University of Stavanger

FACULTY OF SCIENCE AND TECHNOLOGY

SUBJECT: BYG 200 Steel Structures (BYG 200 Stålkonstruksjoner)

DATE: December 07, 2016

TIME: 9.00-13.00

AID: Norsk Standard NS-EN 1993-1-1:2005+NA:2008, Norsk Standard NS-1993-1-8: 2005+NA:2009, Norsk Standard NS-EN 1993-1-5:2006+NA:2009, Norsk Standard NS-EN 1993-1-9:2005+NA:2010, Steel Profile and Formula book "Stålkonstrukjoner", Authorized calculator.

THE EXAM CONSISTS OF 4 QUESTIONS AND 6 PAGES.

REMARKS: **All** the **Four** questions carry **equal marks** and answer **all** the questions

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Question (1)

Two concentrically connected members in a truss are subjected to a design axial tensile load of 200 kN respectively. The cross sections of the members are **same** and it is a **plate** with a cross section 160 mm×10 mm of S275 steel grade. Both ends of the one tension member are connected by **four bolts** as shown in **Figure 1 (a).** The type of the bolts is M16 (i.e. bolt hole diameter is 18 mm) and class of the bolts is 8.8 (i.e. Skruer 8.8). The shear planes of the bolts are passing through **threaded (gjenget)** portions. The both ends of the other tension member are connected by **fillet welds** as shown in **Figure 1 (b)**. The leg length (i.e. weld size) of the weld is 8 mm (i.e. throat thickness is 5.66 mm). Thickness of the connecting plate is 12 mm and steel grade of the connecting plate material is S275.

(a).

(i). Check the suitability of the **tension member** shown in **Figure 1(a)** (i.e. can the member withstand above loading). **(9 Marks)**

(ii). Do you think that the **tension member** shown in **Figure 1(b)** can carry above loading. State the logical reasons for your answer without calculations. **(2 Marks)**

(b).

(i). Check the suitability of **bolt** size in **Figure 1(a)** (i.e. can the bolts withstand the design load). **(3 Marks)**

(ii). Check the **tension member only for bearing failure** (i.e. can the tension member withstand the design load without bearing failure). **(6 Marks)**

(iii). Check the suitability of the **fillet weld** size shown in **Figure 1(b)** (i.e. can the fillet welds withstand the design load). Assume the load is equally transferred to the fillet welds in both sides of the member. **(5 Marks)**

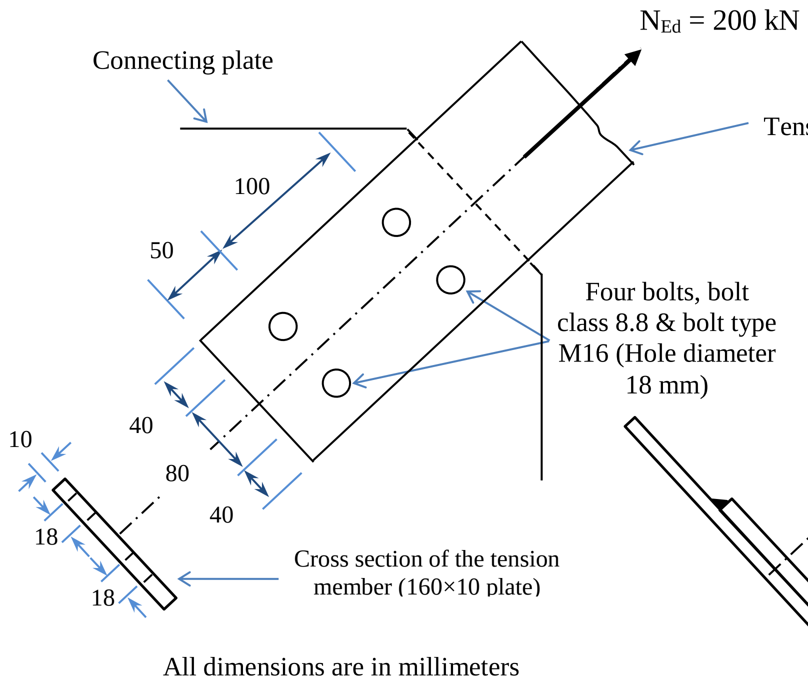


Figure 1 (a)

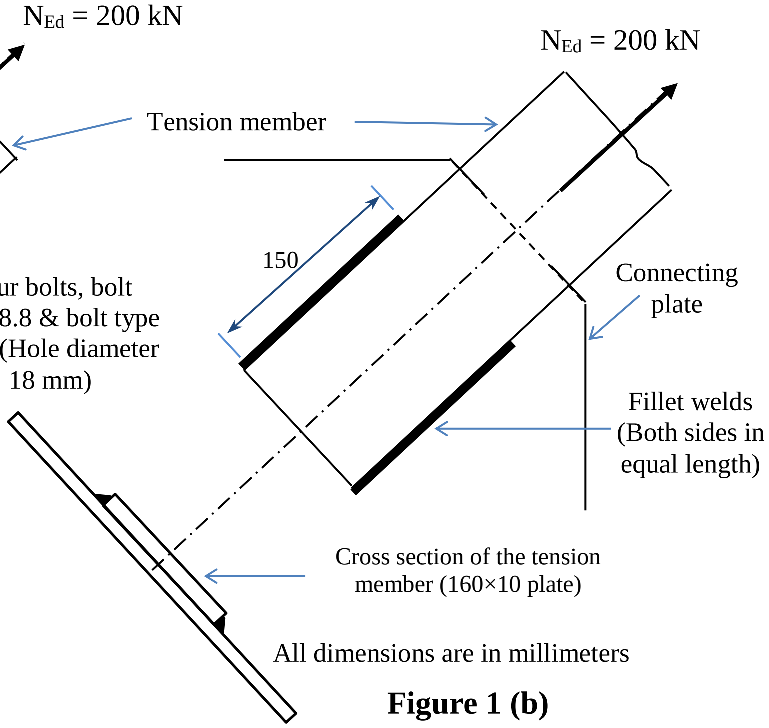


Figure 1 (b)

Question (2)

A compression member is concentrically fixed supported at both *A* and *B* ends while allowing to slide only in vertical direction at the *B* end (i.e. fixed ended compression member) as shown Figure 2. The member *AB* is braced at the mid span *C* to prevent lateral deflections in the minor principal plane (i.e. to prevent lateral deflection to the *y*-direction). The grade of steel is S355 and length of the member is 7 m. The member is subjected to a design axial compressive load (N_{Ed}) of 1630kN at end *B*.

(a). If the cross section of the member shown in Figure 2 is RHS 250×150×10 (RHS Table 1.5 of "STÅLKONSTRUKJONER"),

(i). Check the suitability of the column (i.e. can the column withstand the above loadings). **(9 Marks)**

(ii). If the thickness of the cross section uniformly reduces with the time throughout the member *AB* due to corrosion, discuss how it affects to the resistance of the column (i.e. load capacity of the column). **(3 Marks)**

(b). If the cross section of the member shown in Figure 2 is RHS 300×200×6.3 (RHS Table 1.5 of "STÅLKONSTRUKJONER"),

(i). Confirm the cross section of the member is in Class 4 and determine the effective cross sectional area (A_{eff}). **(7 Marks)**

(ii). Determine the design compressive resistance ($N_{c,Rd}$) of the member and check the suitability of the column against cross sectional yielding (i.e. can the column withstand the axial load without cross sectional yielding). **(2 Marks)**

(iii). Determine the design buckling resistance ($N_{b,Rd}$) of the member and check the suitability of the column against overall flexural buckling (i.e. can the column withstand the axial load without overall flexural buckling). **(4 Marks)**

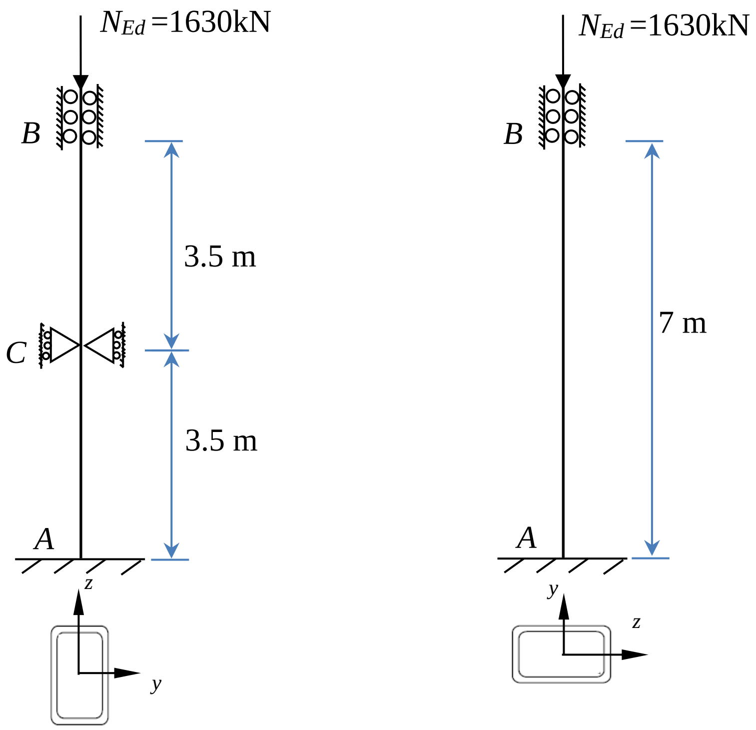


Figure 2

Question (3)

(a). A beam is subjected to a concentrated dead load (P_D) of 100 kN and an imposed load (P_I) of 130 kN at the mid-span as shown in Figure 3 (a). Length of the beam is 3 m and simply supported at both ends. Both supports are prevented from twist rotations in addition to its usual translational restraints.

(i). Design a suitable hot rolled Rectangular Hollow Section (RHS Table 1.5 of "STÅLKONSTRKJONER") of steel grade S355 for this beam by only considering Ultimate Limit State (ULS). **(9 Marks)**

(ii). Check that the beam satisfies the Serviceability Limit State (SLS) which governs the deflection limit for appearance (i.e. Length/200). **(3 Marks)**

(b). The frame *ABC* is subjected to a design vertical force of 400 kN at point *C* as shown in Figure 3(b). The frame is fixed at the bottom *A* and cross section is HE300B (HE-B Table 1.3 of "STÅLKONSTRUKJONER") of steel grade S355. The *AB* and *BC* members are subjected to bending about *y-y* axis. The *BC* beam has been sufficiently laterally braced against lateral torsional buckling. The elastic critical moment (M_{cr}), the interaction factors k_{yy}, k_{zy} for the *AB* column are given as 1105 kNm; 1.058 and 0.968 respectively.

(i). Check the *AB* column for buckling failure (i.e. can the column withstand the above loadings without failure due to flexural or lateral torsional buckling). **(10 Marks)**

(ii). If the *BC* beam has **not** been sufficiently laterally braced against lateral torsional buckling, discuss how it affects the buckling of the column (i.e. buckling capacity of the column). **(3 Marks)**

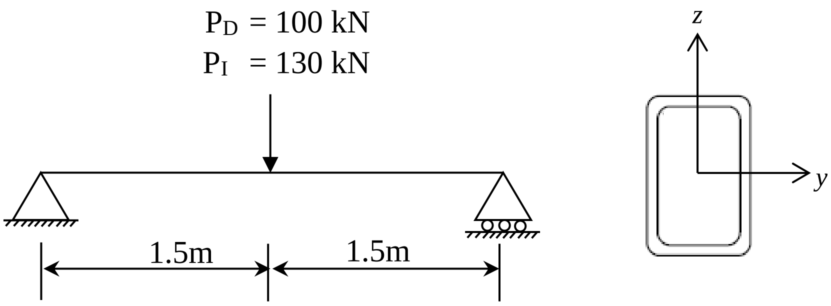


Figure 3 (a)

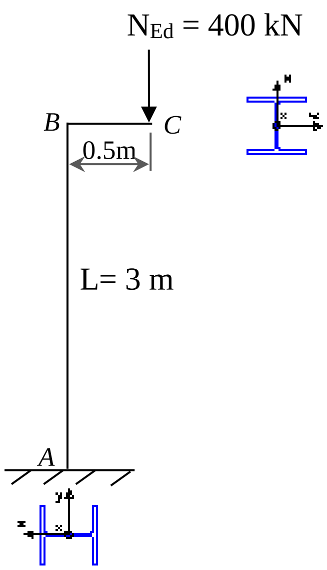


Figure 3 (b)

Question (4)

(a). A member is subjected to uniformly distributed design torque (T_o) 1 kNm/m as shown in Figure 4 (a). The both *A* and *B* ends are torsional fixed (i.e. twist rotation and warping are prevented by both supports). The length of the member is 3 m and cross section is IPE 500 (Table 1.1 of "STÅLKONSTRKJONER") of S355 steel grade. Assume that the Torsional Rigidity (GI_T) is negligible compared to Warping Rigidity (EC_w) of the member (i.e. $EC_w >> GI_T$ and hence effects of St.Venant torsion can be neglected).

(i). Determine the maximum values for warping normal stress ($\sigma_{w,max}$) and warping shear stress ($\tau_{w,max}$). **(9 Marks)**

(ii). Check the suitability of the beam (i.e. can the beam withstand the design torque) in Ultimate Limit State (ULS). **(2 Marks)**

(iii). If the right **end *B*** is changed to a torsional pinned support (i.e. support restrained only for twist rotation), discuss how it affects to the warping normal stress ($\sigma_{w,max}$). State the logical reasons for your answer without calculations. **(2 Marks)**

(b). A member is concentrically connected to 2 plates by 2×6 ordinary bolts as shown in Figure 4(b). The bolts class is 8.8 (i.e. Skruer 8.8) and type of bolts is M22 (i.e. bolt diameter is 22 mm and hole diameter is 24mm). The shear planes of all the bolts are passing through **unthreaded (ugjenget)** portion. Four bolts are located in a single plane, which is perpendicular to the loading axis, as shown in Section *A-A* of Figure 4 (b). The length, width and thickness of the connecting plates are 400mm, 180mm and 20mm respectively. The steel grade of the connecting plates is S275. The cross section of the member is HE180A (HE-A Table 1.2 of "STÅLKONSTRUKJONER") of S275 steel grade. The HE180A member is subjected to constant amplitude cyclic axial force as shown in Figure 4 (b). The maximum (F_{max}) and minimum (F_{min}) values of cyclic axial force are 215 kN and 5 kN and the member HE180A is subjected to 200 similar cycles per day. Assume the assessment method of this member (i.e. safety concept) as safe life (i.e. no inspection is done) and low consequence (i.e. less important member).

(i). Determine the fatigue life of the **member** HE180A. **(6 Marks)**

(ii). Determine the fatigue life of the **connecting plate**. **(4 Marks)**

(iii). State only the detail category which is used to determine the fatigue life of the **bolts**. **(2 Marks)**

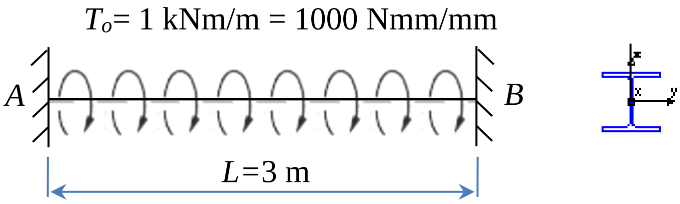
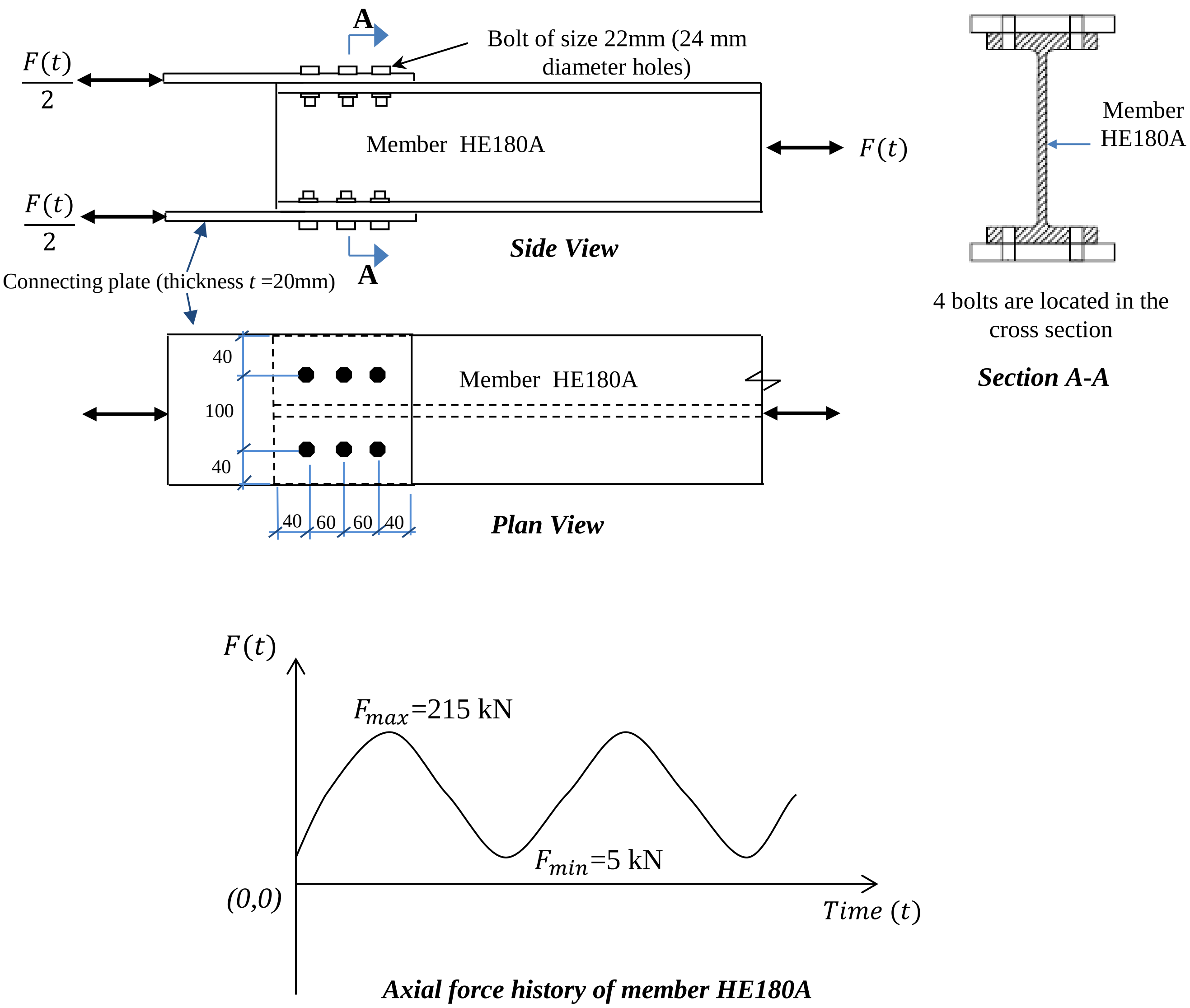


Figure 4 (a)



A
Bolt of size 22mm (24 mm diameter holes)
F(t)/2
Member HE180A
F(t)
F(t)/2
Side View
A
Connecting plate (thickness t =20mm)
Member HE180A
4 bolts are located in the cross section
Section A-A
40
100
40
Member HE180A
40
60
60
40
Plan View
F(t)
Fmax=215 kN
Fmin=5 kN
(0,0)
Time (t)
Axial force history of member HE180A

Figure 4 (b)