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ProtaStructure Design Guide

Beam-Column Joint Shear Design (EC8)

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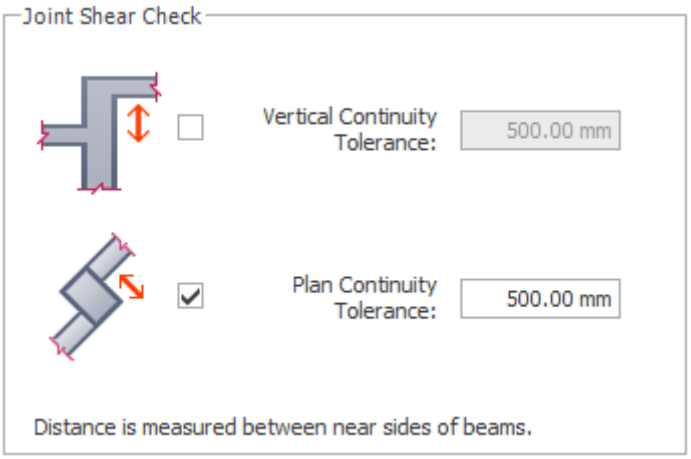
Introduction

ProtaStructure checks the beam-column joint shear design considerations according to **EC8 Chapters 5.5.2.3 and 5.5.3.3**. In this document, calculation details about beam-column joint shear are explained.

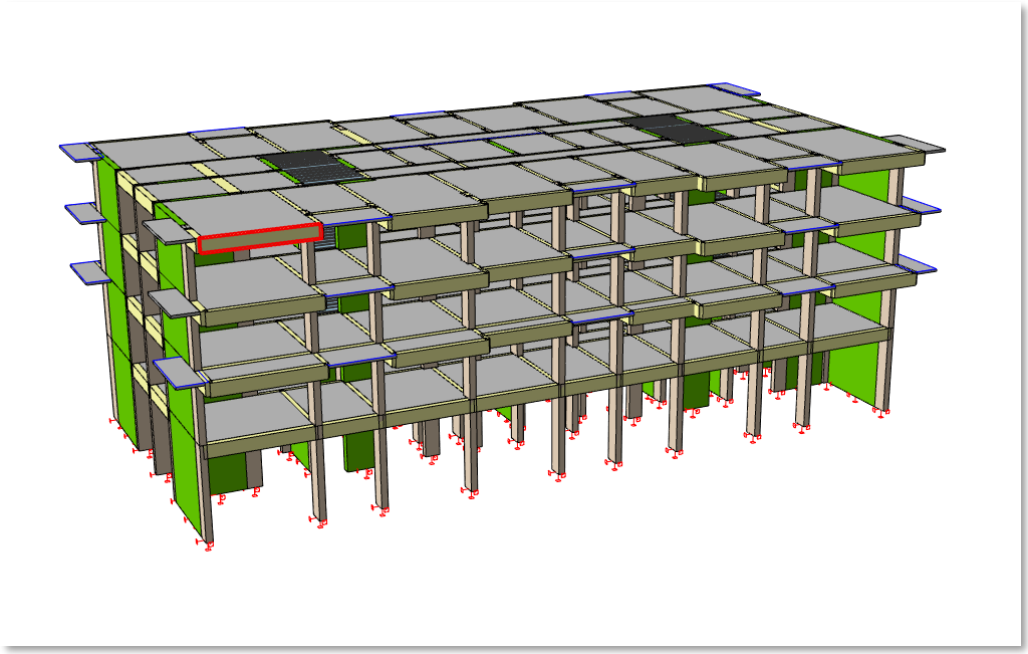
Joint Shear Check Tolerance Settings

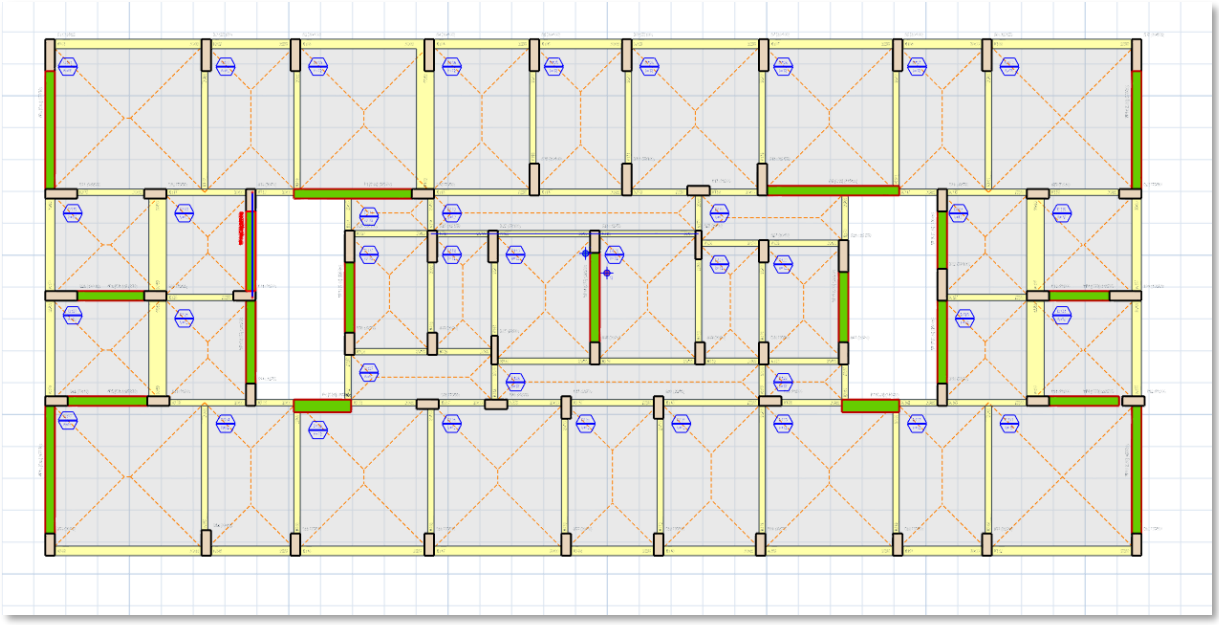
The opposite beams may not be on the same line or level at beam-column joints. In this case, the user should determine both vertical and plan tolerances. Beams that are not within the tolerance limits will be considered separate joints.



Building Model Details

In the current document, joint shear check calculations for a column of45 story residential building. 3D and typical story plan views are shown below.

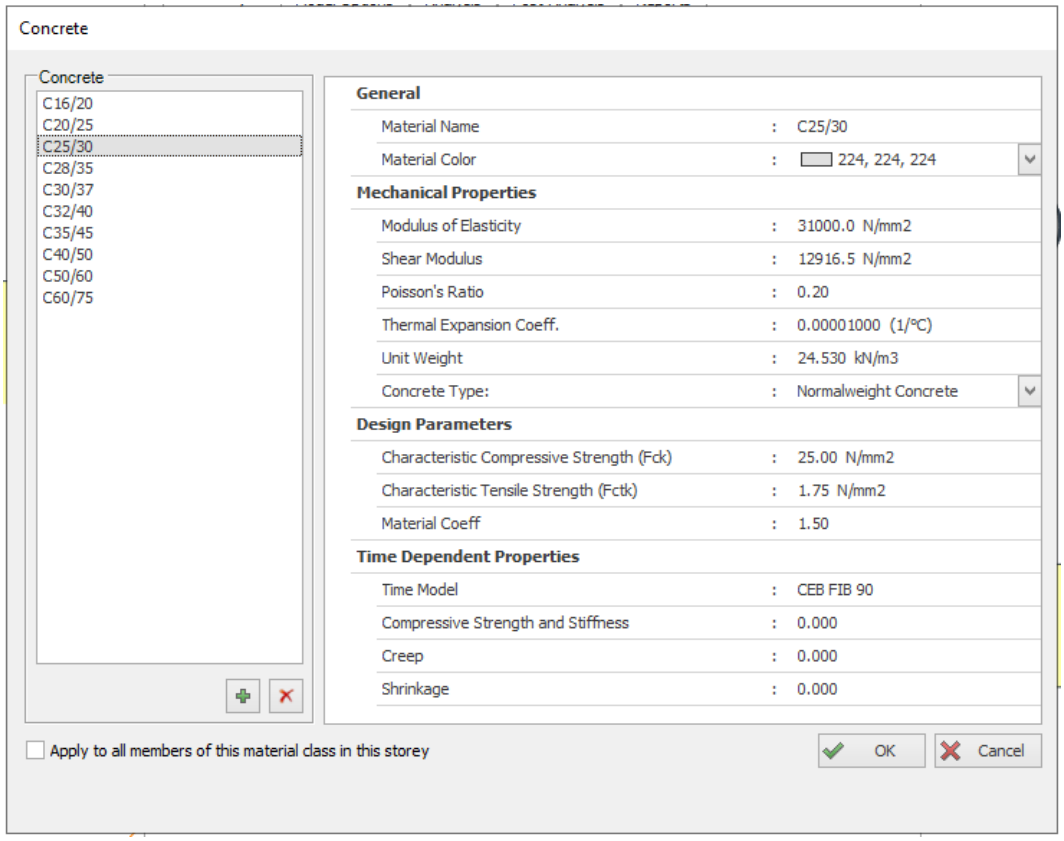




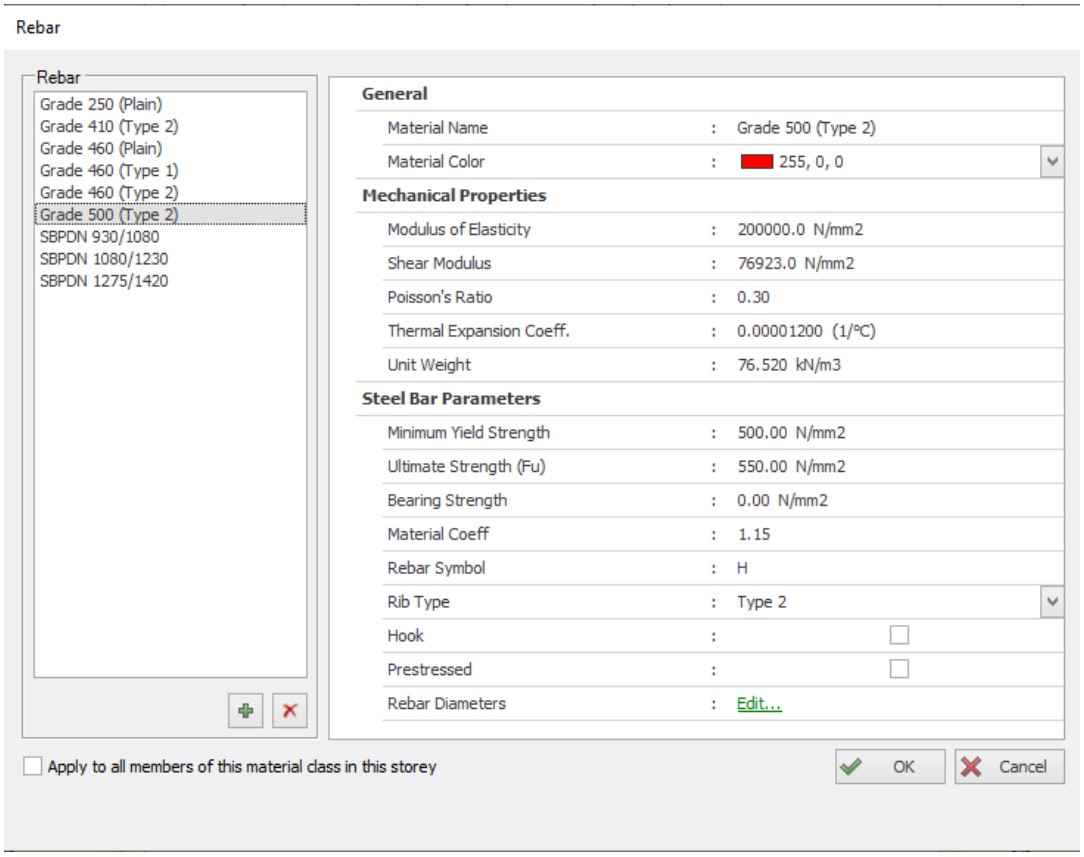
3D and Typical Plan View of Building Models (A and B Block Accordingly)

Material Properties

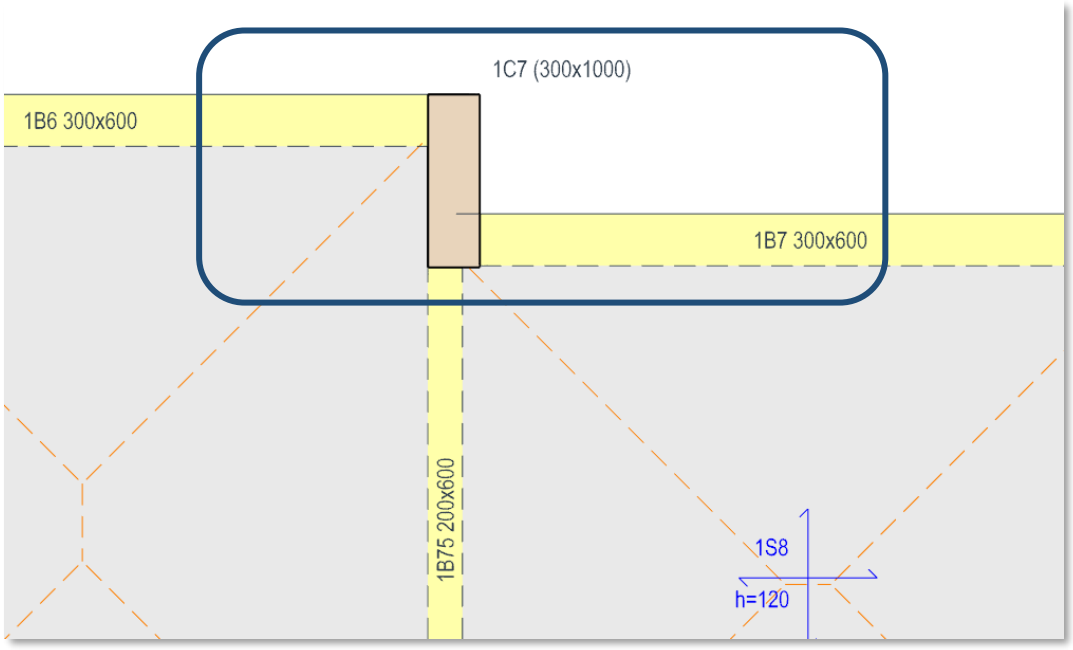
Concrete



Steel

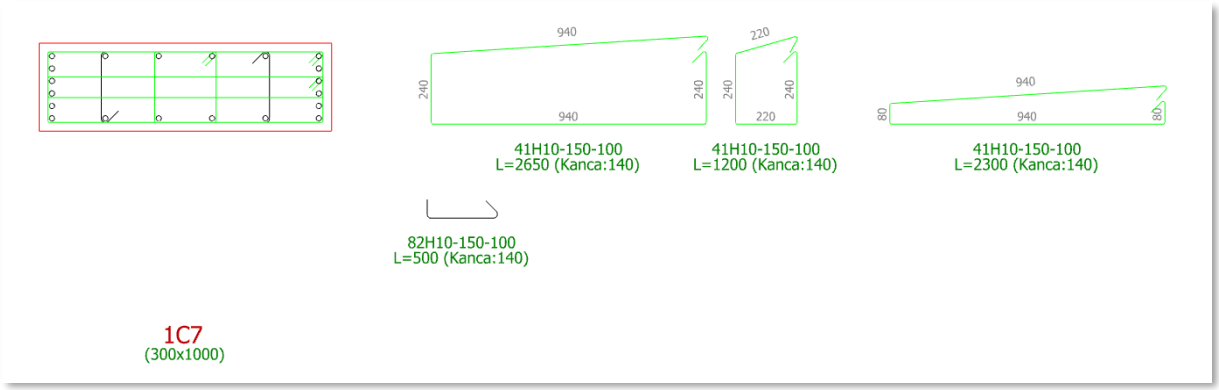


Member Details

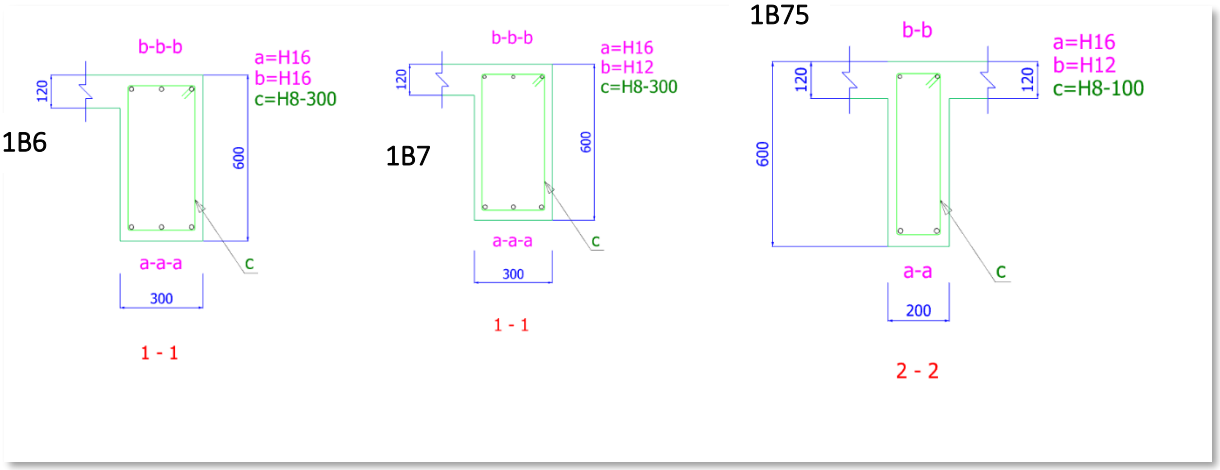


Column 1C7 in the first story will be used for calculations. There are two beams in the X direction connected to columns **1C7** and one in the Y direction. There is a 400 mm distance between near sides of beams in the X-direction. Since Plan Continuity Tolerance is set as 500 mm, beams in the X direction(1B6-1B7) will be considered continuous

Column Section and Reinforcement



Beam Section and Reinforcement



Calculation Details

According to **EC8 5.5,** joint shear conditions are checked only for **DCH** structures, depending on their hysteretic dissipation capacity.

According to **EC8 5.5.2.3,** the shear at the joints should be calculated considering the most adverse conditions under seismic loading, which corresponds to capacity design conditions for the beams framing into the joint.

Joints are separated into two groups according to beam continuity:

(1) Interior Beam-Column Joints: Beam continues from the other side of the column

(2) Exterior Beam-Column Joints: Beam doesn't continue from the other side of the column

Joint Shear Force Calculations

The horizontal shear force acting on the concrete core of the joints will be calculated as follows:

(a) for **interior** beam-column joints:

$$V_{jhd} = \gamma_{Rd} * (A_{s1} + A_{s2}) * f_{yd} - V_c$$

(b) for **exterior** beam-column joints:

$$V_{jhd} = \gamma_{Rd} * A_{s1} * f_{yd} - V_c$$

A_{s1}= Area of the beam top reinforcement

A_{s2}= Area of the beam bottom reinforcement

V_c= The shear force in the column above the joint, from the analysis of the seismic design situation

γ_{Rd}= A factor to account for overstrength due to steel strain-hardening should be not less than 1,2.

Limiting Shear Force Calculations

According to **EC8 5.5.3.3 (1) and (2)**, limiting values for joint shear should be calculated as follows:

(a) At **interior** beam-column joints, the following expression should be satisfied:

$$\eta = 0.6(1 - f_{ck})/250$$

$$v_d = N_{ed}/(f_{cd} * b * h)$$

$$V_{jhd} \leq \eta f_{cd} \sqrt{1 - \frac{v_d}{\eta}} b_j h_c$$

v_d= The normalized axial force in the column above the joint

h_{jc}= The distance between extreme layers of column reinforcement

η = Reduction factor on concrete compressive strength due to tensile strains in the transverse direction

(b) At **exterior** beam-column joints:

V_{jhd} should be less than **80%** of the value given by the right-hand-side of **interior** beam-column joints joint limit shear force expression, where V_{jhd} is given by expressions for horizontal shear force calculations.

Effective Joint Width Calculation

According to **EC8 5.5.3.3**, effective joint width should be calculated as follows:

If $b_c > b_w$

$$b_j = min\{b_c; (b_w + 0.5\, h_c)\}$$

If $b_w > b_c$

$$b_j = min\{b_w; (b_c + 0.5\, h_c)\}$$

Verification of Joint Shear Check Results

In this section, Joint Shear Checks are performed for column 1C7.

X-Direction Checks

1B6 and 1B7 beams are connected to the column in the X-direction.

Calculation of Effective Joint Width, bj:

Since b_c (100 cm) > b_{w1} , b_{w2} (30cm), effective joint width will be calculated with EC8 Eqn(5.34).

h_c = 30 cm

$$b_j = min\{100; (30 + 0.5 * 30)\}$$

$$b_j = 45\ cm$$

Calculation of Shear Force:

$\gamma_{Rd} = 1.25$ (Reinforcement OverStrength Factor)

$F_{yd} = 500 / 1.15\ MPa$

$A_{s1} = 603.19\ mm2$

$A_{s2} = 402.12\ mm2$

$V_c = 1.9\ kN$

$V_{jhd} = 1.25 * (603.19 + 402.12) * 435 - 1870$

$$V_{jhd} = 544.5\ kN$$

Calculation of Shear Force Limit:

$\eta = 0.54$

$v_d = 0.1491$

$f_{cd} = 25/1.5\ MPa$

$h_c = 300\ mm$

$b_j = 450\ mm$

$$V_{jhd,limit} = 1033.75\ \text{kN}$$

Since the joint is not confined, the limit value will be reduced by %80 according to EC8 5.5.3.3 (2)

$$V_{jhd,limit} = 827.5\ kN$$

X Direction Checks

Joint	Confined	Member	b_j (mm)	h (mm)	V_a / V_u (kN)	V_c (kN)	$A_{s,Top}$ (mm2)	$A_{s,Bot}$ (mm2)	η	v_d	V_{jhd} (kN)	$V_{jhd,limit}$ (kN)
1B6 + 2C7 + 1C7 + 1B7	No	2C7 - Storey:2	450.0	300.0	2.8	1.9	-	-	-	-	544.5	827.0
		1C7 - Storey:1	450.0	300.0	1.9	1.9	-	-	0.54	0.1		
		1B6	-	-	-	-	603.19	603.19	-	-		
		1B7	-	-	-	-	402.12	339.29	-	-		

Joint Shear Force, Vjhd = 544.5 kN < 827.0 kN ✓

Y-Direction Checks

Calculation of Effective Joint Width, bj:

Since b_c(30 cm) > b_{w1} , b_{w2} (20cm), effective joint width will be calculated with EC8 Eqn(5.34).

h_c = 100 cm

$$b_j = min\{30; (20 + 0.5 * 100)\}$$

$$b_j = 30\ cm$$

Calculation of Shear Force:

$\gamma_{Rd} = 1.25$ (Reinforcement OverStrength Factor)

$F_{yd} = 500 / 1.15\ MPa$

$A_{s1} = 402.12\ mm2$

$V_c = 1.9\ kN$

$V_{jhd} = 1.25 * (402.12) * 435 - 1870$

$$V_{jhd} = 211.1\ kN$$

Calculation of Shear Force Limit:

$\eta = 0.54$

$v_d = 0.1491$

$f_{cd} = 25/1.5\ MPa$

$h_c = 1000\ mm$

$b_j = 300\ mm$

$$V_{jhd,limit} = 2296.25\ \text{kN}$$

Since the joint is not confined, the limit value will be reduced by %80 according to **EC8 5.5.3.3 (2)**

$$V_{jhd,limit} = 1837.8\ kN$$

Y Direction Checks

Joint	Confined	Member	b_j (mm)	h (mm)	V_a / V_u (kN)	V_c (kN)	$A_{s,Top}$ (mm2)	$A_{s,Bot}$ (mm2)	η	v_d	V_{jhd} (kN)	$V_{jhd,limit}$ (kN)
2C7	No	2C7 - Storey:2	300.0	1000.0	7.7	7.4	-	-	-	-	211.1	1837.8
1B75 +		1C7 - Storey:1	300.0	1000.0	7.4	7.4	-	-	0.54	0.1		
1C7		1B75	-	-	-	-	339.29	402.12	-	-		

Joint Shear Force, Vjhd = 211.1 kN < 1837.8 kN ✓

Summary

This document explains the details of the beam-column joint shear calculations according to EC8 Clause 4.4.2.7.

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