Australian Journal of Basic and Applied Sciences, 9(7) April 2015, Pages: 369-373

ISSN:1991-8178

Australian Journal of Basic and Applied Sciences

Journal home page: www.ajbasweb.com

Finite Element Studies on the Behavior of Reinforced Concrete Structures Using LUSAS

M.Z. Yusof

School of Housing Building and Planning, Universiti Sains Malaysia, 11800, Penang, Malaysia, Perunding Pinang Sdn. Bhd, Suite 111, Kompleks Eureka, 11800, Penang, Malaysia

ARTICLE INFO

Article history:
Received 12 October 2014
Received in revised form 26 December 2014
Accepted 17 January 2015
Available online 28 February 2015

Keywords:
First crack load, failure load, crack width, deflection, crack patterns

ABSTRACT

This paper is to investigate the effect of the concrete properties on the behavior of the RC beams in term of first crack load, ultimate load, crack width, crack pattern as well serviceability. In order to evaluate the effect of the concrete properties, computer simulation was carried out using commercially available finite element software, LUSAS. The reinforced concrete beams were modeled by plane stress element and the reinforcement bar elements. This study clearly indicates that the concrete compressive strength has significant effect on the first crack load, ultimate load as well as crack width of the reinforced concrete. Furthermore the deflection was compared with the design code of practice, EC2 (Eurocodes 2). The analysis results also produced an equation to assess the performance of reinforced concrete members, based on the plasticity smeared crack models.

To Cite This Article: M.Z. Yusof., Finite Element Studies on the Behavior of Reinforced Concrete Structures Using LUSAS. ***Aust. J. Basic & Appl. Sci.,*** *9(7): 369-373, 2015*

INTRODUCTION

A finite element analysis is always performed with one or more specific objectives in mind. These objectives vary according to the type of analysis results-typically, deformation or stresses in structure, or both. Regardless of the purposes, a general purposed of FEAP (finite element analysis program) can be divided into three categories or involves three stages of activity namely modeling or data processing, running analysis finite element model and viewing the results or output post processing. In LUSAS, modeling is often referred to as "pre-processing" and viewing the result is often referred to as 'post-processing'. For example, modeling of 2D continuum element or plane stress involved with creating model of the structure representation and defining its characteristic behavior in terms of its physical properties such material, loading, Lagrangian or Euler geometric nonlinearity, integration schemes, Gauss rules, stiffness matrix, model and nodal freedoms or support conditions. This paper investigates on the performance of RC structures using plasticity-based smeared crack models which were implemented into LUSAS finite element analysis program.

Finite Element Model:

In order to study the effect of the concrete strength on structural behavior, RC beam with dimension of 0.3m depth, 0.15m width and 3.3m long was selected. The beam were analysed into six models namely Model1, Model2, Model3, Model4, Model5 and M6 according to the compressive strength of 20N/mm2, 25N/mm2, 30N/mm2, 40N/mm2, 50N/mm2 and 60N/mm2 respectively. The details of the models is presented in **Figure1**. Due to a the symmetrical nature of the simply supported beam, only the left-hand span of the beam is modelled. The beam is simply supported at the left-hand end with a symmetry support at the right-hand axis of symmetry. The section is represented by plane stress QPM8 elements, and the reinforcement bars are represented by BAR3 elements. A nonlinear concrete cracking material model will applied to the plane stress elements and a von Mises plastic material will be applied to the reinforcement bars.

Design outlines:

All concrete beams were analysed as simply supported beams subjected to point load **(Figure 1).** The reinforcement is provided in the lower face of the beam and has a total cross-sectional of 402 mm2 or 2Y16 reinforced bars. The superposition of nodal of degrees of freedom assumes that the concrete and concrete are perfectly bonded. It is assumed that the

Corresponding Author: M.Z. Yusof, School of Housing Building and Planning, Universiti Sains Malaysia, 11800, Penang, Malaysia, Perunding Pinang Sdn. Bhd, Suite 111, Kompleks Eureka, 11800, Penang, Malaysia
E-mail: zaid_ysf@yahoo.com

self-weight of the beam is negligible compared with the applied load and the effects of any shear reinforcement can be ignored.

Material properties:

Steel reinforcement used in the numerical analysis was steel with diameter 16mm. The properties of the steel reinforcement for all six model are as follows :

Elastic modulus = 210kN/mm2, Poisson's ratio = 0.3, plastic strain = 1.0

Furthermore, the concrete properties employed for these models are evaluated based on the following design conditions:

Elasticity modulus = 42kN/mm2, depth of tension reinforcement =275mm, poisson's ratio =0.2, fracture energy per unit area = 0, uniaxial tensile strength = fcu/10

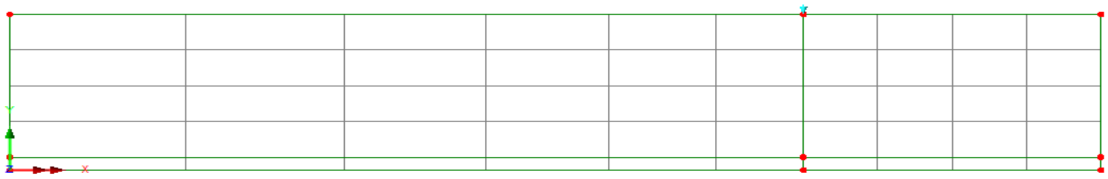


Fig. 1: FEM model of concrete beam 150 x 300 x 3000 (Left-hand span).

Boundary Condition:

The boundary conditions for the numerical analyses are presented in **Table 1** and **Figure 2.** Furthermore, for nonlinear analysis control properties are defined as properties of a load case. The nonlinear analysis is to be terminated when the beam deflection at mid span reaches a limiting value.

Table 1: Boundary conditions of FEM model.

Types of support	Pinned	Roller
u (X-direction)	0	0
v (Y-direction)	0	n/a

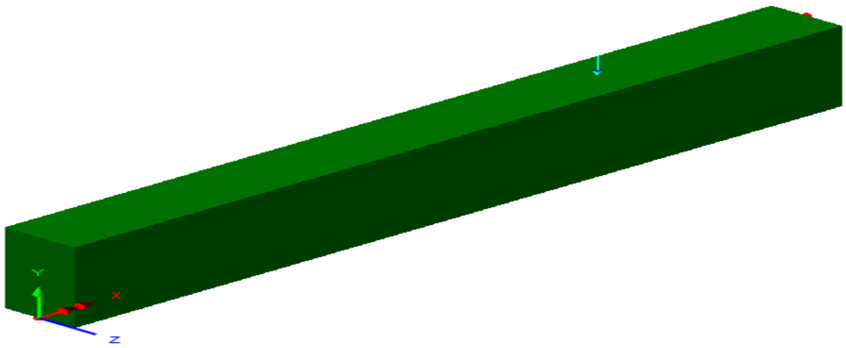


Fig. 2: Boundary condition of RC beam (3D).

RESULTS AND DISCUSSION

A summary of the numerical result are summarised in **Tables 2.** Furthermore, the effect of the concrete strength on the first crack load, failure load, crack width is illustrated in **Figure 3, Figure 4** and **Figure 5** respectively. The maximum deflection versus compressive strength at mid-span for the concrete beam is shown in **Figure 6**. Similarly, **Figure 7** shows numerous crack pattern obtained by the computation of the finite element model for Model1 to model 6. For instance the crack width of RC structures were 0.216mm, 0.188mm, 0.195mm, 0.128mm, 0.178mm and 0.080mm for model1, model 2, model3, model4, model5 and model6 respectively. From this study, the linear relationship between concrete compressive strength-first crack load and failure load can be proposed in the following equations (1) and (2):

F_{cr} =1.3fcu + 2.0333 (First cracking load) Eq (1)

F_u =1.9167fcu + 11.136 (Failure load) Eq (2)

Furthermore, compressive strength-maximum crack width and maximum deflection at mid-span for the concrete beam can be presented in the following equations (3) and (4):

CWMax =-0.0223fcu + 0.242 (maximum crack width) Eq. (3)

δ = 0.0331fcu + 3.0566 (deflection) Eq. (4)

Table 2: Structural Performance.

Model	Fcu (N/mm2)	First crack load, Fcr (N)	Failure load, Fu (N)	Crack width, CWMax (mm)	Max Deflection (δ), mm
Model 1	20	4000	13707.1	0.216360	3.06991<EC2#
Model 2	25	4500	15000.0	0.187546	3.14080<EC2#
Model 3	30	5000	16290.6	0.194795	3.19316<EC2#
Model 4	40	7000	18057.8	0.128200	3.05750<EC2#
Model 5	50	9000	20597.0	0.178000	3.40059<EC2#
Model 6	60	10000	23412.9	0.079600	3.17289<EC2#

EC2, deflection = span/500

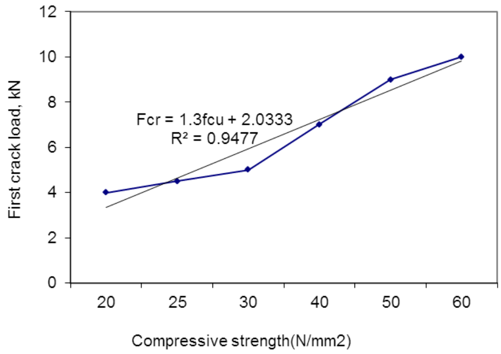


Fig. 3: First cracking load of beam specimens.

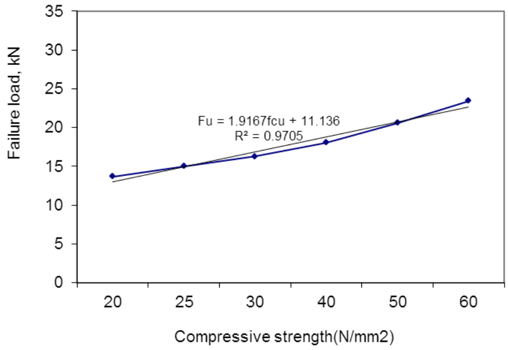


Fig. 4: Failure load of beam specimens.

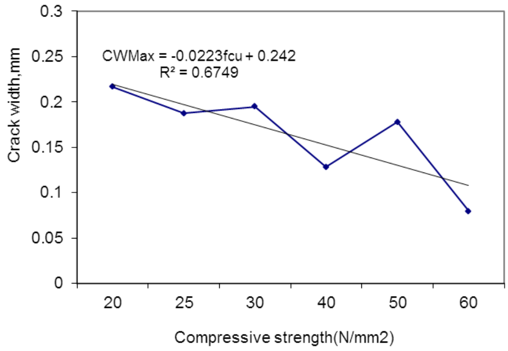


Fig. 5: Maximum crack width of beam specimens.

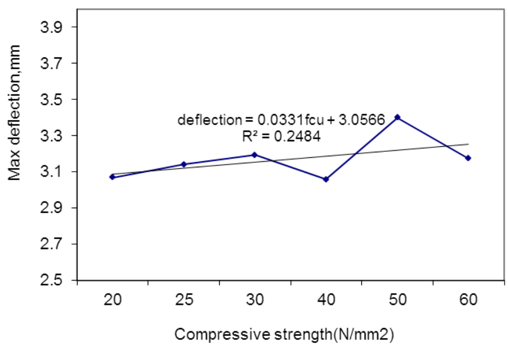
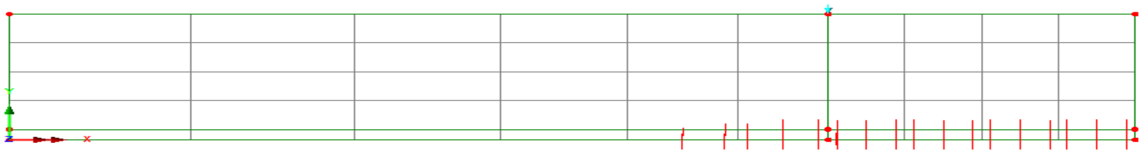


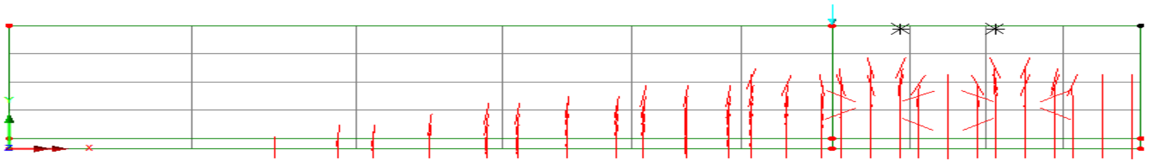
Fig. 6: Maximum deflection of beam specimens.

Australian Journal of Basic and Applied Sciences, 9(7) April 2015, Pages: 369-373

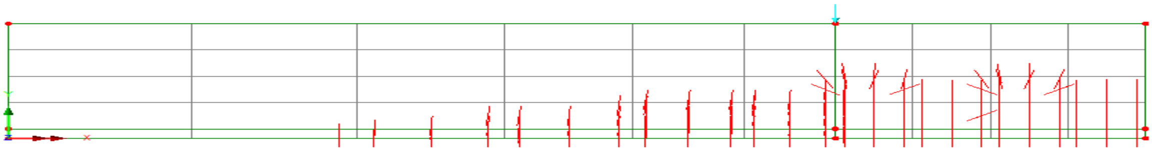


(a) Compressive strength = 20N/mm2

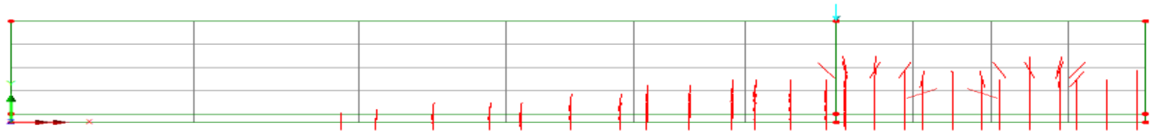
(b) Compressive strength =25N/mm2



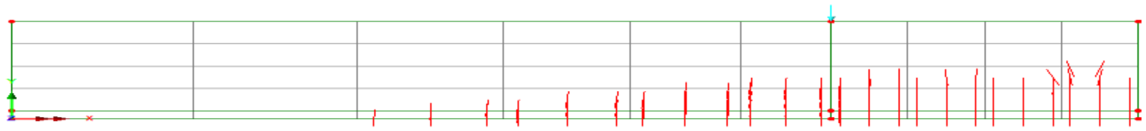
(c) Compressive strength = 30N/mm2



(d) Compressive strength = 40N/mm2



(e) Compressive strength = 50N/mm2



(f) Compressive strength = 60N/mm2

Fig. 7: Crack patterns of beam specimens.

Conclusions:

In general, the proposed two dimensional model using LUSAS FEAP were capable to simulate the structural behavior of the RC structures namely first crack load, failure load, crack width as well as crack pattern.

The effect of compressive strength on ultimate load on the first crack load, failure load as well as crack width is apparent as shown in Figure 3 to Figure 5. However, from simulation study on the reinforced beam appears that it is important to further investigate the effect of the concrete strength on serviceability or deflection concrete structures using other types of plasticity model such as concrete fracture model which takes into account of the fracture energy. Furthermore, from numerical analyses using plasticity-based smeared cracks model on the reinforced concrete beam without shear reinforcement it is clear that the concrete strength had a less significant effect on the crack pattern as well as mode of failure.

REFERENCES

Lusas Version 14.7, Application manual, Surrey, United Kingdom, 2014

Lusas Version 15.0, Application manual, Surrey, United Kingdom, 2015

The Institution of Structural Engineers, 2006. Manual for design of concrete building structure to Eurocode, 2.

The British Standard Institution, 1997. Structural Use of Concrete(BS8110).

Australian Journal of Basic and Applied Sciences, 9(7) April 2015, Pages: 369-373

Yusof, M.Z., 2014. Numerical stress-deformation analyses of composite material using finite element method, 5th International Conference on Science & Technology (ICSTIE).

Yusof, M.Z., 2014. Understanding Building Failures and Limit state Design, Universiti Sains Malaysia Press.