Verification Example

Program: RSTAB 9, Concerte Design

Category: Design Check

Verification Example: 1021 – Uniaxial Spanned Concrete Slab Designed in RSTAB

1021 – Uniaxial Spanned Concrete Slab Designed in RSTAB

Description

A reinforced concrete slab inside a building is to be designed as a 1.0 m stripe with members. The floor slab is uniaxially spanned and runs through two spans. The slab is fixed on masonry walls with free-rotating supports. The middle support has a width of 240 mm and the two edge supports have a width of 120 mm. The two spans are subjected to an imposed load of category C: congregation areas.

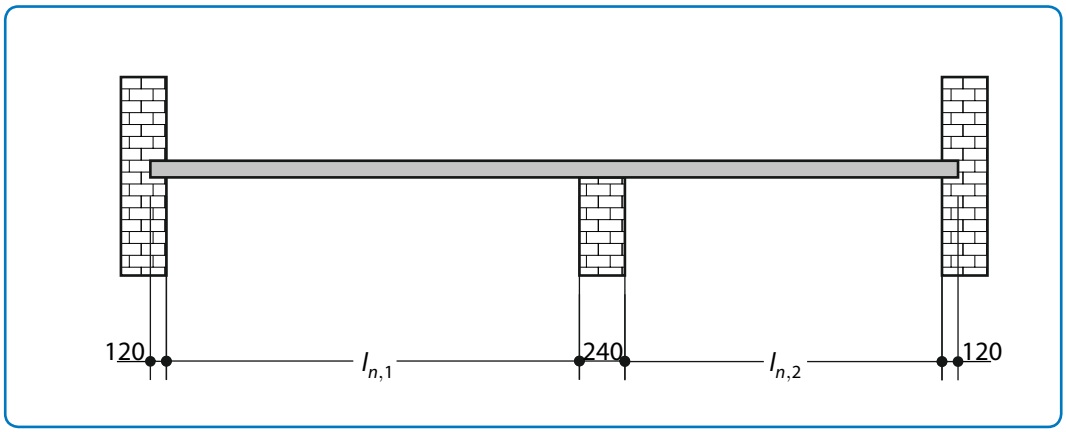

Figure 1: Problem sketch

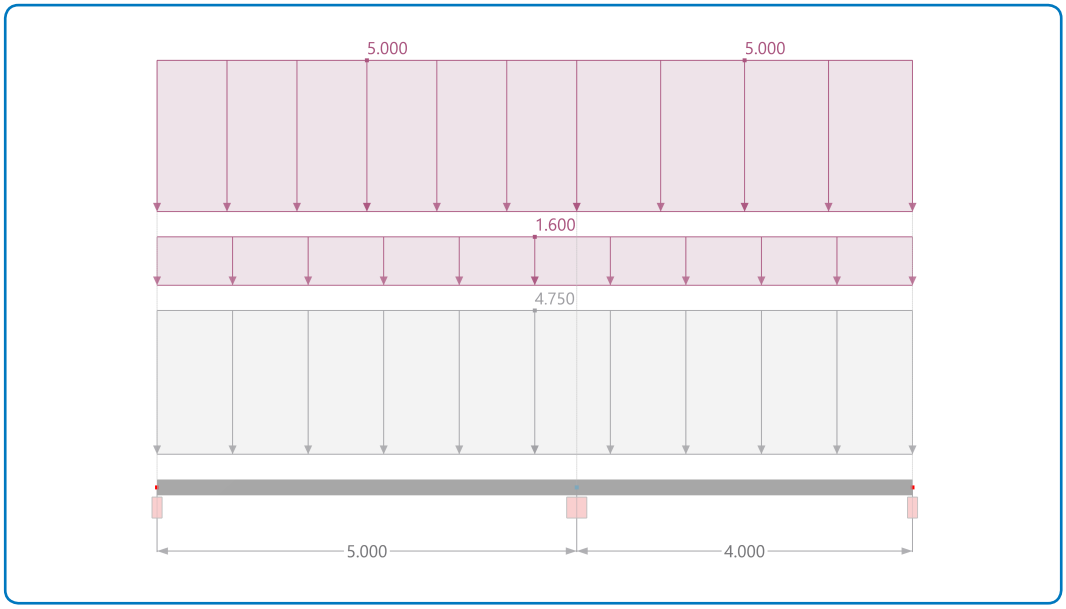

Figure 2: RSTAB system under self-weight and imposed loads

Materials	Concrete	C20/25	E_{cm}	30.000	N/mm^2
			f_{cd}	11.3	N/mm^2
	Reinforcing steel	B500(B)	f_{yk}	500	N/mm^2
			f_{yd}	435	N/mm^2
Geometry	Structure	Length	l	9.0	m
		First span length	$l_{span,1}$	5.0	m
		Second span length	$l_{span,2}$	4.0	m
	Member cross-section	Width	b	1.000	m
		Height	h	0.190	m
Load	Permanent loads	Dead load	Δg_k	1.60	kN/m
		Member self-weight	g_k	4.75	kN/m
	Live loads	First span	$q_{1,k}$	5.0	kN/m
		Second span	$q_{2,k}$	5.0	kN/m
Reinforce-ment	Concrete cover	User-defined concrete cover	c	25.0	mm
	Longitudinal reinforce-ment of the first span	Rebar parameter	$n_s(bottom)$	7	
			$d_s(bottom)$	10	mm
		Reinforce-ment area	Bottom side	5.50	cm^2
	Longitudinal reinforce-ment of the second span	Rebar parameter	$n_s(bottom)$	4	
			$d_s(bottom)$	10	mm
		Reinforce-ment area	Bottom side	3.14	cm^2
	Longitudinal reinforce-ment of the middle support	Rebar parameter	$n_s(top)$	7	
			$d_s(top)$	10	mm
		Reinforce-ment area	top side	5.50	cm^2
	Additional re-infrocement near the edge supports	Rebar parameter	$n_s(top)$	7	
			$d_s(top)$	6	mm
		Reinforce-ment area	Top side	1.98	cm^2

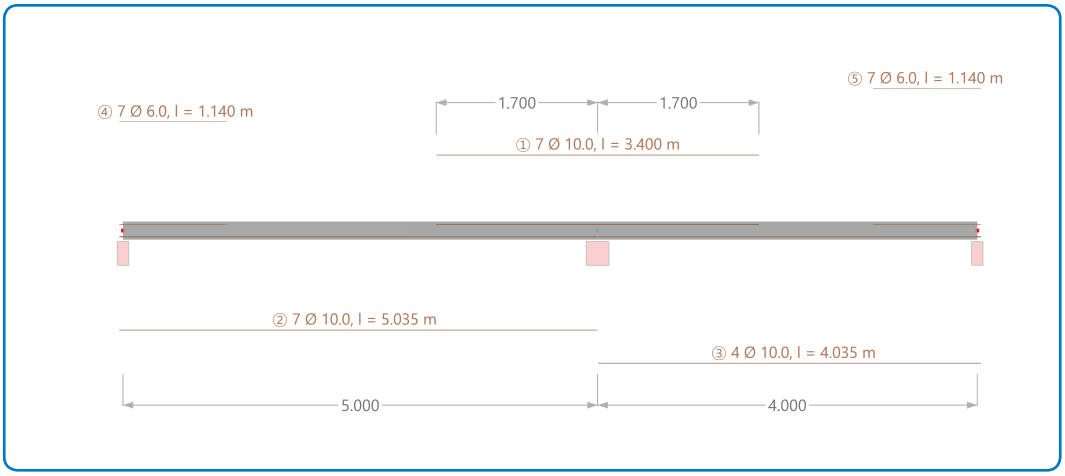

Figure 3: Reinforcement layout

Results

Load case	kNm	Moment in middle support	Moment in first span	Moment in second span
LC1: $\Delta g_d + g_d + q_{1,2,d}$	kNm	42.140	31.140	14.430
LC2: $\Delta g_d + g_d + q_{1,d}$	kNm	35.480	34.000	3.930
LC3: $\Delta g_d + g_d + q_{2,d}$	kNm	29.13	14.200	19.160

Bending

For an accurate bending moment results, the consideration of limited moment redistribution of the supporting moments according to DIN EN 1992-1-1, 5.5 and the reduction of the moments at the face of the middle support according to DIN EN 1992-1-1, 5.3.2.2 are taken into consideration. In the middle support, the ratio of moment redistribution δ is 0.850.

		Middle support	First span	Second span
Bending moment	kNm	-42.140	34.000	19.16
Design bending moment with moment redistribution	kNm	-35.820	36.280	20.750
Design bending moment with moment redistribution and moment reduction	kNm	-33.080	36.280	20.750

The required reinforcement in the two spans and in the middle support according to RSTAB9 are indicated in the following table.

Required reinforcement		RSTAB9
First span	cm^2	5.470
Second span	cm^2	2.990
Middle support	cm^2	4.930

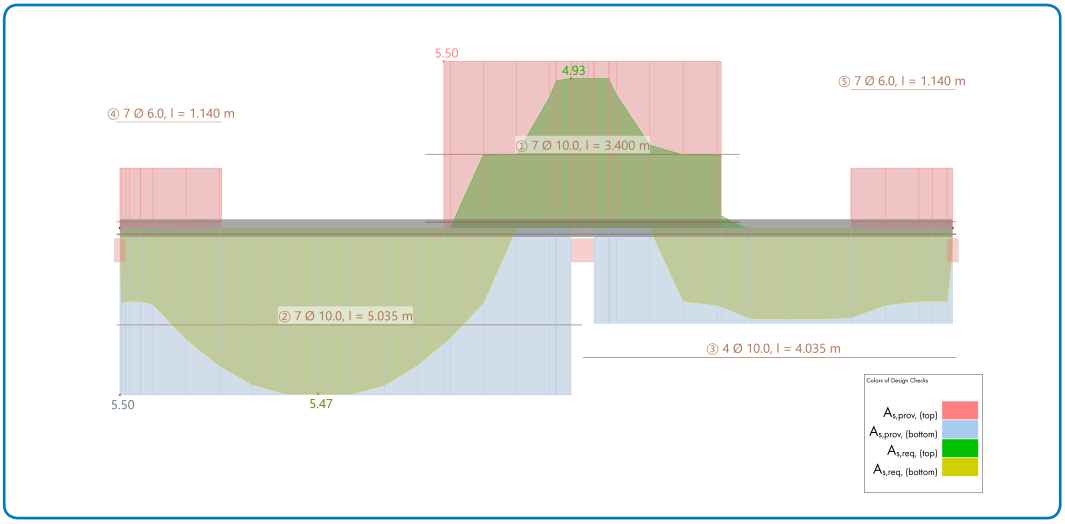

Figure 4: Required reinforcement

Shear Proof

The relevant position for shear force design check is the right side of the middle support. The reduction of shear forces in the support face and distance d according to DIN EN 1992-1-1, 6.2.1(8) is considered.

-		RSTAB 9
Minimum shear capacity without reinforcement $V_{Rd,c,min}$	kN	70.831
Shear capacity without reinforcement $V_{Rd,c}$	kN	60.843

The design shear force and the shear capacity are summarized in the following table:

		RSTAB 9
Design shear force $V_{z,Ed}$	kN	44.108
Shear capacity without reinforcement $V_{Rd,c}$	kN	70.831
Design check ratio $\eta = V_{z,Ed}/V_{Rd,c}$	-	0.623

The diagram below shows the design check ratio along the member. Shear reinforcement is therefore not necessary.

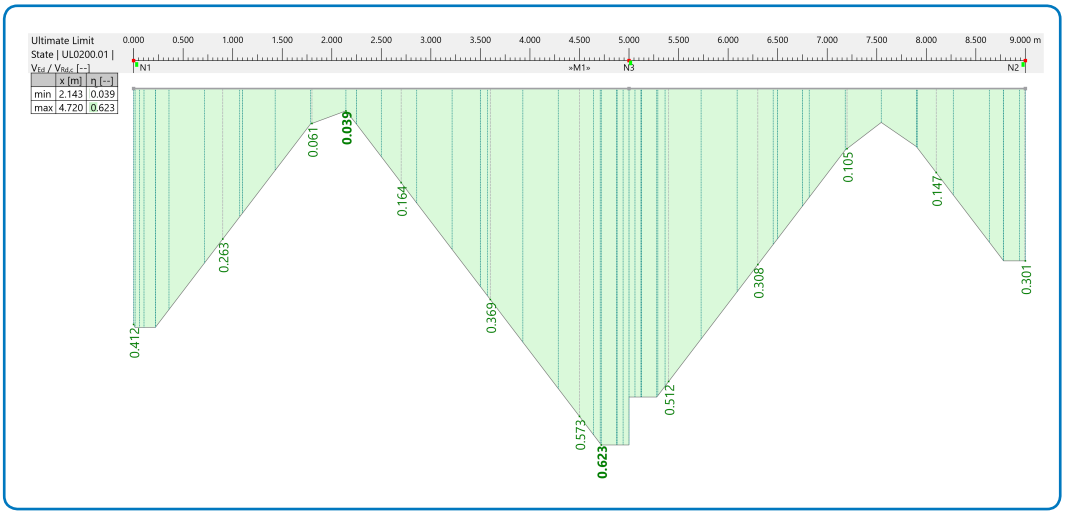

Figure 5: Shear force design check ratio

Evaluation

In the following three tables the results of the design bending moment with moment redistribution and reduction, shear capacity and the required reinforcement are compared to the reference.

		RSTAB 9	Reference	Ratio
First span	kNm	36.280	34.100	1.063
Second span	kNm	20.750	19.200	1.080
Middle support	kNm	-33.080	-33.200	0,996

		RSTAB 9	Reference	Ratio
Design shear force $V_{z,Ed}$	kN	44.108	42.900	1.028
Shear capacity without shear reinforcement $V_{Rd,c}$	kN	70.829	70.800	1.000

Required reinforcement		RSTAB 9	Reference	Ratio
First span	cm^2	5.47	5.16	1.060
Second span	cm^2	2.99	2.89	1.034
Middle support	cm^2	4.93	5.16	0.955

In the reference, moment redistribution according to DIN EN 1992-1-1, 5.5 was only considred in the first load case (governing load case for the bending moment in the middle support). In RSTAB9, however, it was considered in all load cases. This explains the higher design moment and, consequently, the higher required reinforcement in the two spans.

References

[1] Deutscher Beton- und Bautechnik-Verein E. V., Beispiele zur Bemessung nach Eurocode 2 Band 1: Hochbau., Berlin: Ernst & Sohn, 2011.