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Performance of Sustainable Paving Unit

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Abstract : The advancement of concrete technology can reduce the consumption of natural resources and energy sources which in turn further lessen the burden of pollutants on the environment. A granite chip is an industrial waste produced from cutting of granite stone for usage in various construction applications in India. Use of waste granite chips as aggregate can save about 5% and 4% the cost of concrete per meter cube with OPC and PPC respectively, thus it can be say as economical concrete and for sustainable development this material can be used in concrete. More research is still needed to see its wider application in concrete especially as fully replacement of natural coarse aggregate. The objective of this study is to provide a more scientific evidence to support the reuse of accumulated granites waste in India by investigating into the following hardened properties of concrete with waste granite chips, compressive strength thus providing possible solutions to environmental contamination by mining and depletion of natural resources.

IndexTerms **– Sustainable development, Granite waste, compressive strength, cost effective.**

I. INTRODUCTION

Concrete is a man-made construction material that is widely used. It is obtained by mixing cement, water and aggregate in required proportions Aggregate provide higher volume, stability and better durability than cement paste in concrete and provide around 75 per cent of the body of concrete. The aggregate are obtained from natural rock deposits are scarce, but-clay bricks are used as an alternative source of coarse aggregate. Since granite is a lighter material compared to aggregates, its use in concrete will lead to reduced self-weight on members and hence reduced dead load on column and eventually, the foundation system Concrete that has a mixture of coarse aggregate and granite chips in certain proportion will have more strength than the sum which has a coarse aggregate completely replaced with granite chips.

In the present construction world, the solid waste is increasing day by day from the demolitions of constructions. There are some researchers also going on solid waste from construction to reuse them again in the construction to reduce the solid waste and to preserve the natural basic aggregates. These researches promotes to use the recycled aggregates in the concrete mix and they got good result when adding some extent percentages of waste granite in place of natural coarse aggregate. There is a huge usage of ceramic tiles in the present constructions is going on and it is increasing in day by day construction field. And also in other side waste tile is also producing from demolished wastes from construction Indian tiles production is 100 million ton per year in the ceramic industry, about 15%-30% waste material generated from the total production.

This waste is not recycled in any form at present, however the ceramic waste is durable, hard and highly resistant to biological, chemical and physical degradation forces so, we selected these waste granites chips as a replacement material to the basic natural aggregate to reuse them and to decrease the solid waste from demolitions of construction Waste granite were collected from the surroundings. Waste granite are replaced in place of coarse aggregate by the percentage of 10% and 20% and 30%. For analyzing the suitability of these crushed waste granites workability test was conducted for different mixes having different percentages of these materials. Slump cone test is used for performing workability tests on fresh concrete. And compressive strength test is also conducted for7, 14 and 28 days curing periods by casting cubes to analyze the strength variation by different percentage of the waste materials. The present study is to understand the behavior and performance of waste granite in concrete. The waste granites used to partially replace coarse aggregate by 10%, 20% and 30%, the utility of partial replacement of coarse aggregate by waste granite replacement aggregates along with partially replacing OPC by fly ash is also addressed in the work. The strength performance of these concretes (waste granite based) with conventional concretes is studied. Waste granite was collected from the solid waste of manufacturing unit. Crushed them into small pieces by manually and by using crusher and separated the coarse material to use them as partial replacement to the natural course aggregate.

The objective of this study is to provide a more scientific evidence to support the reuse of accumulated granites waste in India by investigating into the following hardened properties of concrete with waste granite chips, compressive strength & cost effective. If this is successful there will be less demand on natural aggregate, thus providing possible solutions to environmental contamination by mining and depletion of natural resources

II. LITERATURE REVIEW

In this review we have search about various sustainable materials which can be used as replacement of conventional materials which are now a day's not available easily. Following are the research made earlier on the sustainable material.

C. Corinaldesi V et al., (2010): They studied and inscribed that Marble as a building material especially in palaces and monuments has been in use for ages. However the use is limited as stone bricks in wall or arches or as lining slabs in walls, roofs or floors, leaving its wastage at quarry or at the sizing industry generally unattended for use in the building industry itself as filler or plasticizer in mortar or concrete. The result is that the mass which is 40% of total marble quarried has reached as high as millions of tons. This huge unattended mass of marble waste consisting of very fine particles is today one of the environmental problems around the world.

Biniciet al. (2012): In a study by the granite waste was used as 100% replacement for natural coarse aggregates by weight in concrete with constant water-cement ratio 0.4. River sand and ground blast furnace slag (GBFS) were used as fine aggregate. It was reported that compressive strength, Flexural strength, splitting tensile strength and young's modulus of elasticity of concrete prepared with GBFS as fine aggregate and marble waste as coarse aggregate was 3-6 %, respectively higher than that of concrete with river sand as fine aggregate and marble waste as coarse aggregate. In case of water absorption by immersion and depth of carbonation, the behavior of concrete containing marble aggregate shows similar results to that of control concrete. Part of this generated waste was used in preliminary studies by several researchers in medium strength concrete mixes in the past.

Roshan Lal et.al (2014): Investigated strength characteristics of concrete containing waste marble and granite as coarse aggregate. The coarse aggregate is partially replaced with marble and granite from 0-40% at 10% interval. Physical properties of cement, fine aggregate and coarse aggregate etc. were explained. Based on this study the hardened properties are high at 20 % replacement. The hardened properties decrease due to grading effect.

Kore Sudarshan Dattatraya (2016): In this work, the impact of marble and granite waste as a partial replacement for conventional coarse aggregate on the properties of concrete mixes such as workability, compressive strength, permeability, abrasion, etc. was evaluated. Coarse aggregate (75% by weight) was replaced by aggregate obtained from granite mining waste. The test results revealed that the compressive strength was comparable to that of control concrete. Other properties such as workability of concrete increased water absorption reduced by 17%, and resistance to abrasion were marginally increased by 2% as compared to that of control concrete.

III.SYSTEM DEVELOPMENT

3.1 General

The concrete is made with concrete wastes which are eco-friendly so called as sustainable concrete. Sustainable concrete is a revolutionary topic in the history of concrete industry. Waste can be used to produce new products or can be used as admixtures so that natural resources are limited and used more efficiently and the environment is protected from waste deposits: Considerable research has been carried out on the use of various industrial by-products and micro fillers in concrete. The main concern of using granite wastes was not only the cost effectiveness but also to improve the properties of concrete, especially durability. Using the waste products like broken granite pieces and marble chips we have developed a new type of concrete for development system of sustainable paving unit.

3.2 Manufacture procedure of specimens:-

The experimental investigation consisted of making M40 concrete with various proportions of granite aggregate as a replacement to coarse aggregate will be done. Standard cubical moulds of size 150mmx150mmx150mm made of cast iron concrete specimen to test compressive strength, The quantities of cement, fine aggregate, coarse aggregate and water for each batch were weighted to an accuracy of 1kg separately. Finally, coarse aggregate shall be add in the course of mixing. The inner surfaces of moulds shall be oil so as to avoid sticking of concrete. Concrete will have to fill in previously prepared moulds with controlled vibrations to the concrete. Surface of concrete shall be of finish level using trowel and date along with batch number marked properly on it. Finished specimens will leave to harden and removed from specimens shall left to harden and remove from moulds approximate after 24hrs of casting. They shall be place in water tank containing portable water and shall left for curing. The specimen will de-molded after 24hrs of casting and the specimen will carried in tank for 7, 14, 28 days. So the value of slump is specifically mentioned along the mix design and thus it should be checked as per your location. As per IS codes, compressive strength of concrete is defined as the compressive strength of concrete is given in the terms of the characteristics compressive strength is of 150mm size cubes tested at 28days (fck).

3.3 Material used

In this project, we have used different material for concrete mix such as cement, natural sand, and aggregates and also used waste material which is described below.

3.3.1 Cement

The cement used was Ordinary Portland cement grade 53 and confirming to IS 12269 -1987**.** Initial and final setting time of cement was 30 min and 600 min, respectively. Ordinary Portland cement is obtained by grinding fly ash with Portland cement clinker, no material other than gypsum or water or both, shall be added.

3.3.2 Aggregate:

Aggregates are the important constituents in concrete. They give body to the concrete. Reduce shrinkage and effect economy. Once of the most important factors for producing workable concrete is a good gradation of aggregates. Good grading implies the sample fraction of aggregates in required proportion such that the sample contains minimum void sample of the well graded aggregate containing minimum voids require minimum paste to fill up the voids in the aggregates. Minimum paste means less quantity of cement and less water, which are further mean increased economy, higher strength, lower shrinkage and greater durability.

a. Fine Aggregate:

Those fractions from 4.75 mm to 150 microns are termed as fine aggregate. The river sand is wash and screen, to eliminate deleterious materials and over size particles. Good quality WARDHA river sand was used as a fine aggregate.

b. Course Aggregate:

The material whose particles are of size as retained on IS Sieve No 480 (4.75 mmm) is termed as course aggregate. Course aggregate used were 10 mm downgraded and 20 mm downgraded

3.3.3 Granite:

Granite is the material, traditionally used in the construction of monuments. It is one of the hardest and most durable of substances. It can withstand extreme weather conditions. It is in fact, one of the main reasons it is used in the construction of monuments. Three Different varieties of granites are available from specific regions of the world. For experimental purpose we use the waste granite. We broke in small pieces and use the pieces passing through 20mm sieve and retained on 10mm sieve. Granite used in the investigation was obtained from Rahul Marble M.I.D.C Amravati.

3.3.4 Marble Chips:

Marble waste produced from marble industries as a result of production Mare production equals more waste, more waste creates environmental contamination. A high volume of marble production has generated a considerable amount of waste materials, almost 70% of the minerals gets wasted in the mining, processing and polishing stages which have a serious impact on the environment. An economically viable solution to this problem should include utilization of these waste materials for new products especially in construction applications which in turn minimizes the heavy burden on the nation's landfills, saves natural. Resources, energy and reduces environmental pollution. If the waste product of one industry is recycled as a substitute for the raw material of another industry, it will thereby reduce the environmental impact of both. For the experimental purpose we use the marble chips as top layer of the pavers to make the paver temperature low. Marble Chips used in the investigation were obtained from Anand Marble M.I.D.C Amravati.

3.3.5 Water:

Water is also one of the important ingredients of concrete. As the strength, workability is depending on water, the quantity of water a required to be taken very carefully. The potable water is used for the experiment.

3.4 Mix Design

Concrete mix design is step by step procedures to work out the various proportions of the ingredients which go to make concrete. There are various methods of mix design available. These methods can only give guideline to the site engineer to work out the various parameters of concrete mix & may or may not be necessary to make minor adjustments thereafter. However, it is very essential for the site engineer to get the feel of concrete material & concrete by continuous check on workability, cohesiveness, finished surface, strength & durability parameter. It is only then that the engineer acquires the art of designing concrete mixes. It is difficult to design concrete mixes in our country as the materials available from time to time at site are not consistent in quality. Therefore a watchful eye and skills of the engineer designing the concrete mix plays an important role. The various properties of a concrete-mix like compressive strength, flexural strength and split tensile strength are to be calculated and compared. For various concrete specifications, various tables from IS 456-2000, IS 10262-2009 were referred. Three specimens of each cubes, cylinder and beams were casted for different proportions of granite pieces. The aim is to calculate the optimum dosage for improvement of qualities in concrete. The compressive, flexural and split tensile strength is calculated for specimens for 7 days, 14 days, and 28 days. Design mix for M40 grade concrete was prepared by partially replacing granite piece with coarse aggregate. For calculating the various strength and properties of concrete tests were performed on the specimens Cubes of size 150 mm, beams of length 500 mm and cross section of 100 mm, and cylinder of diameter 150 mm of length. Temperature at various depths was calculated with the aim to get our experimental temperature differential for our pavers and market manufactured pavers.

Mix design for M40

1) Grade designation =M40
2) Type of cement-Ordinary Portland cement 53 Grade
3) Max nominal size of aggregate e = 20 mm
4) Minimum cement Content-240 kg/m3
5) Maximum Water-Cement Ratio = 0.35
6) Natural Sand confirming to Zone 3
7) Exposure Condition - Moderate
8) Workability=Low (25 mm -75 mm)
9) Target mean Strength =48 N/ mm2

After various calculations and corrections of oversize, the final quantity of materials is calculated for per cubic meter of concrete as:

1) Cement = 403 kg
2) Water content = 173.29 kg
3) Fine Aggregate = 811 kg
4) Coarse aggregate =20 mm=697 kg
   =10 mm=373.08 kg
5) Proportion 1:2.01:2.65

By using this quantity of material a mix design of concrete is prepared. This mix design helps in achieving a desire workability, strength and durability for concrete work.

IV. RESULTS AND DISCUSSION

The experimental tests were carried out to obtain the mechanical properties of granite aggregate added concrete to use them in the paving block. The comparisons of mechanical properties like compressive strength, is carried out Effect of replacing coarse aggregate with granite aggregate on concrete was studied. The replacement of material is in increasing percentages by weight of coarse aggregate. Observation for 7, 14 & 28 days curing period were recorded and presented in the form of tables and graphs. The temperature variations of 24 hours were recorded at interval of one hour. Temperature differential was also calculated. The temperature differential is a function of solar radiation received by the pavement surface, wind velocity, thermal diffusivity of concrete, latitude, longitude and elevation of the place and is thus affected by geological features of the pavement location. As far as possible, temperature differential values estimated realistically for the given site using relevant geographical parameters and material characteristics should be used for calculation of temperature gradient. The variation of temperature with depth is nonlinear during night hours. The maximum temperature differential during the night is nearly half of the day time.

4.1 Test Performance on Concrete

4.1.1 Workability Result

The slump test is the most well-known and widely used test method to characterize the workability of fresh concrete. This test measures the consistency and is used on job sites to determine rapidly whether a concrete batch should be accepted or rejected. The test method widely standardized throughout the world. Replacement mix is as follows the result of conventional mix and replacement mix is as follow.

Table No. 4.1-Result for workability

Sr. No.	% of granite aggregate	Slump value (mm)
1	0%	51
2	20%	53
3	30%	55
4	40%	60

4.1.2. For conventional concrete mix M40

Tests results obtained for compressive strength, are follows:

Table No. 4.2-Compressive strength conventional concrete mix M40

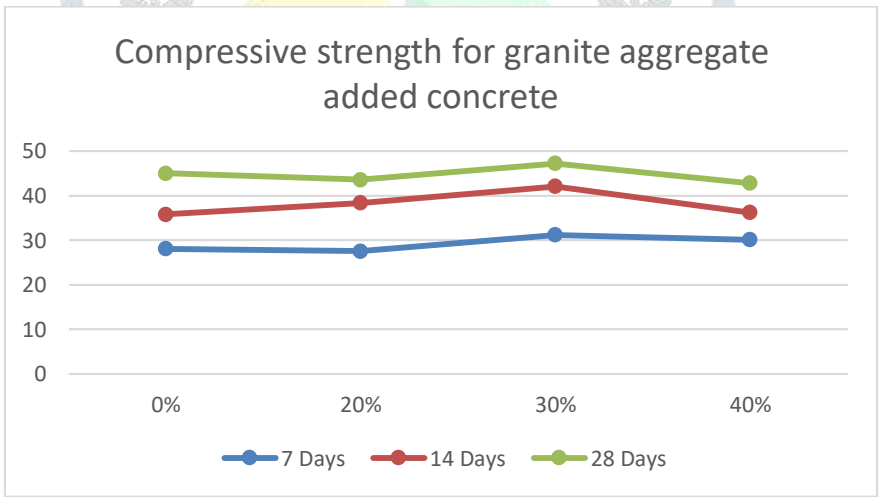
Grade of Concrete	M40		
Days of curing	7 days	14 days	28 days
Strength in N/mm2	28.08	35.80	45.01

4.1.3. Compressive Strength for Granite Aggregate Added Concrete

Compressive strength of concrete is a measure of its ability to resist load, which tends to crush it. Most common test on hardened concrete is compressive strength test. It is because the test is easy to perform. Furthermore, many desirable characteristic of concrete are qualitatively related to its strength and the importance of the compressive strength of concrete in structural design. The compressive strength gives a good and clear indication that how the strength is affected with the increase of granite content in the test specimen.

Table No.4.3-Compressive strength for granite aggregate added concrete

Grade of concrete	M40		
% Granite added/Comp. strength	7 days	14 days	28 days
0 %	28.08	35.80	45.01
20 %	27.52	38.40	43.89
30 %	31.20	42.10	47.25
40 %	30.10	36.24	42.80



From the above the variation in compressive strength for the mix proportion M40 granite replacement with coarse aggregate is added in increasing percentage (0%, 20%, 30% and 40%) in the concrete and the results obtained for compressive strength. It is observed that use of granite aggregate increases the compressive strength at 30% to 40% and reduction in compressive strength is observed when percentage of granite up to 40%. The graph shows drop at 40% granite aggregate. Here the 30% shows higher compressive strength which is more than conventional mix. So we conclude that the optimum value of granite agg.is 30% for compressive strength.

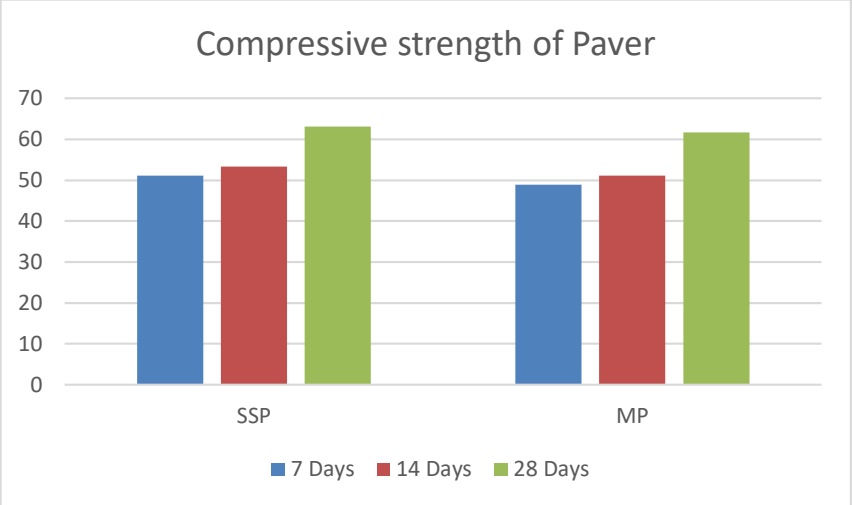
4.2 Results of Paver

For the mix proportion M40 grade concrete granite aggregate replacement with coarse aggregate is added in linearly varying percentage such as 0%, 20%, 30% and 40% in the concrete and the results obtained for compressive strength. It is observed that use of granite aggregate greatly affect the mechanical properties of concrete such as compressive strength. It is seen that gain in strength slightly at 20%. Strength is increasing continuously at 30%. After this the compressive strength for 40% is decreasing. Here the 30% shows greater compressive strength, which is better than conventional concrete. Hence the optimum value of granite aggregate is 30% for compressive strength. From above we can say that the pavers at 30% replacement gives the

maximum strength. As shown below in table that the compressive strength of sustainable paver is comparatively higher than market paver of conventional mix.

Table No.4.4 Compressive Strength of paver

Days	7 Days	14 Days	28 Days
Sustainable Square Paver	51.11	53.35	63.11
Market paver	48.91	51.09	61.61



4.3 Cost Effectiveness

Table No.4.5 Cost comparison of Conventional & Sustainable Paver block

Sr. No.	Material	Rates (Rs./Kg)	Price (Rs.) Conventional	Price (Rs.) Sustainable
1	Cement	7.4	5.92	5.31
2	Fine aggregate	1.08	1.73	1.51
3	Course aggregate 01	0.88	0.65	0.077
4	Course aggregate 02	0.88	1.22	0.570
5	Granite waste	-	-	0
Total cost of one paver			9.52	7.46

4.4 Conclusion

- The experimental work shows that the mechanical properties of concrete of grade M40 get improved due to incorporation of waste granite.
- From the experimental results, we can say that concrete give the optimum results at 30% replacement of coarse aggregates with granite.
- It is observed that the addition of crushed granite improves the compressive strength at 28 days.
- As the percentage of granite increases up to optimum dosage the mechanical properties of concrete like compressive strength, increases.
- It will be more cost effective as the waste product is used.

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