THE INCIDENTS OF BRIDGES AND ROADS AT PLAIN OF REEDS - VIETNAM AND SUGGESTED SOLUTIONS

NGUYEN THANH NGUYEN
Ho Chi Minh City Open University, Vietnam – thanhnguyen@longan.gov.vn

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ABSTRACT

Plain of Reeds, a wetland of Mekong Delta of Vietnam has a very special geologic feature. This area is a contiguous zone between ancien and new alluvia layers which cause sudden change of geology; in addition, the density of river and canal is very high. Because of the geologic alterability and design mistakes, many incidents of traffic constructions have occurred in the Plain. Statistically, most of the incidents are from the careless geology survey and the subjectiveness of designers. This paper presents some road and bridge incidents in the Plain, causes, and recovery plans. The article also proposes solutions for new traffic constructions in such environnment.

Keywords: Geologic survey; land slide; resolution; road-bridge incident; subsidence.

1. Introduction

In the past twenty years, to exploit the Plain of Reeds, many hydraulic and traffic constructions have been constructed. These investments are contributing to the area development. However, there were a lot of road and bridge incidents in this Plain. According to the reports of the Transportation Department of Long An Province, their causes seem similar. Based on the data from design enterprises, this writing presents geologic feature of the area, the incidents and their causes, and suggested solutions. Most of the treatment ways were successful, but there were also failures.

2. Geologic feature and traffic construction incidents

2.1. Geology construction and geomorphology of Plain

Plain of Reeds is a “Back Swamp” with low level (average +1 to the sea level). It is surrounded by high streaks of arenosols along the border of Vietnam and Cambodia, natural digues, and fluvisols tracks of Mekong River. This area has many big swampy-flood pools and it ends at East-Vam Co River of Southern Vietnam.

Plain of Reeds was shaped in Quarternary (Qiv). Its geologic feature is based on two units of sediment, from Pleistocene and Holocene epoch and also the intermediate stage of post - Pleistocene. The complete formation of the Plain began after post-Pleistocene, about 8,000 years ago. In the whole area, the sediment layer of acien alluvia is covered with new material of Holocene sediment. Therefore, the old alluvia mounds and arenosols are found alternate with new alluvia fields. Under the effect of natural factors, wheathering, and biochemical processes, many soil groups were founded: old alluvia, arenosols, fluvisols, thionisols, peat, new alluvia... Geological feature is the weak soil (new alluvia) that situates near the earth’s surface; this soil layer occasionally changes its thickness (see figure 1), especially at places where there are old river-beds, mires, bogs… (Ta *et al*, 2002; Tamura *et al*, 2012). The sudden change within a short distance that is not discovered by surveyors is the reason of many incidents.

Along with low land level, this Plain is an anual flooded area. Every year, flood from Mekong River can cause inundation in about four to five months. The high level of flood is the reason of high embankment and also high clearance of bridges which cause big charge over weak foundation. Besides, the government has digged many canal systems to exploit the plain, and the roads built along canals can cause land slide of embankment.

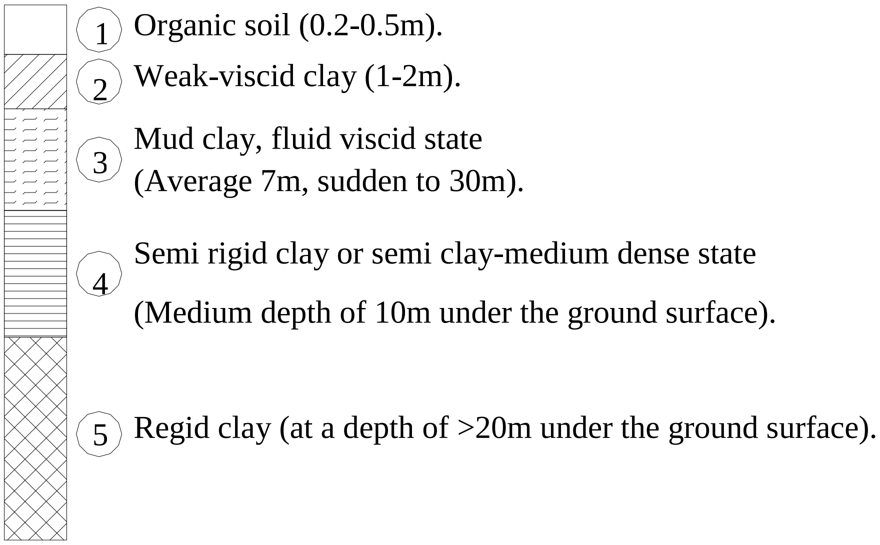

Figure 1. Typical geological section of Plain

2.2. The general reasons of traffic construction incidents

In the last twenty years, many traffic constructions have been built; statistically, there were incidents of roads and bridges by similar causes which were objective or subjective.

➢ According to the government policy, there is the need for cooperation in construction of hydraulic and road projects; when they dig the canals, digged soil is used as the road-bed along these works. The foundation and embankment of roads seem to be cohered naturally, there is no intervention to consolidate the weak soil. Most of national, provincial, and district roads are built by this way. In addition, the minimum distance to canal edge is not observed. This is the reason that causes the deep subsidence and land slide of embankment. Most of road subgrades were built by manual labor and the used soil is organic or peat so its porosity was very high. Generally, the roads are situated near the rivers or canals, along with the weight of embankment, fluctuation of river water level (because of tide and flood), the wave of boats which are agents of road and bridge construction land slide.

➢ In the Plain, because there are many rivers and canals, the density of bridges is very high; in average, the distance of two bridges is 1km. The bridges are usually posed at confluence; because of weak soil, the high approach roadway causes easily two demension land slide (see figure 2). While, the Plain is an anual high flood area of Mekong Delta, so the approach road ways are always built much more higher than the natural earth’s surface to assure clearance of bridge span and flood level; this is the addition cause of construction incidents.

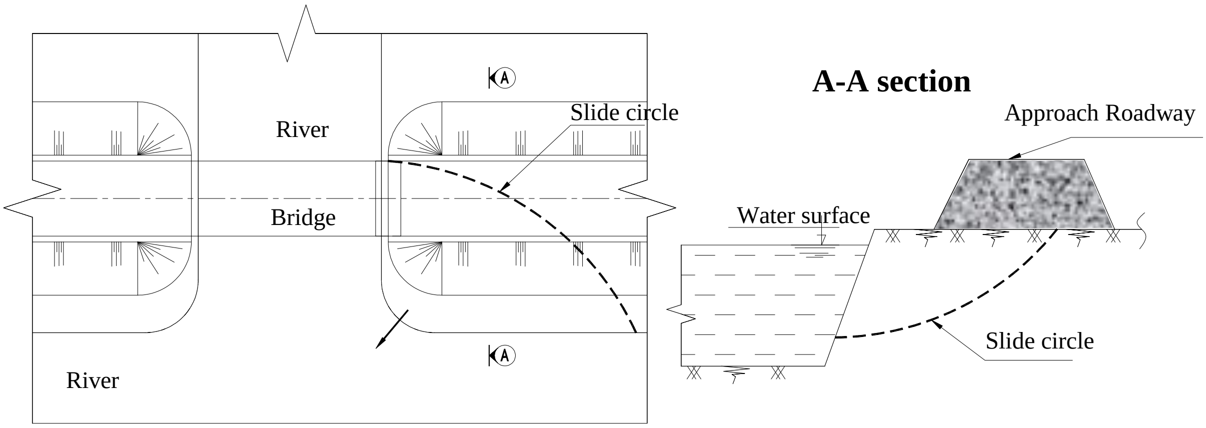

Figure 2. Slide circle of approach roadway

3. The incidents and treatment measures

3.1. Deep subsidence of national road 62 at Tan Lap Commune, Moc Hoa District, Long An Province (LATEC, 1999)

- Incident description: the road was upgraded from the old construction which was built hundred years ago, and there was no elaborate geologycal survey. The medium elevation of old road bed surface was +1.5, the structure of road was graded aggregate, pavement width 4m, subgrade width of 6m. The new road had +4 high level, graded aggregate pavement, 6m of pavement and 9 m width of subgrade. After 6 months of finish, the subgrade subsidence was 1m and 1 year later it reached 1.5m. The incident occured on a distance of 200m and this hindered the traffic, especially in the flood season of 2000-2003 (see figure 3). The resurvey shows that the layer of mud clay layer is very thick and the added hight of fill is 2.5m.

- Treatment measure: after the incident, the geological survey discovered an old river bed in this position and the layer of weak soil was over 30m with low mechanical indicator (c,φ). Two recovery options were proposed.

➢ Option 1: specialists proposed building ‘shoal bridge’ to cross about 300m over the weak soil area. It is safe and long lasting, but time consuming and costly.

➢ Option 2: it is needed to build ‘anti pressure fill’ in two sides of incident road (each side 20m, elevation +3). The method accepted subsidence and added fill. This way had low cost but the recovery time was rather long, and it had to accept traffic inconvinience of frequent fill work (see figure 4).

- Treatment result: because of many reasons, especially of cost, the ‘anti pressure fill’ was chosen. After about 1 year of treatment, the subsidence diminished gradually and after 2 years, the construction was stable and well exploited.

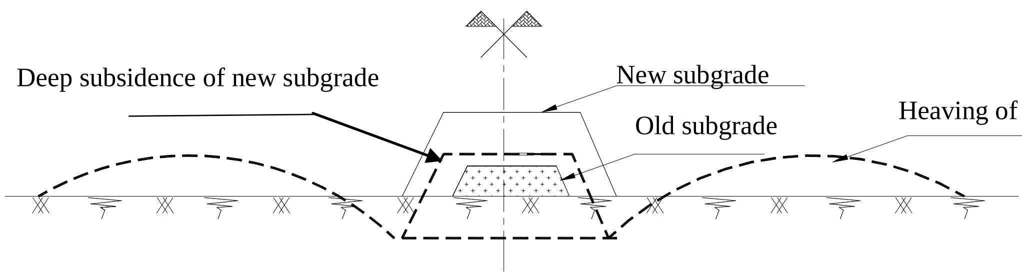

Figure 3. Deep subsidence of subgrade with heaving of soil

3.2. Subsidence incident of Provincial Road 831, near Cai Mon Bridge (LATEC, 2003)

- Description: the road was designed as new construction and situated far of river, the width of subgrade and pavement was 9m and 6m; this area has weak soil with peat and mud clay, its thickness is about 20m. During construction, the fill caused subsidence and the soil heaved two sides of road, the volume of subgrade work increased double to previous calculation. After one year of accomplisment, the subsgrade sank more than one meter.

- Treatment method: because of finance difficulty, 'anti pressure fill' method was used. They filled by soil for 20m each side and the elevation was +2 to the natural land level. When the subgrade sank about 0.4 meter, they continued to fill to assure the pavement level for traffic and anti-flood. After one year of treatment, the subgrade became stable and the construction was exploited normally (see figure 4).

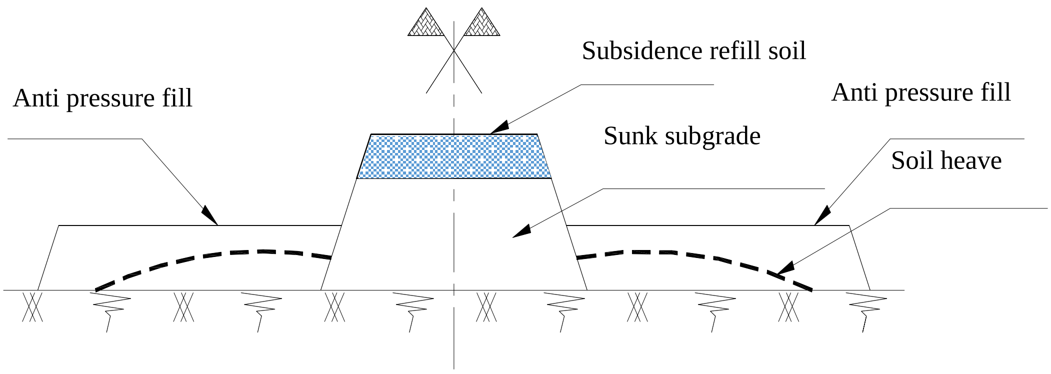

Figure 4. Deep subsidence subgrade treatment

3.3. Approach way of Can Cau brigde incident, Thanh Hung Commune, Tan Hung District, Long An Province (LAHEC, 2011)

- At first, the ferroconcrete bridge was designed and constructed at the cross of two canals. It had following features: width 5m, spans 10-15-10m. The approach way had elevation of +6.5 at abutment (natural land level is +2.1). The soil condition is very weak with the mud clay layer is more than 17m. When the approach way was constructed to +5 level, the land slide of two side slide cicle appeared at A abutment.

- The first treatment: after the incident, they determined that there were three reasons: charge of approach way, weak geological condition and the construction was situated near the canals' bank. The consultant enterprise proposed a solution to treat the land slide by changing heavy soil fill by lighter substance. They changed all embankment soil (γ=1,4-1,5t/m3) by Geofoam, a light material that had natural weight of 33kg/m3, modulus of elasticity of bulk E=7650, compressive strength 79Kpa, flexural strength of 350 Kpa. This light material was protected by HDPE and the steel wall of 5mm (see figure 5-7). After treatment end, this light structure of A abutment continued to slide into the canal. A year later, they discovered that although there was a big load diminishing of approach way, the layer of Biofoam was soaked by flood and rain so their weight increased, in addition with 0.5 m of sand fill and old slide circle, the same incident continued to occur.

- The second treatment: the solution was that: they uncovered all the fill of approach way of A abutment, prolonged other two spans of 15m (see figure 8). The level of fill at new A abutment decreased by 1m to the previous option. The resolution was successful and the bridge is now well exloited.

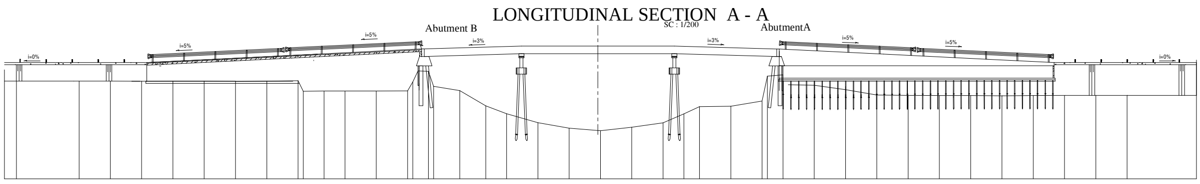

Figure 5. Longitudinal Section of Can Cau bridge first treatment

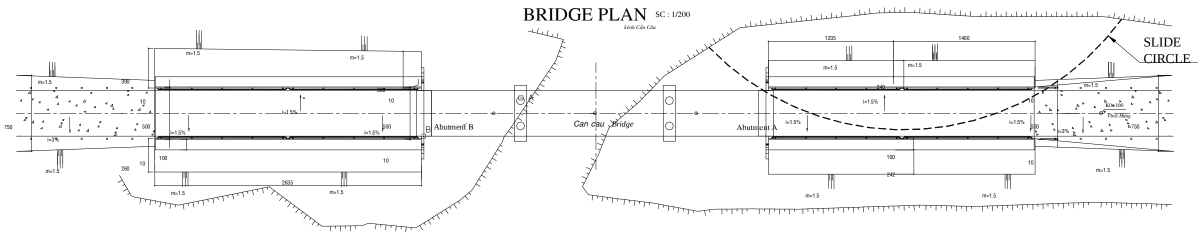

Figure 6. Plan of Can Cau bridge first treatment

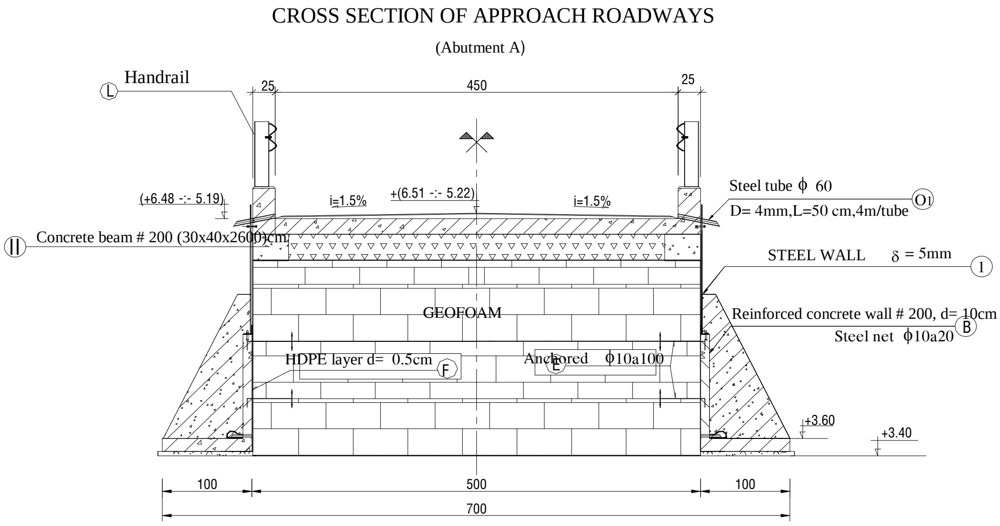

Figure 7. Cross section of approach road way of first treatment

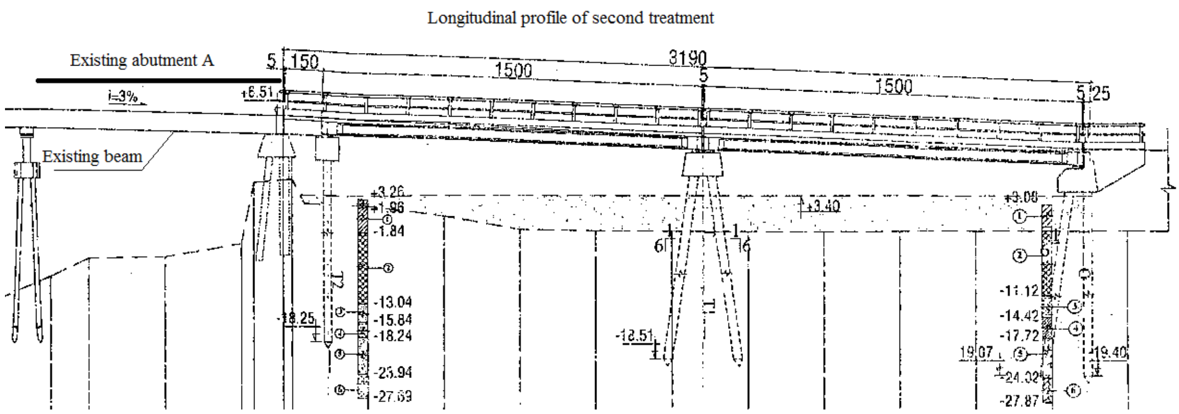

Figure 8. Longitudinal section of second treatment

3.4. Cai Mon bridge incident, Provincial Road 819, Km 37+554, Tan Hung District, Long An Province (TEDISOUTH, 2015-1)

- Incident description: the bridge was designed with these details: width of 10m, prestressed reinforced concrete beams, reinforced concrete pile foundation. It had three spans: 18.6+24.54+18.6. The medium of approach way embankment high was 5m; the foundation of approach way embankment was reinforced in an area of 16x22m by ciment earth piles (Φ600, L12m) with distance of 1.3m. The position of bridge was at the cross of Cai Mon River and 79 Canal. When they filled the embankment to the K98 sand layer (about 4m above natural land level), the M1 embankment slided into the 79 Canal of 75m in length, and the width was more than 20m.

- Reason of the incident: the thickness of weak soil is big. In this area, the clay mud layer is 9m medium and at M1 abutment, it increases to 20m. Besides, the fill of approach way was more than 5m to the existing land level, the construction was near river bank and at the cross of river and canal. The later survey showed that the bed of the canal was deepened more than 2m and this was not updated in the design. Along with the above reasons, the designers did not calculate land slide.

- The proposal treatment options

- Soil reinforcement: all of fill is pulled out, they use geotextile and refill by selected soil to level +3; the position near the M1 abutment (level >+3m), they use the load dispersion floor on reinforced concrete piles (300x300, L=32m).
- Bridge extention: they extend 4 spans of 18.6m or 3 spans of 25.54m from M1 abutment to reduce the fill level of approach road way.
- Load dispersion floor are extended with 75m lenght, 17.5m width, on the piles (l= 20m, 30x30 cm, d=1.8m) from the M1 abutment.
- The approach way of M2 abutment has not yet incident, is under the monitoring of subsidence and slide.

- After analysis of economy and technique, the proposal of four spans extension was selected. The decision was based on cost effectiveness, design, work condition and old slide effect when they continued to reload the approach road way. The bridge was extended 4 spans of 18.6m. The construction treatment finished in 2015 and it is now in good condition (see figure 9-11).

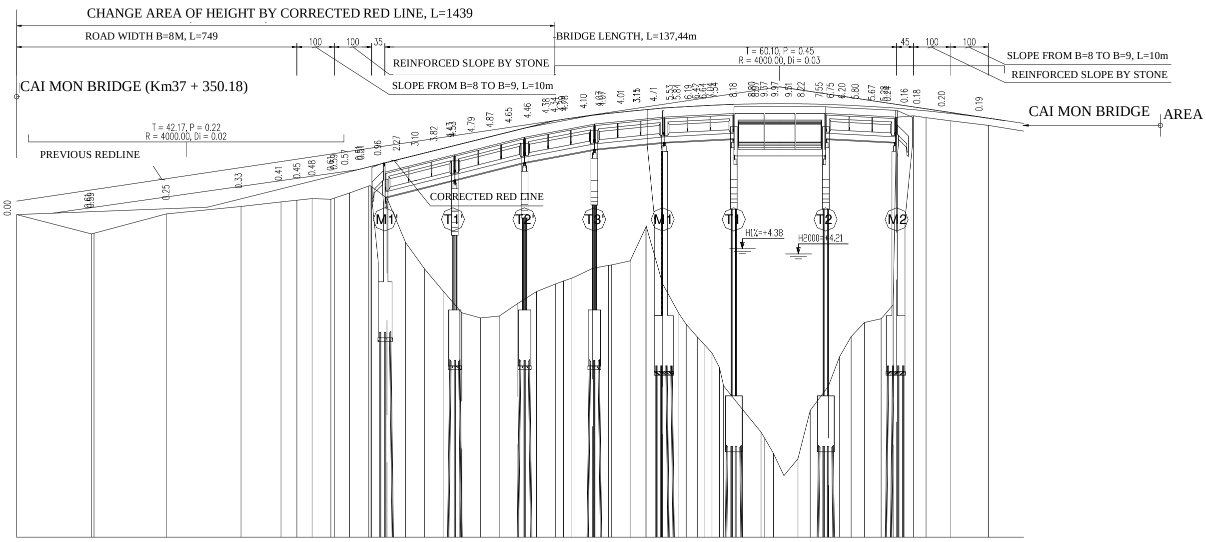

Figure 9. Section of Cai Mon bridge treatment

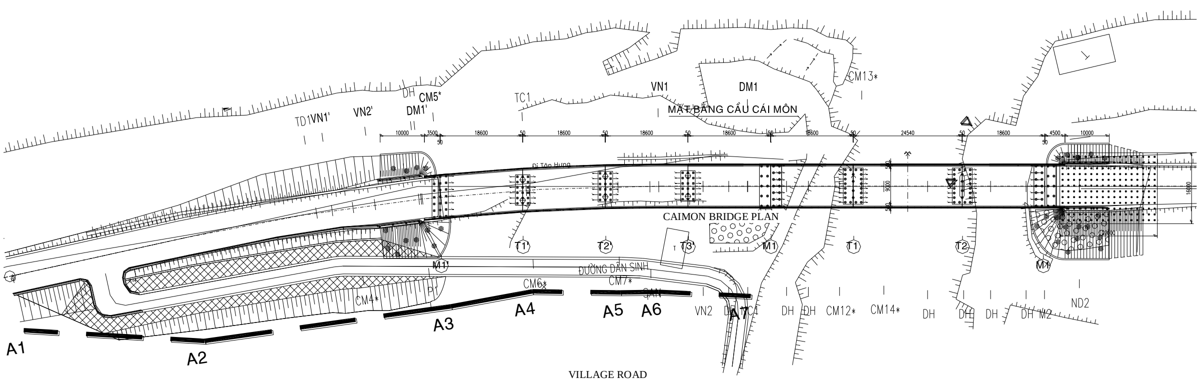

Figure 10. Plan of Cai Mon bridge treatment

Figure 11. Four spans extension of Cai Mon bridge (M1 abutment)

3.5. Incident of Binh Phong Thanh bridge*, *Binh Phong Thanh Town, Moc Hoa District, Long An Province (VBR, 2014)

- The Binh Phong Thanh bridge is a suspension bridge built across Vam Co river. At first, the bridge had 4m width in plate steel, three spans (30-60-30m); two abutments were planned as pile and plank retaining walls for approach road ways. When they built abutment and load A embankment to level +5, it caused a slide circle with its width of 15m to the land. The land slide brought about the overturn of A abutment, the retaining wall inclined to approach way. The cause was determined by many reasons: load of high embankment, near river position of abutment, thick layer of weak soil, design engineers did not calculate land slide, and there was no careful geologic survey.

- The solution: the bridge was extended two spans of 12m for B abutment (it had not yet incident), three spans of 12m for A abutment, the level of embankment is +4 (see figure 12-13). After reconstruction, the bridge was exploited in late 2016.

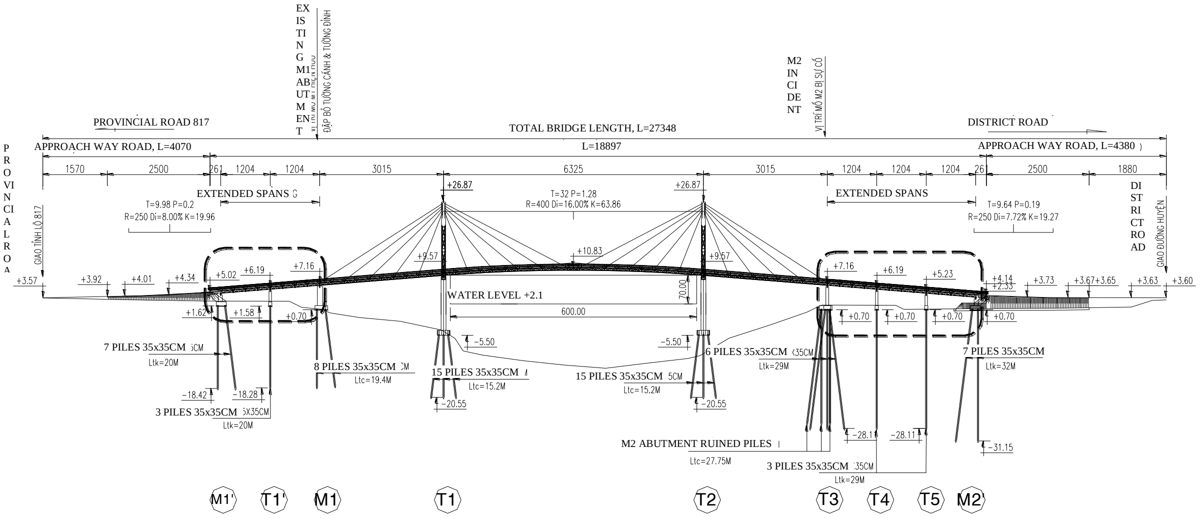

Figure 12. Section of Binh Phong Thanh bridge treatment

Figure 13. Abutment of Binh Phong Thanh bridge after treatment

3.6. The incident of Vinh Binh bridge, Vinh Binh Village, Vinh Hung District, Long An Province (BPLA, 2015; TEDISOUTH, 2015)

- The incident is similar to Binh Phong Thanh bridge. It was also a suspension bridge with three spans (15-24-15m), its width was 3.8m. The brigde had two piers, two abutments that were designed as pile retaining walls for aproach ways. The design was based only the topographic data, and there was no geographic survey. This situation has a thick layer of mud clay and at M1 abutment (along Provincial road 831) there was a land slide five years before. The bridge was unfinished then at M1 abutment, there was a land slide along Provincial road 831, the lengh was 50m, width of 10m. The pressure of land slide overturned the M1 abutment, the retaining wall inclined to approach way, the T1 pier also inclined.

- After incident, the survey showed that there was a thick mud clay layer at bridge, along with the high fill level of Provincial road 831 and approach road way, near the canal. At construction, it occurred a land slide years ago and engineers did not calculate land slide.

- Treatment way: they rebuilt T1 pier, built new T'1 pier, new M1 abutment, extended a span of 3m to connect T'1 pier and new M1 abutment (see figure 14-16).

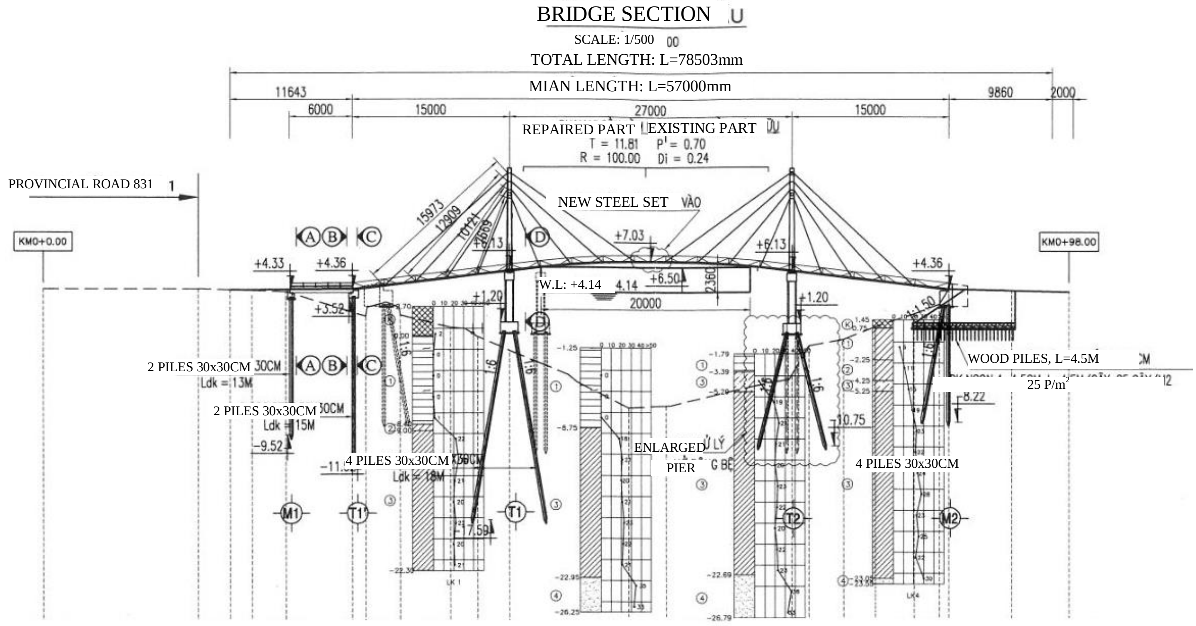

Figure 14. Section of Vinh Binh bridge treatment

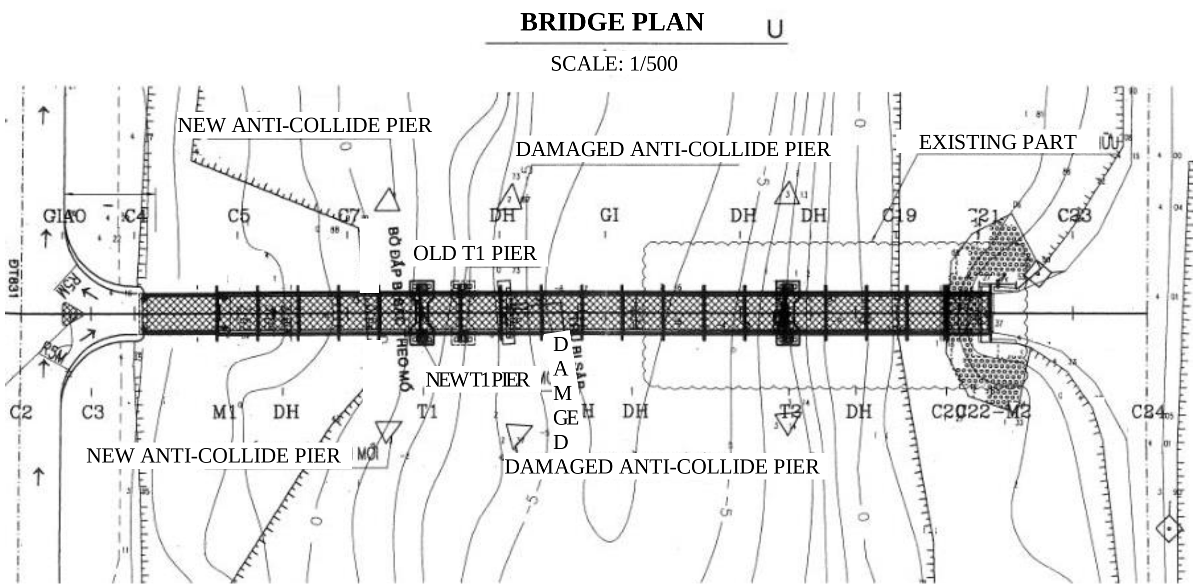

Figure 15. Plan of Vinh Binh bridge treatment

Figure 16. Position of Vinh Binh bridge incident after treatment

4. Causes and lessons

4.1. The causes of incidents

As presented above, the main causes of incidents were the subjectiveness of surveyers and designers.

- Survey works: in choosing the survey option, geologic surveyors usually decided long distance for bore holes, especially for the four grade road (in the design phase, it can be more 200m); so the data of geology couldn't discover the deep weak soil between the two holes. There were cases of bridges constructions: they did not survey or only drilled one hole in the river. The data of soil layer were sometimes interpolated. Beside the unrighteousness, there were subjective factors that they thought in delta, it was not the sudden change of geology.

- About the design organizations: they based on the data of survey units, designers didn't carry out field research, and inclined to paper theory. They skipped the calculation of deep subsidence, land slide circle when there was the high embankment on the weak soil, near the river or river cross; especially where there were the ancien land slide and big fluctuation of tide. When the designers applied new technology, they based on theory in laboratory; there were no experiments on location.

- The association of hydraulic construction with traffic construction is a good idea. However, when they used the dug soil for embankment, they did not reinforce it as well as foundation of road. The position of road is rather near the canal in the weak soil foundation along with high embankment, which caused land slide.

4.2. Lessons and proposals

Through traffic construction incidents in the past twenty years, there are experiences in survey, design and execution of works:

- For survey works, it is necessary to choose the competent organizations which have experience in geologic survey and regional feature. The decision of survey plan (bore holes disposition, deep of holes) needs referring to existing data of previous projects and idea of experienced specialists along with the careful field trips. For instance, when they build a road along a canal, specialists can prevent the change of geology before the survey works. In survey for roads and bridges, it needs not to obey blindly the regulation about road, bridge grade; these Vietnamese instructions are quite unreasonable.

- In design sector, it is necessary to calculate subsidence, land slide for the construction with high embankment on weak soil. Engineers need to test slide circles for embankment of approach way where the construction is near the river or river cross; it is easy to have two dimensional slide circle.

- When choosing the treatment option, it is neccessary to balance between safety and cost effectiveness. Most of bridge treatment options usually extend more spans to diminish the load of embankment. We should consider the association of retaining wall of approach way to decrease the land load and cost.

- The association of hydraulic and road construction is a good idea to decrease the cost of construction, but it needs to cooperate at the beginning, assure the technique of road construction, especially to keep the reasonable distance between the canal and the road. The selection of bridge position at river cross needs a cautious calculation to prevent land slide, consideration of spans and the height of approach way. In the weak soil, the good decision of bridge position can prevent incidents and save cost.

5. Conclusion

Although the presented incidents are rather simple, the author would like to introduce them as the experiences for the next construction in weak soil areas, especially the construction treatment in the case of financial restraint. The role of geologic survey and design is always important in the security of construction. Besides, the government needs to revise the regulation of public investment; they need to check the project procedure from first decision, feasibility, appraisal, approval, supervision of works. In reality, the cited construction incidents have the responsibility of governmental management organizations■

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