

Ask Dr. Galv



DEAR DR. GALV:

Why are designers and engineers saying that they can't use galvanized fasteners for structural joints?

A. In the past, designers and engineers have stayed away from using any type of protective coating when designing a bolted structural joint. Galvanized structural joints are considered inferior to bare steel connections. This is because the slip coefficient, also known as the friction coefficient, associated with protective coatings is lower than bare or mill scale steel. The truth is that in some cases using galvanized structural joints can be advantageous and beneficial to the design and fabrication.

Structural joints that are required to transmit shear forces are sometimes designed to be slip resistant. Bolted structural joints can be designed for either bearing or friction type connections. Bearing type connections resist shear between the connected parts by allowing the plate to bear on the bolt. The presence of protective coatings on the contact surfaces of bearing connections is not detrimental to their performance. Friction type connections resist shear between the connected parts by tightening or clamping the bolt and developing frictional force between the faying surfaces. Friction connections that slip or have unexpected stress reversals turn into bearing connections which are undesirable under certain design conditions.

Slip resistant connections are usually used only when they are specified in design. The slip coefficient is controlled by a number of factors including the amount of clamping force, nature of the contact surfaces in a given connection, tensile area, nominal bolt area, bolt tensile strength (length and diameter), and the proof load. The nature and development of slip and fatigue on structural joints can be

very misleading, especially with different surface conditions. The slip coefficient, k_s , is defined to be the ratio of the force causing slip at the contact surface to the normal force between the plates resulting from bolt tension.

$$k_s = \frac{\text{slip load}}{2 \times \text{clamping force}}$$

Slip load can be graphically represented by Figure 1 shown below.

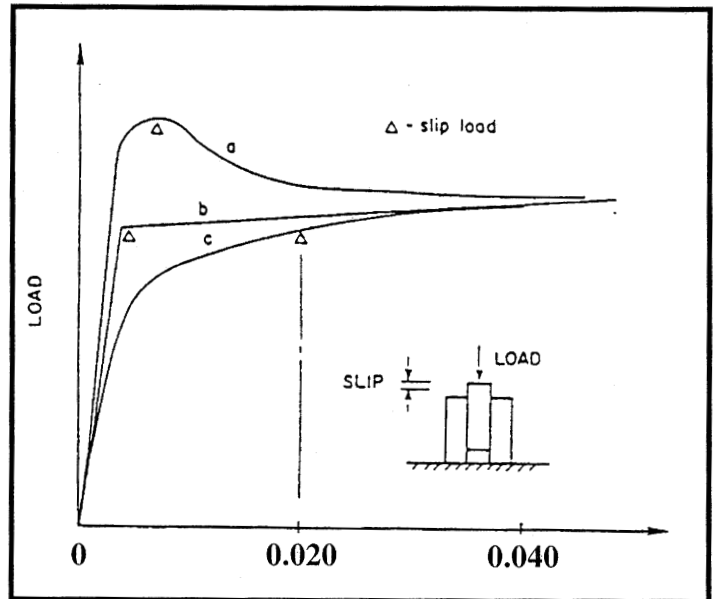


Fig. 1

When comparing mill scale steel to that of galvanized surfaces, the coefficient of friction heavily favors the mill scale steel. Studies showed that the average slip coefficient for bare or mild steel was twice the value of newly galvanized steel. But when the galvanized surface was treated with wire brushing or brush-off blasting, the reported slip values were twice the original value of untreated galvanized steel.

In reality, the slip coefficient and actual clamping force vary widely so frequency distributions are used to calculate slip probability levels. These probability levels signify the percent chance the joint will slip into bearing under specified loads. In Figure 2, typical slip coefficient values are shown.

When discussing the slip coefficient for bolted galvanized structural joints, one has to consider the dynamic properties as well as the static properties. Normally, non-coated structural joints are designed to stay static and perform under given load pressures. This is not the case with galvanized structural joints.

Fig. 2

Contact Surface of Bolted Parts	Hole Type and Direction of Load Application							
	Any Direction				Transverse		Parallel	
	Standard		Oversize & Short Slot		Long Slots		Long Slots	
	A325	A490	A325	A490	A325	A490	A325	A490
Class A (Slip Coefficient 0.33) Clean mill scale and blast- cleaned surfaces with Class A coatings ^a	17	21	15	18	12	15	10	13
Class B (Slip Coefficient 0.50) Blast-cleaned surfaces and blast-cleaned surfaces with Class B coatings ^a	28	34	24	29	20	24	17	20
Class C (Slip Coefficient 0.40) Hot dip Galvanized and rough- ened surfaces	22	27	19	23	16	19	14	16

At low initial load pressures, slip occurs in galvanized structural joints faster than that of mill scale steel or non-coated steel. But the galvanized joint has a property called the lock up phenomenon, which occurs during increasing continuous applied pressure.

If the load is large enough and applied in the same vectored direction, the joints will slip into bearing. But if the load is periodically reversed, the dynamically loaded structures slip will cease after a few cycles of loading. Even if the galvanized surface has not been pretreated, the slip movement in the joint produces the frictional resistance required in friction type design. Although there might be some early slip in the galvanized joints, the fatigue resistance was equal to or greater than the ungalvanized joints. Therefore galvanized connections could be designed for fatigue loadings, and grit blasting or wire brushing is only necessary when initial slip is detrimental to the design.

After disassembly of some representative galvanized

plates, the actual joint was required to be pried off the galvanized surface of the plate, this is a result of the cold welding effect associated with lock up. This property is sometimes termed creep deformation, referring to the displacement of the coating between the steel due to compression. Creep deformation of a specimen is calculated using the average reading of the two displacements on each side. If the creep deformation of any coating exceeds the design slip deformation, the coating will cause failure in the joint.

It is evident that after an insignificant movement, galvanized steel joints resist slip as well as or better than bare steel. If a slight movement can be negligible, then the galvanized structural joint can succeed in providing the necessary friction forces detrimental in joint design. If initial movement is undesirable then the galvanized joints can be physically etched in order to attain higher friction coefficients.