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Analytical and Experimental Studieson Fracture Behaviour of Foundry Sand Concrete

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ABSTRACT
Concrete is a widely used as vital material in the construction world. We can do partial substitution of industrial waste such as foundry sand like material in sand. Foundry sand is not only the economical material also improves the properties of the concrete. Foundry sand has emerged as construction material in its own right. This type of concrete normally contains around (30%, 40%) by mass of total sand materials. It improves the workability, minimizes cracking due to thermal and drying shrinkage, and enhances durability to reinforcement corrosion, sulphateattack, and alkali-silica expansion. Fracture mechanics is the field of mechanics concerned with the study of the formation of cracks in materials. It uses methods of analytical Solid mechanics to calculate the driving force on a crack and those of experimental Solid mechanics to characterize the material's resistance to fracture. J-integral and critical stress intensity factor is the fracture parameter. The fracture parameters calculated in our study are stress intensity factor, Critical j-integral. Three point bending test is used to find the fracture parameter. The study is carried out on beams of grade M20 with 0%, 30%, & 40% foundry sand. The test is conducted for normal beams and pre-cracked beams of having a notch to depth ratio (A/W) of 0.2. This study concludes that the critical j-integral and stress intensity factors increases by comparing the 0%, 30%, 40% foundry sand concrete.

Keywords: Foundry Sand (UFS), NaCl Treated Used Foundry Sand, high quality silica sand and fine aggregate.

I. INTRODUCTION

Concrete is the most widely used man-made product in the world, and is Second only to water as the world's most utilized substance. Slightly more than a ton of concrete is produced each year for every human being on the planet, some six billion tons a year. Concrete is an affordable and reliable material that is applied throughout The infrastructure of a nation's construction, industrial, transportation, defence, utility, and residential sectors. Fundamentally, concrete is economical, strong, and durable. Although concrete technology across the industry continues to rise to the demands of a changing Marketplace, the industry recognizes that considerable improvements are essential in Productivity, product performance, energy efficiency, and environmental performance. The industry will need to face and overcome a number of institutional, competitive, and technical challenges. One of the major challenges, with the environmental awareness and scarcity of space for landfilling, is the wastes/byproductutilization as an alternative to disposal. Throughout the industrial sector, including the concrete industry, the cost of environmental compliance is high. Introduction of use of industrial by-products such as foundry sand, Fly ash, bottom ash, and slag can result insignificant improvements in overall industry energy efficiency and environmental performance.

II. FOUNDRY SAND

A foundry is a manufacturing industry which has a facility to produce metal Castings by pouring molten metal into a preformed mold to yield the resulting hardened cast. The primary metals cast include iron and steel from the ferrous family and aluminum, copper, brass and bronze from the nonferrous family. Foundry sand is high quality silica sand that is a byproduct from the production of both ferrous and nonferrous metal castings. The physical and chemical characteristics of foundry sand will depends upon on the type of casting process and the industry sector. Foundries purchase high quality size-specific silica sands for use in their molding and casting operations. The ferrous foundries (gray iron, ductile iron and steel) produce the most sand. Aluminum, copper, brass and bronze produce the rest. The 3,000foundries in the United States generate 6 million to 10 million tons of foundry sand per year. While the sand is typically used multiple times within the foundry before it becomes a byproduct, only 10percent of the foundry sand was reused elsewhere outside of the foundry industry in 2001.The sands from the brass, bronze and copper foundries are generally not reused. While exact numbers are not available, the best estimate is that approximately 10 million tons of foundry sand can beneficially be used annually. Used foundry sand (UFS) is one of the major issues in the management of foundry waste. UFS are black in color and contain large amount of fines. The typical physical and chemical property of UFS is dependent upon the type of metal being poured, casting process, technology employed, type of furnaces(induction and electric arc) and type of finishing process (grinding, blast cleaning and coating).

Fig: Foundry Sand

III. MATERIALS USED IN EXPERIMENTAL PROGRAM

Cement: For this investigation of strengthening of RCC slender columns using FRP composites, Ordinary Portland Cement (OPC) of 53 grades was used. The physical properties of the cement were conforming to IS 12269 – 1987. The properties of the cement used are shown in the following table 3.1. Tests were made to confirm the specific gravity of the cement. Also the properties noted were the soundness of cement, initial and final setting time of cement and cube compressive strength. All tests were done as per Indian Standards.

Table 4.1 Properties of Cement

Properties	Test Results
Specific Gravity	3.05
Soundness	2mm expansion
Initial setting time	40 minutes
Final setting time	480 minutes

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Aggregates: Course aggregate of 12.5mm size, angular shaped, locally available granite gravel stone were used. The size of the coarse aggregates was maintained by passing 12.5mm sieve and retaining on 10mm sieve conforming to IS 383 – 1970.

Fine aggregates were also of local river sand of size passing through 4.75mm sieve and conforming to zone II as per IS 383 – 1970.

The specific gravity of both fine aggregate and coarse aggregate were found using standard test setup and is shown in following table

Table Specific Gravity of Aggregates

Material	Specific Gravity
Coarse Aggregate	2.72
Fine Aggregate	2.62
Foundry Sand	2.32

Water: According to IS 456 – 2000, potable water and clean in nature was used for casting of concrete. The same specification of water was used for curing of all specimens.

IV. INVESTIGATION METHODOLOGY

Casting of Beams: Plain cement concrete beams of grade M20 prepared with 0%, 30% and 40% foundry sand materials addition, sand is replaced by foundry sand by weight. Single point loading method is used.

Pre Cracking of Beams

- Then a precrack of 30 mm length and 3 mm thick is made at the mid span ofbeam as single edged notched beam by using marble cutter.
- The notch to depth ratio is kept as 0.2.

Figure Pre Cracked Beam

Figure Pre Cracked Beam

Table Mix Proportion for M20 Grade

Water	Cement	Fine Aggregate	Coarse Aggregate
197 Lit/m^3	394 Kg/m^3	637.5Kg/m^3	1150 Kg/m^3
0.5	1.00	1.6	2.92

Figure Experimental Set Up for Beam. (Digital Deflect Meter)

Load(kN)	0% Foundry Sand With Crack	30% Foundry Sand With Crack	40% Foundry Sand With Crack
0	0	0	0
1	0	0.15	0.02
2	0	1.38	0.02
3	0.02	1.38	0.02
4	0.05	1.935	0.075
	0.04	1.965	0.075
6	0.565	2	0.125
7	0.625	2.025	0.125
8	0.635	2.105	0.15
9	0.655	2.18	0.15
10	0.66	2.275	0.17
11	0.66	2.34	0.17
12	0.66	2.425	0.185
13	0.58	2.485	0.185
14	0.57	2.56	0.195
1 5	0.56	2.68	0.195
1 6	0.56	2.81	0.2
17	0.555	2.875	0.2
18	0.555	3.045	0.205
19	0.555	3.08	-
20	0.505	3.16	-
21	0.5	-	-

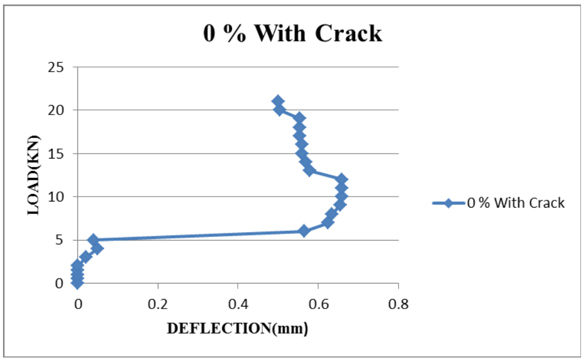

Figure Load Vs. Deflection Curves 0% With Crack

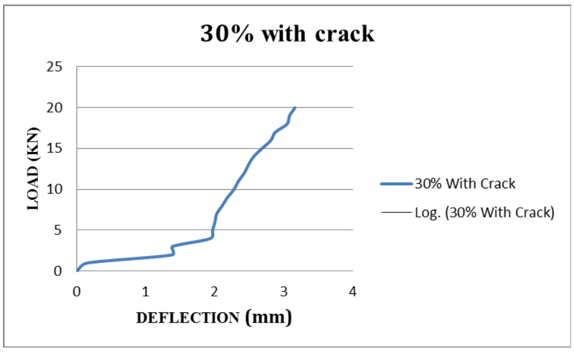

Figure Load Vs. Deflection Curves 30% With Crack

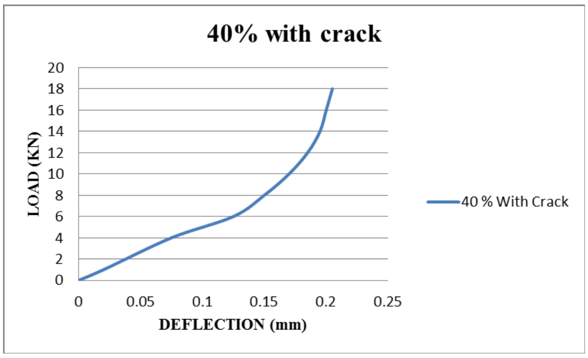

Figure Load Vs. Deflection Curves 40% with Crack

Load(kN)	0% Foundry Sand Without Crack	30% Foundry Sand Without Crack	40% Foundry Sand Without Crack
0	0	0	0
1	0.18	1.12	0.125
2	0.19	1.235	0.13
3	0.21	1.305	0.115
4	0.24	1.92	0.145
5	0.26	1.96	0.22
6	0.3	2.05	0.44
7	0.32	2.18	0.895
8	0.36	2.59	0.885
9	0.39	2.76	0.86
10	0.42	2.8	0.855
11	0.44	2.835	0.85
12	0.46	2.845	0.85
13	0.46	2.86	0.85
14	0.46	2.86	0.85
15	0.46	2.875	0.855
16	0.46	2.875	0.855
17	0.46	2.875	0.855
18	0.46	2.875	0.855
19	0.46	2.875	0.855
20	0.46	2.875	0.855
21	0.46	2.885	0.865
22	0.46	2.885	0.875
23	0.46	2.9	0.875
24	0.46	2.9	0.88
25	0.46	2.91	-
26	0.46	2.91	-
27	0.46	2.92	-
28	0.475	2.92	-
29	0.475	2.93	-
30	0.475	2.93	-
31	0.475	2.945	-
32	0.475	2.945	-
33	0.475	2.96	-
34	0.475	2.96	-
35	0.475	2.91	-
36	0.475	2.91	-
37	0.475	-	-
38	0.475	-	-
39	0.475	-	-
40	0.49	-	-
41	0.49	-	-

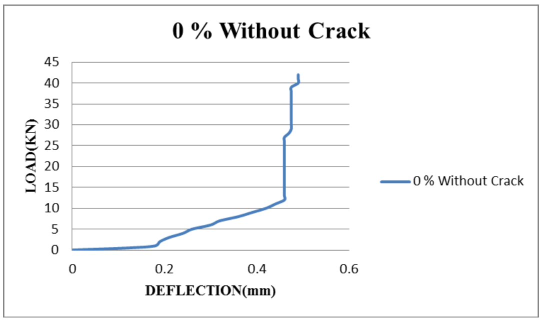

Figure Load vs. Deflection Curves 0% Without Crack

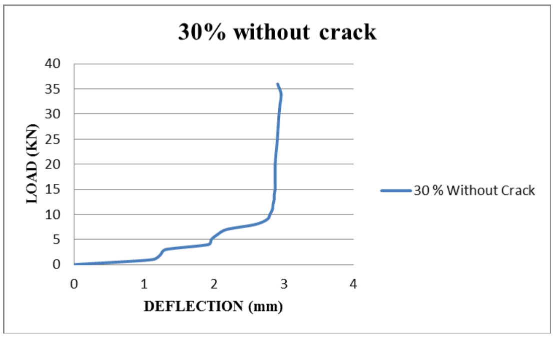

Figure Load vs. Deflection Curves 30% without Crack

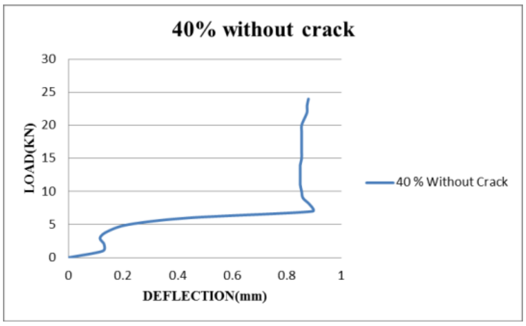

Figure Load Vs. Deflection Curves 40% Without Crack

Si.No	Specimen	Notch To Depth	Ultimate Load Kn	Critical Jintegral	Critical Stress Intensity
1	Control Speciemen With Crack	0.2	2.37	0.000161	1.9604
2	Control Speciemen	-	4.54	0.000573	3.6946
3	30%Foundry Sand Replacement	0.2	2	0.000104	1.5834
4	30%Foundry Sand Replacement	-	3.6	0.000363	2.9404
5	40%Foundry Sand Replacement	0.2	2	0.000104	1.5834
6	40%Foudry Sand Replacemet	-	2.5	0.000173	2.0358

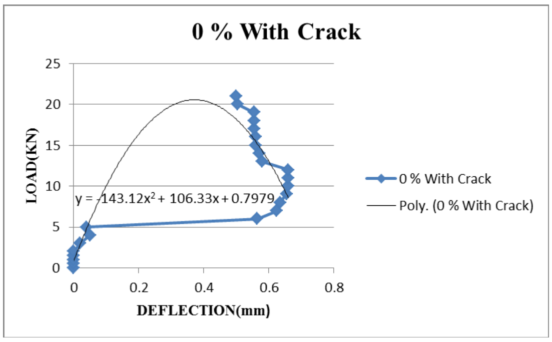

Figure Load vs. Deflection Curve 0% With Crack

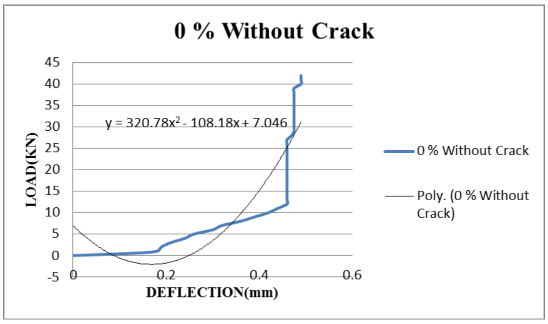

Figure Load vs. Deflection Curve 0% without Crack

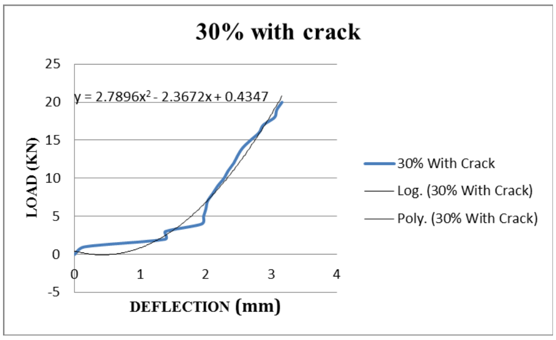

Figure Load Vs. Deflection Curve 30% With Crack

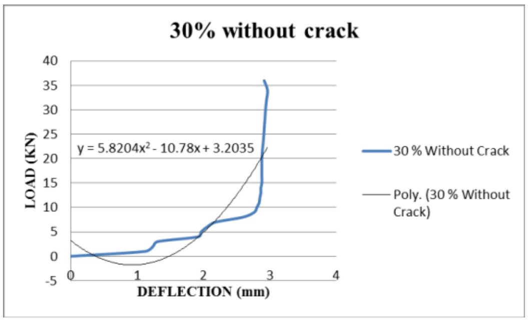

Figure Load vs. Deflection Curve 30% without Crack

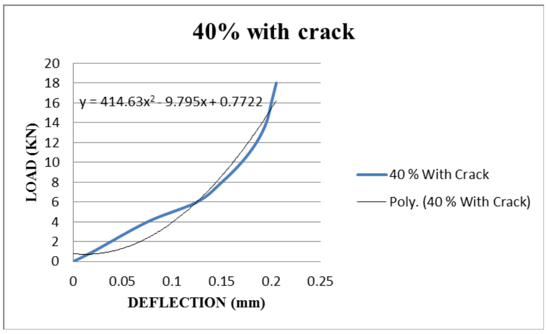

Figure 6.11 Load vs. Deflection Curve 40% with Crac

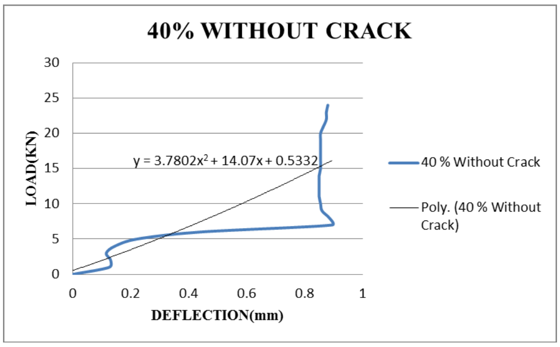

Figure Load Vs. Deflection Curve 40% Without Crack

S. NO	SPECIMEN	NOTCH TO DEPTH	ULTIMATE LOAD kN	CRITICAL JINTEGRAL	CRITICAL STRESS INTENSITY
1	CONTROL SPECIMEN WITH CRACK	0.2	2.37	0.0019	6.65
2	CONTROL SPECIMEN	-	4.54	0.00064	3.86
3	30%FOUNDRY SAND REPLACEMENT	0.2	2	0.00359	9.14
4	30%FOUNDRY SAND REPLACEMENT	-	3.6	0.00239	7.461
5	40%FOUNDRY SAND REPLACEMENT	0.2	2	0.000203	2.17
6	40%FOUNDRY SAND REPLACEMENT	-	2.5	0.00134	5.586

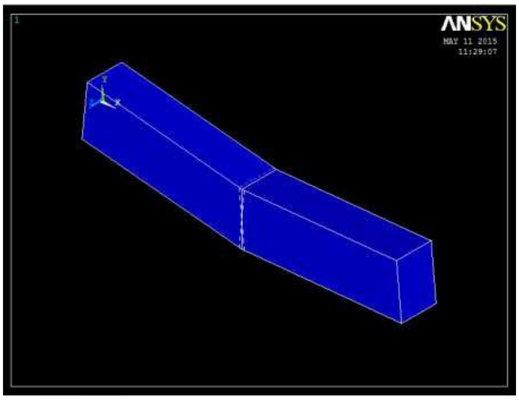

Figure Fracture Beam

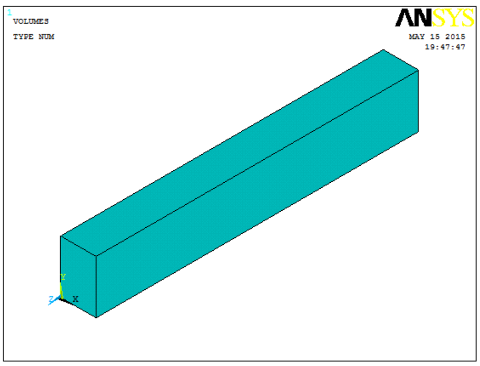

Figure Normal Beam

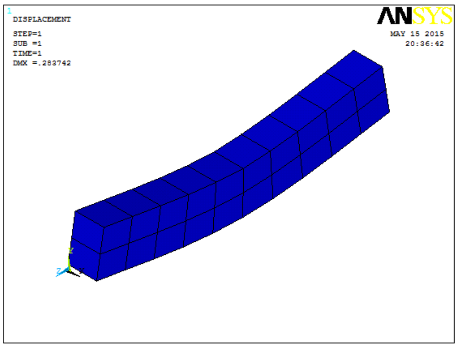

Figure Deflection In Beam

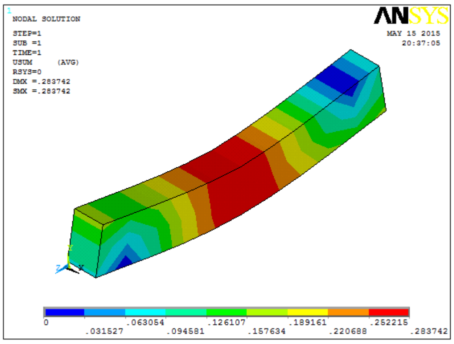

Figure Deformation In Beam

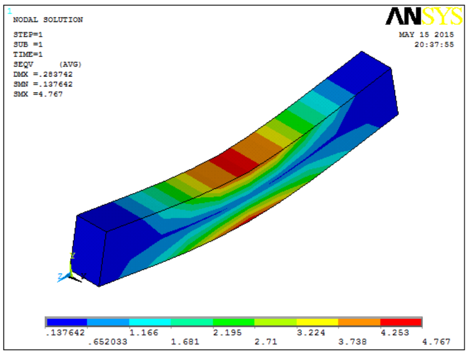

Figure Beam Stress

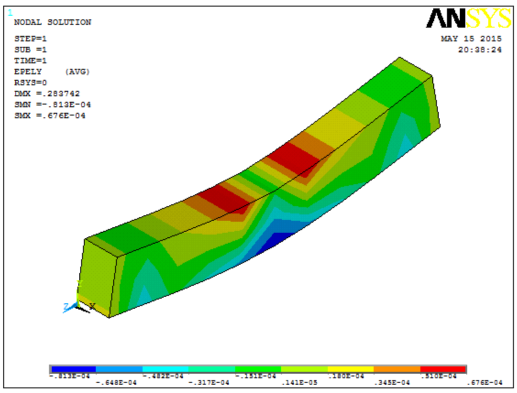

Figure Beam Strain

V. CONCLUSIONS

The following conclusions were drawn based on experimental investigations carried and the results obtained. They are as follows,

- The fracture parameter critical j-integral and critical stress intensity factors was evaluated for normal M20 concrete and foundry sand concrete subjected to the condition that notch to depth ratio is 0.2.
- From the testresult, the rupture load of the specimens calculated, rupture load of the specimens decreased with the increment of foundry sand.
- The failure loadincreases with the increase in the strength of concrete and hence results in higher JIC.
- 21 KN, 20 KN, 18 KN are the maximum rupture load of 0%,30% foundry sand, 40% foundry sand with crack specimens .
- 42 KN, 36 KN, 24 KN are the maximum rupture load of 0%, 30%, 40% foundry sand without crack specimens.
- 0.000161, 0.000573, 0.00010, 0.000363, 0.000104, 0.000173 Mpa mm are Critical j-integral value of 0%. 30%, 40% Foundry sand specimen for notch depth ratio is 0.2 by analytical method.
- 1.9604, 3.6946, 1.5834, 2.9404, 1.5834, 2.0358are critical stress intensity factors value of 0%. 30%, 40% Foundry sand specimen at for notch depth ratio is 0.2 by analytical method.
- 0.0019, 0.00064, 0.00359, 0.00239, 0.000203, 0.00134 Mpa mm are Critical integral value of 0%. 30%, 40% Foundry sand specimen for notch depth ratio is 0.2 by experimental method.
- 6.65, 3.86, 9.14, 7.461, 2.17, 5.586Mpamm are critical stress intensity factor value of 0%. 30%, 40% Foundry sand specimen at for notch depth ratio is 0.2 by experimental method.
- On comparing with 0% for 30%, 40% a/w=0.2 has been absorbed that materials behaves in brittle manner leads to sudden failure.

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