Effect of Vitrified Polish Waste in Concrete as Partial Replacement to Cement

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Abstract— Structural components are considered to be superscript to other types of constructions because of their ability to resist against to the loads, stresses acting on to them, high flexural strength, durability, low maintenance cost when compared to normal constructions. But now a days due to scarcity of cementitious materials there was a great need of other alternate materials to adhere the situation and mostly in countries like India where construction is in great form. Being construction cost is high, as its primary ingredient is cement researchers are looking forward to replace cement by using various substantial materials. In this study, an attempt is made to replacement of cement with industrial produced materials like Vitrified polish waste (VPW), as optimum replacement for cement from past literature and making it as constant. Mix design is done for varying proportions of (5%,10%,15%, 20%) and specimens were casted and tested for mechanical properties. The maximum strength attained at the mix proportioning of 15%VPW when compared with control mix and design of cement concrete has done confining to IS codal provision.

Keywords: Vitrified polish waste (VPW), Mechanical Properties

I. INTRODUCTION

In developing countries, the solid waste management constitutes a major concern to environmental protection agencies. The present scenario in India the most of the problems were created by rapid growth in population and changing technologies and life styles. Due to the increasing cost of disposal, the process of waste disposal has become more problematic to the society and it is detrimental to health, and generating economic burden. To overcome this problem is to utilize this waste for other purposes, such as an replacement ingredient of cement, aggregates in the concrete production. To enhance a sustainable construction in poor communities, utilized some of the industrial and construction wastes can be supplementary cementitious materials like Fly ash, GGBF, Silica fume e.t.c. In the most advanced countries, yet not all the solid waste materials have been recycled successfully, in addition ceramic waste is one of the waste that is currently non-recyclable, therefore these materials disposed into stock pilled and land filled. The production of ceramic waste in India is 100 million tons per year and 15%-30% waste material generated from the total production in the ceramic industry. However, the ceramic waste is hard, durable, and highly resistance to chemical, physical and biological degradation forces.

Vitrified polish waste (VPW), is a type of ceramic tiles waste, during the manufacturing industries of vitrified tiles, these types of waste is produced. The present scenario the rapid growing for the production of Vitrified tiles due to the abundant constructional needs of the country. It is type of solid waste material, and it will cause various disposal problems in the environment. The production of vitrified polish waste is increased 20% every year and 10-15 tones waste is generated from each manufacturing industry. Which is a serious environmental issue, studies showed that these wastes possess good pozzolanic properties, and to enhance the properties of cement concrete here an attempt is made to use this VPW in construction, thereby leading to good quality construction and reducing environmental disposal problems.

II. LITERATURE REVIEW

Mohit, and Sharifi (2019) studied about the thermal and microstructure properties of cement mortar containing ceramic waste powder as alternative cementitious materials. Tested specimens were casted with ceramic waste powder (CPW) of 5%,10%, 15%, 20%, 25% replacement of cement. Analyzed the results the addition of 5%, 10% and 15% CPW as cement replacement improve compressive and flexural strength up to 400˚C. Also, the mixes CP25 and CP20 give the highest compressive and flexural strength attained at 600 and 800˚C respectively. Observed the X-ray diffraction (XRD patterns of mortar specimens showed that the values of portlandite peaks of the mix CP0 are higher than the mix CP10 up to 400˚C. Also, the mix CP20 shows lower intensity of calcium silicate peaks than the mix CP0 which shows a further decomposition of C- S-H gel of the mix CP0, which made the reduction in strength of the mix CP0.Analyzed the Scanning electron microscopy (SEM),images showed that the microstructure of the mix CP10is denser than the mix CP10 at room temperature. With an increase in the temperature to 800˚C, the microstructure of specimens contained CPW as cement replacement is more compacted than control specimens.

Huseien et al. (2019) suggested the Properties of ceramic tile waste-based alkali-activated mortars incorporating GBFS and Fly ash. Proposed the performance of waste ceramic powder (WCP) as binder on the mechanical and microstructure properties of alkali activated mortars (AAMs) containing ground blast furnace slag (GBFS) and fly ash (FA). Microstructure tests were analyzed as X-ray diffraction (XRD), Scanning electron microscope (SEM) and Fourier transform infrared spectroscopy (FTIR) were conducted to evaluate the effect of high content of WCP on the formulation of sodium aluminum silicate hydrate (N-A-S-H), calcium aluminium silicate hydrate (C-A-S-H) and calcium silicate hydrate (C-S-H) gels. The high volume WCP content dependent compressive strength development of AAMs the compressive strength of AAMs was found to vary inversely with the increasing amount of WCP content from 50 to 70%, where the strength dropped from 70.1 to 34.8 MPa at 28 days.

El-Dieb, and Kanaan (2018) investigated on the characterization and evaluation of ceramic waste powder (CWP) an alternative cement replacement. Evaluated the test results through two phases; in phase 1, the main characteristics and properties of the CWP were measured such as specific surface area, particle size distribution, moisture content in addition to the particles' shape and the main oxides of the material. X-ray diffraction (XRD) and X-ray fluorescence (XRF) were used to determine the morphology and chemical composition of the CWP material. The pozzolanic activity potential of the CWP was evaluated through the strength activity index (SAI) as per the ASTM C311 to determine the strength development of a mortar mixture made with hydraulic cement and CWP. In phase 2 the utilization of CWP to partially replace cement (0%, 10%, 20%, 30% and 40% by mass) in different concrete mixtures and three concrete grades with different cement contents were studied (25, 50 and 75 MPa). Observed the results the maximum compressive strength attained at 10% of CPW replacement.

Tarek Aly et al. (2018) proposed that the effect of high-volume ceramic waste powder as partial replacement on fresh and compressive strength of self-compacting concrete. Evaluated the fresh properties of the self-compacting concrete through various tests of slump flow, J-ring, column segregation, V-funnel, and L-box tests. Observed the results, the slump flow values gradually decreased with increased replacement level of ceramic waste powder (CWP) in the tested mixes. Examined the test results of J-ring, L-box, the mixes exhibited better passing ability and great capacity for flow through congested spaces, when the CWP content increased and analyzed the V-funnel test, the CWP increased the V-funnel time had a distinct tendency to increase. This implies that the inclusion of CWP leads to more-viscous concrete. Analyzed the results of compressive strength test, the maximum value attained at the 20% replacement of CWP compared to the control mix.

Huseien et al. (2018) studied about the performance evaluation of waste ceramic powder incorporated alkali activated motors (AAMs) exposed to elevated temperature. Reported the effect of high-volume waste ceramic powder (WCP) inclusion on the mechanical and microstructure properties of alkali activated mortars (AAMs) exposed to elevated temperatures. Prepared the cube samples (50×50×50)mm were casted with varying proportions of WCP (70%,60%,50%) and replaced with GBFS and FA. Observed the results, increase content of WCP from 50 to 70% has enhanced the resistance of AAMs to elevated temperatures up to 900˚C.Evaluated the optimum resistance at elevated temperatures at tested specimens of 70% WCP, 20% GBFS and 10% FA. X-ray diffraction (XRD), scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FTIR), Thermo gravimetric and differential thermal analyzer (TGA) explained the thermal stability of AAMs containing high level of WCP (70%) when exposed to heat.

Ashish et al. (2018) proposed the feasibility of waste marble powder in concrete as partial substitution of cement and sand amalgam for sustainable growth. The tested samples were prepared with the 5%, 10%, and 15% of marble powder in the replacement of cement. Evaluated for the mechanical strength, ultrasonic velocity (UPV), carbonation and microstructure analysis of the tested samples. Observed the results the increase in compressive strength at the curing age of 7, 28, 56 and 90 days was 7.17%, 8.44%, 8.82% and 10.15% for specimens with 10% marble powder as cement replacement compared to the conventional concrete mix.

Kannan et al. (2017) investigated on the high-performance concrete (HPC) incorporating ceramic waste powder as large partial replacement of Portland cement. Evaluated the results at 28 days of age, the highest compressive strength value achieved was the control mixture (51.5 MPa).As the amount of cement decreases gradually, the 28 day compressive strength decreased by 15%, 17%, 18% and 20% for HPC-10, HPC-20, HPC-30, and HPC-40 respectively. After 90 days of age, the rate of compressive strength development slightly increased for all concrete mixtures incorporating CWP. Ceramic waste clearly has two effects; first, a filler effect enabling it to create a dense packing system that favors high performance concrete. Second, a pozzolanic effect that is more pronounced at later ages compared with early age. However, a sufficient amount of CH shall be available in the hydrated concrete mixture for the pozzolanic activity of CWP to take place. The limited pozzolanic reactivity in the examined HPC mixes can be attributed to the lack of water in the concrete mixture given the relatively low water/cement ratio in the reference concrete mixture.

III. RESULTS

Type of mix proportion	Cement (kg/m^3)	VPW (kg/m^3)	F.A (kg/m^3)	C.A (kg/m^3)	Water content (kg/m^3)	Admixture (kg/m^3)
C.C	388	0	611.11	1293.4	147.456	3.88
5	368.6	19.4	611.11	1293.4	147.456	3.88
10	349.2	38.8	611.11	1293.4	147.456	3.88
15	329.8	58.2	611.11	1293.4	147.456	3.88
20	310.4	77.6	611.11	1293.4	147.456	3.88

Table 1: Mix Calculation

Mix Proportion	Slump (mm)
C.C	40
5	36
10	33
15	30
20	27

Table 2: Slump for VPW mix

Mix	Mean Compressive Strength (MPa)		
	7 Days	14 Days	28 Days
CC	23.98	27.89	37.89
5	24.6	29.12	39.12
10	25.9	29.24	39.24
15	26.87	28.18	43.18
20	30.38	30.26	45.26

Table 3: Compressive strength results

Mix	Flexural Strength (MPa)		
	7 Days	14 Days	28 Days

CC	3.52	3.69	4.41
5	3.56	3.82	4.48
10	3.59	3.94	4.52
15	3.64	3.81	5.13
20	3.89	3.96	4.89

Table 4: Flexural Strength results

Mix	Flexural Strength (MPa)		
	7 Days	14 Days	28 Days
CC	1.78	2.09	2.57
5	1.91	2.18	2.63
10	1.95	2.34	2.68
15	2.18	2.96	2.84
20	2.37	2.62	2.76

Table 5: Split Tensile Strength results

IV. Conclusion & Future Scope

A. *Conclusion*

The following major conclusions are achieved from this experimental investigation

- Test Mixes were casted to VPW blended with varying proportions of 5%,10%,15% and 20% in the OPC and the workability of concrete gradually decreased for the mix proportion of C.C. and VPW.
- The results were obtained by the tests of Compressive, Flexural and Split Tensile Strength of specimens at 7, 14 and 28 days and the optimum replacement of VPW found at the mix proportion of 15% VPW to the cement.
- The maximum compressive strength, Flexural strength and Split tensile strength achieved at the mix proportion of 15% VPW to the cement.
- For the replacement of VPW, the compressive strength results were attained at 7, 14 and 28 days with the incremental percentage of 23.54%, 17.72% to the mix proportion when compared to control mix.
- The maximum flexural Strength results were achieved at 7, 14 and 28 days with the incremental percentage of 9.98%, 15.09% to the proportion of 15% VPW.
- In the mix proportion of 15% VPW, the incremental percentage of split tensile strength is 28.43%, 9.98% attained at 7, 14 and 28 days.

B. *Future Scope*

Further investigations can be carried on several industrial waste suitability in concrete making individually or compositely. VPW usage with combination of other industrial wastes in concrete making can be analyzed. They also can be tested with Fly ash a combination to achieve desired properties for the concrete mix. Studies should be encouraged towards innovative materials usage in concrete making which is beneficial in both constructional and environmental aspects.

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