

LESSONS LEARNED / BEST PRACTICE

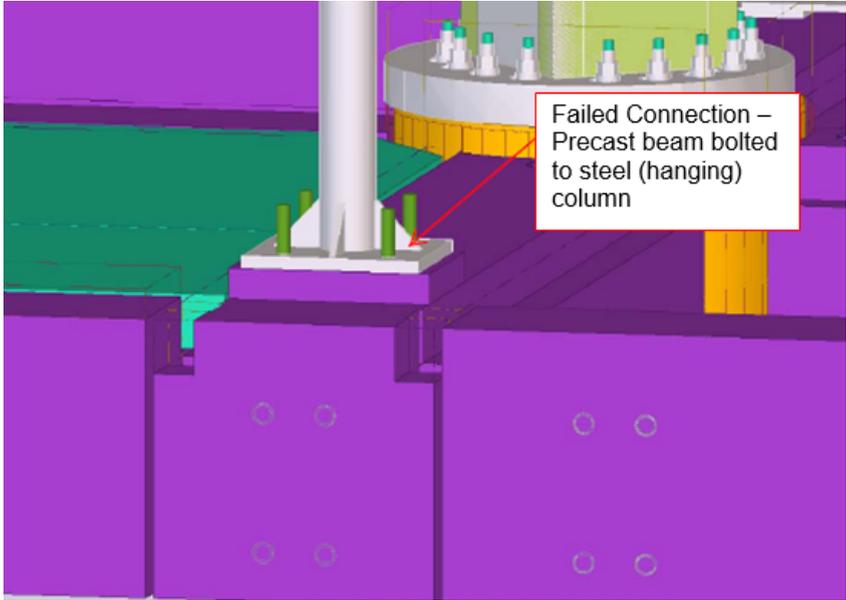
Title:	2019/01 - Failure of Nut and Bolt Connection	
What Happened / Impact?	Photo / Sketches	
<ul style="list-style-type: none"> • An incident occurred where a bolted connection securing a precast beam to a structural steel hanger failed. Refer to <i>Figure 1</i>. • Following examination, it was clear that the retaining bolt support mechanism failed, in a progressive manner over several hours, resulting in the partial collapse of a section of precast. • Subsequent investigations found that incorrect nut specification had been used to retain the four bolts for this specific connection. 	 <p style="text-align: center;"><i>Figure 1 - Shows the connection between the roof member and concrete beam</i></p>	
Why it Happened?		
<ul style="list-style-type: none"> • The connection that failed had nuts of an incorrect sizing fitted to the four bolts; the bolt type was M33, whereas the nuts fitted were type M36. • Two experienced and trained operatives placed the nuts on the bolts and tightened them with spanners. At no stage during the process did the operatives note any concerns in fixing the nuts. 		
Immediate Learnings / Recommendations		
<p>Immediate Learnings:</p> <p>Table 5 from BS 4190:2014 states (at the bottom of the page) that “<i>sizes shown in brackets are non-preferable</i>”. Post incident, the advice offered, to avoid an incorrectly sized nut being placed on a bolt, would be to implement the recommendations of the BS standard and eliminate the use of non-preferred sizes, as displayed in brackets on Table 5 of BS 4190:2014. This would maintain a larger differential in diameters, thus allowing for clearer identification of incompatible nuts and bolts.</p> <p>Key Recommendations:</p> <ul style="list-style-type: none"> • Eliminate non-preferred sizes (as shown in brackets on Table 5 of BS 4190:2014), particularly during the design phase. Refer to <i>Table 1</i> provided. • It is important to communicate to workers the criticality of selecting nuts and bolts of a correct, compatible size and thread pitch. Closely-sized but incompatible nuts and bolts may be easily threaded and can appear secure until such time as a load is applied, whereupon the risk of failure occurs. 		

Table 5 Dimensions of ISO metric black hexagon head bolts and screws (1 of 2)

Dimensions in mm												
1	2	3	4	5	6	7	8	9	10	11	12	13
Nominal size and thread diameter <i>d</i>	Pitch of thread (coarse pitch series)	Diameter of unthreaded shank		Width across flats		Width across corners		Height of head		Radius	Washer face dia. (see note 2)	Depth of washer face
		<i>d</i>		<i>s</i>		<i>e</i>		<i>k</i>		<i>r</i>	<i>dw</i>	<i>c</i>
		max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.
M5	0.8	5.48	4.52	8.00	7.64	9.2	8.63	3.88	3.13	0.35	6.8	0.5
M6	1	6.48	5.52	10.00	9.64	11.5	10.89	4.38	3.63	0.40	8.7	0.5
M8	1.25	8.58	7.42	13.00	12.57	15.0	14.20	5.88	5.13	0.8	11.5	0.6
M10	1.5	10.58	9.42	17.00	16.57	19.6	18.72	7.45	6.55	0.8	15.5	0.6
M12	1.75	12.70	11.30	19.00	18.48	21.9	20.88	8.45	7.55	1.25	17.2	0.6
M16	2	16.70	15.30	24.00	23.16	27.7	26.17	10.45	9.55	1.25	22.0	0.8
M20	2.5	20.84	19.16	30.00	29.16	34.6	32.95	13.90	12.10	1.78	27.7	0.8
(M22)	2.5	22.84	21.16	32.00	31.00	36.9	35.03	14.90	13.10	1.78	–	–
M24	3	24.84	23.16	36.00	35.00	41.6	39.55	15.90	14.10	1.78	33.2	0.8
(M27)	3	27.84	26.16	41.00	40.00	47.3	45.20	17.90	16.10	2.28	–	–
M30	3.5	30.84	29.16	46.00	45.00	53.1	50.85	20.05	17.95	2.28	42.7	0.8
(M33)	3.5	34.00	32.00	50.00	49.00	57.7	55.37	22.05	19.95	2.28	–	–
M36	4	37.00	35.00	55.00	53.80	63.5	60.79	24.05	21.95	2.7	51.1	0.8
(M39)	4	40.00	38.00	60.00	58.80	69.3	66.44	26.05	23.95	2.7	–	–
M42	4.5	43.00	41.00	65.00	63.80	75.1	72.09	27.05	24.95	2.8	60.8	1.0
(M45)	4.5	46.00	44.00	70.00	68.80	80.8	77.74	29.05	26.95	3.3	–	–
M48	5	49.00	47.00	75.00	73.80	86.6	83.39	31.05	28.95	3.8	70.8	1.0
(M52)	5	53.20	50.80	80.00	78.80	92.4	89.04	34.25	31.75	4.7	–	–
M56	5.5	57.20	54.80	85.00	83.60	98.1	94.47	36.25	33.75	4.9	–	–
(M60)	5.5	61.20	58.80	90.00	88.60	103.9	100.12	39.25	36.75	4.9	–	–
M64	6	65.20	62.80	95.00	93.60	109.7	105.77	41.25	38.75	4.9	–	–
(M68)	6	69.20	62.80	100.00	98.60	115.5	111.42	44.25	41.75	4.9	–	–

NOTE 1 Size in brackets are non-preferred.

NOTE 2 Calculations of washer face diameters for other sizes may be obtained from the following formulae:

1) for sizes up to and including M20:
washer face diameter (min.) = s_{min} - IT16;

2) for sizes over M20:
washer face diameter (min.) = s_{min} - IT17;

where IT stands for standard tolerance, and belongs to the ISO series of tolerances (see BS EN ISO 286-1 and BS EN ISO 286-2).

Table 1 - Extract from BS 4190:2014

- If no torque value is provided, it should be sought from the respective designer or manufacturer. For many non-preloaded (ordinary bolted) connections, the designer may not be required to provide a torque value. If this is the case, then the torque values in **Table 2** should be used to verify that any ordinary bolted connection is correctly tightened.

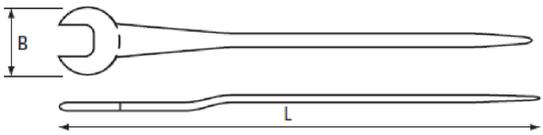
Podger Spanner				
				
Bolt Size	B	L	Approximate Torque (Nm)	* Values are indicative of torque achieved when hand tightened using a force of 250N.
M16	60	460	90 *	
M20	70	550	110 *	
M24	85	640	130 *	
M30	100	730	160 *	

Table 2 - Extract from Steel Construction Institute – Technical Advisory Note AD 302

- All connections designed to withstand significant loads shall be identified and evaluated in a design risk assessment, with appropriate controls specified.

- This specific incident occurred in a heavy structural connection; however, it could occur in any nut and bolt connection (e.g. threaded bar and uni-strut drops, relief angles, shutter connections, etc). All bolted connections should be reviewed to ensure conformity of nut and bolts and that “non-preferred sizes” as per table 5 of BS 4190:2014 are not selected for use.
- Where applicable, a Vernier Callipers, thread Pitch Gauge and Torque Wrench should be available onsite for site verification of bolt and nut compliance.



Figure 2 - Pitch Gauge



Figure 3 – Digital Vernier Callipers

For Further Information (Optional):

Not applicable