

E.3.2 Method

The creep behavior of the YS=50 ksi steel was modeled on the behavior of WTC A 572 specimen HH. The creep behavior of A 36 steel was modeled based on the parameters in Fields (1989). That model is based on tests of Australian AS149 steel, which is similar to ASTM A 36. The creep behavior of CSA G40.21-44W was modeled under the assumption that it was identical to YS = 50 ksi A 572. The uncertainties in these models were estimated to be up to 40 °C in temperature and 20 MPa in stress, based on the observation that the predicted behavior could be as much as a factor of ten different from the observed behavior.

E.3.3 ANSYS Creep Models

The ANSYS implicit creep model 2 (time hardening) used in the analysis modeled the creep rate, $\dot{\epsilon}_{cr}$, using independent functions of stress, σ , and time, t :

$$\dot{\epsilon}_{cr} = C_1 \sigma^{C_2} t^{C_3} \exp\left(-\frac{C_4}{T}\right) \quad (8)$$

Instead of attempting to model the Arrhenius temperature dependence with a single constant, it was easier to specify the individual C_i at each temperature of interest and set $C_4 = 0$. In that way it was possible to set the creep strain to identically zero below a lower limit temperature.

The Fields (1989) model for creep strain of AS149 as a function of time and stress has the form:

$$\begin{aligned} \epsilon_{cr} &= A \sigma^C t^B \\ A(T) &= 10^{-(A_0 + A_1 T)} \\ B(T) &= B_0 + B_1 T \\ C(T) &= C_0 + C_1 T \end{aligned} \quad (9)$$

Expressed in the ANSYS format for creep rate as a function of time, stress, and temperature, the Fields (1989) model is:

$$\begin{aligned} \dot{\epsilon}_{cr} &= AB \sigma^C t^{B-1} \\ A(T) &= 10^{-(A_0 + A_1 T)} \\ B(T) &= B_0 + B_1 T \\ C(T) &= C_0 + C_1 T \end{aligned} \quad (10)$$

The ANSYS parameters for creep rate have the form:

$$\begin{aligned} C_1 &= AB = 10^{-(A_0 + A_1 T)} (B_0 + B_1 T) \\ C_2 &= C = C_0 + C_1 T \\ C_3 &= B - 1 = B_0 + B_1 T - 1 \\ C_4 &= 0 \end{aligned} \quad (11)$$