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# Efficient Management of Waste Ceramic Aggregates Reinforced with Fibre Concrete for Face Masks

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**ABSTRACT:** Concrete has been widely used in construction worldwide; which has led to faster depletion of natural resources and increased the construction cost of structures. It becomes necessary to search for suitable waste materials that could be used either as an additive or as a partial replacement to the conventional concrete ingredients. These waste materials otherwise cause disposal crises, thereby contributing to environmental problems. Hence, the use of waste materials in concrete circumvents the need for safe and economical disposal of waste materials. Use of waste materials saves natural resources and dumping spaces and maintains a clean environment. Here used Face Mask Fiber (FMF) is used as a Partial replacement of fine aggregate in concrete to achieve the desired mechanical properties. This study proposes ceramic waste tile material as a partial replacement of fine aggregate in concrete with a view to find the optimal use of ceramic fine aggregate as a possible substitute for natural fine aggregate respectively in concrete. The test results show that ceramic waste material as a partial replacement for natural fine aggregate provides better performance in terms of compressive strength (CS), tensile strength (TS), flexural strength (FS) and combined flexural and torsional strength (FTS). Furthermore, waste ceramic optimal concrete (WOC) has been obtained by replacing plain concrete (M25 grade) constituent with ceramic constituent 10% ceramic sand. To improve the mechanical properties of waste ceramic optimal concrete (WOC), used Face Masks Fiber (FMF) have been used. The results have shown that using FMF fibres will give enhancement the compression, tension, flexure, and combined (flexure and torsion) of Waste Ceramic Fine Aggregate Concrete (WCFAC).

**KEYWORDS:** Waste Ceramic Aggregates, Reinforced, Fibre Concrete, Face Masks

## I. INTRODUCTION

Structures are significant for human beings. A solid and durable construction must be necessary for a healthy environment. Varieties of materials are available for making structures like brick, stone, sand, cement, glass, concrete, steel, fibre, aluminium, plastic and many more. The materials required to construct any structure must have minimum acceptable properties like strength, aesthetic value, workability, and durability. Concrete is one of the most user-friendly materials in the world. Many innovations are happening in concrete technology in the current era, emphasizing saving energy, reducing costs, and reducing the environmental pollution. Concrete is not a new material and has been used for several thousands of years. Concrete is the next major material after water for the use of human beings. Some disadvantages of concrete, such as using large amounts of non-renewable natural resources, are exploited to produce sand and aggregates. As India is the second-largest concrete manufacturing country globally, there are two ways to reduce the risks of concrete production, either by 100 % replacement or partial replacement of natural material with some solid waste materials. There are a lot of materials available for the replacement of concrete ingredients. Solid waste is the biggest issue for the industries. Industrial solid wastes are generated from the manufacturing of different industrial products. Industrial solid wastes and construction solid waste can be reutilized for producing mortar/concrete. As per need, ceramic waste is considered in this study as a partial replacement of cement & aggregate (fine and coarse)

which is justified by the literature review. Wastes are produced from the ceramic industries is solid and it is used as a fine aggregate. Research on natural material replacement by ceramic is in progress but is not feasible and economical. The effect of incorporating ceramic waste on compressive, tensile and flexural strengths is also examined and after finding the optimum value of ceramic fine aggregate replacement concrete, further adding the used face mask fiber in different proportion. The main reason for incorporating fibers into a cement matrix is to increase the toughness & tensile strength and improve the cracking deformation characteristics of the resultant composite. Fiber-reinforced concrete is cemented concrete reinforced with fiber by randomly adding discrete short fibers in concrete. Since randomly distributed fiber inhibits crack growth and propagation, fiber reinforced concrete is significantly firm and ductile than regular concrete. This material is used in earthquake-resistant structures, tunnel linings, and structures subjected to extreme loads such as impact and explosion. The present study focuses on the effect of ceramic materials and fibers on the mechanical properties of concrete. The first level of the present study includes finding out the optimal use of ceramic materials in concrete to replace aggregate and cement after doing a preliminary survey of different sources of ceramic waste from different ceramic production factories. The waste materials have been selected only one source of ceramic waste materials from the Shirdi Sai Electricals-Kadapa trash dump, Andhra Pradesh (India) and carried out the whole experimental work with the same ceramic waste materials to ensure steady and consistent results. In this research natural fine aggregate is replaced with waste ceramic fine aggregate by 50% constantly and in addition to that used face mask fiber is also incorporated in the concrete with the different proportion of 0%, 1%, 1.5% and 2%.

## II. EXPERIMENTAL INVESTIGATION

### 2.1 Materials

Ordinary Portland cement of grade 53 was purchased from Siva Traders, Namakkal, Tamilnadu. It conforms with IS 12269- 1987. Properties of 53 Grades Cement are given in table.1.

Table.1 Physical Properties of 53 Grades Cement

Sl. No	Test Particulars	Results Obtained
1	Normal consistency (%)	33
2	Initial setting time (min)	60
3	Final setting time (min)	320
4	Compressive strength (MPa)28-days	53.85
5	Specific gravity	3.14

**Fine Aggregate:** The river sand used in this study was purchased from Namakkal, Tamil Nadu. The test results were compiled in Table 2 and the physical characteristics of river sand were determined in accordance with IS: 383-1970 Zone-II.

Table2: Physical characteristics of fine aggregate

Sl. No.	Property	Value
1	Specific gravity	2.70
2	Fineness Modulus	2.48
3	Free Moisture	1%
4	Grading	Zone-II
5	Volumetric density in Kg/m <sup>3</sup> Loose state Dense state	1630.12 kg/m <sup>3</sup> 1865.25 kg/m <sup>3</sup>

**Natural Coarse Aggregate:** The coarse aggregate used in this research was purchased from Namakkal, Tamil Nadu.



Table.3 displays the Physical properties of Natural coarse aggregate.

**Table.3: Physical characteristics of Natural coarse aggregate**

S.No	Property	Value
1	Specific Gravity	2.70
2	Impact value	10.4
3	Aggregate crushing value	20.20%
4	Abrasion value in %	15.65
5	Volumetric density in Kg/m <sup>3</sup> Loose state Dense state	1455.35 kg/m <sup>3</sup> 1575.45 kg/m <sup>3</sup>
6	Water absorption in %	0.13
7	Elongation index in %	20
8	Flakiness index in %	21

**Waste Ceramic Fine Aggregate (WCFA):** The "Shirdi Sai Electricals-Kadapa" trash dump has collected ceramic waste (India). In this research waste ceramic fine aggregate is used for replacing natural fine aggregate by 50% constantly. Properties of waste ceramic aggregate show in Table.4.

**Table.4: Physical characteristics of ceramic waste aggregate**

Sl. No.	Property	Value
1	Specific gravity	2.28
2	Fineness Modulus	2.22
3	Water absorption	2.65
4	Maximum Size	4.75

**Face Mask Fiber (FMF):** Surgical masks were used in this study. The metal nose-fitting piece and the elastic ear bands were manually cut with scissors and discarded, and the filtering parts of the masks were cut into small pieces by means of a paper shredder, passed through in both directions, obtaining small squares. The resulting aspect is given in Figure 1. This material has been labelled as FMF (Face mask Fiber).



**Figure .1. Waste Face Mask Fiber (FMF)**

## 2.2 Mix Proportion

The Indian standard recommended method IS10262- 2009 is used to create a design of the concrete mix for M20 grade, with target strength of 26.6 MPa. Table 5 displays the number of ingredients utilized to prepare the concrete. In the preceding Table 5, concrete that is prepared conventionally abbreviated as CC and WCFAC stands for

waste ceramic fine aggregate replacement concrete, which substitute's waste ceramic fine aggregate for natural Fine aggregate by 50% constantly for all mix. In addition to that mix used face mask fiber in incorporated in to the concrete with the proportion of 0%, 1%, 1.5% and 2%.

### Compressive Strength Test

According to the IS 516-1959, cube specimens measuring  $150 \times 150 \times 150$  mm were cast and the natural fine aggregate was replaced 50% by ceramic waste fine aggregate to investigate the compression behaviour of ceramic waste fine aggregate concrete and In addition to that mix used face mask fiber in incorporated in to the concrete with the proportion of 0%, 1%, 1.5% and 2%. Fig. 2 shows the testing of cube specimen in CTM.



Figure.2. Testing of cube specimen in CTM

### Split Tensile Strength Test

It is crucial to test at least three specimens for the appropriate ages in order to determine the split tensile strength for 7 and 28 days. To ensure proper placement of the specimen in the compression testing machine, a diametrical line connecting the two ends of the specimen was drawn before testing. The fabrication and testing procedure has been followed according to IS 516-1959. Fig. 3 shows the casted specimen for testing split tensile strength.



Figure.3. Specimen for testing Split Tensile Strength

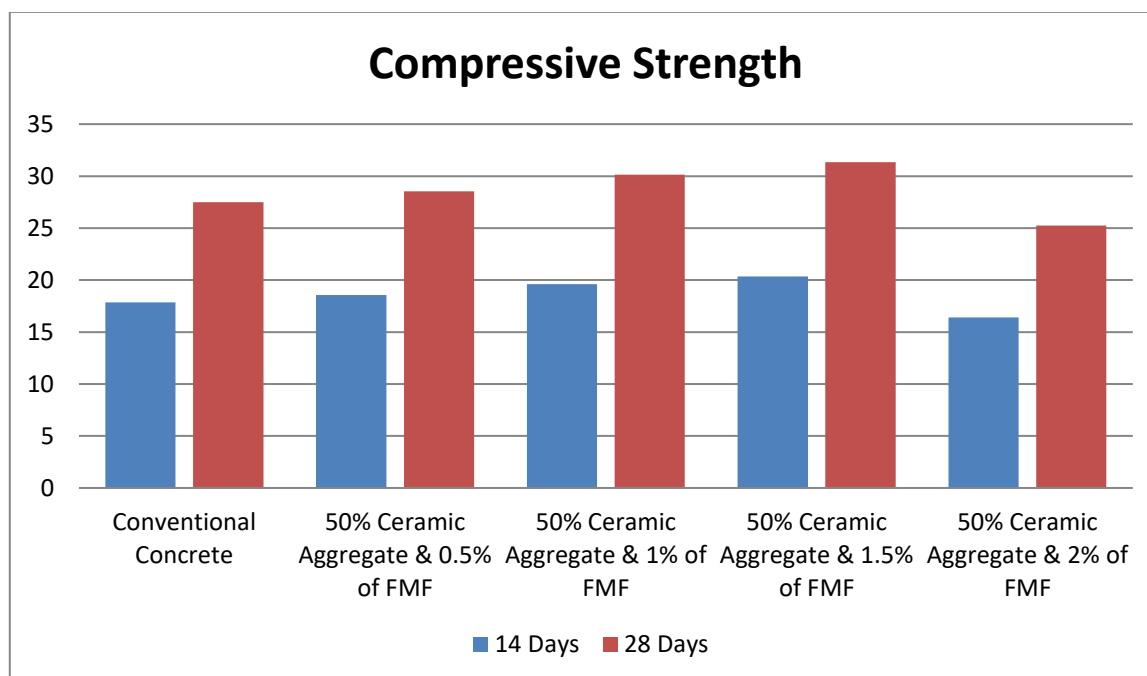
### Flexural Strength Test

For beam specimens, 6 beam specimens were cast in steel moulds with inner dimensions of  $100\text{mm} \times 100\text{mm} \times 500\text{mm}$  according to the IS 516-1959. Three beams were used to evaluate 28 days' flexural strength, and the remaining 3 beams were used to evaluate combined (flexural and torsion strength).

### III. RESULTS AND DISCUSSION

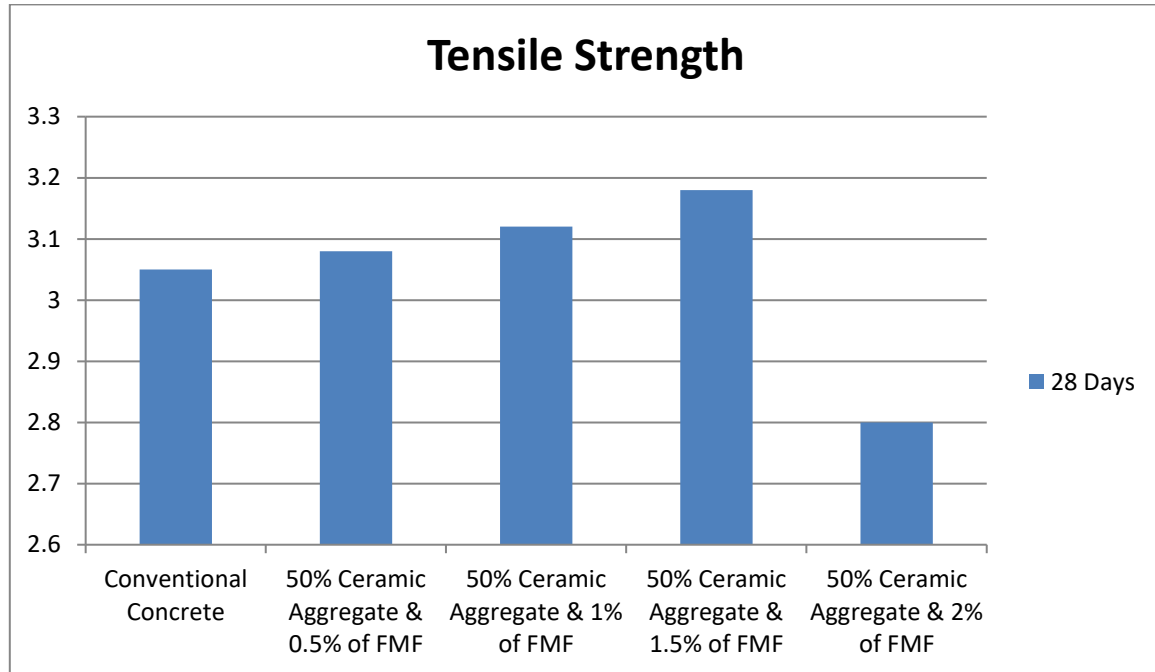
#### 3.1. The effect of ceramic waste and face mask fiber material on concrete's compressive strength

Figures 4 and 5 show the impact of waste ceramic waste and face mask fiber material on concrete's compressive strength after 7 and 28 days. Ceramic waste aggregate was substituted 50% constantly for conventional aggregate and Face Mask Fiber (FMF) is added in the following proportions: 0%, 1%, 1.5% and 2%. According to the experimental results, replacing 1.5% of FMF used in waste ceramic fine aggregate concrete results in higher compressive strength. Comparing compressive strength in CC and WCFAC confirms that when FMF is substituted for 0.5%, 1% and 1.5% of the waste ceramic fine aggregate concrete, the strength is confirmed to be higher by 3.78 %, 9.63% and 14% than that of regular concrete specimens respectively. This is because the surface of waste ceramic fine aggregate is more angular than normal fine aggregate. As a result, it allowed the 1.5% of Face mask fiber (FMF) in waste ceramic aggregate concrete filled the air voids in the concrete and give more bonding in the concrete. Beyond the 1.5% of FMF the strength will be slightly decreased because of over usage of FMF fiber.



#### 3.2. Effect of ceramic waste and face mask fiber material on the split tensile strength of concrete

Figures 4 and 5 show concrete's split tensile strength after 7 and 28 days, respectively, and the impact of ceramic waste and face mask fiber material concrete. Ceramic waste aggregate was substituted 50% constantly for conventional aggregate and Face Mask Fiber (FMF) is added in the following proportions: 0%, 1%, 1.5% and 2%. According to the experimental results, replacing 1.5% of FMF used in waste ceramic fine aggregate concrete results in higher tensile strength. In this proportion 1.5% of FMF replacement concrete gives higher strength, so 1.5% is the optimum dosage of FMF in ceramic fine aggregate concrete. As a result, it allowed the 1.5% of Face mask fiber (FMF) in waste ceramic aggregate concrete filled the air voids in the concrete and give more bonding in the concrete. WCFAC confirms that when FMF is substituted for 0.5%, 1% and 1.5% of the waste ceramic fine aggregate concrete, the strength is confirmed to be higher by 1 %, 2.3% and 4.25% than that of regular concrete specimens respectively. Beyond the 1.5% of FMF the tensile strength will be slightly decreased because of over usage of FMF fiber which reduces bonding between waste ceramic aggregate constituents in concrete.



Shruthi et al., 2016 when coarse aggregate was used in place of 30% of the ceramic tile aggregate, the maximum split tensile strength was attained, according to the results of the investigation. Similar to another study performed by Younis et al., 2022 concluded that, instead of being 3.8 and 2.71 MPa for the AC mixes, the replacement of CC with 50% coarse aggregate containing 1% PEG raised both flexural and splitting tensile strengths to 5.87 and 4.21 MPa, respectively. Ramadevi, 2017 found that after replacing the fine aggregate with ceramic waste to the extent of 50%, the split tensile strength value is 3.5 N/mm<sup>2</sup>. This finding indicates that the strength increases as the replacement proportion of ceramic waste aggregate. Taj et al., 2018 stated that the concrete that was replaced with 5% rubber and 15% tile had a split tension strength that is 9% higher than the control concrete. Ikponmwosa and Ehikhenmen, 2017 concludes that ceramic waste could be used for both structural and non-structural work. The greatest concrete strength of 3.58 MPa was reached in the current study with a 40% substitution of ceramic waste aggregate. The difference in results could be due to the type of materials used, treatment methods utilized, and environmental conditions.

### 3.3 The influence ceramic waste and face mask fiber material on concrete flexural strength

Figures 5 show concrete's flexural strength after 7 and 28 days, respectively, and the impact of ceramic waste and face mask fiber material concrete. Ceramic waste aggregate was substituted 50% constantly for conventional aggregate and Face Mask Fiber (FMF) is added in the following proportions: 0%, 1%, 1.5% and 2%. In this proportion 40% replacement concrete gives higher strength, so 40% is the optimum dosage of ceramic aggregate concrete. Flexural strength evaluation of CC and CRWAC Due to the waste ceramic aggregate's surface being more angular than gravel, the 40% replacing of coarse aggregate with ceramic waste aggregate confirms greater strength than that of a normal concrete specimen by 7.51%. As a result, it allowed the waste ceramic aggregate to better bond with the other aggregates and to fill more air voids than gravel, which has showed a smoother surface. Therefore, the angularity of the waste ceramic aggregate may have contributed to the improvement of the concrete's flexural strength. Concrete's flexural strength decreases when coarse aggregate replaces ceramic aggregate by more than 40%. This might be because waste ceramic aggregate has a smoother surface texture and a greater water absorption capacity, which weakens the bonding between the waste ceramic aggregate components in concrete. Chand and Kumar, 2017 Investigated that M3 mix of concrete produced a better concrete in terms of flexural strength than the other mixes. But the mixes up to 50% of ceramic coarse aggregate can be used. Bommisetty et al., 2019 researched the optimum with 20% replacement the concrete has a flexural strength of 5.43 N/mm<sup>2</sup>, which is 8.27% more than the flexural strength of regular concrete. Concrete's flexural strength increased along with the amount of ceramic waste it contained, According to research by Hasan et al., 2014. In comparison to CC-0 concrete, CC-10 concrete has a flexural strength that is 7.5% higher. Najm and Ahmad, 2022 concluded that the mechanical analysis of waste ceramic concrete showed that ceramic waste material as a partial replacement for natural aggregate, cement, and fine aggregate provides better performance.



With a 40% replacement of ceramic waste material, the current investigation produced concrete with the maximum strength, which was 3.72 MPa. The difference in results could be due to the type of materials used, treatment methods utilized, and environmental conditions.

#### **IV. CONCLUSION**

The present study investigated the compressive, tensile and flexural strength of concrete made of the ceramic waste floor tiles as aggregate (fine) and waste face mask is used as a fiber in concrete. The following conclusions can be drawn:

- Based on the present experimental investigations, it is feasible to use waste ceramic tiles grounded to desired fineness as replacement of river sand replacement to produce waste ceramic concrete. In the case of WAC, the CS, TS and FS decreased as the percentage (%) of AWC increased (from 10% to 100% as replacement of NCA) in the concrete specimens. Also, these strengths were found to be less than that of the PC. However, the UBS was found to be highest and greater than that of the PC for 10% replacement whereas, for 20% replacement, the UBS was found to be equal to that of PC. Hence, the optimal percentage of AWC was taken as 20% as a replacement of NCA.
- In the case of WCC (with 20% AWC constant), the CS of specimens with the 5% & 10% replacement of cement by CWC was found to be greater than that of reference concrete, whereas, for 15-30% CWC, the CS was found to be less than that of reference concrete. TS of WCC was found to be less than the reference concrete for all the replacement percentages of CWC. FS of the specimen with 5% CWC was found to be greater than FS of reference concrete and on further increasing the replacement percentage, the FS was found to be less than FS of reference concrete (WCC-0%). However, the UBS was found to be higher than FS of reference concrete for all the replacement percentages. Therefore, the optimal percentage of CWC was taken as 10% replacement of OPC in WCC (with 20% AWC as constant).

#### **REFERENCES**

1. M.Harikaran and N.Balasundaram, "Performance enhancement of concrete by replacing coarse aggregate with tyre rubber: A Study", Ecology, Environment And Conservation, Vol. 25, Issue No.2 , ISSN No. 0971-765X, pp.702-705, Date of publication (January 2019)
2. M.Sanchaya, M.Harikaran, K.Cheran, M.Varoon, P.Jayaprakash, G.Navin, Experimental investigation on rice husk ash and coconut shell used in building materials, Materials Today: Proceedings, <https://doi.org/10.1016/j.matpr.2022.08.264>
3. B.Sasivarman, Dr.R.Nagalakshmi, Dr.M.Harikaran, Treatment of wastewater by slow sand process with polystyrene, Materials Today: Proceedings, <https://doi.org/10.1016/j.matpr.2022.08.082>
4. M.Harikaran and N.Balasundaram, "Evaluation of Concrete Using Reshaped Waste Tyre Rubber as Partial Replacement of Coarse Aggregate", International Journal of Recent Technology and Engineering, Vol. 7 ,Issue No.6S5 , ISSN No. 2277-3878, , Date of publication (April 2019)
5. M.Harikaran and N.Balasundaram, "Deflection Behaviour of RC Beams using Reshaped Waste Tyre Rubber as Partial Replacement of Coarse Aggregate ", International Journal of Recent Technology and Engineering, Vol.8 ,Issue No.2 , ISSN No. 2277 -3878, Date of publication (July 2019), DOI: 10.35940/ijrte.B3189.078219.
6. Dr.R.Shanmugam., Dr.M.Harikaran., S.Gokulakannan., P.KeerthanaDevi. Compressive Axial Behavior of Short Columns Incorporating Bottom Ash and Reshaped Waste Tyre Rubber, Journal of Xi'an Shiyu University, Natural Science Edition, 19, 02, 2023
7. M. Harikaran, R. Vijayan, P. Senthilkumar, R.S. Suganth, R. Nithishkumar, Vijay,V. Experimental Study on Properties of Paver Block using Coconut Fibre & Nylon Fibre, Grenze International Journal of Engineering and Technology, 9, 1, 2023
8. Dushyanth V Babu R., Mukesh P., Menkapandey., Harikaran M., Balaji G., Monisha K M, Experimental Study Of Concrete By Replacement Of Cement With Polymer Resin, IOP Conf. Series: Earth and Environmental Science, DOI 10.1088/1755-1315/1125/1/012014
9. Dr.M.Harikaran, P.Mukesh, P.Senthilkumar, R.S.Suganth, R.Nithishkumar, V.Vijay, Study of structural bonding strength with tyre rubber instead of coarse aggregate and water hyacinth ash instead of cement, Materials Today: Proceedings, Volume 68, Part 5, 2022, Pages 1330-1334, <https://doi.org/10.1016/j.matpr.2022.06.359>.
10. M. Harikaran, P. Kulanthaivel, A.R. Krishnaraja, P.C. Murugan, Performance enhancement of concrete by using



ceramic waste as a partial replacement for coarse aggregate, Journal of Ceramic Processing Research, Volume 24, Issue 2, 266-273.

11. Sankar. P, P. Suresh, T. Aravind, V.K. Buvanesvari, M. Harikaran, R. Raja, Investigation on Supply Chain Distribution Network Problem using RFID Technique, International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET), 12, 1, 2023, DOI:10.15680/IJIRSET.2023.1201094
12. Sankar. P, P. Suresh, T. Aravind, V.K. Buvanesvari, M. Harikaran, R. Raja, Analysis and Optimization of Supply Chain Travelling Salesman Problem Using K-Means Cluster based Genetic Algorithm, 12, 1, 2023, DOI:10.15680/IJIRSET.2023.1201095
13. M. Harikaran, P. Keerthanadevi, S. Inbarasan, N. Tamilan, R. Manimaran, S. Jayavikram, Experimental examination of concrete using hazardous plasti-fiber and rub – fiber, Materials Today: Proceedings, 2023, <https://doi.org/10.1016/j.matpr.2023.04.598>
14. M. Harikaran, S. Gokulakannan, A. Loganathan, R.D. Chandiran, M. Ajith, V. Dhanasekar, Metakaolin cement concrete evaluation using industrial by-products as fine aggregate, Materials Today: Proceedings, 2023, <https://doi.org/10.1016/j.matpr.2023.04.586>
15. S. Gokulakannan, M. Harikaran, K. Mounesh, S. Sankaranarayanan, R. Sathishkumar, R. Sivakumar, Experimental studies on durability and deflection behavior of concrete in metakaolin cement concrete, Materials Today: Proceedings, 2023, ISSN 2214-7853, <https://doi.org/10.1016/j.matpr.2023.05.236>. (<https://www.sciencedirect.com/science/article/pii/S2214785323028687>)
16. P. Keerthana Devi, M. Sanchaya, M. Harikaran, J. Gopi Krishna, V. Kaviyaran, N. Venkatesh, Effective utilization of waste paper sludge ash as a supplementary material for cement, Materials Today: Proceedings, 2023, ISSN 2214-7853, <https://doi.org/10.1016/j.matpr.2023.05.599>. (<https://www.sciencedirect.com/science/article/pii/S2214785323032339>)
17. M. Harikaran, SampathBoopathi, M. Rajkannan, S. Gokulakannan, Impact analysis of ceramic tile powder aggregates on selfcompacting concrete, Engineering Research Express, 5 (2023) 025069, <https://doi.org/10.1088/2631-8695/acde48>
18. Harikaran.M, Kulanthaivel.P, Gokulakannan.S, Vinodhkumar.S, Eco-friendly soil stabilization: a combined approach using lime and waste eggshell powder, Global NEST Journal, Vol 25, No 7, pp 120-130, <https://doi.org/10.30955/gnj.005077>
19. A. Loganathan, R.D. Chandiran, M. Harikaran, M. Sanchaya, Experimental Investigations on Building Demolition Waste Using as a Fine Aggregate in Concrete, International Research Journal of Engineering and Technology (IRJET), Volume: 10 Issue: 07, Pages 2395-0056, 2023.
20. M. Harikaran, SampathBoopathi, S. Gokulakannan: M. Poonguzhali, Study on the Source of E-Waste Management and Disposal Methods, Sustainable Approaches and Strategies for E-Waste Management and Utilization, 39-60, 2023, DOI: 10.4018/978-1-6684-7573-7.ch003
21. M. Harikaran; P. Kulanthaivel; P. Keerthana Devi; M. Sanchaya, Impacts of Nanomaterials on Enhancing Concrete Quality: A Comprehensive Analysis, Sustainable Utilization of Nanoparticles and Nanofluids in Engineering Applications, DOI: 10.4018/978-1-6684-9135-5



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