EXPERIMENTAL STUDY OF FLEXURAL AND TORSIONAL STRENGTH OF REINFORCED CONCRETE BEAM MADE WITH WASTE CAST IRON FOUNDRY SAND

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Abstract: **Concrete is a chief product in all the construction deeds. Concrete contains cement, fine aggregate, coarse aggregate and water. Several researchers has investigated to find best alternative for the natural resources which are used in concrete. Foundry sand is one of them. In this article natural sand is replaced with cast iron foundry sand. Foundry sand is nothing but the by-product of metal casting foundry industry. In the present work, experiments were performed to calculate the flexural and torsional strength at 7, 28 and 56 days of concrete by replacing fine aggregate with waste cast iron foundry sand. The replacement is done in various percentages from 10%, 20% and 30% by weight of fine aggregate. The ultimate flexural strength on 30 % replacement of fine aggregate is observed to be maximum for cast iron foundry sand. The torsional strength is increased on inclusion of waste cast iron foundry sand. It is possible to use waste foundry sand in construction up to certain limits under certain condition to increase both flexural and torsional strength of the concrete.**

Keywords: **Waste foundry sand, flexural strength etc.**

I. INTRODUCTION

The Waste generated from the industries cause environmental problems. Hence the reuse of this Waste material can be emphasized. Foundry sand is high quality silica sand that is a byproduct from the production of both ferrous and nonferrous metal casting Industries. Foundry sand is used for the centuries as a molding casting material because it's high thermal conductivity. The physical and chemical characteristics of foundry sand will depend in great part on the type of casting process and the industry sector from which it originates.

In the casting process, molding sands are recycled and reused multiple times. Eventually, however, the recycled sand degrades to the point that it can no longer be reused in the casting process. At that point, the old sand is displaced from the cycle as byproduct, new sand is introduced, and the cycle begins again. Two general types of binder systems are used in metal casting depending upon which the foundry sands are classified as: clay bonded systems (Green sand) and chemically- bonded systems. Both types of sands are suitable for beneficial use but they have different physical and environmental characteristics. Over the last decades, much research has been conducted on the mechanical, chemical and durability aspects of foundry sand. But inadequate research focus is given to the study of the strength of foundry sand in RCC beam. In foundry industry during the casting process a large amount of by-product material is produced. The metals which usually cast in foundry industry are cast iron, steel, aluminium, copper, brass and bronze. Over two third of the total by-product material consists of silica and the one third of the total by-product material consists of metals which is casted on the sand. In foundry industry they use high quality silica sand for moulding the metals and also for casting purposes. The sand which they commonly used in the foundry industry should be easily available, it should possess very high resistance to heat, and it should be cost effective. In the foundry industry the same sand will be used for many castings until it loses its original properties fully or until if it is used again it will affect the casting materials by changing its physical as well as chemical properties. The sand which cannot be reused again in the foundry industry for casting purposes then it is termed as waste foundry sand. The disposal of waste foundry sand becomes major issues and creates land pollution. The colour of the foundry sand will be blackish, grey and also brownish in colour based on the material which is casted on it, the number of times it is used for the casting purposes, and the method used in the casting purposes. Possible large scale utilization in making concrete as partial replacement of fine aggregate.

Foundry industry produces large amount of by-product during casting process. About 70% of the total by-product material consists of waste sand because moulds usually consist of moulding sand, which is easily available, inexpensive, heat resistant and easily bonded with binder and other organic material in mould. Foundry industry need high quality specific size silica sand for their moulding and casting process. These WFS contain large amount of fines. The typical physical and chemical property of WFS depends on the type of metal being poured, casting process, technology employed, type of furnace (induction, electric arc and cupola) and type of finishing process (grinding, blast cleaning and coating).

Fig 1.1 Waste Cast iron foundry sand [1]

Fig 1.2 Waste Aluminium foundry sand [2]

Annually approximately 5 to 7 million tons of foundry sand is used in engineering applications. The disposal of waste foundry sand is becoming a major issue leading to land pollution. To overcome this problem use of foundry sand in construction industry will reduce land pollution and will lead to economical construction.
In this study foundry sand is used in percentage variations of10%, 20% and 30% as a partial replacement to river sand. Foundry sand is basically fine aggregate. In this study Beams have been casted with regular R.C.C concrete and concrete with waste foundry sand as partial replacement. Flexural and torsional strength tests are carried out on these beams.

II. LITERATURE REVIEW

1. (Mr. R. D. Koshti, et al. 2016)
MODIFICATION OF PLAIN CONCRETE BY REPLACEMENT OF FINE AGGREGATE WITH FOUNDRY SAND -The study is carried out to use maximum foundry sand with retaining the properties of the concrete, and to produce a low-cost and eco-friendly concrete. In the present work, experimental investigations were performed to calculate comparative study of properties of fresh concrete using replacement of fine aggregate with foundry sand. Foundry sand is replaced by 10%, 20%, 22%, 24%, 26%, 28%, 30% & 40% by weight of fine aggregates.M20 grade of concrete is designed & test are taken for compressive strength, Flexural strength & Split tensile strength for 7 & 28 days curing period.

2. (Mr. R.D.Koshti, et al. 2016)
RATE OF HYDRATION OF CONCRETE WITH FINE AGGREGATEREPLACED BY FOUNDRY SAND- In the present work, experimental investigations were performed to calculate comparative study of strength gain of the concrete at early stage of seven days, of concrete using replacement of fine aggregate with foundry sand. Foundry sand is replaced by 10,20,22,24,26,28,30,40% by weight of fine aggregates.M20 grade of concrete is designed &test are taken for compressive strength, Flexural strength & Split tensile strength for 7 and 28 days curing period..

3. (B. V. Bahoria, et al. 2013)
COMPREHENSIVE LITERATURE REVIEW ON USE OFWASTE PRODUCT IN CONCRETE- This is the situation for the construction industry today and most will agree that it will not change dramatically in the foreseeable future. Crushed aggregate, bottom ash, foundry sand and various by-products are replacing natural sand and gravel in most countries. This paper emphasizes on the use of material to be replaced by natural sand which will give new dimension in concrete mix design and if applied on large scale would revolutionize the construction industry, by economizing the construction cost and enable us to conserve natural resources.

4. (Dushyant R. Bhimani, et al. 2013)
A STUDY ON FOUNDRY SAND: OPPORTUNITIES FOR SUSTAINABLE AND ECONOMICAL CONCRETE-This study presents the information about the opportunities for sustainable and economical concrete. Applications of foundry sand, which is technically, sound, environmentally safe for sustainable development. Use of foundry sand in various engineering applications can solve the problem of disposal of foundry sand and other purposes. Foundry sand consists primarily of silica sand, coated with a thin film of burnt carbon, residual and dust. Foundry sand can be used in concrete to improve its strength and other durability factors. Foundry Sand can be used as a partial replacement of cement or as a partial replacement of fine aggregates or total replacement of fine aggregate and as supplementary addition to achieve different properties of concrete.

5. (Jayesh kumar Pitroda, et al. 2013)
INNOVATIVE IDEAS FOR MANUFACTURING OF THE GREEN CONCRETE BY UTILIZING THE USED FOUNDRY SAND AND POZZOCRETE-This paper presents the results obtained of the concrete having mix proportion 1:1.48:3.21 in which cement is partially replaced by Pozzocrete P60 as 30% by weight of cement; and fine aggregate is partially replaced by used foundry sand obtained from ferrous and non-ferrous metal casting industries as 10%, 30% and 50% by weight of fine aggregate. For this study, five sets of mixture proportions were made. First (A0) were the standard mix containing no Pozzocrete and no used foundry sand, with regional fine aggregate and coarse aggregate. Second mix (C0) contained 30% Pozzocrete P60 as a replacement of cement. Other mixes (C1, C2 and C3) contained Pozzocrete P60 (30%) plus used foundry sand (10%, 30% and 50%) respectively. The compressive strength of each sample is carried out at 7, 14 and 28 days. The water absorption test is also carried out at 28 days. This research was performed to achieve technical, ecological and economic benefits by utilizing the huge amounts of used foundry sand.In the present work, experimental investigations were performed to study of properties of fresh concrete using replacement of fine aggregate with foundry sand. Foundry sand is replaced by 10%, 20%, 22%, 24%, 26%, 28%, 30% & 40% by weight of fine aggregates.M20 grade of concrete is designed & test are taken for compressive strength, Flexural strength & Split tensile strength for 7 & 28 days curing period.

III. Problem Definition and Objective

To study of partial replacement of fine aggregate by waste cast iron foundry sand. To reduce use of natural sand .

- To check the flexural & torsion strength of RCC beam.
- To overcome the disposal problem of industrial waste.
- Reduce the construction cost.

IV. PRACTIAL Analysis

A. The dimensions of Casted Beam
Dimension of the Beam:

700mm*150mm*150mm

B .The properties of the material:
1. Fine Aggregate
Locally available free of debris and nearly riverbed sand is used as fine aggregate. The sand particles should also pack to give minimum void ratio, higher voids content leads to requirement of more mixing water.
Test on Fine Aggregate
Fine aggregate: conforming to zone II of IS 383
silt content= 8%
Specific gravity= 2.53
Water absorption= 1.6 %
silt content of foundry sand=8.8 %
2. Coarse Aggregate
The crushed aggregates used were 20mm maximum size and are tested as per Indian standards and results are within the permissible limit.
Test on coarse aggregate:
Specific gravity= 2.81
Water absorption= 0.23%
Flakiness index= 6.26%
3. Cement
Ordinary Portland cement of 53 grade is used.
Cement Company: Birla Shakti.
Table No. 4.1: Initial setting time and final setting time of the cement sample

Sr. No.	Initial Setting Time		Final Setting Time	
	Time in min.	Penetration in mm	Time in min.	Penetration in mm
1.	53	34	293	0

Fig no. 4.1: Apparatus for initial & final setting time

4. Water
Potable Water available conforming to the requirements of water for concreting and curing as per IS: 456-2000.
5. Foundry Sand
The foundry sand will be collected from M.I.D.C. (PRAJAPATI CASTING INDUSTRY), Bhosari, Pune.
6. Steel
Using 6mm and 10mm diameter bars.
Water cement ratio
Maximum water cement ratio is W/c ratio = 0.55.
Assuming water cement ratio = 0.46<0.55.
Selection of water content form table 2 (35).
Maximum water cement ratio = 197lit.

Water cement ratio = 0.46 Hence cement require = 197/0.46= 428.60 kg
450 ≥ 428 hence ok…
Assuming zone – II sand (Table NO.3 in IS 10262)
Hence volume of coarse aggregate/ total aggregate = 0.62
Hence volume of fine aggregate = 1 – 0.62 = 0.38
Volume of cement = 379.16/ (3.15 x 1000) = 0.1204 cu.m
Volume of water = 197/1000
= 0.197 cu.m
Volume of aggregate = 1 - (0.1204+0.197)
= 0.683 cu.m
Hence mass of coarse concrete = 0.683 x 0.62 x 2.76 x 1000 = 1168.75 kg
Mass of fine aggregate = 0.683 x 0.38 x 2.76 x 1000 =716.33 kg
Mix proportion is (1:1.89:3.08:0.52)
For 1 m^3
Cement = 386.16 kg
Fine aggregate=683.696kg
Coarse aggregate=1136.95kg
Water=1191 lit

For 0.15 x 0.15 x 0.7 m^3
Cement = 9.95kg
Fine aggregate=14.130kg
Coarse aggregate=31.94kg
Water= 4.58 lit

Fig. 5. Views of casting of the Beam

Fig. 6. Views of Flexural Testing of the Beam

Fig. 7. Views of Torsional Testing of the Beam

V. RESULT ANALYSIS

Flexural strength for point load = $\frac{3PL}{2bd^2}$

= $\frac{3X101.75X10^3X700}{2X150X150^2}$

= 31.65 N/mm^2

Torsional strength = load X eccentricity
= 37.80 X 0.137

= 5.07 KN-m

VI. RESULTS AND DISCUSSION

Table No 5.1A Flexural Strength of Conventional Concrete

Sr.no	**Type of concrete**	**Strength in N/mm2**		
		7 Days		
		Load (KN)	**FS (N/mm^2)**	
1	R.C.C.	101.75	31.65	33.9
2		98.2	32.73	
3		105.17	35.05	

Table No 5.1B Flexural Strength of Conventional Concrete

Sr.no	**Type of concrete**	**Strength in N/mm2**		
		28 Days		
		Load (KN)	**FS (N/mm^2)**	
1	R.C.C.	105.1	35.04	35.21
2		101.7	33.9	
3		110.13	36.71	

Table No 5.1C Flexural Strength of Conventional Concrete

Sr.no	**Type of concrete**	**Strength in N/mm2**		
		56 Days		
		Load (KN)	**FS (N/mm^2)**	
1	R.C.C.	108.56	36.18	36.43
2		103.2	*34.4*	
3		116.17	38.72	

Table No 5.2A Torsional Strength of Conventional Concrete

Sr.no	Type of concrete	Eccentricity (m)	Strength in KN-m		
			7 Days		
			Load (KN)	TS(KN-m)	
1	R.C.C.	0.137	37.8	5.07	4.82
2			35.45	4.85	
3			33.15	4.54	

Table No 5.2B Torsional Strength of Conventional Concrete

Sr.no	Type of concrete	Eccentricity (m)	Strength in KN-m		
			28 Days		
			Load (KN)	TS(KN-m)	
1	R.C.C.	0.137	58.25	7.98	7.89
2			57.6	7.89	
3			57.65	7.81	

Table No 5.2C Torsional Strength of Conventional Concrete

Sr.no	Type of concrete	Eccentricity (m)	Strength in KN-m		
			56 Days		
			Load (KN)	TS (KN-m)	
1	R.C.C.	0.137	60.15	8.24	8.24
2			59.75	8.18	
3			60.7	8.31	

Table No 5.3A Flexural Strength of Waste Foundry Sand Concrete

Sr.no	Various proportion of waste foundry sand	Strength in N/mm²		
		7 Days		
		Load (KN)	FS (N/mm²)	
1	10%	100.1	31.14	31.49
		101.55	31.59	
		102.05	31.75	
2	20%	108.85	33.86	33.9
		108.95	33.89	
		109.15	33.96	
3	30%	110.7	34.44	34.62
		111.35	34.64	
		111.8	34.78	

Table No 5.3B Flexural Strength of Waste Foundry Sand Concrete

Sr.no	Various proportion of waste foundry sand	Strength in N/mm3		
		28 Days		
		Load (KN)	FS (N/mm2)	
1	10%	104.75	32.59	32.68
		105.1	32.7	
		105.25	32.74	
2	20%	111.45	34.67	34.79
		111.8	34.78	
		112.2	34.91	
3	30%	115.65	35.98	36.09
		116.05	36.1	
		116.3	36.18	

Table No 5.3C Flexural Strength of Waste Foundry Sand Concrete

Sr.no	Various proportion of waste foundry sand	Strength in N/mm4		
		56 Days		
		Load (KN)	FS (N/mm2)	
1	10%	109	33.91	33.94
		108.95	33.89	
		109.35	34.02	
2	20%	114.65	35.67	35.77
		114.9	35.75	
		115.35	35.89	
3	30%	119.7	37.24	36.52
		120.25	37.41	
		120.65	37.54	

Table No 5.4A Torsional Strength of Waste Foundry Sand Concrete

Sr.no	Various proportion of waste foundry sand	Eccentricity (m)	Strength in KN-m		
			7 Days		
			Load (KN)	TS (KN-m)	
1	10%	0.137	46.15	6.32	6.33
			46.5	6.37	
			45.95	6.29	
2	20%	0.137	48.55	6.65	6.44
			45.7	6.26	
			46.75	6.4	
3	30%	0.137	47.65	6.52	6.54
			48.55	6.65	
			47.1	6.45	

Table No 5.4B Torsional Strength of Waste Foundry Sand Concrete

Sr.no	Various proportion of waste foundry sand	Eccentricity (m)	Strength in KN-m		
			28 Days		
			Load (KN)	TS (KN-m)	
1	10%	0.137	65.75	9.01	9.25
			67.15	9.2	
			69.8	9.56	
2	20%	0.137	73.5	10.07	10.1
			74.1	10.15	
			73.65	10.09	
3	30%	0.137	77.5	10.62	10.44
			74.65	10.23	
			76.35	10.46	

Table No 5.4C Torsional Strength of Waste Foundry Sand Concrete

Sr.no	Various proportion of waste foundry sand	Eccentricity (m)	Strength in KN-m		
			56 Days		
			Load (KN)	TS (KN-m)	
1	10%	0.137	68.25	9.35	9.67
			70.05	9.6	
			73.35	10.05	
2	20%	0.137	78.1	10.7	11.05
			81	11.1	
			82.85	11.35	
3	30%	0.137	86.5	11.85	12.17
			89.05	12.2	
			90.85	12.45	

Table No. 6.1 Flexural Strengths for Different Combinations

S.N.	Details of % replacement of fine aggregate by foundry sand	7 Days strength (N/mm²)	28 Days strength (N/mm²)	56 Days strength (N/mm²)
1.	Normal M30 Grade Concrete	33.92	35.04	36.58
2.	10%	31.49	32.68	33.94
3.	20%	33.9	34.79	35.77
4.	30%	34.62	36.09	37.4

VII. Conclusion

It is clear from the obtained results that, flexural strength for 30% replacement of fine aggregate is maximum for 56 days strength. The least strength is observed for 10% replacement of waste foundry sand for 7 days. From the result here it can be concluded the out of the three combinations selected in this study 30% replacement result of flexural strength found to be better for all the days as compared to the strength of conventional concrete.
Following chart shows the comparison of flexural strength between conventional concrete and waste foundry sand concrete.

Fig. 6.1 Comparison of Flexural Strength between Normal Concrete and Waste Foundry Sand Concrete

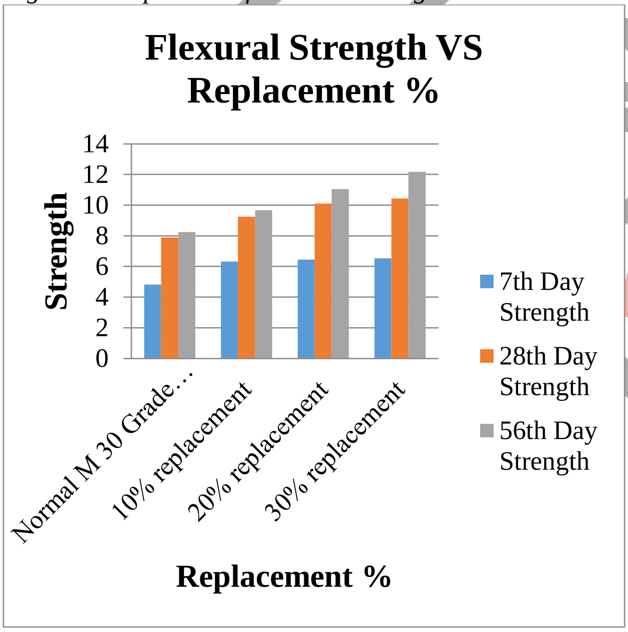
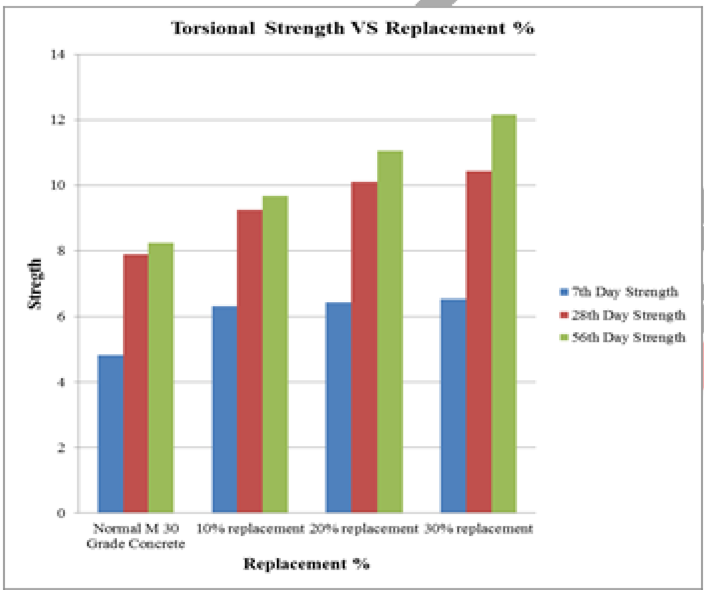


Table No. 6.2 Torsional Strength for Different Combinations

S.N	Details of % replacement of fine aggregate by foundry sand	7 Days strength (KN-m)	28 Days strength (KN-m)	56 Days strength (KN-m)
1	Normal M 30 Grade Concrete	4.82	7.89	8.24
2	10	6.33	9.25	9.67
3	20	6.44	10.1	11.05
4	30	6.54	10.44	12.17

Following chart shows the comparison of torsional strength between conventional concrete and waste foundry sand concrete.



From the obtained results that torsional strength is maximum on superior for all the replacement of waste foundry sand in the concrete and torsional strength is maximum for 56days for 30% replacement of WFS. For all the replacements of WFS results for torsional strength found to be better as compared to conventional concrete.

REFERENCES

[1] Umashankar A, Shashikumarv A, G Narayana, "FLEXURAL BEHAVIOUR OF RC BEAMS USING FOUNDRY SAND AS PARTIAL REPLACEMENT OF FINE AGGREGATE", IJRET: International Journal of Research in Engineering and Technology, Volume: 05 Issue: 08 Aug-2016, ISSN: 2319-1163 | ISSN: 2321-7308.
[2] Pendhari Ankush, Dames Dhananjay, Nikam Madhuri, Karpe Balraj, Khairnar Pramod & Suryawanshi Priyanka, "PARTIAL REPLACEMENT OF SAND BY WASTE FOUNDRY SAND", International Research Journal of Engineering and Technology (IRJET), ISSN: 2395 -0056 Volume: 04 Issue: 05 May -2017.
[3] Adheena Thomas1, Afia S Hameed, "An Experimental Study On Combined Flexural And Torsional Behaviour Of RC Beams", International Research Journal of Engineering and Technology (IRJET) ISSN: 2395-0056 Volume: 04 Issue: 05 May-2017.
[4] Pranita Bhandari & Dr.K. M. Tajne, "Use of Foundry Sand in Conventional Concrete",IJLTET, Vol 6 Issue: 05 Jan 2016.

[5] Xerses N. Irani, Suresh G. Patil, Ramesh Patil, Yuvaraj, Vivekanand S.C., "Utilization of Foundry Waste Sand in the Preparation of Concrete"', IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 12, Issue 6 Ver.III (Nov. - Dec. 2015)
[6] Mahima Ganeshan, Dr. Sreevidya V., Salim P.M., "Waste Foundry Sand as a Replacement for Fine Aggregate in High Strength Solid Masonry Blocks", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 5, Issue 5 May 2016, ISSN : 2319-8753 ISSN : 2347-6710.
[7] Jayachandra, Shashi kumar.A, Sanjith.J, DG.Narayana, "STRENGTH BEHAVIOUR OF FOUNDRY SAND ON MODIFIED HIGH STRENGTH CONCRETE", IJRET: International Journal of Research in Engineering and Technology, eISSN: 2319-1163, pISSN: 2321-7308, Volume: 04, Issue: 05 May-2015.
[8] Vema Reddy Chevuri, S.Sridhar. "Usage of Waste Foundry Sand in Concrete", SSRG International Journal of Civil Engineering (SSRG-IJCE) ,volume 2, Issue 12 December 2015.
[9] Mr.R.D.Koshti , Prof.Pallavi Pasnur, "MODIFICATION OF PLAIN CONCRETE BY REPLACEMENT OF FINE AGGREGATE WITH FOUNDRY SAND. Multidisciplinary Journal of Research in Engineering and Technology, Volume 3, Issue 1, Pg.933-941.
[10] Amitkumar D. Raval, Arti Pamnani, Alefiya I. Kachwala, "FOUNDRY SAND: UTILISATION AS A PARTIAL REPLACEMENT OF FINE AGGREGATE FOR ESTABLISHING SUSTAINABLE CONCRETE, INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY, ISSN: 2277-9655 Scientific Journal Impact Factor: 3.449 (ISRA), Impact Factor: 2.114.
[11] Nithin Kumar A., Sreenivasa Reddy K and Premchand K, "EXPERIMENTAL STUDY OF PARTIAL REPLACEMENT OF WASTE FOUNDRY SAND ON STRENGTH PROPERTIES OF CONCRETE, THE OFFICIAL PUBLICATION OF INTERNATIONAL JOURNAL OF RECENT SCIENTIFIC RESEARCH (IJRSR), ISSN: 0976-3031 Volume: 7(1) January -2016.
[12] Bhosale A. S., Deshmukh M. R., Yachawad N. B., Shinde V. R., Koshti R. D., "REVIEW ON FLEXURAL BEHAVIOUR OF REINFORCED CONCRETE BEAMS USING FOUNDRY SAND", International Journal of Engineering Technology Science and Research, IJETSR, ISSN 2394 – 3386, Volume 5, Issue 3, March 2018.

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