

**C. Prediction of Welding Distortion in Large and Complex Structures**  
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Welding induces residual stresses which result into out-of-plane distortion due to buckling, longitudinal bending (bowing), and angular change. Structures composed of thin section panels as compared to their size are usually prone to buckling distortion. When welding results in buckling distortion, the magnitude of distortion is very large, and distortion control methods should be implemented to remove the source of buckling. Structures with thick sections are more resistant to buckling and usually distort into bowing and angular out-of-plane modes.

2D, 3D small deformation, 3D large deformation, and 2D-3D decoupled applied plastic strain analyses are evaluated in terms of computing welding induced residual stress and distortion. Experimental residual stress and out-of-plane distortion measurements from panels of various sizes are used as reference. The following conclusions are drawn:

- Generalized plane strain analyses cannot capture welding distortion accurately. In thin plates, they account for longitudinal buckling. In thick plates, they result into incorrect angular distortion.
- 3-D small deformation analyses predict correct values of longitudinal residual stress and distortion when buckling doesn't occur. When buckling occurs, the 3-D small deformation analyses correspond to the metastable stress state.
- The longitudinal stress distribution predicted by the 2-D analyses correlate to the metastable stress state of long panels that correspond to the 3-D small deformation results.
- 3-D large deformation analyses predict the correct magnitude of distortion and longitudinal residual stress distribution in case of both angular and buckling distortion. They can also capture end-effects. However, they are computationally very expensive. The computational efficiency of 3D moving source analyses of large structures may be improved by implementing distributed computing and adaptive meshing techniques.
- Large deformation analyses for the prediction of the onset of buckling and the magnitude of post buckling distortion are sensitive to structural imperfections. Decoupled applied plastic strain methods predict the onset and magnitude of buckling distortion accurately. However, they are not suitable for computing angular distortion.