www.ijiarec.com

Experimental analysis of crack width on RC beams

Jithin Chacko[1], Dr. Nalini jebastina[2]

[1]Master of Engineering Student, Civil Engineering Department, EASA College of Engineering and Technology, Coimbatore

[2]Professor, Civil Engineering Department, EASA College of Engineering and Technology, Coimbatore

ABSTRACT

An analytical study was performed to understand and estimate the crack width on RC beams. three sets of 4 beams, that is a total of 12 beams were casted. The beams are of varying area of steel and clear cover on Fe 415 grade steel and M 25 grade steel and M 25 grade concrete. The provisions and guidelines and expressions by different code were compared with experimental data. This comparison helps in checking the accuracy of each code expression.

Index terms: Crack widths

INTRODUCTION

Crack width is one of the two criteria under the limit state of serviceability (the other is deflection). Cracking of concrete should not adversely affect the appearance or durability of the structure, the acceptance limits of cracking would vary with the type of structure and environment. Where specific attention is require to limit the designed crack width to a particular value. Hence crack width is important. From literature it is very clear that the concept of crack width was fascinating to researchers since early 1900s. From literature review, it is very clear that numerous researchers have interest in this concept and have proposed many different formulas to calculate the crack width. Few formulas are similar and most of formulas are entirely different. But there are no 100% accurate formulas. There is always a minimum value difference between experimental analysis and statically analysis. In this research programme, 12 beams were casted (i.e. 3 sets of 4 beams for experimental accuracy). The crack width estimation was done for three specimens by using provisions, guidelines and expressions from Indian, American and European codes. The results of above calculations were studied and compared with experimentally observed values. The influence of parameter taken for the analysis were studied and established for the prediction of crack width. From the comparison studies a modification (within the parameter under study) was suggest to the IS-456 expression [1-5].

CRACK WIDTH ESTIMATION USING BUILDING CODES

IS 456:2000

$$W_{cr} = \frac{3\,a_{cr}\,\varepsilon_m}{1 + \frac{2(a_{cr} - C_{min})}{h - x}}$$

Where,
W_{cr} = Crack width

a_{cr} = distance from the point considered to the surface of the closest longitudinal bar.
C_{min} = Minimum cover to the longitudinal bar.
ε_m = average steel strain at the level considered.
h = overall depth of the member.
x = depth of the neutral axis.

Author for correspondence:
Civil Engineering Department, EASA College of Engineering and Technology, Coimbatore

540

Jithin C et al., Inter. J. Int. Adv. & Res. In Engg. Comp., Vol.–08(03) 2020 [539-543]

EN 1992 – 1-1: 2004

$$W_k = S_{r,max} \left(\varepsilon_{sm} - \varepsilon_{cm} \right)$$

Where,

W_k = Crack width

$S_{r,max}$ = the maximum crack spacing.

ε_{sm} = the mean strain in the fortification under the significant blend of burdens, including the impact of forced distortions and considering the impacts of pressure hardening.

ε_{cm} = the mean strain in the concrete between cracks.

ACI 224 R 07

$$w = 0.076\beta f_s \sqrt[3]{d_c A} \times 10^{-3}$$

Where,

w = most probable crack width.

β = ratio of distance between neutral axis and tension face to distance between neutral axis and reinforcing steel about 1.20 in beams.

f_s = reinforcing steel stress.

d_c = thickness of cover from the extreme tension fiber to the closest bar.

A = area of concrete symmetric with reinforcing steel divided by number of bars.

PROPERTIES OF THE RC BEAMS CHOSEN FOR THE STUDY

Beam	20 A	20 B	30 A	30 B
B(mm)	120	120	120	120
D(mm)	180	180	180	180
d(mm)	150	149	140	139
f_{ck}(N/mm²)	25	25	25	25
f_y(N/mm²)	415	415	415	415
A_{st}(mm²)	100.53	157.08	100.53	157.08
A_{com}(mm²)	100.53	100.53	100.53	100.53

ANALYTICAL STUDIES

The above tested beam properties were used for the crack width calculation using different code expression and were compared and studied with experimental values of crack width. This study gave a clear of the behavior of crack width by various expression to the experimental various. The variation of crack width with different clear cover and area of tension steel were also noted [6-8].

RESULTS AND DISCUSSIONS

Initial observations

The comparison of the crack widths estimated by the different expressions and the experimentally obtained result shows us the randomness of results. We find that the expressions give us an over estimation of crack widths. For example, the American code expression gives an overestimated the crack widths for lower values of concrete while the Indian code and Euro code under estimated it.
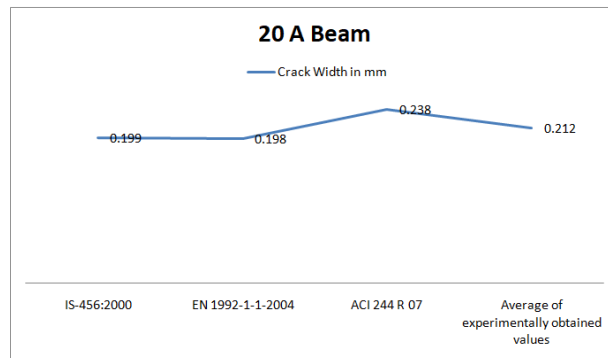

Figure 5.1.1: Estimated crack widths using different formulas compared with experimental data for 20 A Beam
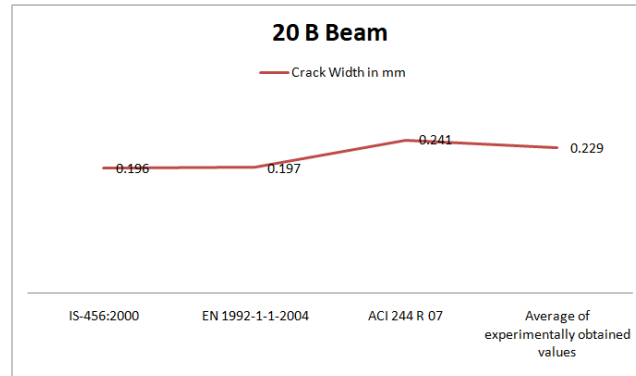
Figure 5.1.2: Estimated crack widths using different formulas compared with experimental data for 20 B Beam.
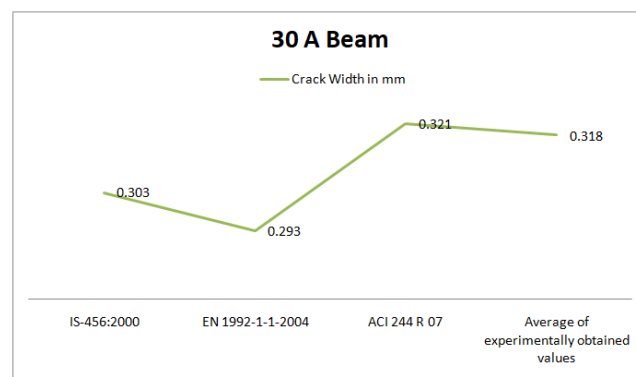

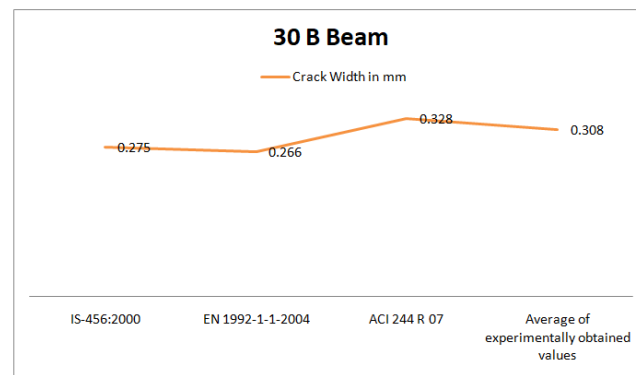**Figure 5.1.3: Estimated crack widths using different formulas compared with experimental data for 30 A Beam.**

Figure 5.1.4: Estimated crack widths using different formulas compared with experimental data for 30 B Beam.

Analytical investigations

Clear cover with same area of tension steel. When comparing the crack widths estimated by the different expressions and the experimentally obtained result on the clear cover, we find that the crack width increases as the clear cover rises for same area of tension steel. From the expressions according to different codes it is very clear that clear cover of beam is directly proportional to crack width.
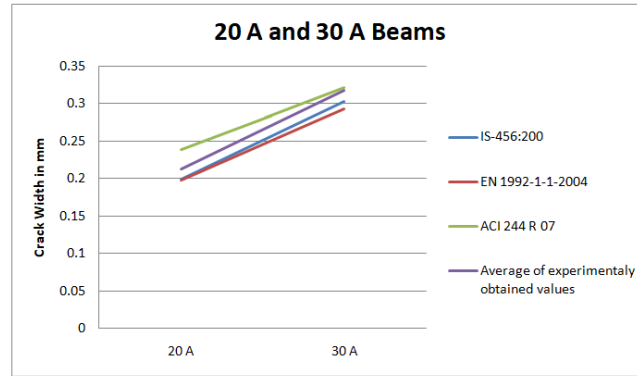
Figure 5.2.1: Comparison of estimated crack widths and experimental data for 20 A and 30 A beams.
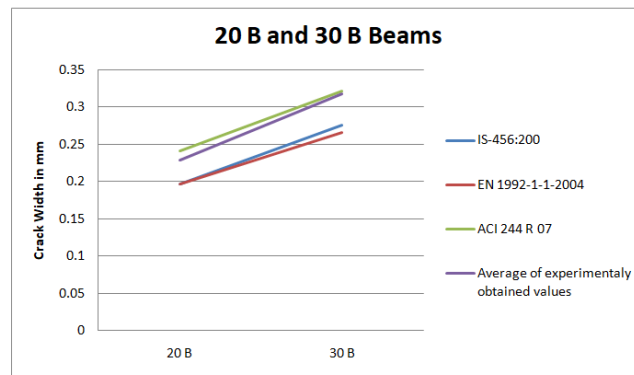

Figure 5.2.2: Comparison of estimated crack widths and experimental data for 20 B and 30 B beams.

Area of tension steel cover with same clear cover. When comparing the crack widths estimated by the different expressions and the experimentally obtained result on the area of tension steel, we find that the crack width decreases the area of tension steel rises for same clear cover, in all except ACI 224R-01 estimated values and experimentally obtained values for 20 A and 20 B beams. But ACI estimated values for 30 A and 30 B remain unchanged.
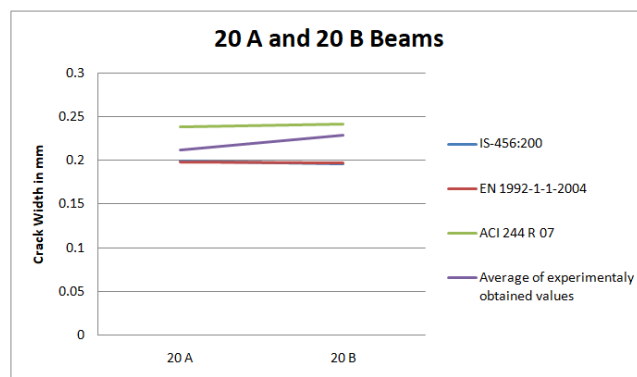

Figure 5.2.3: Comparison of estimated crack widths and experimental data for 20 A and 20 B beams.
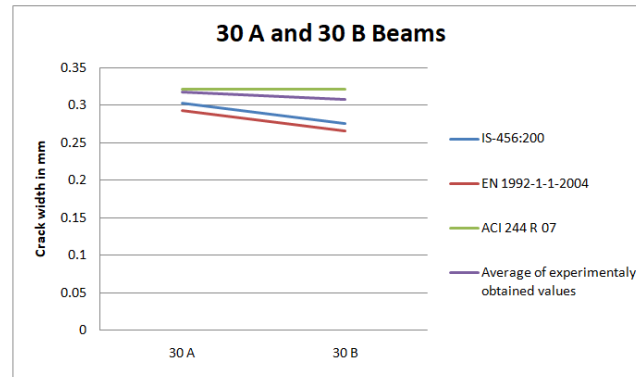
543

Jithin C et al., Inter. J. Int. Adv. & Res. In Engg. Comp., Vol.–08(03) 2020 [539-543]

Figure 5.2.4: Comparison of estimated crack widths and experimental data for 30 A and 30 B beams.

CONCLUSIONS

This analytical study program was carried out to study and compare the different code expressions in use, also to have comparison study of clear cover and area of tension steel influence on crack width.. The main objective of this study was to suggest a simple and effective way to improve the accuracy level of the IS 456 expression in use. A few conclusions drawn from this study are as follows

1) The predictive abilities of all the expressions used so far are questionable as the deviation from the experimental data is high compared to the value obtained from the code expressions.

2) ACI 224R-01 expression over estimates the width of the cracks almost in all cases and the IS-456:200 and EN 1992-1-1:2004 expressions under estimate it.

3) This might be because the ACI 224R-01 suggested expression is a direct function of steel stress and the other expressions use the value of the stress in steel only to calculate the strains.

4) The crack width increases as the clear cover rises for same area of tension steel

5) The crack width decreases the area of tension steel rises for same clear cover, in all except ACI 224R-01 estimated values and experimentally obtained values for 20 A and 20 B beams. But ACI estimated values for 30 A and 30 B remain unchanged.

REFERENCES

[1]. Said M Allam, Crack width evaluation for flexural RC members , Department of structural engineering, Alexandria university, 2012.

[2]. B B Broms, Crack width and crack spacing in reinforced concrete members, Journal of American Concrete Institute 62(10), 1965, 1237-1256.

[3]. Wakchaure M.R, Effect of concrete cover on crack width of RC beams, Elixir international Journal, 47, 2012, 8782-8785.

[4]. Nicholas J Carino, Prediction of cracking in reinforced concrete structures, Building of fire research and laboratory, National Institute of Standards and Technology, 1995.

[5]. Building Code requirements for reinforced concrete, ACI 318-95 and commentary ACI 318R-95, American Concrete Institute, Detriot, 1995.

[6]. Building Code requirements for reinforced concrete, ACI 318-05 and commentary ACI 318R-05, American Concrete Institute, Detriot, 2005.

[7]. Eurocode-2, Design of concrete structures- Part I: General rules and rules for buildings 1992-1, European committee for standardisation, Belgium, 2001.

[8]. Indian Standard for plain and reinforced concrete-code of practice, IS 456:2000, Bureau of Indian Standards