

# Crack Analysis

SectionPro Tutorial — Crack width  $w_k$  and maximum crack spacing  $s_{r, \max}$  at the serviceability limit state per Eurocode 2

BridgeKernel · 2026

## Introduction

Reinforced concrete cracks under service loads. Cracks do not compromise structural safety, but excessive openings allow water, chlorides and  $\text{CO}_2$  to reach the reinforcement, causing corrosion. Design codes therefore limit the crack width  $w_k$  at the serviceability limit state.

SectionPro implements the Eurocode 2 direct calculation approach. The crack width is the product of the maximum crack spacing and the mean differential strain between steel and concrete:

$$w_k = s_{r, \max} \cdot (\varepsilon_{sm} - \varepsilon_{cm})$$

The crack spacing depends on cover  $c$ , bar diameter  $\varphi_s$ , bond factor  $k_1$  and effective reinforcement ratio  $\rho_{p, \text{eff}}$ :

$$s_{r, \max} = k_3 \cdot c + k_1 \cdot k_2 \cdot k_4 \cdot \frac{\varphi_s}{\rho_{p, \text{eff}}}$$

The mean differential strain accounts for tension stiffening (concrete between cracks carries part of the tension):

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \cdot \frac{f_{ct, \text{eff}}}{\rho_{p, \text{eff}}} \cdot (1 + \alpha_e \cdot \rho_{p, \text{eff}})}{E_s} \geq 0.6 \cdot \frac{\sigma_s}{E_s}$$

The effective tension area depth  $h_{c, \text{eff}}$  is a key intermediate result computed automatically from the section geometry:  $h_{c, \text{eff}} = \min(2.5(h - d), (h - x)/3, h/2)$ .

## Computed results

SectionPro provides for each crack width analysis:

### Results per load case

$w_k$ : crack width  
 $s_{r, \max}$ : maximum crack spacing  
 $\sigma_s$ : steel stress

### Intermediate quantities

$h_{c, \text{eff}}$ ,  $A_{c, \text{eff}}$ ,  $A_{s, \text{eff}}$ ,  $\rho_{p, \text{eff}}$   
 $k_2$ ,  $\varphi_s$ ,  $\Delta\varepsilon$   
 $d$ ,  $x$ ,  $c$

### Exports

PDF, Excel (.xlsx), Text  
Critical combinations, intermediate values

# Rectangular slab

## Input data

### Concrete

- Rectangular cross-section
- Width  $b = 1.00$  m
- Depth  $h = 0.30$  m

### Reinforcement

- 14 bars  $\varnothing 14$  ( $\varphi_s = 14$  mm)
- 7 bottom + 7 top, spacing 157 mm
- Cover 30 mm, 1 layer per face
- $A_s = 14 \times 1.539 = 21.55$  cm<sup>2</sup>

### Material laws (EC2)

- Concrete C30/37:  $f_{ck} = 30$  MPa
- Steel B500B:  $f_{yk} = 500$  MPa

Figure 1: Rectangular slab.

## Results

The crack width is evaluated for two loading states: pure bending and tension-dominated. Cracking parameters are kept at their recommended values:  $k_t = 0.6$  (long-term),  $k_1 = 0.8$  (high-bond bars),  $k_3 = 3.4$ ,  $k_4 = 0.425$ ,  $f_{ct,eff} = 3.2$  MPa.

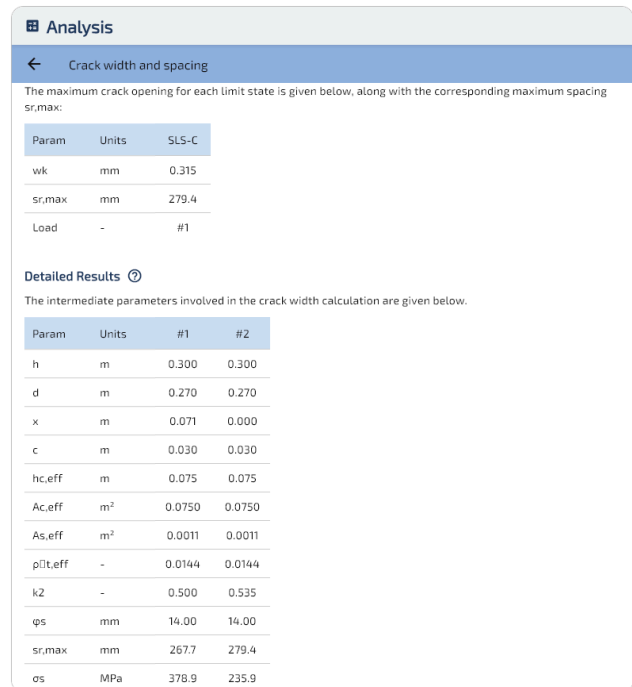
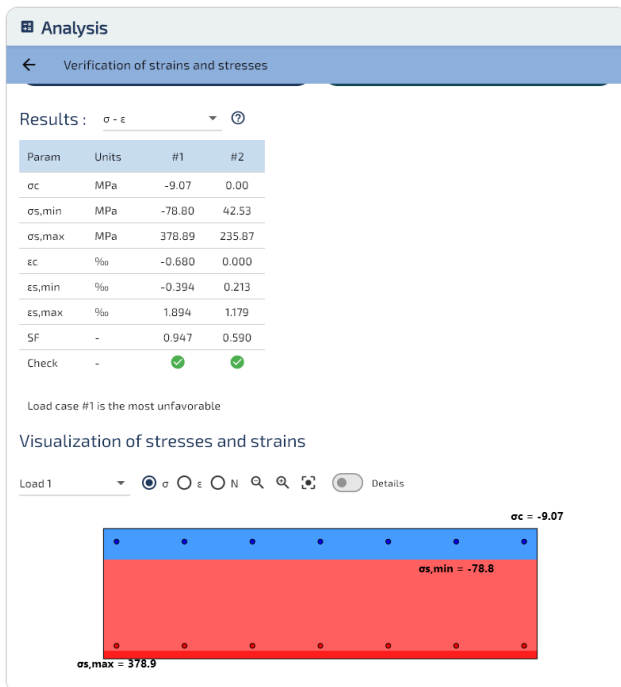


Figure 2: Slab: stress-strain state (left) and crack width results table (right).

Under pure bending ( $M_z = 100$  kN·m), the neutral axis lies at  $x = 71$  mm, leaving  $h - x = 229$  mm of the section in tension. With  $k_2 = 0.5$ , the spacing formula gives  $s_{r,max} = 267.7$  mm. The crack width  $w_k = 0.315$  mm exceeds the usual 0.3 mm limit: a thicker slab or closer bar spacing would be needed in practice.



The crack width increases with the applied moment:  $w_k = 0.078$  mm at  $M_z = 1000$  kN · m, 0.203 mm at 2000 kN · m and 0.267 mm at 2500 kN · m, all below the 0.3 mm limit. The crack spacing  $s_{r, \max} = 186.8$  mm remains constant across all load levels since it depends only on geometry and reinforcement layout.

## Benchmark

The crack width calculation is instantaneous: less than 10 ms for typical projects (up to 1 000 SLS load cases) and under half a second even for 100 000 cases.

## Export

SectionPro exports the crack width analysis in three formats: **PDF**, **text** (fixed-width columns) and **Excel** (.xlsx). Exported data includes all results per load case ( $w_k$ ,  $s_{r, \max}$ ,  $\sigma_s$ ,  $h_{c, \text{eff}}$ ,  $\rho_{p, \text{eff}}$ , etc.) sorted by decreasing  $w_k$ .

Crack width and spacing				
GENERATED BY THE SECTIONPRO SOFTWARE ON : 2026-05-21 17:33				
Main results				
Param	Units	SLS-C		
wk	mm	0.267		
sr,max	mm	186.8		
Load	-	#3		

Below are the crack openings wk and their maximum spacing sr,max for the most unfavorable loads of each limit state. The obtained values can then be compared with the limits prescribed by the normative context.

Detailed Results				
Below are the intermediate parameters involved in the EN-1992 calculation methodology:				
Param	Units	#3	#2	#1
h	m	1.800	1.800	1.800
d	m	1.768	1.768	1.768
x	m	0.379	0.379	0.379
c	m	0.030	0.030	0.030
hc,eff	m	0.079	0.079	0.079
Ac,eff	m <sup>2</sup>	0.0595	0.0595	0.0595
As,eff	m <sup>2</sup>	0.0023	0.0023	0.0023
pt,eff	-	0.0384	0.0384	0.0384
k2	-	0.500	0.500	0.500
φs	mm	19.16	19.16	19.16
sr,max	mm	186.8	186.8	186.8
σs	MPa	345.9	276.7	138.4
Δε	‰	1.432	1.086	0.415
wk	mm	0.267	0.203	0.078

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Figure 5: PDF export: crack width results.

## Conclusion

The direct crack width calculation per EC2 §7.3.4 provides a rigorous assessment of the cracking state at the serviceability limit state. SectionPro automates the entire procedure: from the stress–

strain analysis to the determination of the effective tension area  $h_{c,\text{eff}}$ , the crack spacing  $s_{r,\text{max}}$  and the final crack width  $w_k$ .

The two examples illustrate contrasting scenarios: a rectangular slab under bending and tension, and an I-beam under increasing bending moments.

The calculation applies to cross-sections of arbitrary shape: the effective tension area and reinforcement detection are computed from the general section geometry, without being limited to rectangular assumptions. The method is also applicable to other normative contexts by adapting the cracking parameters ( $k_t, k_1, k_3, k_4, f_{ct,\text{eff}}$ ) to the values prescribed by the relevant design code.