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Analysis of Settlement and Deformation Characteristics of High Fill Subgrade in Southeast Asia

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Analysis of Settlement and Deformation Characteristics of High Fill Subgrade in Southeast Asia

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Abstract. Based on a high fill subgrade in Indonesia, in order to make reasonable arrangements for the safety of the construction period and the reserved earth and stone work, this paper simulated and analyzed the high fill subgrade at different heights and predicted the settlement of the subgrade after construction. The calculation results show that most of the settlement of high fill subgrade with different heights has been completed during the construction period, and the settlement after construction meets the requirements, but it is suggested to increase the load during the construction period for some sections with large settlement after construction..

1. Introduction

High fill subgrade technology is one of the more common engineering technologies in highway construction in China, which is mostly used in highway construction in soft soil and other geological environments. For the high fill subgrade project, it has the characteristics of large quantity of earth and stone filled, higher height than the traditional subgrade, shorter construction period and so on. However, during the highway phase using the high fill subgrade, it is easy to deform the high fill subgrade to different degrees due to the engineering problems of the high fill subgrade itself and the soft soil problems at its location during and after the construction of the subgrade. At the same time, the foundation settlement of high fill subgrade is also different from other subgrade, and uneven settlement often occurs, which will not only affect the normal use of highway, but also reduce the service life of highway. However, due to the limitation of geographical conditions, many high fill subgrade are difficult to achieve good settlement prevention and settlement post - treatment. Therefore, it is very necessary to analyze and predict the settlement and stability of high fill subgrade.

2. Project overview

The first phase of the toll road from Solo to Katosono in Indonesia is located in Java Island, Indonesia. It connects Solo in Central Java to Kertosono in East Java and is part of the main trunk road of Java Island in Indonesia. The construction station range is K154+300-178+340. The road of this section is 22.7km long.



Solo road section is mainly filled with embankment, with paddy fields and densely populated villages along the way. The construction area is relatively low, the water level is too high, and the foundation bearing capacity does not meet the requirements. The owner requires to change the foundation treatment plan, and all road areas of the project are changed from the original design excavation construction plan to the construction plan of laying geotextile after clearing the surface. The construction method is to excavate 50cm after clearing the surface, backfill the ordinary borrowed materials to the surface, lay geotextile, and then backfill the borrowed soil according to the section of the original drawing. According to the construction plan, the whole construction period is about 12 months, including 5 months for subgrade construction, 4 months for shutdown and 3 months for pavement construction.

The calculation parameters are selected according to the calculation of Bandung University. When the standard penetration number of subgrade foundation soil exceeds a certain number, the foundation will not undergo consolidation or compression settlement, and the calculation depth is generally 15m-20m. The calculation parameters are shown in Table 1.

Table 1 Parameter Table of Settlement Calculation

No.	$\gamma(\text{kN/m}^3)$	γ_d (kN/m^3)	c (kN/m^2)	$\varphi(^{\circ})$	ν	$E(\text{kN/m}^2)$	K (m/day)
1	15	11	15	0	0.3	3000	$8.6\text{e-}4$
2	16	12	40	0	0.3	8000	$8.6\text{e-}4$
3	17	14	100	0	0.3	20000	$8.6\text{e-}4$
4	17	14	100	0	0.3	40000	$8.6\text{e-}4$
5	17.8	14.8	22.8	19.2	0.3	3400	0.01

PLAXIS 2D is used to analyze settlement and excess pore pressure due to various working load. PLAXIS 2D is a finite element package intended for the two dimensional analysis of deformation and stability in geotechnical engineering.

Duration of road embankment in this analysis is 180 days and pavement 90 days. If residual settlement still high, we recommend adding duration of road embankment.

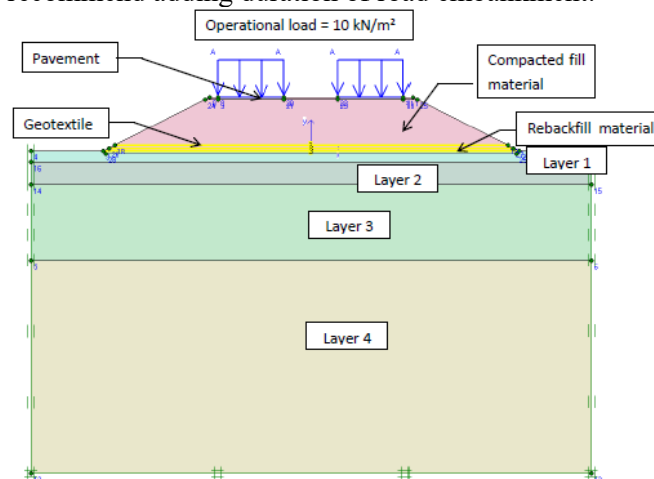


Figure 1 Soil model at PLAXIS

3. Comparative analysis of various schemes

Criteria of road embankment settlement are 10 cm on first two years during operation. Settlement should not exceed these criteria. If these criteria exceeded, the soil should be improved to reduce the

settlement. The purpose analysis of road embankment settlement is to check the residual settlement during operation. Duration during road embankment is 180 days and 90 days for pavement. Higher embankment and softer base soil will spend longer time.

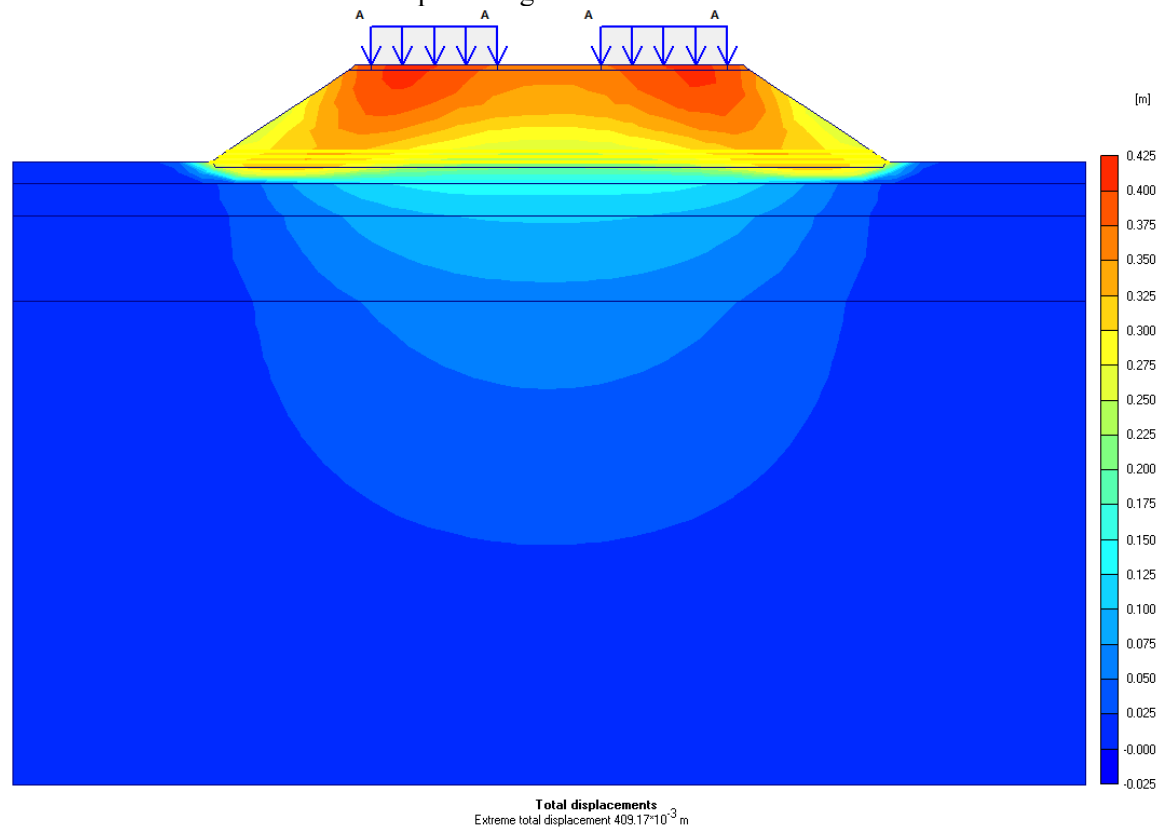


Figure 2 Settlement pavements KSU - 9 m

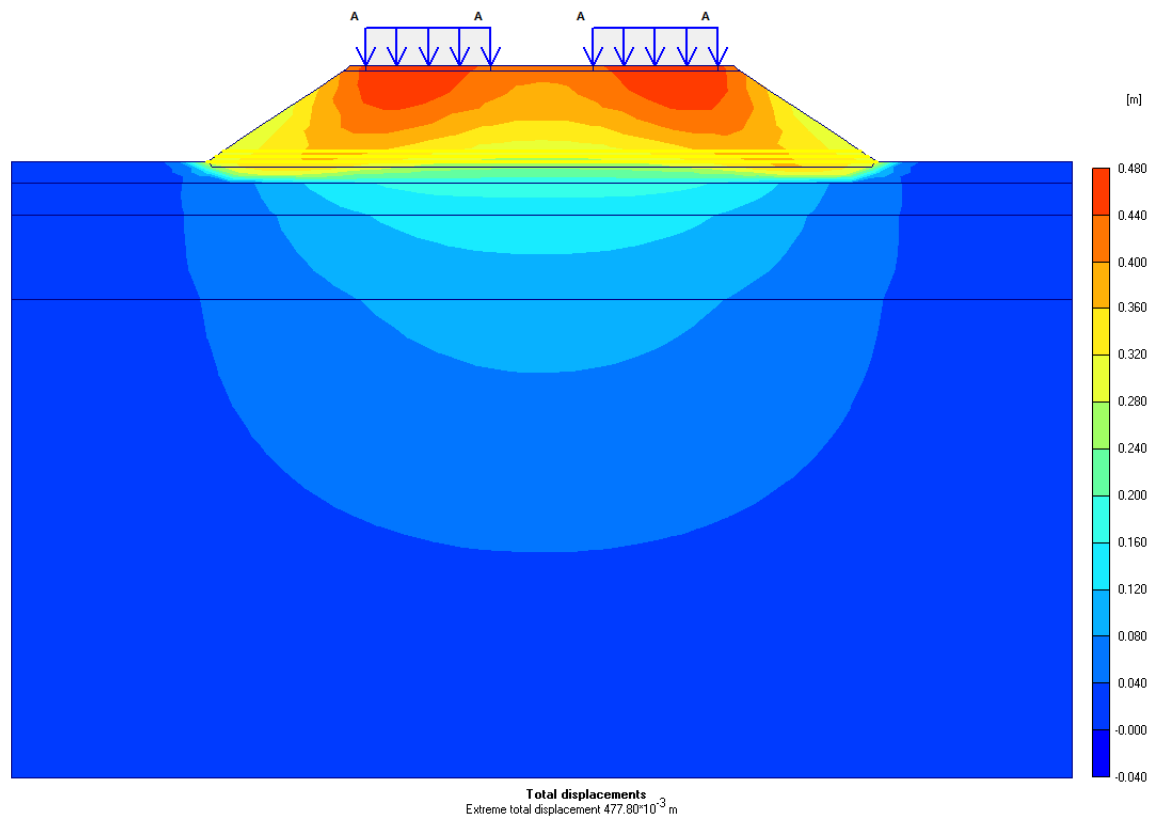


Figure 3 Settlement end of consolidation KSU - 9 m

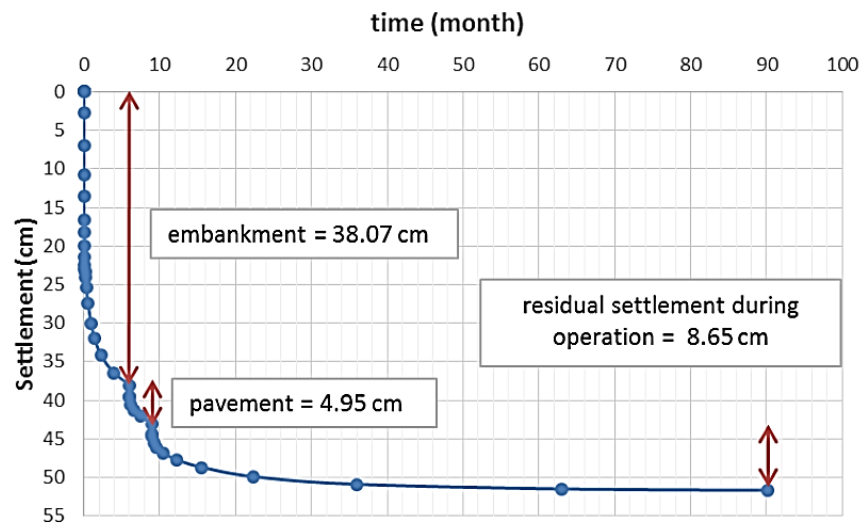


Figure 4 Settlement vs time KSU - 9 m

The calculation results show that the subgrade settlement of the 9m high subgrade in KSU bid section is about 38cm in the six months of subgrade construction, about 4.95cm in the 90 days of pavement construction, and about 8.65cm in the subsequent seven years of post-construction settlement.

According to the design requirements, the post-construction settlement standard of embankment shall not exceed 10 cm, and the settlement shall not exceed this standard. If this standard is exceeded, subgrade soil should be improved to reduce settlement.

The calculation results show that the subgrade settlement of 8.5 m high in BKPN bid section is about 38.2cm in the six months of subgrade construction and 5.14cm in the 90 days of pavement

construction, and the settlement is about 10.0cm in the subsequent seven years of post-construction settlement. BKPN bid section 8.5 m high subgrade settled about 38.2cm in the 6 months of subgrade construction, and 5.14cm in the 90 days of pavement construction, and the settlement was about 10.0cm in the subsequent 7 years of post-construction settlement. The roadbed settlement of RBC bid 9 m high is about 35.57cm in the six months of roadbed construction, and about 4.32cm in the 90 days of pavement construction. In the next seven years of post-construction settlement, the settlement is about 7.0cm. ELMA bid section 9.5 m high subgrade settlement is about 35.0cm in the 6 months of subgrade construction, and 4.18cm in the 90 days of pavement construction. In the subsequent 7 years of post-construction settlement, the settlement is about 6.88cm. TKL bid section 9.5 m high subgrade settlement is about 52.76cm in the 6 months of subgrade construction, 7.11cm in the 90 days of pavement construction, and 9.73cm in the subsequent 7 years of post-construction settlement.

4. Conclusion

The purpose of embankment settlement analysis is to check the residual settlement during construction and operation. The duration of subgrade and pavement construction is 180 days and 90 days. Higher embankment and softer foundation will take longer. To avoid residual settlement during operation until end of consolidation more than 10 cm, embankment and pavement time duration is increased or added additional load (open traffic) during embankment step.

Finite element simulation can simulate the settlement of high fill subgrade during construction and predict the settlement after construction. According to the calculation results, the settlement of high fill subgrade mainly occurs during the construction period, accounting for more than 80 % of the total settlement during the construction period, and the secondary consolidation of soft soil is the main settlement in the later period.

In order to reduce subgrade settlement, the subgrade height can be increased during the construction period and unloaded to the set elevation after the completion of construction. This method can effectively reduce subgrade settlement after construction.

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