United States Department of Agriculture
Soil Conservation Service
P.O. Box 2890
Washington, D.C.
20013

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TECHNICAL RELEASE NOTICE 54-1

The principal purpose of this technical release notice is to update the wingwall design procedure contained in TR-54 by removing a previously existing conservative approximation.

The wingwall design model treats the wingwall toewall as non-existent, reference TR-54, page 44. However, the procedure for determining the required internal strength of the wingwall heel slab has been approximate, on the conservative side. This approximation was felt justified on recognition that the toewall might actually bring some bending moment to the heel slab. Thus the approximation provided an allowance for the effects of toewall loading. The allowance increased with increasing slope of backfill behind the wingwall, beginning at zero for horizontal slopes and becoming excessive for steep slopes.

With extensions to the area of application of the model, steep slopes are more commonly encountered. Hence the approximation in the moment summation for determining required internal strength of the wingwall heel slab tends to be too conservative and is no longer desirable. The approximation is now removed. The computations conform to the assumed wingwall design model, that is, an L-shaped wall retaining various combinations of backfill slope.

If a designer feels it desirable to include additional moment strength in the heel slab to resist toewall loading, that strength must be added overtly. Conditions which might occur over the life of the structure would need consideration.

Pages 49/50, 51/-, 59/60, and 61/62 should be removed from current copies of TR-54 and the enclosed four sheets should be inserted.

for [signature]
NEIL F. BOGNER
Acting Director of Engineering

Enclosure

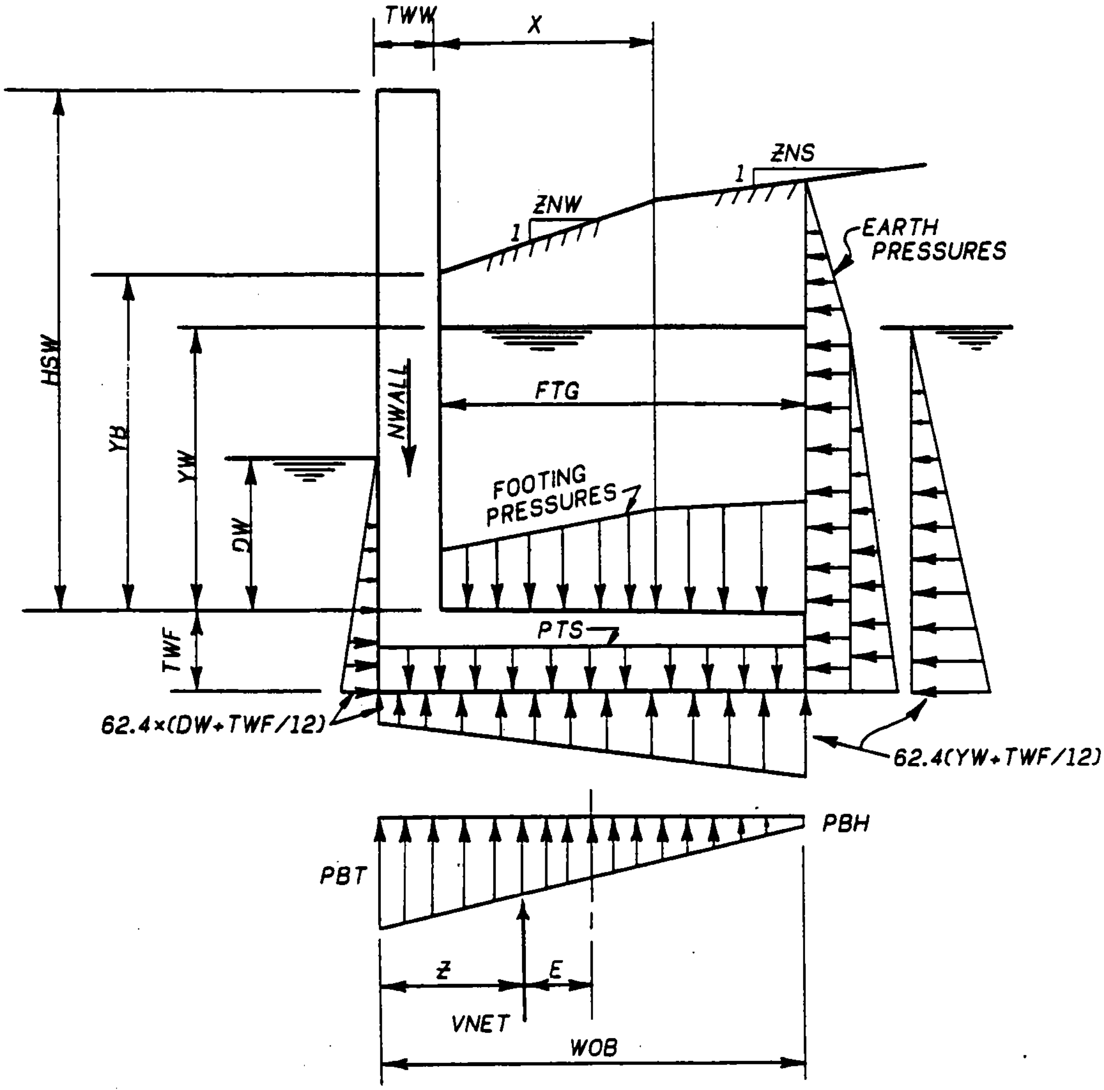

Figure 39. Wingwall overturning and bearing

trial. If VNET is located within the middle third of the base, the section is safe against overturning and the contact bearing pressures, PBT and PBH, are computed in the usual way. If the higher pressure exceeds the allowable value, taken as

PALLOW = 2000 + GB x (YB + TWF/12)

FTG is again incremented. Each trial recycles the footing design back to the first load condition for the section under investigation.

When bearing pressure requirements are satisfied, footing thickness required for moment is determined. If the required thickness is more than the actual thickness, TWF is incremented and the footing design is recycled starting at the first location, (section 1 of Figure 38) and the first load condition. Analyses have shown that shear seldom controls footing thickness in these wingwalls. Hence the thickness required for shear is only checked, and the design recycled if necessary, in detail design.

<u>Sliding</u>. The basin proper is designed to satisfy longitudinal sliding requirements, by itself. Therefore, no additional sliding force should be brought to the basin by the wingwalls. This means the wingwalls should be adequate themselves to resist sliding in the longitudinal direction of the basin. (Any tendency of the wingwall to slide in a transverse direction, toward the center of the channel, is resisted by the wingwall-to-basin tie discussed in the next section.) Let the resultant horizontal driving force normal to the sidewall be FSLIDE, see Figure 40. This force is obtained by summing, over the length of the sidewall, the net horizontal forces per unit length, HNET, at each of

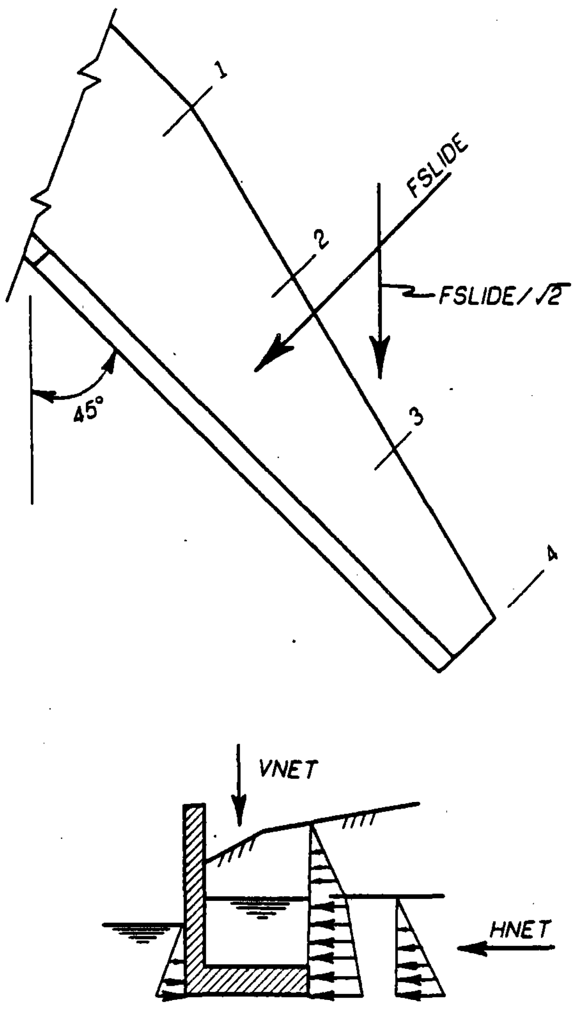

Figure 40. Longitudinal sliding of wingwall

the four sections. HNET is obtained from the indicated horizontal forces, for a particular section and load condition. Thus

FSLIDE = (HNET1/2 + HNET2 + HNET3 + HNET4/2) x (J - 1)/3.

Similarly, if VWING is the resultant vertical force on the wingwall, and VNET is the resultant per unit length, then

VWING = (VNET1/2 + VNET2 + VNET3 + VNET4/2) x (J - 1)/3.

The longitudinal component of FSLIDE is FSLIDE/$\sqrt{2}$. To adequately resist sliding, the wingwall must satisfy the relation

$$\frac{1.4142 \times VWING \times CFSC}{FSLIDE} \geq SLIDER$$

for each load condition of Figure 36.

If the above relation is not satisfied for any load condition, BUP and BDN are incremented equally. The design is recycled to the start of the overturning analysis with the new footing projection values. This is necessary because the wingwall footing thickness, TWF, may require incrementing with the larger footing projections.

Wingwall-to-basin tie. A structural tie is provided between the wingwall footing and the footing and floor slab of the basin proper. This wingwall-to-basin tie prevents rotation of the wingwall about its junction with the basin sidewall and thus effectively prevents any possibility of transverse sliding of the wingwall. The wingwall-to-basin tie is designed for the full moment due to the resultant horizontal force, FSLIDE, of Figure 40. This is admittedly conservative in that it completely neglects any frictional resistance that is developed. Let MTIE be the full moment, in foot lbs, and ARM be the moment arm shown in Figure 41. Then, in inches

$$ARM = BUP \times 12 - 6 + TWW/2$$

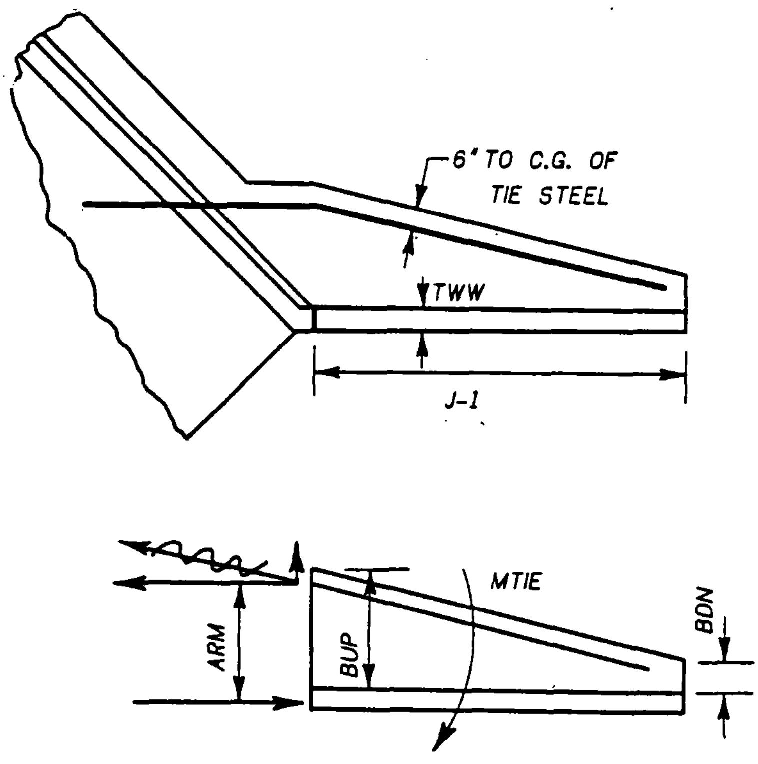

Figure 41. Wingwall-to-basin tie steel area

and the required area of the tie steel, in sq. in., just downstream of the section through the articulation joint is approximately

$$ATIE = \frac{MTIE \times 12}{20{,}000 \times ARM} \times \frac{((J-1)^2 + (BUP - BDN)^2)^{1/2}}{(J-1)}$$

only in T and S amounts.

Determination of the steel requirements at point a, b, or c in any section necessitates the evaluation of the force system MZ, NZ, and VZ shown in Figure 49 where Z is the distance from the top of the section down to the point in question. Possible cases of DW, YW, and YB are illustrated from which MZ, NZ, and VZ are computed for a particular load condition. At interior sections where X > (J - DW), the water depths, YW and DW, are equal and exceed the height of the section, HSW. All five load conditions of Figure 36 are investigated to determine maximum requirements.

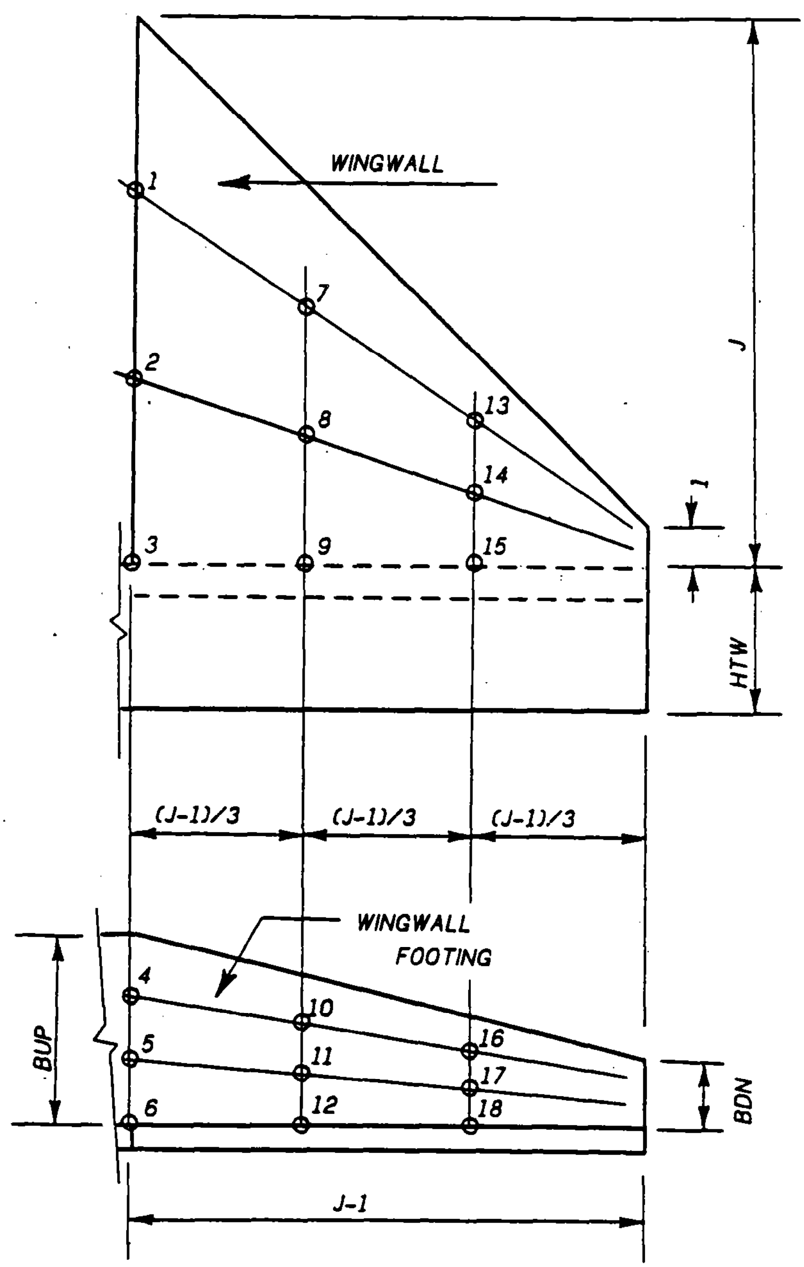

Figure 47. Wingwall steel point locations

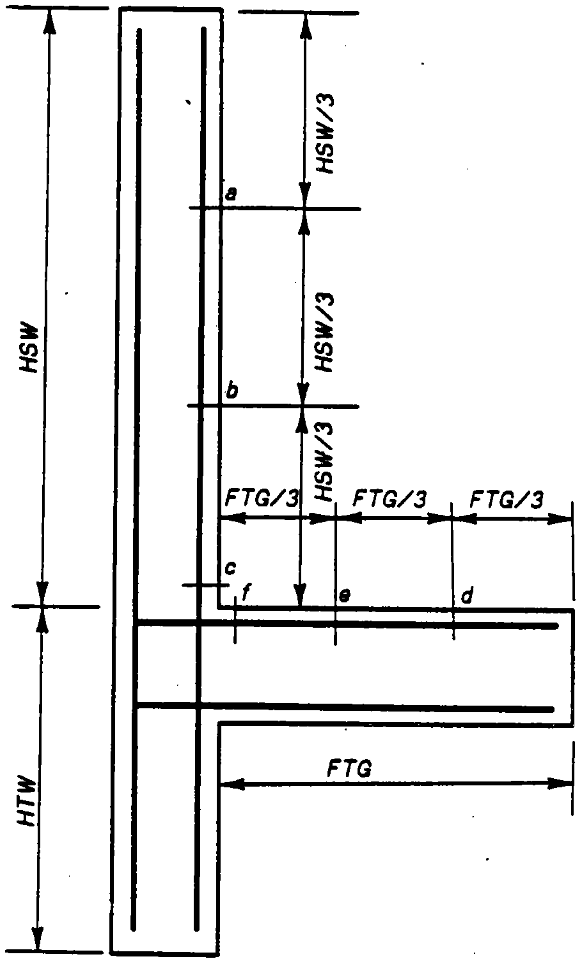

Figure 48. Wingwall section steel layout

Determination of the steel requirements at point, d, e, or f similarly necessitates the evaluation of the force system MZ, NZ, and VZ shown in Figure 50 where Z is the distance from the edge of the footing projection to the point in question. Sketch (A) shows a possible combination of YB, YW, and DW. Sketch (B) shows the resulting loadings and bearing pressures and indicates the summation to obtain MZ and VZ. The moment, MZ, includes the difference in the moments due to the two resultant horizontal forces, H1 and HZ, shown. However, this difference is not taken greater than that which would just produce zero footing pressure on the top end of the heel. HZ is the resultant horizontal force on the vertical plane at distance Z. HZ is due to the material above the top of the footing. The moment due to the frictional force assumed acting on the bottom of the footing in sketch (D), is conservatively neglected in the summation as being too uncertain. The direct compressive force, NZ, is obtained as suggested by sketches (C) and (D). Sketch (C) defines the resultant horizontal forces involved. Sketch (D) puts the section in horizontal equilibrium using the resultant horizontal forces and indicates the summation to obtain NZ. All five load conditions of Figure 36 are investigated. The critical section for moment in the heel can occur at the face of the wingwall or at an interior location. Arbitrarily, the steel requirement at point f is not taken less than that at e.

The wingwall footing thickness required for shear is checked during these computations. Maximum shear in the footing can occur at the face of the wall or at some interior location. Shear seldom controls thickness. When it does, the thickness is incremented and the footing steel design is begun again.

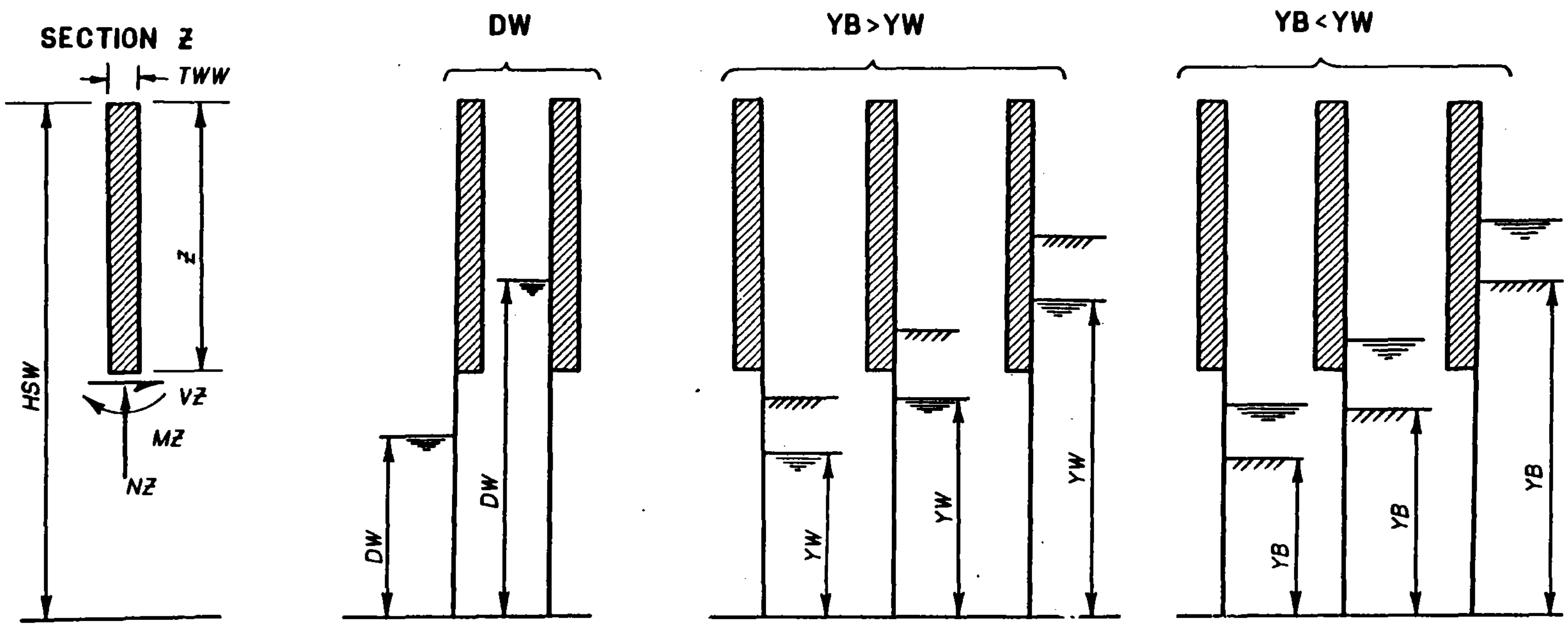

Figure 49. Determination of the force system at a point in wingwall

(TR Notice 54-1, September 1981)

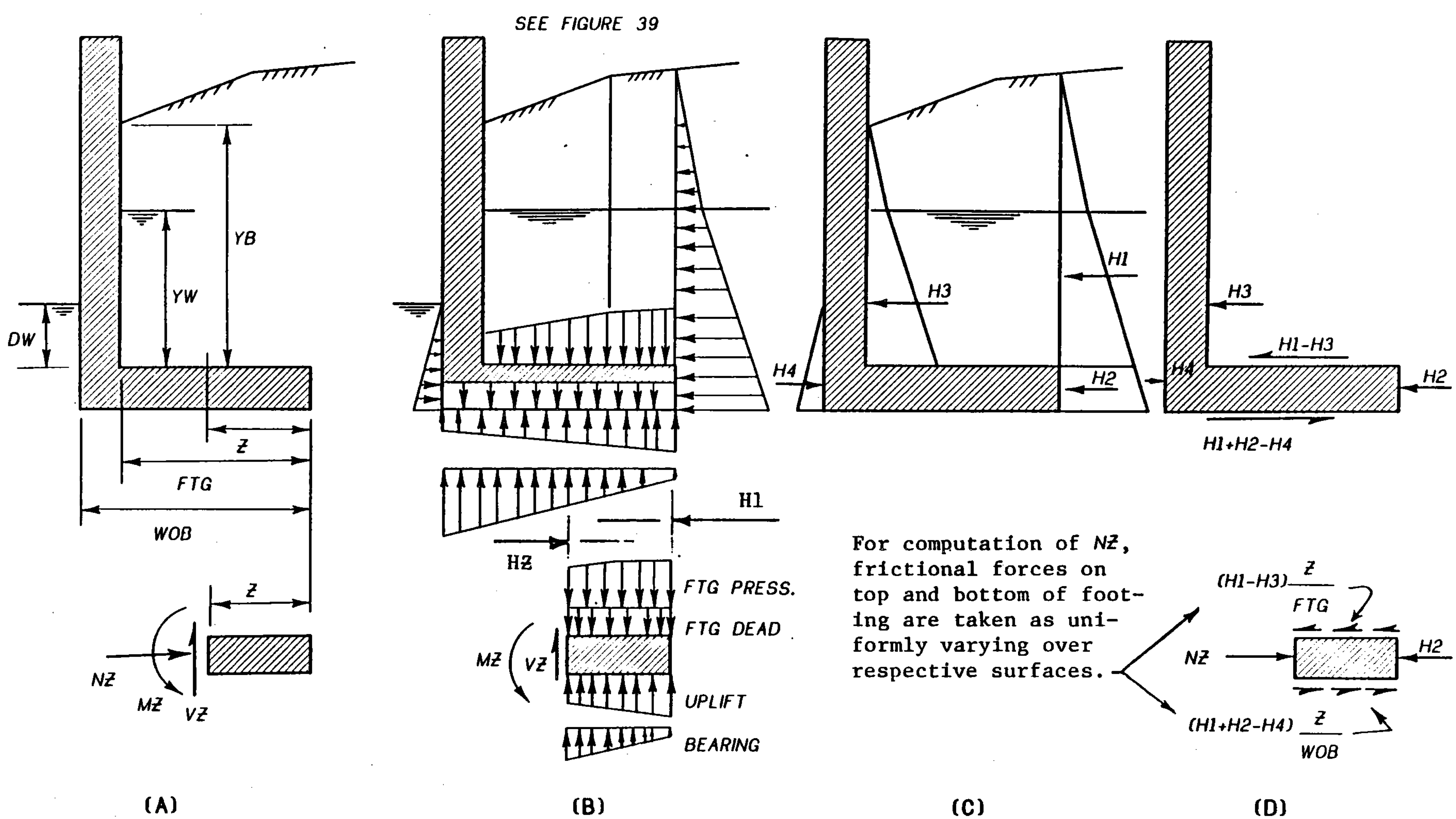

Figure 50. Determination of the force system in wingwall footing