Experimental Study on Self – Curing Concrete with Red Mud and Quarry Dust

Gaddam Sai Krishna

Abstract— **we all know water plays a very key role in construction industry. Plain concrete needs congenial atmosphere by providing moisture for a minimum of 28 days for good hydration and to attain desired properties. Any laxity in curing will badly affect the concrete properties. The main aim of this investigation is to study the strength and durability properties of concrete using water-soluble Polyethylene Glycol as self-curing agent. The function of self-curing agent is to reduce the water evaporation from concrete, and hence they increase the water retention capacity of concrete compared to the conventionally cured concrete. The use of self-curing admixtures is very important from the point of view that saving of water is a necessity everyday (each one cubic meter of concrete requires 3m^3 of water in a construction, most of which is used for curing). In this investigation, the use of water-soluble polyethylene glycol of molecular weight 400 (PEG-400) with a dosage of 0.5% to the weight of cement added to the mixing water as self-curing agent for concrete of M40 grade. The concrete was casted by replacing cement with red mud by 0%, 10%, 20%, 30%, 40% and 50% and fine aggregate by varying quantity of Quarry dust by 0%, 50%, 40%, 30%, 20% and 10% accordingly. In this study, compressive strength, split tensile strength, Non-Destructive testing (Rebound hammer) and flexural strength of self-curing concrete with replacement of red mud and quarry dust was compared with the conventional concrete specimens.**

Index Terms— **Self – curing, Red mud, Quarry dust, Polyethylene Glycol, Compressive strength, Flexural strength, Non – destructive testing, Rebound hammer.**

I. INTRODUCTION

Curing of concrete is one major are that lacks due attention and due importance in the construction field, especially in India. Durability, quality, performance of concrete structures and its longevity is at stake due to lack of awareness of the importance of curing of concrete. New developments in curing of concrete are on the horizon throughout the world. In the next century, mechanization of the placement, maintenance and removal of curing mats and covers will advance as performance based specifications quantify curing for acceptance and payment. In addition, effective sealants and compounds that prevent the loss of water and promote moist curing conditions of concrete will be in high demand. Self – curing technology should available commonly in the not too distant future.

The construction sector is very demanding in terms of water use, it was noted that the construction of a 100,000 sq. ft. multi – storey structure can require about 10 million liters of water for production, curing and site development activity. A double lane flyover can consume about 70 million liters of water on the same scale. So it is the time now, we need to adapt and adopt newer and newer technologies, that contribute to the sustainability in construction. Internal curing/self curing is one such technology.

Concrete is the second most consumed material in the world after water and it is used most widely in the construction industry due to its high compressive strength and durability. Conventional concrete (a mixture of cement, fine aggregate, coarse aggregate and water) needs proper curing and moisture contents for a minimum of 28 days for good heat of hydration and high strength. Lack of proper curing can badly affect the strength and durability.

Self-curing concrete is one type of special concrete which is mitigated insufficient curing due to human negligence paucity of water in arid areas, inaccessibility of structures in difficult terrains and in areas where the presence of fluorides in water will badly affect the characteristics of concrete.

The global production of bauxite in 2015 is 285 million tones approximately and the main producing countries are china, Australia, India, Brazil, Guinea. Ranking best in the worldwide production, India produced 15.5 million tons of bauxite [1] in 2015. Indian bauxite is grouped into 5 major geological & geographical areas. They are as Eastern ghats, central India, west coast, Gujarat, Jammu & Kashmir. The Indian aluminium sector is characterized by large integrated players like Hindal co., national aluminium company (NALCO), Indian aluminium company (INDAL) bharat aluminum (BALCO) and madras aluminum (MALCO). Bayer process production of aluminum: Alumina refining comprises the conversion of bauxite to aluminium oxide (AL_2O_3) (alumina) using the Bayer process. In the production of alumina process waste is generated is a red mud. Roughly 0.5-1.0 tons of red mud waste is generated per 1 ton of aluminium produced. The storage of large quantities of bauxite residue (red mud) is ex-pensive and high pH rate (10-12) and requiring large of disposal areas and causing serious environmental problems are issued.

In recent year's present replacing clinker by pozzolanic materials and using new alternative binder's produced by industrial solid wastes have become a prime interest in cement industry. With attempts to lower co_2 emissions and decrease the production cost of cement, have been red mud used as a pozzolanic pigment for colored concrete.
The successful utilization of various industrial by products

Gaddam Sai Krishna, Master of Technology in Structural Engineering/ Department of Civil Engineering/ JNTU Kakinada, Guntur, Andhra Pradesh, India/ email: saikrishna.g@outlook.in

such as (fly ash, silica fume, rice husk ash, foundry waste lime stone powder, red mud) in cement concrete has already developed. In addition to this an alternative source for the potential replacement of natural aggregates in cement concrete has gained good attention.

As a result reasonable studies have been conducted to find the suitability of quarry dust in cement concrete to overcome the stress and demand for river sand and cement in construction of roads and other works.

II. LITERATURE REVIEW

The below are the literatures collected on each materials and findings of the authors are quoted and shown below for reference, study and understanding of literature purpose only:

Swamy et. al. (1990) introduced a straightforward strategy to acquire a 50MPa 28-day quality cement having 50 and 65 percent by weight concrete supplanting with slag having a moderately low particular surface. The compressive and flexural qualities and the versatile modulus of these two cements as influenced by curing conditions are then introduced. With no water curing, concrete with 50 percent slag substitution came to almost 90 percent of its objective quality of 50MPa at 28 days 14 and kept on indicating unassuming quality change up to 6 months. The outcomes underlined that even 7day wet curing was lacking for large amounts of slag substitution, and that proceeded with introduction to a drying situation can have unfavorable impact on the long haul solidness of deficiently cured slag concrete.

Sathanandham T *et. al.* (Nov 2013, 2014) preliminary studies of self-curing concrete with the addition of polyethylene glycol (PEG) were done by them. They studied due excess of hydration in plain concrete shrinkage occurs which affect the durability hence introduced shrinkage reducing admixture polyethylene glycol (PEG 4000) which results in self-curing and helps in better hydration and hence good strength.

Magda I. Mousa *et. al.* (2014) the mechanical properties of concrete containing self-curing agents are investigated in his paper. In this study, two materials were selected as self-curing agents with different amounts, and the addition of silica fume was studied. The self-curing agents were, pre-soaked lightweight aggregate (LECA) and polyethylene-glycol PEG (CH). The result shows that concrete used polyethylene-glycol as self-curing agent, attained higher values of mechanical properties than concrete with saturated LEC.

Siddiqui M. Junaid *et. al.* (2015) presented the use of shrinkage reducing admixture i.e. polyethylene glycol (By adding 1% & 1.25% of PEG-4000 by weight of cement) in M40 grade of concrete (Grade ratio =1:2.23:3.08) which helps in self-curing with better hydration which reduces shrinkage cracks and hence increases strength and is compared with that of conventional cured concrete of the same grade.

Patel Manishkumar Dahyabhai, Prof. Jayeshkumar Pitroda studied on “introducing the self-curing concrete in construction industry”. Compressive strength of self-curing concrete is increased by applying self-curing admixtures. The compressive strength of concrete mix increased by 37% by adding 1.0% of PEG600 and 33.9by adding 1.0% of PEG1500 as compared to the conventional concrete. The optimum dosage of PEG600 for maximum compressive strength was found to be 1% of weight of cement for M25 grade of concrete. The optimum dosage of PEG1500 of maximum compressive strength was found to be 1% of weight of cement for M25 grade of concrete. Self-curing concrete is the best solution to the problem faced in the desert region and faced due to lack of proper curing.

Basil M Joseph Studied on self-curing concrete and PEG400 were used as a self-curing agent in concrete. M20 grade of concrete is adopted for investigation. He added 0-1.5% of PEG400 by weight of cement for M20 grade concrete from that he found 1% of PEG400 by weight of cement was optimum for M20 grade of concrete for achieve maximum strength. He also found that if percentage of PEG400 gets increased slump as well as compaction factor also increased.

Mohammed Shafeeque Sanofar.P.B, Praveen.K.P., Jitin Raj, Nikhil.V.P, Gopikrishna has used PEG600 as a self-curing agent in concrete. M20 and M25grade of concrete are adopted for investigation. They added 0-2% of PEG600 by weight of cement for M20 and M25 grade concrete. From that they found 1% of PEG600 by weight of cement was optimum for M20 and M25 grade of concrete for achieve maximum strength.

Dayalan J had used super absorbent polymers as a self-curing agent in concrete. He was added 0.0-0.48% of super absorbent polymer by weight of cement for M25 grade concrete. He was found that super absorbent polymer 0.48% by the weight of cement provides higher compressive, tensile as well as flexural strength than the strength of conventional mix.

V Revathy et. al. (April 2017) used PEG-400 as self curing agent in M40 concrete, in which she replaced sand by Quarry dust with 50% and cement by fly ash 5%,10%,15%,20%, & 25%. She concluded that use of 50% Quarry dust and 15% fly ash with 0.5% PEG-400 got good results for maximum compressive strength, split tensile strength and flexural strength.

Shikha Tyagi (2015) in his study, the effect of curing compound on workability (slump and compaction factor) and compressive strength is studied. In this study the percentage of PEG by weight of cement from 0% to 2% as the dosage of internal curing compound was fixed .The test results were studied both for M25 and M40 mixes. It is found through this experiment study that PEG 400 help in self curing by giving strength on par with that of the conventional curing method and also improved workability. The optimum dosage of PEG400 for maximum strength was found to be 1% for M25 and 0.5%for M40 grade. As the percentage of PEG400 increased, slump values are also increased for M25 and M40 grades of concrete.

Vishnu Kumari M aimed to compare strength of M30 grade concrete achieved by conventional curing method and self curing method. The present study involves the use of shrinkage reducing admixture polyethylene glycol in concrete which helps in self-curing and helps in better hydration and hence strength. Both PEG-400 and PEG-200 are used in the study in 0% to 2% by weight of cement. The compressive strength of concrete mix increased by 12.04% by adding 1.0% of PEG 400 and 9.18% by adding 0.5% of PEG 200 as compared to the conventional concrete. The optimum dosage of PEG400 for maximum compressive strengths was found to be 1% of weight of cement for M30 grades of concrete. The optimum dosage of PEG200 for maximum compressive strengths was found to be 0.5% of weight of cement for M30 grades of concrete.

Patel Manish Kumar Dahyabhai,Prof. Jayesh Kumar R. Pitroda presented the results of an experimental investigation carried out to find out the effect of admixture (PEG400) on compressive strength, split tensile strength and modulus of rupture by varying the percentage of PEG by weight of cement from 0% to 2% . M20 grade concrete is considered for the study. The study shows that PEG400 could help with self-curing by giving strength on par with conventional curing. It was also found that 1% of PEG400 by weight of cement was optimum for M20 grade concrete for achieving maximum strength without compromising workability. The test result indicates that use of water soluble polymers in concrete has improved performance of concrete.

Sreenivasa kumar A, Dr.Suresh Babu T studied the effect of admixture (PEG-200) on compressive strength, split tensile strength at one percentage for M25 mix was studied and it compared with the properties of PEA (PolyEthylene Alcohol). He studied the mechanical characteristics of concrete such as compressive strength, split tensile strength and modulus of rupture by varying the percentage of PEG and PEA from 0% to 2% by weight of cement for M25 grade concrete. He concluded that the optimum strength values for both the self curing agents were found and among both the agents PEG-200 is a best and good self curing agent because in the durability and normal compressive strength aspects it was giving good results when compared with both conventional concrete and PolyEthylene Alcohol (PEA). It was found that Poly Ethylene Glycol-200 is a good self curing agent when compared with Poly Ethylene Alcohol.

III. METHODOLOGY

Self curing concrete mix of M40 grade is adopted from the past researchers. The concrete was casted by replacing cement with red mud by 0%, 10%, 20%, 30%, 40%, 50% and fine aggregate by varying quantity of Quarry dust by 0%, 50%, 40%, 30%, 20% and 10% respectively by adding PEG-400 to mixing water at 0.5% to weight of cement. Strength properties are studied through

- Compressive strength of cube specimens of size 150mm x 150mm x 150mm.
- Split tensile strength of cylinder specimens of size 150mm dia x 300mm height.
- Flexural strength of beam specimens of size 150mm x 150mm x 700mm.

Concrete cube and cylinder specimens are tested in Compressive testing machine (CTM) to analyse compressive strength and split tensile strength. Beam specimens are tested by centre point loading method in Universal testing machine (UTM) to find out modulus of rupture. Workability of concrete was measured by using Abram's cone or slump cone testing apparatus.

IV. MATERIAL SPECIFICATION AND DESCRIPTION

In the present investigation materials used are given below with their specifications:

A. Cement: Ordinary Portland cement (OPC) of 53 grade manufactured by Sagar cement company conforming to IS: 12269 with specific gravity 3.141 is used.

B. Red mud: The Red mud used for the replacement of cement is brought from nearby red mud storage pond located at Guntur, Andhra Pradesh, India., Obtained from manufacturing of alumina from bauxite ore by Bayer's process. The specific gravity of red mud sample taken was 2.938. Chemical composition of cement and red mud are given below:

Chemical composition	Cement	Red mud
CaO	63.6	43.3
Sio_2	19.49	18
Al_2O_3	4.54	6.31
Fe_2O_3	3.38	12.28
Na_2O_3	0.13	1.71
MgO	2.36	1.13
K_2O	0.58	0.45

Table.1: Chemical compositions of cement and red mud.

C. Fine aggregate: Natural River sand of zone III with specific gravity 2.488 and having fineness modulus as 3.096 is used.

D. Quarry Dust: Quarry dust obtained from local resource crushers near parecherla village of Guntur district was used in casting of test specimens. The specific gravity and fineness modulus of test sample is 2.735 and 5.96.

E. Coarse aggregate: A crushed aggregate with specific gravity 2.967, fineness modulus 9.494 and water absorption 1.8 is employed in this project.

F. Polyethylene glycol – 400: For the present study PEG 400 was purchased from Loba chemie Pvt. Ltd Company. Some of its Physical properties are

- Density: 1.13 g/cm³.
- Formula: $C_{2n}H_{4n}+2O_{n+1}$, n=8.2 to 9.1.
- Melting point: 4 to 8 °C (39 to 46 °F; 277 to 281 K).
- Viscosity: 85 – 105 cS at 20 °C, 90 cS at 25 °C, 7.3 cS at 99 °C.
- Molar mass: 380 - 420 g/mol.
- Flash point: 238 °C (460 °F; 511 K).
- Specific gravity: 1.12.

- pH value: 6.
- Moisture: 0.2 %.
- Appearance: Clear fluid.
- Odor: Smells like Palmyra fruit.

Fig. 1: Polyethylene Glycol – 400 tin.

V. TEST PROCEDURE

A. TEST SPECIMENS: Test specimens used for the present investigation are cubes, cylinders and beams. The concrete cubes of size 150mm×150mm×150 mm were used as test specimens to determine the compressive strength. The specimens were cast for M40 grade of concrete with coarse aggregate of size 20mm. The workability of fresh concrete was measured in terms of slump values. The ingredients of concrete were thoroughly mixed till uniform consistency was achieved. The cubes were compacted on a vibrating table. Compressive strength was obtained as per IS: 516-1959.

For split tensile strength cylinders of size 150mm diameter and 300mm height were used as test samples. Flexural strength of concrete specimens was calculated by using prism moulds of size 700mmx150mmx150mm. These entire specimens are casted for different mixes and tested on respective testing dates. Compressive strength and split tensile strength of concrete specimens are calculated under compressive testing machine (CTM) and flexural strength of concrete specimens is calculated by using Universal testing machine (UTM).

B. MIX PROPORTIONS: Samples are prepared for M40 grade concrete. For the design mix IS: 10262-2009 recommendations are adopted. Mix proportions obtained are 1:1.305:2.768 with w/c ratio 0.43.

C. MIXING: The individual mix ingredients are weighed with their proportions exactly and then the materials are placed on a pan. The materials are thoroughly mixed in their dry conditions before water is added. The prepared mix was then immediately used for testing fresh mix for workability. In this study, the early age properties of fresh concrete and mechanical performance and tensile strength of hardened concrete were examined. All tests were conducted using the following sample groups:

1. Conventional concrete.
2. Conventional concrete with self curing agent.
3. Sand is replaced by quarry dust by 50%, 40%, 30%, 20%, 10% and cement is replaced by red mud 10%, 20%, 30%, 40%, and 50% respectively.

Each of the above samples was test for compressive strength, split tensile strength, and modulus of rupture.

Mix Designation	Red mud	Quarry dust	Polyethylene Glycol - 400
M 40	Concrete Mix		
Mix 1	0 %	0 %	0 %
Mix 2	0 %	0 %	0.5%
Mix 3	10%	50 %	0.5%
Mix 4	2 %	40 %	0.5%
Mix 5	0 %	30 %	0.5%
Mix 6	40 %	20 %	0.5%
Mix 7	50 %	10 %	0.5%

Table.2: Mix Proportion of specimens

C. CASTING OF SPECIMENS: After applying oil to the moulds, as per the design mix concrete was prepared. Casting of concrete specimens for the present investigation should be done for Cubes, Cylinders and Beam moulds of respective sizes. These specimens are casted and tested as per IS 516 – 1959 specifications. Details of the specimens are tabulated below:

Specimen details (mm)	No. of specimens							
	% of RM	0%	0%	10 %	20 %	30 %	40 %	50 %
	% of QD	0%	0%	50 %	40 %	30 %	20 %	10 %
	% of PEG-400	0%	0.5 %	0.5 %	0.5 %	0.5 %	0.5 %	0.5 %
Cube (150x150x 150)	_	12	12	12	12	12	12	12
Cylinder (Diameter= 150 & height= 300)	_	6	6	6	6	6	6	6
Prism (700x150x 150)	_	3	3	3	3	3	3	3

Table.3: Details of specimens

D. CURING OF TEST SAMPLES: After casting, the mould specimens are stored in laboratory at room temperature for 24 hours. After 24 hours specimens are removed from the moulds and immediately submerged in clean, fresh water tank for curing of conventional concrete mix. But for the present investigation we are using Polyethylene glycol – 400 as self curing agent. So there is no need of curing. After casting of specimens, keep the moulds a side for a day and remove the moulds after final setting.

VI. RESULTS AND DISCUSSION

A. *Workability*

Various mixes of freshly mixed concrete were tested for workability by slump cone value. It was observe that, the workability decreases with increase in Quarry dust content in the mix. The mix with cement as the only binder, the workability was medium. As per the table and figure below it shows that there is an increase in workability with the inclusion of red mud.

Mix Designation	Slump value of concrete (mm)	Degree of workability	Type of slump
Mix 1	98	Medium	True
Mix 2	99	Medium	True
Mix 3	74	Low	Shear
Mix 4	83	Medium	True
Mix 5	87	Medium	True
Mix 6	89	Medium	True
Mix 7	91	Medium	True

Table.4: Slump cone test values.

Fig.2: Variation of slump cone values.

B. *Compressive strength*

Compressive strength values of the cube specimens were tested at 7, 14, 21 and 28 days for all the seven different mix. It is observed that the compressive strength of concrete decreased when percentage of red mud increased. So, 40% quantity of quarry dust can be replaced in sand with 20% of red mud at a time. The results obtained are tabulated below with proper graphs.

Mix Designation	**Compressive strength (in N/mm^2)**			
	7 Days testing	**14 Days testing**	**21 Days testing**	**28 Days testing**
Mix 1	37.775	40.444	45.778	48.889
Mix 2	35.556	40.889	41.778	43.111
Mix 3	27.556	34.222	35.111	38.667
Mix 4	**28.444**	**35.111**	**36**	**40.444**
Mix 5	25.333	27.556	28	29.333
Mix 6	20.444	25.778	27.111	30.667
Mix 7	17.333	18.667	19.556	22.667

Table.5: compressive strength results for different mix.

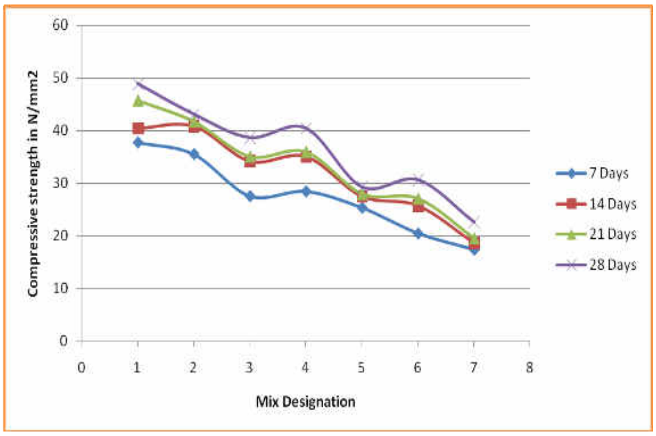

Fig.3: Compressive strength values for different mix

C. *Non destructive testing*

In order to evaluate the compressive strength of concrete, 3 cube specimens provided were analyzed for each mix at 0.5% dosage of PEG-400 by rebound hammer test apparatus at 28 days of casting. It is observed that there is a difference of 14% on average to the compressive strength tested through destructive testing method. The results of specimens are shown in the table.

Mix Designation	Compressive strength values (N/mm^2)	Rebound Hammer values (N/mm^2)
Mix 1	48.889	38.22
Mix 2	43.111	37.10
Mix 3	38.667	34.33
Mix 4	**40.444**	**36.11**
Mix 5	29.333	24.70
Mix 6	30.667	28.22
Mix 7	22.667	-

Table.6: Comparison of compressive strength between Destructive and NDT methods

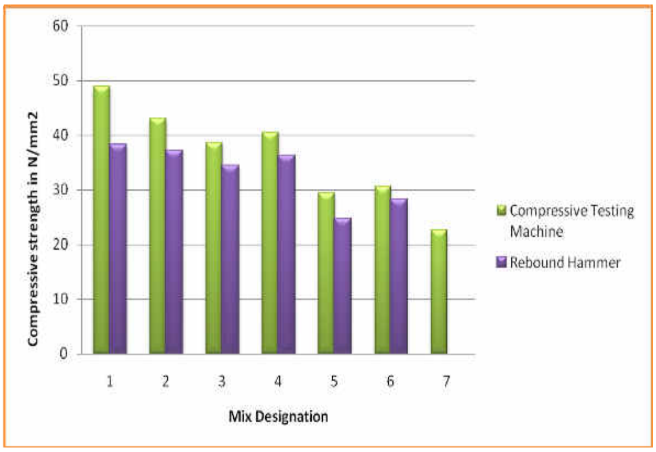

Fig.4: Variation of Compression between CTM and Rebound Hammer

D. *Split tensile strength*

Split Tensile strength of the cylinder specimens were tested at 7 and 28 days for all the seven different mix. It is observed that the tensile strength of concrete decreased when percentage of red mud increased. Self curing concrete without any replacement got very good results when compared with conventional concrete mix. After 20% of red mud and 40% of quarry dust replacement the split tensile strength decreased with increase in red mud percentage. The results obtained are tabulated below with proper graphs.

Mix Designation	Split tensile strength=(2P/ π LD) in N/mm^2	
	7 Days testing	28 Days testing
Mix 1	2.545	5.798
Mix 2	3.111	6.081
Mix 3	2.263	5.374
Mix 4	**2.687**	**5.515**
Mix 5	2.687	3.677
Mix 6	2.263	3.394
Mix 7	1.556	2.97

Table 7: Split tensile test results for different mix

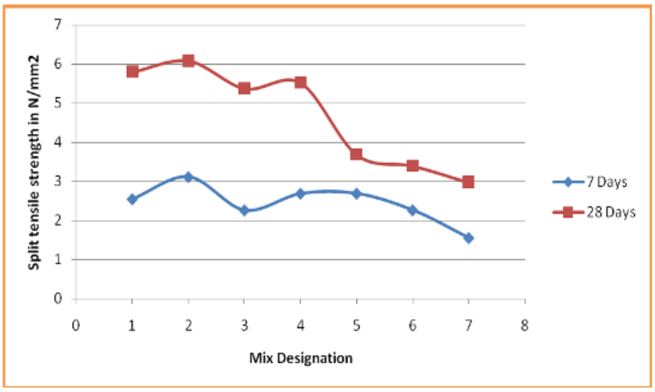

Fig.5: Split tensile strength for different mix.

E. Flexural strength

Flexural strength or modulus of rupture for the beam specimens are tested on Universal testing machine (UTM) at 28 days for all the different mix. Average modulus of rupture at 28 days increased with 10% red mud and 50% quarry dust concrete mix. Also there a slight increase in flexural strength with 50% red mud and 10% quarry dust concrete mix.

Mix Designation	Flexural strength = $3PL/2BD^2$
Mix 1	5.071
Mix 2	4.598
Mix 3	3.920
Mix 4	4.182
Mix 5	2.789
Mix 6	2.52
Mix 7	2.955

Table.8: Variation of modulus of rupture at 28 days

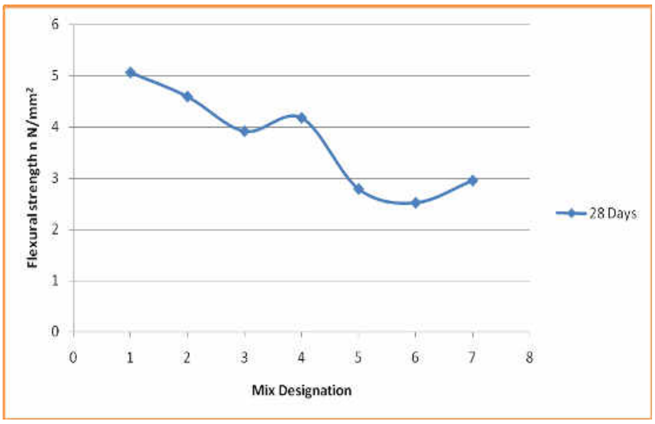

Fig.6: Flexural strength for different mix.

F. Rate analysis and cost comparison

The attempt was made to find out the rates and comparison of cost between the conventional concrete and self curing concrete having a dosage of 0.5% PEG – 400 including the cost of water required for curing and a labor that is needed in case of conventional concrete as shown in the table.

Grade	Requirements	Quantity (m^3)	Analysis (Rs.)	Amount (Rs.)
M40 conventional concrete mix	Concrete	0.119556	7867	941
	Water	0.2355	160	38
	Labour	8hrs/day	400*7	2800
			Total =	**3779**
M40 Self curing concrete mix	Concrete	0.119556	7867	941
	PEG – 400	0.269	1800	484
			Total =	**1425**

Table.9: Rate analysis and cost comparison.

VII. CONCLUSION

Based on the experimental the following conclusions have been drawn.

- Optimum percentage replacement of red mud with cement by weight is found to be 20%, it is due to the increased pozzolanic property of cement due to addition of red mud in case of M40 concrete mix.
- From the study it is concluded that quarry dust can be used as a substitute for sand. It is identical the 40% replacement of sand by quarry dust give good result in strength for M40 mix concrete. Thus the environmental effects and waste can be significantly reduced.
- It is observed that 50% replacement of sand with quarry dust is not workable for M40 design mix.
- Increase in percentage of quarry dust will cause decrease in the degree of workability.
- The specific gravity and sieve analysis result shows that the quarry dust can be used as alternative to sand. The specific gravity of all the crushed samples lies in between 2 to 2.8 which fulfill the sand requirement.
- Split tensile strength of self curing concrete is relatively high when compared with conventional concrete.

- Self curing concrete is the viable answer to many problems faced due to lack of proper curing. It will be an alternative to conventional concrete in desert regions where scarcity of water is a major problem.
- The percentage of PEG – 400 recommended for M40 grade of concrete would be 0.5% to the weight of cement.
- Red mud usage with cement leads to improvement in binding quality by showing by showing the same setting time as conventional concrete and also improves strength parameters up to 20% replacement for M40 grade concrete.
- It is concluded that use of PEG – 400 is a better option to form an internally cured concrete which does not compromise with its strength. 100% curing water can be saved as there is no need of curing process required for internally cured concrete.
- The cost of self cured concrete is less when compared to the conventional concrete as there is not additional labor cost for curing.

REFERENCES

[1] R. Sundaram, M. Priya, S. Ranjitha and R. Tamil Elakkiya, "SELF CURING", International Conference on Current Research in Engineering Science and Technology (ICCREST – 2016), E-ISSN: 2348-8352.

[2] K Shyam Prakash and Dr Ch Hanumantha Rao, "Strength Characteristics of Quarry Dust in Replacement of Sand", International Conference on Materials, Alloys and Experimental Mechanics (ICMAEM-2017), Volume 225.

[3] Basl M Joseph, "Studies on Properties of Self-Curing Concrete Using Poly - Ethylene Glycol", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), e-ISSN: 2278-1684, p-ISSN: 2320-334X, PP 12-17, International Conference on Emerging Trends in Engineering & Management (ICETEM-2016).

[4] Sowmyashree T, Arpitha D J, Manjunath C S, Siddu Karthik C S, "STUDY ON MECHANICAL PROPERITES OF RED MUD AS A PARTIAL REPLACEMENT OF CEMENT WITH HYDRATED LIME FOR M40 GRADE CONCRETE WITH SUPERPLASTICISED", International Journal of Research in Engineering and Technology, eISSN: 2319-1163, pISSN: 2321-7308, Volume: 05 Issue: 04, April-2016.

[5] P Ashok, M P Suresh Kumar, "Experimental Studies on Concrete Utilizing Red Mud as A Partial Replacement Of Cement With Hydrated Lime", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), e-ISSN: 2278-1684, p-ISSN: 2320-334X, PP 01-10, 2016, International Conference on Recent Trends in Engineering and Management.

[6] Dr. U.B. Choubey, Gajendra Raghuvanshi, "A STUDY ON PROPERTIES OF SELF-CURING CONCRETE USING POLYETHYLENE GLYCOL-400", International Journal of Research in Engineering and Technology, eISSN: 2395-0056, pISSN: 2395-0072, Volume: 04 Issue: 10, Oct-2017.

[7] Siddiqui Mohammed Junaid, Bhadki Safwan, Bodale Ahamad, Sayyad Kaleem, Ulde Nuh, "An Experimental Investigation on Internally Cured Concrete", International Journal on Recent and Innovation Trends in Computing and Communication, ISSN: 2321-8169, PP 241-244, Volume: 04, Issue: 04, April 2016.

[8] V. Revathy, C.J.Ganga Lakshmi, "EXPERIMENTAL STUDY ON SELF CURING CONCRETE WITH FLYASH AND QUARRY DUST", SSRG International Journal of Civil Engineering (ICRTCETM-2017), ISSN" 2348-8352, Special Issue – April 2017.

[9] Manvendra Verma and Mayank Nigam, "Mechanical Behaviour of Self Compacting and Self Curing Concrete", International Journal of Innovative Research in Science, Engineering and Technology, Volume 6, Issue 7, July 2017.

[10] Sumit L. Chauhan and Raju A.Bondre, "Partial Replacement of Sand by Quarry Dust in Concrete", International Journal of Scientific and Research Publications, ISSN 2250-3153 Volume 5, Issue 7, July 2015.

[11] R. Pavan Kumar, P. Satya Sagar, "Experimental study on the Effect of Cement and Sand Replacement with Red mud and Quarry Dust in Cement Concrete Pavements", International Journal of Recent and Innovation Trends in Computing and Communication, ISSN: 2321-8169, PP 636-639, Volume: 4, Issue: 6, June 2016.

[12] Muddassir Bora, Mausam Vohra, Mohammed Sakil Patel and Dhruv Vyas, "Self Curing Concrete – Literature Review, International Journal of Engineering Development and Research, ISSN: 2321-9939, Volume: 5, Issue: 1, 2017.

[13] Kiran Kumar M S, Raghavendra naik, Harish K S, Ramesh M, "International Journal of Civil and Structural Engineering Research", ISSN 2348-7607 (Online) Vol. 4, Issue 1, pp: (324-330), Month: April 2016 - September 2016.