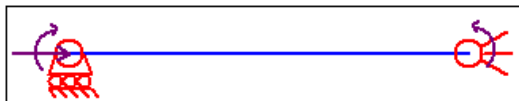


|                           |                                       |                              |
|---------------------------|---------------------------------------|------------------------------|
| <b>TEST SCHEDULE B 22</b> | <b>EN 1993-1-1: 2005 (EUROCODE 3)</b> | <b>Sargon ©, Cescoplus ©</b> |
| BUCKLING                  | COMPRESSION + BENDING 2               | <b>EC3.BUC.NNM2.002</b>      |



**Program:** WEURO © version October 2007 for Sargon and Cescoplus  
**Keywords:** EN 1993, Eurocode 3, example, validation, benchmark, reliability, quality control, error measure. **Parole chiave:** Eurocodice 3, esempio, validazione, test, affidabilità, controllo di qualità, misura dell'errore  
**Tv**=exploitation target value, **Cv**=exploitation computed value  
**Authors:** Ing. Marco Croci, Ing. Paolo Rugarli

| BEAM        |                                             |                  |           |
|-------------|---------------------------------------------|------------------|-----------|
| Length [mm] | Buckling factors                            | Left end         | Right end |
| 3500        | $\beta_1=0 \quad \beta_2=1 \quad \beta_3=1$ | SIMPLY SUPPORTED | HINGE     |

| LOAD                 |                  |                      |  |
|----------------------|------------------|----------------------|--|
| Type                 | Value            | Point of application |  |
| COMPRESSION          | N=400.000N       | LEFT END             |  |
| Type                 | Value            | Point of application |  |
| BENDING MOMENT $M_2$ | M=30.000.000Nmm  | LEFT END             |  |
| BENDING MOMENT $M_2$ | M=-30.000.000Nmm | RIGHT END            |  |

| MATERIAL                   | S235                       |                        |       |               |               |               |
|----------------------------|----------------------------|------------------------|-------|---------------|---------------|---------------|
| $f_y$ [N/mm <sup>2</sup> ] | $f_u$ [N/mm <sup>2</sup> ] | E [N/mm <sup>2</sup> ] | $\nu$ | $\gamma_{M0}$ | $\gamma_{M1}$ | $\gamma_{M2}$ |
| 235                        | 360                        | 2,10E+05               | 0,3   | 1,1           | 1,1           | 1,25          |

| CROSS-SECTION                       | HE 240 A                            | CLASS: N → 1 M <sub>2</sub> → 1 N + M <sub>2</sub> → 1 (reclasses method****) |                                   |                                   |                                   |
|-------------------------------------|-------------------------------------|-------------------------------------------------------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|
| A [mm <sup>2</sup> ]                | J <sub>2</sub> [mm <sup>4</sup> ]   | J <sub>3</sub> [mm <sup>4</sup> ]                                             | J <sub>t</sub> [mm <sup>4</sup> ] | W <sub>2</sub> [mm <sup>3</sup> ] | W <sub>3</sub> [mm <sup>3</sup> ] |
| 7684                                | 7,763E+07                           | 2,769E+07                                                                     | 4,155E+05                         | 6,751E+05                         | 2,307E+05                         |
| W <sub>pl2</sub> [mm <sup>3</sup> ] | W <sub>pl3</sub> [mm <sup>3</sup> ] | i <sub>2</sub> [mm]                                                           | i <sub>3</sub> [mm]               | i <sub>t</sub> [mm]               |                                   |
| 7,446E+05                           | 3,517E+05                           | 100,5                                                                         | 60                                | 69,28                             |                                   |
| h                                   | b                                   | t <sub>w</sub>                                                                | t <sub>f</sub>                    | r                                 |                                   |
| 230                                 | 240                                 | 7,5                                                                           | 12                                | 21                                |                                   |

| OTHER DATA* |          |          |          |          |
|-------------|----------|----------|----------|----------|
|             | $k_{yy}$ | $k_{yz}$ | $k_{zy}$ | $k_{zz}$ |
| Method 1    | 1,024    | /        | 0,542    | /        |
| Method 2    | 1,044    | /        | 0,627    | /        |

#### TARGET VALUES BASED ON PRELIMINAR COMPUTATIONS

$$\left. \begin{aligned}
 T_{v1,j} &= N / (\chi_2 A f_y / \gamma_{M1}) + k_{yy} M_2 / (\chi_{LT} W_{pl2} f_y / \gamma_{M1}) \\
 T_{v2,j} &= N / (\chi_3 A f_y / \gamma_{M1}) + k_{zy} M_2 / (W_{pl2} f_y / \gamma_{M1})
 \end{aligned} \right\} T_{v_{method\ j}} = \max(T_{v1,j}, T_{v2,j})$$

|                          |                           |
|--------------------------|---------------------------|
| Tv <sub>method1</sub> ** | Tv <sub>method2</sub> *** |
| 4,530E-01                | 4,569E-01                 |

#### CHECKER'S RESULTS (COMPUTED VALUES) AND COMPARISON WITH THE TARGET

|                       |                                                     |                       |                                                     |
|-----------------------|-----------------------------------------------------|-----------------------|-----------------------------------------------------|
| Cv <sub>method1</sub> | (Cv <sub>1</sub> -Tv <sub>1</sub> )/Tv <sub>1</sub> | Cv <sub>method2</sub> | (Cv <sub>2</sub> -Tv <sub>2</sub> )/Tv <sub>2</sub> |
| 4,530E-01             | <b>6,589E-05</b>                                    | 4,569E-01             | <b>4,253E-05</b>                                    |

(\*) formulae given in EN 1993-1-1 6.3.3, annex A and annex B

(\*\*) more accurated

(\*\*\*) easier to use

(\*\*\*\*) P. Rugarli, *Strutture in acciaio, La classificazione delle sezioni, Commento all'Eurocodice 3*, EPC Libri, 2007