International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9, Issue-7, May 2020

Effects of Zeolite and Used Foundry Sand in Concrete

P.Ragavi Nalina, S.Vimala, N.Sree Vidhya

Abstract*: In Current scenario, the CO_2 concentration is getting increased in the environment which leads to climatic change and greenhouse effect. By using zeolite powder (pozzolanic material),it can reduce the CO_2 emissions in the atmosphere. Using zeolite as partial replacement material of cement could make the concrete high strength, hence it eco-friendly. Used Foundry Sand (UFS) is an industrial by-product which is another material used in this research. The UFS can be used as a replacement for natural sand due to its properties.The present research work is aimed at studying the effect of the physical and chemical properties of Zeolite and UFS in M_{20} grade concrete. Based on previous literature 10, 15 and 20 % of Zeolite as replacement of cement and 30 % of UFS as replacement of sand are considered for the present study. The main objective is to estimate the test result of using Zeolite and UFS as partial replacement for cement and fine aggregates in fresh and hardened properties of concrete. Compressive strength and split tensile strength were carried out for 7,14 and 28 days and flexural strength of element will be observed from optimum percentage of test result.

***Keywords* : Zeolite, Used Foundry Sand(UFS), Compressive Strength, Split Tensile Strength**

I. INTRODUCTION

Concrete is an important material which is used for the constructions. Based on its usage, it should be placed second position after water. Concrete is brittle in nature and also it can be molded into any desire shapes. Fundamentally, concrete is strong, durable and economic. The fresh concrete is prepared by mixing the ingredients of cement, river sand and coarse aggregate with water in required ratio. Concrete is most versatile due to its property, workability, strength and durability and also which is widely used as a manmade construction materials. By using the industrial waste, the required properties of concrete can be achieved.

Portland cement is a binding material which is used in a construction industry. During cement production, the CO_2 emissions comes from the construction industry.To controlling the CO_2 emissions, the zeolite can be used as a partial replacement of cement.

Revised Manuscript Received on May 30, 2020.
***** Correspondence Author
Ms. RagaviNalina P*, Master of Engineering, Structural Engineering, PSNA College of Engineering and Technology(Dindigil), Anna University, Chennai, Tamil Nadu,India.
Dr. Vimala S, Professor, Faculty of Civil Engineering, PSNA College of Engineering and Technology, Dindigul, Tamilnadu,India.
Ms. Sree Vidhya N , Assistant Professor in the Faculty of Civil Engineering, at PSNA College of Engineering and Technology, Dindigul, Tamilnadu,India.

Also nowadays, the demand of natural sand used for construction work had been increased. Due to this critical issues, it has to look for alternatives for sand used in concrete. Used Foundry sand is one of the alternate material which can be used as a partial replacement of sand in a concrete. Used Foundry Sand is a industrial by-product which is comes from ferrous and non-ferrous metal casting industries. Foundry sand can be recycled and reuse many times in a foundry industry. When the foundry sand can be stored in a industry for long period, so that it can be taken out from the industry and it is named as used foundry sand.. There was number of studies have been made to look over the addition of UFS as partial and whole replacement of natural sand in a concrete.

II. MATERIALS

A. Cement

Cement is used to bind the other materials together. In this research, Ordinary Portland cement (53 grade) was used. The cement is stored in closed area when it is not in used during the test period to controlling weathering effect.

B. Aggregates

Aggregates in concrete is a structural filler and is act as a economic space filler. Aggregates includes gravel, crushed stone, sand, etc. Aggregates are of two types,

- *Coarse Aggregate:* In this research, the crushed grained aggregate of 20mm size was used as a coarse aggregate.
- *Fine Aggregate:* In this research, river sand passing through IS 4.75 mm sieve was used as a Fine aggregate.

C. Zeolite

Due to volcanic eruption, emission of volcanic ash takes place. When these ash mixed with sea water, the chemical reaction occurs and the natural mineral formes which is termed as zeolite. The properties of zeolite is used to increase the strength of the concrete and it also to decrease CO_2 emission from atmosphere. The sample of zeolite used for the investigation shown in Fig 1. The physical properties and chemical composition of zeolite are shown in Table-I and Table -II respectively.

Fig. 1. Zeolite Sample

Table- I:Physical Properties of Zeolite

S.No	Physical Properties	Results
1	Appearance	Off –white
2	PH (10% SOLIDS)	4.5-5.5
3	Bulk Density (kg/lit)	0.4-0.5
4	Specific surface area (m^2/g)	19-20
5	Specific gravity	2.6

Table- II: Chemical composition of Zeolite

S.No	Chemical Property	Zeolite %
1	SiO_2	52.0
2	Al_2O_3	46.0
3	FeO_2	0.60
4	CaO	0.09
5	K_2O	0.03
6	Na_2O	0.01
7	TiO_2	0.65
8	MgO	0.03

D. Used Foundry Sand

Foundry sand is an industrial by-product of ferrous and nonferrous metal casting industry. Foundry sand containing high quality silica and few amounts of impurity of ferrous and nonferrous by-products from metal casting process itself and variety of binders. This sand is economic one and the physical and the chemical properties of foundry sand is based on manufacturing process and the nature of industry from which it came. The sample of UFS used for the investigation is shown in Fig 2.

Fig. 2. Used Foundry Sand Sample

III. EXPERIMENTAL INVESTIGATION

A. Material Properties

The cement was used as a Ordinary Portland Cement of 53 grade. A study was undertaken to find out the various important aspects such as percentage of consistency, specific gravity, fineness, initial and final setting time.

The test was carried out as per IS 4031-1968. The cement specific gravity was determined as 3.12 and its consistency is 32%.Initial and Final setting time of cement is 40 minutes and 6 hours. Fineness of cement was obtained as 0.2%.Fine aggregates having specific gravity of 2.61 with fineness modulus 3.20 which conforming Zone III. The specific gravity of coarse aggregate was determined as 2.7 with fineness modulus 5.28. UFS was collected from industry(metal casting) near Dindigul, Tamil Nadu, India. The fineness modulus and specific gravity and of UFS 2.76 and 2.21 respectively. Zeolite is a pozzolan which is collected from Astrra Chemicals, Chennai. It is available in dry densified form. The specific gravity were found to be 2.6 for zeolite.

B. Mix Proportion

Concrete mix design were done by BIS: 10262-2009 and its mix proportion was 1:1.6:2.9 which is expressed as 1 part cement, 1.6 part fine aggregates, and 2.9 part coarse aggregates with a water cement ratio of 0.48.

Three different concrete mixes of (10, 15 and 20%) are made for replacement of cement and natural sand with zeolite and UFS respectively**.**

A constant water-cement ratio of 0.48 was used in the preparation of all concrete mix and super plasticizer were used as 0.3 0f cement . Design Mix are shown in Table- III.

Table- III: Concrete design mix

Cement Kg/m^3	Fine Aggregate Kg/m^3	Coarse Aggregate Kg/m^3	w/c Ratio Kg/m^3
393	652.81	1149.876	0.48

C. For arriving optimum percentage

Three concrete mixes were prepared for compressive strength ie., M1,M2 and M3 are shown in Table II from that optimum percentage are arrived for those mechanical properties. Concrete different mix ratio are shown in Table-IV and mix proportions are shown in Table- V.

Table- IV: Concrete different mix proportion

Mix ratio	Concrete mix
Zeolite 10 % - UFS 30%	M1
Zeolite 15 % - UFS 30%	M2
Zeolite 20 % - UFS 30%	M3

Table -V: Concrete mix proportions

Mix designation	CC	M1	M2	M3
Cement kg/m^3	393	353.7	334.05	314.4
Sand kg/m^3	652.87	457	457	457
Coarse aggregate kg/m^3	1149.88	1149.88	1149.88	1149.88
Zeolite kg/m^3	-	39.3	58.95	78.6
Foundry sand kg/m^3	-	195.86	195.86	195.86
w/c	0.48	0.48	0.48	0.48

D. Specimen preparation and casting

Specimens were prepared as per code. After casting, specimens were stored a room for 24 h at a temperature of about 27 ± 1 _C. After 24 h, they were demolded and it were put into a water-curing chamber until the time of test period. Three specimens were casted for each proportion and tested and then average value of proportions were taken.

E. Fresh Concrete Properties

Fresh concrete properties like slump flow were obtained. Moreover while preparing concrete for different mixes, workability of concrete does not affect the replacement of Zeolite and UFS for cement and fine aggregate respectively in the concrete.

F. Hardened Concrete Properties

- *Compressive Strength Test:* The compressive strength were tested at the period of 7,14 and 28 days in accordance with the provisions of IS Specifications BIS: 516-1959.
- *Split Tensile Test:* The splitting tensile Strength were tested at the period of 7,14 and 28 days according to the provisions of IS Specifications BIS: 516-1959.
- *Flexural Strength Test:* Structural beam of size 100 x 150 mm will be casted for flexural strength will be obtained for 28 days only.
- *Modulus of Elasticity Test:* The modulus of elasticity were tested at the period of 28 days according to the provisions of IS Specifications BIS: 516-1959.

IV. RESULT AND DISCUSSION

A. Compressive Strength

The compressive strength for concrete mixes (CC, M1, M2 and M3) was found at the period of 7, 14 and 28 days. The Compressive strength for ratio M1 (Zeolite 10 % - UFS 30%) are marginally increased as compared to conventional concrete and slightly decreases in the compressive strength of concrete mix ratio of M2 (Zeolite 15 % - UFS 30%) and M3 (Zeolite 20 % - UFS 30%). The Compressive strength for concrete mix for the period of 7, 14 and 28 days are investigated. The results of compressive strength for concrete mixtures are tested at 7, 14 and 28 days are represented in Table-VI and the graphical representation for these concrete mixes are given in Fig 3.

Table- VI: Compressive Strength

Mix designation	7 days N/mm^2	14 days N/mm^2	28 days N/mm^2
CC	18.25	21.28	26.60
M1	12.87	17.62	29.50
M2	10.89	14.05	20.91
M3	10.69	13.70	17.29

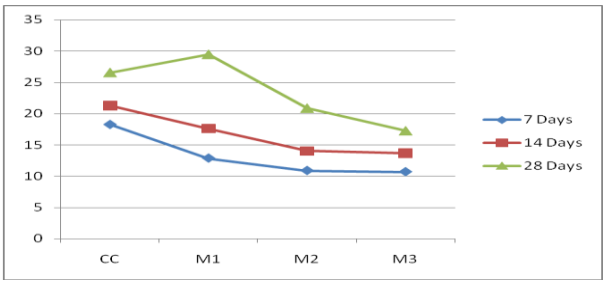

Fig.3. Compressive strength in N/mm2

B. Splitting Tensile Strength

The split tensile strength of concrete mixes (CC, M1, M2 and M3) was found at the period of 7 , 14 and 28 days.Split tensile strength of mix ratio M1 (Zeolite 10 % - UFS 30%) are marginally increased as compared to conventional concrete and also slightly decreases of concrete mix ratio of M2 (Zeolite 15 % - UFS 30%) and M3 (Zeolite 20 % - UFS 30%). The test results of split tensile strength for concrete mix are tested at 7,14 and 28 days are represented in Table-VII and the graphical representation for these concrete mixes are given in Fig 4.

Table -VII: Split Tensile Strength

Mix designation	7 days N/mm^2	14 days N/mm^2	28 days N/mm^2
CC	1.70	1.85	2.29
M1	1.56	1.79	2.37
M2	1.60	1.79	2.29
M3	1.58	1.71	2.25

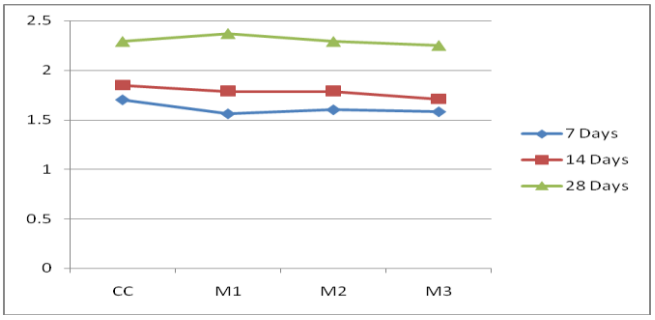

Fig 4. Split Tensile strength in N/mm2

V. CONCLUSION

- In this investigation for M20 grade of concrete it can be calculated that the cement can be replaced at 10%, 15% and 20% of zeolite and along with the sand can be replaced at 30% of Used Foundry Sand.
- In this present research work, it is concluded that the strength of concrete attained only by using zeolite at 10% replacement of cement and UFS at 30% replacement of sand.
- In compressive strength of concrete marginally increases only by using zeolite at 10% replacement of cement and UFS at 30 % replacement of sand in a period of 28 days compared with conventional concrete.
- In compressive strength of concrete slightly decreases for zeolite 15%,UFS 30% and zeolite 20%, UFS 30% replaced at cement and sand respectively for the period of 7,14 and 28 days.
- In split tensile strength of concrete increases by using zeolite at 10% replacement of cement for 28days and it slightly decreases by using zeolite at 15% and 20 % of cement.
- The high strength of concrete can be acheived by replacing 10% of cement by zeolite and 30% of sand by UFS.

REFERENCES

1. ACI 318-08, 'Building code requirements for structural concrete and commentary (ACI 318R-99)', Detroit: American Concrete Institute.
2. American Foundry Society 2010, Available from: <http://www.afsinc. Org>. [October 2010].
3. IS 383-2016, 'Indian standard code of practice for specification for coarse and fine aggregate from natural sources for concrete', Bureau of Indian Standards, New Delhi, India.
4. IS 456-2000, 'Indian standard plain and reinforced concrete - code of practice', Bureau of Indian Standards, New Delhi, India.
5. IS 516-1959, 'Indian standard code of methods of test for strength of concrete', Bureau of Indian Standards, New Delhi, India.
6. IS 2386 (Part 3) -1963, 'Methods of test for aggregates for concrete: specific gravity, density, voids, absorption and organic impurities', Bureau of Indian Standards, New Delhi, India.
7. IS 1199-1959, 'Methods of sampling and analysis of concrete', Bureau of Indian Standards, New Delhi, India.
8. IS 4031-1988, 'Indian standard method of physical tests for hydraulic cement', Bureau of Indian Standards, New Delhi, India
9. IS 5816-1999, 'Indian standard splitting tensile strength of concrete-method of test', Bureau of Indian Standards, New Delhi, Indi
10. IS 10262-2019, 'Indian standard recommended guide lines for concrete mix design', Bureau of Indian Standards, New Delhi, India.
11. IS 12269-2013, 'Indian standard specification for 53 grade ordinary Portland cement', Bureau of Indian Standards, New Delhi, India.
12. K.Prasanth,T.Naresh Kumar (2017), "A Study on mechanical and durability properties of concrete by partial replacement of natutral zeolite in cement,vol 4, pp 2348-4470
13. N. Gurumoorthy and K. Arunachalam (2016) "Micro and Mechanical Behavior of Treated Used Foundry Sand": Construction and building materials (2016) vol. 123, pp: 184-190.
14. Neelam Pathak, Rafat Siddique (2012) "Effects of Elevated Temperature on Properties of Self Compacting Concrete Containing Fly Ash and Spent Foundry Sand": Construction and building materials, vol-34, pp: 512-521.
15. Rafat Siddique, Yogesh Aggarwal, Paratibha Aggarwal, and El-hadj Kadri, Rachid Bennacer (2011) Strength, durability, and micro-structural properties of concrete made with used-foundry sand (UFS): Construction and building materials, vol.25, pp: 1916-1925.
16. Rafat Siddique and Yogesh Aggarwal (2014), micro-structural properties of concrete using bottom ash and waste foundry sand as partial replacement of fine aggregate. Construction and building materials, vol.54, and pp: 210-223
17. Saveria monosi, Daniela sani nd Francesca tittarelli (2010) "Used Foundry Sand In Cement Mortars and Concrete Production": The open waste management journal, vol.3, pp.18-25.
18. Taras Marki, Khrystyna Sobol, Małgorzata Franus, Wojciech Franus (2016) "Mechanical and durability properties of concretes incorporating natural zeolite" Elsevier, vol 3,pp 554-562
19. Yudhishthir V. Sharma , S.R. Satone and S.S. Waghmare (2016) " An Investigation on the effect of partial replacement of cement by zeolite on the properties of concrete" International Research Journal of Engineering and Technology, vol 3, pp 2321-0613.

AUTHORS PROFILE

Ms. RagaviNalina P obtained her Bachelor of Engineering in Civil Engineering from Anna University, Chennai, Tamil Nadu. Presently she is pursuing her Master of Engineering in Structural Engineering from PSNA College of Engineering and Technology(Dindigil), Anna University, Chennai, Tamil Nadu. She published 1 paper in International Journal during her Bachelor Degree. She has attended many conference. She is interested in design of RC building.

Dr. Vimala S obtained her Bachelor of Engineering in Civil Engineering from Bharathiar University, Coimbatore. She completed his Master of Engineering in Structural Engineering from Madurai Kamaraj University, Madurai and obtained Ph.D. from Gandhigram Rural Institute (Deemed University), Dindigul. Currently she is working as Professor in the Faculty of Civil Engineering, at PSNA College of Engineering and Technology, Dindigul, Tamilnadu. His specializations include Structural Engineering in Concrete materials and Analysis of Structures. His current research interests are strength and durability behaviour of alternative Building materials and Fibre Reinforced Concrete. She is a member of ISTE and IEI. She published 18 papers in various National and International Journals and also presented 15 papers in National and International conferences.

Ms. Sree Vidhya N obtained his Bachelor of Engineering in Civil Engineering and Master of Engineering in Structural Engineering from Anna University, Chennai. Currently she is working as Assistant Professor in the Faculty of Civil Engineering, at PSNA College of Engineering and Technology, Dindigul, Tamilnadu. His current research interests is Fibre Reinforced Concrete. She published 2 papers in International Journals and also presented 4 papers in National and International conferences.