FACULTY OF SCIENCE AND TECHNOLOGY

University of Stavanger

SUBJECT: **BYG 200 Steel Structures (BYG 200 Stålkonstruksjoner)**

DATE: **December 07, 2013**

DURATION: **4 hours**

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 EXAMINATION PAPER CONSISTS OF 4 QUESTIONS AND 6 PAGES.

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

Question (1)

Both ends of a tension member are concentrically connected by symmetrically arranged 2×6 number of ordinary bolts in each flange as shown in Figure 1. 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 cross section of the tension members is HE180A (HE-A Table 1.2 of "STÅLKONSTRUKJONER") of S275 steel grade. The tension member is subjected to a design tensile force (N_{Ed}) of 760 kN.

(a). The four bolts are located in a single plane, which is perpendicular to the loading axis, as shown in Section *A-A* in Figure 1.

(i). Check the suitability of **tension member** (i.e. can the tension members withstand the design load). **(10 Marks)**

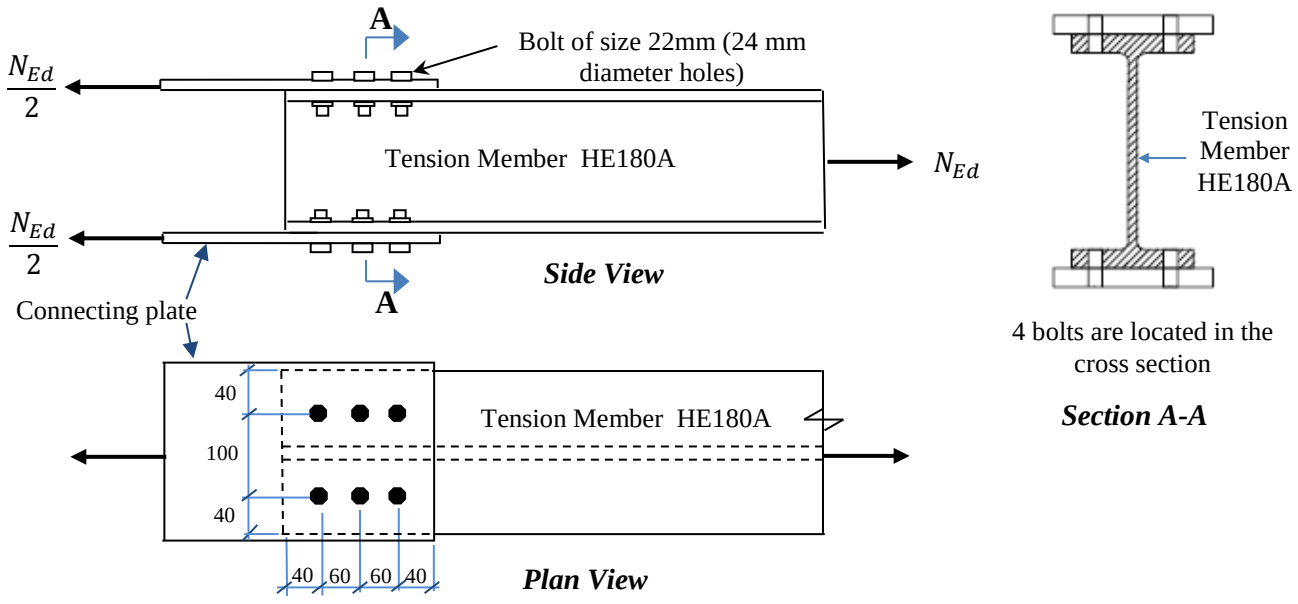
(ii). If these 12 ordinary bolts are replaced by M20 bolts of same class (i.e. bolts class 8.8), do you think that this **tension member** can transmit/withstand the given load. State the logical reasons for your answer without calculations. **(3 Marks)**

(b). The shear planes of all the bolts are passing through **threaded (gjenget)** portion. The connecting plate material is S275 steel and thickness of the connecting plate is 8 mm. The spacing, end and edge distances are as shown in Figure 1.

(i). Check the suitability of **bolt** size (i.e. can the bolts withstand the design load). **(4 Marks)**

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

(iii). Do you think that flanges of tension member can transmit the design load without bearing failure. State the logical reasons for your answer without calculations. **(2 Marks)**



All dimensions are in millimeters

Figure 1. Connection detail of one end of the tension member

Question (2)

A compression member is concentrically connected at both A and B ends. The end A of the member behaves as a pinned while other end B behaves as a fixed as shown in Figure 2. The grade of steel is S355 and length of the member is 6 m. The member is subjected to a design axial compressive load of 2000 kN.

(a). If the cross section of the member shown in Figure 2 is HE200B (HE-B Table 1.3 of "STÅLKONSTRUKJONER").

(i). Confirm that the column is not suitable (i.e. column cannot withstand the above loadings). **(8 Marks)**

(ii). Discuss the suggestions to improve the load capacity/resistance of the column. **(3 Marks)**

(b). If the cross section of the member shown in Figure 2 is HE800A (HE-A Table 1.2 of "STÅLKONSTRUKJONER").

(i). Confirm the cross section of the member is in Class 4 and determine the effective cross sectional area (A_{eff}). **(6 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)**

(iv). Do you think that given HE800A section is the optimized cross section for this column (i.e. most economical cross section). State the logical reasons for your answer without calculations. **(2 Marks)**

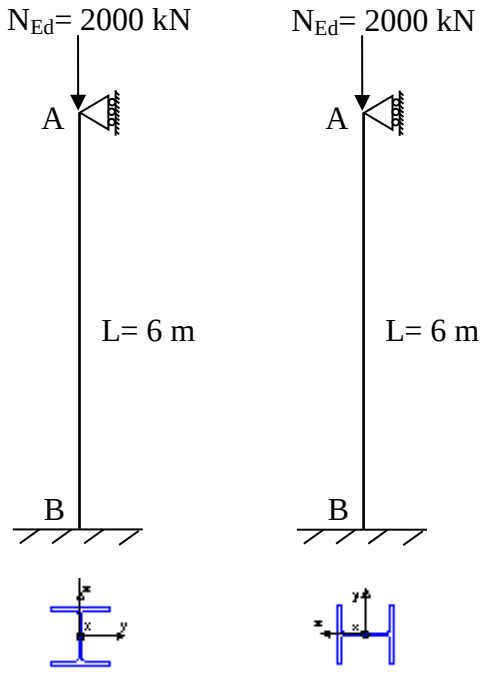


Figure 2

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). A 3 m height column is subjected to a design axial compressive force of 600 kN and a design end moment of 200 kNm about *y-y* axis at the top end as shown in Figure 3(b). The column is fixed at the bottom and column section is HE300B (HE-B Table 1.3 of "STÅLKONSTRUKJONER") of steel grade S355. The elastic critical moment (M_{cr}), the interaction factors $k_{yy,}$ k_{zy} for the column are given as 1105 kNm; 1,058 and 0,968 respectively.

(i). Confirm the cross section of the column is in Class 1. Explain the importance of the cross sectional classes in design process and how they affect the design resistances. **(3 Marks)**

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

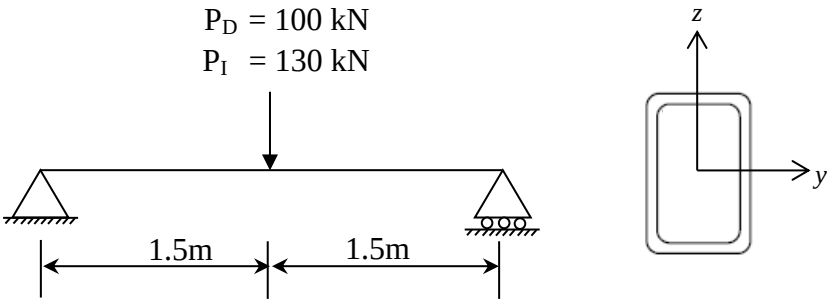


Figure 3 (a)

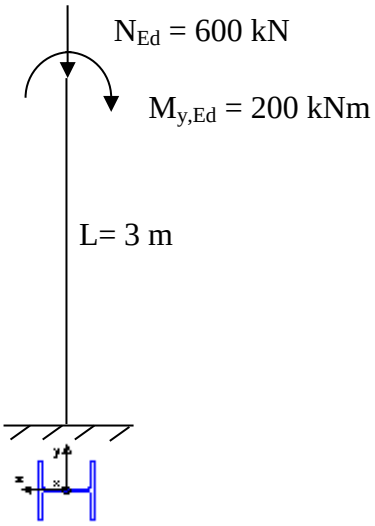


Figure 3 (b)

Question (4)

(a). A cantilever member is subjected to a design torque (T) 2 kNm at the end as shown in Figure 4 (a). The length of the member is 3 m and cross section is U 400 (Table 1.8 of "STÅLKONSTRUKSJONER") of S355 steel grade. Assume that 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). The twist rotation and warping are prevented by the left end support while other end is free to warp as shown in Figure 4 (a).

(i). Determine the maximum values for warping normal stress ($\sigma_{w,max}$) and warping shear stress ($\tau_{w,max}$). **(11 Marks)**

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

(b). The Figure 4 (b) shows a part of a steel truss. The member *AB* (refer Figure 4(b)) is a plate of size 120×10 mm. The both *A* and *B* ends of the member are connected by fillet welds (i.e. fillet welded lap joint) to the connecting plate as shown in Figure 4 (b). The leg length of the weld is 8 mm (i.e. throat thickness is 5, 66 mm) and length of the weld of each side is 100 mm. The member *AB* 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 40 kN and -20 kN and the member *AB* is subjected to 10 similar cycles per day. Assume the assessment method of this truss (i.e. safety concept) as safe life (i.e. no inspection is being done) and high consequence (i.e. important member).

(i). Determine the fatigue life of the member *AB*. **(5 Marks)**

(ii). Determine the fatigue life of the fillet weld at the end *B*. **(5 Marks)**

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

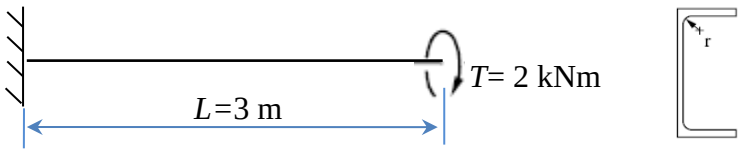
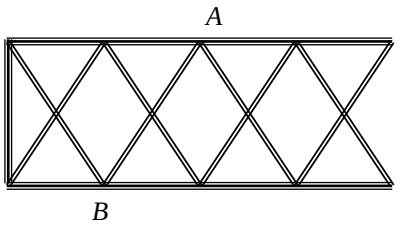
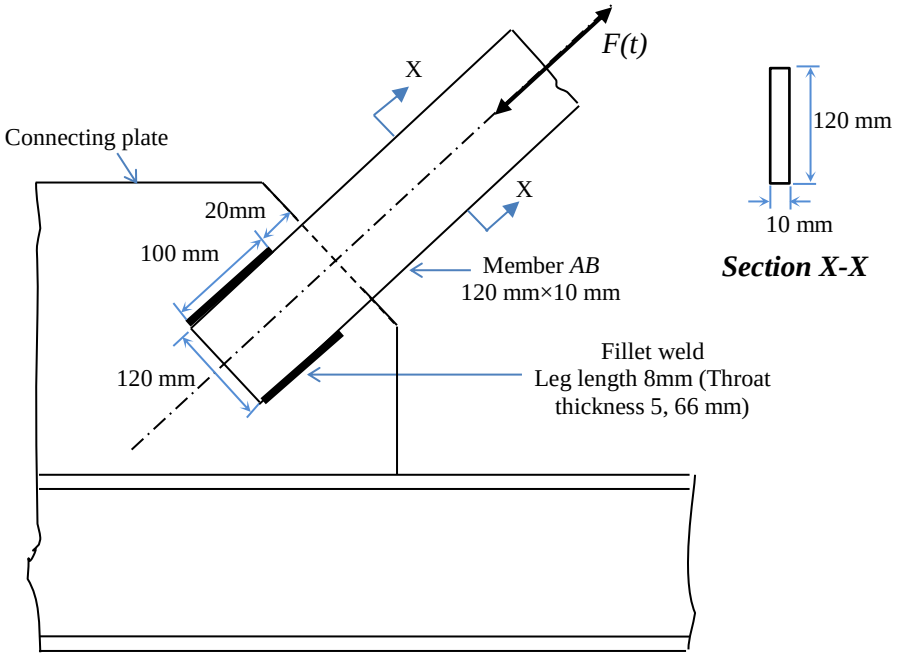


Figure 4 (a)

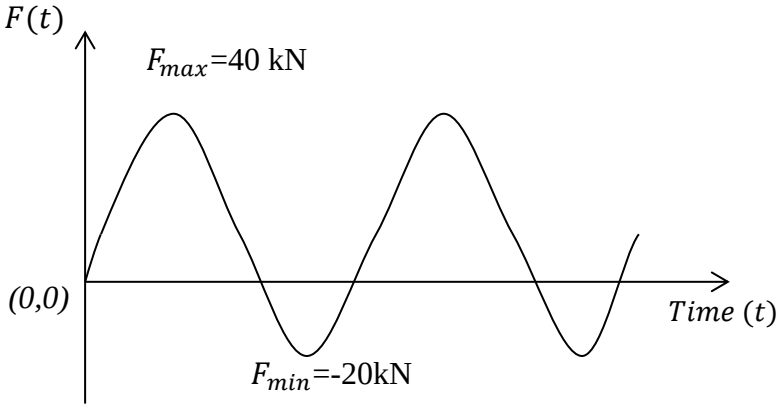


Part of steel truss



Section X-X

Part of connection B



Axial force history of member AB

Figure 4 (b)