Secondary Stresses in Trusses*

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Secondary stresses in steel trusses may be neglected in most cases. It is important, however, that *secondary stresses* be defined properly and the analysis and design be consistent with each other, as follows:

1. If the truss members are designed for the axial forces that would occur if the members were pin-connected, then the flexural stresses indicated by a more refined analysis may be defined as secondary stresses and may be neglected, within reasonable limits.
2. If the axial forces for member design are obtained from an analysis that includes flexural effects, flexural stresses cannot be dismissed as secondary stresses, since the presence of flexural effects in the analysis might have reduced the axial forces indicated by the analysis. In this case, the designer who wishes to neglect flexural stresses must first judge whether (and by how much) the axial forces indicated by the analysis were affected by flexural effects. And he must then make appropriate corrections in the axial forces to be used for design.

When secondary stresses are defined narrowly, as explained above, they may be neglected. However, it is recommended that a limit of about 4,000 psi be observed (as in bridge specifications) to guard against local buckling, connection distress and other possible problems. The limit may be raised or eliminated, in specific situations, after evaluation of the potential problems.

In most trusses of customary shape and dimensions, flexural stresses will be lower than the suggested 4,000-psi limit. However, in trusses with very large gusset plates or unusually stubby members (where the ratio of member width to free length outside connections is more than about 1/5), flexural stresses might be much higher than the recommended secondary stress limit and should be checked by analysis. If flexural stresses are found to be excessive, the "truss" should be regarded as a "frame" and members should be designed for axial force, flexure and shear.

This discussion, so far, has been restricted to trusses in which members meet concentrically at panel points and all loads are applied at those points. Similar reasoning may be used for other types of trusses, as explained here:

Truss with loads applied on chord between panel points

The loaded chord may be analyzed as a continuous beam on non-moving, knife-edge supports at the truss panel point locations. The truss may then be analyzed as a pin-connected structure. The reactions from the chord/beam analysis should be applied as joint loads in the truss analysis. The flexural stresses in the chord from the beam analysis and the axial stresses in all members from the truss analysis are *primary* stresses. The additional flexural stresses in the chord and the flexural stresses in other members caused by truss deformation are secondary stresses and may be neglected. If design is based on a single analysis, it is not possible to separate primary and secondary stresses. A reasonable compromise, in this case, is to model the loaded chord as a continuous member and other elements as pin-connected members. All the resulting stresses should be regarded as primary stresses, even though the chord flexure would include truss-deformation effects.

Truss with eccentric joints

Some trusses are detailed with the centroids of web members meeting near the edge of the chord instead of at the centroid of the chord. Typically, these trusses have heavy chords (for loads applied between panel points) and light web members. There is no practical way of separating primary and secondary stresses in these trusses. A reasonable approach for design purposes is to model the chord as a continuous member with rigid stubs to the web member intersection points. The web members may be modeled as pin-connected elements. All the resulting stresses should be treated as primary stresses, even though the flexure in the chord would include truss-deformation effects.

In summary, the key to proper treatment of secondary stresses in steel trusses is to be consistent between analysis and design. If member forces for design are determined from an analysis that neglects certain stiffness components (such as flexural stiffness of some or all members), stresses corresponding to those stiffness components may be regarded as secondary stresses and may be neglected in design. This approach is consistent with *plastic* and *ultimate* design concepts. Limits on secondary stress need to be observed only to guard against local buckling, connection distress, fatigue and other problems which might occur in unusual cases.

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