

Assume a 4 mm thick steel liner with studs every 15 cm in each orthogonal direction laid on a 50 cm thick mat, 10x10 meters in plan. The free thermal elongation along one axis will be

$$E := 2.1 \cdot 10^6 \cdot \frac{\text{kgf}}{\text{cm}^2} \quad \xi := 11 \cdot 10^{-6} \cdot \frac{\text{m}}{\text{K}} \quad SF := 1.5 \quad \text{ton} := 1000 \cdot \text{kgf}$$

$$L := 10 \cdot \text{m} \quad h := 50 \cdot \text{cm} \quad s := 15 \cdot \text{cm} \quad t := 4 \cdot \text{mm}$$

$$\Delta := 100 \cdot K \cdot \xi \cdot L \quad \Delta = 11 \text{ mm}$$

In free expansion this expansion would exceed the length of the underlying assumed unheated concrete in each side, half this length, i.e., the steel plate would surpass in 5.5 mm each side of the slab. Now we determine what stress would be required in the steel to restrain back the steel to the original length

$$\varepsilon := \frac{\frac{\Delta}{2}}{\frac{L}{2}} \quad \varepsilon = 1.1 \times 10^{-3} \quad \sigma := E \cdot \varepsilon \quad \sigma = 2.31 \times 10^3 \frac{\text{kgf}}{\text{cm}^2}$$

well within what structural steels can deliver even if we then adopt over it a factor. Now the force standing compression force in the steel for the 4mmx150mm strip is

$$C := .4 \cdot \text{cm} \cdot 15 \cdot \text{cm} \cdot \sigma \quad C = 13.86 \text{ ton}$$

Now this compressive force corresponding to half the length needs be sustained plastically by the studs in the strip in half the width, hence we can determine the required service level plastic requirement for each stud in X direction by

$$V_p := \frac{C}{\frac{\frac{L}{2}}{s}} \quad V_p = 0.416 \text{ ton} \quad V_e := 2 \cdot V_p \quad V_e = 0.832 \text{ ton}$$

Since these shears act as well at worse in X and Y directions we compose the elastic shear per stud at corner of underlying mat as

$$V := V_e \cdot \sqrt{2} \quad V = 1.176 \text{ ton} \quad \text{service level per worse stud}$$

$$V_d := SF \cdot V_e \quad V_d = 1.247 \text{ ton} \quad \text{factored, per worse stud}$$

these shouldn't be a problem for electrowelded  $\phi=10$  mm and maybe 8m studs where all the shaft section is put in shear

Since upon imparting the force of the restrained expansion there would be some deformation in the underlying concrete, if something there will be some relaxation of the shears per stud. The imparted moments at center of X direction resume the shearing in half length, i.e.

$$\text{Moment} := C \cdot \frac{h}{2} \quad \text{Moment} = 3.465 \text{ m} \cdot \text{ton} \quad \text{service level, each direction}$$