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Research Paper

Study on Mechanical Properties of Concrete by Partial Replacement of Cement with Polyvinyl Chloride Powder from waste materials

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ABSTRACT: *Concrete is the most widely used building material. It is versatile, has desirable engineering properties, can be moulded into any shape, and more importantly, is produced with cost effective materials. The main constituents of concrete are Fine Aggregate (20-30%), Coarse Aggregate (40-70%),Cement (5-15%), Water(5-20%) and they are responsible for the main properties of concrete such as air content, fluidity, strength, setting time, and durability. Though, several materials are used to manufacture good quality concrete. It is important to know the properties of cement, aggregate and water, as they impart strength and durability to concrete. Of all the materials that influence the behaviour of concrete, cement is the most important constituent, because it is used to bind sand (F.A) and it resists atmospheric action. The global production of cement is approximately 1.5 billion tons per year. As they are produced by consumption of raw materials like limestone ($CaCo_3$), sand (SiO_2), stale clay (SiO_2, Al_2O_3, or Fe_2O_3) and iron ore (Fe_2O_3). Thus obtained from naturally occuring limestone, chalk, marble, lime sand shell deposit, lime sludge, clay, shale, tuff ash, stale, glass. So, they need also to be conserved for future generations for their requirements. And we, our present generations are facing a challenging pollution problems. So incorporating the pollutants in the manufacture of cement will drastically reduce the affects of pollutants caused by environment. Plastics in the form of PVC are major used all over the environment , so as to reduce its impact of pollution on environment and to conserve the natural materials used in production of cement we have to find an alternative material for Cement in construction works. Our project aims to attempt the PVC as a replacement for cement. Concrete design mix is designed and adding PVC as a partial replacement for cement in the proportions of 2.5%-10% in the increments of 2.5%. Mechanical strength parameters such as Compressive Strength and Split Tensile Strength of specimens are compared with that of the conventional concrete specimens. Eventually the optimal percentage of PVC replacement will be arrived.*

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I. GENERAL

Concrete is the most widely used building material. It is versatile, has desirable engineering properties, can be moulded into any shape, and more importantly, is produced with cost effective materials. The main constituents of concrete are Fine Aggregate (20-30%), Coarse Aggregate (40-70%),Cement (5-15%), Water(5-20%) and they are responsible for the main properties of concrete such as air content, fluidity, strength, setting time, and durability. Though, several materials are used to manufacture good quality concrete. It is important to

know the properties of cement, aggregate and water, as they impart strength and durability to concrete. The water-cement ratio is the weight of the mixing water divided by the weight of the cement. High-quality concrete is produced by lowering the water-cement ratio as much as possible without sacrificing the workability of fresh concrete, allowing it to be properly placed, consolidated, and cured. A properly designed mixture possesses the desired workability for the fresh concrete and the required durability and strength for the hardened concrete. Typically, a mix is about 10 to 15 percent cement, 60 to 75 percent aggregate and 15 to 20 percent water. Entrained air in many concrete mixes may also take up 5% to 8%.

Almost any natural water that is drinkable and has no pronounced taste or odor may be used as mixing water for concrete. Excessive impurities in mixing water not only may affect setting time and concrete strength, but can also cause efflorescence, staining, corrosion of reinforcement, volume instability, and reduced durability. Concrete mixture specifications usually set limits on chlorides, sulfates, alkalis, and solids in mixing water unless tests can be performed to determine the effect the impurity has on the final concrete. Although most drinking water is suitable for mixing concrete, aggregates are chosen carefully. Aggregates comprise 60 to 75 percent of the total volume of concrete. The type and size of aggregate used depends on the thickness and purpose of the final concrete product.

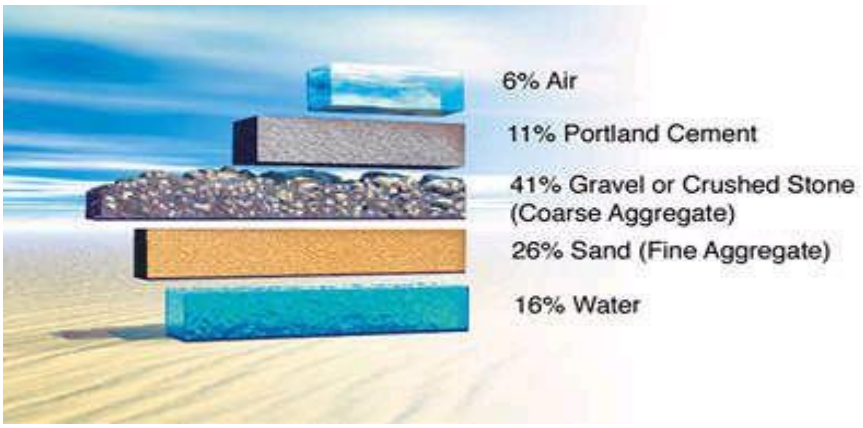


Fig 1: Composition of Concrete

II. LITERATURE REVIEWS

Flexural Behaviour of RC beams containing Polyvinyl Waste Powder [PWP] as replacement of concrete: 150x150x150 cube specimens were casted and cured for 28 days and sun-dried before testing. From the observed results we came to know that density increased with increase in the % of PWP in the mix .Due to pore refinement of the mix that resulted in more closely-packed paste particles. The compressive strength increased up to 20% cement replacement and seems to be decreased after 20% replacement of cement. Deflection characteristics of beam specimens improved progressively as the level of cement replacement with PWP increased. Ultimate Moments of the beam specimen increased with 20% PWP replacement level.

Utilization of pulverized plastic in cement concrete as fine aggregate: 45 nos. of 150mm X 150mm X 150mm cement concrete cubes of 1:1:2 (M25) mix were casted for 0%, 25%, 50%, 75%.100% sand being replaced with pulverized material .Volumetric proportioning was adopted instead of design mix since the density of plastic material was too low (460kg/m^3). Workability test, weight and compressive strength of the cubes were determined. The w/c ratio of concrete is found to increase with increase in replacement of sand by plastic material. It is seen that the weight of the cube decreases with an increase in replacement of sand linearly. There is gradual decrease in strength for replacement up to 25% and then the strength decreases rapidly for 25% to 50%, after 50% the strength variation is somewhat gradual. The ultimate as well as the yield strength of concrete at 7^{th} day decreased by about 3 to 3.2N/mm^2 for 25% replacement & 4 to 6.5 N/mm^2 for higher replacements of Plastic when compared to conventional concrete. The ultimate as well as the yield strength of concrete at 14^{th} day & 28^{th} day decreased by about 0.2 to 1 N/mm^2 for 25% replacement & 9.1to14.6 N/mm^2 for higher replacements of Plastic when compared to conventional concrete.

***Use of plastic waste as aggregate in cement mortar and concrete preparation*:** Irrespective of the type of plastics and amount of substitution, the incorporation of plastic aggregate lowers the various strength properties of resulting concrete and mortar specimens. This is mainly due to the very low binding strength between the surfaces of the plastic particles and the cement paste. Compared to control mixes, up to 72% reductions in compressive strength were observed for concrete prepared by replacing natural aggregate at the replacement level of 20%. However, about 16% reductions in compressive strength of mortar prepared by replacing 50% in volume of sand were also reported. The variations in the various compressive strength values

are due to the differences in the type of plastic wastes used, their size and shape and the differences in the workability behaviour of concrete mix. The reduction in tensile splitting strength and flexural strength were relatively less prominent than the reduction in compressive strength of concrete due to the incorporation of plastic aggregate. Concrete containing modified EPS aggregate exhibited higher frost resistance than conventional concrete. Similarly, fire behaviour of concrete containing PET- aggregate is inferior to that of conventional concrete.

III. MATERIAL PROPERTIES

Portland Pozzolana Cement

Portland Pozzolana Cement is a kind of Blended Cement which is produced by either intergrinding of OPC clinker along with gypsum and pozzolanic materials in certain proportions or grinding the OPC clinker, gypsum and Pozzolanic materials separately and thoroughly blending them in certain proportions.

Pozzolana is a natural or artificial material containing silica in a reactive form. It may be further discussed as siliceous or siliceous and aluminous material which in itself possesses little, or no cementitious properties but will in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperature to form compounds possessing cement properties. It is essential that Pozzolana be in a finely divided state as it is only then that silica can combine with calcium hydroxide (liberated by the hydrating Portland Cement) in the presence of water to form stable calcium silicates which have cement properties. The pozzolanic materials commonly used are :

- Volcanic Ash
- Calcined Clay
- Fly Ash &
- Silica Fume.

PPC is ideally suited for the following constructions:

- Hydraulic Structures
- Mass Concreting Works
- Marine Structures
- Masonry mortars and Plastering
- Under aggressive conditions
- All other applications where OPC is used

The compressive strength of PPC as per BIS code at present is equivalent to that of 33 grade OPC.

Coarse aggregate

Coarse aggregate passing through 25mm IS sieve & retained on 20mm IS sieves were used and the specific gravity of the coarse aggregate was found.

Fine aggregate

Fine aggregate passing through 2.36 mm IS Sieve was used and its specific gravity was found.

Water

Portable water available in laboratory with pH value of not less than 6 and conforming to the requirements of IS: 456-2000 was used for mixing concrete and curing the specimen as well.

Poly Vinyl Chloride [PVC]

Chemical stability is a common feature among substances containing halogens such as chlorine and fluorine. This applies to PVC resins, which furthermore possess fire retarding properties, durability, and oil/chemical resistance. PVC has polar groups (chlorine), and is amorphous, therefore mixes well with various other substances. The required physical properties of end products (e.g., flexibility, elasticity, and impact resistance, anti-fouling, prevention of microbial growth, anti-mist, fire retarding) can be freely designed through formulation with plasticisers and various additives, modifiers, and coloring agents. PVC is the only general purpose plastic that allows free, wide and seamless adjustment of the required physical properties of products such as flexibility, elasticity, and impact resistance, by adding plasticisers, additives, and modifiers. Since the physical properties of end products are adjustable through compounding with additives, only a few types of resin are required to cover all applications (fiber, rigid and flexible plastic, rubber, paint, and adhesive). This controllability is also extremely beneficial for recycling. Poly vinyl chloride was used as partial replacement of cement in casting the specimens. 2.5%,5%,7.5%10% of cement was replace by poly vinyl chloride in order to study the mechanical strength parameters. The specific gravity and, the fineness of PVC resin were tested.

Fig 2: Characteristics of PVC

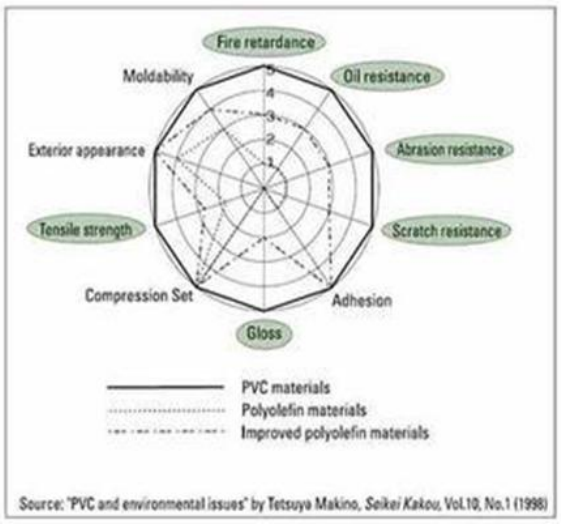
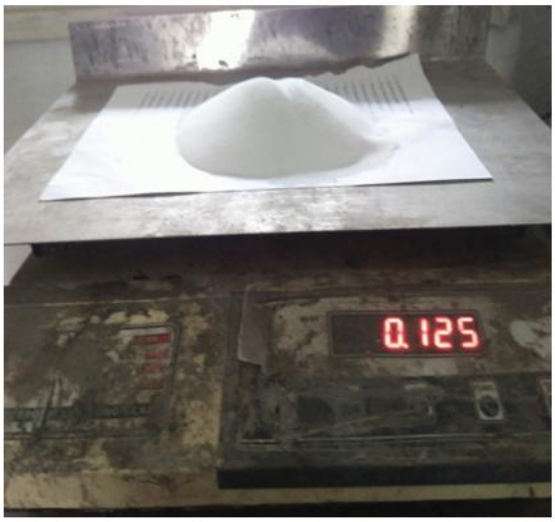


Fig 3: PVC Powder



TEST RESULTS OF MATERIAL PROPERTIES

CEMENT

S.NO	TESTS	RESULTS
1	Fineness	5%
2	Specific Gravity	3.16
3	Consistency	37%
4	Initial Setting Time	32min

Table 1: Properties of Cement

COARSE AGGREGATE

S.NO	TESTS	RESULTS
1	Specific Gravity	3.18
2	Aggregate Impact Value	20%

Table 2: Properties of Coarse Aggregate

FINE AGGREGATE

S.NO	TESTS	RESULTS
1	Specific Gravity	2.6

Table 3: Properties of Fine Aggregate

POLY VINYL CHLORIDE

S.NO	TESTS	RESULTS
1	Specific Gravity	1.25
2	Fineness	5%

Table 4: Properties of Polyvinyl Chloride

IV. RESULTS AND DISCUSSION

COMPRESSIVE STRENGTH TEST RESULT

Compressive strength test is calculated by the ratio of load to the area of the cube, where its unit is N/mm^2.

S.NO	TYPE OF REPLACEMENT	SIZE OF CUBE (mm^3)	7^{th} DAY RESULT IN N/mm^2	14^{th} DAY RESULT IN N/mm^2	28^{th} DAY RESULT IN N/mm^2
1	0%[Conventional]	150X150X150	20.46	22.18	24.01
2	2.5%	150X150X150	24.63	25.48	30.82
3	5%	150X150X150	20.72	23.93	26.67

4	7.5%	150X150X150	19.53	21.45	22.91
5	10%	150X150X150	18.24	19.00	21.85

SPLIT TENSILE TEST RESULT

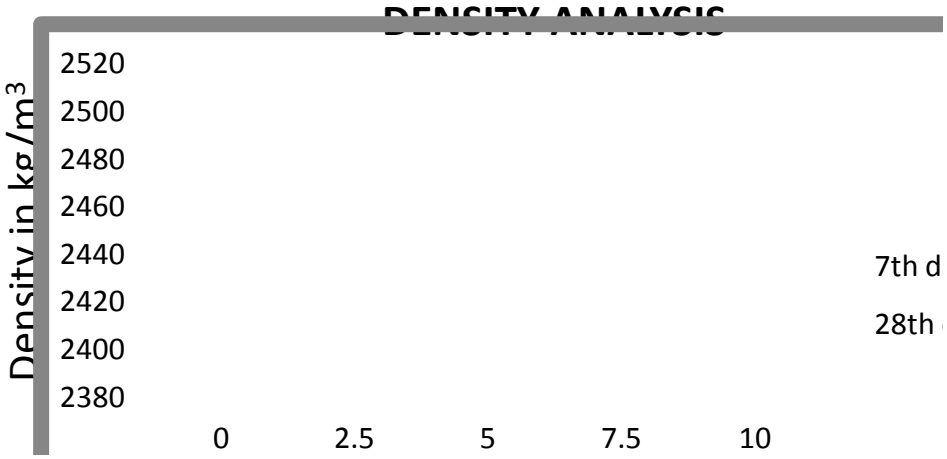
Tensile strength of the cylindrical specimen was calculated by the following formula,

Magnitude of the tensile stress = $2P/\pi dl$ [N/mm^2]

S.NO	TYPE OF REPLACEMENT	SIZE OF CUBE (mm^2)	7^{th} DAY RESULT IN N/mm^2	28^{th} DAY RESULT IN N/mm^2
1	0%[Conventional]	150X300	0.865	2.29
2	2.5%	150X300	1.627	2.49
3	5%	150X300	1.532	2.22
4	7.5%	150X300	1.346	1.983
5	10%	150X300	1.24	1.665

DENSITY COMPARISION

S.NO	TYPE OF REPLACEMENT	SIZE OF CUBE (mm^3)	7^{th} DAY DENSITY IN kg/m^3	28^{th} DAY DENSITY IN kg/m^3
1	0%[Conventional]	150X150X150	2499.3	2508.8
2	2.5%	150X150X150	2462.6	2478.1
3	5%	150X150X150	2465.3	2481.9
4	7.5%	150X150X150	2425.3	2467.3
5	10%	150X150X150	2428.6	2492.1



V. CONCLUSION

1. From the experimental analysis, it is clearly noticed that compressive strength increases little greater than the conventional mix up to 2.5% of replacement level with gradual decrease in the water absorption percentage.
2. The compressive strength of the concrete plays significant role in relationship with the density of the concrete whose degree of compactness is responsible for the movement of ultra sonic waves with a grater velocity.
3. Therefore, it is suggested that the PVC powder can be used as admixture in the concrete, which is to be used for the construction of temporary structures like storage sheds in a site.

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