§3.8.1 Detailing of HS bolted connection

1.A connection with high-strength bolts is classified as either a bearing or slip-critical connection.

- **Bearing**
  - Slippage acceptable
  - Shear and bearing on the connector
- **Slip-critical**
  - Slippage unacceptable (Proper installation)
  - Sufficient shear and bearing strength in overload that causes slip.
  - Used in the important connection

2. Bolt installation

1) Tightening methods

A. Turn of the Nut (扭角法)

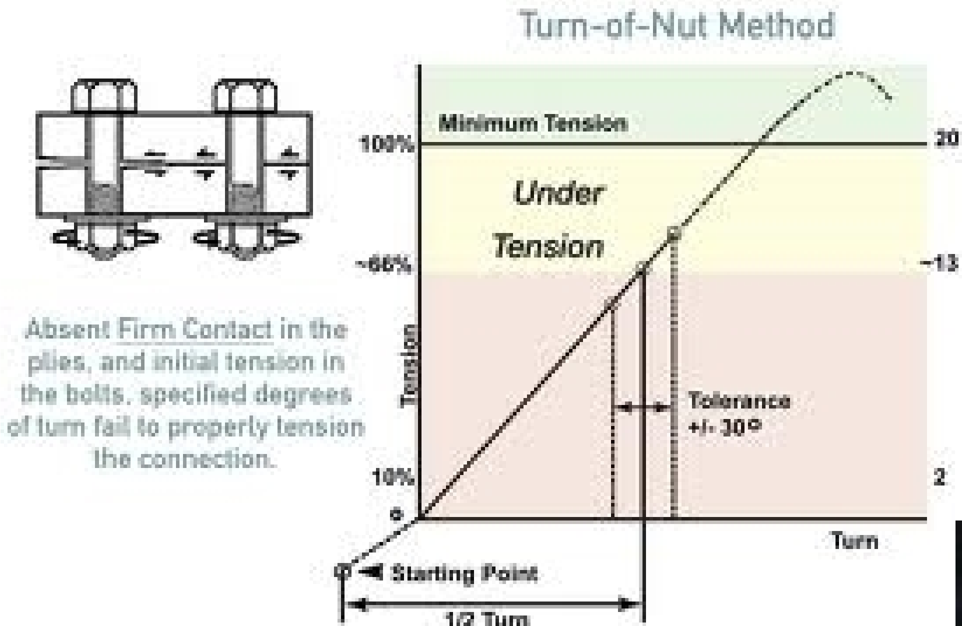
B. Calibrated wrench tightening (扭矩法)

C. Twist-off-type tension-control bolt （拧断型拉力控制螺栓）

D. Direct tension indicator (拉力测量仪)

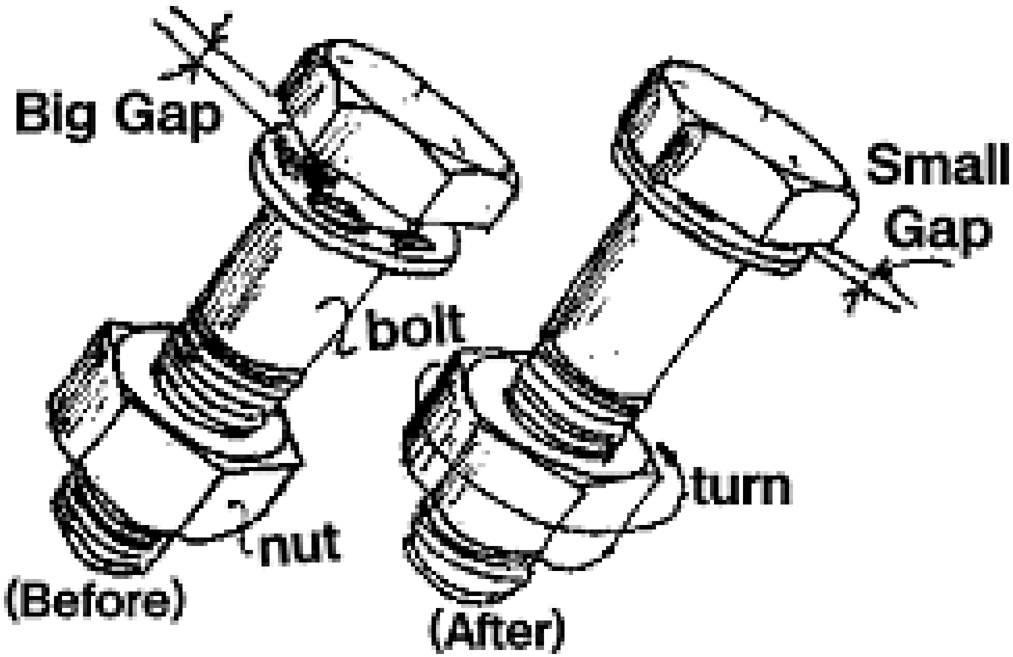
A. Turn of the Nut

B. Calibrated wrench tightening

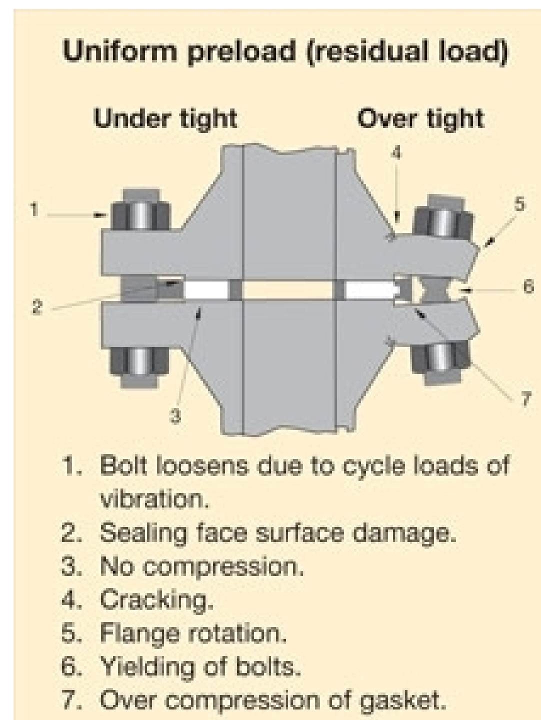


C. Twist-off-type tension-control bolt

D. Direct tension indicator



Direct Tension Indicators



2） Preload design

The following factors are considered as

- Reduction of material properties (0.9)
- Reduction of over tensioning of bolt (0.9)
- Reduction of shear which will decrease tension strength of bolt (1.2)
- safety factor 0.9

Bolt preload is

$$P = \frac{0.9 \times 0.9 \times 0.9}{1.2} A_e f_u$$

Grade	Nominal diameter					
	M16	M20	M22	M24	M27	M30
8.8	80	125	150	175	230	280
10.9	100	155	190	225	290	355

A_e—bolt effective area；

f_u—bolt tension strength, f_u =830N/mm^2 for grade 8.8 and f_u =1040N/mm^2 for grade 10.9

3） Friction coefficient

- Friction coefficient depends on the surface treatment and the steel grade. **Table 7.2 for china**

Treatment of surface	Coefficient of friction *(μf)*
Surfaces not treated	0.20
Surfaces blasted with short or grit with any loose rust removed, no	0.50
Surfaces blasted with shot or grit and hot-dip galvanized	0.10
Surfaces blasted with shot or grit and spray-metallized with zinc (thickness 50-70 *μm*)	0.25
Surface s blasted with shot or grit and painted with ethyl zinc silicate coat (thickness 30-60 *μm*)	0.30
Sand blasted surface, after light rusting	0.52
Surfaces blasted with shot or grit and painted with ethyl zinc silicate coat (thickness 60-80 *μm*)	0.30
Surfaces blasted with shot or grit and painted with alkali zinc silicate coat	0.30
Surface blasted with shot or grit and spray metallized with aluminium (thickness > 50 *μm*)	0.50
Clean mill scale	0.33
Sand blasted surface	0.48
Red lead painted surface	0.10

§3.8.2 Strength of HS bolted connection

(1) Behavior of HS bolt

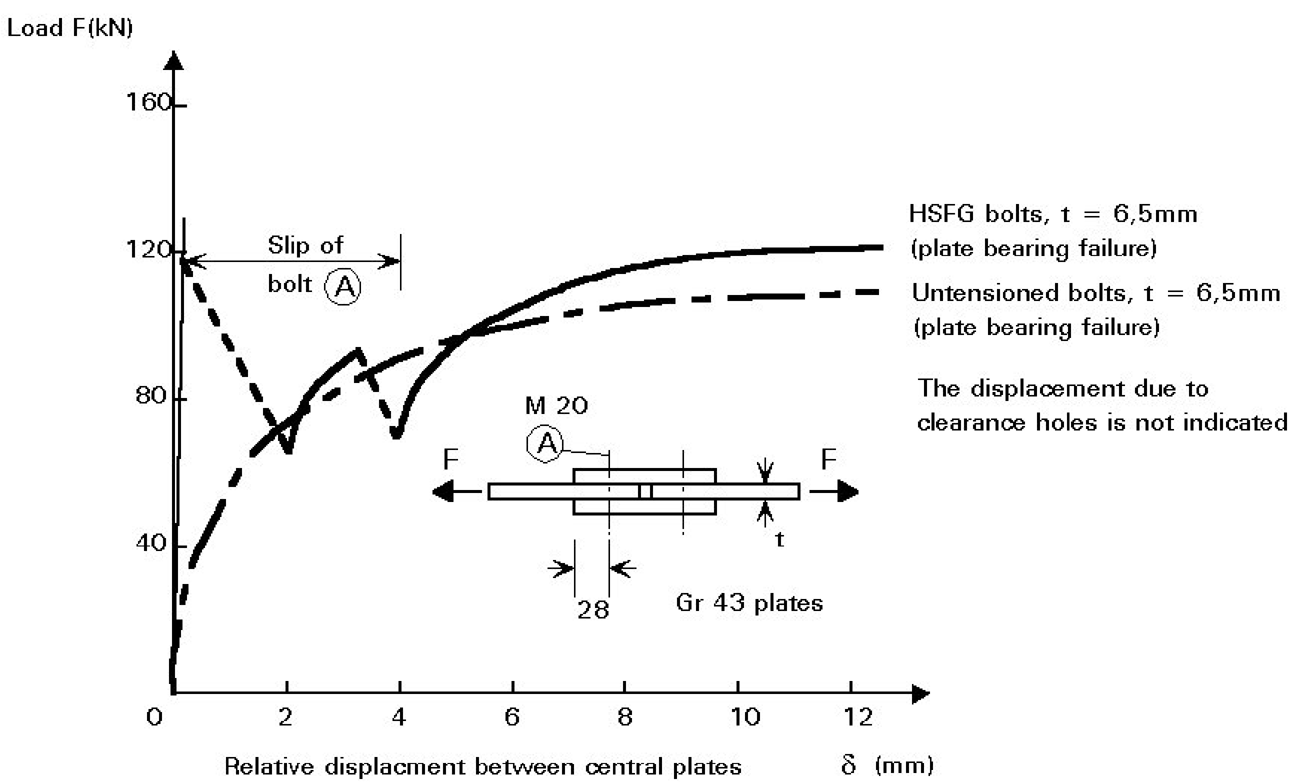
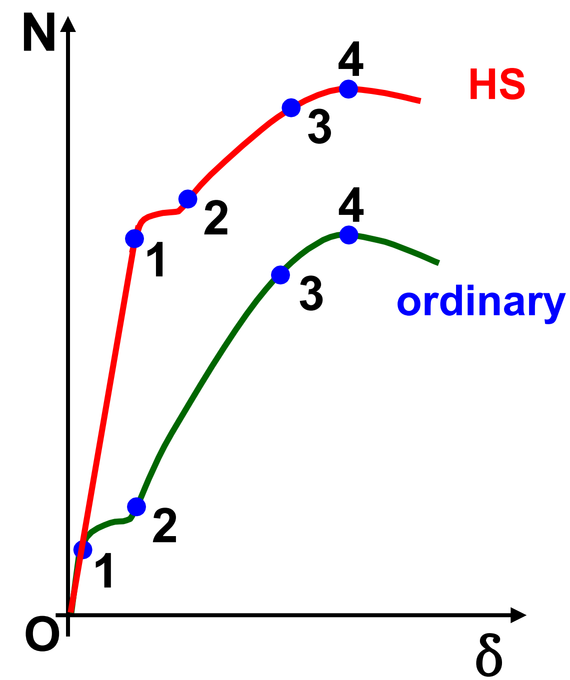
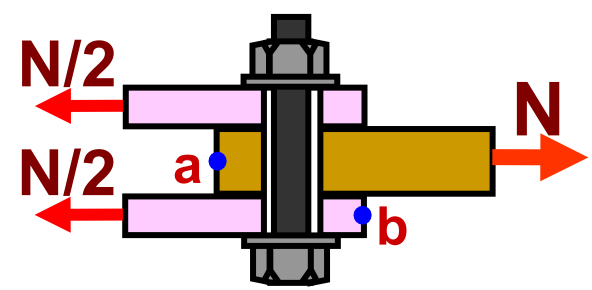


Figure 1 Comparison of load/deformation response for a lap joint

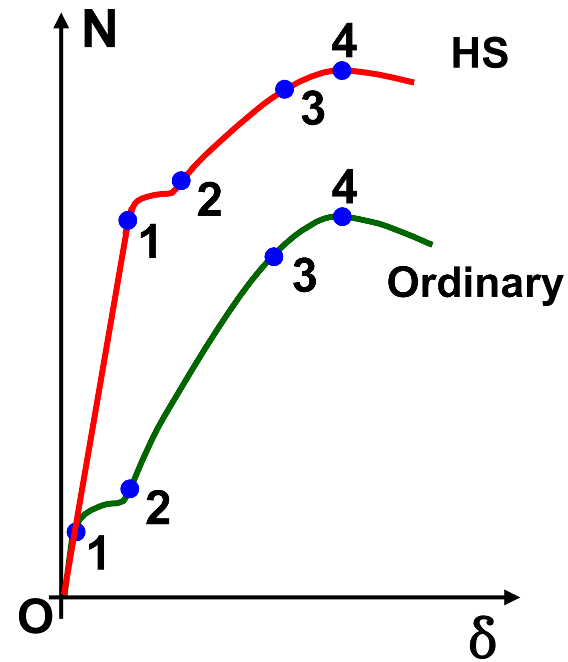




（2）Shear capacity of single bolt

For the slip-critical bolt,

$$N_v^b = 0.9 n_f \cdot \mu \cdot P$$



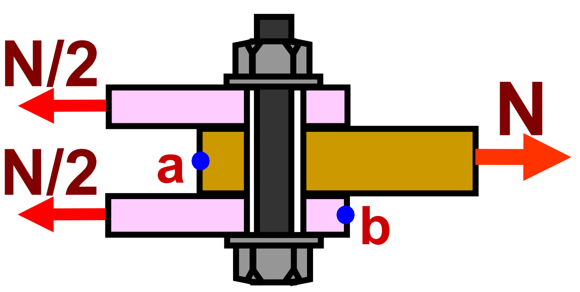
where:

0.9—reciprocal of resistance factor γ_R (γ_R=1.111)；

n_f—number of friction surface；

μ--friction coefficient

P—design value of preload



For the bearing type bolt,

Shear capacity is

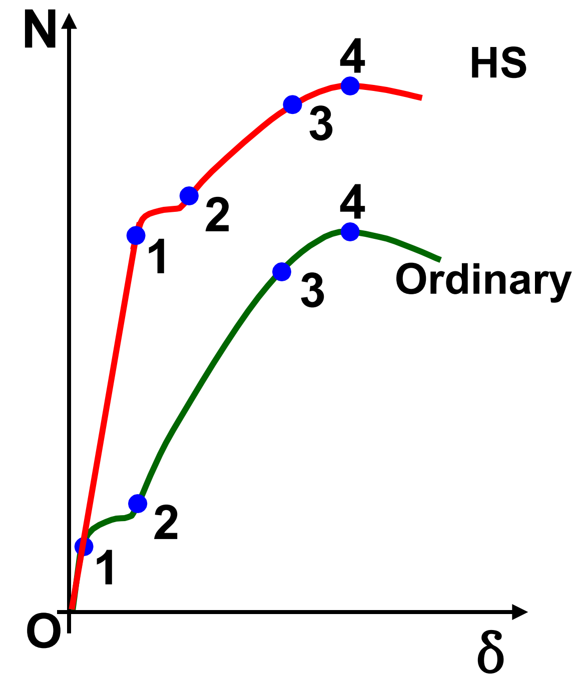
$$N_v^b = n_v \frac{\pi d_e^2}{4} f_v^b$$

Bearing capacity is

$$N_c^b = d \sum t f_c^b$$

Strength is

$$N_{min}^b = \min\{N_v^b \ \ N_c^b\}$$



（3）Tension capacity of single bolt

For the slip-critical bolt,

$$N_t^b = 0.8P$$

For the bearing type bolt,

$$N_t^b = A_e f_t^b = \frac{\pi d_e^2}{4} f_t^b$$

where:A_e--Effective area of bolt;

d_e--Effective diameter of bolt;

f_t^b—design value of bolt tension strength

The results is approximately equal

（4）Combined tension and shear

For the slip-critical bolt,

$$\frac{N_t}{N_t^b}+\frac{N_v}{N_v^b}\leq 1$$

For the bearing type bolt,

$$\sqrt{\left(\frac{N_v}{N_v^b}\right)^2+\left(\frac{N_t}{N_t^b}\right)^2}\leq 1$$

And to avoid bearing failure, should also satisfy as

$$N_v\leq\frac{N_c^b}{1.2}$$

N_t、N_v – **Design value of tension and shear load of single bolt**

N_t^b、N_v^b – **Design value of tension and shear capacity of single bolt**

1.2 is reduction of bearing capacity due to the tension of bolt