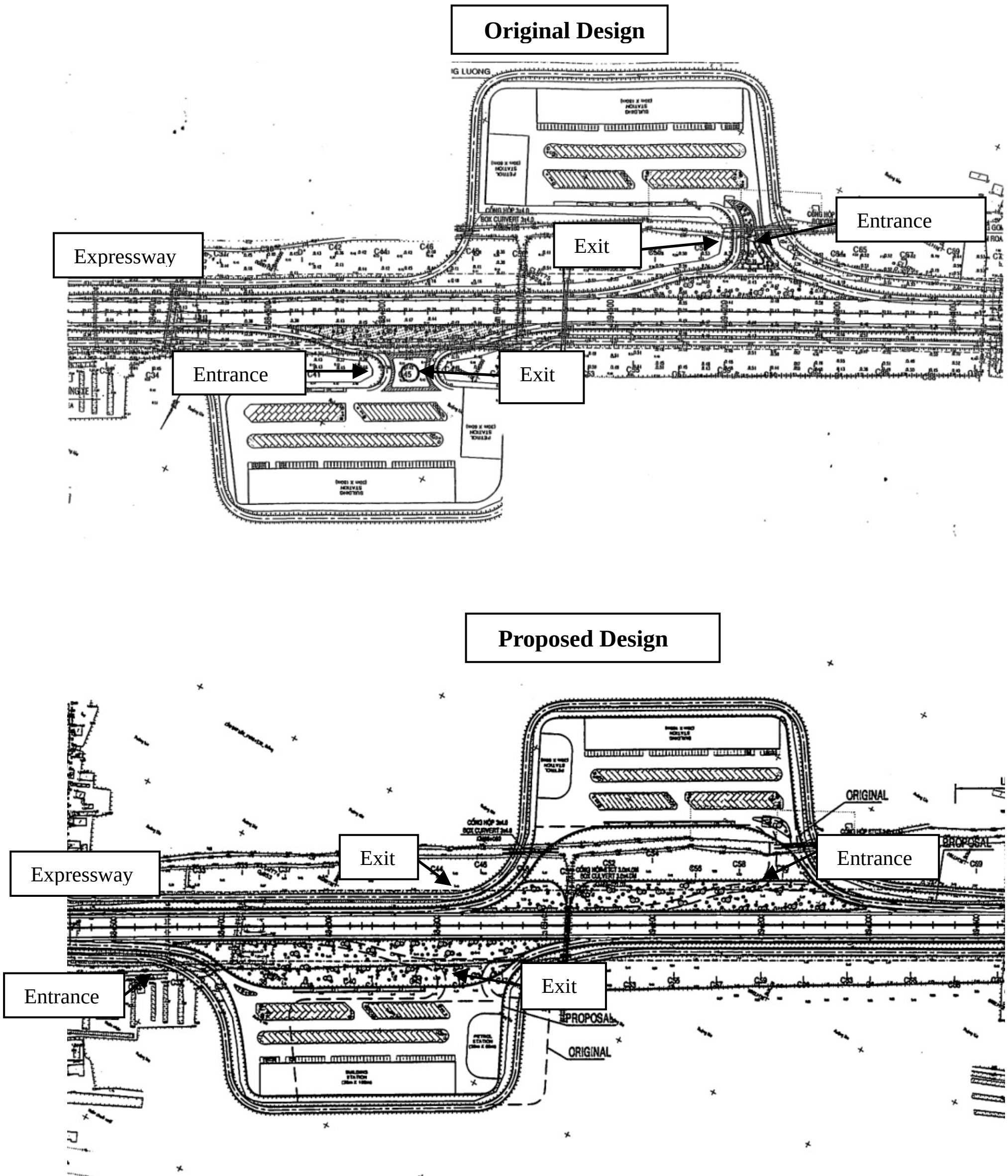
e) Modification of position of entrance/exit of service area

- The original design of the service area poses risk because entrance to and exit from the parking lot are too close. Moreover, the traffic flows intersect in the parking lot.
- Hence, it was proposed to shift the entrance and exit access to both ends of the parking area. Consequently, the traffic flow in the parking lot becomes simpler without any intersection.
- Drawing showing original and proposed design of the service area is shown in Figure 6.17.

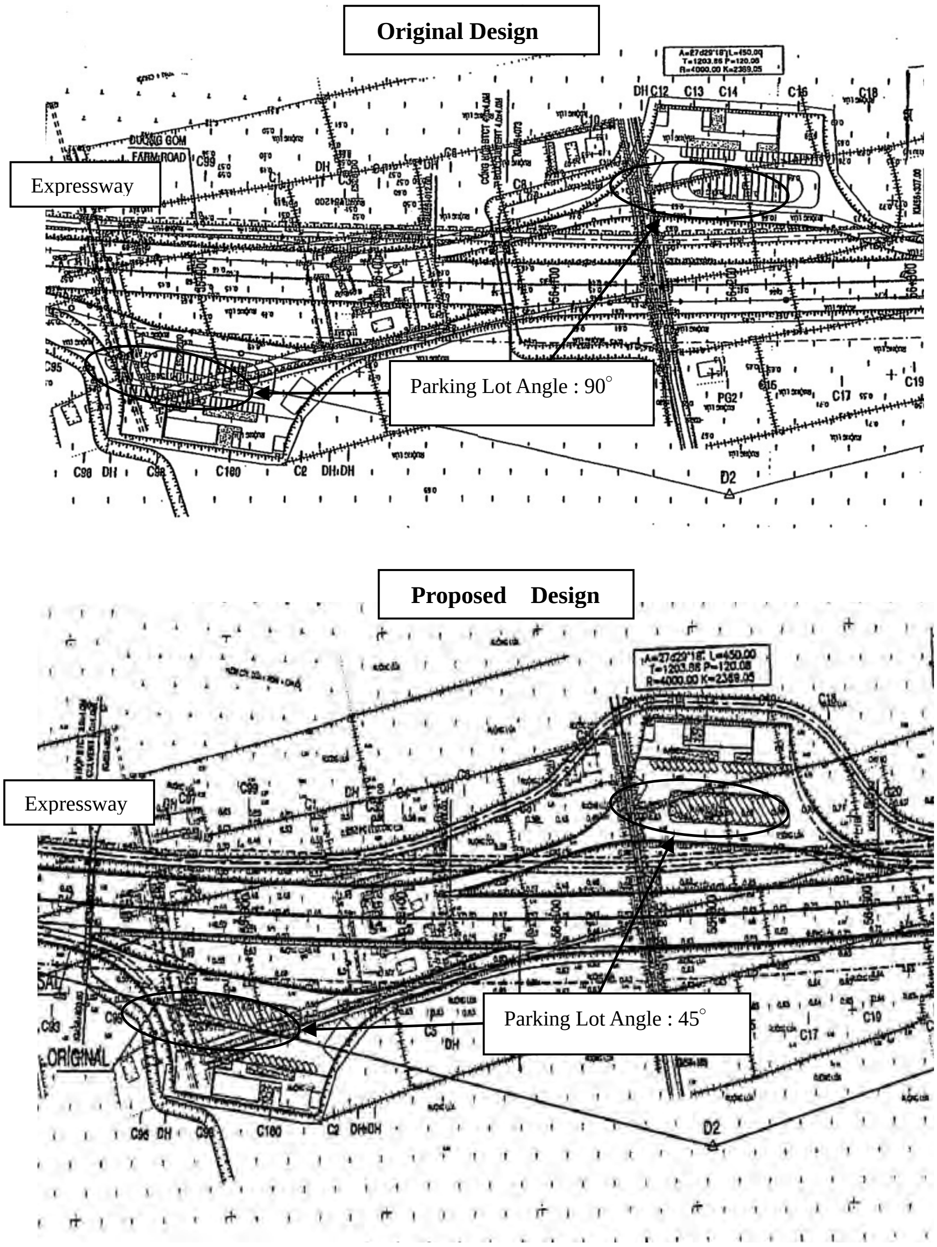



Source: TL-MT D/D (upper figure), JICA Survey Team (lower figure)

**Figure 6.17. Original and Proposed Design of Service Area**

f) Modification of parking area

- In the original design, the parking method for large vehicles is head-in/back-out, and parking angle is at 90°. This poses risk and difficulty in parking. Moreover, the required parking space shall be larger.
- Thus, it was proposed to change the parking method to a back-in/head out diagonal parking with an angle of 45°.
- Drawing showing original and proposed design of parking area is shown in **Figure 6.18.**

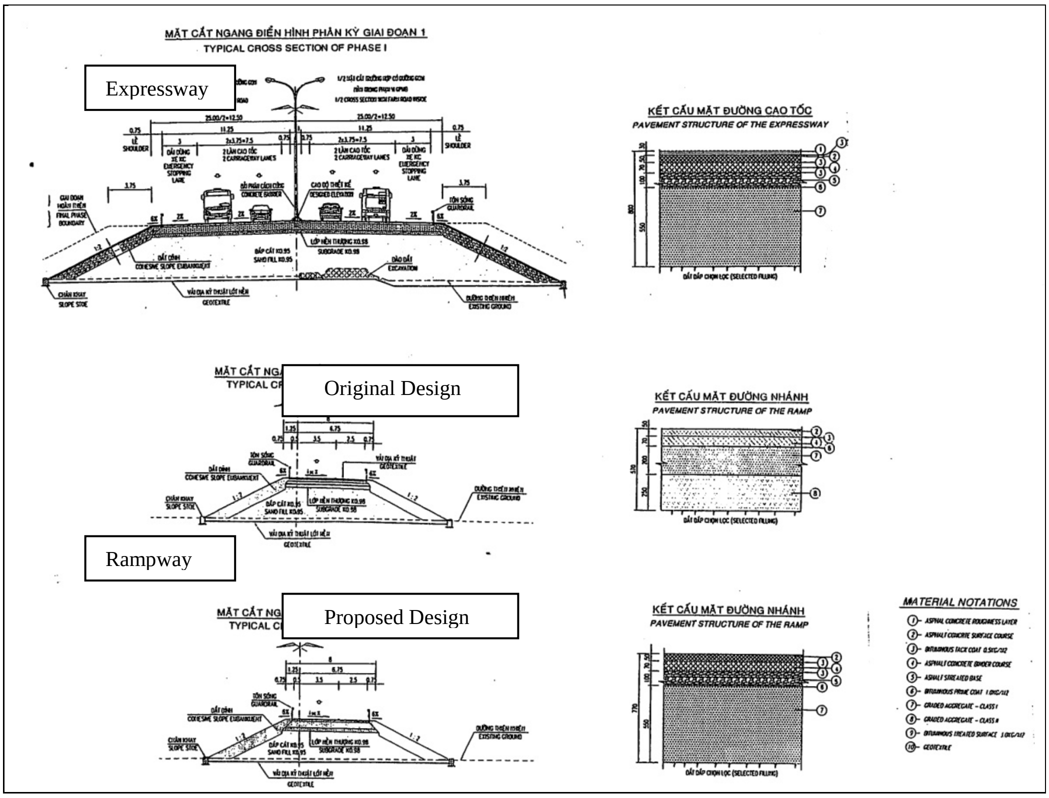



Source: TL-MT D/D (upper figure), JICA Survey Team (lower figure)

**Figure 6.18. Original Design and Proposed Design of PA**

g) Application of expressway pavement structure to rampway

- In the original design, pavement structure of rampway was designed as asphalt concrete, which is thinner than the main road pavement structure, based on traffic demand forecast for the interchange.
- Same pavement structure as that for the main road was proposed considering that maintenance work is difficult along the narrow width of the rampway. Moreover it will become possible to lengthen the interval for regular maintenance of overlay.
- Drawing showing original and proposed pavement design is shown **Figure 6.19**.

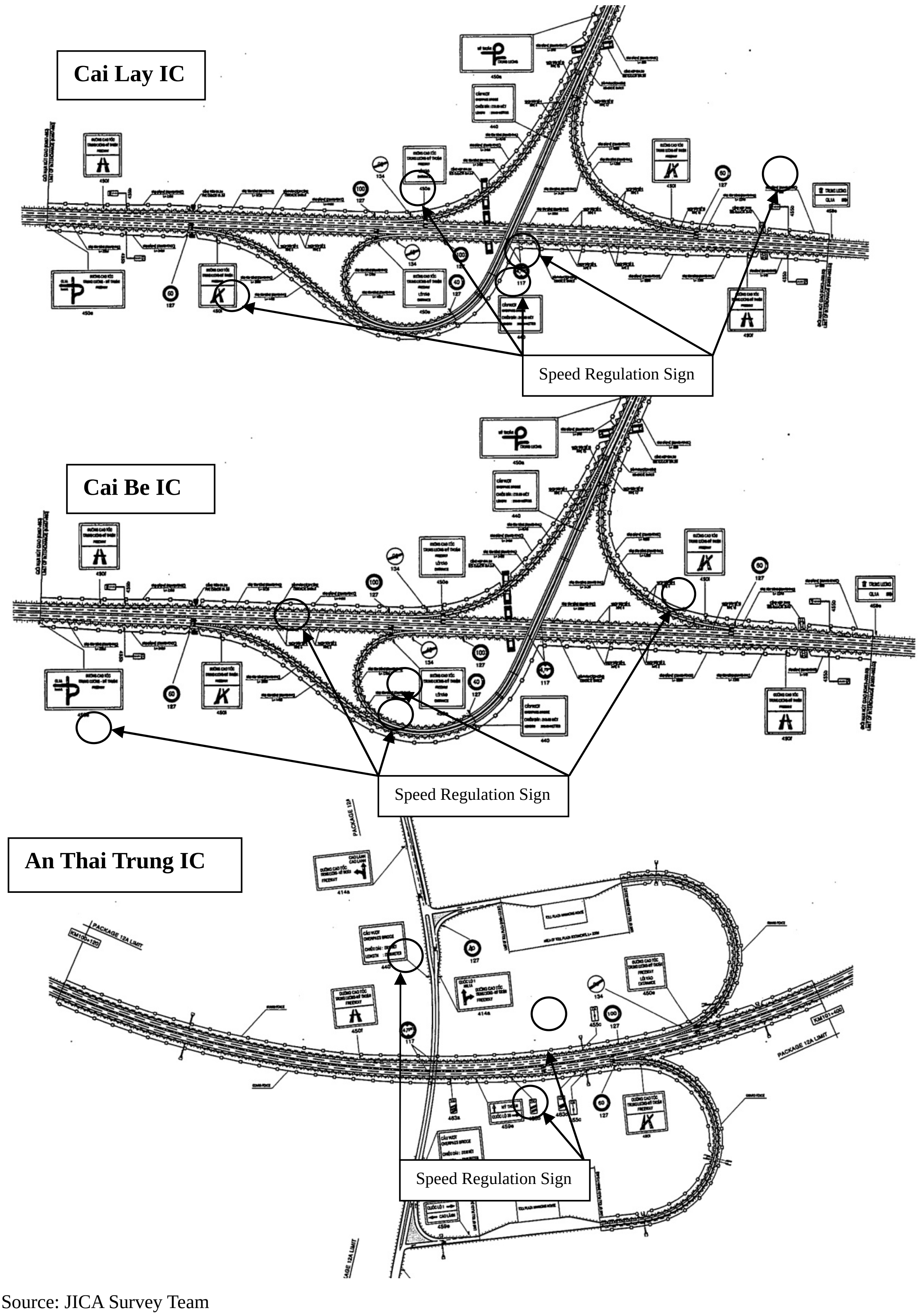



Source: JICA Survey Team

**Figure 6.19. Original and Proposed Pavement Design**

h) Installation of speed regulation sign at IC

- In the original design, speed regulation signs were not planned at interchanges, though informatory signs were proposed.
- It is necessary for vehicles to decelerate on the rampway because of the small horizontal curve and steep gradient of the rampway.
- It is also necessary to slow down on the rampway to ensure safe approach to the main road where high-speed vehicles are passing.
- Moreover, it is necessary to decelerate before the Than Cuu Nghia IC and the An Thai Trung IC as the smallest possible horizontal curve was adopted in these interchanges, within this expressway.
- Thus, it was proposed to install speed regulation signs on the expressway and on the rampway at the interchange.
- Drawings showing the proposed design of traffic safety on Cai Lay IC ,Cai Be IC and An Thai Truong IC are shown in **Figure 6.20**.



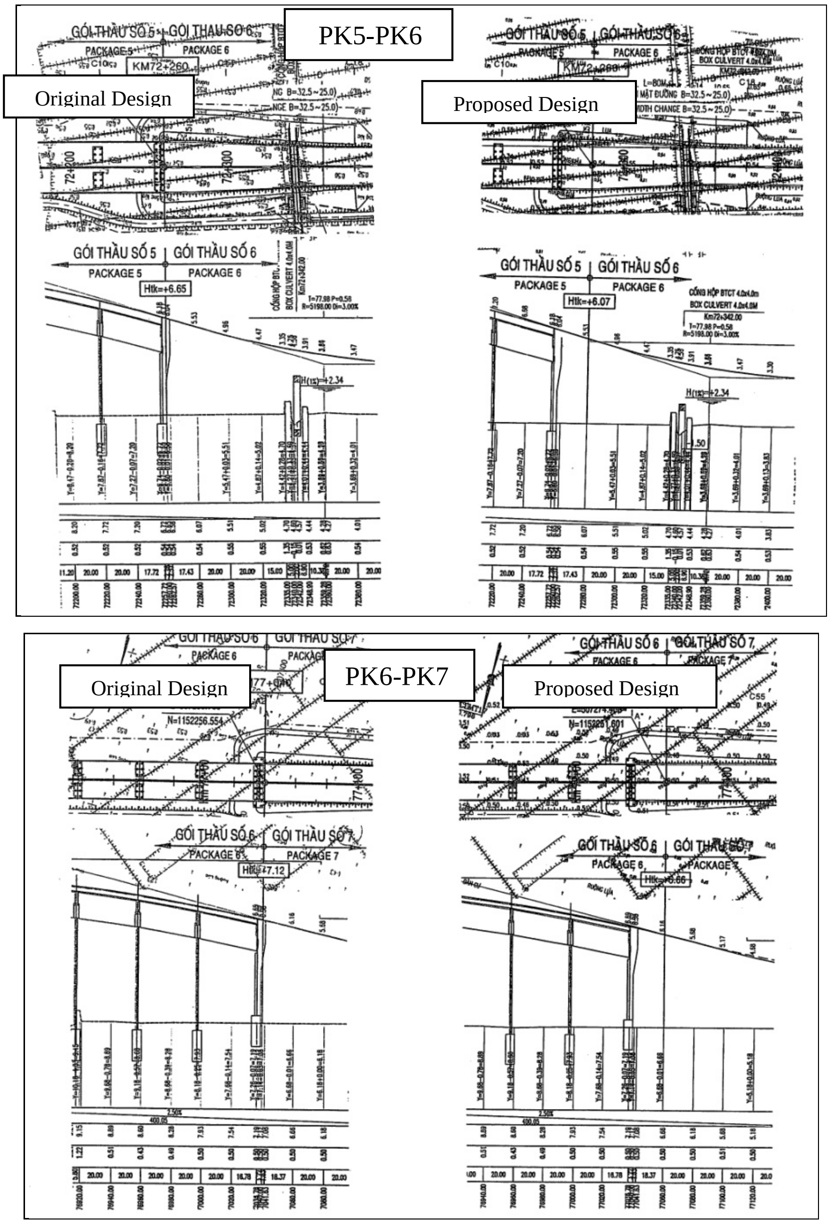

Source: JICA Survey Team

**Figure 6.20. Proposed Traffic Safety Design**

i) Shift of package border

- In the original design, the boundaries of packages PK5-PK6 and PK6-PK7 are located on bridge abutments. Therefore, it is difficult to separate the earthworks from the bridge work, and divide the construction volume.

- Thus, it was proposed to shift the boundary of the said packages from the abutment of the bridge, to a point 20 m away from the abutments.
- Drawings of the original design and proposed design are shown **Figure 6.21**.




Source: TL-MT D/D (left figure), JICA Survey Team (right figure)

**Figure 6.21. Proposed Package Limits**

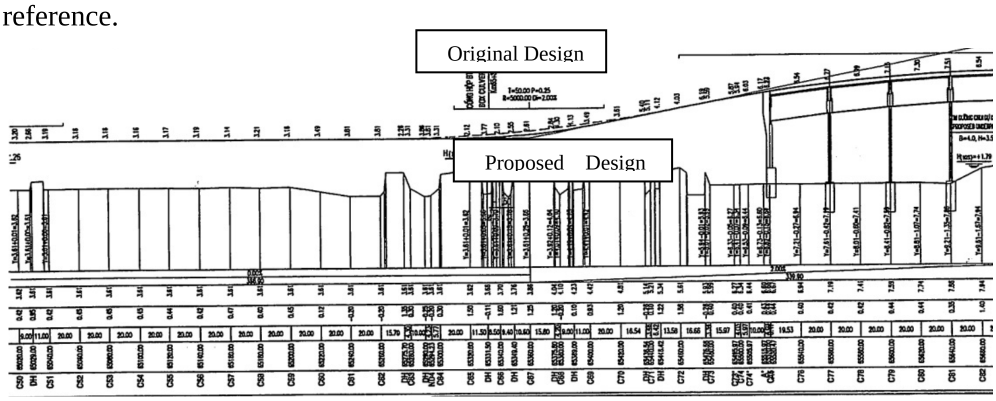
**(2) Cost Down**

a) Application of minimum concave vertical curve

- In the original design, a convex vertical curve with a 12,000 m radius, which is the minimum standard value, was adopted for crest, but a concave vertical curve of 10,000 m was mainly adopted for sag.
- Hence, it was proposed to apply the minimum standard value of concave vertical curve in

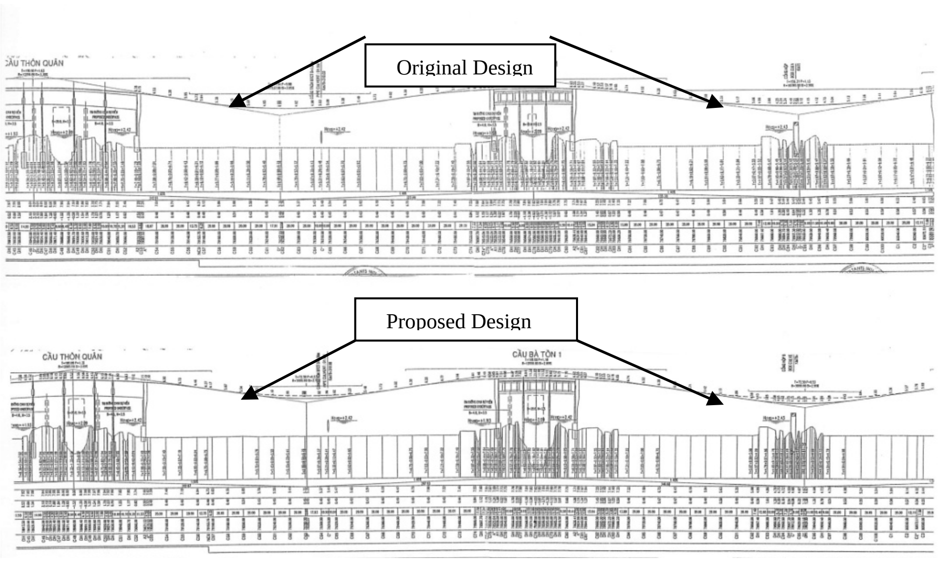
order to reduce the elevation of embankment.

- A radius of 5000 m as minimum standard for concave vertical curve was applied for the sag at embankment section, considering the minimum embankment height and the height of box culvert.
- Drawing of the section around Km 65+360 is shown in Figure 6.22 for reference.
- However, a minimum standard value of concave vertical curve was not applied for the section where the convex and the concave vertical curves are located between a short distance considering the continuity and the visibility of the alignment.
- Drawing of the section from Km 79+000 to Km 80+000 is shown in Figure 6.23 for reference.




Source: JICA Survey Team

**Figure 6.22. Original Design and Proposed Design of Vertical Alignment (Km 65+360)**




Source: TL-MT D/D (upper figure), JICA Survey Team (lower figure)

**Figure 6.23. Original Design and Proposed Design of Vertical Alignment (Km 79+000 – Km 80+000)**

#### 6.2.3.5. Evaluation of Highway Design Alternatives

The JICA Survey Team evaluated in the highway design alternatives were proposed in Section 6.2.4.4, taking into account effectiveness and cost reduction. The results of the evaluation are summarized in **Table 6.17** below. Illustrations of the adopted eight alternatives are presented in the Appendix (separate volume supplement): Drawings of Progress Report.

**Table 6.17. Evaluation of Highway Design Alternatives**

| Alternative Design | Advantages | Cost Impact | | Evaluation |
|---|---|---|---|---|
| | | Cost Increase (+)/Decrease (-) | Ratio to Total Construction Cost (%)* | |
| 0.3% Longitudinal slope at reverse superelevation section | ▪ Safe driving in rain<br>▪ Maintain good pavement condition | +1.8 | 0.01% | Adopted |
| Drainage inside median strip R<4,000m | ▪ Safe driving<br>▪ Easy maintenance of drainage ditch | +10.2 | 0.06% | Adopted |
| Direct connection type of deceleration lane | ▪ Safe and easy driving | +12.8 | 0.08% | Adopted |
| Expressway over connecting road at interchanges (Than Cuu Nghia IC and An Thai Trung IC) | ▪ Safe driving on connecting road<br>▪ Easy access from connecting road near expressway | +1,478 | 9.22% | - |
| Position of entrance/exit Access for service area | ▪ Easy guide to parking lot<br>▪ Safe and easy parking | +14.9 | 0.09% | Adopted |
| Layout of parking area | ▪ Safe and easy parking | 0 | 0.00% | Adopted |
| Pavement structure of rampway | ▪ Long interval of regular pavement maintenance work | +133 | 0.830% | - |
| Installation of speed regulation sign boards at interchanges | ▪ Safe driving on rampway of interchanges | 0 | 0.00% | Adopted |
| Shifting of package limits of PK5-PK6, PK6-PK7 | ▪ Easy construction between bridge and earthwork | 0 | 0.00% | Adopted |
| Minimum concave vertical curve | ▪ Slight reduction of cost | -1.4 | -0.01% | Adopted |

Note: *Ratio to the construction cost VND 16,029 billion in detailed design (%)

Source: JICA Survey Team

### 6.2.4 Bridge and Road Structure Design

**Review for Cost Savings**

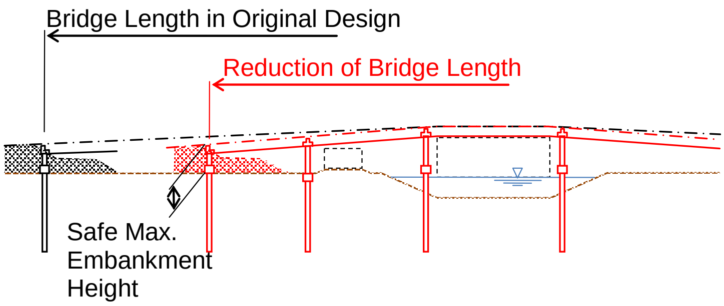
The construction cost of the expressway is expected to become high because it runs through a vast soft ground area and crosses numerous water channels in the Mekong Delta. In addition, the expressway is designed to meet a high standard such as complex highway geometries to guarantee a 120 km/h design travel speed, and road embankment with a minimum of 3.5 m height from ground to withstand the 100 year probability flood. Consequently, bridges are designed with longer spans on the expressway to cross rivers and canals as well as to elevate the expressway from soft ground. Therefore, if cost saving is possible on the bridge design, it will contribute significantly to the project economy.

Reviews by the JICA Survey Team were shared with BEDC who acts as the counterpart and project implementation body. BEDC will examine the JICA Survey Team's design change proposals in detail, and finally decide if these could be adopted in the D/D.

#### 6.2.4.1. Points Reviewed

##### (1) Reduction of Bridge Length

The difference in road construction costs between the embankment road accompanied by soft ground treatment and elevated road supported by bridges is estimated approximately at VND 130 million/m and VND 620 million/m, respectively. It is however noted that land acquisition cost and value added tax are not yet included. Thus, the shorter the bridge length design, the more savings on construction cost is anticipated. (See **Figure 6.24**)




Source: JICA Survey Team

**Figure 6.24. Reduction of Bridge Length**

Towards the reduction of the bridge length, it is suggested to examine the following design conditions:

a) Waterway Navigation Clearance

Reconfirm the waterway navigation clearance to the Inland Water Transport Authority (IWTA) for each waterway crossing point.

Result of the study: No changes.

The JICA Survey Team reported that this issue was already reconfirmed with IWTA, and found no changes in the required navigation clearances.

b) Lowering of Geometric Profile Elevation

The geometric profile elevations at bridge sections to be minimized were reexamined, within the geometric design limits to accommodate 120 km/h design travel speed as well as after reserving the vertical clearances of waterways and local roads.

Result of the study: No significant changes except for minor corrections.

The JICA Survey Team confirmed that this problem was already examined. It was found out that there was no more room to lower the profile elevations at the bridge sections, except for the case of reducing the bridge structural heights.

c) Maximum Road Embankment Height

Road embankment will be highest at bridge abutments, that is, the higher the road embankment the shorter the bridge length can be designed.

The maximum road embankment height will be evaluated by investigating the following:

- Consolidation settlement of soft ground and its required preloading time; and
- Safety of embankment against sliding.

Result of the study: No significant changes in analysis results except for minor variations.

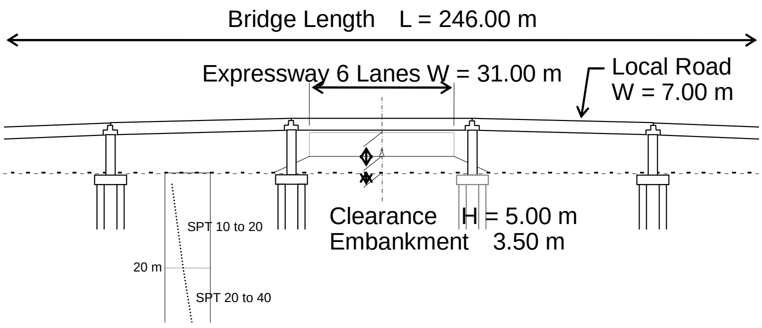
Consolidation analysis was performed again for the soils at each bridge location with the analysis conditions agreeing with the JICA Survey Team, which are the filling/preloading period of 18 months and prefabricated vertical drain (PVD) spacing of 1.2 m in average. It was found that there is no more room to increase the embankment height under a severe design criteria for residual consolidation settlement of 10 cm. However, further investigation will be necessary to detail the difference in soil conditions between both ends of a bridge.

**(2) Grade Separation with Local Roads**

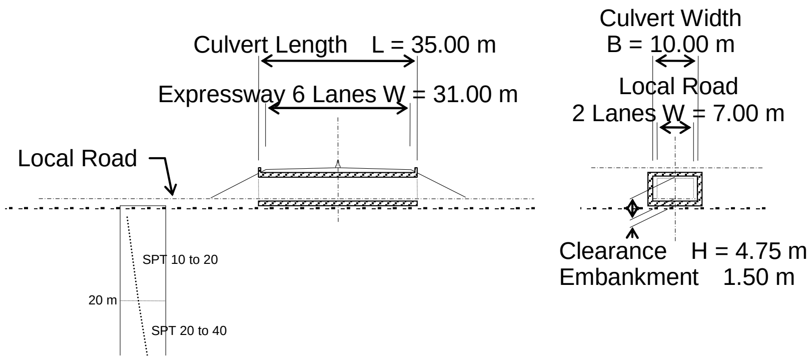
The expressway is designed to cross many local roads by grade separation wherein the local road shall pass over the expressway. The construction costs for these local road overpass bridges including their approaches are factored in to the the Project budget.

However, upon review of Dwg II-3.5 Flyover No.4 (Km 59+260), it was advised to change the grade separation method in the opposite manner wherein the expressway will pass over the local road. This was realized at this location since the ground condition is not so soft and thus, higher embankment can be constructed instead of a flyover bridge. This will cause significant cost savings. The local road can therefore pass under the expressway through a 10 m wide box culvert with a minimum cost. (See Figure 6.25)

For further cost saving, it is also advised that the construction cost only for the grade separation structure within the right-of-way of the expressway be covered by the budget while the construction cost for the local road itself should not be included.




Grade Separation of Local Road over Expressway




Grade Separation of Expressway over Local Road

Source: JICA Survey Team

**Figure 6.25. Grade Separation Between Expressway and Local Road**

The clearance and embankment height of local road shown in Figure 6.25 above are for reference only, and are to be confirmed with the local government.

Result of the study: Change the configuration to allow the expressway to pass over the local road at this location.

D/D Consultants revealed that the design of the expressway above the local road is more costly because the bridge becomes wider under this configuration. After studying this advice, it was also found possible to reduce cost of grade separation method at this location. However, it should be noted that the construction cost may increase depending on the range and method of soft ground treatment such as vacuum consolidation method (VCM) for high embankment section where a box culvert is placed. In addition, according to the D/D Consultants, local roads are planned to be widened in the future, and Tien Giang Province Peoples Committee already agreed to the flyover plan. These issues should be taken into consideration to judge whether this proposal should be adopted or not.

### (3) Elevated Road Bridges on Soft Ground Area

The Co Co section (Km 95+400 – Km 98+000), where soft ground is deep, is designed with elevated road bridges stretching to as long as over 2 km. A bridge is considered to be the most reliable structure to support the road on soft ground; however, this section becomes the most costly among the whole section of the expressway.

Before reaching a final decision, it is advised to further study a less expensive alternative. The following four alternatives are suggested for study:

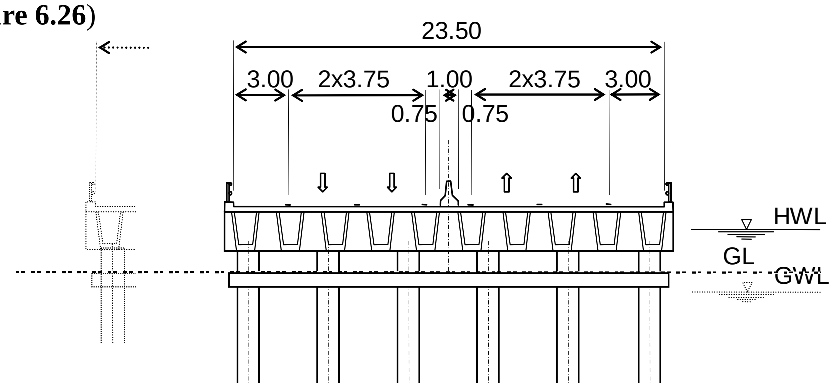
Alternative-1  Elevated Road Bridge with Longer Span (Figure 6.26)

Alternative-2  Elevated Road Bridge with Shorter Span (Figure 6.27 and 6.28)

Alternative-3  Replacement + Lightweight Road Embankment (Figure 6.29)

Alternative-4  PVD/Preloading + Lightweight Road Embankment (Figure 6.30)

Alternative-1 is a bridge option similar to the existing design. However, even though it is same the bridge case, the design has room for cost savings through the modification of structural configurations such as from super T to conventional I girder, from cantilever pier to simple multiple columns, and from double row of piles to single row of piles. (See **Figure 6.26**)

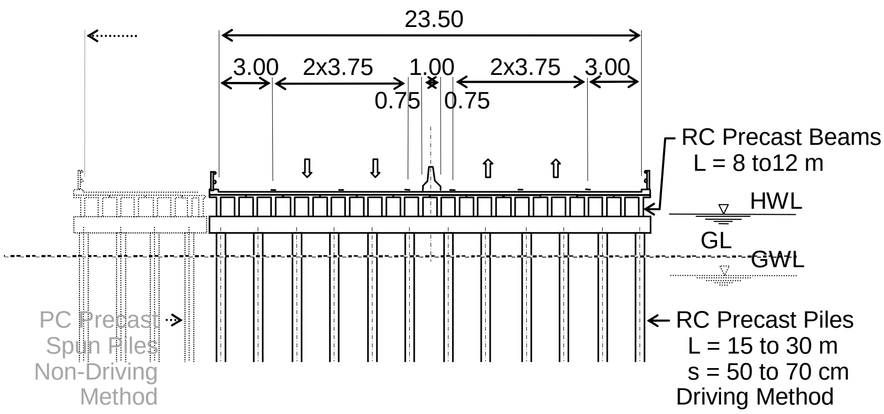



Source: JICA Survey Team

**Figure 6.26. Alternative-1: Elevated Road Bridge with Longer Span**

To achieve a cost-efficient span length for multiple span bridges, a cost comparison study is suggested between the two different span arrangements namely: (1) longer girder span length supported by double row of piles; and (2) shorter girder span length supported by single row of piles (Refer to Figure 6.33).

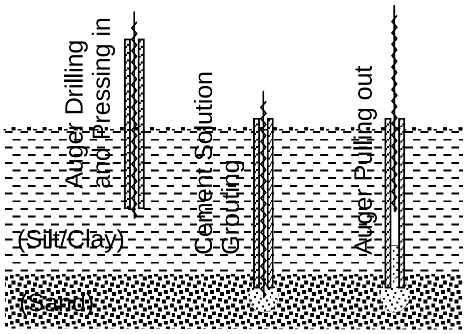
Alternative-2 is another bridge option for comparison with Alternative-1. The option requires a smaller scale viaduct structure, suggesting a shorter span length with RC precast girders supported by precast piles resting on the upper sand layer. (See **Figure 6.27**)




Source: JICA Survey Team

**Figure 6.27. Alternative-2: Elevated Road Bridge with Shorter Span**

For the future road widening construction from four to six lanes, non-driving tube drilling method is suggested for adjacent piling construction. (See **Figure 6.28**)



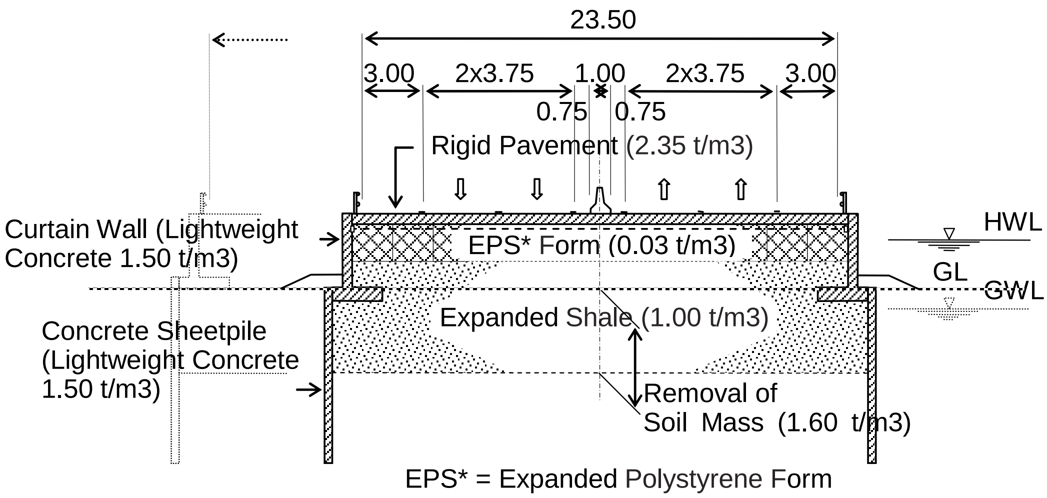

Source: JICA Survey Team

**Figure 6.28. Non-Driving Tube Drilling Piling Method**

Alternative-3 is an embankment road option using lightweight fill materials such as expanded polystyrene (EPS) form and expanded shale. The road construction method using lightweight fill materials is seen mainly in Norway, the United States of America (USA), and Japan. The method, in principle, does not need preloading time since there is no ground settlement considered. Therefore, this achieves a speedy embankment construction. However, the method has also technical concerns about the replacement work of lightweight materials below groundwater. (See **Figure 6.29**)

Two key points in the design of the method are as follows:

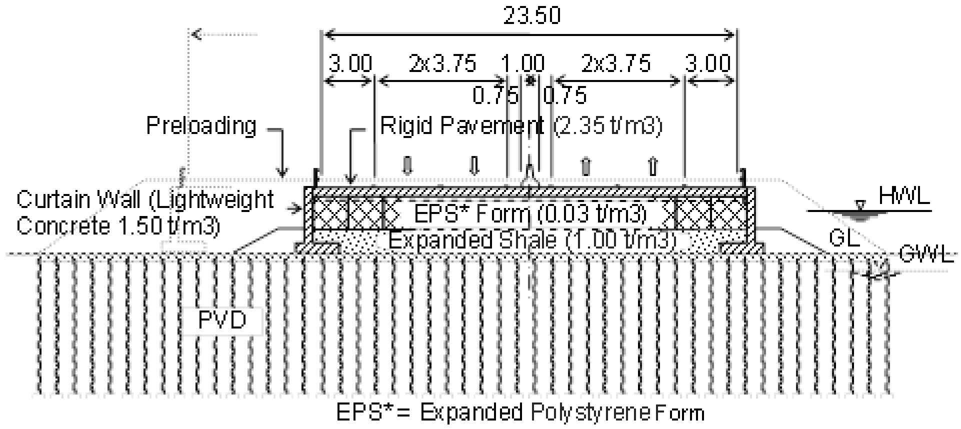
- Buoyancy/uplift for design flood water level shall be checked considering a safety factor of 1.05, which may be sufficient for a 100-year flood event.
- The total road embankment load shall be compensated by removing an equivalent mass of ground soil and replacing it with lightweight fill materials.




Source: JICA Survey Team

**Figure 6.29. Alternative-3: Replacement and Lightweight Road Embankment**

Alternative-4 is a combination of soft soil treatment and lightweight embankment to avoid ground removal. By decreasing the road embankment load, the method can reduce the scale of soft ground treatment (PVD) work as well as decrease the residual settlement. (See **Figure 6.30**)




Source: JICA Survey Team

**Figure 6.30. Alternative-4: PVD/Preloading and Lightweight Road Embankment**

Result of the study: Alternative-2, the elevated road bridge with shorter span, is likely the most economical. However, there are some important issues that remain such as the depth of supporting layer at the level where driven pile can be applied, and consolidation characteristics of the soft soil under medium supporting layer (sand layer) shall be examined in detail, whether residual settlement meets the requirement or not.

In Vietnam, there is no experience on road construction using lightweight fill materials. One of the D/D Consultants, KCI, disclosed a failed experience on lightweight embankment road construction in Korea, claiming that the EPS form is vulnerable to buoyancy/uplift at high water. KCI also explained that deep soft ground conditions and accordingly, the difficulty in PVD installation were the reasons why viaduct bridges were proposed.

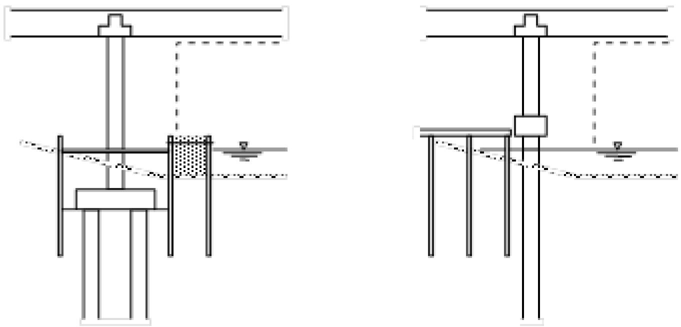
The road construction cost based on Alternative-4, PVD/reloading and lightweight road embankment is estimated tentatively at about VND 320 million/m. It is noted that there is no similar example of such method in Vietnam. Nevertheless, although Alternative-4 is costlier than the conventional embankment road, it is still fairly less costly than an elevated road bridge. This difference in road construction costs by method indicates that lightweight embankment road has potential in saving further cost for bridge construction, through the application of EPS form at bridge approaches.

**(4) Modification of Bridge Type and Structure**

Bridge construction cost will be reduced by the modification of bridge type and structure.

1) Position of Pilecap and Rows of Piles

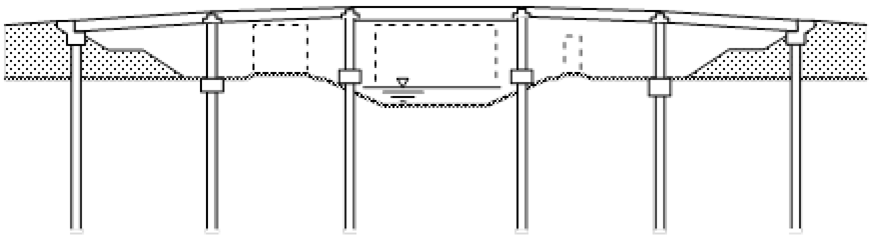
To save cost on temporary cofferdam and dewatering for pilecap construction, it is advised to raise the position of pilecap above the water level. In order to minimize the width of the pilecap above water, it is also advised to examine a single row piles layout by reducing the bridge span length. (See **Figure 6.31**)



Source: JICA Survey Team

**Figure 6.31. Position of Pilecap and Row of Piles**

A bridge pier standing alone with single row piles during construction is not so rigid along the bridge direction. However, after completion, the lateral stability of a bridge is secured by the entire bridge structural frame. (See **Figure 6.32**)



Source: JICA Survey Team

**Figure 6.32. Lateral Stability Secured by Bridge Structural Frame**

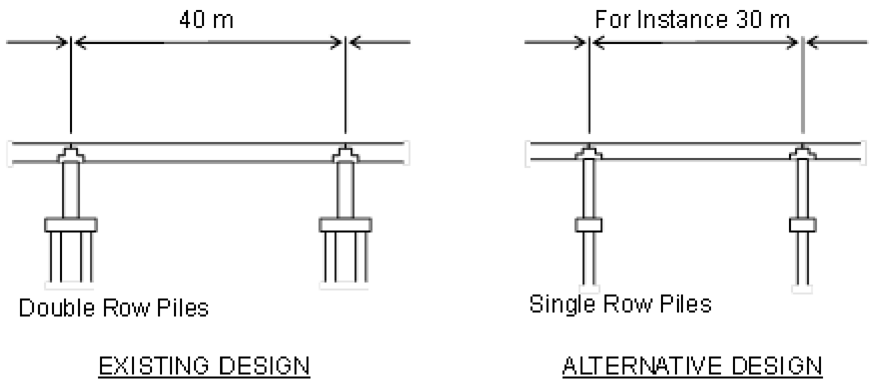
Attention is given to the construction of bridge abutments, which can start after completion of the preloading period of the adjoining road embankment. Moreover, it is better for abutments to be constructed on top of the embankment since it is supported on piles. In such case, there is no need to excavate down the embankment to construct the abutment. (See **Figure 6.32**)

Result of the study: Pier pilecaps in waterway will be raised above water level.

However, structural analysis considering another alternative with single row of piles and abutment design are required in the D/D.

2) Study of Cost-Efficient Span Length for Multiple Span Bridges

The existing design consists of a standard structural configuration for multiple span bridges with 40 m long super T girders supported by double row of piles each having a diameter of 1.2 m. There are several designs of multiple span bridges along the project road, including a 2 km long viaduct bridge; and therefore, there is a possibility of saving cost by comparing the configuration and modifying the span length and number of foundation piles per pier. In view of this, a cost comparison study is suggested between: (1) the existing design of 40 m span length with double row of piles; and (2) an alternative design of shorter span length with single row of piles. The span length for the alternative design should be determined based on its structural analysis, considering the maximum span that can be supported by a single row of piles. (See **Figure 6.33**)




Source: JICA Survey Team

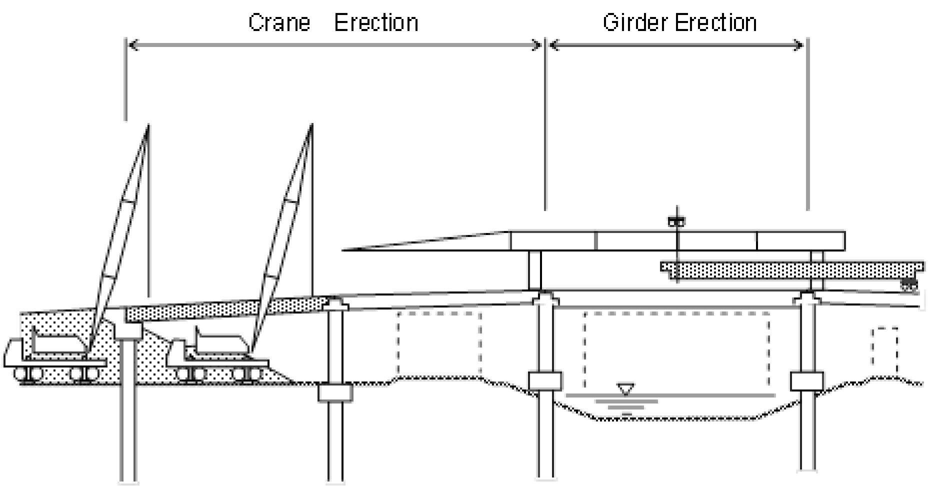
**Figure 6.33. Comparison Study for Cost-Efficient Span Length**

Result of the study: Study may be in progress by TEDI-South.

To determine the cost-efficient span length of multiple span bridges, structural analysis is required in the D/D.

3) Preference to Less Costly Precast Girders

The existing design adopted a cantilever box girder to span over relatively wide water channels considering the difficulty of crane erection in case of precast girders, although cantilever box girders are more costly than precast girders. However, it is advised to adopt precast girders using erection girders even at bridge spans over waterways, if the navigation clearance is about 30 m or less. (See **Figure 6.34**)




Source: JICA Survey Team

**Figure 6.34. Erection Method of Precast Girder on Waterway**

For the selection of the geometry of precast girders, it is advised to compare the costs of the two girder types. This is because simple I-girders seem to be less costly than complicated super T-girders.

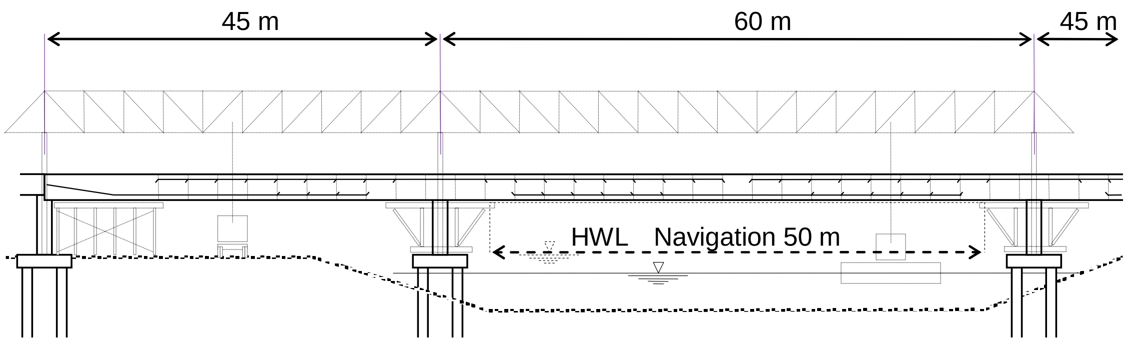
Result of the study: Cantilever box girder bridges to cross over the 30 m wide navigation clearance will be changed to precast girders, but super T-girders will not be changed to I-girders.

TEDI-South confirmed that the cantilever box girder bridges on 30 m class navigation clearance could be changed using super T-girders with 40 m span length. Also, they reaffirmed that super T-girders are less costly than I-girders in Vietnam.

4) Shorter Span Length and Constant Girder Depth for Cantilever Box Girder

The existing design adopted a cantilever box girder bridge with varying depth, with its center span of 85 m to pass over the 50 m wide navigation clearance. The existing design also adopted a full width bridge design covering the future six lanes from the initial four lanes stage, taking into account the difficulty of future widening of cantilever box girder bridges.

However, the span length of 85 m appears to be overdesigned, and therefore, the span length of about 60 m is suggested appropriate for 50 m wide navigation clearance, including a clear zone at either side. However, 60 m long span, in case of precast girder, will be heavy, and difficult to transport and erect on waterway. Therefore, studying a suitable bridge type to span a range of 60 m was carried out. Accordingly, a cantilever segmental box girder with constant depth is recommended instead of previously designed cantilever cast-in-situ box girder with varying depth. The segmental box girder of constant depth is commonly adopted for grade separation bridges in urban intersections. This also contributes to lowering the road profile elevation. (See Figure 6.35)




Source: JICA Survey Team

**Figure 6.35. Cantilever Segmental Box Girder of Constant Depth**

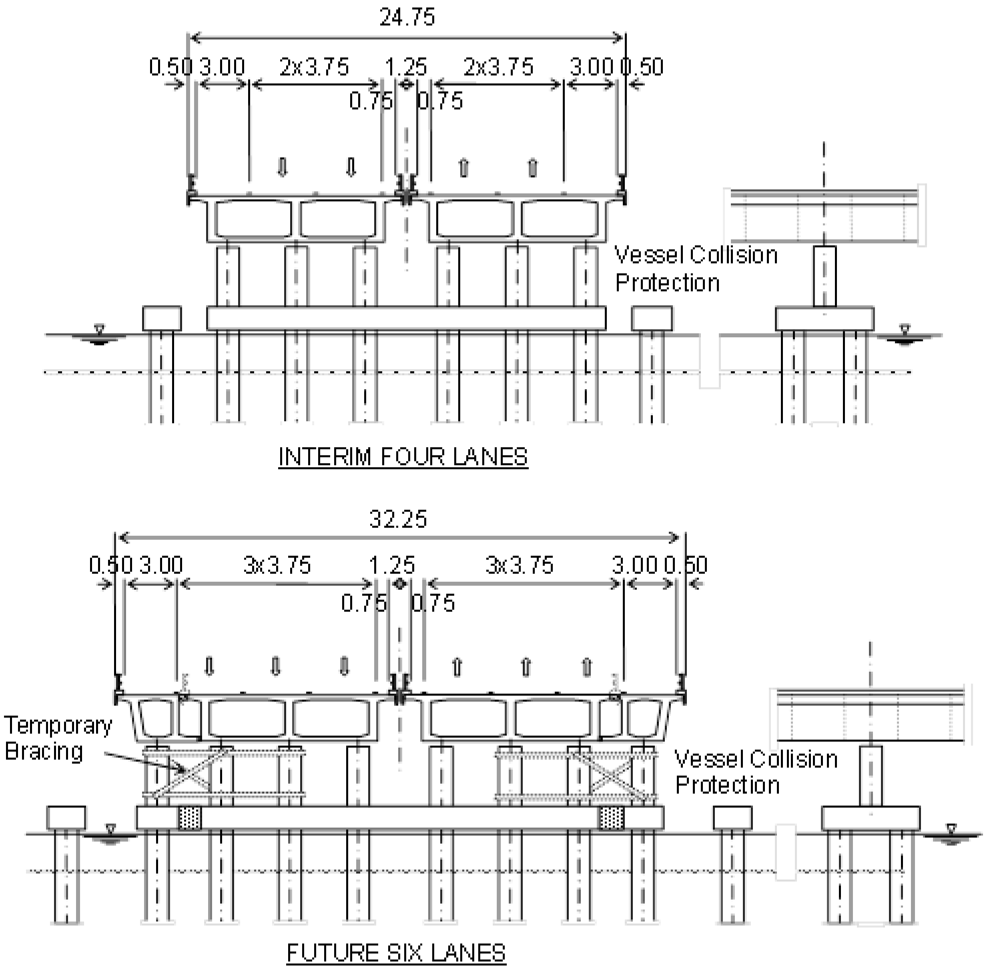
It is also advised that widening of cantilever box girder bridges is technically possible through careful preparation of design. Therefore, the bridge should be designed with only four lanes in the initial stage to save initial construction cost. (See **Figure 6.36**)

Toward the design of this constant depth cantilever segmental box girder, it is suggested to consider the following parameters:

- Girder height may be around 2.6 m based on a span-to-depth ratio of 23.
- Superstructure is separated into inbound and outbound lanes to avoid heavy girder segment in case the whole width is completed.
- For widening from four to six lanes in the future, a small one-cell box girder will be erected on either side of the existing bridge using cantilever method, similar to the initial construction stage. The widened section will be initially independent from the existing structure. Then, the existing and new bridge components will be attached together; firstly, the pilecaps and subsequently the box girder and deck slab. As shown in **Figure 6.36**, an additional pier will be laterally flexible being supported by a single row piles during the new girder erection work. Therefore, it needs to be connected temporarily to the existing

bridge pier during such stage.

- Cantilever segmental erection method should be adopted both for the initial construction and future widening, in order to avoid large size erection equipment as well as to adjust the long time girder deflection performance between the initial and finally widened width.
- Vessel collision protection piles are recommended, if heavy waterborne traffic is envisaged from the wide navigation clearance.




Source: JICA Survey Team

**Figure 6.36. Cross-Section of Constant Depth Cantilever Segmental Box Girder Bridge**

Result of the study: Variable depth box girder will be altered to a constant depth box girder as suggested.

The constant depth box girder will be employed to pass over the 50 m wide navigation clearance. Even if a cantilever box girder is adopted, it is proposed that the design be in proportion to four lanes to save initial construction cost.

**(5) Technical Notes for Widening Design of Box Girder Bridge**

Structural performances of a widened concrete box girder bridge under dead load, prestressing force, shrinkage and creep of concrete and settlements of piers are prerequisite problems in design analysis. The existing and new box girder bridges are connected to each other through their deck slabs. Connection of the two bridges will cause internal force to be redistributed between them. This will cause significant local stress along the connecting slab. To reduce the influence of internal force redistribution, factors such as connecting time, use of low-shrinkage concrete and prestressing arrangement for the new bridge need to be considered in the structural analysis. Other than structural analysis, structural details and construction process for the connecting slab are also needed to be cleared up in the design drawings. For the construction of bridge widening, it is critically important to follow the construction method and process specified in the design.

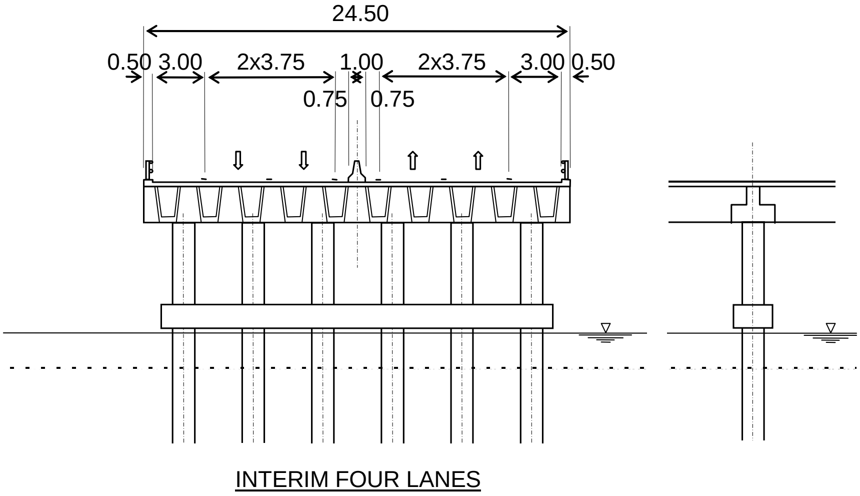
The following are common technical rules for bridge widening construction:

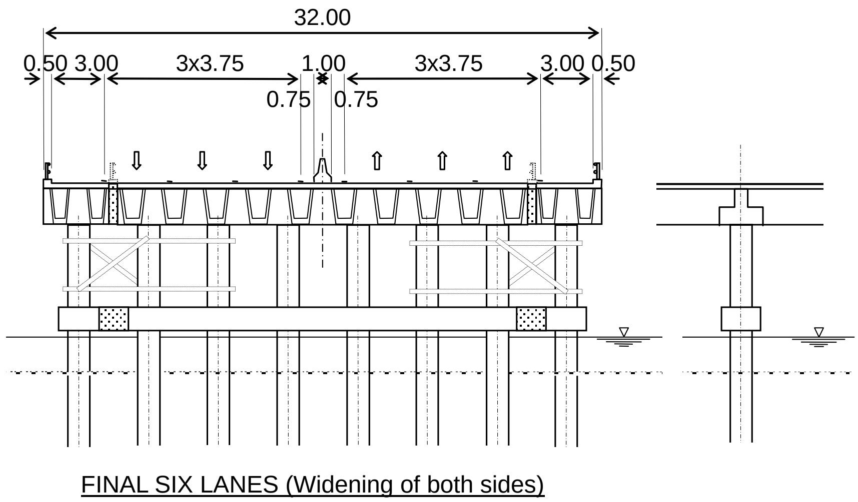
- The time for connecting the two bridges should be as delayed as possible.
- Use of low-shrinkage concrete will reduce internal force redistribution.
- Optimization of the prestressing design of the new bridge can improve the stress states in both the existing and new bridges.
- Settlements of piers of the new bridge must be strictly controlled.

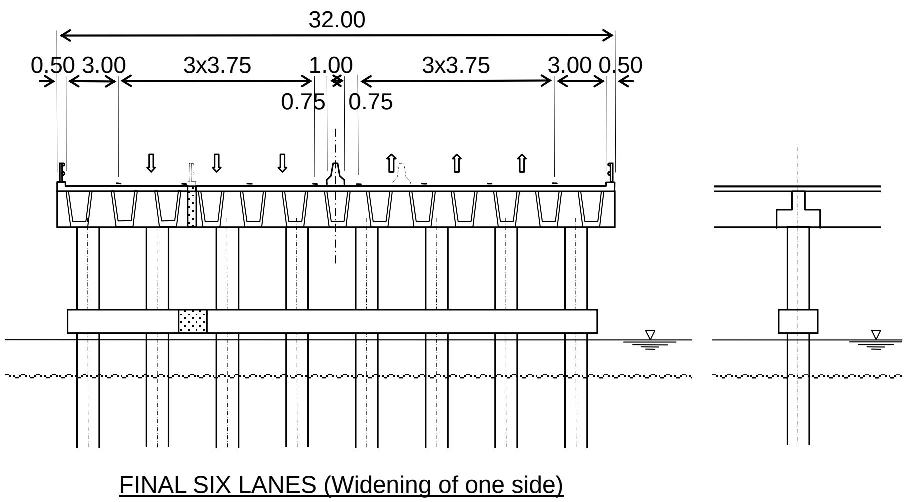
a) Bridge Widening Method

The expressway is scheduled to be initially constructed with four lanes and later widened to six lanes in the future. Bridges will also need widening from four to six lanes. Considering these, the existing design of precast girder bridges requires the provision of excessive number of piles to support the future six lanes in the initial stage of four lanes, judging that widening of pile foundation is difficult. This is despite the superstructure being designed with only four lanes. Meanwhile, the cantilever box girder bridge is designed for six lanes, both its piles and superstructure, even if it is initially intended as a four-lane structure.

However, it is advised to design all the bridge components just for four lanes at the initial stage to save initial construction cost. The structural engineer of the JICA Survey Team has the opinion that the widening of bridge, both of pile and superstructure components is technically not so difficult if design is prepared taking into account the future widening. Symmetrical widening can maintain the road center at the same position after being widened. However, it requires repeating widening construction twice on either side of the existing bridge. It will also need temporary bracing to hold the narrow widening structure of 3.75 m width. It is noted that one-sided widening is economical for one time widening construction; however, the road center will shift after being widened. Consequently, the approach road needs to be adjusted to match the road centerline and that of the bridge. (See **Figure 6.37**)




Source: JICA Survey Team

**Figure 6.37. Recommended Bridge Widening Method**

Result of the study: Bridges will be designed for four lanes only for both the pile and superstructure components during the initial construction.

D/D consultant is concerned about the additional piling work adjacent to the existing bridge structure when constructing the bridge widening. This is his reason for designing the pile components to support the future six lanes even in the initial four lanes stage. However, the Bridge Engineer of the JICA Survey Team explained that adjacent pile construction will not be a construction problem because bored pile is widely acknowledged as the safest piling method for constructing adjacent to the existing structure. Adjacent bored piling work is often observed being adopted for building construction sites also in HCMC.

#### 6.2.4.2. Evaluation of Alternatives in Bridge Design

The JICA Survey Team evaluated alternative designs which are described in Section 6.2.4.1, taking into consideration cost reduction. The results of evaluation are summarized in **Table 6.18** below.

**Table 6.18. Evaluation of Alternatives in Bridge Design**

| Alternative Design | Comments | Cost | | Evaluation |
|---|---|---|---|---|
| | | Cost Reduction (VND billion) | Ratio to the Total Construction Cost (%) * | |
| Embankment height and Bridge Length | ▪ No room to reduce the embankment height at abutment because maximum height was applied in D/D. | ±0 | 0.00% | - |
| Expressway over Provincial Road | ▪ Depending on the method and range of soft soil treatment, the cost may significantly increase.<br>▪ It is difficult to widen the box culvert in the future. | -251.2 | -1.57% | - |
| Road Structure Alternatives for 2 km Soft Ground Section (elevated road bridge) | ▪ Short span bridge (method-2) could significantly reduce the cost.<br>▪ However, there are serious issues that remain such as depth of sand layer (support layer) and the characteristics of its lower soft soil. | -641.5 | -4.00% | - |
| Bridge Structural Type and Structure Change | ▪ Change to precast girder bridge<br>▪ Constant bridge girder depth and economical span length | -398.0 | -2.48% | Adopted |
| | ▪ Position of pile cap is above water | -56.5 | -0.35% | Adopted |
| 4-lane Bridge Design and Widening Method | ▪ Significant reduction of initial investment cost is anticipated with due consideration to adjacent construction of bored piles | -718.3 | -4.48% | Adopted |

Note: *Ratio to the construction cost VND 16,029 billion in detailed design (%)

Source: JICA Survey Team

### 6.2.5 Soft Soil Treatment

The expressway crosses a broad area from northeast to southwest of the Mekong Delta. The ground condition of this road foundation is described below in detail, noting that it varies through the entire section, and there is a soft soil layer with the depth ranging from 5 m to 40 m. Therefore, many problems are likely to occur; for example, sliding or residual settlement of an embankment.

Soft ground treatments were planned as countermeasure against these problems, and thus, detailed design for these was carried out. In this study, the review of the D/D of soft ground treatments was carried out, and alternative solutions were proposed from the perspective of mainly, cost reduction. The result of this review and study is summarized in this section.

**(1) Reviewed and Summarized D/D**

1) Outline of Soft Soil Treatment Design

a) Design Policy

(i) Standards

Design criteria were set refering to the standards shown in **Table 6.19**. Generally in Vietnam, these standards are used for the design of soft soil treatment. Hence, there is no issue in adopting these standards.

**Table 6.19. Reference Standards**

| Standard No. | Purpose |
|---|---|
| 22 TCN 211-2006<br>(For the design of flexible pavement) | Setting of the residual settlement |
| TCVN5729-1997<br>(Expressway design) | Setting of the residual settlement |
| 22TCN 262-2000 | Setting of study condition (load, safety factor)<br>Method of consolidation settlement and stability analysis |

Source: JICA Survey Team

(ii) Design Criteria

The design criteria are summarized in T**able 6.20**. The standard, 22 TCN211-2006, states that residual settlement of normal embankment section shall be less than or equal to 30 cm. However, considering the experience in the area adjacent to this Project, the maximum residual settlement considered in this design is 10 cm. Therefore, the design was carried out on a safer side as compared to the provision in the standard.

**Table 6.20. Design Criteria**

| Segment | | Design criteria |
|---|---|---|
| Settlement | Residual Settlement | Sr ≤ 10cm |
| | Consolidation Degree | U ≥ 90% |
| | Others | Annual residual settlement velocity ≤ 2 cm/year |
| Stability | Factor of Safety | During construction Fs ≥ 1.2 |
| | | After construction Fs ≥ 1.4 |
| Load Condition | Settlement Analysis | Embankment load, pavement load, surcharge, traffic load (=1.3 t/m$^2$) |
| | Stability Analysis | Embankment load, pavement load, surcharge, traffic load (=1.5 t/m$^2$) |

Source: JICA Survey Team

(iii)Design Policy

A comparison table from the D/D is shown in **Table 6.21** below. According to the table, the PVD method which has economical superiority, shall be mainly applied at each section when possible. In case of deep soft soil layer existence and where embankment stability cannot be ensured with application of PVD, deep cement mixing (DCM) or pile slab method is applied on the section.

The performance of these soft soil treatment methods have actually been witnessed in Vietnam, and thus, the policy for such selection is reasonable.

**Table 6.21. Comparison Table of Soft Soil Treatment Methods**

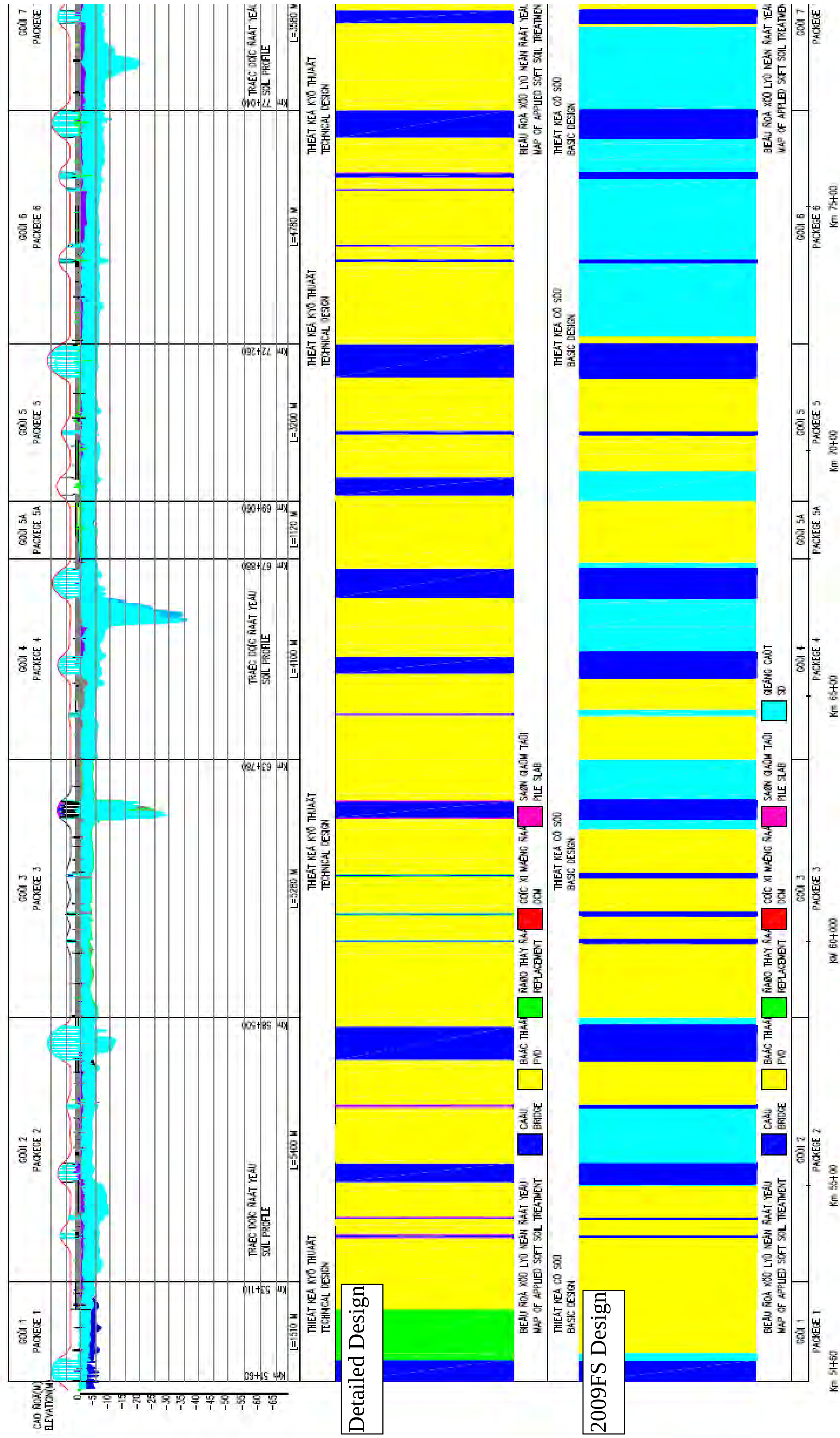
| | Methods | Prefabricated Vertical Drain(PVD) with preloading | Soil Replacement with Preloading | Soil Replacement | PVD+Surchage +Counterweight | SD+Surchage +Counterweight | Deep cement mixing column(DCM) | Pile slab |
|---|---|---|---|---|---|---|---|---|
| Technical Issues | *Consolidation Settlement* | High | Controlled by soil replacement thickness | Controlled by soil replacement thickness, can reach to zero | High | High | Low | Low |
| | *Residual Settlement* | Can be controlled through proper application of surcharge | Controlled by replacement thickness and preloading period | Controlled by soil replacement thickness | Controlled by spacing of PVD and Surchage period | Controlled by SD spacing and Surchage period | Controlled by length of pile | Controlled by length of pile |
| | *Stability* | Increase in Factor of Safety due to increase in soil strength during consolidation | Increase in Factor of Safety due to replacement with firmer soil | Increase in Factor of Safety due to replacement with firmer soil | Increase in Factor of Safety due to increase in soil strength during consolidation | Increase in Factor of Safety due to increase in soil strength during consolidation | Increase in Factor of Safety due to High load bearing capacity of DCM columns | Increase in Factor of Safety due to High load bearing capacity of pile. |
| Financial Issues | *Maintenance Cost* | Moderate | Moderate | Low | High | High | Low | Low |
| | *Construction Cost* | Low if thickness of soft soil | Moderate –Depend on replacement depth | Depend on replacement depth | Low | Low | Fairly high | Fairly high |
| Other Related Issues | *Construction Period* | Longest - depend on surcharge time | Moderate – Depend on equipment used, material supply and surcharge time | Moderate – Depend on equipment used, material supply and surcharge time | Longest - depend on surcharge time | Longest - depend on surcharge time | Fast– Depend on equipment used. | Fast– Depend on equipment used |
| | *Long Term Performance* | Small differential settlement | Small differential settlement | Good | Moderate | Moderate | Good | Good |
| | *Right of Way* | Require significant area for counterweight berm | Require some ROW | In area of roadbed occupancy | Need large area for counter weight when deep soft soil, high embankment | Need large areas for counter weight when deep soft soil, high embankment | No need area for counter weight | No need area for counter weight |
| | *Local Experience in Construction* | Good | Good – Mainly earthwork | Good – Mainly earthwork | Moderate | Moderate | Little used | Good – Mainly reinforcement concrete work |
| | *Use in Vietnamese Road project before* | Yes | Yes | Many | Many | Many | Little | Many |
| | *Market Supply* | No problem, except sand mat supply | Black sand fill supply may be major issue | No problem, mainly fine sand | No problem, except sand mat supply | Need a big quantity medium sand to make sand drain and sand mat layer | No problem, except import of construction equipment | No problem, mainly product in Viet Nam. |
| | *Likelihood of Usage* | Attractive method but requiring long construction period | Suitable method for thin soft clay deposit | Suitable solution for thin soft clay deposit | Attractive method with low cost but requiring long construction period | Attractive method with low cost but requiring long construction period | Attractive method with high cost and requiring experience in construction managerment, need more tests: pilot test, shear test, bearing capacity test etc… | Suitable solution for height and thickness of mud larger |

Source: D/D Report

b) Outline of the D/D

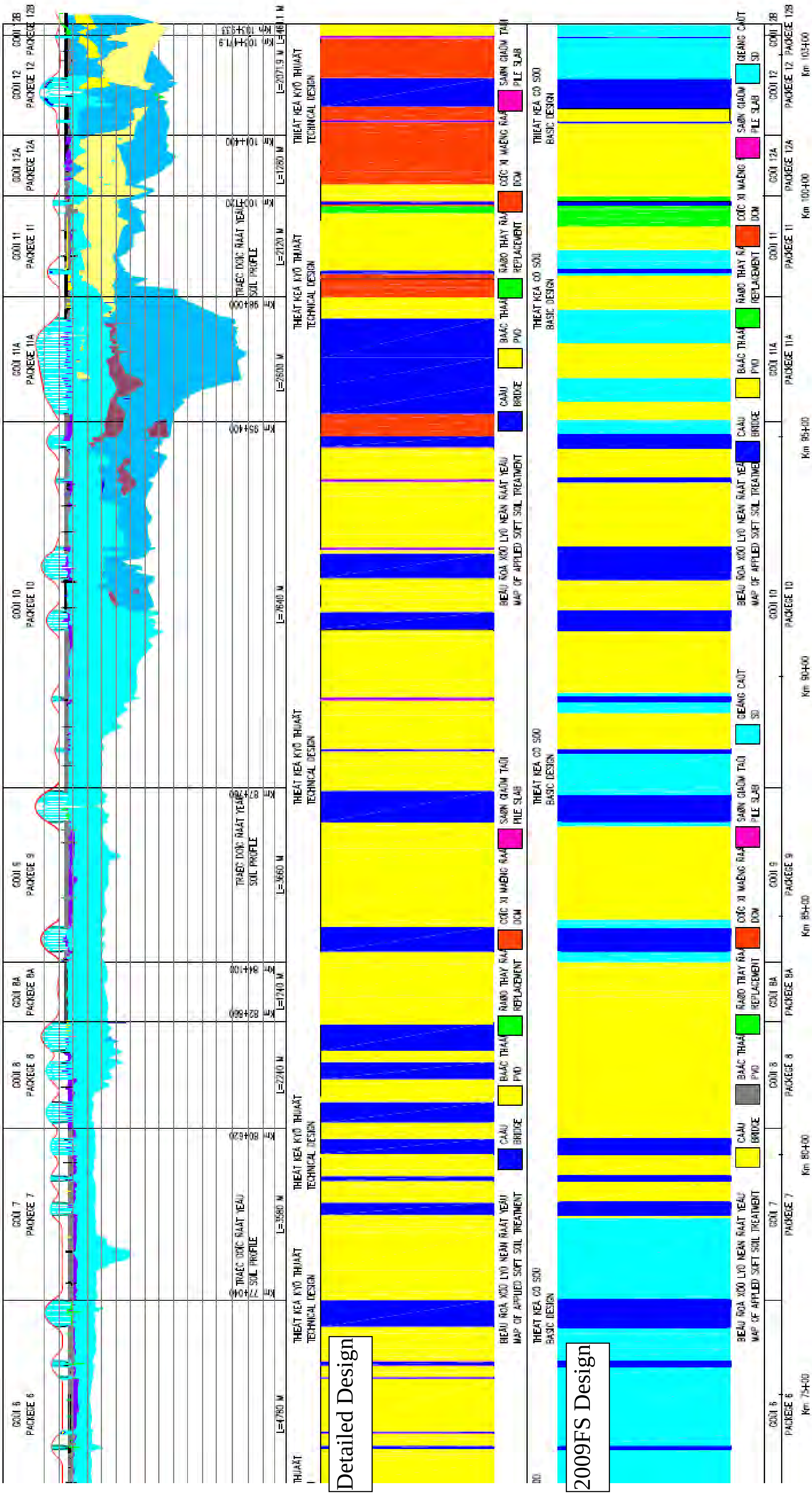
According to the soil investigation and calculation results, the most suitable soft soil treatment method is applied to each section in conformity with the above selection policy. The soil investigation results and application of soft soil treatment methods are summarized in **Figure 6.38** and **Figure 6.39**. These figures show that PVD method is applied to many sections, while DCM is applied to various sections of PK-10, PK-11, and PK-12 where soft soil layer is thick. The section lengths and costs of soft soil treatments are summarized in **Figure 6.40**. These costs were estimated referring to the cost estimate results dated October 2011. Soft soil treatment costs/embankment length were calculated and summarized in **Figure 6.42**. These figures show that the costs of soft soil treatment on PK-10 to PK-12 are higher than on other sections, and especially, PK-12 is significantly more costly (about 3 to 9 times) than others. Therefore, it is judged that the detailed review of PK-12 design is required. Results of review are summarized and shown in below item (3) 3) Review of PK-12 Design.

**Figure 6.38. Soil Profile and the Application of Soft Soil Treatments (PK-1 to PK-6)**



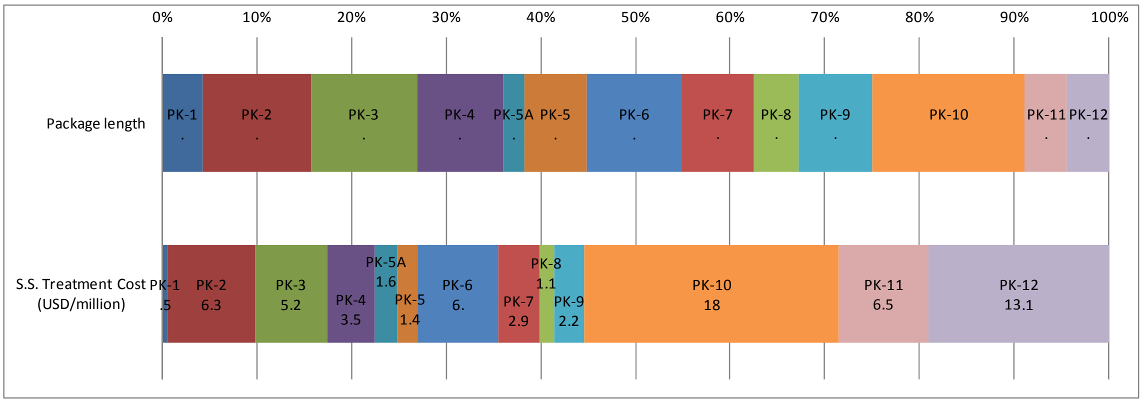

Source: JICA Survey Team

**Figure 6.39. Soil Profile and the Application of Soft Soil Treatments (PK-7 to PK-12)**




Source: JICA Survey Team

**Figure 6.40. Package Lengths and Soft Soil Treatment Costs**




Source: JICA Survey Team

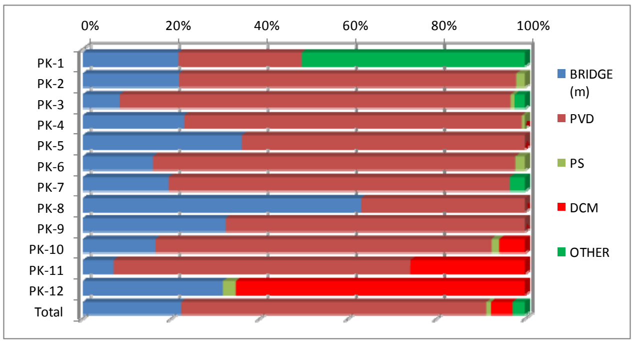
**Figure 6.40** shows that the soft soil treatment costs under PK-10 to PK-12 are more than half of all the packages. The primary reason of these is the thickness of soft soil layer, which is about 30 m in PK-10 to PK-12.

**Figure 6.42** and **Table 6.22** show that the costs of soft soil treatment under PK-10 to PK-12 are higher than on other sections, and especially, PK-12 costs is significantly higher (about 3 to 9 times) than others. The primary reason for this is only DCM was applied to all sections of PK-12 as shown in **Table 6.22** and **Figure 6.41**.

**Table 6.22. Bridge and Soft Soil Treatment Lengths**

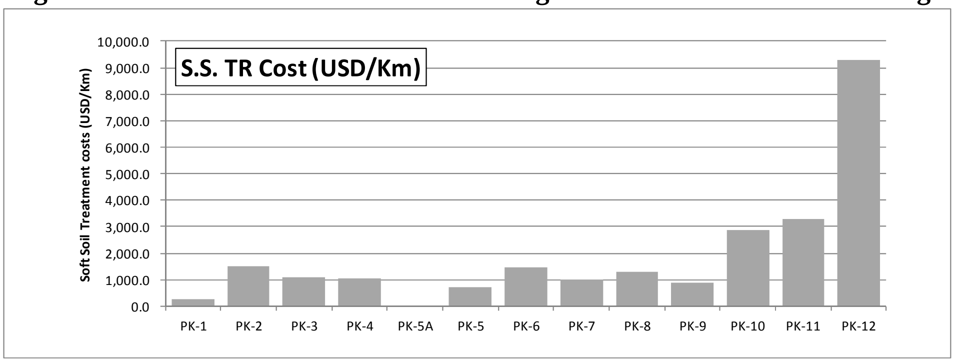
| | TOTAL (m) | BRIDGE (m) | Soft Soil Treatment (m) | | | |
|---|---|---|---|---|---|---|
| | | | PVD | PS | DCM | OTHER |
| PK-1 | 2,050 | 444 | 570 | 0 | 0 | 1,036 |
| PK-2 | 5,390 | 1,173 | 4,108 | 104 | 0 | |
| PK-3 | 5,280 | 440 | 4,673 | 47 | 0 | 120 |
| PK-4 | 4,320 | 992 | 3,299 | 30 | 0 | |
| PK-5 | 3,100 | 1,118 | 1,982 | 0 | 0 | |
| PK-6 | 4,780 | 766 | 3,914 | 100 | 0 | |
| PK-7 | 3,580 | 697 | 2,762 | 0 | 0 | 121 |
| PK-8 | 2,240 | 1,410 | 830 | 0 | 0 | |
| PK-9 | 3,660 | 1,189 | 2,471 | 0 | 0 | |
| PK-10 | 7,640 | 1,262 | 5,792 | 150 | 436 | |
| PK-11 | 2,120 | 147 | 1,426 | 0 | 547 | |
| PK-12 | 2,071 | 659 | 0 | 60 | 1,353 | |
| Total | 46,231 | 10,298<br>22.3% | 31,826<br>68.8% | 491<br>1.1% | 2,335<br>5.1% | 1,277<br>2.8% |

**Figure 6.41. Bridge and Soft Soil Treatment lengths**




Source: JICA Survey Team

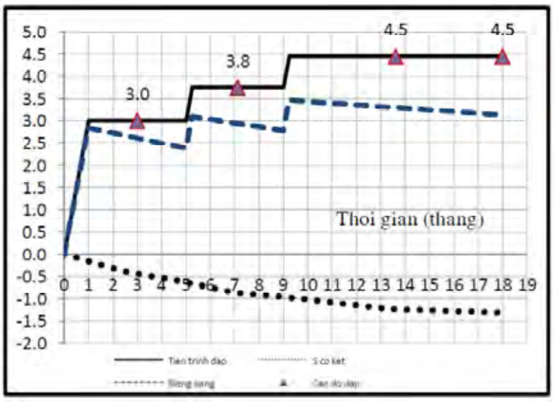
**Figure 6.42. Soft Soil Treatment Cost/Length of Each Construction Package**



c) Outline of PVD Method

PVD method is one of the accelerating consolidation methods. Prefabricated drain material is installed through the ground in fixed spaces by using a PVD machine. Consequently, a faster rate of settlement will be achieved due to the shortened drainage distance. As this method has economical priority and is easy to construct, this has been applied at various locations in Vietnam. Moreover in this detailed design, PVD method is proposed for many sections. A calculation example of this method is shown in **Figure 6.43**. PVD spaces are set by analyzing each section to suit the permitted residual settlement (10 cm) within 18 months of its construction period (from the beginning of filling an embankment to the end of awaiting settlement). Stability analyses were carried out to clarify the safety of embankment construction.

**Figure 6.43. Filling Step of the Section Applied with PVD**




Source: Detailed Design Report

These studies are carried out reasonably based on a general policy.

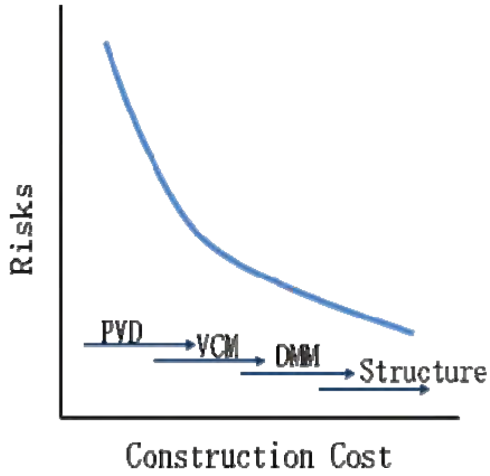
d) Envisioned Risks

In the detailed design, PVD method is mainly applied to each section considering economical aspects. This method is one of the accelerating consolidation methods as described above. Therefore, it is subject to some risks such as settlement behavior, which will be different from the expected result, or the period for awaiting settlement will not be sufficient due to construction delay.

These risks are summarized in **Table 6.23.**

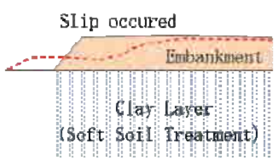
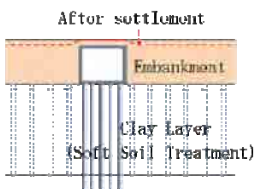
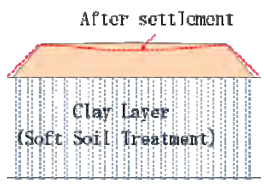
Methods that have no residual settlement are, for example, DCM or pile slab method; however, construction costs for these are significantly higher than PVD methods as described above. Therefore, it is important to reduce risks through adequate management during construction. Moreover, a study of alternative treatment methods for reducing risks during construction was carried out and described in Table 6.23 below (VCM application).

**Figure 6.44. Relation of Risks and Costs**




Source: JICA Study Team

**Table 6.23. Envisioned Risks**

| Risks During Construction | | Risks After Construction | |
|---|---|---|---|
| |   |   |   |
| Construction delay risks bec ause settlement occurs slow er than expected. | Construction delay risks beca use of embankment destabili zation and required counterm easure works | Uneven surface at adjacent area of the structure beca use of residual settlement | Poor drainage because of i nverse draft with residual s ettlment |

Source: JICA Survey Team

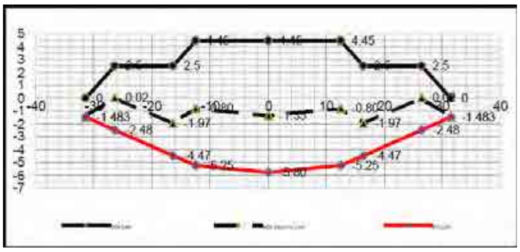
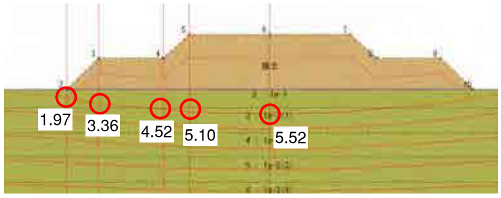
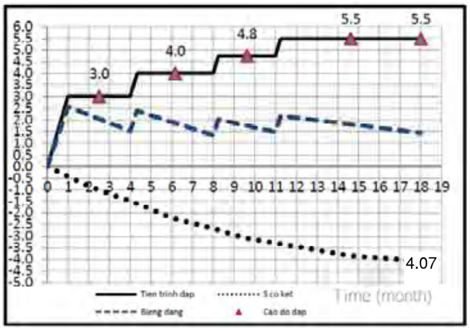
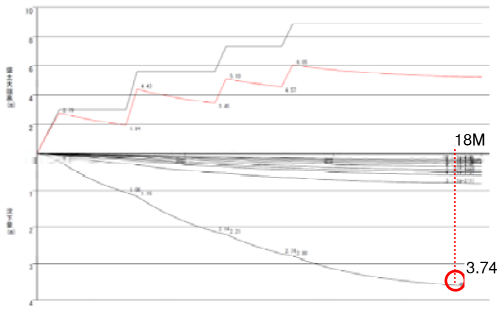
### (2) Review of the Analysis

In order to verify the results of the D/D, analysis, the use of another standard code and program was carried out. The conditions of PK-4, Section 10, were selected as model case because expected settlements were larger and could occur at a slower rate than the other sections. The results are summarized below:

1) Consolidation Settlement

Consolidation settlement analysis method does not vary in each standard, and the formula applied is the same. The differences between results by each calculation program are due to differences in the method of interpreting the results of stress distribution of 2D section. Analysis results are summarized in **Table 6.24**

**Table 6.24. Results of the Analysis**

| | Analysis of D/D | Review Analysis |
|---|---|---|
| Final Consolidation Settlement |   |   ※Consolidation settlement + Immediate settlement (40%) |
| Time - settlement Chart |   |   |

Source: JICA Survey Team

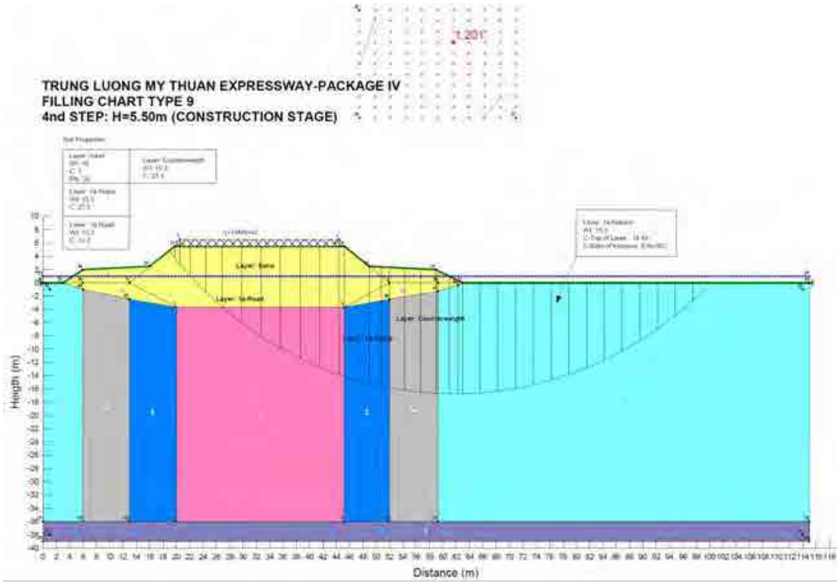
These results of both analyses are almost the same under a common condition. Hence, it is judged that the D/D analysis was reasonably carried out.

2) Stability Analysis

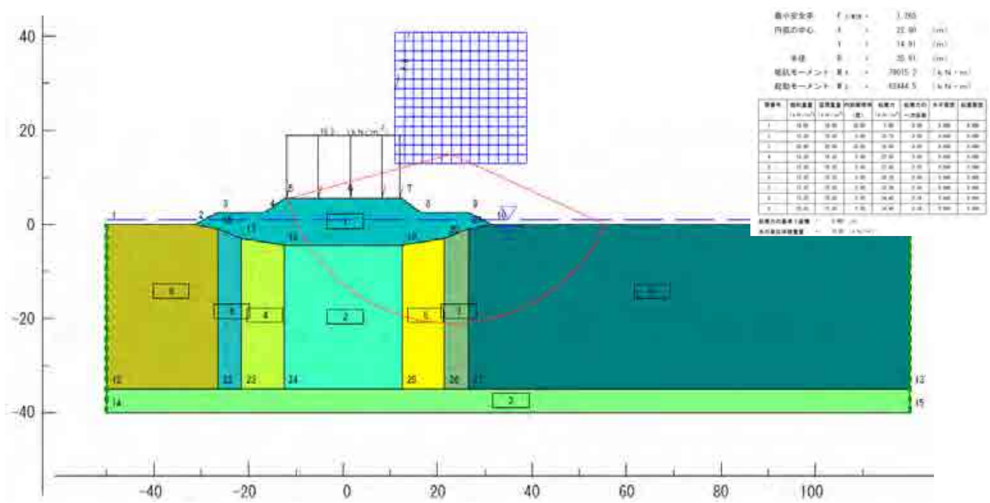
Stability analysis in the detailed design was carried out using the GEO-SLOPE, Bishop method. In this study, this analysis was carried out using COSTANA, Bishop method and modified Fellenius method, which are referred from the "Design Method of Expressway" (H22.7, East Nippon Expressway Co., Ltd. and others). One of the model cases is the Step 4 during construction, and the other is final step after construction. Corresponding results are shown in **Figure 6.45** and **Figure 6.46**. However, slight difference (about Fs 0.05) between the GEO-SLOPE Bishop method and COSTANA Bishop method is observed on each results. Thus, it can be judged that the D/D analysis was reasonably carried out considering that the results are almost the same.

**Figure 6.45. Results of D/D Analysis and Review Analysis (During Construction)**

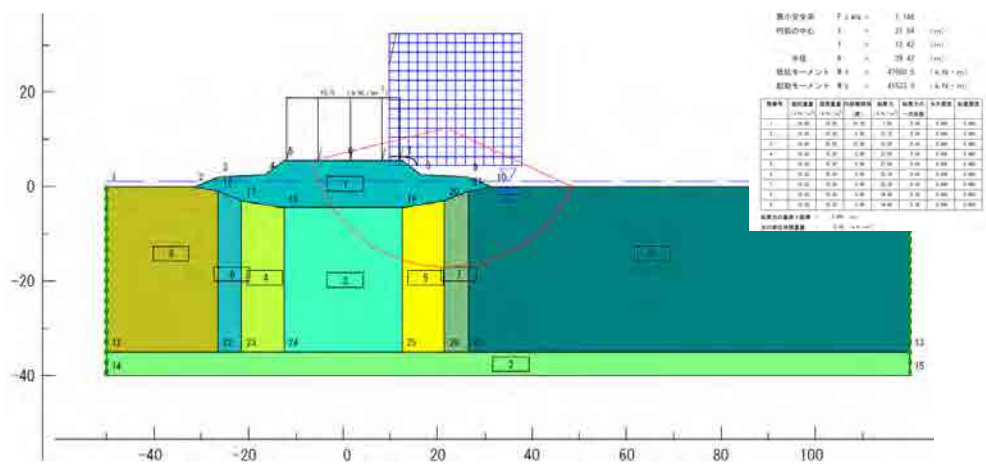
Detailed Design / BISHOP Method




Review Analysis / BISHOP Method



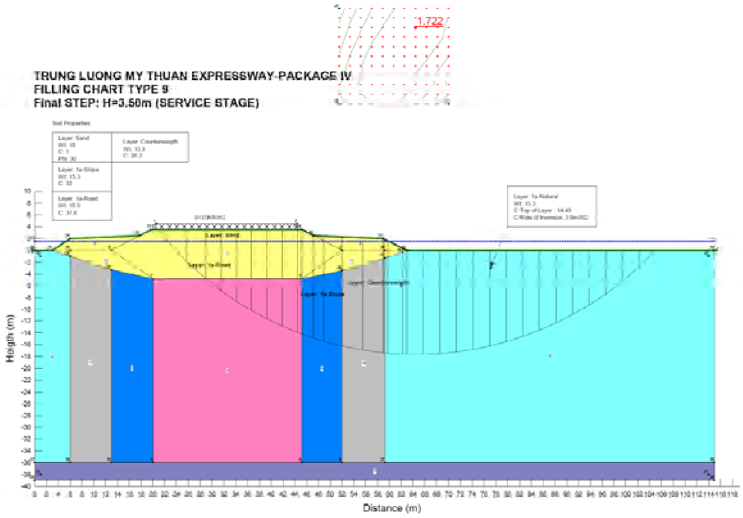

Review Analysis / Modified Fellenius Method



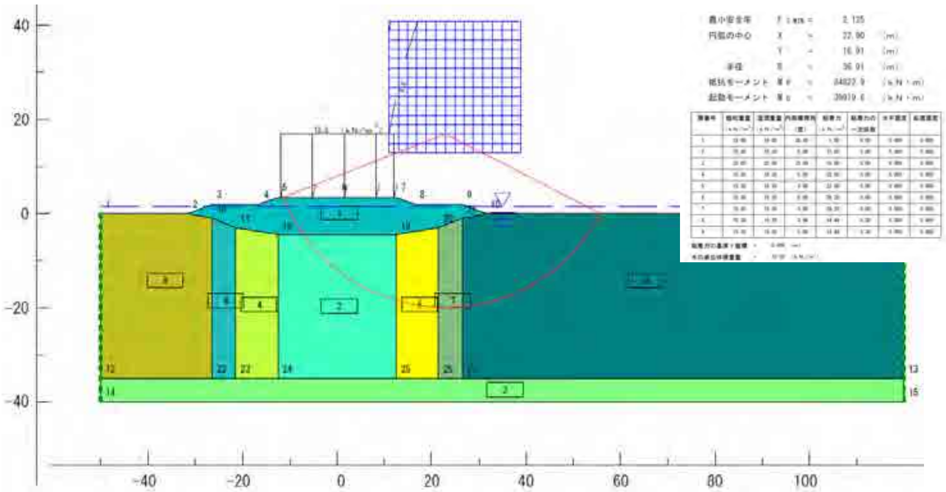

SOURCE: JICA Survey Team

**Figure 6.46. Results of D/D analysis and Review Analysis (After Construction)**

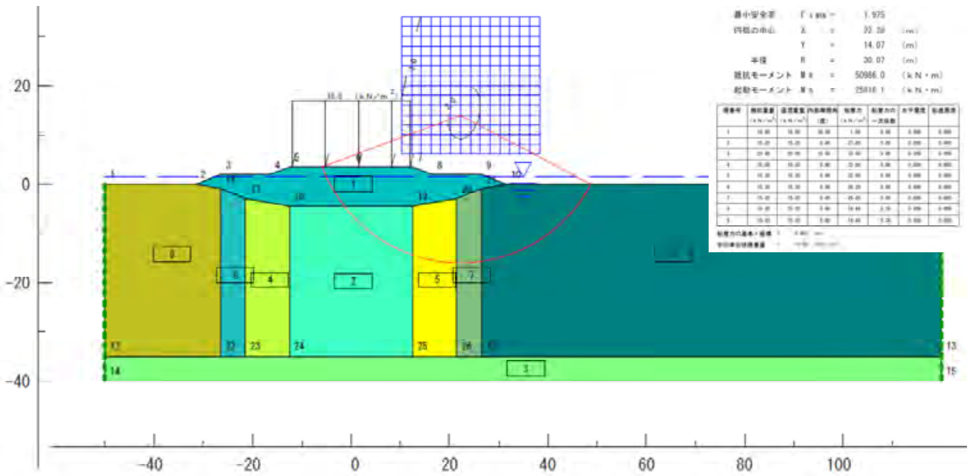
Detailed Design / BISHOP method




Review analysis / BISHOP method




Review Analysis / modified fellenius method




SOURCE: JICA Survey Team

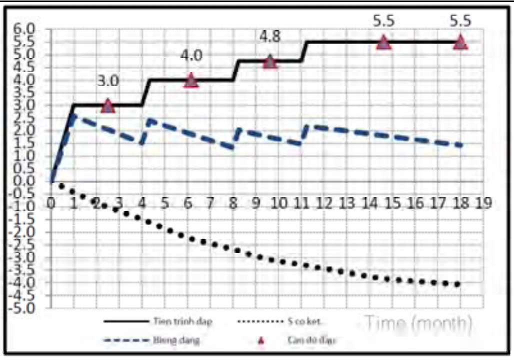
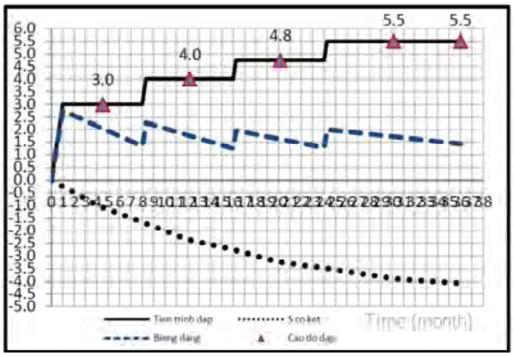
**(3) Study of Alternative Soft Soil Treatment**

1) Tolerate Long Construction Period

One of the cost cutting solutions for accelerating consolidation method (PVD, etc.) is to tolerate longer construction period. In the D/D, construction period (from the beginning of embankment filling to the end of awaiting settlement) is set to 18 months, and the space for installing PVD was determined. In this study, considering a construction period of 36 months, consolidation analysis was carried out. The conditions of PK-4 Section 10 were selected as model case because the expected settlements were larger and could occur at a slower rate than those of the other sections.

The results of analyses are shown in **Table 6.25**. Based on these, PVD spacing can be changed from 1.1 m to 1.5 m. Corresponding costs are shown in **Table 6.26**, which indicates a 7% decrease of the original design costs.

**Table 6.25. Analysis Results of D/D and Alternative 1 (Tolerate Long Construction Period)**

| Detailed Design | Alternative Study |
|---|---|
| PVD Spacing: 1.1 m<br>Construction Period: 18 months | PVD Spacing: 1.5 m<br>Construction Period: 36 months |
|  |  |

SOURCE: JICA Survey Team

**Table 6.26. Cost Estimates of Alternative 1 (Tolerate Long Construction Period)**

| Item | Unit | Unit cost | Quanity | | Cost | | decrease rate |
|---|---|---|---|---|---|---|---|
| | | | Detailed Design | Alternative 1 | Detailed Design | Alternative 1 | |
| **SOFT SOIL TREATMENT** | | | | | | | |
| - Surcharge by fine sand K90 | $m^3$ | 110,000 | 41,743 | 41,743 | 4,591,757,073 | 4,591,757,073 | |
| - Removing surcharge | $m^3$ | 32,000 | 41,743 | 41,743 | 1,335,783,876 | 1,335,783,876 | |
| - PVD | m | 10,000 | 497,506 | 320,205 | 4,975,061,000 | 3,202,051,000 | 35.6% |
| - Polyester Covering sheet | $m^2$ | 7,000 | 24,566 | 24,566 | 171,964,665 | 171,964,665 | |
| - Covering settlement by fine sand K95 | $m^3$ | 116,000 | 81,472 | 81,472 | 9,450,797,748 | 9,450,797,748 | |
| - Medium sand mat | $m^3$ | 180,000 | 14,333 | 14,333 | 2,579,940,000 | 2,579,940,000 | |
| - Fine sand (counterweight) | $m^3$ | 116,000 | 16,051 | 16,051 | 1,861,939,200 | 1,861,939,200 | |
| - Vacuum pump 60~70KPa | $m^2$ | 840,000 | | | - | - | |
| - Steel panel | m | 147,000 | | | - | - | |
| **MONITORING TASK** | | | | | | | |
| - Settlement plate | piece | 1,500,000 | 20 | 20 | 30,000,000 | 30,000,000 | |
| - Inclinometer | piece | 26,000,000 | 8 | 8 | 208,000,000 | 208,000,000 | |
| - Observation well | piece | 2,000,000 | 8 | 8 | 16,000,000 | 16,000,000 | |
| - Lateral displacement observing stake | piece | 120,000 | 24 | 24 | 2,880,000 | 2,880,000 | |
| - Electrical piezonmeter | piece | 58,000,000 | 4 | 4 | 232,000,000 | 232,000,000 | |
| TOTAL | | | | | **25,456,123,562** | **23,683,113,562** | 7.0% |

SOURCE: JICA Survey Team

Referring to these results, the costs of applying PVD to all packages were roughly estimated as shown in **Table 6.27**.

**Table 6.27. Approximate Costs in PVD is Applied to All Packages**

| | 1)Soft Soil Treatment Cost (VND) | 2)Percentage of PVD length | Reduce cost 1)x2)x7% (VND) |
|---|---|---|---|
| PK-1 | 12,997,495,593 | 35.5% | 322,914,118 |
| PK-2 | 190,949,108,906 | 97.4% | 13,019,740,695 |
| PK-3 | 196,183,982,328 | 96.5% | 13,259,047,488 |
| PK-4 | 98,892,199,210 | 99.1% | 6,862,631,296 |
| PK-5 | 36,654,690,254 | 100.0% | 2,565,543,513 |
| PK-6 | 107,858,134,746 | 97.5% | 7,362,047,441 |
| PK-7 | 74,564,922,747 | 95.8% | 5,000,108,519 |
| PK-8 | 27,371,857,740 | 100.0% | 1,916,030,042 |
| PK-9 | 57,262,416,462 | 100.0% | 4,008,369,152 |
| PK-10 | 467,793,663,234 | 90.8% | 29,737,334,315 |
| PK-11 | 167,523,359,808 | 72.3% | 8,475,095,297 |
| PK-12 | 335,157,318,227 | 0.0% | 0 |
| Total | | | 92,528,861,876 |

By tolerating 36 months of construction period, the total duration becomes about two years longer than the original design period. Reduced cost, which is about VND 92 billion as shown above, is below 1% of total the construction cost. Therefore, considering Vietnam's inflation rate, this alternative is not recommended unless there is another reason to tolerate long construction periods.

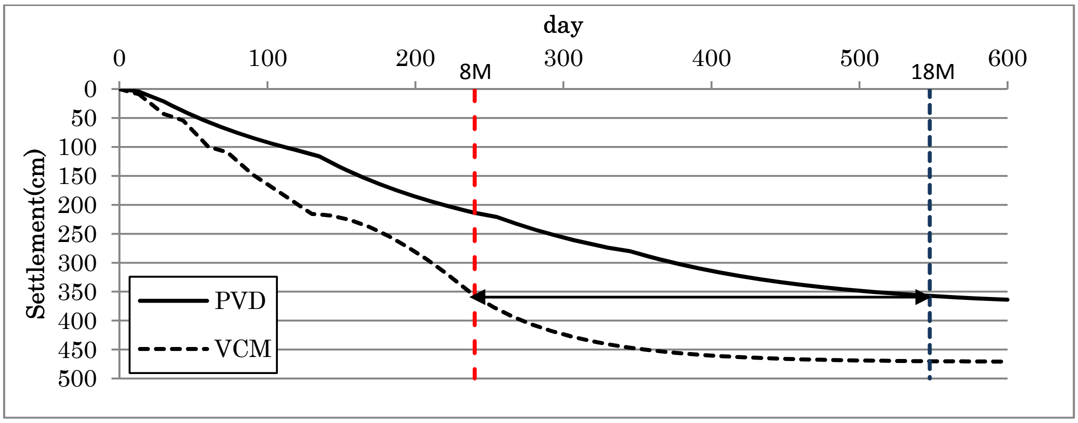
2) Application of VCM

VCM is one of the accelerating consolidation methods. In this case, PVD material is installed at the foundation, the same as for PVD method. The heads of the PVD are then linked to each other. Vacuum pump is connected to these and covered by air sealing, then forcibly drained. By applying this method, construction period can be shorter than that of the PVD method. On the other hand, as vacuum pump and other facilities are required, construction costs are expected to increase.

Though this method is not generally at this moment applied to many sites in Vietnam, and is not a comparable solution to the D/D, this has been actually applied at some projects in Vietnam. Moreover, the cost of VCM is generally lower than of DCM. Therefore, it is worth studying the application of VCM. The conditions of PK-4 Section 10 were selected as a model case because expected settlements were larger and could occur at a slower rate than that of the other sections.

Calculation results for VCM and PVD application are shown in **Figure 6.47,** with the condition that PVD spacing is 80 cm and considering 60 KPa vacuum pressure. Settlement after eight months with VCM is almost the same as after 18 months with PVD method.

**Figure 6.47. Calculation Results of VCM and PVD Application**




SOURCE: JICA Survey Team

Cost estimates were carried out, and the results compared with those of PVD are shown in **Table 6.28**. This table shows that the cost of VCM increased by 36% as compared to that of PVD.

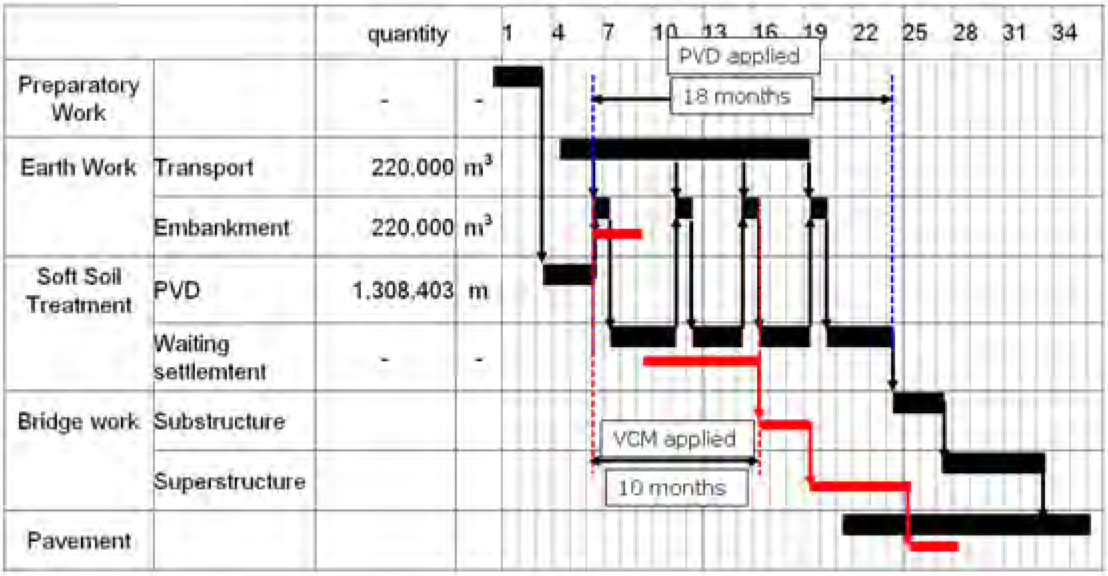
**Table 6.28. Approximate Costs of VCM (PK-4 Section10)**

| Item | Unit | Unit cost | Quanity | | Cost | | decrease rate |
|---|---|---|---|---|---|---|---|
| | | | Detailed Design | Alternative 3 | Detailed Design | Alternative 3 | |
| **SOFT SOIL TREATMENT** | | | | | | | |
| - Surcharge by fine sand K90 | $m^3$ | 110,000 | 41,743 | | 4,591,757,073 | - | |
| - Removing surcharge | $m^3$ | 32,000 | 41,743 | | 1,335,783,876 | - | |
| - PVD | m | 10,000 | 497,506 | 801,276 | 4,975,061,000 | 8,012,756,000 | -61.1% |
| - Polyester Covering sheet | $m^2$ | 7,000 | 24,566 | 20,273 | 171,964,665 | 141,911,912 | 17.5% |
| - Covering settlement by fine sand K95 | $m^3$ | 116,000 | 81,472 | 72,438 | 9,450,797,748 | 8,402,855,499 | 11.1% |
| - Medium sand mat | $m^3$ | 180,000 | 14,333 | 9,570 | 2,579,940,000 | 1,722,600,000 | 33.2% |
| - Fine sand (counterweight) | $m^3$ | 116,000 | 16,051 | | 1,861,939,200 | - | 100.0% |
| - Vacuum pump 60~70KPa | $m^2$ | 840,000 | | 18,720 | - | 15,724,800,000 | ** |
| - Steel panel | m | 147,000 | | 1,038 | - | 152,586,000 | |
| **MONITORING TASK** | | | | | | | |
| - Settlement plate | piece | 1,500,000 | 20 | 12 | 30,000,000 | 18,000,000 | |
| - Inclinometer | piece | 26,000,000 | 8 | 8 | 208,000,000 | 208,000,000 | |
| - Observation well | piece | 2,000,000 | 8 | 8 | 16,000,000 | 16,000,000 | |
| - Lateral displacement observing stake | piece | 120,000 | 24 | 24 | 2,880,000 | 2,880,000 | |
| - Electrical piezonmeter | piece | 58,000,000 | 4 | 4 | 232,000,000 | 232,000,000 | |
| TOTAL | | | | | **25,456,123,562** | **34,634,389,411** | -36.1% |

Source: JICA Survey Team

Referring to these results, though the cost of VCM will change depending on the construction period, such cost will be about 30%-40% higher than that of PVD. On the other hand, construction period will be about half shorter than that of the original design. Approximate construction schedule for the area adjacent to the bridge abutment is shown in **Figure 6.48**. This figure indicates that there is limited allowance in construction. Therefore, if preparatory works, earthworks or progress of consolidation settlement is delayed, road service will also likely be delayed leading to large loss in project profits. If

VCM is applied in this section, the construction schedule shall change as shown by the red lines in **Figure 6.48**, It indicates that there is enough margin for construction and risks of construction delays can be significantly reduced.




SOURCE: JICA Survey Team

**Figure 6.48. Approximate Construction Schedule**

Among all the construction packages, the section with the highest construction delay risk is PK-4 section 11 because its soft soil layer is rather thicker. Also, its consolidation settlement is expected to occur at a very slow rate according to soil investigation results (low Cv).

Costs of the case applied with VCM to PK-4 section 11 can be roughly estimated by multiplying the Section 10 costs (refer to Table 6.29) by the rate for Section 11 length. The resulting cost is VND 2.2 billion.

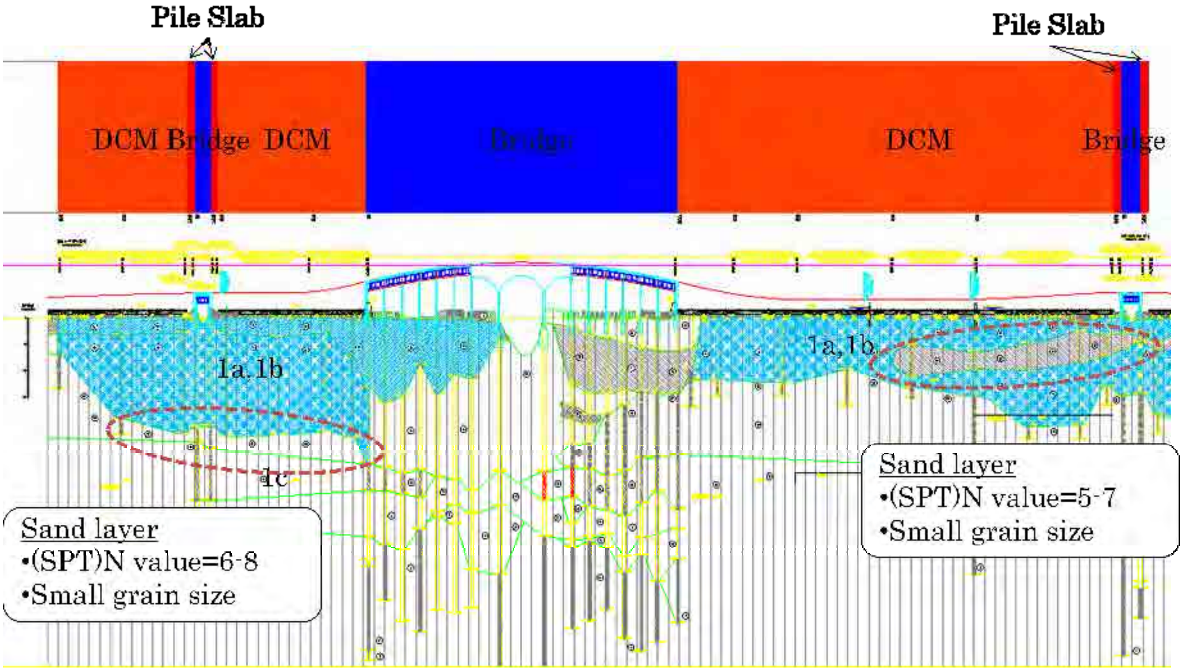
Because the delay in road service will not be tolerated, application of VCM, especially to PK-4 section 11, which has the highest construction delay risk, is recommended.

3) Study of Alternative for PK-12 Soft Soil Treatment Solution

The cost of PK-12 soft soil treatment solution is significantly high as described above. In order to figure out the possible application of alternative, the study is carried out and summarized in this section. DCM method as soft soil treatment is applied to all sections of PK-12, except for pile slab method on adjacent area of the bridge as shown in **Figure 6.49**. Regarding foundation conditions, soft clay layer (1a,1b) thickness is about 10 m to 20 m, sand layer (S1) thickness is about 5 m, sand layer (S2) thickness is about 5 m or more, and slightly soft clay layer (1c) are found in PK-12. It was concluded in the detailed design that the PVD method cannot be applied because of the difficulty in installing PVD through the sand layers when using a PVD machine. Thus, to reduce risks in construction, application of DCM is reasonable.

Review of the sand layer (S1, S2) condition is described below. Results of soil laboratory tests are shown in **Table 6.29** and Standard Penetration Test results are shown in **Figure 6.50**, and **Figure 6.51**. These table and figures show that gravel particle is not included in these layers, and corresponding N-values are 5 to 8.

**Figure 6.49. Soil Profile and Application of Soft Soil Treatment Solution in PK-12**

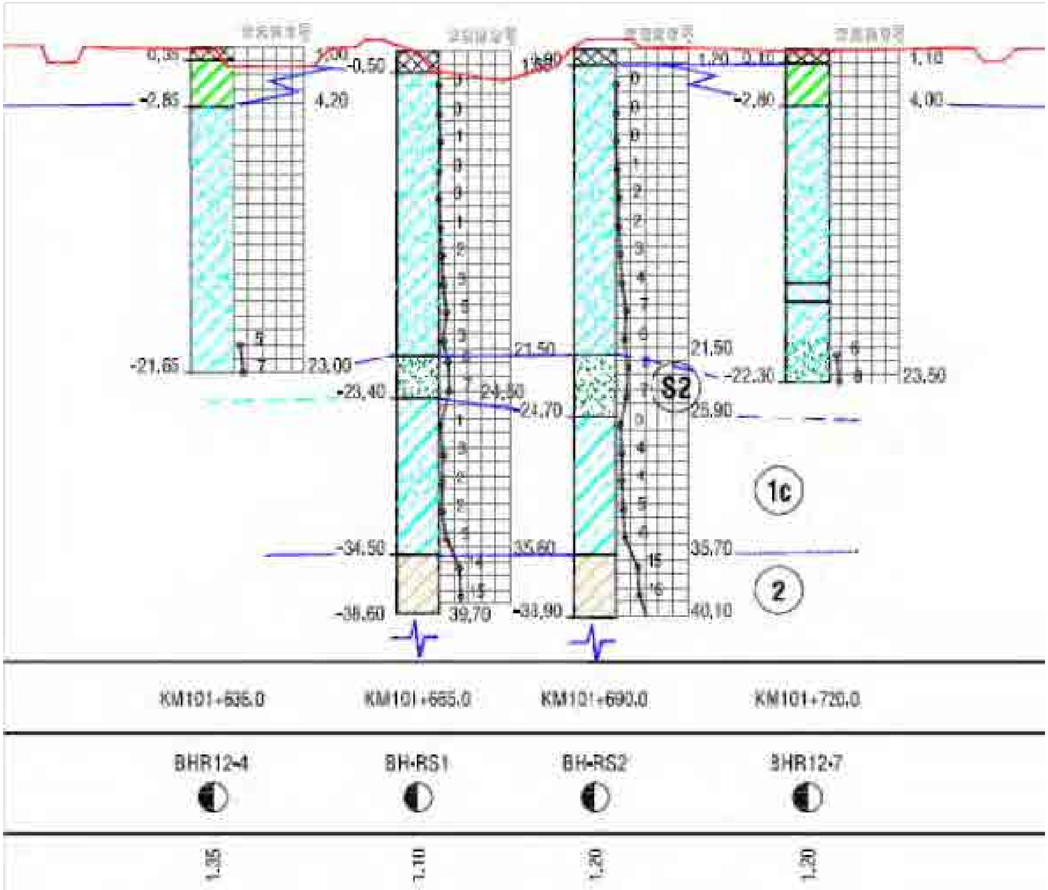



SOURCE: JICA Survey Team

**Table 6.29. Labolatory Test Results for Sand layers (S1,S2)**

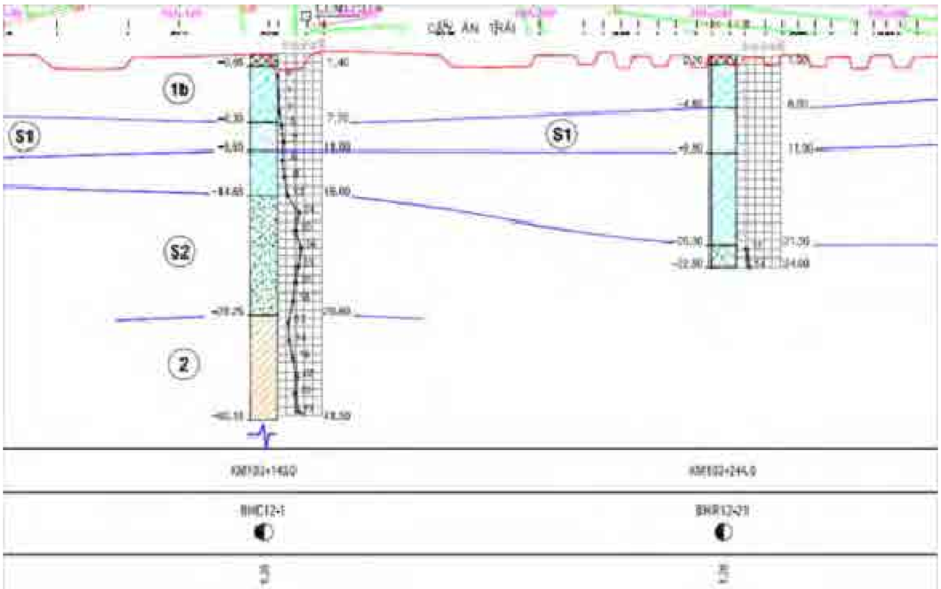
| Properties | Units | Average value |
|---|---|---|
| Percentage of sand | % | 70.5 |
| Percentage of silt and clay | % | 29.5 |
| Moisture contents W | % | 29.3 |
| Wet unit weight ρ | g/cm$^3$ | 1.83 |
| Specific gravity $\rho_s$ | | 2.69 |
| Void ratio $e_o$ | | 0.903 |
| Liquid limit LL | % | 28.9 |
| Plastic limit PL | % | 21.6 |
| Plasticity index PI | % | 7.3 |
| Internal friction angle φ° (Direct shear test) | Degree | 27°44' |
| Cohesion C (Direct shear test) | kG/cm$^2$ | 0.101 |

| Properties | Units | Average value |
|---|---|---|
| Percentage of sand | % | 77.7 |
| Percentage of silt and clay | % | 22.3 |
| Moisture contents W | % | 27.2 |
| Specific gravity $\rho_s$ | | 2.68 |
| Unsoaked angle of repose | | 36 |
| Soaked angle of repose | % | 23 |
| Max void ratio $e_{max}$ | % | 1.323 |
| Min void ratio $e_{min}$ | % | 0.704 |




Source: Soil Investigation Report

**Figure 6.50. SPT Results of S2 Layer**




Source: Soil Investigation Report

**Figure 6.51. SPT Results of S1 Layer**

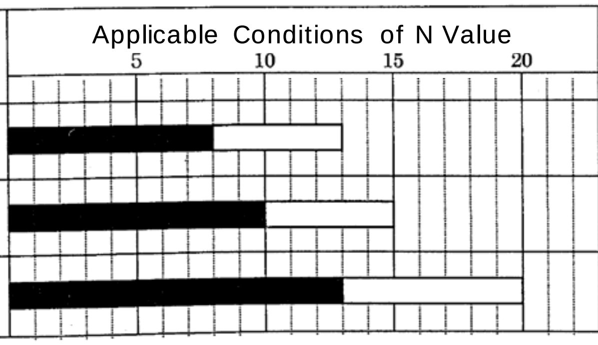
There is a useful document about the ability of PVD machine as shown below. This document was published by NCB construction method association in Japan. This shows that there are three kinds of PVD machine namely, standard size, middle size, and large size. The applicable conditions for each machine are described below. Depth of soft soil treatment in PK-12 is about 15 m to 35 m; therefore, middle or large size machine will be used for the actual condition. According to this document, middle or large size machine can install PVD through layers with N-values under 10 to 13.

Table 1 Installation Machine

| Class | Specific | | | Remarks |
|---|---|---|---|---|
| | Installation length | | | |
| | Under 20m | Under 30m | Under 40m | |
| Power | 81kW (110ps) | 96kW(130ps) | 147kW(200ps) | |
| Size | Standard | Middle | Large | |

Table 2 Applicable Conditions

| Size | Power | Applicable Conditions of N Value | Remarks |
|---|---|---|---|
| Standard | 81kW(110PS) | | |
| Middle | 96kW(130PS) | | |
| Large | 147kW(200PS) | | |




SOURCE: "NCB drain construction method design and construction manual"

(H13.4, NCB drain construction method association in Japan)

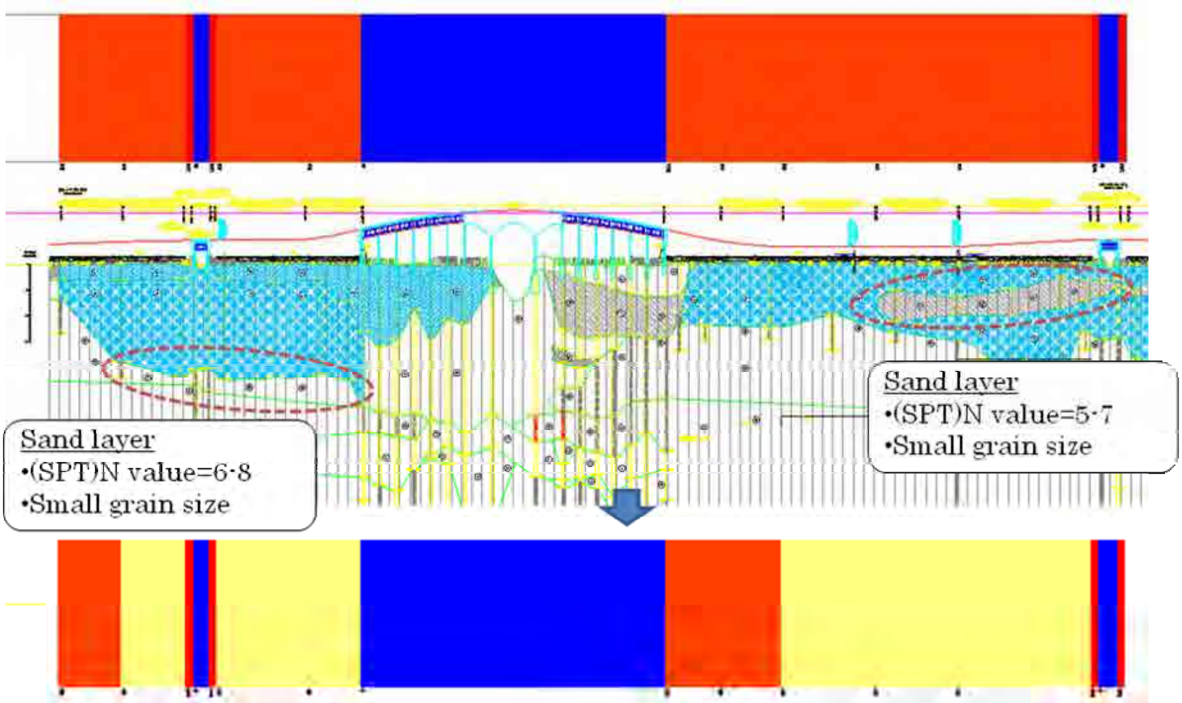
Hearing investigation from engineers involved in the Long Than-Dau Giay Expressway construction project and the National Highway 3 construction project was carried out in order to figure out differences between machines used in Japan as above, and those in Vietnam. Results of investigation are as follows:

- Clay layer with N-value of 10 to 12 could be installed by middle sized PVD machines.
- According to the experience on the Can Tho Bridge construction project, clay and sand layer with N-values of 12-15 could be installed with PVD material using large size machine.
- Soil layers with N-value lower than 9 could be installed with PVD using standard size machines. In the case of soil layers with N value higher than 10, sand drain machines will be applicable.

According to these results, it is realized that there are little differences between machines in Japan and in Vietnam.

Noting the sand layer's condition in PK-12 and actual performance of PVD machines, PVD can be applied to many sections of PK-12. Therefore, Changing DCM to PVD in some section of PK-12 is recommended as shown in **Figure 6.52**.

**Figure 6.52. Proposed Design Change in PK-12**




SOURCE: JICA Survey Team

Costs of the above proposed design was estimated as shown in **Table 6.30**. Referring to these results, the cost becomes 50.5% of the original design cost.

**Table 6.30. Approximate Costs of Alternative Design for PK-12**

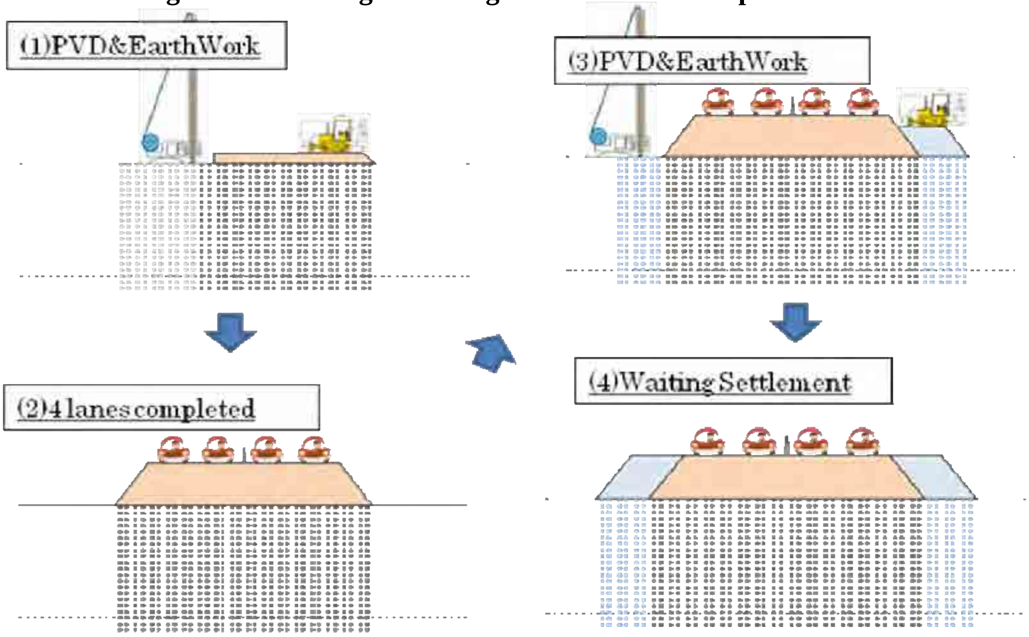
| ITEM | UNIT | QUANTITY | | | UNIT PRICE (VND) | PRICE (VND) | | |
|---|---|---|---|---|---|---|---|---|
| | | Original DD | Recommend design | difference | | Original DD | Recommend design | difference |
| SOFT SOIL TREATMENT | | | | | | | | |
| - Surcharge by fine sand K90 | $m^3$ | 1,275 | 42,018 | 40,743 | 110,000 | 140,250,000 | 4,621,938,194 | 4,481,688,194 |
| - Removing surcharge | $m^3$ | 0 | 42,018 | 42,018 | 32,000 | 0 | 1,344,563,838 | 1,344,563,838 |
| - PVD | m | 0 | 811,843 | 811,843 | 10,000 | 0 | 8,118,434,000 | 8,118,434,000 |
| - DCM | m | 373,522 | 170,570 | -202,952 | 900,000 | 336,169,800,000 | 153,513,000,000 | -182,656,800,000 |
| - Polyester Covering sheet | $m^2$ | 0 | 39,922 | 39,922 | 7,000 | 0 | 279,453,580 | 279,453,580 |
| - Covering settlement by fine sand K95 | $m^3$ | 0 | 21,901 | 21,901 | 116,000 | 0 | 2,540,552,681 | 2,540,552,681 |
| MONITORING TASK | | | | | | | | |
| - Settlement plate | piece | 82 | 82 | 0 | 1,500,000 | 123,000,000 | 123,000,000 | - |
| - Inclinometer | piece | 16 | 16 | 0 | 26,000,000 | 416,000,000 | 416,000,000 | - |
| - Observation well | piece | 16 | 16 | 0 | 2,000,000 | 32,000,000 | 32,000,000 | - |
| - Lateral displacement observing stake | piece | 90 | 90 | 0 | 120,000 | 10,800,000 | 10,800,000 | - |
| - Electrical piezonmeter | piece | 8 | 8 | 0 | 58,000,000 | 464,000,000 | 464,000,000 | - |
| TOTAL | | | | | | 337,355,850,000 | 170,417,942,294 | -165,892,107,706 |
| Percentage | | | | | | | 50.5% | |

Source: JICA Survey Team

4) Six-Lane Embankment and Soft Soil Treatment in the Initial Stage

Though it is planned that six-lane bridge structures will be constructed in the initial stage, four-lane embankments will be provided instead of six lanes in the D/D. Rough drawings showing construction steps is shown in **Figure 6.53** below.

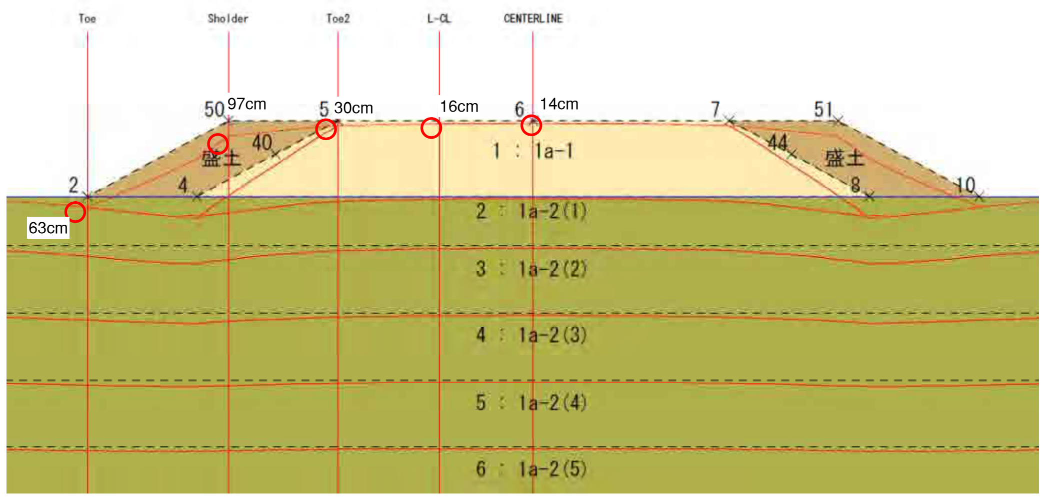
**Figure 6.53. Rough Drawing of Construction Step in the D/D**




SOURCE:JICA Survey Team

**Figure 6.53** (3) and (4) show that PVD, earthwork and awaiting settlement will be carried out during the service period of four lanes. Due to soft soil, it is expected that not only settlement of new soil embankments will occur, but also that of the existing lane. The amount of settlements (Model: PK-4 Section10 / not considering surcharge embankment) was estimated roughly through consolidation analysis as shown in **Figure 6.54**. The results shows that settlement of existing shoulder is 30 cm and that of the centerline is 14 cm. Therefore, when the six-lane road widening is constructed, it is expected that large scale maintenance work will be required.

**Figure 6.54. Consolidation Settlement Calculation Results for Road Widening**




SOURCE:JICA Survey Team

Cost of six-lane embankment construction in the initial stage can be roughly estimated by assuming a 30% increase of the cost for preparatory work, soft soil treatment and embankment work for four lanes. It is expected that the total additional costs of PK-1 to PK-12, and PK-12B for six lanes initial construction would be about VND 766 billion.

As described above, initial construction cost becomes rather high. As it stands now, it is not clear when the six-lane widening works will be carried out; therefore, this alternative cannot be recommended.

**(4) Summary and Conclusions**

1) Summary

a) Review of the D/D

D/D was carried out according to the Vietnam Standards using generally, maximum residual settlement set to 10 cm for all the sections. Soft soil treatment solution was selected for each section by comparing various measures which have already been adopted in Vietnam; for example, PVD, DCM and pile slab. It is judged based on the review that the policy of the study is reasonable.

In view of soft soil treatment, corresponding cost for PK-10 to PK-12 is higher than the other packages. Since PK-12 costs are noted to be significantly higher than the others, it is necessary to clarify the reasons behind and restudy the application of the solution.

b) Review Analysis

Review analysis was carried out using another calculation program; with PK-4 Section 10 as the selected study condition. Because the results were almost the same as for the original design calculation, it is judged that the results are reasonable.

c) Study of Alternatives

Study of alternatives to the original design was carried out. The results are shown in **Table 6.31**.

**Table 6.31. Study of Alternatives**

| Proposal | Advantage | Disadvantage | Cost (billion VND,%) Decrease(-)/ Increase(+) | | Evaluation |
|---|---|---|---|---|---|
| Reduction of Nos. of PVD | •Decrease construction cost | •longer construction period and delay service | -93 | -0.50% | - |
| Vacuum Consolidation Method | •Shorten Construction period(18M->10M)<br>•No counterberm required | •Increase Construction cost | 2 | 0.00% | Recommend |
| Alternative for Deep Cement Mixing | •Decrease Cost | •Longer Construction period<br>•Increase risks in the construction stage | -168 | -1.20% | Recommend |
| 6-lane embankment in initial stage | •Mitigate risks and costs in the future widening | •Increase initial construction costs and period | 766 | 5.30% | - |

Source: JICA Survey Team

2) Recommend Alternatives

- Because the delay of road service will not be tolerated, the application of VCM especially to PK-4 Section 11, which has the highest construction delay risk, is recommended.
- PVD can be applied in many sections of PK-12. Therefore, changing DCM to PVD in some sections in PK-12 is recommended as shown in **Figure 6.52**.

3) Remaining Issues to be Solved (proposed additional investigation for PK-12 Study)

The following are some remaining works to be studied concernning alternative solution to PK-12 as proposed above:

- Accuracy of the data on sand layer's condition for estimating density and thickness is not enough
- The data for the lower part of the clay layer (1 c) used for estimating thickness and consolidation characteristic is not enough

Therefore, it is difficult to select the most suitable soft soil treatment solution and determine a reasonable depth of treatment. Conducting an additional investigation is strongly recommended in order to carry out an economical design.

### 6.2.6 Design of Other Facilities

Design review of other facilities design was confirmed from the result of the geological survey and hydrological survey.

#### (1) Slope Ratio and Slope Protection of Embankment

Ratio of embankment slope was decided to be 1:2.0 in case the embankment height is 6 m or less, according to TCVN5729.

The entire face of slope was designed, though it was protected with concrete block to serve as countermeasure against the influence of the entire interval flood.

#### (2) Drainage Design

Road surface water is collected on the shoulder through concrete curb and flows to the toe of the embankment slope by longitudinal ditches installed at every 20 m.

In the superelevated section, drainage ditch with grating cover was planned at the marginal strip (safety lane) to collect road surface water.

Box culverts and pipe culverts, which cross the roadway, are planned to be installed considering topographic terrain, vertical alignment and hydrographical condition.

Length of box culverts and pipe culverts are planned to suit four-lane width roads, including those for farm road (frontage road).

Box culverts and pipe culverts are planned to be provided along the expressway and farm road as summarized in **Table 6.32.**

**Table 6.32. Summary of Box Culverts and Pipe Culverts**

| | Box-culvert | | | | Pipe-Culvert | | | |
|---|---|---|---|---|---|---|---|---|
| | Location | Size | Length(m) | Crossing Road | Location | Size | Length(m) | Crossing Road |
| 1 | 51+363 | 4x4 | 12 | Farm Road | 53+285 | D1500 | 48 | Expressway |
| 2 | 51+708 | 3x4 | 56 | Expressway | 53+539 | D1500 | 57 | Expressway |
| 3 | 52+174 | 3x4 | 51 | Expressway | 54+164 | D1500 | 60 | Expressway |
| 4 | 52+636 | 6x4.5 | 48 | Expressway | 54+510 | D1500 | 63 | Expressway |
| 5 | 52+879 | 4x4 | 43 | Expressway | 56+829 | D2000 | 66 | Expressway |
| 6 | 55+285 | 6x4.5 | 6 | Farm Road | 58+064 | D2000 | 9 | Farm Road |
| 7 | 55+800 | 3x4 | 50 | Expressway | 58+904 | D1500 | 51 | Expressway |
| 8 | 56+073 | 4x4 | 53 | Expressway | 59+663 | D1500 | 51 | Expressway |
| 9 | 56+463 | 4x4 | 66.5 | Expressway | 64+278 | D1500 | 48 | Expressway |
| 10 | 57+154 | 4x4 | 58 | Expressway | 64+988 | D1500 | 48 | Expressway |
| 11 | 57+383 | 4x4 | 60.5 | Expressway | 66+883 | D1500 | 48 | Expressway |
| 12 | 57+955 | 2(4x4) | 6 | Farm Road | 68+100 | D1500 | 49.5 | Expressway |
| 13 | 58+536 | 6x4.5 | 60 | Expressway | 69+786 | D1500 | 63 | Expressway |
| 14 | 59+203 | 4x4 | 47 | Expressway | 72+710 | D1500 | 52 | Expressway |
| 15 | 59+831 | 3x4 | 54 | Expressway | 72+917 | D2000 | 54 | Expressway |
| 16 | 60+301 | 4x4 | 54.1 | Expressway | 73+592 | D1500 | 54 | Expressway |
| 17 | 60+830 | 6x4.5 | 66 | Expressway | 74+600 | D1500 | 51 | Expressway |
| 18 | 61+466 | 3x4 | 48 | Expressway | 74+952 | D2000 | 48 | Expressway |
| 19 | 61+728 | 3x4 | 47 | Expressway | 75+994 | D1500 | 60 | Expressway |
| 20 | 62+008 | 3x4 | 46 | Expressway | 76+335 | D1500 | 54 | Expressway |
| 21 | 62+183 | 3x4 | 46 | Expressway | 77+710 | D1500 | 51 | Expressway |
| 22 | 63+233 | 3x4 | 50 | Expressway | 78+360 | D1500 | 48 | Expressway |
| 23 | 63+795 | 4x4 | 44 | Expressway | 79+310 | D1500 | 57 | Expressway |
| 24 | 65+333 | 4x4 | 61 | Expressway | 80+625 | D1500 | 57 | Expressway |
| 25 | 66+241 | 6x4.5 | 73.5 | Expressway | 82+780 | D2000 | 12 | Farm Road |
| 26 | 67+812 | 6x4.5 | 48 | Expressway | 85+972 | D1500 | 63 | Expressway |
| 27 | 68+535.4 | 6x4.5 | 32.5 | Expressway | 90+033 | D1500 | 48 | Expressway |
| 28 | 68+962 | 3x4 | 48 | Expressway | 90+700 | D1500 | 48 | Expressway |
| 29 | 70+071 | 6x4.5 | 69.5 | Expressway | 91+758 | D1500 | 51 | Expressway |
| 30 | 70+184 | 3x4 | 64 | Expressway | 93+873 | D1500 | 72 | Expressway |
| 31 | 70+768 | 6x4.5 | 57.5 | Expressway | 94+408 | D1500 | 72 | Expressway |
| 32 | 71+270 | 4x4 | 43 | Expressway | 100+340 | D1500 | 65.5 | Expressway |
| 33 | 71+685 | 4x4 | 7 | Farm road | 101+000 | D1500 | 72.5 | Expressway |
| 34 | 72+342 | 4x4 | 52 | Expressway | 101+300 | D1500 | 49.5 | Expressway |
| 35 | 73+230 | 4x4 | 47 | Expressway | | | | |
| 36 | 77+395 | 4x4 | 43 | Expressway | | | | |
| 37 | 78+054 | 6x4.5 | 45 | Expressway | | | | |
| 38 | 79+620 | 6x4.5 | 68.5 | Expressway | | | | |
| 39 | 81+485 | 4x4 | 59 | Expressway | | | | |
| 40 | 82+271 | 3x4 | 7 | Farm Road | | | | |
| 41 | 84+151 | 6x4.5 | 63 | Expressway | | | | |
| 42 | 85+448 | 6x4.5 | 56 | Expressway | | | | |
| 43 | 86+604 | 6x4.5 | 72 | Expressway | | | | |
| 44 | 86+866 | 6x4.5 | 78 | Expressway | | | | |
| 45 | 88+214 | 3x4 | 61 | Expressway | | | | |
| 46 | 88+980 | 3x4 | 8 | Farm road | | | | |
| 47 | 89+058 | 3x4 | 48 | Expressway | | | | |
| 48 | 89+230 | 3x4 | 47 | Expressway | | | | |
| 49 | 91+090 | 6x4.5 | 8 | Farm Road | | | | |
| 50 | 91+511 | 6x4.5 | 76 | Expressway | | | | |
| 51 | 92+054 | 6x4.5 | 67 | Expressway | | | | |
| 52 | 93+092 | 3x4 | 66 | Expressway | | | | |
| 53 | 93+637 | 4x4 | 66 | Expressway | | | | |
| 54 | 98+836 | 6x4.5 | 42 | Expressway | | | | |
| 55 | 99+395 | 3x4 | 64 | Expressway | | | | |
| 56 | 102+942 | 3x4 | 48 | Expressway | | | | |
| 57 | 103+144 | 4x4 | 43 | Expressway | | | | |

Source: JICA Survey Team

**(3) Pavement Design**

a) General

Asphalt concrete pavement for expressway was designed based on the BEDC F/S prepared by TEDI in June 2010. The applied design standard is the Vietnamese Design Standard 22TCN211-06. The service life duration for the designed pavement for Phase I, considering 4-lanes (2x2 lanes) is 15 years from 2014 to 2028.

b) Design Traffic

In the design of pavement for TL-MT section in BEDC F/S, the pavement structure for HCM-Trung Luong Expressway was adopted. In the D/D, review of the pavement design was not carried out based on the traffic volume of TL-MT section, and thus, the design in BEDC F/S was applied.

c) Design Elastic Module

Minimum elastic module of expressway recommended in the F/S is Eyc (Mps) ≧ 2000 daN/$cm^2$.

d) Designed Pavement Structure

Pavement structure for expressway and rampway is calculated based on the module of 22TCN211-06 as shown in **Table 6.33**.

**Table 6.33. Pavement Structure**

| | Expressway | Rampway |
|---|---|---|
| Roughness Layer (Wearing Course) | 3 cm | |
| Asphalt Concrete Surface Course | 5 cm | 5 cm |
| Asphalt Concrete Binder Course | 7 cm | 7 cm |
| Asphalt Treated Base | 10 cm | |
| Graded Aggregate (Class I) | 55 cm | 20 cm |
| Graded Aggregate (Class II) | | 25 cm |
| Total | 80 cm | 57 cm |

Source: D/D Report

The JICA Survey Team reviewed the pavement design based on the updated traffic volume as shown in **Table 6.34**. As a result, it was confirmed that pavement structure is similar with that in BEDC F/S and D/D. Therefore, it is not necessary to change the pavement structure.

**Table 6.34. Forecasted Traffic Volume in this Study(2017,2030)**

| Vehicle/day | Expressway (TL-MT) | |
|---|---|---|
| | 2017 | 2030 |
| Car | 6780 | 15750 |
| Small Bus | 950 | 1430 |
| Medium Bus | **240** | **470** |
| Large Bus | **3560** | **6670** |
| Bus | **1690** | **3260** |
| Pickup | 1660 | 3140 |
| 2 axle truck | **3930** | **7610** |
| 3 axle truck | **1010** | **1710** |
| Container | **280** | **510** |
| Total | 20100 | 40550 |
| Only large size vehicles | **10710** | **20230** |

Source: JICA Survey Team

**(4) Farm Road**

Farm roads were planned to be provided at both sides of the expressway to connect with the main expressway crossing the road, when existing small road crossings are blocked by the expressway. Moreover, farm roads are planned to be constructed up to the big river; however it is realized that crossing such big rivers is not possible The width of farm road is 5.5 m (one lane), based on rural street standard (class VI) in TCVN4054. Elevation of farm road is designed based on high-water level (1.86 m-2.16 m) of 4% probability.

**(5) Traffic Safety**

Except for regulatory signs, traffic signs such as guide signs and warning signs are planned to be installed on throughways and rampways. Road markings are planned to be provided also on throughways and rampways, and at the toll gate section. Guard rails are planned to be provided at the shoulder of throughways and rampways. Concrete barriers are planned to be provided along the median strip of throughways and two-way rampways.

**(6) Guard Fence**

Guard fences (trellis type) are planned to be installed at the toe of the embankment slope.

**(7) Lighting**

Lighting systems are planned to be provided for the entire section of the expressway. Lighting poles, 12-m high (double arm type), are planned to be installed along the median strip, at intervals of 40 m. Moreover, 12 m lighting poles (single arm type) are planned to be installed on the shoulder at intervals of 30 m. Mast type lighting poles, 25 m high, are planned to be installed between the throughway and rampway of the interchange.

### 6.2.7 Construction Planning

#### (1) Review of F/S and D/D

Construction planning was mentioned in Chapter 14 of the F/S report. The report give details to the construction organization, material supply planning and construction schedule of the project. However, the construction work itself was not mentioned.

Construction planning in the D/D report was briefly mentioned in the design document, Volume III-1 (cost estimation) of each package as well as in the "Material Investigation Report" submitted to BEDC by TEDIS. These contents also mentioned mainly the material supply as a condition for the cost estimation.

#### (2) Construction Items

Construction items for general construction works of the TL-MT Expressway include excavation, embankment, soft soil treatment (PVD, DCM), drainage, pavement and bridge works (PC single spanned girder and PC continuous box section girder). No special construction work is planned for this project.

In the D/D drawing report, it was shown that 66% of the 54.313 km expressway length is the highway (embankment) section, 23.5% is the bridge section and the remaining 10.5% is the interchange section as shown in **Table 6.35.**

**Table 6.35. D/D Inventory of the TL-MT Expressway**

| Package | Length of Inventory (m) | | | | Ratio of Inventory (%) | | |
|---|---|---|---|---|---|---|---|
| | Total | Interchange | Highway | Bridge | Interchange | Highway | Bridge |
| 0 | 1,440.00 | 1,440.00 | | | 100.0 | | |
| 1 | 2,050.00 | | 1,611.00 | 439.00 | | 78.6 | 21.4 |
| 2 | 5,390.00 | | 4,232.03 | 1,157.97 | | 78.5 | 21.5 |
| 3 | 5,280.00 | | 4,853.16 | 426.84 | | 91.9 | 8.1 |
| 4 | 4,100.00 | | 3,121.14 | 978.86 | | 76.1 | 23.9 |
| 5A | 1,280.00 | 1,280.00 | | | 100.0 | | |
| 5 | 3,100.00 | | 1,995.46 | 1,104.54 | | 64.4 | 35.6 |
| 6 | 4,780.00 | | 4,032.03 | 747.97 | | 84.4 | 15.6 |
| 7 | 3,580.00 | | 2,897.06 | 682.94 | | 80.9 | 19.1 |
| 8 | 2,240.00 | | 842.82 | 1,397.18 | | 37.6 | 62.4 |
| 8A | 1,240.00 | 1,240.00 | | | 100.0 | | |
| 9 | 3,660.00 | | 2,480.20 | 1,179.80 | | 67.8 | 32.2 |
| 10 | 7,640.00 | | 6,402.11 | 1,237.89 | | 83.8 | 16.2 |
| 11A | 2,600.00 | | | 2,600.00 | | 0.0 | 100.0 |
| 11 | 2,120.00 | | 1,981.24 | 138.76 | | 93.5 | 6.5 |
| 12A | 1,280.00 | 1,280.00 | | | 100.0 | | |
| 12 | 2,072.00 | | 1,425.16 | 646.84 | | 68.8 | 31.2 |
| 12B | 461.00 | 461.00 | | | 100.0 | | |
| Total | 54,313.00 | 5,701.00 | 35,873.41 | 12,738.59 | 10.5 | 66.0 | 23.5 |

Source: JICA Survey Team based on D/D drawings

Major construction amounts are shown in **Table 6.36**. In this table, the amount of sand fill is remarkably high. About 11 billion $m^3$ may be compared to a small on-land airport construction project or much longer highway construction project. The reasons why the amount of sand decreased from the F/S to the D/D are that: 1) the width of median strip was reduced from 2 m to 1 m because the D/D team did not put the pier of the flyover bridge along the median strip, 2) The D/D team extended the bridge to reduce the sand backfill.

**Table 6.36. Major Construction Amounts**

| No. | Items | | Unit | F/S | D/D |
|---|---|---|---|---|---|
| 1 | Sand fill, sand for drainage blanket + sand for resettlement compensation | | million $m^3$ | 17.46 | **11,103** |
| 2 | Sand drain | | million m | 13.244 | 0 |
| 3 | PVD | | million m | 9.455 | 18.098 |
| | DCM | | million m | 0 | 1.048 |
| 4 | Bridge | Expressway bridge | nos | 55 | 42 |
| | | Flyover | nos | 26 | 9 |

Source: F/S and D/D

### (3) Procurement of Materials

Procurement of major construction materials had been mentioned in the F/S report, D/D report, and materials investigation report. In both reports the amount of materials are sufficient for the construction works.

In this JICA Survey, an approximate calculation of the daily required materials was conducted assuming that the entire construction packages will commence at the same time.

**Table 6.37** shows the result of review for the required quantity of embankment sand for procurement. The quantity for daily transportation/construction and the number of transportation shipments are big but workable if each package contractor could mobilize enough construction machines and ships.

The issue is the total quantity of sand embankment to be procured. In the F/S report, daily production of each sand pit is reported to be ranged from 300 to 800 $m^3$/day. With this, the daily production capacity of sand pits cannot meet the daily demand in some packages in case of embankment work done at the same timing.

**Table 6.37. Outline for the Required Quantities of Embankment Sand**

| Package | Quantity | | |
|---|---|---|---|
| | For Procurement ($m^3$) | Daily Transportation/ Construction ($m^3$/day) | Number of transportation shipments (nos/day) |
| 1 | 390,090 | 1,084 | 11 |
| 2 | 1,136,367 | 3,157 | 32 |
| 3 | 1,101,765 | 3,060 | 31 |
| 4 | 841,260 | 2,337 | 24 |
| 5A | 559,269 | 1,554 | 16 |
| 5 | 530,777 | 1,474 | 15 |
| 6 | 934,630 | 2,596 | 26 |
| 7 | 964,005 | 2,678 | 27 |
| 8 | 344,234 | 956 | 10 |
| 8A | 727,873 | 2,022 | 21 |
| 9 | 805,337 | 2,237 | 23 |
| **10** | **1,960,340** | **5,445** | **55** |
| 11A | 0 | 0 | 0 |
| 11 | 377,346 | 1,048 | 11 |
| 12A | 220,450 | 612 | 7 |
| 12 | 150,452 | 418 | 5 |
| 12B | 58,767 | 163 | 2 |
| Average | 616,831 | 1,713 | 18 |
| Total | 11,102,960 | 30,842 | 309 |

Note 1: Daily quantity is assumed as; quantity of sand ($m^3$) / 18 months of the embankment construction period / 20 working days per month
Note 2: The capacity of the sand transportation ship is assumed as 100 $m^3$.

Source: JICA Survey Team

### (4) Construction Method

In Vietnam, sand squeeze pumping is a major construction method adopted for embankment construction. Sand is liquefied and transported by pump and tubes. Using this method, embankment can be constructed faster and easier without preparing a train of cargo trucks and backhoes for the loading and unloading of sand.

**Table 6.38** shows the capacity of resemble squeeze pumping machines. The performance of the pump is enough for the construction of embankment if the contractors should select properly multiple pumps with large capacities for construction.

**Table 6.38. Capacity of Resemble Squeeze Pumping Machines**

| | Capacity ($m^3$/h) | Transportable Distance |
|---|---|---|
| Sand bypass | 80-250 | 1-2 km |
| Sediment transportation of shield tunnel | 30-150 | more than 2 km (using relay pump) |
| Dredge ship | 220-550 | 1-4 km |

Source: JICA Survey Team

**Table 6.39** shows the distance from the far most embankment construction site to the nearest rivers with navigation width. From the table, it shows that the distance is less than 2.5 km from the nearest river, and squeeze pumping method is available with some modification of the construction machines.

**Table 6.39. Station Distance to Intermediate Point of Embankment Construction**

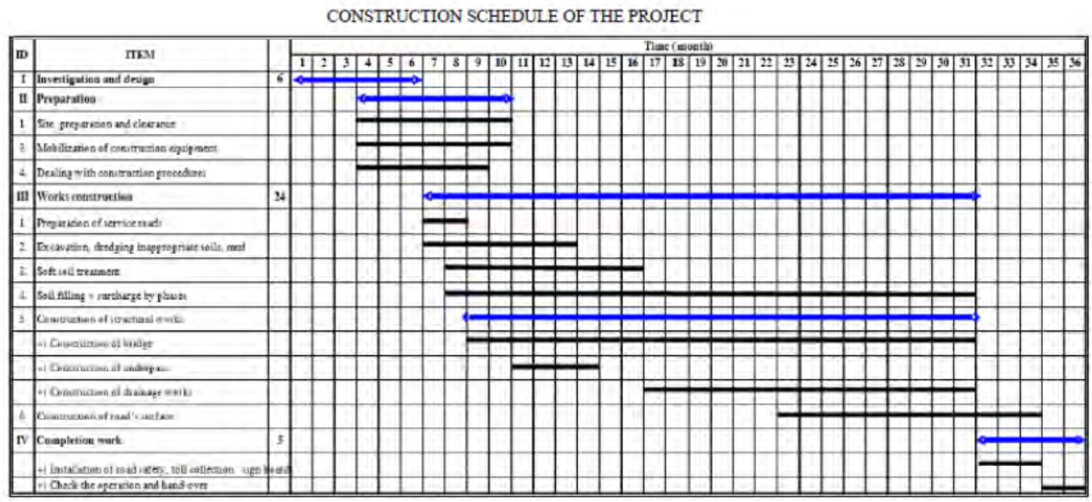
| Package | Station | | Length (m) | River/Channel/Road | | Distance to intermediate point (m) | |
|---|---|---|---|---|---|---|---|
| | from | to | | Station | Description | Origin | Destination |
| 0 | 49,620.00 | 51,060.00 | 1,440.00 | | | | |
| 1 | 51,060.00 | 53,110.00 | 2,050.00 | 51293.00 | River, B=25m | 1673.00 | 2016.30 |
| 2 | 53,110.00 | 58,500.00 | 5,390.00 | 54043.00 | Channel | | |
| | | | | 54413.00 | Channel | | |
| | | | | 55325.60 | River, B=20m | 2016.30 | 1327.20 |
| | | | | 56693.00 | Channel | | |
| | | | | 57980.00 | River, B=30m | 1327.20 | 2380.00 |
| 3 | 58,500.00 | 63,780.00 | 5,280.00 | 60071.00 | Channel | | |
| | | | | 60620.00 | Channel | | |
| | | | | 61404.50 | Channel | | |
| | | | | 62740.00 | River, B=20m | 2380.00 | 1480.00 |
| 4 | 63,780.00 | 67,880.00 | 4,100.00 | 64693.20 | Channel | | |
| | | | | 65700.00 | River, B=20m | 1480.00 | 838.00 |
| | | | | 67376.00 | River, B=10m | 838.00 | 1537.50 |
| | | | | 67385.06 | Underpass | | |
| 5A | 67,880.00 | 69,160.00 | 1,280.00 | | | | |
| 5 | 69,160.00 | 72,260.00 | 3,100.00 | 69354.30 | Channel, Underpass | | |
| | | | | 70451.00 | River, B=10m | 1537.50 | 735.24 |
| | | | | 71921.49 | River, B=20m | 735.25 | 1018.75 |
| 6 | 72,260.00 | 77,040.00 | 4,780.00 | 73959.00 | River, B=10m | 1018.76 | 1409.13 |
| | | | | 74273.00 | Channel | | |
| | | | | 75410.30 | Channel | | |
| | | | | 75708.00 | Channel | | |
| | | | | 76777.25 | River, B=20m | 1409.13 | 1101.38 |
| 7 | 77,040.00 | 80,620.00 | 3,580.00 | 78980.00 | River, B=20m | 1101.38 | 300.00 |
| | | | | 79580.00 | River, B=10m | 300.00 | 340.00 |
| | | | | 80260.00 | River, B=10m | 340.00 | 350.00 |
| 8 | 80,620.00 | 82,860.00 | 2,240.00 | 80960.00 | River, B=25m | 350.00 | 437.00 |
| | | | | 81834.00 | River, B=15m | 437.00 | 355.50 |
| | | | | 82545.00 | River, B=15m | 355.50 | 1015.00 |
| 8A | 82,860.00 | 84,100.00 | 1,240.00 | | | | |
| 9 | 84,100.00 | 87,760.00 | 3,660 | 84575.00 | River, B=25m | 1015.00 | 1387.45 |
| | | | | 87349.90 | River, B=30m | 1387.45 | 1945.05 |
| 10 | 87,760.00 | 95,400.00 | 7,640 | 88534.00 | Channel | | |
| | | | | 89605.00 | Channel | | |
| | | | | 91240.00 | River, B=25m | 1945.05 | 554.15 |
| | | | | 92348.30 | River, B=25m | 554.15 | 1318.35 |
| | | | | 92710.00 | Channel | | |
| | | | | 94163.00 | Channel | | |
| | | | | 94985.00 | River, B=25m | 1318.35 | 1771.00 |
| 11A | 95,400.00 | 98,000.00 | 2,600 | | | | |
| 11 | 98,000.00 | 100,120.00 | 2,120 | 98527.00 | River, B=20m | 1771.00 | 1876.50 |
| | | | | 99965.00 | Channel | | |
| 12A | 100,120.00 | 101,400.00 | 1,280 | | | | |
| 12 | 101,400.00 | 103,472.00 | 2,072 | 101675.00 | Channel | | |
| | | | | 102280.00 | River, B=50m | 1876.50 | 1653.00 |
| | | | | 103438.00 | Channel | | |
| 12B | 103,472.00 | 103933.00 | 461 | | | | |

Source: JICA Survey Team

Other construction works include bridge works and structural works. These two work items can proceed independently from the embankment construction. However, abutments and piers of the bridge shall not be constructed during embankment construction because negative friction occurs while backfilled soil settles. In some cases, the inclination of piers and abutments could occur due to differential settlement of the soft soil.

### (5) Construction Period

In F/S the planned construction period is 36 months (see **Figure 6.55**).




Source: F/S

**Figure 6.55. Construction Schedule for the TL-MT Expressway Project in the F/S**

During the D/D stage, BEDC also announced that the construction can be done in 36 months. It is conceived that a 36 month construction period is not an estimated period but has been the applied general construction period for general expressway construction projects.

Considerations in this JICA Survey showed that the amount of embankment sand is too big to compare the general project which will make the construction difficult.

Materials obtained from natural resources are limited in Vietnam. Many big projects in southern Vietnam will need large amount of sand filling, including a new international airport, other expressways, national highways, high speed railways, and new trading port. The construction schedule reviewed by this JICA Survey is shown in Appendix A3.

**(6) Recommendations**

- A construction period of 36 months for the TL-MT Expressway Project is very limited. The most affected condition shall be the material supply of filling sand.
- Soft soil treatment by PVD method takes 18 months, although the construction of embankment might take longer 18 months unless filling sand is supplied properly.
- The construction of the embankment itself within 18 months might be possible with the subdivision of construction packaging, but issues regarding material supply still exist.

**(7) Supplements**

Coordination on procurement of materials, especially for embankment sand, is strongly needed for the completion of work within a designated construction period of the Project. The Government shall guarantee the borrow pit of the materials even for the BOT/PPP construction project.

### 6.2.8 Construction Cost and Contract Packaging

**(1) Review of F/S and D/D**

Total investment cost of the TL~MT Expressway was estimated in the F/S and was also mentioned in Chapter 15 of the JICA Survey report.

**Table 6.40. Total Investment Cost of TL~MT Expressway in the F/S**

| No. | Items | Cost (VND in million) |
|---|---|---|
| I | Construction cost | 11,159,833 |
| II | Equipment cost | 223,022 |
| Total Construction & equipment cost | | 11,382,855 |
| III | Land acquisition & resettlement | 785,849 |
| IV | Project management cost | 175,133 |
| V | Consultant cost | 677,685 |
| VI | Other cost | 245,100 |
| VII | Interest | 2,881,645 |
| VIII | Contingency | 2,739,557 |
| **TOTAL INVESTMENT COST** | | **18,887,824** |

Source: F/S

The D/D Consultant Team estimated the construction cost based on the tentative D/D design drawings and quantities. Compared with the F/S cost for the "construction and equipment cost", the D/D cost increases by about 39%.

**Table 6.41. Total Construction Cost of TL~MT Expressway in the D/D**

| No. | Items | Cost (VND in million) |
|---|---|---|
| 1 | Highway | 5,632,277 |
| 2 | Bridge (simple girder) | 4,423,350 |
| 3 | Bridge (continuous girder ) | 2,758,259 |
| 4 | Overpass | 612,681 |
| 5 | Interchange | 1,883,267 |
| 6 | Access road to NH1A | 92,333 |
| 7 | Lighting | 121,581 |
| 8 | Equipment | 258,625 |
| **TOTAL CONSTRUCTION COST** | | **15,782,373** |

Source: D/D Consultant Team

### (2) Related Laws and Regulations

Related laws and regulations for the project cost estimate are shown in **Table 6.42,** which is also applied in the cost estimation of the detailed design.

**Table 6.42. Related Laws and Regulations**

| Regulations | Type of Letter | Letter No. | Date | Sender |
|---|---|---|---|---|
| Cost estimate standard | Circular | No.04/2010/TT-BXD | 25 June 2010 | Ministry of Construction |
| Management of construction investment project | Decree | No.12/2009/ND-CP | 10 February 2009 | Government |
| Management of construction investment project | Decree | No.83/2009/ND-CP | 15 October 2009 | Government |
| Quality management of construction works | Decree | No.209/2004/ND-CP | 16 December 2004 | Government |
| Quality management of construction works | Decree | No.49/2008/ND-CP | 17 April 2008 | Government |
| Making and managing construction investments costs | Circular | No.05/2007/TT-BXD | 25 July 2007 | Ministry of Construction |
| Cost of project management and consultant in construction investment project | Decision | No.957/QD/BXD | 29 September 2009 | Ministry of Construction |

Source: JICA Survey Team

### (3) Construction Cost Structures

Cost structure for the JICA Survey is used based on the D/D cost estimation as listed in Table 6.43 below.

**Table 6.43. Cost Structure**

| Items | Description |
|---|---|
| Total Project Cost | 1+2+3+4+5+6+7 |
| 1 Construction Cost | (1)+(2)+(3)+(4)+(5)+(6) |
| (1) Civil Engineering Work | a)+b)+c)+d)+e)+f)+g)+h)+i) |
| a) Highway | 1)+…+8) |
| 1) Preparation | |
| 2) Soft Soil Treatment | |
| 3) Embankment | |
| 4) Pavement | |
| 5) Farm road (frontage road) | |
| 6) Service Area, Parking Station | |
| 7) Traffic safety | |
| 8) Drainage | |
| b) Bridge (simple girder, pass river) | 9)+…+12) |
| 9) Superstructure | |

| | |
|---|---|
| 10) Substructure | |
| 11) Auxiliary | |
| 12) Other | |
| c) Bridge (continuous girder, pass river) | 13)+…+17) |
| 13) Superstructure | |
| 14) Substructure | |
| 15) Auxiliary | |
| 16) Other | |
| 17) Viaduct | Package 11A |
| d) Overpass Bridge | |
| e) Interchange | 18)+…+22) |
| 18) Than Cuu Nghia IC | |
| 19) Cai Lay IC | |
| 20) Cai Be IC | |
| 21) An Thai Trung IC | |
| 22) Bac My Thuan Intersection | |
| f) Access Road to NH1A | 23)+24) |
| 23) Cai Lay | |
| 24) Cai Be | |
| g) Lighting System | |
| h) Equipment Cost, Control and Exploitation System | |
| (2) All Risk Insurance Premium | (1)*1.0% |
| (3) HIV Prevention Program Cost | {(1)+(2)}*0.1% |
| (4) Environmental Monitoring Cost | |
| (5) Initial O&M Equipment Cost | Include ITS system cost |
| (6) Contingency | |
| 25) Price Contingency | {(1)+(2)+(3)+(4)+(5)}*rate% |
| 26) Physical Contingency | {(1)+(2)+(3)+(4)+(5)+26}}*10% |
| 2 Engineering Cost | (7)+(8)+(9) |
| (7) D/D Review and Tender Assistance | Σ{(1)~(5)}*4.0% |
| (8) Construction Service | Σ{(1)~(5)}*3.0% |
| (9) Contingency | 27)+28) |
| 27) Price Contingency | {(7)+(8) }*rate% |
| 28) Physical Contingency | {(7)+(8)+27) }*10% |
| 3 Project Management Cost | (10)+(11) |
| (10) Project Management Cost | Σ{(1)~(5)}*0.35% |
| (11) Contingency | 29)+30) |
| 29) Price Contingency | {(10) }*rate% |
| 30) Physical Contingency | {(10)+29) }*10% |
| 4 Other Cost | (12)+(13) |
| (12) Other Cost | Σ{(1)~(5)}*4.0% |

| | |
|---|---|
| (13) Contingency | 31)+32) |
| 31) Price Contingency | {(12) }*rate% |
| 32) Physical Contingency | {(12)+31) }*10% |
| 5 SPC Establishment Cost | (14)+(15) |
| (14) Establishment and Initial SPC Operation | |
| (15) Contingency | 33)+34) |
| 33) Price Contingency | {(14) }*rate% |
| 34) Physical Contingency | {(14)+33) }*10% |
| 6 Land Acquisition / Compensation Cost | (16)+(17) |
| (16) Land Acquisition / Compensation | |
| (17) Contingency | 35)+36) |
| 35) Price Contingency | {(16) }*rate% |
| 36) Physical Contingency | {(16)+35) }*10% |
| 7 Value Added Tax (VAT) | (18) |
| (18) Value Added Tax (VAT) | (1+2+5)*10.0% |

Source: JICA Survey Team

**(4) Methodology**

Project cost estimate for the JICA Survey was carried out based on the D/D and design proposals in accordance with the structural design review.

1) Basic cost estimate methodology for construction cost

In accordance with Circular No. 04, cost-based estimate is basically applied as the methodology. The basic methodology for cost estimate in this JICA Survey is based on the general unit cost (GUC). The GUC consists of direct cost (material, labor, and equipment), other direct costs, and indirect costs. Construction cost is computed based on the GUC and estimated quantity.

2) Engineering cost

Engineering cost which includes engineering fees of the D/D review, tender assistance and construction service are estimated by proportion of construction cost.

3) Project management cost and other cost

Project management cost and other costs incurred during the construction stage are estimated based on Circular No.04/2010/TT-BXD.

4) Initial O&M cost

The conditions and result of the cost estimate for the initial O&M are shown in Section (9).

5) Environmental monitoring cost

The conditions and result of the cost estimate for environmental management are shown in (10) in this section.

6) Land acquisition and compensation cost

The conditions and result of the cost estimate for land acquisition and compensation are shown in Section 6.4.3 (3). .

7) SPC establishment cost

Under the BOT/PPP Scheme, Investor's Study cost, SPC-setup cost, and SPC advisory cost are estimated at about VND 125 billion as detailed in Table 6.44 below:

**Table 6.44. SPC Extablishment Cost**

| | SPC Establishment Cost | Cost (million VND) |
|---|---|---|
| i) | Legal fees for BOT and Loan/collateral agreements. | 50,000 |
| ii) | Financial Advisory fees for Project Implementation Plan, cashflow projection and negotiation with banks | 25,000 |
| iii) | Office rent | 7,500 |
| iv) | Personnel expenses | 12,500 |
| v) | Corporate registration fee | 7,500 |
| vi) | General consultation fees in relation to the Project | 7,500 |
| vii) | Inauguration and promotion fees | 10,000 |
| viii) | Other expenses | 5,000 |
| | Total | 125,000 |

### (5) Conditions of Cost Estimation

1) Time Reference of Cost Estimate

The cost estimate was made as of the second quarter of 2011 (July).

2) Currency

Vietnam Dong (VND) is used as currency in the project cost estimate. Foreign currency part is also indicated in VND equivalent using the exchange rates below.

3) Exchange Rates

Exchange rates used are as shown below (sourced by the State Bank of Vietnam)

JPY 1 = VND 252.305 (as of May 2011)

USD 1 = VND 20,915 (as of May 2011)

4) Classification Condition of Currency

**Table 6.45** shows the classification condition of currency in the JICA Survey.

**Table 6.45. Classification Condition of Currency**

| Items | Description | |
|---|---|---|
| | Foreign Currency | Local Currency |
| 1 Construction Cost | | |
| (1) Civil Engineering Work | O | O |
| (2) All Risk Insurance Premium | O*1 | |
| (3) HIV Prevention Program Cost | | O |
| (4) Environmental Monitoring Cost | | O |
| (5) Initial O&M Equipment Cost | O | O |
| (6) Contingency | O | O |
| 2 Engineering Cost | | |
| (7) D/D review and Tender Assistance | O | O |
| (8) Construction Service | O | O |
| (9) Contingency | O | O |
| 3 Project Management Cost | | |
| (10) Project Management Cost | O | O |
| (11) Contingency | O | O |
| 4 Other Cost | | |
| (12) Other Cost | | O |
| (13) Contingency | | O |
| 5 SPC Establishment Cost | | |
| (14) Establishment and Initial SPC Operation | O | O |
| (15) Contingency | O | O |
| 6 Land acquisition / Compensation Cost | | |
| (16) Land acquisition / Compensation | | O |
| (17) Contingency | | O |
| 7 Value Added Tax (VAT) | | |
| (18) Value Added Tax (VAT) | | O |

Note*1: The cost of all risk insurance premium is in foreign currency assuming insurance at contractor's home country (under international tendering).

Source: JICA Survey Team

5) Price Escalation Rate

Price escalation was described in Paragraph 7.3.1(3) 6) of the financial analysis report.

6) Physical Contingency Rate

Physical contingency rate applied is 10%.

7) Value of Estimated Cost

The construction cost was estimated for the 2011 present value.

**(6) Cost Adjustment by Design Review**

**Table 6.46** shows the result of cost adjustment from the design review of the JICA Survey.

Some design reviews have prioritized on safety and improvement of utilities resulted in increase of the cost, though cost reduction effects due to design change of bridge were found. A total cost of VND 1,175 billion could be proposed to reduce the construction cost based on the JICA Survey.

**Table 6.46. Cost Adjustment by Design Review**

| Item | | | Revised Cost (VND million) |
|---|---|---|---|
| 1. | Highway | | -114,208 |
| | 1) | Preparing | 0 |
| | 2) | Soft Soil Treatment | -143,878 |
| | 3) | Embankment | 16,649 |
| | 4) | Pavement | 0 |
| | 5) | Farm Road (Frontage Road) | 0 |
| | 6) | Service Area, Parking Station | 13,016 |
| | 7) | Traffic Safety | 0 |
| | 8) | Drainage | 0 |
| 2. | Bridge (simple girder, pass river) | | -464,020 |
| | 9) | Superstructure | -14,319 |
| | 10) | Substructure | -384,560 |
| | 11) | Auxiliary | -65,141 |
| | 12) | Other | 0 |
| 3. | Bridge (continuous girder, pass river) | | -602,071 |
| | 13) | Superstructure | -352,327 |
| | 14) | Substructure | -46,316 |
| | 15) | Auxiliary | -33,312 |
| | 16) | Other | 2,863 |
| | *Viaduct | | -172,979 |
| 4. | Overpass Bridge | | 0 |
| 5. | Interchange | | 5,167 |
| | 17) | Than Cuu Nghia IC | 0 |
| | 18) | Cai Lay IC | 1,649 |
| | 19) | Cai Be IC | 2,111 |
| | 20) | An Thai Trung IC | 1,407 |
| | 21) | Bac My Thuan Intersection | 0 |
| 6. | Access Road to NH1A | | 0 |
| 7. | Lighting System | | 0 |
| 8. | Equipment Cost + Control and Exploitation System | | 0 |
| Total Cost Revision (VND million) | | | -1,175,132 |

Source: JICA Survey Team

### (7) Updated Construction Cost

An updated project cost estimate of the JICA Survey was carried out based on the Project’s detailed design and the design proposals. Cost estimate was also prepared in accordance with the structural design review under this JICA Survey.

**Table 6.47. Total Project Cost of the TL~MT Expressway**

| No. | Items | Cost (VND million) |
|---|---|---|
| 1 | Construction Cost | 14,815,072 |
| | (1) Civil Engineering Work | 13,172,476 |
| | (2) All Risk Insurance Premium | 131,725 |
| | (3) HIV Prevention Program Cost | 13,304 |
| | (4) Environmental Monitoring Cost | 5,103 |
| | (5) Initial O&M Equipment Cost | 53,000 |
| | (6) ITS Equipment Cost | 733,984 |
| | (7) Contingency | 705,480 |
| 2 | Engineering Cost | 780,354 |
| | (8) D/D and Tender Documents Preparation | 226,485 |
| | (9) DD for ITS | 31,479 |
| | (10) Review of DD and Tender Assistance | 66,613 |
| | (11) Construction Supervision Service | 423,288 |
| | (12) Contingency | 32,489 |
| 3 | Project Management Cost | 51,852 |
| | (13 Project Management Cost | 49,383 |
| | (14) Contingency | 2,469 |
| 4 | Other Cost | 592,603 |
| | (15) Other Cost | 564,384 |
| | (16) Contingency | 28,219 |
| **5** | SPC Establishment Cost | 131,250 |
| | (17) Establishment and Initial SPC Operation | 125,000 |
| | (18) Contingency | 6,250 |
| **6** | Land acquisition / Compensation Cost | 2,267,339 |
| | (19) Land acquisition / Compensation | 2,159,370 |
| | (20) Contingency | 107,969 |
| **7** | Value Added Tax (VAT) | 1,572,668 |
| | (21) Value Added Tax (VAT) | 1,572,668 |
| TOTAL PROJECT COST (excluding price contingency) | | 20,211 billion |
| TOTAL PROJECT COST (including price contingency) | | 25,222 billion |

Source: JICA Survey Team

### (8) Annual Disbursement

**Table 6.48** shows the annual disbursement of the TL-MT Expressway Project, assuming the construction starts in 2014 and will be completed within 36 months. The years 2012 and 2013 are preparation phases where engineering works, tender, land acquisition and SPC setup are planned to be conducted. The cost expenses in 2017 will be for environmental monitoring after the construction phase.

**Table 6.48. Annual Disbursement of the Project Cost (unit: VND million)**

| 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|
| F/C | L/C | F/C | L/C | F/C | L/C |
| 138,997 | 1,014,966 | 134,885 | 1,700,460 | 1,428,986 | 3,411,159 |

| 2015 | | 2016 | | Total | |
|---|---|---|---|---|---|
| F/C | L/C | F/C | L/C | F/C | L/C |
| 1,442,888 | 3,485,459 | 2,569,762 | 4,884,866 | 5,715,518 | 14,496,910 |

Source: JICA Survey Team

**(9) O&M cost**

1) Initial O&M Cost

Initial O&M cost for the TL–MT Expressway is estimated based on the estimation from similar expressway projects and from the following assumptions.

- Silimar O&M such as the HCM-Trung Luong Expressway which is under operation
- Traffic Control Center (TCC) which is under construction and the existing Expressway Management Center are utilized.
- Costs of toll gates and its management offices, Intelligent Transportation System (ITS) facilities, vehicles are considered into the initial O&M cost.

Initial O&M item and cost is shown in Table 6.49 and further details may be referred in Paragraph 6.3.5.1.

**Table 6.49. Initial O&M Cost**

| O&M Items | | Cost (VND million) |
|---|---|---|
| Building | Toll Gates and Management Office (4 locations) | 170,951 |
| O&M Facilities | Traffic Management System | 221,460 |
| | Toll Collection System | 293,531 |
| | Communication System | 98,187 |
| | Electrical Facilities | 120,807 |
| O&M Equipment | O&M Vehicles | 53,000 |
| Total O&M Cost | | 957,936 |

Source: JICA Survey Team

2) O&M Cost

O&M cost during operation is shown in Table 6.50. Further details may be referred in paragraph 6.3.5.2.

**Table 6.50. O&M Cost During Operation**

| O&M Items | Cost（VND billion/year） | Description |
|---|---|---|
| Maintenance Cost | 13 | Maintenance for road facilities |
| Operation Cost | 73 | Operation cost of toll gates etc. |
| ITS Cost | 9 | Maintenance for ITS facilities |
| | 721 | Renewal cost of ITS (one time per 13 years) |
| SPC Operation Cost | 41 | Personnel cost, direct cost of office |

Source: JICA Survey Team

**(10) Environmental Monitoring Cost**

Environmental monitoring cost was estimated in the EIA report, entitled the "Environmental Impact Assessment – Project of Trung Luong - My Thuan - Can Tho Expressway construction investment according to BOT form (Period 1)" (Approved letter No. 2140/QD-BTNMT). **Table 6.51** shows the estimated environmental monitoring cost in the EIA report.

**Table 6.51. Environmental Monitoring Cost**

| No. | Phase | Estimated Expenses (VND) | | |
|---|---|---|---|---|
| | | Pre-construction | Construction | Operation |
| 1 | Air Quality | 198,000,000 | 950,000,000 | 175,000,000 |
| 2 | Noise | 30,760,000 | 641,520,000 | 95,040,000 |
| 3 | Vibration | 43,200,000 | 691,200,000 | 89,400,000 |
| 4 | Surface Water Quality | 120,000,000 | 920,000,000 | 360,000,000 |
| 5 | Underground Water Quality | 75,000,000 | 560,800,000 | 50,100,000 |
| 6 | Soil Quality | 25,000,000 | 320,000,000 | 78,000,000 |
| Subtotal | | 491,960,000 | 4,083,520,000 | 847,540,000 |
| Total | | 5,423,020,000 | | |

Source: EIA report

Here,

- The estimated cost includes not only for the TL-MT section of the target Project but also for the My Thuan-Can Tho section.
- The cost estimation period is September 2008.

Assumptions for the environmental monitoring cost are;

- The cost is proportional to the length of the expressway. Thus, the cost of the TL-MT section is assumed to be 68.8% of the whole section (the length of the Trung Luong-My Thuan section is 54.3 km and the My Thuan-Can Tho section is 24.5 km in the F/S).
- For the purpose of meeting the cost estimate period (July 2011), price adjustment is considered using the price escalation rate of the years 2008 to 2011.

The environmental monitoring cost of TL-MT Expressway is estimated as:

VND 5,423 million*0.688*(1+$r_{08}$*3/12)*(1+$r_{09}$)*(1+$r_{10}$)*(1+$r_{11}$*7/12) = <u>VND 5,103 million</u>

(Here rxx: price escalation rate of each year, $r_{08}$=0.231, $r_{09}$=0.067, $r_{10}$=0.092, $r_{11}$=0.188, based on IMF World Economic Outlook, September 2011))

**(11) Supplements**

- The result of the D/D review and the design change proposal of this JICA Survey are based mostly on the approximate design calculation and cost estimation. Because of this, it is appropriate that the D/D be reviewed and further developed in the next implementation phase.
- The design of the Tan Cuu Nghia interchange with "clover leaf shape" is not in progress. After the interchange was designed as a "diamond shape", the government proposed to change it to a "clover leaf shape". The cost estimate of the JICA Survey is based on the ratio estimation of similar interchanges. The interchange must be surveyed at the site and be designed as fast as possible.
- The 6-lane widening plan has also not yet been designed by far. The cost estimation is based on the approximate ratio estimate.
- D/D has not yet been finished by the time the Engineering Team submitted the report in July 2012. D/D might be changed or revised after that period.

**(12) Contract Packaging**

In the D/D of the TL-MT Expressway, the project is divided into 18 packages by the decision of BEDC. The contract package was not determined for the same division that was adopted in the JICA Survey.