Ⅲ－B120 Prediction of surface ground movements due to slurry shield tunnelling

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1. INTRODUCTION

This paper proposes the practical design charts to predict ground surface movements due to shield tunnelling based on previous monitoring data and centrifuge tests results. This paper focuses on the ground surface movements, particularly the transverse settlement profiles in relation to the ground conditions.

2. GAUSSIAN DISTRIBUTION CURVE

The Gaussian distribution curve(Peck, 1969) that represents the transeverse settlement trough immediately after a tunnel can be written as(Figure 1):

$$S = S_{\max} \exp\left(\frac{-y^2}{2i^2}\right) \quad \text{---------- (1)}$$

where S is settlement

Smax is the maximum settlement on the tunnel centre line

y is the horizontal distance from the centre line

i is the horizontal distance from the tunnel centre line to the point of inflection

More recently, Mair and Taylor (1998) summarized a wide range of field data observed during tunnelling, including conventional shield tunnelling. They concluded that values of the trough width parameter K ($i=Kz_0$) for tunnels in clays, and sands or gravels, can be taken as average values of 0.50 and 0.35 respectively, regardless of tunnel size and tunnelling method.

3. PREDICTION OF TRANSVERSE SURFACE SETTLEMENT

Figure 2 shows relationships between z0 and i based on the plots of field measurements given by Mair and Taylor(1998), together with previous centrifuge results (Mair(1979), Imamura et al. (1998)). It can be clearly seen that both sets of centrifuge results are consistent with the results from past field data in spite of different conditions, including tunnel size and construction method. This is also consistent with the conclusion of Mair and Taylor(1998) that the width of the surface settlement trough, based on field measurements, is independent of construction method.

Figure 3 shows relationships between i/(D/2) and C/D plotted in a similar way to Figure 2, although the data is now plotted on a log-log scale. The following relationships have been derived from Figure 3:

(a) Clays

$$\left(\frac{i}{D/2}\right) = 1.5\left(\frac{C}{D}\right)^{0.8} \quad \text{-------- (2)}$$

$$|r| = 0.94$$

(b) Sands and Gravels

$$\left(\frac{i}{D/2}\right) = \left(\frac{C}{D}\right)^{0.7} \quad \text{---------- (3)}$$

$$|r| = 0.62$$

where r: Correlation coefficient

On the basis of the Correlation coefficient(r) for the above equations, the data can be reasonably approximated by the proposed power functions of C/D, although the data for tunnels in sands and gravels exhibit somewhat more scatter than in the case of clays. In the cases of very shallow tunnels and large diameter tunnels, Figure 3 and equations (2) and (3) may be more useful for tunnel engineers to predict i, because of tunnel diameter having significant effects on i as well as the ground depth.

4. CONCLUSIONS

Two kinds of practical design charts to appropriately predict surface transverse settlement troughs due to shield tunnelling were proposed for ground conditions such as clays or sands and gravels. In addition, previous centrifuge test resluts are in reasonable agreement with the design

Key words:Tunnel, Settlement, In-situ data, Centrifuge model test

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charts.

REFERENCES

Peck, R. B. (1969) : "Deep excavation and tunneling in soft ground," Proc. of the 7th ICSMFE (Mexico), State of the Art Volume, pp. 225-290.

Mair, R. J. and Taylor, R. N. (1998):"Bored tunnelling in the urban environment," Theme Lecture, Plenary Session 4, Proc. 14th, Int. Conf. on Soil Mechanics and Foundation Engineering, Hamburg.

Mair, R. J. (1979):"Centrifuge modelling of tunnel construtíon in soft clay", Ph. D Thesis, University of Cambridge.

Imamura, S. et al. (1998):"Settlement trough above a model shield observed in a centrifuge," Proceedings of Centrifuge 98, pp. 713-719.

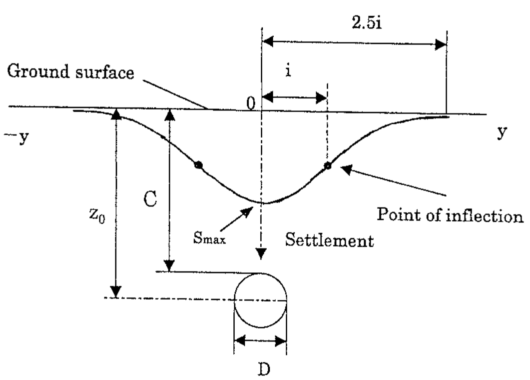

Fig. 1 Definition of settlement profiles of Gaussian form (1) (2) (3)

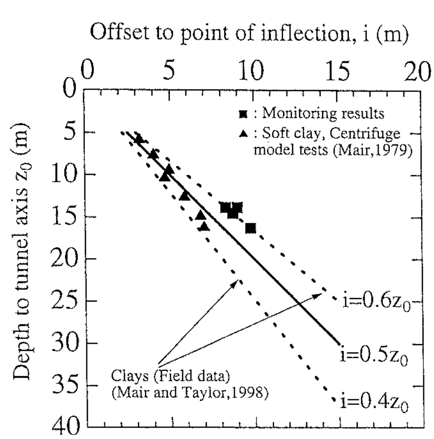

Fig. 2(a) Variation in suface settlement trough width parameter with tunnel depth for tunnels in clays

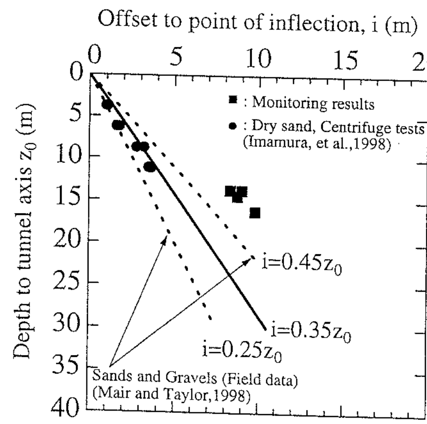

Fig. 2(b) Variation in suface settlement trough width parameter with tunnel depth for tunnels in sands and gravels

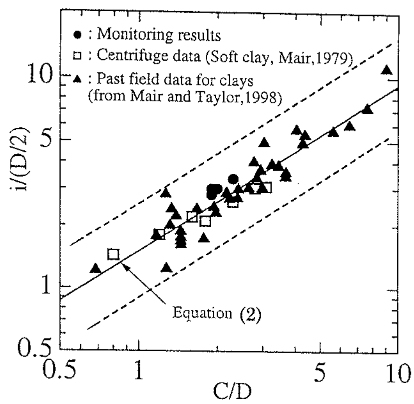

Fig. 3(a) Variation in suface settlement trough width parameter with C/D in clays

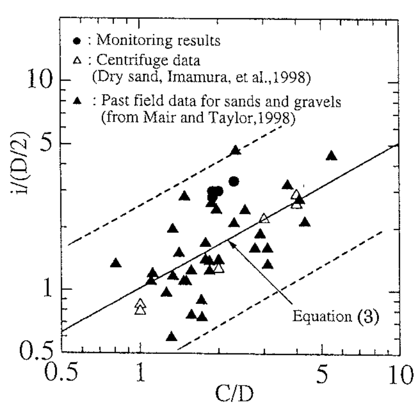

Fig. 3(b) Variation in suface settlement trough width parameter with C/D in sands and gravels