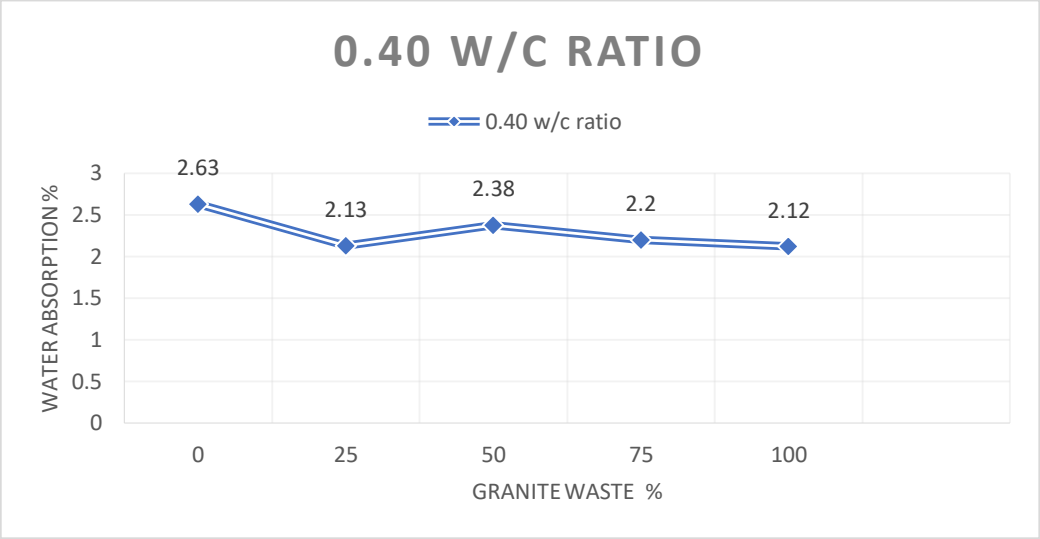

Figure 5 Water Absorption of concrete paving blocks containing granite waste at 28 days.

c) Flexural Strength:

The flexural strength of concrete specimens was determined after 28 days of standard curing. Results of flexural strength of concrete with different percentage level of granite waste have been shown for w/c ratio 0.40 in Table 9.

Table 9 Flexural Strength Test Results for M45 Concrete Mix: Normal Concrete with Different Proportions at 28 days

Samples	W/C Ratio	Granite replacement level (%)	Flexural Strength (N/mm2)
A	0.40	0	4.59
A 1	0.40	25	5.05
A 2	0.40	50	4.88
A 3	0.40	75	4.51
A 3	0.40	100	4.13

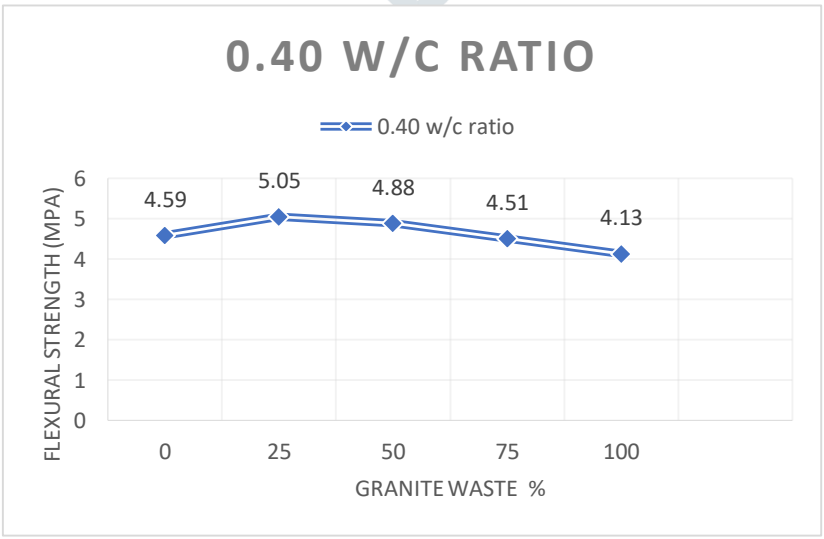

Figure 6 Flexural strength of concrete paving blocks containing granite waste at 28 days.

d) Abrasion Resistance:

It was observed from the above results that minimum loss in thickness (Abrasion) occurs in control sample whereas also minimum loss occurs when the replacement level of granite waste is 25-100 %.

Table 10 Abrasion Loss Test Results for M45 Concrete Mix: Normal Concrete with Different Proportions at 28 days

Samples	W/C Ratio	Granite replacement level (%)	Abrasion Loss t (mm)
A	0.40	0	0.405
A 1	0.40	25	0.402
A 2	0.40	50	0.411
A 3	0.40	75	0.421
A 3	0.40	100	0.425

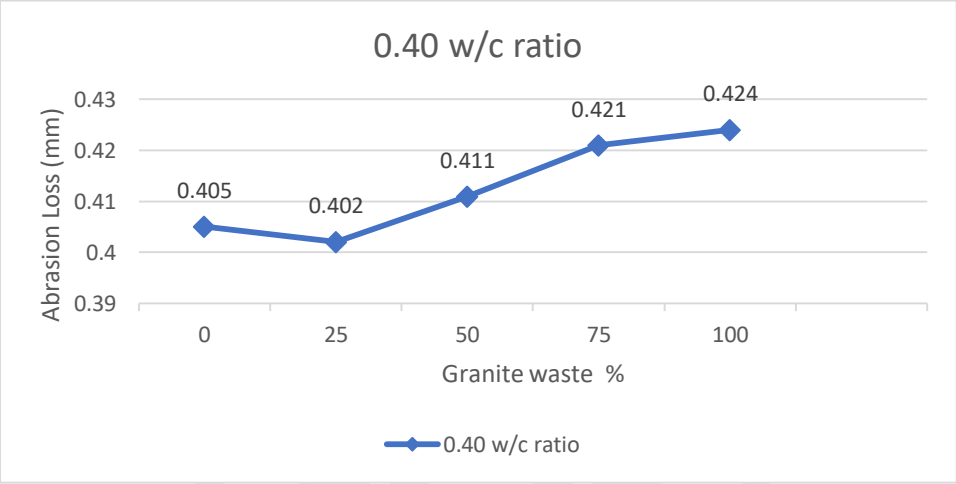

Figure 7 Abrasion Loss test of concrete paving blocks containing granite waste at 28 days.

e) Cost Analysis:

Following table 11 shows the rate analysis as per different quantity of items as per current market rates for various concrete mixes.

Table 11 Cost of Materials

Materials	Rupees per kg
Cement	6.00
Fine aggregates	0.70
Coarse aggregates	0.83
Granite waste	0.40
Admixture	47
Pigment	60

Table 12 Total Cost of Concrete Mixes Paver Blocks with Replacement of Granite waste in Different Proportions

Rubber Mould Mix	% Replacement	Cost
A	0	8.68
A1	25	8.43
A2	50	8.18
A3	75	7.91
A4	100	7.65

V. CONCLUSION

Based on experimental investigations concerning compressive strength, water absorption, flexural strength, abrasion resistance and rate analysis for control mix concrete and green concrete with Granite waste in different proportions mixes the following conclusions are drawn out for different parameters.

1. The compressive strength achieved maximum at 25% replacement of granite waste at 28 days that is 48.42 N/mm^2. Other mix proportions also gives better results.
2. Compressive strength also increased at 56 days that is greater than natural aggregates Paver Blocks (49.86 N/mm^2).
3. The flexural strength is 5.05 N/mm^2 after 28 days at 25% replacement of natural aggregates which is better than natural aggregates Paver Blocks.
4. Abrasion resistance is decrease as compared to controlled mix design that is 0.402 mm at 25% replacement.
5. Water absorption is also decrease when the granite waste use up to 25% that is 2.13%.

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Author's Biography

Ravi Goutam received Bachelor of Technology degree (Civil Engineering) from Techno India NJR in 2017. At present, he is final year student of Master of Technology in Construction Engineering & Management from Birla Vishwakarma Mahavidyalaya, Gujarat Technological University.

Dr. Jayeshkumar Pitroda received his Bachelor of Engineering Degree in Civil Engineering from Birla Vishwakarma Mahavidyalaya Engineering College, Sardar Patel University (Vallabh Vidyanagar, Gujarat-India) in 2000. In 2009 he received his master's degree in Construction Engineering and Management form Birla Vishwakarma Mahavidyalaya Sardar Patel University (Vallabh Vidyanagar, Gujarat-India). In 2015 he received his Doctor of Philosophy (Ph.D.) Degree in Civil Engineering from Sardar Patel University (Vallabh Vidyanagar, Gujarat-India). He has joined Birla Vishwakarma Mahavidyalaya Engineering College as a faculty in 2009, where he is lecturer of Civil Engineering Department and at present working as Associate Professor from February 2018 having total experience of 19 years in the field of Research, Designing and Education. At present holding charge of PG Coordinator Construction Engineering and Management. He is guiding M.E. / M. Tech (Construction Engineering and Management/ Construction Project Management/ Environmental Engineering) thesis work in the field of Civil / Construction Engineering/ Environmental Engineering. He is also guiding Ph.D. students (Civil Engineering). He has published many papers in National / International Conferences and Journals. He has published nine Research Books in the field of Civil Engineering, Rural Road Construction, National Highways Construction. Utilization of Industrial Waste. Flv Ash Bricks. Construction

Dr. Vihangraj V. Kulkarni received his Bachelor of Engineering Degree in Civil Engineering from Government College of Engineering, Aurangabad in 2009. In 2012 he received his master's degree in Environmental Engineering from Indian Institute of Technology Guwahati, India. In 2018 he received his Doctor of Philosophy (Ph.D.) Degree in Civil Engineering from Indian Institute of Technology Guwahati, India. He has joined Civil Engineering Department at Government Engineering College Banswara, Rajasthan. He is guiding M. Tech. thesis work in the field of Civil / Construction Engineering/ Environmental Engineering. He has published 17 papers in National / International Conferences and Journals. He has published one Research Books in the field of Civil Engineering, "Utilization of Fly ash in construction industries: The way forward".