Stability of Road Embankment Adjacent Canal in Rural Road Network

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ABSTRACT: This study focuses in the road embankment stability which beside irrigation canal of Department of Rural Road (DOR) in 3 provinces at central of Thailand (Ayutthaya, Pathumthani, Chacheongsao). The almost of rural roads are used for community transported that low traffic volume and rare heavy load. DOR has 92 road embankments with 1,203 kilometers road networks in 3 study province. The most at risk 9 roads are selected from preliminary survey with 4 criteria: close by canal, tension crack detected, used to failure and narrow right of way. The main study for 9 embankment are soil investigation and geometry survey for 5 sections in each embankment road, The slope stability analyses are perform for 45 sections by PLAXIS finite element program, The factor of safety from analyses are found between 1.5-2.0. Some sections were slope failure or high differential settlement. The analysis results show that the stabilities of embankment are slightly low for normal situation. The embankment probably toward to failure when the rapid drawn-down of adjacent canal occurred or the heavy traffic load was placed.

1 INTRODUCTION

This study is focus on the stability of road embankment beside irrigation canal in 3 provinces of central region, Thailand. The almost area in Ayuthaya province, Pathumthani province and Chacheongsao province are deltaic deposited soil in a basin, which consists of a series of thick marine and soil deposits. Up to a depth of 14 m to 18 m from the ground surface, soft clay was encountered as shown in Figure 1.

This soft clay layer becomes the serious problem of stability failure and long term settlement.

Below that, the highest layer of stiff clay can be found with a thickness of approximately 10 to 15 m. A layer of sand, which consists of fine sands or sandy clays with a thickness of 5 m to 15 m, underlies the stiff clay layer. Underneath this first sand layer, a second layer of stiff clay is present, which is followed again by a second layer of sand. The soil layer in this study zone is presented in Figure 2.

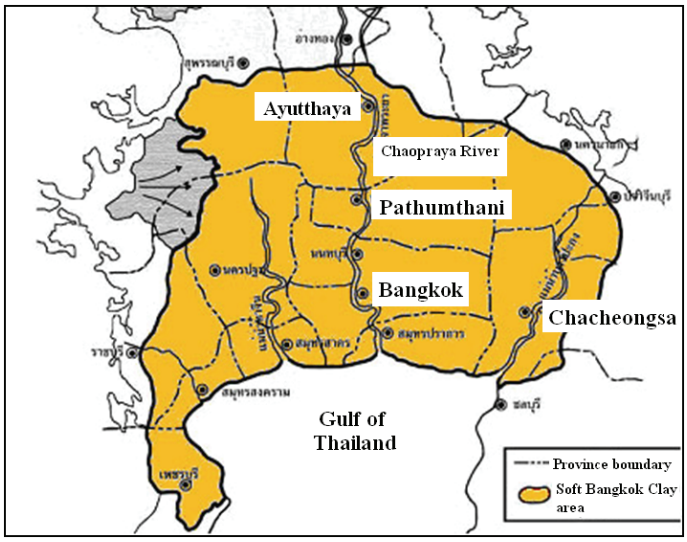

Figure 1: Soft Bangkok Clay area and Study area.

The road embankments in these 3 provinces especially beside the irrigation or natural canal usually face with high settlement problem and slope failure problem. The almost of rural roads are operated for community transported that low traffic volume and rare heavy load. The causes of failure are changing of water level suddenly and limit of right of way that cannot construct the flat slope of

embankment. This study is analyzed the stability of road embankment adjacent canal to check the safety for rural road service and determine the suitable protection and maintenance method in the future.

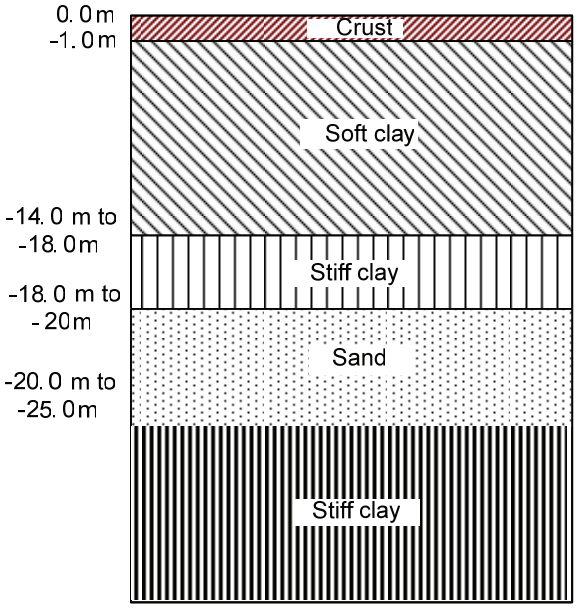

Figure 2: Soil layer in study area.

There are 3 major steps of methodology for this study.

1.Preliminary survey; to classify the road embankment in study area that risk to failure of slope. There are 4 criteria to consider the rural road as follow; a) adjacent the canal, b) used to failure in the past, c) tension crack was found at embankment surface and d) narrow right of road way.

2.Detailed investigation; to survey the embankment and canal sections and subsoil investigation from selected road in step 1 which matched with criteria. The road failure or any damage also observed in this step.

3.Analysis; to analyses the investigation results and slope stability analysis by PLAXIS.

2 INVESTIGATION DATA

From preliminary survey, Ayutthaya province has 35 rural roads in responsibility which constructed in 17 Amphur (district) and 372.67 kilometers for total length. In Pathumthani province, there are 31 rural roads in province area that constructed in 6 Amphur with 419.33 kilometers for total length. In Chacheongsao province, there are 26 rural road which constructed in 10 Amphur and 411.06 kilometers for total length. The preliminary data with the consideration of 4 risk criteria condition shown that there are 9 rural roads mostly tend to face with stability problem which found in Ayutthaya province 4 rural roads, 3 rural roads in Pathumthani province and 2 rural roads in Chacheongsao province.

For detailed investigation, the leveling survey to obtain the cross section of embankment and adjacent canal were perform in subsequently stage. The investigations of embankment damages were also made in most 9 risk rural road. The visual investigation was applied for damage observation. The embankment and canal cross sections were observed 5 cross sections in each rural road, totally 45 sections for 9 rural roads. The investigations of damage or destruction in rural roads show that road and embankment damages can be detected in every investigated roads. The road damage that found can be divided into 3 types.

1.Damage caused by high or differential settlement rate.

2.Damage caused by stability failure.

3.Damage caused by combination of settlement and stability failure.

The details for each type were described as follows. In type 1, the damage was found in high settlement of embankment or differential settlement of cross section. This settlement can be noticed the rough surface from the top layer of embankment. The water can be storage in this difference level and seepage to subsoil below caused of softening of embankment and foundation soil. Subsequently, the problems and damages are expanded and affect to road utilization as shown in Figure 3.


Figure 3: High settlement damage type.

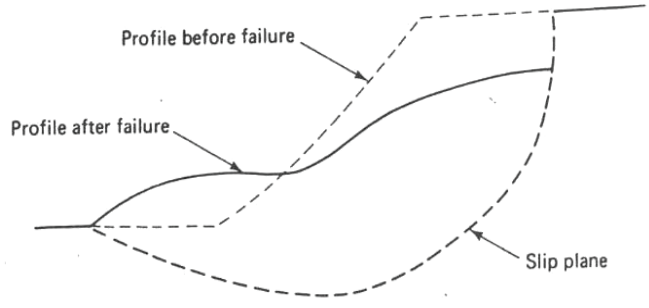

Figure 4: Embankment cross section before and after of slope failure.

The damage type 2 is failure from slope stability. The typical cross section at before and after of failure is shown in Figure 4. Early stage of this damage notified by tension crack at surface of road embankment and continued increasing of width and length. The embankment body collapsed down and occurred the heave at embankment toe in final stage as shown in Figure 5 from investigation data.

Figure 5: Slope failure of embankment.

The damage type 3 is the combination of high settlement in early stage and develop to slope stability failure. The road embankment may failure if high settlement was monitored and no maintenance or restore in appropriate time.

The analysis of road condition after the physical survey was perform to evaluate the road damage level and progressive of failure. In this study, the levels of damage condition were classified into 3 levels as follows.

Level A : Good Condition. In this level, the embankment including road surface have been good characteristic. There were no destructions or damage in very small scale to observe. For example, hair crack on road surface or very tiny erosion at slope of embankment were not detected by visual investigation and traffic serviceability still in safe condition for users. The road embankment in good condition is shown as Figure 6. Road in good condition no require the repairing but the period monitored of damage progressive still required.

Level B : Fair Condition. Some surface carcks or small destruction may be observed on road surface in this level condition. There are no serious fracture or large settlement generate into embankment. The traffic still safely operate for this level, Figure 7 shown the embankment for this condition. The damage that already noticed must be reported to responsible person to begin the maintenance procedure.

Figure 6: Road in Level A : Good condition.

Figure 7: Road in Level B : Fair condition.

Level C : Poor Condition. The differential settlement of fracture and crack can be clearly observed in this level. The tendency of damage progressive may be appeared. In some case, the embankment damage was extremely unstable or collapse through out of service traffic area as shown in Figure 8. The damage of this level was in danger to road user which must be immediately restabilized and restore the embankment to safely condition.

Figure 8: Road in Level C : Poor condition.

3 RESULTS

The damage investigation in 45 points of 9 roads can be classified into type and level of damage.

Table 1: show the number of damage which separated by type and level.

Type of Damage	Settlement			Slope Failure			Sett. + Failure		
Damage Level	A	B	C	A	B	C	A	B	C
Road No. PT 1021	1		1			3			
PT 3020	1				2	1	1		
PT 3014				1	3			1	
AY 4014		1	1			3			
AY 3011	2	1	1						1
AY 4028	1			2		2			
AY 4031	2				2	1			
CS 3028	1	1						2	1
CS 4016		1						2	2
Total	8	4	3	3	7	10	1	5	4

* PT = Pathumthani province
AY = Ayuthaya province
CS = Chacheongsao province

The establishment of execution criteria after the road evaluation was achieved in this study. The decision to resolve the road damage in immediately repair or normally maintenance depend on the field investigation data. The damage evaluation should be considered the level of destruction, the extension of damage and effect to people. The selection of maintenance method was plotted in Figure 9.

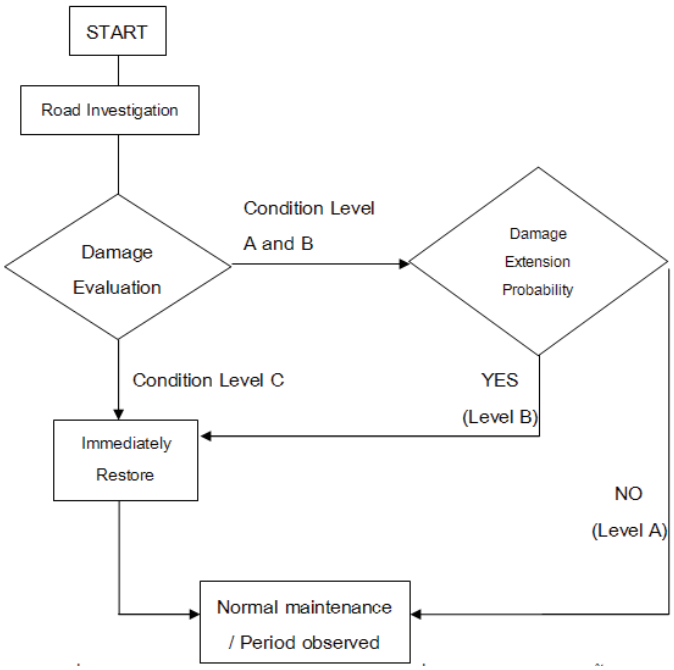

Figure 9: Flow chart for select the maintenance method.

Subsequently, the analysis of finite element model by PLAXIS was accomplished to determine the stability of road embankment adjacent the canal. In PLAXIS, the stability analysis was calculated in the method of *Phi-c-reduction* that can be used in PLAXIS to calculate a global safety factor. In this approach the cohesion and the tangent of the friction angle are reduced in the same proportion:

$$\frac{c}{c_r} = \frac{\tan\phi}{\tan\phi_r} = \sum Msf \qquad (1)$$

The reduction of strength parameters is controlled by the total multiplier *ΣMsf*. This parameter is increased in a step-by-step procedure until failure occurs. The safety factor is then defined as the value of *ΣMsf* at failure, provided that at failure a more or less constant value is obtained for a number of successive load steps. The failure surface was plotted by PLAXIS analysis as shown in Figure 10.

The slope stability analyses are perform for 45 sections by PLAXIS finite element program, The factor of safety from analyses are found between 1.5-2.0. Some sections slope failure or high differential settlement were discovered. The analysis results show that the stabilities of rural road embankment are slightly low for normal situation. The embankment probably toward to failure when the rapid drawn-down of adjacent canal occurred or the heavy traffic load was placed.

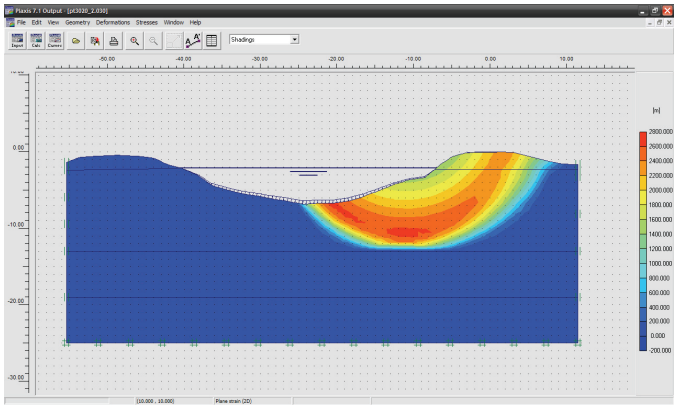

Figure 10: Failure surface plotted by PLAXIS.

REFERENCES

Abramson, L.W., T.S. Lee, S. Sharma and G.M. Boyce, 1996, Slope stability and stabilization methods, New York, Wiley.

Chirapuntu, S. And J.M. Duncan, 1977, Cracking and progressive failure of embankments on soft clay foundations, International symposium on soft clay, Bangkok, Thailand, July.

Dikau, R., D. Brunsden, L.M. Schrott and L. Ibsen, 1996, Landslide recognition identification movement and causes, New York, Wiley.

Leroueil, S., Jean, P. and Tavenas, F., 1990, Embankments on Soft Clays, London, Ellig Horwood, pp. 40-49.

Varnes D.J., 1996, Landslide types and processes, Landslides: Investigation and Mitigation. Transp. Res. Board, Spec. Rep. 247, pp 36-75.