Raw Water Canal Stabilization for Protection against flood

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Abstract

Metropolitan Waterworks Authority (MWA) had been greatly affected by the flood disaster in October to November 2011. Overwhelming low quality water from the flooded Industrial Park and its surrounding communities overflowed the canal's dyke and entered into the east bank raw water canal. As the result, MWA needed to increase the amount of chemicals to cope with such unacceptably low quality of raw water. Temporary dyke was also constructed along the canal with afford to stop low quality water to additionally enter into the canal. After the crisis, permanent scheme for protecting the entire length of canal from Bangkhen Water Treatment Plant to Samlae Raw Water Pumping Station is developed into the urgent plan. The objective of this paper was to studied appropriate flood protecting structures for raw water canal that optimized all requirements including limited time and cost. Additionally, the method of piling along the canal's existing dyke that provided the minimum effect to slope stability was also of interest. Findings could be drawn as follows; The final solution for flood protection should be comprised of 3 main forms of structures including 1) light reinforced concrete retaining structure, 0.22×0.22×12 m L-shape pile, 2) reinforced concrete retaining wall, 0.35×0.35×14 m I-shape pile, 3) compacted clay dyke. Having been finished, these structures were expected to effectively provide sustainable protection to east bank raw water canal as well as provide acceptably improved canal's stability.

Keywords : Flood, Canal, Stabilization, Pile foundation, Concrete structure

1 STATEMENT OF THE PROBLEMS

In 2011, there were the great floods in Thailand that results in low quality water entered into the east bank raw water canal of Metropolitan Waterworks Authority and overflowed to the nearby communities along the canal. From that situation, Metropolitan Waterworks Authority had to incurring the expenses of about 500 million baht. So, in order to protect the flood for east bank canal that may occur in the future, raw water canal system design and construction plan for flood protection was initiated. The plan could be divided into 3 phases; details are shown in Table 1.

2 OBJECTIVES

To study about the design and construction of the flood protection system in different methods, for the flood protection along water canal from Samlae raw water pumping station to Bangkhen

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water treatment plant in the total distance of 17.8 kilometers (or 35.6 kilometers length, including both side of raw water canal) and also assess the stability of the canal. The results would be calculated as the safety factors, not to exceed a certain threshold.

Table 1. Construction Plan.

Phase of Construction	Budget (Million Baht)	Details
1. Emergency	40	Reinforcing an existing dyke by increase its height to prevent flooding
2. Urgent	517	Reinforcing an existing dyke, Constructing road, Piling, Constructing re-taining wall, constructing reinforced concrete retaining structures
3. Permanent	2,000	Constructing and Improving the efficiency and stability of the bank in or-der to completing the Construction from Phase 1 and 2

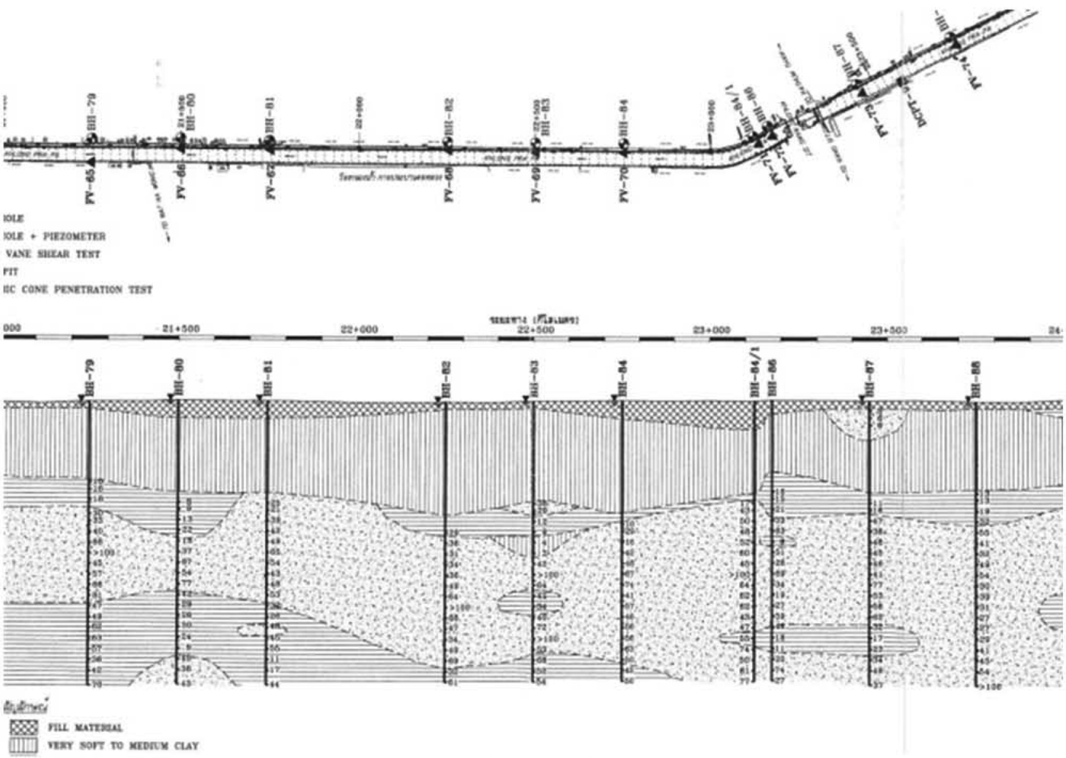
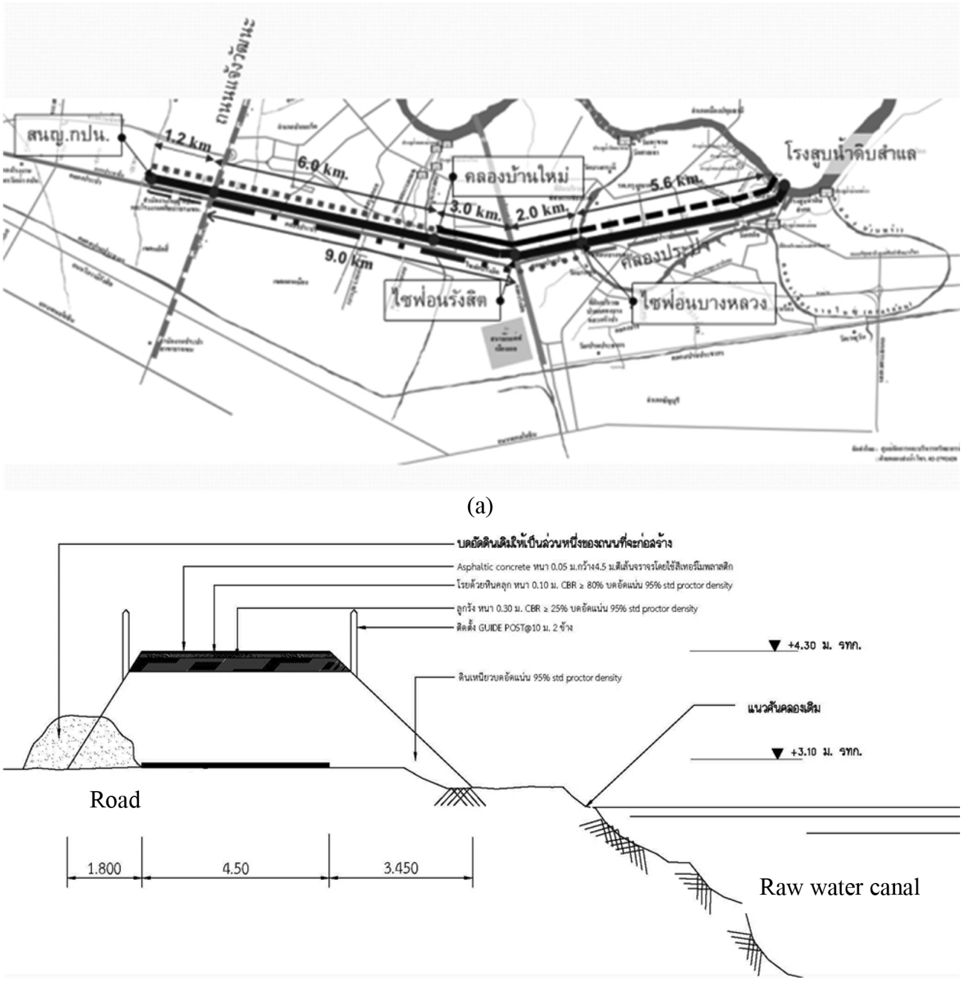


Figure 1. Boring Logs.



(a)

(b)

Figure 2. Cross-sectional Profile of Raw water canal.

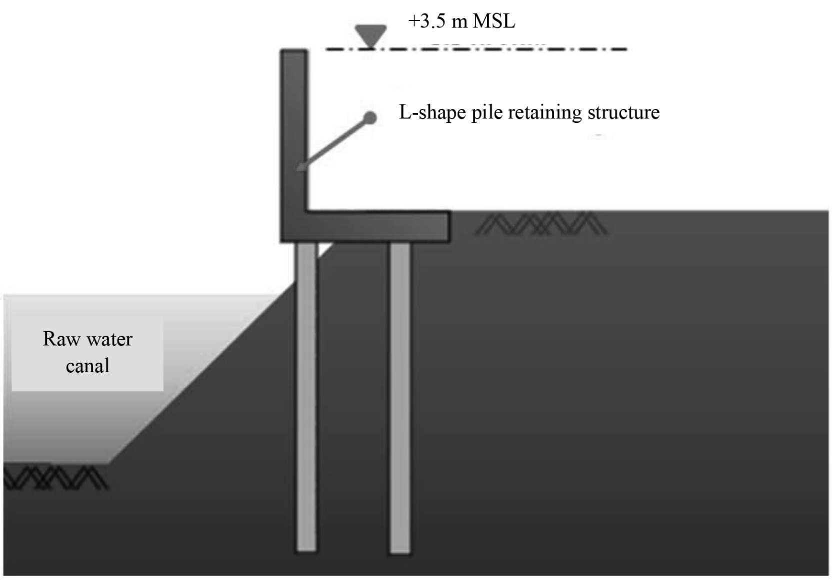


Figure 3. L-shape reinforced concrete retaining structure.

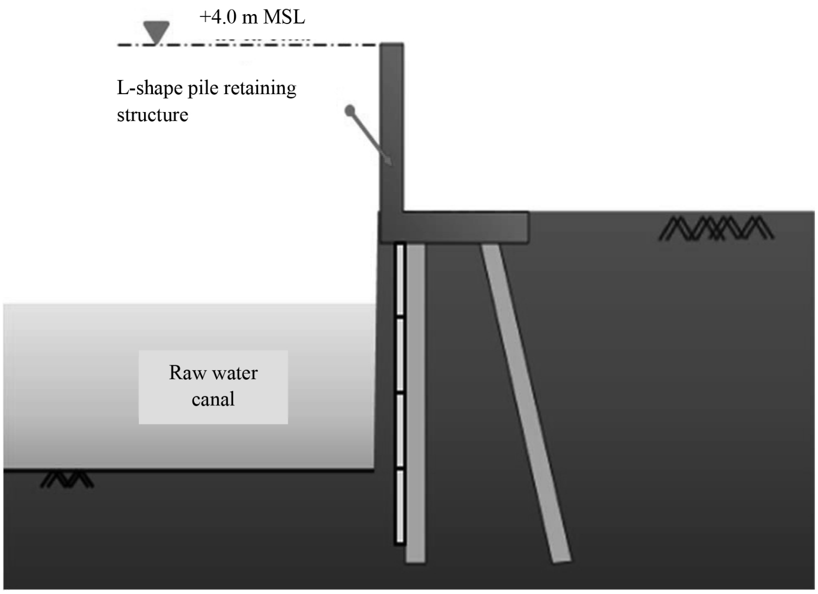


Figure 4. Retaining wall.

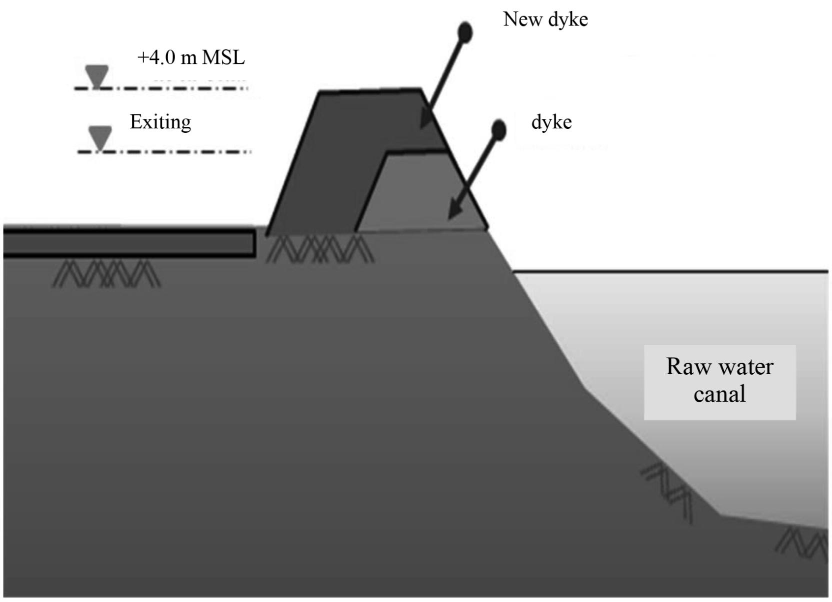


Figure 5. Dyke Reinforcement with pile.

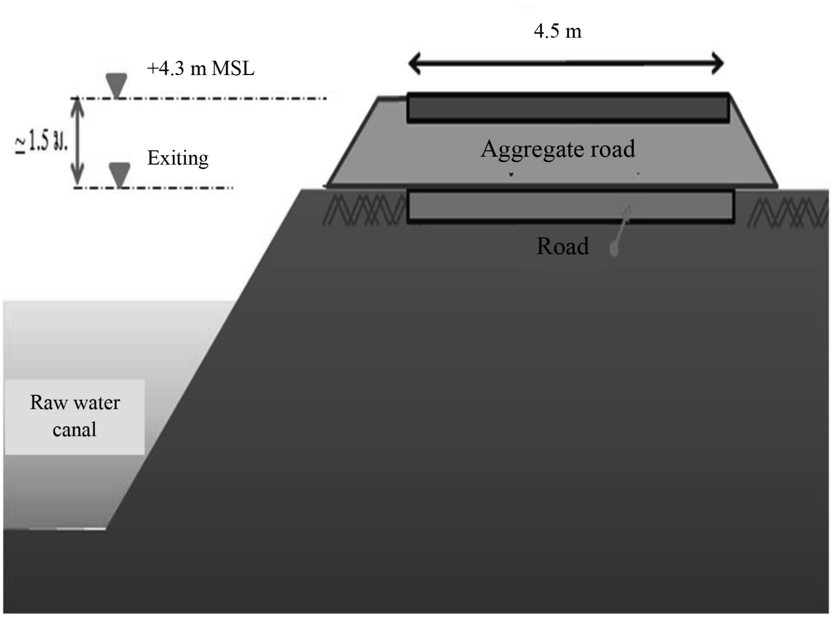


Figure 6. Road Enhancement.

3 METHODOLOGIES

To study about the design and construction of the flood protection system in different methods, for the flood protection along water canal from Samlae raw water pumping station to Bangkhen water treatment plant in the total distance of 17.8 kilometers (or 35.6 kilometers length, including both side of raw water canal) and also assess the stability of the canal. The results would be calculated as the safety factors, not to exceed a certain threshold.

3.1 Soil horizon characteristics along the raw water canal

From the boring logs showed the detail of soil hori-zon that consists of soft clay, stiff clay, silty clay, and dense sand layers. While each layers of soil are featured in Figure 1.

3.2 Construction area and raw water canal appearance

Construction area of flood protection system starting from Samlae raw water pumping station along the canal to Bangkhen water treatment plant is shown in Figure 2(a), and the cross-sectional profile of raw water canal is shown in Figure 2(b).

3.3 Criteria Principles and Design

The criteria to design flood protection system consists of: 1) Able to prevent flooding along raw water canal with stability and security 2) Designing according to Green Building criteria, to reduce the impact on the environment and nearby communities 3) Designing flood protection system in consistent with raw water canal profile 4) Taking the constraints of times and budgets used for designing into accounts. The criteria for determining the Factor of Safety of earthworks is shown in Table 2.

From the criteria, characteristic, and construction area stated above, the plan will mainly focus on Phase 2 construction. Therefore, the plan would be subdivided into six minor plans as detailed in Table 3. Construction form details of the L-shape reinforced concrete retaining structures, retaining wall construction, dyke reinforcement, and road en-hancement are shown in Figure 3 to 6.

4 SAFETY FACTORS ANALYSIS

The area for flood protection system is the area along raw water canal with a length of 17.8 kilometers, re-sults to high cost of construction. The construction must be completed in a limited time (within one year to prevent expected flooding) and must have the min-imum affect to raw water canal characteristics.

L-shape pile retaining structure for flood protection was designed to use the light reinforced concrete square pile sized 0.22x0.22 m with the length of 12 m. This structure is designed to support 2.1 ton shear force and also can support the bending moment caused by ground movement while there is the load acting on. The raw water bank was designed to support the moment of 1.6 tons per meter according to the reinforced concrete by special pre-stressed concrete wire standard. The analysis for designing the pre-stressed con-crete pile in order to support sided ground move-ment around the raw water canal re-quires checking, and analyzing for the stability of raw water canal slope, both before piling, and between the first and the second piling. Moreover, the analysis of sudden flood that the weight of water will affect L-shape reinforced concrete retaining structure also needed to be done. The retaining structure must be controlled to prevent Overturning failure, Sliding failure, Bearing Capacity failure, and Rota-tional failure that may occurred behind the L-shape reinforced concrete retaining structure.

The controlling needed to be done by given that the summation of shear force and moment due to lat-eral earth pressure loads in the event of action, whether the weight of the car that runs along the canal and weight of flood water, must not exceed the lateral bearing capacity of the concrete piles. The analysis is done by using the static calculation to determine the forces. Also, in order to analyze the ground movement around raw water canal slope, computer is needed to be an analyzing tool; in this case we mostly used the KU slope program. For entering the parameters into the program, adjusting of the ground strength needed to be done at all times, particularly adjusting of the Field vane shear obtained from the field test. This is done in order to make an analysis corresponding to reality as much as possible.

There is a tremendous need for the analysis of ground movement, because the area of piling is placed in the community with high traffic density (on Changwattana Road, behind Muang Thong Thani). The finite element method is used as an aid in the analysis, by simulates piling in a computer program then analyzes the ground movement. Due to small size of pile coupled with pre-bore before piling, the soil replacement is relatively small. This causes the analyzing result being based on the acceptable crite-ria, of not more than 10 centimeters [1-8].

Table 2: Criteria for determining Factor of safety of Earthworks.

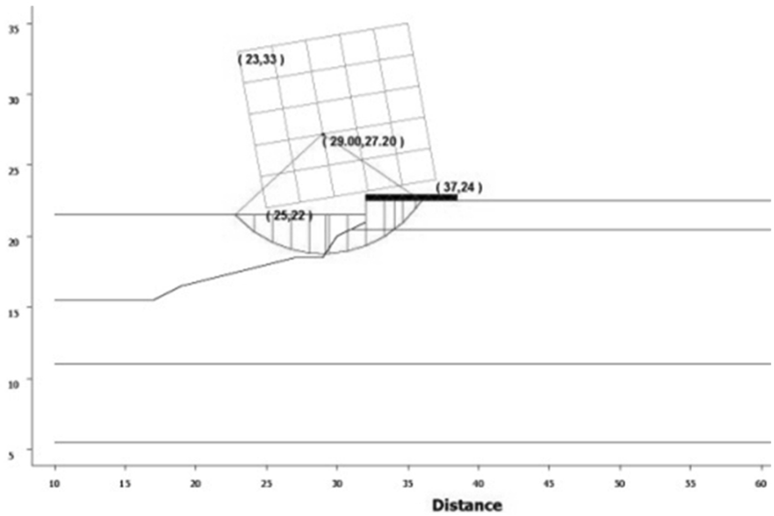
Characteristics of Earthworks	Factor of Safety
Embankment, end of construction	1.00-1.20
Cuts , end of construction	1.20 and over
Embankment , long term stability	1.20-1.40
Cuts , long term stability	1.20-1.40
Earth dams	1.50 and over
Earth dams – extreme conditions of immediate loading, viz. severe flood followed by sudden drawdown	1.10-1.25

Table 3: Urgent Construction Plan.

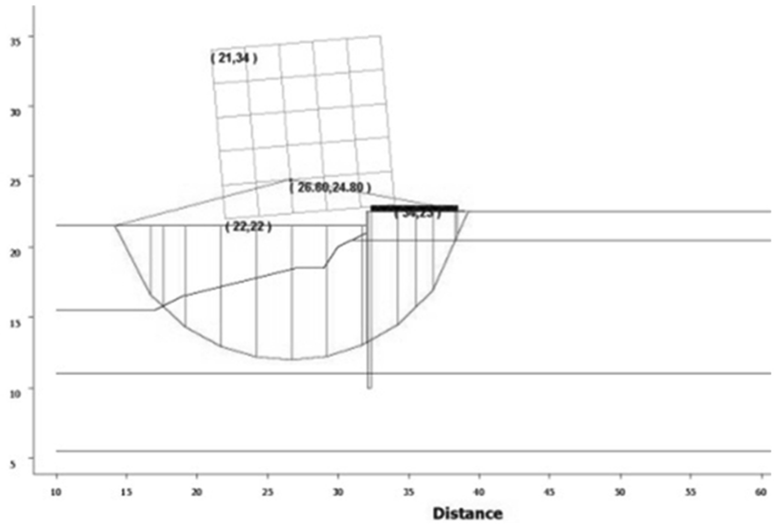
Construction Characteristics	Construction Area	Distance (km)
1) Enhancing the height of the road along raw water canal	From Samlae raw water pumping station to Rangsit siphon	7.6
2) Retaining wall construction	Specifically for the east bank of raw water canal where the failure occurred, from Bangluang siphon to Rangsit siphon	0.05
3) Enhancing the height of existing road, together with construction of L-shape reinforced concrete retaining structure	Along the Westside of raw water canal, from Rangsit siphon to Ban Mai canal	5.0
4) Construction of L-shape reinforced concrete retaining structure	Along the Westside of raw water canal, from Ban Mai canal to Bangkhen water treatment plant	7.2
5) Reinforcing the dyke, pile, and L-shape reinforced concrete retaining structure	Along the Eastside of raw water canal, from Rangsit siphon to Changwattana road	9.0
6) Reinforcing the dyke	Along the Eastside of raw water canal, from Changwattana road to Bangkhen water treatment plant	1.2

Table 4: Sta.23+555 slope stability analysis of the FV-16

Construction case	Factor of Safety analyzed by KU slope method			
	Ordinary	Simplified Janbu	Simplified Bishop	Spencer
Before Piling	2.523	2.383	2.485	2.487
After first piling	3.594	3.204	3.455	3.470
After second piling	4.154	3.597	4.001	4.019



(a)



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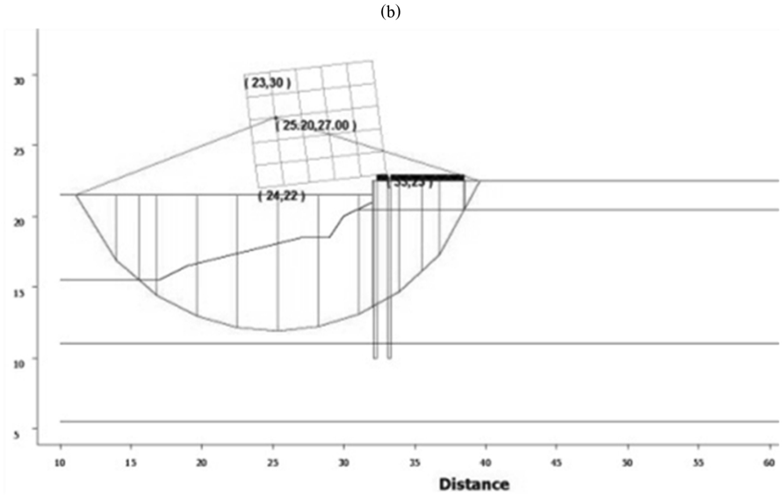

(c)

Figure 7. The calculation results of slope stability, while no piling (a), after first piling (b), and after second piling (c).

5 RESULTS OF CALCULATIONS AND ANALYSIS

From the given information, found that the Factor of safety of raw water canal after the first piling is greater than 1.1 to 1.25 as shown in Table 2, which is in accordance to the criteria. For preventing the sided ground movement, there are the calculated results listed in Table 4.

Computational load exerted on raw water canal slope could be classified into two cases: the case of no flood while there are vehicles running along the canal (The load of the vehicle that exerted to raw water canal slope equal to 1 ton per square meter), and the case of flood condition including vehicle load acting on the raw water canal (The total load is equal to 3 tons per square meter). The calculated results are shown in Figure 7.

6 CONCLUSION

Designing of flood protection system for raw water canal slope can be seen that, there are many possible concepts to solve flood problem. The design must be subject to the restriction on the budget, limited con-struction time, and traffic density around raw water canal areas, which are the hindrance to the process of design and construction. These hindrances may result in the imperfections to the flood protection system, so the restrictions must be checked and continued with budget setting-up for design and construction of flood protection along the canal permanently.

In the part of dyke that supporting by a single pile which is the temporary structure, when time passed for a while and if there is plenty of rain, the soil may hold water to its capacity and there might be a failure in the slope along raw water canal. Erosion of the raw water canal, due to the flow and fluctuations of raw water in the canal are also the factors those affect the stability of the slope of the canal. So, the water level needed to be controlled to be not exceeds a given threshold of Rapid Drawn Down. The various factors mentioned above, are the factors that affect the stability of flood protection system. The construction analysis, design, and problem solving, require engineers' knowledge and experiences in order to solve and mitigate flooding problems those may occur in the future.

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