LIGHTWEIGHT CONCRETE, SUCCESSFULLY APPLYING IN VIETNAMESE TRANSPORTATION ENGINEERING

BÊ TÔNG NHẸ, ỨNG DỤNG THÀNH CÔNG TRONG KỸ THUẬT XÂY DỰNG CẦU ĐƯỜNG VIỆT NAM

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ABSTRACT

A new method in reducing settlement and improving stability of embankment built on soft soil was introduced in this paper. Lightweight concrete was used to treat damage of high approaches at Ba Lon Bridge and Ma Voi Bridge on Nguyen Van Linh highway, Ho Chi Minh City. The result of method, after opening to public traffic 7 months, was completely successful. The author of this paper also a member of consultants, expects that the application of light weight will be widened in civil infrastructure, including transportation engineering in Viet Nam.

Keywords: *lightweght concrete, soft soil, settlement, stabitility, embankment*

TÓM TẮT

Bài báo này giới thiệu giải pháp mới dùng bê tông nhẹ để giảm thiểu lún và tăng cường ổn định nền đường đắp cao xây dựng trên nền đất *yếu. Việc xử lý dùng bê tông nhẹ áp dụng cho đường đầu cầu Bà Lớn và Mã Vôi trên đường Nguyễn Văn Linh, Tp. Hồ Chí Minh. Kết quả gia cố sau 7 tháng thông xe được đánh giá là rất thành công. Tác giả bài viết, cũng là thành viên tư vấn tham gia xử lý, hy vọng việc áp dụng bê tông nhẹ sẽ ngày càng rộng rãi trong việc xây dựng cơ sở hạ tầng bao gồm lĩnh vực cầu đường ở Việt Nam.*

Từ khóa: *bê tông nhẹ, đất yếu, lún, ổn định, đường đắp cao*

1. INTRODUCTION

Soil profiles of Southern Ho Chi Minh city in particular, in Mekong Delta in general, often show a very deep soft alluvial soil (≥ 20m) as a surface layer (or almost surface layer). Under high loadings of embankment after bridge abutment, the soft soil may cause some issues as follows: large settlement, large pressure on abutment (or retaining wall), low slope stability, low load bearing capacity, negative friction acting on piles due to soil compression...

In above mentioned issues, the large settlement should be appropriately focused because it can be the source of others, e.g., double pressure on retaining wall using pile foundation shall be produced under soil settlement, impact loading from truck on head abutment also much increases [1]...Treating these issues requires effective solution with short time for straight - through traffic and reasonable cost.

In Vietnam, lightweight concrete (or foam concrete) has been mainly applied in housing – construction such as light panel or block for wall. The application of them in transportation engineering is still limit in Vietnam. Up to now, only the local road in

Carbon Vietnam Factory (Ha Nam Province) has been used the lightweight concrete with low traffic [2,3].

Using lightweight concrete instead of normal filling soil of embankment is a new practical method in Vietnam for reducing settlement. This method shall be introduced in this paper.

2. SCALE AND CHARACTERSATION OF PROJECT

Nguyen Van Linh highway with 10 lanes (a section of ring road 2) was built on soft soil in Binh Chanh and Nha Be district. Ba Lon and Ma Voi bridge are two of ten bridges on this highway with 10.6 m width (2 lanes) with span L=24.54 m. According to cross section of bridge, there are 6 prestressed girders. Stub abutment was designed on 4-bored pile foundation, diameter of pile 1.2m. After abument; embankment was 4.8m high. The investigated geology at bridge area can be described as follows [4]:

+ Layer 1: Soft soil layer on surface about 28 m deep with cohesive c=0.099 kG/cm^2, inner friction angle φ = 4.2 degree, porosity ratio ε =1.99, consistence b = 1.22, natural density γ_w = 1.53 T/m^3.

+ Layer 2: Clay, fluid plasticity, about 4.2 m deep with cohesive c =0.152 kG/cm^2, inner friction angle φ = 28.8 degree, porosity ratio ε=1.378, consistence b = 0.78, natural density γ_w = 1.69 T/m^3.

+ Layer 3: Fine sand, medium dense, more than 9.5 m deep with cohesive c=0.137 kG/cm^2, inner friction angle φ = 17.0 degree, porosity ratio ε=0.830, natural density γ_w = 2.20 T/m^3.

Figure 1. *Approach was levelled by crushed aggregate and asphalt concrete many times*

Figure 2. *Large cracks appeared on head wall, wingwall of abutment*

Figure 3*. Bearings appeared oblique dispacement, steel pith was posed without rubber covering layer*

The foundation of highway was not treated when building (to reduce investment cost of project), thus, much damage occured after service period 10 years such as: large settlement of approach, large horizontal displacement and cracking at abutments of Ba Lon bridge, showed in Fig. 1, 2 & 3.

In addition to repair abutments and bearings, proposing a method to limit

settlement was very important because the settlement speed at present was still high and led to other issues.

3. TREATMENT OF DAMAGES

The treatment of damages was expected to restore load bearing capacity of bridge and approaches as initial design. The treatment included some main works was follows:

+ Enhancing load bearing capacity of abutment foundation by adding more two bored piles, diameter 1.2m.
+ Repairing cracks of head wall and wing wall of abutments.
+ Replacing damage bearings
+ Controlling the settlement and improving load bearing capacity of soil

Two options were considered to control the settlement as shown in Fig.4: option 1 using supporting slab on pipe pile foundation; option 2 using lightweight concrete to replace existing filling soil of embankment. Option 1 showed an absolute solution (i.e. safer) but its cost was rather high (12 millions VND/m^2), double cost compared with option 2. Therefore, the owner of project decided to select option 2 for treating settlement.

Details of the settlement treatment could be described as follows:

+ Replacing existing filling soil (sand) of embankment by lightweight concrete for section 40m after abutment. Beyond this zone, normal filling soil was still used.
+ Each layer of lightweight concrete (0.6m thickness) was casted in place to design elevation (shown in Fig. 5 &6).
+ Dry density of lightweight concrete was about 0.5 T/m^3, wet density was 0.8 T/m^3.
+ Compressive strength of lightweight concrete $f_c^{'} \geq 0.8$ MPa.
+ The cost to construct 1 m^3 lightweight concrete was about 1.5 million VND.

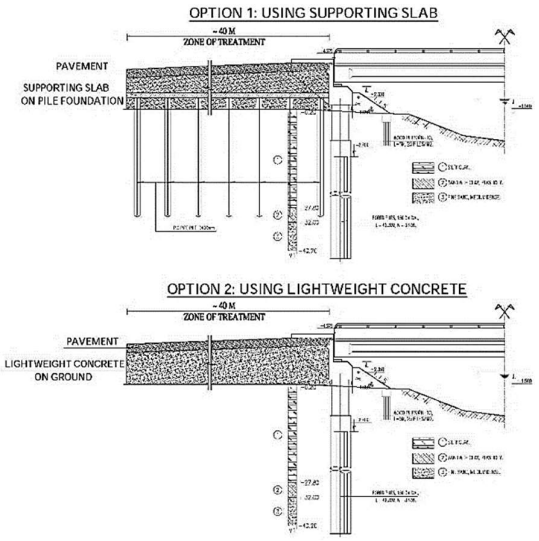

Figure 4 *– Two options with 40 m treatment zone after abutment*

Figure 5 *– Body of embankment using lightweight concrete – front view*

Figure 6 *– Body of embankment using lightweight concrete – side view (under construction)*

Vertical pressure causing settlement due to self-weight of embankment: w= $\gamma_đ.H_đ$;

horizontal pressure causing displacement of abutment due to self-weight of embankment: $E= 0.5\mu.B.\gamma_đ.H_t^2$. Where $\gamma_đ$ is density of filling soil, $H_đ$ and H_t are height of embankment and abutment, respectively; μ is factor of horizontal pressure, B is abutment width [5]. Consequently, the reduction 60% of density of filling material (lightweight concrete 0.8 T/m^3 compared with normal filling one about 1.9 T/m^3) can lead to reduction of vertical pressure (causing settlement) and horizontal pressure (causing displacement of abutment). It is assumed that the factor of horizontal pressure is constant. In fact, when lightweight concrete became hard, horizontal pressure on abutment shall be negligible; sliding stability was greatly reliable owing to characteristic of mass concrete.

The result of treatment has been successful with very light settlement after opening to public traffic 7 months, according to strict observation (only 5mm settlement), shown in Fig.7. Although embankment body was used lightweight material but vertical pressure causing settlement was not zero, the reduction only about 50%, e.g. pavement and live load of highway cannot be reduced, described in Fig.8. Therefore, levelling work will be required annually in maintenance.

Figure 7. *Approach was still smooth after 7 months in traffic*

Figure 8. *Pavement was recovered after treatment*

4. CONCLUSION

The treatment of embankment using lightweight concrete was effective and easily applied as well as short time, although the settlement of embankment cannot be disappeared. Owing to much cheaper cost compared with supporting slab treatment, transportation engineers could refer to this project treatment as a comparative option.

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