

# EXPERIMENTAL STUDY ON CONCRETE USING POLYESTER FIBER AND CERAMIC WASTE AS PARTIAL REPLACEMENT WITH COARSE AGGREGATE

Jaivin. J. Boda<sup>1\*</sup>, C. G. Solanki<sup>2\*</sup>,

1. M.Tech. Research Scholar, Student, Darshan University, Rajkot, Gujarat, India
2. Assistant professor, Faculty of School of Engineering, Darshan University, Rajkot, Gujarat, India

<sup>1</sup> [21010302001@darshan.ac.in](mailto:21010302001@darshan.ac.in),

<sup>2</sup> [Chetan.solanki.civil@darshan.ac.in](mailto:Chetan.solanki.civil@darshan.ac.in)

**Abstract:** In this present study, to investigate the strength and quality of M-25 grade concrete mix using ceramic tiles waste aggregate as coarse aggregate and replacement of polyester fiber with cement furthermore, to compare the strength and workability of concrete by using ceramic waste aggregate at replacement level of 10% and 20%, and polyester fiber at replacement level of 0.5%, 1.0%, 1.5% and 2.0% by weight of cement.

**Keyword:** concrete, environmental problem, coarse aggregate, ceramic waste, polyester fiber.

## 1. INTRODUCTION

The best building material for all types of structures has historically been cement concrete. The country currently experiences a paucity of construction supplies and an increase in productivity waste during every building project. In all types of construction projects, including tiny houses infrastructure, low and high-rise buildings, and domestic developments, concrete is one of the world's oldest, most durable, most adaptable building materials. Concrete is becoming more and more well-liked as a result of innovation and progress in this industry.

Concrete is primarily a man-made substance made of cement, aggregates, water, and additives. Aggregates or inert granular materials like sand, crushed stone, or gravel, make up the majority of these. Lack of building materials is a problem caused by the unjustified population growth rate. In the past, aggregates have been easily accessible at reasonable rates and with the necessary properties to serve all uses. Depletion of natural resources is a common occurrence in developing countries like India due to rapid urbanization and industrialization involving the construction of infrastructure and other amenities. However, in recent years the wisdom of our continuous, extraction and overuse of aggregates from natural resources has been questioned at an international level.

India is one among the leading countries in manufacturing and export of ceramic tiles. geologically, the western belts of the nation are abundant in ceramic deposits. 90% of ceramics tiles produced in India come from Morbi of Gujarat. Indian ceramic tiles have become the most sought- after and extensively used ceramic tiles in building construction

and massive structure work throughout the world, and it is well known in international market, not only for graceful and aesthetic quality, but also for its durability.

The ceramic tiles industries generated waste about 10% of the total production of tiles. ceramic tiles cut into square and rectangular shape and size. During the process of cutting ceramic waste is released. today industries disposal of ceramic waste is one of the environmental problems around the world, currently ceramic waste is dumped for just landfilled. So, it poses a severe threat on the environment and eco-system.

Polyester fiber is a synthetic fiber that is widely used in the textile industry for various applications. It is made from a polymer called polyethylene terephthalate (PET), which is derived from petroleum.

Polyester fiber is known for their high strength and durability. They have excellent resistance to stretching. Polyester fiber has low moisture absorbency, meaning they do not readily absorb water.

Polyester fibre is frequently utilised in applications for home furnishings. It is used to create curtains, bed sheets, blankets, and pillows in addition to upholstery materials. Polyester is a good choice for these applications because to its strength, resistance to stretching and shrinking, and capacity to withstand fading and stains.

These are just a few examples of the many applications of polyester fiber. Its versatility and performance characteristics make it a widely used material in numerous industries.

## 2. OBJECTIVE OF STUDY

- To examine the strength and density of a typical concrete mix that includes cement with polyester fiber, natural fine aggregate, ceramic waste aggregate as coarse aggregate.
- To investigate the various percentages of ceramic waste aggregate and polyester fiber with a mix proportion.
- To compare the compressive and split tensile strength of concrete which made by ceramic waste aggregate and polyester fiber with normal concrete.

## 3. RAW MATERIALS AND IT'S PROPERTIES

In this investigation PPC-Cement is used to work according to IS: 1489 part-1.

Fine aggregate is used to work according to IS: 383-2016 specification for coarse and fine aggregate from natural sources for concrete which fraction is from 4.75 mm to 150  $\mu$ .

Coarse aggregate is used to work according to IS: 383-2016 specification for coarse and fine aggregate from natural source of concrete which fraction is from 20 mm to 4.75 mm.

The ceramic waste use as coarse aggregate and partial replacement with natural coarse aggregate.

Polyester fiber with a cut length of 12 mm has been used in this investigation.



- Physical properties of materials

*Table -1 Physical properties of materials*

Sr No.	Properties of materials	Fine aggregate	Coarse aggregate	Ceramic waste	Polyester fiber
1	Specific gravity	2.64	2.86	2.26	1.34
2	Water absorption	1.50%	0.34%	3.77%	-

## 4. MIX PROPORTION

The mix design was calculated for M25 grade of concrete according to IS: 10262-2019.

The main aim objective of this research is to replace the ceramic waste as coarse aggregate and polyester fiber with cement. This experiment has carried out to find understanding of factor that can increase concrete strength and properties to determine the value of ceramic waste and polyester fiber in the concrete. The concrete cubes were cast for compressive test and cylinder were cast for find to split tensile strength.

Ceramic waste replaced with 20mm natural coarse aggregate and polyester fiber with cement at different percentages as follows (0%, 10% and 20%) and (0.5%, 1.0%, 1.5% and 2.0%) respectively.

*Table2 mix proportion*

MIX PROPORTION FOR M25 GRADE OF CONCRETE FOR 1m <sup>3</sup>	
Materials	Quantity
Water-cement ratio	0.49
Cement	392 kg/m <sup>3</sup>
Coarse aggregate	1174 kg/m <sup>3</sup>
Fine aggregate	664 kg/m <sup>3</sup>
water	206 kg/m <sup>3</sup>

- Preparation of casting and testing

A hydraulic testing equipment with a 2000 KN capacity is used to assess the compressive strength of concrete specimens. For determining the sample's compressive strength, IS: 516 (Part-1/Sec-1): 20021, specifies a sample size of 150mm x 150 mm x 150 mm. According to IS 516 (Part-1/Sec-1): 20021, this test is carried out. The compressive testing equipment uses two steel plates to perform a split tensile test. 30 cm is the length of the plate, and 20 mm is its thickness. It is possible to delete the longitudinal orientation from each cylinder's mould. The cylindrical object has an internal diameter of 150mm and a 300mm height.

- Result and analysis

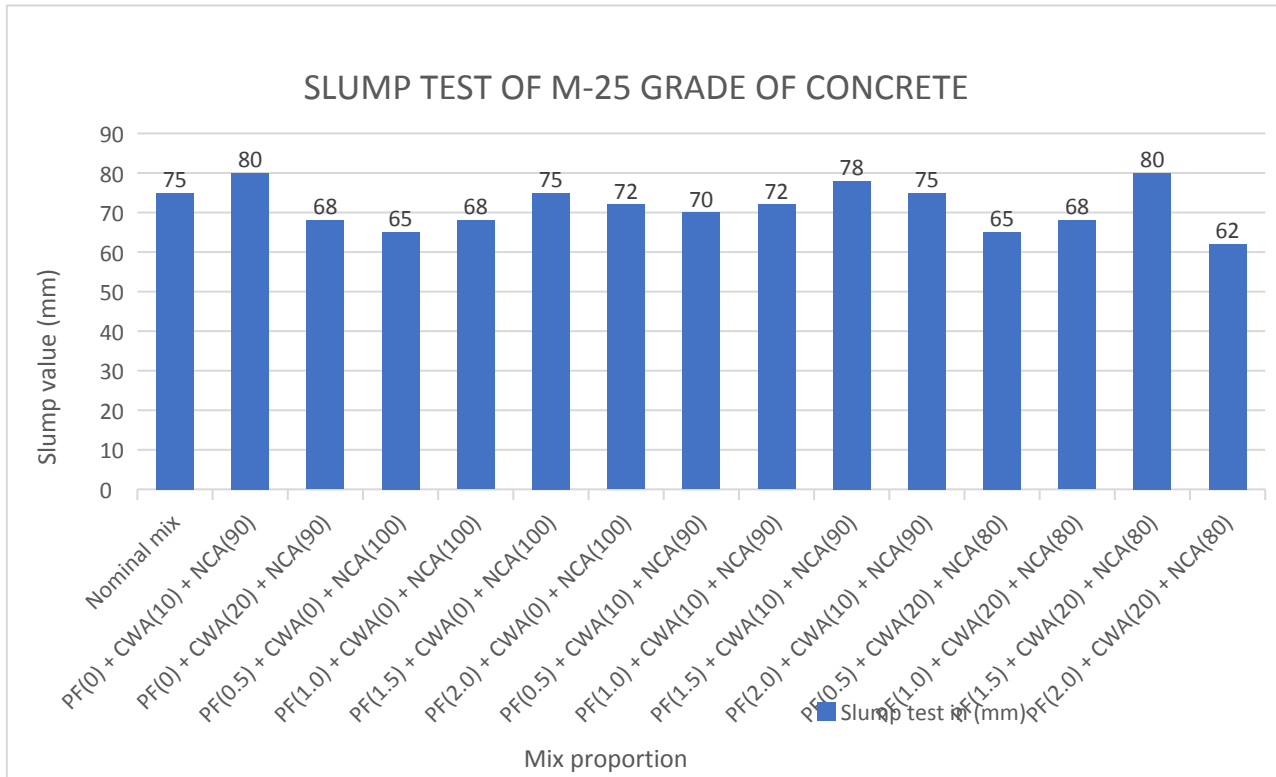
Table2 Slump test result

Mix detail PF(%) + CWA(%) + NCA(%)	Slump value	% Difference
PF(0) + CWA(0) + NCA(100)	75.00	0
PF(0) + CWA(10) + NCA(90)	80.00	6.66
PF(0) + CWA(20) + NCA(80)	68.00	-9.33
PF(0.5) + CWA(0) + NCA(100)	65.00	-13.33
PF(1.0) + CWA(0) + NCA(100)	68.00	-9.33
PF(1.5) + CWA(0) + NCA(100)	75.00	0
PF(2.0) + CWA(0) + NCA(100)	72.00	-4
PF(0.5) + CWA(10) + NCA(90)	70.00	-6.66
PF(1.0) + CWA(10) + NCA(90)	72.00	-4
PF(1.5) + CWA(10) + NCA(90)	80.00	6.66
PF(2.0) + CWA(10) + NCA(90)	75.00	0
PF(0.5) + CWA(20) + NCA(80)	65.00	-13.33

PF(1.0) + CWA(20) + NCA(80)	68.00	-9.33
PF(1.5) + CWA(20) + NCA(80)	78.00	4
PF(2.0) + CWA(20) + NCA(80)	62.00	-17.33

#### Slump test result

- From the observation replacement of ceramic waste aggregate with NCA in concrete the slump value is increase 6.66% at 10% replacement of ceramic waste aggregate and similarly the slump value is decrease 9.33% at 20% replacement of ceramic waste aggregate.



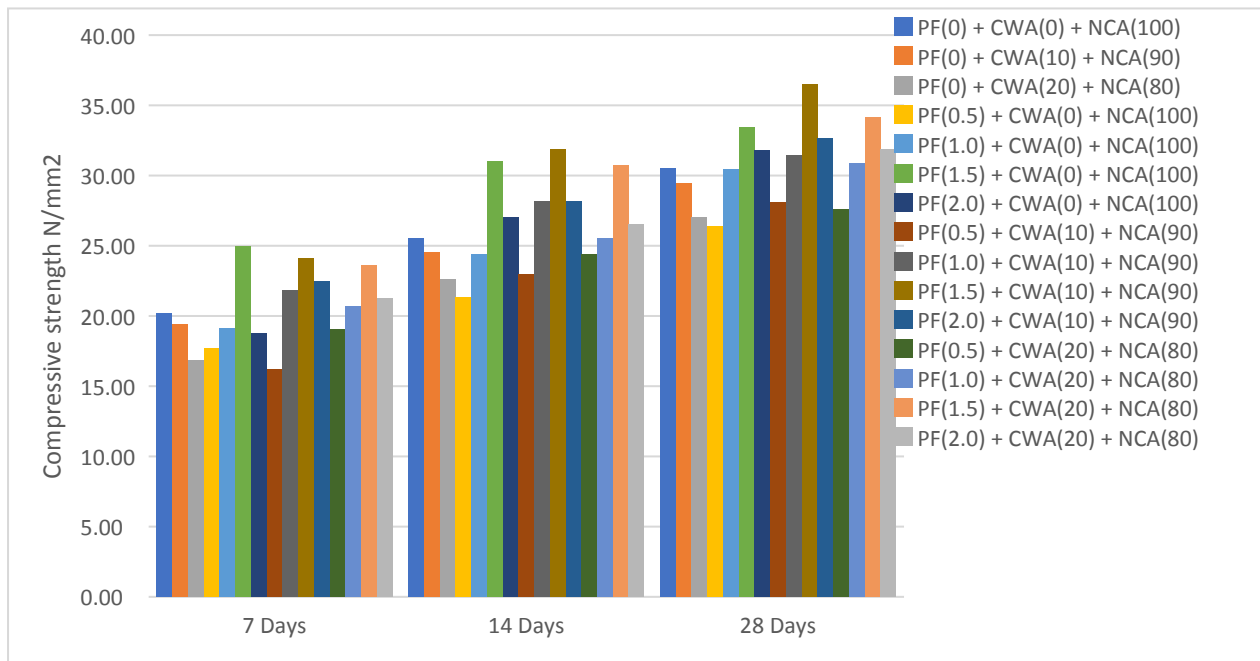
- The compressive strength test performs at 7, 14 and 28 days after curing of specimen. The average of result of the three cubes is shown in all the result tables.

Table3 Compressive strength result

Mix detail PF(%) + CWA(%) + NCA(%)	Compressive strength (N/mm <sup>2</sup> )			% Difference
	7 DAYS	14 DAYS	28 DAYS	
PF(0) + CWA(0) + NCA(100)	20.20	25.56	30.50	0
PF(0) + CWA(10) + NCA(90)	19.40	24.56	29.47	-3.37
PF(0) + CWA(20) + NCA(80)	16.84	22.60	27.03	-11.37
PF(0.5) + CWA(0) + NCA(100)	17.73	21.33	26.39	-13.47
PF(1.0) + CWA(0) + NCA(100)	19.12	24.41	30.46	-0.13
PF(1.5) + CWA(0) + NCA(100)	24.98	31.03	33.45	9.67
PF(2.0) + CWA(0) + NCA(100)	18.79	26.99	31.77	4.16

PF(0.5) + CWA(10) + NCA(90)	16.21	22.94	28.08	-7.93
PF(1.0) + CWA(10) + NCA(90)	21.82	28.19	31.41	2.98
PF(1.5) + CWA(10) + NCA(90)	24.11	31.86	36.46	19.54
PF(2.0) + CWA(10) + NCA(90)	22.49	28.19	32.68	7.14
PF(0.5) + CWA(20) + NCA(80)	19.05	24.39	27.57	-9.6
PF(1.0) + CWA(20) + NCA(80)	20.71	25.50	30.90	1.31
PF(1.5) + CWA(20) + NCA(80)	23.64	30.70	34.17	12.03
PF(2.0) + CWA(20) + NCA(80)	21.29	26.53	31.90	4.59

- From the observation table the compressive strength is increases up to 19.54% at replacement of PF(1.5)% and CWA(10)%.



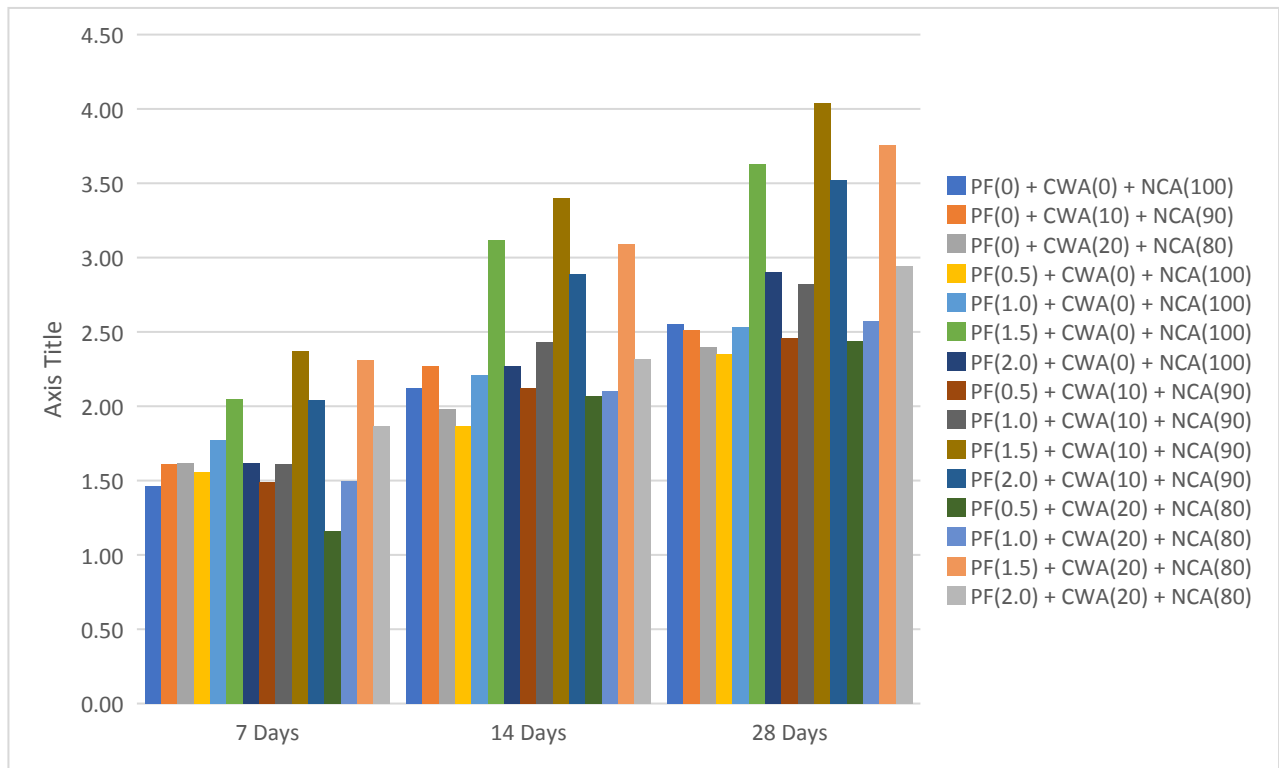
Graph 2 compressive strength graph

Table4 Split tensile test result

Mix detail PF(%) + CWA(%) + NCA(%)	Tensile strength (N/mm <sup>2</sup> )			% Difference
	7 DAYS	14 DAYS	28 DAYS	
PF(0) + CWA(0) + NCA(100)	1.46	2.12	2.55	0
PF(0) + CWA(10) + NCA(90)	1.61	2.27	2.51	-1.56
PF(0) + CWA(20) + NCA(80)	1.62	1.98	2.40	-5.88

PF(0.5) + CWA(0) + NCA(100)	1.56	1.87	2.35	-7.84
PF(1.0) + CWA(0) + NCA(100)	1.77	2.21	2.53	-0.78
PF(1.5) + CWA(0) + NCA(100)	2.05	3.12	3.63	42.35
PF(2.0) + CWA(0) + NCA(100)	1.62	2.27	2.90	13.72
PF(0.5) + CWA(10) + NCA(90)	1.49	2.12	2.46	-3.52
PF(1.0) + CWA(10) + NCA(90)	1.61	2.43	2.82	10.58
PF(1.5) + CWA(10) + NCA(90)	2.37	3.40	4.04	58.43
PF(2.0) + CWA(10) + NCA(90)	2.04	2.89	3.52	38.03
PF(0.5) + CWA(20) + NCA(80)	1.16	2.07	2.44	-4.31
PF(1.0) + CWA(20) + NCA(80)	1.50	2.10	2.57	0.78
PF(1.5) + CWA(20) + NCA(80)	2.31	3.09	3.76	47.45
PF(2.0) + CWA(20) + NCA(80)	1.87	2.32	2.94	15.29

- From the observation table the tensile strength is increases up to 58.53% at replacement of PF(1.5)% and CWA(10)%.



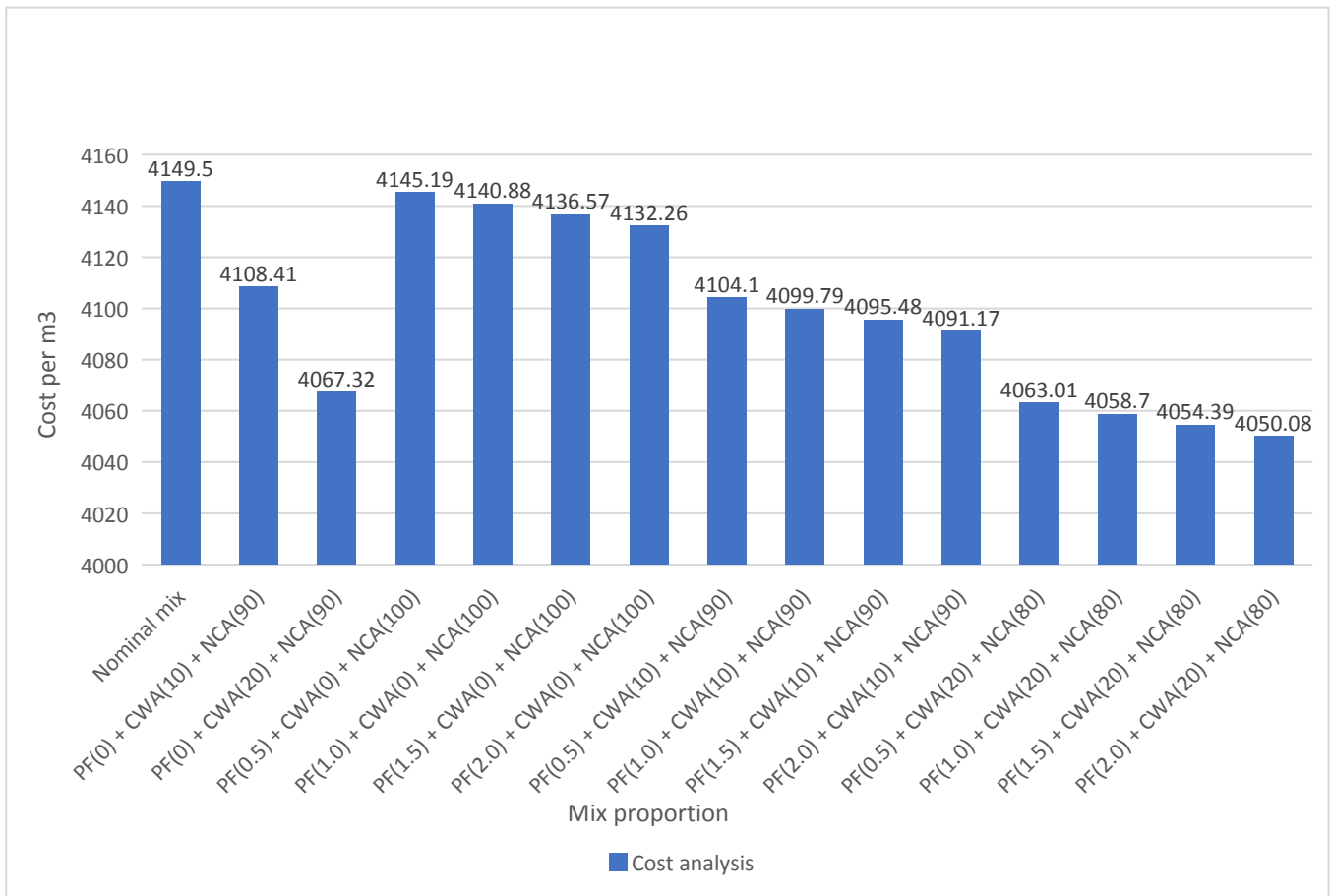
- Cost analysis:  
When we replaced some new material in concrete. Coast analysis is essential requirement in concrete mix.

Table5 Cost analysis

Mix detail PF(%) + CWA(%) + NCA(%)	cement	F.A	N.C.A	C.W.A	P.F	total coat (RS)
---------------------------------------	--------	-----	-------	-------	-----	--------------------

PF(0) + CWA(0) + NCA(100)	2822.40	564	763.10	0.0	0.0	4149.50
PF(0) + CWA(10) + NCA(90)	2822.40	564	686.79	35.22	0.0	4108.41
PF(0) + CWA(20) + NCA(80)	2822.40	564	610.48	70.44	0.0	4067.32
PF(0.5) + CWA(0) + NCA(100)	2808.29	564	763.10	0.0	9.80	4145.19
PF(1.0) + CWA(0) + NCA(100)	2794.18	564	763.10	0.0	19.60	4140.88
PF(1.5) + CWA(0) + NCA(100)	2780.07	564	763.10	0.0	29.40	4136.57
PF(2.0) + CWA(0) + NCA(100)	2765.96	564	763.10	0.0	39.20	4132.26
PF(0.5) + CWA(10) + NCA(90)	2808.29	564	686.79	35.22	9.80	4104.10
PF(1.0) + CWA(10) + NCA(90)	2794.18	564	686.79	35.22	19.60	4099.79
PF(1.5) + CWA(10) + NCA(90)	2780.07	564	686.79	35.22	29.40	4095.48
PF(2.0) + CWA(10) + NCA(90)	2765.96	564	686.79	35.22	39.20	4091.17
PF(0.5) + CWA(20) + NCA(80)	2808.29	564	610.48	70.44	9.80	4063.01
PF(1.0) + CWA(20) + NCA(80)	2794.18	564	610.48	70.44	19.60	4058.70
PF(1.5) + CWA(20) + NCA(80)	2780.07	564	610.48	70.44	29.40	4054.39
PF(2.0) + CWA(20) + NCA(80)	2765.96	564	610.48	70.44	39.20	4050.08

- From the observation table the combined replacement of CWA with NCA and PF with cement, overall cost of optimum mix is decreases as compare to nominal concrete mix.



## 5. CONCLUSION

- In this investigation tests were carried out on different mixes of concrete containing replacing polyester fiber and ceramic waste along with M-25 grade of concrete.
- When NCA is replaced by 10% of ceramic waste and 1.5% of polyester fiber with cement, the slump value is increases up to 6.66%. Further the increasing in percentage leads to decrease in slump value.
- The compressive strength is increases 19.54% when NCA replaced by 10% of ceramic waste and 1.5% of polyester fiber with cement. And, the compressive strength is also improved with 12.03% at NCA and cement replaced by 20% & 1.5% of ceramic waste and polyester fiber respectively.
- The split tensile strength is increases 58.43% when NCA replaced by 10% of ceramic waste and 1.5% of polyester fiber with cement. And, the tensile strength is also improved with 47.45% by combination of PF (1.5) % and CWA (20) %.
- In the cost analysis, cost is reduced 2.40% when NCA replaced by 20% of ceramic waste and 2% of polyester fiber with cement.
- So, in this study taking all these analysis of results into consideration, the conclusion come out to be that the ceramic waste 10% use as coarse aggregate and polyester fiber replaced with cement at 1.5% is increases the strength and properties of concrete.

## 6. REFERENCES

1. Akash agrawal. "Utilization of ceramic waste as a replacement of aggregates and its effect on variation of expenditure." International research journal of engineering research, (2017)
2. Manikanta kopuri, S. Anitha priyadharshani, Ranjeet sah. "Durability study on concrete with ceramic waste as partial replacement to coarse aggregate." Elsevier Science Direct, (2022)
3. Rajat Kumar Goyal, Vinay Agarwal, Rajesh Gupta, Kusum Rathore, Prakash Somani. "Optimum utilization of ceramic tile waste for enhancing concrete properties." Elsevier Science Direct, (2021)
4. R. Johnson Daniel, S.P. Sangeetha. "Experimental study on concrete using waste ceramic as partial replacement of aggregate." International research journal of engineering research, (2020)
5. Zahra Keshavarz, Davood Mostofinejad. "Porcelain and red ceramic wastes used as replacements for coarse aggregate in concrete." Elsevier Science Direct, (2018)

6. Nishma V Mohan, Aswathy L S, Sruthy Sreekumar, Aparna A V. "Strength Characteristic Study of Polyester Fiber Reinforced Concrete." International Journal of Engineering Research & Technology, (2018)
7. Venu Malagavelli, Neelakanteswara Rao Paturu. "Polyester Fibers in the Concrete an Experimental Investigation." International Journal of Engineering Research & Technology, (2020)
8. Garikapati Rambabu, Sontineni Kanakambara Rao, P Mohana Ganga Raju. "An Experimental Study to Compare the Strength Characteristics of Concrete using Polypropylene Fiber and Polyester Fiber Admixtures." International Journal of Innovative Research in Science, Engineering and Technology, (2017)
9. V.B. Reddy Suda, Rumpa Sutradhar. "Strength characteristics of micronized silica concrete with polyester fibres." International Journal of Innovative Research in Science, Engineering and Technology, (2020)
10. IS: 10262 – 2019. "Concrete Mix Proportioning – Guidelines"
11. IS: 456 – 2000. "Plain and Reinforced Concrete Code of Practice"
12. IS: 2386 (Part-1 & 3) – 1963. "Method of Test for Aggregate for Concrete"
13. IS: 516 (Part-1/Sec-1) :2021. "Hardened concrete - Methods of Test"
14. IS: 383 – 2016. "Specification for Coarse and Fine Aggregate for Natural Sources for Concrete"