Prestressed Concrete SLS and ULS External and Equivalent Load Concepts

ITEM	CONTENT	√
1.0	**SLS / ULS External Load**	

Span, L	10.000 m
SLS beam loading, $\omega_{SLS,E/E}$	50.0 kN/m
ULS beam loading, $\omega_{ULS,E/E}$	70.0 kN/m

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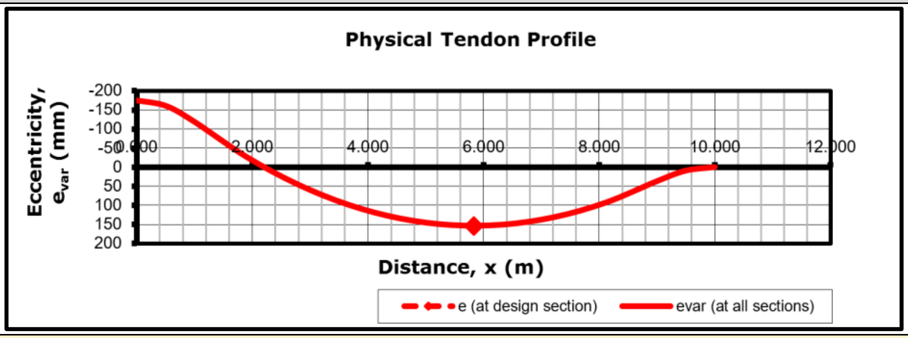
Note.

ITEM	CONTENT	√
2.0	**SLS Equivalent Load**	

	L-Sup	Span	R-Sup		
Span, L			10.000 m		
Distance between points of inflexion, s	2.000	8.000	2.000 m		
Total drape between points of inflexion, e_d	56	195	37 mm		
SLS equivalent load, $\omega_{SLS,E/L} = \pm[8\|2]KP_0.e_d/s^2$	231.6	-50.0	151.8 kN/m		
Note that the equivalent load calculation includes the support peak tendon reverse curvature;					
Dimensions, $\{p_1, L\text{-}p_1\text{-}p_2, p_2\}$	1.000	8.000	1.000 m		
Σ SLS equivalent load, $\Sigma\{p_1, L\text{-}p_1\text{-}p_2, p_2\}.\omega_{SLS,E/L}$	232	-400	152 kN		-17



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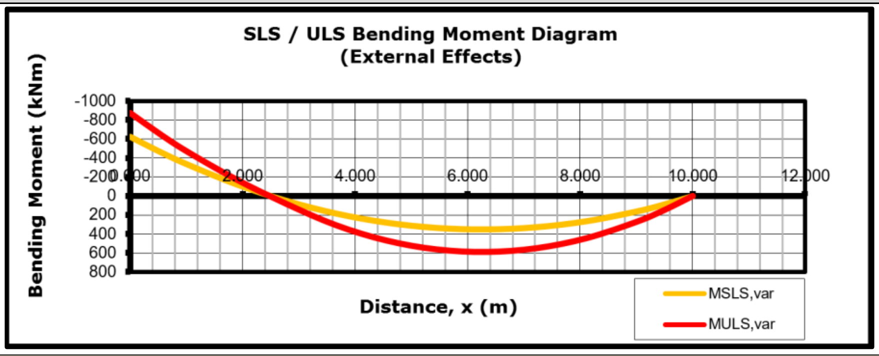
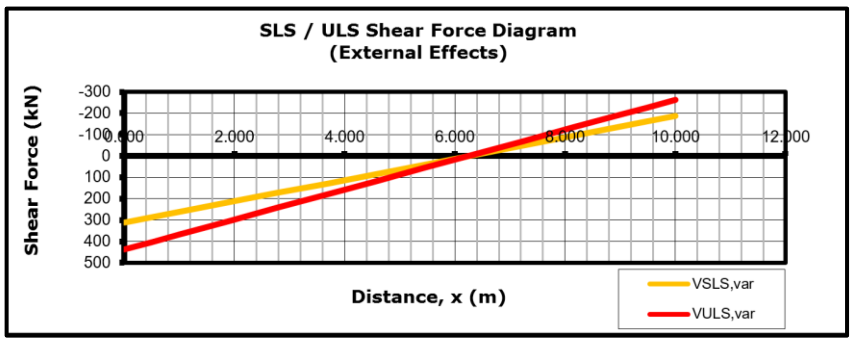
The SLS equivalent load is chosen to balance the SLS external load by 100%. Note that the total SLS equivalent load will always be zero (cl.A.1.1.1 TR.43). A non-zero value here is an indication that the tendons are not horizontal at termination and thus produces a vertical SLS equivalent load component to a total of this magnitude.

ITEM	CONTENT	√
3.0	**SLS / ULS External Load Effects**	





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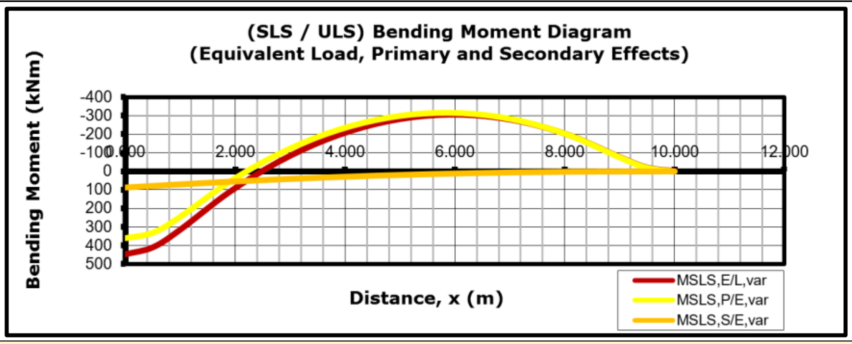
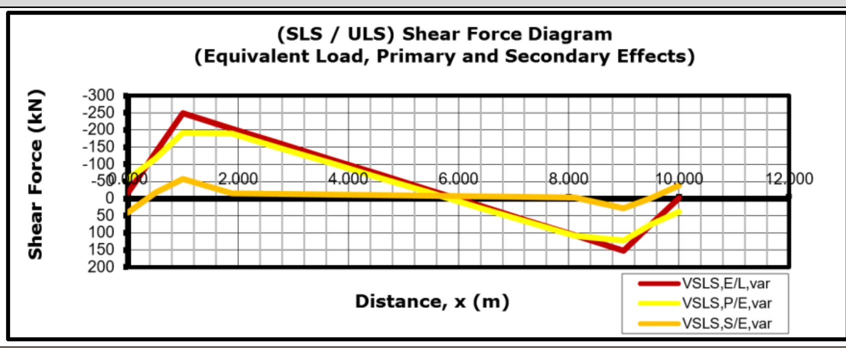
The SLS / ULS external load produce: -

- SLS / ULS external effects bending moment
- SLS / ULS external effects shear force
- SLS / ULS external effects reactions.

ITEM	CONTENT	√
4.0	**(SLS / ULS) Equivalent Load Effects**	





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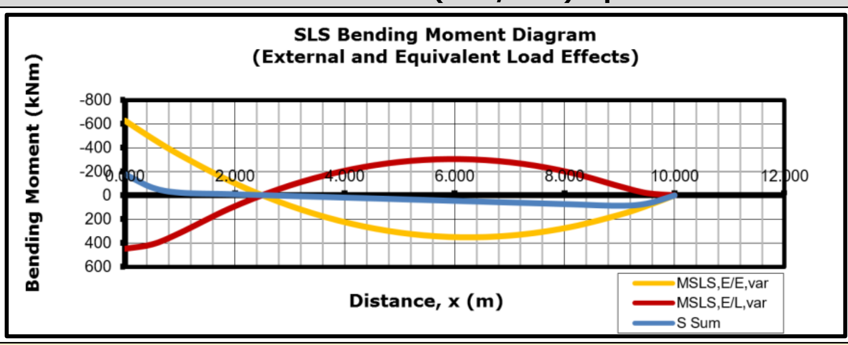
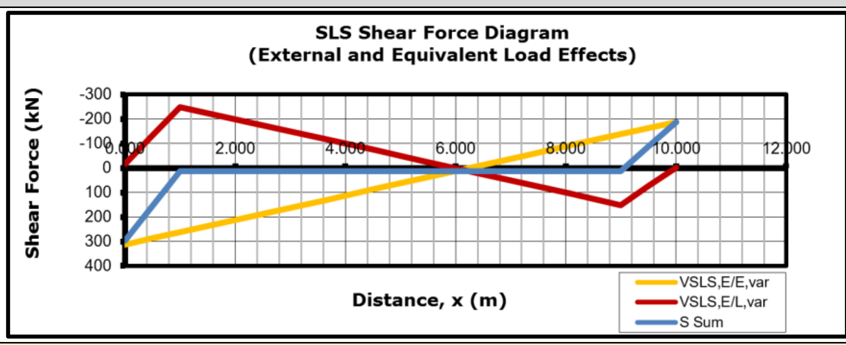
The SLS equivalent load produce: -

- (SLS / ULS) equivalent load effects bending moment
- (SLS / ULS) equivalent load effects shear force

but no (SLS / ULS) equivalent load effects reactions (ignoring secondary effects).

ITEM	CONTENT	√
5.0	**Summation of SLS External Load and (SLS / ULS) Equivalent Load Effects**	





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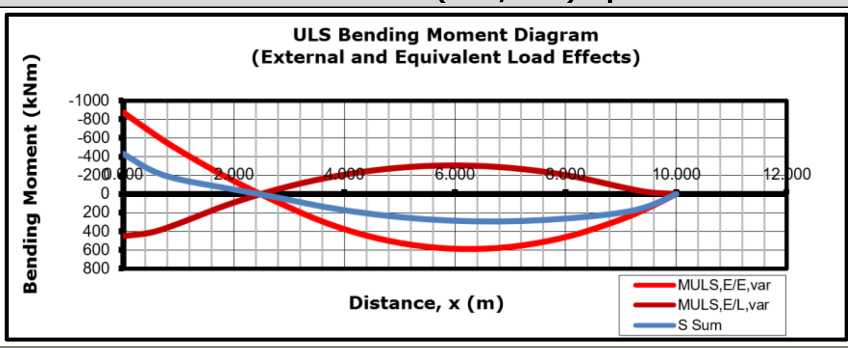
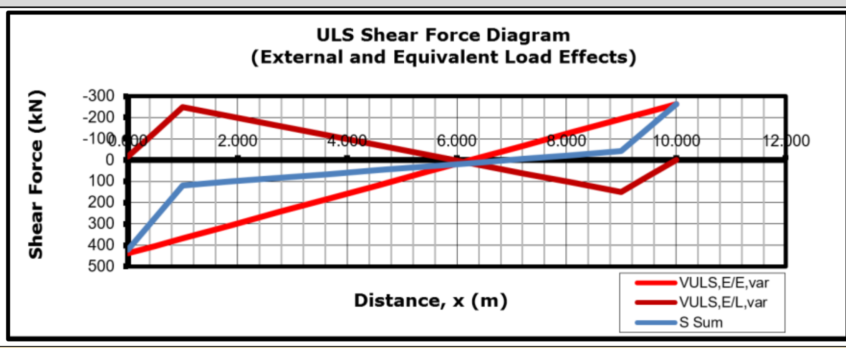
The summation of the SLS external load and the (SLS / ULS) equivalent load **effects** is **effectively zero** as the SLS equivalent load was chosen to balance the SLS external load by 100%. Any **residual non-zero** effect must be resisted by the concrete material itself, this check being undertaken by the SLS stress check or the Magnel Diagram check.

ITEM	CONTENT	√
6.0	**Summation of ULS External Load and (SLS / ULS) Equivalent Load Effects**	





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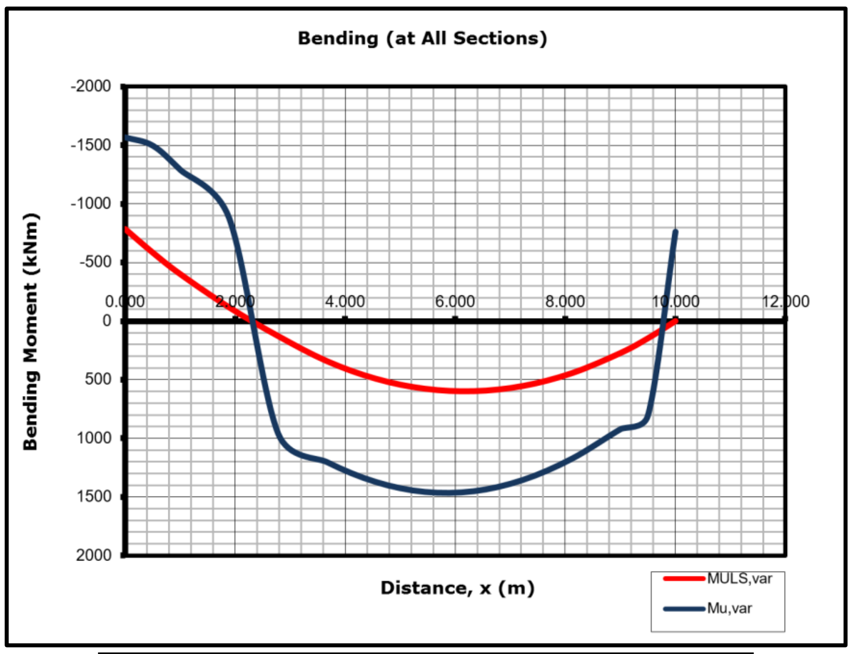
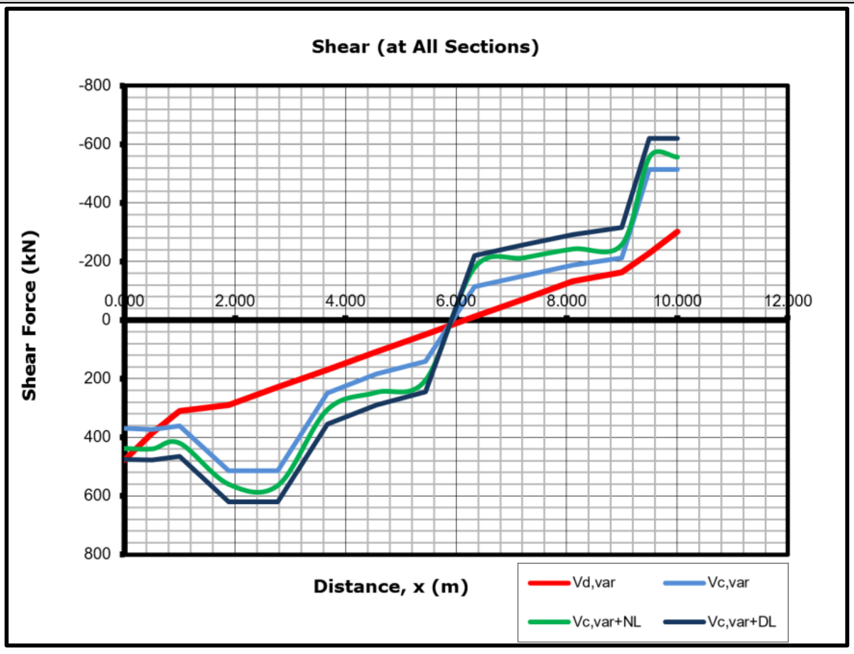
The summation of the ULS external load and the (SLS / ULS) equivalent load **effects** is **not zero** as the SLS equivalent load was chosen to balance the SLS external load by 100% and not the ULS external load. This **non-zero** effect must be resisted by steel reinforcement or the concrete material itself, this check being undertaken by the ULS bending and shear design.

7.0	ULS Bending And Shear Design	



$M_u = f_{pb}A_{ps}(d_{cen} - 0.45x)$ [Rectangular] or [Flanged - NA in Flange]

$M_u = f_{pb}(A_{ps} - A_{pf})(d_{cen} - 0.45x) + 0.45f_{cu}(b - b_w)h_f(d_{cen} - 0.45h_f)$ [Flanged - NA in Web]



V_c = {V_{co} uncracked, MIN (V_{co}, V_{cr}) cracked}

$V_{co}+KP_0\sin\beta$ where $V_{co} = 0.67 b_v h \sqrt{(f_t^2 + 0.8 f_{cp} f_t)}$

$$V_{cr} = \left(1 - 0.55\frac{f_{pe}}{f_{pu}}\right) v_c b_v d + M_o \frac{V}{M}$$

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The bending moment capacity, M_u must be greater than the ULS external effects bending moment plus the (SLS / ULS) secondary effects bending moment, $M_{ULS} = M_{ULS.E/E} + M_{ULS.S/E}$. The shear force capacity, V_c must be greater than the ULS external effects shear force plus the (SLS / ULS) secondary effects shear force, $V_{ULS} = V_{ULS.E/E} + V_{ULS.S/E}$. Equivalent loads will automatically generate primary and secondary effects when applied to the structure. SLS calculations do not require any separation of the primary and secondary effects, and analysis using the equivalent loads is straightforward. However, at ULS the two effects must be separated because the secondary effects are treated as applied loads. The primary prestressing effects are taken into account by including the tendon force in the calculation of the ultimate section capacity. This primary prestressing effect is represented by: -

- $f_{pb}.A_{ps}(d_{cen}-0.45x)$ in the bending moment capacity
- $KP_0\sin\beta$ in the uncracked shear capacity
- M_0V/M in the cracked shear capacity.