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Experimental Study on Clamping Force of Torque Shear Type High Strength Bolts Subjected to Temperature

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1. Introduction

High strength bolt is used for the purpose of slip critical connection of steel structure. Nowadays torque shear type high strength bolt substitutes for high strength hexagon bolt at design of slip resistant joints. The torque shear type high strength bolt reaches the required torque when the pin tail twisted off at the end of shank. However it does not mean that this bolt has the required direct tension, but it subjects to torqued tension. This is why torque coefficient is affected on the design strength in tension on the process of tightening. The clamping method of torque shear bolts also follows the torque control method the same as the high strength hexagon bolt does. The torque coefficient of high strength bolt responds sensitively to the change of temperature still. In this study, torque test of torque shear bolts were conducted under the condition of -10℃, 0℃, 10℃, 20℃, 30℃, 40℃, 50℃ to observe the trends of tension due to temperature fluctuation.

2. Description of Experiment

The specimens were constituted by sampling of length 140mm and diameter 20mm based on KS B2819 S10T M20 as following Table 1;

Table 1. List of Specimen

Bolt Grade	Type	Size	Temperature Parameter	Quantity of Specimen
S10T	KS B 2819 Torque Shear Bolt	M20×140	-10℃	10
			0℃	10
			10℃	10
			20℃	10
			30℃	10
			40℃	10
			50℃	10

3. Experimental Results

The total experimental results depended on temperature parameter are shown on Table 2. From these results, the relation between design strength in tension and torqued tension, the relation between torqued tension and turn of nut was derived at each temperature parameter. At the break of pintail, the average of torque coefficient ranged from 0.136 to 0.151, the torque value ranged from 525N·m to 542N·m. The overall trend of torque coefficient was increased as temperature went down. The torqued tension also varied from 179.2kN to 192.5kN, as turn of nut varied from 151° to 160°. The maximum torqued tension was recorded from 260.8kN to 267.6kN, which was lower about 6.5% than tensile test results of full sized bolt. This is why torsional shear force was affected on shank as nut was turned. At this time of max torqued tension, the turn of nut ranged from 347° to 376°.

Table 2. Experimental Result of Specimens

Temp. Parameter	Break at Pintail				Ultimate Value		
	N (kN)	T (N. m)	θ (°)	k	N (kN)	T (N. m)	θ (°)
-10℃ Ave.	179	542	153	0.15	267	743	376
Standard Deviation	6.9	18.2	5.8	0.0	4.1	44.4	34.9
0℃ Ave.	180	537	154	0.15	267	718	375
Standard Deviation	9.7	2.4	10.6	0.0	5.0	53.1	55.8
10℃ Ave.	181	536	151	0.15	263	723	350
Standard Deviation	6.5	2.9	7.1	0.0	2.1	12.2	37.4
20℃ Ave.	182	533	158	0.15	267	691	354
Standard Deviation	4.4	2.0	10.1	0.0	1.7	17.5	26.2
30℃ Ave.	182	528	154	0.15	262	701	365
Standard Deviation	5.3	2.6	5.2	0.0	4.8	32.1	62.7
40℃ Ave.	187	526	155	0.14	260	691	347
Standard Deviation	11.6	3.5	9.1	0.0	6.8	43.2	26.1
50℃ Ave.	192	525	160	0.14	263	656	357
Standard Deviation	7.9	4.3	5.4	0.0	3.2	37.9	27.6

Figure 1. After break of pin tail

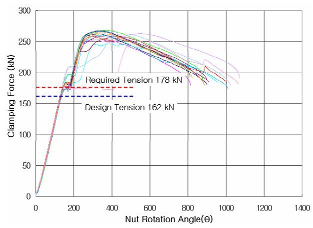

Figure 2. Torqued tension - Turn of Nut

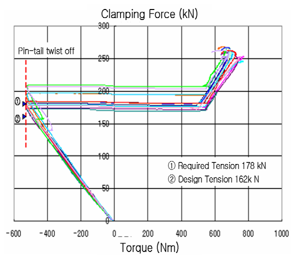

Figure 3. Clamping Force-Torque

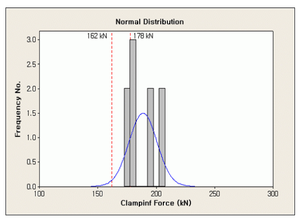

Figure 4. Histogram of Clamping Force (40℃)

3.1 Analysis of torqued tension

The torqued tension ranged from 175kN to 208kN at the break of pintail when ambient temperature varied from -10℃ up to 50℃. This average values were beyond not only design strength in tension,162 kN,but also the required strength in tension,178 kN, specified in KS code. Figure 5. shows a plot of he measured correlation between the torqued tension and temperature. At 50℃, the average of torqued tension was the highest. As temperature goes up, the torqued tension generally trends to go up.

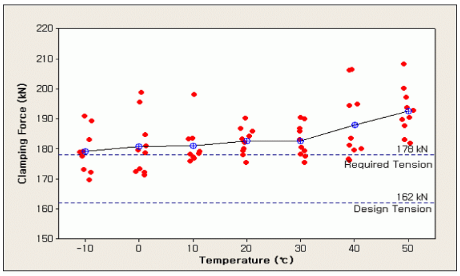

Figure 5. Trend of Clamping Force at the break of pintail

3.2 Analysis of torque coefficient

The torque coefficient ranged from 0.126 to 0.158 at the break of pintail when ambient temperature varied from -10℃ up to 50℃. This value was within the range from 0.11 to 0.17 recommended in KS B2819. Figure 6. shows a plot of the measured torque coefficient at each temperature.

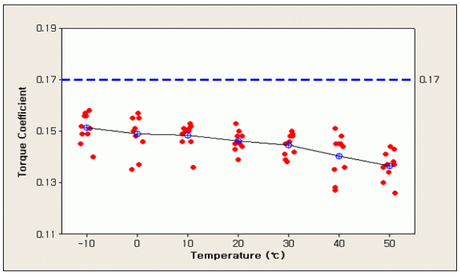

Figure 6. Trend of Torque Coefficient

3.3 Analysis of turn of nut

The turn of nut ranged from 143° to 177° at the break of pintail when ambient temperature varied. Differently from torqued tension described above, the turn of nut did not affect on variation of temperatue as shown on Figure 7.

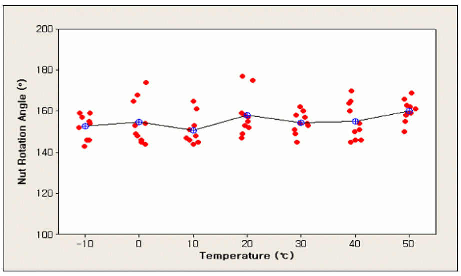

Figure 7. Trend of Turn of nut at the break of pintail

3.4 Analysis of torque

The torque ranged from 521N·m to 540N·m at the break of pintail when ambient temperature varied. Fig.8 shows a plot of the measured torque at each temperature. By equation between torque and tension, as temperature goes up, the torque trends to go down in contrary.

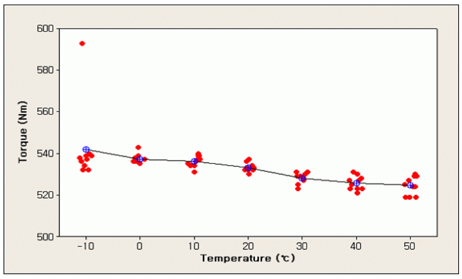

Figure 8. Trend of Torque at the break of pintail

4. Conclusion

The torque test results of torque shear bolts were conducted under the condition of -10℃, 0℃, 10℃, 20℃, 30℃, 40℃, 50℃ to observe the trends of tension due to temperature fluctuation as follows.

Most of torqued tension of specimens except some specimens at -10℃, was satisfied with the required strength in tension, 178kN. When the ambient temperature goes up, the torqued tension also goes up. For this reason, even if the bolts for slip resistant connection has the proper torque, it is necessary to maintain the proper management of torque shear bolts in storage not to be affected under the exterior environment.

REFERENCES

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