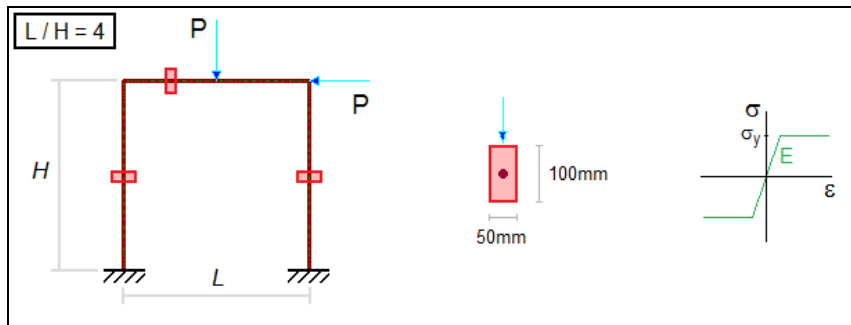


<b>CURAN: BEAMS (HERMITIAN)</b>	TEST 028	rev.1 21/10/13	version 10.70
VALIDATION, CROSS CHECKS, RELIABILITY, BENCHMARK	Tested by: Marco Croci - Checked by: Paolo Rugarli		



MODEL		
MODELS NAME (see notes)	OUTPUT FILES (see notes)	ANALYSIS TYPE
curanBE 028 elem xxxx.WSR	curanBE 028 elem xxxx.cog	nonlinear static (Curan)

DATA					
L [mm]	L/H	P [N]	E [N/mm <sup>2</sup> ]	$\sigma_y$ [N/mm <sup>2</sup> ]	$W_{pl}$ [mm <sup>3</sup> ]
3000	4	156667	210000	235	125000

THEORETICAL COMPUTATION
Material is elastic-perfectly plastic. For L/H=4, frame failure occurs when (see note below):
$P_{lim} = 8M_{pl} / L$
where $M_{pl} = W_{pl} * \sigma_y = 125000\text{mm}^3 * 235\text{N/mm}^2 = 2.938\text{E}+07\text{Nmm}$ It is
$P_{lim} = 8 * 2.938\text{E}+07\text{Nmm} / 3000\text{mm} = 78333\text{N} < P$
Since applied load P is greater than limit load $P_{lim}$ , frame failure occurs. Load multiplier is:
$P_{lim} / P = 78333\text{N} / 156667\text{N} = 0.5$

### CROSS-CHECK

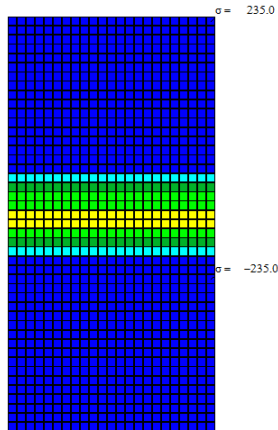
Value	Model	Number of beam elements	Theory	Sargon	% difference (S-T) / T*100
Load multiplier	curanBE 028 elem 0006	6	0.5	0.6539	30.8
Load multiplier	curanBE 028 elem 0012	12	0.5	0.6036	20.7
Load multiplier	curanBE 028 elem 0024	24	0.5	0.5494	9.9
Load multiplier	curanBE 028 elem 0048	48	0.5	0.5225	4.5
Load multiplier	curanBE 028 elem 0096	96	0.5	0.5047	0.9
Load multiplier	curanBE 028 elem 0192	192	0.5	0.5036	0.7
Load multiplier	curanBE 028 elem 0384	384	0.5	0.5006	0.1

### NOTES

- 7 different models were created, with different meshes; precision of load multiplier computation depends on mesh refinement. Each model name ends with the number of elements (for example, *curanBE\_028\_elem\_0006.WSR* has 6 elements; related output file is *curanBE\_28\_elem\_0006.cog*).
- Theoretical multiplier is computed according to *Calcul Plastique des Constructions*, Ch. Massonnet, M. Save - Italian translation by AA.VV. from Istituto di Scienza e Tecnica delle Costruzioni del Politecnico di Milano, Clup Milano, 1982.
- Applied force is computed in order to get a theoretical load multiplier exactly equal to 0.5.
- Analysis parameters: Lobatto's points: 5. Fibers number: 1000.
- Shear area: not considered.
- Fibers stress in relevant sections of the last model are shown in the following page.

NONLINEAR FIBER MODEL ANALYSIS RESULTS - NORMAL STRESS  
 Beam #1 Lobatto's section #1 (csi = -1.000) Lcase = 1 / 1  
 Sigma, max= 235.0 N/mm<sup>2</sup>; Sigma, min= -235.0 N/mm<sup>2</sup>;

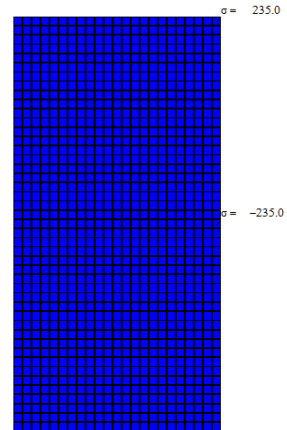
1



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NONLINEAR FIBER MODEL ANALYSIS RESULTS - NORMAL STRESS  
 Beam #3 Lobatto's section #1 (csi = -1.000) Lcase = 1 / 1  
 Sigma, max= 235.0 N/mm<sup>2</sup>; Sigma, min= -235.0 N/mm<sup>2</sup>;

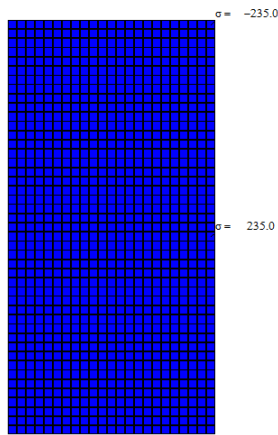
2



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NONLINEAR FIBER MODEL ANALYSIS RESULTS - NORMAL STRESS  
 Beam #322 Lobatto's section #5 (csi = 1.000) Lcase = 1 / 1  
 Sigma, max= 235.0 N/mm<sup>2</sup>; Sigma, min= -235.0 N/mm<sup>2</sup>;

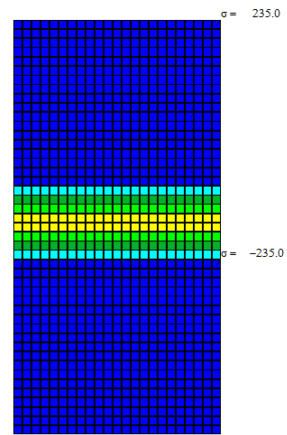
3



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NONLINEAR FIBER MODEL ANALYSIS RESULTS - NORMAL STRESS  
 Beam #259 Lobatto's section #5 (csi = 1.000) Lcase = 1 / 1  
 Sigma, max= 235.0 N/mm<sup>2</sup>; Sigma, min= -235.0 N/mm<sup>2</sup>;

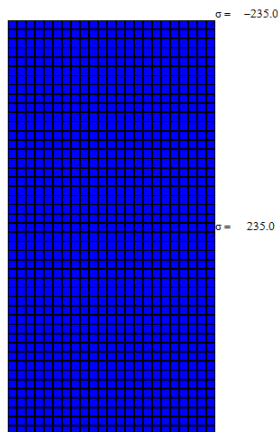
4



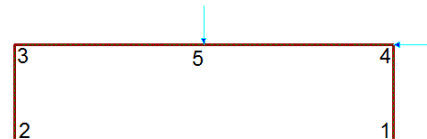
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NONLINEAR FIBER MODEL ANALYSIS RESULTS - NORMAL STRESS  
 Beam #70 Lobatto's section #5 (csi = 1.000) Lcase = 1 / 1  
 Sigma, max= 235.0 N/mm<sup>2</sup>; Sigma, min= -235.0 N/mm<sup>2</sup>;

5



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