Assessment of Structural Concrete Members using the *fib* ModelCode 2010 Shear Provisions

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Summary

In this contribution the *fib* Model Code 2010 (MC10) shear provisions for members with shear reinforcement are outlined. Furthermore, they are compared to those of the Eurocode 2 (EC2). The Model Code developments comprise two novelties: These include the concept of the Levels of Approximation (LoA) and the dependence of the member's strength on its strain state. The idea behind MC10 is to have a solid basis for the design as well as the structural analysis of members in shear (assessment). Additionally, future developments should be enabled and a framework for this defined. In the comparison of the two codes it is shown that the results are partially in good agreement but deviate from each other in certain ranges of parameters.

Keywords: assessment, concrete structures, design, ModelCode, shear

1. Introduction

For the development of the shear chapters of the new *fib* Model Code 2010 (MC10) the following goals were identified: The provisions should be based on physical models (understandable), include the important influences (such as e.g. the strain dependence of the strength) and be open for future developments. Furthermore, it was agreed to introduce the Level of Approximation approach as in engineering practice the assessment of structures significantly gains in importance and hence, more refined models are required.

To achieve consistency within MC10, the shear equations are further developed with reference to the well known approaches and adjusted with help of a wide comparison with experimental data. One of the underlying ideas was to bring different design philosophies closer together by explicitly taking account of a concrete contribution to the shear resistance and creating a link between the analysis of members without and with shear reinforcement. As expected (and quite usual in code writing), not all aspects could be treated with the same thoroughness but overall, the equations given in the code yield good results and are more general and accurate as in any design code before.

For members with shear reinforcement the MC10 shear provisions are based on a general stress field approach. As it is preferred in engineering practice, a cross sectional calculation procedure is outlined in the code and, because the strain state in the web at failure is taken into account, simple equations for determining the longitudinal strain at the mid-depth of the web are given for non-prestressed and prestressed members, respectively.

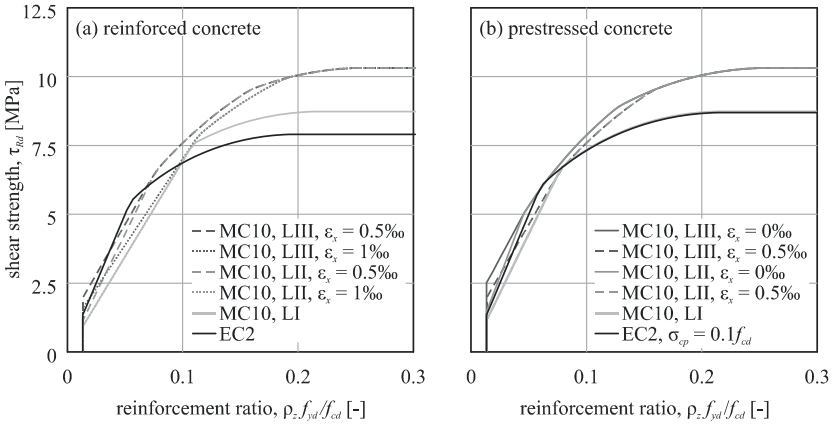
The Level of Approximation approach is introduced to differentiate between (preliminary) design, analysis and detailed structural assessment. The higher the level, the more input data is needed and hence, the calculation effort increases, but a higher accuracy is obtained as well. It is a principle that the code equations of a lower level can directly be derived from the superior; this is why there is (with exceptions for members with only little prestress) no overlap of results and the resistances of the lower levels lie below those of the upper ones. This means that for lower levels more conservative results are obtained which is reasonable in cases where not all the details are well

https://doi.org/10.2749/222137813806521379

defined, for instance in the preliminary design or even the design stage of a project, or other criteria than resistance govern the member dimensions.

2. Shear Strength according to Model Code 2010 and Eurocode 2

In the diagrams below shear strengths according to MC10 and EC2 as a function of the mechanical stirrup reinforcement ratio $\rho_z f_{yd}/f_{cd}$ are shown. The linear branches of the curves are associated with the minimum stress field inclinations θ_{min}. The adjoining parts of the curves refer to concrete crushing in conjunction with yielding of the stirrups and the horizontal branches at high reinforcement ratios to concrete crushing and θ_{max} (while the stirrups remain in the elastic range).



Shear strength of members with shear reinforcement according to Model Code 2010 (MC10) and Eurocode 2 (EC2) for f_{cd} = 60/1,5 = 40 MPa; the parameters are chosen to exemplarily depict the behavior of (a) reinforced and (b) prestressed members

Level I of MC10 (solid, light grey) constitutes a lower limit of the shear strength for reinforced as well as prestressed members and small stirrup reinforcement ratios. The EC2-curves (solid, black) lie well above these lines but intersect at a certain point in diagram (a) and coincide in diagram (b). Note that the MC10 results depend on f_{ck} and therefore, different relations are found for other concrete strength classes. In the case of MC10 Level II or III analyses the longitudinal strain in the web is accounted for. With the diagrams two ranges are exemplarily depicted: An end and an intermediate support region of a reinforced concrete member with ε_x-values between 0,5‰ and 1‰ and of a prestressed member with ε_x-values between 0‰ and 0,5‰. For Levels II and III and high stirrup reinforcement ratios an identical upper limit, defined by $\theta = 45°$, is reached; this limit clearly exceeds the EC2 results. For low and medium reinforcement ratios and ε_x = 0,5‰ the MC10 curves (dashed lines) are close, for ε_x = 1‰ (dotted lines) they are below and for ε_x = 0‰ (solid lines) they are above those of EC2. Typically, the Level III approach yields the highest strength values in this range of the reinforcement ratio.

The MC10 Level of Approximation approach presented here covers design, detailed analysis and elaborate structural assessment of members in shear. Evidently, the effort in calculating the shear strength is low for designing and high for evaluating a member's strength but accuracy is increased as well. In comparison of the results from MC10 and EC2 there is good agreement of the results in certain ranges of parameters but clear divergence in others. Therefore, additional and more specific theoretical and experimental studies should be carried out to further investigate these aspects.