

# List of Tables

**Table 1.** Typical mix proportions for slabs, plugs, and grout

	Slabs (kg/m <sup>3</sup> )	Plugs (kg/m <sup>3</sup> )	Grout (kg/m <sup>3</sup> )
Cement	313	500	910
Cement type	CEM II A-L 32.5 R	CEM I 52.5N	Hanson Quickcem
Water	189	182	455
Sand	825	713	910 'fine sand'
Gravel	1093 (size 10 mm)	1011 (size 10 mm)	-
Superplasticizer	0.8% of cement weight	1.2% of cement weight	-

**Table 2.** Specifications of push-out tests

Test No.	Bolt Dia. (mm)	Bolt preloads (kN)		Slabs		Plugs		Grout
		Nuts 1-2*	Nuts 2-3*	Comp. strength (MPa)	Tensile strength (MPa)	Comp. strength (MPa)	Tensile strength (MPa)	Comp. strength (MPa)
1	16	88-106	88-106	31	2.5	65	4.2	122
2	16	88-106	0.0	31	2.5	65	4.2	-
3	16	88-106	88-106	31	2.5	83	5.2	43
4	16	88-106	10	31	2.5	83	5.2	43
5	16	88-106	88-106	37	-	71	4.3	58
6	16	64	55-70	41	4.0	86	5.1	44
7	12	47-56	24	50	4.0	91	4.8	28
8	14	68-81	23	50	4.0	95	4.6	32
9	16	failed	23	42	3.6	80	4.8	39
10	16	88-106	24	43	3.1	50	3.7	27
11	16	88-106	26	43	3.2	96	4.8	28
12	16	88-106	26	42	3.5	91	4.9	28

\* See Fig. 3 for locations of nuts 1, 2 and 3

11 **Table 3.** Sieve analysis of ‘fine sand’ used in grouts

Sieve size (mm)	Cumulative (% by weight)	Passing (% by weight)	BSI (1976), Table 1, Type B, Passing (% by weight)
0.6	0	100	55 - 100
0.3	34	66	5 - 75
0.15	58	8	0 - 20
0.063	8	0	< 5

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14 **Table 4.** Properties of bolts

	Modulus of elasticity (GPa)	Yield stress (MPa)	Tensile strength (MPa)	Maximum elongation %	Bolt tensile resistance (kN)
Avg. of 9 specimens	209	787	889	8	
Min.	201	719	832	5	
Max.	215	847	950	15	
Standard deviation	5	50	41	5	
D12 mm					100.5
D14 mm					136.9
D16 mm					178.7

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18 **Table 5.** Results of tests 6, 11, and 12

Test No.	Ultimate load (kN)	Slip capacity (mm)
6	198.1	12.2
11	196.7	13.9
12	189.5	13.8
Average	194.8	13.3
Standard deviation	3.76	0.779
Error %	2	6

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22 **Table 6.** Angle ' $\beta$ ' of the deflected shape of the bolt from the vertical (in degrees) - M16 bolts of  
 23 tests 11 and 12

Test No.	Bolt 1	Bolt 2	Bolt 3	Bolt 4	Average
11	12.9	12.1	12.1	9.7	11.7
12	11.3	11.3	13.7	13.7	12.5
Average					12.1

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25 **Table 7.** Results of tests 7, 8, and 12

Test No.	Bolt diameter (mm)	Collar height (mm)	Conical nut width (mm)	Ultimate load (kN)	Slip capacity (mm)	Ultimate load / Bolt tensile resistance*	Bolt internal load / Bolt tensile resistance*
7	12	2.5	23	99.3	7.0	0.99	0.34
8	14	5.0	27	155.2	12.9	1.1	0.35
12	16	6.0	29	189.5	13.8	1.1	0.45
* Bolt tensile resistance is provided in Table 4.					Average	1.06	0.38
					Standard deviation	0.0596	0.0497
					Error %	6	13

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27 **Table 8.** Angle ' $\beta$ ' (in degrees) and length of deflected shape for M12, M14, and M16 bolts

Bolt Dia. (mm)	Bolt 1	Bolt 2	Bolt 3	Bolt 4	Average	Deflected length (mm)
12	7.7	9.9	8.5	9.9	9.0	28
14	10.5	11.3	11.3	12.1	11.3	35
16	11.3	11.3	13.7	13.7	12.5	40

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30 **Table 9.** Effect of plug concrete strength on M16 shear connector behavior

Test No.	Bolt diameter (mm)	Plug strength (MPa)	Ultimate load (kN)	Slip capacity (mm)	Ultimate load / Bolt tensile resistance*	$\beta$ (degrees)
10	16	50	180.7	14.7	1.01	13.0
11	16	96	196.7	13.9	1.10	11.7
12	16	91	189.5	13.8	1.06	12.5

\* Bolt tensile resistance is provided in Table 4.

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33 **Table 10.** Comparison among the predictions of Eq. (4) and the push-out tests results

Test No.	Bolt diameter (mm)	Plug strength (MPa)	Ultimate load (kN)	Eq. (4) (kN)	Error %
7	12	91	99.3	107.6	8.0
8	14	95	155.2	149.2	-4.0
10	16	50	180.7	190.7	6.0
11	16	96	196.7	195.5	-1.0
12	16	91	189.5	196.8	4.0

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