SB-0033
Calculation C-CSS-099.20-054, Revision 0:

Page 6: The discussion states that "vertical reinforcement next to each flute (i.e. in a vertical strip approximately 10 ft wide) is conservatively ignored for evaluating the structural integrity of the shield building under mechanical loads (i.e., D and E') as shown in Figure 5 of Attachment B. No rebar is removed for calculation of thermal stresses or crack width under normal operation conditions". Please explain why the load conditions are treated differently. Also explain why the impact on the horizontal bars (located outside of the vertical rebars and also affected by cracks) is not considered.

Similarly, while the impact of cracks on vertical rebars in the shoulder area is addressed through removal of the vertical rebars in the analysis, is the condition involving identification of cracks all around near the top of the shield building also addressed through removal of rebars? How is the concern regarding effect on the rebar splices addressed if the condition is assumed to be existing all around in the top cylindrical region of the SB.

BECHTEL RESPONSE

Part A: Explanation of the approach used for evaluation of mechanical and thermal stresses:

Thermal stresses are produced by the effect of internal or external restraint; temperature changes do not result in thermal stresses for statically determinate structures. For reinforced concrete structures, once concrete cracks due to a temperature gradient, thermal moments are only due to the restraint induced by the tensile reinforcement. In the case of the Shield Building cylinder, the Outside Face of the reinforcement provides such restraint. Therefore, the thermal moment is equal to zero if the Shield Building Outside Face reinforcement is ignored in the calculation of thermal stresses. Thus Calculation C-CSS-099.20-054, Rev 0 follows the following conservative procedure to calculate the demand due to D+E'+TA:

1. Conservatively ignore the Outside Face reinforcement to calculate the maximum concrete and steel strains required in Eqs. 1 and 2 to calculate P_t and P_c for the mechanical loads (i.e., D+E'), as described below in numeral Part A.1.
2. Conservatively used Pt and Pc from step 1 to calculate the thermal stresses. In this step, conservatively, the Outside Face reinforcement is not ignored, otherwise the thermal moment will be equal to zero.

Part A.1. Combined demand due to DL+E'+T_A

The approach used to calculate the combined demand due to DL+E'+T_A is consistent with ACI 307-69 (Refer to ACI 307-69 supplement) and can be summarized as follows:

(a) Determine the mechanical/external axial and moment demand at the section of interest according to the applicable design load combination (i.e., in the case of interest for D+E').

D/2

(b) Calculate the maximum compressive (ε_c) and tensile (ε_{smax}) strains due to mechanical loads (i.e., in the case of interest for D+E') per the procedures presented in Calculation C-CSS-099.20-054 Section 3.2, as shown in Figure 1. Note that similar procedures are presented in ACI 307-69 supplement figure 18 and its accompanying equations.

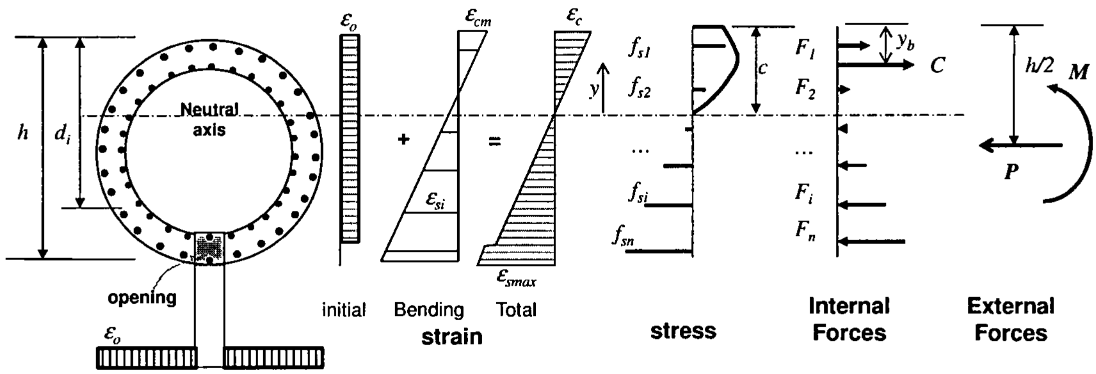

Figure 1: Shield building section showing strain, stress, and force distribution under axial and bending demands

(c) Calculate the maximum compression force (P_c) and tension force (P_t) due to mechanical loads (i.e., in the case of interest for D+E') using the equations shown below, where the maximum stress is conservatively uniformly distributed through the thickness. The forces P_c and P_t are shown in figure 2. Note that similar procedures are presented in ACI 307-69 supplement figure 22.

$$P_c = f_c(\varepsilon_c)t$$ Maximum compressive force Eq. 1

$$P_t = (A_s + A_s')E_s\varepsilon_{smax}$$ Maximum tensile force Eq. 2

(d) Calculate the thermal gradient for the load combination of interest.

(e) Calculate the total demand for (D + E' + T_A) per the procedures presented in sections 3.3.1 and 3.3.2, which are consistent with ACI 307-69 Supplement Section ***EQUATIONS FOR COMBINING STRESSES DUE TO WIND AND DEAD LOAD WITH VERTICAL STRESSES DUE TO TEMPERATURE.***

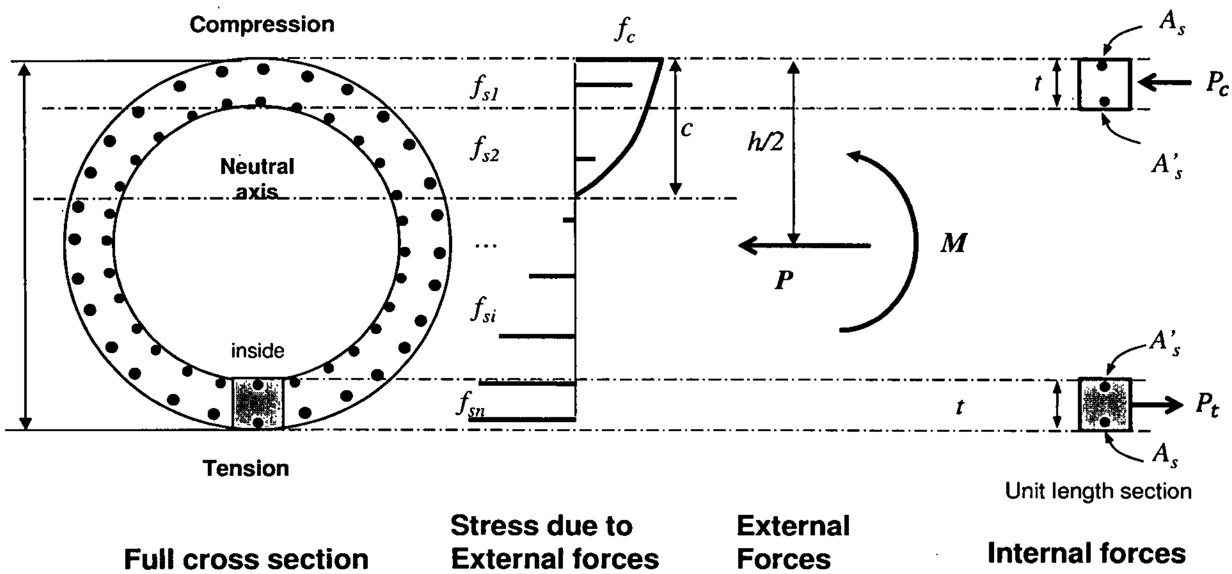

Figure 2: Maximum compression (Pc) and tension (Pt) forces per unit length.

Part B: Hoop Reinforcement Removal/Effect

Calculation C-CSS-099.20-054 evaluates the design of Shield Building for the critical design basis loads. The controlling load combination involving the SSE results in maximum stress in the vertical reinforcement (not hoop reinforcement). In that sense vertical reinforcement is the critical component that dictates the overall capacity of the section against design basis loads per USAR. The hoop reinforcement is not expected to be a critical component of the structure for the above controlling load condition. Note also that although vertical reinforcement in removed to study the lower-bound effect, it is actually present and effective (as discussed in the Technical Assessment Report by Bechtel) along with the horizontal reinforcement.

The hoop reinforcement is of importance at the top of the Shield Building for a different set of load conditions involving dead, thermal and wind effects. Review of original construction drawings indicates that there is significant amount of reinforcement in the top 20 ft of Shield Building. The lap splices are generous and well staggered. Our preliminary review of the original design indicates that maximum stress in the hoop reinforcement under the design basis load in this region is expected to be low because of the available margins that may be of comparable magnitude to those for the vertical reinforcement. In that sense, the situation of hoop reinforcement at the top which is the critical component for one set of design basis loads is similar to that of vertical reinforcement at the bottom which is the critical component for another set of controlling design basis loads. Therefore, many of the arguments presented to justify negligible effect of cracking on vertical reinforcement in Bechtel Technical Assessment Report also apply to the hoop reinforcement at the top of the Shield Building