Pre-Tensioning of High Strength Holding Down Rods

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Introduction

Holding down bolts are typically threaded rods of varying lengths. Tightening of the hold down bolts to achieve a minimum level of bolt pre-tension eliminates a potential source of undesirable connection flexibility. Such as in column base plate connections in a seismic-resisting system where the frame stiffness will change if the base plate lifts off the footing, as the rigidity of this connection has a significant effect on the behaviour of the seismic-resisting system(s) and the overall building.

One option for achieving the necessary pre-tensioning would be to use direct tensioning equipment but this is difficult to calibrate reliability for structural bolts if galvanised. However, a simpler option is to use the part turn concept of NZS 3404. A bolt extension associated with achieving the minimum bolt proof load applied as a specified turn of nut past snug tight.

The method modifies the method previously presented in HERA Design & Construction Bulletin No 56. Included in the end of this article is a worked example for determining the calculation of required amount of nut rotation from snug tight. This article provides additional information to ERC1001 *High Strength Bolting*.

Pre-Tensioning Using Part turn of Nut Method

Controlling tension by the part turn of nut method is primarily a strain control procedure and the desired tension in the holding down bolt can be obtained with accuracy. Since the bolt tension-bolt elongation curve is relatively flat (Figure 1), variations in the level of snug tightening result in only small variations in final bolt tension.

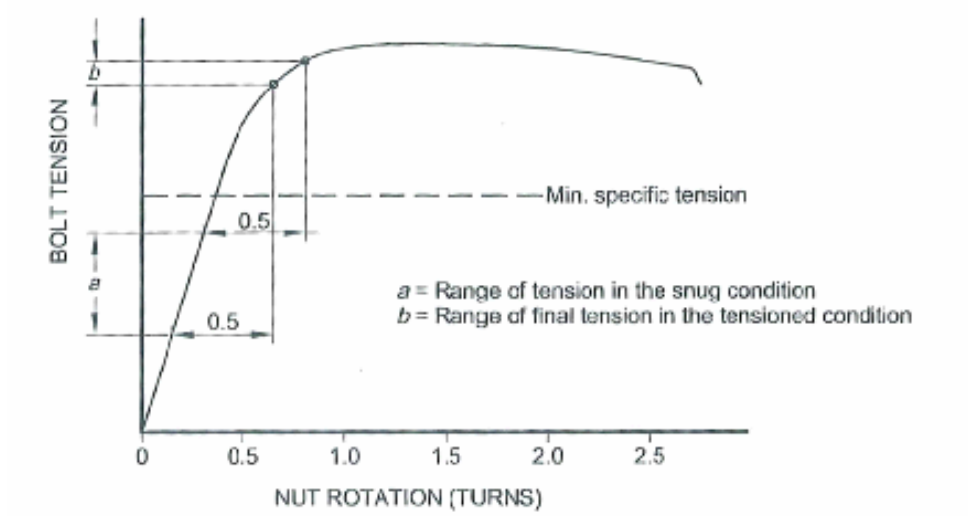

Figure 1: Indicative Bolt Stress Relative to Part Turns (Hogan, T.J. 1997)

Tightening of the holding down bolt must be applied after the grout between the base plate and concrete have reached their specified compression strength. The holding down bolt must not be able to rotate. The holding down bolt must be debonded from the concrete to permit elongation over the length of the bolt

The part-turn procedure can be broken down into the following steps:

1. Snug tighten all bolts starting from the rigid and moving to the free edge. Then repeat the procedure. Snug tight is the tightness attained by a few impacts of an impact wrench or by the effort of a person using a standard podger spanner
2. Match mark the nuts and bolts using a cold chisel striking across both the nut and bolt threads so that the part turn can be measured.
3. Conduct the part turn tightening working from the rigid part of the joint to the free edge. Amount of nut rotation is as calculated below
4. Mark the completed joint to indicate that the joint has been tensioned.
5. Inspect that this tightening has been applied. A random sample of bolts can be removed and the bolt extension measured and compared with the extension required to achieve specified amount of nut rotation.

Calculation of Amount of Nut Rotation from the Snug Tight Condition

Step 1 Calculate the required bolt extension to achieve minimum proof load

$$\Delta = \frac{f_{pf}}{E_f} L$$

Where:

f_{pf} = stress under proof load, 600 MPa for Property Class 8.8 from AS4291.1:2000 Table 3

E_f = 205,000 MPa

L = Length of holding down bolt over which elongation will occur, measured from top of anchor plate to free end of bolt.

Step 2 Calculate the required rotation past snug tight in degrees

$$\theta = \frac{\Delta}{\rho} x 360°$$

Where:

ρ = specified pitch for the hold down bolt diameter, from AS/NZS 1252 Table 2.1

Step 3 Round the required rotation to the nearest proportion of turn consistent with the values used in NZS 3404 Table 15.2.5.2

$1/4$ turn = 90°

$1/3$ turn = 120°

$1/2$ turn = 180°

$2/3$ turn = 240°

$3/4$ turn = 270°

Worked Example

Eccentrically braced frames (EBFs) have been designed for the lateral loads of additional carpark levels to an existing concrete framed building. The EBFs columns will be bolted through existing floor beams to a transfer truss below. Based on the above part turn method the recommended amount of nut rotation from the snug-tight condition is as follows:

Step 1 Calculate the required bolt extension to achieve minimum proof load

$$\Delta = \frac{f_{pf}}{E_f} L$$

Where:

f_{pf} = stress under proof load, 600 MPa for Property Class 8.8 from AS4291.1:2000 Table 3

E_f = 205,000 MPa

L = Length of hold down bolt over which extension can occur. = 700mm

$$\therefore \Delta = \frac{600}{205000} x700 = 2mm$$

Step 2 Calculate the required rotation past snug tight in degrees

$$\theta = \frac{\Delta}{\rho} x360°$$

$$\theta = \frac{2}{4} x360° = 180°$$

Where:

ρ = 4mm Table 2.1 AS/NZS 125:1996

Step 3 Round the required rotation to the nearest proportion of turn consistent with the values used in NZS 3404 Table 15.2.5.2

Nearest proportion is $\frac{1}{2}$ turn = 180°

References

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