International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 1 Issue 6, August - 2012

A STUDY ON LOAD -DEFLECTION BEHAVIOUR OF CRACKED CONCRETE BEAM USING FEM: FRACTURE MECHANICS APPROACH

P.Subba Rao[1] ,A.Venkateswara Rao[2]

1. Professor& HOD, Dept.of Civil Engg.JNTUCEK,Kakinada,E.G.Dist,India.
2. Asst.Professor,Dept.of CE, Swarnadhra coll.of Engg.&Tech,Narspur,W.G.Dist-534275

ABSTRACT:-This paper presents a series of load-deflection tests on concrete beams in order to develop a load –deflection model for concrete beam with an edge crack , under vertical loading condition. The proposed model is based on analysis of a series of Finite element analysis generated models and an edge crack of 75 mm is modeled based on the principles of the fracture mechanics.A total of 6 beams of length 3000mm,3100mm and 3200mm and 250x125m cross-sectional area ,with and without edge cracks were tested in this investigation .The beams were modeled and tested as four point bending test under a gradual loading of 70000N.The load-deflection behaviour of cracked beams and normal beams were predicted using finite element analysis(ANSYS).For normal beams comparision has been made between theoretical values with the Ansys predicted value and found good correlation .Throughout the analysis the pre-peak responses of the load-deflection is recoreded.The results show that the presence of a crack reduces the strength of the member and shifts the load-deflection curve downwards when compared with the normal beams.finally the percentage increase in deflection of the beam with and without crack with respect to the length is plotted .This shows the effect of the length and crack on load –deflection behavior.it is found that the proportionate percentage increase in central deflection is reduced with an increase in length but not in magnitude.

1. INTRODUCTION:-

Concrete commonly used in engineering structures is defined as a composite material produced using cement, aggregate, water and chemical and mineral admixture materials when necessary. The strength and durability of concrete has undergone continuous improvement over the years and these improved materials are now commonly used. The definition of high strength concrete has changed with time, region and the production technology used. For example, in the 1950s, concrete having 34MPa characteristic compressive strength was considered as high strength. Currently, high strength concrete with 250MPa compressive strength is produced using high strength aggregate. Today, high strength concrete is used in high-rise buildings and bridges. Therefore it is necessary to study the load deflection behaviour of the concrete with cracks ,as the structures are regularly face loading the chances of the cracks cannot be ruled out.

2.REVIEW OF LITERATURE:-

According to the model proposed by Popovics (1973), the initial modulus of elasticity for concrete tested at a constant stress rate will result in a higher slope than that of concrete tested at a constant strain rate. This theory will be compared with the experimental test data. Also, the equations submitted for determining the shape of the stress-strain curve will be used to evaluate the model's ability to predict the stress-strain diagram for confined concrete. Toutanji (1999) proposed a model to predict the stress-strain curves of concrete externally confined with FRP sheets.Teng and Lam (2003, 2004) compare the results from design-oriented models and analysis-oriented models.An analytical model introduced by Berthet et al (2006) considers the confinement level, as well as the FRP mechanical properties, to evaluate the ultimate capacity and the stress-strain relationship as a function of the concrete and confining material. There are several theories developed to assess the stress-strain curve of the concrete. T. Suresh Babu et.al (2008) developed the stress-strain for self compacting concrete with and without fibre reinforcement and proposed an empirical model for stress strain behaviour of the concerete.

Therefore in this investigation it is proposed to study the beahviour of the concrete under load-deflection curve with and without crack.

3.FINITE ELEMENT MODELLING:-

The beam is modeled as a plane stress with thickness option using Plane 82 elements. This study consists of testing three beams, having size of 150 X 250 X 3200 mm, 150 X 250 X 3100 mm and 150 X 250 X 3000 mm length. All the beams were tested over a simply supported span under bending, The load of 70000 N applied gradually in load steps .The vertical mid-span deflection were measured using finite element analysis and load vs deflections curve was plotted using finite element analysis.the material properties are taken as Youngs Modulus E=25743 N/mm^2 and Poissions ration 0.15 as specified by T. Suresh Babu et.al (2008).FEA software ANSYS is adopted for predicting the load displacement response of the beams with cracks and without cracks numerically. An edge crack of 75mm is modeled using fracture mechanics approach and crack tip is concentrated and the final mesh at the crack tip is as shown in the figure1.The deflected form of the normal beam under load steps is shown in fig.2.

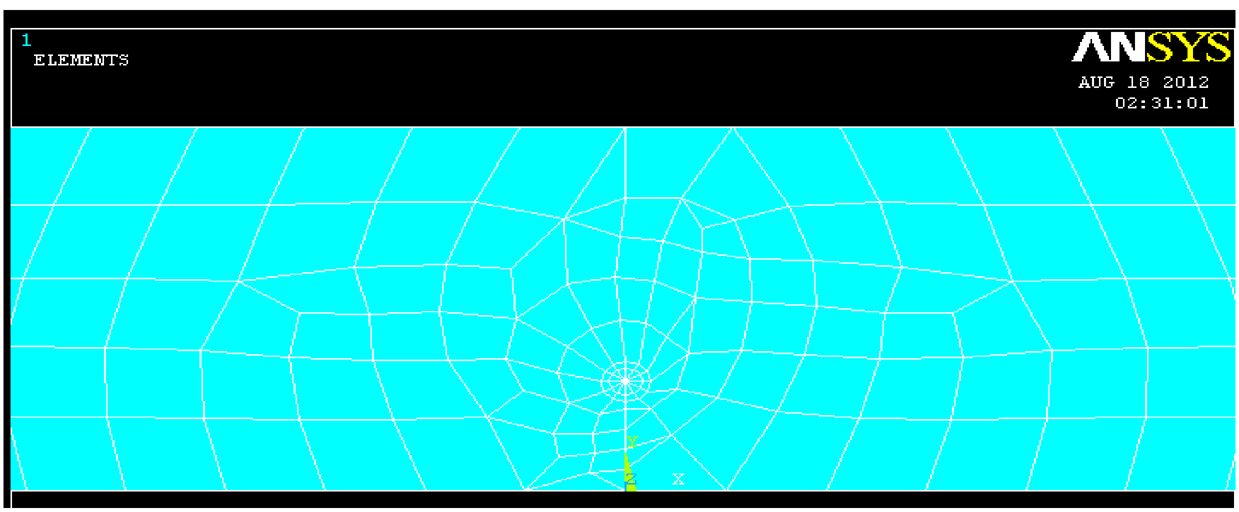


Fig1:Beam with 75mm edge crack (Cracked beam-CB)

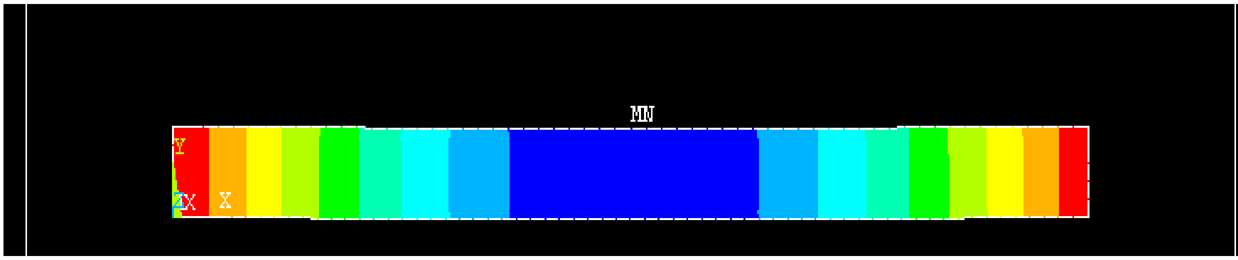


Fig 2: Normal Beam without crack (NB)

4.NUMERICAL (ANSYS) RESULTS OF LOAD DEFLECTION BEHAVIOUR:-

(a) Without edge crack:-The load vs central deflection for a Normal beam(NB)are analyzed using ansys and are as shown in the given table.The theoretical values also shown for reference. It is found that the error in predicting the central deflection of a beam when compared with the calculated theoretical values is very less.

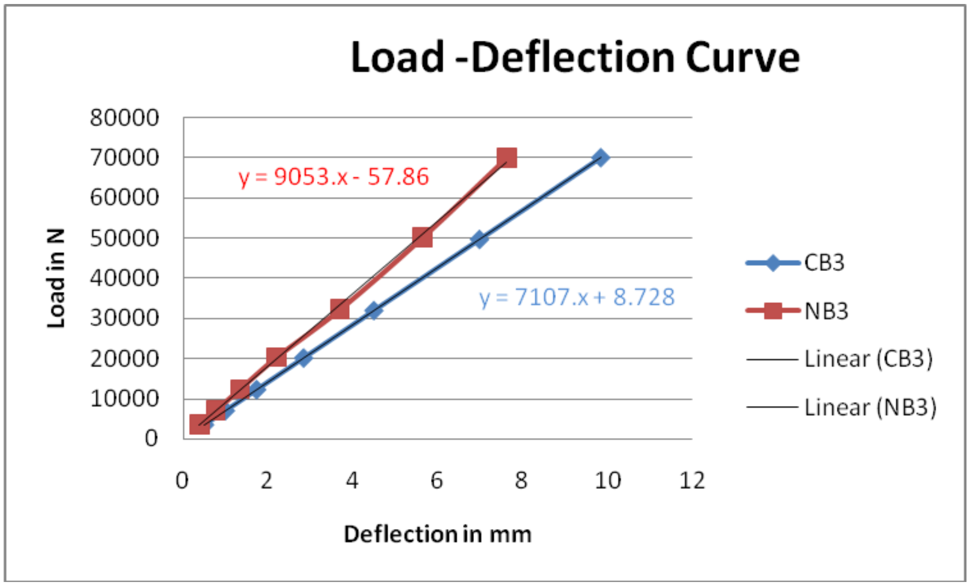
S.No	Beam dimension s in mm	Central Deflection in mm (Ansys)	Theoritical Value (mm)
1	125 X 250 X 3000 (NB1)	7.62	9.6
2	125 X 250 X 3100 (NB2)	8.92	10.3
3	125 X 250 X 3200 (NB3)	10.60	11.4

(b) With edge crack:- similarly the load vs central deflection for a cracked beam(CB) are analyzed using ansys and as shown in the given table.

S.No	Beam dimension s in mm	Central Deflection in mm (Ansys)
1	125 X 250 X 3000 (CB1)	9.8
2	125 X 250 X 3100 (CB2)	11.3
3	125 X 250 X 3200 (CB3)	13.04

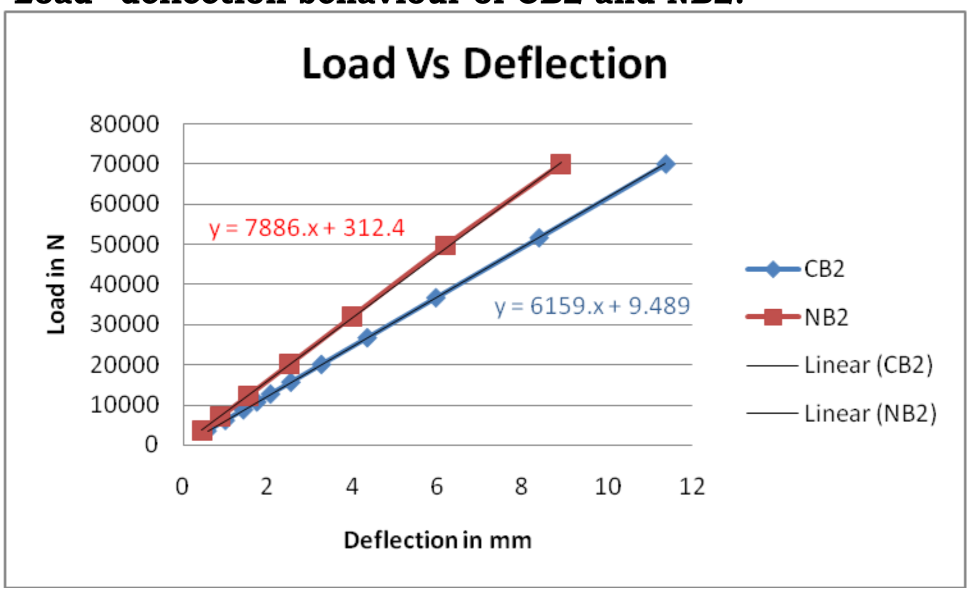
5. FEA ANALYSIS AND RESULTS:- A total of six beams namely CB1,CB2,CB3,NB1,NB2 and NB3 were tested using finite element analysis and the load –deflection response is plotted as shown below.

(a) Load –deflection behaviour of CB3 and NB3:-



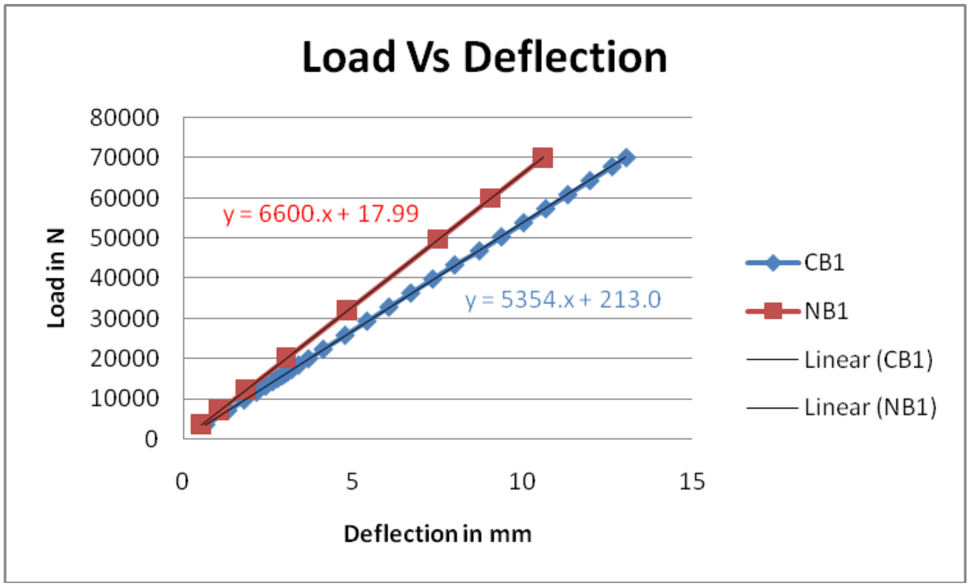
From the above graph it is clear that the effect of the crack increased the central deflection from 10.60mm to 13.04 mm with a geometric increae of 29%.

(b) Load –deflection behaviour of CB2 and NB2:-



From the above plot it is observed that the effect of the crack increased the central deflection from 8.92 mm to 11.3 mm with a geometric increae of 27.5%.

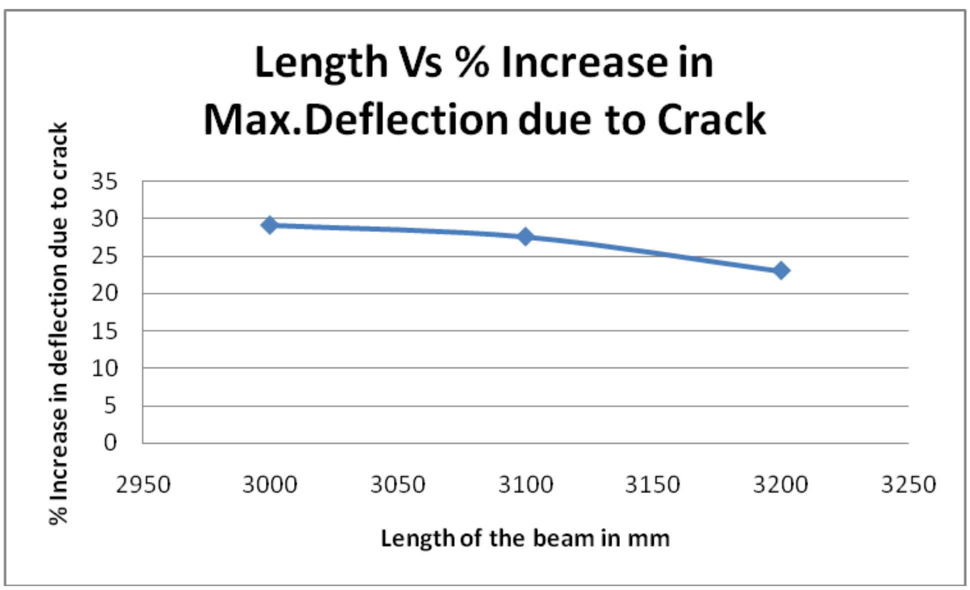
(c) Load –deflection behaviour of CB1 and NB1:-



From the above plot it is found that the effect of the crack increased the central deflection from 7.62 mm to 9.8 mm with a geometric increae of 23 %.

6.Effect of crack and Length of the beam on Load-Deflection behaviour:-

Finally the following plot is drawn as Length of the beam Vs percentage increase in the maximum deflection of a beam due to the presence of the crack as shown in the plot.



The above plot reveals that the proportianate percentage increase in deflection is varied from 23% to 29% with in an increase in length of 200mm i.e from 3000mm to 3200mm.

ISSN: 2278-0181
Vol. 1 Issue 6, August - 2012

7.Conclusions:

Based on the results obtained from FEM,and theoritical analysis ,the following conclusions are drawn.

1.In this investigation it is noted that presence of a crack reduced the strength of the beam when compared with the normal beam.

2.Results obtained for a normal beam using finite element analysis are in good corelation with the theoritical values.

3.It is found that for a 3000 x250 x125 mm beam the presence of a crack increases its proportionate maximum deflection by 29%

4. It is observed that for a 3100 x250 x125 mm beam the presence of a crack increases its proportionate maximum deflection by 27.5%.

5. It is found that for a 3200 x250 x125 mm beam the presence of a crack increases its proportionate maximum deflection by 23%.

6. Finally it is noted the that presence of the crack with respect to the Increase in length of the beam reduced the proportionate percentage in central deflection but not in magnitude of the deflection.

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