• **BOLT**

Grade of bolt according to mechanical properties	Mechanical properties of test piece machined from bolt				Mechanical properties of full - size bolt						
					Tensile load (min) (kgf)						Hardness
	YIELD Strength Kgf/mm2	TENSILE Strength (Kgf/mm2)	ELON-GATION (%)	REDUC-TION of Area (%)	M16	M20	M22	M24	M27	M30	
F10T	90 MIN	100-120	14 MIN	40 MIN	15,700	24,500	30,300	35,300	45,900	56,100	HRC 27-38

• **NUT**

Grade of nut according to mechanical properties	Hardness Test	Tension Test
	Hardness	Proof Load
F10	HRB 95 -HRC 35	Same as tensile load (MIN) of bolt

• **WASHER**

Grade of washer according to mechanical properties	Hardness
F35	HRC 35-45

4. TIGHTENING AXIAL STRENGTH AND TORQUE VALUE

The design strength of a high strength friction grip bolted joint is calculated from the design tensile strength of the bolt. Because of tightening variations, the standard tensile strngth is taken as 10% move than the standard tensile strength.

The design bolt TIGHTENING AXIAL STRENGTH is calculated using the formula.

$No = 0.75\, f_y Ae$ where No = Design Bolt Tensile Strength

f_y = Bolt Yield Strength (Min)

Ae = Effective Cross Section Area.

GRADE	Nominal size of thread	Design bolt tensile strength	Standard bolt tensile strength	Standard yorque coefficient	Standard tightening torque value
2 (F10T)	M16	10.6	11.7	B 0.165	31
	M20	16.5	18.2		60
	M22	20.5	22.6	A 0.125	62
	M24	23.8	26.2		78

The Tightening Torque Value is Calculated Using the Following Formula

$$T = K \times d \times N$$

T = Tightening Torque Value
d = Nominal Bolt Diameter
K = Torque Coefficient
N = Bolt Tensile Strength

5. DESIGN DATA

Table of Allowable Yield Strength for High Strength Bolts

Type of high strength bolt	Nominal size of bolt	Bolt axial diameter	Bilt hole diameter	Bolt axial cross-selection area	Bolt effective cross-section area	Design bolt tensile strength	Allowable shear strength		Allowable tensile strength
							Serface 1 friction	Serface 2 friction	
F 10 T	M16	16	17.0	2.01	1.57	10.6	3.02	6.03	6.23
	M20	20	21.5	3.14	2.45	16.5	4.71	9.42	9.73
	M22	22	23.5	3.80	3.03	20.5	5.70	11.4	11.8
	M24	24	25.5	4.52	3.53	23.8	6.78	13.6	14.0

Friction connections use patch plates to clamp the glass in place and are commonly used for single ply sheets of toughened glass.
Friction grip bolt torques should be designed to generate a frictional clamping force of $N=F/\mu$, where the coefficient of friction is generally $\mu=0.2$.

Friction Grip Connections

These were first pioneered by Pilkington Glass and have been used for many years with single-ply toughened glass. For the Glass Reading Room of the Arab Urban Development Institute in Riyadh, Saudi Arabia * (1998) a solution was found to friction-grip laminated glass and overcome the problem of interlayer creep relaxing the bolt tension and hence losing the friction in the long term.

The cube is 8m x 8m x 8m and has no internal structure. Toughened glass beams 2.67m in length formed of two 15mm thick leaves were joined using friction grip connectors to create portal frames which carry the glazing loads and provide stability. Because of the high forces that arise when the bolts are tightened, an aluminium spacer of low temper yet creep-resistant was inserted between the glass leaves at the connection.

We have found that for these connections attention to detail at manufacturing stage is vital. Key things to watch for are: the steel surfaces at the friction connection must be milled perfectly flat; the fibre gaskets must be used only once and should be made of semi-flex vulcanised fibre; the thickness of aluminium must be carefully matched to the edge tape thickness to provide 5-10% compression to the tape; the joint must be clamped during UV curing of the resin.