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A Laboratory Review on Compressive Strength of Concrete Made with Recycled and Natural Aggregates with Inclusion of Plastic Fibers

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Abstract:

Large quantity of coarse solid waste are generated during mining and quarrying both marble and granite rocks. These large quantities are major environmental concern in the surrounding areas of the quarry site. However, due to the similarity of these wastes to conventional aggregates, they could be the potential source of environmental study to evaluate marble and granite solid waste materials along with construction and demolition waste as coarse particulate aggregates in road pavement. An experimental investigation was carried out on these materials to assess their physical, chemical and mechanical properties according to Indian standards. Various tests are performed to evaluate the suitability of waste materials to road construction. The compressive strength test results are evaluated for the normal concrete, full aggregate replaced concrete and found that results are much better than the normal concrete and compressive strength is obtained higher than expected for the coarse aggregate particulate respectively. This means that these waste materials can be safely used in road pavement. The positive uses of these three wastes are considered beneficial from the economical point of view and saving the natural resources.

Keywords — compressive strength, water absorption, marble waste, granite waste, plastic fiber, slump test, recycled waste.

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I. INTRODUCTION

Since long, natural materials like stone has played a vital role in human race development. Since billions of years man when started being civilized, they used stones as a tool, resource and a vital ingredient for hunting. Large masses of stones are cut and reused as a habitat and safe refuge. Every place on earth is gifted with ample natural resources like different type and qualities of stones and they display different properties as per creation while the formation of earth. They range from light to very heavy and soft to very hard and durable. Since ages when the population is least and utilization and natural resources control is limited there exists almost no pollution of nature. Natural materials like rocks posses quality stones like marble, pumice , granite and other hard stones which can be used for industrial purpose. From geographical point of view India is gifted with large deposits of quality stones and a few of them are marble and granite of durable grade and quality. From the old epics it is evident that they are used since ages and are considered holy in many cases. The production of stones throughout the globe has touched 830 million square meters or almost 85 million ton. The actual production is even more than this, as the official figures are generally hidden due to environmental concerns and many

activists raising the voice for concern of ecological balance. Almost 40 million ton of stone waste is generated every year and dumps near the sites causing natural resources degradation. Assessments are generally made through government figures which may be generally lower than actual production hence the rank of waste production may vary from state to state. India being one of the top producers of waste aggregates due to high usage in construction and industrial purposes. Waste marble and granite dust posses' imminent harm to local residents making them exposed to diseases like plumbolisis having similar features like TB and can cause lung cancer and other incurable skin diseases. They can cause irritation to eyes. India ranks second in production of waste marble and granite and recycled waste.

1. Process of manufacturing:

When the stones of marble and granite are processed, quality is an important parameter. Taking marble and granite stones and then putting for quality check and then making them separate as per sorted order and processed as per requirement. The virgin stones are called raw stones. These stone blocks are blade cutted as per demand raised. The stone size can be different or as per requirement. The stone is generally shaped into slab of different thickness or may be planed to tiles. The stones are generally cut into more than 1 cm and goes up to 5 cm, for this purpose diamond fixed bladed are used. They have very sharp edge and very hard and can easily cut any thickness stone. The diamond blades becomes very warm while cutting the stones hence continuous water pouring is necessary to let them cool and work smoothly. Blades cut the sheets into different thickness. The dust is spread everywhere and cause nuisance if not controlled during production process. This stone dust is slowly mixed into water and gently the stones are cut. Large quantity of dust mixed water is produced while cutting the marble and granite stones. Due to higher alkaline nature due to the presence of stone powder this water is unfit to reuse. The color of the processed sheets, slabs and tiles will become dim if this powdered mixed water is reused. When this process of cutting and cooling takes place dust mixed water flows continuously into large tanks to place for settling the dust, these tanks are called sediment collection tanks. When this dust is settled it is in the form of slurry. This slurry is collected into large sized tankers and trucks and disposed off with the pits available else on the natural grounds causing natural pollution. After drying this slurry is collected in the form of powder of stone. This is now able to be reused as a stone polisher after long use to regain the colour of stone with added colorants. The sundried slurry becomes sludge and after total drying the upper layers turn the small particulate into suspended particulates and mix into air causing air pollution. The nearby areas are disturbed due to this dust and can impact highly the settled population, animals and plants along with ecological flora and fauna. The other waste generated by the marble and granite stone industry is the residue stones which is obtained after dimensional cutting as required and these cutted units of stones can be of different shape, size and aggregation along with shape and textures and flakiness and elongations. When definite dimensions are specified over the machine by the operator slabs are cutted, finished and textured or polishing is done as per desired operations and demands requisites of customization. This complete process is machine and software automated hence error are least. This texture, upper surface of the stones becomes glossy clear due to constant abrasive action of powders being used for smoothening purposing and texturing. Continuous water gun makes the diamond blades to work gently and cut the stone to very sharp edge and mat finish.

2. How waste generated is quantified

In India the amount of waste generated from granite and marble and other recyclable materials is actually not known, the figures of government can be accessed through the portals this actual figure and produced figures may vary to an extent. This is due to the law enforcement point of view and ecological and pollution and ranking, which makes this figures to hide from the real pictures. Apart from that it is actually not monitored by government and third party inspection agencies. The actual figures as per assumption are nearly 42 % wastage production in the procession stage in a 300mm length and 20 mm breadth in free dimensional floor tiles. This can be 55 percent in metre cube for a free dimensional of

310mm length and 310mm breadth and 10mm height. The simple conclusion is more the dimension less is the waste generated. As per research estimation is that 22 percent to 28 percent of granite and marble production results in formation of powder as slurry for every 20 mm slab production. Nearly 5 to 8 mm being crushed to powder form during the cutting and this is made to slurry being mixed with water. An expected estimation is that an average marble and granite production site produces about 7000 ton of waste/year.

3. Impact felt on nature and ecology

Being the most unfriendly industry from the ecological and environment point, marble along with granite produces most waste that is stagnant for years and remains inert after plastic. When the rock of granite and marble are prepared, they produce good amount of dust, pieces of rocks, water mixed wet slurry and large amount of heat. The waste is accumulated in the soil system and makes the ecology of the area totally barren. It does not possess threat to climate change condition but becomes a rogue in nature and a destroyer of below water table, water quality, and air. The granite and marble waste leachate is reactive as per tests done on the sludge bed. The dust being highly alkaline can be highly hazardous to health; the pH value of this dust is more than 11. The blades being used and worn out metal grit has chromium and other heavy metals which are used for making the blades tough and can cause toxicity after weathering and being mixed with this slurry. This powder slurry is reused if, can cause severe heath complication. The water bodies are polluted from top surface till accumulates formation and lasts to ground water deterioration and contamination. Marble has a few compounds which are calcium oxide, magnesium oxide, silicon dioxide, alumina, iron oxide, sodium oxide, and titanium oxide and phosphorus pentaoxide. When the rock is cut to pieces as desired, due to mixing of water it does not cause air pollution hence formation of dust is avoided. This will prevent marble to produce gases and cause global climate changes impact. The water-dust-slurry is captured in large tanks called sedimentation units and later on will dry up this to powder form and carefully if not used will lead to severe pollution. During storms and runoff this dried powder can mixed and can float to channels of water bodies and can enlarge the contamination problem. Blowing winds can impact the air quality. The dust of marble is a problem with mixed with air and can cause visibility pollution because the marble dust is pure while in color due to the presence of calcium carbonate. The visibility is almost less when more dust is mixed in the air. After the dried state there is almost nil humidity and the particles are free to roam in any direction and can cause irritation to eyes and breathe. Chlorine is a bad pollutant when it is in contact with marble dust unlike soils which have greater ion exchange probability, they convert to inert pollutants and cause air pollution and smog formation. The water marble slurry system is having very fine particles having size of 80 microns, which consolidates and accumulates on the soil in later stages after drying. Runoff can cause deep impact in marble slurry and carries it with rainwater to channels and dumps it below the bottom lines causing them to chock and flood during heavy rains and very difficult to clean as it becomes a dense mass with the waste leachate hence it is predicted that waste marble powder is denser and chocks the water bodies. This will also seep into the ground water and can badly impact the underground water and can cause fluorine like pollution. This slurry is so enormous that it is almost not possible to hold in sediment tanks hence is thrown along the road sides causing it to dry and fly in air and causing dense air pollution along with body itching and irritation and nasal problems. The airborne particles are able to travel long distance as being very light and can fly higher too. This slurry can clog the soil, raising the soil pH and alkalinity values and hinders photosynthesis of plants and abrupt leaf transpiration action. Totally the plant fertility along with soil parameters causing overall fertility of soil being impacted. The flora and fauna will be impacted by the stone dust and slurry and can cause nutrients imbalance along with plant and animal growth. They are not dyeing but will suffer in terms of growth and mutations. The gases coming out of the marble industry will destroy the plant chemistry as a whole and plants will be greatly affected. The ecological balance is impacted hence policies must be framed

for the same. Hence it can be concluded that ecological disturbance and destruction can impact the human life and feeding behaviour and thus human health will be deteriorated. The natural scenic beauty too is impacted by the pollution.

When supplementary materials like construction and demolition waste is utilized in making concrete then there are a lot advantages as per research and material costing.

Following are noted as a few benefits

1. Construction materials are cheaply available and locally generated as resource.
2. They turn economical materials for construction.
3. Waste dumping is regulated and reused for less volume creation.
4. Natural materials are less used hence they are economized for future and less impact felt on ecology and conservation is done as mountains and rocks are left over from cutting and utilizing as a material of construction.
5. Flora and fauna of the zone are saved and ecology is saved and human health is less impacted.

In the present work whole replacement is done of natural aggregates and they are replaced with recycled waste having the feasible engineering properties as expected from naturally available aggregates. Thus the cost is reduced and savings are done. Hence the replacement is done with coarse materials like broken pieces of granite and marble and construction and demolition waste. The polymer fibers are used for binding the mass and creating less impact on the symmetry on the concrete and hence good bonding is made. Overall it is clear that granite and marble and other strong aggregates are being used as total replacing the available market aggregates.

The concept of fibers in concrete is not new. This has been used since long the invent of concrete and there are evidences that Indians used concrete like materials with other supplements and they are used visible in ancient temples and monuments. Various fibers like coconut shell fibers, coir and banana composite fibers, sisal, and other natural fibers impact the concrete matrix and workability. The plastic fibers are also a good medium that can impact the similar behaviour as that to natural fibers and they are more durable as compared to nature fibers. When fibers are used in simple concrete its appearance changes and workability along with enhanced properties are seen. Hence adding fibers in concrete is good for all strength aspects.

Following are the advantages of using fibers in concrete:

1. Cracks are bonded in an effective manner.
2. Reinforcement is done in a better way.
3. Macro structure and micro cracking are controlled.
4. Small length and long length fibers impact the concrete matrix and improve its stamina and setting time too.
5. Good strength is achieved.
6. Pullout strength is generated more and effective in combating sudden strains and stress.
7. Cracking faces are well ruptured and tackled effectively
8. Compressive strength is increased.
9. Cracks are filled in a better way by the fibers and aggregates are packed with the fibers along with cracks if any and water cement ratio too is impacted if the fiber is natural and absorbs water , whereas in our work this is not impacted as plastic fibers being very thin absorbs least or almost nil water.
10. Polymers can strength the overall strength of the concrete.

Figure 1 plastic fibers

The activity of the polymer fibers inside the concrete in our case:

1. Permeability of concrete is affected due to crack management.
2. Concrete structure is modified.
3. Corrosion will be least due to no presence of crack avoiding air entrance.
4. Cut back is avoided and impair good strength and looks to the concrete.
5. The crack management is better controlled by fibers and hence less cost on wastage.
6. Stability is increased and scaling of cracks is possible due to least length of cracks in concrete.
7. Thus addition of fibers in the modified concrete can raise stability against many odds.

1.2 OBJECTIVES

To produce concrete using recycled waste construction and demolition waste, marble waste and granite waste along with inclusion of plastic fibers, and look out for possibilities of its better use to save cost and natural aggregates. The utilization can be better if computed effectively.

1. To find out the aggregate properties and compare them with the natural aggregates.
2. To find the compressive strength of the concrete and compare it with the recycled matter added concrete using the mix with marble aggregates, granite aggregates and CND waste aggregates with addition of fibers made of polypropylene.
3. To develop a methodology for evaluation of modified concrete with application of waste in earlier used concrete.
4. To investigate the adoptability and suitability of various recycled waste in the concrete.
5. To justify the application of waste aggregates in construction sector.
6. To quantify the design mix matrix with the standards laid earlier.

II. LITERATURE SURVEY

1) Korae sudarshaan et.al (2022) investigated and found that granite and marble industries generate significant quantity of waste. This is from the mining sector and initial to final finished good stage. This generated waste is put to disposal in an unscientific manner and left near the preparation sites itself and this cause greater inconvenience to common people. As the dust generated will be an agent of pollution and can cause deep health hazards. The dumping on open sites causes natural contamination of multiple sources apart from destroying nature and ecology. They found a way to use marble and granite waste as a coarse aggregate in preparation of concrete. They have examined extensively to check the utility of waste aggregates and their significance in concrete. They found a suitable water cement and aggregate ratio as sixty percent. They concluded that workability of such aggregates being mixed in concrete is more than 15 percent as optimal as the normal made concrete. They have suggested a optimal replacement of 45 percent to that of coarse granite aggregates and 20 percent marble aggregates for best results at curing periods of 28 days.

2) Mahendra tripathi et.al (2021) found that solid waste generation from multiple sources and its segregation then dumping is a big issue in metropolitan cities throughout the globe as they being big industrials hubs too for the production and generation of wrapping waste and other assessed wasted allied them to assist the remaining processes. Many types of waste are not even recycled and do not accord to recycling standards and must be thrown or dumped or incinerated to dispose them off. This causes greater changes of global warming. Many efforts have been done to reuse them in any form or even recycle them or reduce them for efficient usage. One better option being to use them as an aggregate in construction industry. They found that around the world various marble and granite industries generated waste are dumped as landfills and later on these reclaimed landfills are used for rehabilitation of settlements causing health hazards. The granite and marble industry generate small rock

fragments which can fill the undulated land and cover the surrounding agricultural land too causing land degradation. Residential locations use the ground water which is contaminated or chemically changed earlier causing diseases. The other findings are of key importance like marble and granite when polished as expected to customize needs when generate stone coarse aggregates and if reused in concrete as an aggregate then it will decrease compressive strength values. They also found a significant change in flexural strength and tensile strength with this polished aggregates and it is lower than expected. They also concluded that polished granite can produce good water absorption capability, good abrasion capacity and optimal results for permeability of water. They have tested the concrete made with polished granite material aggregates can be used as a good replacement up to twenty percent of available natural coarse aggregates and can be mixed up to 50 percent for footpath and other low capacity applications like low density roads and structures.

3) Le kaiku albert et. Al (2019) concluded that sustainable materials can be made using recycled waste and construction industry has enormous opportunities for the same. The green concept and construction methods can be turn efficient when recycled materials are used for low cost application and low capacity applications. They concluded that use of different recycled waste must be verified before being used as they can impact the chemistry of concrete and in long run will adhere to ill impacts on the structures. They concluded that proper mixing and design criteria if used can benefit the reuse criteria of waste recycled aggregates. They achieved a target compressive strength with the design mix concept. They expected that properties impacting the duration, life and ageing must be checked carefully for better results. Recycled waste arise from numerous sources must be quantified and used for better design results. They found a suitable mix of M30 having 50 percent replacement of construction waste and 60 percent of marble waste along with granite waste for optimal results.

4) Hedrick & James (2015) they found that there are multiple options available for re use of recycled materials in various light weight and general structures and pavements. Numerical methods are available for various materials as per choice. Life of the aggregates can be an important option as the generated waste is originated from multiple options. They can impact the natural and hence pollution is created with the use of recycled waste.

III. MATERIALS TAKEN

The marble dust and granite dust has fine particles having size less than 90 microns with 92 percent particles having particle size less than 30 microns in marble but for granite it is 25 microns. 60 percent particles are having fine particles size 10 microns. Thus the marble and granite dust lies in the very fine particles range that of clay to silt. Marble has more fine particles and granite has less fine particles when both are compared.

When the waste materials are collected, emphasis is on the sorting process. Thus the cleaned materials are taken on priority without taking more dust. Hence it is obvious from above that slurry powder is intact with marble and granite aggregates and hence will amount to disturbance in concrete sample, hence fine particles analysis is also done. The specimen are processed as per lab requirement and moulded for testing.

1. Ordinary Portland cement is taken as binder among the aggregates
2. Fine particles are taken as sand, accounts to fine aggregates.
3. Various coarse aggregates taken above are replacement to natural aggregates.

They are construction waste, marble waste and granite waste.

4. Fibers of polypropylene plastic.

Figure 2 marble aggregates

Figure 3 river sand

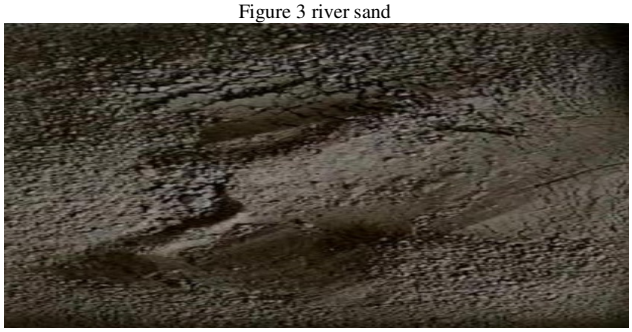

Figure 4 OPC 53 grade

Figure 5 casted samples

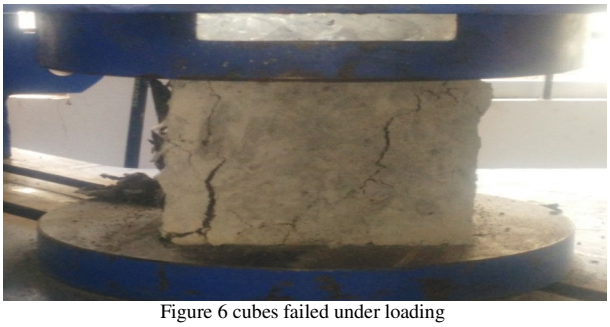

Figure 6 cubes failed under loading

IV.LAB PROCESSING AND TESTS BEING DONE

Table 1 Mixing proportion of various ingredients used in the lab for making samples

Sample	Percentage exchange of materials for making samples			
	Broken marble in kg	Broken granite in kg	Construction and demolition waste in kg	Plastic fiber threads
Mix sample 1	40%	20%	39%	1%
Mix sample 2	50%	30%	19.25%	0.75%
Mix sample 3	60%	10%	29.5%	0.50%

For making the above said proportions the amount of materials needed for making samples 1 are now calculated and different samples are casted for testing. Three cubes are casted.

Table 2 sample 1 data

S.N	Cement in kg	Fine sand in kg	Replacing the coarse particles with the said percentages (total amount 20 kilo)				Water in litre
			Marble pieces in kg	Granite pieces in kg	Construction and demolition waste in kilogram	Plastic fiber in kilogram	
cube 1A	5.0	8.7	8	4	7.8	0.20	3 litre
cube 1B	5.0	8.7	8	4	7.8	0.20	3 litre
cube 1C	5.0	8.7	8	4	7.8	0.20	3 litre

Table 3 for sample 2, casting of cubes is done and this is quantified as below

S.NO	cement in kg	sand kg	Exchange of rough ingredients in percentage with 20 kilogram weight				water in litres
			Pieces of marble in kg	Pieces of granite in kg	Construction and demolition waste in kg	Plastic fiber in kg	
Cube 2A	5.0	8.7	10	6	3.9	0.150	3
Cube 2B	5.0	8.7	10	6	3.9	0.150	3
Cube 2C	5.0	8.7	10	6	3.9	0.150	3

Table 4 to cast sample of third type we need this quantity of materials.

S.no	Cement in kg	Quantity of sand in kilogram	Exchange of rough particles is done with the following particles to make the sample taking as 20 kilogram				water in litre
			marble in kg	granite in kg	Construction and demolition waste in kg	Plastic fiber in kg	
cube 3A	5.0	8.7	12	2	5.9	0.050	3
cube 3B	5.0	8.7	12	2	5.9	0.050	3
cube 3B	5.0	8.7	12	2	5.9	0.050	3

Compressive strength values after Seven day
Here NC is the normal concrete, MD1, MD2, MD3 are the samples of type 1, 2 and 3.

V. RESULTS

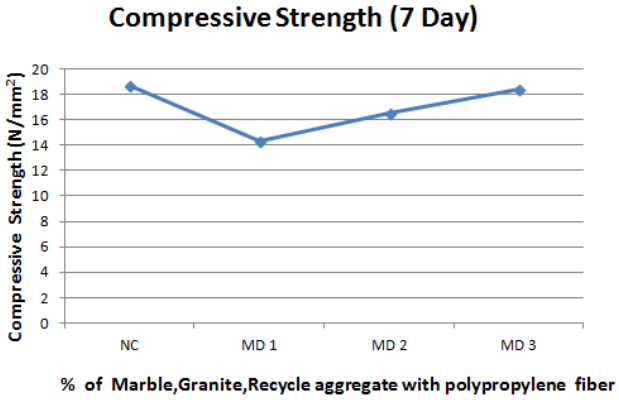

Figure 7 compressive strength after 7 day

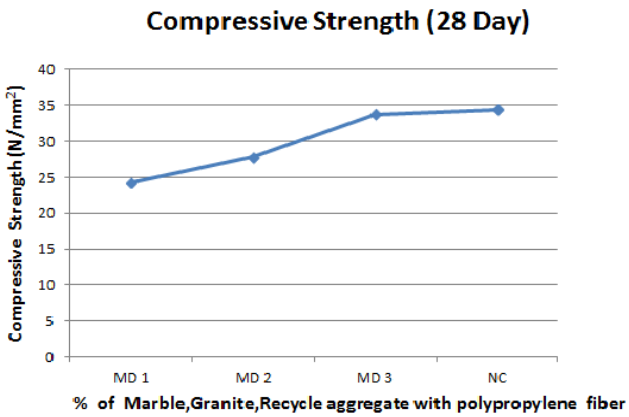

Figure 8 compressive strength after 28 day

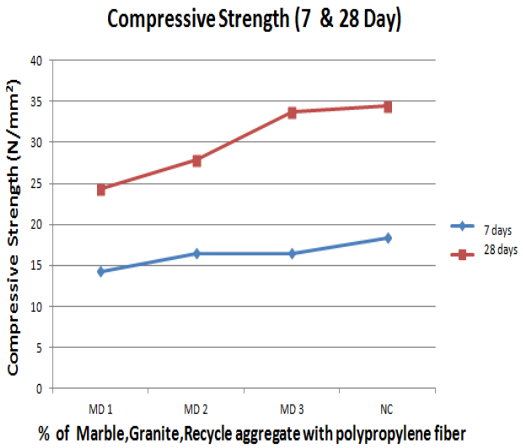

Figure 9 compressive strength for 7-28 days

IV. CONCLUSIONS

1. Compressive strength of modified concrete increased with full replacement of natural aggregates
2. The highest compressive strength which is obtained in the lab for 7 day is and for 28 day is and this is percent higher than normal concrete mix.
3. The decreasing percentage of compressive strength of samples MD 1, MD 2, MD 3 are 29.31%, 20.59%, and 1.85% respectively compared with the control concrete mix.
4. The highest compressive strength of 7 day sample MD 3 was observed almost equal to compared with the control concrete mix (Normal Concrete).

5. The decreasing percentage of compressive strength of samples MD 1, MD 2, MD 3 are 23.32%, 11.52%, and 1.44% respectively compared with the control concrete mix.
6. Casting strength gain after 7 day in NC is 74.5%, MD1 is 57%, MD 2 is 66%, and MD 3 is 73.5%.
7. Compressive strength is also increase continuously by Continuous increase marble value up to 40%, 50%, and 60%.
8. Reducing the amount of granite and polypropylene fiber will increase compressive strength.

FUTURE SCOPE:

1. Demolished pavement waste and other waste marble and granite coarser materials can replace natural aggregate in concrete.
2. Increased volume of experimental data with other materials and is to be collected and used to study the suitability of different waste materials.
3. Waste materials used in concrete saves the environments and become economically efficient for construction. If we further research in this field it will be helpful to minimize waste from industries.
4. The highest compressive strength of sample Mix Design ratio 3(MD 3) was observed almost same to compressive strength of normal mix concrete (NC).

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