



A simplified method for flexural capacity assessment of circular RC cross-sections

Edoardo Cosenza^a, Carmine Galasso^{a,*}, Giuseppe Maddaloni^b

^a Dipartimento di Ingegneria Strutturale, Università degli Studi di Napoli Federico II, via Claudio 21, 80125, Naples, Italy

^b Dipartimento per le Tecnologie, Università degli Studi di Napoli Parthenope, Centro Direzionale isola C4, 80143, Naples, Italy

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ABSTRACT

A simplified method for the assessment of bending moment resistance for reinforced concrete (RC) members with circular cross-sections is presented. In the proposed method longitudinal rebars arrangement is replaced with a thin steel ring equivalent to the steel total area; moreover, according to modern codes, simplified stress–strain relationships for concrete and reinforcing steel are used.

The performed analyses demonstrate that the value of flexural capacity determined by the proposed approach, is very close to the results obtained by applying rigorous methods based on analytical and numerical algorithms.

The study also proves that in members subjected to bending moment without axial load, the flexural strength depends on the geometry of the section (i.e. radius and concrete cover) and on mechanical ratio of steel reinforcement by a very simple formula.

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1. Introduction

Reinforced concrete (RC) members with circular cross-sections are widely used in structural and geotechnical engineering (e.g. columns in frame structures, foundation piles, contiguous pile walls) due to simplicity of construction and because their strength characteristics under wind and seismic load are similar in any direction. Generally, for such members, the analysis is more complex than that for rectangular cross-sections. In particular, circular shape and uniform distribution of reinforcement along the perimeter (at discrete points) cause some difficulties for a simple assessment of bending moment capacity.

Codes do not usually propose specific formulation (or specific instruction) for evaluating the ultimate flexural capacity of such structural types; likewise, in the engineering literature this problem is not investigated enough.

Some studies (e.g., [1–4]) on the rectangular and the circular concrete cross-section design focus on integration methods based on analytical and numerical algorithms. In this case a computer program implementing these procedures is necessary and a quick “manual” calculation is not possible because the methods require trial-and-error techniques too lengthy for manual computation. In particular, in [1] a comparative study of different integration methods of stresses (both analytical and numerical) for circular and rectangular concrete sections subjected to axial loads and biaxial bending is presented. The constitutive equation used for concrete is a parabola–rectangle from the Eurocode 2 (EC2) [5]. The comparison is performed with regard to the accuracy and the

computational speed of each method. Similarly, in [4] a numerical procedure along with a computer program for the analyses/design of RC circular cross-sections subjected to axial loads (compression or tension) and bending moments is developed. Recently in [6] a closed form solution is obtained for optimal design of RC sections but only for the rectangular shape. This method is valid for ultimate loads, axial load and uniaxial bending and a parabola–rectangle diagram. Finally, in [7] an analytical model for evaluating the contribution of the transverse reinforcement to the shear strength of concrete members of solid and hollow circular cross-sections is presented.

In this paper a simple method for the analysis of RC circular cross-sections is presented. The developed equations are based on the assumption that the reinforcement steel area is lumped into an equivalent steel ring; in the proposed method, the stress–block diagram is assumed for concrete, whereas steel is supposed to be always yielded. An illustrative example of the proposed method indicates a good correlation of the results with the values obtained by methods widely used in practice.

2. RC member flexural capacity according to the Italian building code¹

The new Italian Building Code (NIBC) [8] in its *Sec. 4.1.2.1.2* provides principles and rules for the evaluation of RC member flexural capacity (with or without axial force). When determining

* Corresponding author. Tel.: +39 0817683659; fax: +39 0817683491.
E-mail address: carmine.galasso@unina.it (C. Galasso).

¹ In the rest of the article, all calls and verbatim citations of NIBC and EC2 will be simply indicated in *italic*.