Research Paper Engineering

Computer aided design of reinforced concretecolumn subjected to axial compression and bending

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ABSTRACT

In structural design of column,the dimensions of the column and reinforcement are initially assumed and then interaction formula is used to verify the suitability of chosen dimension and reinforcement. This approach necessitates few trials to coming up with and economical and safe design.P-M interaction diagram are given in design aids for analysis and design of column for symmetrical arrangement of reinforcement and limited cover to depth ratio.An attempt has been made in this paper to computerize the design of rectangular and square column section with graphical user interface using limit state method of design.Which facilitates analysis and design of symmetrical as well as unsymmetrical arrangement of reinforcement and also developsinteraction diagram for the section.

KEYWORDS Reinforced concrete column, uniaxial bending, biaxial bending, P -M interaction diagram.

INTRODUCTION

Columns are the most common vertical load bearing elements in reinforced concrete structures.The method of design of the column section consists of choosing its cross-section and reinforcement distribution.Appropriate shape of column section and optimum reinforcement distribution result in economical design.The adequacy of section is checked by calculating its capacity to resist axial loads and moments.This involves lengthy calculations.several design aids are available for design of R.C.C column sectionThere are some design approaches in which the design effort is reduced by approximated shape of strength envelopes([2] and IS-456[3][4]).Dr.S.N.Sinha has developed p-m interaction curves for rectangular,circular as well as flanged column sections[5].Although several noteworthy articles [6,7,8, and 9] on biaxial bending of square/rectangular column sections,which contributed greatly to understanding of this subject,have appeared in recent years,significant gaps in the area of design aids for biaxial bending still exist. All these researches have been carried outfor symmetrical column sections,unsymmetrical sections are not being considered. Non dimensional P-M interaction diagrams used for column design are given for limited cover to depth ratio and typical arrangement of reinforcement. When cases differ from those given in design aids, interpolation method are to be resorted which introduces approximations.To lessen these gaps comprehensive design aids are presented in the present investigation.

This paper deals with limit state analysis of short rectangular and square shaped reinforced concrete column sections. Various.The aim of limit state design is to achieve acceptable probabilities that the structure will not become unfit for the use forwhich it is intended,that is,that it will not reach limit state.To ensure the above objectives, the design should be based on characteristic values for material strength and applied loads.

ASSUMPTIONAND MATERIAL PROPERTIES

In the analysis, the following assumptions, which are almost the same as those codified in IS-456[3], are made:

(a) the strain distribution in the concrete in compressionand the strain in the reinforcement, whether in tension or compression, are derived from the assumption that plane sections normal to the axis remain plane after bending, and that there is no bond-slip between the reinforcement and the concrete,
(b) the tensile strength of concrete is ignored,
(c) The relationship between stress-strain distributions inconcrete is assumed to be parabolic as shown in Fig. 1. The maximum compressive stress is equal to 0.67l.5 (see Fig. 6)
(d) The stresses in reinforcement are derived from therepresentative stress-strain curve for the type of steelused. Typical curves are shown in Fig 2,
(e) the maximum compressive strain in concrete in axialcompression is taken as 0.002,
(f) the maximum compression strain at the highly compressedextreme fibre in concrete subjected to axial compression and bending, but when there is no tension on the section, is taken as 0.0035 minus 0.75 times the strain at the least compressed extreme fibre (see Fig. 4),
(g) the maximum compressive strain at the highly compressed extreme fibre in concrete subjected to axial compression and bending, when part of the section is in tension, is taken as 0.0035 (see Fig. 6). In the limiting

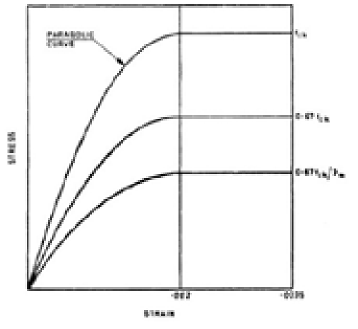

Figure 1.Idealized stress-strain curve for concrete

Case, when the neutral axis lies along one edge of the section, the strain varies from 0.0035 at the highly compressed edge to zero at the opposite edge.

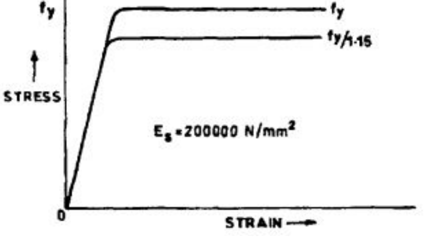

Figure 2.Idealized stress-strain curve for mild steel bars

METHOD OF ANALYSIS

The criteria generally proposed for determining the ultimate strength of R.C. members subjected to axial compression combined with bending are based on limitingthe maximum strain (or stress) in the concrete to someprescribed value. The load-carrying capacities discussedhere apply to relatively short columns for which the effectof lateral deflections on the magnitude of bending momentsis negligible. Also effects of sustained load and reversal ofbending moments are not considered.

In the present investigation, rectangular section as shown in figure isconsidered. User can insert dimension of section, cover to depth ratio as per requirements. In present work number of bars for reinforcement are limited to 7 bars on X face and 7 bars on Y face.

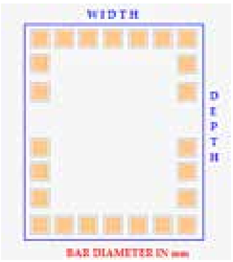

Figure3.Column section

For each position of the neutral axis, the strain distribution across the section and the stress block parameters are determined. The stresses in the reinforcement are also calculated from the known strains. Thereafter the resultant axial force and the moment about the centroid of the section are calculated as follows

To find the forces and moments due to concrete in the section subjected to axial compression and bending (both uniaxial and biaxial bending with equal eccentricities), the following procedure is used in the analysis. The stress block (see Fig. 4, 5, 6) is divided into number of strips. First the width of each strip is calculated. This strip width is multiplied by corresponding width of the section and depth of the strip, which gives the force in that strip of concrete. The algebraic sum of all such elemental forces gives the total force in concrete. This force in concrete multiplied by the distance between centroid of the stress block and centroid of the section gives the moment due to concrete. The forces and moments due to reinforcement (both for uniaxial and biaxial bending) are determined as follows:

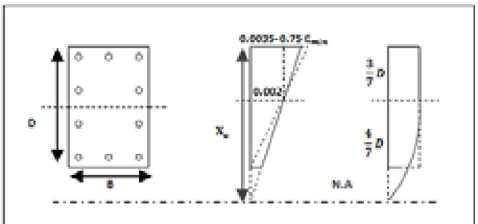

Figure 4.Neutral axis outside the section

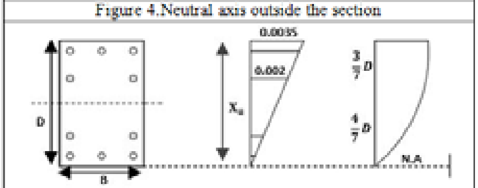

Figure 5.Neutral axis at edge of the section

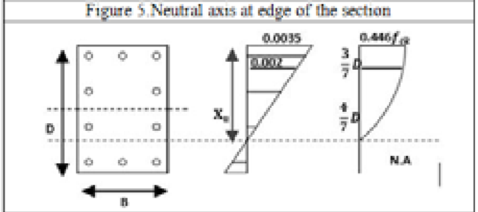

Figure 6.Neutral axis inside the section

Force in reinforcement$=\sum_{i=1}^{n}(f_{si}-f_{ci})p_iA_c/100$

Moment of resistance

with respect to steel$=\sum_{i=1}^{n}(f_{si}-f_{ci})p_iA_cy_i/100$

In which n is the number of rows of reinforcement, is the stress in the row of steel (compression being positive and tension negative), is the stress in concrete at the level of the row of reinforcement,is the area of concrete, may be taken equal to the gross area, $p_i=(A_{si}/A_c)/10$ =is the percentage of steel in the row,is the area ofreinforcement in the i^{th} row, y^i is the distance of the i^{th} row of reinforcement measured from the centroid of the section. It is positive towards the highly compressed edge and negative towards the least compressed edge.

As explained above equations derived for below position of neutral axis.

1.	Neutral axis outside the section
2.	Neutral axis at edge of the section
3.	Neutral axis inside the section

COMPUTER PROGRAM

Computer programs have been developed using VB.net for analysis and design of plus-shaped column sections subjected to axial compression with uniaxial and biaxial bending respectively(see fig.10 flow chart).a listing of program is given in the Appendix.

The input data to be given in the programs are as follows:

(1) Dimension of plus section.
(2) Cover in X and Y direction.
(3) Numbers of reinforcement bars
(4) Characteristic compressive strength of concrete
(5) Characteristic strength of steel

Figure7.Nymber of bars

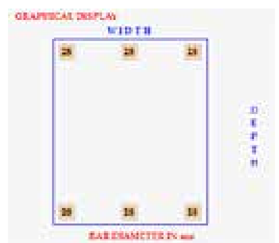

Figure8.Column cross section.

Figure8.Grade of concrete

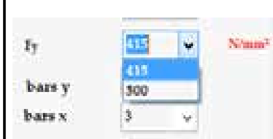

Figure9.Grade of steel

(6) Design load, design moment in X-direction, design moment in Y-direction.

Output data

(1) Load carrying capacity of given section.

(2) Moment of resistance in both direction.

(3)P-M interaction diagram for axial load with uniaxial bending in X and Y direction for given section and reinforcement arrangement.

(4)It gives value of interaction formula.$[\frac{Mux}{Muxl}]^{\alpha} + [\frac{Muy}{Muyl}]^{\alpha}$.

Features of the computer program

(1) All the variables are in S.I. units
(2)The modulus of elasticity of steel is 2, 00,000
(3)Number of bars can be selected by user and maximum number of bars are limited to 7 on both faces.

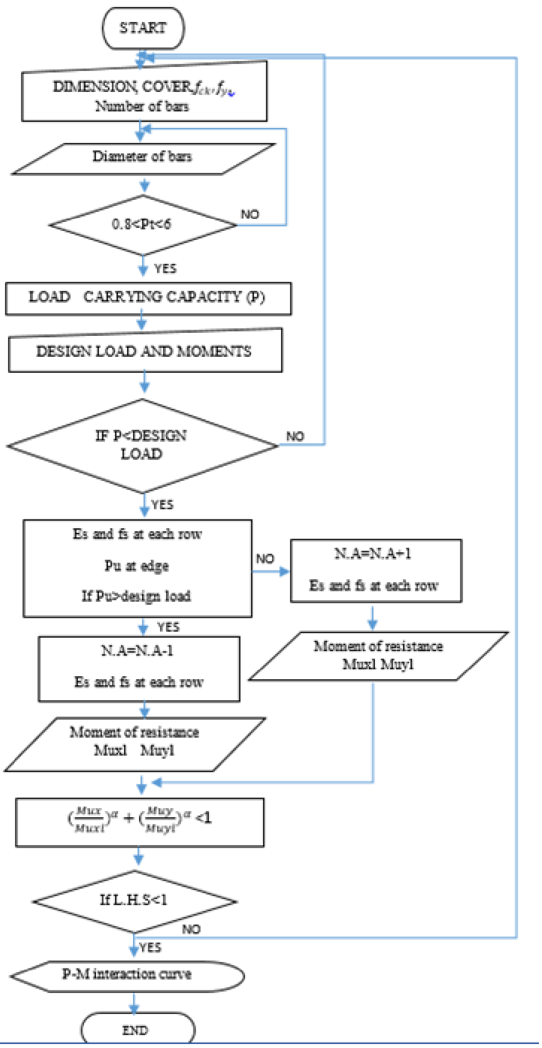

Figure10.Flow chart

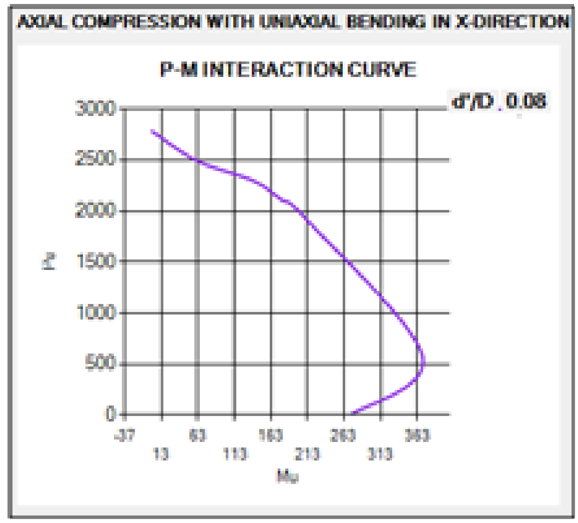

Figure11.P-M interaction di

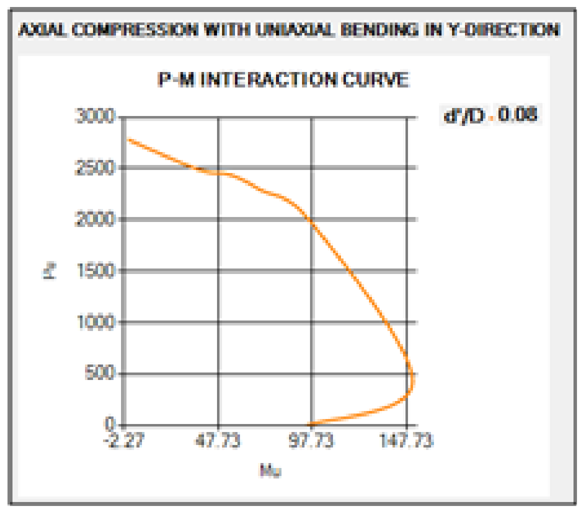

Figure12.P-M interaction diagram.

CONCLUSION

The design of reinforced concrete rectangular and square column sections subjected to axial compression and bending (uniaxial and biaxial) has been computerized. Prepared computer program also forms P-M interaction curve for given section and given reinforcement arrangement. It is hoped that prepared computer program will prove to be useful aids for designers and also will bring some attention to the particular form of resistance exhibited by these cross-sections. Present paper implement the existing design procedure.

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