6.4 Spread footings

6.4.1 General

Footings may be supported on piles, on drilled shafts, on sound rock, or on soil. This article covers spread footings supported on rock or soil. For footings on piles, see the abutment articles [BDM 6.5.4.1, 6.5.4.2] or pier footing article [BDM 6.6.5.1.3] and, for footings on drilled shafts, see the drilled shaft article [BDM 6.3].

6.4.1.1 Policy overview

For bridge projects for which it is appropriate to found substructure components on spread footings, the office requires the footings to be founded on sound rock. The allowable bearing pressure on rock and footing elevations are recommended for the bridge site by the Soils Design Section.

Spread footings for retaining walls, sign trusses, and other miscellaneous structures may be founded on soil unless rock is encountered at an elevation above normal footing depth. Maximum allowable bearing capacity for typical sign truss footings on soil is 1.5 tsf or 3 ksf (144 kPa) as noted on the standard road plans [OD SRP RD-22C~~, RD-22D~~] and standard sign truss footing detail sheet [OBS SS STOH-15-05].

Sign posts and light poles generally are placed on small drilled shafts in soil unless rock is encountered close to the surface. Typical footings for each condition are given on standard road plans [OD SRP RD-22A, RM-39, RM-47].

In all cases the designer shall consider existing foundations, utilities, and drainage when locating new spread footings.

6.4.1.2 Design information

The “Report of Bridge Soundings” provided for each bridge site by the Soils Design Section contains recommendations for foundation type and also contains the soil logs needed for design. If the report recommends spread footings on rock for abutments or piers, the report also will recommend allowable bearing pressure and elevations of bottoms of footings. The designer shall consult the Soils Design Section as necessary for additional information and for interpretations of subsurface data.

Usually there is no specific soils information available for sign structures, light poles, and other miscellaneous structures, but there may be soils information available for the adjacent road design. Typical spread foundations given on standard road plans [OD SRP RD-22A, RD-22C, RD-22D, RM-39, and RM-47] usually are adequate, however, in cases where the allowable bearing capacity may be less than 3 ksf (144 kPa) the designer shall consult the Soils Design Section for an appropriate design value.

6.4.1.3 Definitions

Reserved

6.4.1.4 Abbreviations and notation

Reserved

6.4.1.5 References

[OD SRP sheet number] refers to an Office of Design, Highway Division “Standard Road Plan” with sheet number. (Available on the Internet at: http://www.erl.dot.state.ia.us/)

6.4.2 Load application [AASHTO-I 3.8.1.2]

Loads are transmitted directly to spread footings from bridge substructure components such as abutments and piers and from other structures such as retaining walls, cantilever sign trusses, and

overhead sign trusses. Live, dead, and other loads transmitted to a spread footing shall be determined from the design manual articles for the component or structure supported by the footing as follows: abutments [BDM 6.5.2], piers [BDM 6.6.2], retaining walls [BDM 6.7, in process], and sign supports [BDM, 10.2.2 in process].

For the design of spread footings for abutments and piers, impact shall be excluded from the vertical loads and the pressures transmitted to rock [AASHTO-I 3.8.1.2].

In cases where spread footings are placed below the water table, loads due to buoyancy shall be considered.

Lateral loads and eccentric loads applied to a bridge substructure component or structure will cause moment and potential for overturning at the level of the spread footing. The designer shall consider the eccentric pressure at the base of the footing and apply the limitations stated in the spread footing analysis and design article that follows [BDM 6.4.4].

6.4.3 Service load groups and application to footings [AASHTO-I Table 3.22.1A]

For bridge footings, load groups and allowable stress increases are given in the AASHTO specifications [AASHTO-I Table 3.22.1A]. Also note the policies for bridge substructure components and structures supported by spread footings: abutments [BDM 6.5.3], piers [BDM 6.6.3], retaining walls [BDM 6.7 in process], and sign supports [BDM 10.2.3 in process]

6.4.4 Analysis and design [AASHTO-I 4.4, 4.4.7, 4.4.7.1.1, 4.4.8, 4.4.8.1.3, 4.8-4.11, 5]

Allowable bearing pressure for spread footings shall be as recommended by the Soils Design Section. For bridge spread footings the designer shall verify that the allowable bearing pressure includes the factor of safety against bearing capacity failure [AASHTO-I 4.4.8.1.3]. The maximum design pressure shall be indicated on the bridge or structure plans.

Spread footings subject to frost heave shall have a bottom elevation a minimum of 4 feet (1.220 m) below ground line.

Spread footings for abutments and piers shall be founded on sound rock and notched into rock as shown in Figure 6.4.5. On hard rock, the excavation shall be at least 6 inches (150 mm) deep and to neat lines of the footing. On soft rock, a footing shall extend at least 18 inches (460 mm) into the rock, with the final 12 inches (300 mm) of the excavation to neat lines of the footing.

Limestone and cemented sandstone are considered hard rock, and shale and uncemented siltstone and sandstone are considered soft rock; however, the classification is subject to the judgment of the Soils Design Section. By standard penetration test blow count, rock generally is classified as hard when blow counts are above 200.

The office prefers that spread footings be designed by the allowable stress design method [AASHTO-I 4.4], but the designer may use the load factor design method with proper consideration of eccentric loads, overturning, and uplift [AASHTO-I 4.8-4.11].

For spread footings on rock designed by the allowable stress design method [AASHTO-I 4.4], the eccentricity of the pressure resultant on the base of footings shall not exceed 1/4 of the footing dimension in any direction [AASHTO-I 4.4.8]. For abutments and piers the office requires that there be no uplift under Service Load Group 1, which will require that the eccentric resultant for that load group be further restricted to the kern limit. Exceptions to the eccentricity limit may be considered for spread footings of multi-column frame bents and other spread footings where overturning is not a concern; however, such exceptions shall require the specific approval of the supervising Section Leader.

For a spread footing on rock the maximum actual bearing pressure usually is at the corner of the footing. The corner pressure shall not exceed the allowable bearing stress for the footing concrete or the allowable bearing pressure for the foundation rock.

For spread footings on soil designed by the allowable stress design method [AASHTO-I 4.4], such as footings for overhead sign trusses, the eccentricity of the resultant of pressure on the base of footing shall not exceed 1/6 of the footing dimension in any direction [AASHTO-I 4.4.7]. For double eccentricities this rule will permit a small amount of uplift, and it is the designer's responsibility to ensure that the uplift is acceptable and consult with the supervising Section Leader.

A spread footing shall be sufficiently thick so that the footing does not require shear reinforcement. For punching shear the designer shall use the average bearing pressure resulting from vertical load, with consideration of allowable stress increases for load groups other than Service Load Group I.

For beam shear the designer shall use the full allowable bearing pressure, with consideration of allowable stress increases for load groups other than Service Load Group I. To minimize footing thickness the designer may use the higher allowable shear stress in the AASHTO specifications [AASHTO-I 8.15.5.2.1]. In cases where the full allowable bearing pressure is too severe a design condition the design pressure may be reduced with approval of the supervising Section Leader.

For moment the design loads should include the upward forces exerted by soil or rock and the downward forces of the soil and footing, considering buoyant effects if applicable. For design of moment steel in the bottom of the footing, the designer shall use the maximum footing pressure resulting from axial load plus moment about the moment's axis and apply the pressure uniformly over the projecting portion of the footing.

Reinforcing shall be provided in the top of a spread footing subjected to uplift.

Spread footings supporting retaining walls shall be designed in accordance with the AASHTO specifications section on retaining walls [AASHTO-I 5].

6.4.5 Detailing

For spread footings notched into rock the limits for Class 22 excavation shall be as given in Figure 6.4.5.

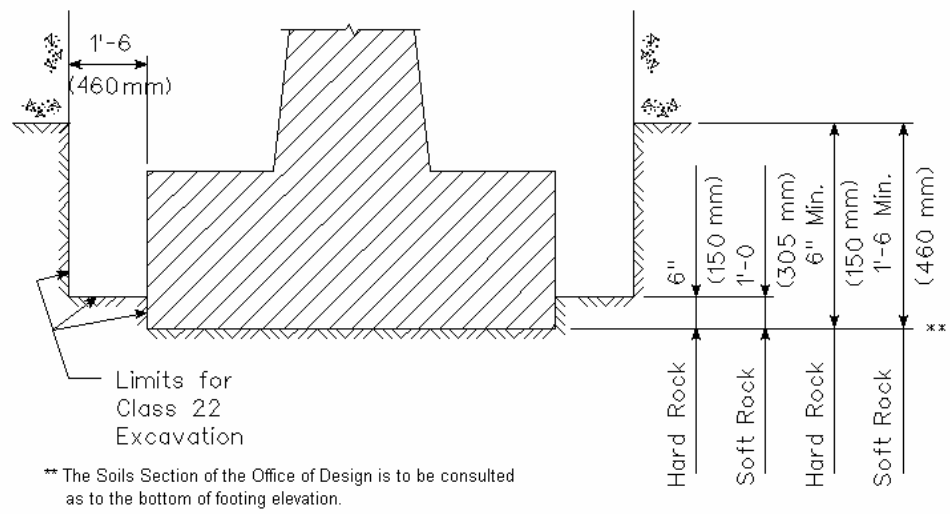

Figure note:

- The lower portion of the notch into rock shall be to neat lines.

Figure 6.4.5. Footing placement on rock and limits for Class 22 excavation

The allowable bearing pressure shall be indicated in a note on the bridge plans [BDM 11.6 E721A, E721B, or E721C (M721A, M721B, or M721C)].

The office prefers that moment reinforcing in spread footings be developed with straight bar lengths rather than hooks. If straight bar lengths cause excessive enlargement of a footing the designer may consider hooks.

When detailing horizontal construction joints such as the joint between column and footing, the designer shall assume the ends of vertical bars rest on the construction joint and determine the bar lengths accordingly [OBS MM No. 75].