Development of Sustainable concrete using CWP and HDPE – A Review

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Abstract. So far as concrete is concerned it's been widely used material till date worldwide and also will be used with more intensity as construction sectors are in boom demand. Sustainable concrete structure is one that is constructed in such a way that the overall social impact of the entire life cycle is minimized. Sustainability in mind requires considering the structure's short-term and long-term effects. Such Concrete is also called Green Concrete. Use of unsafe waste in concrete will result in undesirable surroundings. kind of concrete may called sustainable concrete and some may call it Green concrete. In recent era use of different products and hence its by-products as waste growing tremendously which want right discarding , For environmental protection, the reduction of dependence on herbal compounds, the reduction of CO2, and the creation of greener concrete, its recycling, and reuse are essential. not pricey. The importance of sustainable concrete has turn out to be sizeable for educational Institutions, University and industries. The manufacturing of ceramics in India has increased to over 750 million m2 [1]. Each year, waste created from the production and transportation of ceramic products is generated. Hazardous metals such cobalt, vanadium, barium, manganese, lead, cadmium, copper, chromium and antimony are used in the clay, stains and glazes used to make CW and CWP. [2]. In recent time line such kind of ceramic waste is generally used to fill up nearby land which makes surrounding land unfertile as well as it makes sounding ground water contaminate. The main objective of the this review is to lookout for the different effects of CW and CWP as FA,CA and Combination. Also in present review Coarse aggregates have been partly replaced by High-density polyethylene granules (HDPE). Different concrete mix have been studied for M30 grade. CA have been replaced in the range of 1% to 5%. Numerous properties have been studied for durability and strength i.e. split tensile test, compressive strength, durability and flexural test as well as rapid chloride permeability test, alkaline test, acid test.

Keywords: Green Concrete, Ceramic Waste, CW, CWP, HDPE, LDPE

INTRODUCTION

In Recent era construction industries taking an important part for ongoing construction projects in at most all region. Use of concrete as building material have expanded due to its useful properties. Concrete is mixture of CA, FA and Cement (binder). Now a days exploitation of natural resources is booming for the development and uplifting the Civilization. Consequences of using cement in huge amount lead to produce green house gases. Cement production generates 6% of CO2 emission globally. 1.57 tonnes of Clinkers used per ton production of cement. Such clinkers contains shale, lime stone and clay[3]. Also waste from different industries have been increasing rapidly to overcome the demand of Humans for ongoing activity. Some of them are injurious to health. From many waste only few can be used as recycled and reused to produce another material. Ceramic waste and

HDPE waste are two of them. These both waste produced as by product from industry. Since ceramic industry is widely enhancing the production and by that consequences waste material generating more.

As per the data of 2011-12 approximately 600 M.Sq.m ceramic was produced by India[4]. Which was updated to 750 M.Sq.m[1]. If we look for Plastic Industries than it is also producing waste like HDPE (High density polyethylene) and LDPE (linear density polyethylene). Such material are light in weight but strong enough to take load. Among HDPE and LDEP, HDPE have less impact on surrounding environment because it is less chemically affected by other material. Aggregates were replaced partially by HDPE to increase the strength. HDPE were introduced in the form of Granules which has to deal with split tensile test, compressive test, shrinkage test, flexural strength, compressive strength etc. Generally HDPE is used to enhance the mechanical Property of concrete namely compressive strength.

LITERATURE REVIEW

Some literature have been studied thoroughly and CW and HDPW waste are discussed below.

Alves et al. [6] investigated the mechanical properties of recycled aggregate (recycled brick and sanitary ware aggregate) at 0%, 20%, 50%, and 100% of total natural aggregate volume for compressive strength, abrasion, modulus of elasticity, abrasion resistance, split tensile strength, modulus of elasticity, workability, the effect of super plasticizers fresh density and fresh density.

As per investigation of Willetta et al. [7] he investigates that by incorporating cement scraps (10%, 15% and 20% cement) into the mortar, the properties of concrete were modified in CW, improving its freeze-thaw resistance, consistency retention, bending and compression testing, workability Retention, and shrinkage were tested. Test results of 2, 7, 14, 28, and 56 days.

Jiménez et al[8] . examined with substituting Naturally available FA made of natural sand at 0%, 5%, 10%, 20%, and 40% with ceramic waste in masonry mortar at a ratio of 1:7 volumetric cement-to-aggregate.

The aim of this study was to find out if you could use recycled HDPE with the same degree of tensile strength as pure HDPE. To use pure and recycled HDPE in different plastics, the analysis of both materials' tensile strength was performed. In pHDPE and r-HDPE respectively, the maximum tensile energy changed into 26,843 MPa and 15,889 Mpa. Improved with advanced melting temperature, strain of injection and time of maintaining to reach the most efficient tensile energy price (16,058 MPa). The end result suggests that the decrease in r-HPDE tensile power value (sixteen,058 MPa). The result suggests that the decrease in r-HPDE ensile strength drops from 40.73% to forty three.478% (2017) [17].

Some of them have conducted research on the mechanical and thermal expansion performance of high density polyethylene composites reinforced with hybrid inorganic fillers. Their experimental study on HDPE fibre and glass fibre is concluded in this report. The tensile modulus and strength of various composite constructions served as the foundation for this study. It was discovered that putting a pure polypropylene (PP) or high-density polyethylene (HDPE) shell over a core of comparatively to non-coextruded materials, wood polymer composites (WPC) reduced humidity [3].

In addition to obtaining sawdust from a nearby sawmill, the post-consumer HDPE was gathered at a plastic recycling facility. The tensile and flexural properties of composites made from recycled HDPE are comparable to those of composites made from virgin HDPE. A study of the microstructure of MAPP-modified composites with broken surfaces and improved interfacial bonding is presented in [19].

In this publication, laboratory research on the alkali tolerance and fibre quality of recycled polypropylene (PP) fibres in concrete 25 MPa and 40 MPa, used for walkways and prefabricated boards, respectively, is presented. After cracking in concrete, the recycled PP fibre demonstrated remarkable performance, leading to significant ductility. Recycled PP fibre supplied reinforcement comparable to or slightly lower than that of virgin PP fibre since it has been discovered that the tensile strength of recycled PP fibre is lower but higher than that of virgin PP fibre. The recycled PP fibre produced superior reinforcement than the fresh PP fibre in the 25 MPa concrete because the Young's fibre module was stronger than their reinforcement's tensile strength [20].

Sr. No	Type of concrete	Form of ceramic	Replacement	Properties evaluated	Outcome
1	High-performance concrete	Waste ceramic powder	Cement (0, 10, 20, 30 and 40% 10 interval)	Slump and slump loss, setting time, XRD compressive strength, Frattini test, Permeable pores, Chloride ion permeability, electrical resistivity	**The addition of ceramic waste powder reduced the compressive strength of High-performance concrete (HPC). However, durability was enhanced.**
2	Concrete	Waste ceramic electrical insulator	Coarse aggregate (100% replacement)	Slump, Compressive strength, STS, Flexural strength and Modulus of elasticity	**The compressive strength, flexural strength, and STS of ceramic electrical insulator waste coarse aggregate (CEIWCA) concrete are lower by 3.8, 6, and 18.2% respectively to RC. However, the workability was higher.**
3	Concrete	Sanitary ceramic waste	Coarse aggregate (15,20,25%,5% interval)	Slump, consistency, bulk density, XRD, SEM, ITZ, compressive strength, and STS	**Compressive strength and STS was improved with sanitary ceramic waste aggregate, and ITZ between paste and sanitary ceramic waste aggregate was high compact, less porous and narrower better than RC**
4	Concrete	Ceramic wall tile and floor tile	Coarse & fine aggregate (100% replacement)	Slump, density, Air content, Compressive strength, Bending strength, STS, Bohme Abrasion value, Ultra pulse velocity (UPV), Thermal Conductivity, Shrinkage, Open porosity, Total porosity, and Water absorption	**The floor tile aggregate concrete found identical mechanical properties of the limestone concrete, and wall tile aggregate concrete mechanically properties compare to lower than limestone concrete(LSC)**
5	Concrete	Ceramic sanitary ware	Fine and coarse aggregate (100%)	Workability, consistence, Compressive, STS, Abrasion resistance, Resistance to high temperature,	**After heating in 1000 C, concrete with WC sanitary ware aggregate and alumina cement preserved its form and high strength**
6	Concrete	Ground ceramic powder	Cement (0, 10, 15, 20, 25, 30 and 40%)	Compressive strength, Water absorption	**The study settled that the slightly reduced compressive strength and water absorption capacity of concrete with ground ceramic powder compare to the**
7	Concrete	Waste ceramic + fly ash	Fine Aggregate with ceramic waste aggregate (0, 10, 20,30, 40, 50, 100% replacement) and fly ash with cement (0, 30%)	Compressive strength, XRD, SEM, EDS, Density, Workability	**The highest compressive strength of the concrete was obtained with a 50 % WC fine aggregate.**
8	Concrete	Ceramic waste wall and floor tile	Fine and coarse aggregate (0, 25, 50, 75, 100% interval 25%)	Slump, Compressive strength, and STS	**Concrete containing 100% fine and coarse ceramic aggregate better performed than that of RC.**
9	Concrete	Bone china ceramic	Fine aggregate (0–100%, 20% interval).	Voids percentage, Abrasion resistance, Freezing–thawing resistance, Drying and wetting resistance, Resistance to corrosion and chloride penetration	**The resistance to (chloride penetration and freeze and thaw) of the bone china ceramic fine aggregate (BCCFA) concrete was better to compare to the SCC.**
10	Concrete	Waste ceramic electrical insulator	Coarse aggregate (100% replacement)	Water absorption, Sorptivity, Volume of voids, Chloride diffusion,	**The study concluded that CEIWCA can be recycled for the manufacture of concrete.**
11	Concrete	Waste ceramic tile	Coarse aggregate (20%, 25%, 35%,	Slump value, Compressive strength, Flexural strength, STS and Modulus of elasticity	**Used WC as a feasible CA substitution material with a**

			50%, 65%, 75%, 80% and 100%)		**small change in mechanical properties.**
12	Concrete	Porcelain tile and Red ceramic	Coarse Aggregate (0, 25, 50,75, 100%, 25 interval)	Water absorption, Compressive strength, Flexural strength, Tensile strength	**Mechanical strength and water absorption of 100% (Porcelain tile and Red ceramic) containing concrete was more as compared to RC.**
13	Concrete	Waste ceramic aggregate	Coarse Aggregate(0, 10, 20 and 30%, 10% interval)	Compressive strength, workability, bulk density, water absorption Environmental impact	**The inclusion of WC aggregate in concrete mixes improved compressive strength. However, workability was reduced**

MATERIALS & METHODS

PROPERTIES OF CONCRETE ADDED WITH CERAMIC WASTE

Following are the results of test performed on concrete added with recycled ceramic waste aggregates.

Workability

Concrete that can be handled without segregating, put without losing homogeneity, and compacted with a specific amount of force is said to be workable. According to Wioletta et al. [7], the reference mortar had the highest liquid consistency, and the consistency and plasticity of the mortar decreased when the amount of ceramic filler was increased.

The results of the consistency and plasticity tests indicate that the time of workability retention increased along with the amount of ceramic filler in mortar.

This is a result of the hygienic ceramic filler's greater water absorption. To reach the desired consistency, even a small amount of replacement of CA with 4 mm retained and 12.5 mm passing aggregates made from Ceramic waste required more water to add. For all w/c (0.5, 0.55, and 0.60) ratios, Katzer [9] finds the linear relation, which is distinguished by very high correlation.

According to Mandavi et al. [15], slump value declines as replacement percentage rises. At 10% replacement, the value of the slump is 75, and at 50% replacement, it drops to 31.

Hunchate et al. [11] investigated that Slump value reduced when recycled coarse ceramic aggregate was used in place of coarse natural aggregate at constant weight-to-cement ratios for all mixes, but it remained the same at 20%, 40%, 60%, and 80%, or 110 mm and 100 mm, respectively. According to Tavakoli et al. [13], the slump value reduces as the ceramic sand replacement percentage rises up to 50%, after which it starts to rise. According to Anderson et al. [14], slump value climbed up to 35% replacement before starting to decline and finally reaching a higher slump value at 100% replacement.

Density

According to Katzer [9], the density of ceramic is 1.8 g/cm3, which is significantly lower than the density of cement (3.18 g/cm3). As a result, the density of mortar is significantly reduced when ceramic fume replaces cement. According to Hunchate et al. [11], The density of fresh concrete decreases at 0% or 100% ceramic coarse aggregate replacement as the ceramic coarse aggregate replacement increases from 2436 kg/m3 to 2328 kg/m3. Also Investigation have been done by Tabacoli et al. [13], According to that ready-mixed concrete decreases in density with increasing ceramic sand substitution, from 2441 kg/m3 to 2385 kg/m3 at 0% and 100%, respectively.

As per investigation of Katzer [9], ceramic has a density of 1.8 g/cm3, which is much less than cement's density of 3.18 g/cm3. As a result, when ceramic fume substitutes cement, the density of mortar is greatly lowered. Hunchate et al. [11] found that the density of new concrete decreased to 2328 kg/m^3 which was earlier 2436 kg/m^3 and its done by replacing ceramic coarse aggregate from 0% and 100% respectively, as ceramic coarse aggregate substitution increased. Fresh concrete loses density when ceramic sand replacement rises, going from 0% to 100% we get density of 2441 kg/m3 to 2385, respectively, according to Tavakoli et al. [13].

Compressive strength

According to Wioletta et al. [7], the addition of ceramic waste aggregate caused a 2 day increase in compressive strength of up to 42%. Over the course of 56 days, there was an increase of 11%. According to Jiménez et al. [8], the mechanical properties of the masonry mortar were somewhat enhanced when up to 40% of the material was replaced with CW by its volume. The average of compressive strength for different five substitution levels at different curing times is roughly the same for each age. For the results exception of 180 days

Flexural Strength

According to Wioletta et al. [7], after the addition of ceramic waste aggregate, flexural strength increased by up to 50% after just two days. However, over the course of 56 days, only a 12% increase was observed. According to Jiménez et al. [8], all mean values of flexural strength during curing durations of 7, 28, 90, and 180 days are approximately the same for the five replacement levels. The highest flexural strength was attained at w/c 0.55 when 10% of the cement was replaced with ceramic fume, according to Katzer [9], and after that, the flexural strength started to decline.

According to Anderson et al. [14], 100% replacement of ceramic tile waste results in a 25% reduction in flexural strength. The diminished cement's ability to stick to surfaces.

Split Tensile Test

According to Medina et al. [10], mixes including ceramic material have narrower, more compact, and less porosity than ordinary concrete, which results in an improvement in split tensile strength with an increase in replacement ratio. Inclusion of ceramic tile waste increased the tensile strength of concrete, with the exception of 100% replacement, which showed a maximum 6.5% degradation in tensile strength, according to Anderson et al[14].

Modulus of elasticity

Incorporating discarded ceramic floor tile aggregate produces an elasticity modulus with a maximum value of 27.4 Gpa in 100% replacement, which is 26.9% higher than the 21.6 Gpa of the reference mortar, according to Anderson et al. [14]. The modulus of elasticity decreases as more ceramic waste is added, according to Alves et al. [6]. With 100% replacement, it is said that reductions of 33.8% take place.

SPECIMENS

M30 concrete was used to cast each specimen. The 150 mm 150 mm 150 mm cube and the 150 mm 300 mm cylinder were cast to develop compressive strength and split tensile strength for 28 days in order to achieve the best resistance of high density polyethylene granules. The 700 mm by 150 mm by 150 mm prism sample pieces are cast. 53-grade Portland cement was utilized as the standard. River sand is utilized as a fine aggregate in compliance with the requirements of IS 383-1970 and passes an IS sieve of 4.75 mm. The river's sand is devoid of dust particles and removes trash and microscopic debris. As coarse material, 10 mm sieve-length crushed angular gravel that is easily accessible locally is employed.

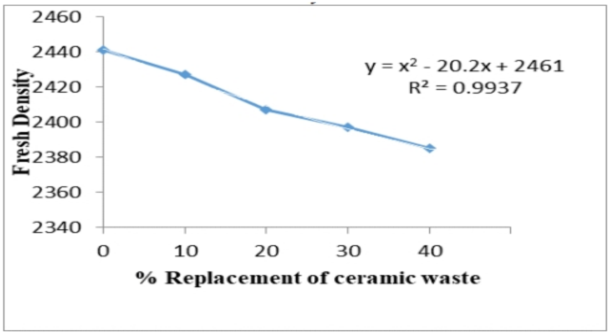
HIGH DENSITY POLYETHYLENE GRANULES (HPDE)

HDPE often replaces bulkier materials. Being strong and light could reduce the environmental impact. The density of HDPE ranges from 930 to 970 kg/m3. An LDPE-like white, semi-opaque, semi-crystalline thermoplastic polymer that is stronger, tougher, and even chemically resistant. Its crystallinity is typically between 70 and 80 percent. The effect tolerance is almost high and at low temperatures, while being significantly bigger than that of LDPE. HDPE granules are shown in Fig. 1.

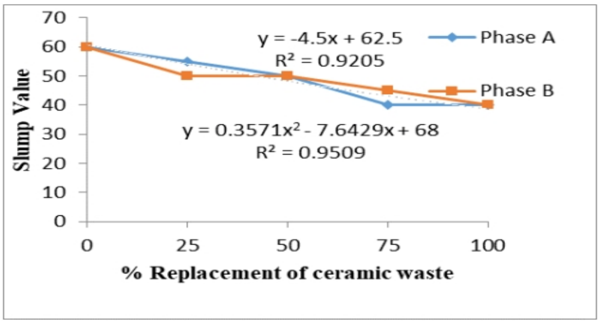
FIGURE 1 HDPE GRANULES

RESULTS AND GRAPHS

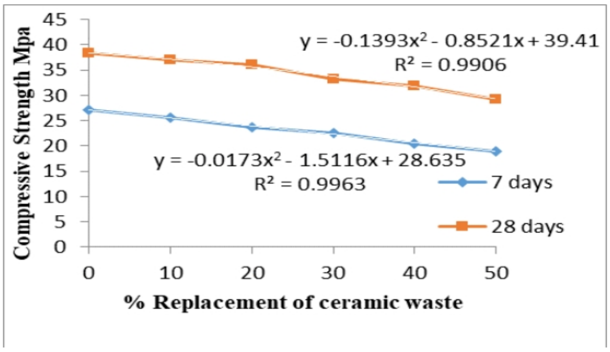
In this section Results in the form of Tables and graphs are represented. Starting from Density of Fresh Concrete which followed by Workability, Compressive strength, Split Tensile Test and Flexural test are given by various authors. They have performed test by replacing different concrete content by ceramic waste. Also tabulated results are also given for HDPE material which replace the CA.



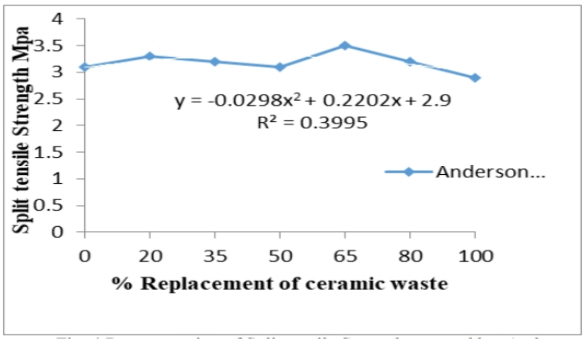
GRAPH 1. DEPICTION OF FRESH CONCRETE AS PER TAVAKOLI ET AL. [13]



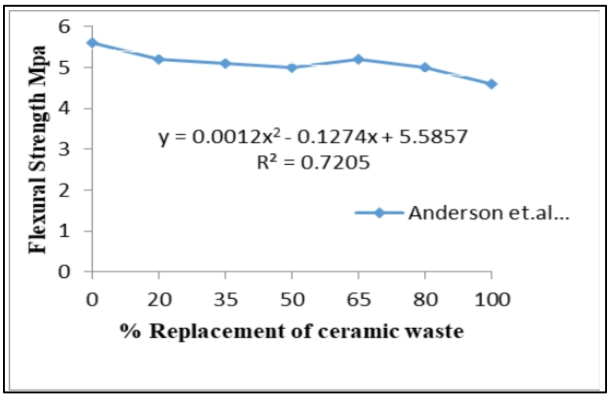
GRAPH 2. DEICTION OF SLUMP TEST AS PER BY TAVAKOLI ET AL. [13]



GRAPH 3. DEPICTION OF TEST RESULT FOR COMPRESSION TEST AS PER RAVAL ET AL. [12]



GRAPH 4. DEPICTION OF TEST RESULTS OF SPLIT TENSILE TEST AS PER ANDERSON ET.AL [14]



Specimens	Load (KN)	Compressive strength	Difference in %	%With C_1
C_1	520	23.1	-	-
C_2	550	24.4	5.62% increase	5.6% increase
C_3	570	25.3	3.68% increase	10.3% increase
C_4	600	26.78	5.84% increase	15.93% increase
C_5	470	21.1	21.2% decrease	8.65% decrease
C_6	450	19.97	5.35% decrease	13.64% decrease

TABLE 1. COMPRESSIVE STRENGTH FOR 7 DAYS.

Specimens	Load (KN)	Compressive strength	Difference in %	%With C_1
C_1	700	31	-	-
C_2	720	31.99	3.19% increase	3.19% increase
C_3	760	33.8	5.65% increase	9.03% increase
C_4	870	38.1	12.72% increase	22.9% increase
C_5	620	27.2	28.6% decrease	12.25%decrease
C_6	610	26.7	1.84% decrease	13.8% decrease

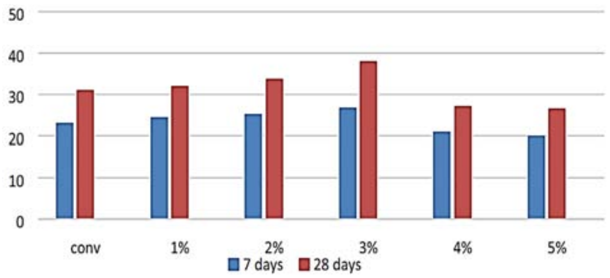
TABLE 2 COMPRESSIVE STRENGTH FOR 28 DAYS

specimens	Load (KN)	Compressive strength	Difference in %	% with C_1
C_1	210	2.92	-	-
C_2	230	3.06	4.79% increase	4.79% increase
C_3	220	3.15	2.94% increase	7.87% increase
C_4	250	3.48	10.47% increase	19.17% increase
C_5	170	2.44	2.9% decrease	16.4% decrease
C_6	140	2.07	15.16% decrease	29.1% decrease

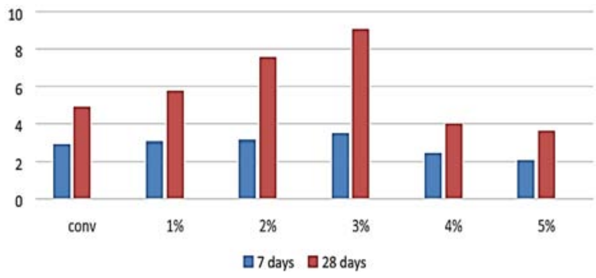
TABLE 3 SPLIT TENSILE STRENGTH FOR 7 DAYS.

Specimens	Load (KN)	Compressive strength	Difference in %	with C_1
C_1	350	4.9	-	-
C_2	410	5.75	17.34% increase	17.34% increase
C_5	280	4.00	55.8% decrease	18.3% decrease
C_6	260	3.62	9.5% decrease	26.1% decrease

TABLE 4 SPLIT TENSILE STRENGTH FOR 28 DAYS



GRAPH 6. COMPARISON OF COMPRESSIVE STRENGTH FOR 7 DAYS AND 28 DAYS



GRAPH 7. COMPARISON OF SPLIT TENSILE STRENGTH FOR 7 DAYS AND 28 DAYS

CONCLUSION

The outcome of this experiment shows that it is definitely possible to partially replace traditional aggregate and binder material with recycled ceramic aggregate and ceramic fume. With regard to replacement ratio, only small positive and negative reactions were found in the characteristics of recycled ceramic concrete, which is sufficient for practical use. Fresh concrete loses part of its workability as the replacement ratio increases. As the replacement ratio rises, the compressive strength, split tensile strength, and flexural strength all decline. In conclusion, it can be seen that ceramic aggregate absorbs water readily due to its high porosity, which also makes it less workable and necessitates presoaking.

The characteristics of concrete are not appreciably changed when recycled ceramic fine aggregate replaces natural sand to the extent of 40% by volume. Concrete's characteristics are not considerably changed when 25% of the volume of natural coarse aggregate is replaced with recycled coarse ceramic aggregate. Concrete is unaffected greatly by the replacement of ceramic fume with binder material that contains up to 10% ceramic fine. It is simple to employ ceramic waste as a binder and fine or coarse aggregate in concrete without having an impact on the material's mechanical qualities.

Comparison of typical concrete and concrete granules that have been partially substituted. It was discovered that the strength of concrete grade M30 that had some of the coarse aggregate replaced with high density polyethylene granules was higher than the strength of concrete grade M30 as is.

The values are rising by 4% and 5% when the ideal number is 3%. It is seen as economically advantageous since HDPE GRANULES can partially replace coarse aggregate and improve concrete strength.

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