SeismoBuild

Verification Report

For version 2021

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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 2021** 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:

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

(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:

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

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

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

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:

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

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:

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

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:

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

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

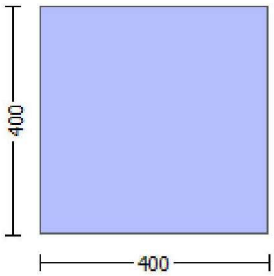
DESCRIPTION

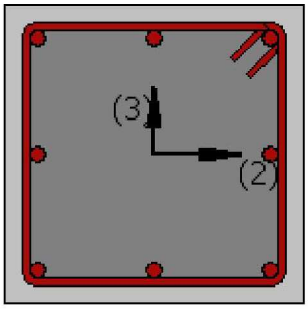
A rectangular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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





<u>Units in N, mm</u>

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	End	3	0.00667540	0.00667540
	Life Safety	Start	2	¾* 0.0375204	¾* 0.0375204
	Collapse Prevention	Start	3	0.04782821	0.04782821

Check	Limit State	Edge	Local Axis	SeismoBuild 2021	Hand calculations
Shear Capacity [kN]	Operational Level	End	3	274.813618	274.813618

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

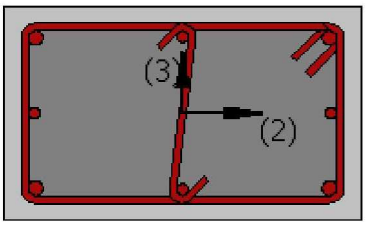
DESCRIPTION

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	Start	2	0.00231875	0.00231874
	Life Safety	End	3	¾*0.00873476	¾*0.00873479
	Collapse Prevention	End	2	0.01836581	0.01836581
Shear Capacity [kN]	Damage Limitation	Start	2	290.93661	290.93661

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

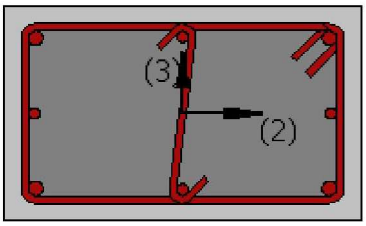
DESCRIPTION

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

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	Start	3	0.00810936	0.00810936
	Life Safety	End	2	¾*0.09956572	¾*0.09956572
	Collapse Prevention	End	3	0.0467182	0.0467182
Shear Capacity [kN]	Life Safety	Start	3	361.990813	361.990813

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

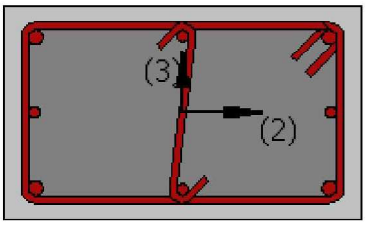
DESCRIPTION

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	End	2	0.0090437	0.0090437
	Life Safety	Start	3	¾* 0.19187627	¾* 0.19187617

Check	Limit State	Edge	Local Axis	SeismoBuild 2021	Hand calculations
	Collapse Prevention	Start	2	0.16273609	0.16273610
Shear Capacity [kN]	Collapse Prevention	End	2	642.322702	642.322702

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

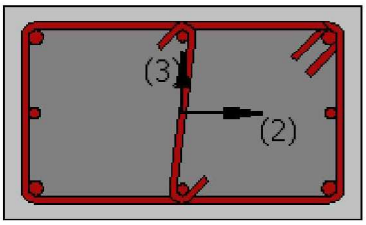
DESCRIPTION

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	End	3	0.00421525	0.00421525
	Life Safety	Start	2	¾*0.05684679	¾*0.05684679
	Collapse Prevention	Start	3	0.06784042	0.06784042
Shear Capacity [kN]	Operational Level	Start	2	656.377903	656.377903

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

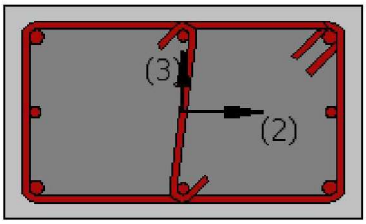
DESCRIPTION

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	Start	2	0.00772503	0.00772501
	Life Safety	End	3	3/4*0.01868758	3/4*0.01868758
	Collapse Prevention	End	2	0.03982565	0.03982565
Shear Capacity [kN]	Damage Limitation	End	3	264.270407	264.270407

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

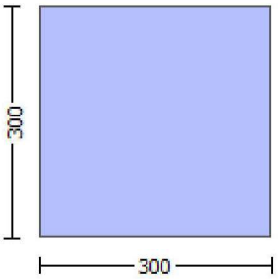
DESCRIPTION

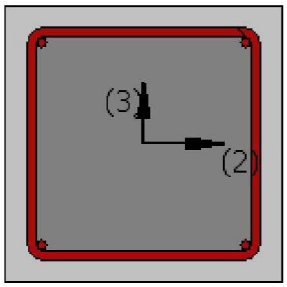
A rectangular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	End	3	0.01185089	0.01185089
	Life Safety	Start	2	3/4*0.01259184	3/4*0.01259184
	Collapse Prevention	Start	3	0.02045552	0.02045551
Shear Capacity [kN]	Operational Level	Start	2	145.4402172	145.4402172

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

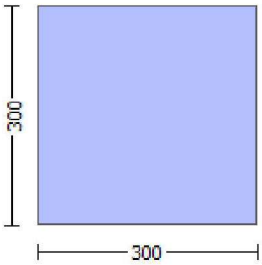
DESCRIPTION

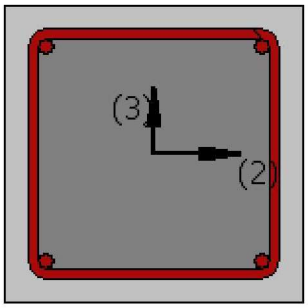
A rectangular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	End	2	0.00488051	0.00488051
	Life Safety	Start	3	3/4* 0.01751787	3/4* 0.01751787
	Collapse Prevention	Start	2	0.0107859	0.0107859
Shear Capacity [kN]	Operational Level	Start	2	144.3214463	144.3214463

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

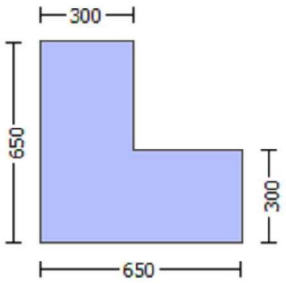
DESCRIPTION

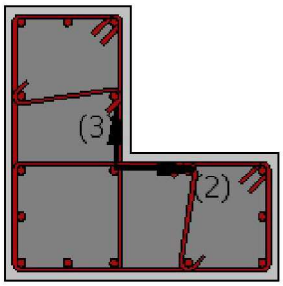
An L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	End	3	0.00649442	0.00649442
	Life Safety	Start	2	¾*0.04366193	¾*0.04366193
	Collapse Prevention	Start	3	0.04896188	0.04896188
Shear Capacity [kN]	Operational Level	End	3	360.1181461	360.1181461

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

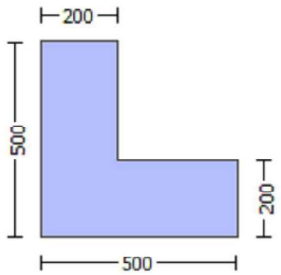
DESCRIPTION

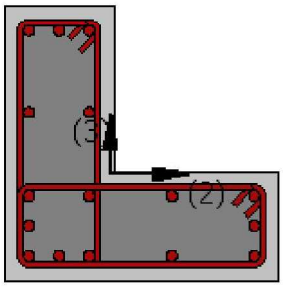
An L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	Start	2	0.00843167	0.00843167
	Life Safety	End	3	¾*0.05328558	¾*0.05328558
	Collapse Prevention	End	2	0.07676374	0.07676374
Shear Capacity [kN]	Damage Limitation	Start	2	227.376563	227.376376

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

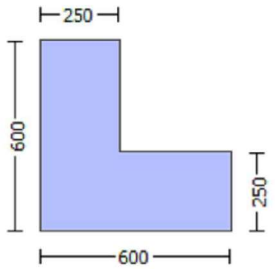
DESCRIPTION

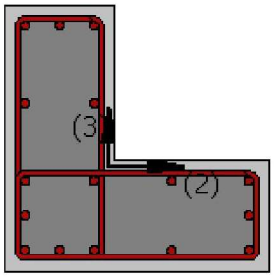
An L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	Start	3	0.03705121	0.03705121
	Life Safety	End	2	¾*0.03616271	¾*0.03616271
	Collapse Prevention	End	3	0.03454886	0.03454886
Shear Capacity [kN]	Life Safety	Start	3	748.575566	748.575566

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

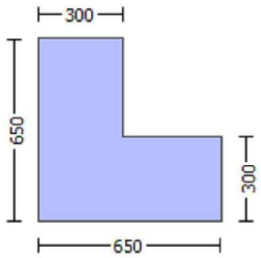
DESCRIPTION

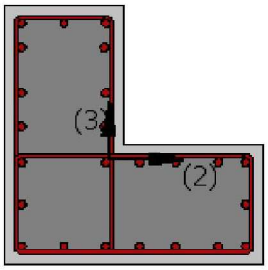
An L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	End	2	0.00433487	0.00433487
	Life Safety	Start	3	¾*0.0891948	¾*0.0891948
	Collapse Prevention	Start	2	0.08259909	0.08259909
Shear Capacity [kN]	Collapse Prevention	End	2	466.640070	466.640070

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

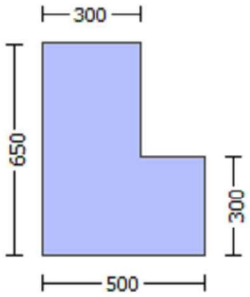
DESCRIPTION

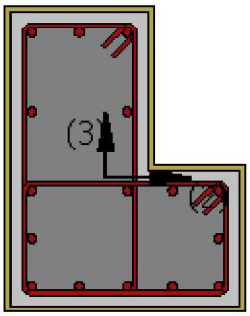
An L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	End	3	0.00633896	0.00633896
	Life Safety	Start	2	¾*0.06616078	¾*0.06616078
	Collapse Prevention	Start	3	0.03486821	0.03486821
Shear Capacity [kN]	Operational Level	Start	2	357.027152	357.027152

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

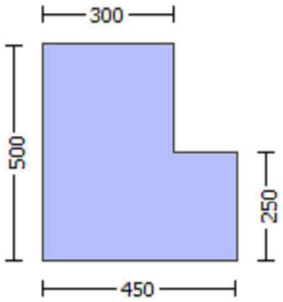
DESCRIPTION

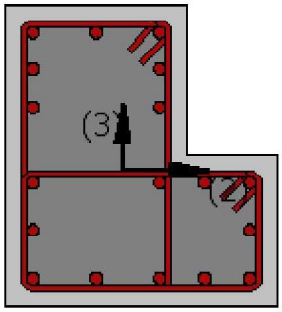
An L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	Start	2	0.008024045	0.008024045
	Life Safety	End	3	¾* 0.03823738	¾* 0.03823738
	Collapse Prevention	End	2	0.06457027	0.06457027
Shear Capacity [kN]	Damage Limitation	End	3	457.228566	457.228566

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

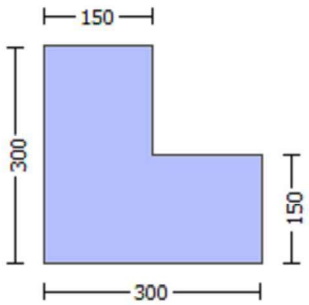
DESCRIPTION

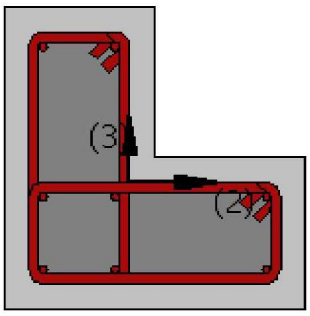
An L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	End	3	0.00408065	0.00408065
	Life Safety	Start	2	¾* 0.0235892	¾* 0.0235892
	Collapse Prevention	Start	3	0.03832073	0.03832073
Shear Capacity [kN]	Operational Level	Start	2	75.461541	75.461641

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

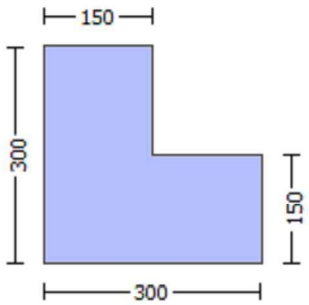
DESCRIPTION

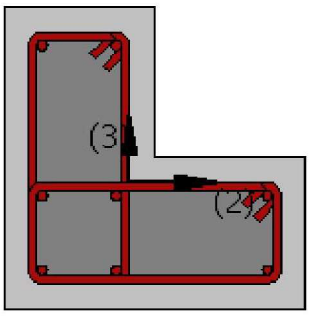
An L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	End	2	0.00866685	0.00866685
	Life Safety	Start	3	¾* 0.04354751	¾* 0.04354751
	Collapse Prevention	Start	2	0.01736079	0.01736079
Shear Capacity [kN]	Operational Level	Start	2	43.331704	43.331704

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

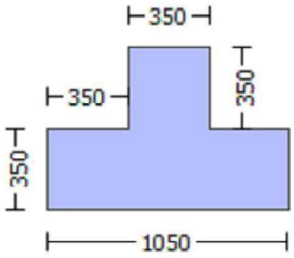
DESCRIPTION

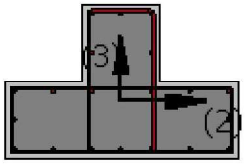
A T-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	End	3	0.00911301	0.009113006
	Life Safety	Start	2	¾*0.04121366	¾*0.04121366
	Collapse Prevention	Start	3	0.04818532	0.04818533
Shear Capacity [kN]	Operational Level	End	3	558.8683363	558.8683363

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

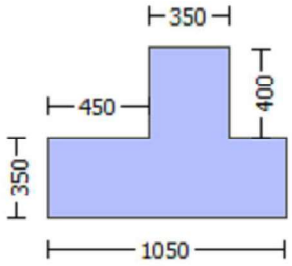
DESCRIPTION

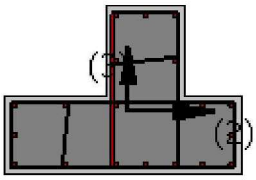
A T-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	Start	2	0.00338766	0.00338766
	Life Safety	End	3	¾*0.01447451	¾*0.01447451
	Collapse Prevention	End	2	0.02749797	0.02749797
Shear Capacity [kN]	Damage Limitation	Start	2	736.796512	736.796512

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

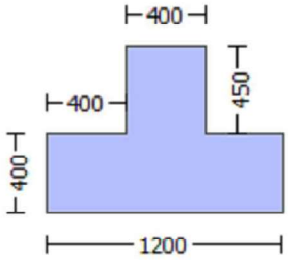
DESCRIPTION

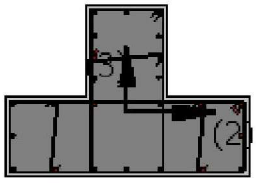
A T-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	Start	3	0.00441101	0.00441101
	Life Safety	End	2	¾*0.02681072	¾*0.02681072
	Collapse Prevention	End	3	0.01832698	0.01832698
Shear Capacity [kN]	Damage Limitation	Start	2	841.930247	841.930247

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

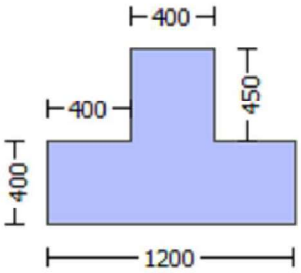
DESCRIPTION

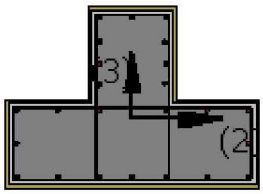
A T-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	End	2	0.00450953	0.00450953
	Life Safety	Start	3	¾*0.03416143	¾*0.03416143
	Collapse Prevention	Start	2	0.0280938	0.0280938
Shear Capacity [kN]	Collapse Prevention	End	2	822.732073	822.732073

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

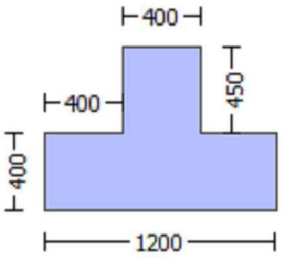
DESCRIPTION

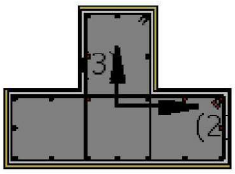
A T-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	End	3	0.00982379	0.00982381
	Life Safety	Start	2	¾*0.08187092	¾*0.08187092
	Collapse Prevention	Start	3	0.10087094	0.10087094
Shear Capacity [kN]	Operational Level	Start	2	1204.754660	1204.754660

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

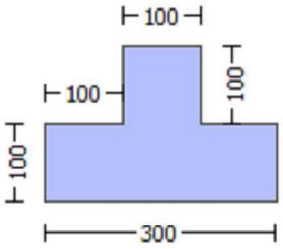
DESCRIPTION

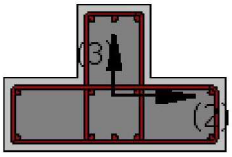
A T-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	End	3	0.005986765	0.005986765
	Life Safety	Start	2	¾* 0.0227396	¾* 0.0227396
	Collapse Prevention	Start	3	0.03144992	0.03144992
Shear Capacity [kN]	Operational Level	Start	2	66.636125	66.636125

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

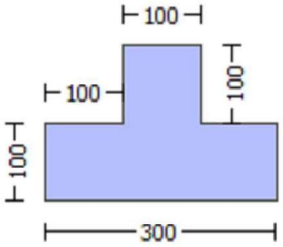
DESCRIPTION

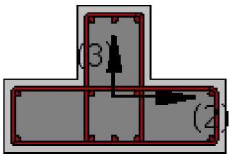
A T-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	End	2	0.00754874	0.00754874
	Life Safety	Start	3	¾* 0.03428044	¾* 0.03428044
	Collapse Prevention	Start	2	0.03336634	0.03336634
Shear Capacity [kN]	Collapse Prevention	End	2	52.376665	52.376858

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

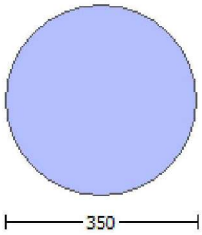
DESCRIPTION

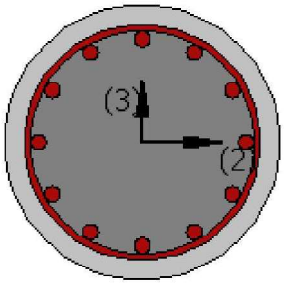
A circular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	End	3	0.01839097	0.01839097
	Life Safety	Start	2	¾*0.04145194	¾*0.04145194
	Collapse Prevention	Start	3	0.05690814	0.05690814
Shear Capacity [kN]	Operational Level	End	3	164.2137082	164.2137082

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

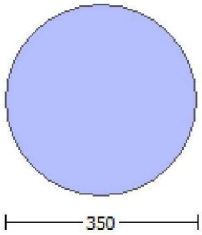
DESCRIPTION

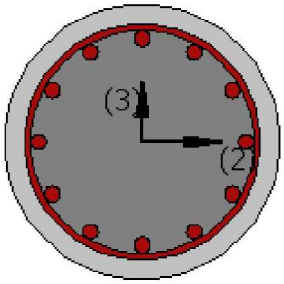
A circular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	Start	2	0.01971517	0.01971517
	Life Safety	End	3	¾*0.01971517	¾*0.01971517
	Collapse Prevention	End	2	0.01971517	0.01971517
Shear Capacity [kN]	Damage Limitation	Start	2	149.3357946	149.3357946

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

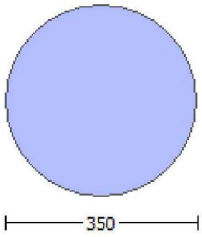
DESCRIPTION

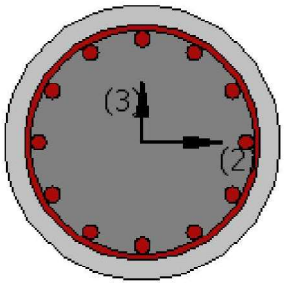
A circular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	Start	3	0.01385462	0.00713507
	Life Safety	End	2	¾*0.00948792	¾*0.00948792
	Collapse Prevention	End	3	0.00948792	0.00948792
Shear Capacity [kN]	Life Safety	Start	3	146.017153	146.017153

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

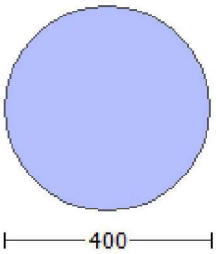
DESCRIPTION

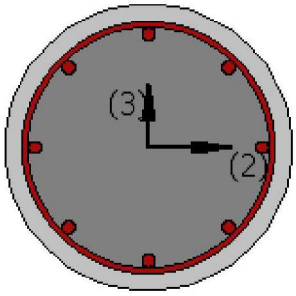
A circular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	End	2	0.00836428	0.00836428
	Life Safety	Start	3	¾*0.03121172	¾*0.03121171
	Collapse Prevention	Start	2	0.02361868	0.02361868
Shear Capacity [kN]	Collapse Prevention	End	2	230.288466	230.288466

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

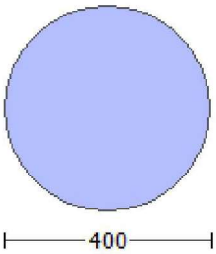
DESCRIPTION

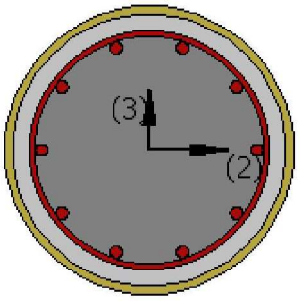
A circular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	End	3	0.01203826	0.01203826
	Life Safety	Start	2	¾*0.02682173	¾*0.02682173
	Collapse Prevention	Start	3	0.03628175	0.03628175
Shear Capacity [kN]	Operational Level	Start	2	145.5311235	145.5311235

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

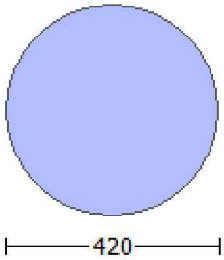
DESCRIPTION

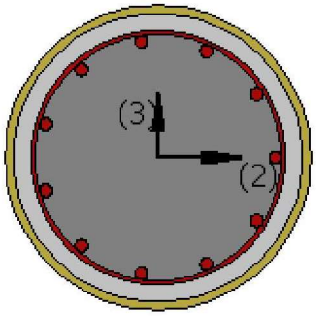
A circular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	Start	2	0.01032174	0.01032174
	Life Safety	End	3	¾*0.02534890	¾*0.02534890
	Collapse Prevention	End	2	0.02534889	0.02534889
Shear Capacity [kN]	Damage Limitation	End	3	189.9165891	189.9165891

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

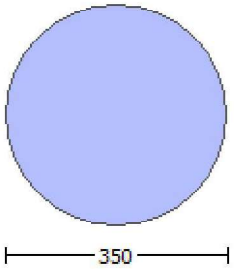
DESCRIPTION

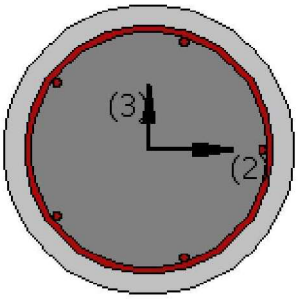
A circular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	End	2	0.00894352	0.00894352
	Life Safety	End	3	¾*0.0414840	¾*0.0414840
	Collapse Prevention	End	2	0.02290113	0.02290113
Shear Capacity [kN]	Operational Level	Start	2	155.658426	155.658426

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

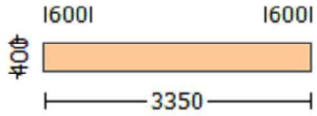
DESCRIPTION

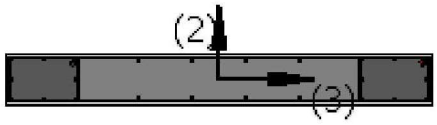
A wall section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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

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

For Shear Capacity Calculations

Existingmaterial of Primary Member: Concrete Strength,

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	End	3	0.00588029	0.00588029
	Life Safety	Start	2	¾*0.02197318	¾*0.02197318
	Collapse Prevention	Start	3	0.03623736	0.03623736
Shear Capacity [kN]	Operational Level	End	3	3296.690720	3296.690720

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

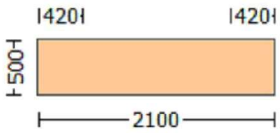
DESCRIPTION

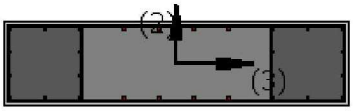
A wall section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	Start	2	0.00267658	0.00267658
	Life Safety	End	3	¾*0.01124502	¾*0.01124502
	Collapse Prevention	End	2	0.00381998	0.00381998
Shear Capacity [kN]	Damage Limitation	Start	2	832.333178	832.333178

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

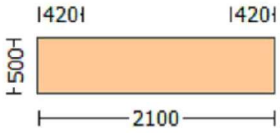
DESCRIPTION

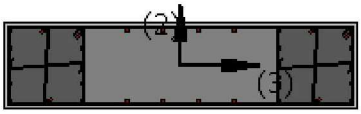
A wall section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	Start	3	0.00565485	0.00565485
	Life Safety	End	2	¾*0.00854091	¾*0.00854091
	Collapse Prevention	End	3	0.02479636	0.02479636
Shear Capacity [kN]	Life Safety	Start	3	2923.58197	2923.6000

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

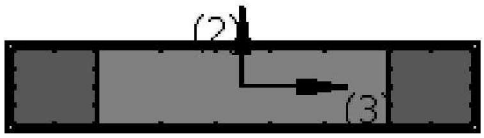
DESCRIPTION

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	End	2	0.00232618	0.00232618
	Life Safety	Start	3	¾*0.03494118	¾*0.03494118
	Collapse Prevention	Start	2	0.02397036	0.02397035
Shear Capacity [kN]	Collapse Prevention	End	2	1668.098121	1668.098121

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

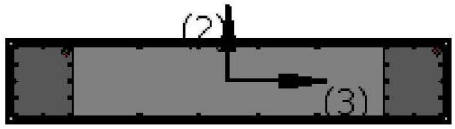
DESCRIPTION

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	End	3	0.00625042	0.00625042
	Life Safety	Start	2	¾*0.02633207	¾*0.02633207
	Collapse Prevention	Start	3	0.03792301	0.03792301
Shear Capacity [kN]	Damage Limitation	End	3	4135.3339684	4135.3339684

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

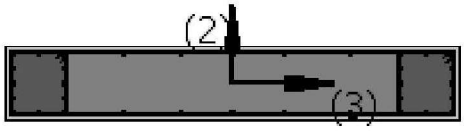
DESCRIPTION

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

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

For Shear Capacity Calculations

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	Start	2	0.00321688	0.00321688
	Life Safety	End	3	¾*0.04993095	¾*0.04993095
	Collapse Prevention	End	2	0.0148424	0.0148424
Shear Capacity [kN]	Damage Limitation	End	3	3795.546580	3795.546580

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

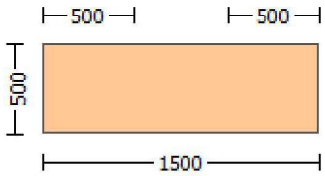
DESCRIPTION

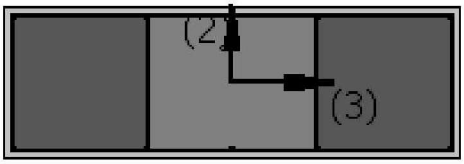
A wall section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	Start	2	0.00386984	0.00386984
	Life Safety	End	3	¾*0.00699089	¾*0.00699089
	Collapse Prevention	End	2	0.00773145	0.00773145
Shear Capacity [kN]	Operational Level	Start	3	1152.271234	1152.265302

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

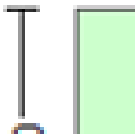
DESCRIPTION

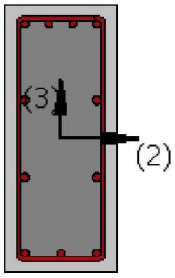
A beam section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	End	3	0.0107568	0.0107568
	Life Safety	Start	2	¾*0.02966248	¾*0.02966248
	Collapse Prevention	Start	3	0.02480615	0.02480615
Shear Capacity [kN]	Operational Level	End	3	406.764078	406.762769

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

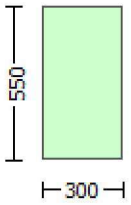
DESCRIPTION

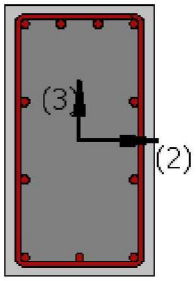
A beam section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	Start	2	0.00507618	0.00507618
	Life Safety	End	3	¾*0.04317844	¾*0.04317844
	Collapse Prevention	End	2	0.02830713	0.02830713
Shear Capacity [kN]	Damage Limitation	Start	2	245.986705	245.986705

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

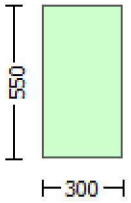
DESCRIPTION

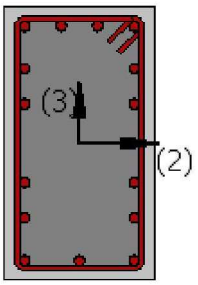
A beam section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	Start	3	0.00937222	0.009372218
	Life Safety	End	2	¾*0.0134480	¾*0.0134480
	Collapse Prevention	End	3	0.02011349	0.02011349
Shear Capacity [kN]	Life Safety	Start	3	417.968414	417.968414

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

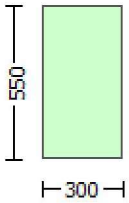
DESCRIPTION

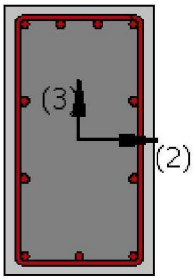
A beam section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	End	2	0.00456411	0.00456411
	Life Safety	Start	3	¾*0.03764612	¾*0.03764612
	Collapse Prevention	Start	2	0.04946556	0.04946556
Shear Capacity [kN]	Collapse Prevention	End	2	164.398981	164.398981

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

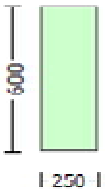
DESCRIPTION

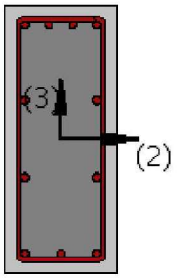
A beam section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	End	3	0.0107568	0.0107568
	Life Safety	Start	2	¾*0.02726331	¾*0.02726331
	Collapse Prevention	Start	3	0.02279977	0.02279977
Shear Capacity [kN]	Operational Level	Start	2	166.454029	166.452680

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

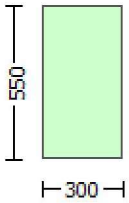
DESCRIPTION

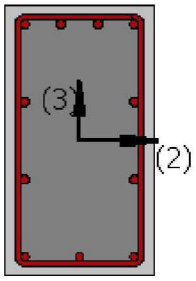
A beam section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	Start	2	0.00564274	0.00564274
	Life Safety	End	3	¾*0.02704478	¾*0.02704478
	Collapse Prevention	End	2	0.01338347	0.01338347
Shear Capacity [kN]	Operational Level	Start	3	87.434181	87.434203

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

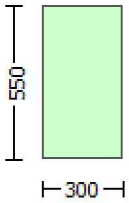
DESCRIPTION

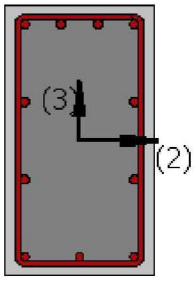
A beam section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	Start	2	0.00562931	0.00562931
	Life Safety	End	3	¾* 0.0271428	¾* 0.0271428
	Collapse Prevention	End	2	0.01434402	0.01434402
Shear Capacity [kN]	Operational Level	Start	3	187.065978	187.065924

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

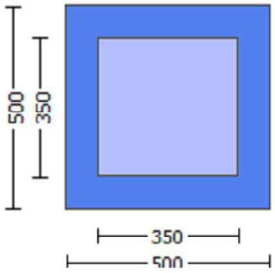
DESCRIPTION

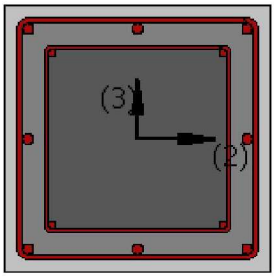
A jacketed rectangular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	End	3	0.00511880	0.00542725
	Life Safety	Start	2	¾*0.04590387	¾*0.04590387
	Collapse Prevention	Start	3	0.05851108	0.05851105
Shear Capacity [kN]	Operational Level	End	3	584.502484	584.502484

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

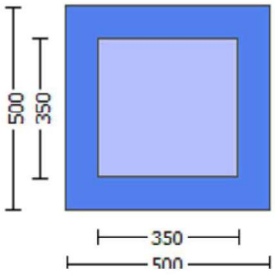
DESCRIPTION

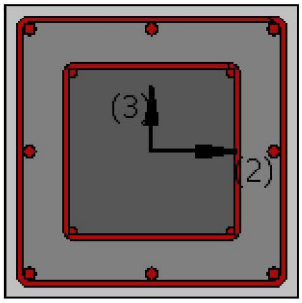
A jacketed rectangular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	Start	2	0.00498522	0.00498521
	Life Safety	End	3	¾*0.02743346	¾*0.02743351
	Collapse Prevention	End	2	0.04818589	0.04818589
Shear Capacity [kN]	Damage Limitation	Start	2	715.4245661	715.4245661

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

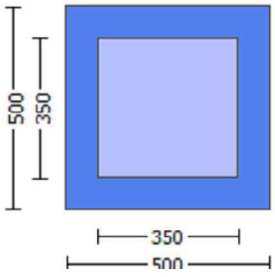
DESCRIPTION

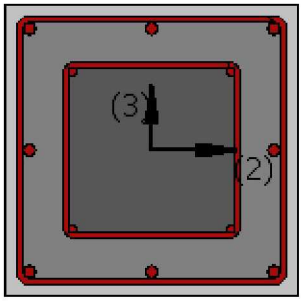
A jacketed rectangular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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

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
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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	Start	3	0.00651839	0.00651839
	Life Safety	End	2	¾*0.0418922	¾*0.0418922
	Collapse Prevention	End	3	0.02385015	0.02385015
Shear Capacity [kN]	Life Safety	Start	3	333.785174	333.785174

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

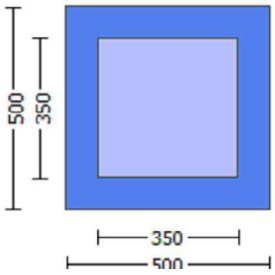
DESCRIPTION

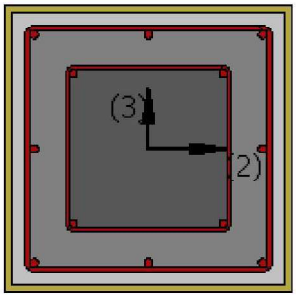
A jacketed rectangular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	End	2	0.0045651	0.0045651
	Life Safety	Start	3	¾* 0.04365971	¾* 0.04365971
	Collapse Prevention	Start	2	0.03422882	0.03422882
Shear Capacity [kN]	Collapse Prevention	End	2	378.263125	378.263125

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

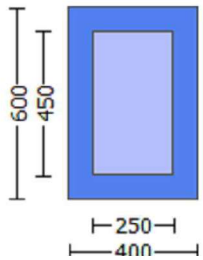
DESCRIPTION

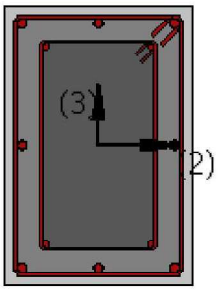
A jacketed rectangular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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

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

For Shear Capacity Calculations

Jacket
New material of Primary Member: Concrete Strength,

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	End	3	0.00256257	0.00256257
	Life Safety	Start	2	¾*0.00865723	¾*0.00865723
	Collapse Prevention	Start	3	0.01256111	0.01256111
Shear Capacity [kN]	Operational Level	Start	2	275.556391	275.556391

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

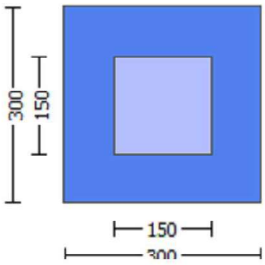
DESCRIPTION

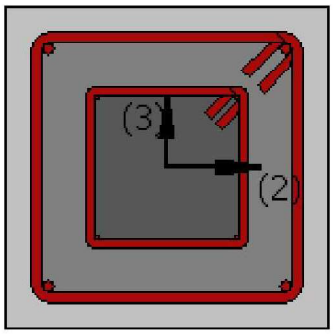
A jacketed rectangular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	Start	2	0.00446815	0.00446815
	Life Safety	End	3	¾*0.0511883	¾*0.0511883
	Collapse Prevention	End	2	0.03150192	0.03150192
Shear Capacity [kN]	Operational Level	Start	2	53.054081	53.054165

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

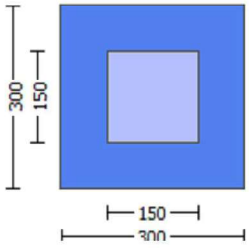
DESCRIPTION

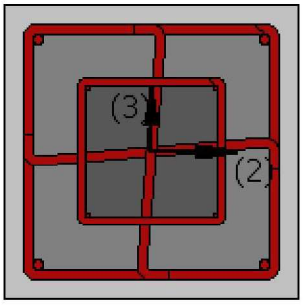
A jacketed rectangular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	Start	3	0.00451657	0.00451657
	Life Safety	End	3	¾* 0.02544405	¾* 0.02544405
	Collapse Prevention	End	2	0.04133392	0.04133392
Shear Capacity [kN]	Life Safety	End	3	42.819507	42.819507

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

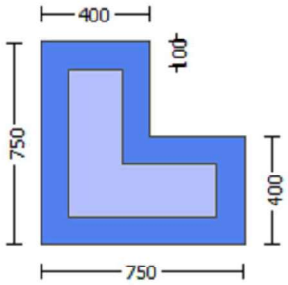
DESCRIPTION

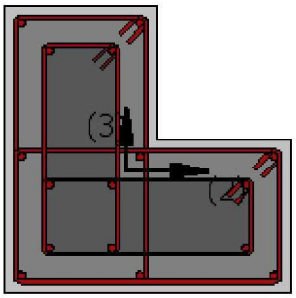
A jacketed L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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

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

For Shear Capacity Calculations

Jacket
New material of Primary Member: Concrete Strength,

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	End	3	0.00667167	0.00667168

Check	Limit State	Edge	Local Axis	SeismoBuild 2021	Hand calculations
	Life Safety	Start	2	¾*0.05854865	¾*0.05854865
	Collapse Prevention	Start	3	0.06706171	0.06706171
Shear Capacity [kN]	Operational Level	End	3	700.371658	700.371658

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

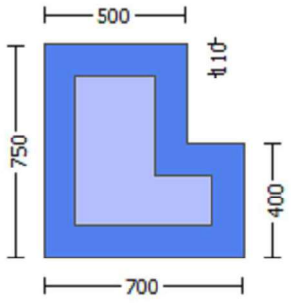
DESCRIPTION

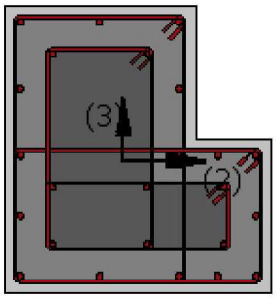
A jacketed L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	Start	2	0.00497054	0.00497054
	Life Safety	End	3	¾*0.0123846	¾*0.0123727
	Collapse Prevention	End	2	0.01906604	0.01906604
Shear Capacity [kN]	Damage Limitation	Start	2	589.985238	589.985238

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

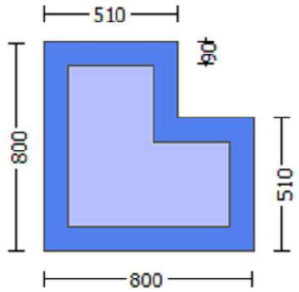
DESCRIPTION

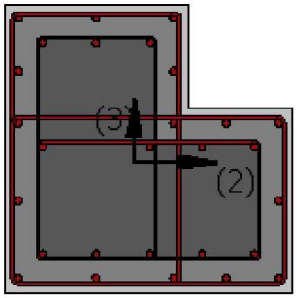
A jacketed L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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

For Shear Capacity Calculations

Jacket
New material of Secondary Member: Concrete Strength,
fc = fck = 25.00
New material of SecondaryMember: Steel Strength,
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

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	Start	3	0.0057442	0.0057442
	Life Safety	End	2	¾*0.03616271	¾*0.03616271
	Collapse Prevention	End	3	0.02230521	0.02230521
Shear Capacity [kN]	Life Safety	Start	3	1355.319424	1355.319424

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

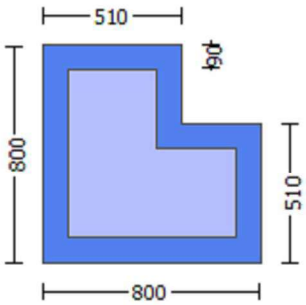
DESCRIPTION

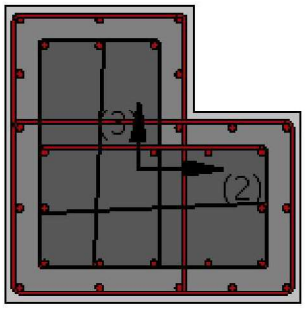
A jacketed L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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

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

For Shear Capacity Calculations

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	End	2	0.00474192	0.00474192
	Life Safety	Start	3	¾*0.05989353	¾*0.05989353
	Collapse Prevention	Start	2	0.02962346	0.02962346
Shear Capacity [kN]	Collapse Prevention	End	2	1084.700	1084.667

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

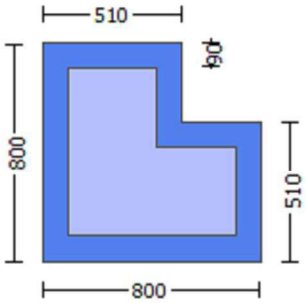
DESCRIPTION

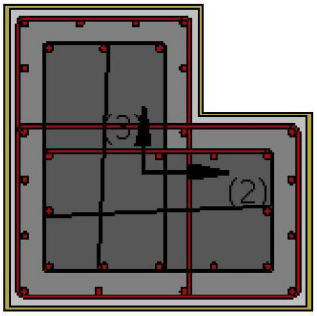
A jacketed L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	End	3	0.00667382	0.00667382
	Life Safety	Start	2	¾* 0.03680145	¾* 0.03680145
	Collapse Prevention	Start	3	0.03680224	0.03680224

Check	Limit State	Edge	Local Axis	SeismoBuild 2021	Hand calculations
Shear Capacity [kN]	Damage Limitation	Start	2	962.996285	962.996285

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

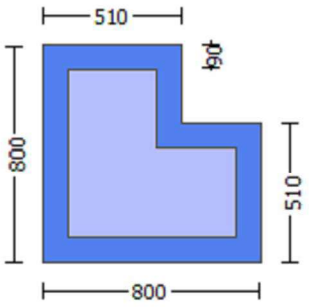
DESCRIPTION

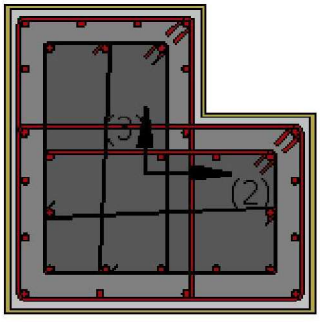
A jacketed L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	Start	2	0.00438072	0.00438072
	Life Safety	End	3	¾* 0.03014648	¾* 0.03014648
	Collapse Prevention	End	2	0.04549054	0.04549054
Shear Capacity [kN]	Life Safety	Start	3	1355.291312	1355.291312

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

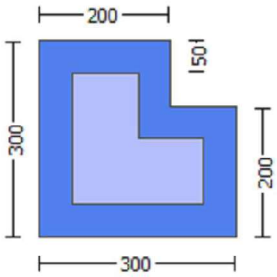
A jacketed L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

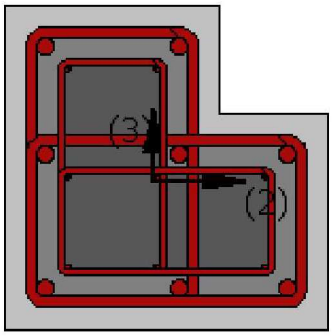
The resulting chord rotation capacity and shear capacity with the FE analysis program SeismoBuild are compared with hand calculations.

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	Start	2	0.01281574	0.01281574
	Life Safety	End	3	¾* 0.0508885	¾* 0.0508885
	Collapse Prevention	End	2	0.03481979	0.03481979
Shear Capacity [kN]	Operational Level	Start	2	84.1458510	84.1458510

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

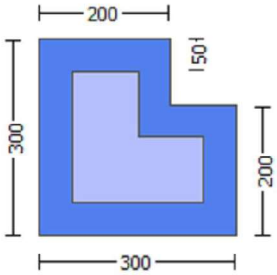
DESCRIPTION

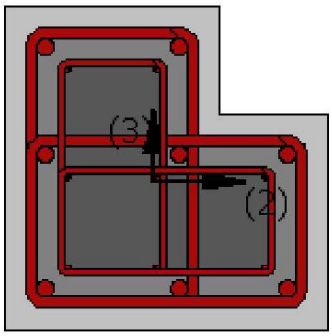
A jacketed L-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	Start	2	0.00960693	0.00960693
	Life Safety	End	3	¾* 0.0508958	¾* 0.0508958
	Collapse Prevention	End	2	0.027646356	0.027646356
Shear Capacity [kN]	Operational Level	Start	2	84.3455079	84.3455079

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

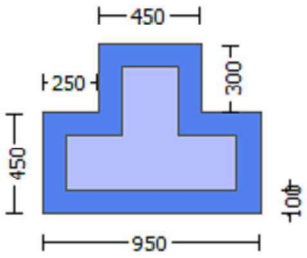
DESCRIPTION

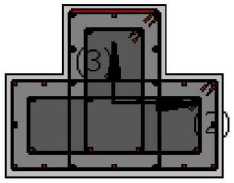
A jacketed T-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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
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

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	End	3	0.00767942	0.00767941
	Life Safety	Start	2	¾*0.0690273	¾*0.0690273
	Collapse Prevention	Start	3	0.08418327	0.08418327
Shear Capacity [kN]	Operational Level	End	3	829.500927	829.500927

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

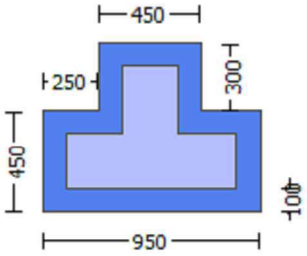
DESCRIPTION

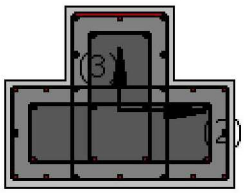
A jacketed T-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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

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

For Shear Capacity Calculations

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	Start	2	0.0029917	0.0029917
	Life Safety	End	3	¾* 0.01037982	¾* 0.01037982
	Collapse Prevention	End	2	0.01571297	0.01571297
Shear Capacity [kN]	Damage Limitation	Start	2	990.805498	990.805498

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

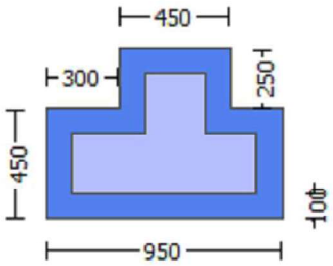
DESCRIPTION

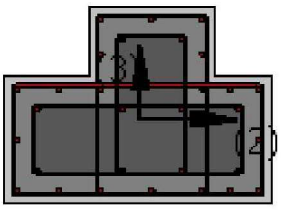
A jacketed T-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	Start	3	0.00543406	0.00543406
	Life Safety	End	2	¾* 0.04206076	¾* 0.04206076
	Collapse Prevention	End	3	0.02712272	0.02712272
Shear Capacity [kN]	Damage Limitation	Start	2	1432.882294	1432.882294

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

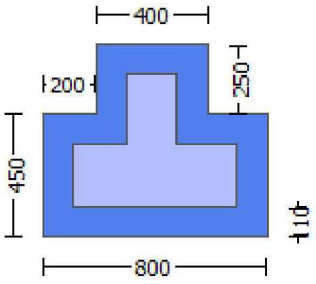
DESCRIPTION

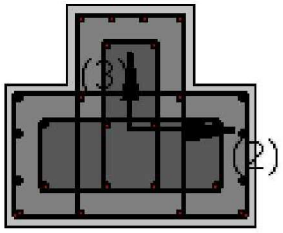
A jacketed T-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	End	2	0.00454367	0.00454367

Check	Limit State	Edge	Local Axis	SeismoBuild 2021	Hand calculations
	Life Safety	Start	3	¾*0.06641402	¾*0.06641402
	Collapse Prevention	Start	2	0.0540562	0.0540562
Shear Capacity [kN]	Collapse Prevention	End	2	888.406923	888.406923

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

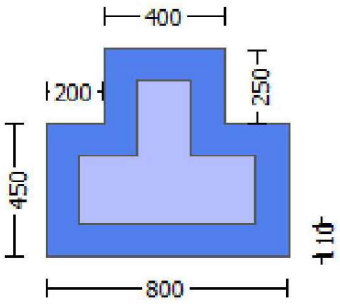
DESCRIPTION

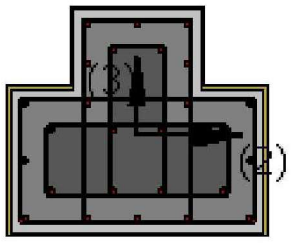
A jacketed T-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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

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

For Shear Capacity Calculations

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	End	3	0.00642522	0.00642522
	Life Safety	Start	2	¾*0.02941774	¾*0.02941883
	Collapse Prevention	Start	3	0.03573685	0.03573665
Shear Capacity [kN]	Operational Level	Start	2	888.298113	888.298113

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

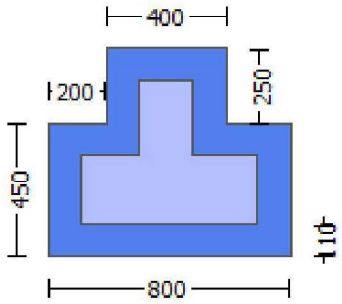
DESCRIPTION

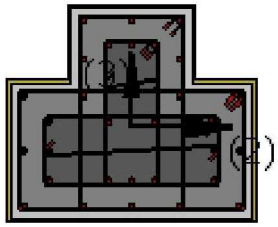
A jacketed T-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	Start	2	0.0051905	0.00519049
	Life Safety	End	3	¾* 0.04508491	¾* 0.04508491
	Collapse Prevention	End	2	0.06600421	0.06600421
Shear Capacity [kN]	Collapse Prevention	End	2	1195.798828	1195.798828

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

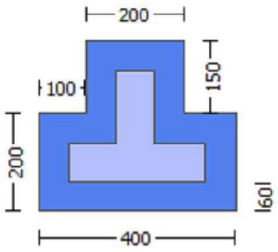
DESCRIPTION

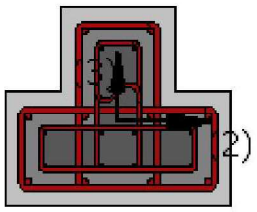
A jacketed T-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Operation Level	Start	2	0.01052979	0.01052979
	Life Safety	End	3	¾* 0.02066309	¾* 0.02066309
	Collapse Prevention	End	2	0.01349039	0.01349039
Shear Capacity [kN]	Collapse Prevention	End	2	115.5293379	115.5293379

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

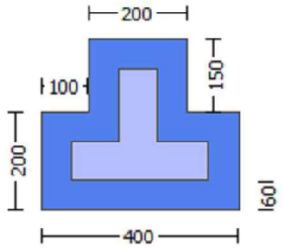
DESCRIPTION

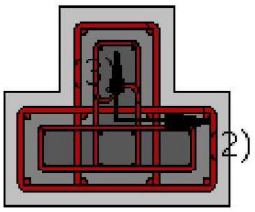
A jacketed T-shaped column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	End	2	0.01198317	0.01198317
	Life Safety	End	3	¾* 0.1434056	¾* 0.1434056
	Collapse Prevention	Start	2	0.024244208	0.024244208
Shear Capacity [kN]	Collapse Prevention	End	3	139.9452944	139.9452944

COMPUTER FILES

- NTC_rcjtcs8.bpf
- Report_NTC_rcjtcs8.pdf

EXAMPLES SET 10: CIRCULAR JACKETED COLUMN 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

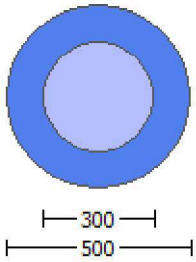
DESCRIPTION

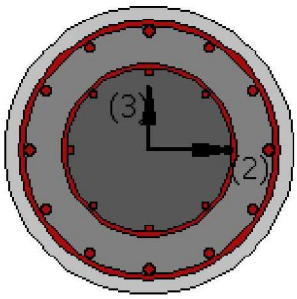
A jacketed circular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 Strength,
Existing material of Primary Member: Steel 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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	End	3	0.00931549	0.00650109
	Life Safety	Start	2	¾* 0.0227474	¾* 0.0227474
	Collapse Prevention	Start	3	0.03022738	0.03022733
Shear Capacity [kN]	Operational Level	End	3	339.044291	339.044291

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

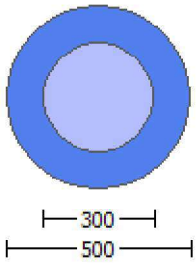
DESCRIPTION

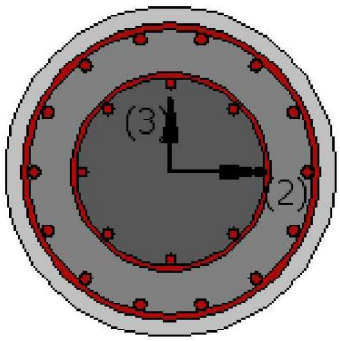
A jacketed circular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	Start	2	0.00955046	0.00955045
	Life Safety	End	3	¾* 0.00966009	¾* 0.00966009
	Collapse Prevention	End	2	0.00966009	0.00966009

Check	Limit State	Edge	Local Axis	SeismoBuild 2021	Hand calculations
Shear Capacity [kN]	Damage Limitation	Start	2	317.932237	317.932237

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

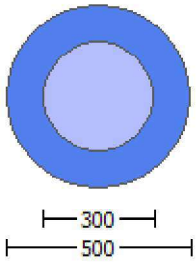
DESCRIPTION

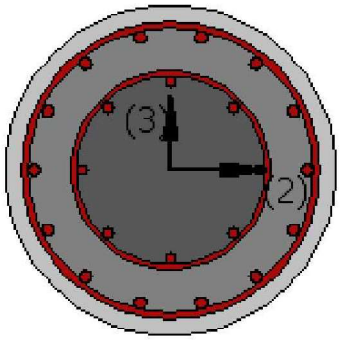
A jacketed circular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	Start	3	0.022508	0.022508
	Life Safety	End	2	¾* 0.01722811	¾* 0.017228107
	Collapse Prevention	End	3	0.01722811	0.01722811
Shear Capacity [kN]	Life Safety	Start	3	409.476918	409.476918

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

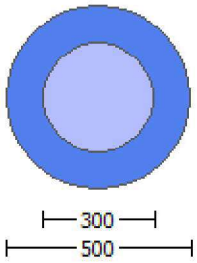
DESCRIPTION

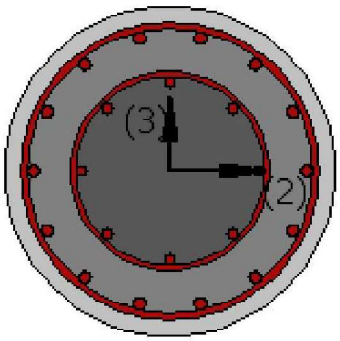
A jacketed circular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	End	2	0.01513417	0.01513417
	Life Safety	Start	3	¾* 0.02198046	¾* 0.02198046
	Collapse Prevention	Start	2	0.01513417	0.01513417
Shear Capacity [kN]	Collapse Prevention	End	2	339.063766	339.063766

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

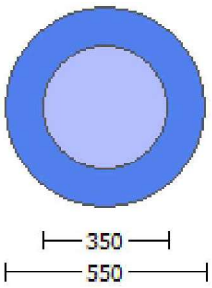
DESCRIPTION

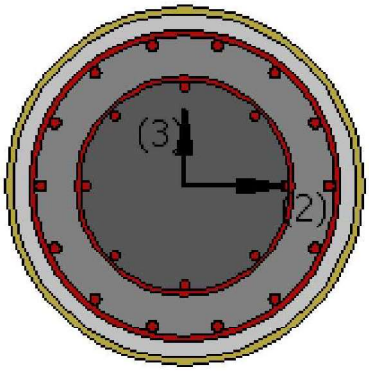
A jacketed circular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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
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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	End	3	0.00940435	0.00940435
	Life Safety	Start	2	¾* 0.01764233	¾* 0.01764233
	Collapse Prevention	Start	3	0.02334016	0.02334016
Shear Capacity [kN]	Operational Level	Start	2	422.4430413	422.4430413

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

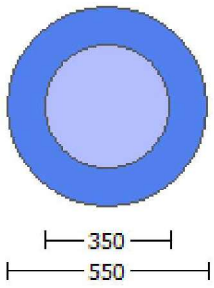
DESCRIPTION

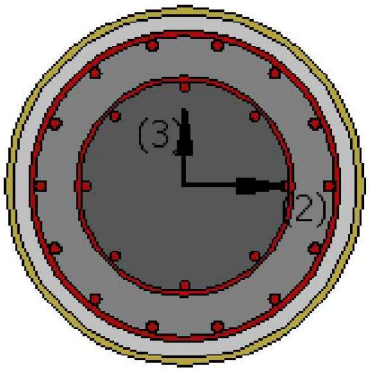
A jacketed circular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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

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

For Shear Capacity Calculations

Jacket
New material of Primary Member: Concrete

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	Start	2	0.01668051	0.01668051
	Life Safety	End	3	¾* 0.0166805	¾* 0.0166805
	Collapse Prevention	End	2	0.01668051	0.01668051
Shear Capacity [kN]	Damage Limitation	End	3	422.4430413	422.4430413

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

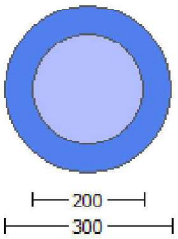
DESCRIPTION

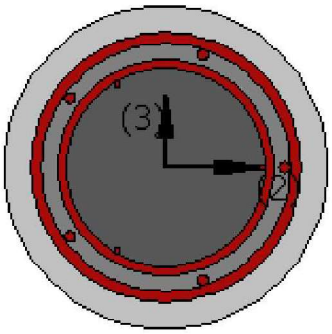
A jacketed circular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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
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 3.74. Comparison between SeismoBuild and hand-calculated results for EXAMPLE 10.7

Check	Limit State	Edge	Local Axis	SeismoBuild 2021	Hand calculations
Chord Rotation Capacity	Operational Level	Start	3	0.01587914	0.01587914
	Life Safety	End	2	¾* 0.02131647	¾* 0.02131623
	Collapse Prevention	End	3	0.03296220	0.03296220
Shear Capacity [kN]	Operational Level	Start	2	64.98642536	64.98642536

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

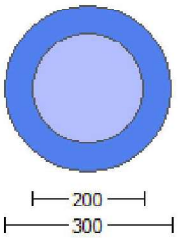
DESCRIPTION

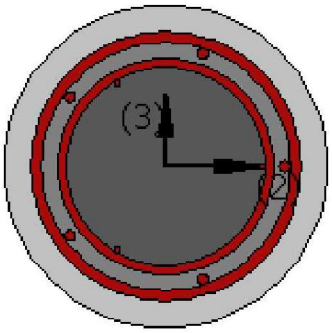
A jacketed circular column section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	Start	3	0.01124644	0.01124644
	Life Safety	End	2	¾* 0.02106527	¾* 0.02106527
	Collapse Prevention	End	3	0.03295507	0.03295507
Shear Capacity [kN]	Operational Level	Start	2	64.90693825	64.90693825

COMPUTER FILES

- NTC_rcjcs8.bpf
- Report_ NTC_rcjcs8.pdf

EXAMPLES SET 11: JACKETED BEAM SECTION

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

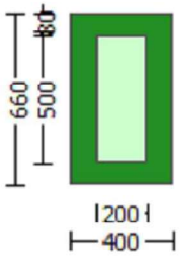
DESCRIPTION

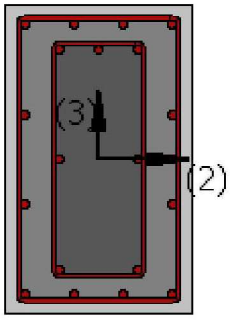
A jacketed beam section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	End	3	0.00664176	0.00664176
	Life Safety	Start	2	¾*0.03610675	¾*0.03610675
	Collapse Prevention	Start	3	0.02648413	0.02648413
Shear Capacity [kN]	Operational Level	End	3	645.242878	645.242878

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

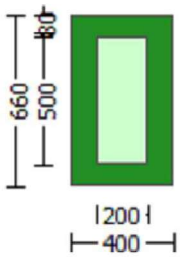
DESCRIPTION

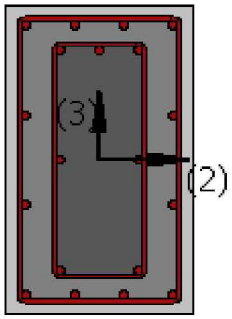
A jacketed beam section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	Start	2	0.00453572	0.00453572
	Life Safety	End	3	¾*0.0222439	¾*0.0222439
	Collapse Prevention	End	2	0.01440502	0.01440502
Shear Capacity [kN]	Damage Limitation	Start	2	431.822415	431.822857

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

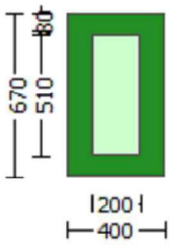
DESCRIPTION

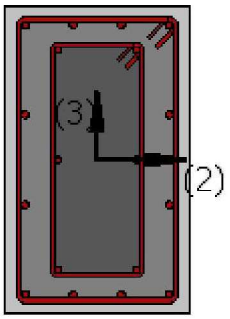
A jacketed beam section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Operational Level	Start	3	0.00504372	0.00504372
	Life Safety	End	2	¾*0.0150317	¾*0.0150317
	Collapse Prevention	End	3	0.02248618	0.02248618
Shear Capacity [kN]	Life Safety	Start	3	700.510345	700.510345

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

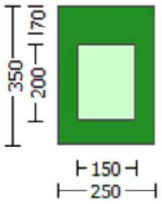
DESCRIPTION

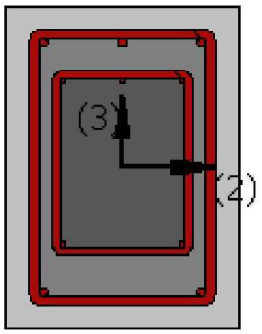
A jacketed beam section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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
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
Newmaterial of Primary Member: Concrete Strength,
fc = fck/γc = 8.00
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 = 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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	End	2	0.00577469	0.00577469
	Life Safety	Start	3	¾*0.0313674	¾*0.0313674
	Collapse Prevention	Start	2	0.04253962	0.04253962
Shear Capacity [kN]	Collapse Prevention	End	2	417.096561	417.096561

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

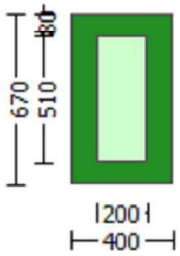
DESCRIPTION

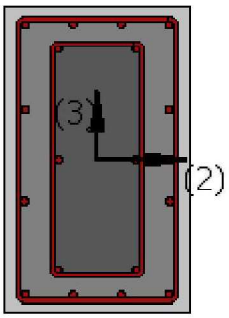
A jacketed beam section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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 2021	Hand calculations
Chord Rotation Capacity	Damage Limitation	End	3	0.00335514	0.003357201
	Life Safety	Start	2	¾* 0.00423433	¾* 0.00423433
	Collapse Prevention	Start	3	0.00762884	0.00762884
Shear Capacity [kN]	Operational Level	Start	3	64.352579	64.352579

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

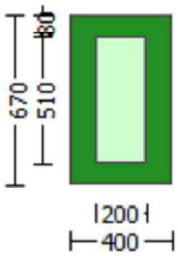
DESCRIPTION

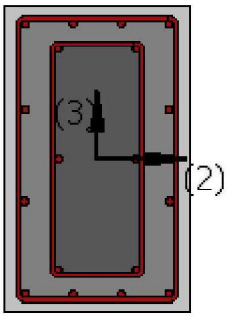
A jacketed beam section is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

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

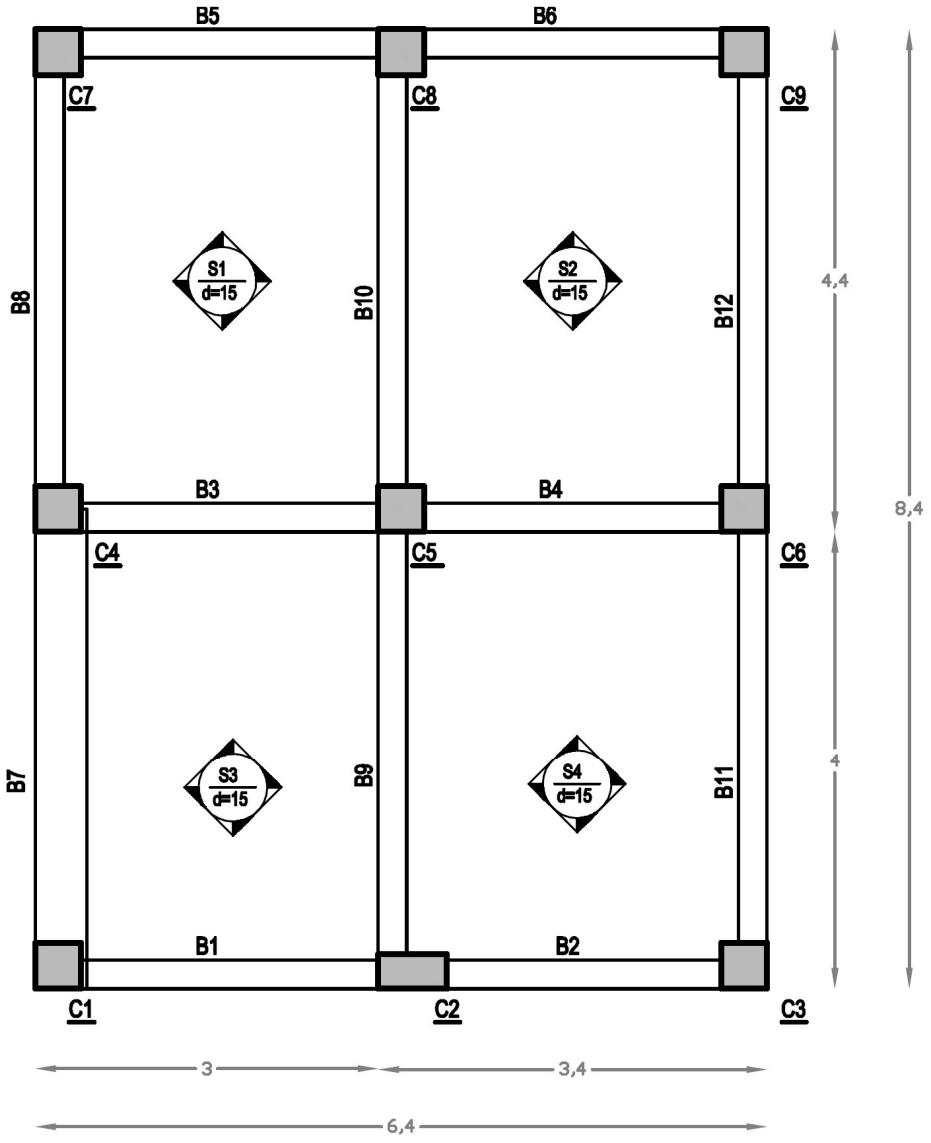
Check	Limit State	Edge	Local Axis	SeismoBuild 2021	Hand calculations
Chord Rotation Capacity	Operational Level	Start	2	0.00464922	0.00464921
	Life Safety	End	3	¾*0.02756536	¾*0.02756536
	Collapse Prevention	End	2	0.01785243	0.01785262
Shear Capacity [kN]	Damage Limitation	End	3	782.619701	782.619701

COMPUTER FILES

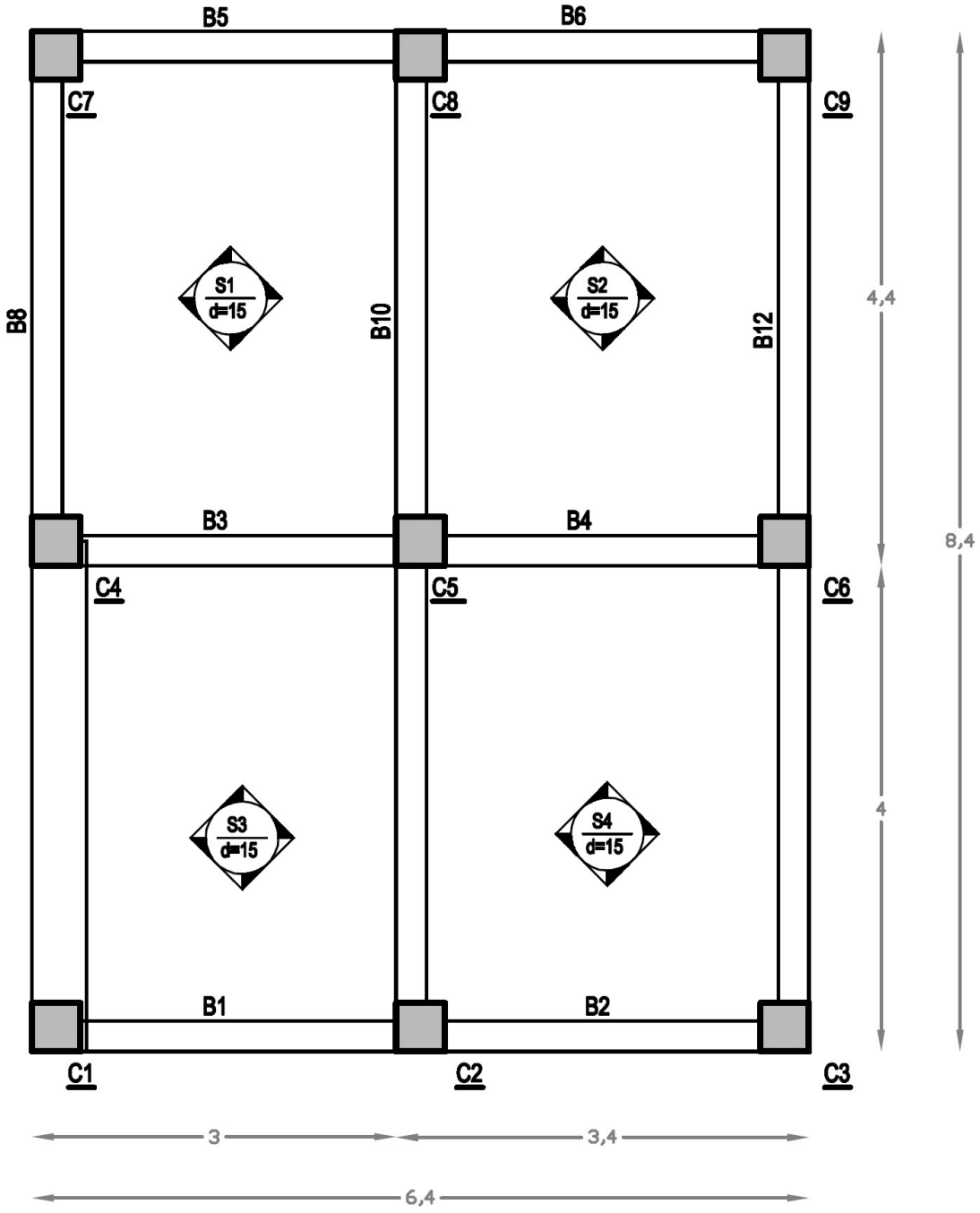
- NTC_JBeam6.bpf
- Report_NTC_JBeam6.pdf

Chapter 4 COMPARISON WITH INDEPENDENT HAND-CALCULATIONS – BEAM-COLUMN JOINTS CHECKS

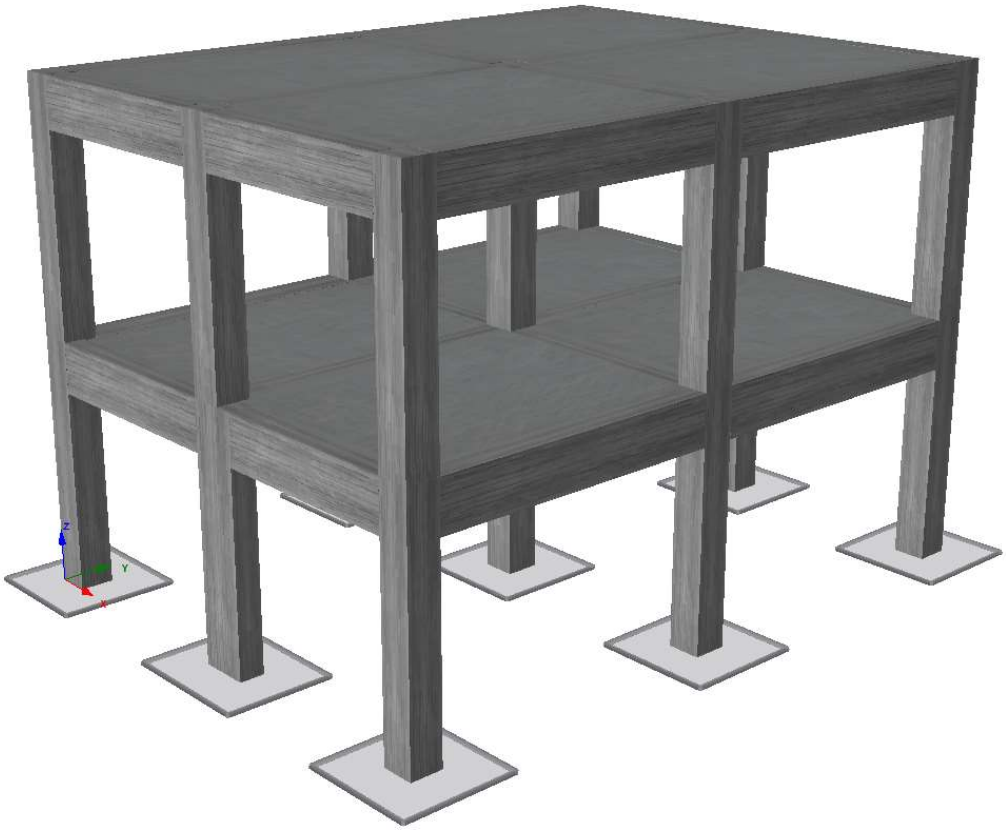
As noted above, this chapter makes use of examples, and their corresponding independent hand-calculations. A two storey 3D model with Typical Building Geometry (TBG) has been used for all the beam-columns joints examples. The plan views and the 3D model of the TBG are shown before each example:



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

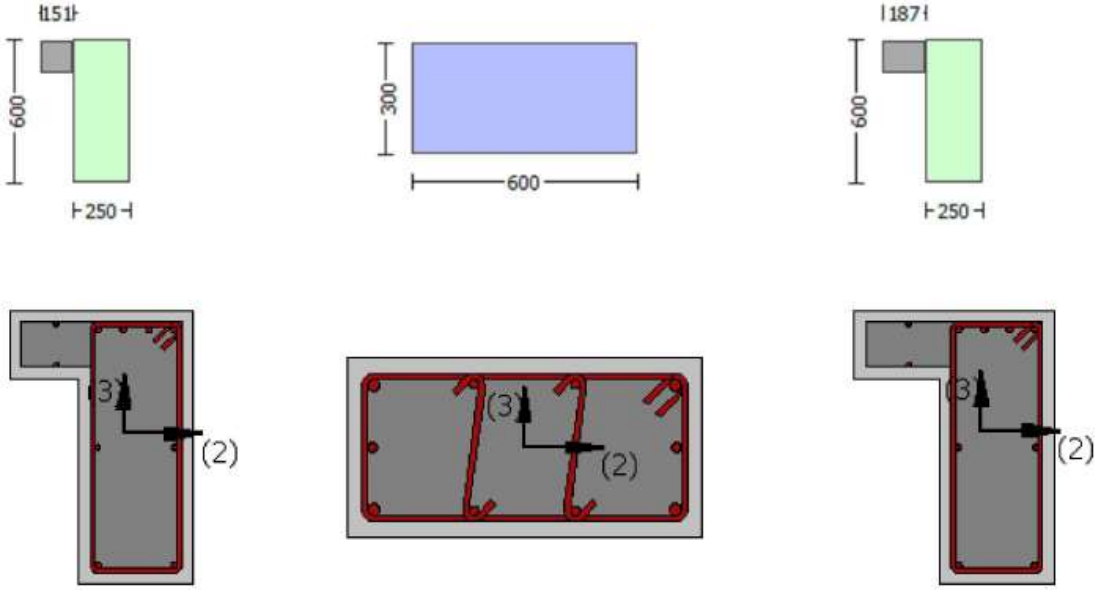
DESCRIPTION

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	SeismoBuild 2021		Hand calculations	
		Demand	Capacity	Demand	Capacity
Joints Diagonal Tension [MPa]	Operational Level	0.00335454	1.0	0.003354537	1.0
Joints Diagonal Compression [MPa]		0.30575683	5.5556	0.305756826	5.5556

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

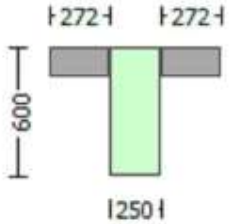
DESCRIPTION

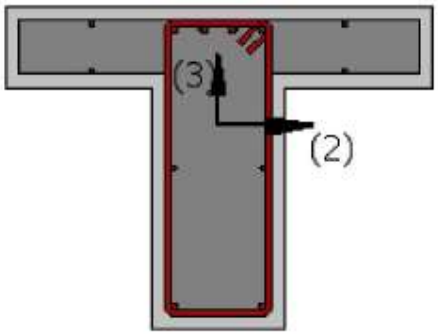
The 3D model is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

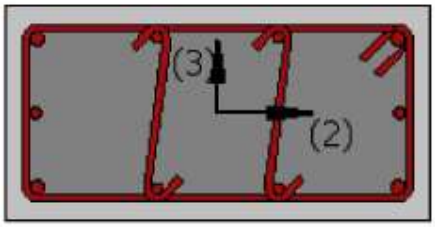
The resulting joints shear forces, horizontal hoops area and vertical reinforcement area of the FE analysis program SeismoBuild are compared with hand calculations.

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	SeismoBuild 2021		Hand calculations	
		Demand	Capacity	Demand	Capacity
Joints Diagonal Tension [MPa]	Damage Limitation	0.00012922	1.0	0.00012922	1.0
Joints Diagonal Compression [MPa]		0.42065143	5.5556	0.42065143	5.5556

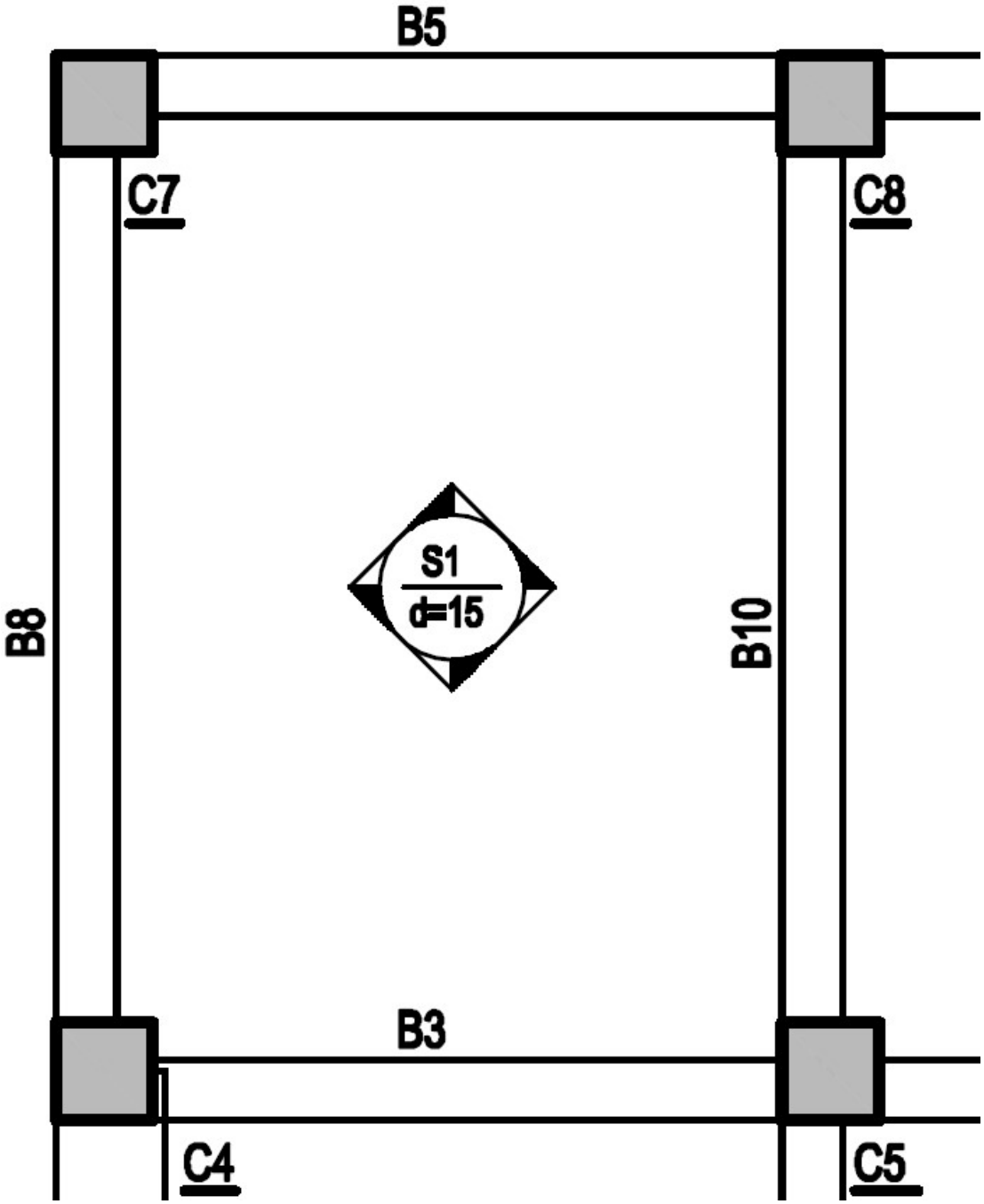
COMPUTER FILES

- 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

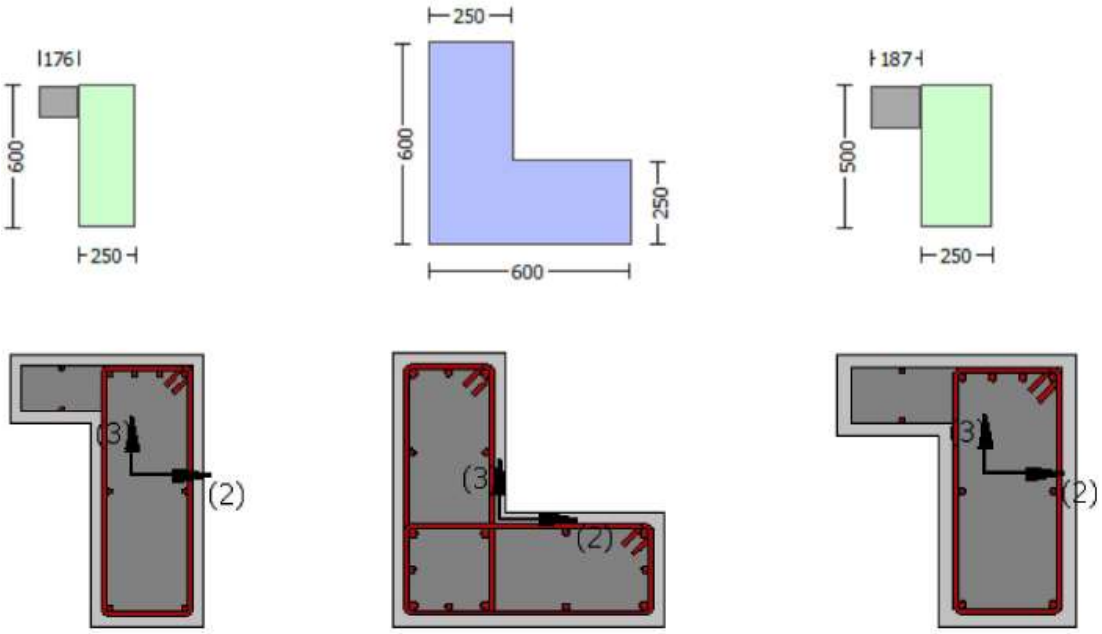
DESCRIPTION

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	SeismoBuild 2021		Hand calculations	
		Demand	Capacity	Demand	Capacity
Joints Diagonal Tension [MPa]	Life Safety	0.088778317	1.0	0.088778317	1.0
Joints Diagonal Compression [MPa]		0.433555519	5.5556	0.433555519	5.5556

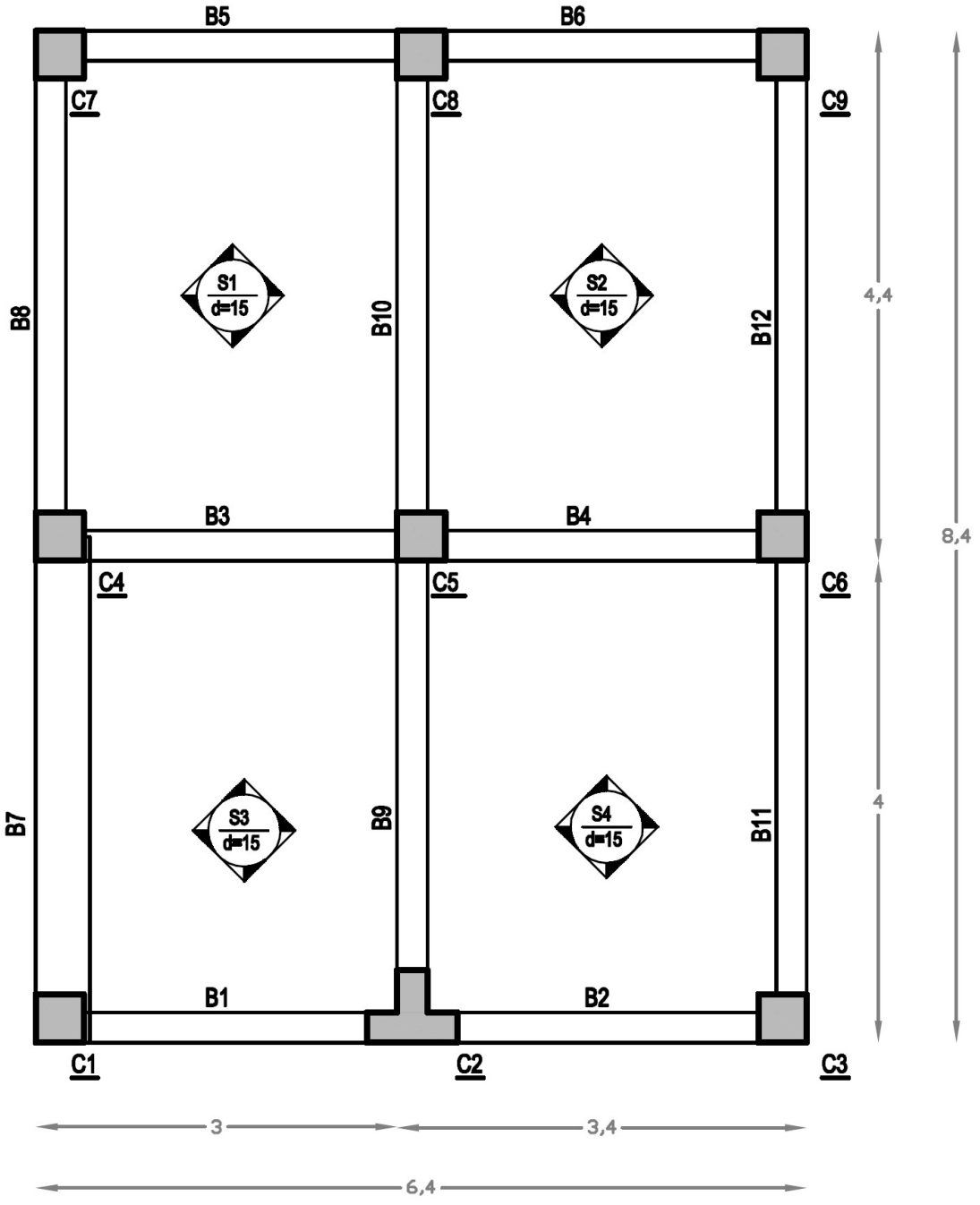
COMPUTER FILES

- 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

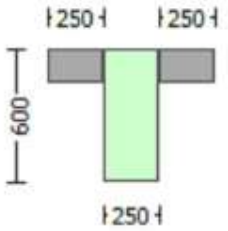
DESCRIPTION

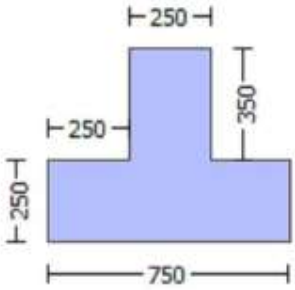
The 3D model is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

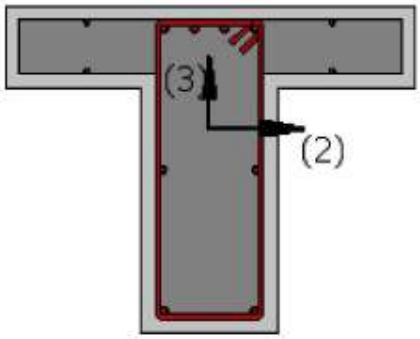
The resulting joints shear forces, horizontal hoops area and vertical reinforcement area of the FE analysis program SeismoBuild are compared with hand calculations.

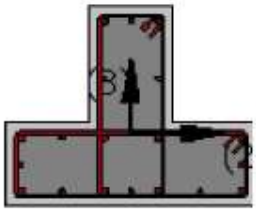
The employed equations are: (8.7.2.11) of commentary of NTC-18 for Joints Diagonal Tension checks and (8.7.2.12) of commentary of NTC-18 for Joints Diagonal Compression checks.

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	SeismoBuild 2021		Hand calculations	
		Demand	Capacity	Demand	Capacity
Joints Diagonal Tension [MPa]	Collapse Prevention	0.000147839	1.0	0.000147839	1.0
Joints Diagonal Compression [MPa]		0.321230746	5.5556	0.321230746	5.5556

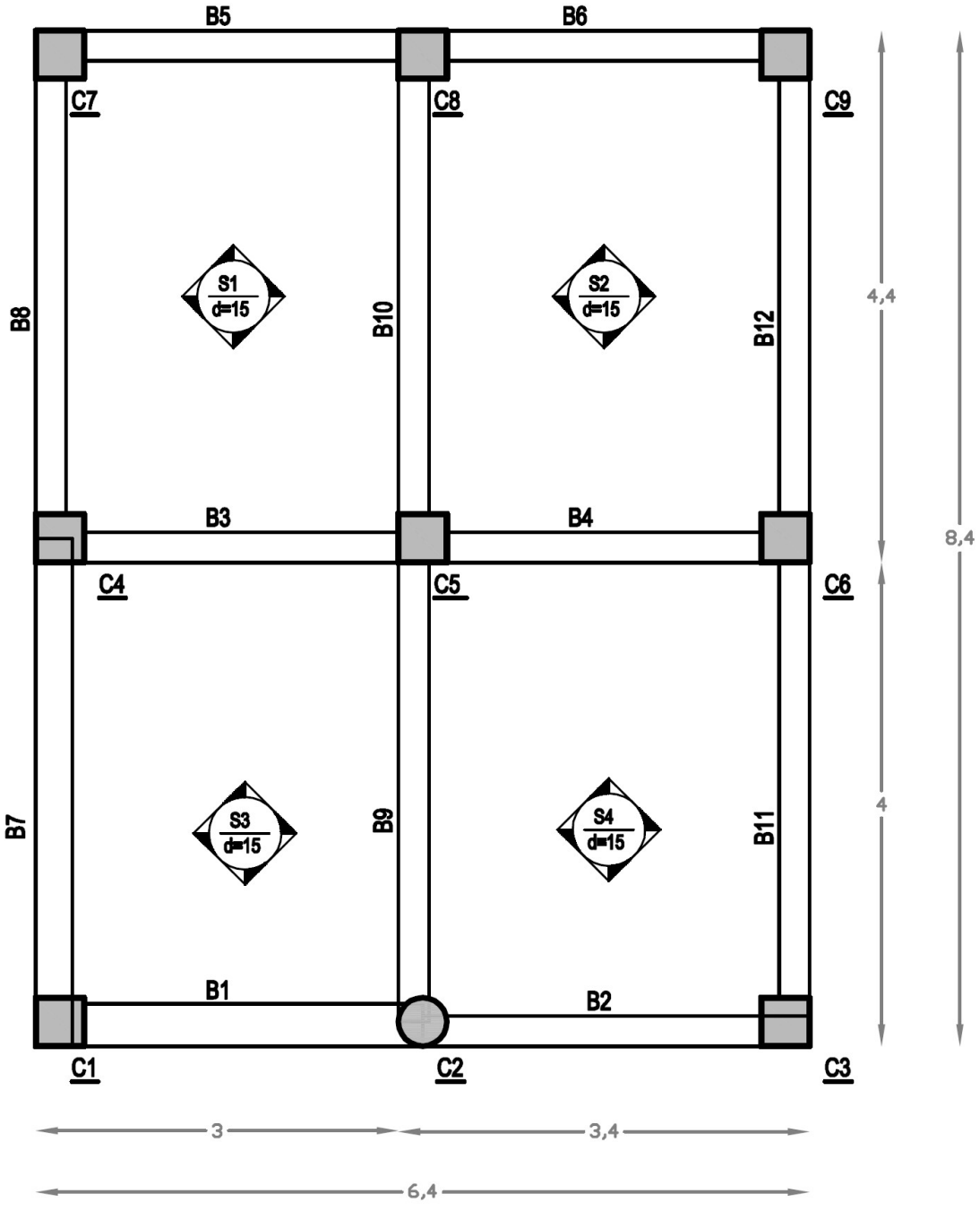
COMPUTER FILES

- 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

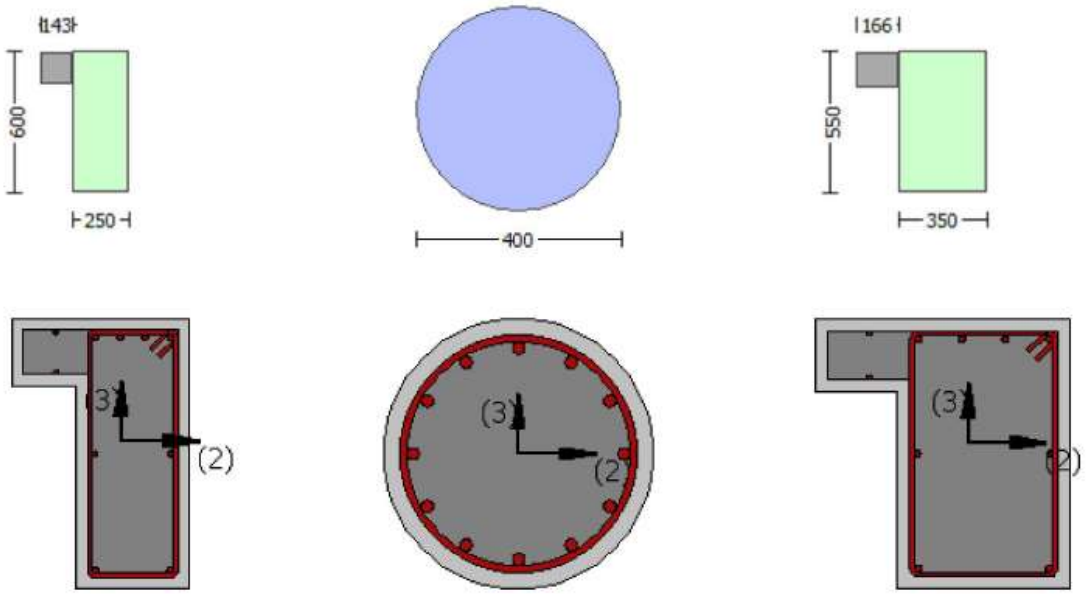
DESCRIPTION

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	SeismoBuild 2021		Hand calculations	
		Demand	Capacity	Demand	Capacity
Joints Diagonal Tension [MPa]	Operational Level	0.0095818	1.0	0.0095818	1.0
Joints Diagonal Compression [MPa]		0.2779575	5.5556	0.2779575	5.5556

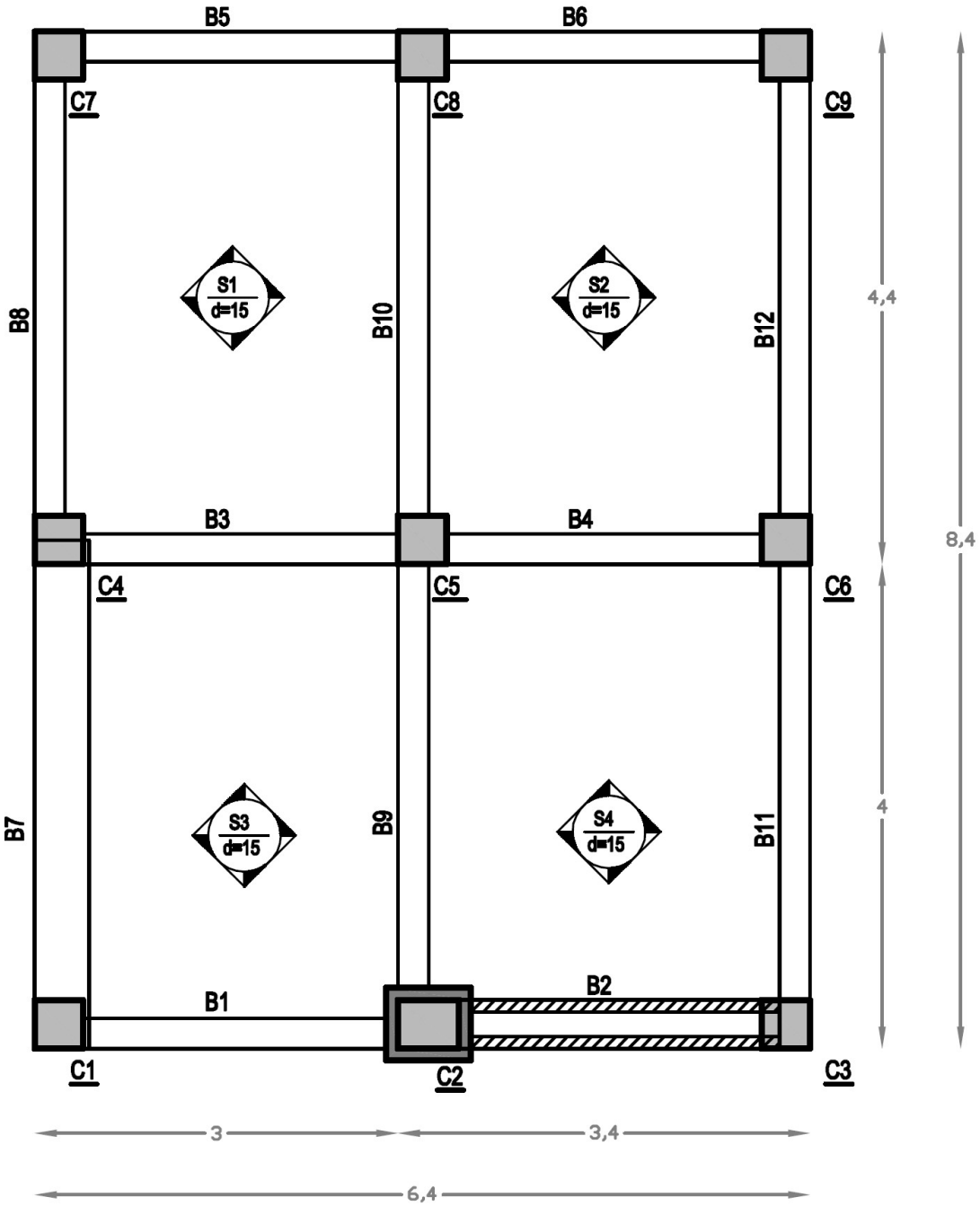
COMPUTER FILES

- 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

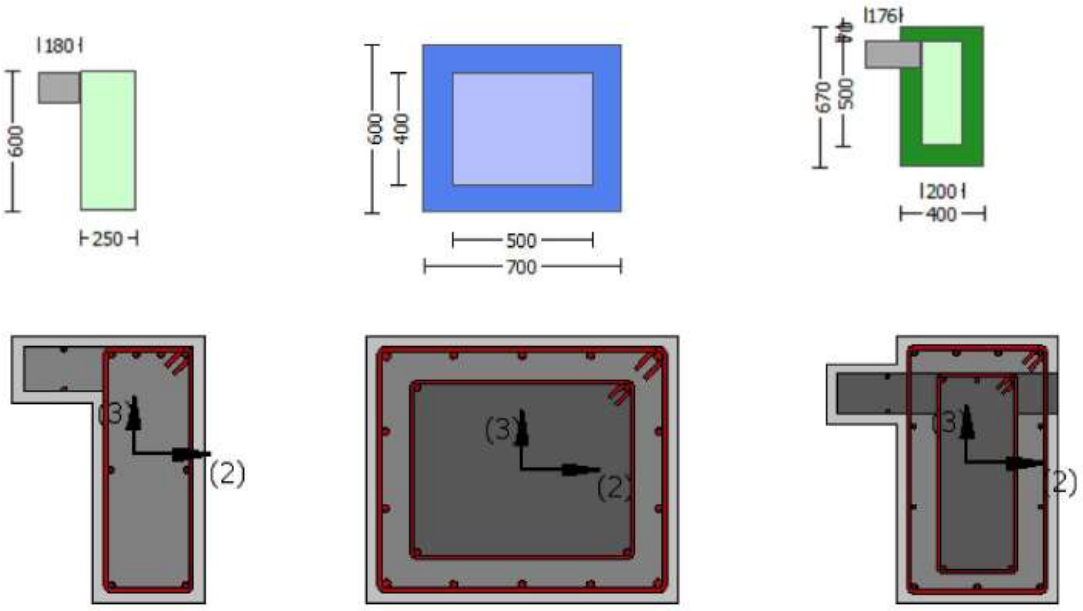
DESCRIPTION

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	SeismoBuild 2021		Hand calculations	
		Demand	Capacity	Demand	Capacity
Joints Diagonal Tension [MPa]	Damage Limitation	0.00147335	1.0	0.00147335	1.0
Joints Diagonal Compression [MPa]		0.12505168	5.5556	0.12505168	5.5556

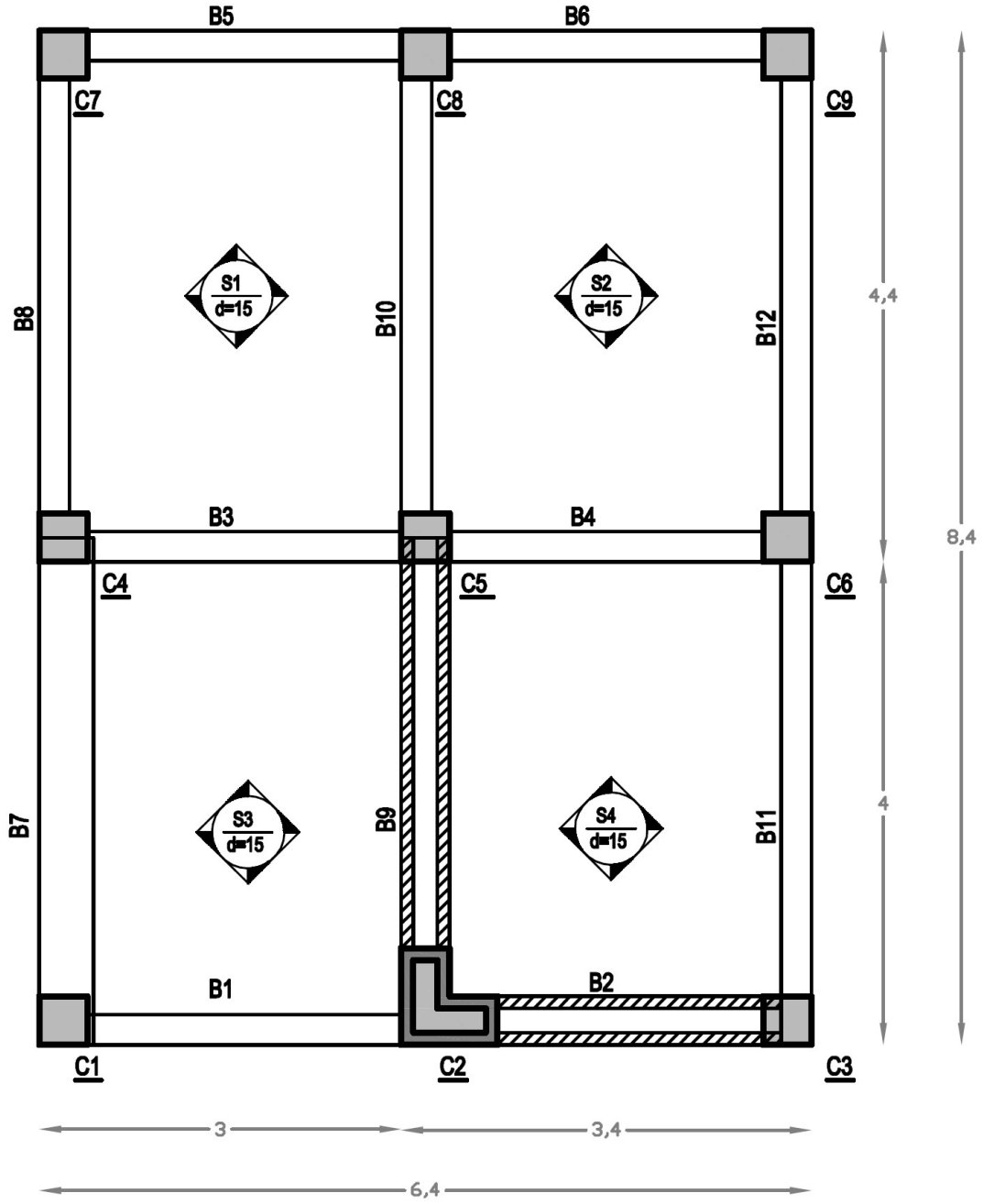
COMPUTER FILES

- 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

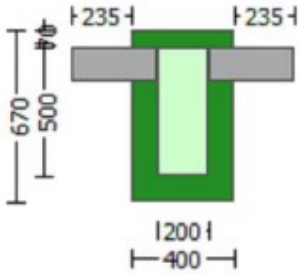
DESCRIPTION

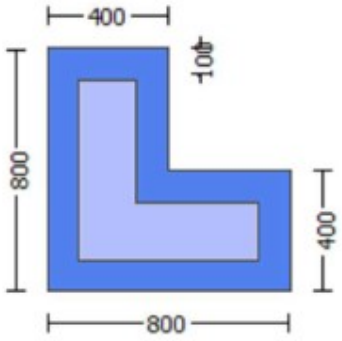
The 3D model is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

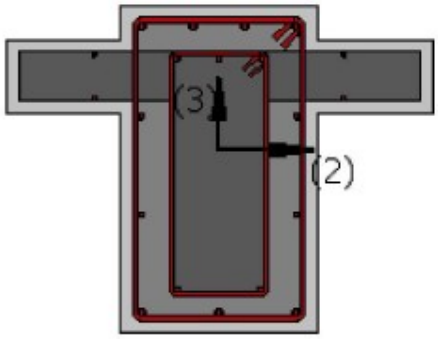
The resulting joints shear forces, horizontal hoops area and vertical reinforcement area of the FE analysis program SeismoBuild are compared with hand calculations.

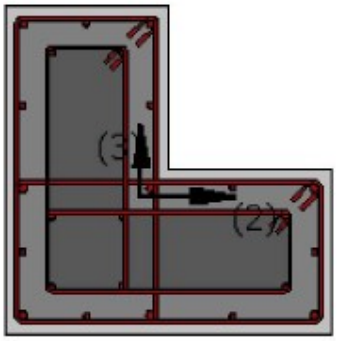
The employed equations are: (8.7.2.11) of commentary of NTC-18 for Joints Diagonal Tension checks and (8.7.2.12) of commentary of NTC-18 for Joints Diagonal Compression checks.

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	SeismoBuild 2021		Hand calculations	
		Demand	Capacity	Demand	Capacity
Joints Diagonal Tension [MPa]	Life Safety	0.0000429	1.0	0.0000429	1.0
Joints Diagonal Compression [MPa]		0.1879081	5.5556	0.1879081	5.5556

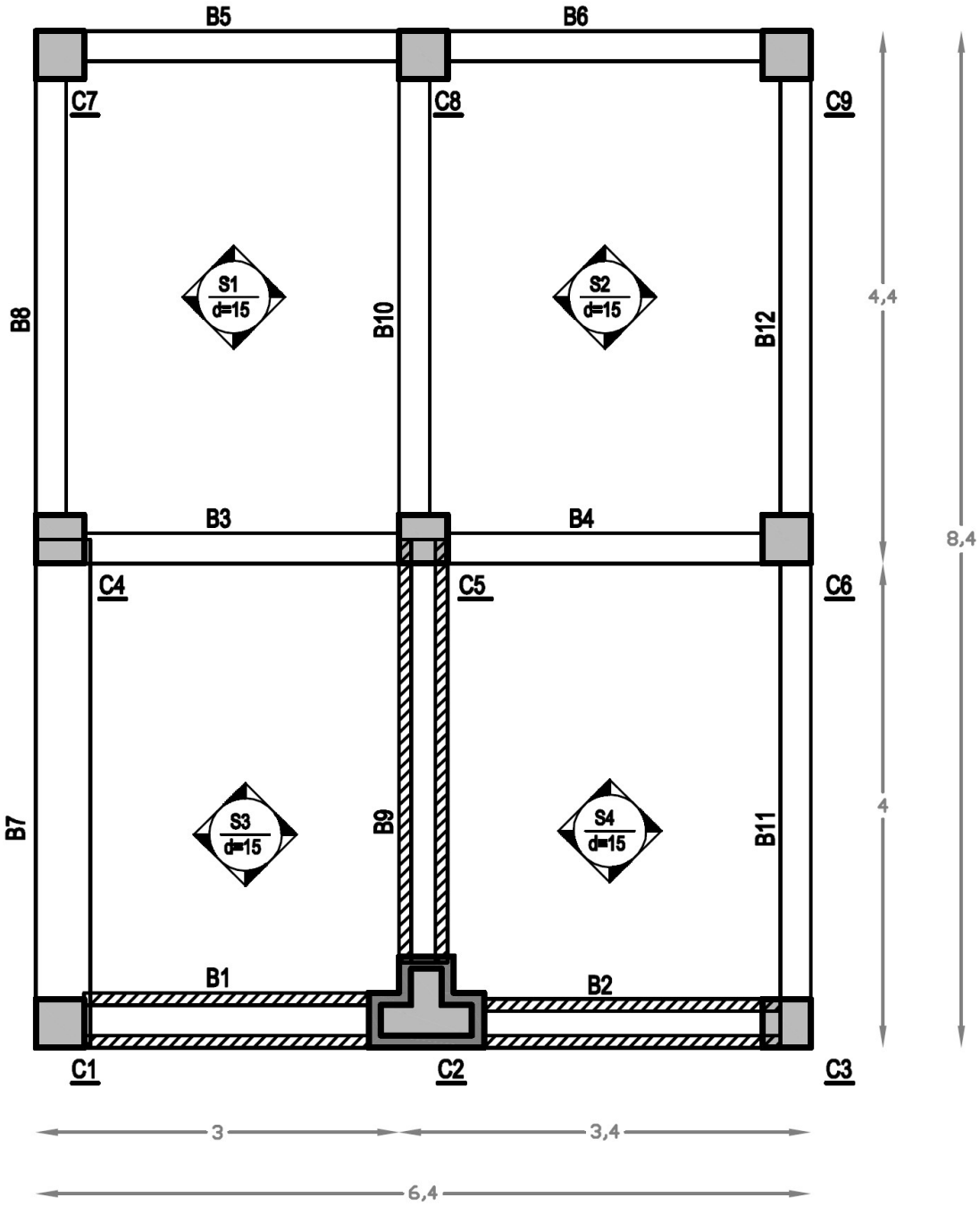
COMPUTER FILES

- 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

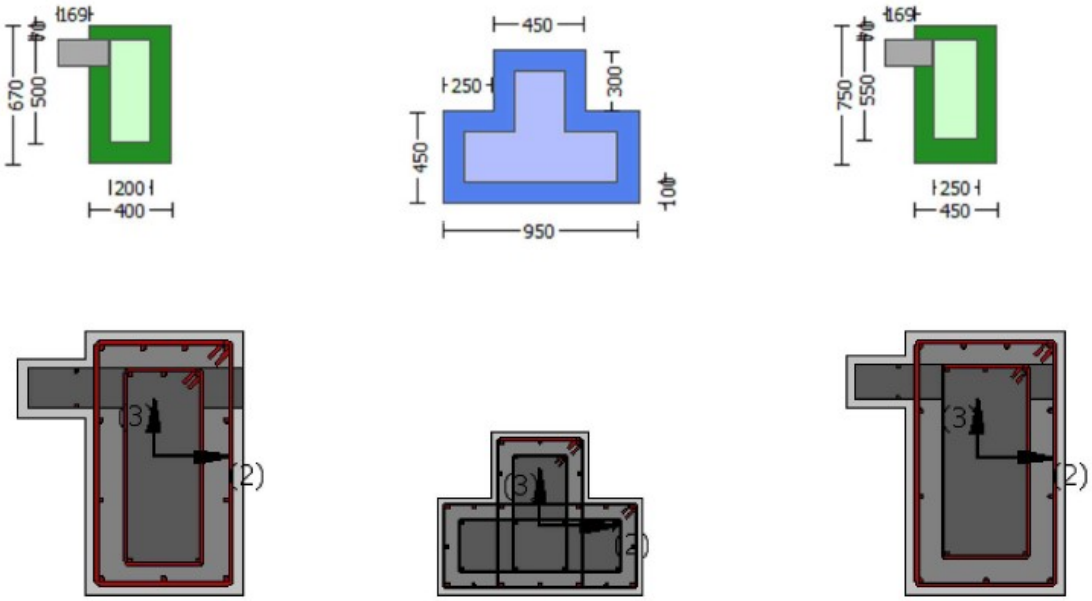
DESCRIPTION

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	SeismoBuild 2021		Hand calculations	
		Demand	Capacity	Demand	Capacity
Joints Diagonal Tension [MPa]	Life Safety	0.0018574	1.0	0.0018574	1.0
Joints Diagonal Compression [MPa]		0.1234533	5.5556	0.1234533	5.5556

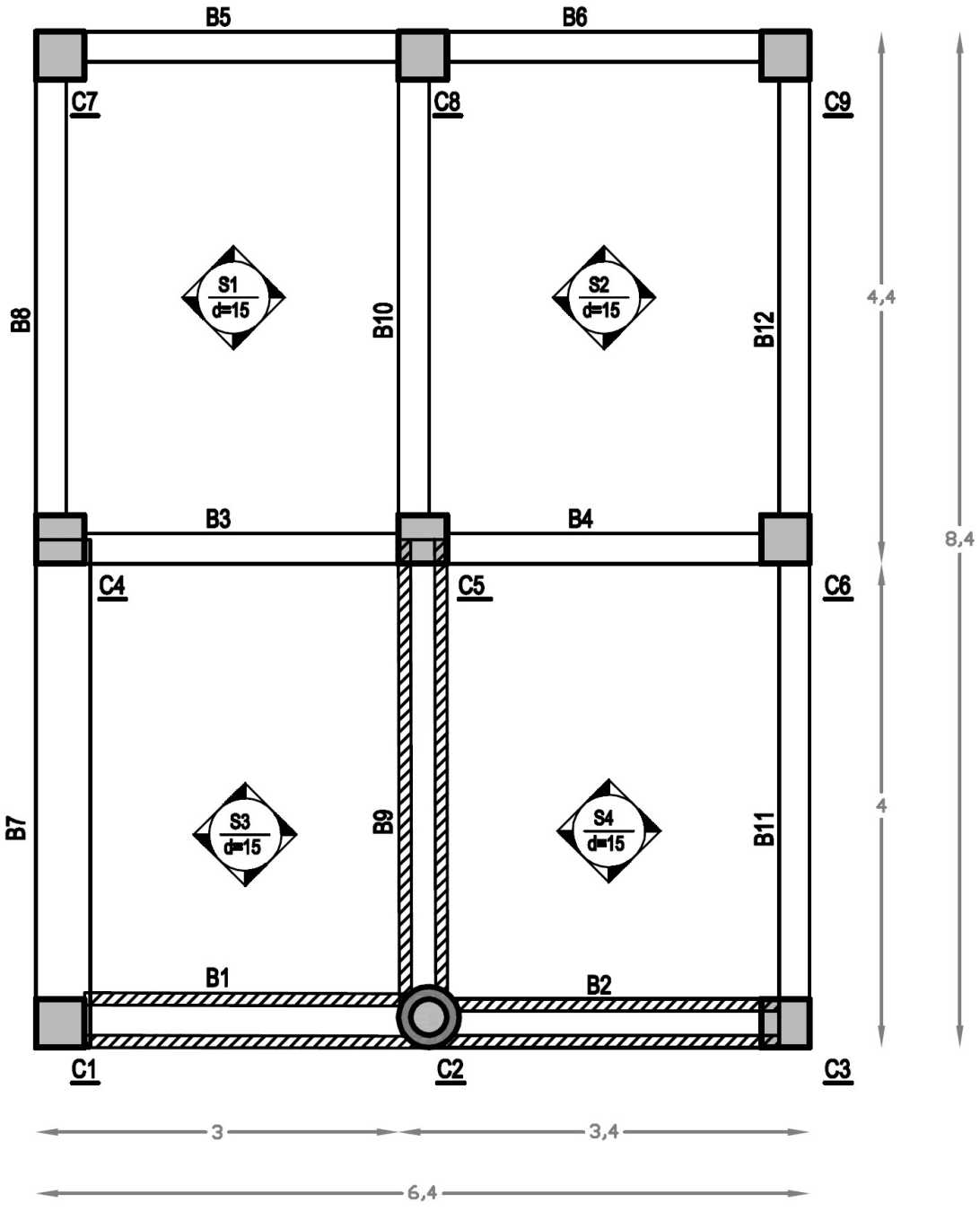
COMPUTER FILES

- 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

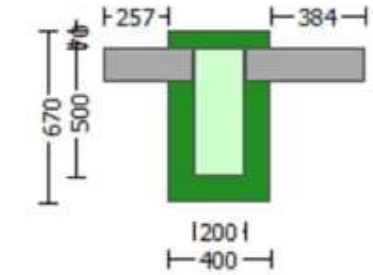
DESCRIPTION

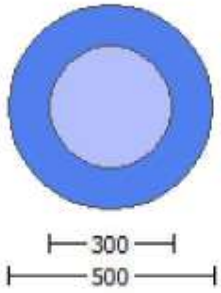
The 3D model is subjected to a Uniaxial without Eccentricity-Uniform Pushover Analysis in the +X direction.

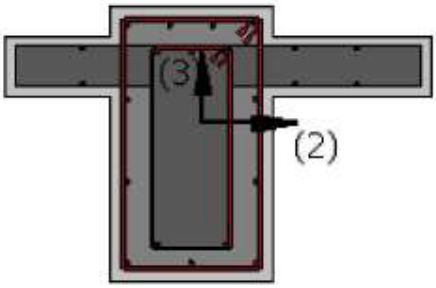
The resulting joints shear forces, horizontal hoops area and vertical reinforcement area of the FE analysis program SeismoBuild are compared with hand calculations.

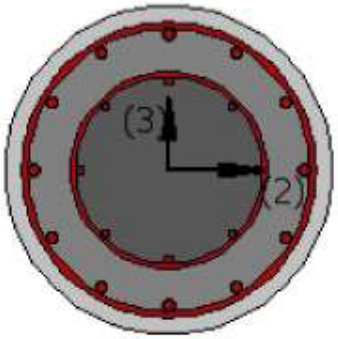
The employed equations are: (8.7.2.11) of commentary of NTC-18 for Joints Diagonal Tension checks and (8.7.2.12) of commentary of NTC-18 for Joints Diagonal Compression checks.

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	SeismoBuild 2021		Hand calculations	
		Demand	Capacity	Demand	Capacity
Joints Diagonal Tension [MPa]	Operational Level	0.00073462	1.0	0.00073462	1.0
Joints Diagonal Compression [MPa]		0.18848547	5.5556	0.18848547	5.5556

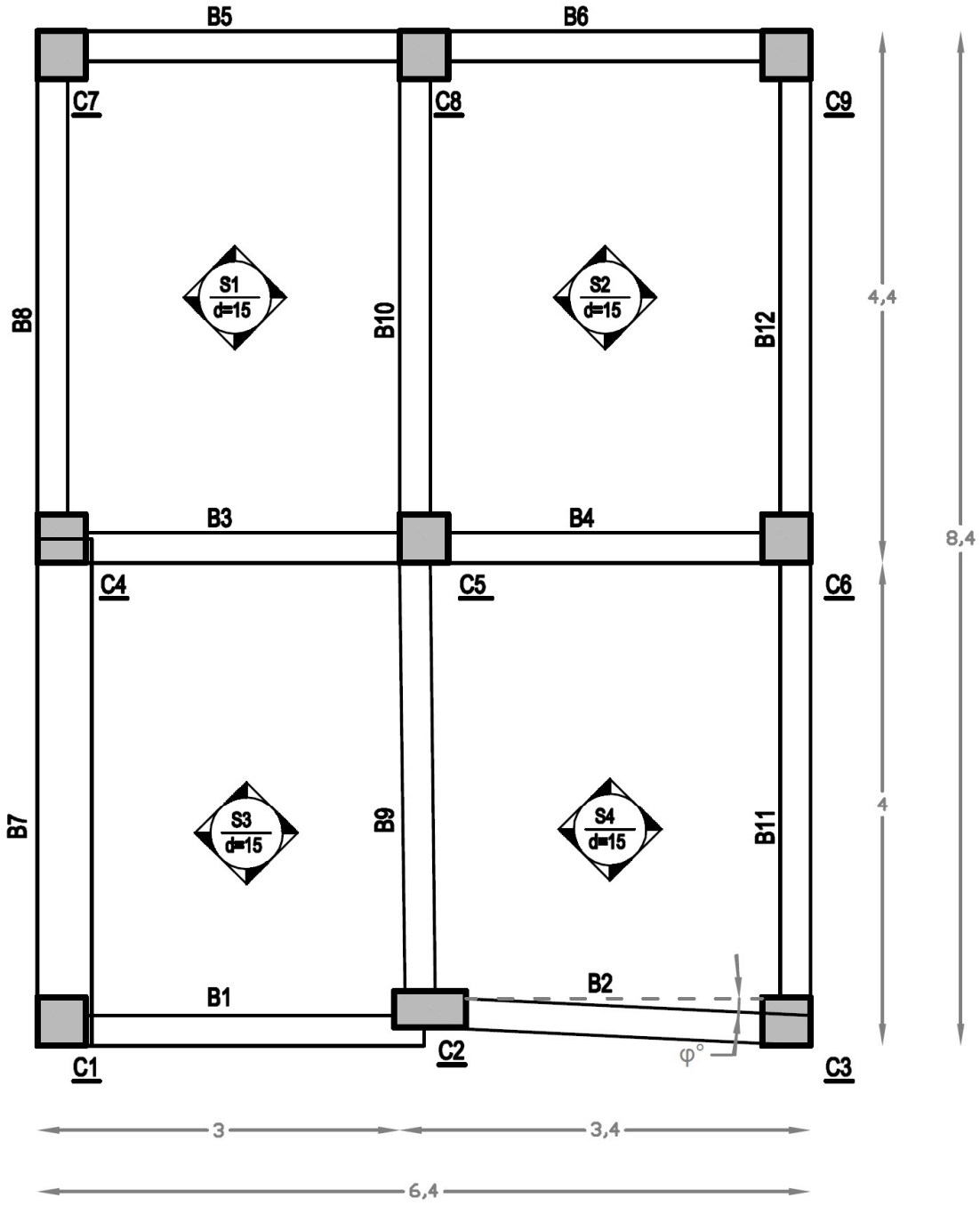
COMPUTER FILES

- 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

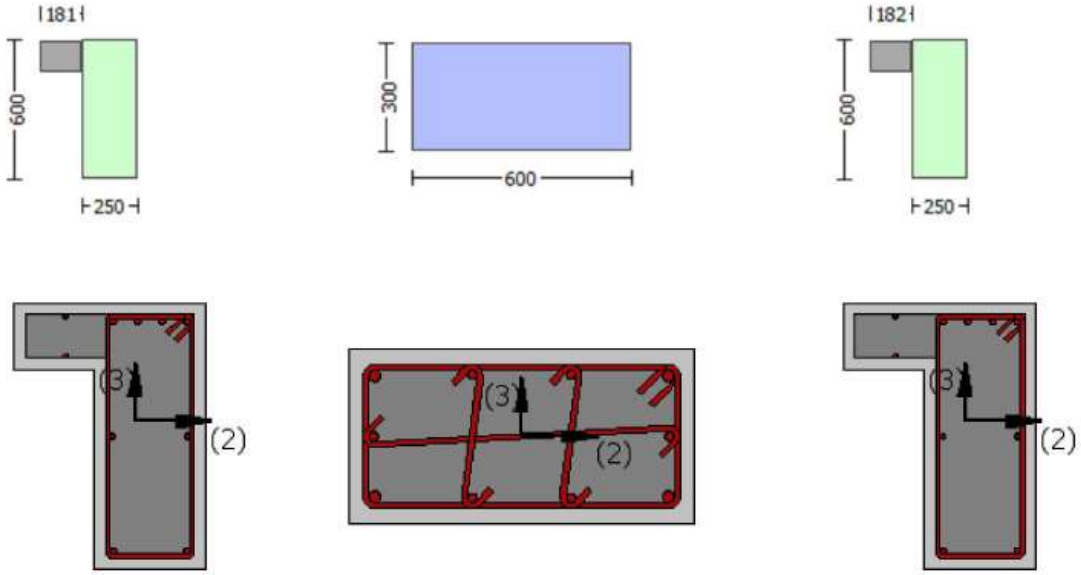
DESCRIPTION

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	SeismoBuild 2021		Hand calculations	
		Demand	Capacity	Demand	Capacity
Joints Diagonal Tension [MPa]	Damage Limitation	0.06771071	1.0	0.06771071	1.0
Joints Diagonal Compression [MPa]		0.34322013	5.5556	0.34322013	5.5556

COMPUTER FILES

- NTC_Joint10.bpf
- Report_NTC_Joint10.pdf