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A Study of Corrosion Behaviour based on Flexural Strength

[1]Syed Sohailuddin, [2] Mirza Affan Baig, [3]Riya Dey, [4]Abdul Mohsin, [5]Simran Goswami, [6]Mohd. Faizan, [7]Mohd. Tanweer Alam.

[1, 2, 3, 4, 5, 6, 7]*Civil Engineering Department, Anjuman College of Engineering and Technology, Nagpur.*

Abstract: Flexure is commonly encountered in structural elements such as beams and slabs, which are transversely loaded. Flexural strength is a measure of a resistance against failure in bending. In coastal environment reinforcement, corrosion is an obvious cause of deterioration of concrete structures, which affects the durability, and service of reinforced concrete beams. The general objective of this work is to study the effect of reinforcement corrosion on the flexural strength of reinforced concrete beams. Accelerated corrosion technique using 5%Nacl and impressed current were adopted to corrode the beam experimentally. Beam specimens are prepared using M25 grade concrete for Portland Pozzolana Cement (PPC). Beam specimens casted are tested as vertical beam in normal loading setup and load deflection behaviour is studied. In general, the corroded beam has lesser load carrying capacity and higher deflection then conventional beams.

Keywords: Corrosion, Flexural Strength, Portland Pozzolana Cement, Load deflection.

I. INTRODUCTION

Flexure or bending is commonly encountered in structural elements such as beams and slabs which are transversely loaded. Flexural strength is measure of the tensile strength of PPC concrete, in other words it is a measure of a resistance against failure in bending. Although the probability of the structures being flexure deficient is low, failures have occurred due to a variety of factors: errors in design calculations and improper detailing of reinforcement, construction fails or poor construction practices, changing the function of a structure from a lower service load to a higher service load, seismic and wind action, reduction or total loss of reinforcement steel area causing the corrosion in service environments.

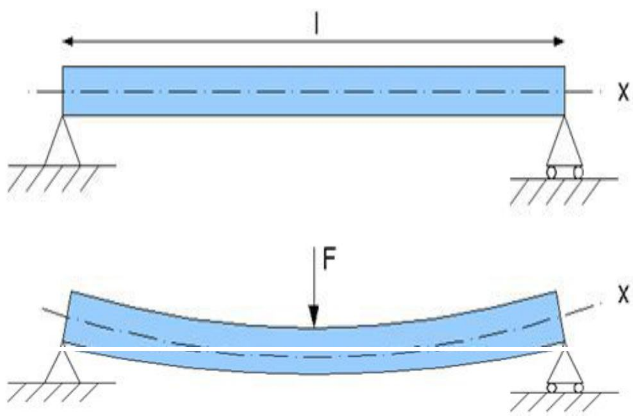

Fig.1 Deflection of beam.

A. Corrosion

Corrosion is caused by the destructive attack of chloride ions penetrating by diffusion or other penetration mechanisms from the outside, by incorporation into the ppc concrete mixture, by carbonation of the cement cover, or their combination. Carbonation of concrete or penetrations of acidic gases into the concrete causes of reinforcement corrosion. Besides these there are few factors, some related to the concrete quality, such as w/c ratio, cement content, impurities in the concrete ingredients, presence of surface cracking, etc. and others related to the external environment, such as moisture, bacterial attack, stray currents, etc., which affect reinforcement corrosion. Uncontaminated cover concrete provides a physical barrier that prevents the direct exposure of the steel surface to the outside environment. It also provides a highly alkaline chemical environment that protects steel from corrosion.

Corrosion of steel reinforcing bars is an electrochemical process that requires a flow of current and several chemical reactions.

The three essential components of a galvanic corrosion cell are

1) Anode
2) Cathode
3) Electrolyte

The general relationship between components of a corrosion cell is illustrated in the figure 2

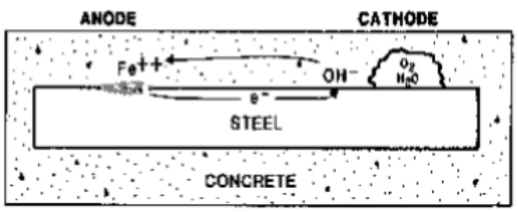

Fig.2 Electro chemical Corrosion Cell

The anode and cathode can be on the same steel reinforcing bar. The anode is the location of the steel reinforcing bar where corrosion is taking place and metal is being lost. At the anode, the iron atom lost electrons to become iron ions (Fe+2).This oxidation reaction is referred to as the anodic reaction. The cathode is the location on a steel reinforcing bar where metal is not consumed. At the cathode, oxygen, in the presence of water, accepts electrons to form hydroxyl ions (OH). This reduction reaction is referred to as the cathode reaction. The electrolyte is the medium that facilitates the flow of electrons (electric current) between the anode and the cathode. Both the anodic and cathode reactions are necessary for the corrosion process to occur and they need to take place concurrently

B. Factors Affecting the Corrosion Rate:

Factors influencing the corrosion rate of steel reinforcing bars embedded in the concrete include

1) Availability of water and oxygen
2) Ratio of steel surface area at the anode to that at the cathode
3) Amount of chloride ions in pore water
4) Resistivity of concrete
5) Temperature
6) Relative humidity
7) Concrete micro structure

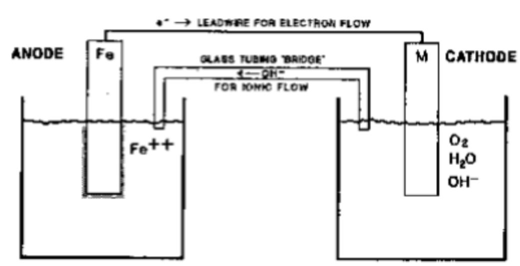

Fig.3 Corrosion Cell in Reinforced Concrete.

C. Corrosion Control Measures

Corrosion-induced deterioration of reinforced concrete structures occurs when the environmental loading on the structure is greater than the ability of the structure to resist the environmental resistance. The main deterioration mechanism (chloride-induced corrosion of rebar) focuses on there in reinforcement and its protection. Corrosion can also occur as are sult of other deterioration processes: freeze-thaw cycles, expansive reactions, excessive deflections, fatigue, etc. These processes cause the concrete to crack, which subsequently allows water and chlorides easy access to the interior of the concrete and the steel reinforcing bars.

II. LITERATURE REVIEW

A. IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320- 334X, Volume 11, Issue 4 Ver. II (Jul- Aug. 2014), PP 98-109 by Naga Chaitanya. C and Vamsi Krishna. B

In this study, reinforced concrete beams are normally designed as under reinforced to provide ductile 2292behaviour such as the tensile moment of resistance. In coastal environment reinforcement corrosion is an obvious cause of deterioration of concrete structure, which affects the durability and service of reinforced concrete structure. The corrosion was measured using Applied Corrosion monitoring instrument. Beam specimens are prepared using M20 grade concrete for OPC. Beam specimens casted are Tested as vertical cantilever beam in specially prepared loading setup and load deflection 2292behaviour is studied.

B. International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 IJERTV5IS020611 Vol. 5 Issue 02, February-2016

By K. Venkateswara Rao, B. Devi Pravallika and K. Phani Krishna.

The main aim of this study is to investigate and compare the flexural strength and theoretically estimated steel loss of corroded and un corroded reinforced concrete beams replaced with 0%, 10%, 20%, 30% fly ash with cement respectively. Accelerated corrosion technique using 5%Nacl and impressed current were adopted to corrode the beam experimentally. The important factors that influence the test results are grade of the concrete and percentage replacement of fly ash. At 10% replacement of fly ash there is a much reduction in the steel loss and as the replacement increases there is a little reduction in steel loss and considerable change in flexural strength.

C. International Journal of Innovations in Engineering and Technology(IJIET) ISSN: 2319-1058 Vol.5 Issue 01 February 2015

By S Tejaswi and J Eeshwar Ram.

In this study, reinforced cement concrete is a general material which is widely used for various types of constructions and structural elements. For the efficient use of RCC it is necessary to know the properties and the behaviour of RCC elements under various constrains. To estimate and analyse the basic properties and behaviour of RCC an experimental study is needed. In the present study an experiment in which flexural behaviour of RCC under various constrains was the major criteria. For the experimental analysis simply supported beams of under reinforced, balanced and over reinforced sections are considered. When the beam is simply supported and is subjected to some external loading the corresponding deflections are examined such that the flexural behaviour of the RCC beams of under reinforce, balanced and over reinforced sections analysed. In order to study the flexural behaviour of any material one had need some basic constant conditions as their limitations. In the present study stress-strain behaviour of Concrete and steel are taken as a base and the flexural behaviour of the material in various fibres.

III.EXPERIMENTAL PROGRAM

The experimental program consists of the following steps

1) Testing of materials
2) Mix design
3) Casting
4) Curing
5) Accelerated corrosion technique
6) Testing

A. Testing of Materials.

The constituent materials used in this investigation were procured from local sources. These materials are required by conducting various tests. From the test results obtained we selected the type of materials we are using which include cement, brick powder, coarse aggregate, fine aggregate, quarry dust, water, sulphuric acid.

1) *Cement:* Ordinary Portland cement of C53 grade conforming to both the requirements of IS: 12269 and ASTMC 642-82type-I was used. From the test results obtained the conventional concrete can be designed according to IS10262-82(Mix design Code). Finally M25 Grade concrete is designed.

Physical Properties

Color –Grey

Specific gravity -3.15

Specific surface area (cm^2/g)- 3540

2) *Coarse Aggregate:* Normal aggregate that is crushed blue granite of maximum size 20mm was used as coarse aggregate. The size of the coarse aggregates used ranges between 12.5 mm to 20 mm of specific gravity 2.44.
3) *Fine Aggregate:* Well graded river and passing through 4.75mm was used as fine aggregate. The sand was air-dried and sieved to remove any foreign particles prior to mixing. For fine aggregates, uncrushed locally available natural river sand of maximum size 2.36mm with a fineness modulus of 3.35 and specific gravity of 2.43 was used.
4) *Water:* Ordinary potable tap water was used for mixing and curing.
5) *Reinforcement:* Steel bars of Fe 500 grade was used for reinforcement. The Fe415 steel has been used as the shear reinforcement.

B. Mix Design.

Mix design is the one of the most important step to be considered in any experimental program dealing with concrete. In this study we considered M20 grade concrete. The porosity of the concrete mainly depend upon the grade of the concrete, richer the mix higher the strength and durability.

1) Mix proportions

Table I Mix proportions.

Mix	Cement	Fine aggregate	Coarse aggregate	Water
M25	383.16 kg/m3	666.792 kg	1004.3 kg	191.58 lit.
	1 m3	1.74	2.62	0.5

C. Casting

180mm × 230mm ×700mm size beam specimens were cast for optimum mix proportion obtained for both M25 grade of concrete. Concrete were placed in the well lubricated mould and compacted and the specimens were left at room temperature for 24hrs

Fig.4 Moulds during casting.

D. Curing

Curing is done by laying Jute sack before testing.

Fig.5 Curing of beams.

E. Accelerated Corrosion Process.

In this experiment the electrochemical corrosion technique is using to accelerate the corrosion of steel bars embedded in the specimens. To simulate the corrosion process, direct current is impressed on the bar embedded in the specimens using an Thyristor based full wave bridge Rectifier system incorporating a small direct current power supply with an in-built ammeter with an output of 8 volts to monitor the current. After specimens were immersed in a 5.0 % NaC1 solution for a day to ensure full saturation

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condition, the direction of current was arranged so that the steel bars in the specimens served as the anode. The stainless steel plate used as a cathode was placed along the length of beam. This arrangement ensured a uniform distribution of the corrosion current along the whole length of the bar.

Fig.6 Accelerated corrosion process setup.

Fig.7 Corroded beam.

F. Testing

1) *Flexural strength test:* Here 18 beams are tested after completion of curing and for 28 days under UTM with a loading rate ranging from 1.2 N / (mm^2/min) to 2.4 N/ (mm^2/min).

Fig.8 Universal testing machine.

G. Estimation of Steel Loss

The applied potential was regularly monitored and adjusted if required time to time during the ongoing test. The current inflow in the different was measured with a multi-meter and the estimated steel loss was calculated as per faraday's law for determination of degree of induced corrosion in different beams.

$\Delta w = MIT/FZ$

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Where Δw = mass of steel loss (in grams)
I = current (amperes)
t = time (seconds)
F = Faraday's constant (96,500 amperes seconds)
Z = valency of Fe (2)
M = atomic mass of Fe (56 grams/ mole)

Fig.9 Steel loss estimation setup.

IV. RESULTS AND DISCUSSIONS.

A. *Flexural Strength Results*

Beam Specimen	Ultimate load (kN)	Average Ultimate load (kN)	Deflection (mm.)	Average Deflection (mm.)	Flexural Strength (N/mm^2)	Average Flexural Strength (N/mm^2)
7 days Conventional	126.30	127.77	2.4	2.44	6.63	6.70
	127.40		2.3		6.69	
	129.60		2.62		6.80	
28 days conventional	150.2	152.30	0.77	0.77	7.89	7.99
	150.2		0.77		7.89	
	156.5		0.77		8.21	
7 days corrosion	103.40	105.64	0.09	0.14	5.43	5.54
	108.30		0.15		5.68	
	105.20		0.18		5.52	
28 days corrosion	128.30	131.2	1.31	3	6.73	6.88
	138.00		3.28		7.24	
	127.10		4.41		6.67	

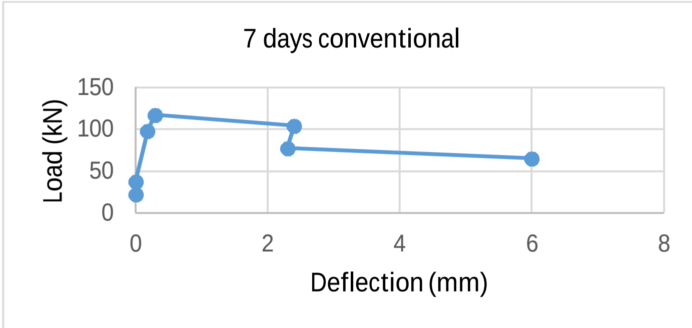

Fig.10 Load vs Deflection for 7 days conventional.

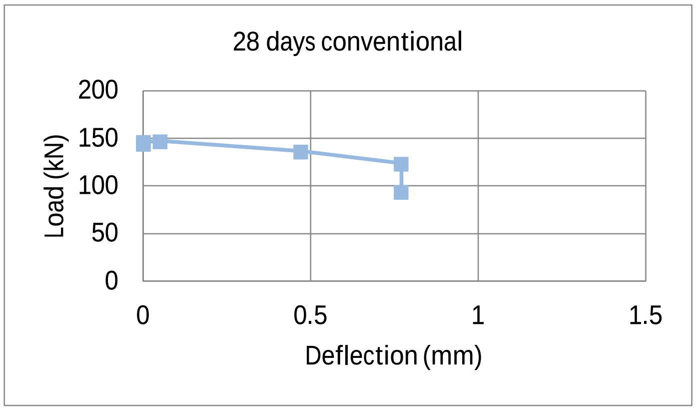

Fig.11 Load vs Deflection for 28 days conventional.

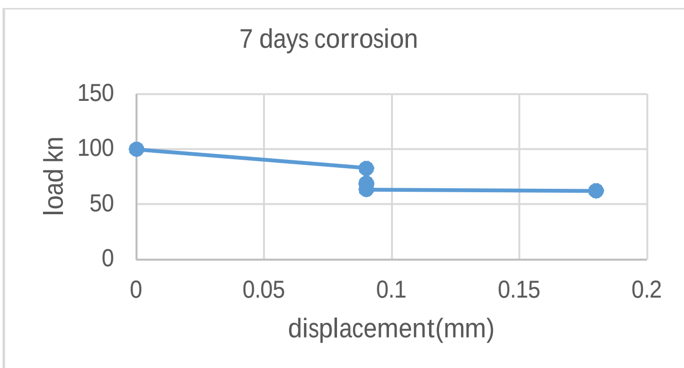

Fig.12 Load vs Deflection for 7 days corrosion.

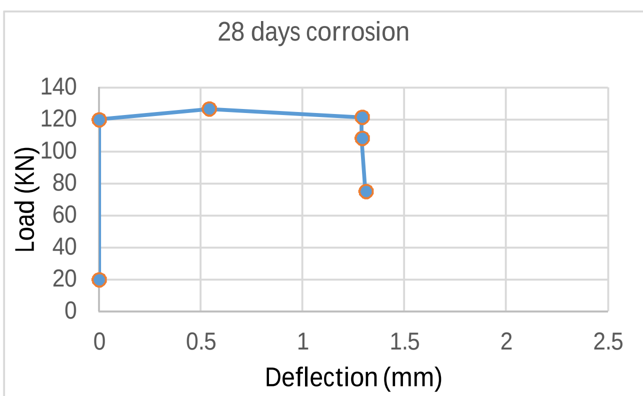

Fig.13 Load vs Deflection for 28 days corrosion.

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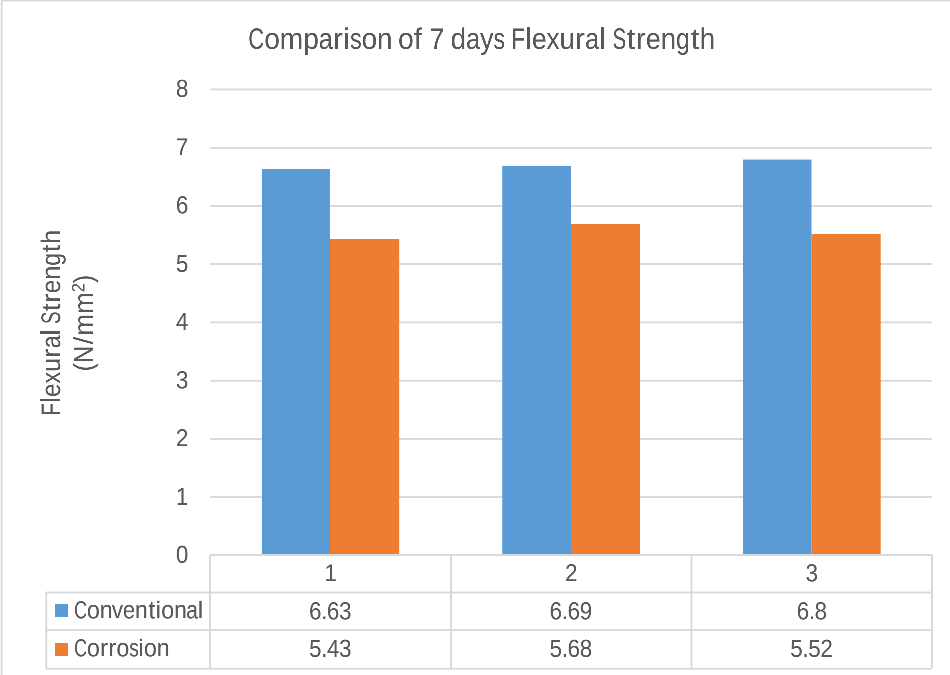

Fig.14 Comparison of 7 days Flexural Strength

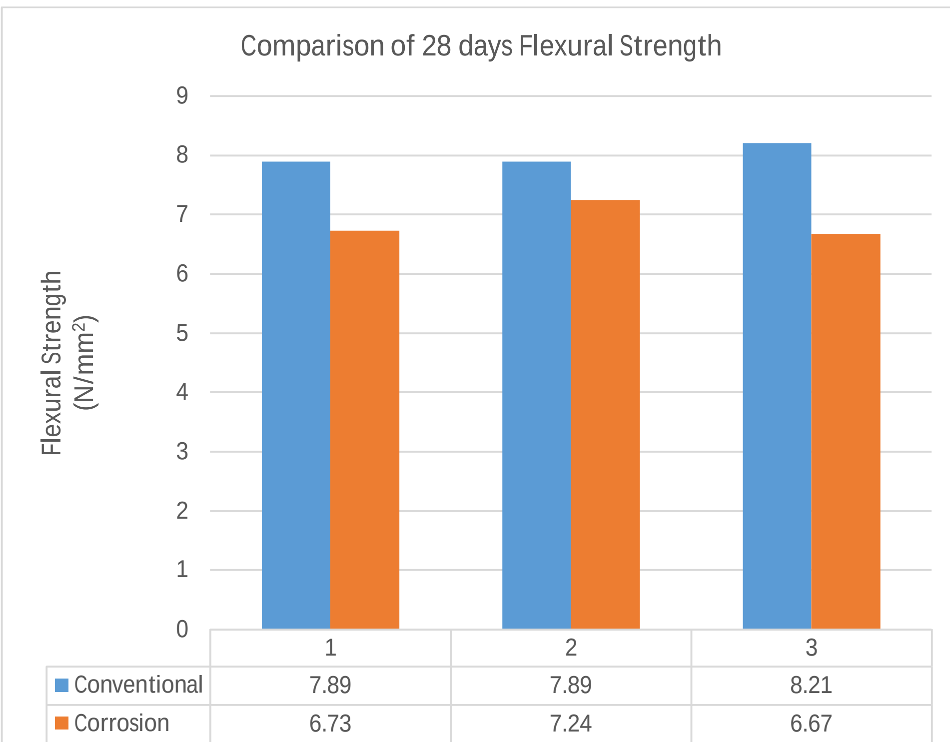

Fig.15 Comparison of 28 days Flexural Strength

The observations are-

1) The conventional 7 days testing beams have high load taking capacity as well higher deflection than 7 days corroded beam.
2) The 28 days conventional beam have higher load taking capacity and lesser deflection compared to 28 days corroded beam.
3) The corroded beam will have lesser load carrying capacity and higher deflection then conventional beams in general.

B. *Estimation of Steel Loss*

Table II. Steel loss during 7 days of Corrosion

DAYS	Voltage (volts)	Current (Amps)	Steel Loss (gms.)
0	8	5	0
3	8	6.2	7.77
6	8	9.2	23.06

Table III. Steel loss during 28 days corrosion

Days	Voltage (volts)	Current (Amps)	Steel Loss (gms.)
0	8	5	0
4	8	5.6	9.35
8	8	6.2	20.72
12	8	6.8	34.09
16	8	7.6	50.8
20	8	8.6	71.86
24	8	9.2	92.25
28	8	10.2	119.3

Steel loss is one of the measure of strength of corrosion. Based on the above results we can judge that time and current are directly proportional to the steel loss i.e. as time increases current goes on increasing and there is increase

In the reduction of the steel, we also noticed that after certain amount of time there is not much change in the current and despite the circuit closed there is a certain amount of change in steel loss on higher side.

V. CONCLUSIONS.

By completion of our experimental study, we conclude these following points:

1) From the flexural strength and theoretically estimated steel loss values, we can conclude that in conventional beams, the strength is gained after 7 days and in corroded beams, the corrosion comes into play after 7 days and tamper the strength there after.
2) The corroded beam will have lesser load carrying capacity and higher deflection then conventional beams in general.
3) The number of cracks developed is more in case of Conventional Beams as that of Corroded Beams, but as the rate of corrosion increases the crack width increases in Corroded Beams than in Conventional Beams.
4) Poor workmanship gives ultimate results in the form of failure but corrosion is time consuming and deadly and its failure is mostly uncertain.

A. Scope for Future Work

1) Tests should be carried out on different grades of concrete to study their effects on strength.
2) Tests should be carried out on different beam sizes to verify the accuracy of the proposed method and to observe the size effect.
3) Study should be carried out in different exposure conditions such as, natural corrosion and sea corrosion, to study the effect of corrosion on strength and durability aspects of structures.
4) Tests should be conducted with new corrosion resistant materials to be applied on steel reinforcement which are cheap and reliable.

VI. ACKNOWLEDGEMENT

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REFERENCES

[1] IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 11, Issue 4 Ver. II (Jul- Aug. 2014), PP 98-109 www.iosrjournals.org by Naga Chaitanya and Vamsi Krishna.

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[3] International Journal of Innovations in Engineering and Technology (IJIET) ISSN: 2319-1058 Vol.5 Issue 01 February 2015

[4] By S Tejaswi and J Eeshwar Ram.

[5] For design purpose IS 456: 2000, IS 10262: 1982 are used.

[6] Concrete technology by Dr.MS SHETTY.

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