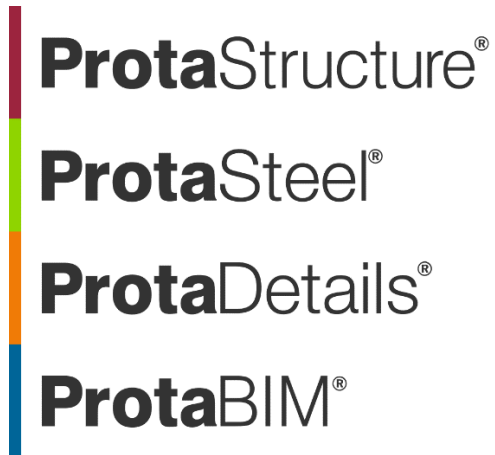




# ProtaStructure Design Guide

## Beam-Column Joint Shear Design (EC8)

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Version 2.0

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# Table of Contents

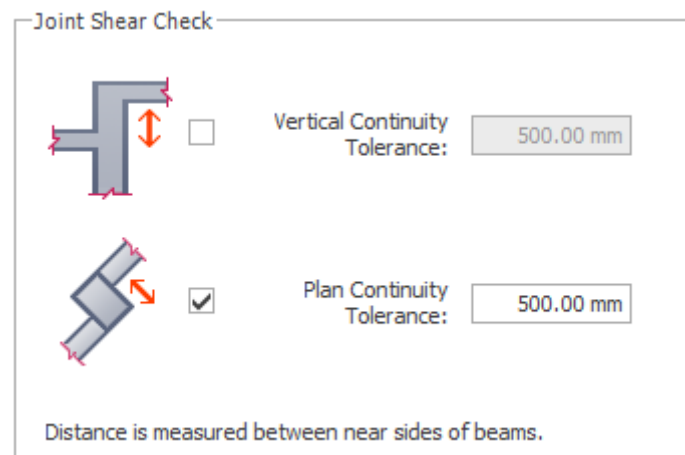
|                                                     |    |
|-----------------------------------------------------|----|
| Introduction .....                                  | 4  |
| Joint Shear Check Tolerance Settings .....          | 4  |
| Building Model Details .....                        | 4  |
| Material Properties .....                           | 5  |
| Concrete .....                                      | 5  |
| Steel .....                                         | 6  |
| Member Details .....                                | 6  |
| Column Section and Reinforcement .....              | 7  |
| Beam Section and Reinforcement .....                | 7  |
| Calculation Details .....                           | 7  |
| Joint Shear Force Calculations .....                | 7  |
| Limiting Shear Force Calculations .....             | 8  |
| Effective Joint Width Calculation .....             | 8  |
| Verification of Joint Shear Check Results .....     | 9  |
| X-Direction Checks .....                            | 9  |
| Calculation of Effective Joint Width, $b_j$ : ..... | 9  |
| Calculation of Shear Force: .....                   | 9  |
| Calculation of Shear Force Limit: .....             | 9  |
| Y-Direction Checks .....                            | 10 |
| Calculation of Effective Joint Width, $b_j$ : ..... | 10 |
| Calculation of Shear Force: .....                   | 10 |
| Calculation of Shear Force Limit: .....             | 10 |
| Summary .....                                       | 11 |
| Thank You... .....                                  | 12 |

## 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.

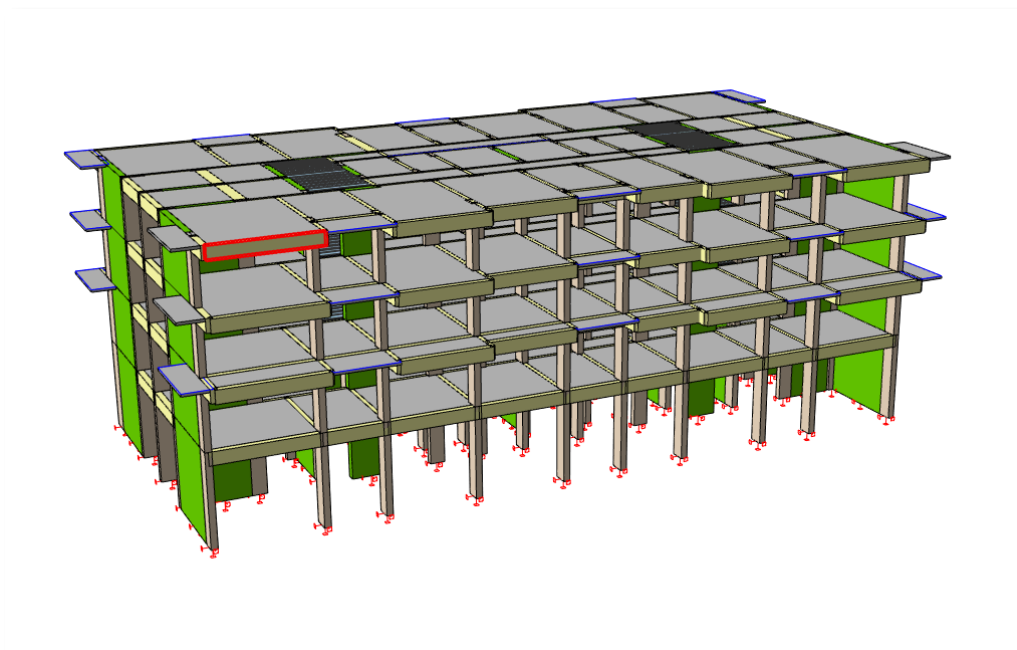
## Joint Shear Check Tolerance Settings

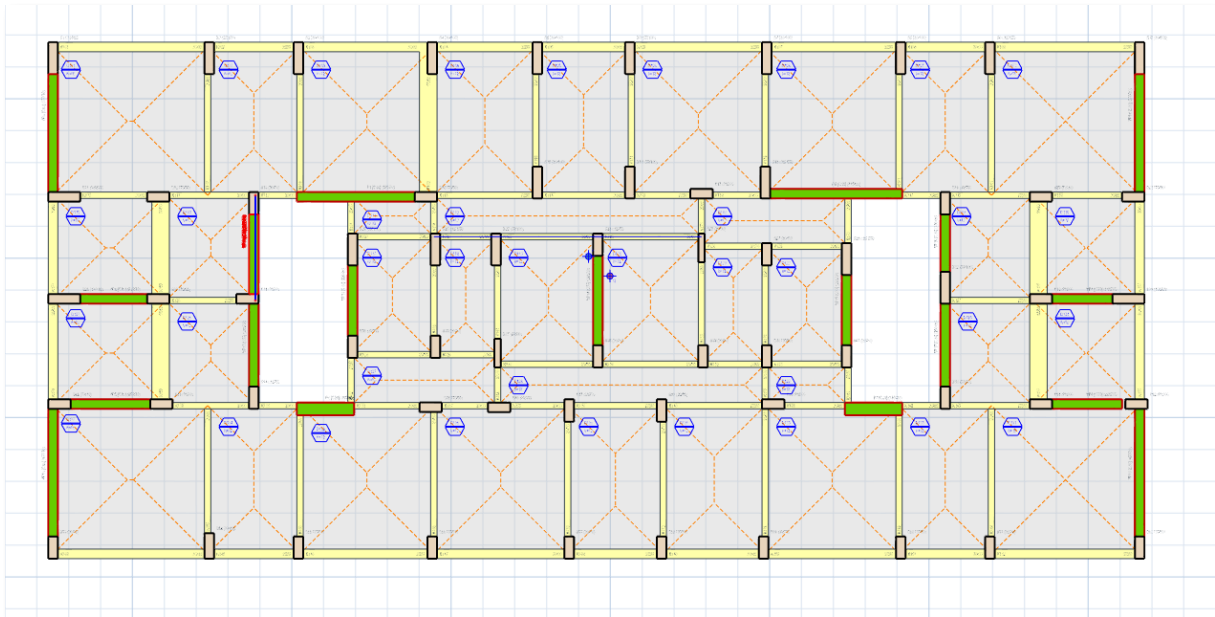
The opposite beams may not be on the same line or level at beam-column joints. In this case, the user should determine both vertical and plan tolerances. Beams that are not within the tolerance limits will be considered separate joints.



## Building Model Details

In the current document, joint shear check calculations for a column of 45 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

Concrete

- C16/20
- C20/25
- C25/30
- C28/35
- C30/37
- C32/40
- C35/45
- C40/50
- C50/60
- C60/75

**General**

Material Name : C25/30

Material Color : 224, 224, 224

**Mechanical Properties**

Modulus of Elasticity : 31000.0 N/mm<sup>2</sup>

Shear Modulus : 12916.5 N/mm<sup>2</sup>

Poisson's Ratio : 0.20

Thermal Expansion Coeff. : 0.00001000 (1/°C)

Unit Weight : 24.530 kN/m<sup>3</sup>

Concrete Type: Normalweight Concrete

**Design Parameters**

Characteristic Compressive Strength (F<sub>ck</sub>) : 25.00 N/mm<sup>2</sup>

Characteristic Tensile Strength (F<sub>ctk</sub>) : 1.75 N/mm<sup>2</sup>

Material Coeff : 1.50

**Time Dependent Properties**

Time Model : CEB FIB 90

Compressive Strength and Stiffness : 0.000

Creep : 0.000

Shrinkage : 0.000

☐ Apply to all members of this material class in this storey

OK Cancel

## Steel

Rebar

Rebar

- Grade 250 (Plain)
- Grade 410 (Type 2)
- Grade 460 (Plain)
- Grade 460 (Type 1)
- Grade 460 (Type 2)
- Grade 500 (Type 2)
- SBPDN 930/1080
- SBPDN 1080/1230
- SBPDN 1275/1420

**General**

Material Name : Grade 500 (Type 2)

Material Color : ■ 255, 0, 0

**Mechanical Properties**

Modulus of Elasticity : 200000.0 N/mm<sup>2</sup>

Shear Modulus : 76923.0 N/mm<sup>2</sup>

Poisson's Ratio : 0.30

Thermal Expansion Coeff. : 0.00001200 (1/°C)

Unit Weight : 76.520 kN/m<sup>3</sup>

**Steel Bar Parameters**

Minimum Yield Strength : 500.00 N/mm<sup>2</sup>

Ultimate Strength (Fu) : 550.00 N/mm<sup>2</sup>

Bearing Strength : 0.00 N/mm<sup>2</sup>

Material Coeff : 1.15

Rebar Symbol : H

Rib Type : Type 2

Hook : ☐

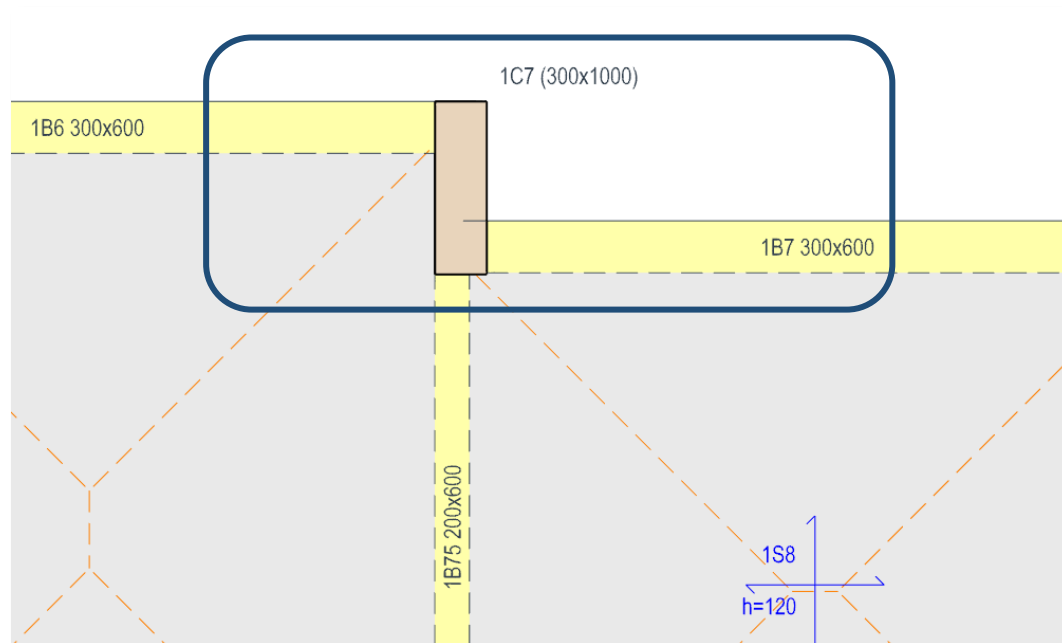
Prestressed : ☐

Rebar Diameters : [Edit...](#)

☐ Apply to all members of this material class in this storey

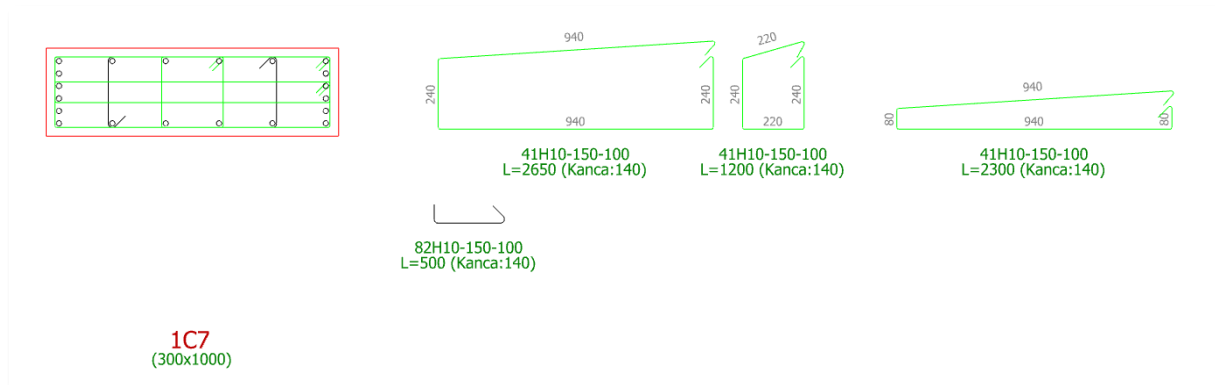
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## Member Details

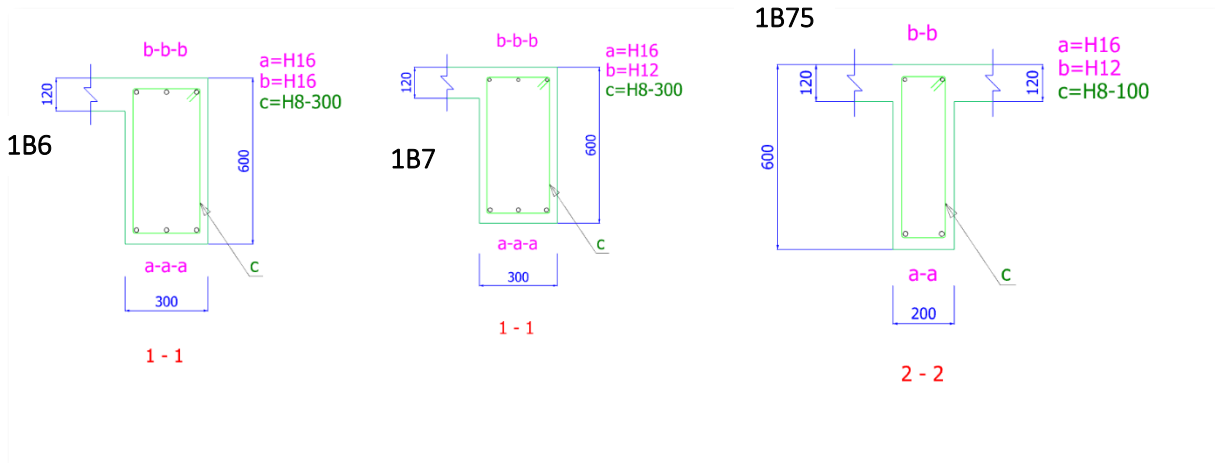


Column **1C7** in the first story will be used for calculations. There are two beams in the X direction connected to columns **1C7** and one in the Y direction. There is a 400 mm distance between near sides of beams in the X-direction. Since Plan Continuity Tolerance is set as 500 mm, beams in the X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

$\gamma_{Rd}$ = 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

$\eta$  = 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, $b_j$ :

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

$$h_c = 30 \text{ cm}$$

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

$$b_j = 45 \text{ cm}$$

#### Calculation of Shear Force:

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

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

$$A_{s1} = 603.19 \text{ mm}^2$$

$$A_{s2} = 402.12 \text{ mm}^2$$

$$V_c = 1.9 \text{ kN}$$

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

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

#### Calculation of Shear Force Limit:

$$\eta = 0.54$$

$$v_d = 0.1491$$

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

$$h_c = 300 \text{ mm}$$

$$b_j = 450 \text{ mm}$$

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

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

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

### X Direction Checks

| Joint                 | Confined | Member         | $b_j$ (mm) | $h$ (mm) | $V_s / V_u$ (kN) | $V_c$ (kN) | $A_{s,Top}$ (mm <sup>2</sup> ) | $A_{s,Bot}$ (mm <sup>2</sup> ) | $\eta$ | $v_d$ | $V_{jhd}$ (kN) | $V_{jhd,limit}$ (kN) |
|-----------------------|----------|----------------|------------|----------|------------------|------------|--------------------------------|--------------------------------|--------|-------|----------------|----------------------|
| 2C7<br>+<br>1B6 + 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,  $V_{jhd} = 544.5 \text{ kN} < 827.0 \text{ kN}$  ✓

### Y-Direction Checks

#### Calculation of Effective Joint Width, $b_j$ :

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

$$h_c = 100 \text{ cm}$$

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

$$b_j = 30 \text{ cm}$$

#### Calculation of Shear Force:

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

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

$$A_{s1} = 402.12 \text{ mm}^2$$

$$V_c = 1.9 \text{ kN}$$

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

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

#### Calculation of Shear Force Limit:

$$\eta = 0.54$$

$$v_d = 0.1491$$

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

$$h_c = 1000 \text{ mm}$$

$$b_j = 300 \text{ mm}$$

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

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

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

## Y Direction Checks

| Joint            | Confined | Member         | $b_f$ (mm) | $h$ (mm) | $V_s / V_u$ (kN) | $V_c$ (kN) | $A_{s,Top}$ (mm <sup>2</sup> ) | $A_{s,Bot}$ (mm <sup>2</sup> ) | $\eta$ | $V_d$ | $V_{jhd}$ (kN) | $V_{jhd,limit}$ (kN) |
|------------------|----------|----------------|------------|----------|------------------|------------|--------------------------------|--------------------------------|--------|-------|----------------|----------------------|
| 1B75<br>+<br>1C7 | No       | 2C7 - Storey:2 | 300.0      | 1000.0   | 7.7              | 7.4        | -                              | -                              | -      | -     | -              | -                    |
|                  |          | 1C7 - Storey:1 | 300.0      | 1000.0   | 7.4              | 7.4        | -                              | -                              | 0.54   | 0.1   | 211.1          | 1837.8               |
|                  |          | 1B75           | -          | -        | -                | -          | 339.29                         | 402.12                         | -      | -     | -              | -                    |

Joint Shear Force,  $V_{jhd} = 211.1 \text{ kN} < 1837.8 \text{ kN}$  ✓

## Summary

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

## Thank You...

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