Acta Technica Napocensis: Civil Engineering & Architecture Vol. 57, No. 1 (2014)
Journal homepage: http://constructii.utcluj.ro/ActaCivilEng

Updating the Nomographical Diagrams for Dimensioning the Concrete Slabs

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Received 20 September 2013; Accepted 24 April 2014
(Technical note)

Abstract

In order to reduce the time period needed for structures design it is strongly recommended to use nomographical diagrams. The base for formation and updating the nomographical diagrams, stands on the charts presented by different technical publications. The updated charts use the same algorithm and calculation elements as the former diagrams in accordance to the latest prescriptions and European standards. The result consists in a chart, having the same properties, similar with the nomogragraphical diagrams already in us. As a general conclusion, even in our days, the nomographical diagrams are very easy to use. Taking into consideration the value of the moment it's easy to find out the necessary reinforcement area and vice-verse, having the reinforcement area you can find out the capable moment. It still remains a useful opportunity for pre-sizing and designs the reinforced concrete sections.

Rezumat

Articolul cuprinde actualizarea nomogramelor utilizate la predimensionarea plăcilor din beton armat, prezentate în volumul: "Proiectarea betonului armat", autori: Igor Tertea,Traian Oneţ, Marieta Beuran,Vasile Păcurar; Editura didactică şi pedagogică – Bucureşti -1984. Pentru reducerea duratei de proiectare și a ușurinței utilizării lor, acestea sunt recomande în activitatea de proiectare. Folosind linii sau puncte cotate, nomogramele sunt o reprezentare grafică în plan a unei relaţii dintre două sau mai multe mărimi variabile, cu ajutorul cărora se pot determina rapid valoarea unei mărimi, în funcţie de valorile cunoscute ale celorlalte mărimi care intră în relaţia considerată. Intr-o epocă a programelor de proiectare, nomogramele rămîn un instrument util, deoarece cunoscînd valoarea momentului se poate afla aria de armatură corespunzătoare și invers. Spre deosebire de un program de calcul, folosirea nomogramelor nu presupune introducerea de date.

Keywords: updating, diagrams, reinforced, concrete, slabs

1. Introduction

In order to reduce the time period needed for structures design it is strongly recommended to use nomographical diagrams.

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The base for updating the nomographical diagrams using a computer designing program lays on the charts presented by the volume: "The Design of reiforced concrete", author: Igor Tertea, Traian Oneț, Marieta Beuran, Vasile Păcurar; Didactic and Pedagogic Publishing House – Bucharest-1984. At the pages: (46-79) are presented the nomographical diagrams for sizing reinforced concrete slabs floors and beams, related to the type of used concrete.

Concrete types taken into consideration in the old version are: Bc10, Bc15, Bc20, Bc25, Bc30, and for steel reinforcement: OB 37, PC52, and PC60. The program elaborated for updating the diagrams uses the same algorithm and calculation elements as the former ones. The result consists in a chart, having the same properties, similar with the nomogragraphical diagrams already in us. The test of the sections consists in checking the following fundamental inequality:

$$M \leq b \cdot h_o^2 \cdot R_c \cdot B = A_a \cdot R_a \cdot h_o \cdot \zeta \quad (1)$$

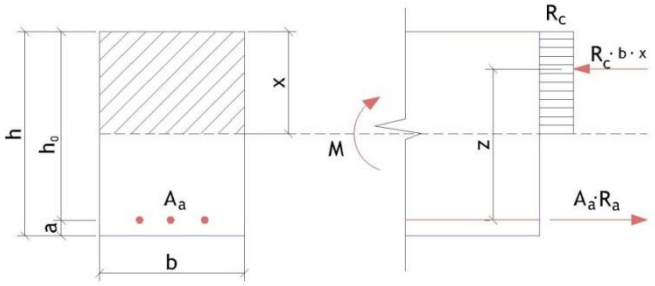

Fig.1: The simple rectangular section in stage III

For a simple reinforcement, the calculation for sections stressed by bending moment is done under the following relationships:

$$M \leq b \cdot R_c \, (h_o - 0{,}5x) = A_a \cdot R_a \, (h_o - 0{,}5x \quad (2)$$

$$x = \xi \cdot h_o = \mu \frac{R_a}{R_c} \cdot h_o \leq \xi_{lim} \cdot h_o \quad (3)$$

$$M \leq b \cdot h_o^2 \cdot R_c \cdot B = A_a \cdot R_a \cdot h_o \cdot \zeta \quad (4)$$

$$B = \xi(1-0{,}5\,\xi) \quad (5)$$

$$\zeta = (1-0{,}5\,\xi) \quad (6)$$

ξ_{lim} = 0,60 for heavy concrete (Bc10 .... Bc20)
ξ_{lim} = 0,55 for heavy concrete Bc 30
ξ_{lim} = 0,50 light concrete Bc 3

It is allowed, as a minimum reinforcement percentage on the stretched face of a concrete element, the value of 0.05%. If the calculations result is between: (0,45% .. 0,085%) it is foreseen this quantity increased with 15%, and if the calculations results shows (0,085%. ...0,1%) the minimum required is 0,1%. The design of the sections is done using the relationship (7) for dimensioning the concrete section:

$$h_o = r \sqrt{\frac{M}{b \cdot R_c}} \quad \text{where} \quad r = \frac{1}{\sqrt{B}} \quad (7)$$

or under the form of relationship (8) for dimensioning the reinforcement section:

$$A_a = \frac{M}{R_a \cdot h_0 \cdot \zeta} \quad (8)$$

As minimum percentages of reinforcement are known, there are already known and the maximum percentages of reinforcement for straight sections simple reinforced.

If the concrete elements are reinforced with welded wire mesh, it is admitted 0,1% as the minimum percentage of reinforcement up to concrete Bc35 – (included).

2. Forming the nomographical diagrams for dimensioning concrete slabs

Considering a plain diagram, on X-axis are figured the values for moments Mx10 $^{-6}$ Nmm/m representing values within (0; 0,1; 0,2;.. 2,5) and on Y-axis is figured the reinforcement type area A_a (cm²/m):
PC 52: 1 ... 17 cm^2
PC 60: 1 ... 14 cm^2
For making an comparison, in Fig. 2 is showed a nomographical diagram for dimensioning Bc 20-Rc = 12,5 N/mm²- heavy or light reinforced concrete slabs, as presented in „ Designing Reinforced Concrete", author: Igor Tertea, Traian Oneț, Marieta Beuran, Vasile Păcurar; Didactic and pedagogic publishing house – Bucharest-1984.
The reinforcements in use today are at least PC 60 and PC52. Reinforcing with OB 37 is no longer in use for resistance bars. Fig.3 shows an example of a new diagram adapted to the requirements of our days designing demands and prescriptions.

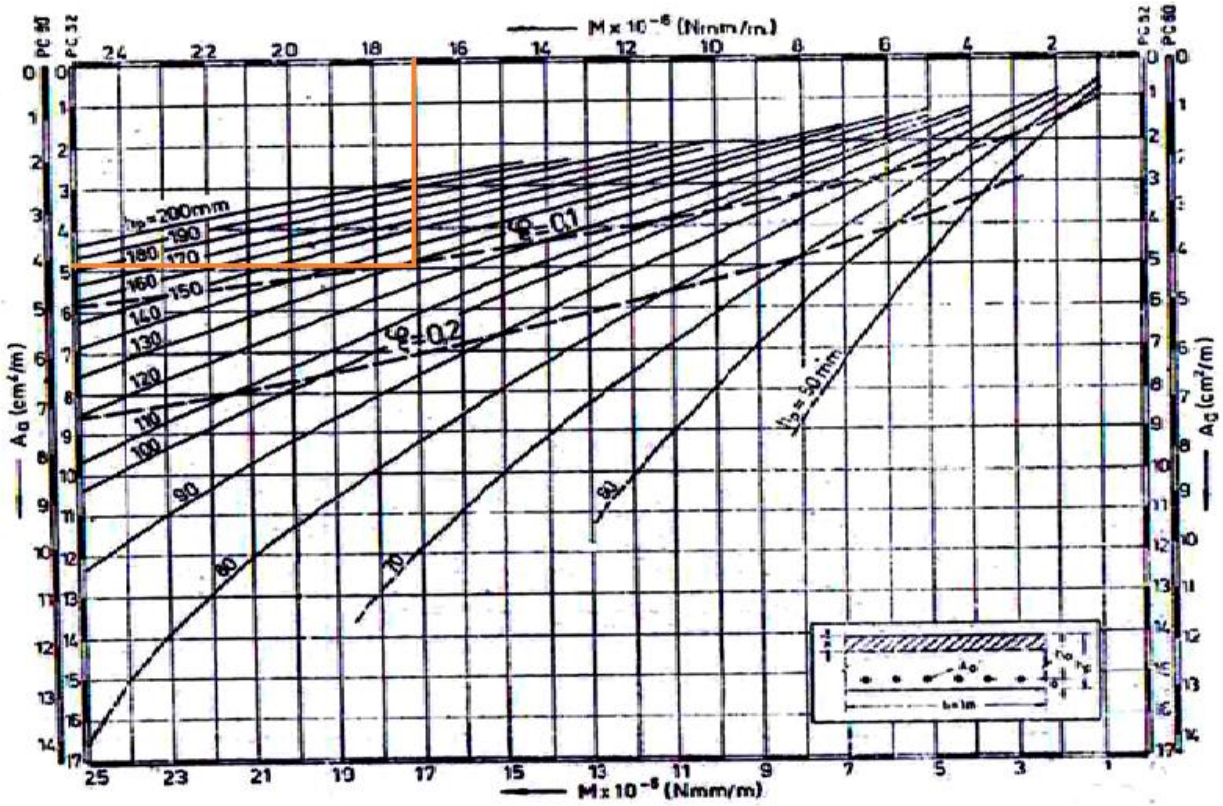

Fig. 2 : Nonomographical diagram for dimensioning B_c20-R_{ck} = 12,5 N/mm²-heavy or light reinforced concrete slabs, (old version)

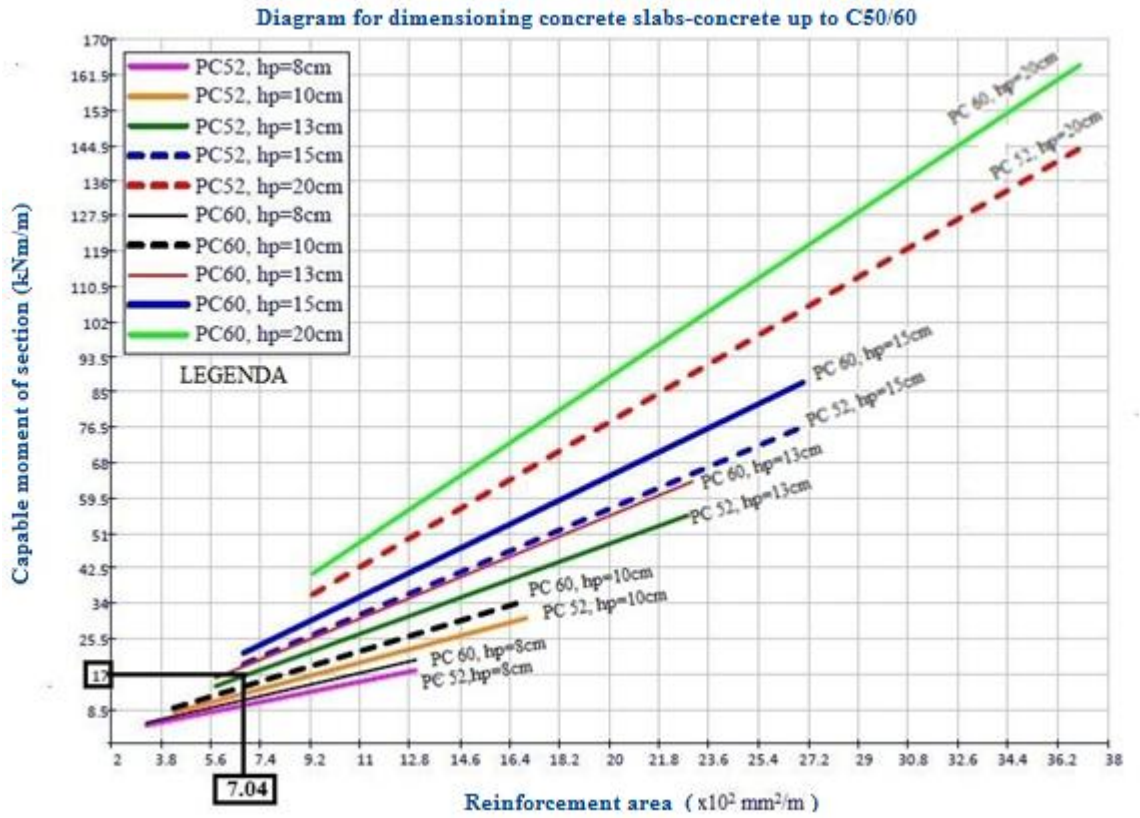

Fig. 3 : Nonomographical diagram for dimensioning concrete slabs - heavy or light reinforced concrete up to C50/60, in accordance with SR EN 1992-1

3. Conclusions

As it comes out of Fig. 2 and 3, using the old nomographical diagram the result are different from the new one. Considering the same value of the bending moment $17 \cdot 10^{-6}$ N·mm/m the reinforcement area results 531 mm^2 for the old version and 704 mm^2 in the new version considering: h_p= 130 mm; PC52.

The differences results from the following facts:

- the calculus resistance of the reinforcement steel R_a = 290 N/mm^2 (old value) compared to $f_{yd} = \frac{345}{1,15} = 300$ N/mm^2 (new value);
- the slabs reinforcement percentages (old version) p_{min} %=0,05- p_{max}%=1,74 (Bc15) – 3,92% (Bc40) for PC52, but in accordance with SR EN 1992-1 percentages are spread within the value : 0,5% - 2% (new version);
- different values of ζ= 0,95 for ξ =0,1 (old version) compared with ζ= 0,65 ξ_{lim}= 0,700 (new version) for PC52;
- concrete coating a = 116mm (old value) and c_{nom}=115 mm (new value).

For the old chart: $A_a = \frac{17.000.000}{290 \cdot 116 \cdot 0,95} = 5,31$ cm^2

For the new chart: $p = \frac{17.000.000}{1000 \cdot 115^2 \cdot 300 \cdot 0,70} = 0,00612$

$A_a = p \cdot b \cdot h_o = 0,00612 \cdot 1000 \cdot 115 = 7039$ mm^2 = 7,04 cm^2

The tests done for the old diagrams considered an applicable area within $\xi = 0,1$ and $\xi = 0,2$ meaning the optimal reinforcing domain for concrete slabs.

We can strongly conclude that, in accordance with the tests result, that the prescriptions of SR EN 1992-1 brings an additionally quantity of reinforcement for superior quality concrete slabs, using the same type and quality of the steel for reinforcement. The main goal of this presentation is to update the nomographical diagrams in use before 1990 , considering the concrete classes (C12/15 – C50/60) and reinforcement: PC 52 (S355, S345, S335), PC60 (S420, S405, S395).

Consideration the value of the moment it's easy to find out the necessary reinforcement area and vice versa, having the reinforcement area you can find out the capable moment. It still remains a useful opportunity for pre-sizing and designs the reinforced concrete sections.

4. References:

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