7 Footings & Slabs

7.1 GENERAL

Portal frames are commonly designed on the assumption of pinned bases, although it is sometimes an advantage to fix the bases. A pinned base is designed assuming no moment transfer, so that the only design forces at the base of the column are axial and shear forces. In reality, there will be some moment resistance at the base. Fixing or partially fixing the bases reduces the lateral frame deflections significantly and this can result in substantial savings in frame weight if the columns are tall. Of course, the savings in weight will be offset by the extra cost of footings and holding down bolts. Reductions in frame bending moments due to fixing of bases are not usually as significant as the reductions in deflections. Typical base plate and holding down arrangements for pinned and fixed bases are shown in Figure 5.5.

The most common footing type for a pinned base is the square pad footing as shown in Figure 7.1, although bored piers can be very economical in clayey soils because the adhesion of even soft clays to the sides of a bored pier can result in substantial holding down capacity. The lateral capacity also needs to be considered.

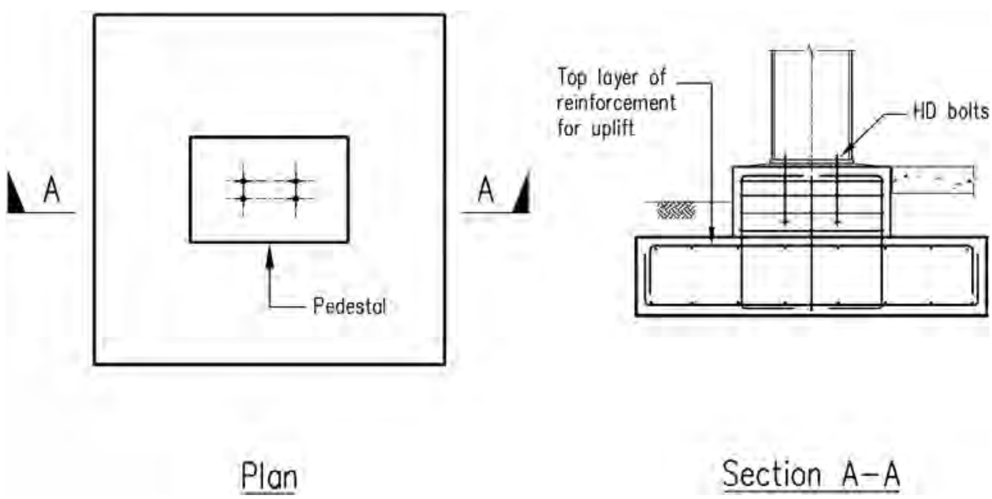

Figure 7.1 *Typical Pad Footing*

In expansive clays, it is usually much cheaper to design details for relative movement of the column footings and slab rather than to use a raft footing for the whole floor slab. Such detailing includes isolation joints between column footings and the floor slab. It may also be necessary to suspend the bridging for wall girts from the eaves rather than prop the bridging from the floor slab to allow the floor to move relative to the wall. Paved areas or concrete strips around the perimeter of the building will help maintain a more constant moisture content in the soil under the edge of the building. If masonry walls are used in some parts such as office and administration areas, it may be necessary to provide a raft foundation in these regions. If the masonry is restricted to reinforced block perimeter walls, the footings and the blockwork can sometimes be designed to cater for differential ground movements along the length of the wall without resorting to a raft foundation.

It should be remembered that the expansiveness of clay soils cannot be realistically assessed from Atterberg Limits. This is because Atterberg Limits are determined for the clay fraction of the soil which might be a small proportion of the whole sample. Shrink/swell tests which are carried out using whole samples of soil give a much better indication of likely soil movements.

There are cases where it may be necessary to use a full raft or even a piled foundation for an industrial building. For example, full raft foundations have been used successfully in reclaimed areas where there have been two to three metres of compacted fill over marine mud and the site has been preloaded for many months. If a raft footing is used for a portal framed building, it may be beneficial to design the frames with fixed bases with the moments at the column bases resisted by ribs on the frame centrelines.

7.2 DESIGN UPLIFT FORCES

The frame computer analysis provides factored reactions for the design of footings. In uplift cases, the design uplift applied by the superstructure to the footings is $W_u - 0.9G$, where W_u is the limit state uplift and G is the dead load reaction. In calculating the resistance to uplift, the weight of footings must also be factored by 0.9.

7.3 PAD FOOTINGS

In industrial buildings without cranes, excessive bearing pressure under pad footings is not usually a problem because the footing size necessary to restrain uplift is often large enough to ensure that the bearing pressure under gravity loads is less than 100 kPa. An allowable bearing pressure of 100 kPa is readily achieved on all but the poorest of sites. If the allowable bearing pressure is less than 100 kPa, then a raft foundation, piers or even piles may be necessary.

One of the best collections of geotechnical data for foundations is contained in Section 3 of the superseded Bridge Design Code SA HB77.3-1996 [1] and its commentary SA HB77.3.1-1996 [2]. Ultimate limit state bearing pressures for cohesive and non-cohesive soils are tabulated, and principles for checking the serviceability limit state are given. However at this stage, the building industry has not fully embraced limit state bearing pressures for pad footings and allowable bearing pressures are still often provided in geotechnical reports.

In determining the weight of pad footings necessary to resist factored uplift forces, it is important to take advantage of the weight of the slab and any soil contributing. Apart from the weight of the slab and soil directly above the footing, the slab beyond the edge of the footing also contributes. A contribution of a one metre strip of slab beyond the edge of the pad footing would be a reasonable, perhaps conservative, assumption in the absence of detailed calculations. Such calculations could involve a yield line analysis of the slab. However this would be complex and subject to many variables such as joint layout, tolerance on mesh position in the slab and random cracking of the slab due to shrinkage. Realistically, therefore, it becomes a matter of engineering judgment as to how much of the slab will

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