Structural Breadth

With the weight of several ice tanks located on the roof, a structural analysis must be performed to ensure that installing the thermal energy storage system does not affect the structural integrity of the building.

As previously calculated, 47 ice tanks are proposed to be installed in the chilled water plant redesign to meet cooling capacity for current loads. An additional 77 ice tanks are required to meet cooling capacity for future loads. The weight of this equipment is illustrated below in Table 5.1.

# Of Tanks	Filled Weight [kips]	Floor Loading [psf]
1	16.77	388
47	788.19	776 (2 stacks)
77	1,291.29	776
124	2,079.48	776

TABLE 5.1

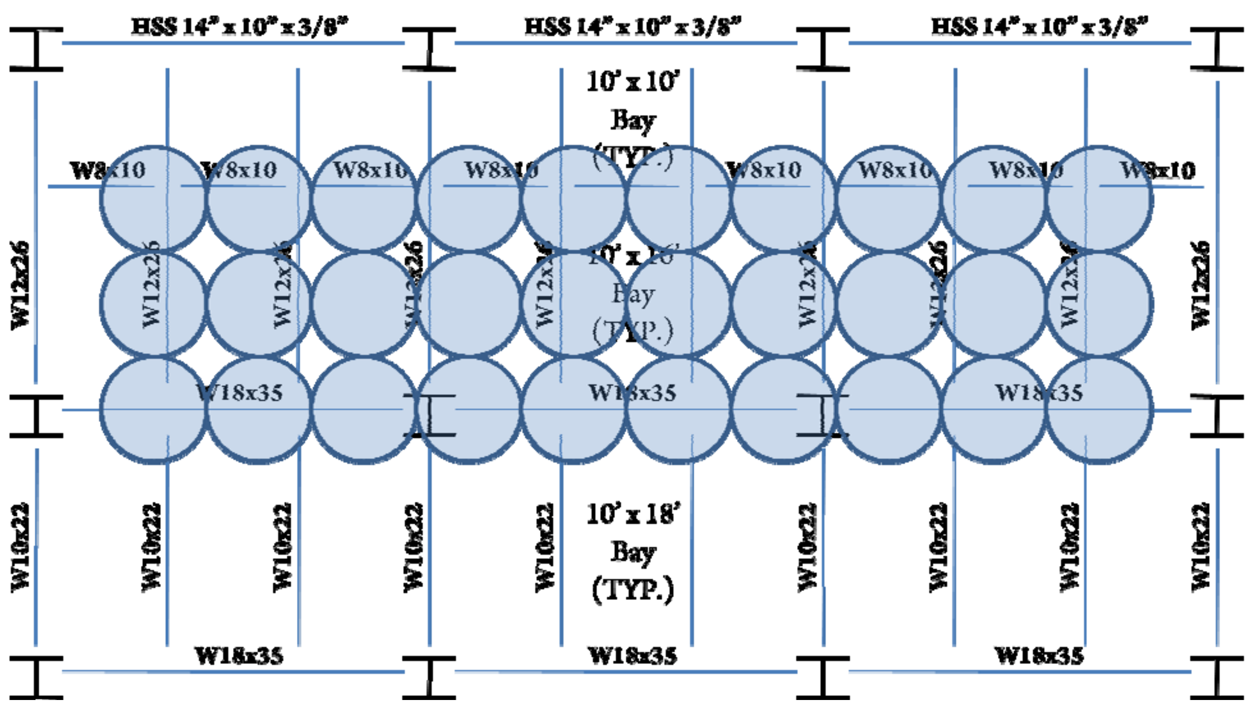

FIGURE 5.1

Figure 5.1 details the framing plan of one side of the roof where the ice tanks will be situated. This will determine whether or not measures need to be taken in order to support the ice tanks. The other existing roof loads to consider are the live load, the dead load of the structure, and the snow load. Table 5.2 summarizes all the loads.

Ice Tank Load:	770 psf
Live Load:	40 psf
Structure Dead Load:	15 psf
Snow Load (Baltimore, MD):	25 psf
Total Load:	850 psf

TABLE 5.2

The slab thickness of the roof is 5". Figure 5.2 shows the wall section of the roof area in discussed previously.

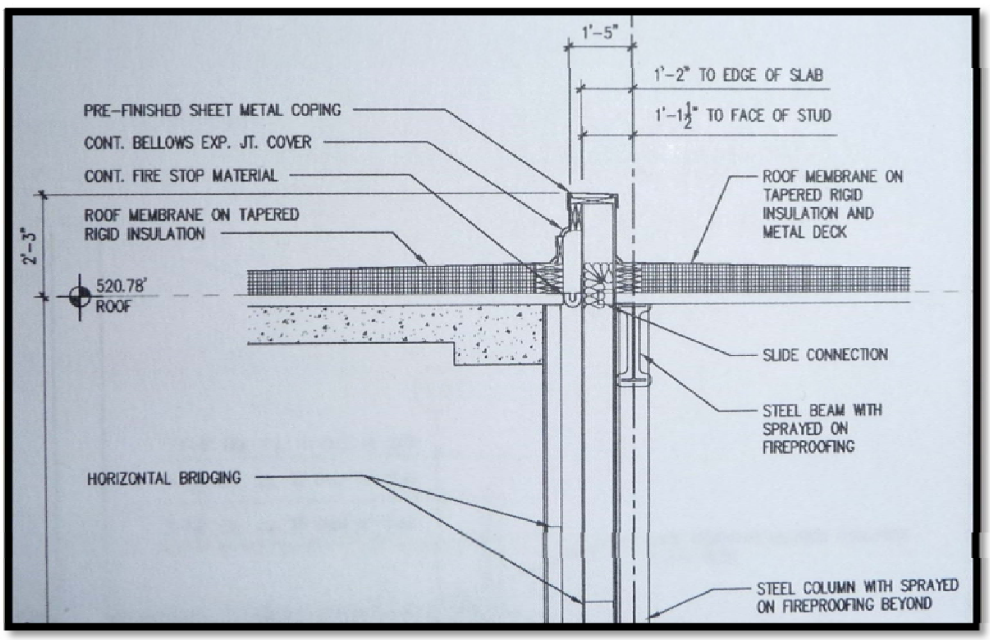

FIGURE 5.2

From Figure 5.1, most of the loading occurs on the central W12x26 and W18x35 beams. Each W12x26 beam takes the load of about two ice tanks while each W18x35 beam takes the load of about three ice tanks. Table5.3 summarizes each beam's load (2 stacks) and the associated tributary area.

Beam	Load [psf]	Tributary Area [ft^2]	Total Load [kips]
W12x26	850	80	68
W18x35	850	150	127.5

TABLE 5.3

Using the figures from Table 5.1, the total load (including dead, snow, and tank) on each W12x26 beam is 64.8 kips and on each W18x35 is 121.5 kips.

CALCULATIONS

Assumptions:	▪ Loaded in middle ▪ Beam fixed at both ends ▪ A36 steel

TABLE 5.4

W12x26

$$Maximum\ Bending\ Moment = \frac{68\ [kips] \times 26\ [ft]}{8}$$

$$Maximum\ Bending\ Moment = 221\ [kips - ft]$$

$$Section\ Modulus = \frac{221\ [kips - ft] \times 1{,}000\ \left[\frac{lbs}{kips}\right] \times 12\ [\frac{in}{ft}]}{36{,}000\ psi \times 0.55\ (yield)}$$

$$Section\ Modulus = 134\ [in^3]$$

$$Allowable\ Deflection = \frac{312\ [in]}{240}$$

$$Allowable\ Deflection = 1.3\ [in]$$

$$Moment\ Of\ Inertia = \frac{2 \times 68{,}000\ [lbs] \times 312\ [in]^3}{48 \times 30{,}000{,}000\ [psi] \times 1.3\ [in]}$$

$$Moment\ Of\ Inertia = 2{,}207\ [in^4]$$

W18x35

$$Maximum\ Bending\ Moment = \frac{127.5\ [kips] \times 30\ [ft]}{8}$$

$$Maximum\ Bending\ Moment = 479\ [kips - ft]$$

$$Section\ Modulus = \frac{479\ [kips - ft] \times 1{,}000\ \left[\frac{lbs}{kips}\right] \times 12\ [\frac{in}{ft}]}{36{,}000\ psi \times 0.55\ (yield)}$$

$$Section\ Modulus = 291\ [in^3]$$

$$Allowable\ Deflection = \frac{360\ [in]}{240}$$

$$Allowable\ Deflection = 1.5\ [in]$$

$$Moment\ Of\ Inertia = \frac{2 \times 127{,}500\ [lbs] \times 360\ [in]^3}{48 \times 30{,}000{,}000\ [psi] \times 1.5\ [in]}$$

$$Moment\ Of\ Inertia = 5{,}508\ [in^4]$$

Table 5.5 summarizes the calculation results and shows whether or not the current beams are appropriately sized to meet the additional loads of the ice tanks.

	Actual Property Values		Required Property Values	
	Section Modulus [in^3]	Moment Of Inertia [in^4]	Section Modulus [in^3]	Moment Of Inertia [in^4]
W12x26:	33.4	204	134	2,207
W18x35:	57.6	510	291	5,508

TABLE 5.5

As seen in Table 5.5, the beams are incredibly undersized. If the load bearing capacity of the beams is not increased, the structural integrity of the building would be severely compromised. Table 5.6 recommends beams which would be able to support the ice tanks.

Recommended Beam	Section Modulus [in^3]	Moment Of Inertia [in^4]
W24x84	196	2,370
W27x146	411	5,630

TABLE 5.6