SeismoBuild

Verification Report

(NTC-18)

For version 2020

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Chapter 1 INTRODUCTION

PRESENTATION OF THE ANALYSIS PROGRAM

SeismoBuild is an innovative Finite Elements package wholly and exclusively dedicated to seismic assessment and strengthening of reinforced concrete framed structures. The program is capable of fully carrying out the Code defined assessment methodologies from the structural modelling, through to the required analyses, and the corresponding member checks. Currently six Codes are supported (Eurocodes, the American Code for Seismic Evaluation and retrofit of Existing Buildings, ASCE 41-17, Italian National Seismic Codes NTC-08 and NTC-18, Greek Seismic Interventions Code KANEPE and the Turkish Seismic Evaluation Building Code TBDY).. Both metric and imperial units, as well as European and US reinforcing rebar types are supported.

The rational and intuitive structure, as well as the simplicity of the package, which stem from the fact that it is the only software worldwide that is totally committed to seismic assessment, result in a very smooth learning curve, even for engineers that are not familiar with the Finite Elements method.The user-friendly, CAD-based, graphical interface increases the productivity significantly, to the point that the assessment of a multi-storey RC building may be completed within a few minutes, including the creation of the report and the CAD drawings to be submitted to the client.

The nonlinear analysis solver of SeismoBuild, which features both *geometric nonlinearities* and *material inelasticity,* is based on the advanced solution algorithms of SeismoStruct, a package that has been extensively used and verified by thousands of users for more than ten years.The accuracy of the solver in nonlinear analysis of framed structures is well demonstrated by the successes in many Blind Test Prediction Exercises.

The SeismoBuild results presented in this document were obtained using **version 2020** of the program, running on an AMD Phenom II X4 965 @ 3.40GHz machine with Windows 10 64-bit. All model files are included in SeismoStruct's installation folder.

STRUCTURE OF THE REPORT

The present report consists of a comprehensive collection of examples, which have been selected to test the various features that affect the member's capacity. It is structured in two main sections, which are briefly described below:

- In the first section (Chapter 2), the main relationships used for the Chord Rotation, Shear capacity and Beam-Column Joint checks used in NTC-18 are summarized.
- In the second section (Chapter 3), the results for chord rotation and shear capacity produced by SeismoBuild are compared with the independent hand-calculations. The results are provided in tabular form;
- In the third section (Chapter 4), the results from checks for Beam-Column Joints capacity according to the NTC-18 produced by SeismoBuild are compared with independent hand calculations. The results are provided in tabular form;

PROGRAM FEATURES COVERED BY THE PROGRAM

The aim of this section is to illustrate, through the table provided below, which program features (i.e. types of analyses, Codes, equations, member's advanced properties) are addressed in each example of the present report.

No. of Example	Employed CODE	Section Type	File name	Element Type	Material Type	Jacketed	FRP	Adequate lap length	Inadequate relative lap length	Absolute lap length	Members with longitudinal bars without lapping in the vicinity of the end	Without detailing for earthquake resistance	Smooth (Plain) Longitudinal Bars	Different Safety/Partial Factors from the default values
Example 1.1	NTC-18	Rectangular	NTC_rcrs1.bpf	Primary	Existing			√						
Example 1.2			NTC_rcrs2.bpf	Primary	Existing					√	√			√
Example 1.3			NTC_rcrs3.bpf	Secondary	Existing			√			√	√	√	√
Example 1.4			NTC_rcrs4.bpf	Secondary	New		√	√			√	√	√	√
Example 1.5			NTC_rcrs5.bpf	Secondary	New		√			√				
Example 1.6			NTC_rcrs6.bpf	Primary	Existing				√		√	√		
Example 1.7			NTC_rcrs7.bpf	Primary	Existing				√		√	√		
Example 1.8			NTC_rcrs8.bpf	Primary	Existing				√		√	√		
Example 2.1		L-Shaped	NTC_rclcs1.bpf	Primary	Existing					√			√	√
Example 2.2			NTC_rclcs2.bpf	Primary	Existing			√						
Example 2.3			NTC_rclcs3.bpf	Secondary	New				√		√	√		
Example 2.4			NTC_rclcs4.bpf	Secondary	Existing			√				√	√	
Example 2.5			NTC_rclcs5.bpf	Primary	Existing		√		√		√		√	
Example 2.6			NTC_rclcs6.bpf	Primary	New					√			√	√
Example 2.7			NTC_rclcs7.bpf	Primary	New					√			√	√
Example 2.8			NTC_rclcs8.bpf	Primary	New			√					√	√
Example 3.1		T-Shaped	NTC_rctcs1.bpf	Primary	New			√				√	√	√
Example 3.2			NTC_rctcs2.bpf	Primary	Existing				√		√	√	√	√
Example 3.3			NTC_rctcs3.bpf	Primary	New				√					
Example 3.4			NTC_rctcs4.bpf	Primary	Existing		√			√		√		
Example 3.5			NTC_rctcs5.bpf	Secondary	Existing		√	√			√		√	√
Example 3.6			NTC_rctcs7.bpf	Primary	Existing			√				√	√	√
Example 3.7			NTC_rctcs8.bpf	Primary	Existing			√				√	√	√
Example 4.1		Circular	NTC_rccs1.bpf	Primary	New			√						
Example 4.2			NTC_rccs2.bpf	Primary	New			√				√	√	√
Example 4.3			NTC_rccs3.bpf	Primary	Existing				√		√	√		√
Example 4.4			NTC_rccs4.bpf	Secondary	Existing					√	√		√	
Example 4.5			NTC_rccs5.bpf	Primary	New		√	√				√	√	
Example 4.6			NTC_rccs6.bpf	Primary	New		√			√	√			
Example 4.7			NTC_rccs7.bpf	Primary	New			√				√	√	√
Example 5.1		Wall	NTC_wall1.bpf	Primary	Existing			√						
Example 5.2			NTC_wall2.bpf	Primary	Existing				√			√	√	√
Example 5.3			NTC_wall3.bpf	Primary	New				√		√			√
Example 5.4			NTC_wall4.bpf	Secondary	New		√			√		√		
Example 5.5			NTC_wall5.bpf	Primary	New		√	√					√	
Example 5.6			NTC_wall6.bpf	Secondary	New					√	√		√	
Example 5.7			NTC_wall7.bpf	Primary	Existing				√			√	√	√
Example 6.1		Beam	NTC_Beam1.bpf	Primary	Existing					√	√	√	√	√
Example 6.2			NTC_Beam2.bpf	Secondary	New			√				√	√	√
Example 6.3			NTC_Beam3.bpf	Primary	New				√		√		√	
Example 6.4			NTC_Beam4.bpf	Secondary	Existing				√		√	√		
Example 6.5			NTC_Beam5.bpf	Primary	Existing					√	√	√		√
Example 6.6			NTC_Beam6.bpf	Primary	New			√						√
Example 6.7			NTC_Beam7.bpf	Primary	New			√						√
Example 7.1		Jacketed Rectangular	NTC_rcjrs1.bpf	Primary	New+Existing	√			√			√	√	
Example 7.2			NTC_rcjrs2.bpf	Secondary	New+Existing	√			√		√	√	√	
Example 7.3			NTC_rcjrs3.bpf	Primary	New+Existing	√				√		√	√	√
Example 7.4			NTC_rcjrs4.bpf	Primary	New+Existing	√	√			√		√		√
Example 7.5			NTC_rcjrs5.bpf	Primary	New+Existing	√			√					
Example 7.6			NTC_rcjrs6.bpf	Secondary	New+Existing	√		√			√			
Example 7.7			NTC_rcjrs7.bpf	Secondary	New+Existing	√		√			√	√	√	
Example 8.1		Jacketed L-Shaped	NTC_rcjls1.bpf	Primary	New+Existing	√		√						√
Example 8.2			NTC_rcjls2.bpf	Primary	New+Existing	√			√		√		√	√
Example 8.3			NTC_rcjls3.bpf	Secondary	New+Existing	√				√		√	√	√
Example 8.4			NTC_rcjls4.bpf	Primary	New+Existing	√		√				√	√	
Example 8.5			NTC_rcjls5.bpf	Primary	New+Existing	√	√		√		√	√		
Example 8.6			NTC_rcjls6.bpf	Secondary	New+Existing	√	√			√	√			
Example 8.7			NTC_rcjls7.bpf	Primary	New+Existing	√		√				√	√	√
Example 8.8			NTC_rcjls8.bpf	Primary	New+Existing	√		√				√	√	√
Example 9.1		Jacketed T-Shaped	NTC_rcjtcs1.bpf	Primary	New+Existing	√		√						
Example 9.2			NTC_rcjtcs2.bpf	Primary	New+Existing	√			√		√	√		√
Example 9.3			NTC_rcjtcs3.bpf	Secondary	New+Existing	√			√			√	√	√
Example 9.4			NTC_rcjtcs4.bpf	Primary	New+Existing	√		√			√	√		
Example 9.5			NTC_rcjtcs5.bpf	Primary	New+Existing	√	√			√	√	√		
Example 9.6			NTC_rcjtcs6.bpf	Secondary	New+Existing	√	√			√	√		√	
Example 9.7			NTC_rcjtcs7.bpf	Primary	New+Existing	√			√		√	√	√	
Example 9.8			NTC_rcjtcs8.bpf	Secondary	New+Existing	√			√		√	√	√	
Example 10.1		Jacketed Circular	NTC_rcjcs1.bpf	Primary	New+Existing	√		√						
Example 10.2			NTC_rcjcs2.bpf	Primary	New+Existing	√				√		√	√	√
Example 10.3			NTC_rcjcs3.bpf	Secondary	New+Existing	√			√		√	√	√	√
Example 10.4			NTC_rcjcs4.bpf	Primary	New+Existing	√			√		√	√		
Example 10.5			NTC_rcjcs5.bpf	Primary	New+Existing	√	√		√				√	
Example 10.6			NTC_rcjcs6.bpf	Primary	New+Existing	√	√			√	√	√		
Example 10.7			NTC_rcjcs7.bpf	Primary	New+Existing	√				√		√		
Example 10.8			NTC_rcjcs8.bpf	Primary	New+Existing	√				√		√		
Example 11.1		Jacketed Beam	NTC_JBeam1.bpf	Primary	New+Existing	√		√			√	√	√	√
Example 11.2			NTC_JBeam2.bpf	Secondary	New+Existing	√			√			√	√	√
Example 11.3			NTC_JBeam3.bpf	Primary	New+Existing	√				√	√			
Example 11.4			NTC_JBeam4.bpf	Primary	New+Existing	√		√				√		
Example 11.5			NTC_JBeam5.bpf	Primary	New+Existing	√			√		√	√		
Example 11.6			NTC_JBeam6.bpf	Secondary	New+Existing	√				√		√	√	

As it is shown, in the above table, all the parameters that affect the chord rotation capacity and the shear capacity of all the section types have been examined.

Chapter 2 Capacity Models for Assessment and Checks according to the Italian National Seismic Code NTC-18

In this chapter the Capacity Models for Assessment and Checksaccording to the Italian National Seismic Code (NTC-18) are presented.

CAPACITY MODELS FOR ASSESSMENT AND CHECKS

All the member checks (chord rotation capacity and shear capacity) should be carried out for all the elements of every floor, according to section 4.1.2.3.5 of NTC-18, and sections C8.7.2.5, C8.7.2.3.5 and 8.7.2.1 of the commentary, considering the members as primary or secondary (section 7.2.3 of NTC-18) seismic elements. Moreover, beam-column joints checks can be employed in order to check (i) the joint's diagonal tension and (ii) the joint's diagonal compression. Finally, interstorey drift checks may be carried out, when needed, for the vertical elements of every floor, according to section 7.3.7.2 of NTC-18.

Deformation Capacity

The deformation capacity of beams, columns and walls is defined in terms of the chord rotation θ, that is the angle between the tangent to the axis at the yielding end and the chord connecting that end with the end of the shear span (L_V=M/V=moment/shear at the end section). The chord rotation is also equal to the element drift ratio, which is the deflection at the end of the shear span with respect to the tangent to the axis at the yielding end divided by the shear span.

Deformation capacity of beams and columns is highly influenced by the lack of appropriate seismic resistant detailing in longitudinal reinforcement, as well as by the bars type, that is whether there are smooth bars. Inadequate development of splicing along the span (beams) and height (columns); and inadequate embedment into beam-column joints can control the members' response to seismic action, drastically limiting its capacity in respect to the situation in which the reinforcement is considered fully effective. The above limitations to the deformation capacity are taken into consideration.

The value for the chord rotation capacity for the limit state of collapse prevention (SLC) is the value of the total chord rotation capacity at ultimate of concrete members under cyclic loading, which is calculated from the following expression:

For beams and columns:

$$\theta_u = \frac{1}{\gamma_{el}} \cdot 0{,}016 \cdot (0{,}3^{\nu}) \left[\frac{\max(0{,}01;\omega')}{\max(0{,}01;\omega)} f_c\right]^{0{,}225} \cdot \left(\frac{L_V}{h}\right)^{0{,}35} 25^{\left(\alpha\rho_{sx}\frac{f_{yw}}{f_c}\right)} (1{,}25^{100\rho_d})$$

(8.7.2.1) commentary of NTC-18

Where γ_{el} is equal to 1,5 for primary seismic elements and to 1,0 for secondary seismic ones; L_V is the ratio between bending moment, M, and shear force, V. The remaining relevant parameters are defined in section C8.7.2.3.2 of the commentary of NTC-18.

For the wall elements the value given in the expressionabove must be divided by 1.6.

The chord rotation capacity corresponding to the limit state of life safety (SLV) is assumed to be ¾ of the ultimate chord rotation, calculated from the equationabove.

The capacity that corresponds to the limit states of operational level (SLO) and of damage limitation (SLD) is given by the chord rotation at yielding, evaluated as:

For beams and columns:

$$\theta_y = \varphi_y \frac{L_V}{3} + 0{,}0013\left(1 + 1{,}5\frac{h}{L_V}\right) + 0{,}13\varphi_y \frac{d_b f_y}{\sqrt{f_c}} \qquad \text{(8.7.2.7a) commentary of NTC-18}$$

For walls:

$$\theta_y = \varphi_y \frac{L_V}{3} + 0{,}002\left(1 - 0{,}125\frac{L_V}{h}\right) + 0{,}13\varphi_y \frac{d_b f_y}{\sqrt{f_c}} \qquad \text{(8.7.2.7b) commentary of NTC-18}$$

The relevant parameters are defined in section C8.7.2.3.4 of the commentary of NTC-18.

The yield curvature of the end section is calculated according to the following expression for the sections whose compressive zone is of constant width and for the case that the section's yielding is due to steel yielding.

$$\varphi_y = (1/r)_y = \frac{f_y}{E_s(1 - \xi_y)d}$$

If the section yields due to the deformation non-linearities of the concrete in compression, that is for deformation of the edge compressive fibre larger than $\varepsilon_c \approx 1.8\, f_c/E_c$, then the yield curvature is calculated according to the following expression:

$$\varphi_y = (1/r)_y = \frac{\varepsilon_c}{\xi_y d} \approx \frac{1.8 f_c}{E_c \xi_y d}$$

The lower value from the above calculations is used for the calculation of the chord rotation capacity.

According to section C8.7.2.3.2 of the commentary of NTC-18 the chord rotation capacity is highly influenced by a number of different factors such as the type of the longitudinal bars. If smooth (plain) longitudinal bars are applied, the ultimate chord rotation should be multiplied by the factor calculated from equation 8.7.2.4 of the commentary of NTC-18, taking, also, into consideration whether the longitudinal bars are well lapped or not by employing the factor of 8.7.2.3. In case of members with lack of appropriate seismic resistant detailing the ultimate chord rotation capacity is multiplied by 0,85.

In the case of circular column sections, the equationsabove cannot be employed for the calculation of the elements' chord rotation capacity. In SeismoBuild the equations below suggested by D. Biskinis and M. N. Fardis [2013] are employed for θ_y and θ_u.

$$\theta_y = \varphi_y \frac{L_V + \alpha_V z}{3} + 0.0027\left(1 - \min\left(1; \frac{2}{15}\frac{L_s}{D}\right)\right) + \alpha_{sl}\frac{\varphi_y d_{bL} f_y}{8\sqrt{f_c}}$$

Where f_y and f_c values are in MPa, α_V=1 if $V_{Rc}<V_{My}$, V_{Rc} is calculated according to Eurocode 2 (CEN 2004), otherwise α_V=0, and α_{sl}=0 if pull-out of the tension bars from their anchorage zone beyond the yielding end is physically impossible, otherwise α_{sl}=1.

$$\theta_u = \left(\theta_y + (\varphi_u - \varphi_y)L_{pl}(1 - 0.5\, L_{pl}/L_s) + \alpha_{sl}\Delta\theta_{u,slip}\right)/\gamma_{el}$$

Where γ_{el} is equal to 2.0 for primary seismic elements and to 1.0 for secondary seismic elements, $\Delta\theta_{u,slip}$ and L_{pl} are calculated according to the following equations:

$$\Delta\theta_{u,slip} = 10 d_{bl}\left(\varphi_u + \varphi_y\right)/2$$

$$L_{pl} = 0.6D\left[1 + \frac{1}{6}\min\left(9; \frac{L_s}{D}\right)\right]$$

Users are advised to refer to the relevant publications for the definition of the other parameters and further details on the expression.

Concrete Jacketing

The values of the jacketed members for M_y^*, $\theta_y^*$and θ_u^* that are adopted in the capacity verifications depend on the corresponding values calculated under the requirements of sections C8.7.4.2.1 of the commentary of NTC-18, according to the following equations of section C8.7.4.2.1 of the commentary of NTC-18:

The yield moment:

$M_y^* = 0.9M_y$ (8.7.4.2) commentary of NTC-18

The chord rotation at yield:

$\theta_y^* = 0.9\theta_y$ (8.7.4.3) commentary of NTC-18

The ultimate chord rotation:

$\theta_u^* = \theta_u$ (8.7.4.4) commentary of NTC-18

FRP wrapping

The contribution of the FRP wrapping to the members' capacity is taken into account according to Annex A of EN1998-3:2005, as described below:

The effect of FRP wrapping on the members' flexural resistance at yielding,computed in accordance with equations 8.7.2.1 of the commentary of NTC-18, is neglected.

The total chord rotation capacity and its plastic part for the members of rectangular sections with corners rounded is calculated through the expressions (8.7.2.1) of the commentary of NTC-18, respectively, with the exponent of the term due to confinement increased by $\alpha\rho_f f_{f,e}$, where α is the confinement effectiveness factor, ρ_f the FRP ratio parallel to the loading direction and $f_{f,e}$ the effectiveness stress given from the (A.35) equation of EC8: Part 3.

Shear Capacity

Shear capacity is calculated through the following expression according to section C.8.7.2.3.5 of NTC-18.

$V_R = \max\{V_{Rd}, \max[\min(V_{R,Seismic}, V_{Rcd}), \min(V_{Rsd}, V_{Rcd})]\}$ for $\mu\Delta \leq 1$

$V_R = \max[\min(V_{R,Seismic}, V_{Rcd}), \min(V_{Rsd}, V_{Rcd})]$ for $1 \leq \mu\Delta \leq 2$

$V_R = \min(V_{R,Seismic}, V_{Rcd})$ for $\mu\Delta \geq 3$

And a linear interpolation when μΔ falls between 2 and 3 where μΔ is the ductility demand for the element.

V_{Rd} is the shear resistance that corresponds to the elements without taking into consideration the transverse reinforcement:

$$V_{Rd} = \{0{,}18 \cdot k \cdot (100 \cdot \rho_1 \cdot f_{ck})^{1/3}/\gamma_c + 0{,}15 \cdot \sigma_{cp}\} \cdot b_w \cdot d \geq (v_{min} + 0{,}15 \cdot \sigma_{cp}) \cdot b_w \cdot d$$

(4.1.23) NTC-18

V_{Rsd} is the shear strength that corresponds to the contribution of the shear reinforcement and is calculated according to the equation below:

$$V_{Rsd} = 0{,}9 \cdot d \cdot \frac{A_{sw}}{s} \cdot f_{yd} \cdot (\mathrm{ctg}\alpha + \mathrm{ctg}\theta) \cdot \sin\alpha$$ (4.1.27) NTC-18

V_{Rcd} is the shear strength that corresponds to the confined concrete core and is calculated according to the following equation:

$$V_{Rcd} = 0{,}9 \cdot d \cdot b_w \cdot \alpha_c \cdot f'_{cd} \cdot (\mathrm{ctg}\alpha + \mathrm{ctg}\theta)/(1 + \mathrm{ctg}^2\theta)$$ (4.1.28) NTC-18

Finally, $V_{R,Seismic}$ is the shear strength in cases of cyclic loading as is calculated according to the equation below:

$$V_{R,Seismic} = \frac{1}{\gamma_{el}}\left[\frac{h-x}{2L_v}\min(N, 0.55A_c f_c) + \left(1 - 0.05\min(5, \mu_{\Delta,pl})\right)\left[0.16\max(0.5, 100\rho_{tot})\left(1 - 0.16\min\left(5, \frac{L_v}{h}\right)\right)\sqrt{f_c}A_c\right] + V_w\right]$$

(8.7.2.8) NTC-18

V_w is computed using the following equations:

$V_w = \rho_{sx} b_w z f_y$, for rectangular sections (8.7.2.9) commentary of NTC-18

$$V_w = \frac{\pi}{2}\frac{A_{sx}}{s} f_{yw} (D - 2c)\ ,\ \text{for circular sections} \qquad \text{(8.7.2.9) commentary of NTC-18}$$

Concrete Jacketing

The value for the shear capacity, $\widetilde{V_R}$, of the jacketed members that is adopted in the capacity verifications depend on the corresponding value calculated under the assumptions of section 8.7.4.1 of the commentary of NTC-18, according to the following equation:

$$\widetilde{V_R} = 0.9 V_R \qquad \text{(8.7.4.1) commentary of NTC-18}$$

FRP wrapping

The cyclic resistance V_R, may be calculated from the section C8.7.2.3.5 of the commentary of NTC-18 adding to V_w the contribution of the FRP jacket to shear resistance. The contribution of the fully wrapped FRP jacket to V_w is computed according to 4.19 equation of CNR-DT 200 R1/2013 in the following form:

$$V_{Rd,f} = \frac{1}{\gamma_{Rd}} \cdot 0.9 \cdot d \cdot f_{fed} \cdot 2 \cdot t_f \cdot (\cot\theta + \cot\beta) \cdot \sin\beta$$

Joints Diagonal Tension

According to C8.7.2.5 ofthe commentary ofNTC-18 the diagonal tensile stressthat can be induced in the joint may be calculated from the following expression:

$$\sigma_{nt} = \left| \frac{N}{2A_g} - \sqrt{\left(\frac{N}{2A_g}\right)^2 + \left(\frac{V_n}{A_g}\right)^2} \right| \leq 0{,}3\sqrt{f_c} \qquad \text{(8.7.2.11) commentary of NTC-18}$$

Joints Diagonal Compression

The diagonal compression induced in the joint by the diagonal strut mechanism shall not exceed the compressive strength of concrete in the presence of transverse tensile strains. NTC-18 indicates the following expression for the calculation of the joints' diagonal compression capacity:

$$\sigma_{nc} = \frac{N}{2A_g} + \sqrt{\left(\frac{N}{2A_g}\right)^2 + \left(\frac{V_n}{A_g}\right)^2} \leq 0{,}5 f_c \qquad \text{(8.7.2.12) commentary of NTC-18}$$

For the definition of the values you may refer to section C8.7.2.5 ofthe commentary ofNTC-18.

Chapter 3 COMPARISON WITH INDEPENDENT HAND-CALCULATIONS – MEMBER CHECKS

As noted above, this chapter makes use of examples, and their corresponding independent hand-calculations.

EXAMPLES SET 1: RECTANGULAR COLUMN SECTION

EXAMPLE 1.1

SUCCINCT DATA

- Primary Member
- Ribbed Bars
- Ductile Steel
- With Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Adequate Lap Length (lo/lou,min>=1)
- No FRP Wrapping
- Program's Default Safety/Confidence Factors
- Existing Material Sets type

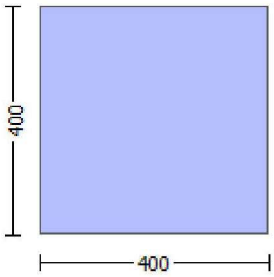
DESCRIPTION

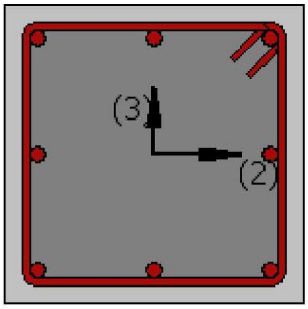
A rectangular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuildare compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Existing material: Concrete Strength,
fc = fcm/Cf = 16.66667
Existing material: Steel Strength,
fs = fs/Cf = 370.3704

For Shear Capacity Calculations

Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 11.11111
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 322.0612

Member's Properties

Section Height, H = 400.00
Section Width, W = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
γel = 1.50 for Chord Rotation checks
γel = 1.2 for Shear Capacity checks
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations (Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.1. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 1.1

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	End	3	0.0060825	0.0060825
	Life Safety	Start	2	0.0281403	0.0281403
	Collapse Prevention	Start	3	0.0478282	0.0478282

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Shear Capacity [kN]	Operational Level	End	3	274.814	274.814

COMPUTER FILES

- NTC_rcrs1.bpf
- Report_NTC_rcrs1.pdf

EXAMPLE 1.2

SUCCINCT DATA

- Primary Member
- Ribbed Bars
- Ductile Steel
- With Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Lap Length lo = 150.00
- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- Existing Material Sets type

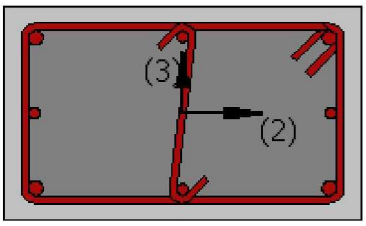
DESCRIPTION

A rectangular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES



Units in N, mm

Confidence Factor, Cf = 1.30

Materials' Properties
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Existing material: Concrete Strength,
fc = fcm/Cf = 15.38462
Existing material: Steel Strength,
fs = fs/Cf = 341.8769

For Shear Capacity Calculations

Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 10.25641
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 297.2843

Member's Properties

Section Height, H = 300.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Element Length, L = 3100.00
Primary Member
γel = 1.50 for Chord Rotation checks
γel = 1.15 for Shear Capacity checks
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Lap Length lo = 150.00
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations (Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.2. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 1.2

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	Start	2	0.0023187	0.0023187
	Life Safety	End	3	0.0065511	0.0065511
	Collapse Prevention	End	2	0.0183658	0.0183658
Shear Capacity [kN]	Damage Limitation	Start	2	290.937	290.937

COMPUTER FILES

- NTC_rcrs2.bpf
- Report_NTC_rcrs2.pdf

EXAMPLE 1.3

SUCCINCT DATA

- Secondary Member
- Smooth Bars
- DuctileSteel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Adequate Lap Length (lo/lou,min>=1)
- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- Existing Material Sets type

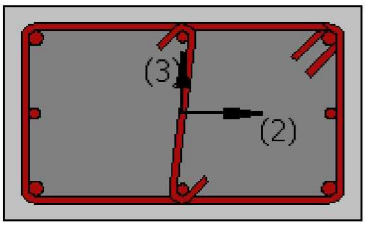
DESCRIPTION

A rectangular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES



Units in N, mm

Confidence Factor, Cf = 1.30

Materials' Properties
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Existing material: Concrete Strength,
fc = fcm/Cf = 15.38462
Existing material: Steel Strength,
fs = fs/Cf = 341.8769

For Shear Capacity Calculations

Existing material of Secondary Member:
Concrete Strength,
fc = fcm/Cf = 15,38462

For Shear Capacity Calculations

Existing material of Secondary Member: Steel Strength,
fs = fs/Cf = 341,8769

Member's Properties

Section Height, H = 300.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Element Length, L = 3100.00
Secondary Member
γel = 1.50 for Chord Rotation checks
γel = 1.00 for Shear Capacity checks
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.3. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 1.3

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	Start	3	0.0081094	0.0081094
	Life Safety	End	2	0.0746742	0.0746742
	Collapse Prevention	End	3	0.0467182	0.0467182
Shear Capacity [kN]	Life Safety	Start	3	361.991	361.991

COMPUTER FILES

- NTC_rcrs3.bpf
- Report_NTC_rcrs3.pdf

EXAMPLE 1.4

SUCCINCT DATA

- Secondary Member
- Smooth Bars
- DuctileSteel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Adequate Lap Length (lo/lou,min>=1)
- FRP Wrapping (Type: Carbon)
- Not the Program's Default Safety/Confidence Factors
- New Material Sets type

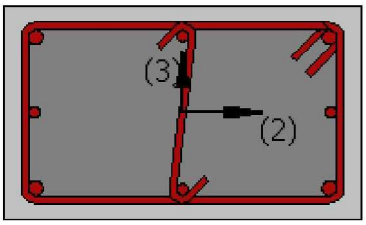
DESCRIPTION

A rectangular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES



Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties
Concrete Elasticity, Ec = 28972.746
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Newmaterial: Concrete Strength,
fc = fck = 30.00
Newmaterial: Steel Strength,
fs = fsk = 400.00

For Shear Capacity Calculations

New material of Secondary Member: Concrete Strength,
fc = fck = 30.00
New material of Secondary Member: Steel Strength,
fs = fsk = 400.00

Member's Properties

Section Height, H = 300.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Element Length, L = 3100.00
Secondary Member
γel = 1.60 for Chord Rotation checks
γel = 1.00 for Shear Capacity checks
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Adequate Lap Length (lo/lou,min>=1)
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 0.329
Tensile Strength, ffu = 4410.00
Tensile Modulus, Ef = 390000.00
Elongation, efu = 0.011
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 2
Radius of rounding corners, R = 40.00
Environmental conversion factor, na = 0.85
Partial factor for the type of application, γm = 1.50
Nominal to design conversion factor, γm/n = γm/na = 1.76471

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.4. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 1.4

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	End	2	0.0090437	0.0090437
	Life Safety	Start	3	0.1439072	0.1439072
	Collapse Prevention	Start	2	0.1627361	0.1627361
Shear Capacity [kN]	Collapse Prevention	End	2	642.323	642.323

COMPUTER FILES

- NTC_rcrs4.bpf
- Report_NTC_rcrs4.pdf

EXAMPLE 1.5

SUCCINCT DATA

- Secondary Member
- Ribbed Bars
- DuctileSteel
- With Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Lap Length lo = 200.00
- FRP Wrapping (Type: Carbon)
- Program's Default Safety/Confidence Factors
- New Material Sets type

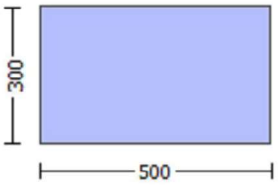
DESCRIPTION

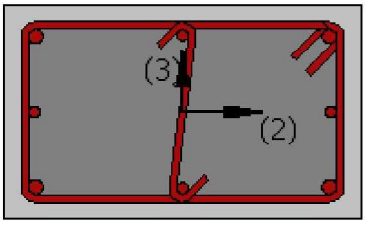
A rectangular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties
Concrete Elasticity, Ec = 28972.746
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Newmaterial: Concrete Strength,
fc = fck = 30.00
Newmaterial: Steel Strength,
fs = fsk = 400.00

For Shear Capacity Calculations

New material of Secondary Member: Concrete Strength,
fc = fck = 30.00
New material of Secondary Member: Steel Strength,
fs = fsk = 400.00

Member's Properties

Section Height, H = 300.00
Section Width, W = 500.00
Cover Thickness, c = 15.00
Element Length, L = 3100.00
Secondary Member
γel = 1.50 for Chord Rotation checks
γel = 1.00 for Shear Capacity checks
RibbedBars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 200.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 0.329
Tensile Strength, ffu = 4410.00
Tensile Modulus, Ef = 390000.00
Elongation, efu = 0.011
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 2
Radius of rounding corners, R = 40.00
Environmental conversion factor, na = 0.85
Partial factor for the type of application, γm = 1.50
Nominal to design conversion factor, γm/n = γm/na = 1.76471

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.5. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 1.5

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	End	3	0.0043922	0.00439221
	Life Safety	Start	2	0.0426351	0.0426351
	Collapse Prevention	Start	3	0.0678404	0.0678404
Shear Capacity [kN]	Operational Level	Start	2	656.378	656.378

NOTE: The small difference in the Chord Rotation Capacity damage limitation values is due to the rounding of the shear capacity value exported to the Report.

COMPUTER FILES

- NTC_rcrs5.bpf
- Report_NTC_rcrs5.pdf

EXAMPLE 1.6

SUCCINCT DATA

- Primary Member
- Ribbed Bars
- DuctileSteel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Inadequate Lap Length with lo/lou,min = 0.60
- No FRP Wrapping
- Program's Default Safety/Confidence Factors
- Existing Material Sets type

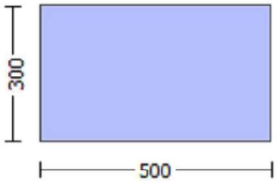
DESCRIPTION

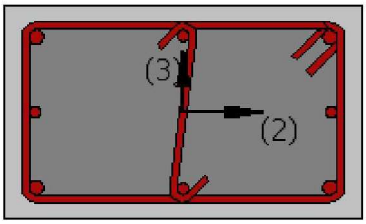
A rectangular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.30

Materials' Properties

Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Existing material: Concrete Strength,
fc = fcm/Cf = 15.38462
Existing material: Steel Strength,
fs = fs/Cf = 341.8769

For Shear Capacity Calculations

Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 10.25641
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 297.2843

Member's Properties

Section Height, H = 300.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Element Length, L = 3100.00
PrimaryMember
γel = 1.50 for Chord Rotation checks
γel = 1.00 for Shear Capacity checks
RibbedBars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Inadequate Lap Length with lo/lou,min = 0.60
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.6. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 1.6

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	Start	2	0.0077250	0.0077250
	Life Safety	End	3	0.0140157	0.0140157
	Collapse Prevention	End	2	0.0398256	0.0398256
Shear Capacity [kN]	Damage Limitation	End	3	264.270	264.270

COMPUTER FILES

- NTC_rcrs6.bpf
- Report_NTC_rcrs6.pdf

EXAMPLE 1.7

SUCCINCT DATA

- Primary Member
- Ribbed Bars
- DuctileSteel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Inadequate Lap Length with lo/lou,min = 0.60
- No FRP Wrapping
- Program's Default Safety/Confidence Factors
- Existing Material Sets type

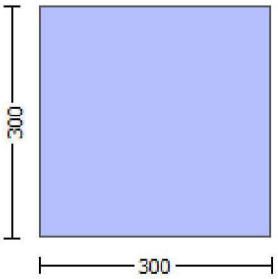
DESCRIPTION

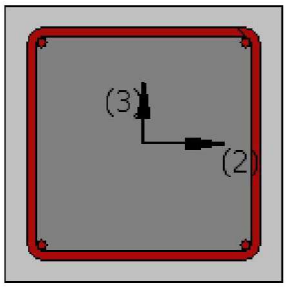
A rectangular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Existing material: Concrete Strength,
fc = fcm/Cf = 16.66667
Existing material: Steel Strength,
fs = fs/Cf = 203.70

For Shear Capacity Calculations

Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 11.11111
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 177.1304

Member's Properties

Section Height, H = 300.00
Section Width, W = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3100.00
PrimaryMember
γel = 1.50 for Chord Rotation checks
γel = 1.15 for Shear Capacity checks
RibbedBars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Inadequate Lap Length with lo/lou,min = 0.60
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.7. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 1.7

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	End	3	0.0118509	0.0118509
	Life Safety	Start	2	0.0094438	0.0094438
	Collapse Prevention	Start	3	0.0204555	0.0204555
Shear Capacity [kN]	Operational Level	Start	2	89.941	89.941

COMPUTER FILES

- NTC_rcrs7.bpf
- Report_NTC_rcrs7.pdf

EXAMPLE 1.8

SUCCINCT DATA

- Primary Member
- Ribbed Bars
- DuctileSteel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Inadequate Lap Length with lo/lou,min = 0.60
- No FRP Wrapping
- Program's Default Safety/Confidence Factors
- Existing Material Sets type

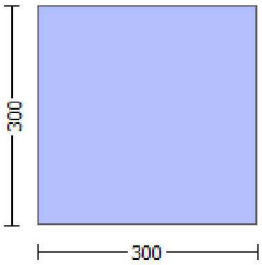
DESCRIPTION

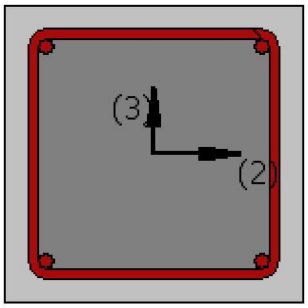
A rectangular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–08 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Existing material: Concrete Strength,
fc = fcm/Cf = 16.66667
Existing material: Steel Strength,
fs = fs/Cf = 203.70

For Shear Capacity Calculations

Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 11.11111
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 177.1304

Member's Properties

Section Height, H = 300.00
Section Width, W = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3100.00
PrimaryMember
γel = 1.50 for Chord Rotation checks
γel = 1.15 for Shear Capacity checks
RibbedBars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Inadequate Lap Length with lo/lou,min = 0.60
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.8. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 1.8

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	End	2	0.0048805	0.0048805
	Life Safety	Start	3	0.0131409	0.0131409
	Collapse Prevention	Start	2	0.0107859	0.0107859
Shear Capacity [kN]	Operational Level	Start	2	51.450	51.450

COMPUTER FILES

- NTC_rcrs8.bpf
- Report_NTC_rcrs8.pdf

EXAMPLES SET 2: L-SHAPED COLUMN SECTION

EXAMPLE 2.1

SUCCINCT DATA

- Primary Member
- Smooth Bars
- Ductile Steel
- With Detailing for Earthquake Resistance (including stirrups not closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Lap Length lo = 500.00
- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- Existing Material Sets type

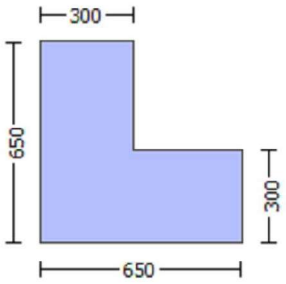
DESCRIPTION

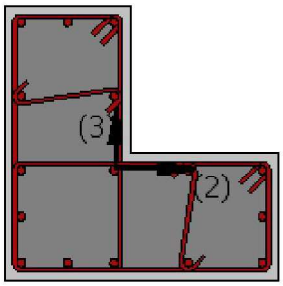
An L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.30

Materials' Properties

Concrete Elasticity, Ec = 23025.204
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Existing material: Concrete Strength,
fc = fcm/Cf = 18.46154
Existing material: Steel Strength,
fs = fs/Cf = 341.8769

For Shear Capacity Calculations

Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 11.53846
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 284.8974

Member's Properties

Max Height, Hmax = 650.00
Min Height, Hmin = 300.00
Max Width, Wmax = 650.00
Min Width, Wmin = 300.00
Cover Thickness, c = 20.00
Element Length, L = 3100.00
Primary Member
γel = 1.70 for Chord Rotation checks and
γel = 1.00for Shear Capacity checks
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 500.00
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.9. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 2.1

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	End	3	0.0066717	0.0066717
	Life Safety	Start	2	0.0439115	0.0439115
	Collapse Prevention	Start	3	0.0670617	0.0670617
Shear Capacity [kN]	Operational Level	End	3	700.372	700.372

COMPUTER FILES

- NTC_rclcs1.bpf
- Report_NTC_rclcs1.pdf

EXAMPLE 2.2

SUCCINCT DATA

- Primary Member
- Ribbed Bars
- Ductile Steel
- With Detailing for Earthquake Resistance (including stirrups not closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Adequate Lap Length (lo/lou,min>=1)
- No FRP Wrapping
- Program's Default Safety/Confidence Factors
- Existing Material Sets type

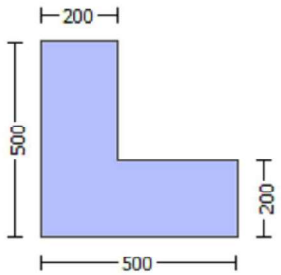
DESCRIPTION

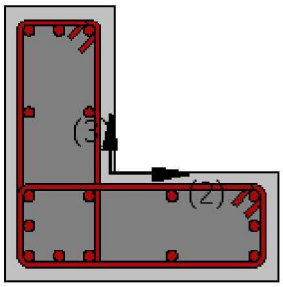
An L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Existing material: Concrete Strength,
fc = fcm/Cf = 16.66667
Existing material: Steel Strength,
fs = fs/Cf = 370.3704

For Shear Capacity Calculations

Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 11.11111
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 322.0612

Member's Properties

Max Height, Hmax = 500.00
Min Height, Hmin = 200.00
Max Width, Wmax = 500.00
Min Width, Wmin = 200.00
Cover Thickness, c = 25.00

Element Length, L = 3000.00
Primary Member
γel = 1.50 for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.10. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 2.2

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	Start	2	0.0049705	0.0049705
	Life Safety	End	3	0.0092884	0.0092884
	Collapse Prevention	End	2	0.0190660	0.0190660
Shear Capacity [kN]	Damage Limitation	Start	2	589.985	589.985

COMPUTER FILES

- NTC_rclcs2.bpf
- Report_NTC_rclcs2.pdf

EXAMPLE 2.3

SUCCINCT DATA

- Secondary Member
- Ribbed Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Inadequate Lap Length with lo/lou,min = 0.60
- No FRP Wrapping
- Program's Default Safety/Confidence Factors
- New Material Sets type

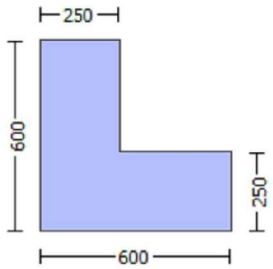
DESCRIPTION

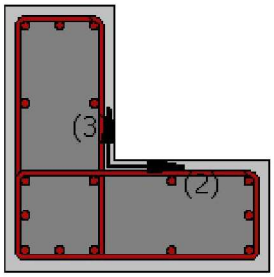
An L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

New material: Concrete Strength,
fc = fck = 25.00
Newmaterial: Steel Strength,
fs = fsk = 500.00

For Shear Capacity Calculations

Newmaterial of Secondary Member: Concrete Strength,
fc = fck = 25.00
Newmaterial of SecondaryMember: Steel Strength,
fs = fsk = 500.00

Member's Properties

Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
SecondaryMember
γel = 1.50 for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Inadequate Lap Length with lo/lou,min = 0.60
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.11. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 2.3

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	Start	3	0.0057442	0.0057442
	Life Safety	End	2	0.0271220	0.0271220
	Collapse Prevention	End	3	0.0223052	0.0223052
Shear Capacity [kN]	Life Safety	Start	3	1355.3	1355.319

NOTE: The small difference in the Shear Capacity values is due to the rounding of the shear capacity value exported to the Report.

COMPUTER FILES

- NTC_rclcs3.bpf
- Report_NTC_rclcs3.pdf

EXAMPLE 2.4

SUCCINCT DATA

- Secondary Member
- Smooth Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Adequate Lap Length (lo/lou,min>=1)
- No FRP Wrapping
- Program's Default Safety/Confidence Factors
- Existing Material Sets type

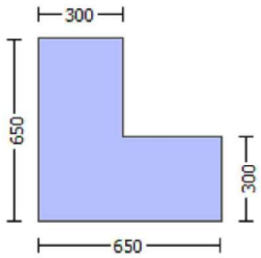
DESCRIPTION

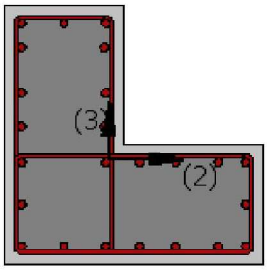
An L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity, Ec = 23025.204
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Existing material: Concrete Strength,
fc = fcm/Cf = 20.00
Existingmaterial: Steel Strength,
fs = fs/Cf = 203.70

For Shear Capacity Calculations

Existingmaterial of Secondary Member:
Concrete Strength,
fc = fcm/Cf = 20.00
Existingmaterial of SecondaryMember: Steel Strength,
fs = fs/Cf = 203.70

Member's Properties

Max Height, Hmax = 650.00
Min Height, Hmin = 300.00
Max Width, Wmax = 650.00
Min Width, Wmin = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
SecondaryMember
γel = 1.50 for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.12. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 2.4

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	End	2	0.0047419	0.0047419
	Life Safety	Start	3	0.0449201	0.0449201
	Collapse Prevention	Start	2	0.0296223	0.0296223
Shear Capacity [kN]	Collapse Prevention	End	2	1084.7	1084.667

NOTE: The small difference in the Shear Capacity values is due to the rounding of the shear capacity value exported to the Report.

COMPUTER FILES

- NTC_rclcs4.bpf
- Report_NTC_rclcs4.pdf

EXAMPLE 2.5

SUCCINCT DATA

- Primary Member
- Smooth Bars
- Ductile Steel
- With Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Inadequate Lap Length with lo/lou,min = 0.60
- FRP Wrapping (Type: Carbon)
- Program's Default Safety/Confidence Factors
- Existing Material Sets type

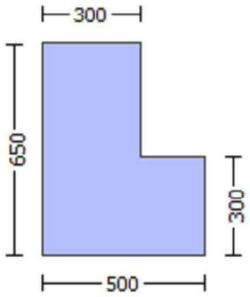
DESCRIPTION

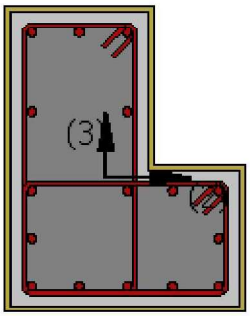
An L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity, Ec = 23025.204
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Existing material: Concrete Strength,
fc = fcm/Cf = 20.00
Existing material: Steel Strength,
fs = fs/Cf = 370.3667

For Shear Capacity Calculations

Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 13.33333
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 322.058

Member's Properties

Max Height, Hmax = 650.00
Min Height, Hmin = 300.00
Max Width, Wmax = 500.00
Min Width, Wmin = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
PrimaryMember
γel = 1.50 for Chord Rotation checks
γel = 1.20 for Shear Capacity checks
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Inadequate Lap Length with lo/lou,min = 0.60
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 0.10
Tensile Strength, ffu = 4800.00
Tensile Modulus, Ef = 230000.00
Elongation, efu = 0.021
Number of directions, NoDir = 2
Fiber orientations, bi: 0.00°, 90.00°
Number of layers, NL = 2
Radius of rounding corners, R = 40.00

Environmental conversion factor, na = 0.85
Partial factor for the type of application, γm = 1.50
Nominal to design conversion factor, γm/n = γm/na = 1.76471

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.13. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 2.5

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	End	3	0.0063390	0.0063390
	Life Safety	Start	2	0.0496620	0.0496620
	Collapse Prevention	Start	3	0.0348682	0.0348682
Shear Capacity [kN]	Operational Level	Start	2	357.027	357.027

COMPUTER FILES

- NTC_rclcs5.bpf
- Report_NTC_rclcs5.pdf

EXAMPLE 2.6

SUCCINCT DATA

- Primary Member
- Smooth Bars
- Ductile Steel
- With Detailing for Earthquake Resistance (including stirrups not closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Lap Length lo = 600.00
- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- New Material Sets type

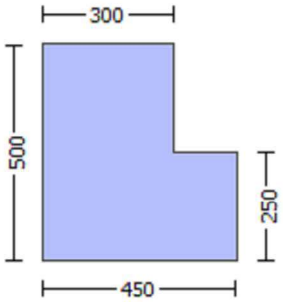
DESCRIPTION

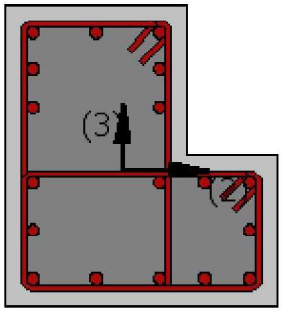
An L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Newmaterial: Concrete Strength,
fc = fck = 25.00
Newmaterial: Steel Strength,
fs = fsk = 500.00

For Shear Capacity Calculations

New material of Primary Member: Concrete Strength,
fc = fck/γc = 16.66667
New material of Primary Member: Steel Strength,
fs = fsk/γs = 434.7826

Member's Properties

Max Height, Hmax = 500.00
Min Height, Hmin = 250.00
Max Width, Wmax = 450.00
Min Width, Wmin = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
PrimaryMember
γel = 1.70 for Chord Rotation checks
γel = 1.15 for Shear Capacity checks
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length lo = 600.00
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.14. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 2.6

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	Start	2	0.0195248	0.0195248
	Life Safety	End	3	0.0286780	0.0286780
	Collapse Prevention	End	2	0.1048947	0.1048947
Shear Capacity [kN]	Damage Limitation	End	3	457.228	457.228

COMPUTER FILES

- NTC_rclcs6.bpf
- Report_NTC_rclcs6.pdf

EXAMPLE 2.7

SUCCINCT DATA

- Primary Member
- Ribbed Bars
- Ductile Steel
- With Detailing for Earthquake Resistance (including stirrups not closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Adequate Lap Length (lo/lou,min>=1)
- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- New Material Sets type

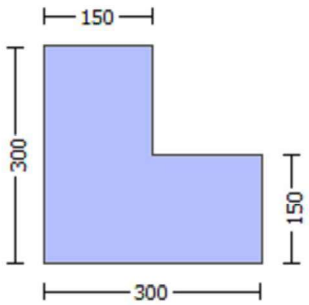
DESCRIPTION

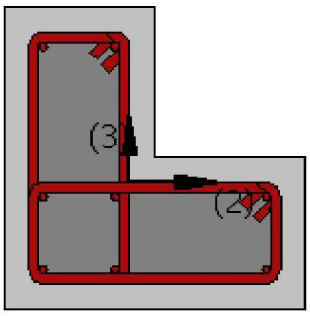
An L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Existing material: Concrete Strength,
fc = fcm/Cf = 16.66667
Existing material: Steel Strength,
fs = fs/Cf = 203.70

For Shear Capacity Calculations

Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 11.11111
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 177.1304

Member's Properties

Max Height, Hmax = 300.00
Min Height, Hmin = 150.00
Max Width, Wmax = 300.00
Min Width, Wmin = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
PrimaryMember
γel = 1.60 for Chord Rotation checks
γel = 1.15 for Shear Capacity checks
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.15. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 2.7

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	End	3	0.0040806	0.0040806
	Life Safety	Start	2	0.0287439	0.0287439
	Collapse Prevention	Start	3	0.0383257	0.0383257
Shear Capacity [kN]	Operational Level	Start	2	75.803	75.803

COMPUTER FILES

- NTC_rclcs7.bpf
- Report_NTC_rclcs7.pdf

EXAMPLE 2.8

SUCCINCT DATA

- Primary Member
- Ribbed Bars
- Ductile Steel
- With Detailing for Earthquake Resistance (including stirrups not closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Adequate Lap Length (lo/lou,min>=1)
- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- New Material Sets type

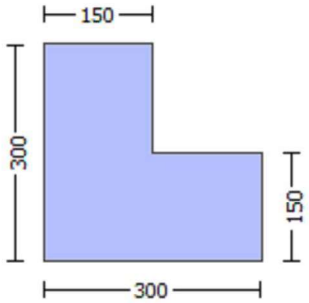
DESCRIPTION

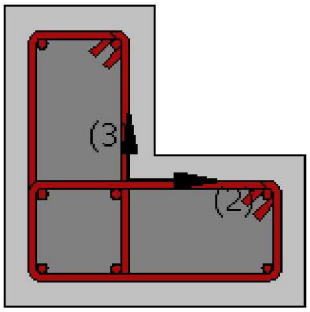
An L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Existing material: Concrete Strength,
fc = fcm/Cf = 16.66667
Existing material: Steel Strength,
fs = fs/Cf = 203.70

For Shear Capacity Calculations

Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 11.11111
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 177.1304

Member's Properties

Max Height, Hmax = 300.00
Min Height, Hmin = 150.00
Max Width, Wmax = 300.00
Min Width, Wmin = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
PrimaryMember
γel = 1.70 for Chord Rotation checks
γel = 1.15 for Shear Capacity checks
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.16. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 2.8

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	End	2	0.0086640	0.0086640
	Life Safety	Start	3	0.0326606	0.0326606
	Collapse Prevention	Start	2	0.0173468	0.0173468
Shear Capacity [kN]	Damage Limitation	Start	2	42.484	42.484

COMPUTER FILES

- NTC_rclcs8.bpf
- Report_NTC_rclcs8.pdf

EXAMPLES SET 3: T-SHAPED COLUMN SECTION

EXAMPLE 3.1

SUCCINCT DATA

- Primary Member
- Smooth Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Adequate Lap Length (lo/lou,min>=1)
- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- New Material Sets type

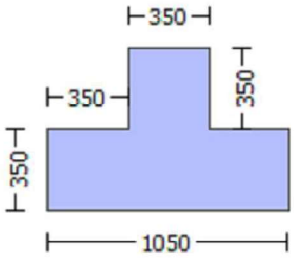
DESCRIPTION

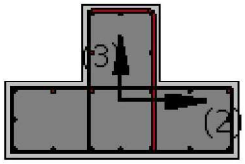
A T-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

New material: Concrete Strength,
fc = fck = 25.00
New material: Steel Strength,
fs = fsk = 500.00

For Shear Capacity Calculations

New material of Primary Member: Concrete Strength,
fc = fck/γc = 15.625
New material of Primary Member: Steel Strength,
fs = fsk/γs = 416.6667

Member's Properties

Max Height, Hmax = 700.00
Min Height, Hmin = 350.00
Max Width, Wmax = 1050.00
Min Width,Wmin = 350.00
Eccentricity, Ecc = 350.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
γel = 1.70 for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.17. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 3.1

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	End	3	0.0091130	0.0091130
	Life Safety	Start	2	0.0309102	0.0309102
	Collapse Prevention	Start	3	0.0481853	0.0481853
Shear Capacity [kN]	Operational Level	End	3	558.868	558.868

COMPUTER FILES

- NTC_rctcs1.bpf
- Report_NTC_rctcs1.pdf

EXAMPLE 3.2

SUCCINCT DATA

- Primary Member
- Smooth Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Inadequate Lap Length with lo/lou,min = 0.70
- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- Existing Material Sets type

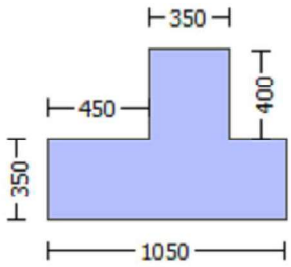
DESCRIPTION

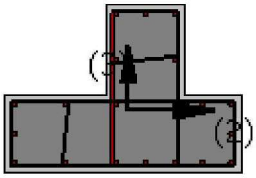
A T-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.30

Materials' Properties

Concrete Elasticity, Ec = 24870.062
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Existing material: Concrete Strength,
fc = fcm/Cf = 21.53846
Existingmaterial: Steel Strength,
fs = fs/Cf = 188.0308

For Shear Capacity Calculations

Existingmaterial of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 13.46154
Existingmaterial of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 156.6923

Member's Properties

Max Height, Hmax = 750.00
Min Height, Hmin = 350.00
Max Width, Wmax = 1050.00
Min Width, Wmin = 350.00
Eccentricity, Ecc = 450.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
γel = 1.70 for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Inadequate Lap Length with lo/lou,min = 0.70
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.18. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 3.2

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	Start	2	0.0033877	0.0033877
	Life Safety	End	3	0.0108558	0.0108558
	Collapse Prevention	End	2	0.0274980	0.0274980
Shear Capacity [kN]	Damage Limitation	Start	2	736.794	736.794

COMPUTER FILES

- NTC_rctcs2.bpf
- Report_NTC_rctcs2.pdf

EXAMPLE 3.3

SUCCINCT DATA

- Primary Member
- Ribbed Bars
- Ductile Steel
- With Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Inadequate Lap Length with lo/lou,min = 0.60
- No FRP Wrapping
- Program's Default Safety/Confidence Factors
- New Material Sets type

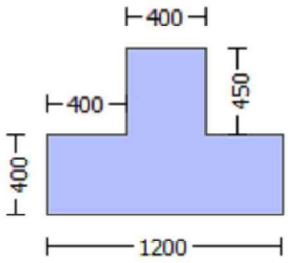
DESCRIPTION

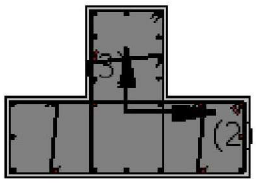
A T-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

New material: Concrete Strength,
fc = fck = 25.00
New material: Steel Strength,
fs = fsk = 500.00

For Shear Capacity Calculations

New material of Primary Member: Concrete Strength,
fc = fck/γc = 16.66667
New material of Primary Member: Steel Strength,
fs = fsk/γs = 400.00

Member's Properties

Max Height, Hmax = 850.00
Min Height, Hmin = 400.00
Max Width, Wmax = 1200.00
Min Width, Wmin = 400.00
Eccentricity, Ecc = 400.00
Cover Thickness, c = 20.00
Element Length, L = 3000.00
Primary Member
γel = 1.60 for Chord Rotation checks and
γel = 1.25 for Shear Capacity checks
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.60
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.19. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 3.3

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	Start	3	0.0044110	0.0044110
	Life Safety	End	2	0.0201080	0.0201080
	Collapse Prevention	End	3	0.0183270	0.0183270
Shear Capacity [kN]	Life Safety	Start	3	841.930	841.930

COMPUTER FILES

- NTC_rctcs3.bpf
- Report_NTC_rctcs3.pdf

EXAMPLE 3.4

SUCCINCT DATA

- Primary Member
- Ribbed Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Lap Length lo = 500.00
- FRP Wrapping (Type: Carbon)
- Program's Default Safety/Confidence Factors
- Existing Material Sets type

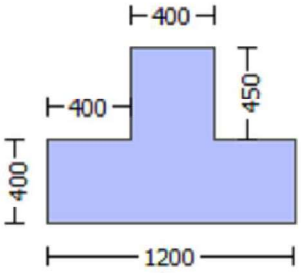
DESCRIPTION

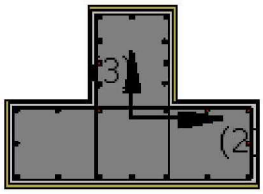
A T-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Existing material: Concrete Strength,
fc = fcm/Cf = 16.66667
Existingmaterial: Steel Strength,
fs = fs/Cf = 370.3667

For Shear Capacity Calculations

Existingmaterial of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 11.11111
Existingmaterial of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 322.058

Member's Properties

Max Height, Hmax = 850.00
Min Height, Hmin = 400.00
Max Width, Wmax = 1200.00
Min Width, Wmin = 400.00
Eccentricity, Ecc = 400.00
Cover Thickness, c = 20.00
Element Length, L = 3000.00
Primary Member
γel = 1.50 for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 500.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 0.165

Tensile Strength, ffu = 2600.00
Tensile Modulus, Ef = 230000.00
Elongation, efu = 0.013
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 50.00
Environmental conversion factor, na = 0.85
Partial factor for the type of application, γm = 1.50
Nominal to design conversion factor, γm/n = γm/na = 1.76471

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.20. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 3.4

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	End	2	0.0045095	0.0045095
	Life Safety	Start	3	0.0256210	0.0256210
	Collapse Prevention	Start	2	0.0280938	0.0280938
Shear Capacity [kN]	Collapse Prevention	End	2	822.732	822.732

COMPUTER FILES

- NTC_rctcs4.bpf
- Report_NTC_rctcs4.pdf

EXAMPLE 3.5

SUCCINCT DATA

- Secondary Member
- Smooth Bars
- Ductile Steel
- With Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Adequate Lap Length (lo/lou,min>=1)

- FRP Wrapping (Type: Aramid)
- Not the Program's Default Safety/Confidence Factors
- Existing Material Sets type

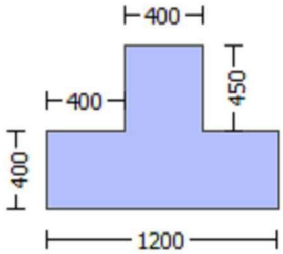
DESCRIPTION

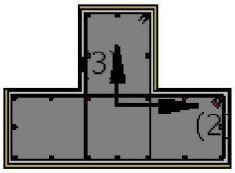
A T-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Existing material: Concrete Strength,
fc = fcm/Cf = 16.66667
Existing material: Steel Strength,
fs = fs/Cf = 370.3667

For Shear Capacity Calculations

Existing material of Secondary Member:
Concrete Strength,
fc = fcm/Cf = 16.66667
Existing material of Secondary Member: Steel Strength,
fs = fs/Cf = 370.3667

Member's Properties

Max Height, Hmax = 850.00
Min Height, Hmin = 400.00
Max Width, Wmax = 1200.00
Min Width, Wmin = 400.00
Eccentricity, Ecc = 400.00
Cover Thickness, c = 20.00
Element Length, L = 3000.00
SecondaryMember
γel = 1.00 for Chord Rotation and Shear Capacity checks

Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Adequate Lap Length (lo/lou,min>=1)
FRP Wrapping Data
Type: Aramid
Dry properties (design values)
Thickness, t = 0.20
Tensile Strength, ffu = 2231.00
Tensile Modulus, Ef = 92308.00
Elongation, efu = 0.025
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 2
Radius of rounding corners, R = 50.00
Environmental conversion factor, na = 0.85
Partial factor for the type of application, γm = 1.50
Nominal to design conversion factor, γm/n = γm/na = 1.76471

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.21. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 3.5

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	End	3	0.0098238	0.0098238
	Life Safety	Start	2	0.0614032	0.0614032
	Collapse Prevention	Start	3	0.1008709	0.1008709
Shear Capacity [kN]	Operational Level	Start	2	1204.8	1204.754

NOTE: The small difference in the Shear Capacity values is due to the rounding of the shear capacity value exported to the Report.

COMPUTER FILES

- NTC_rctcs5.bpf
- Report_NTC_rctcs5.pdf

EXAMPLE 3.6

SUCCINCT DATA

- Primary Member
- Smooth Bars
- Ductile Steel
- With Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Adequate Lap Length (lo/lou,min>=1)
- FRP Wrapping (Type: Aramid)
- Not the Program's Default Safety/Confidence Factors
- Existing Material Sets type

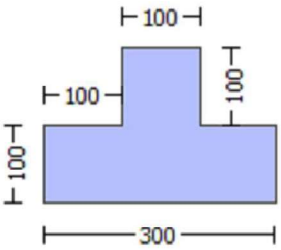
DESCRIPTION

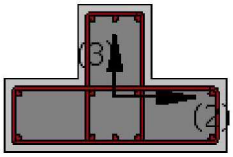
A T-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

New material: Concrete Strength,
fc = fck = 25.00
New material: Steel Strength,
fs = fsk = 500.00

For Shear Capacity Calculations

New material of Secondary Member: Concrete Strength,
fc = fck/γc = 15.625
New material of Secondary Member: Steel Strength,
fs = fsk/γs = 416.6667

Member's Properties

Max Height, Hmax = 200.00
Min Height, Hmin = 100.00
Max Width, Wmax = 300.00
Min Width, Wmin = 100.00
Eccentricity, Ecc = 100.00
Cover Thickness, c = 10.00
Element Length, L = 3000.00
SecondaryMember
γel = 1.70 for Chord Rotation checks and
γel = 1.15 for Shear Capacity checks
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.22. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 3.5

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	End	3	0.0057063	0.0057063
	Life Safety	Start	2	0.0114207	0.0114207
	Collapse Prevention	Start	3	0.0324681	0.0324681

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Shear Capacity [kN]	Operational Level	Start	2	23.011	23.011

COMPUTER FILES

- NTC_rctcs6.bpf
- Report_NTC_rctcs6.pdf

EXAMPLE 3.7

SUCCINCT DATA

- Primary Member
- Smooth Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Adequate Lap Length (lo/lou,min>=1)
- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- Existing Material Sets type

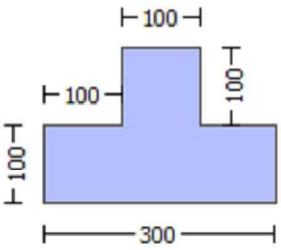
DESCRIPTION

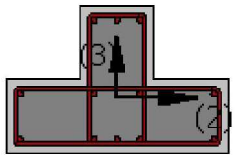
A T-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

New material: Concrete Strength,
fc = fck = 25.00
New material: Steel Strength,
fs = fsk = 500.00

For Shear Capacity Calculations

New material of Secondary Member: Concrete Strength,
fc = fck/γc = 15.625
New material of Secondary Member: Steel Strength,
fs = fsk/γs = 416.6667

Member's Properties

Max Height, Hmax = 200.00
Min Height, Hmin = 100.00
Max Width, Wmax = 300.00
Min Width, Wmin = 100.00
Eccentricity, Ecc = 100.00
Cover Thickness, c = 10.00
Element Length, L = 3000.00
SecondaryMember
γel = 1.70 for Chord Rotation checks and
γel = 1.15 for Shear Capacity checks
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.23. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 3.7

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	End	2	0.0469869	0.0469869
	Life Safety	Start	3	0.0324049	0.0324049
	Collapse Prevention	Start	2	0.0432229	0.0432229
Shear Capacity [kN]	Collapse Prevention	End	2	49.348	49.345

NOTE: The small difference in the Shear Capacity values is due to the rounding of the shear capacity value exported to the Report.

COMPUTER FILES

- NTC_rctcs7.bpf
- Report_NTC_rctcs7.pdf

EXAMPLES SET 4: CIRCULAR COLUMN SECTION

EXAMPLE 4.1

SUCCINCT DATA

- Primary Member
- Ribbed Bars
- Ductile Steel
- With Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Adequate Lap Length (lo/lou,min>=1)
- No FRP Wrapping
- Program's Default Safety/Confidence Factors
- NewMaterial Sets type

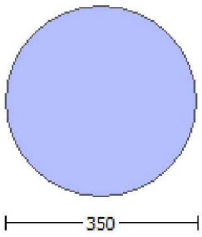
DESCRIPTION

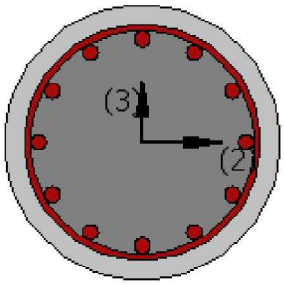
A circular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The equations of the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks cannot be employed in the case of circular column sections. The employed equations in SeismoBuild are those suggested by D. Biskinis andM. N. Fardis [2013]. The equations of section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary are employed for Shear Capacity checks.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

New material: Concrete Strength,
fc = fck = 25.00
Newmaterial: Steel Strength,
fs = fsk = 500.00

For Shear Capacity Calculations

Newmaterial of Primary Member: Concrete Strength,
fc = fck/γc = 16.66667
Newmaterial of Primary Member: Steel Strength,
fs = fsk/γs = 434.7826

Member's Properties

Diameter, D = 350.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
γel = 1.60for Chord Rotation checks
γel = 1.00for Shear Capacity checks
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.24. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 4.1

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	End	3	0.0115626	0.0115626
	Life Safety	Start	2	0.0310889	0.0310889
	Collapse Prevention	Start	3	0.0569081	0.0569081
Shear Capacity [kN]	Operational Level	End	3	164.214	164.214

COMPUTER FILES

- NTC_rccs1.bpf
- Report_NTC_rccs1.pdf

EXAMPLE 4.2

SUCCINCT DATA

- Primary Member
- SmoothBars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Adequate Lap Length (lo/lou,min>=1)
- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- NewMaterial Sets type

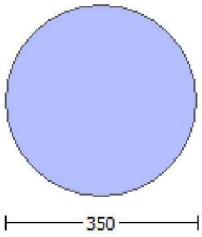
DESCRIPTION

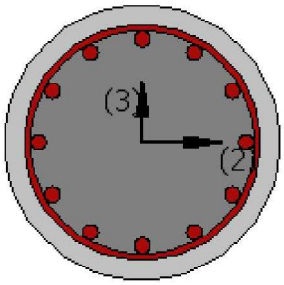
A circular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The equations of the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks cannot be employed in the case of circular column sections. The employed equations in SeismoBuild are those suggested by D. Biskinis andM. N. Fardis [2013]. The equations of section 4.1.2.1.3 of NTC–08 are employed for Shear Capacity checks.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.35

Materials' Properties

Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

New material: Concrete Strength,
fc = fck = 25.00
New material: Steel Strength,
fs = fsk = 500.00

For Shear Capacity Calculations

New material of Primary Member: Concrete Strength,
fc = fck/γc = 15.15152
New material of Primary Member: Steel Strength,
fs = fsk/γs = 416.6667

Member's Properties

Diameter, D = 350.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
γel = 1.75for Chord Rotation checks
γel = 1.00for Shear Capacity checks
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.25. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 4.2

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	Start	2	0.0197152	0.0197152
	Life Safety	End	3	0.0092005	0.0092005
	Collapse Prevention	End	2	0.0197152	0.0197152
Shear Capacity [kN]	Damage Limitation	Start	2	149.336	149.336

COMPUTER FILES

- NTC_rccs2.bpf
- Report_NTC_rccs2.pdf

EXAMPLE 4.3

SUCCINCT DATA

- Primary Member
- RibbedBars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Inadequate Lap Length with lo/lou,min = 0.30
- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- ExistingMaterial Sets type

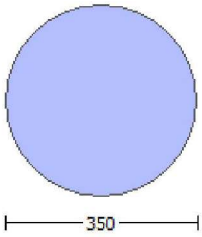
DESCRIPTION

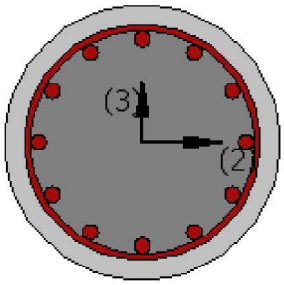
A circular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The equations of the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks cannot be employed in the case of circular column sections. The employed equations in SeismoBuild are those suggested by D. Biskinis andM. N. Fardis [2013]. The equations of section 4.1.2.1.3 of NTC–08 are employed for Shear Capacity checks.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.35

Materials' Properties

Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Existing material: Concrete Strength,
fc = fcm/Cf = 24.44444
Existing material: Steel Strength,
fs = fs/Cf = 329.2148

For Shear Capacity Calculations

Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 14.81481
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 274.3457

Member's Properties

Diameter, D = 350.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
γel = 1.75for Chord Rotation checks
γel = 1.00for Shear Capacity checks
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Inadequate Lap Length with lo/lou,min = 0.30
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.26. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 4.3

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity	Operational Level	Start	3	0.0071351	0.0071351
	Life Safety	End	2	0.0042589	0.0042589
	Collapse Prevention	End	3	0.0036910	0.0036910
Shear Capacity [kN]	Life Safety	Start	3	146.017	146.017

COMPUTER FILES

- NTC_rccs3.bpf
- Report_NTC_rccs3.pdf

EXAMPLE 4.4

SUCCINCT DATA

- Secondary Member
- Smooth Bars
- Ductile Steel
- With Detailing for Earthquake Resistance (including stirrups not closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- LapLengthlo = 300.00
- No FRP Wrapping
- Program's Default Safety/Confidence Factors
- ExistingMaterial Sets type

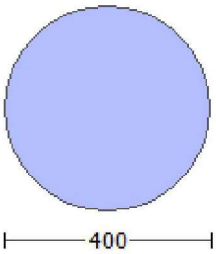
DESCRIPTION

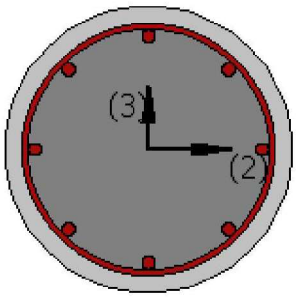
A circular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The equations of the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks cannot be employed in the case of circular column sections. The employed equations in SeismoBuild are those suggested by D. Biskinis andM. N. Fardis [2013]. The equations of section 4.1.2.1.3 of NTC–08 are employed for Shear Capacity checks.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Existing material: Concrete Strength,
fc = fcm/Cf =27.50
Existing material: Steel Strength,
fs = fs/Cf = 370.3667

For Shear Capacity Calculations

Existing material of Secondary Member:
Concrete Strength,
fc = fcm/Cf = 27.50
Existing material of SecondaryMember: Steel Strength,
fs = fs/Cf = 370.3667

Member's Properties

Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
SecondaryMember
γel = 1.00for Chord Rotation and Shear Capacity checks
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Lap Length lo = 300.00
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.27. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 4.4

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	End	2	0.0083643	0.0083643
	Life Safety	Start	3	0.0234088	0.0234088
	Collapse Prevention	Start	2	0.0236187	0.0236187
Shear Capacity [kN]	Collapse Prevention	End	2	230.288	230.288

COMPUTER FILES

- NTC_rccs4.bpf
- Report_NTC_rccs4.pdf

EXAMPLE 4.5

SUCCINCT DATA

- Primary Member
- Smooth Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Adequate Lap Length (lo/lou,min>=1)
- FRP Wrapping (Type: Carbon)
- Program's Default Safety/Confidence Factors
- NewMaterial Sets type

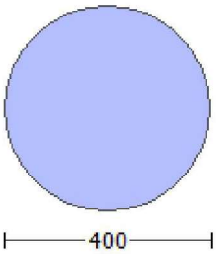
DESCRIPTION

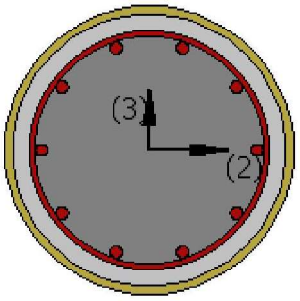
A circular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The equations of the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks cannot be employed in the case of circular column sections. The employed equations in SeismoBuild are those suggested by D. Biskinis andM. N. Fardis [2013]. The equations of section 4.1.2.1.3 of NTC–08 are employed for Shear Capacity checks.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity, Ec = 23025.204
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

New material: Concrete Strength,
fc = fck = 16.00
New material: Steel Strength,
fs = fsk = 400.00

For Shear Capacity Calculations

New material of Primary Member: Concrete Strength,
fc = fck/γc = 10.66667
New material of Primary Member: Steel Strength,
fs = fsk/γs = 347.8261

Member's Properties

Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
γel = 1.60 for Chord Rotation checks
γel = 1.00for Shear Capacity checks
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 0.064
Tensile Strength, ffu = 4800.00
Tensile Modulus, Ef = 230000.00
Elongation, efu = 0.021
Number of directions, NoDir = 2
Fiber orientations, bi: 0.00°, 90.00°
Number of layers, NL = 2
Radius of rounding corners, R = 50.00
Environmental conversion factor, na = 0.95
Partial factor for the type of application, γm = 1.50
Nominal to design conversion factor, γm/n = γm/na = 1.57895

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.28. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 4.5

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	End	3	0.0080587	0.0080587
	Life Safety	Start	2	0.0201163	0.0201163
	Collapse Prevention	Start	3	0.0362817	0.0362817
Shear Capacity [kN]	Operational Level	Start	2	145.531	145.531

COMPUTER FILES

- NTC_rccs5.bpf
- Report_NTC_rccs5.pdf

EXAMPLE 4.6

SUCCINCT DATA

- Primary Member
- Ribbed Bars
- Ductile Steel
- With Detailing for Earthquake Resistance (including stirrups not closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- LapLengthlo = 500.00
- FRP Wrapping (Type: Glass)
- Program's Default Safety/Confidence Factors
- NewMaterial Sets type

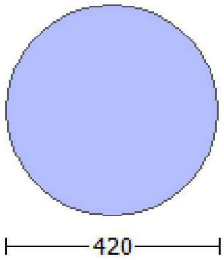
DESCRIPTION

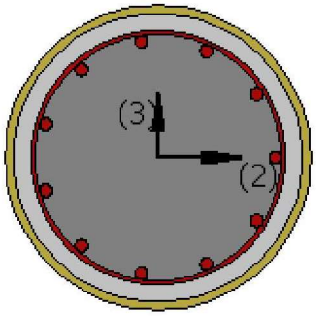
A circular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The equations of the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks cannot be employed in the case of circular column sections. The employed equations in SeismoBuild are those suggested by D. Biskinis andM. N. Fardis [2013]. The equations of section 4.1.2.1.3 of NTC–08 are employed for Shear Capacity checks.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties
Concrete Elasticity, Ec = 24870.062
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

New material: Concrete Strength,
fc = fck = 20.00
New material: Steel Strength,
fs = fsk = 400.00

For Shear Capacity Calculations

New material of Primary Member: Concrete Strength,
fc = fck/γc = 13.33333
New material of Primary Member: Steel Strength,
fs = fsk/γs = 347.8261

Member's Properties

Diameter, D = 420.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
γel = 1.60for Chord Rotation checks
γel = 1.00for Shear Capacity checks
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Lap Length lo = 500.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°

Number of layers, NL = 1
Radius of rounding corners, R = 40.00
Environmental conversion factor, na = 0.95
Partial factor for the type of application, γm = 1.00
Nominal to design conversion factor, γm/n = γm/na = 1.05263

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.29. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 4.6

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	Start	2	0.0103217	0.0103217
	Life Safety	End	3	0.0113601	0.0113601
	Collapse Prevention	End	2	0.0253489	0.0253489
Shear Capacity [kN]	Damage Limitation	End	3	189.916	189.916

COMPUTER FILES

- NTC_rccs6.bpf
- Report_NTC_rccs6.pdf

EXAMPLE 4.7

SUCCINCT DATA

- Primary Member
- Smooth Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Adequate Lap Length (lo/lou,min>=1)
- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- NewMaterial Sets type

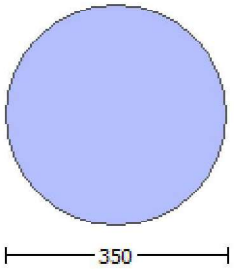
DESCRIPTION

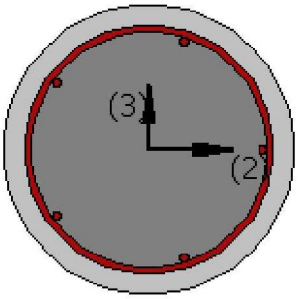
A circular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The equations of the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks cannot be employed in the case of circular column sections. The employed equations in SeismoBuild are those suggested by D. Biskinis andM. N. Fardis [2013]. The equations of section 4.1.2.1.3 of NTC–08 are employed for Shear Capacity checks.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties
Concrete Elasticity, Ec = 26999.44
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

New material: Concrete Strength,
fc = fck = 25.00
New material: Steel Strength,
fs = fsk = 500.00

For Shear Capacity Calculations

New material of Primary Member: Concrete Strength,
fc = fck/γc = 15.15152
New material of Primary Member: Steel Strength,
fs = fsk/γs = 500.00

Member's Properties

Diameter, D = 350.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
γel = 1.50 for Chord Rotation checks
γel = 1.15 for Shear Capacity checks
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.30. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 4.6

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	End	2	0.0100569	0.0100569
	Life Safety	End	3	0.0210100	0.0210100
	Collapse Prevention	End	2	0.0151821	0.0151821
Shear Capacity [kN]	Operational Level	Start	2	99.056	99.056

COMPUTER FILES

- NTC_rccs7.bpf
- Report_NTC_rccs7.pdf

EXAMPLES SET 5: WALL SECTION

EXAMPLE 5.1

SUCCINCT DATA

- Primary Member
- Ribbed Bars
- Ductile Steel
- With Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Adequate Lap Length (lo/lou,min>=1)
- No FRP Wrapping
- Program's Default Safety/Confidence Factors
- Existing Material Sets type

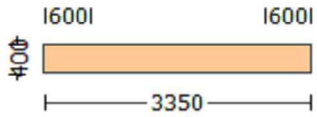
DESCRIPTION

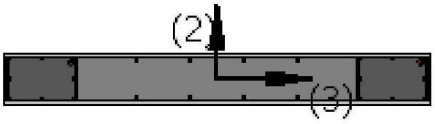
A wall section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7β) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Existing material: Concrete Strength,
fc = fcm/Cf = 16.66667
Existingmaterial: Steel Strength,
fs = fs/Cf = 370.3667

For Shear Capacity Calculations

Existingmaterial of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 11.11111
Existingmaterial of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 322.058

Member's Properties

Total Height, Htot = 3350.00
Edges Width, Wedg = 400.00
Edges Height, Hedg = 600.00
Web Width, Wweb = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
γel = 1.50for Chord Rotation checks and
γel = 1.00for Shear Capacity checks
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The wall member is modeled through an inelastic force-based frame element (infrmFB) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.31. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 5.1

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	End	3	0.0058803	0.0058803
	Life Safety	Start	2	0.0164799	0.0164799
	Collapse Prevention	Start	3	0.0362374	0.0362374
Shear Capacity [kN]	Operational Level	End	3	3296.7	3296.690

NOTE: The small difference in the Shear Capacity values is due to the rounding of the shear capacity value exported to the Report.

COMPUTER FILES

- NTC_wall1.bpf
- Report_NTC_wall1.pdf

EXAMPLE 5.2

SUCCINCT DATA

- Primary Member
- Smooth Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Inadequate Lap Length with lo/lou,min = 0.30
- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- Existing Material Sets type

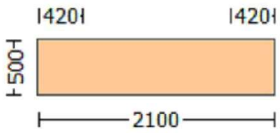
DESCRIPTION

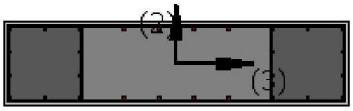
A wall section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7β) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.45

Materials' Properties

Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Existing material: Concrete Strength,
fc = fcm/Cf = 22.75862
Existing material: Steel Strength,
fs = fs/Cf = 306.5103

For Shear Capacity Calculations

Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 14.22414
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 255.4253

Member's Properties

Total Height, Htot = 2100.00
Edges Width, Wedg = 500.00
Edges Height, Hedg = 500.00
Web Width, Wweb = 500.00
Cover Thickness, c = 20.00
Element Length, L = 3000.00
Primary Member
γel = 1.65for Chord Rotation checks and
γel = 1.00for Shear Capacity checks
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The wall member is modeled through an inelastic force-based frame element (infrmFB) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.32. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 5.2

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	Start	2	0.0026766	0.0026766
	Life Safety	End	3	0.0084337	0.0084337
	Collapse Prevention	End	2	0.0038120	0.0038120
Shear Capacity [kN]	Damage Limitation	Start	2	832.333	832.333

COMPUTER FILES

- NTC_wall2.bpf
- Report_NTC_wall2.pdf

EXAMPLE 5.3

SUCCINCT DATA

- Primary Member
- Ribbed Bars
- Ductile Steel
- With Detailing for Earthquake Resistance (including stirrups not closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Inadequate Lap Length with lo/lou,min = 0.70
- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- New Material Sets type

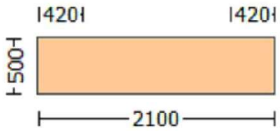
DESCRIPTION

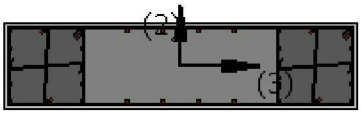
A wall section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7β) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.45

Materials' Properties
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

New material: Concrete Strength,
fc = fck = 25.00
New material: Steel Strength,
fs = fsk = 500.00

For Shear Capacity Calculations

New material of Primary Member: Concrete Strength,
fc = fck/γc = 15.625
New material of Primary Member: Steel Strength,
fs = fsk/γs = 416.6667

Member's Properties

Total Height, Htot = 2100.00
Edges Width, Wedg = 500.00
Edges Height, Hedg = 500.00
Web Width, Wweb = 500.00
Cover Thickness, c = 20.00
Element Length, L = 3000.00
Primary Member
γel = 1.65 for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Inadequate Lap Length with lo/lou,min = 0.70
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The wall member is modeled through an inelastic force-based frame element (infrmFB) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.33. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 5.3

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	Start	3	0.0056548	0.0056548
	Life Safety	End	2	0.0064057	0.0064057
	Collapse Prevention	End	3	0.0247964	0.0247964
Shear Capacity [kN]	Life Safety	Start	3	2923.6	2923. 582

NOTE: The small difference in the Shear Capacity values is due to the rounding of the shear capacity value exported to the Report.

COMPUTER FILES

- NTC_wall3.bpf
- Report_NTC_wall3.pdf

EXAMPLE 5.4

SUCCINCT DATA

- Secondary Member
- Ribbed Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Lap Length lo = 500.00
- FRP Wrapping (Type: Glass)
- Program's Default Safety/Confidence Factors
- New Material Sets type

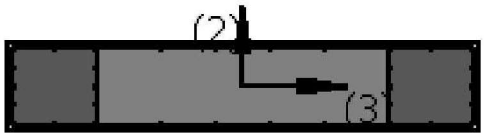
DESCRIPTION

A wall section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7β) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES



Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity, Ec = 28972.746
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

New material: Concrete Strength,
fc = fck = 30.00
New material: Steel Strength,
fs = fsk = 500.00

For Shear Capacity Calculations

New material of Secondary Member: Concrete Strength,
fc = fck = 30.00
New material of Secondary Member: Steel Strength,
fs = fsk = 500.00

Member's Properties

Total Height, Htot = 2700.00
Edges Width, Wedg = 500.00
Edges Height, Hedg = 540.00
Web Width, Wweb = 500.00
Cover Thickness, c = 20.00
Element Length, L = 3000.00
Secondary Member
γel = 1.00 for Chord Rotation and Shear Capacity checks
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 500.00
FRP Wrapping Data
Type: Glass
Dry properties (design values)
Thickness, t = 0.1096
Tensile Strength, ffu = 2600.00
Tensile Modulus, Ef = 73000.00

Elongation, efu = 0.035
Number of directions, NoDir = 4
Fiber orientations, bi: 0.00°, 90.00°, 45.00°, -45.00°
Number of layers, NL = 1
Radius of rounding corners, R = 50.00
Environmental conversion factor, na = 0.75
Partial factor for the type of application, γm = 1.50
Nominal to design conversion factor, γm/n = γm/na = 2.00

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The wall member is modeled through an inelastic force-based frame element (infrmFB) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.34. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 5.4

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	End	2	0.0023262	0.0023262
	Life Safety	Start	3	0.0262059	0.0262059
	Collapse Prevention	Start	2	0.0239704	0.0239704
Shear Capacity [kN]	Collapse Prevention	End	2	1668.1	1668.098

NOTE: The small difference in the Shear Capacity values is due to the rounding of the shear capacity value exported to the Report.

COMPUTER FILES

- NTC_wall4.bpf
- Report_NTC_wall4.pdf

EXAMPLE 5.5

SUCCINCT DATA

- Primary Member
- Smooth Bars
- Ductile Steel

- With Detailing for Earthquake Resistance (including stirrups not closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Adequate Lap Length (lo/lou,min>=1)
- FRP Wrapping (Type: Glass)
- Program's Default Safety/Confidence Factors
- New Material Sets type

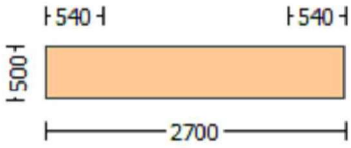
DESCRIPTION

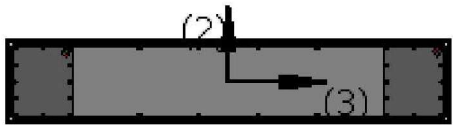
A wall section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7β) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties
Concrete Elasticity, Ec = 28972.746
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

New material: Concrete Strength,
fc = fck = 30.00
New material: Steel Strength,
fs = fsk = 500.00

For Shear Capacity Calculations

New material of Primary Member: Concrete Strength,
fc = fck/γc = 20.00
New material of Primary Member: Steel Strength,
fs = fsk/γs = 434.7826

Member's Properties

Total Height, Htot = 2700.00
Edges Width, Wedg = 500.00
Edges Height, Hedg = 420.00
Web Width, Wweb = 500.00
Cover Thickness, c = 20.00
Element Length, L = 3000.00

PrimaryMember
γel = 1.50 for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
FRP Wrapping Data
Type: Glass
Dry properties (design values)
Thickness, t = 0.067
Tensile Strength, ffu = 2429.00
Tensile Modulus, Ef = 52143.00
Elongation, efu = 0.045
Number of directions, NoDir = 2
Fiber orientations, bi: 0.00°, 90.00°
Number of layers, NL = 3
Radius of rounding corners, R = 30.00
Environmental conversion factor, na = 0.65
Partial factor for the type of application, γm = 1.50
Nominal to design conversion factor, γm/n = γm/na = 2.30769

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The wall member is modeled through an inelastic force-based frame element (infrmFB) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.35. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 5.5

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	End	3	0.0062504	0.0062504
	Life Safety	Start	2	0.0197491	0.0197491
	Collapse Prevention	Start	3	0.0379230	0.0379230
Shear Capacity [kN]	Operational Level	Start	2	4135.3	4135.340

NOTE: The small difference in the Shear Capacity values is due to the rounding of the shear capacity value exported to the Report.

COMPUTER FILES

- NTC_wall5.bpf
- Report_NTC_wall5.pdf

EXAMPLE 5.6

SUCCINCT DATA

- Secondary Member
- Smooth Bars
- Ductile Steel
- With Detailing for Earthquake Resistance (including stirrups not closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Lap Length lo = 600.00
- No FRP Wrapping
- Program's Default Safety/Confidence Factors
- New Material Sets type

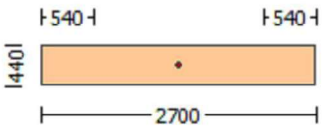
DESCRIPTION

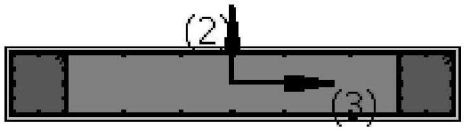
A wall section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7β) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

New material: Concrete Strength,
fc = fck = 25.00
New material: Steel Strength,
fs = fsk = 500.00

For Shear Capacity Calculations

New material of SecondaryMember: Concrete Strength,
fc = fck = 25.00
New material of SecondaryMember: Steel Strength,
fs = fsk = 500.00

Member's Properties

Total Height, Htot = 2700.00
Edges Width, Wedg = 440.00
Edges Height, Hedg = 400.00
Web Width, Wweb = 440.00
Cover Thickness, c = 30.00
Element Length, L = 3000.00
SecondaryMember
γel = 1.00 for Chord Rotation and Shear Capacity checks
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Lap Length lo = 600.00
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The wall member is modeled through an inelastic force-based frame element (infrmFB) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.36. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 5.6

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	Start	2	0.0032169	0.0032169
	Life Safety	End	3	0.0374482	0.0374482
	Collapse Prevention	End	2	0.0148424	0.0148424
Shear Capacity [kN]	Damage Limitation	End	3	3795.5	3795.546

NOTE: The small difference in the Shear Capacity values is due to the rounding of the shear capacity value exported to the Report.

COMPUTER FILES

- NTC_wall6.bpf
- Report_NTC_wall6.pdf

EXAMPLE 5.7

SUCCINCT DATA

- Primary Member
- Smooth Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
- Longitudinal Bars Straight Ends Lapped Starting at the End Sections
- Inadequate Lap Length with lo/lou,min = 0.30
- No FRP Wrapping
- Not Program's Default Safety/Confidence Factors
- Existing Material Sets type

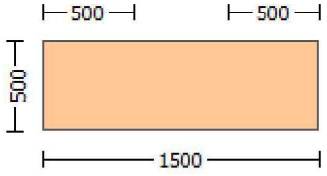
DESCRIPTION

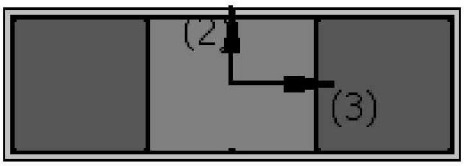
A wall section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7β) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

New material: Concrete Strength,
fc = fcm/Cf = 27.50
New material: Steel Strength,
fs = fs/Cf = 370.3667

For Shear Capacity Calculations

New material of SecondaryMember: Concrete Strength,
fc = fcm/(Cf*γc) = 17.1875
New material of SecondaryMember: Steel Strength,
fs = fs/(Cf*γs) = 308.6389

Member's Properties

Total Height, Htot = 1500.00
Edges Width, Wedg = 500.00
Edges Height, Hedg = 500.00
Web Width, Wweb = 500.00
Cover Thickness, c = 20.00
Element Length, L = 3000.00
PrimaryMember
γel = 1.65 for Chord Rotation checks

γel = 1.15 for Shear Capacity checks
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars Straight Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The wall member is modeled through an inelastic force-based frame element (infrmFB) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.37. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 5.6

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	Start	2	0.0038698	0.0038698
	Life Safety	End	3	0.0033066	0.0033066
	Collapse Prevention	End	2	0.0019456	0.0019456
Shear Capacity [kN]	Operational Level	Start	3	585.686	585.686

COMPUTER FILES

- NTC_wall7.bpf
- Report_NTC_wall7.pdf

EXAMPLES SET 6: BEAM SECTION

EXAMPLE 6.1

SUCCINCT DATA

- Primary Member
- SmoothBars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Lap Length lo = 500.00
- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- Existing Material Sets type

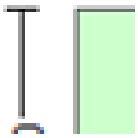
DESCRIPTION

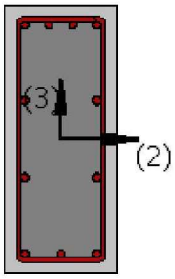
A beam section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.35

Materials' Properties
Concrete Elasticity, Ec = 28972.746
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Existing material: Concrete Strength,
fc = fcm/Cf = 28.14815
Existing material: Steel Strength,
fs = fs/Cf = 411.5259

For Shear Capacity Calculations

Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 17.59259
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 342.9383

Member's Properties

Section Height, H = 600.00
Section Width, W = 250.00
Cover Thickness, c = 25.00
Element Length, L = 2700.00
Primary Member
γel = 1.65for Chord Rotation checks and
γel = 1.00for Shear Capacity checks
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Lap Length lo = 500.00
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The beam member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH).

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.38. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 6.1

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	End	3	0.0107568	0.0107568
	Life Safety	Start	2	0.0222469	0.0222469
	Collapse Prevention	Start	3	0.0248061	0.0248061
Shear Capacity [kN]	Operational Level	End	3	406.764	406.763

NOTE: The small difference in the Shear Capacity values is due to the rounding of the shear capacity value exported to the Report.

COMPUTER FILES

- NTC_Beam1.bpf
- Report_NTC_Beam1.pdf

EXAMPLE 6.2

SUCCINCT DATA

- Secondary Member
- SmoothBars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Adequate Lap Length (lo/lou,min>=1)
- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- New Material Sets type

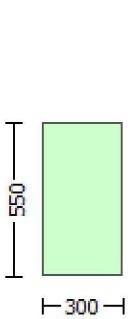
DESCRIPTION

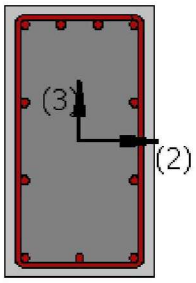
A beam section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.35

Materials' Properties
Concrete Elasticity, Ec = 28972.746
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

New material: Concrete Strength,
fc = fck = 30.00
New material: Steel Strength,
fs = fsk = 400.00

For Shear Capacity Calculations

New material of Secondary Member: Concrete Strength,
fc = fck = 30.00
New material of Secondary Member: Steel Strength,
fs = fsk = 400.00

Member's Properties

Section Height, H = 550.00
Section Width, W = 300.00
Cover Thickness, c = 20.00
Element Length, L = 2700.00
Secondary Member
γel = 1.10for Chord Rotation checks and
γel = 1.00for Shear Capacity checks
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The beam member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH).

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.39. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 6.2

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	Start	2	0.0050762	0.0050762
	Life Safety	End	3	0.0323838	0.0323838
	Collapse Prevention	End	2	0.0283071	0.0283071
Shear Capacity [kN]	Damage Limitation	Start	2	245.987	245.987

COMPUTER FILES

- NTC_Beam2.bpf

- Report_NTC_Beam2.pdf

EXAMPLE 6.3

SUCCINCT DATA

- Primary Member
- SmoothBars
- Ductile Steel
- With Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Inadequate Lap Length with lo/lou,min = 0.40
- No FRP Wrapping
- Program's Default Safety/Confidence Factors
- New Material Sets type

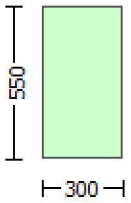
DESCRIPTION

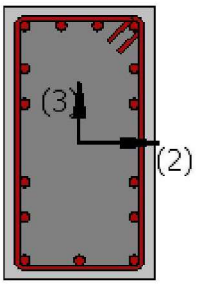
A beam section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties
Concrete Elasticity, Ec = 28972.746
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

New material: Concrete Strength,
fc = fck = 30.00

New material: Steel Strength,
fs = fsk = 400.00

For Shear Capacity Calculations

New material of PrimaryMember: Concrete Strength, fc = fck/γc = 20.00
New material of Primary Member: Steel Strength, fs = fsk/γs = 347.8261

Member's Properties

Section Height, H = 550.00
Section Width, W = 300.00
Cover Thickness, c = 20.00
Element Length, L = 2846.05
Primary Member
γel = 1.50 for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Inadequate Lap Length with lo/lou,min = 0.40
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The beam member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH).

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.40. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 6.3

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	Start	3	0.0093722	0.0093722
	Life Safety	End	2	0.0099968	0.0099968
	Collapse Prevention	End	3	0.0201135	0.0201135
Shear Capacity [kN]	Life Safety	Start	3	417.968	417.968

COMPUTER FILES

- NTC_Beam3.bpf
- Report_NTC_Beam3.pdf

EXAMPLE 6.4

SUCCINCT DATA

- Secondary Member
- RibbedBars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Inadequate Lap Length with lo/lou,min = 0.80
- No FRP Wrapping
- Program's Default Safety/Confidence Factors
- Existing Material Sets type

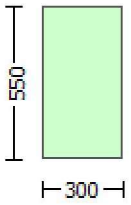
DESCRIPTION

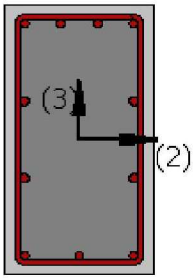
A beam section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties
Concrete Elasticity, Ec = 23025.204
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Existing material: Concrete Strength,
fc = fcm/Cf = 20.00
Existing material: Steel Strength,
fs = fs/Cf = 203.70

For Shear Capacity Calculations

Existing material of SecondaryMember:
Concrete Strength,
fc = fcm/Cf = 20.00
Existing material of Secondary Member: Steel Strength,
fs = fs/Cf = 203.70

Member's Properties

Section Height, H = 550.00
Section Width, W = 300.00
Cover Thickness, c = 20.00
Element Length, L = 2700.00
Secondary Member
γel = 1.00 for Chord Rotation and Shear Capacity checks
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Inadequate Lap Length with lo/lou,min = 0.80
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The beam member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH).

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.41. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 6.4

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	End	2	0.0045641	0.0045641
	Life Safety	Start	3	0.0282346	0.0282346
	Collapse Prevention	Start	2	0.0494656	0.0494656
Shear Capacity [kN]	Collapse Prevention	End	2	164.399	164.399

COMPUTER FILES

- NTC_Beam4.bpf
- Report_NTC_Beam4.pdf

EXAMPLE 6.5

SUCCINCT DATA

- Primary Member
- Ribbed Bars
- Ductile Steel

- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Lap Length lo = 500.00
- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- Existing Material Sets type

DESCRIPTION

A beam section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES

Units in N, mm

Confidence Factor, Cf = 1.35

Materials' Properties
Concrete Elasticity, Ec = 28972.746
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Existing material: Concrete Strength,
fc = fcm/Cf = 28.14815
Existing material: Steel Strength,
fs = fs/Cf = 411.5259

For Shear Capacity Calculations

Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 17.59259
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 342.9383

Member's Properties

Section Height, H = 600.00
Section Width, W = 250.00
Cover Thickness, c = 25.00
Element Length, L = 2700.00
Primary Member
γel = 1.65 for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
Ribbed Bars

Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Lap Length lo = 500.00
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The beam member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH).

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.42. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 6.5

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	End	3	0.0107568	0.0107568
	Life Safety	Start	2	0.0204475	0.0204475
	Collapse Prevention	Start	3	0.0227998	0.0227998
Shear Capacity [kN]	Operational Level	Start	2	166.454	166.453

NOTE: The small difference in the Shear Capacity values is due to the rounding of the shear capacity value exported to the Report.

COMPUTER FILES

- NTC_Beam5.bpf
- Report_NTC_Beam5.pdf

EXAMPLE 6.6

SUCCINCT DATA

- Primary Member
- Ribbed Bars
- Ductile Steel
- With Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Adequate Lap Length (lo/lou,min>=1)

- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- New Material Sets type

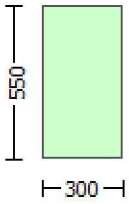
DESCRIPTION

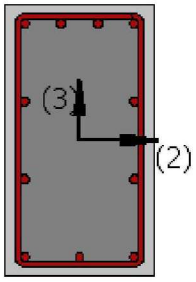
A beam section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.35

Materials' Properties
Concrete Elasticity, Ec = 28972.746
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

New material: Concrete Strength,
fc = fck = 30.00
New material: Steel Strength,
fs = fsk = 400.00

For Shear Capacity Calculations

New material of Primary Member: Concrete Strength,
fc = fck/γc = 18.75
New material of Primary Member: Steel Strength,
fs = fsk/γs = 333.3333

Member's Properties

Section Height, H = 550.00
Section Width, W = 300.00
Cover Thickness, c = 20.00
Element Length, L = 2700.00
Primary Member
γel = 1.65 for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The beam member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH).

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.43. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 6.6

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	Start	2	0.0056427	0.0056427
	Life Safety	End	3	0.0202836	0.0202836
	Collapse Prevention	End	2	0.0133835	0.0133835
Shear Capacity [kN]	Operational Level	Start	3	80.439	80.439

COMPUTER FILES

- NTC_Beam6.bpf
- Report_NTC_Beam6.pdf

EXAMPLE 6.7

SUCCINCT DATA

- Primary Member
- Ribbed Bars
- Ductile Steel
- With Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Adequate Lap Length (lo/lou,min>=1)
- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- New Material Sets type

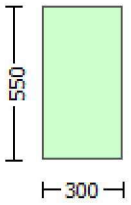
DESCRIPTION

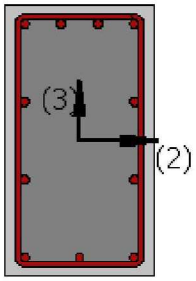
A beam section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.35

Materials' Properties

Concrete Elasticity, Ec = 28972.746
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

New material: Concrete Strength,
fc = fck = 30.00
New material: Steel Strength,
fs = fsk = 400.00

For Shear Capacity Calculations

New material of Primary Member: Concrete Strength,
fc = fck/γc = 18.75
New material of Primary Member: Steel Strength,
fs = fsk/γs = 333.3333

Member's Properties

Section Height, H = 550.00
Section Width, W = 300.00
Cover Thickness, c = 20.00
Element Length, L = 2700.00
Primary Member
γel = 1.65 for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The beam member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH).

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.44. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 6.7

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	Start	2	0.0056293	0.0056293
	Life Safety	End	3	0.0203571	0.0203571
	Collapse Prevention	End	2	0.0143440	0.0143440
Shear Capacity [kN]	Operational Level	Start	3	185.285	185.285

COMPUTER FILES

- NTC_Beam7.bpf
- Report_NTC_Beam7.pdf

EXAMPLES SET 7: JACKETED RECTANGULAR SECTION

EXAMPLE 7.1

SUCCINCT DATA

- Primary Member
- Smooth Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Inadequate Lap Length with lo/lou,min = 0.80
- No FRP Wrapping
- Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing Column

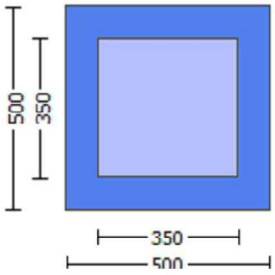
DESCRIPTION

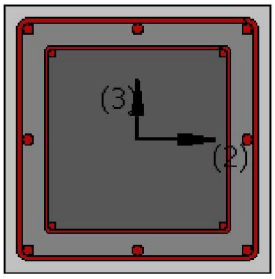
A jacketed rectangular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.30

Materials' Properties:

Concrete Elasticity for Jacket, Ec = 28972.746
Concrete Elasticity for Existing Column,Ec = 21019.039
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = f_{ck} = 30.00
New material: Steel Strength,
fs = fsk = 400.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 15.38462
Existing material: Steel Strength,
fs = fs/Cf = 341.8769

For Shear Capacity Calculations

Jacket
New material of Primary Member: Concrete Strength,
fc = fck/γc = 20.00
New material of Primary Member: Steel Strength,
fs = fsk/γs = 347.8261
Existing Column
Existingmaterial of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 10.25641
Existingmaterial of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 297.2843

Member's Properties

External Height, H = 500.00
External Width, W = 500.00
Internal Height, H = 350.00
Internal Width, W = 350.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00

Primary Member
γel = 1.50 for Chord Rotation checks and
γel = 1.00for Shear Capacity checks
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.80
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH)fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.45. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 7.1

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	End	3	0.0054272	0.0054272
	Life Safety	Start	2	0.0344279	0.0344279
	Collapse Prevention	Start	3	0.0585111	0.0585111
Shear Capacity [kN]	Operational Level	End	3	584.502	584.502

COMPUTER FILES

- NTC_rcjrs1.bpf
- Report_NTC_rcjrs1.pdf

EXAMPLE 7.2

SUCCINCT DATA

- Secondary Member
- Smooth Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Inadequate Lap Length with lo/lou,min = 0.50
- No FRP Wrapping

- Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing Column

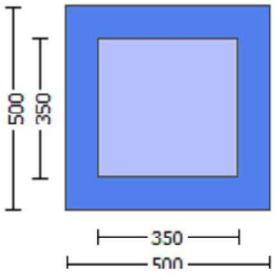
DESCRIPTION

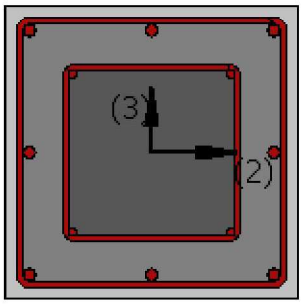
A jacketed rectangular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.30

Materials' Properties

Concrete Elasticity for Jacket, Ec = 24870.062
Concrete Elasticity for Existing Column, Ec = 23025.204
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = f_{ck} = 20.00
New material: Steel Strength,
fs = fsk = 400.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 18.46154
Existing material: Steel Strength,
fs = fs/Cf = 188.0308

For Shear Capacity Calculations

Jacket
New material of Secondary Member: Concrete Strength,
fc = fck = 20.00
New material of SecondaryMember: Steel Strength,
fs = fsk = 400.00
Existing Column
Existing material of SecondaryMember: Concrete Strength,
fc = fcm/Cf = 18.46154
Existing material of SecondaryMember: Steel Strength,
fs = fs/Cf = 188.0308

Member's Properties

External Height, H = 500.00
External Width, W = 500.00
Internal Height, H = 300.00
Internal Width, W = 300.00
Cover Thickness, c = 20.00
Element Length, L = 3000.00
SecondaryMember
γel = 1.00 for Chord Rotation checks and for Shear Capacity checks
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Inadequate Lap Length with lo/lou,min = 0.50
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH)fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.46. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 7.2

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	Start	2	0.0049852	0.0049852
	Life Safety	End	3	0.0205751	0.0205751
	Collapse Prevention	End	2	0.0481859	0.0481859
Shear Capacity [kN]	Damage Limitation	Start	2	715.424	715.424

COMPUTER FILES

- NTC_rcjrs2.bpf
- Report_NTC_rcjrs2.pdf

EXAMPLE 7.3

SUCCINCT DATA

- Primary Member

- Smooth Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- LapLength lo = 500.00
- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing Column

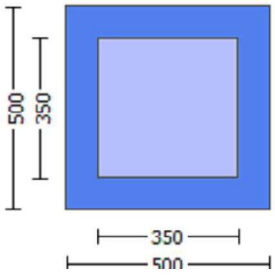
DESCRIPTION

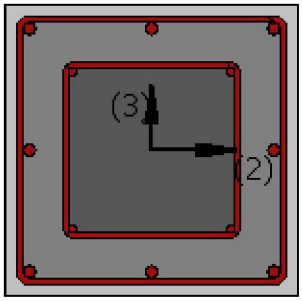
A jacketed rectangular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity for Jacket, Ec = 24870.062
Concrete Elasticity for Existing Column, Ec = 23025.204
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = fck = 20.00

New material: Steel Strength,
fs = fsk = 400.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 20.00

Existing material: Steel Strength,
fs = fs/Cf = 203.70

New material of Primary Member: Steel Strength,
fs = fsk/γs = 333.3333
Existing Column
Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 11.76471
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 169.75

For Shear Capacity Calculations

Jacket
New material of Primary Member: Concrete Strength,
fc = fck/γc = 11.76471

Member's Properties

External Height, H = 500.00
External Width, W = 500.00
Internal Height, H = 300.00
Internal Width, W = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
γel = 1.50 for Chord Rotation checks
γel = 1.00 for Shear Capacity checks
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 500.00
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH)fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.47. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 7.3

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity	Operational Level	Start	3	0.0065184	0.0065184

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
[rad]	Life Safety	End	2	0.0314191	0.0314191
	Collapse Prevention	End	3	0.0238501	0.0238501
Shear Capacity [kN]	Life Safety	Start	3	333.785	333.785

COMPUTER FILES

- NTC_rcjrs3.bpf
- Report_NTC_rcjrs3.pdf

EXAMPLE 7.4

SUCCINCT DATA

- Primary Member
- Ribbed Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- LapLength lo = 500.00
- FRP Wrapping (Type: Carbon)
- Not the Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing Column

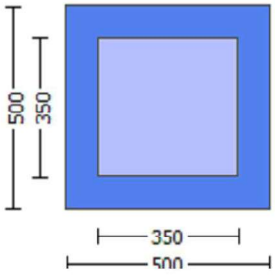
DESCRIPTION

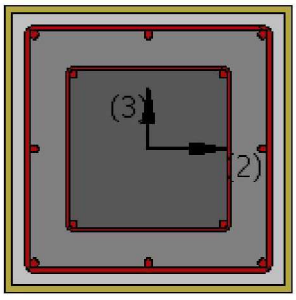
A jacketed rectangular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity for Jacket, Ec = 24870.062
Concrete Elasticity for Existing Column, Ec = 23025.204
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = fck = 20.00
New material: Steel Strength,
fs = fsk = 400.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 20.00
Existing material: Steel Strength,
fs = fs/Cf = 203.70

For Shear Capacity Calculations

Jacket
New material of Primary Member: Concrete Strength,
fc = fck/γc = 11.76471
New material of Primary Member: Steel Strength,
fs = fsk/γs = 333.3333
Existing Column
Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 11.76471
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 169.75

Member's Properties

External Height, H = 500.00
External Width, W = 500.00
Internal Height, H = 300.00
Internal Width, W = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
γel = 1.50 for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 500.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 0.329
Tensile Strength, ffu = 4410.00
Tensile Modulus, Ef = 390000.00
Elongation, efu = 0.011
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00
Environmental conversion factor, na = 0.85
Partial factor for the type of application, γm = 1.50
Nominal to design conversion factor, γm/n = γm/na = 1.76471

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH)fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.48. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 7.4

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	End	2	0.0045651	0.0045651
	Life Safety	Start	3	0.0327448	0.0327448
	Collapse Prevention	Start	2	0.0342288	0.0342288
Shear Capacity [kN]	Collapse Prevention	End	2	378.262	378.262

COMPUTER FILES

- NTC_rcjrs4.bpf
- Report_NTC_rcjrs4.pdf

EXAMPLE 7.5

SUCCINCT DATA

- Primary Member
- Ribbed Bars
- Ductile Steel
- With Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Inadequate Lap Length with lo/lou,min = 0.30
- No FRP Wrapping
- Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Materials Sets type for the Existing Column

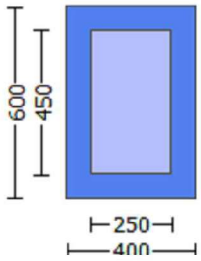
DESCRIPTION

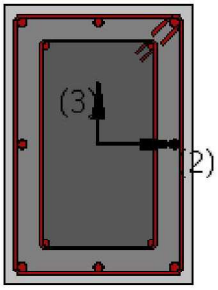
A jacketed rectangular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity for Jacket, Ec = 24870.062
Concrete Elasticity for Existing Column, Ec = 23025.204
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = fck = 20.00
New material: Steel Strength,
fs = fsk = 400.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 20.00
Existing material: Steel Strength,
fs = fs/Cf = 203.70

For Shear Capacity Calculations

Jacket
New material of Primary Member: Concrete Strength,
fc = fck/γc = 13.33333
New material of Primary Member: Steel Strength,
fs = fsk/γs = 347.8261
Existing Column
Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 13.33333
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 177.1304

Member's Properties

External Height, H = 600.00
External Width, W = 400.00

Internal Height, H = 450.00
Internal Width, W = 250.00
Cover Thickness, c = 20.00
Element Length, L = 3000.00
Primary Member
γel = 1.70 for Chord Rotation checks
γel = 1.00 for Shear Capacity checks
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.30
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH)fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.49. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 7.5

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	End	3	0.0023167	0.0023167
	Life Safety	Start	2	0.0072997	0.0072997
	Collapse Prevention	Start	3	0.0131569	0.0131569
Shear Capacity [kN]	Operational Level	Start	2	275.556	275.556

COMPUTER FILES

- NTC_rcjrs5.bpf
- Report_NTC_rcjrs5.pdf

EXAMPLE 7.6

SUCCINCT DATA

- Primary Member
- Ribbed Bars
- Ductile Steel

- With Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Adequate Lap Length (lo/lou,min>=1)
- No FRP Wrapping
- Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing Column

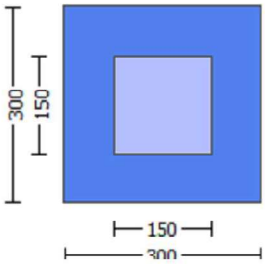
DESCRIPTION

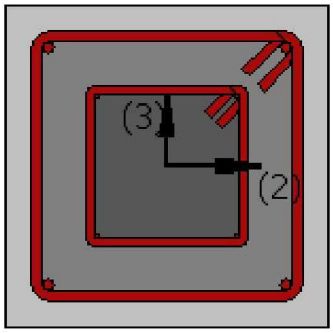
A jacketed rectangular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity for Jacket, Ec = 24870.062
Concrete Elasticity for Existing Column, Ec = 21019.039
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = fck = 20.00
New material: Steel Strength,
fs = fsk = 500.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 16.66667
Existing material: Steel Strength,
fs = fs/Cf = 203.70

For Shear Capacity Calculations

Jacket
New material of Secondary Member: Concrete Strength, fc = fck/γc = 10.66667
New material of Secondary Member: Steel Strength, fs = fsk/γs = 191.3043
Existing Column
Existing material of Secondary Member: Concrete Strength, fc = fcm/(Cf *γc)= 11.1111
Existing material of Secondary Member: Steel Strength, fs = fs/(Cf*γs) = 177.1304

Member's Properties

External Height, H = 300.00
External Width, W = 300.00
Internal Height, H = 150.00
Internal Width, W = 150.00
Cover Thickness, c = 25.00
Element Length, L = 3500.00
Secondary Member
γel = 1.60 for Chord Rotation checks
γel = 1.20 for Shear Capacity checks
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH)fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.50. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 7.6

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	Start	2	0.0044699	0.0044699
	Life Safety	End	3	0.0511750	0.0511750
	Collapse Prevention	End	2	0.0315019	0.0315019
Shear Capacity [kN]	Operational Level	Start	2	48.293	48.293

COMPUTER FILES

- NTC_rcjrs6.bpf
- Report_NTC_rcjrs6.pdf

EXAMPLE 7.7

SUCCINCT DATA

- Secondary Member
- Smooth Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Inadequate Lap Length with lo/lou,min = 0.80
- No FRP Wrapping
- Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing Column

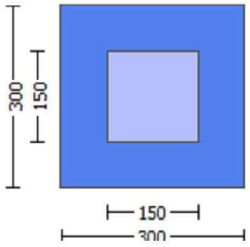
DESCRIPTION

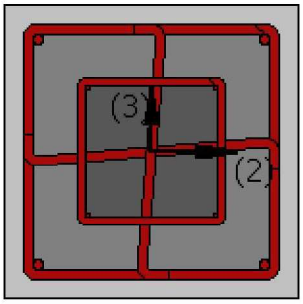
A jacketed rectangular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity for Jacket, Ec = 23025.204
Concrete Elasticity for Existing Column, Ec = 21019.039
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = fck = 16.00

New material: Steel Strength,
fs = fsk = 220.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 16.66667

Existing material: Steel Strength,
fs = fs/Cf = 203.70

For Shear Capacity Calculations

Jacket
New material of Secondary Member: Concrete Strength,
fc = fck = 16.00
New material of Secondary Member: Steel Strength,
fs = fsk = 220.00
Existing Column
Existing material of Secondary Member: Concrete Strength,
fc = fcm/Cf = 16.66667
Existing material of Secondary Member: Steel Strength,
fs = fs/Cf = 203.70

Member's Properties

External Height, H = 300.00
External Width, W = 300.00
Internal Height, H = 150.00
Internal Width, W = 150.00
Cover Thickness, c = 20.00
Element Length, L = 3500.00
Secondary Member
γel = 1.50 for Chord Rotation checks
γel = 1.00 for Shear Capacity checks
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.80
NoFRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH)fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +Y)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.51. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 7.7

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	Start	3	0.0126693	0.0126693
	Life Safety	End	2	0.019083	0.019083
	Collapse Prevention	End	3	0.0413334	0.0413334
Shear Capacity [kN]	Life Safety	End	2	42.819	42.819

COMPUTER FILES

- NTC_rcjrs7.bpf
- Report_NTC_rcjrs7.pdf

EXAMPLES SET 8: JACKETED L-SHAPED COLUMN SECTION

EXAMPLE 8.1

SUCCINCT DATA

- Primary Member
- Ribbed Bars
- Ductile Steel
- With Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Adequate Lap Length (lo/lou,min>=1)
- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing column

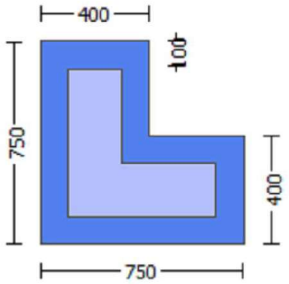
DESCRIPTION

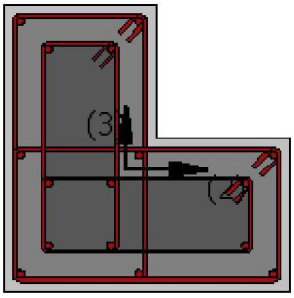
A jacketed L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity for Jacket, Ec = 26999.444
Concrete Elasticity for Existing Column, Ec = 21019.039
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = fck = 25.00
New material: Steel Strength,
fs = fsk = 500.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 16.66667
Existing material: Steel Strength,
fs = fs/Cf = 370.3667

For Shear Capacity Calculations

Jacket
New material of Primary Member: Concrete Strength,
fc = fck/γc = 15.625
New material of Primary Member: Steel Strength,
fs = fsk/γs = 416.6667
Existing Column
Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 10.41667
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 308.6389

Member's Properties

Max Height, Hmax = 750.00
Min Height, Hmin = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
γel = 1.70for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.52. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 8.1

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	End	3	0.0066717	0.0066717
	Life Safety	Start	2	0.0439114	0.0439114
	Collapse Prevention	Start	3	0.0670617	0.0670611
Shear Capacity [kN]	Operational Level	End	3	700.372	700.372

COMPUTER FILES

- NTC_rcjls1.bpf
- Report_NTC_rcjls1.pdf

EXAMPLE 8.2

SUCCINCT DATA

- Primary Member
- Smooth Bars
- Ductile Steel
- With Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Inadequate Lap Length with lo/lou,min = 0.20
- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing column

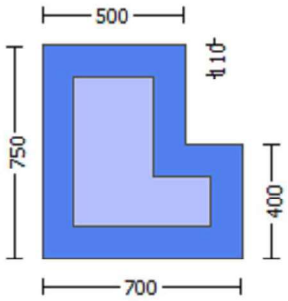
DESCRIPTION

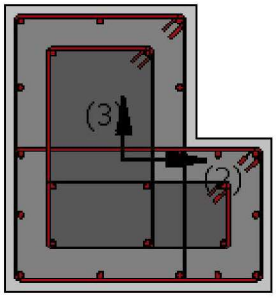
A jacketed L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.35

Materials' Properties

Concrete Elasticity for Jacket, Ec = 26999.444
Concrete Elasticity for Existing Column, Ec = 23025.204
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = fck = 25.00
New material: Steel Strength,
fs = fsk = 500.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 17.77778
Existing material: Steel Strength,
fs = fs/Cf = 181.0667

For Shear Capacity Calculations

Jacket
New material of Primary Member: Concrete Strength,
fc = fck/γc = 15.625
New material of Primary Member: Steel Strength,
fs = fsk/γs = 454.5455
Existing Column
Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 11.11111
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 164.6061

Member's Properties

Max Height, Hmax = 750.00
Min Height, Hmin = 400.00
Max Width, Wmax = 700.00
Min Width, Wmin = 500.00
Jacket Thickness, tj = 110.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
γel = 1.50 for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Inadequate Lap Length with lo/lou,min = 0.20
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.53. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 8.2

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	Start	2	0.0049705	0.0049705
	Life Safety	End	3	0.0092884	0.0092884
	Collapse Prevention	End	2	0.0190660	0.0190660
Shear Capacity [kN]	Damage Limitation	Start	2	589.985	589.985

COMPUTER FILES

- NTC_rcjls2.bpf
- Report_NTC_rcjls2.pdf

EXAMPLE 8.3

SUCCINCT DATA

- Secondary Member
- Smooth Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Lap Length lo = 400.00
- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing column

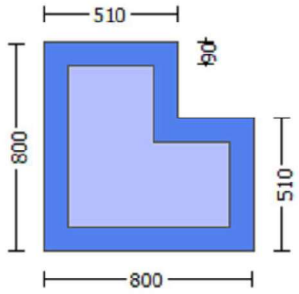
DESCRIPTION

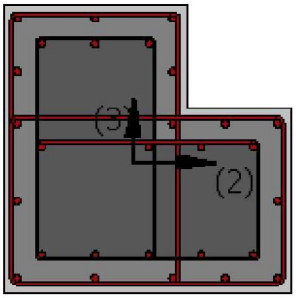
A jacketed L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.35

Materials' Properties
Concrete Elasticity for Jacket, Ec = 26999.444
Concrete Elasticity for Existing Column, Ec = 21019.039
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = fck = 25.00
New material: Steel Strength,
fs = fsk = 500.00

Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 14.81481
Existing material: Steel Strength,
fs = fs/Cf = 329.2148

fs = fsk = 500.00
Existing Column
Existing material of SecondaryMember:
Concrete Strength,
fc = fcm/Cf = 14.81481
Existing material of SecondaryMember: Steel Strength,
fs = fs/Cf = 329.2148

For Shear Capacity Calculations

Jacket
New material of Secondary Member: Concrete Strength,
fc = fck = 25.00
New material of SecondaryMember: Steel Strength,

Member's Properties

Max Height, Hmax = 800.00
Min Height, Hmin = 510.00
Max Width, Wmax = 800.00
Min Width, Wmin = 510.00
Jacket Thickness, tj = 90.00
Cover Thickness, c = 20.00
Element Length, L = 3000.00
SecondaryMember
γel = 1.10 for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 400.00
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.54. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 8.3

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	Start	3	0.0057442	0.0057442
	Life Safety	End	2	0.0271220	0.0271220

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
	Collapse Prevention	End	3	0.0223052	0.0223052
Shear Capacity [kN]	Life Safety	Start	3	135.530	135.531

NOTE: The small difference in the Shear Capacity values is due to the rounding of the shear capacity value exported to the Report.

COMPUTER FILES

- NTC_rcjls3.bpf
- Report_NTC_rcjls3.pdf

EXAMPLE 8.4

SUCCINCT DATA

- Primary Member
- Smooth Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Adequate Lap Length (lo/lou,min>=1)
- No FRP Wrapping
- Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing column

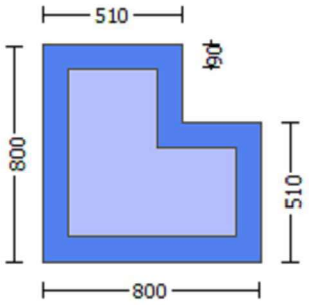
DESCRIPTION

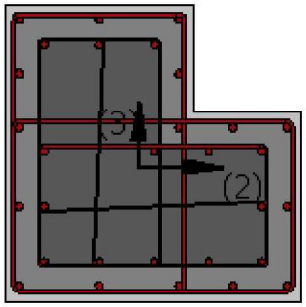
A jacketed L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity for Jacket, Ec = 28972.746
Concrete Elasticity for Existing Column, Ec = 23025.204
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = fck = 30.00
New material: Steel Strength,
fs = fsk = 500.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 20.00
Existing material: Steel Strength,
fs = fs/Cf = 203.70

For Shear Capacity Calculations

Jacket
New material of Primary Member: Concrete Strength,
fc = fck/γc = 20.00
New material of Primary Member: Steel Strength,
fs = fsk/γs = 434.7826
Existing Column
Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 13.33333
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 177.1304

Member's Properties

Max Height, Hmax = 800.00
Min Height, Hmin = 510.00
Max Width, Wmax = 800.00
Min Width, Wmin = 510.00
Jacket Thickness, tj = 90.00
Cover Thickness, c = 20.00
Element Length, L = 3000.00
PrimaryMember
γel = 1.50 for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.55. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 8.4

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	End	2	0.0047419	0.0047419
	Life Safety	Start	3	0.0449201	0.0449201
	Collapse Prevention	Start	2	0.0296223	0.0296223
Shear Capacity [kN]	Collapse Prevention	End	2	1084.7	1084.667

NOTE: The small difference in the Shear Capacity values is due to the rounding of the shear capacity value exported to the Report.

COMPUTER FILES

- NTC_rcjls4.bpf
- Report_NTC_rcjls4.pdf

EXAMPLE 8.5

SUCCINCT DATA

- Primary Member
- RibbedBars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Inadequate Lap Length with lo/lou,min = 0.60
- FRP Wrapping (Type: Glass)
- Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing column

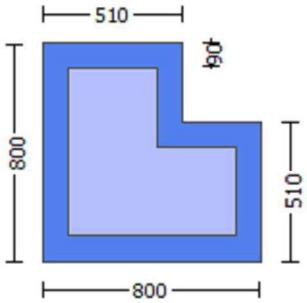
DESCRIPTION

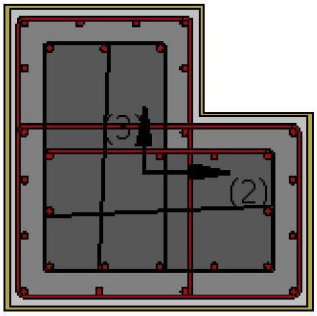
A jacketed L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity for Jacket, Ec = 26999.444
Concrete Elasticity for Existing Column, Ec = 23025.204
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = fck = 25.00
New material: Steel Strength,
fs = fsk = 500.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 20.00
Existing material: Steel Strength,
fs = fs/Cf = 203.70

For Shear Capacity Calculations

Jacket
New material of Primary Member: Concrete Strength,
fc = fck/γc = 16.66667
New material of Primary Member: Steel Strength,
fs = fsk/γs = 434.7826
Existing Column
Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 13.33333
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 177.1304

Member's Properties

Max Height, Hmax = 800.00
Min Height, Hmin = 510.00
Max Width, Wmax = 800.00

Min Width, Wmin = 510.00
Jacket Thickness, tj = 90.00
Cover Thickness, c = 20.00
Element Length, L = 3000.00
PrimaryMember
γel = 1.50 for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Inadequate Lap Length with lo/lou,min = 0.60
FRP Wrapping Data
Type: Glass
Dry properties (design values)
Thickness, t = 0.067
Tensile Strength, ffu = 2429.00
Tensile Modulus, Ef = 52143.00
Elongation, efu = 0.045
Number of directions, NoDir = 2
Fiber orientations, bi: 0.00°, 90.00°
Number of layers, NL = 3
Radius of rounding corners, R = 20.00
Environmental conversion factor, na = 0.65
Partial factor for the type of application, γm = 1.50
Nominal to design conversion factor, γm/n = γm/na = 2.30769

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.56. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 8.5

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	End	3	0.0066738	0.0066738
	Life Safety	Start	2	0.023769	0.023769
	Collapse Prevention	Start	3	0.0368022	0.0368022

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Shear Capacity [kN]	Operational Level	Start	2	962.995	962.995

COMPUTER FILES

- NTC_rcjls5.bpf
- Report_NTC_rcjls5.pdf

EXAMPLE 8.6

SUCCINCT DATA

- Secondary Member
- RibbedBars
- Ductile Steel
- With Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Lap Length lo = 400.00
- FRP Wrapping (Type: Aramid)
- Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing column

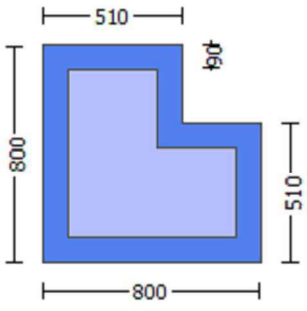
DESCRIPTION

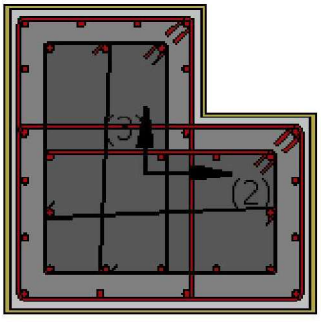
A jacketed L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





<u>Units in N, mm</u>

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity for Jacket, Ec = 26999.444
Concrete Elasticity for Existing Column, Ec = 23025.204
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = fck = 25.00
New material: Steel Strength,
fs = fsk = 500.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 20.00
Existing material: Steel Strength,
fs = fs/Cf = 203.70

For Shear Capacity Calculations

Jacket
New material of Secondary Member: Concrete Strength,
fc = fck = 25.00
New material of Secondary Member: Steel Strength,
fs = fsk = 500.00
Existing Column
Existing material of Secondary Member: Concrete Strength,
fc = fcm/Cf = 20.00
Existing material of Secondary Member: Steel Strength,
fs = fs/Cf = 203.70

Member's Properties

Max Height, Hmax = 800.00
Min Height, Hmin = 510.00
Max Width, Wmax = 800.00
Min Width, Wmin = 510.00
Jacket Thickness, tj = 90.00
Cover Thickness, c = 20.00
Element Length, L = 3000.00
SecondaryMember
γel = 1.00 for Chord Rotation and Shear Capacity checks
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Lap Length lo = 400.00
FRP Wrapping Data
Type: Aramid
Dry properties (design values)
Thickness, t = 0.20
Tensile Strength, ffu = 2231.00
Tensile Modulus, Ef = 92308.00
Elongation, efu = 0.025
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 3
Radius of rounding corners, R = 20.00
Environmental conversion factor, na = 0.75
Partial factor for the type of application, γm = 1.50
Nominal to design conversion factor, γm/n = γm/na = 2.00

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.57. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 8.6

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	Start	2	0.0043807	0.0043807
	Life Safety	End	3	0.0226099	0.0226099
	Collapse Prevention	End	2	0.0454905	0.0454905
Shear Capacity [kN]	Damage Limitation	End	3	1355.3	1355.287

NOTE: The small difference in the Shear Capacity values is due to the rounding of the shear capacity value exported to the Report.

COMPUTER FILES

- NTC_rcjls6.bpf
- Report_NTC_rcjls6.pdf

EXAMPLE 8.7

SUCCINCT DATA

- Primary Member
- Smooth Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Adequate Lap Length (lo/lou,min>=1)
- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing column

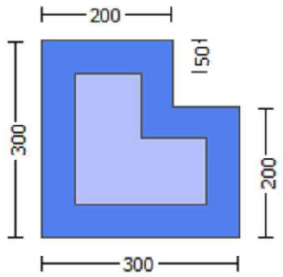
DESCRIPTION

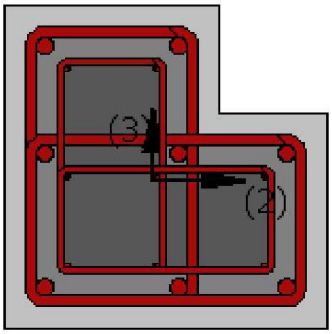
A jacketed L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity for Jacket, Ec = 26999.444
Concrete Elasticity for Existing Column, Ec = 21019.039
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = fck = 12.00
New material: Steel Strength,
fs = fsk = 220.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 16.66667
Existing material: Steel Strength,
fs = fs/Cf = 203.70

For Shear Capacity Calculations

Jacket
New material of Primary Member: Concrete Strength,
fc = fck/γc = 7.50
New material of Primary Member: Steel Strength,
fs = fsk/γs = 220.00
Existing Column
Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 10.41667
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 203.70

Member's Properties

Max Height, Hmax = 300.00
Min Height, Hmin = 200.00
Max Width, Wmax = 300.00
Min Width, Wmin = 200.00
Jacket Thickness, tj = 50.00
Cover Thickness, c = 20.00
Element Length, L = 3000.00
Primary Member
γel = 1.15 for Chord Rotation checks and
γel = 1.15 for Shear Capacity checks
Smooth Bars

Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +Y)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.58. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 8.7

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	Start	2	0.0091295	0.0091295
	Life Safety	End	3	0.0383361	0.0383361
	Collapse Prevention	End	2	0.0503813	0.0503813
Shear Capacity [kN]	Operational Level	Start	2	82.766	82.766

COMPUTER FILES

- NTC_rcjls7.bpf
- Report_NTC_rcjls7.pdf

EXAMPLE 8.8

SUCCINCT DATA

- Primary Member
- Smooth Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Adequate Lap Length (lo/lou,min>=1)
- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing column

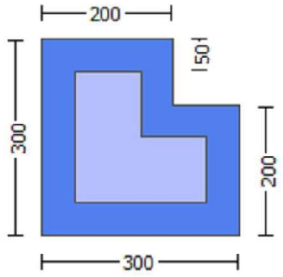
DESCRIPTION

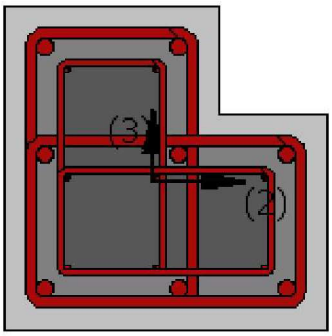
A jacketed L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity for Jacket, Ec = 26999.444
Concrete Elasticity for Existing Column, Ec = 21019.039
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = fck = 12.00
New material: Steel Strength,
fs = fsk = 220.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 16.66667
Existing material: Steel Strength,
fs = fs/Cf = 203.70

For Shear Capacity Calculations

Jacket
New material of Primary Member: Concrete Strength,
fc = fck/γc = 7.50
New material of Primary Member: Steel Strength,
fs = fsk/γs = 220.00
Existing Column
Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 10.41667
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 203.70

Member's Properties

Max Height, Hmax = 300.00
Min Height, Hmin = 200.00
Max Width, Wmax = 300.00
Min Width, Wmin = 200.00

Jacket Thickness, tj = 50.00
Cover Thickness, c = 20.00
Element Length, L = 3000.00
Primary Member
γel = 1.15 for Chord Rotation checks and
γel = 1.15 for Shear Capacity checks
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +Y)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.59. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 8.8

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	Start	2	0.0040379	0.0040379
	Life Safety	End	3	0.0376321	0.0376321
	Collapse Prevention	End	2	0.0365267	0.0365267
Shear Capacity [kN]	Operational Level	Start	2	84.964	84.964

COMPUTER FILES

- NTC_rcjls8.bpf
- Report_NTC_rcjls8.pdf

EXAMPLES SET 9: JACKETED T-SHAPED COLUMN SECTION

EXAMPLE 9.1

SUCCINCT DATA

- Primary Member
- Ribbed Bars

- Ductile Steel
- With Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Adequate Lap Length(lo/lou,min>=1)
- No FRP Wrapping
- Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing column

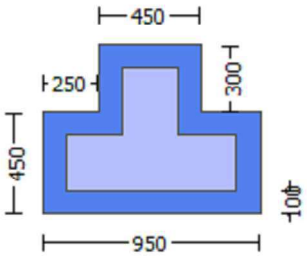
DESCRIPTION

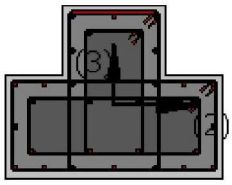
A jacketed T-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity for Jacket, Ec = 26999.444
Concrete Elasticity for Existing Beam,Ec = 21019.039
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = f_{ck} = 25.00
New material: Steel Strength,
fs = fsk = 500.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 16.66667

For Shear Capacity Calculations

Jacket
New material of Primary Member: Concrete Strength,
fc = fck/γc = 16.66667
New material of Primary Member: Steel Strength,
fs = fsk/γs = 434.7826

For Chord rotation Calculations

Existing material: Steel Strength,
fs = fs/Cf = 370.3704

For Shear Capacity Calculations

Existing Column
Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 11.11111
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 322.0612

Member's Properties

Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
γel = 1.50 for Chord Rotation checks and
γel = 1.00for Shear Capacity checks
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.60. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 9.1

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	End	3	0.0076794	0.0076794
	Life Safety	Start	2	0.0514171	0.0514171
	Collapse Prevention	Start	3	0.0842105	0.0842105
Shear Capacity [kN]	Operational Level	End	3	829.504	829.504

COMPUTER FILES

- NTC_rcjtcs1.bpf
- Report_ NTC_rcjtcs1.pdf

EXAMPLE 9.2

SUCCINCT DATA

- Primary Member
- Ribbed Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Inadequate Lap Length with lo/lou,min = 0.43
- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing column

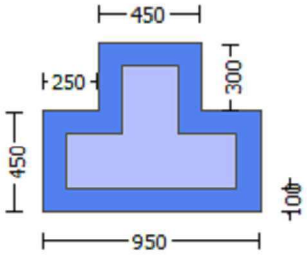
DESCRIPTION

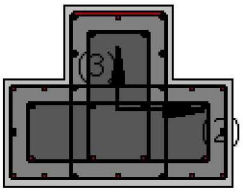
A jacketed T-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.40

Materials' Properties

Concrete Elasticity for Jacket, Ec = 26999.444
Concrete Elasticity for Existing Beam, Ec = 21019.039
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = f_{ck} = 25.00
New material: Steel Strength,
fs = fsk = 500.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 14.28571
Existing material: Steel Strength,
fs = fs/Cf = 317.4603

For Shear Capacity Calculations

Jacket
New material of Primary Member: Concrete Strength,
fc = fck/γc = 15.625
New material of Primary Member: Steel Strength,
fs = fsk/γs = 400.00
Existing Column
Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 8.92857
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 253.9683

Member's Properties

Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
γel = 1.70 for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
RibbedBars
Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Inadequate Lap Length with lo/lou,min = 0.43
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.61. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 9.2

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	Start	2	0.0029917	0.0029917
	Life Safety	End	3	0.0077842	0.0077842
	Collapse Prevention	End	2	0.0157130	0.01571230
Shear Capacity [kN]	Damage Limitation	Start	2	990.805	990.805

COMPUTER FILES

- NTC_rcjtcs2.bpf
- Report_ NTC_rcjtcs2.pdf

EXAMPLE 9.3

SUCCINCT DATA

- Secondary Member
- Smooth Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Inadequate Lap Length with lo/lou,min = 0.70
- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing column

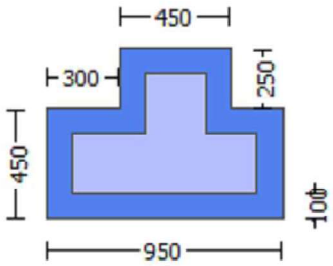
DESCRIPTION

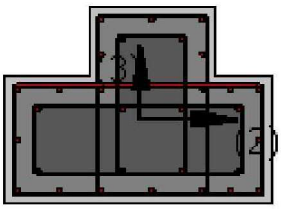
A jacketed T-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.40

Materials' Properties

Concrete Elasticity for Jacket, Ec = 26999.444
Concrete Elasticity for Existing Beam, Ec = 21019.039

Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = f_{ck} = 25.00
New material: Steel Strength,
fs = fsk = 500.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 14.28571
Existing material: Steel Strength,
fs = fs/Cf = 317.4571

For Shear Capacity Calculations

Jacket
New material of Secondary Member: Concrete Strength,
fc = fck = 25.00
New material of Secondary Member: Steel Strength,
fs = fsk = 500.00
Existing Column
Existing material of Secondary Member: Concrete Strength,
fc = fcm/Cf = 14.28571
Existing material of Secondary Member: Steel Strength,
fs = fs/Cf = 317.4571

Member's Properties

Max Height, Hmax = 700.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 300.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
γel = 1.15 for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.70
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.62. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 9.3

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	Start	3	0.0054341	0.0054341
	Life Safety	End	2	0.0315456	0.0315456
	Collapse Prevention	End	3	0.0271227	0.0271227
Shear Capacity [kN]	Life Safety	Start	3	1432.9	1432.882

NOTE: The small difference in the Shear Capacity values is due to the rounding of the shear capacity value exported to the Report.

COMPUTER FILES

- NTC_rcjtcs3.bpf
- Report_ NTC_rcjtcs3.pdf

EXAMPLE 9.4

SUCCINCT DATA

- Primary Member
- Ribbed Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Adequate Lap Length (lo/lou,min>=1)
- No FRP Wrapping
- Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing column

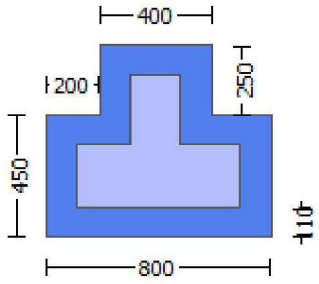
DESCRIPTION

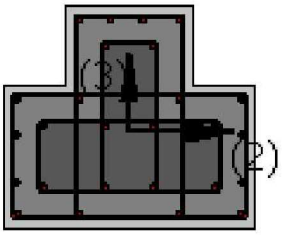
A jacketed T-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity for Jacket, Ec = 26999.444
Concrete Elasticity for Existing Beam, Ec = 24870.062
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = f_{ck} = 25.00
New material: Steel Strength,
fs = fsk = 500.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 23.33333
Existing material: Steel Strength,
fs = fs/Cf = 370.3667

For Shear Capacity Calculations

Jacket
New material of Primary Member: Concrete Strength,
fc = fck/γc = 16.66667
New material of Primary Member: Steel Strength,
fs = fsk/γs = 434.7826
Existing Column
Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 15.55556
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 322.058

Member's Properties

Max Height, Hmax = 700.00
Min Height, Hmin = 450.00
Max Width, Wmax = 800.00
Min Width, Wmin = 400.00
Eccentricity, Ecc = 200.00
Jacket Thickness, tj = 110.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
γel = 1.50 for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.63. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 9.4

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	End	2	0.0045437	0.0045437
	Life Safety	Start	3	0.0498105	0.0498105
	Collapse Prevention	Start	2	0.0540562	0.0540562
Shear Capacity [kN]	Collapse Prevention	End	2	710.349	710.349

COMPUTER FILES

- NTC_rcjtcs4.bpf
- Report_NTC_rcjtcs4.pdf

EXAMPLE 9.5

SUCCINCT DATA

- Primary Member
- Ribbed Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Lap Length lo = 300.00
- FRP Wrapping (Type: Carbon)
- Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing column

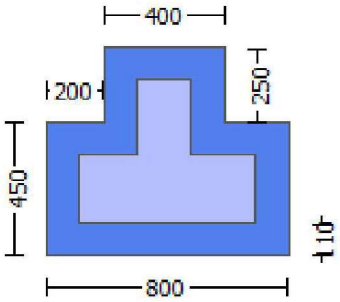
DESCRIPTION

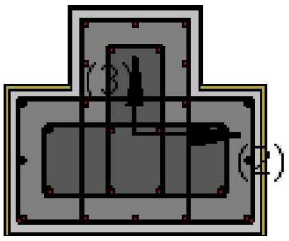
A jacketed T-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity for Jacket, Ec = 26999.444
Concrete Elasticity for Existing Beam, Ec = 24870.062
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = f_{ck} = 25.00
New material: Steel Strength,
fs = fsk = 500.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 23.33333
Existing material: Steel Strength,
fs = fs/Cf = 370.3667

For Shear Capacity Calculations

Jacket
New material of Primary Member: Concrete Strength,
fc = fck/γc = 16.66667
New material of Primary Member: Steel Strength,
fs = fsk/γs = 434.7826
Existing Column
Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 15.55556
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 322.058

Member's Properties

Max Height, Hmax = 700.00
Min Height, Hmin = 450.00
Max Width, Wmax = 800.00
Min Width, Wmin = 400.00
Eccentricity, Ecc = 200.00
Jacket Thickness, tj = 110.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
γel = 1.50 for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
Ribbed Bars
Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 0.34
Tensile Strength, ffu = 3793.00
Tensile Modulus, Ef = 234500.00
Elongation, efu = 0.015
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 2
Radius of rounding corners, R = 20.00
Environmental conversion factor, na = 0.95
Partial factor for the type of application, γm = 1.50
Nominal to design conversion factor, γm/n = γm/na = 1.57895

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.64. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 9.5

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	End	3	0.0064252	0.0064252
	Life Safety	Start	2	0.0220633	0.0220633
	Collapse Prevention	Start	3	0.0357368	0.0357366
Shear Capacity [kN]	Operational Level	Start	2	888.409	888.409

COMPUTER FILES

- NTC_rcjtcs5.bpf
- Report_ NTC_rcjtcs5.pdf

EXAMPLE 9.6

SUCCINCT DATA

- Secondary Member
- Smooth Bars
- Ductile Steel
- With Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Lap Length lo = 400.00
- FRP Wrapping (Type: Carbon)
- Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing column

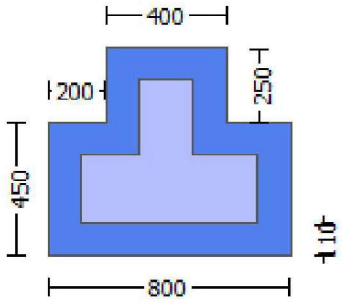
DESCRIPTION

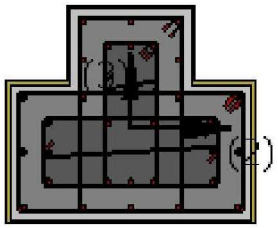
A jacketed T-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity for Jacket, Ec = 26999.444
Concrete Elasticity for Existing Beam, Ec = 24870.062
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = f_{ck} = 25.00
New material: Steel Strength,
fs = fsk = 500.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 23.33333
Existing material: Steel Strength,
fs = fs/Cf = 370.3667

For Shear Capacity Calculations

Jacket
New material of Secondary Member: Concrete Strength,
fc = fck = 25.00
New material of Secondary Member: Steel Strength,
fs = fsk = 500.00
Existing Column
Existing material of Secondary Member: Concrete Strength,
fc = fcm/Cf = 23.33333
Existing material of Secondary Member: Steel Strength,
fs = fs/Cf = 370.3667

Member's Properties

Max Height, Hmax = 700.00
Min Height, Hmin = 450.00
Max Width, Wmax = 800.00
Min Width, Wmin = 400.00
Eccentricity, Ecc = 200.00
Jacket Thickness, tj = 110.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
γel = 1.00 for Chord Rotation and Shear Capacity checks
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Lap Length lo = 400.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 0.129
Tensile Strength, ffu = 3200.00
Tensile Modulus, Ef = 220000.00
Elongation, efu = 0.017
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 2
Radius of rounding corners, R = 20.00
Environmental conversion factor, na = 0.85
Partial factor for the type of application, γm = 1.50
Nominal to design conversion factor, γm/n = γm/na = 1.76471

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.65. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 9.6

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	Start	2	0.0051905	0.0051905
	Life Safety	End	3	0.0338137	0.0338137
	Collapse Prevention	End	2	0.0660042	0.0660042
Shear Capacity [kN]	Damage Limitation	End	3	1195.8	1195.798

NOTE: The small difference in the Shear Capacity values is due to the rounding of the shear capacity value exported to the Report.

COMPUTER FILES

- NTC_rcjtcs6.bpf
- Report_NTC_rcjtcs6.pdf

EXAMPLE 9.7

SUCCINCT DATA

- Primary Member
- Smooth Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Inadequate Lap Length with lo/lou,min = 0.43
- No FRP Wrapping
- Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing column

DESCRIPTION

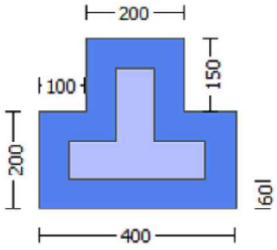
A jacketed T-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

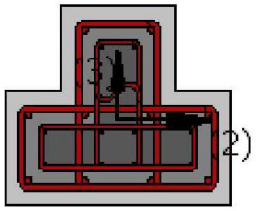
The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary. The final chord rotation capacity of the jacketed section is

calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity for Jacket, Ec = 26999.444
Concrete Elasticity for Existing Beam, Ec = 21019.039
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = f_{ck} = 12.00
New material: Steel Strength,
fs = fsk = 220.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 16.66667
Existing material: Steel Strength,
fs = fs/Cf = 203.70

For Shear Capacity Calculations

Jacket
New material of Primary Member: Concrete Strength,
fc = fck/γc = 8.00
New material of Primary Member: Steel Strength,
fs = fsk/γs = 191.3043
Existing Column
Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 11.11111
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 177.1304

Member's Properties

Max Height, Hmax = 350.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00
Jacket Thickness, tj = 60.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
γel = 1.15 for Chord Rotation checks and

γel = 1.20 for Shear Capacity checks
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Inadequate Lap Length with lo/lou,min = 0.43
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.66. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 9.7

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	End	2	0.0033857	0.0033857
	Life Safety	Start	3	0.0173178	0.0173178
	Collapse Prevention	Start	2	0.0171785	0.0171785
Shear Capacity [kN]	Collapse Prevention	End	2	94.038	94.038

COMPUTER FILES

- NTC_rcjtcs7.bpf
- Report_NTC_rcjtcs7.pdf

EXAMPLE 9.8

SUCCINCT DATA

- Secondary Member
- Smooth Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Inadequate Lap Length with lo/lou,min = 0.43
- No FRP Wrapping
- Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing column

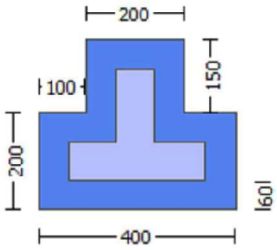
DESCRIPTION

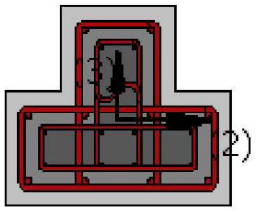
A jacketed T-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity for Jacket, Ec = 26999.444
Concrete Elasticity for Existing Beam, Ec = 21019.039
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = f_{ck} = 12.00
New material: Steel Strength,
fs = fsk = 220.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 16.66667
Existing material: Steel Strength,
fs = fs/Cf = 203.70

For Shear Capacity Calculations

Jacket
New material of Primary Member: Concrete Strength,
fc = fck/γc = 8.00
New material of Primary Member: Steel Strength,
fs = fsk/γs = 191.3043
Existing Column
Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 11.11111
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 177.1304

Member's Properties

Max Height, Hmax = 350.00
Min Height, Hmin = 200.00
Max Width, Wmax = 400.00
Min Width, Wmin = 200.00
Eccentricity, Ecc = 100.00
Jacket Thickness, tj = 60.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
γel = 1.10 for Chord Rotation checks and
γel = 1.10 for Shear Capacity checks
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Inadequate Lap Length with lo/lou,min = 0.43
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH) fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +Y)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.67. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 9.7

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	End	2	0.0117899	0.0117899
	Life Safety	Start	3	0.0175973	0.0175973
	Collapse Prevention	Start	2	0.0244426	0.0244426
Shear Capacity [kN]	Collapse Prevention	Start	3	139.359	139.359

COMPUTER FILES

- NTC_rcjtcs8.bpf
- Report_NTC_rcjtcs8.pdf

EXAMPLES SET 10: CIRCULARJACKETEDCOLUMN SECTION

EXAMPLE 10.1

SUCCINCT DATA

- Primary Member
- Ribbed Bars
- Ductile Steel
- With Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Adequate Lap Length(lo/lou,min> = 1)
- No FRP Wrapping
- Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing column

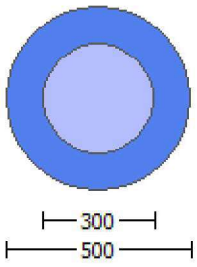
DESCRIPTION

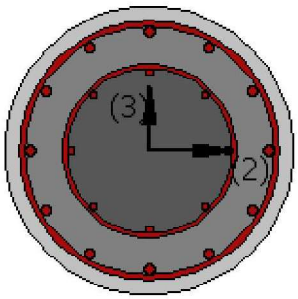
A jacketed circular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The equations of the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks cannot be employed in the case of circular column sections. The employed equations in SeismoBuild are those suggested by D. Biskinis and M. N. Fardis [2013].The equations of section 4.1.2.1.3 of NTC–08 are employed for Shear Capacity checks. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity for Jacket, Ec = 26999.444
Concrete Elasticity for Existing Column,Ec = 21019.039
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = f_{ck} = 25.00
New material: Steel Strength,
fs = fsk = 500.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 16.66667
Existing material: Steel Strength,
fs = fs/Cf = 370.3704

For Shear Capacity Calculations

Jacket
New material of Primary Member: Concrete Strength,
fc = fck/γc = 16.66667
New material of Primary Member: Steel Strength,
fs = fsk/γs = 434.7826
Existing Column
Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 11.11111
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 322.0612

Member's Properties

External Diameter, Dext = 500.00
Internal Diameter, Dint = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
γel = 1.75 for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH)fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.68. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 10.1

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	End	3	0.0065011	0.0065011
	Life Safety	Start	2	0.0170605	0.0170605
	Collapse Prevention	Start	3	0.0302274	0.0302274
Shear Capacity [kN]	Operational Level	End	3	339.044	339.044

COMPUTER FILES

- NTC_rcjcs1.bpf
- Report_ NTC_rcjcs1.pdf

EXAMPLE 10.2

SUCCINCT DATA

- Primary Member
- Smooth Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Lap Length lo = 600.00
- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing column

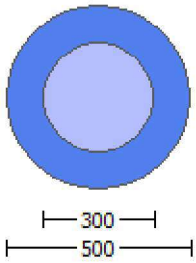
DESCRIPTION

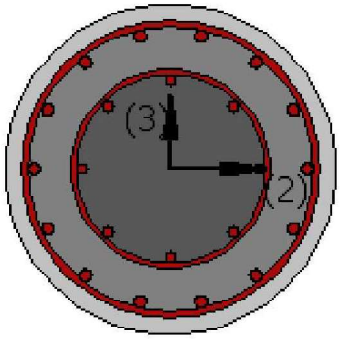
A jacketed circular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The equations of the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks cannot be employed in the case of circular column sections. The employed equations in SeismoBuild are those suggested by D. Biskinis and M. N. Fardis [2013]. The equations of section 4.1.2.1.3 of NTC–08 are employed for Shear Capacity checks. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.35

Materials' Properties

Concrete Elasticity for Jacket, Ec = 26999.444
Concrete Elasticity for Existing Column,Ec = 21019.039
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = f_{ck} = 25.00
New material: Steel Strength,
fs = fsk = 500.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 14.81481
Existing material: Steel Strength,
fs = fs/Cf = 329.2181

For Shear Capacity Calculations

Jacket
New material of Primary Member: Concrete Strength, fc = fck/γc = 15.625
New material of Primary Member: Steel Strength, fs = fsk/γs = 416.6667
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm/(Cf*γc) = 9.25926
Existing material of Primary Member: Steel Strength, fs = fs/(Cf*γs) = 274.3484

Member's Properties

External Diameter, Dext = 500.00
Internal Diameter, Dint = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
γel = 1.75 for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 600.00
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH)fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.69. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 10.2

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	Start	2	0.0095505	0.0095505
	Life Safety	End	3	0.0049714	0.0049714
	Collapse Prevention	End	2	0.0096601	0.0096601
Shear Capacity [kN]	Damage Limitation	Start	2	317.932	317.932

COMPUTER FILES

- NTC_rcjcs2.bpf
- Report_ NTC_rcjcs2.pdf

EXAMPLE 10.3

SUCCINCT DATA

- Secondary Member
- Smooth Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Inadequate Lap Length with lo/lou,min = 0.70
- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing column

DESCRIPTION

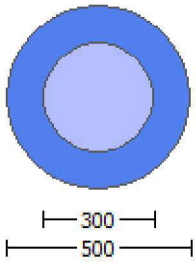
A jacketed circular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

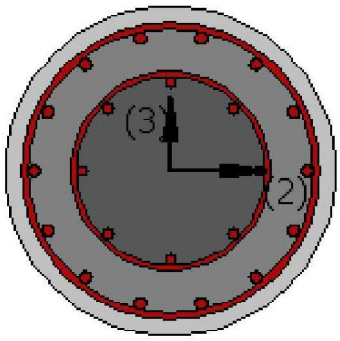
The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The equations of the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks cannot be employed in the case of circular column sections. The employed equations in SeismoBuild are those suggested by D. Biskinis and M. N. Fardis [2013]. The equations of section 4.1.2.1.3 of NTC–08 are employed for Shear Capacity checks. The final chord rotation capacity of the jacketed section is

calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.35

Materials' Properties

Concrete Elasticity for Jacket, Ec = 26999.444
Concrete Elasticity for Existing Column,Ec = 24870.062
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = f_{ck} = 25.00
New material: Steel Strength,
fs = fsk = 500.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 20.74074
Existing material: Steel Strength,
fs = fs/Cf = 181.0667

For Shear Capacity Calculations

Jacket
New material of Secondary Member: Concrete Strength,
fc = fck = 25.00
New material of Secondary Member: Steel Strength,
fs = fsk = 500.00
Existing Column
Existing material of Secondary Member: Concrete Strength,
fc = fcm/Cf = 20.74074
Existing material of Secondary Member: Steel Strength,
fs = fs/Cf = 181.0667

Member's Properties

External Diameter, Dext = 500.00
Internal Diameter, Dint = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
γel = 1.00 for Chord Rotation and Shear Capacity checks
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions

Inadequate Lap Length with lo/lou,min = 0.70
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH)fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.70. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 10.3

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	Start	3	0.022508	0.022508
	Life Safety	End	2	0.0129211	0.0129211
	Collapse Prevention	End	3	0.0110343	0.0110343
Shear Capacity [kN]	Life Safety	Start	3	409.477	409.477

COMPUTER FILES

- NTC_rcjcs3.bpf
- Report_ NTC_rcjcs3.pdf

EXAMPLE 10.4

SUCCINCT DATA

- Primary Member
- Ribbed Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Inadequate Lap Length with lo/lou,min = 0.70
- No FRP Wrapping
- Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing column

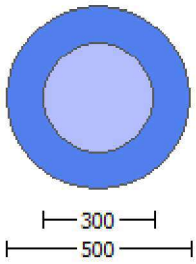
DESCRIPTION

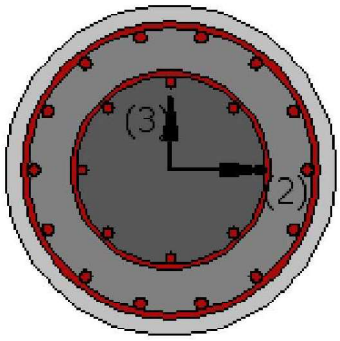
A jacketed circular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The equations of the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks cannot be employed in the case of circular column sections. The employed equations in SeismoBuild are those suggested by D. Biskinis and M. N. Fardis [2013]. The equations of section 4.1.2.1.3 of NTC–08 are employed for Shear Capacity checks. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity for Jacket, Ec = 26999.444
Concrete Elasticity for Existing Column,Ec = 24870.062
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = f_{ck} = 25.00
New material: Steel Strength,
fs = fsk = 500.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 23.33333
Existing material: Steel Strength,
fs = fs/Cf = 203.70

For Shear Capacity Calculations

Jacket
New material of Primary Member: Concrete Strength,
fc = fck/γc = 16.66667
New material of Primary Member: Steel Strength,
fs = fsk/γs = 434.7826
Existing Column
Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 15.55556
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 177.1304

Member's Properties

External Diameter, Dext = 500.00
Internal Diameter, Dint = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00

Primary Member
γel = 1.60 for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Inadequate Lap Length with lo/lou,min = 0.70
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH)fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.71. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 10.4

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	End	2	0.0151348	0.0151348
	Life Safety	Start	3	0.0164854	0.0164854
	Collapse Prevention	Start	2	0.0151342	0.0151342
Shear Capacity [kN]	Collapse Prevention	End	2	339.063	339.063

COMPUTER FILES

- NTC_rcjcs4.bpf
- Report_NTC_rcjcs4.pdf

EXAMPLE 10.5

SUCCINCT DATA

- Primary Member
- Smooth Bars
- Ductile Steel
- With Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Inadequate Lap Length with lo/lou,min = 0.70
- FRP Wrapping (Type: Carbon)

- Program's Default Safety/Confidence Factors
- NewMaterial Sets type for the Jacket and Existing Material Sets type for the Existing column

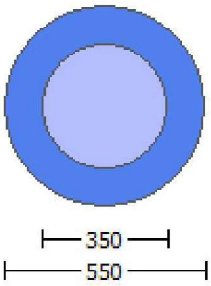
DESCRIPTION

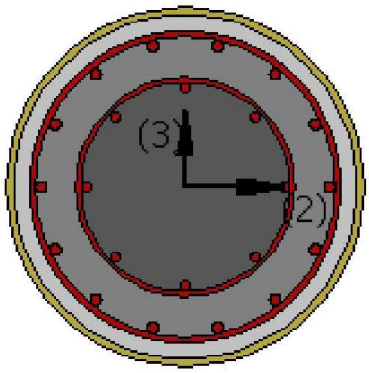
A jacketed circular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The equations of the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks cannot be employed in the case of circular column sections. The employed equations in SeismoBuild are those suggested by D. Biskinis and M. N. Fardis [2013].The equations of section 4.1.2.1.3 of NTC–08 are employed for Shear Capacity checks. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity for Jacket, Ec = 26999.444
Concrete Elasticity for Existing Column,Ec = 21019.039
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = fck = 25.00
New material: Steel Strength,
fs = fsk = 500.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 16.66667
Existing material: Steel Strength,
fs = fs/Cf = 203.70

For Shear Capacity Calculations

Jacket
New material of Primary Member: Concrete Strength,
fc = fck/γc = 16.66667
New material of Primary Member: Steel Strength,
fs = fsk/γs = 434.7826
Existing Column
Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 11.11111

-

For Shear Capacity Calculations

Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 177.1304

Member's Properties

External Diameter, Dext = 550.00
Internal Diameter, Dint = 350.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
γel = 1.60 for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.70
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 0.166
Tensile Strength, ffu = 3800.00
Tensile Modulus, Ef = 230000.00
Elongation, efu = 0.015
Number of directions, NoDir = 2
Fiber orientations, bi: 0.00°, 90.00°
Number of layers, NL = 1
Radius of rounding corners, R = 20.00
Environmental conversion factor, na = 0.95
Partial factor for the type of application, γm = 1.50
Nominal to design conversion factor, γm/n = γm/na = 1.57895

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH)fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.72. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 10.5

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	End	3	0.0065794	0.0065794
	Life Safety	Start	2	0.0132317	0.0132317
	Collapse Prevention	Start	3	0.0233402	0.0233402
Shear Capacity [kN]	Operational Level	Start	2	422.443	422.443

COMPUTER FILES

- NTC_rcjcs5.bpf
- Report_ NTC_rcjcs5.pdf

EXAMPLE 10.6

SUCCINCT DATA

- Primary Member
- Ribbed Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Lap Length lo = 400.00
- FRP Wrapping (Type: Carbon)
- Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing column

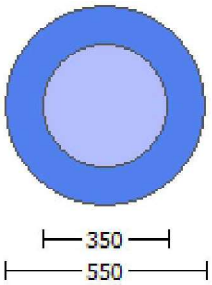
DESCRIPTION

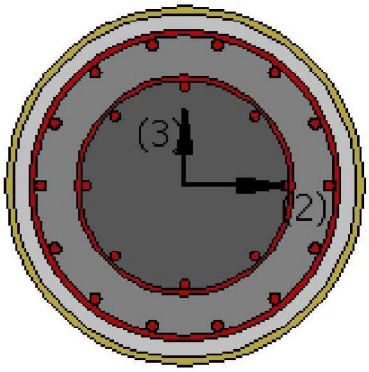
A jacketed circular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The equations of the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks cannot be employed in the case of circular column sections. The employed equations in SeismoBuild are those suggested by D. Biskinis and M. N. Fardis [2013]. The equations of section 4.1.2.1.3 of NTC–08 are employed for Shear Capacity checks. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity for Jacket, Ec = 26999.444
Concrete Elasticity for Existing Column,Ec = 21019.039
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = fck = 25.00
Newmaterial: Steel Strength,
fs = fsk = 500.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 16.66667
Existing material: Steel Strength,
fs = fs/Cf = 203.70

For Shear Capacity Calculations

Jacket
New material of Primary Member: Concrete Strength,
fc = fck/γc = 16.66667
New material of Primary Member: Steel Strength,
fs = fsk/γs = 434.7826
Existing Column
Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 11.11111
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 177.1304

Member's Properties

External Diameter, Dext = 550.00
Internal Diameter, Dint = 350.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
γel = 1.60 for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Lap Length lo = 400.00
FRP Wrapping Data

Type: Carbon
Dry properties (design values)
Thickness, t = 0.17
Tensile Strength, ffu = 3800.00
Tensile Modulus, Ef = 380000.00
Elongation, efu = 0.015
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 2
Radius of rounding corners, R = 20.00
Environmental conversion factor, na = 0.95
Partial factor for the type of application, γm = 1.50
Nominal to design conversion factor, γm/n = γm/na = 1.57895

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH)fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.73. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 10.6

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	Start	2	0.0166805	0.0166805
	Life Safety	End	3	0.0079393	0.0079393
	Collapse Prevention	End	2	0.0166805	0.0166805
Shear Capacity [kN]	Damage Limitation	End	3	422.443	422.443

COMPUTER FILES

- NTC_rcjcs6.bpf
- Report_ NTC_rcjcs6.pdf

EXAMPLE 10.7

SUCCINCT DATA

- Primary Member
- Smooth Bars
- Ductile Steel

- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Straight Ends Lapped Starting at the End Sections
- Lap Length lo = 600.00
- No FRP Wrapping
- Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing column

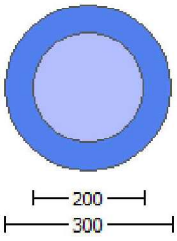
DESCRIPTION

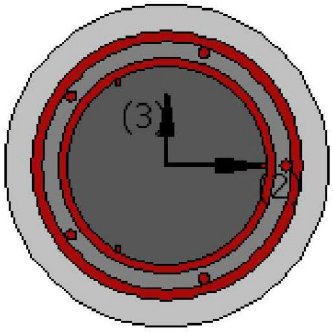
A jacketed circular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The equations of the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks cannot be employed in the case of circular column sections. The employed equations in SeismoBuild are those suggested by D. Biskinis and M. N. Fardis [2013]. The equations of section 4.1.2.1.3 of NTC–08 are employed for Shear Capacity checks. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity for Jacket, Ec = 23025.204
Concrete Elasticity for Existing Column, Ec = 24870.062
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = fck = 16.00
New material: Steel Strength,
fs = fsk = 220.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 16.66667

For Shear Capacity Calculations

Jacket
New material of Primary Member: Concrete Strength,
fc = $f_{ck}/\gamma c$= 15.00
New material of Secondary Member: Steel Strength,
fs = fsk = 183.3333

For Chord rotation Calculations

Existing material: Steel Strength,
fs = fs/Cf = 203.70

For Shear Capacity Calculations

Existing Column
Existing material of Secondary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 10.41667
Existing material of Secondary Member: Steel Strength,
fs = fs/(Cf*γs) = 169.75

Member's Properties

External Diameter, Dext = 300.00
Internal Diameter, Dint = 200.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
γel = 1.5 for Chord Rotation checks
γel = 1.15 for Shear Capacity checks
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars Straight Ends Lapped Starting at the End Sections
Lap Length lo = 600.00
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH)fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.74. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 10.7

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	Start	3	0.0138108	0.0138108
	Life Safety	End	2	0.0159874	0.0159874
	Collapse Prevention	End	3	0.0333803	0.0334448
Shear Capacity [kN]	Operational Level	Start	2	34.357	34.357

COMPUTER FILES

- NTC_rcjcs7.bpf
- Report_ NTC_rcjcs7.pdf

EXAMPLE 10.8

SUCCINCT DATA

- Primary Member
- Smooth Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Straight Ends Lapped Starting at the End Sections
- Lap Length lo = 600.00
- No FRP Wrapping
- Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing column

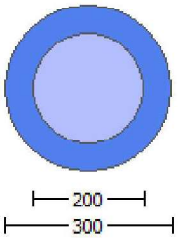
DESCRIPTION

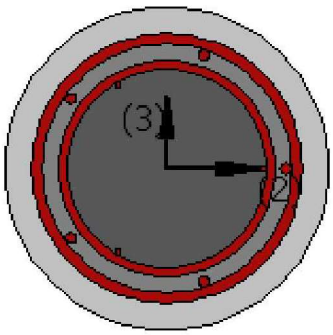
A jacketed circular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The equations of the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks cannot be employed in the case of circular column sections. The employed equations in SeismoBuild are those suggested by D. Biskinis and M. N. Fardis [2013]. The equations of section 4.1.2.1.3 of NTC–08 are employed for Shear Capacity checks. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity for Jacket, Ec = 23025.204
Concrete Elasticity for Existing Column, Ec = 24870.062
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = fck = 16.00
New material: Steel Strength,
fs = fsk = 220.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 16.66667
Existing material: Steel Strength,
fs = fs/Cf = 203.70

For Shear Capacity Calculations

Jacket
New material of Primary Member: Concrete Strength,
fc = f_{ck}/γc= 15.00
New material of Secondary Member: Steel Strength,
fs = fsk = 183.3333
Existing Column
Existing material of Secondary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 10.41667
Existing material of Secondary Member: Steel Strength,
fs = fs/(Cf*γs) = 169.75

Member's Properties

External Diameter, Dext = 300.00
Internal Diameter, Dint = 200.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
γel = 1.5 for Chord Rotation checks
γel = 1.15 for Shear Capacity checks
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars Straight Ends Lapped Starting at the End Sections
Lap Length lo = 600.00
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The column member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH)fully restrained at its support.

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.75. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 10.8

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	Start	3	0.0112464	0.0112464
	Life Safety	End	2	0.008442	0.008442
	Collapse Prevention	End	3	0.0163604	0.0163604
Shear Capacity [kN]	Operational Level	Start	2	31.073	31.073

COMPUTER FILES

- NTC_rcjcs8.bpf
- Report_ NTC_rcjcs8.pdf

EXAMPLES SET 11: JACKETED BEAMSECTION

EXAMPLE 11.1

SUCCINCT DATA

- Primary Member
- SmoothBars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Adequate Lap Length (lo/lou,min>=1)
- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing beam

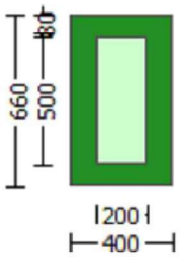
DESCRIPTION

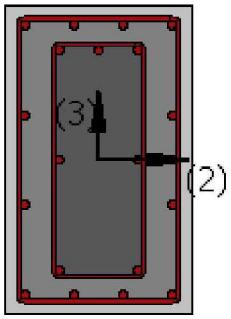
A jacketed beam section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.35

Materials' Properties

Concrete Elasticity for Jacket, Ec = 28972.746
Concrete Elasticity for Existing Column, Ec = 26999.444
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = fck = 30.00
New material: Steel Strength,
fs = fsk = 500.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 24.44444
Existing material: Steel Strength,
fs = fs/Cf = 329.2148

For Shear Capacity Calculations

Jacket
Newmaterial of Primary Member: Concrete Strength,
fc = fck/γc = 18.75
New material of Primary Member: Steel Strength,
fs = fsk/γs = 416.6667
Existing Column
Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 15.27778
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 274.3457

Member's Properties

External Height, H = 660.00
External Width, W = 400.00
Internal Height, H = 500.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Element Length, L = 2700.00
Primary Member
γel = 1.65for Chord Rotation checks and
γel = 1.00for Shear Capacity checks
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions

Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The beam member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH).

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.76. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 11.1

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	End	3	0.0066418	0.0066418
	Life Safety	Start	2	0.0270800	0.0270800
	Collapse Prevention	Start	3	0.0264841	0.0264841
Shear Capacity [kN]	Operational Level	End	3	645.243	645.243

COMPUTER FILES

- NTC_JBeam1.bpf
- Report_NTC_JBeam1.pdf

EXAMPLE 11.2

SUCCINCT DATA

- Secondary Member
- SmoothBars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Inadequate Lap Length with lo/lou,min = 0.40
- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing beam

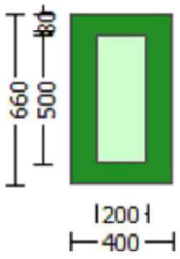
DESCRIPTION

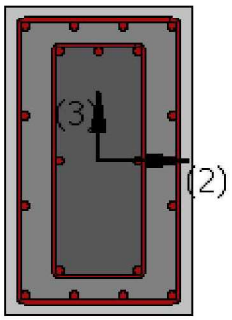
A jacketed beam section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.35

Materials' Properties

Concrete Elasticity for Jacket, Ec = 28972.746
Concrete Elasticity for Existing Column, Ec = 26999.444
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = fck = 30.00
New material: Steel Strength,
fs = fsk = 500.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 24.44444
Existing material: Steel Strength,
fs = fs/Cf = 329.2148

For Shear Capacity Calculations

Jacket
Newmaterial of Secondary Member: Concrete Strength,
fc = fck = 30.00
New material of Secondary Member: Steel Strength,
fs = fsk = 500.00
Existing Column
Existing material of Secondary Member: Concrete Strength,
fc = fcm/Cf = 24.44444
Existing material of Secondary Member: Steel Strength,
fs = fs/Cf = 329.2148

Member's Properties

External Height, H = 660.00
External Width, W = 400.00
Internal Height, H = 500.00
Internal Width, W = 200.00
Cover Thickness, c = 20.00

Element Length, L = 2700.00
Secondary Member
γel = 1.10 for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lou,min = 0.40
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The beam member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH).

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.77. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 11.2

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	Start	2	0.0045357	0.0045357
	Life Safety	End	3	0.0166818	0.0166818
	Collapse Prevention	End	2	0.0144050	0.0144050
Shear Capacity [kN]	Damage Limitation	Start	2	431.822	431.822

COMPUTER FILES

- NTC_JBeam2.bpf
- Report_NTC_JBeam2.pdf

EXAMPLE 11.3

SUCCINCT DATA

- Primary Member
- Ribbed Bars
- Ductile Steel
- With Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Lap Length lo = 400.00

- No FRP Wrapping
- Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing beam

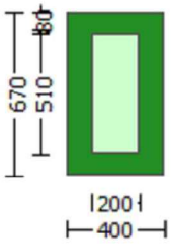
DESCRIPTION

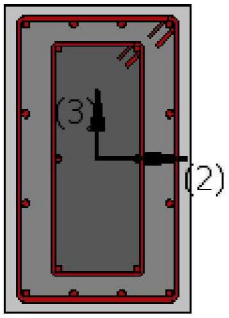
A jacketed beam section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity for Jacket, Ec = 28972.746
Concrete Elasticity for Existing Column, Ec = 23025.204
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = fck = 30.00
New material: Steel Strength,
fs = fsk = 400.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 20.00
Existing material: Steel Strength,
fs = fs/Cf = 203.70

For Shear Capacity Calculations

Jacket
Newmaterial of Primary Member: Concrete Strength, fc = fck/γc = 20.00
New material of Primary Member: Steel Strength, fs = fsk/γs = 347.8261
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm/(Cf*γc) = 13.33333
Existing material of Primary Member: Steel Strength, fs = fs/(Cf*γs) = 177.1304

Member's Properties

External Height, H = 670.00
External Width, W = 400.00
Internal Height, H = 510.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Element Length, L = 2745.906
Primary Member
γel = 1.50 for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions
Lap Length lo = 400.00
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The beam member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH).

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.78. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 11.3

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	Start	3	0.0057747	0.0057747
	Life Safety	End	2	0.0189817	0.0189817
	Collapse Prevention	End	3	0.0425396	0.0425396
Shear Capacity [kN]	Life Safety	Start	3	417.096	417.096

COMPUTER FILES

- NTC_JBeam3.bpf
- Report_NTC_JBeam3.pdf

EXAMPLE 11.4

SUCCINCT DATA

- Primary Member
- Ribbed Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Adequate Lap Length (lo/lou,min>=1)
- No FRP Wrapping
- Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing beam

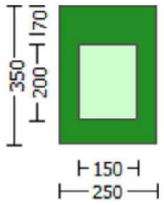
DESCRIPTION

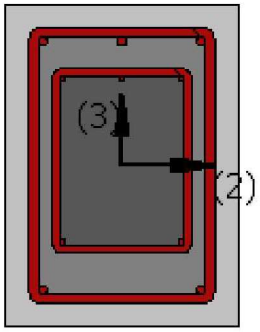
A jacketed beam section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties
Concrete Elasticity for Jacket, Ec = 28972.746
Concrete Elasticity for Existing Column, Ec = 23025.204
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = fck = 12.00
New material: Steel Strength,
fs = fsk = 220.00

For Shear Capacity Calculations

Jacket
Newmaterial of Primary Member: Concrete Strength,
fc = fck/γc = 8.00

For Chord rotation Calculations

Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 16.66667
Existing material: Steel Strength,
fs = fs/Cf = 203.70

For Shear Capacity Calculations

New material of Primary Member: Steel Strength,
fs = fsk/γs = 347.8261
Existing Column
Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 13.33333
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 177.1304

Member's Properties

External Height, H = 350.00
External Width, W = 250.00
Internal Height, H = 200.00
Internal Width, W = 150.00
Cover Thickness, c = 25.00
Element Length, L = 2700.00
Primary Member
γel = 1.50 for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The beam member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH).

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.79. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 11.4

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	End	2	0.0057747	0.0057747
	Life Safety	Start	3	0.0189827	0.0189827
	Collapse Prevention	Start	2	0.0425396	0.0425396
Shear Capacity [kN]	Collapse Prevention	End	2	417.097	417.097

COMPUTER FILES

- NTC_JBeam4.bpf
- Report_NTC_JBeam4.pdf

EXAMPLE 11.5

SUCCINCT DATA

- Primary Member
- RibbedBars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars Without Lapping in the Vicinity of the End Regions
- Inadequate Lap Length with lo/lou,min = 0.30
- No FRP Wrapping
- Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing beam

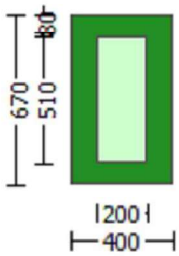
DESCRIPTION

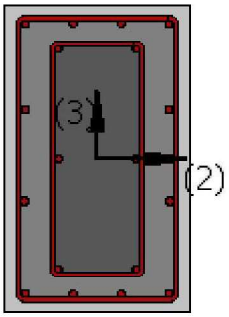
A jacketed beam section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.20

Materials' Properties

Concrete Elasticity for Jacket, Ec = 28972.746
Concrete Elasticity for Existing Column, Ec = 23025.204
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = fck = 30.00
New material: Steel Strength,
fs = fsk = 400.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 20.00
Existing material: Steel Strength,
fs = fs/Cf = 203.70

For Shear Capacity Calculations

Jacket
New material of Primary Member: Concrete Strength,
fc = fck/γc = 20.00
New material of Primary Member: Steel Strength, fs = f
sk/γs = 347.8261
Existing Column
Existing material of Primary Member: Concrete Strength,
fc = fcm/(Cf*γc) = 13.33333
Existing material of Primary Member: Steel Strength,
fs = fs/(Cf*γs) = 177.1304

Member's Properties

External Height, H = 670.00
External Width, W = 400.00
Internal Height, H = 510.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Element Length, L = 2700.00
Primary Member
γel = 1.50 for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars Without Lapping in the Vicinity of the End Regions

Inadequate Lap Length with lo/lou,min = 0.30
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The beam member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH).

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.80. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 11.5

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Damage Limitation	End	3	0.0033551	0.0033572
	Life Safety	Start	2	0.0031757	0.0031757
	Collapse Prevention	Start	3	0.0076288	0.0076288
Shear Capacity [kN]	Operational Level	Start	3	64.354	64.354

COMPUTER FILES

- NTC_JBeam5.bpf
- Report_NTC_JBeam5.pdf

EXAMPLE 11.6

SUCCINCT DATA

- Secondary Member
- Smooth Bars
- Ductile Steel
- Without Detailing for Earthquake Resistance (including stirrups closed at 135°)
- Longitudinal Bars With Ends Lapped Starting at the End Sections
- Lap Length lo = 400.00
- No FRP Wrapping
- Not the Program's Default Safety/Confidence Factors
- New Material Sets type for the Jacket and Existing Material Sets type for the Existing beam

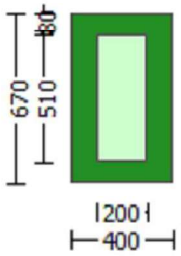
DESCRIPTION

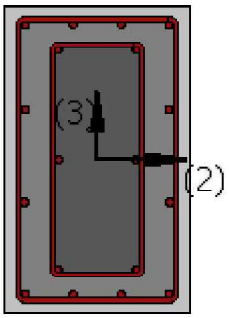
A jacketed beam section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are the (8.7.2.1) and (8.7.2.7a) of NTC–18 for Chord Rotation Capacity checks while Shear capacity checks are carried out according to the equations in section 4.1.2.1.3.5 of NTC–18 and C8.7.2.3.5 of NTC-18 commentary. The final chord rotation capacity of the jacketed section is calculated from the (8.7.4.2), (8.7.4.3) and (8.7.4.4) equations of the commentary of NTC–18 and the final shear capacity from the (8.7.4.1) equation of the commentary of NTC–18.

GEOMETRY AND PROPERTIES





Units in N, mm

Confidence Factor, Cf = 1.35

Materials' Properties

Concrete Elasticity for Jacket, Ec = 28972.746
Concrete Elasticity for Existing Column, Ec = 26999.444
Steel Elasticity, Es = 200000.00

For Chord rotation Calculations

Jacket
New material: Concrete Strength,
fc = fck = 30.00
New material: Steel Strength,
fs = fsk = 500.00
Existing Column
Existing material: Concrete Strength,
fc = fcm/Cf = 24.44444
Existing material: Steel Strength,
fs = fs/Cf = 329.2148

For Shear Capacity Calculations

Jacket
New material of Secondary Member: Concrete Strength,
fc = fck = 30.00
New material of Secondary Member: Steel Strength
fs = fsk = 500.00
Existing Column
Existing material of Secondary Member: Concrete Strength,
fc = fcm/Cf = 24.44444
Existing material of Secondary Member: Steel Strength,
fs = fs/Cf = 329.2148

Member's Properties

External Height, H = 660.00
External Width, W = 400.00
Internal Height, H = 500.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00

Element Length, L = 2700.00
Secondary Member
γel = 1.10 for Chord Rotation checks and
γel = 1.00 for Shear Capacity checks
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 400.00
No FRP Wrapping

NOTE 1: For the limit states of Operational Level and Damage Limitation, bar lapping is considered according to EC8, part-3.

NOTE 2: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

The beam member is modeled through an inelastic plastic-hinge force-based frame element (infrmFBPH).

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 3.81. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 11.6

Check	Limit State	Edge	Local Axis	SeismoBuild 2020	Hand calculations
Chord Rotation Capacity [rad]	Operational Level	Start	2	0.0046492	0.0046492
	Life Safety	End	3	0.0206740	0.0206740
	Collapse Prevention	End	2	0.0178524	0.0178526
Shear Capacity [kN]	Damage Limitation	End	3	782.620	782.620

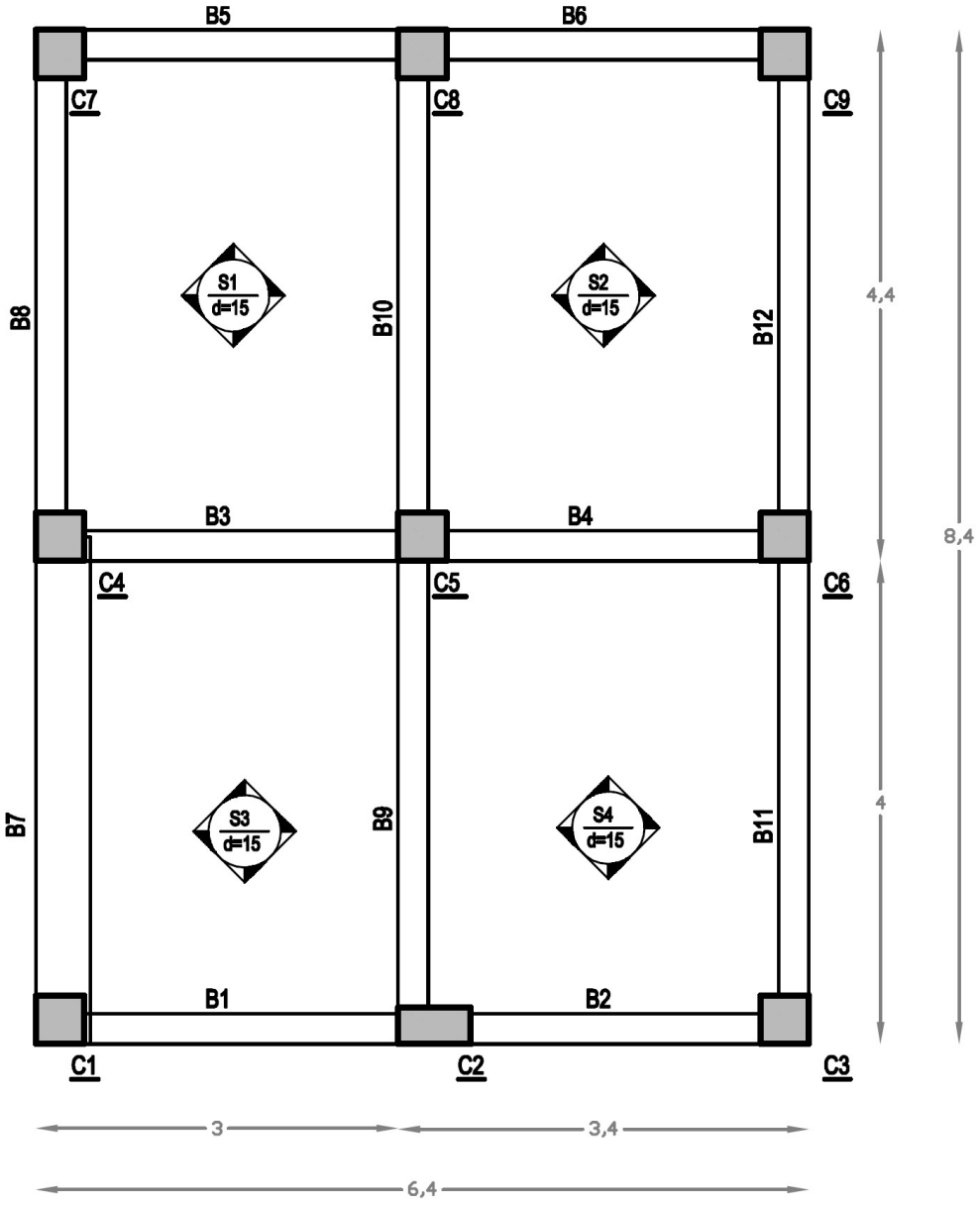
NOTE: The small difference between the Chord Rotation Capacity obtained from the Hand Calculations and SeismoBuild is due to the rounding of the shear capacity value exporte

COMPUTER FILES

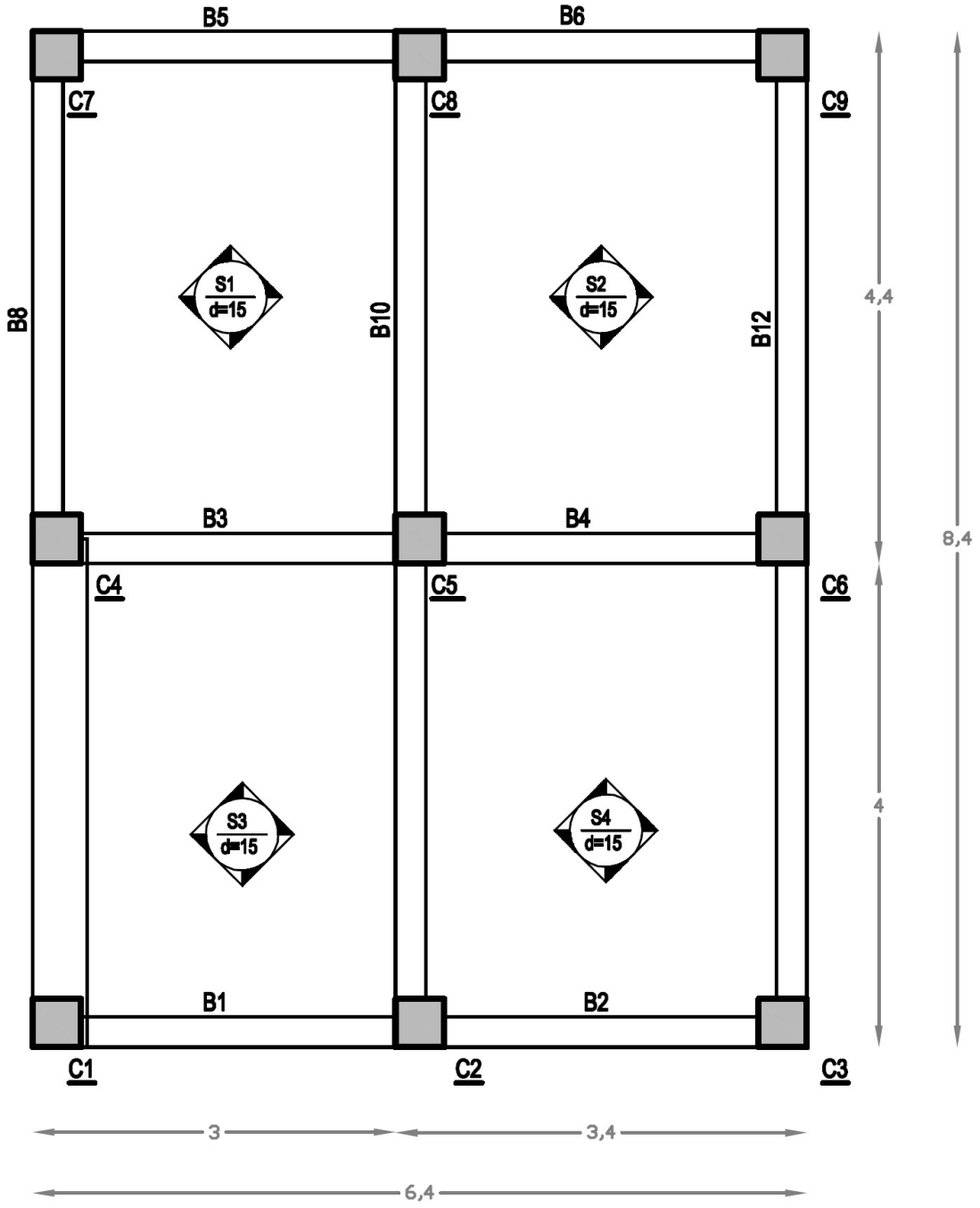
- NTC_JBeam6.bpf
- Report_NTC_JBeam6.pdf

Chapter 4 COMPARISON WITH INDEPENDENT HAND-CALCULATIONS – BEAM-COLUMN JOINTS CHECKS

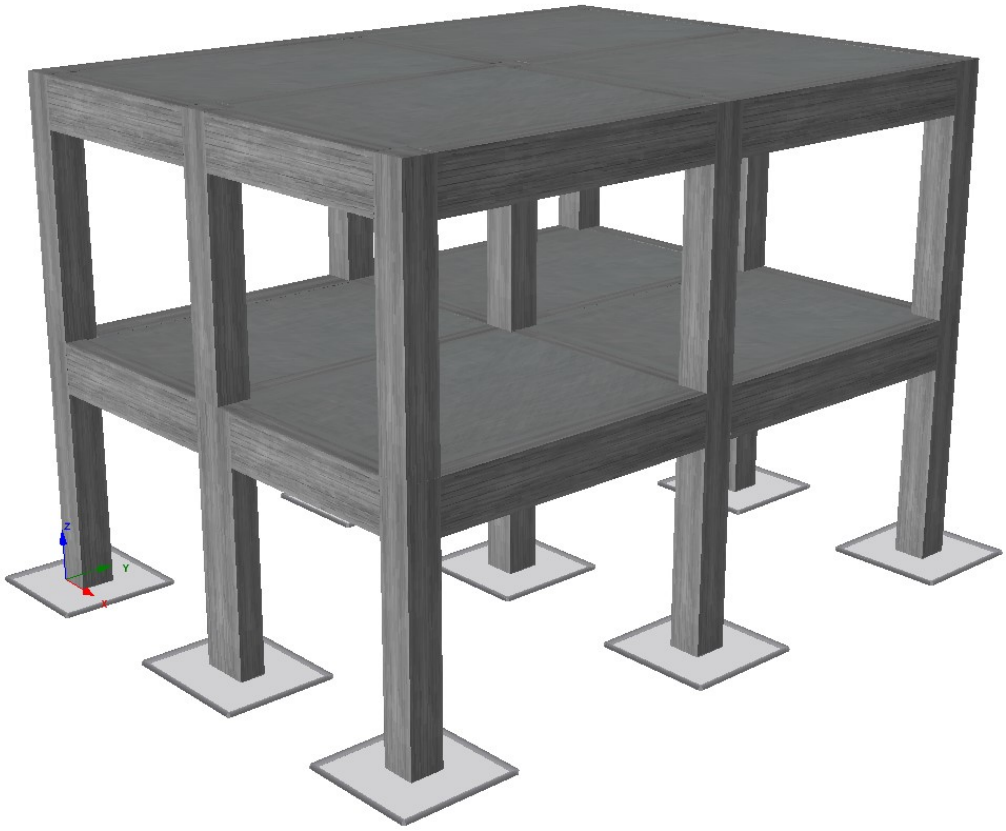
As noted above, this chapter makes use of examples, and their corresponding independent hand-calculations. A two storey 3D model with Typical Building Geometry (TBG) has been used for all the beam-columns joints examples. The plan views and the 3D model of the TBG are shown before each example:



1st floor Plan view of the building



2nd floor Plan view of the building



3D model of the building

EXAMPLE 1

SUCCINCT DATA

- Interior Joint: Beam B1- Column C2-Beam B2 of Floor 1
- Program's Default Safety/Confidence Factors
- Column Below:
  Rectangular Column section
  Primary Member
  Existing Material Sets type
- Beam B1:
  Beam section with effective width included
  Primary Member
  Existing Material Sets type
- Beam B2:
  Beam section with effective width included
  Primary Member
  Existing Material Sets type
- 1st and 2nd floor plan views are the same with TBG

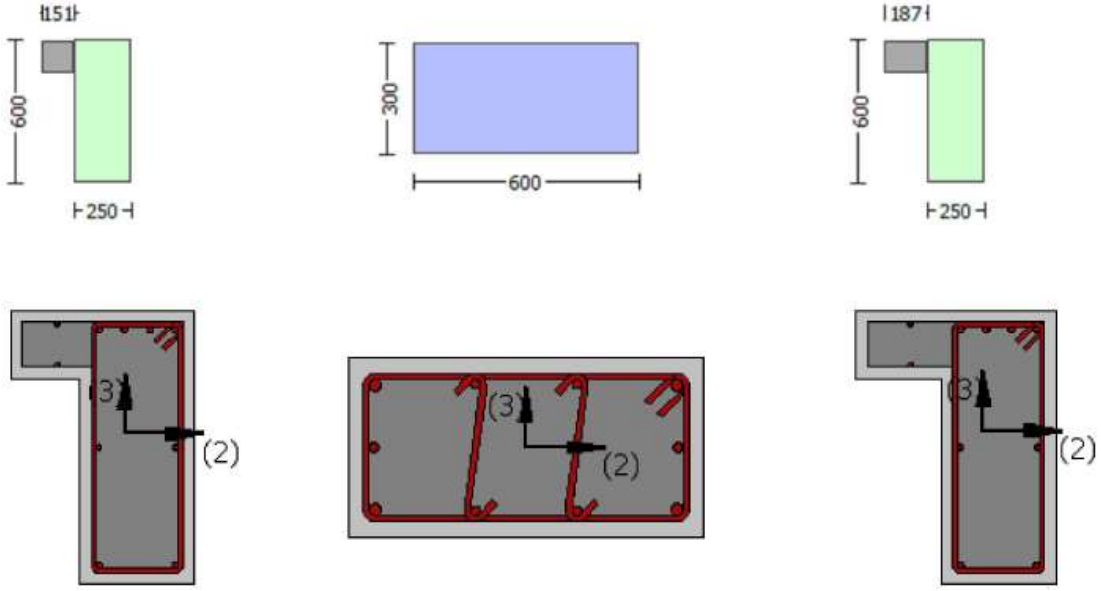
DESCRIPTION

The 3D model is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting joints diagonal tension and compression of the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are: (8.7.2.11) of commentary of NTC-18 for Joints Diagonal Tension checks and (8.7.2.12) of commentary of NTC-18 for Joints Diagonal Compression checks.

GEOMETRY AND PROPERTIES



Units in N, mm

Materials' Properties

Column Below: Existing Material: fcd_column = fcm_column/(γc*Confidence Factor) = 11.11111
fyd = fsm/(γs*Confidence Factor) = 322.058
Beam B1: Existing Material: fcd_beam = fcm_beam/(γc*Confidence Factor) = 11.11111
fyd = fsm/(γs*Confidence Factor) = 322.058
Beam B2: Existing Material: fcd_beam = fcm_beam/(γc*Confidence Factor) = 11.11111
fyd = fsm/(γs*Confidence Factor) = 322.058

Members' Properties

Column Below

Section Height, H = 300.00
Section Width, W = 600.00

Beam B1

Section Height, H = 600.00
Section Width, W = 250.00

Beam B2

Section Height, H = 600.00
Section Width, W = 250.00

NOTE: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

Beam and column members are modeled through the inelastic plastic-hinge force-based frame element type (infrmFBPH).

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 4.1. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 1.1

Check	Limit State	Capacity	
		SeismoBuild 2020	Hand calculations
Joints Diagonal Tension	Operational Level	1.0	1.0
Joints Diagonal Compression		5.556	5.556

COMPUTER FILES

- NTC_Joint1.bpf
- Report_NTC_Joint1.pdf

EXAMPLE 2

SUCCINCT DATA

- Exterior Joint: Column C2-Beam B9 of Floor 1
- Program's Default Safety/Confidence Factors
- Column Below:
  Rectangular Column section
  Primary Member
  Existing Material Sets type
- Beam B9:
  Beam section with effective width included
  Primary Member
  Existing Material Sets type
- 1st and 2nd floor plan views are the same with TBG

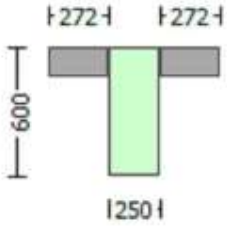
DESCRIPTION

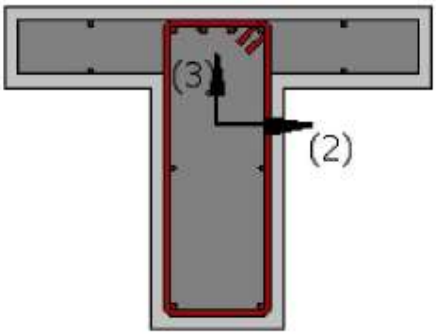
The 3D model is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

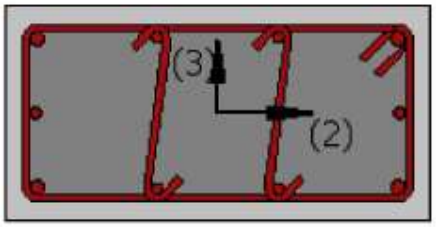
The resulting joints shear forces, horizontal hoops area and vertical reinforcement area of the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are: (8.7.2.11) of commentary of NTC-18 for Joints Diagonal Tension checks and (8.7.2.12) of commentary of NTC-18 for Joints Diagonal Compression checks.

GEOMETRY AND PROPERTIES







Units in N, mm

Materials' Properties

Column Below: Existing Material: fcd_column = fcm_column/(γc*Confidence Factor) = 11.11111
fyd = fsm/(γs*Confidence Factor) = 322.058
Column Above: Existing Material: fcd_column = fcm_column/(γc*Confidence Factor) = 11.11111
fyd = fsm/(γs*Confidence Factor) = 322.058
Beam B9: Existing Material: fcd_beam = fcm_beam/(γc*Confidence Factor) = 11.11111
fyd = fsm/(γs*Confidence Factor) = 322.058

Members' Properties

Column Below

Section Height, H = 300.00
Section Width, W = 600.00

Beam B9

Section Height, H = 600.00
Section Width, W = 250.00

NOTE: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

Beam and column members are modeled through the inelastic plastic-hinge force-based frame element type (infrmFBPH).

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 4.2. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 1.2

Check	Limit State	Capacity	
		SeismoBuild 2020	Hand calculations
Joints Diagonal Tension	Damage Limitation	1.0	1.0
Joints Diagonal Compression		5.556	5.556

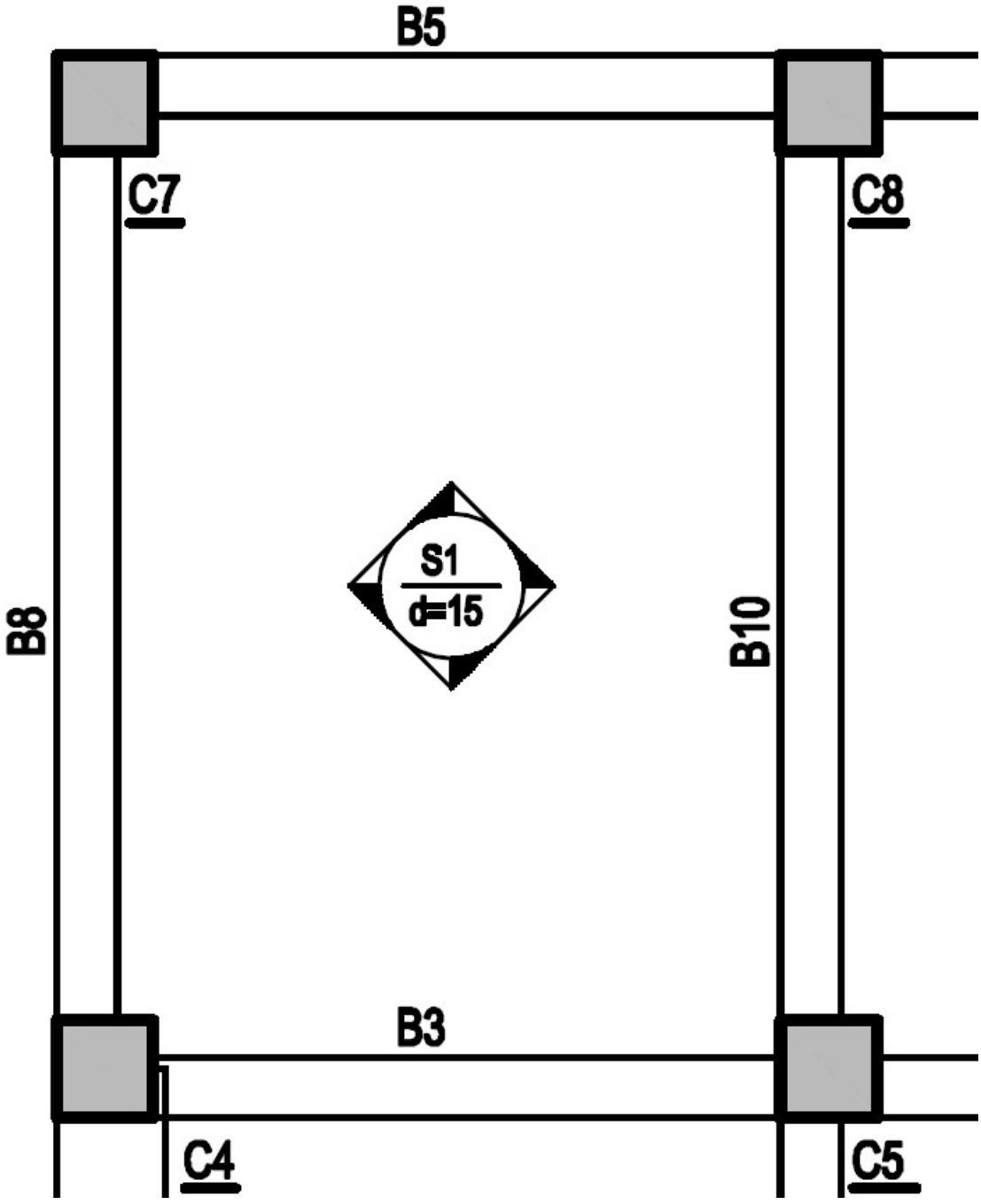
COMPUTER FILES

- NTC_Joint2.bpf
- Report_NTC_Joint2.pdf

EXAMPLE 3

SUCCINCT DATA

- Interior Joint: Beam B1-Column C2-Beam B2 of Floor 1
- Not the Program's Default Safety/Confidence Factors
- Column Below:
  L-Shaped Column section
  Primary Member
  Existing Material Sets type
- Beam B1:
  Beam section with effective width included
  Primary Member
  Existing Material Sets type
- Beam B2:
  Beam section with effective width included
  Primary Member
  New Material Sets type
- 2nd floor plan view is the same with TBG



1st floor Plan view of the building

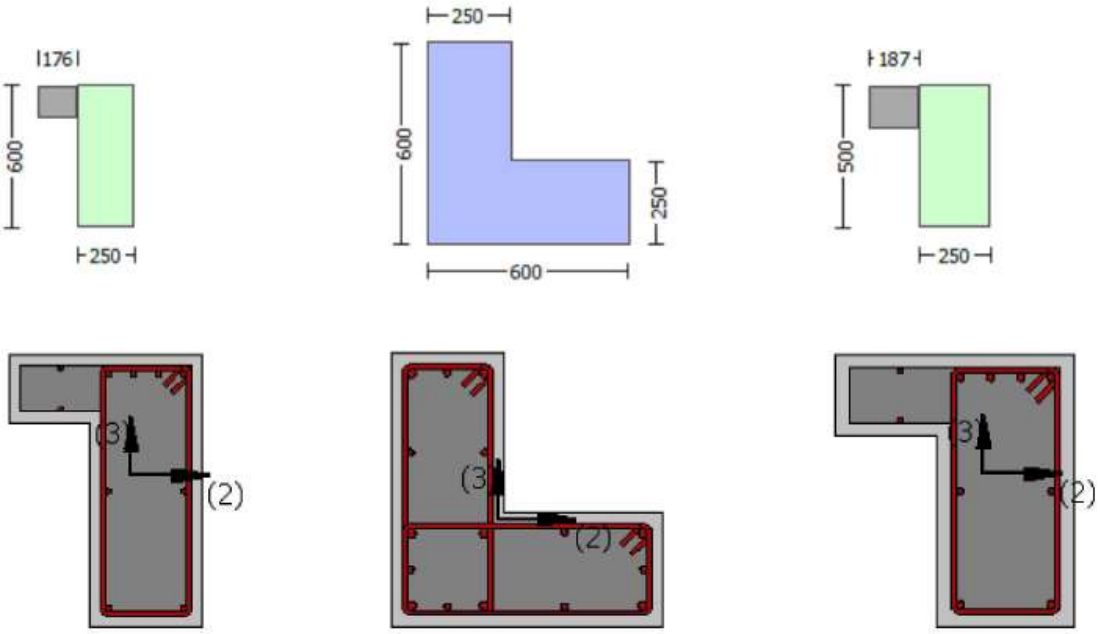
DESCRIPTION

The 3D model is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting joints shear forces, horizontal hoops area and vertical reinforcement area of the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are: (8.7.2.11) of commentary of NTC-18 for Joints Diagonal Tension checks and (8.7.2.12) of commentary of NTC-18 for Joints Diagonal Compression checks.

GEOMETRY AND PROPERTIES



Units in N, mm

Materials' Properties

Column Below: Existing Material: fcd_column = fcm_column/(γc*Confidence Factor) = 11.11111
fyd = fsm/(γs*Confidence Factor) = 322.058
Beam B1: Existing Material: fcd_beam = fcm_beam/(γc*Confidence Factor) = 11.11111
fyd = fsm/(γs*Confidence Factor) = 322.058
Beam B2: New Material: fcd_beam = fck_beam/γc = 16.66667
fyd = fsk/γs = 434.7826

Members' Properties

Column Below

Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 600.00
Min Width, Wmin = 250.00

Beam B1

Section Height, H = 500.00
Section Width, W = 250.00

Beam B2

Section Height, H = 600.00
Section Width, W = 250.00

NOTE: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

Beam and column members are modeled through the inelastic plastic-hinge force-based frame element type (infrmFBPH).

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 4.3. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 1.3

Check	Limit State	Capacity	
		SeismoBuild 2020	Hand calculations
Joints Diagonal Tension	Life Safety	1.0	1.0
Joints Diagonal Compression		5.556	5.556

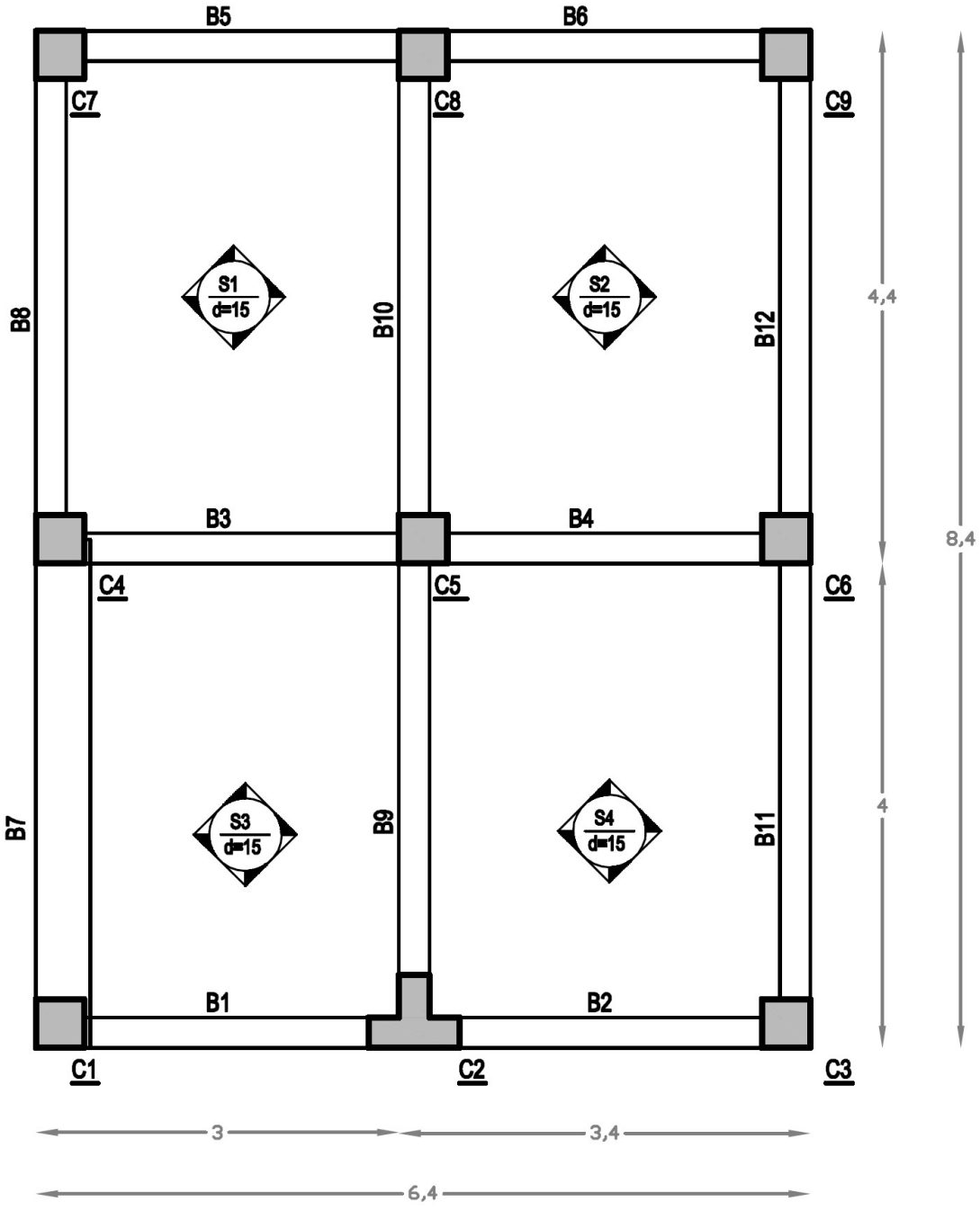
COMPUTER FILES

- NTC_Joint3.bpf
- Report_NTC_Joint3.pdf

EXAMPLE 4

SUCCINCT DATA

- Exterior Joint: Column C2-Beam B9 of Floor 1
- Program's Default Safety/Confidence Factors
- Column Below:
  T-Shaped Column section
  Primary Member
  Existing Material Sets type
- Beam B9:
  Beam section with effective width included
  Primary Member
  Existing Material Sets type
- 2nd floor plan view is the same with TBG



1st floor Plan view of the building

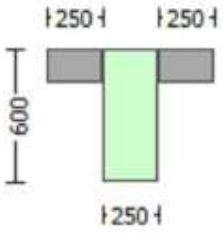
DESCRIPTION

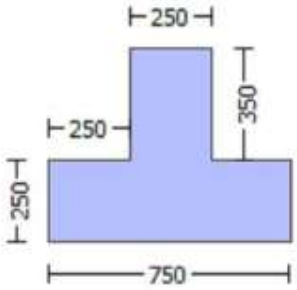
The 3D model is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

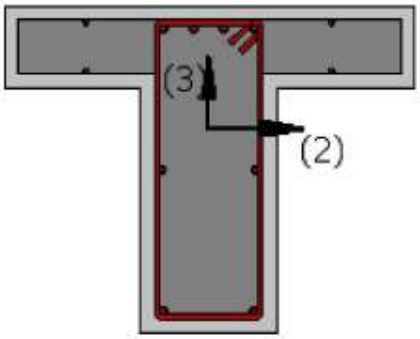
The resulting joints shear forces, horizontal hoops area and vertical reinforcement area of the FE analysis program SeismoBuild are compared with hand calculations.

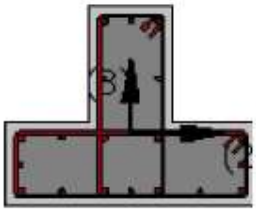
The employed equations are: (8.7.2.11) of commentary of NTC-18 for Joints Diagonal Tension checks and (8.7.2.12) of commentary of NTC-18 for Joints Diagonal Compression checks.

GEOMETRY AND PROPERTIES









Units in N, mm

Materials' Properties

Column Below: Existing Material: fcd_column = fcm_column/(γc*Confidence Factor) = 11.11111
fyd = fsm/(γs*Confidence Factor) = 322.058
Beam B9: Existing Material: fcd_beam = fcm_beam/(γc*Confidence Factor) = 11.11111
fyd = fsm/(γs*Confidence Factor) = 322.058

Members' Properties

Column Below

Max Height, Hmax = 600.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00

Beam B9

Section Height, H = 600.00
Section Width, W = 250.00

NOTE: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

Beam and column members are modeled through the inelastic plastic-hinge force-based frame element type (infrmFBPH).

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 4.4. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 1.4

Check	Limit State	Capacity	
		SeismoBuild 2020	Hand calculations
Joints Diagonal Tension	Collapse Prevention	1.0	1.0
Joints Diagonal Compression		5.556	5.556

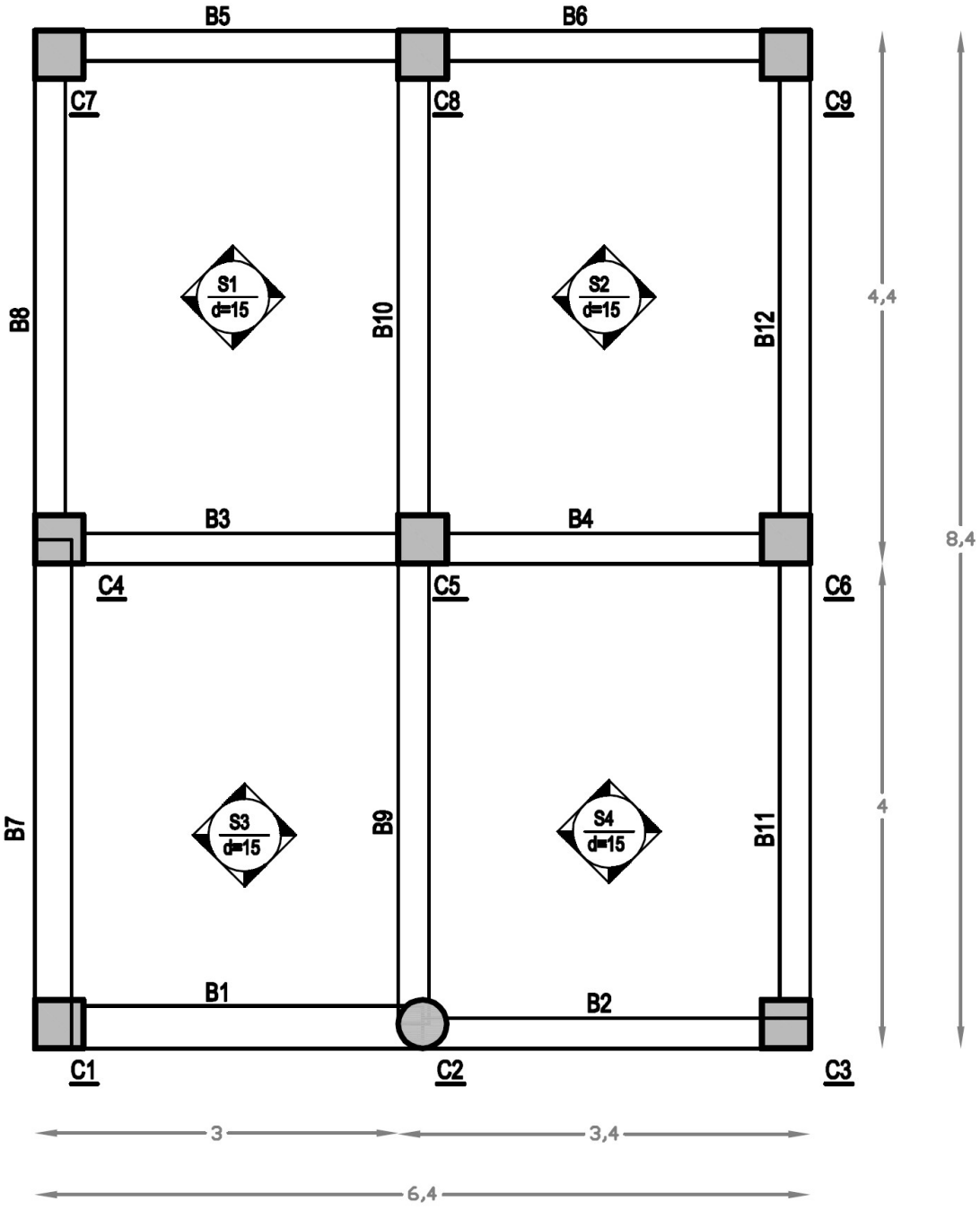
COMPUTER FILES

- NTC_Joint4.bpf
- Report_NTC_Joint4.pdf

EXAMPLE 5

SUCCINCT DATA

- Interior Joint: Beam B1-Column C2-Beam B2 of Floor 1
- Program's Default Safety/Confidence Factors
- Column Below:
  Circular Column section
  Primary Member
  New Material Sets type
- Beam B1:
  Beam section with effective width included
  Primary Member
  Existing Material Sets type
- Beam B2:
  Beam section with effective width included
  Primary Member
  New Material Sets type
- 2nd floor plan view is the same with TBG



1st floor Plan view of the building

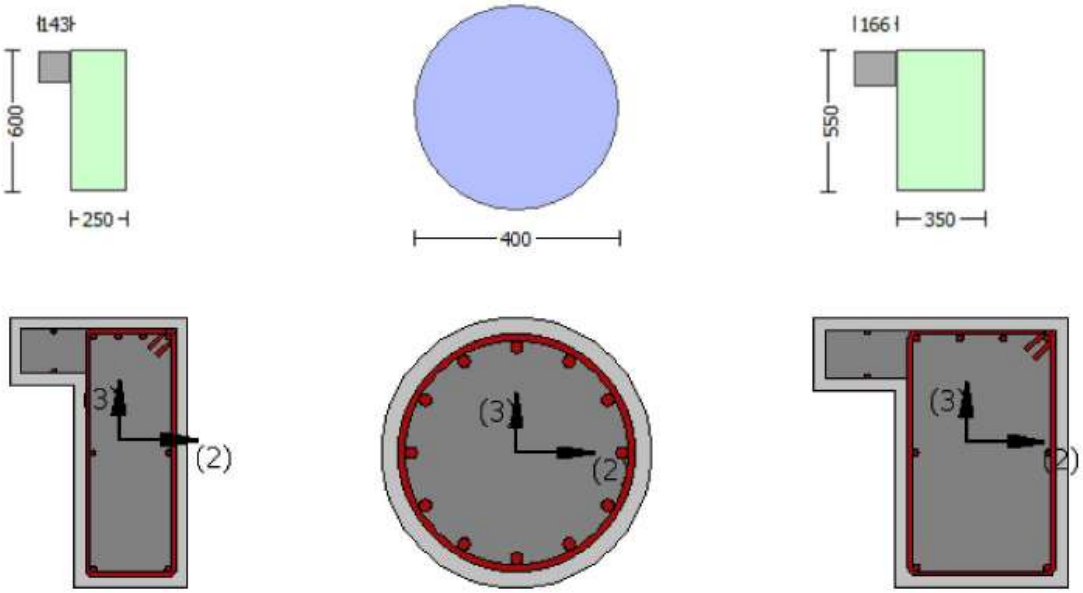
DESCRIPTION

The 3D model is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting joints shear forces, horizontal hoops area and vertical reinforcement area of the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are: (8.7.2.11) of commentary of NTC-18 for Joints Diagonal Tension checks and (8.7.2.12) of commentary of NTC-18 for Joints Diagonal Compression checks.

GEOMETRY AND PROPERTIES



Units in N, mm

Materials' Properties

Column Below: New Material: fcd_column = fck_column/γc = 16.66667
fywd = fsk_column/γs = 434.7826
Beam B1: Existing Material: fcd_beam = fcm_beam/(γc*Confidence Factor) = 11.11111
fyd = fsm/(γs*Confidence Factor) = 322.058
Beam B2: New Material: fcd_beam = fck_beam/γc = 16.66667
fyd = fsk/γs = 434.7826

Members' Properties

Column Below

Diameter, D = 400.00

Beam B1

Section Height, H = 550.00
Section Width, W = 350.00

Beam B2

Section Height, H = 600.00
Section Width, W = 250.00

NOTE: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

Beam and column members are modeled through the inelastic plastic-hinge force-based frame element type (infrmFBPH).

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 4.5. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 1.5

Check	Limit State	Capacity	
		SeismoBuild 2020	Hand calculations
Joints Diagonal Tension	Operational Level	1.0	1.0
Joints Diagonal Compression		5.556	5.556

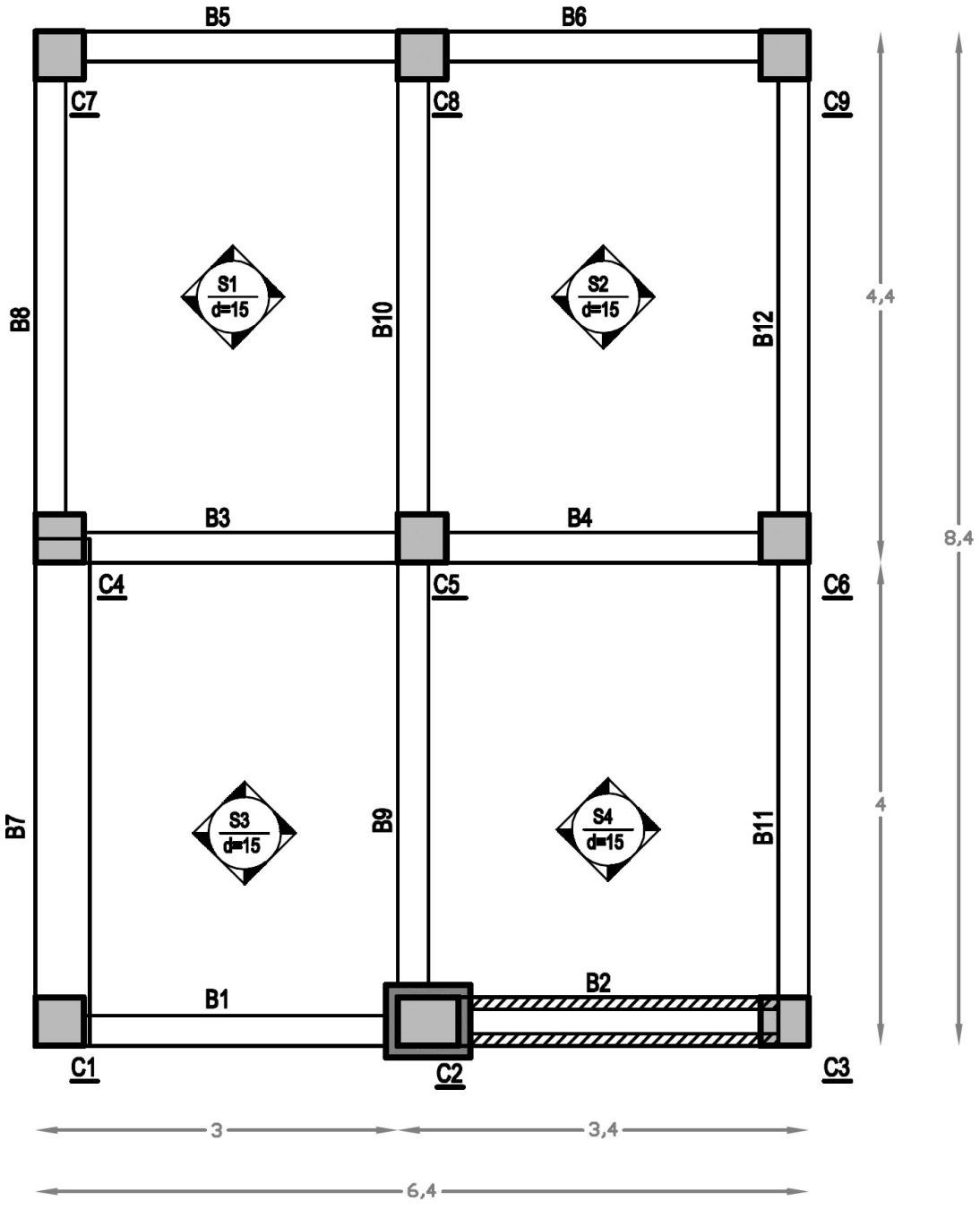
COMPUTER FILES

- NTC_Joint5.bpf
- Report_NTC_Joint5.pdf

EXAMPLE 6

SUCCINCT DATA

- Interior Joint: Beam B1-Column C2-Beam B2 of Floor 1
- Program's Default Safety/Confidence Factors
- Column Below:
  Jacketed Rectangular Column section
  Primary Member
  New Material Sets type for the Jacket and Existing Material Sets type for the Existing column
- Beam B1:
  Beam section with effective width included
  Primary Member
  Existing Material Sets type
- Beam B2:
  Jacketed Beam section with effective width included
  Primary Member
  New Material Sets type for the Jacket and Existing Material Sets type for the Existing beam
- 2nd floor plan view is the same with TBG



1st floor Plan view of the building

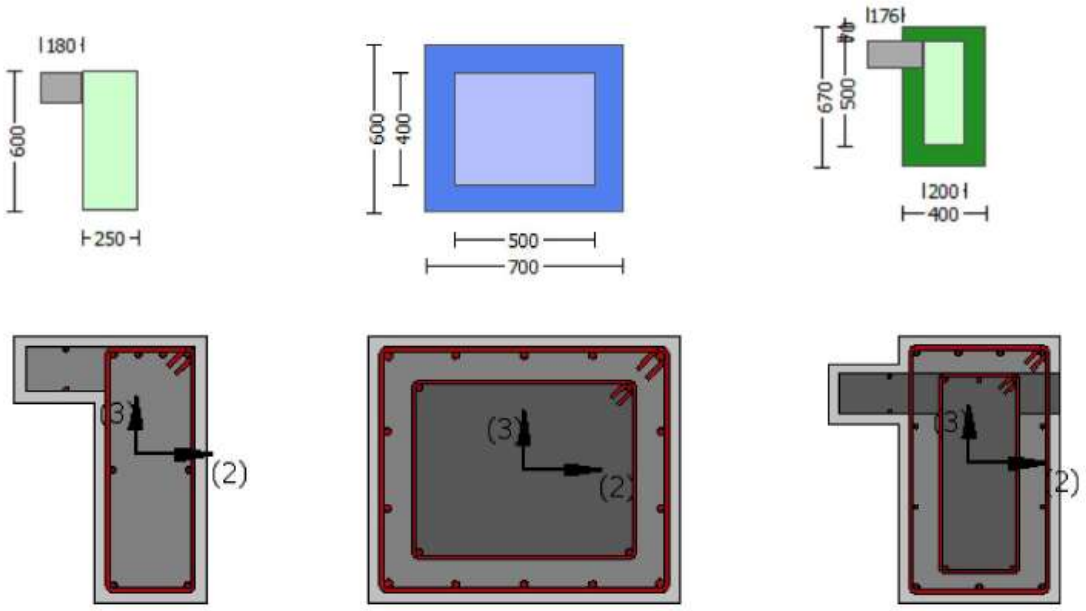
DESCRIPTION

The 3D model is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting joints shear forces, horizontal hoops area and vertical reinforcement area of the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are: (8.7.2.11) of commentary of NTC-18 for Joints Diagonal Tension checks and (8.7.2.12) of commentary of NTC-18 for Joints Diagonal Compression checks.

GEOMETRY AND PROPERTIES



Units in N, mm

Materials' Properties

Column Below: Existing Material: fcd_column = fcm_column/(γc*Confidence Factor) = 11.11111
New Material: fcd_column = fck_column/γc = 16.66667
fywd = fsk_column/γs = 434.7826

Beam B1: Existing Material: fcd_beam = fcm_beam/(γc*Confidence Factor) = 11.11111
fyd = fsm/(γs*Confidence Factor) = 322.058

Beam B2: Existing Material: fcd_beam = fcm_beam/(γc*Confidence Factor) = 11.11111
fyd_core = fsm_core/(γs*Confidence Factor) = 322.058
New Material: fyd_jacket = fsk_jacket/γs = 434.7826

Members' Properties

Column Below

External Height, H = 600.00
External Width, W = 700.00
Internal Height, H = 400.00
Internal Width, W = 500.00

Beam B1

Section Height, H = 600.00
Section Width, W = 250.00

Beam B2

External Height, H = 670.00
External Width, W = 400.00
Internal Height, H = 500.00
Internal Width, W = 200.00

NOTE: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

Beam and column members are modeled through the inelastic plastic-hinge force-based frame element type (infrmFBPH).

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 4.6. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 1.6

Check	Limit State	Capacity	
		SeismoBuild 2020	Hand calculations
Joints Diagonal Tension	Damage Limitation	1.0	1.0
Joints Diagonal Compression		5.556	5.556

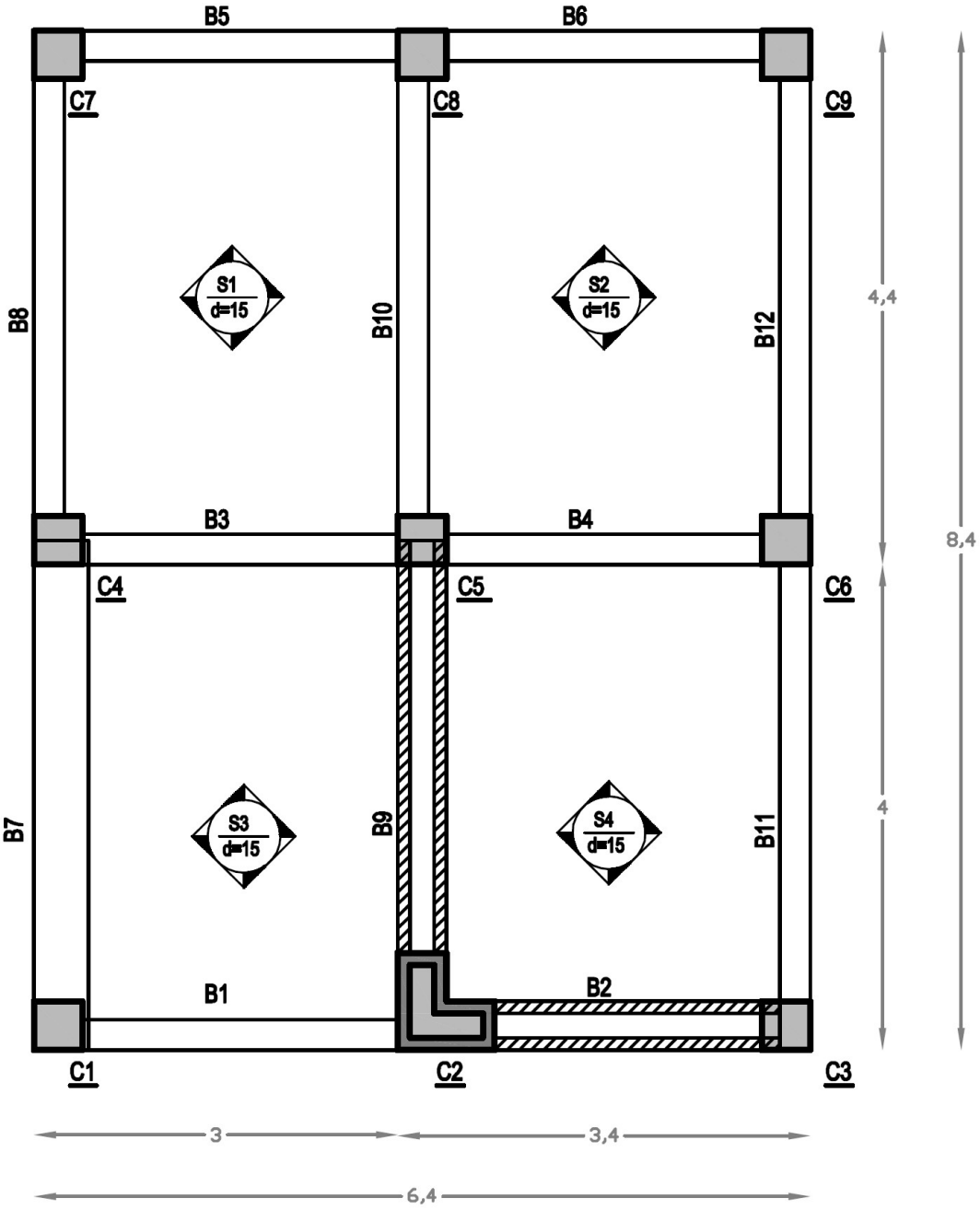
COMPUTER FILES

- NTC_Joint6.bpf
- Report_NTC_Joint6.pdf

EXAMPLE 7

SUCCINCT DATA

- Exterior Joint: Column C2-Beam B9 of Floor 1
- Program's Default Safety/Confidence Factors
- Column Below:
  Jacketed L-Shaped Column section
  Primary Member
  New Material Sets type for the Jacket and Existing Material Sets type for the Existing column
- Beam B9:
  Jacketed Beam section with effective width included
  Primary Member
  New Material Sets type for the Jacket and Existing Material Sets type for the Existing beam
- 2nd floor plan view is the same with TBG



1st floor Plan view of the building

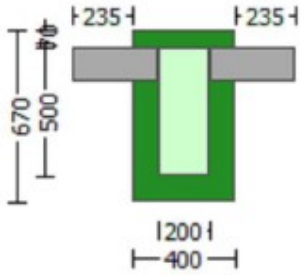
DESCRIPTION

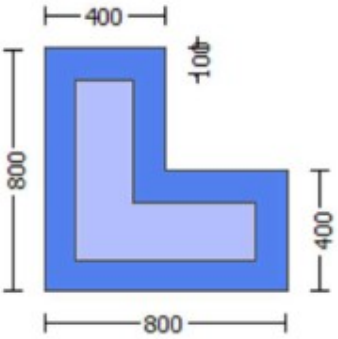
The 3D model is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

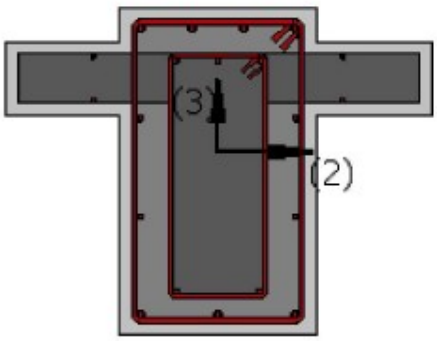
The resulting joints shear forces, horizontal hoops area and vertical reinforcement area of the FE analysis program SeismoBuild are compared with hand calculations.

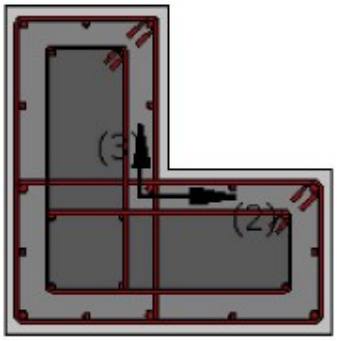
The employed equations are: (8.7.2.11) of commentary of NTC-18 for Joints Diagonal Tension checks and (8.7.2.12) of commentary of NTC-18 for Joints Diagonal Compression checks.

GEOMETRY AND PROPERTIES









Units in N, mm

Materials' Properties

Column Below: Existing Material: fcd_column = fcm_column/(γc*Confidence Factor) = 11.11111
New Material: fcd_column = fck_column/γc = 16.66667
fywd = fsk_column/γs = 434.7826

Beam B9: Existing Material: fcd_beam = fcm_beam/(γc*Confidence Factor) = 11.11111
fyd_core = fsm_core/(γs*Confidence Factor) = 322.058
New Material: fyd_jacket = fsk_jacket/γs = 434.7826

Members' Properties

Column Below

Max Height, Hmax = 800.00
Min Height, Hmin = 400.00
Max Width, Wmax = 800.00
Min Width, Wmin = 400.00
Jacket Thickness, tj = 100.00

Beam B9

External Height, H = 670.00
External Width, W = 400.00
Internal Height, H = 500.00
Internal Width, W = 200.00

NOTE: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

Beam and column members are modeled through the inelastic plastic-hinge force-based frame element type (infrmFBPH).

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 4.7. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 1.7

Check	Limit State	Capacity	
		SeismoBuild 2020	Hand calculations
Joints Diagonal Tension	Life Safety	1.0	1.0
Joints Diagonal Compression		5.556	5.556

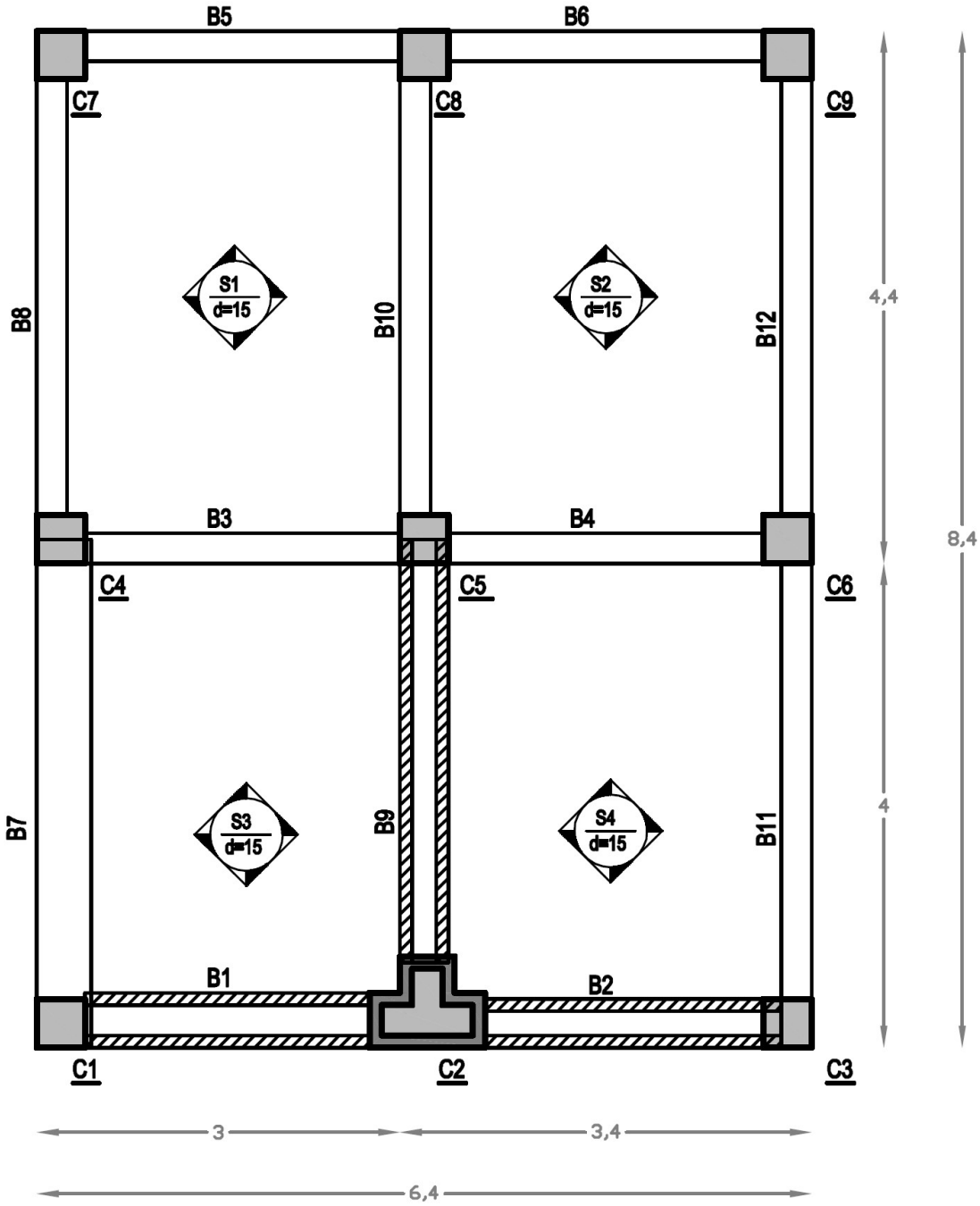
COMPUTER FILES

- NTC_Joint7.bpf
- Report_NTC_Joint7.pdf

EXAMPLE 8

SUCCINCT DATA

- Interior Joint: Beam B1-Column C2-Beam B2 of Floor 1
- Program's Default Safety/Confidence Factors
- Column Below:
  Jacketed T-Shaped Column section
  Primary Member
  New Material Sets type for the Jacket and Existing Material Sets type for the Existing column
- Beam B1:
  Jacketed Beam section with effective width included
  Primary Member
  New Material Sets type for the Jacket and Existing Material Sets type for the Existing beam
- Beam B2:
  Jacketed Beam section with effective width included
  Primary Member
  New Material Sets type for the Jacket and Existing Material Sets type for the Existing beam
- 2nd floor plan view is the same with TBG



1st floor Plan view of the building

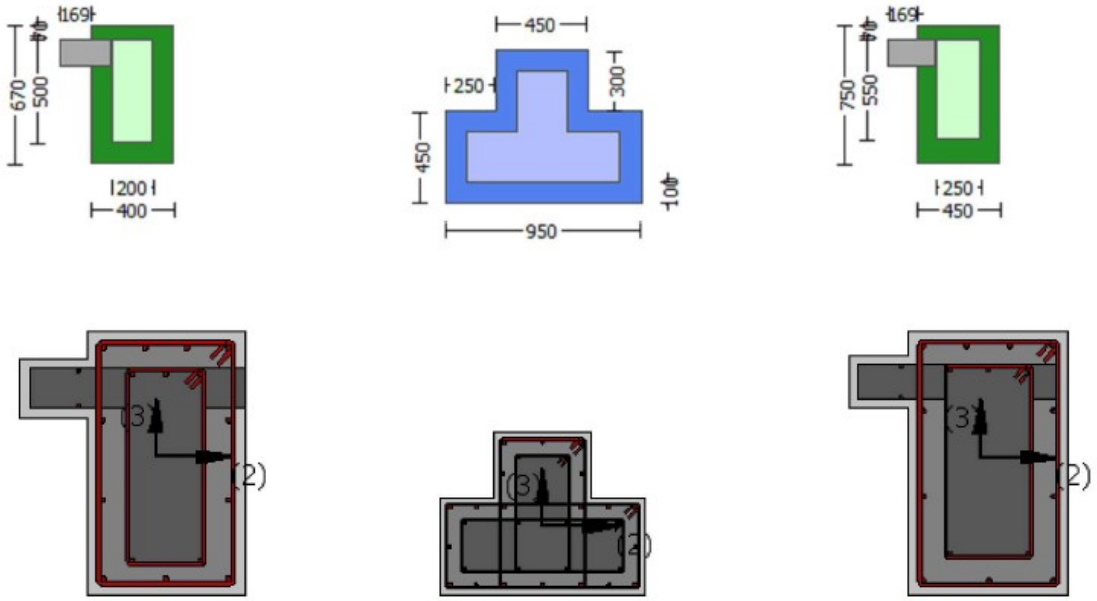
DESCRIPTION

The 3D model is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting joints shear forces, horizontal hoops area and vertical reinforcement area of the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are: (8.7.2.11) of commentary of NTC-18 for Joints Diagonal Tension checks and (8.7.2.12) of commentary of NTC-18 for Joints Diagonal Compression checks.

GEOMETRY AND PROPERTIES



Units in N, mm

Materials' Properties

Column Below: Existing Material: fcd_column = fcm_column/(γc*Confidence Factor) = 11.11111
New Material: fcd_column = fck_column/γc = 16.66667
fywd = fsk_column/γs = 434.7826

Beam B1: Existing Material: fcd_beam = fcm_beam/(γc*Confidence Factor) = 11.11111
fyd_core = fsm_core/(γs*Confidence Factor) = 322.058
New Material: fyd_jacket = fsk_jacket/γs = 434.7826

Beam B2: Existing Material: fcd_beam = fcm_beam/(γc*Confidence Factor) = 11.11111
fyd_core = fsm_core/(γs*Confidence Factor) = 322.058
New Material: fyd_jacket = fsk_jacket/γs = 434.7826

Members' Properties

Column Below

Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00

Beam B1

External Height, H = 750.00
External Width, W = 450.00
Internal Height, H = 550.00
Internal Width, W = 250.00

Beam B2

External Height, H = 670.00
External Width, W = 400.00
Internal Height, H = 500.00
Internal Width, W = 200.00

NOTE: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

Beam and column members are modeled through the inelastic plastic-hinge force-based frame element type (infrmFBPH).

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 4.8. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 1.8

Check	Limit State	Capacity	
		SeismoBuild 2020	Hand calculations
Joints Diagonal Tension	Collapse Prevention	1.0	1.0
Joints Diagonal Compression		5.556	5.556

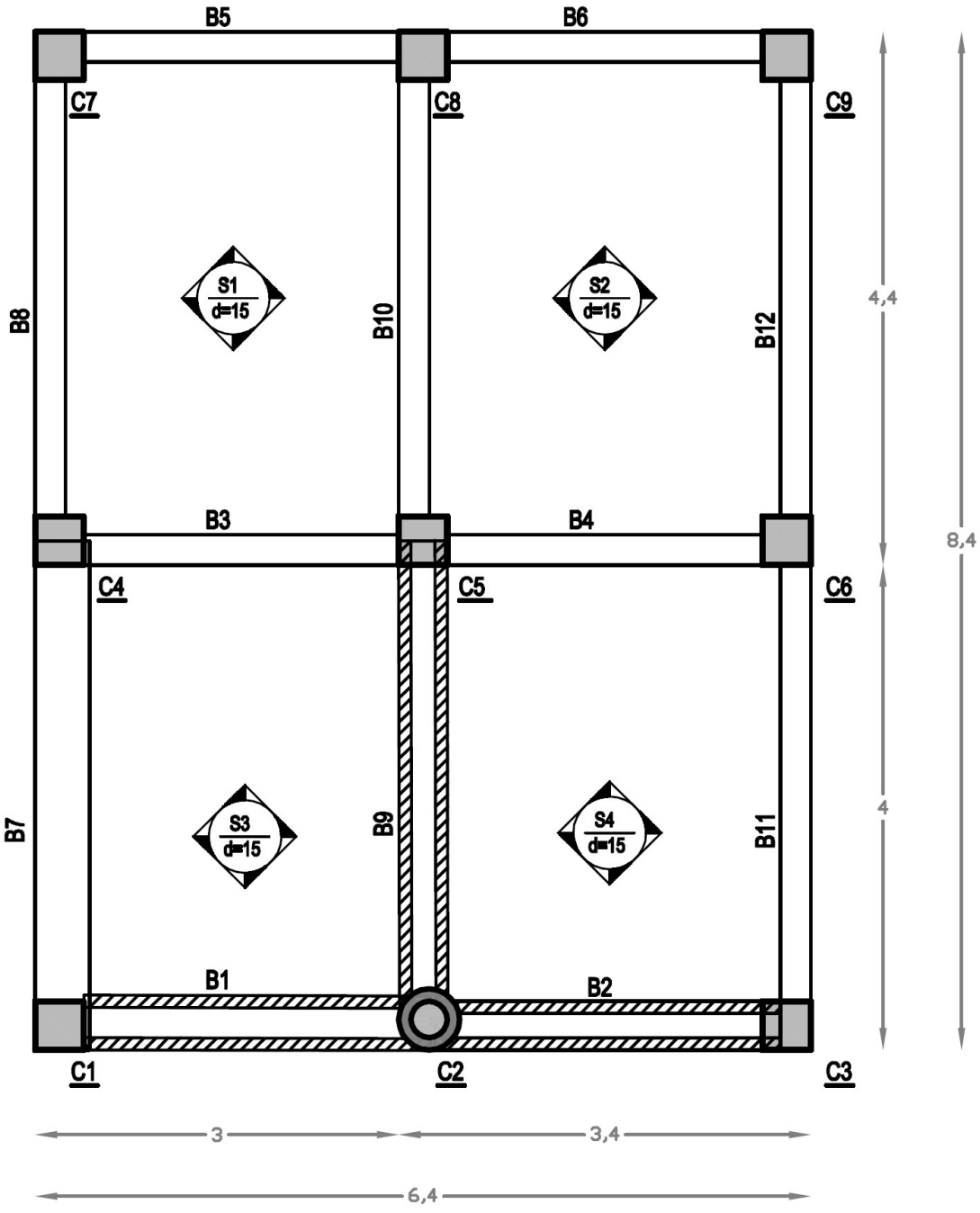
COMPUTER FILES

- NTC_Joint8.bpf
- Report_NTC_Joint8.pdf

EXAMPLE 9

SUCCINCT DATA

- Exterior Joint: Column C2-Beam B9 of Floor 1
- Program's Default Safety/Confidence Factors
- Column Below:
  Jacketed Circular Column section
  Primary Member
  New Material Sets type for the Jacket and Existing Material Sets type for the Existing column
- Beam B9:
  Jacketed Beam section with effective width included
  Primary Member
  New Material Sets type for the Jacket and Existing Material Sets type for the Existing beam
- 2nd floor plan view is the same with TBG



1st floor Plan view of the building

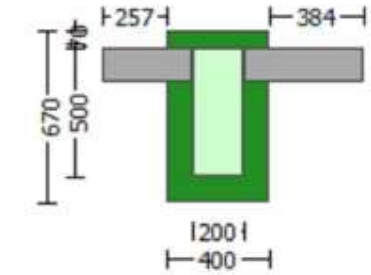
DESCRIPTION

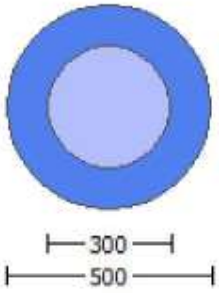
The 3D model is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

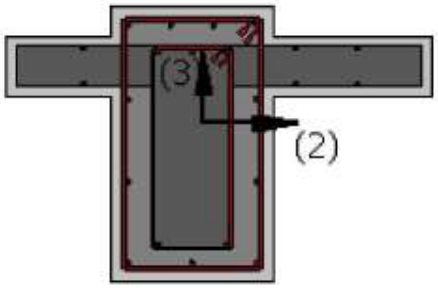
The resulting joints shear forces, horizontal hoops area and vertical reinforcement area of the FE analysis program SeismoBuild are compared with hand calculations.

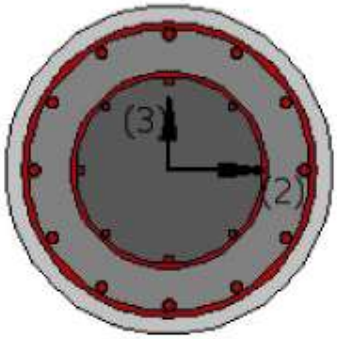
The employed equations are: (8.7.2.11) of commentary of NTC-18 for Joints Diagonal Tension checks and (8.7.2.12) of commentary of NTC-18 for Joints Diagonal Compression checks.

GEOMETRY AND PROPERTIES









Units in N, mm

Materials' Properties

Column Below: Existing Material: fcd_column = fcm_column/(γc*Confidence Factor) = 11.11111
New Material: fcd_column = fck_column/γc = 16.66667
fywd = fsk_column/γs = 434.7826

Beam B9: Existing Material: fcd_beam = fcm_beam/(γc*Confidence Factor) = 11.11111
fyd_core = fsm_core/(γs*Confidence Factor) = 322.058
New Material: fyd_jacket = fsk_jacket/γs = 434.7826

Members' Properties

Column Below

External Diameter, D = 500.00
Internal Diameter, D = 300.00

Beam B9

External Height, H = 670.00
External Width, W = 400.00
Internal Height, H = 500.00
Internal Width, W = 200.00

NOTE: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

Beam and column members are modeled through the inelastic plastic-hinge force-based frame element type (infrmFBPH).

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 4.9. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 1.9

Check	Limit State	Capacity	
		SeismoBuild 2020	Hand calculations
Joints Diagonal Tension	Operational Level	1.0	1.0
Joints Diagonal Compression		5.556	5.556

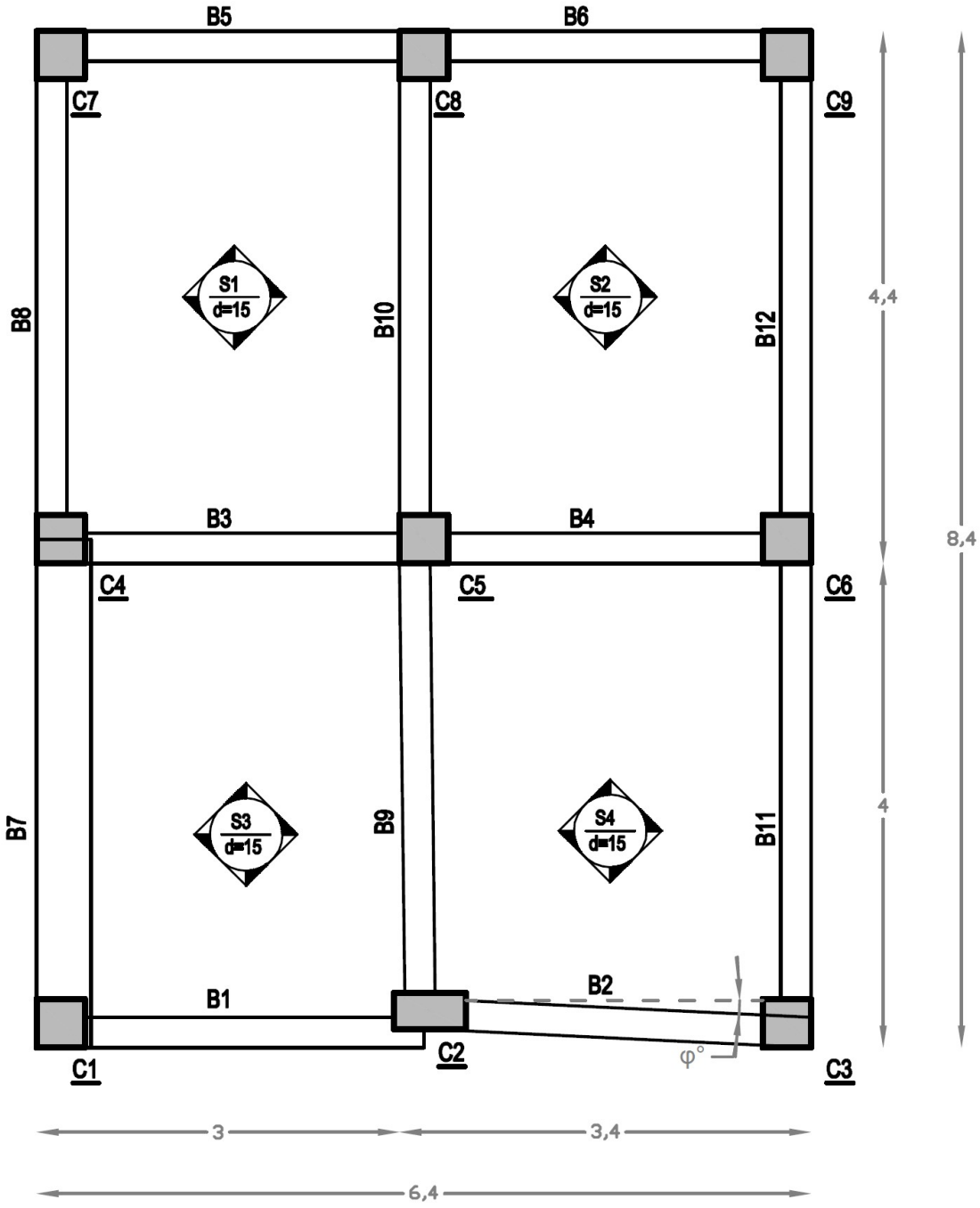
COMPUTER FILES

- NTC_Joint9.bpf
- Report_NTC_Joint9.pdf

EXAMPLE 10

SUCCINCT DATA

- Interior Joint: Beam B1- Column C2-Beam B2 of Floor 1
- Program's Default Safety/Confidence Factors
- Column Below:
  Rectangular Column section
  Primary Member
  Existing Material Sets type
- Beam B1:
  Beam section with effective width included
  Primary Member
  Existing Material Sets type
- Beam B2:
  Beam section with effective width included
  Primary Member
  Existing Material Sets type
- 2nd floor plan view is the same with TBG



1st floor Plan view of the building

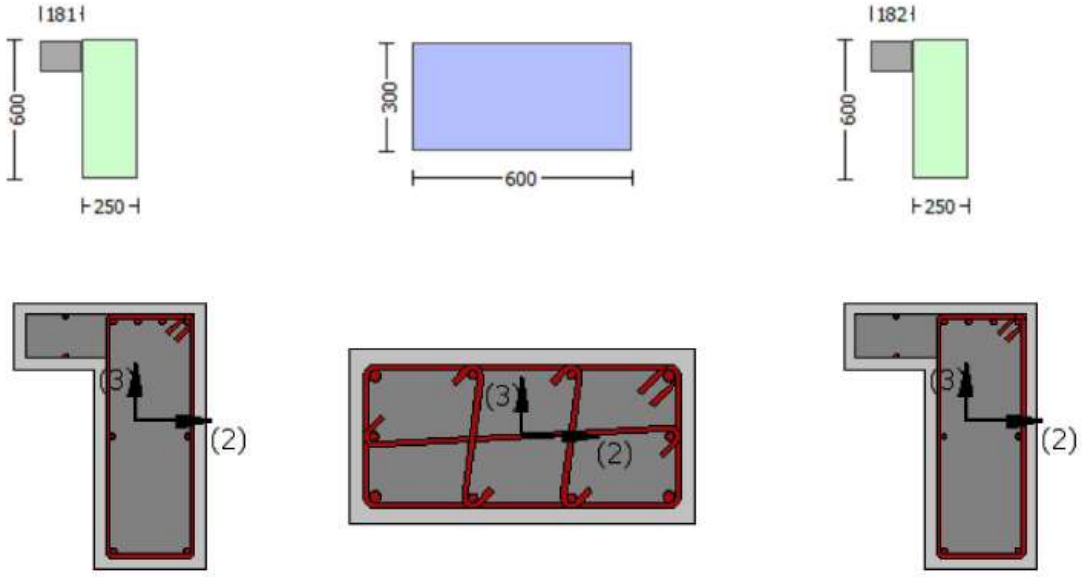
DESCRIPTION

The 3D model is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

The resulting joints shear forces, horizontal hoops area and vertical reinforcement area of the FE analysis program SeismoBuild are compared with hand calculations.

The employed equations are: (8.7.2.11) of commentary of NTC-18 for Joints Diagonal Tension checks and (8.7.2.12) of commentary of NTC-18 for Joints Diagonal Compression checks.

GEOMETRY AND PROPERTIES



Units in N, mm

Materials' Properties

Column Below: Existing Material: fcd_column = fcm_column/(γc*Confidence Factor) = 11.11111
fyd = fsm/(γs*Confidence Factor) = 322.058
Beam B1: Existing Material: fcd_beam = fcm_beam/(γc*Confidence Factor) = 11.11111
fyd = fsm/(γs*Confidence Factor) = 322.058
Beam B2: Existing Material: fcd_beam = fcm_beam/(γc*Confidence Factor) = 11.11111
fyd = fsm/(γs*Confidence Factor) = 322.058

Members' Properties

Column Below

Section Height, H = 300.00
Section Width, W = 600.00

Beam B1

Section Height, H = 600.00
Section Width, W = 250.00

Beam B2

Section Height, H = 600.00
Section Width, W = 250.00

NOTE 1: The structural eccentricity between beam B1 and column C2 is not taken into account according to Eurocode 8-Part 1.

NOTE 2: If the rotation angle between beam B2 and column C2(φ°) is less than 45°then the beam B2 is taken as horizontal. Else, if φ > 45°then the beam B2 is taken as vertical.

NOTE 3: All the required values for hand calculations may be exported to the Report by selecting the member of interest in the *Detailed Calculations(Annex)* tab of the Print-out Options module.

MODELLING AND LOADING

Beam and column members are modeled through the inelastic plastic-hinge force-based frame element type (infrmFBPH).

ANALYSIS TYPE

Pushover analysis (Uniaxial without Eccentricity-Uniform +X)

RESULTS COMPARISON

The most significant results are compared in the table below:

Table 4.10. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 1.10

Check	Limit State	Capacity	
		SeismoBuild 2020	Hand calculations
Joints Diagonal Tension	Damage Limitation	1.0	1.0
Joints Diagonal Compression		5.556	5.556

COMPUTER FILES

- NTC_Joint10.bpf
- Report_NTC_Joint10.pdf