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RESEARCH ARTICLE OPEN ACCESS

Experimental Investigation on Strength Properties of Concrete by Partial Replacement of PVC Powder with Cement and Flyash

S.Priyadarshika[1]; M.Rajkannan[2]

[1] PG student(Structural Engineering), Civil Department, Paavai Engineering College, Pachal.

[2]Assistant Professor, Civil Department, Paavai Engineering College, Pachal.

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Abstract:

The present paper is an effort to investigate the strength properties of Polyvinyl Chloride dust (PVC) at the various replacement levels. Large scale production of cement is causing environmental problems. This has made the researchers to use supplementary cementations material in making concrete. Polyvinyl Chloride dust is a waste material produced in pipe industry. PVC dust is used as filler material to way towards the waste utilization. M40 grade of concrete is used in the study and mix design was carried out according to guidelines10262 (2009). A constant 20% of Fly-Ash was used as on cement replacement for all the mix. Effect of PVC was studied added 0 to 30% as additive. Mechanical Strengths such as compressive, Split Tensile strength and Flexural strength are investigated. The results show that the compressive strength of concrete is increased for PVC dust whereas split tensile strength of concrete is decreased when the PVC is added.

KeyWords: Cement, Flyash, PVC powder, Super plasticizer.

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INTRODUCTION

Concrete is a mixture of paste and aggregates, or rocks. The paste, composed of Portland cement and water, coats the surface of the fine (small) and coarse (larger) aggregates. Through a chemical reaction called hydration, the paste hardens and gains strength to form the rock-like mass known as concrete. The key to achieving a strong, durable concrete rests in the careful proportioning and mixing of the ingredients. A mixture that does not have enough paste to fill all the voids between the aggregates will be difficult to place and will produce rough surfaces and porous concrete. A mixture with an excess of cement paste will be easy to place and will produce a smooth surface; however, the resulting concrete is not cost-effective and can more easily crack. Portland cement's chemistry comes to life in the presence of water. Cement and water form a paste that coats each particle of stone and sand - the aggregates. Through a chemical reaction called hydration, the cement paste hardens and gains the strength. The quality of the paste determines the character of the concrete. The strength of the paste, in turn, depends on the ratio of water to cement. 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%.

Water is the most important and least expensive ingredient of concrete. It distributes the cement evenly. It lubricates the mix. The quantity of water is the most important parameter and is controlled by the w/c ratio. As the quantity of water in a mix goes up, the following effects are notices: the strength decreases, durability decreases, workability increases, cohesion decreases and the economy may increase at the expense of quality and reliability. Portable water is used in the study for both mixing and curing.

LITERATURE REVIEW

[1] K.N.JANARDHANAN, E.MOHANA PRIYA(2015) Currently India has taken a major initiative on developing the infrastructures such as express highways, power projects and industrial structures etc., to meet the requirements of globalization, in the construction of buildings and other structures. Concrete plays the key role and a large quantum of concrete is being utilized in every construction practices. River sand, which is one of the constituents used in the production of conventional concrete, has become very expensive and also becoming scarce due to depletion of river bed. In the present study, the hardened and durable properties of concrete using fly ash and PVC powder were investigated. Also, the use of fly ash and PVC powder as the fine aggregate decreases the cost of concrete production in terms of the partial replacement for cement. This paper reports the experimental study which investigated the influence of partial replacement of cement with fly ash and PVC powder. Initially cement mortar cube was studied with various percentages of replacement of fly ash and PVC powder (5, 10, 15 upto 50%). The experimental results showed that the addition of fly ash and PVC powder for a fine to coarse aggregate ratio of 0.6 was found to enhance the compressive properties as well as elastic modulus.

[2] B SESHAIAH 1*, K LALITHA 2*(2017)presents paper is an effort to investigate the strength properties of Polyvinyl Chloride dust (PVC) at the various replacement levels. Large scale production of cement is causing environmental problems. This has made the researchers to use supplementary cementations material in making concrete. Polyvinyl Chloride dust is a waste material produced in pipe industry. PVC dust is used as filler material to way towards the waste utilization. M40 grade of concrete is used in the study and mix design was carried out according to guidelines10262 (2009). A constant 20% of Fly-Ash was used as on cement replacement for all the mix. Effect of PVC was studied added 0 to 50% as additive. Mechanical Strengths such as compressive, Split Tensile strength and Flexural strength are investigated. The results show that the compressive strength of concrete is increased for PVC dust whereas split tensile strength of concrete is decreased when the PVC is added.

[3] Gopal Swarup Sangal(2018)(Student, Swami Vivekanand Subharti University, Meerut, Uttar Pradesh) this era of Global Warming, the increase in plastic waste has become a major concern in our society. The influence of plastic waste can be minimized by using them in the concrete. The plastic can lead to the increment in the strength of the mix. The objective of this research is to investigate the effectiveness of using waste plastic(pvc powder) as the cement replacement in concrete mixtures. The compressive and tensile strengths of various concrete specimens were tested to determine how the replacement of cement by plastic waste(pvc powder) would affect the development of strength in the mixes. For different plastics, the different methodology was taken into the consideration. For plastic bottle mix concrete, the size of the bottle had an impact on strength. Both the strength, i.e., compressive and tensile increased due to it. By using the plastic bag and seat, the compressive strength decreases while tensile strength increases while by using PVC in concrete, both the strength increases. The 10% replacement level only showed a 15% loss of compressive strength at 28 days compared to the control. Despite being much weaker in compression, the tensile strength test showed that 10%, 20%, and 30% replacements were stronger in tension compared to the control.

[4] KP.Ravikumar,A.Ranjini Selvameenal, A.Ayappan, R. Kumar(2017)
this Project evolves on experimentally investigating the concrete using polyvinyl chloride. Polyvinyl chloride, commonly known as "PVC" or "vinyl," is one of the most common synthetic materials. PVC is a versatile resin and appears in thousands of different formulations and configurations. With the growing needs for resource materials and the environmental protection requirements associated with sustainable development, it has become necessary to study all the possibilities of reusing and recycling industrial wastes and by-products. In the research presented by us, non-biodegradable polyvinyl chloride (PVC) waste, obtained from scrapped PVC pipes, is used in partial replacement of conventional aggregates in concrete. The project proceeds with testing and comparing analyzing the strength of the concrete with normal concrete. We will enhance our project through several tests and methods. The partial replacement to coarse aggregate at levels 15, 20, 25upto 50

percent and the basic material properties, strength parameters are studied. The strength will be tested during the period of 7, 14 and 28 days respectively.

[5] Ansar Khan*, C.S. Malvi(2010)Polyvinyl chloride (PVC) products are 100% recyclable physically, chemically and energetically. This can be used to make various products like steam houses, kid's houses, shoes stands, laptop stands, kid's scooters, bookshelves etc. There are many benefits of PVCsuch as, high impact resistance, good temperature capability, light weight etc. PVC's versatility, cost effectiveness and an excellent record of use, makes it capable enough that it can replace traditional building materials such as wood, metal, concrete and clay in many applications. In current scenario of cut-throat competition where new products are coming inthe market every day, PVC comes as a 'wonder material' which can be used in any way we want to make enormous products by several methods, and PVC furniture is one of the most popular products among them.

MATERIALS AND PRELIMINARY TESTS

CEMENT

Ordinary Portland cement (OPC) confirming to IS 12269 (53 Grade) was used for the experimental work. Laboratory tests were conducted on cement to determine specific gravity, fineness, standard consistency, initial setting time, final setting time and compressive strength.

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.

FINE AGGREGATE

Manufactured sand was used as fine aggregate. Laboratory tests were conducted on fine aggregate to determine the different physical properties as per IS 2386 (Part III)-1963. Fineness modulus is the index of coarseness or fineness of material. It is an empirical factor obtained by adding cumulative percentage of aggregate retained on each of the standard sieves and dividing this by 100. Fine aggregate passing through 2.36 mm IS Sieve was used and its specific gravity was found. The fine aggregates serve the purpose of filling all the open spaces inbetween the coarse particles. Thus it reduces the porosity of the final mass and considerably increases its strength. M- sand is used as a fine aggregate, confirmed to grading zone II of IS 383-1970.

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.

SUPER PLASTICIZER

The super plasticizer used was Ceraplast-300. Ceraplast-300 is high performance new generation super plasticizer cum retarding admixture which lowers the surface tension of water and makes cement particles hydrophilic, resulting in excellent dispersion as well as controls the setting of concrete, depending on dosage. This increases the workability of concrete drastically and also facilitates excellent retention of workability. The workability offered at a lower water-cement ratio eliminates chances of bleeding and increased workability retention allows increased travel time. Reduced water-cement ratio reduces capillary porosity and improves water tightness. Improve workability facilities easy placing and good compaction. This results in production of dense, impermeable concrete. Advantages of super plasticizer Ceraplast-300 are:

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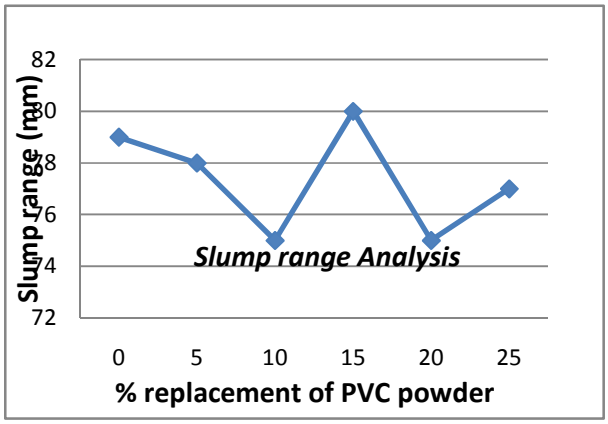
FLY ASH

Fly ash is a by-product of the combustion of pulverised coal in thermal power plants. Figure *2-2* shows the process of producing fly ash in a power station. Coal is fed to a series of mills within a power station that pulverise the coal to a very fine powder. This pulverised coal is fed into a boiler to combust the coal to generate heat, which is then used to produce steam required for power generation. During the coal combustion process, minerals in the coal fuse to form glassy alumina-silicate spheres. These spheres remain in suspension within the flue gas from the boiler and are ultimately collected downstream by either electrostatic or mechanical precipitation. When coal is burnt in a modern pulverised fuel furnace, two types of ash are produced. The fine ash, which is recovered from the flue gas, is called fly ash (FA). This material comprises up to 90% of the total ash produced. The remainder consists of similar particles that have fused together into aggregate sized lumps. These fall to the bottom of the furnace and are known as furnace bottom ash (FBA).

PVC POWDER

Last six decades have witnessed the growth of PolyVinyl Chloride (PVC) as a useful manmade polymer because of its several beneficial properties. PVC is very economic and its performance diversity makes it competitive than most other materials. At a time when we are using PVC in the production of water pipes and few other products, we can experimentally use it for several other products ranging from roofing membranes to credit cards. Products made from PVC require minimum maintenance as it is very reliable and durable. Another most important property of PVC is its flame resistance, which makes it even more usable in different kinds of applications. After a long potential first life, PVC's unique physical properties allow it to be easily recycled (over 50,000tonnes of PVC are already recycled in the UK each year throughthe industry sponsored Recovinyl Programme) and this contributes to its favorably small environmental foot print.

PolyVinyl Chloride (PVC) is a versatile thermoplastic material that is used in the production of hundreds of products that consumers encounter in everyday life and many more that are encountered less frequently but are nevertheless very important in construction, electronics, healthcare, and other applications. Its low cost and desired mechanical and physical properties make its use widespread. Both, flexible and rigid products can be made from PVC. Researches have shown that the possibility of substitute material for PVC is very less and even if there are some, they are neither as efficient nor economic.



S.NO	DESCRIPTION	RESULT
1	Specific gravity	3.15
2	Initial setting time	30mins
3	Final setting time	600mins

TEST ON CEMENT

FINE AND AGGREGATE

DESCRIPTION	FINE AGGREGATE
Specific gravity	2.6
Water absorption	nil
Fineness modulus	3.087(zone II)
Bulk density	1450kg/m^3

COARSE AGGREGATE

PROPERTIES	COARSE AGGREGATE
Specific gravity	2.75
Bulk density	2886 Kg/m^3
Impact value	22.87%
Crushing value	6.55%
Fineness modulus	6.4

Los Angeles abrasion	8.24%
Attrition	18.56%
Flakiness index	22.55%
Elongation index	52.5%
Water absorption	0.8%
Angularity number	20.83%

RESULTS AND DISCUSSION

TEST RESULTS OF SLUMP TEST

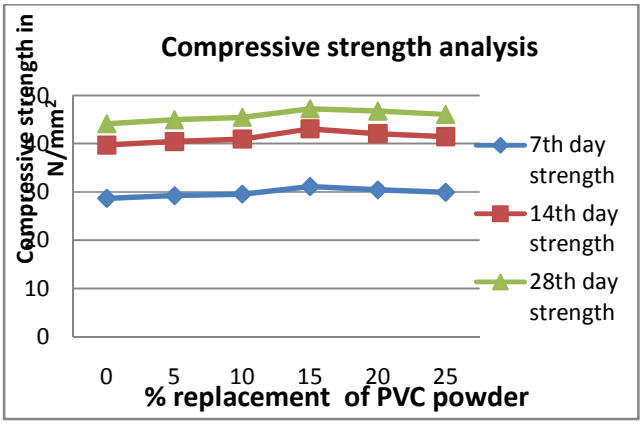
% OF REPLACEMENT OF PVC POWDER	M40 GRADE SLUMP RANGE IN (mm)
0%	79
5%	78
10%	80
15%	75
20%	75
25%	77

Slump range for M40 grade concrete

From the graph shown in Fig all percentage replacement of slag from 0% to 25% meets the minimum slump value of 50mm. For M40 grade of concrete the percentage replacement of PVC powder from 10% to 15% meets the minimum slump value of 75mm and the percentage of replacement of slag from 5% to 10% meets the maximum slump of 80mm respectively.

COMPRESSIVE TEST RESULTS

PERCENTAGE REPLACEMENT OF PVC POWDER	M40 GRADE 7th DAY STRENGTH IN (N/mm^2)	M40 GRADE 14th DAY STRENGTH IN (N/mm^2)	M40 GRADE 28th DAY STRENGTH IN (N/mm^2)
0%	28.67	39.70	44.12
5%	29.22	40.46	44.96
10%	29.55	40.92	45.47
15%	31.10	43.07	47.26
20%	30.40	42.09	46.77
25%	29.93	41.44	46.05



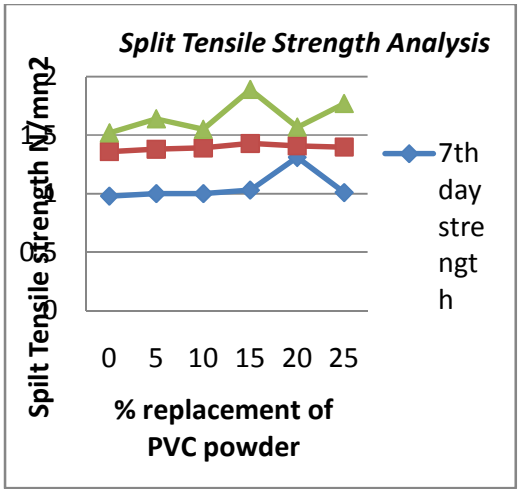
Compressive strength for M40 grade concrete

From figure it is observed that the replacement of PVC powder with cement is not affecting the strength of concrete. For the replacement of about 15% replacement, the strength is improved and it is noted through graph. Beyond that even though the strength increment is reduced, from 0% to 10% replacement of PVC powder, but they satisfy the required strength of grade M40 of concrete.

SPLIT TENSILE TEST RESULTS

PERCENTAGE REPLACEMENT OF PVC POWDER	M40GRADE 7th DAY STRENGTH IN (N/mm^2)	M40 GRADE 14th DAY STRENGTH IN (N/mm^2)	M40 GRADE 28th DAY STRENGTH IN (N/mm^2)
0%	0.98	1.36	1.52
5%	1.00	1.38	1.64
10%	1.00	1.39	1.55
15%	1.03	1.43	1.89

20%	2.41	1.41	1.57
25%	1.01	1.40	1.77



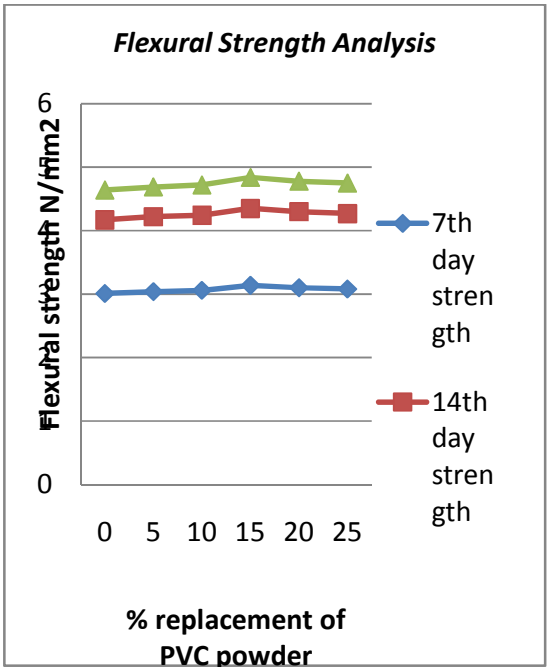
Split tensile strength for M40 grade concrete

Figure shows that split tensile strength increases with increase in replacement of PVC powder. Hence for the 15% replacement of PVC powder the value of split tensile strength is maximum, beyond that it shows decrement pattern in split tensile strength. But all percentages (0% to 25%) meet the Indian standard recommendations.

FLEXURAL STRENGTH TEST RESULTS

PERCENTAGE REPLACEMENT OF PVC POWDER	M40 GRADE MODULUS OF ELASTICITY VALUE (28th day) IN (N/mm^2)
0%	41191
5%	44154
10%	42745
15%	43024
20%	42114
25%	41158

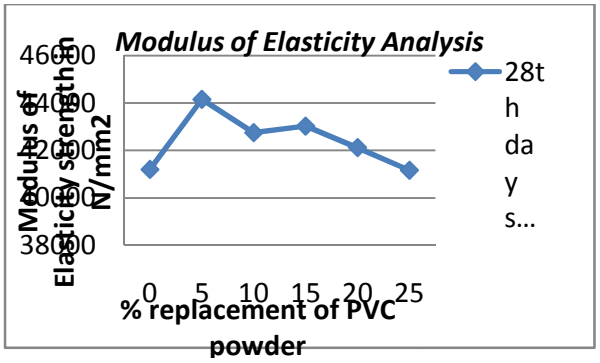
PERCENTAGE REPLACEMENT OF PVC POWDER	M40 GRADE 7th DAY STRENGTH IN (N/mm^2)	M40 GRADE 14th DAY STRENGTH IN (N/mm^2)	M40 GRADE 28th DAY STRENGTH IN (N/mm^2)
0%	3.01	4.17	4.64
5%	3.04	4.22	4.69
10%	3.06	4.24	4.72
15%	3.14	4.35	4.84
20%	3.10	4.30	4.78
25%	3.08	4.27	4.75



Flexural strength for M40 grade concrete

Figure shows flexural strength of concrete increases with increase in replacement of PVC powder for the replacement percentage of about 15%, beyond that it shows decrement pattern from 0% to 10% replacement of PVC powder. But all percentage (0% to 25%) meets 0.7√fck as per 456:2000 recommendations.

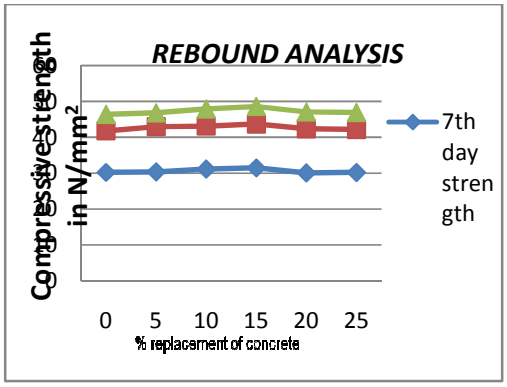
MODULUS OF ELASTICITY TEST RESULTS



From figure shows that, the Modulus of Elasticity of concrete at all replacement from 0% to 25% of PVC powder meets the requirement of IS 456-2000 recommendations. For the M40 grade of concrete specimens, the maximum value occurs at 15% replacement of PVC powder.

REBOUND HAMMER NUMBER TEST

% OF REPLACEMENT	M40 GRADE 7th DAY STRENGTH IN (N/mm2)	M40 GRADE 14th DAY STRENGTH IN (N/mm2)	M40 GRADE 28th DAY STRENGTH IN (N/mm2)
0%	30.18	41.74	46.38
5%	30.32	42.88	46.76
10%	31.10	43.10	47.89
15%	31.44	43.68	48.54
20%	30.03	42.33	47.02
25%	30.16	42.18	46.87



Rebound hammer strength for M40 grade concrete

From figure it is observed that the replacement of cement with PVC powder is not affecting the strength of concrete. In case of rebound hammer test, for the replacement of about 15% replacement, the strength is improved. When compared to the hardened properties of concrete (compressive strength test) the rebound hammer test shows comparatively large value and it is more over exact value**.**

CONCLUSION

The characteristic of PVC powder is almost same with that of cement and flyash.

1. From the experimental analysis, concluded that the replacement of PVC powder, the strength improvements was notably observed at 15% replacement level of PVC powder.
2. The substitution of PVC powder with cement improved the compressive, flexure and split tensile strength at the replacement in between 10% to 20%.
3. Hence, it could be recommended that PVC powder could be effectively utilized as cement in all concrete applications either partial or full replacement of cement.
4. It is concluded that there are lot of scope to utilize PVC powder as partial replacement for cement. In-depth research is needed to investigate on durability properties. The outcome of

this project is going be beneficial to construction industry.

5. 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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