SOFiSTiK


Benchmark Example No. 58

# Automatic computation of spring constant values in BDK

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**VERiFiCATiON**
**BE58 Automatic computation of spring constant values in BDK**

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**Front Cover**

6th Street Viaduct, Los Angeles Photo: Tobias Petschke

| Overview | |
|---|---|
| **Element Type(s):** | B3D |
| **Analysis Type(s):** | |
| **Procedure(s):** | |
| **Topic(s):** | |
| **Module(s):** | BDK |
| **Input file(s):** | automatic_spring_constant.dat |

# 1 Problem Description

The problem consists of three steel members, as shown in Fig. 1. Member 1 is subjected to a compressive load P. Its displacements and torsional rotations at the lower end are fixed and there are pinned supports in the middle and at the top. Moreover, the top of member 1 is rigidly connected to the rest of the structure. In order to determine the buckling resistance of member 1 in BDK, the spring constant values are computed automatically at node 1, 2 and 3 using the literal AUTO in the CVA, CVE and CVM input.

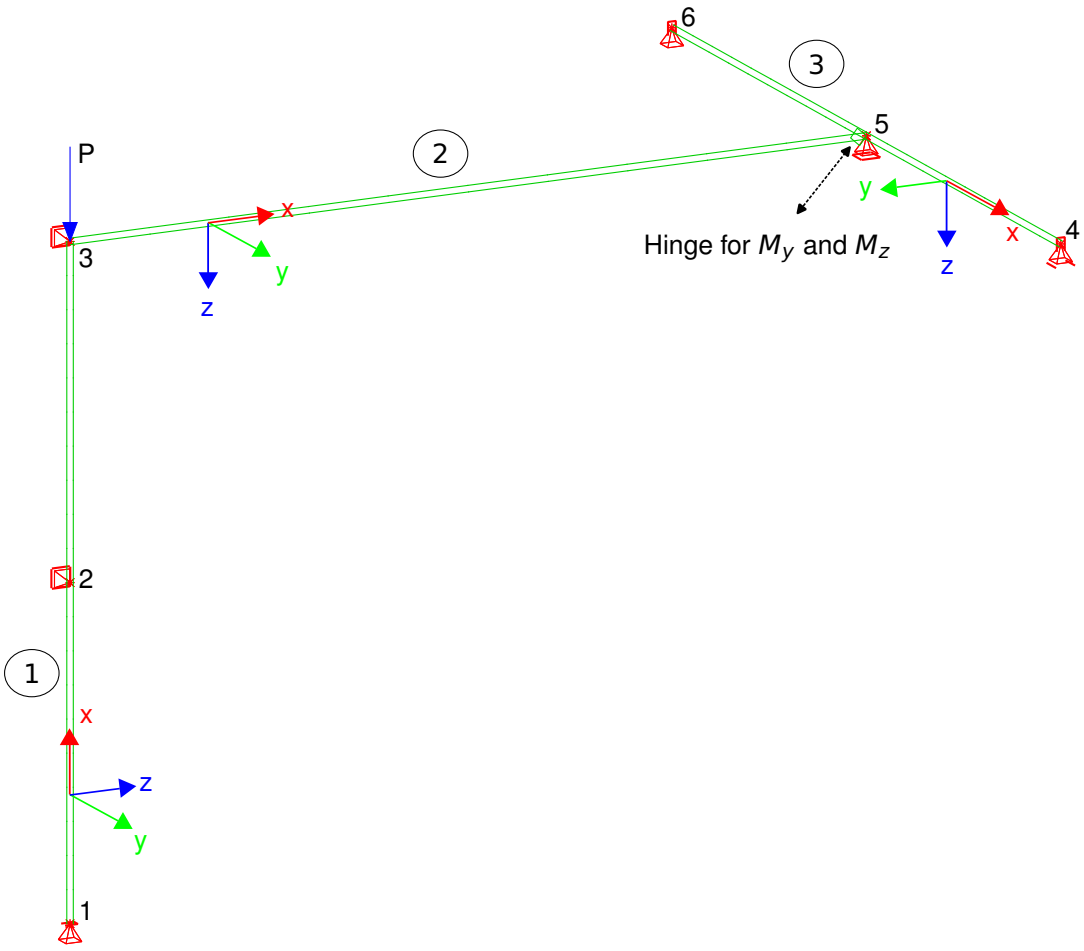
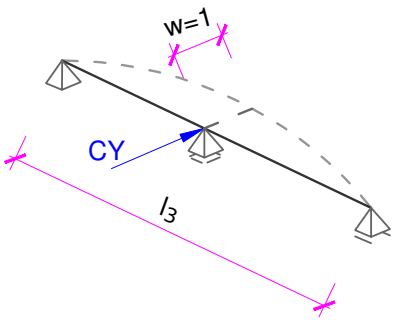
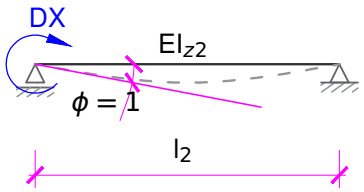
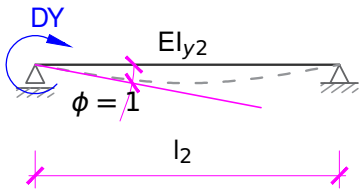
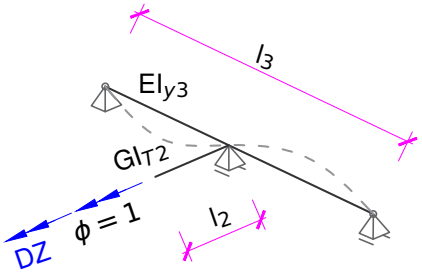



Figure 1: Problem Description

## 2 Reference Solution

Based on the approach described in [1], the reference values of the spring constants at node 3 are calculated from the stiffness of the connected beams 2 and 3 in consideration of the boundary conditions:

Table 1: Model Properties

| Analytical Solution | |
|---|---|
| $CY = \frac{48EI_{z3}}{l_3^3}$ |   |
| $DX = \frac{3EI_{z2}}{l_2}$ |   |
| $DY = \frac{3EI_{y2}}{l_2}$ |   |
| $DZ = \frac{1}{\frac{l_2}{GI_{T2}} + \frac{l_3}{12EI_{y3}}}$ |   |

## 3 Model and Results

The properties of the model are listed in Table 2. Standard cross-sections and a standard steel material are used.

Table 2: Model Properties

| | Member 1 | Member 2 | Member 3 |
|---|---|---|---|
| Material | S 355 | S 355 | S 355 |
| Cross-Section | RHS 260x180x10 | SHS 180x10 | HEA 220 |
| A $[cm^2]$ | 83 | 67 | 64 |
| $I_T$ $[cm^4]$ | 8933.0 | 5142.4 | 28.2 |
| $I_y$ $[cm^4]$ | 7740.2 | 3193.0 | 5410.8 |
| $I_z$ $[cm^4]$ | 4350.3 | 3193.0 | 1954.6 |
| Length [m] | 8 | 10 | 10 |

The spring constant values provided by SOFiSTiK agree very well with the reference, as shown in Table 3. There are only small differences, which can be mainly attributed to longitudinal and shear deformations considered by SOFiSTiK but not in the reference.

Table 3: Spring constant values

| | Ref. | SOF. | $e_r$ [%] |
|---|---|---|---|
| CZ [kN/m] | 197.0 | 196.5 | 0.28 |
| DX [kNm/rad] | 2011.6 | 2009.7 | 0.09 |
| DY [kNm/rad] | 2011.6 | 2009.7 | 0.09 |
| DZ [kNm/rad] | 403.1 | 402.9 | 0.03 |

# 4 Conclusion

This example verifies the spring constant values that are computed automatically in BDK. It has been shown that they are determined accurately from a linear analysis. However, it should be made sure that connected beams are not or only insignificantly subjected to compressive forces because they can lead to a considerable reduction of the bending stiffness [1]. In those cases, as illustrated in Figure 2, a global analysis that takes second order effects and imperfections into account can be used to verify the structural stability as described in [2].

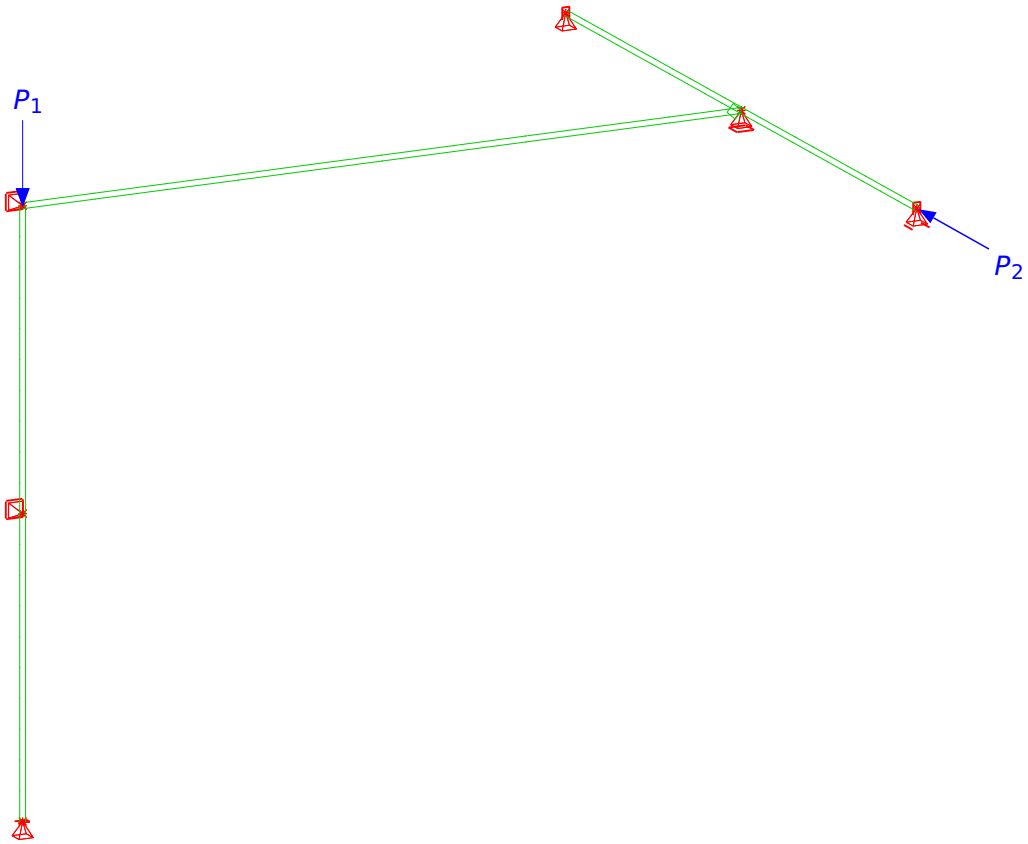



Figure 2: Example with $2^{nd}$ Order Effects

# 5 Literature

[1] C. Petersen. *Statik und Stabilität der Baukonstruktionen*. 2nd. Vieweg, 1982.

[2] U. Kuhlmann and F. Jörg. *Stahlbaunormen - DIN EN 1993-1-1: Allgemeine Bemessungsregeln und Regeln für den Hochbau, in Stahlbau-Kalender 2020*. Ernst & Sohn, 2020.