DESIGN OF POST-TENSIONED MAT FOUNDATIONS ON SOIL SUPPORT

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BACKGROUND

The common method for strength design of post-tensioned members is "load balancing". Load balancing in its traditional form does not work for design of post-tensioned mat foundations, however. The following explains the reason, and offers an alternative.

The load balancing method of design requires the explicit computation of hyperstatic actions from post-tensioning. The hyperstatic actions are an integral part of the load combinations for strength design. Using load balancing method, the basic load combination is:

U = 1.2D + 1.6L + 1.0HYP (Exp 1)

Where,

D = dead load effects;
L = live load effects; and
HYP = hyperstatic effects from post-tensioning.

Hyperstatic actions are generated at the supports of a post-tensioned member. The hyperstatic actions are caused by the restraint of supports to free movement of the member subject to post-tensioning forces.

The applied forces from post-tensioning tendons are in self-equilibrium. Consequently, the reactions of a member that contains post-tensioning must also be in self-equilibrium.

Consider the post-tensioned mat foundation shown in Fig. 1. The mat rests on compression only soil. The distribution of pressure from the combination of dead load and post-tensioning is shown in the figure. The contribution of post-tensioning in the structure is to provide uplift below the wall and the column in balance with downward forces between them.

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If the post-tensioning is viewed on its own, without the contribution of downward forces from the building, the post-tensioning results in uplift below the wall and column and compression elsewhere. But, in a "compression only" soil uplift forces cannot develop. Pressure below the mat and soil from post-tensioning cannot be in self-equilibrium. For self-equilibrium, pressure must be balanced by tension – tension cannot develop in compression only soil.

For this reason, hyperstatic reactions from post-tensioning on compression only soil cannot exist without the presence of other loads, such as dead weight of the structure.

Since "load balancing" method requires the explicit value of hyperstatic reactions from post-tensioning, other design alternatives, such as the "straight method" [Aalami, 2019] must be used for strength design of post-tensioned mat foundations.

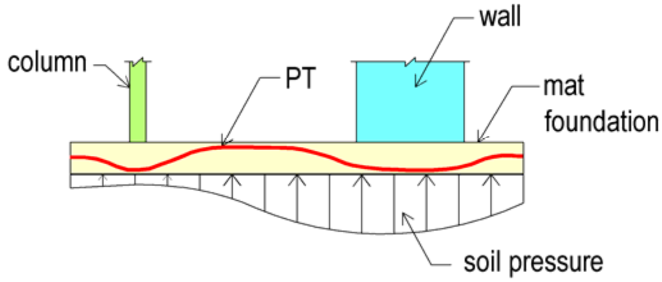

FIGURE 18.4-1 Post-Tensioned mat foundation on compression only soil. Distribution of soil pressure (PTS944)

In the "straight" methods, the post-tensioning tendons are viewed as an "applied load" to the structure in both "service" and "safety" conditions. The following load combinations apply.

Service condition (SLS)

U = 1.0DL + 1.0LL + 1.0PT (Exp. 2)

Safety Condition (ULS)

U = 1.2DL + 1.6LL + 1.0PT (Exp. 3)

In the ULS condition, the tendons are assumed as "applied force." Hence, the demand forces must be resisted entirely by nonprestressed reinforcement. This is contrary to load balancing, where at ULS the demand forces are resisted by the combined action of prestressing tendons and nonprestressed reinforcement.

It is important to note that the design moments (Exp. 2) computed using the "straight method," are much smaller than those from "load balancing" method. The smaller demand moment is offset in part by accounting for the increase in tendon force at ultimate limit state.

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