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FIELD PERFORMANCE OF TRANSITION RIGID PILED EMBANKMENT WITH SURCHARGED VERTICAL DRAIN OVER SOFT GROUND

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ABSTRACT: Commonly, thick filling works over soft clay is aided with piled embankment at bridge approach to reduce differential settlement between the piled abutment and embankment over soft ground. However, long stretched thick filling works over soft ground requires substantial resources and time to construct rigid piled embankment. Generally for such long stretched and thick filling development over soft ground, other ground treatment such as prefabricated vertical drain (PVD) with surcharge is introduce to reduce the cost of construction. However, excessive total and differential settlement at the surcharged prefabricated vertical drain (SPVD) and rigid piled embankment intersection during post construction period may leads to rectification works over the time. This paper presents the field performance of an alternative design approach for long stretched thick filled embankment over soft clay at structure approach to control the differential settlement between the two conventional ground treatment approaches. With the introduction of the alternative ground treatment approach at the intersection of the two conventional ground treatment, post construction total settlement and differential settlement is reduced significantly.

Keywords: *Transition of Rigid Piled Embankment; Prefabricated Vertical Drain; Surcharge, Soft Clay, Maximum Total Settlement.*

1. INTRODUCTION

Earlier decades, construction of road embankment over thick soft clay is not favored to due to expensive ground treatment and foundation design. Rapid and massive development growth past years consumed large area of land leads to limited land for construction for road embankment and causes to development over soft ground is inevitable. As such, recently construction of embankment over soft clay has become common in most of the South East Asia countries especially in Thailand, Vietnam and Malaysia. Embankment construction normally involves various ground treatment for optimized ground treatment design [1]. Many embankment defects and damage due to differential settlement has been reported yearly which requires high maintenance cost and time for rectification [2]. Prefabricated Vertical Drain (PVD) with surcharge for moderately low fill embankment and rigid piled embankment with transition piled embankment for thick fill are two common ground treatment approaches adopted to reduce the post construction settlement over soft ground [3]. Generally, with presence of the vertical drain and surcharge, settlement is accelerated at the surcharged prefabricated vertical drain (SPVD) zone where by less settlement occurs during the treatment period at the transition rigid piled embankment (TPE) zone without SPVD [4]. However, the root problem which causes differential settlement between the two conventional ground treatments is the large post settlement at the TPE and less post construction settlement at the SPVD. Post construction differential settlement promote undulating (bumpy effect) at the structure approach.

Elimination of the effect of the post construction settlement and differential settlement is achieved through construction of full piled embankment throughout the heavy fill embankment over soft ground [5]. Alternatively, author presents in this paper performance of the SPVD at TPE.

2. FULL SCALE FIELD STUDY

Full scale embankment with SPVD and TPE field study is constructed at Pulau Indah Ring Road in Selangor, Malaysia**.** The location and general geological of the site is shown in Figure 1.

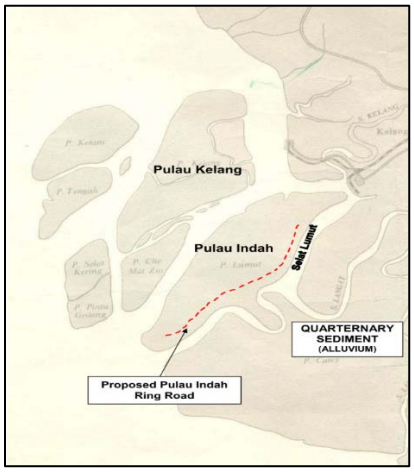

Fig. 1 site location and General Geology

Pile load transfer is computed based on equivalent raft concept as recommended by Egyptian code for pile design. Plan View of Intersection of transition pile with PVD as shown in Figure 2. The PVD is installed of 30m long up to the compressible layer throughout the transition piled embankment at half of pile spacing and also surcharged up to 1.5 m with rest period of six (6) months (Figure 2). The ground treatment details and field performance in term of settlement and differential settlement is assessed by installing several numbers of instruments namely settlement gauge and settlement markers. The profile of the road embankment and corresponding location of instruments is shown in Figure 3. Embankment profile with instruments locations is illustrated in Figure 4.

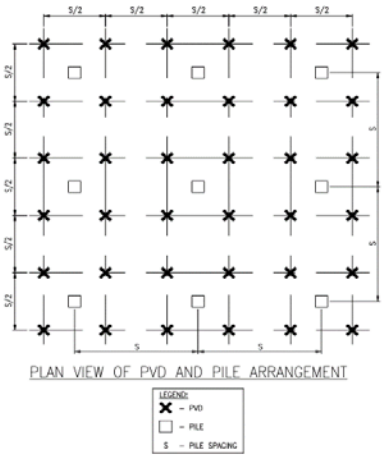

Fig. 2 Plan View of Intersection of Transition Pile with PVD

Flexible piled embankment with geotextile is not adopted by author due to the drawback of the system where post construction defects such as "mushroom effects" [1]. The rigid pile embankment including pile spacing, maximum shear, punching shear and reinforcement for bending moment and shear is designed in accordance to British Standard, BS 5400-Part 4 and BS8110-Part 1. Design of PVD is performed based as recommendation from Indraratna, Aljorany [6] to determine the optimum spacing and length of PVD to achieve the desired degree of consolidation whilst, surcharge is designed to achieve optimum design surcharge height with minimum surcharge removal [7]. Transition pile from "pile to set" to "pile to length" piled embankment is designed where pile length is reduced gradually [8]. In this paper, PVD is designed at the transition pile zone where PVD is installed at the pile spacing or minimum twice of the pile diameter between the transition piles up to the compressible soil depth. The sequence of construction of full scale model is presented in Table 1.

Table 1: Full scale model configuration and stages of construction

Stage	Construction Works
0	Site Clearing
1	Install Pile Points for Piled Embankment
2	Install Prefabricated Vertical Drain
3	Install Settlement Gauge
4	Backfill up to platform
5	Backfill surcharge up to Designed Surcharge
6	Backfill up to 1m
7	Backfill up to 2m
8	Backfill up to 3m
9	Backfill up to Proposed Platform Level
10	Surcharge up to Designed Surcharge Level
11	Install Settlement Marker
12	Rest Period of 1 Month
13	Rest Period of 2 Months
14	Rest Period of 3 Months
15	Rest Period of 4 Months
16	Rest Period of 5 Months
17	Rest Period of 6 Months
18	Remove Surcharge

3. RESULTS AND DISCUSSIONS

Field instrumentation and monitoring works was carried out from embankment filling works till removal of surcharge to records the settlement occurrence at the treatment zones. The monitoring results of the installed settlement gauges and settlement markers up to surcharge removal is presented in Figure 5 and 6 respectively. Whilst, Asaoka plot based on the instrumentation results is presented in Figure 7.

Instrumentation field results is presented in Figure 8. The field performance of the intersection SPVD results indicate that the ground has undergone majority of the settlement during the construction period and very minimal settlement is anticipated upon removal of the surcharge. The main concern of the study which is to reduce significantly the differential settlement between two conversational ground treatments at thick filling over soft ground is resolved as the differential settlement between Chainages are well within the tolerable limit.

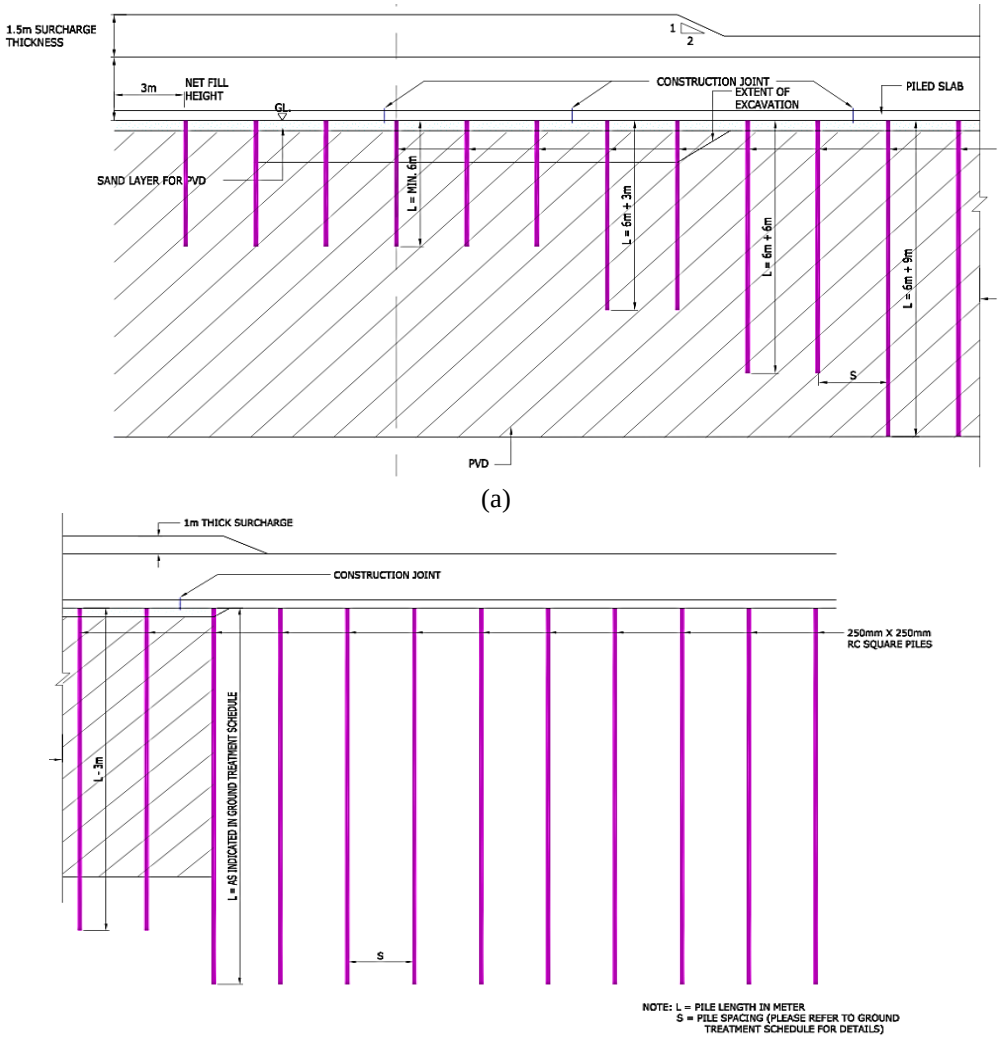

Fig 3 Typical profile of intersection surcharged PVD at transition rigid piled embankment

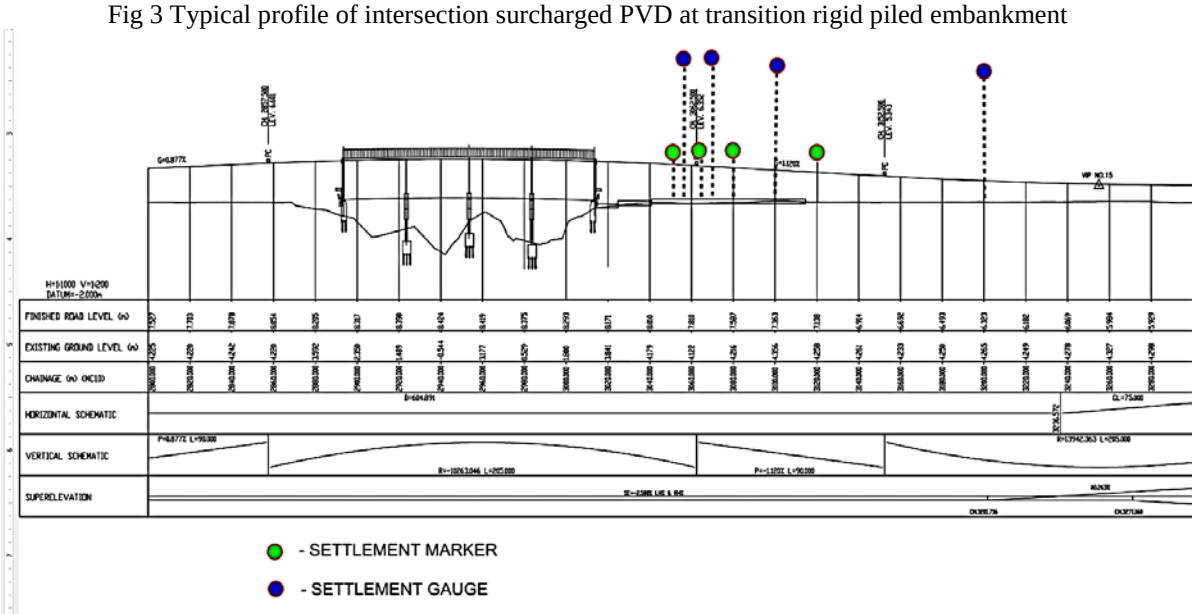

Fig 4 Embankment profile with instruments locations

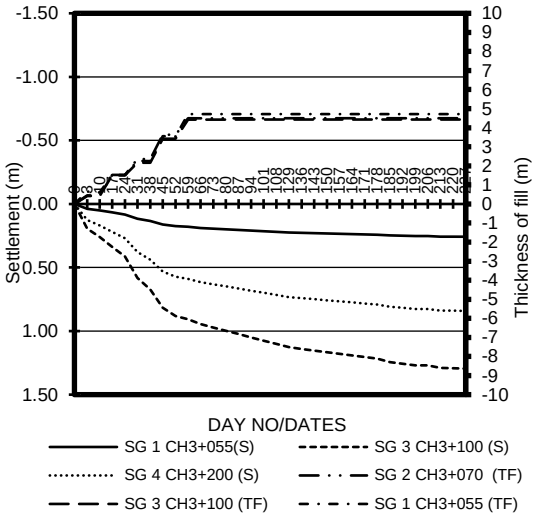

Fig. 5: Settlement gauges results

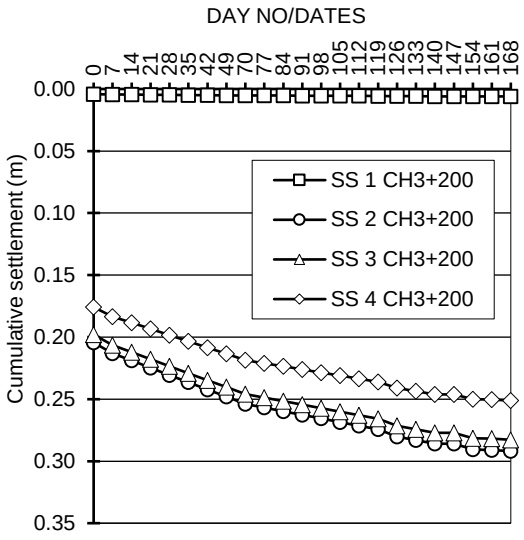

Fig 6 Settlement markers results

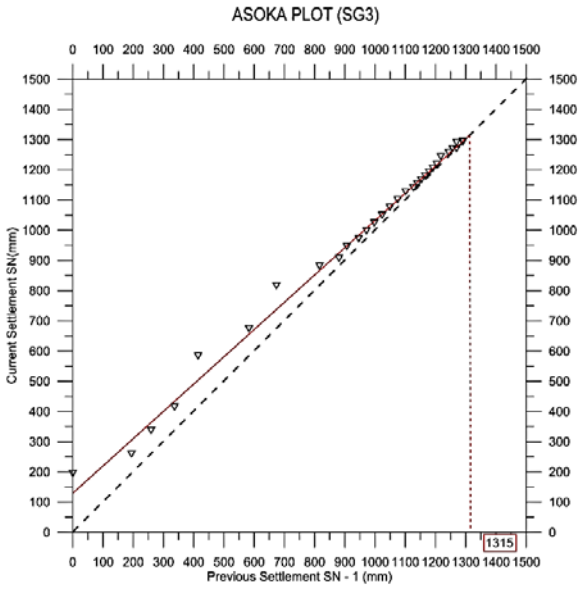

Fig. 7 Asaoka Plot for settlement gauge #3

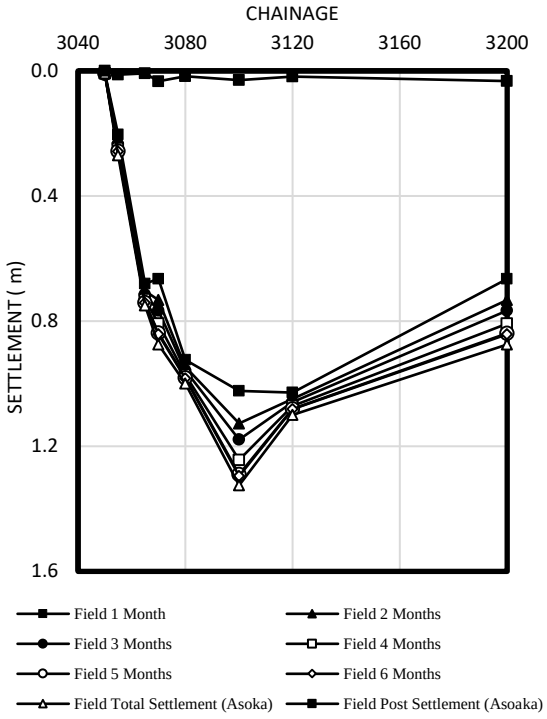

Fig. 8 Comparison of field and theory results

4. CONCLUSION

The results obtained and the observation made inthis study draw some conclusions. These are:

1) Transition Piled Embankment with surcharged PVD zone successfully accelerated the settlement at the transition piled embankment by 95 to 99% during construction period.

2) Differential settlement is within the acceptable limit as the post construction settlement is less than 5% of the total settlement induced by the embankment fill.

3) Insignificant total settlement throughout the embankment with the aid of Transition Piled Embankment with surcharged PVD zone promote smooth road embankment.

4) Undulating problem is arrested with the introduction of Transition Piled Embankment with surcharged PVD zone.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

[1] Gue, S. and Y. Tan. Prevention of failures related to Geotechnical Works on Soft Ground. in Special Lecture, Malaysian Geotechnical Conference. 2004.

[2] Kordi, N.E., I.R. Endut, and B. Baharom. Types of damages on flexible pavement for Malaysian Federal Road. in Proceeding of Malaysian Universities Transportation Research Forum and Conferences. 2010.
[3] Hewlett, W. and M. Randolph. Analysis of piled embankments. in International Journal of Rock Mechanics and Mining Sciences and Geomechanics Abstracts. 1988. Elsevier Science.
[4] Dey, A. Vertical drains and smear effects: a brief review. in Proceedings of the National Symposium on Geoenvironment, Geohazards, Geosynthetics and Ground Improvement, New Delhi, India. 2008.
[5] Balasubramaniam, A., et al., Settlement of embankments in soft soils. Geotechnical Engineering. Vol. 41, No. 1, 2010, pp. 61.
[6] Indraratna, B., A. Aljorany, and C. Rujikiatkamjorn, Analytical and numerical modeling of consolidation by vertical drain beneath a circular embankment. International Journal of Geomechanics, Vol. 8, No. 3, 2008, pp. 199-206.
[7] Bo, M.W., et al., Laboratory measurements of factors affecting discharge capacity of prefabricated vertical drain materials. Soils and Foundations. Vol. 56, No. 1, 2016, pp. 129-137.
[8] Tomlinson, M.J., Pile design and construction practice, E & FN Spon, London. 1994: ISBN 0-203-23885-0. 411p.