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Laboratory Investigation of Modified Paver Blocks Using Recycled Materials for Sustainable Growth

Ramagya Gupta*, Dr. P.K. Sharma**, Prof. P.K.Roy***
*(M. Tech. Scholar, Department of civil engineering, NIRT, and Bhopal
Email: ramagya.gupta.bct@gmail.com)
** (Senior Professor. NIRTand Bhopal
Email :ramagya.gupta.bct@gmail.com)
*** (A.P. Department of civil engineering, NIRT, and Bhopal
Email :ramagya.gupta.bct@gmail.com)

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Abstract:

Paver blocks are nowadays is a better answer for pavement surfaces bearing varied loads. Paver blocs are large in variety in terms of features ranging from enhanced engineered properties like better bearing capacity, multi functionality, varied shapes and locking features along with better visibility and porosity features, turned to be a better choice. The interlocking mechanism makes them easy to erect and quick to install almost in any surface having diversity in loading and traffic. The availability of recycled materials has further evolved the market and new range of novel materials is now available in wide spectrum. Various testes are done on the casted samples highlighting their novelty for use of recycled materials and not hampering or impacting their general properties. The maintenance of the casted paver blocks is least and repair and replacement is simple and fast. The versatility available in terms of shape, size, texture, thickness, interlocking, porosity and color along with visibility makes them a good material for use along the pavement. Paver blocks are different from loading condition like for heavy or medium traffic. This work is focused on use of recycled waste materials dumped into quarry and land fill sites and in the form of powder for materials reclamation and sustainable development. In this work replacement of cement is done by marble powder, granite powder, and m sand powder along with the quarried materials of the same recycled aggregates taken for lying the finished paver blocks. The work is focused on replacing the cement quantity with the waste marble, waste granite powder and m sand powder and least impacting the quality standards of the paver blocks. The main motto is to promote the use of recycled materials paver blocks and lower the waste generation issue. This work proved that 3 materials cannot be taken at the same time as replacement of cement, but partials replacement along 10 % marble powder and granite powder, 15 % m sand displayed good strength and results for casting medium traffic paver blocks with the concrete. These cheap blocks can reduce the cost and promote less usage of natural materials and increase use of recycled materials

Keywords **—paver blocks, urban pavements, waste granite powder, marble powder, recycled materials, m- sand powder, low-cost materials, loading.**

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I. INTRODUCTION

Multiple vehicles like high stamina bikes, heavy vehicles, mixed vehicles need special lanes and covered lanes having vast parking allotments and multistory in nature, the side walkways and the square lanes and points find it quite congesting for this enormous vehicle traffic. Almost 90 % of the pedestrian traffic feels uncomfortable due to heavy congestions and visual issues and surface texture discomforts. The medium, low traffic has to be separated from the heavy and fast-moving traffic along with lanes and grades separations. When the traffic is different and pavement lanes are different, they need specific solutions for the surface too and this surface shall be suitable to bear enough loading and generate enough thresholds from being overburdened. As per the different demand, needed different solution for the paved surface, and same is with the technology and up gradation of the paved surface and loading and bearing capacity. The bitumen and asphalt solution to the flexible surfaces pavements has created coloured and textures surfaces along with high end solutions like pervious concrete surface and hot/warm and cold mix asphaltssolution for long life of the pavements. This new design has attracted new and novel materials along with recycled materials. Hence, we can see the coloured paver blocks along with multiple type of paving solutions across various paved surfaces. Many thick and thin surfaces of the pavements have raised further improvement and seek comfort in terms of jerks over the road surfaces. Cobble stones are general nowadays along with asphalt and bituminous sidewalks and lanes having mixed and low or varied traffic. When we consider old and tradition cities like Ujjain and Varanasi else Madurai there is one thing in common, they are now being used with paving solution for smooth manoeuvring of man and materials. Paver solutions are cheap and made with recycled materials and various attractive shapes and design, ranging from texture, finish, cut and interlocking shapes and sharp and smooth edges and variable thickness, hence are nowadays favourable for urban solutions.

The typical paver blocks are made with the cement and concrete and natural fine and coarse aggregates along with binding supplement and colorants. The design mix is a choice as per the requirement. When the case is taken for outdoor application or movement of people and pedestrian traffic, these are preferred. Porous concrete is good for those pavements where water can percolate and pass along without causing chocking and skidding along with girt formation. Hence parking lots are fixed with the paver blocks having porous nature. When the vehicles are parked and are of heavy nature else stand for long time then heavy paver blocks and large blocks are needed along with good compression and other engineering properties.

There are many researches available which challenge the usability of waste materials and support them to be intended for use and this supports our work. They did not compromise the ethics laid in the safety protocols and standards of construction, hence waste is having wealth scope and are being recycled in good scope in many countries. The recycling industry is opening a new frontier for materials and their scope in a new arena. The paver blocks segment is being touched by this area of recycling materials. Production of cement causes good amount of greenhouses gases; enormous pressure for demand of natural materials hence is a cause of concern for its generation. Portland cement and pozzolanic materials are being studied for their concrete jungle participation and almost finishing the green ecosystem and promoting greenhouse gases. Nearly 10 % of carbon dioxide is produced per year by the production of cement. The overheating of the raw materials and formed materials like the balls or the clinkers of the formed cement and compounds alite, belite and ettringite add temperature point of almost 1000 plus degree centigrade causing heath island impacts on the area where it is produced. The formation of materials of cement and its components in the plant produce enormous cycles of heat with raising use of energy and fuels along with great evolution of waste and flue gases.

What actually is paver blocks-?

Earlier stone paver is dressed and used and this is accounted to nearly thousands of years ago, the stones which are transported and dressed locally are still seen in ancient Indian cities of Lothal and Harappa and Mohenjo-Daro. This is started in the early 1940's. Interconnected pavers blocks are conceptualized with reduce and recycle concept along with reclaimed materials and reused waste which are rejected in a way or the other. Since then they have been used and the year 1960 has seen most growth in the use of interconnected and zigzagged paver blocks.

The credit goes to Holland for the first usage, in the late 50's the paver is in the form of paver bricks. They easily break upon application of load and replacement is a big headache. Then they are redesigned as concrete materials paver blocks. By then they are designed just like bricks and are rectangular. They look same like bricks and are non-porous as burnt clay bricks. But since the last sixty years rapid development evolved multiple designs and the paver blocks are improvised over the time. Then they are designed to self-locking zigzag pattern and partial locking among the geometry is provided making them self-locking and resist to opening with force or being crushed. Then the locking criterion is further evolved from just rectangular non locking, partial locked and then self-locking to fully locking among the usage of its zigzag shape and pattern. The self-interlocking paver blocks are made with concrete and other recycled materials as per demand and specifications and have two surfaces. One lower surface is non reinforced and hard without any texture of surface specification then this solid surface is top packed with a upper layer which is smooth, textured, small grooved or hooked or engraved with small dots and friction points or false nails for antiskid and grip and this profile is embedded over the previous solid layer. The paver blocks look good and are hard, durable, quick to make.

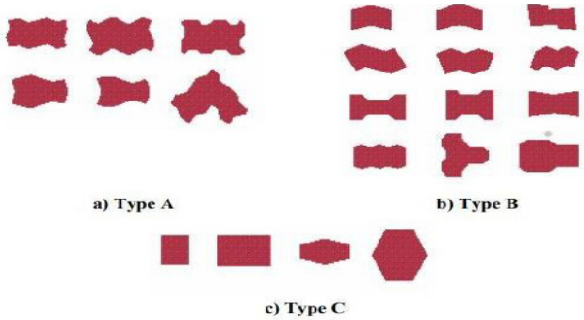


Figure 1 Types of paver blocks

II. MATERIALS TAKEN

1. Dried marble slurry powder for the pavement bed and for casting the paver blocks along the mixed (used as a recycle material)
2. Dried granite powder along with small aggregates content in it and fine powder for casting the blocks and to be mixed in the paver blocks as a recycled material.
3. Small recycled aggregates of marble and granite for finally laying alongside the flexible road
4. M sand powder for mixing in the paver block material and then again at the bed of the paver blocks before lying them at the site
5. Lab tested Paver blocks after all tests for final usage at site.
6. Cement (as a binder with the existing pavement.)
7. Wooden hammer for pressing and fixing the marble pavers.

Combinations of materials taken:

Different combinations of granite powder, sun dried marble slurry powder, and m sand powder is taken in different proportions as per the nomenclature taken. These three materials are not taken at one time for replacing cement, but taken as per the combinations suitable for the mix criteria and minimizing the impact on the strength characters of the paver blocks. The minimum thickness of the casted paver blocks as per the mold is sixty millimeters. These paver blocks once casted will be tested in the lab and inferred as

per the characteristics strength and properties thus obtained. The casted paver blocks will be used for least traffic or loading conditions and are to be put along sides the main traffic section. Bureau of Indian standards 15658- 2006 suggest guidelines for the casting, usage, and other allied mixing of recycled waste materials. In this work concrete of grade M 30 is used in all set of blocks having a standard mix proportion of one part cement or binder, 2.04 % fine particles and coarse aggregates in the ratio of 3.33.

The aggregates taken are passing almost ten mm sieve are forty % and sixty % taken is of twenty millimetres. The m sand is good for compaction and packing hence river sand is not used. The aspect water cement ratio taken for the concrete is 0.40. The amount by weight of binder cement is just 2 % of super plasticizer.

Here A= Running number of paver blocks

B = Cement, D= Marble powder, E= Granite powder, M= M sand powder

Test results of cement

1. Fineness found – 4 %
2. Standard Consistency found – 35 %
3. Initial setting time- 31 minutes

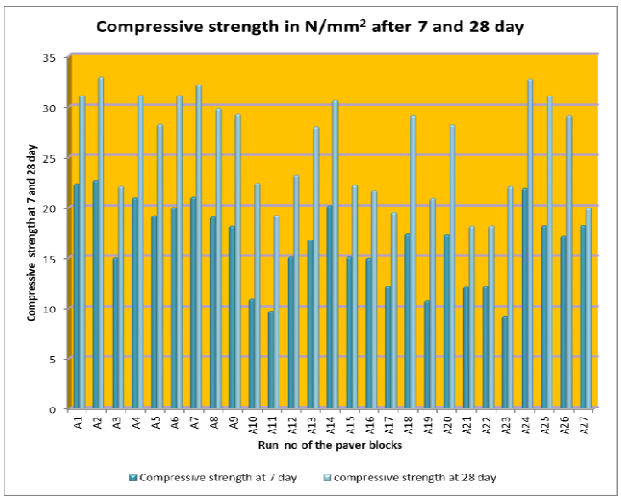
Final setting time –595 minutes

Table 1 Character of the material proportions

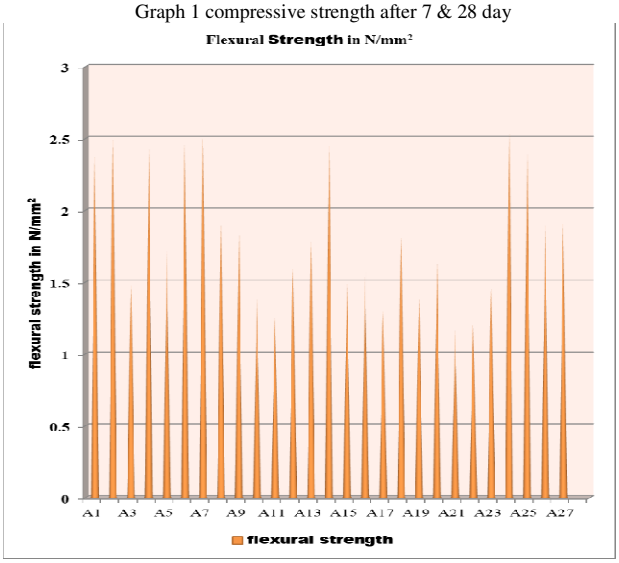
Run no	%age of material
A1	100.00 % cement
A2	85.00 cement (B) & 15.00 % marble powder(D)
A3	75.00 % cement (B) & 25.00 % marble powder (D)
A4	90.00 % cement (B) & 10.00 % granite powder (E)
A5	85.00 % cement (B) & 15.00 % granite powder (E)
A6	85.00 % cement (B) & 15.00 % M sand powder (M)
A7	75.00 % cement (B) & 25.00 % M sand powder (M)
A8	75.00 % cement (B) & 15.00 % marble powder (D) & 10.00 % granite powder (E)
A9	65.00 % cement (B) & 25.00 % marble powder (D) & 10.00 granite powder (E)
A10	70.00 % cement (B) & 15.00 % marble powder (D) & 15.00 % granite powder (E)
A11	60.00 % cement (B) & 25.00 % marble powder (D) & 15.00 % granite powder (E)
A12	70.00 % cement (B) & 15.00 % marble powder (D) & 15.00 % M sand powder (M)
A13	60.00 % cement (B) & 25 % marble powder (D) & 15 % M sand powder (M)
A14	60.00 % cement (B) & 15.00 % marble powder (D) & 25.00 % M sand powder (M)
A15	50.00 % cement (B) & 25.00 % marble powder (D) & 25.00 % M sand powder (M)
A16	60.00 % cement (B) & 15.00 % marble powder (D) & 10.00 % granite powder (E) & 15.00 % M sand powder (M)
A17	50.00 % cement (B) & 15.00 % marble powder(D) & 10.00 % granite powder (E) & 25.00 % M sand powder (M)
A18	50.00 % cement (B) & 25.00 % marble powder (D) & 10.00 granite powder (E) & 15.00 % M sand powder (M)
A19	40.00 % cement (B) & 25.00 % marble powder (D) & 10.00 % granite powder (E) & 25.00 % M sand powder (M)
A20	55.00 % cement (B) & 15.00 % marble powder (D) & 15.00 % granite powder (E) & 15.00 % M sand powder (M)
A21	45.00 % cement (B) & 15.00 % marble powder (D) & 15.00 % granite powder (E) & 25.00 % M sand powder (M)
A22	45.00 % cement (B) & 25.00 % marble powder (D) & 15.00 % granite powder (E) & 15.00 % M sand powder (M)
A23	35.00 % cement (B) & 25.00 % marble powder (D) & 15.00 % granite powder (E) & 25.00 % M sand powder (M)
A24	75.00 % cement (B) & 10.00 % granite powder (E) & 15.00 % M sand powder (M)
A25	65.00 % cement (B) & 10.00 % granite powder (E) & 15.00 % M sand powder (M)
A26	70.00 % cement (B) & 15.00 % granite powder (E) & 15.00 % M sand powder (M)
A27	60.00 % cement (B) & 15.00 % granite powder (E) & 25.00 % M sand powder (M)

III. RESULTS AFTER VARIOUS LAB TESTS

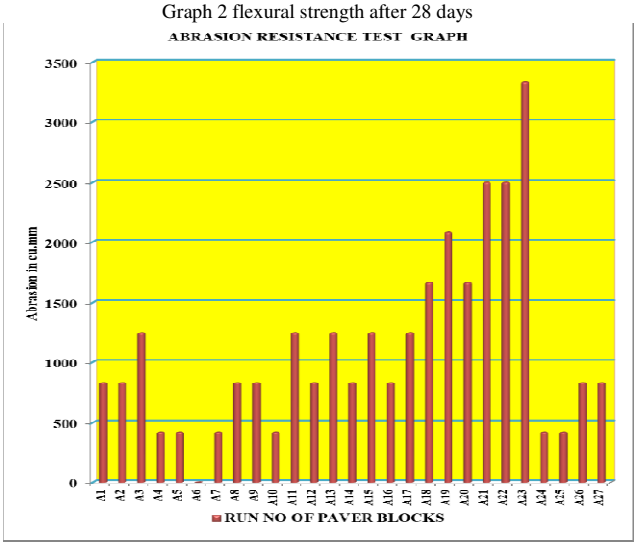
A total of 27 concrete mixes are created and 4 replica of each paver is casted, the set is formed using the cement and then the binder along with the proportion laid for aggregates. Then the quantity of water, admixture, and hardener are added to the mixture. The aggregate and cement or the binder materials is mixed and water is added for a slump of 0. The aggregate to binder ratio is taken as **4.62**as suggested by a paver block manufacturer. The mixture is transferred to the mold. The mold is made up of hard plastic. The paver block thus formed is demolded after 24 hours and cured for next 28-day age.



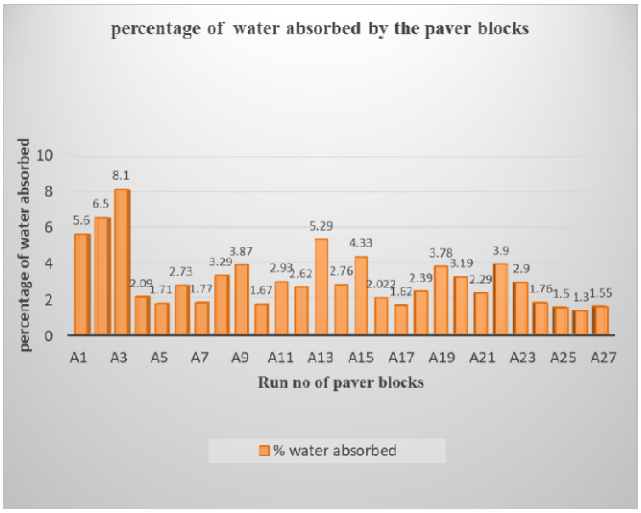
Graph 1 compressive strength after 7 & 28 day



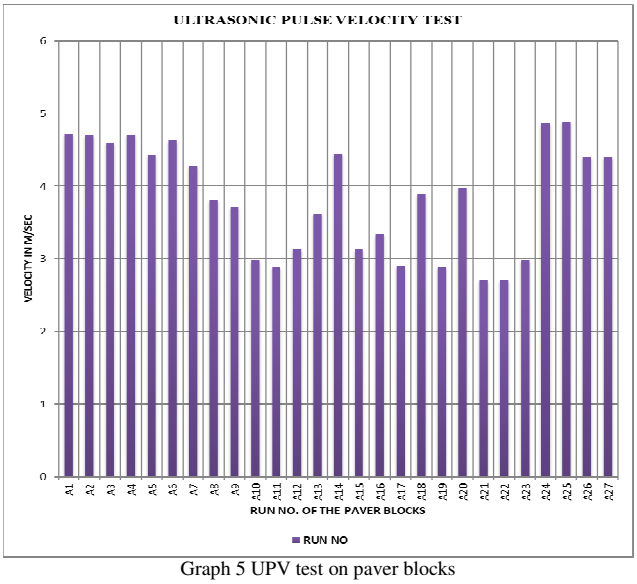
Graph 2 flexural strength after 28 days



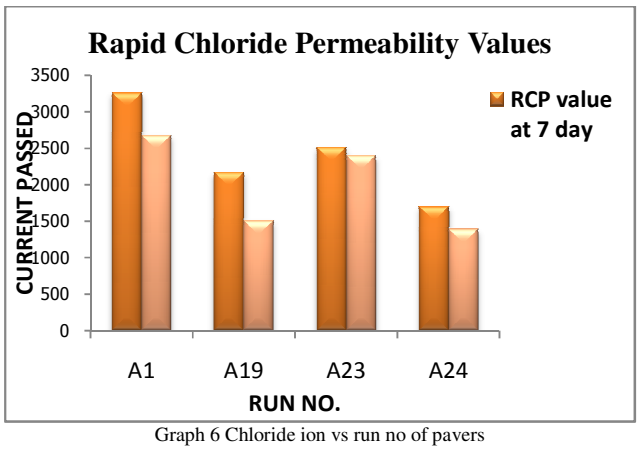
Graph 3 abrasion resistance



Graph 4- % of water absorbed by blocks



Graph 5 UPV test on paver blocks



Graph 6 Chloride ion vs run no of pavers

IV. COST ANALYSIS

When casted with 100 percent ordinary Portland cement:

1. One bag of cement is used to make hundred paver blocks of type A.
2. Cement in the bag= 50 kg.
3. Cost of the bag= 350 Rs.

When partial replacement of the materials is done than—

Paver block casted with marble slurry powder, cement granite waste powder

For making 100 paver blocks then

1. Cement required as per the combinations = 35 kg, cost = 245 Rs.
2. Marble powder = 15 kg, cost = (recycled waste) = 30 Rs.
3. Total cost = 245+ 30 = 275 Rs.

Savings:-

Material cost = 350 -275 = 75 Rs.

Total material saving for making the blocks = (75/350)*100 = 21.42 %

V. CONCLUSIONS

1. Adding marble dust in concrete increase the strength of the material and when the casted paver blocks are tested for various strength values then strength increased as compared to the normal concrete at 15 percent partial replacement of cement.

2. Good compressive stamina is obtained when marble dust is used and heaviness is also obtained making it less prone to sink, but when this material is used in structural work they can cause weight issues.

3. Marble dust is fine, and hence helps in achieving good finish over the textured surface.

4. Granite powder can be good in concrete and in making paver blocks but this is suitable at addition on only 10 percent, when more addition is done it causes strength reduction and other parameters impact is also seen.

5. Paver block turn resistant to fire and acid attack and spilling of chemicals when m sand powder is partially replaced with cement at 15 percent. Strength gain is also visible from results.

6. When all three materials, marble powder, granite powder and M sand are used at once and partially replacement of cement is done, then strength and other parameters are impacted and is less useful, least strong, highest permeable as compared to the normal concrete. Thus, this combination is fatal to the pavers and concrete.

7. All mix combinations when taken into account, only 15 percent of m sand and 10 percent of granite powder is found optimal and given better strength and other parametric values, as found from this work.

8. Reduction in cost is achieved by using the recycled materials, and saving the nature from dumping of pollutants causing various pollution and marble powder, granite powder and m sand can be easily available and obtained from the dumping sites.

9. Silicosis is a TB like disease when marble powder is inhaled for long is caused, thus this issue can be reduced when recycling of the dust is properly done.

The paver blocks of the recycled materials will be safe, eco-friendly and cost effective along with shape freedom and use at ease facility.

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