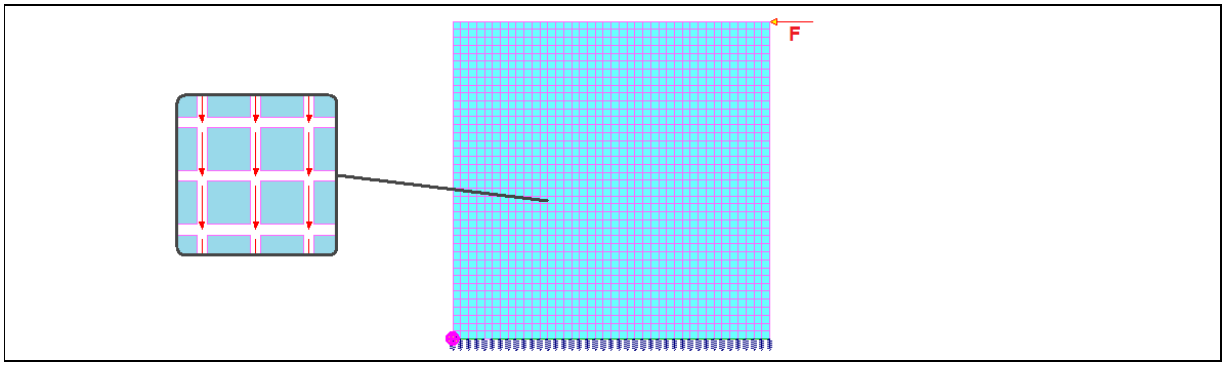
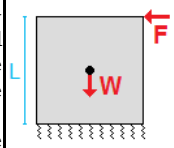
| Validation of Sargon Nonlinear solver (CURAN, version 9.70) | | | |
|---|---|---|---|
| **TEST SP002** | **VALIDATION, RELIABILITY, BENCHMARK** | **Marco Croci** | **Rev.1-18/03/2011** |




## 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.

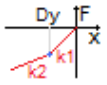



Test model: **curanSP_002.WSR**

## Springs properties

| $k_1$ | $D_y$ | ($k_2$) | ($D_u$) | Law | Gap |
|---|---|---|---|---|---|
| 375N/mm | 500mm | 250N/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 weight

| Sides | Mesh | Elements thickness | Weight |
|---|---|---|---|
| L = 5000mm | 40x40 elements | 150mm | W = 93750N |

## Load cases

| Load case 1 | Load case 2 | Load path |
|---|---|---|
| Weight + $F_1$=1/3W | $F_2$=1/3W | active |

## CHECK

Since horizontal force is applied at the top of the block, the value of F which causes a lack of equilibrium is equal to W/2. In the first step the following forces are applied: total weight W (vertical) and $F_1$=1/3W (horizontal). There is equilibrium. In the second step, $F_2$=1/3W is applied to the previous condition. Total applied F is equal to 2/3W > W/2, so there is a lack of equilibrium: load case 2 can not be completely applied. Limit condition is reached when $F_2/2$ has been applied: $F_1+F_2/2$=1/3W+1/6W=1/2W: load multiplier for load case 2 should be equal to 0,5.

| Load case | Value | Unit | CURAN | THEORETICAL | % diff. |
|---|---|---|---|---|---|
| 2 | Load multiplier | / | 5,002E-01 | 5,000E-01 | 0,04 |

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

Precision of limit multiplier for the analysis: 0.005