Reliability Rosetta Stone

Larry S. Muir

I call this the Reliability Rosetta Stone, named after the famed stone discovered in Egypt in 1799, which aided in the translation of hieroglyphics. The graph presented below provides a simple method to roughly translate ASD factors of safety (Ω) to LRFD reliability factors (ϕ). It was developed during discussions related to revisions to the design of slip critical bolts in the 2005 AISC Specification. Though much of the theory behind this plot can be obtained from various sources, I have never seen the information presented in this fashion. The plot proved quite useful in converting from ASD to LRFD "on the fly" during the discussions.

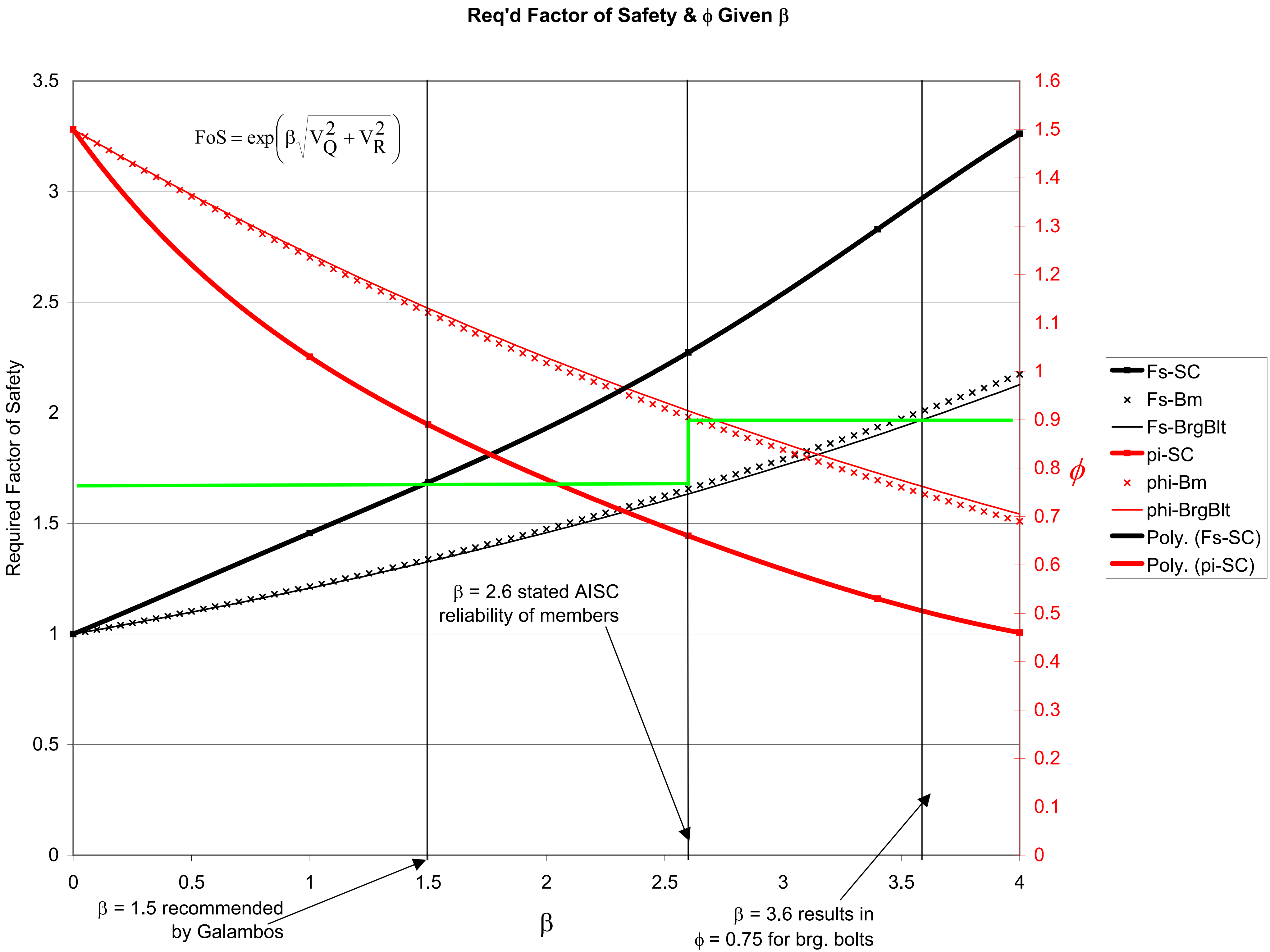
Given the variances in the loads (V_Q) and resistances (V_R), the corresponding factor of safety can be calculated for a given β using the relationship $\text{FoS} = \exp\left(\beta\sqrt{V_Q^2 + V_R^2}\right)$.

It should be noted that different variances must be used for different elements. Shown on the graph are gravity beams (Bm), bearing bolts (BrgBlt), and slip-critical "bolts" (SC). As might be expected the bearing bolts and beams plot out pretty close to each other, but the slip-critical connections have considerably lower reliability for a given ϕ. This is due to the larger number of factors governing the slip resistance as well as the increased variability of the factors involved. These factors include the pretension in the bolts and the preparation of the faying surfaces.

In order to convert from factor of safety to ϕ:

1. Choose a factor of safety (Ω). For this example we will choose Ω =1.67, the accepted factor of safety for beam flexure.
2. Draw a horizontal line (green line) from the chosen factor of safety (left axis) to the FoS vs. β plot (shown in black).
3. Draw a vertical line (green line) from the point found in step 2 to the ϕ vs. β plot (shown in red).
4. Draw a horizontal line (green line) from the point found in step 3 to determine ϕ (right axis).
5. To find corresponding β draw vertical line from the point found in step 2 to bottom axis.

In the example shown $\Omega \approx 1.67,\ \phi \approx 0.9,\ \beta \approx 2.6$ as we would expect.



Req'd Factor of Safety & ϕ Given β
$FoS = \exp\left(\beta\sqrt{V_Q^2 + V_R^2}\right)$
Required Factor of Safety
ϕ
β
β = 2.6 stated AISC reliability of members
β = 1.5 recommended by Galambos
β = 3.6 results in ϕ = 0.75 for brg. bolts
Fs-SC
Fs-Bm
Fs-BrgBlt
pi-SC
phi-Bm
phi-BrgBlt
Poly. (Fs-SC)
Poly. (pi-SC)