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Final Grade Work

Ciencias y Tecnologías de la Edificación

# PRONTUARIO EN EXCEL DE HORMIGÓN ARMADO

(Adaptado a EHE-08)

USER MANUAL

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Convocation: September 2013

# INDEX

# SUMMARY

This document is the *User Manual* of the **Prontuario en Excel de Hormigón Armado**, which help the user in the usage and understanding of different spreadsheets that make up the program. The manual has four distinct parts: the first shows the general operating criteria of the program, the second describes the operation of each sheet then the symbolism of each sheet and finally an annex with a tutorial need to use correctly a spreadsheet.

# A. INTRODUCTION DATA AND RESULTS INTERPRETATIONS

# GENERAL CRITERIA

All Excel worksheets are designed with virtually identical criteria to make the data and the results easy to interpret for the user.

## DATA INPUT

There are three types of data that the user can enter:

1) Characteristics and materials section:

| | | |
|---|---|---|
| h | 0,50 | m |
| fyk | 500 | N/mm² |

This data type boxes are highlighted with a blue background and font "Calibri" in black.

2) Safety coefficients and concrete fatigue factor.

| | | |
|---|---|---|
| $\gamma_s$ | 1,15 | u |
| $\gamma_c$ | 1,50 | u |
| $\alpha_{cc}$ | 1,00 | u |

This data is entered by default as determined by **EHE-08**, but is editable for easy modification in case of any future regulatory change requiring modification or user-

3) Tabs dropdown: We have created two types of tabs down.

   a. The first type of tabs, are shown in a gray rectangular box with a white background with a symbol of a black arrow in a gray box. Clicking the arrow, displays a list. The selected option will be displayed in blue, and appear in the box when the table is folded.

| | |
|---|---|
| Tipologia de anclaje | Patilla |

| | |
|---|---|
| Tipologia de anclaje | Patilla |
| | Prolongación recta |
| | Patilla |
| | Gancho |
| | Gancho en U |
| | Barra transversal soldada |

   This table is intended for cases in which the regulation gives to choose between various options that are taken into consideration in the calculations.

   b. In some cases they have had to create dropdown lists due to the limitations of the spreadsheet, not regulations constraints. These lists are displayed as a data entry box of blue, but when clicking on it, the user will be shown the list, rather than the ability to edit the text:

**Armadura**

| | | |
|---|---|---|
| Ø | 20 | mm |
| $\#_{barras}^{(y)}$ | 5 | ud |
| $\#_{barras}^{(x)}$ | 4 | ud |

**Armadura**

| | | |
|---|---|---|
| Ø | 20 | mm |
| $\#_{barras}^{(y)}$ | 5 | d |
| $\#_{barras}^{(x)}$ | 2 | d |
| | 3 | |
| | 4 | |
| | 5 | |
| | 6 | |
| | 7 | |
| | 8 | |

4) Select Button: in some cases, has preferred to create a selection button instead of a dropdown list, but its function is the same. The user must click on the appropriate button, this is highlighted in black, and the others remain white.

**Tipo de vano:**

- ○ Biempotrado
- ○ Apoyado-Empotrado
- ◉ Biapoyado
- ○ Voladizo

# RESULTS INTERPRETATION

The results of intermediate calculations required to obtain the final result of the spreadsheet, which also are considered important to the user data, are represented by gray and cursive letter.

| | | |
|---|---|---|
| $f_{yd}$ | *434,8* | N/mm² |
| $F_{C,LIM}$ | *925,3* | kN |

They also facilitate two types of "Final results", the favorable and unfavorable. The favorable, as shown below, are highlighted with yellow background and bold, if an unfavorable outcome, graphing appear in red.

| | | |
|---|---|---|
| $A_{S1}$ | ***11,85*** | cm² |

In some cases, such as dimensioning tables of reinforcements in which they appear various possible outcomes are displayed to the user that some values are wrong, but that may be of interest. To avoid possible confusion have been highlighted in red and crossed out, leaving visible but showing values that are not valid.

| | | |
|---|---|---|
| $S_{REAL}$ | ~~*11,85*~~ | cm |

In the event of results or factors determined by some tables EHE-08 are included those tables. They highlight the row and column in which it is the result and the intersection of both shows with a more ocher and bold letters.

| m | | |
|---|---|---|
| fck | $f_{yk}$ | |
| | 400 | 500 |
| 25 | 1,2 | **1,5** |
| 30 | 1,0 | 1,3 |
| 35 | 0,9 | 1,2 |
| 40 | 0,8 | 1,1 |
| 45 | 0,7 | 1,0 |
| 50 | 0,7 | 1,0 |

In the case of Test sheets and in the case of sizing sheets in which has to calculate the strength of concrete, can be found two types of results:

1) Favorable results that meet the requirements set by the regulations. Highlighted in green, bold and italic.

| | | |
|---|---|---|
| $V_{U1}$ | ***675,00*** | kN |
| $b_0 \times d$ | ***Cumple*** | |

2) Results unfavorable, that do not meet the requirements of the regulations. Highlighted in red, italic and bold.

| | | |
|---|---|---|
| $V_{U1}$ | ***675,00*** | kN |

As described in the description section of the leaves, the leaves testing sections, annotations were made automatically displayed to assist the interpretation of the results.

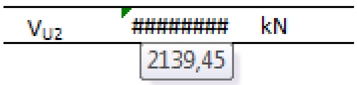
## POSSIBLE ERROR IN READING FOR RESULTS

In any case, it is likely that to enter the data into the spreadsheet, the result is displayed as follows:

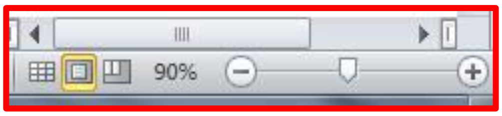
| | | |
|---|---|---|
| $V_{SU}$ | ###### | kN |

These pads do not necessarily imply an error in the calculation; it may be because the result is too large a figure that will not fit in the box.

There are two ways to see the result, the first and simplest is that the user places the cursor on the box where it appears that "error", in a few seconds you will see a box with the pads hidden value:




If, for convenience, you want that result to be visible permanently in your spreadsheet, and since you cannot change the type or font size of the boxes of results, another possible solution is to increase or decrease the zoom leaf:




The results boxes are designed to support up to 3 decimal places, and have changed their sizes ensuring that this error is not, but this may vary depending on your computer and Office Pack is used.

# B. SHEETS DESCRIPTION
# CALCULATION PROCEDURES

## SIMPLE BENDING

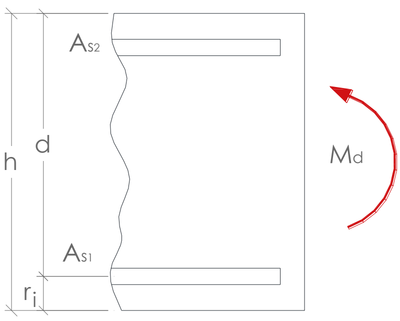
For the calculation of sections subjected to pure bending (where we have only bending moment) we have used the *Rectangular diagram*, reflected in ***Article 39.5*** of the ***EHE-08***, is an estimate but very effective method that is based on the fact that, from a given bending moment, called Limit Moment ($M_{LIM}$) have only a bending reinforcement stops to being effective. That is because must always exist a balance of forces between the concrete and compressed tensile zone, if the compressed increases, the mechanical arm is decreasing, so the armor needed a exponentially greater section to resist the efforts.

$M_{LIM}$ is calculated from $x_{LIM}$, which is determined by *Deformation Domains* listed in ***Article 42.1.3*** of the ***EHE-08***.

## DIMENSIONING

The spreadsheet initially requests the user to input the materials characteristics, the dimensions of the section and the stress it is subjected.

Is an indispensable condition to enter the values in the same direction as shown in the sketch. The bending moment will always be positive and in the direction as shown in the figure:




If the Real bending moment is negative, their absolute value will be introduced and user must interpret if $A_{s1}$ will be at the top of the section and $A_{s2}$ in the lower.

Of all entered data will be extracted some characteristic values of the section, which means, the *limits* ($y_{LIM}$, $F_{c,LIM}$ y $M_{LIM}$) and calculate the "real" values ( $F_c$ e $y$), all of which are shown in the Calculations section . Over the "real" values automatically appear one of the following cases: $0<Md\leq Mlim$ o $Md>Mlim$ the first indicates that the effort is less than the *Limit Moment*, and therefore, the section does not require minimum compressive mechanical rebar; the second case, determined that the effort is greater than the limit, and therefore should increase the compression reinforcement, $A_{S2}$, to make the sizing of the armor section be optimum.

After determining these values are given so much mechanical reinforcement required as the minimum geometric standard.

The spreadsheet detects which are the highest values, and highlighted in yellow and bold. These outstanding values are those used in the last section, it determines how many bars would be required for any diameter and determines both the actual and the minimum separation. The sheet detects which results meet or not, highlighting which they do and crossing out which not. This means that will reflect several suitable results, and the user should determine the optimal.

**$A_{S1}$**

| $Ø_{S1}$ (mm) | $\#_{barras}$ (ud) | $A_{REAL}$ (cm²) | $S_{REAL}$ (cm) | $S_{MIN}$ (cm) |
|---|---|---|---|---|
| ~~*14*~~ | ~~*8*~~ | ~~*12,32*~~ | ~~*0,54*~~ | ~~*2,00*~~ |
| ~~*16*~~ | ~~*6*~~ | ~~*12,06*~~ | ~~*1,08*~~ | ~~*2,00*~~ |
| ***20*** | ***4*** | ***12,57*** | ***2,33*** | ***2,00*** |
| ***25*** | ***3*** | ***14,73*** | ***3,75*** | ***2,50*** |
| ***32*** | ***2*** | ***16,08*** | ***8,6*** | ***3,20*** |
| ~~*40*~~ | ~~*1*~~ | ~~*12,57*~~ | — | ~~*4,00*~~ |

If all values of the table appear crossed, it means, none meets the minimum separations established by the regulations, a notation will appear at the top of the table, indicating that the section should be increased.

## TESTING

The introduction of the data in the Test Sheet is similar to that described in the previous section, should be introduced characteristics of materials, calculation efforts (to be introduced in their absolute value) and the geometric characteristics of bars.

The procedure used to obtain the results of this sheet are based on the application of a previous hypothesis which states that the two rebars work in their mechanical capability and which are in Domain 2. And estimated values are obtained, which are not shown because are not always real. These estimated values are compared with the limit values (that determine the limit between domains 3 and 4), these values are shown in the Calculations section together with the results of the mechanical capabilities of the reinforcements.

In the *Results* section, shows the values of $F_c$, $y_{REAL}$ y $M_U$ and also determines the domain of deformation which is the section. The *latter moment* ($M_U$) determines the maximum moment that section can resist.

In case rebar section is not enough, that means, the $M_U$ were less than $M_d$, the result will be highlighted in red. Whatever the result, a note will always help to your interpretation and also provide more information.

**Interpretación de resultados:**

***No cumple, insuficientes armaduras S1 y S2***

This note will determine if section meets or not, and will also provide the user with information about the reason of failure: whether due to $A_{S1}$, $A_{S2}$ or both. Numerical results are not shown because it is a test. For correct sizing of the rebar can be used both by probing at the testing sheet as the previous sheet (dimensioning).

# COMBINED BENDING

In this sheet we use the ***Ehlers method***, which states that «*all combined bending problem can be reduced to one of simple bending, with no more than taking as moment, that produces A normal effort regarding the tension reinforcement $M_d$=$N_d$·e*»

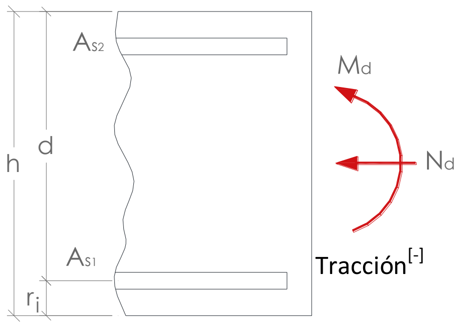
After this simplification, we can use the same method as for pure bending Rectangular diagram, reflected in ***Article 39.5*** of the ***EHE-08***, is an estimate but very effective method that is based on the fact that, from a given bending moment, called Limit Moment ($M_{LIM}$) have only a bending reinforcement stops to being effective. That is because must always exist a balance of forces between the concrete and compressed tensile zone, if the compressed increases, the mechanical arm is decreasing, so the armor needed a exponentially greater section to resist the efforts.

$M_{LIM}$ is calculated from $x_{LIM}$, which is determined by *Deformation Domains* listed in ***Article 42.1.3*** of the ***EHE-08***.

## DIMENSIONING

The spreadsheet initially requests the user to input the materials characteristics, the dimensions of the section and the stress it is subjected.

It is essential that the user enters the bending moment in the same direction established the figure, although it may vary the direction of axial, establishing as positive value the compressions and as the negative value for the tractions.




If the Real bending moment is negative, their absolute value will be introduced and user must interpret if $A_{s1}$ will be at the top of the section and $A_{s2}$ in the lower.

With the introduction of new actions, bending moment named $M_d'$, obtained from the application of the *Ehlers method*, and is the sum of the bending moment over the moment generated by axial effort.

Of all entered data will be extracted some characteristic values of the section, which means, the *limits* ($y_{LIM}$, $F_{c,LIM}$ y $M_{LIM}$) and calculate the "real" values ( $F_c$ e $y$), all of which are shown in the Calculations section . Over the "real" values automatically appear one of the following cases: *0<Md≤Mlim* o *Md>Mlim* the first indicates that the effort is less than the *Limit Moment*, and therefore, the section does not require minimum compressive mechanical rebar; the second case, determined that the effort is greater than the limit, and therefore should increase the compression reinforcement, $A_{s2}$, to make the sizing of the armor section be optimum.

After determining these values are given so much mechanical reinforcement required as minimum geometric.

| Armadura mecánica mínima | | |
|---|---|---|
| $A_{S1}$ | **11,85** | cm² |
| $A_{S2}$ | 0,00 | cm² |

| Armadura geométrica mínima | | |
|---|---|---|
| $A_{S1}$ | 3,50 | cm² |
| $A_{S2}$ | **1,05** | cm² |

The spreadsheet detects which are the highest values, and highlighted in yellow and bold. These outstanding values are used in the last section, it determines how many bars would be required for any diameter and determines both the real and the minimum separation. In case this set of bars breach, the results would be crossed out in red, if met, will be highlighted in yellow and bold. This means that results will reflect several suitable, and the user should determine the optimal.

**$A_{S1}$**

| $Ø_{S1}$ (mm) | $\#_{barras}$ (ud) | $A_{REAL}$ (cm²) | $S_{REAL}$ (cm) | $S_{MIN}$ (cm) |
|---|---|---|---|---|
| ~~14~~ | ~~8~~ | ~~12,32~~ | ~~0,54~~ | ~~2,00~~ |
| ~~16~~ | ~~6~~ | ~~12,06~~ | ~~1,08~~ | ~~2,00~~ |
| **20** | **4** | **12,57** | **2,33** | **2,00** |
| **25** | **3** | **14,73** | **3,75** | **2,50** |
| **32** | **2** | **16,08** | **8,6** | **3,20** |
| ~~40~~ | ~~1~~ | ~~12,57~~ | ~~-~~ | ~~4,00~~ |

If all values of the table appear crossed, which means, none meets the minimum separations established by the regulations, a notation will appear at the top of the table, indicating that the section should be increased.

## TESTING

The introduction of the data in the testing sheet is similar to that described in the previous section, should be introduced in section geometric characteristics, characteristics of materials and design stresses: remember that the bending moment must be entered in absolute value, but is important that the axial force is introduced with the proper sign (positive for compression and negative for tension zones), following the criteria determined by the shape of the sheet.

The procedure used to obtain the results of this sheet are based on the application of a previous hypothesis which states that the two rebars work in their mechanical capability and which are in Domain 2. And estimated values are obtained, which are not shown because are not always real. These estimated values are compared with the limit values (that determine the limit between domains 3 and 4), these values are shown in the Calculations section together with the results of the mechanical capabilities of the reinforcements.

In the *Results* section, shows the values $F_c$, $y_{REAL}$, $M_U'$, $M_U$ y $N_U$. The last two values are obtained proportionally from $M_U'$, $M_d$ y $N_d$, as $M_U'$ not the real applied moment, and is intended to give the user an idea of the values that can support section.

**Resultados**

| | DOMINIO 4 | |
|---|---|---|
| $y_{real}$ | *0,24* | m |
| $F_c$ | *984,0* | kN |
| $M_u'$ | **405,3** | m·kN |
| $M_u$ | *405,3* | m·kN |
| $N_u$ | *0,0* | kN |

In case rebar section is not enough, that means, the $M_U$ were less than $M_d$, the result will be highlighted in red. Whatever the result, a note will always help to your interpretation and also provide more information.

**Interpretación de resultados:**

***No cumple, insuficientes armaduras S1 y S2***

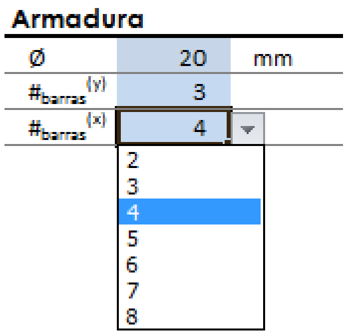
This note will determine if section meets or not, and will also provide the user with information about the reason of failure: whether due to $A_{S1}$, $A_{S2}$ or both. Numerical results are not shown because it is a test. For correct sizing of the rebar can be used both by probing at the testing sheet as the previous sheet (dimensioning).

# TESTING BENDING COMPRESSION OBLIQUE OR SYMMETRICAL

This spreadsheet provides the place in which is located the neutral axis of the piece and the balance of forces, using as criteria the axial equals the calculation axial.

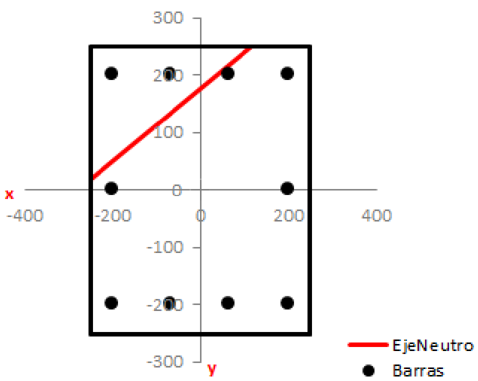
Regarding the data input this sheet is very similar to all the others, the dimensions of the requested section, the characteristics of the materials, the design stresses and REBAR.

To determine the rebar are requested three items: the diameter, the number of bars in the direction of the y-axis and the number of bars in the direction of the axis x. By limitations of the use of Excel, created a drop down list, instead of allowing the user to enter any value. In this list, the user can choose between 2 and 8 bars in each direction:

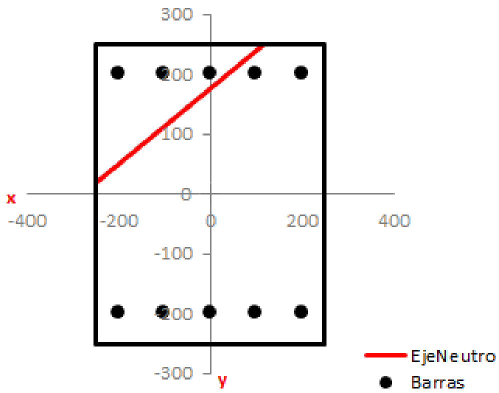



To make it more graphic and simple for the user, and for it to be sure you have correctly entered values, we have created a graph of the section, which changes depending on the input values.

So if you decide that in the vertical direction are 3 and 4 on the horizontal, appears this drawing:



If you choose 5 horizontal and 2 vertical bars, the following chart:




And so on for all possible combinations.

As can be seen in the two graphs displayed neutral axis line is identical, this is because the sheet to calculate this result must be used ***Solver*** application. For this should activate this option in Excel, as default is disabled in ***Microsoft Excel 2010***. Activation and the use of this option are shown in Annex of this document, entitled "Function Solver".

Once you have done the calculations we can see the results, we have created a table that shows all bars with their respective coordinates, and indicates if they are tensioned or compressed, which is resisting bending moment each and the unitary deformation.

In the results section shows the balance of effort, the values for neutral axis graphing (the tilt angle) and a table with the neutral axis vertexes (so that users find it easier to determine if graphing is precised).

# SHEAR

To carry out the calculations in this sheet carefully followed the procedures established in ***Article 44*** of the ***EHE-08***. For this reason it will not proceed to detailed explanation, this section will explain just a list of the input data and a brief explanation of the calculations and interpretation of results

Both sheets *Testing* and *Dimensioning* have made the necessary verifications in terms of fissuring moment ($M_{FIS}$), shear exhaustion oblique compression ($V_{U1}$) and exhaustion shear traction in the soul ($V_{U2}$), and also shows the contribution of both the concrete ($V_{CU}$) and the rebar ($V_{SU}$) to the shear strength.

## DIMENSIONING

Data input and calculations of this sheet can be a bit complicated for the user since it requires the introduction of many data even has tried to simplify.

In the first section of the sheet are 4 types of data requested:

- Those relating to the section are almost identical to those of any other application sheet, although with a slight catch: $b_0$ is requested, which is the width lower in this section.
- Characteristics of materials.
- Disposition of long reinforcement: it is necessary to enter the data of the longitudinal reinforcement of the section and the criteria for placement of transverse reinforcements. You can also enter values for: $S_{t,\ rings}$ (separation between rings) and $\#_{BRANCHES}$ (number of branches), when the user wants to enter this data you will see that you can choose a range of values from a list or select the option ns / nc (Do not know / no answer), this is because you can assume that the user knows beforehand what separations wants to have between the fences or the number of branches that should be placed, or the user may prefer that these data may supply by spreadsheet.
- Efforts of calculation.

In the *calculation* section shows two columns, the first listed all the factors and coefficients used, and the second column shows all checks required by the law. To facilitate interpretation of results automatic annotations have been added to determine if the section meets or not, and if it fissures or not and if required transverse reinforcement.

Regarding the *results* also show different values despite not determine the required reinforcement, are considered important. These values are transverse separations (between branches) maximum and minimum set by the regulations, and the actual separation (so you can determine whether meets the standard or not) and the area of geometric and mechanical rebar (and likewise that in other sheets, highlighting the greater of the two values). From these values, the data entered by the user and the calculations will determine the diameter, number of branches and rings separation between optimal transverse section. In the case that the number of branches or separation between rings have been determined by the user, these boxes will repeat such values.

## TESTING

Data input on this sheet is slightly more extensive (although only by 2 squares) than the previous section, similarly requested data on the section, characteristics of materials, calculation efforts and the provision of rerebars, an essential difference in the introduction of data on this sheet is that the user is free to put any transverse separation value and number of branches.

In the *calculations* section only shows the values of the coefficients and the factors used to obtain $V_{U1}$ and $V_{U2}$. Unlike the previous section, these calculations are not shown in this section as are both calculations and checks for compliance with Section.

The results are essentially the interpretation of Fissuring moment values ($M_{FIS}$), shear exhaustion oblique compression ($V_{U1}$) and exhaustion shear traction on the soul ($V_{U2}$), differentiating between $V_{CU}$ and $V_{SU}$. For the interpretation of these results have added automatic annotations that determine compliance or not, if there is cracking or not and if you need armor. In addition we have added a second sub in the interpretation appears synthesized all results.

Being a test, it indicates to the user if there are any errors or non-compliance at some point in the calculations, and what is this fault, although no provide a value of the optimum design, since this may depend on the user preferences. The correct dimensioning can be done by *Shear Dimensioning* sheet or by trial and error with the same Testing Sheet.

# TORSION

Following the criteria established by the regulations, calculations were made for two types of sections: rectangular and hollow sections. In essence, the calculations for both cases are the same, and vary only a few values in the data entry, and some subsequent formulas given in the hollow sections which can be placed on the inside reinforcement and the outside, which does not occur into rectangular sections, and that in the case of hollow sections is necessary to determine the wall thickness. These differentiations are simple, but we preferred to differentiate these two cases in two sheets, to facilitate data entry and simplify the calculations.

The regulations establish dimensioning to pure torsion, torsion combined with bending and axial, and torsion combined with shear. Has not been conducted a combination of bending and axial torsion because regulations state that «*the longitudinal reinforcement required for torsion and bending-traction or bending-compression will be a separate calculation assuming the performance of both types of effort independently".* Although all sheets allowed the introduction of shear. If the user enters this value, the spreadsheet tests the rules established by, however, user can decide that $V_d$ = 0, these calculations do not appear.

## DIMENSIONING

Regarding the introduction of data, these sheets requested sectional dimensions, the characteristics of the materials, the arrangement of the reinforcements to torsion, efforts calculation and dimensioning of the longitudinal reinforcement compressed. It is important to note that the longitudinal reinforcement $A_S'$ (or $A_{S2}$ on other sheets) does not correspond to the minimum longitudinal reinforcement torsion but depends on the tension generated by the axial, that is, if the value of axial force is 0, the dimensioning of $A_S'$ does not interfere with the calculations, since it only is used for obtaining the coefficient *K*, but if $N_d$>0 will be necessary.

In the section on testing calculations show the maximum torsional moments that can resist concrete compression struts ($T_{U1}$), transverse reinforcements ($T_{U2}$) and longitudinal reinforcements ($T_{U3}$).

The testing of transverse and longitudinal reinforcement, in the case of sizing, always comply because is obtained from the result of the dimensioning, and will always be equal to the torque effort applied to the piece. The only section that cannot comply is that which depends on the dimensions of the section (concrete), in case of no to comply, a note appears with the text that is displayed in red:

**M. torsores máximos que puede resistir**

| | | | |
|---|---|---|---|
| $T_{U1}$ | *75,6* | m·kN | ***No cumple: Δ(b*h)*** |
| $T_{U2}$ | *400,0* | m·kN | |
| $T_{U3}$ | *400,0* | m·kN | ***Cumple*** |

This means that $T_{U1}$ "fails", so that should increase the area of concrete (b * h).

If the user determines that combination with shear, in the same section of *Calculations* will appear: *Torsion combined with shear* ,where is show the intermediate necessary calculations ($V_{U1}$) and the maximum shear that piece, in the conditions set by the user, can resist. Three cases are possible:

- $V_{rd,MAX}$= Error : with the data provided, section no admits shear effort interaction with the torsion moment.
- $V_{rd,MAX}<V_{rd}$ : section supports the application of shear, but less than introduced.
- $V_{rd,MAX}\geq V_{rd}$ : Section fulfills with interaction shear.

**Torsión combinada con cortante**

| | | | |
|---|---|---|---|
| $V_{U1}$ | *980,00* | kN | |
| $V_{rd,MAX}$ | *Error* | kN | ***No admite Cortante*** |

The interpretation of these three possibilities will be highlighted in the same paragraph, by the phrases: "*No admite Cortante*", "*No cumple*" y "*Cumple*".

Finally, in the *Results* section, transverse reinforcement is required and the rings separation and the minimum required total area longitudinal reinforcement. Below these results are two tables, the first shows the diameter of the rebar that makes up the ring/s. In the case of rectangular sections or hollow sections with a single bar in the outer perimeter, only one ring will be shown, in the case of hollow sections with reinforcement on both sides of the section appear two rings.

The dimensioning chart establishes longitudinal reinforcement bar diameters and numbers of bars needed assuming both were equal. It is not possible to differentiate between $A_{S1}$ and $A_{S2}$ (as in other sheets) because is not requested any bending moment.

## TESTING

The *Testing* sheet to torsion, is simpler than the *Dimensioning*, because, although the user must enter some additional values, are less results, and also have created automatic annotations that explain each of the cases.

In the *Data* section user must provide the dimensions of the section, the provisions of longitudinal and transverse the reinforcements, the characteristics of the materials and the design stresses.

It may happen, that by introducing the value of the transverse spacing of the rings this value turns red and display the following notation: <<** st value is higher than that established by art.45.2.3*>>. This means that the value of the transverse spacing is higher than that established by the regulations, the user can decide to keep or modify the wrong value, but if it's modified will impact on the final results (as explained below).

In the calculations section only shows the geometric characteristics typical of the section, the coefficients used in the calculations and, if there is shear, the design values used for determining the maximum shear which can resist the piece.

If no interaction with shear in the results section, are displayed only maximum torsional moments that can resist the concrete, longitudinal reinforcements and transverse reinforcements, and a section for interpretation of results.

Along with the values of $T_{U1}$, $T_{U2}$ y $T_{U3}$ notes appear "*Cumple*" or "*No cumple*", which called the attention of the user, making it easily visible section failure points . And under *"Interpretation* *of results"* will help you understand why it fails the section. At this point automatic annotation will determine if the section complies at all points (p.e.: *Cumple, el dimensionado es correcto*) or fails dimensioning section or any of their rebar (p.e.: *No cumple, es necesario aumentar la sección y la armadura transversal*).

It may be that in the *Results* section the user is the case with the value of $T_{U2}$, although this is higher than $T_d$, notice appear <<*No cumple*>>, this is because the value of st entered by the user was higher than that established by the regulations, this implies that the formula establishing $T_{U2}$ is incorrect because, finding rings too far apart, they will not work at 100% capacity. Consequently, the maximum torsional moment ($T_{U,\ MAX}$) that can resist the piece will be less than any of the three previous results ($T_{U1}$, $T_{U2}$ and $T_{U3}$).

**Momentos torsores máximos que puede resistir**

| | | | | | | |
|---|---|---|---|---|---|---|
| $T_{U1}$ | ***48,0*** | m·kN | ***Cumple*** | | | |
| $T_{U2}$ | ***32,2*** | m·kN | ***No cumple*** | | | |
| $T_{U3}$ | ***67,0*** | m·kN | ***Cumple*** | | | |
| **Torsor máximo que puede resistir:** | | | | | | |
| $T_{U,MAX}$ | ***32,00*** | m·kN | | *limitado por $s_{t,MAX}$ =* | *6,00* | *cm* |

The value of $T_{U,MAX}$ taken is $2/3 \cdot T_{U1}$, since it follows that the steel does not work properly and that is concrete alone which must resist torsion.

If there is shear in addition to the maximum torsional moments that resist the concrete and armor, also displays a table with the maximum allowable shear section. As in the dimensioning section, there may be following cases as regards shear:

$V_{rd,MAX}$= Error : with the data provided, section no admits shear effort interaction with the torsion moment.

$V_{rd,MAX}<V_{rd}$ : section supports the application of shear, but less than introduced.

$V_{rd,MAX}\geq V_{rd}$ : Section fulfills with interaction shear.

The interpretation of these three possibilities will be highlighted in the same paragraph, by the phrases: "*No admite Cortante*", "*No cumple*" y "*Cumple*".

In this case, the interpretation of results may determine that:

"*Cumple, el dimensionado es correcto"* which means it is correctly sized for both pure torsion and shear interaction.
"*El dimensionado es incorrecto*" implies that at least one of the maximum torsional moments which can resist fails and which does not support shear or shear is greater than section can resist.
"*No cumple, es necesario aumentar [...]*" which implies that despite interaction with shear can be resist, but does not comply any of the maximum torsional moments that can resist the concrete or the reinforcements.
"*La armadura transversal no cumple las separaciones de norma, Tu,max=2/3·Tu*" user must review the value of st, and that does not comply rules, and therefore do not take into account other calculations.

# PUNCHING SHEAR

For the use of this spreadsheet is essential to use the respective sheet symbology. This is due to two reasons: the first is the large amount of data that the user must add, with whose initials/symbology probably not so used, and secondly because, since in various sections of the norm uses the same symbology to represent different values, it is necessary to add subscripts which are not listed in the norm and therefore the user can not know.

In the *Data* section, despite its size, the user has to enter too much data, so only the provisions relating to the support (pillar) and the slab, the reinforcements, the characteristics of materials and the calculation effort. The biggest difference between this page and the other is that, in this section, some intermediate calculations appear.

Given that data of punching reinforcements may lead to misunderstanding by the similarity of various data, then will explain what each one of them, despite being defined in the section above symbology.

**Rebar disposition**

| | |
|---|---|
| $\alpha$ | Rebar angle with axis of the piece |
| $s_{max}$ | Maximum distance radially concentric perimeters of rebar |
| $s$ | Distance radially concentric perimeters of rebar, used in calculations |
| $s_{1,min}$ | Minimum distance in radial direction between the support and the first line of rebar (0,5·d) |
| $s_{1,max}$ | Maximum distance in radial direction between the support and the first line of rebar (0,5·d) |
| $s_1^{(user)}$ | Distance in radial direction between the support and the first line of rebar, choose by user |
| $b_{x2}$ | Width of the perimeter $u_{n,ef}$ en *x* axis. |
| $b_{y2}$ | Width of the perimeter $u_{n,ef}$ en *y* axis. |
| $\rho_l$ | Geometric ratio total main rebar reinforcement inside the perimeter $u_{n,ef}$* |

Separations data the reinforcements that user must enter are *s*, which corresponds to the separation between the different perimeters of bars and $s_1^{(user)}$ which is the separation between the support and the first line of bars, above this value appear $s_{1,max}$ and $s_{1,min}$, these values are the maximum and minimum by norm, so user must provide a value intermediate between them. Default was entered a formula that calculates the average between the two, the user can modify it at will. To avoid possible errors in data entry, formulas are linked to $s_1^{(user)}$ will be limited, so if the user enters a $s_1$ higher than the maximum, the formulas will take as correct $s_{1,max}$, value, and if less than minimum value will be correct $s_{1,min}$.

With respect to stress calculation subsection, we can see $M_d$ value is not requested, it is required to know only whether there are or not moments applied. This is because it is the only specification that requests the normative, and has been estimated simpler, because the user can ignore this information accurate, despite knowing that there is a bending moment applied.

In the section calculations and testing appear the coefficients and values that may be of interest to the user, and four sections of testing:

- Checks for slabs without punching shear reinforcement: This section checks whether or not the punching shear reinforcement needed. Besides values appear nominal tangential stress and the maximum stress calculation resistant of critical perimeter will display an interpretation of results.

- Dimensioning of punching shear reinforcement: display the required reinforcement area in $cm^2$.
- Checking the area outside the punching shear reinforcement: their failure determines the need to add reinforcement for punching in the area outside the critical perimeter.
- Checking the limitation of the area adjacent to support: is the checking that the maximum stress of punching complies the limitation: $F_{sd,ef}/(u_0 d) \leq 0,5 * f_{1cd}$.

# SHEAR STRESS

Dimensioning sheet to shear stress on joints between concrete, in the section *Data* requested provisions relating to section, characteristics of materials, arrangement of rebar and computational efforts.

In calculation efforts is required the variation of the resulting normal stress blocks, instead of the more usual axial calculation in other sections.

Is also requested to determine the roughness of the piece, where you can choose from three cases:

- High roughness.
- High roughness with imbrication.
- Low roughness.

Three values are requested because in checking sections without transverse reinforcement, the coefficient β depends on these three factors.

In checking sections with transverse reinforcement, the value of β depends only on whether the roughness is high or low, so that both the "high roughness with overlap" as the "high roughness" is considered simply "high". Because β corresponds to two different values depending on the test being performed, it has established a superscript being: $\beta^1$ corresponding to verification without transverse reinforcement, and $\beta^2$ corresponding to checking with transverse reinforcement.

In Calculations section are shown the two calculations shown above testing explained before and determine its fulfillment or breach as required by ***artículos 47.2.1*** and ***47.2.2*** of ***EHE-08.***

**Armadura transversal**

| | | |
|---|---|---|
| $A_{st,min}$ | *0,80* | cm² |
| $A_{st}$ | **12,30** | cm² |

**Dimensionado de la armadura (para 1ml)**

| | | |
|---|---|---|
| $\#_{b,TOTAL}$ | **10,00** | ud |
| $\emptyset_{st}$ | **14,00** | mm |

# ANCHORAGE REINFORCEMENT

This sheet was created following the simplified method set out in ***Article 69.5*** of the ***EHE-08***.

It is a very simple method, whose calculations differ between two types of bars: the certified and non-certified, so it is a fact that the user must specify.

For $l_b$ calculation of the first one is required the diameter (Ø), and the elastic limits of the concrete and steel ($f_{yk}$ y $f_{ck}$) for uncertified is necessary to find the adhesion tension ($\tau_{bd}$) which depends on the resistance tensile strength of the concrete ($f_{ctd}$) and diameter.

To establish $l_{b,neta}$ is necessary to know two values: β and $A_{s,mec}/A_{s,real}$; to obtain is required: the coating ($c$), $A_{s,mec}$, $A_{s,real}$ and determine the type of anchor (pin, hook, straight extension ...)

It has created a section called *Factors and Coefficients* which will provide users with all the necessary values for calculating $l_b$ and $l_{b,neta}$. These values are usually not provided, but it is considered appropriate in accordance with the didactic nature of the whole project.

In *Results* are shown in a table with all net anchorage lengths depending on the diameter, if they work on compression or tension or your type of adhesion (adhesion good: Position I, and poor adherence: Position II).

| Certificada (cm) | | | | |
|---|---|---|---|---|
| Ø | lbnet | | | |
| | TRACCION | | COMPRESIÓN | |
| | POS. I | POS. II | POS. I | POS. II |
| 6 | **15,00** | **15,00** | **15,00** | **20,20** |
| 8 | **15,00** | **20,00** | **18,85** | **26,93** |
| 10 | **23,57** | **33,67** | **23,57** | **33,67** |
| 12 | **28,28** | **40,40** | **28,28** | **40,40** |
| 14 | **33,00** | **47,14** | **33,00** | **47,14** |
| 16 | **37,71** | **53,87** | **37,71** | **53,87** |
| 20 | **47,14** | **67,34** | **47,14** | **67,34** |
| 25 | **58,92** | **84,17** | **58,92** | **84,17** |
| 32 | **75,42** | **107,74** | **75,42** | **107,74** |
| 40 | **94,27** | **134,67** | **94,27** | **134,67** |

You see this table for two reasons: the first is that it is considered more useful in the future to use in any project and because it simplifies data entry. If the intention is to give a single result would require the user to determine both the type adhesion, as if they are compressed or tensioned and its diameter.

# ANCHORAGE BY OVERLAP

In the first instance was raised the calculating of anchorage by overlap in the same worksheet that the anchors, but has seen fit to do it separately because, although some data are identical, for these calculations we need to know much more data than for calculating the Anchors.

Finally we have created a sheet which data section is requested: the characteristics of the materials (steel and concrete) and the characteristics of the reinforcement: diameter separations between overlaps, mechanical areas and real, if you use isolated bars or groups bar, adherence and whether or not certified.

It has created a section of factors and coefficients which shows the values of m and β.

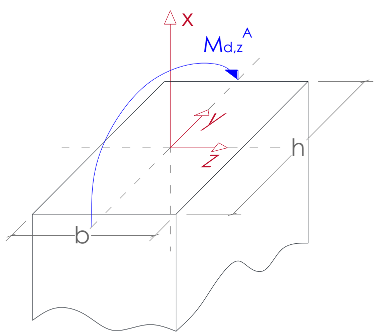
Since many data are requested, the results section is greatly simplified. In this case, as is necessary to know both values as lb lb, net for the correct arrangement of the overlaps, both these data are given, together with the overlap length ($l_s$) and, where necessary also facilitate the separation overlaps ($s_{emp}$) and the supplemental bar length ($l_{supl}$).

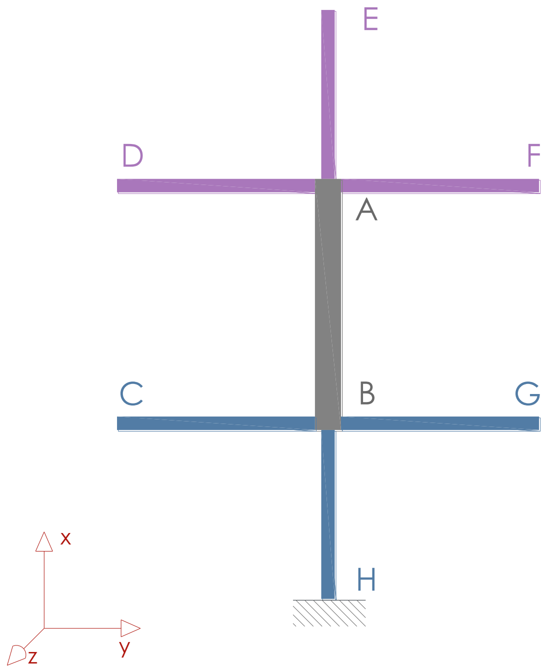
# INSTABILITY OF SUPPORTS (BUCKLING)

This sheet is used for checking supports with respect to their possible buckling. The calculations are made according to ***Artículo 43*** of the ***EHE.***

To successfully entering data to the spreadsheet, it is essential to observe user actions and bar scheme provided, because, although some data are apparently simple, are numerous and it is quite usual there are errors by confusing the axes of the structure. Excel calculates only the structure bidimensionally, therefore, if the user intends to calculate a three-dimensional portico must enter data twice, once for each direction.

The data requested are: first determining whether it is a translational or non-sway structure (as shown in ***Figura 43.1.1*** of normative), the characteristics of materials, the effort and the characteristics of the bars forming the portico to check. Of these bars is requested length *L*, and its dimensions *b* y *h*, given that *h* is parallel to the *y axis* and *b* is parallel to the *z axis*. These data are distinguished by a subscript (ie AB) which determines which bar it is




In section Calculations and Results are given the factors used for calculations, the slenderness of the piece and its buckling length. If the support is not going to buckling, does not show any result and displays the note " *No pandea* ", but if it buckles this note is modified by " *El soporte pandea* " and appears a new list with the eccentricities and computational efforts in the Z axis . These efforts will provide that the axial force equal and that the moment will be increased due to the eccentricity caused by the buckling of the support.

# DEFORMATION

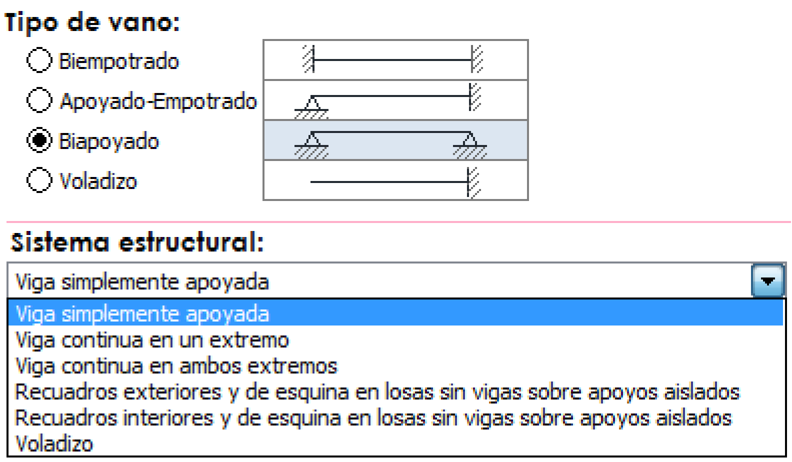
These spreadsheets, follow the procedures established by ***Artículo 50*** of the ***EHE-08*** and the ***Anejo 8***, ***Apartados 2.2*** and ***2.3***, to complement it. But first, to obtain the maximum bending moments and maximum deformations produced by the actions of the bars have been followed in ***Prontuario Ensidesa*** and ***Prontuario de Estructuras*** by ***CEDEX***.

It has created a single document to talk about *Deformations*, despite there are two spreadsheets, because the difference between them is minimal in the face of its use. Although the calculations differ between the two, the needs of data entry and the results are so similar that it is not worth overwhelming the user with two sections which, in essence, give the same information.

Since these sheet "only" trying to give the user the values of maximum bending moments which it is subjected beam object of calculation and the maximum deformations, deferred, total and active. Has been simplified to the maximum data entry, although as unusual symbology used in the *Prontuario*, as in some specific cases there are some limitations in introducing the values of some loads. No wonder it is necessary to consult the manual at least the first time you use the sheet

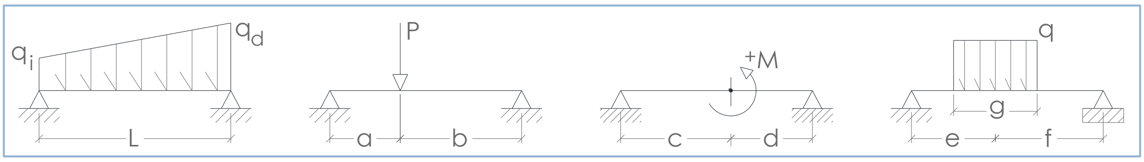
The procedure for using this sheet is as follows:

1º. Identify the type of vain and structural system rod:




2º. Enter the dimensions of the rod section and the characteristics of the materials and rebar. Once this can be recommended, refer to section Previous calculations where the relation appears Lenght/Edge, and determines if necessary (according to ***Tabla 50.2.2.1.a*** of ***EHE-08***) make checking of the deformations.

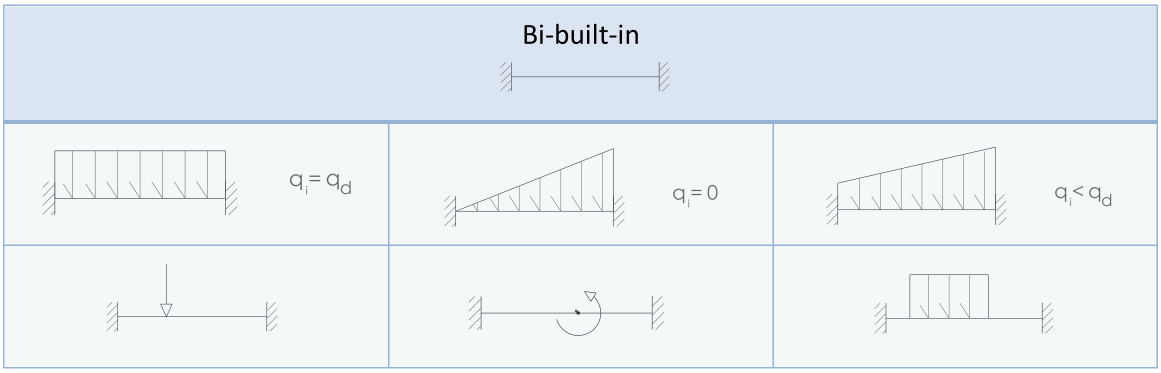
3º. *Shares In Calculation* subsection, the user must enter values for the applied loads on the bar. They have distinguished between four types:

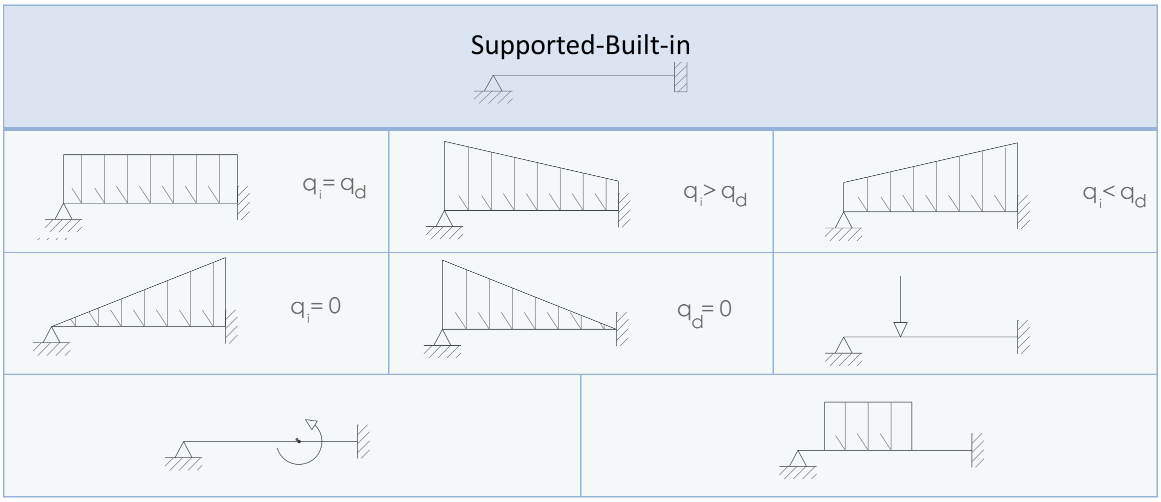


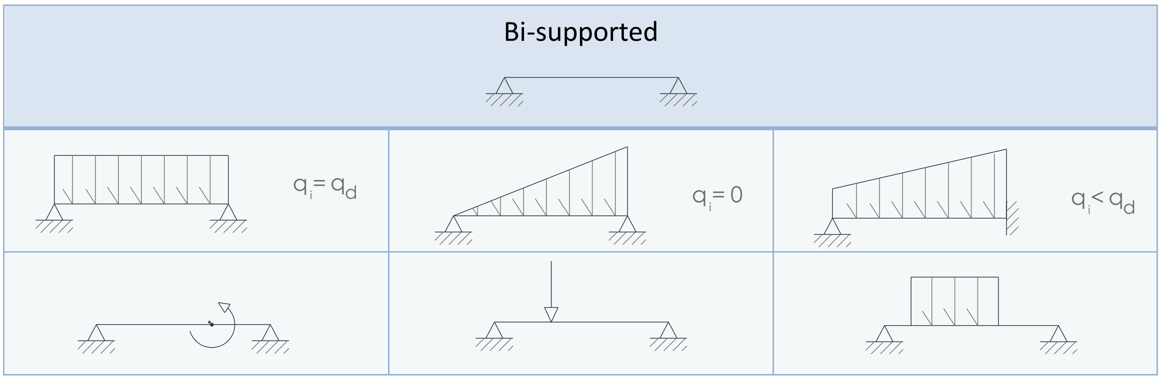

- Dealt trapezoidal end to end of the rod: this load calculation serves both uniform and triangular loads distributed.
- Point load
- Applied Bendign moment
- Dealt uniform in a section of the rod.

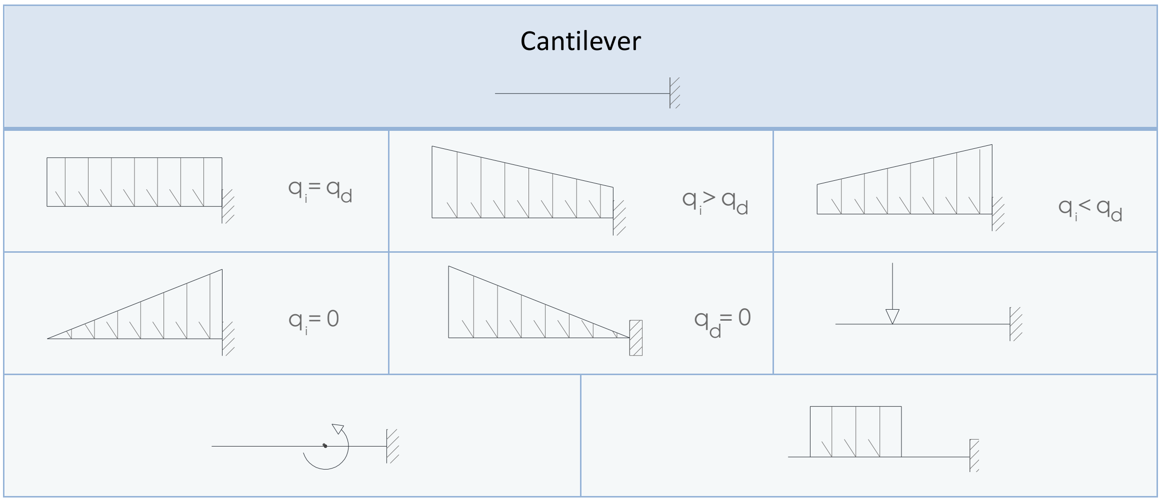
There is a limitation, is that in the rods whose ends are equal (bi-supported or bi-built-in) trapezoidal distributed load must always comply that $q_i$ can never be greater than $q_d$.

To avoid possible errors, then displays a table with all types of loads and possible distribution by type of vain.






When all these data, the spreadsheet calculates the maximum bending moments for the uncentering and in *n* days, this value, which is displayed in the *Results* section, serves to establish the moments of inertia to be used in the calculation of deformations

The procedure is as follows: we compare the maximum bending moment with the moment of fissuring of the workpiece. If set to fissure the piece, with these two facts, together with the brute inertia moment of the piece, is calculated $I_e$ (Equivalent Moment of Inertia), which will be used to calculate the maximum deformations. If the piece does not fissure the MOI used for the calculation is $I_b$ (Brute Inertia Moment)

The values of the moments of inertia are shown in section *Previous calculations* along with deformation modules and some other useful information such as Mf (Moment of fissuring) and the modulus of elasticity of steel.

Finally, in the *Results* section are shown Bending Moments maximums, which is under the rod and the maximum deformations generated by actions. Along with these values has created a dropdown tab where you should choose the length of the loads in order to establish the value of $\lambda$, as provided ***Artículo 50.2.2.3*** of the ***EHE-08.***

With this value is calculated the deferred deformation, and can be obtained,finally the active and total deformations of the rod.

# FISSURATION

This spreadsheet is used to check if an element fissure or not, and if the opening feature of its fissures exceed the maximum determined by the rules in the ***Tabla 5.1.1.2***.

In order to perform this check will require the user to provide the dimensions of the section, the characteristics of the materials, whether they are direct or indirect actions, the characteristics of the main reinforcement in tension and shall also determine the mode of operation of the section . This latter serves for the effective area of the concrete ($A_{c,ef}$).

To determine $A_{c,ef}$ are four figures, which have been designated *Case 1a*, *Case 1b*, *Case 2* and *Case 3*. These figures are copied from ***Figure 49.2.4*** and can be chosen by drop-down tab in subsection "*Area eficaz del hormigón*".

En el apartado de resultados, si se diera el improbable caso de que la sección no fisurara, simplemente aparecería la nota "La sección no fisura", en el caso de que si lo haga se mostrará el valor de $w_k$ (abertura característica de la fisura) y un fragmento de la ***Tabla 5.1.1.2*** de la ***EHE-08***.

In the results section, if given the unlikely event that the section not fissures simply appear the note " La sección no fisura " in the case if it does, is show the value of $w_k$ (characteristic of the fissure opening ) and a fragment of ***Tabla 5.1.1.2*** of the ***EHE-08.***

This table will be highlighted in green and yellow background values for the opening of the fissure comply with regulations and red for non-compliance, as follows:

**Abertura característica de la fisura**

| | | |
|---|---|---|
| $w_k$ | ***0,30*** | mm |

| **Abertura máxima de fisura** | |
|---|---|
| Clases de exposición | $w_{máx}$ [mm] |
| I | **0,4** |
| IIa, IIb, H | **0,3** |
| IIIa, IIIb,IV,F,Qa | 0,2 |
| IIIc, Qb, Qc | 0,1 |

# C. SIMBOLOGY AND ARTICULATED

# SIMPLE BENDING – RECTANGULAR SECTIONS

## DIMENSIONING

| Dimensions of section | | EHE-08 Articles |
|---|---|---|
| h | Edge | |
| b | Base | |
| $r_{MEC,INF}$ | Lower rebar's mechanical covering | 37.2.4. (rec. nominal) |
| $r_{MEC,SUP}$ | Top rebar's mechanical covering | |
| d | Useful edge $d=h-r_{MEC,INF}$ | |

| Material characteristics | | |
|---|---|---|
| $f_{yk}$ | Steel characteristic yield | |
| $f_{ck}$ | Concrete characteristic yield | |
| T.M.A. | Maximum aggregate size | |
| $\gamma_s$ | Partial safety coefficient of steel | Table 15.3 |
| $\gamma_c$ | Partial safety coefficient of concrete | |
| $\alpha_{cc}$ | Concrete fatigue factor. | 39.4 |
| $f_{yd}$ | Calculation resistance of steel (passive rebar) | 38.3 |
| $f_{cd}$ | Calculation resistance of concrete. | 39.4 |

| Calculation stress | | |
|---|---|---|
| $M_d$ | Calculation bending moment | |

| Rectangular diagram | | 39.5 |
|---|---|---|
| $x_{LIM}$ | $M_{LIM}$ delimiting axis, considering $\varepsilon_{cu}$ and $\varepsilon_y$ | 42.1.3 |
| $y_{LIM}=\lambda(x)h$ | Application depth limit compressive forces | |
| y | Applied depth of compression forces | |
| $F_{C,LIM}$ | Compressed concrete strength limit | |
| $F_c$ | Compressed concrete strength ($F_c=\eta(x)\cdot f_{cd}\cdot \lambda(x)h$ | |
| $M_{LIM}$ | Limit blending moment | |

| Minimum mechanical rebar | | |
|---|---|---|
| $A_{S1}$ | Main rebar area (tractee) | |
| $A_{S2}$ | Secondary rebar area (compressed) | |

| Results, rebar dimensioning. | | |
|---|---|---|
| $Ø_S$ | Rebar diameter | 32.2 |
| $\#_{barras}$ | Number of bars | |
| $A_{REAL}$ | Real rebar area | |
| $S_{REAL}$ | Real separation between bars | |
| $S_{MIN}$ | Minimum separation between bars | 69.4.1.1 |

# TESTING

### Dimensions of section

| | | EHE-08 Articles |
|---|---|---|
| h | Edge | |
| b | Base | |
| $r_{MEC,INF}$ | Lower rebar's mechanical covering | 37.2.4. (rec. nominal) |
| $r_{MEC,SUP}$ | Top rebar's mechanical covering | |
| d | Useful edge: $d=h-r_{MEC,INF}$ | |

### Material characteristics

| | | |
|---|---|---|
| $f_{yk}$ | Steel characteristic yield. | |
| $f_{ck}$ | Concrete characteristic yield | |
| T.M.A. | Maximum aggregate size | |
| $\gamma_s$ | Partial safety coefficient of steel | Table 15.3 |
| $\gamma_c$ | Partial safety coefficient of concrete | |
| $\alpha_{cc}$ | Concrete fatigue factor. | 39.4 |
| $f_{yd}$ | Calculation resistance of steel (passive rebar) | 38.3 |
| $f_{cd}$ | Calculation resistance of concrete. | 39.4 |

### Rebar features

| | |
|---|---|
| $\#b_{S1}$ | Main rebar tractee number of bars |
| $\varnothing_{S1}$ | Main rebar tractee diameter of bars |
| $A_{S1}$ | Main rebar area (tractee) |
| $\#b_{S2}$ | Compressed rebar number of bars |
| $\varnothing_{S2}$ | Compressed rebar diameter of bars |
| $A_{S2}$ | Secondary rebar area (compressed) |

### Calculation stress

| | |
|---|---|
| $M_d$ | Calculation bending moment |

### Previous calculations

| | |
|---|---|
| $U_{S1}$ | Tractee rebar mechanical capacity |
| $U_{S2}$ | Compressed rebar mechanical capacity |

### Rectangular diagram

| | | |
|---|---|---|
| | | 39.5 |
| $x_{LIM}$ | $M_{LIM}$ delimiting axis, considering $\varepsilon_{cu}$ and $\varepsilon_y$ | 42.1.3 |
| $y_{LIM}=\lambda(x)h$ | Application depth limit compressive forces | |
| $M_{LIM}$ | Limit blending moment | |

### Results, rebar dimensioning.

| | | |
|---|---|---|
| $Y_{REAL}$ | Real applied depth of compression forces | 32.2 |
| $F_c$ | Compressed concrete strength ($F_c=\eta(x)\cdot f_{cd}\cdot \lambda(x)h$ | |
| $M_U$ | Final blending moment | |

# SIMPLE BENDING – T SECTIONS

## DIMENSIONING

| Dimensions of section | | EHE-08 Articles |
|---|---|---|
| $h_{ALA}$ | Flange edge | |
| $h_{ALMA}$ | Web edge | |
| $b_{ALA}$ | Flange base | |
| $b_{ALMA}$ | Web base | |
| $r_{MEC,INF}$ | Lower rebar's mechanical covering | 37.2.4. (rec. nominal) |
| $r_{MEC,SUP}$ | Top rebar's mechanical covering | |
| d | Useful edge: $d=h-r_{MEC,INF}$ | |

| Material characteristics | | |
|---|---|---|
| $f_{yk}$ | Steel characteristic yield | |
| $f_{ck}$ | Concrete characteristic yield. | |
| T.M.A. | Maximum aggregate size | |
| $\gamma_s$ | Partial safety coefficient of steel | 15.3 |
| $\gamma_c$ | Partial safety coefficient of concrete | |
| $\alpha_{cc}$ | Concrete fatigue factor. | 39.4 |
| $f_{yd}$ | Calculation resistance of steel (passive rebar) | 38.3 |
| $f_{cd}$ | Calculation resistance of concrete. | 39.4 |

| Calculation stress | | |
|---|---|---|
| $M_d$ | Calculation bending moment | |

| Rectangular diagram | | 39.5 |
|---|---|---|
| $x_{LIM}$ | $M_{LIM}$ delimiting axis, considering $\varepsilon_{cu}$ and $\varepsilon_y$ | 42.1.3 |
| $y_{LIM}=\lambda(x)h$ | Application depth limit compressive forces | |
| y | Applied depth of compression forces | |
| $F_{C,LIM}$ | Compressed concrete strength limit | |
| $F_c$ | Compressed concrete strength ($F_c=\eta(x)\cdot f_{cd}\cdot \lambda(x)h$ | |
| $M_{LIM}$ | Limit blending moment | |

| Minimum mechanical rebar | | |
|---|---|---|
| $A_{S1}$ | Main rebar area (tractee) | |
| $A_{S2}$ | Secondary rebar area (compressed) | |

| Results, rebar dimensioning. | | |
|---|---|---|
| $\emptyset_S$ | Rebar diameter | 32.2 |
| $\#_{barras}$ | Number of bars | |
| $A_{REAL}$ | Real rebar area | |
| $S_{REAL}$ | Real separation between bars | |
| $S_{MIN}$ | Minimum separation between bars | 69.4.1.1 |

# TESTING

| Dimensions of section | | EHE-08 Articles |
|---|---|---|
| $h_{ALA}$ | Flange edge | |
| $h_{ALMA}$ | Web edge | |
| $b_{ALA}$ | Flange base | |
| $b_{ALMA}$ | Web base | |
| $r_{MEC,INF}$ | Lower rebar's mechanical covering | *37.2.4.* (rec. nominal) |
| $r_{MEC,SUP}$ | Top rebar's mechanical covering | |
| d | Useful edge: $d=h-r_{MEC,INF}$ | |

| Material characteristics | | |
|---|---|---|
| $f_{yk}$ | Steel characteristic yield | |
| $f_{ck}$ | Concrete characteristic yield | |
| T.M.A. | Maximum aggregate size | |
| $\gamma_s$ | Partial safety coefficient of steel | *Table 15.3* |
| $\gamma_c$ | Partial safety coefficient of concrete | |
| $\alpha_{cc}$ | Concrete fatigue factor. | *39.4* |
| $f_{yd}$ | Calculation resistance of steel (passive rebar) | *38.3* |
| $f_{cd}$ | Calculation resistance of concrete. | *39.4* |

| Rebar features | |
|---|---|
| $\#b_{S1}$ | Main rebar tractee number of bars |
| $\emptyset_{S1}$ | Main rebar tractee diameter of bars |
| $A_{S1}$ | Main rebar area (tractee) |
| $\#b_{S2}$ | Compressed rebar number of bars |
| $\emptyset_{S2}$ | Compressed rebar diameter of bars |
| $A_{S2}$ | Secondary rebar area (compressed) |

| Calculation stress | |
|---|---|
| $M_d$ | Calculation bending moment |

| Previous calculations | |
|---|---|
| $U_{S1}$ | Tractee rebar mechanical capacity |
| $U_{S2}$ | Compressed rebar mechanical capacity |

| Rectangular diagram | | *39.5* |
|---|---|---|
| $x_{LIM}$ | $M_{LIM}$ delimiting axis, considering $\varepsilon_{cu}$ and $\varepsilon_y$ | *42.1.3* |
| $y_{LIM}=\lambda(x)h$ | Application depth limit compressive forces | |
| $y_{est}$ | Applied depth of compression forces | |
| $M_{LIM}$ | Limit blending moment | |
| $M_U$ | Final blending moment | |

| Minimum mechanical rebar | |
|---|---|
| $A_{S1}$ | Main rebar area (tractee) |
| $A_{S2}$ | Secondary rebar area (compressed) |

| Results, rebar dimensioning. | | |
|---|---|---|
| $\emptyset_S$ | Rebar diameter | *32.2* |
| $\#_{barras}$ | Number of bars | |
| $A_{REAL}$ | Real rebar area | |
| $S_{REAL}$ | Real separation between bars | |
| $S_{MIN}$ | Minimum separation between bars | *69.4.1.1* |

# COMBINED BENDING – RECTANGULAR SECTIONS

## DIMENSIONING

| Dimensions of section | | EHE-08 Articles |
|---|---|---|
| h | Edge | |
| b | Base | |
| $r_{MEC,INF}$ | Lower rebar's mechanical covering | *37.2.4.* (rec. nominal) |
| $r_{MEC,SUP}$ | Top rebar's mechanical covering | |
| d | Useful edge: $d=h-r_{MEC,INF}$ | |

| Material characteristics | | |
|---|---|---|
| $f_{yk}$ | Steel characteristic yield | |
| $f_{ck}$ | Concrete characteristic yield | |
| T.M.A. | Maximum aggregate size | |
| $\gamma_s$ | Partial safety coefficient of steel | *Table 15.3* |
| $\gamma_c$ | Partial safety coefficient of concrete | *Table 15.3* |
| $\alpha_{cc}$ | Concrete fatigue factor. | *39.4* |
| $f_{yd}$ | Calculation resistance of steel (passive rebar) | *38.3* |
| $f_{cd}$ | Calculation resistance of concrete. | *39.4* |

| Calculation stress | | |
|---|---|---|
| $M_d$ | Calculation bending moment | |
| $N_d$ | Calculation axial force | |
| $M_d'$ | Calculation bending moment (Ehlers' conversion) | |

| Rectangular diagram | | *39.5* |
|---|---|---|
| $x_{LIM}$ | $M_{LIM}$ delimiting axis, considering $\varepsilon_{cu}$ and $\varepsilon_y$ | *42.1.3* |
| $y_{LIM}=\lambda(x)h$ | Application depth limit compressive forces | |
| y | Applied depth of compression forces | |
| $F_{C,LIM}$ | Compressed concrete strength limit | |
| $F_c$ | Compressed concrete strength ($F_c=\eta(x)\cdot f_{cd}\cdot \lambda(x)h$ | |
| $M_{LIM}$ | Limit blending moment | |

| Minimum mechanical rebar | | |
|---|---|---|
| $A_{S1}$ | Main rebar area (tractee) | |
| $A_{S2}$ | Secondary rebar area (compressed) | |

| Results, rebar dimensioning. | | |
|---|---|---|
| $\varnothing_S$ | Rebar diameter | *32.2* |
| $\#_{barras}$ | Number of bars | |
| $A_{REAL}$ | Real rebar area | |
| $S_{REAL}$ | Real separation between bars | |
| $S_{MIN}$ | Minimum separation between bars | *69.4.1.1* |

# TESTING

### Dimensions of section

**EHE-08 Articles**

| | | |
|---|---|---|
| h | Edge | |
| b | Base | |
| $r_{MEC,INF}$ | Lower rebar's mechanical covering | *37.2.4.* (rec. nominal) |
| $r_{MEC,SUP}$ | Top rebar's mechanical covering | |
| d | Useful edge: $d=h-r_{MEC,INF}$ | |

### Material characteristics

| | | |
|---|---|---|
| $f_{yk}$ | Steel characteristic yield | |
| $f_{ck}$ | Concrete characteristic yield. | |
| T.M.A. | Maximum aggregate size | |
| $\gamma_s$ | Partial safety coefficient of steel | *Table 15.3* |
| $\gamma_c$ | Partial safety coefficient of concrete | |
| $\alpha_{cc}$ | Concrete fatigue factor. | *39.4* |
| $f_{yd}$ | Calculation resistance of steel (passive rebar) | *38.3* |
| $f_{cd}$ | Calculation resistance of concrete. | *39.4* |

### Rebar features

| | |
|---|---|
| $\#b_{S1}$ | Main rebar tractee number of bars |
| $Ø_{S1}$ | Main rebar tractee diameter of bars |
| $A_{S1}$ | Main rebar area (tractee) |
| $\#b_{S2}$ | Compressed rebar number of bars |
| $Ø_{S2}$ | Compressed rebar diameter of bars |
| $A_{S2}$ | Secondary rebar area (compressed) |

### Calculation stress

| | |
|---|---|
| $M_d$ | Calculation bending moment |
| $N_d$ | Calculation axial force |
| $M_d'$ | Calculation bending moment (Ehlers' conversion) |

### Previous calculations

| | |
|---|---|
| $U_{S1}$ | Tractee rebar mechanical capacity |
| $U_{S2}$ | Compressed rebar mechanical capacity |

### Rectangular diagram

*39.5*

| | | |
|---|---|---|
| $x_{LIM}$ | $M_{LIM}$ delimiting axis, considering $\varepsilon_{cu}$ and $\varepsilon_y$ | *42.1.3* |
| $y_{LIM}=\lambda(x)h$ | Application depth limit compressive forces | |
| $M_{LIM}$ | Limit blending moment | |
| $F_{cLIM}$ | Compressed concrete strength limit | |

### Results, rebar dimensioning.

| | | |
|---|---|---|
| $Y_{REAL}$ | Real applied depth of compression forces | *32.2* |
| $F_c$ | Compressed concrete strength ($F_c=\eta(x)\cdot f_{cd}\cdot \lambda(x)h$) | |
| $M_U'$ | Ehlers final moment | |
| $M_U$ | Final blending moment | |
| $N_U$ | Final axial stress | |

# COMBINED BENDING – T SECTIONS

## DIMENSIONING

| Dimensions of section | | EHE-08 Articles |
|---|---|---|
| $h_{ALA}$ | Flange edge | |
| $h_{ALMA}$ | Web edge | |
| $b_{ALA}$ | Flange base | |
| $b_{ALMA}$ | Web base | |
| $r_{MEC,INF}$ | Lower rebar's mechanical covering | *37.2.4.* (rec. nominal) |
| $r_{MEC,SUP}$ | Top rebar's mechanical covering | |
| d | Useful edge: $d=h-r_{MEC,INF}$ | |

| Material characteristics | | |
|---|---|---|
| $f_{yk}$ | Steel characteristic yield | |
| $f_{ck}$ | Concrete characteristic yield | |
| T.M.A. | Maximum aggregate size | |
| $\gamma_s$ | Partial safety coefficient of steel | *15.3* |
| $\gamma_c$ | Partial safety coefficient of concrete | |
| $\alpha_{cc}$ | Concrete fatigue factor. | *39.4* |
| $f_{yd}$ | Calculation resistance of steel (passive rebar) | *38.3* |
| $f_{cd}$ | Calculation resistance of concrete. | *39.4* |

| Calculation stress | | |
|---|---|---|
| $M_d$ | Calculation bending moment | |
| $N_d$ | Calculation axial force | |
| $M_d'$ | Calculation bending moment (Ehlers' conversion) | |

| Rectangular diagram | | *39.5* |
|---|---|---|
| $x_{LIM}$ | $M_{LIM}$ delimiting axis, considering $\varepsilon_{cu}$ and $\varepsilon_y$ | *42.1.3* |
| $y_{LIM}=\lambda(x)h$ | Application depth limit compressive forces | |
| y | Applied depth of compression forces | |
| $F_{C,LIM}$ | Compressed concrete strength limit | |
| $F_c$ | Compressed concrete strength ($F_c=\eta(x)\cdot f_{cd}\cdot \lambda(x)h$ | |
| $M_{LIM}$ | Limit blending moment | |

| Minimum mechanical rebar | | |
|---|---|---|
| $A_{S1}$ | Main rebar area (tractee) | |
| $A_{S2}$ | Secondary rebar area (compressed) | |

| Results, rebar dimensioning. | | |
|---|---|---|
| $\varnothing_S$ | Rebar diameter | *32.2* |
| $\#_{barras}$ | Number of bars | |
| $A_{REAL}$ | Real rebar area | |
| $S_{REAL}$ | Real separation between bars | |
| $S_{MIN}$ | Minimum separation between bars | *69.4.1.1* |

# TESTING

| Dimensions of section | | EHE-08 Articles |
|---|---|---|
| $h_{ALA}$ | Flange edge | |
| $h_{ALMA}$ | Web edge | |
| $b_{ALA}$ | Flange base | |
| $b_{ALMA}$ | Web base | |
| $r_{MEC,INF}$ | Lower rebar's mechanical covering | *37.2.4.* (rec. nominal) |
| $r_{MEC,SUP}$ | Top rebar's mechanical covering | |
| d | Useful edge: $d=h-r_{MEC,INF}$ | |

| Material characteristics | | |
|---|---|---|
| $f_{yk}$ | Steel characteristic yield | |
| $f_{ck}$ | Concrete characteristic yield | |
| T.M.A. | Maximum aggregate size | |
| $\gamma_s$ | Partial safety coefficient of steel | *Table 15.3* |
| $\gamma_c$ | Partial safety coefficient of concrete | |
| $\alpha_{cc}$ | Concrete fatigue factor. | *39.4* |
| $f_{yd}$ | Calculation resistance of steel (passive rebar) | *38.3* |
| $f_{cd}$ | Calculation resistance of concrete. | *39.4* |

| Rebar features | |
|---|---|
| $\#b_{S1}$ | Main rebar tractee number of bars |
| $Ø_{S1}$ | Main rebar tractee diameter of bars |
| $A_{S1}$ | Main rebar area (tractee) |
| $\#b_{S2}$ | Compressed rebar number of bars |
| $Ø_{S2}$ | Compressed rebar diameter of bars |
| $A_{S2}$ | Secondary rebar area (compressed) |

| Calculation stress | |
|---|---|
| $M_d$ | Calculation bending moment |
| $N_d$ | Calculation axial force |
| $M_d'$ | Calculation bending moment (Ehlers' conversion) |

| Previous calculations | |
|---|---|
| $U_{S1}$ | Tractee rebar mechanical capacity |
| $U_{S2}$ | Compressed rebar mechanical capacity |
| $M_{MAX,ALA}$ | Maximum flange moment |

| Rectangular diagram | | *39.5* |
|---|---|---|
| $x_{LIM}$ | $M_{LIM}$ delimiting axis, considering $\varepsilon_{cu}$ and $\varepsilon_y$ | *42.1.3* |
| $y_{LIM}=\lambda(x)h$ | Application depth limit compressive forces | |
| $F_{C,LIM}$ | Compressed concrete strength limit | |
| $M_{LIM}$ | Limit blending moment | |

| Results, rebar dimensioning. | | |
|---|---|---|
| $Y_{REAL}$ | Real applied depth of compression forces | *32.2* |
| $F_c$ | Compressed concrete strength ($F_c=\eta(x)\cdot f_{cd}\cdot \lambda(x)h$ | |
| $M_U'$ | Ehlers final moment | |
| $M_U$ | Final blending moment | |
| $N_U$ | Final axial stress | |

# BENDING COMPRESSION, SYMMETRICAL OR BIAXIAL

| Dimensions of section | | EHE-08 Articles |
|---|---|---|
| b | Base. | |
| h | Edge | |
| $r_H$ | Horizontal covering | |
| $r_V$ | Vertical covering | |

| Material characteristics | | |
|---|---|---|
| $f_{ck}$ | Concrete characteristic yield | |
| $f_{yk}$ | Steel characteristic yield | |
| $\gamma_c$ | Partial safety coefficient of concrete | *Table 15.3* |
| $\gamma_s$ | Partial safety coefficient of steel | |
| $f_{y,cd}$ | Calculation resistance of compressed steel | *38.3* |

| Calculation stress | |
|---|---|
| $N_d$ | Calculation axial force |
| $M_{y,d}$ | Calculation bending moment in the y axis |
| $M_{x,d}$ | Calculation bending moment in the x axis |

| Steel results | |
|---|---|
| $\varepsilon_s$ | Steel strain |

| Concrete results | |
|---|---|
| h | Edge total. |
| d | Useful edge |
| x | Neutral axis |
| y | Compressions block |
| $x_{cdg}$ | X coordinates of gravity center |
| $y_{cdg}$ | Y coordinates of gravity center |

| Solver | |
|---|---|
| $\phi$ | Neutral axis angle |
| $\xi$ | Neutral axis depth |

# SHEAR

## DIMENSIONING

| Dimensions of section | | EHE-08 Articles |
|---|---|---|
| $h$ | Edge | |
| $b_0$ | Net minimum width | 40.3.5 |
| $r_{MEC,INF}$ | Lower rebar’s mechanical covering | 37.2.4. (rec. nominal) |
| $r_{MEC,SUP}$ | Top rebar’s mechanical covering | |
| $d$ | Useful edge: $d=h-r_{MEC,INF}$ | |

| Material characteristics | | |
|---|---|---|
| $f_{yk}$ | Steel characteristic yield | |
| $f_{y\alpha,k}$ | Transversal rebar characteristic yield | |
| $f_{ck}$ | Concrete characteristic yield | |
| $f_{cv}$ | Concrete effective resistance to shear | 44.2.3.2.2 |
| T.M.A. | Maximum aggregate size | |
| $\gamma_s$ | Partial safety coefficient of steel | Table 15.3 |
| $\gamma_c$ | Partial safety coefficient of concrete | |
| $\alpha_{cc}$ | Concrete fatigue factor. | 39.4 |
| $f_{yd}$ | Calculation resistance of steel (passive rebar) | 38.3 |
| $f_{y\alpha,d}$ | Transversal rebar calculation yield | 44.2.3.2.2 |
| $f_{cd}$ | Calculation resistance of concrete. | 39.4 |
| $E_s$ | Steel modulus elasticity | 38.4 |

| Rebar features | | |
|---|---|---|
| $\#b_{S'}$ | Compressed rebar number of bars | |
| $Ø_{S'}$ | Compressed rebar diameter of bars | |
| $A_{S'}$ | Compressed rebar total area | |
| $\#b_S$ | Tractee rebar number of bars | |
| $Ø_S$ | Tractee rebar diameter of bars | |
| $A_S$ | Tractee rebar total area | |
| $\theta_t$ | Angle between compression connecting rods and piece axis | 44.2.3.1 |
| $\alpha_t$ | Angle between rebar and piece axis | 44.2.3.1 |
| $S_{t,cercos}$ | Separation between rings | |
| $\#_{RAMAS}$ | Number branch | |

| Calculation stress | | |
|---|---|---|
| $V_{rd}$ | Calculation shear effort | 44.2.2 |
| $N_d$ | Calculation axial force | |
| $M_d$ | Calculation bending moment | |

| Relative to materials | | |
|---|---|---|
| $f_{1cd}$ | Concrete compress resistance | 44.2.3.1 |
| $f_{ct,k}$ | Concrete tractee characteristic resistance | 39.1 |
| $f_{ct,d}$ | Concrete tractee calculation resistance | |
| $f_{ct,m}$ | Concrete tractee average resistance | 39.1 |

| Relative to stress | | |
|---|---|---|
| $K$ | Coefficient which depends on the axial force. | 44.2.3.1 |
| $\sigma'_{cd}$ | Concrete effective axial stress (positive compression) | 44.2.3.1 |

### Relating to section

| | | |
|---|---|---|
| $I_z$ | Cross-section inertia moment | *44.2.3.2.1.1.* |
| S | Static moment of the cross section | *4.2.3.2.1.1.* |
| $\xi$ | Dimensionless coefficient | *44.2.3.2.1.2* |
| $\rho_l$ | Tractee rebar geometric ratio | *44.2.3.2.1.2* |
| $\theta_e$ | Reference angle of inclination of fissures | *44.2.3.2.2.* |
| $\beta$ | Dimensionless coefficient | *44.2.3.2.2.* |

### Minimum mechanical rebar

| | |
|---|---|
| $A_{S1}$ | Main rebar area (tractee) |
| $A_{S2}$ | Secondary rebar area (compressed) |

### Exhaustion by oblique compression in the soul

| | | |
|---|---|---|
| $V_{U1}$ | Shear stress exhaustion by oblique compression in the soul | *44.2.3.1.* |

### Exhaustion by traction in the soul

| | | |
|---|---|---|
| $M_{fis}$ | Fissure moment | *44.2.3.1.* |
| $V_{U2}$ | Shear stress exhaustion by traction in the soul | *44.2.3.2* |
| $V_{CU}$ | Concrete contribution to the shear strength | *44.2.3.2.2* |
| $V_{SU}$ | Transverse rebar contribution to shear resistance | *44.2.3.2.2* |

### Transversal rebar

| | |
|---|---|
| $A_{\alpha,mec}$ | Transversal rebar area |
| $A_{\alpha,geom}$ | Minimum geometric normalized transverse rebar area |
| $S_{t,trans\ MAX}$ | Maximum distance between rings |
| $S_{t,trans\ MIN}$ | Minimum distance between rings |
| $S_{t,trans\ REAL}$ | Real distance between rings |

### Rebar dimensioning

| | |
|---|---|
| $\emptyset_{s,t}$ | Rings diameter |
| $\#_{ramas}$ | Number branch |
| $s_{t,cercos}$ | Separation between rings |

# TESTING

### Dimensions of section

| | | EHE-08 Articles |
|---|---|---|
| $h$ | Edge | |
| $b_0$ | Net minimum width | *40.3.5* |
| $r_{MEC,INF}$ | Lower rebar's mechanical covering | *37.2.4.* (rec. nominal) |
| $r_{MEC,SUP}$ | Top rebar's mechanical covering | |
| $d$ | Useful edge: $d=h-r_{MEC,INF}$ | |

### Material characteristics

| | | |
|---|---|---|
| $f_{yk}$ | Steel characteristic yield | |
| $f_{y\alpha,k}$ | Transversal rebar characteristic yield | |
| $f_{ck}$ | Concrete characteristic yield | |
| $f_{cv}$ | Concrete effective resistance to shear | *44.2.3.2.2* |
| T.M.A. | Maximum aggregate size | |
| $\gamma_s$ | Partial safety coefficient of steel | *Table 15.3* |
| $\gamma_c$ | Partial safety coefficient of concrete | |
| $\alpha_{cc}$ | Concrete fatigue factor. | *39.4* |
| $f_{yd}$ | Calculation resistance of steel (passive rebar) | *38.3* |
| $f_{y\alpha,d}$ | Transversal rebar calculation yield | *44.2.3.2.2* |
| $f_{cd}$ | Calculation resistance of concrete. | *39.4* |
| $E_s$ | Steel modulus elasticity | *38.4* |

### Rebar features

| | | |
|---|---|---|
| $\#b_{S'}$ | Compressed rebar number of bars | |
| $\emptyset_{S'}$ | Compressed rebar diameter of bars | |
| $A_{S'}$ | Compressed rebar total area | |
| $\#b_S$ | Tractee rebar number of bars | |
| $\emptyset_S$ | Tractee rebar diameter of bars | |
| $A_S$ | Tractee rebar total area | |
| $\theta_t$ | Angle between compression connecting rods and piece axis | *44.2.3.1* |
| $\alpha_t$ | Angle between rebar and piece axis | *44.2.3.1* |
| $S_{t,cercos}$ | Separation between rings | |
| $\#_{RAMAS}$ | Number branch | |

### Calculation stress

| | | |
|---|---|---|
| $V_{rd}$ | Calculation shear effort | *44.2.2* |
| $N_d$ | Calculation axial force | |
| $M_d$ | Calculation bending moment | |

### Relative to materials

| | | |
|---|---|---|
| $f_{1cd}$ | Concrete compress resistance | *44.2.3.1* |
| $f_{ct,k}$ | Concrete tractee characteristic resistance | *39.1* |
| $f_{ct,d}$ | Concrete tractee calculation resistance | |
| $f_{ct,m}$ | Concrete tractee average resistance | *39.1* |

### Relative to stress

| | | |
|---|---|---|
| $K$ | Coefficient which depends on the axial force | *44.2.3.1* |
| $\sigma'_{cd}$ | Concrete effective axial stress (positive compression) | *44.2.3.1* |

### Relative to section

| | | |
|---|---|---|
| $I_z$ | Cross-section inertia moment | *44.2.3.2.1.1.* |
| S | Static moment of the cross section | *4.2.3.2.1.1.* |
| $\xi$ | Dimensionless coefficient | *44.2.3.2.1.2* |
| $\rho_l$ | Tractee rebar geometric ratio | *44.2.3.2.1.2* |
| $\theta_e$ | Reference angle of inclination of fissures | *44.2.3.2.2.* |
| $\beta$ | Dimensionless coefficient | *44.2.3.2.2.* |
| z | Mechanical arm | *44.2.3.2.2* |

### Shear stress the section can resist

| | | |
|---|---|---|
| $M_{fis}$ | Fissure moment. | *44.2.3.1.* |
| $V_{U1}$ | Shear stress exhaustion by oblique compression in the soul | *44.2.3.1.* |
| $V_{U2}$ | Shear stress exhaustion by traction in the soul | *44.2.3.2* |
| $V_{CU}$ | Concrete contribution to the shear strength | *44.2.3.2.2* |
| $V_{SU}$ | Transverse rebar contribution to shear resistance | *44.2.3.2.2* |

# TORSION – RECTANGULAR SECTIONS

## DIMENSIONING

| Dimensions of section | | EHE-08 Articles |
|---|---|---|
| h | Edge | |
| b | Base | |
| $r_{MEC,INF}$ | Lower rebar's mechanical covering | 37.2.4. (rec. nominal) |
| $r_{MEC,SUP}$ | Top rebar's mechanical covering | |
| d | Useful edge: $d=h-r_{MEC,INF}$ | |

| Material characteristics | | |
|---|---|---|
| $f_{yk}$ | Steel characteristic yield | |
| $f_{ck}$ | Concrete characteristic yield | |
| T.M.A. | Maximum aggregate size | |
| $\gamma_s$ | Partial safety coefficient of steel | Table 15.3 |
| $\gamma_c$ | Partial safety coefficient of concrete | |
| $\alpha_{cc}$ | Concrete fatigue factor. | 39.4 |
| $f_{yd}$ | Calculation resistance of steel (passive rebar) | 38.3 |
| $f_{1cd}$ | Concrete compress resistance | 45.2.2.1 |

| Rebar features | | |
|---|---|---|
| $\theta_t$ | Angle between compression connecting rods and piece axis | |
| $\alpha_t$ | Angle between rebar and piece axis | |

| Compressed rebar | | |
|---|---|---|
| $\#b_{S'}$ | Compressed rebar number of bars | |
| $Ø_{S'}$ | Compressed rebar diameter of bars | |
| $A_S'$ | Compressed rebar total area | |

| Calculation stress | | |
|---|---|---|
| $N_d$ | Calculation axial force | |
| $T_d$ | Calculation torsion moment | 45.2.2 |
| $V_{rd}$ | Calculation shear effort | |

| Coefficients | | |
|---|---|---|
| K | Coefficient which depends on the axial force | 44.2.3.1 |
| $\alpha$ | Dimensionless coefficient rings dependent | 45.2.2.1 |
| $\beta$ | Dimensionless coefficient | 45.3.2.2 |

| Section characteristics | | |
|---|---|---|
| $h_e$ | Effective wall thickness of the calculation section. | 45.2.1 |
| $A_e$ | Area enclosed by the midline of the effective hollow section. | 45.2.1 |
| $u_e$ | Midline perimeter of effective hollow section | 45.2.1 |

### Maximum torsor moments the section can resist

| | | |
|---|---|---|
| $T_{U1}$ | Maximum torsion moment which can resist the concrete connecting rods | *45.2.2.1* |
| $T_{U2}$ | Maximum torsion moment which .transversal rebar can resist. | *45.2.2.2* |
| $T_{U3}$ | Maximum torsion moment which .main rebar can resist. | *45.2.2.3* |

### Torsion combined with shear stress

| | | |
|---|---|---|
| $V_{U1}$ | Shear stress exhaustion by oblique compression in the soul | *44.2.3.1.* |
| $V_{rd,MAX}$ | Maximum calculation shear effort | *44.2.2* |

### Torsion transversal rebar

| | |
|---|---|
| $A_t$ | Torsion transversal rebar area. |
| $S_t$ | Torsion transversal rebar separation. |
| $Ø_{St}$ | Torsion transversal rebar diameter |
| $\#_{cercos}$ | Rings number |

### Torsion main rebar

| | |
|---|---|
| $A_{l,MIN}$ | Minimum torsion main rebar area. |
| Sl | Separation between torsion main rebar |
| $Ø_{Sl}$ | Torsion main rebar diameter. |
| $\#_{barras}$ | Number of bars |

# TESTING

| Dimensions of section | | EHE-08 Articles |
|---|---|---|
| h | Edge | |
| b | Base | |
| $r_{MEC,INF}$ | Lower rebar's mechanical covering | *37.2.4.* (rec. nominal) |
| $r_{MEC,SUP}$ | Top rebar's mechanical covering | |
| d | Useful edge: $d=h-r_{MEC,INF}$ | |

| Rebar features | | |
|---|---|---|
| $\#b_{S'}$ | Compressed rebar number of bars | |
| $Ø_{S'}$ | Compressed rebar diameter of bars | |
| $\#b_S$ | Tractee rebar number of bars | |
| $Ø_S$ | Tractee rebar diameter of bars | |
| $Ø_{St}$ | Rings diameter. | |
| $S_t$ | Distance between rings | |
| $A_t$ | Total area of each ring branch | |
| $\theta_t$ | Angle between compression connecting rods and piece axis | *44.2.3.1* |
| $\alpha_t$ | Angle between rebar and piece axis | *44.2.3.1* |

| Material characteristics | | |
|---|---|---|
| $f_{yk}$ | Steel characteristic yield | |
| $f_{ck}$ | Concrete characteristic yield | |
| T.M.A. | Maximum aggregate size | |
| $\gamma_s$ | Partial safety coefficient of steel | *Table 15.3* |
| $\gamma_c$ | Partial safety coefficient of concrete | *Table 15.3* |
| $\alpha_{cc}$ | Concrete fatigue factor. | *39.4* |
| $f_{yd}$ | Calculation resistance of steel (passive rebar) | *38.3* |
| $f_{cd}$ | Calculation resistance of concrete. | *39.4* |
| $f_{1cd}$ | Concrete compress resistance | *45.2.2.1* |

| Calculation stress | | |
|---|---|---|
| $N_d$ | Calculation axial force | |
| $T_d$ | Calculation torsion moment | *45.2.2* |
| $V_{rd}$ | Calculation shear effort | |

| Section characteristics | | |
|---|---|---|
| $h_e$ | Effective wall thickness of the calculation section. | *45.2.1* |
| $A_e$ | Area enclosed by the midline of the effective hollow section. | *45.2.1* |
| $u_e$ | Midline perimeter of effective hollow section | *45.2.1* |

| Torsion combined with shear stress | | |
|---|---|---|
| $V_{U1}$ | Shear stress exhaustion by oblique compression in the soul | *44.2.3.1.* |

| Coefficients | | |
|---|---|---|
| K | Coefficient which depends on the axial force | *44.2.3.1* |
| α | Dimensionless coefficient rings dependent | *45.2.2.1* |
| β | Dimensionless coefficient | *45.3.2.2* |

### Maximum torsor moments the section can resist

| | | |
|---|---|---|
| $T_{U1}$ | Maximum torsion moment which can resist the concrete connecting rods | 45.2.2.1 |
| $T_{U2}$ | Maximum torsion moment which .transversal rebar can resist. | 45.2.2.2 |
| $T_{U3}$ | Maximum torsion moment which .main rebar can resist. | 45.2.2.3 |

### Maximum shear effort section can resist

| | | |
|---|---|---|
| $V_{rd,MAX}$ | Maximum calculation shear effort | 44.2.2 |

# TORSION – HOLLOW SECTION

## DIMENSIONING

| Dimensions of section | | EHE-08 Articles |
|---|---|---|
| $h$ | Edge | |
| $b$ | Base | |
| $h_0$ | Real wall thickness | |
| $r_{MEC,INF}$ | Lower rebar's mechanical covering | *37.2.4.* (rec. nominal) |
| $r_{MEC,SUP}$ | Top rebar's mechanical covering | |
| $d$ | Useful edge: $d=h-r_{MEC,INF}$ | |

| Material characteristics | | |
|---|---|---|
| $f_{yk}$ | Steel characteristic yield | |
| $f_{ck}$ | Concrete characteristic yield. | |
| T.M.A. | Maximum aggregate size | |
| $\gamma_s$ | Partial safety coefficient of steel | *Table 15.3* |
| $\gamma_c$ | Partial safety coefficient of concrete | *Table 15.3* |
| $\alpha_{cc}$ | Concrete fatigue factor. | *39.4* |
| $f_{yd}$ | Calculation resistance of steel (passive rebar) | *38.3* |
| $f_{cd}$ | Calculation resistance of concrete. | *39.4* |
| $f_{1cd}$ | Concrete compress resistance | *45.2.2.1* |

| Calculation stress | | |
|---|---|---|
| $N_d$ | Calculation axial force | |
| $T_d$ | Calculation torsion moment. | *45.2.2* |
| $V_{rd}$ | Calculation shear effort | |

| Torsion rebar features | | |
|---|---|---|
| $\theta_t$ | Angle between compression connecting rods and piece axis | *44.2.3.1* |
| $\alpha_t$ | Angle between rebar and piece axis | *44.2.3.1* |

| Compressed main rebar | | |
|---|---|---|
| $\#b_{S'}$ | Compressed rebar number of bars | |
| $Ø_{S'}$ | Compressed rebar diameter of bars | |
| $A_S'$ | Compressed rebar total area | |

| Section characteristics | | |
|---|---|---|
| $h_e$ | Effective wall thickness of the calculation section. | *45.2.1* |
| $A_e$ | Area enclosed by the midline of the effective hollow section. | *45.2.1* |
| $u_e$ | Midline perimeter of effective hollow section | *45.2.1* |

| Coefficients | | |
|---|---|---|
| $K$ | Coefficient which depends on the axial force | *44.2.3.1* |
| $\alpha$ | Dimensionless coefficient rings dependent | *45.2.2.1* |
| $\beta$ | Dimensionless coefficient | *45.3.2.2* |

### Maximum torsor moments the section can resist

| | | |
|---|---|---|
| $T_{U1}$ | Maximum torsion moment which can resist the concrete connecting rods | 45.2.2.1 |
| $T_{U2}$ | Maximum torsion moment which .transversal rebar can resist. | 45.2.2.2 |
| $T_{U3}$ | Maximum torsion moment which .main rebar can resist. | 45.2.2.3 |

### Torsion combined with shear stress

| | | |
|---|---|---|
| $V_{U1}$ | Shear stress exhaustion by oblique compression in the soul | 44.2.3.1. |
| $V_{rd,MAX}$ | Maximum calculation shear effort | 44.2.2 |

### Torsion transversal rebar

| | |
|---|---|
| $A_t$ | Torsion transversal rebar area. |
| $S_t$ | Torsion transversal rebar separation. |
| $Ø_{St}$ | Torsion transversal rebar diameter |
| $\#_{cercos}$ | Rings number |

### Main rebar

| | |
|---|---|
| $A_{l,}$ | Main rebar area |
| $Ø_{Sl}$ | Torsion main rebar diameter |
| $\#_{barras}$ | Number of bars |

# TESTING

| Dimensions of section | | EHE-08 Articles |
|---|---|---|
| h | Edge | |
| b | Base | |
| $h_0$ | Real wall thickness | |
| $r_{MEC,INF}$ | Lower rebar's mechanical covering | *37.2.4.* (rec. nominal) |
| $r_{MEC,SUP}$ | Top rebar's mechanical covering | |
| d | Useful edge: $d=h-r_{MEC,INF}$ | |

| Rebar features | | |
|---|---|---|
| $\#b_{S'}$ | Compressed rebar number of bars | |
| $Ø_{S'}$ | Compressed rebar diameter of bars | |
| $\#b_S$ | Tractee rebar number of bars | |
| $Ø_S$ | Tractee rebar diameter of bars | |
| $A_L$ | Total main rebar area. | |
| $Ø_{St}$ | Rings diameter. | |
| $S_t$ | Distance between rings | |
| $A_t$ | Total each rings branch area. | |
| $\theta_t$ | Angle between compression connecting rods and piece axis | *44.2.3.1* |
| $\alpha_t$ | Angle between rebar and piece axis | *44.2.3.1* |

| Calculation stress | | |
|---|---|---|
| $N_d$ | Calculation axial force | |
| $T_d$ | Calculation torsor moment in the section | *45.2.2* |
| $V_{rd}$ | Calculation shear effort | |

| Material characteristics | | |
|---|---|---|
| $f_{yk}$ | Steel characteristic yield | |
| $f_{ck}$ | Concrete characteristic yield | |
| T.M.A. | Maximum aggregate size | |
| $\gamma_s$ | Partial safety coefficient of steel | *Table 15.3* |
| $\gamma_c$ | Partial safety coefficient of concrete | |
| $\alpha_{cc}$ | Concrete fatigue factor. | *39.4* |
| $f_{yd}$ | Calculation resistance of steel (passive rebar) | *38.3* |
| $f_{cd}$ | Calculation resistance of concrete. | *39.4* |
| $f_{1cd}$ | Concrete compress resistance | *45.2.2.1* |

| Section characteristics | | |
|---|---|---|
| $h_e$ | Effective wall thickness of the calculation section. | *45.2.1* |
| $A_e$ | Area enclosed by the midline of the effective hollow section. | *45.2.1* |
| $u_e$ | Midline perimeter of effective hollow section | *45.2.1* |

| Torsion combined with shear stress | | |
|---|---|---|
| $V_{U1}$ | Shear stress exhaustion by oblique compression in the soul | *44.2.3.1.* |

| Coefficients | | |
|---|---|---|
| K | Coefficient which depends on the axial force | *44.2.3.1* |
| $\alpha$ | Dimensionless coefficient rings dependent | *45.2.2.1* |
| $\beta$ | Dimensionless coefficient | *45.3.2.2* |
| **Maximum torsor moments the section can resist** | | |
| $T_{U1}$ | Maximum torsion moment which can resist the concrete connecting rods | *45.2.2.1* |
| $T_{U2}$ | Maximum torsion moment which .transversal rebars can resist. | *45.2.2.2* |
| $T_{U3}$ | Maximum torsion moment which .main rebar can resist. | *45.2.2.3* |

| Maximum shear effort section can resist | | |
|---|---|---|
| $V_{rd,MAX}$ | Maximum calculation shear effort | *44.2.2* |

# PUNCHING SHEAR

| Support characteristics | | EHE-08 Articles |
|---|---|---|
| $c_1$ $^{(x)}$ | Support edge in x axis | *Figure 46.2.a, b y c* |
| $c_2$ $^{(y)}$ | Support edge in y axis | |
| $l_x$ | Shortest distance between the edge of the concrete support and the x axis. | |
| $l_y$ | Shortest distance between the edge of the concrete support and the y axis. | |

| Slab characteristics | | |
|---|---|---|
| h | Slab edge | |
| $r_{mec,inf}$ | Lower rebar's mechanical covering | *37.2.4.* (rec. nominal) |
| d | Slab's useful edge | |
| $u_1$ | critical perimeter | *Figure 46.2.d y e* |
| $b_{x1}$ | Critical perimeter width x. | *Figure 46.2.a, b y c* (1) |
| $A_x$ | Defined area on the side $b_x$ and singing. | *46.3* |
| $b_{y1}$ | Critical perimeter width y | *Figure 46.2.a, b y c* (1) |
| $A_y$ | Defined area on the side $b_y$ and singing | *46.3* |

| Material characteristics | | |
|---|---|---|
| $f_{ck}$ | Concrete characteristic yield | *Table 15.3* |
| $\gamma_c$ | Partial safety coefficient of concrete | |
| $f_{cd}$ | Calculation resistance of concrete. | *39.4* |
| $f_{1cd}$ | Concrete compress resistance | *46.3* |
| $f_{cv}$ | Concrete effective resistance to shear | |
| $f_{y\alpha,k}$ | Punching shear rebar characteristic yield | |
| $\gamma_s$ | Partial safety coefficient of steel | *Table 15.3* |
| $f_{y\alpha,d}$ | Transversal rebar calculation yield | |

| Rebar features | | |
|---|---|---|
| $\alpha$ | Rebar angle with axis of the piece | |
| $s_{max}$ | Maximum distance radially concentric perimeters of rebar | |
| s | Distance radially concentric perimeters of rebar, used in calculations | |
| $s_{1,min}$ | Minimum distance in radial direction between the support and the first line of rebar (0,5·d) | *Figure 46.5.b* |
| $s_{1,max}$ | Maximum distance in radial direction between the support and the first line of rebar (0,5·d) | *Figure 46.5.b* |
| $s_1$ $^{(user)}$ | Distance in radial direction between the support and the first line of rebar, choose by user | |
| $b_{x2}$ | Width of the perimeter $u_{n,ef}$ en *x* axis. | *Figure 46.5.a* (2) |
| $b_{y2}$ | Width of the perimeter $u_{n,ef}$ en *y* axis. | |
| $\rho_l$ | Geometric ratio total main rebar reinforcement inside the perimeter $u_{n,ef}$* | |

### Calculation stress

*Article 46.3*

| | | |
|---|---|---|
| $F_{sd}$ | Punching shear calculation | |
| $N_{d,x}$ , $N_{d,y}$ | Longitudinal forces in the critical surface from a load. | |
| $M_d$ | Moment transferred between slab and support | |

### Coefficients

| | | |
|---|---|---|
| $\beta$ | Eccentricity coefficient according | *46.3* |
| $\xi$ | Dimensionless coefficient | *46.3* |

### Other values of interest

| | | |
|---|---|---|
| $\sigma'_{cd}$ | Average axial stress testing in the critical surface | *46.3* |
| $u_{n,ef}$ | Perimeter continent of punching shear reinforcement | *Figure 46.5.a* |
| $u_o$ | Testing perimeter | *Figure 46.4.3* |
| $\tau_{rd}^1$ | Resistant stress critical perimeter | *46.3* |
| $\tau_{rd}^2{}_{,min}$ | Minimum value of the critical perimeter resistant stress | |

### Tests for slabs without punching shear reinforcement

*46.3*

| | |
|---|---|
| $\tau_{sd}$ | Nominal tangential stress calculation |
| $\tau_{rd}$ | Maximum stress resistant critical perimeter (Biggest between $\tau_{rd}^1$ y $\tau_{rd}^2{}_{,min}$ ) |

### Dimensioning of punching shear reinforcement

| | | |
|---|---|---|
| $A_{sw}$ | Total area of reinforcement for punching in a perimeter or area concentric to the load support. | *46.4.1* |

### Checking the area outside the punching area

*46.4.2*

| | |
|---|---|
| $F_{sd,ef}$ | Effective stress punching |
| $F_{ext}$ | Punching Shear outer perimeter |

[(1) (2)] Have had to add the subscripts 1 and 2 to distinguish the two values together, because regulations uses the same nomenclature to be different although both.

* Equivalent to the square root of x rebar and y rebar with a maximum value of 2 ‰.

# DIMENSIONING TO SHEARING – RECTANGULAR SECTIONS

| Symbol | Description | EHE-08 Articles |
|---|---|---|
| **Dimensions of section** | | |
| h | Edge | |
| b | Base | |
| p | Contact surface per unit length | |
| **Material characteristics** | | |
| $f_{ck}$ | Concrete characteristic yield | |
| $\gamma_s$ | Partial safety coefficient of steel | Table 15.3 |
| $\gamma_c$ | Partial safety coefficient of concrete | |
| $\alpha_{cc}$ | Concrete fatigue factor. | 39.4 |
| $f_{cd}$ | Calculation resistance of concrete. | 39.4 |
| $f_{ct,d}$ | Concrete tractee calculation resistance | |
| $f_{y\alpha,d}$ | Transversal rebar calculation yield | 44.2.3.2.2 |
| **Torsion rebar features** | | |
| s | Separation between rings | |
| $\alpha$ | Rebar angle with axis of the piece | 44.2.3.1 |
| **Calculation stress** | | |
| $\Delta C$ o $\Delta T$ | Variation of the resultant of the normal stresses blocks (in compression or traction) | |
| $\sigma_{cd}$ | Calculation external stress plane normal of the joint | |
| **Coefficients** | | |
| $\beta^1$ | Dimensionless coefficient for calculation without transversal rebar. | 47.2.2.2 |
| $\beta^2$ | Dimensionless coefficient for calculation with transversal rebar. | 47.2.2.2 |
| $\mu$ | Dimensionless coefficient surface dependent | 47.2.2.2 |
| **Previous calculations** | | |
| $\tau_{r,d}$ | Calculating shear stress | 47.1 |
| **Testing in sections without transverse rebar** | | |
| $\tau_{r,u}$ | Shearing depletion stress | 47.2.1 o 47.2.2 |
| **Transversal rebar** | | |
| $A_{st,min}$ | Minimum rings area. | |
| $A_{st}$ | Rings area. | |
| **Rebar dimensioning (to 1ml)** | | |
| $\#_{b,TOTAL}$ | Total number of rings to 1ml | |
| $\varnothing_{St}$ | Rings diameter | |

# REBAR OR MESH ANCHORAGE

## Material characteristics

| | | |
|---|---|---|
| $f_{ck}$ | Concrete characteristic yield. | |
| $\gamma_s$ | Partial safety coefficient of steel | *Table 15.3* |
| $\gamma_c$ | Partial safety coefficient of concrete | |
| $\alpha_{cc}$ | Concrete fatigue factor. | *39.4* |
| $f_{cd}$ | Calculation resistance of concrete. | *39.4* |
| $f_{ct,d}$ | Concrete tractee calculation resistance | |
| $f_{yd}$ | Calculation resistance of steel (passive rebar) | *38.3* |

## Bars characteristics

| | | |
|---|---|---|
| Ø | Bar diameter. | |
| $c_1$ | Geometric covering | |
| $A_{s,mec.}$ | Mechanical rebar area | |
| $A_{s,real}$ | Real rebar from which anchor the reinforcement. | |
| $\tau_{bd}$ | Constant adhesion tension | *69.5.1.2* |

## Basic anchorage length

| | | |
|---|---|---|
| $l_b$ | Basic anchorage length. | *69.5.1.2* |

## Net anchorage length

| | | |
|---|---|---|
| $l_{b,neta}$ | Net anchorage length | *69.5.1.2* |

# ANCHORAGE BY OVERLAP

| Material characteristics | | EHE-08 Articles |
|---|---|---|
| $f_{ck}$ | Concrete characteristic yield | |
| $\gamma_c$ | Partial safety coefficient of concrete | |
| $f_{ct,d}$ | Concrete tractee calculation resistance | *39.4 , 39.1* |
| $f_{yk}$ | Steel characteristic yield | |
| $\gamma_s$ | Partial safety coefficient of steel | *15.3* |
| $f_{yd}$ | Calculation resistance of steel (passive rebar) | |

| Rebar characteristics | | |
|---|---|---|
| Ø | Bars to overlap diameter. | |
| a | Separation between nearest overlaps | *Figure 69.5.2.2* |
| $A_{S,mec.tot}$ | Total calculation mechanical rebar | |
| $A_{S1,real}$ | Real main rebar area (tractee) | |
| $A_{S2,real}$ | Real secondary rebar area (compressed) | |
| $A_{s,real}$ | Real total steel area | |
| $\%A_{s,tracc.}$ | Percentage of tractee rebar | |
| $\tau_{bd}$ | Adhesion tension | *69.5.1.2* |

| Basic anchorage length | | |
|---|---|---|
| $l_b$ | Basic anchorage length | *69.5.1.2* |

| Net anchorage length | | |
|---|---|---|
| $l_{b,neta}$ | Net anchorage length | *69.5.1.2, 69.5.1.4* |

| Overlap length | | |
|---|---|---|
| $l_s$ | Overlap length | *69.5.2.2* |
| $l_{supl}$ | Supplementary bar length | *69.5.2.3* |
| $S_{empalmes}$ | Separation between overlaps | |

# INSTABILITY OF SUPPORTS

## Portico data

| Symbol | Description | EHE-08 Articles |
|---|---|---|
| $b_{AB}$ | Section width of support A-B | |
| $h_{AB}$ | Section edge of support A-B | |
| $L_{AB}$ | A-B support length | |
| $d_{AB}'$ | Lower rebar's mechanical covering | |
| $d$ | Useful edge: $d=h-d_{AB}'$ | |
| $A_c$ | Section area of support A-B | |
| $I_{AB,z}$ | Cross-section inertia moment of support A-B | |

## Beam data

| | | |
|---|---|---|
| $b_{DA}$ | Section width of beam D-A | |
| $h_{DA}$ | Section high of beam D-A | |
| $L_{DA}$ | D-A beam length | |
| $I_{DA,z}$ | Cross-section inertia moment of support D-A | |

## Material characteristics

| | | |
|---|---|---|
| $f_{ck}$ | Concrete characteristic yield | |
| $\gamma_c$ | Partial safety coefficient of concrete | |
| $f_{cd}$ | Calculation resistance of concrete. | *39.4* |
| $f_{yk}$ | Steel characteristic yield | |
| $\gamma_s$ | Partial safety coefficient of steel | *15.3* |
| $f_{yd}$ | Calculation resistance of steel (passive rebar) | *38.3* |
| $\varepsilon_y$ | Steel deformation for $f_{yd}$ | *43.5.1* |
| $E$ | Steel modulus elasticity | *38.4* |

## Calculation stress

| | | |
|---|---|---|
| $M_{d,z}^{A}$ | Calculation bending moment in support A | |
| $M_{d,z}^{B}$ | Calculation bending moment in support B | |
| $N_d$ | Calculation axial force | |

## Coefficients and factors

| | | |
|---|---|---|
| $\psi_A$ | Ratio between rigidities, extreme A | *43.4* |
| $\psi_B$ | Ratio between rigidities, extreme B | *43.4* |
| $e_1$ | First order eccentricity, in the extreme with a major moment. | *43.1.2* |
| $e_2$ | First order eccentricity, in the extreme with a lower moment. | *43.1.2* |
| $\upsilon$ | Dimensionless axial | *43.1.2* |
| $C$ | Dimensionless coefficient, bar position dependent | *43.1.2* |
| $\beta$ | Arming factor | *43.5.1* |

## Slenderness

| | | |
|---|---|---|
| $\lambda_{inf}$ | Lower limit slenderness | *43.1.2* |
| $\lambda_{mec}$ | Mechanical slenderness | *43.1.1* |

## Buckling length

| | | |
|---|---|---|
| $\alpha$ | Buckling length factor | *43.4* |
| $l_o$ | Buckling length | *43.4* |

# DEFORMATIONS

## RECTANGULAR SECTIONS

| Section dimensions | | EHE-08 Articles |
|---|---|---|
| L | Beam length | |
| $h_c$ | Edge | |
| $b_c$ | Base | |
| $r_{inf}$ | Lower rebar's mechanical covering | *37.2.4.* |
| $d_c$ | Useful edge | |

| Material characteristics | | |
|---|---|---|
| $f_{ck}$ | Concrete characteristic yield | |
| $f_{ctm,fl}$ | Medium strength concrete bending traction | *39.1* |
| $f_{yk}$ | Steel characteristic yield | |
| $\gamma_s$ | Partial safety coefficient of steel | *15.3* |
| $f_{yd}$ | Calculation resistance of steel (passive rebar) | *38.3* |

| Rebar disposition | | |
|---|---|---|
| $\#b_{S1}$ | Tractee rebar number of bars | |
| $Ø_{S1}$ | Rebar diameter | *39.1* |
| $A_{S1}$ | Total rebar area | |
| $\#b_{S2}$ | Compress rebar number of bars | *15.3* |
| $Ø_{S2}$ | Compress rebar diameter | *38.3* |
| $A_{S2}$ | Total rebar area | |

| Actions: initial (uncentering) / at 8 days. | |
|---|---|
| $q_{izq}^{(i)/(n)}$ | Distributed load value at the left end |
| $q_{der}^{(i)/(n)}$ | Distributed load value at the right end |
| $P^{(i)/(n)}$ | Point load |
| a | Distance between the right end of the bar and point load |
| b | Distance between the left end of the bar and point load |
| $M^{(i)/(n)}$ | Applied bending moment. |
| c | Distance between right end of bar and bending moment |
| d | Distance between left end of bar and bending moment |
| $q^{(i)/(n)}$ | Uniformly distributed load that occupies a section of bar |
| e | Distance between the right end of the bar and the center of the uniformly distributed load |
| f | Distance between the center of the uniformly distributed load and the left end of the bar |
| g | Width of the section affected by the uniform load |

| Previous testing: | | |
|---|---|---|
| L/d | Relation length / effective edge | |
| L/d * | Minimal relation L/d to not require deformation testing | **Tabla 50.2.2.1.a* |

| Previous calculations: uncentering and n days | | |
|---|---|---|
| $E_s$ | Steel modulus elasticity | *38.4* |
| $M_f$ | Nominal fissuring moment | *50.2.2.2* |
| X/d | Relative depth of the neutral fiber | *Annex 8 art.2.2* |
| $I_b$ | Brute moment of inertia | |
| $I_f$ | Moment of inertia of fissured section | *Annex 8 art.2.2* |

### Inertia and deformation modules

| | | |
|---|---|---|
| $E_c^{(i)/(n)}$ | Modulus of deformation of the concrete | *39.6* |
| $I_e^{(i)/(n)}$ | Equivalent inertia moment | *50.2.2.2* |
| $I^{(i)/(n)}$ | inertia moment used for calculating ($I_b$ o $I_e$) | |

### Maximum stresses and deformations

| | |
|---|---|
| $M_{MAX}{}^{i}$ | Maximum bending moment in the uncentering |
| $f_{inst}{}^{i}$ | Instant deformation in the uncentering |
| $M_{MAX}{}^{n}$ | Maximum bending moment at n days |
| $f_{inst}{}^{n}$ | Instant deformation at n days |

### λ Factor ($f_{dif}$ calculations) *50.2.2.3*

| | |
|---|---|
| λ | Factor in the calculation of deferred deformation |
| ξ | Coefficient depending on the duration of the load |
| ρ' | Amount geometric compression reinforcement |

### Calculating the total and active deformations *50.2.2.3*

| | |
|---|---|
| $f_{dif}{}^{i}$ | Deferred deformation of uncentering loads. |
| $f_{dif}{}^{n}$ | Deferred deformation of loads at n days |
| $f_{tot}{}^{i}$ | Total deformation of uncentering loads |
| $f_{tot}{}^{n}$ | Total deformation of loads at n days |
| $f_{ACTIVA}$ | Active deformation |

# T SECTIONS

| Section dimensions | | EHE-08 Articles |
|---|---|---|
| L | Beam length | |
| $h_{ALA}$ | Flag edge | |
| $h_{ALMA}$ | Soul edge | |
| $b_{ALA}$ | Flag base | |
| $b_{ALMA}$ | Soul base | |
| $r_{inf}$ | Lower rebar's mechanical covering | *37.2.4.* |
| $d_c$ | Useful edge | |

| Material characteristics | | |
|---|---|---|
| $f_{ck}$ | Concrete characteristic yield | |
| $f_{ctm,fl}$ | Medium strength concrete bending traction | *39.1* |
| $f_{yk}$ | Steel characteristic yield | |
| $\gamma_s$ | Partial safety coefficient of steel | *15.3* |
| $f_{yd}$ | Calculation resistance of steel (passive rebar) | *38.3* |

| Rebar disposition | | |
|---|---|---|
| $\#b_{S1}$ | Tractee rebar number of bars | |
| $Ø_{S1}$ | Rebar diameter | *39.1* |
| $A_{S1}$ | Total rebar area | |
| $\#b_{S2}$ | Compress rebar number of bars | *15.3* |
| $Ø_{S2}$ | Compress rebar diameter | *38.3* |
| $A_{S2}$ | Total rebar area | |

| Actions: initial (uncentering) / at 8 days. | |
|---|---|
| $q_{izq}^{(i)/(n)}$ | Distributed load value at the left end |
| $q_{der}^{(i)/(n)}$ | Distributed load value at the right end |
| $P^{(i)/(n)}$ | Point load |
| a | Distance between the right end of the bar and point load |
| b | Distance between the left end of the bar and point load |
| $M^{(i)/(n)}$ | Applied bending moment. |
| c | Distance between right end of bar and bending moment |
| d | Distance between left end of bar and bending moment |
| $q^{(i)/(n)}$ | Uniformly distributed load that occupies a section of bar |
| e | Distance between the right end of the bar and the center of the uniformly distributed load |
| f | Distance between the center of the uniformly distributed load and the left end of the bar |
| g | Width of the section affected by the uniform load |

| Previous testing: | | |
|---|---|---|
| L/d | Relation length / effective edge | |
| L/d * | Minimal relation L/d to not require deformation testing | **Tabla 50.2.2.1.a* |

| Previous calculations: uncentering and n days | | |
|---|---|---|
| $E_s$ | Steel modulus elasticity | *38.4* |
| $M_f$ | Nominal fissuring moment | *50.2.2.2* |
| X/d | Relative depth of the neutral fiber | *Annex 8 art.2.2* |
| $I_b$ | Brute moment of inertia | |
| $I_f$ | Moment of inertia of fissured section | *Annex 8 art.2.2* |

### Inertia and deformation modules

| | | |
|---|---|---|
| $E_c^{(i)/(n)}$ | Modulus of deformation of the concrete | 39.6 |
| $I_e^{(i)/(n)}$ | Equivalent inertia moment | 50.2.2.2 |
| $I^{(i)/(n)}$ | inertia moment used for calculating ($I_b$ o $I_e$) | |

### Maximum stresses and deformations

| | |
|---|---|
| $M_{MAX}^{i}$ | Maximum bending moment in the uncentering |
| $f_{inst}^{i}$ | Instant deformation in the uncentering |
| $M_{MAX}^{n}$ | Maximum bending moment at n days |
| $f_{inst}^{n}$ | Instant deformation at n days |

### λ Factor ($f_{dif}$ calculations) 50.2.2.3

| | |
|---|---|
| $\lambda$ | Factor in the calculation of deferred deformation |
| $\xi$ | Coefficient depending on the duration of the load |
| $\rho'$ | Amount geometric compression reinforcement |

### Calculating the total and active deformations 50.2.2.3

| | |
|---|---|
| $f_{dif}^{i}$ | Deferred deformation of uncentering loads. |
| $f_{dif}^{n}$ | Deferred deformation of loads at n days |
| $f_{tot}^{i}$ | Total deformation of uncentering loads |
| $f_{tot}^{n}$ | Total deformation of loads at n days |
| $f_{ACTIVA}$ | Active deformation |

# FISSURATION

| Section dimensions | | EHE-08 Articles |
|---|---|---|
| $h_c$ | Section edge | |
| $b_c$ | Section width | |
| c | Lower rebar's mechanical covering | |
| d | Useful edge: d= hc - c | |

| Main rebar tractee | | |
|---|---|---|
| $Ø_S$ | Main rebar tractee diameter | |
| $\#b_S$ | Main rebar tractee number of bars | |
| S | Distance between bars | |
| $A_s$ | Main rebar tractee total area | |

| Material characteristics | | |
|---|---|---|
| $f_{ck,j}$ | Concrete characteristic yield for *j* days | *49.2.1* |
| $f_{ctm,fl}$ | Medium strength concrete bending traction | *39.1* |
| β | Coefficient depending the actions (indirect or other cases) | *49.2.4* |

| Calculation stress | | |
|---|---|---|
| $N_d$ | Calculation axial force | |
| $M_d$ | Calculation bending moment | |

| Calculation | | |
|---|---|---|
| $M_f$ | Fissuration moment | *50.2.2.2* |
| $\sigma_s$ | Rebar service stress | *49.2.4* |
| $\sigma_{sr}$ | Rebar stress of fissured section | *49.2.4* |
| $s_m$ | Medium distance between fissures | *49.2.4* |
| $\varepsilon_{sm}$ | Rebar medium lengthening | *49.2.4* |

# ANNEX 1. REBAR CALCULATION

**EHE-08 Articles**

| Symbology | |
|---|---|
| $Ø_s$ | Rebar diameter |
| $\#_{barras}$ | Number of bars |
| $b_c$ | Concrete section width |
| $h_c$ | Concrete section edge |
| $A_s$ | Rebar total area |
| $A_c$ | Concrete total area |
| $\rho_l$ | Geometric amount |

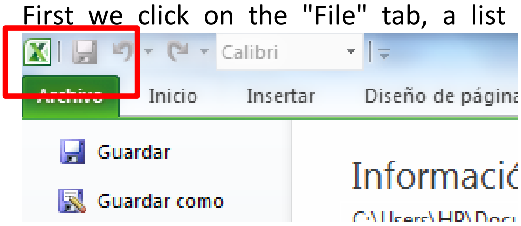
# D. ANNEX

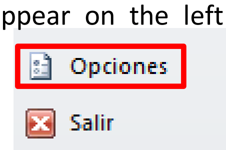
# EXCEL TUTORIALS

## *SOLVER* FUNCTION

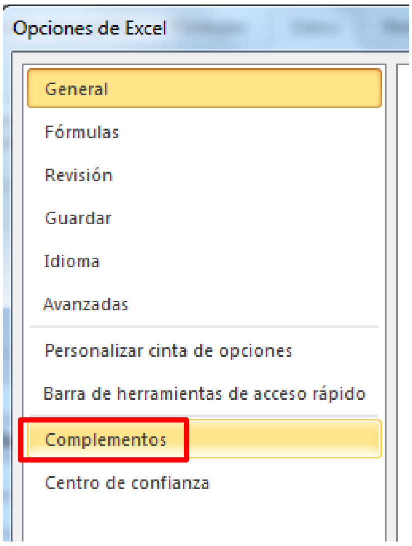
To resolve some of the bending-compression sheet, will be necessary to apply the solver function, since some calculations are not done automatically. It is a very simple procedure, but it is common in 2007 or 2010 Excel solver function (or solve) is hidden.
So, in order to access it, we proceed as follows:

First we click on the "File" tab, a list of options appear on the left side of the screen.

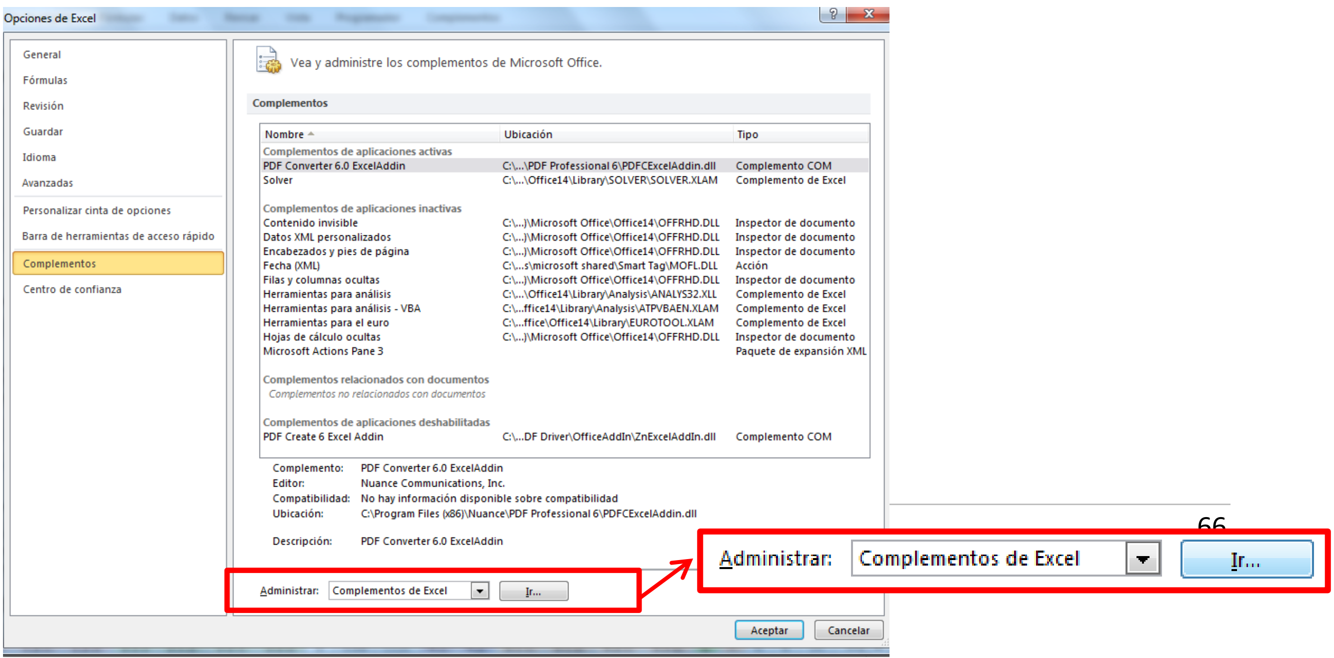



We will click on the " ***Opciones de Excel*** " which will open a window. And select " ***Complementos"*** options.

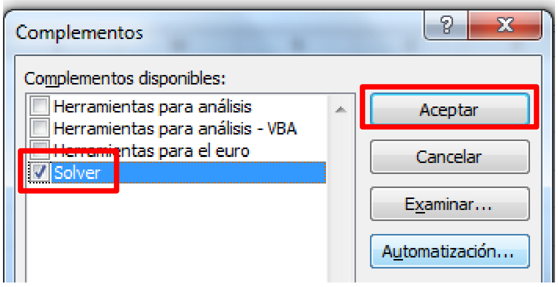



In the bottom of the window that opens, appears the word Manage and next to it a drop down list:



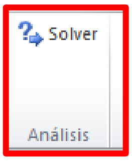
You must select the option "***Complementos de Excel***" and click ***Ir…***

At this point, □***Solver*** is selected and press ***Aceptar***.

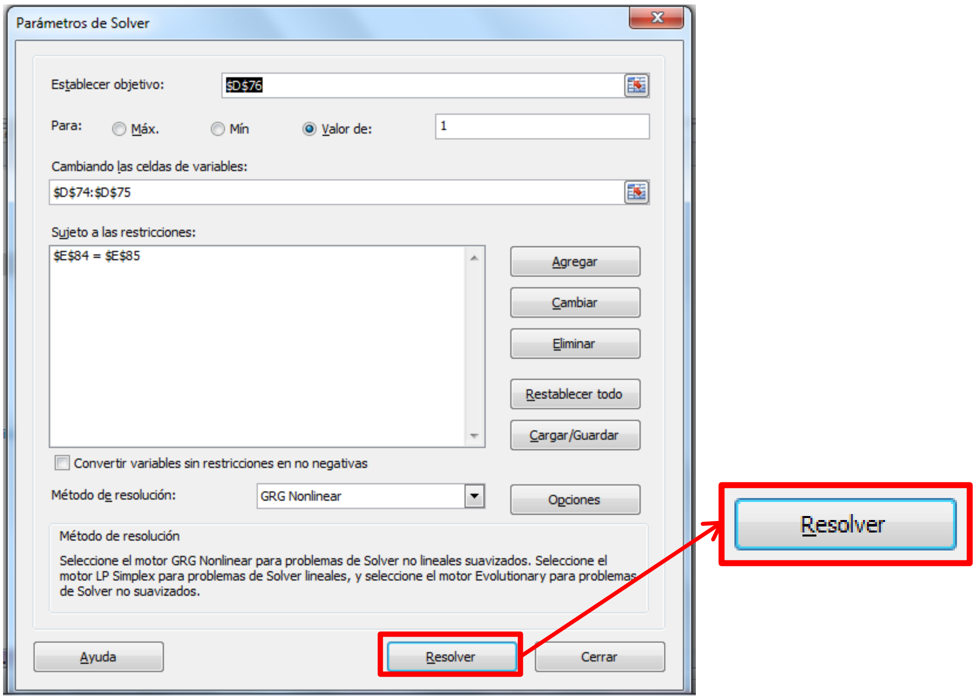



If using *Excel 2007*, maybe the computer requesting permission to install this plugin, you must agree to install.

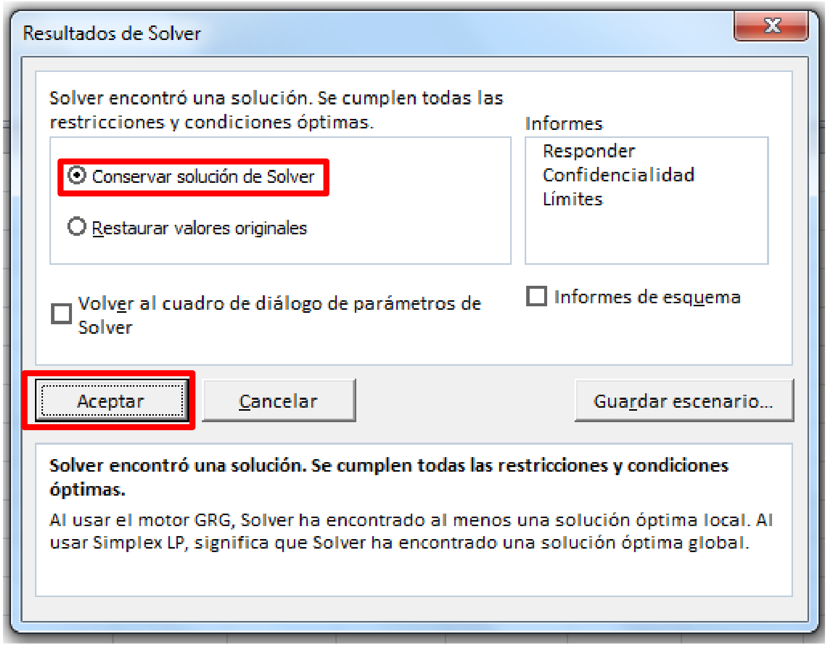
Once all this procedure, the solver option and will be visible. It will be on the ***Datos*** tab in subsection called ***Análisis***.




By clicking the ***Solver*** option will open a window in which there is no need to modify anything, just click the ***Resolver*** button.



Then opens a window where you can select various options, the default is marked ***Conservar solución de Solver***, so that should click Aceptar (if you leave this option selected by default, should be selected).




Next, it will be seen as are modified section data results in calculation sheet and how it changes the graphing of the neutral axis.