Semester Poster Project

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ARP Bolt Analysis

When performing a bolt analysis, it is important to take a very methodical approach. The methodical approach can be reduced to three steps. The first step is to perform a stress analysis on the bolt. The second step is to perform a material analysis on the bolt. The third step is to do a fatigue analysis on the bolt.

In the stress analysis, the first step is to find the stiffness of the bolt and the member (km and kb). The stiffness of the member is dependent on the stiffness of the members. The frustum begins from the head of the bolt and extends along the bolt at thirty degrees from the horizontal. It is at its widest at half the length of the member being clamped together. Its beginning width is 1.5*d. A new frustum must be started whenever the material being clamped changes. For more explanations on calculating frustums, refer to Figure 1. The equation for calculating the stiffness of each frustum is:

$$k = ((pi * E * d * \tan(alpha))) / \ln((1.15 * t + D - d) * (D + d)) / ((1.15 * t + D + d) * (D - d))$$

Once each frustum has been found the total stiffness of the member can be calculated in the following manner: $1/km = (1/k1) + (1/k2)$.

To calculate the stiffness of the bolt, the following equation may be used. $kb = (Ad * At * E)/(Ad * lt + At * ld)$. The joint constant (C) can then be calculated with the following equation: $C = kb/(km + kb)$ For further instruction on calculating the stiffness of the bolt, refer the bolts poster and figure 1.

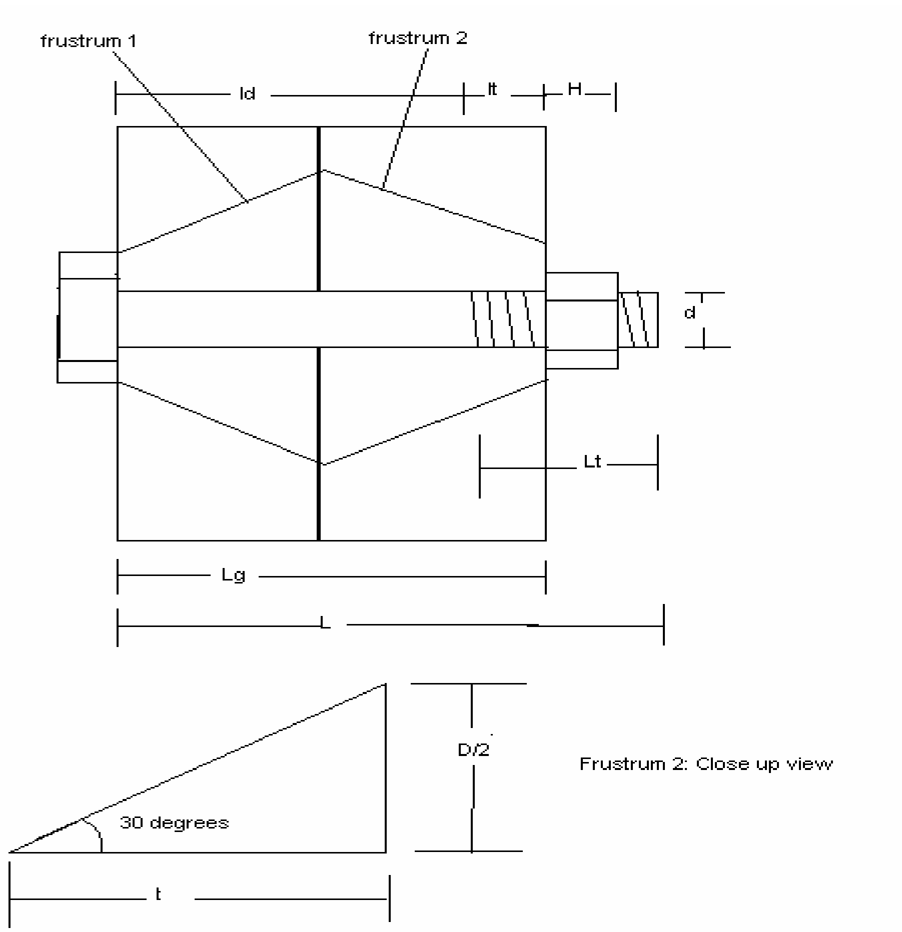

Figure 1

At this point, the material analysis can be completed for the bolt. Luckily, the material analysis of bolts is very simple. Material properties can be found by examining tables. You will need to find the proof strength (Sp) and the tensile stress area (At). By multiplying these values together you are able to find the proof load (Fp).

Using the proof load value that was just found, you are able to calculate the optimal preload (Fi). This equation changes based on whether the bolts will be reused or are final connections. For permanent connections the equation is $Fi = .9 * Fp$. For reusable connections the equation is $Fi = .75 * Fp$.

The static factor of safety and the joint factor of safety can now be calculated by using the initial preload values. The equation for the static factor of safety can be calculated using the following equation: $n = (Sp * At - Fi) / C * P$, where P is the external load applied to the bolt. The joint factor of safety can be calculated using the following equation: $n = (Fi)/(P * (1 - C))$.

Then you may proceed to the fatigue analysis. The first step in this process is to calculate the alternating stress and the mean stress. The alternating stress can be calculated using the equation $\sigma\_a = (C * P)/(2 * At)$ and the mean stress can be calculated using this equation $\sigma\_m = ((C * P)/(2 * At)) + (Fi / At)$. The fatigue factor of safety can be found by $n = Sa / \sigma\_a$. The value Sa can be found with the following equation $Sa = (Sut - (Fi / At))/(1 + (Sut / Se))$. Sut is the ultimate strength of the material and Se is the endurance limit. Note that the endurance limit is dependant on the size factor, the load factor, the surface factor, and the temperature factor.