Rapid Determination of Consolidation Settlements

Détermination rapide des tassements dus à la consolidation

by, S. J. BUTTON, B.Sc., A. Inst. P., F.G.S., Terresearch Ltd., London, England.

Summary

The paper gives curves from which the integral of the vertical stress with depth as used for settlement analysis can be directly determined to any depth from the surface or between any two depths. Two curves are given [1] below the centre point, and [2] below the corner of rectangular footings.

It also gives curves from which the settlement after any time can be directly obtained for foundations on a thick bed of clay. The curves given are for long strip and square footings with vertical drainage only and for long strip and circular footings with three-dimensional drainage.

Sommaire

L'article donne des courbes d'après lesquelles l'intégrale de la contrainte verticale en fonction de la profondeur que l'on utilise pour analyser la consolidation, peut être déterminée directement pour n'importe quelle profondeur à partir de la surface ou entre deux profondeurs quelconques.

Il comporte deux courbes : 1) au-dessous du point central et 2) au-dessous de l'angle de semelles rectangulaires.

Il comporte aussi des courbes d'après lesquelles la consolidation peut être trouvée directement après n'importe quelle durée pour des fondations dans une couche épaisse d'argile.

Les courbes données ont été établies pour des semelles allongées et des semelles carrées avec drainage vertical seulement et pour de longues semelles et des semelles circulaires avec drainage dans les trois dimensions.

Given the consolidation characteristics of the soil and the thicknesses of consolidating layers, estimation of consolidation settlement is in two stages :

1) Estimation of final settlement from the distribution of the vertical stresses in the ground and the coefficients of volume decrease.
2) Estimation of the rate of settlements from the drainage conditions and the coefficients of consolidation.

The stresses due to a point load on the surface of an elastic medium have been calculated. These results have been extended for finite areas with different pressure distributions.

Having determined the stress distribution below the point for which the settlement is to be calculated, the settlement is obtained as a function of the coefficient of volume compressibility, m_v vertical stress n_z, and the thickness dz, being :

$$S = \int m_v \cdot n_z \cdot dz$$

If m_v is a constant, the settlement is :

$$S = m_v \int n_z \cdot dz = m_v \, I.B.p$$

where p is the pressure on a foundation of width B.

Fig. 1 gives the values of I below the centre point of rectangular footings. Fig. 2 gives the values below a corner. These values are derived from the Boussinesq stress distribution.

These diagrams are particularly useful because the value of I may be obtained between any intervals of depth.

For example, if a footing is placed as shown in Fig. 3, the settlement is :

$$S = B \cdot p \left[m_{v_1} \, (I_{z_2} - I_{z_1}) + m_{v_2} \, (I_{z_4} - I_{z_3}) \right]$$

Figs. 1 & 2 give the values of I, and the settlement is obtained directly.

Having calculated the final settlement, the rate of settlement is obtained by use of tables giving values of percentage of final settlement (μ) for different values of the time factor

For simple cases, however, the two stages can be combined, so that a settlement factor M can be obtained for different values of the time factor τ for the given conditions.

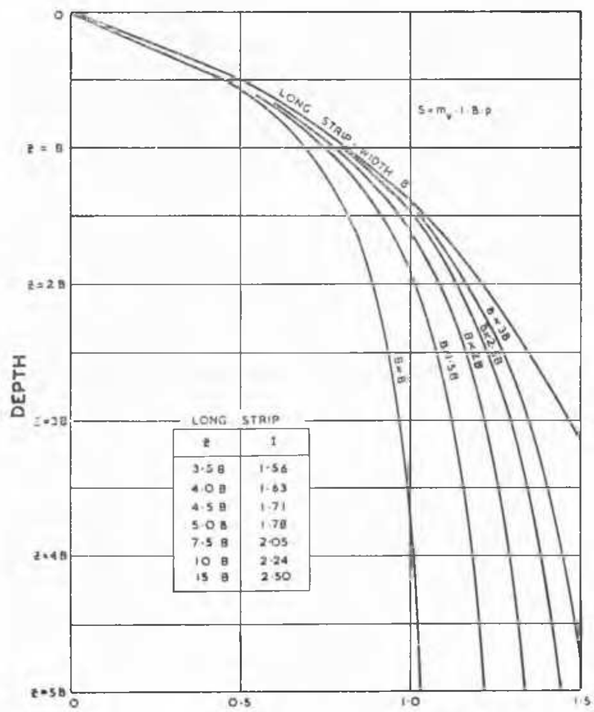

Fig. 1 Integrals of stress distribution under centre points of rectangular footings.

Intégrales des répartitions des contraintes sous les centrales des semelles rectangulaires.

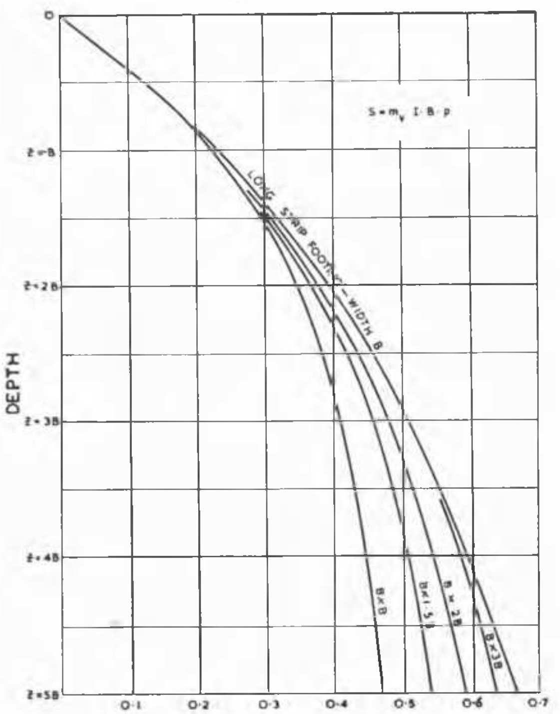

Fig. 2 Integrals of stress distribution under corner of rectangular footings.

Intégrales des répartitions des contraintes sous les angles des semelles rectangulaires.

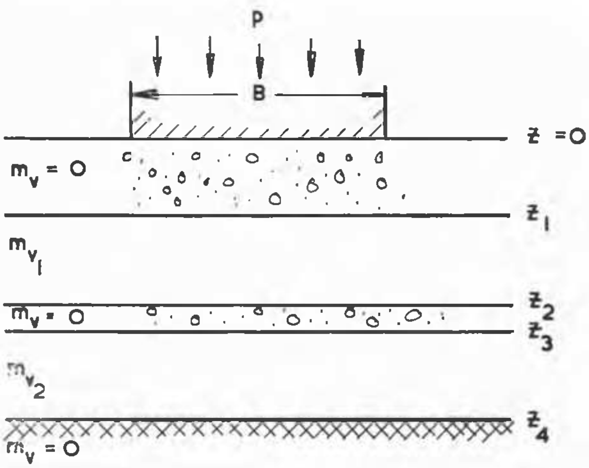

Fig. 3

The settlement is obtained as:

$S_t = m_v \cdot p \cdot M.$

and time :

$t = \tau / c_v$

where :

S_t = Settlement after time t

m_v = Cœfficient of volume decrease

p = Net pressure on footing

M = Settlement factor

τ = Time factor

c_v = Coefficient of consolidation

Fig. 4 gives value of M & τ for the centre points of long strip footings of different widths. These values are for a consolidating layer extending from the footing to a depth of 2·5 times its width. It assumes vertical drainage from the top only with triangular distribution of stresses.

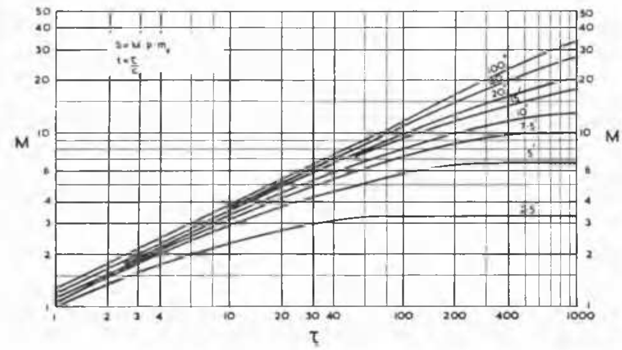

Fig. 4 Settlement of long strip footings (Vertical drainage only).

Tassement des fondations sur semelles allongées. (Drainage vertical seulement).

Fig. 5 gives values of M & τ for similar conditions, except in this case, the rate of settlement has been computed for three-dimensional dissipation of pore water pressure.

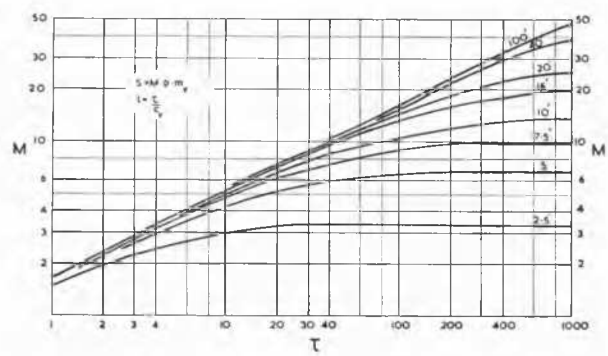

Fig. 5 Settlement of long strip footings. (3 Dimensional drainage).

Tassement des fondations sur semelles allongées. (Drainage à 3 dimensions).

Details of the method of calculation are given in Appendix 1. Fig. 6 is similar to Fig. 4, but applies to square footings.

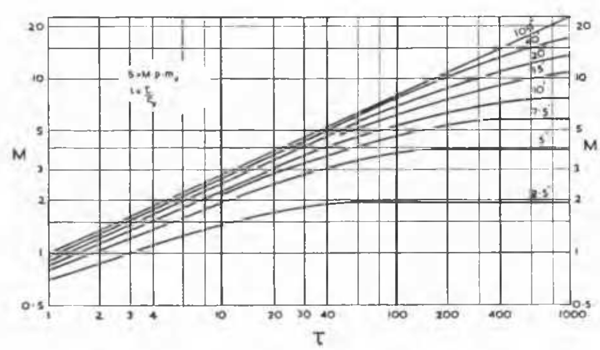

Fig. 6 Settlement of square footings. (Vertical drainage only).

Tassement des semelles carrées. (Drainage vertical seulement).

Fig. 7 gives values of M & τ for three-dimensional consolidation for circular footings on a compressible stratum extending to a depth equal to three times the radius.

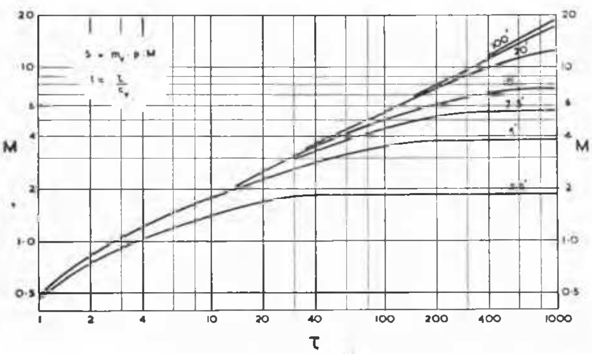

Fig. 7 Settlement of circular footings. (3 Dimensional drainage).

Tassement des semelles circulaires. (Drainage à 3 Dimensions).

As an example of the use of these curves, consider a strip footing, 10 ft. wide, carrying a net pressure of 2·50 tons/sq.ft. If this rests on a clay for which $m_v = 0{\cdot}01$ ft.²/ton and $c_v = 5$ ft.²/year, thus :

$$t = \frac{\tau}{5} \quad S = 2{\cdot}5 \times 0{\cdot}01\ M = 0{\cdot}025\ M \text{ ft.}$$

$$= 0{\cdot}30\ M \text{ ins.}$$

We then have :

Time (t) (years)	τ ($= c_v t$)	M (*from Fig. 5*)	S(inches) ($= 0{\cdot}30\ M$)
1	5	3·6	1·1
2	10	4·8	1·4
5	25	7·3	2·2
10	50	9·0	2·7
20	100	10·5	3·1
50	250	12·2	3·7
100	500	13·1	3·9

Appendix — Method of Estimating Degree of Consolidation

(1) *Stress Distribution*

A flexible footing with a uniform pressure was assumed. The distribution of vertical pressures is based on the formula given by Boussinesq [1] for a point load, and extended to finite areas by Carothers [2] and others. These vertical pressures were obtained at each point on a grid.

(2) *Dissipation of Pore Water Pressures*

The pore water pressures immediately after loading were taken to be proportional to the vertical stresses. The dissipation of these pressures was calculated by numerical methods similar to those used by Gibson & Lumb [3].

The proportion of the final settlement was obtained by a numerical integration of the pore water pressures after different time intervals using the integration formula given by Bickley [4] the final settlement being given by the integration of the initial pore water pressures.

Acknowledgement

The author is indebted to Terresearch Limited for permission to publish this paper.

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