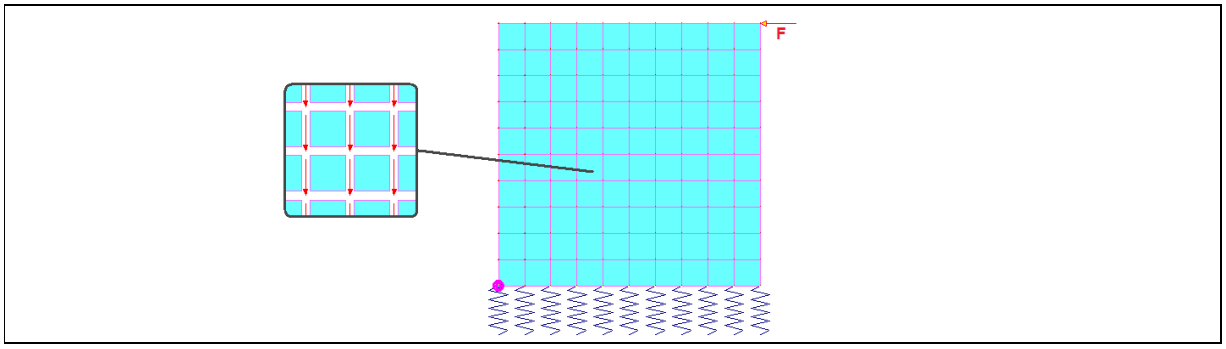
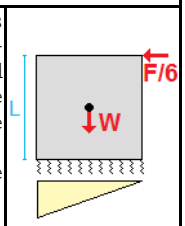
Validation of Sargon Nonlinear solver (CURAN, version 9.70)			
TEST SP001	**VALIDATION, RELIABILITY, BENCHMARK**	**Marco Croci**	**Rev.1-18/03/2011**



Test description

Support is made of no-tension springs. A horizontal force F is applied on the top-right node of a concrete block made of plate-shell elements; self weight of each plate-shell element is applied as nodal loads on element nodes. When F is null, all the springs are in compression under self weight. Increasing F, compression in the springs on the right decreases until compression is equal to zero, then they stop to work. When a critical value of F is reached there is no more equilibrium. In this test a force equal to W/6 is applied to the block, so springs reaction should coincide to the diagram in the figure on the right.

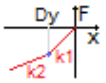


Test model: **curanSP_001.WSR**

Springs properties

k_1	D_y	k_2	D_u	Law	Gap
1500N/mm	500mm	1000N/mm	∞	no tension	0mm

Note: external springs have the following stiffnesses: $k_1/2$ and $k_2/2$



Concrete properties (plate-shell elements)

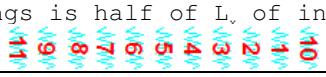
ρ	E	ν	F_y	F_t
2,5e-05N/mm^3	25491N/mm^2	0,2	20N/mm^2	20N/mm^2

Geometry and loads

Sides	Mesh	Elements thickness	Weight	Force
L = 5000mm	10x10 elements	150mm	W = 93750N	F = W/6

CHECK

Internal force in each spring should be equal to: $-2*W/L*(x_i/L)*Lx_i$ where x_i is the position of the spring 'i' and L_{xi} is the length associated to that spring. As check, axial forces computed by Curan in some springs were compared with hand computations according to the previous formula. Springs numbering is reported. Note that L_x of external springs is half of L_y of internal ones.



Load case	Value	Unit	CURAN	THEORETICAL	% diff.
1	Spring #5 axial force	N	-9,374E+03	-9,375E+03	-0,02
1	Spring #9 axial force	N	-1,489E+04	-1,500E+04	-0,76
1	Spring #11 axial force	N	-9,290E+03	-9,141E+03	1,64

% difference = (CURAN - THEORETICAL) / THEORETICAL * 100

Precision of limit multiplier for the analysis: 0.005