Appendix 25 Survey and Discussion on Improvement of Duong Bridge

A 25.1 Purposes

The Duong River is the middle portion of trunk line waterway "Corridor 1". "Corridor 1" is a waterway, which links Hai Phong Port, metropolitan Hanoi and Viet Tri at the northwest end of the Red River delta.

Duong Bridge crosses the Duong River at about 8 km downstream from the Red River divergence to the Duong River. This bridge is a railway- and highway-combined bridge. It has the center lane for railway and two side lanes for road made of cantilever structure. The railway directs the northern area from Hanoi and the roadway is NH 1A. Duong Bridge was composed of the truss of four reams, and the superstructure was constructed in 1980's.

The bridge elevation is +11.78 m and water level of H 5% is 8.9 m. Hence, the clearance under the deck is 2.88m at Duong Bridge (11.78-8.9=2.88m). As the clearance under the deck is low, sailing of river vessels is limited for about 75 days in a year. The ship with high structure is moving south via the Luoc River. It is compelled to detour by 60 km at the waterway distance or to spend an extra navigation of about 9 hours in case of a speed of 7 km/hour at the sailing time.

If the ships, which sail from Hanoi to Hai Phong, could navigate in the Duong River throughout a year, more economic water transportation can become possible, and the effect to national economy is expected to be large.

For this purpose, surveys and discussions are made on possibilities and methods of raising height from the surface of the water under the deck, which can be devised by making Duong Bridge a movable bridge. This movable bridge plan is first examined in 1998 by the TA of ADB (Greater Mekong Sub-region Study by Haskoning). In this study, the cost was calculated to be US$ 2,450,000. In the study of ADB, however, a site investigation of the natural conditions such as soil investigation was not executed, and the design level was the conceptual design.

In this JICA Study this concept is checked again to make Duong Bridge a movable bridge so as to enable the ships to sail through the Duong River all the year round.

A 25.2 Investigations on Duong Bridge

A 25.2.1 General Features of Duong Bridge

The general information on the design of Duong Bridge is as follows:

Width of bridge: 5.5 m x 2 (the roadway) + 5.0 m (train)
Arrangement: 45.14 + 64.64 + 69.78 + 44.50 = 224.06m
Design load : Road = H13 and X60,
Train = T16
Superstructure : All spans of the bridge are simple supported Warren truss girders with a distance between two main trusses of 5.75m and the width of cantilevers used for motorized and non-motorized vehicles of 5.5m
Substructure: Reinforced concrete abutments and piers with caisson foundation by reusing the structure of the old bridge and strengthening and expanding
Elevation of top rail: +13.71m
Elevation of bottom of girder: +11.78m
Navigation water level
HWL (H5%): +8.2m
LWL (H95%): +2.8m
Horizontal width of navigation span: 57.0m

A 25. 2.2 Results of Investigation of the Present Bridge

2.2.1 Size and Dimensions

The structural size of the bridge is measured this time. Compared with the last investigation of ADB, some differences are revealed such as span length. Reference is made to **Figure A 25.2.1** " General Arrangement of Duong Bridge".

2.2.2 Degree of Aging

More than 20 years have passed since Duong Bridge was constructed. Generally speaking, the bridge still maintains healthy conditions. However, rust is seen on the main body of the bridge girder. The concrete floor slab of the road portion has been deteriorated considerably already.

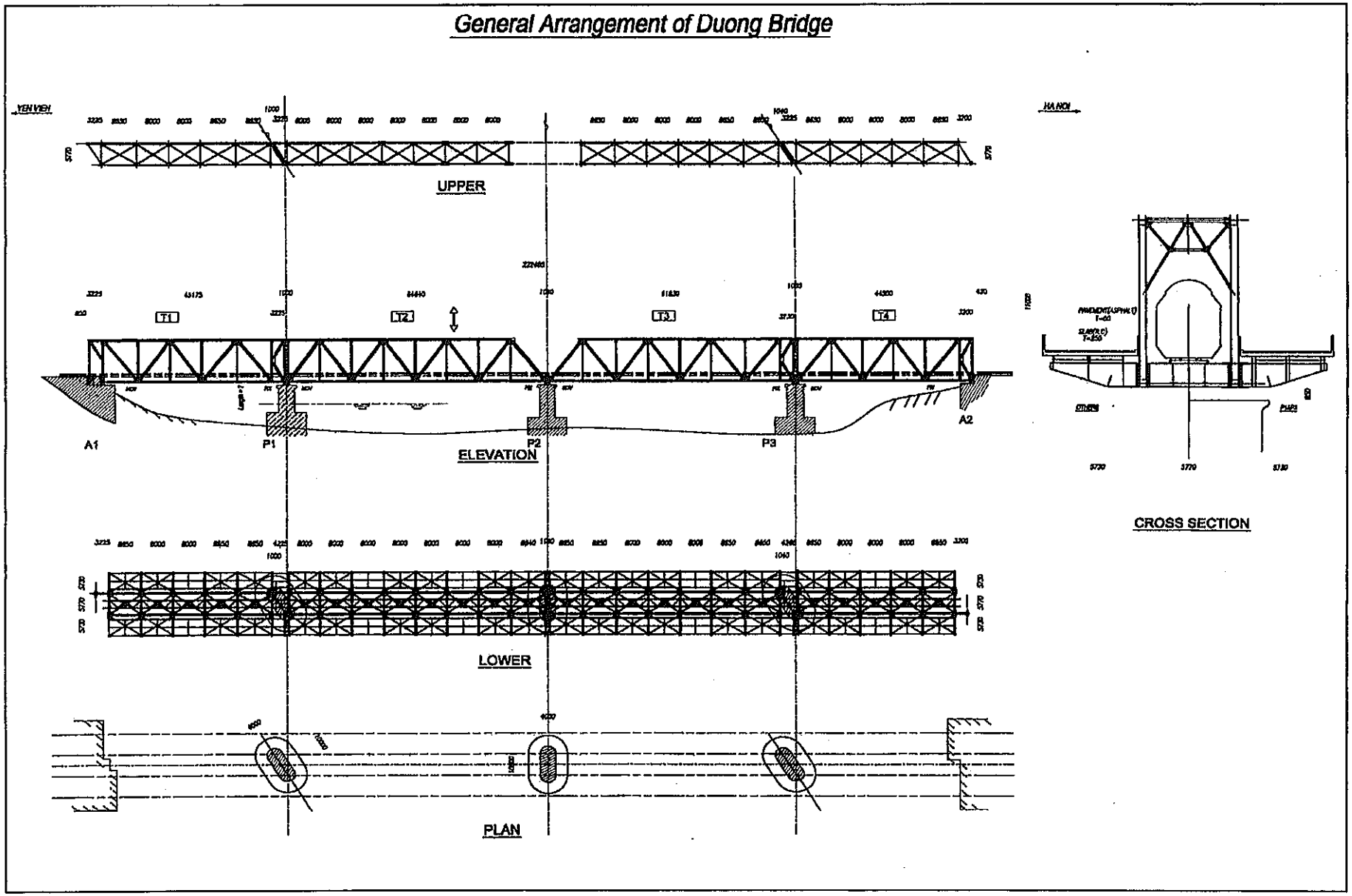


Figure A 25.2.1 General Arrangement of Duong Bridge

On the other hand, when a large-sized motor vehicle passes due to traffic increase in recent years, an abnormal sound is generated at the stringer of the road, which is caused by sliding between bearings of the bridge. Moreover, when a train passes, an excessive vibration has been generated in the bridge girder. It is judged that a cause is defective grinding by the train wheels.

2.2.3 Operation Conditions

The result of traffic surveys is summarized in **Chapter 3** in the main text of this report. During the site investigation works, the following is observed related to conditions of the usage of the bridge by the trains and vehicles:

(1) Train Operations

The operations of the trains are listed in **Table A 25.2.1** recorded on the 30th of July 31, 2002. Among these, trains from 9:05 to 16:47 are confirmed by site investigation team, and the rest are taken from the timetable. The operation of the freight train and the locomotive at nighttime is not included in this table.

The traffic intensity of the trains is about 1.6 trains/hour, which is which is not very frequent.

(2) Vehicle Passages

The traffic volume of vehicles, motorcycles and bicycles was measured on July 31, 2002. The measurement was made twice for ten minutes and multiplied by six to obtain an hourly traffic volume. The record is shown in **Table A 25. 2.2.**

The total traffic of the vehicles and the motorcycles was 4,500 an hour. It is a stand at ten o'clock when traffic was comparatively small. It was an order of 7,000 vehicles/hour at 16 o'clock, which represents the traffic during the commuting time zone in the morning and the evening.

Thus, it can be said that the present road traffic volume is very large.

Table A 25. 2.1 Passage Time of Trains at Duong Bridge

No	Time	From Hanoi	To Hanoi	Kind of train
1	356		○	Train
2	610	○		Train
3	622	○		Train
4	716	○		Train
5	905	○		Independent Locomotive
6	925		○	Train
7	950		○	Freight train
8	1045	○		Independent Locomotive
9	1105		○	Independent Locomotive
10	1115		○	Train
11	1130		○	Train
12	1140		○	Independent Locomotive
13	1325	○		Train
14	1405	○		Train
15	1445		○	Freight train
16	1600		○	Freight train
17	1647		○	Train
18	1911		○	Train
19	1924		○	Train
20	2217	○		Train

Source: Study Team

Table A 25. 2.2 Vehicle Traffic on Duong Bridge

(Number/ hour)

Time zone / Type of the cars	At 10 o'clock	At 16 o'clock
Vehicles (4 wheels or more)	720	840
Bicycles and motorcycles	3,720	6,300

Source: Study Team

2.2.4 Examination of Strength of Truss

Calculations of the steel truss (Length = 67.865 m) of the present bridge are made to examine the strength of the truss, based on the result of the surveys on the materials, sizes and cross sections of the members. The load conditions applied are Vietnamese Bridge Design Code 22 TCN 18-79:

Dead Load: 970 tf for steel RC slab, RC curb, pavement, rails, and hand rails.

Live load: T-16 for trains, and
H30 for vehicle load.

Materials of the truss are:

Alloy steel for steel materials of main truss,
C35 for concrete of deck slab, and
Rivets for connection type.

Geometric dimensions are:

Effective length of truss:	67,865 mm
Effective height of truss:	11,000 mm
Number and length of large segment:	8 x 8,000 mm
Number and length of shortest segment:	1 x 3,225 mm

Analysis of stress of all the members is carried out. The maximum stresses are confirmed to be less than the allowable stress of 2,700kgf/cm^2.

Deflection of the truss is examined, and the result is:

Deflection under dead weight of truss:	8.48 cm
Deflection under T-16 and H30	6.00 cm
Total deflection:	14.48 cm

Thus, it is assessed that the present truss structure can bear the design loads.

A 25.3 Design of Movable Bridge

A 25.3.1 Time Requirement for Operation of Movable Bridge

When ships pass, one span of the bridge shall be opened or raised as a movable bridge. Shortest time may be realized by a vertical lift type bridge. The opening and shutting time of a movable bridge requires about 15 minutes from the stop of the traffic of the vehicles to the re-opening to traffic.

Under the present traffic conditions, daytime may be very difficult to close the bridge, when the amount of road traffic is large while maintaining the operation of the trains. Therefore, the movable bridge can be opened for a short time of midnight and the early morning.

A 25.3.2 Preliminary Design of Movable Bridge

3.2.1 Structural Types of Movable Bridge

There are mainly three types of movable bridges, i.e. Bascule Bridge, Swing Bridge, and Vertical Lift Bridge in the kind of the mobile bridges as shown in **Figure A 25. 3.1**.

In the case of remodeling of Duong Bridge, application of the structure types of the Bascule Bridge and the Swing Bridge is difficult. Thus, it is judged that the Vertical Lift Bridge is the most suitable.

3.2.2 Design Clearance and Deck Height

In selecting the clearance under the deck for a vertical lift-type movable bridge, there are the cases as shown in **Table 25.3.1** to be considered.

Table 25.3.1 Required Clearance at Duong Bridge

Case	HWL H5%	Height of sailing ship	Sub-total	Clearance under deck	Necessary height
Case- 1	+8.7m	9m (IW class 2)	+17.7m	11.78m	5.92m
Case- 2	+8.7m	7m (IW class 3)	+15.7m	11.78m	3.92m
Case- 3	+8.7m	4.4m (Same as Ho Bridge)	+13.1m	11.78m	1.32m

Source : Study Team

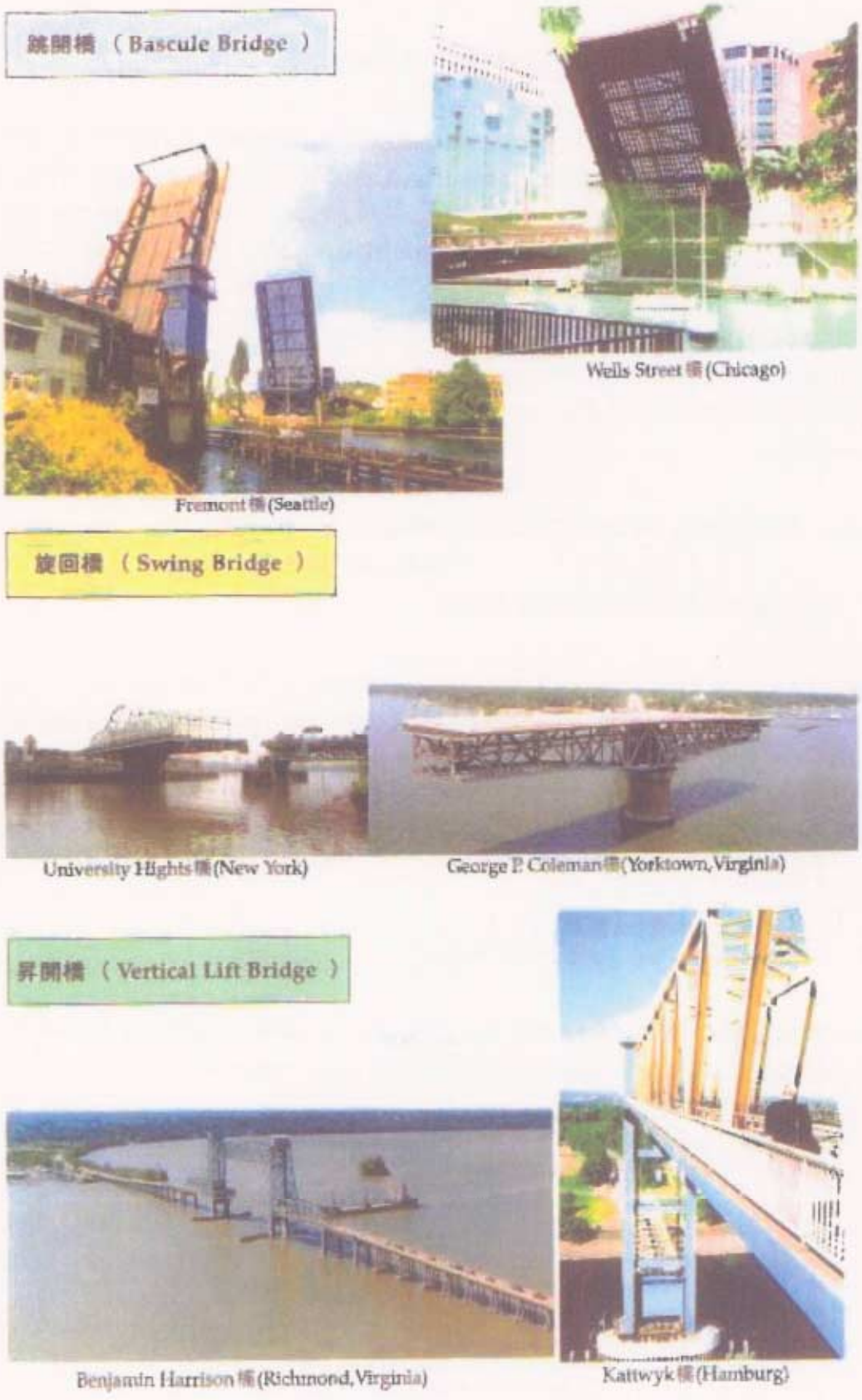


Figure A 25. 3.1 Major Types of Movable Bridges

Source: Study Team

Necessary height of the movable bridge is assumed to be **6.0m,** judging from the maximum value of the above-mentioned table.

3.2.3 Design of the Vertical Lift Bridge

The movable bridge to be considered is the span between piers P1 and P2. The span is called as T2.

In designing the mobile bridge, two cases are chosen for the side road part of the Bridge, i.e. the present RC floor and the steel deck to be newly strengthened.

The calculation of the dead load, the design of the movable bridge, the assessment of quantity of materials, and the construction schedule table are presented below.

(1) Dead Load

The dead load of the existing span is 970 tf as calculated above. In the case where the cantilever side-roads are rebuilt by steel, the dead weight becomes 650 tf, or 33% decrease in the dead weight.

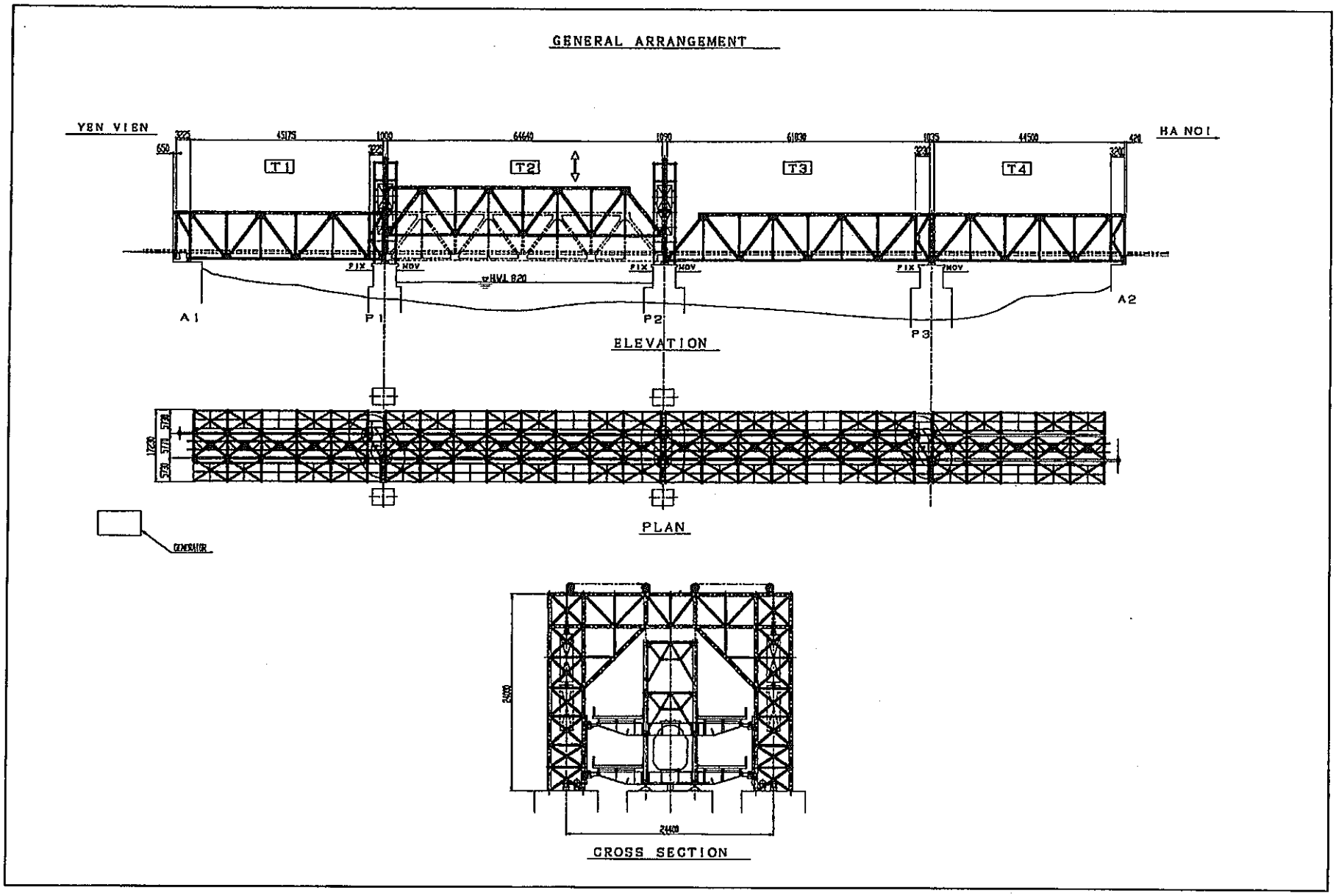
(2) Design of Lifting Devices

Preliminary Design are made for the individual parts, and their weights are as follows:

	Existing Structure	Steel Deck structure
1) Steel frame	239 tf	209 tf
2) Counter weight	929 tf	616 tf
3) Wire rope and others	121 tf	89 tf
4) Lifting device (mechanical)	31 tf	31 tf
5) Lifting guide	15 tf	15 tf
6) Others	10tf	10 tf
Total weight	1,345 ft	970 tf

(3) Preliminary Design of Movable Bridge

As the output of the preliminary design, the general arrangement and major cross sections of the Movable Duong Bridge are shown in **Figure A 25. 3.2 (1)** and **(2)**.



25.3.2(1) General Arrangement of Movable Duong Bridge

Source: Study Team

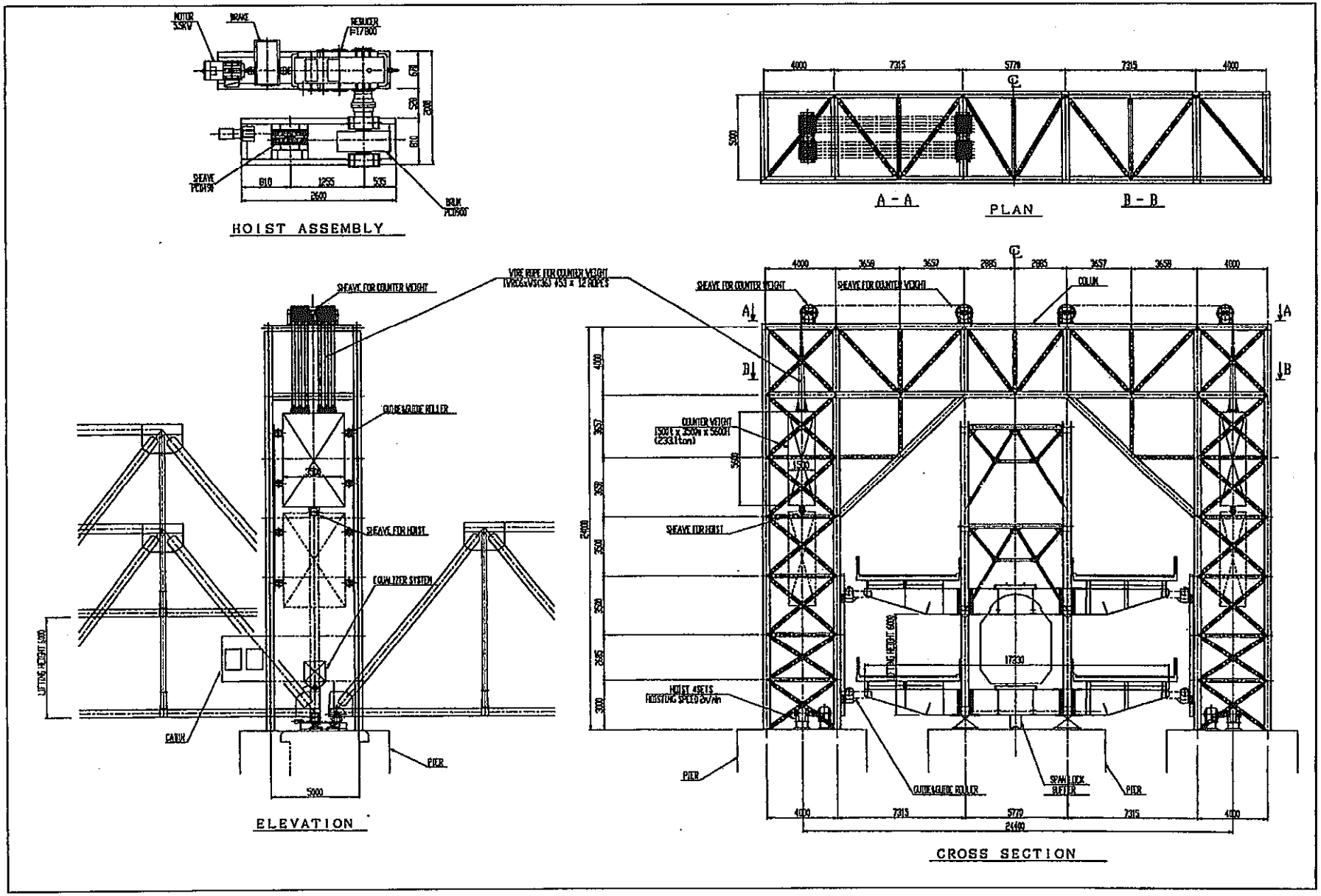


Figure A 25. 3.2 (2) Major Cross Sections of Movable Duong Bridge

Source: Study Team

3.2.4 Construction Period

Required construction period is illustrated in **Table A 25.3.1**.

It is estimated that the construction period will take about 20 months except detailed design works.

3.2.5 Rough Cost Estimate

Rough cost estimate for construction works is carried out and the result is as follows:

1) Construction cost of superstructure:	US$ 8.0 million (Existing structure)
Construction cost of superstructure:	US$ 7.3 million (Steel deck structure)
2) Construction cost of substructure:	US$ 0.7 million (4 additional piers)
3) Construction cost of temporary bridges:	US$1.5 million (1,800 m^2)
4) Installation cost of signals and stopping equipment:	US$ 0.1 million (for trains, vehicles, and ships)
Total Construction Cost:	US$ 10.3 million (Existing structure)
	US$ 9.6 million (Steel deck structure)

Rough cost estimate for operation and maintenance is conducted. The operation and maintenance expenses of the movable bridge include the following three fcctors and costs. Here, the operation period is assumes to be 50 years.

1) The maintenance expenses:	The cost of the check and repair (10 years interval), consumption part and so on, US$ 11.7 million
2) The operation expenses:	The cost of fuel of the power generator, receptacle and so on (for 50 years) US$ 0.1 million
3) The personnel expenses:	The personnel expenses of the personnel who operate the movable bridge (3 psns) US$ 0.1 million
Total OM cost:	**US$ 11.9 million** for 50 years

Table A 25. 3.1 Construction Schedule

Description	1 year				2 year				3 year			
	3	6	9	12	3	6	9	12	3	6	9	12
1. Detail Design												
2. Shop Drawings												
3. Fabrication of Frame for Lifting up												
3.1 Material Procurement												
3.2 Fabrication												
4. Construction of Fram for Lifting up												
5. Construction of Frame for Lifting up												
6. Supply of lifting up device												
6.1 Counter weight and others												
6.2 Wire rope and others												
6.3 Lifting Device (Mecanical Devise)												
6.4 Generator												
6.5 Other												
7. Installation of lifting up device												
7.1 Counter weight and others												
7.2 Wire rope and others												
7.3 Lifting Device (Mecanical Devise)												
7.4 Lifting Guide												
7.5 Generator												
7.6 Other												
8. Remodeling of existing trucss (T2) for lifting up												
9. Cleaning, Others												

Source: Study Team

A 25.4 Possibility of Improvement and Alternative Choices

A 25.4.1 Possibility of Remodeling the Existing Duong Bridge

As the result of the above investigation, examination and design, it can be concluded that introduction of a movable bridge, or vertical Lift Bridge, is technically possible. However, the difficult issue is management of road and railway traffic in relation to operation of the movable bridge.

Due to the presently congested NH 1A and the moderate usage of the railway, it might be very hard to apply the modification except midnight to the early morning. Moreover, the operation and maintenance costs become to a considerable amount, which is necessary for a movable bridge to manage the bridge throughout a period of 50 years.

It is thought that a further examination is necessary for planning of a movable bridge before its execution.

A 25.4.2 Alternative Bridge Construction Plan

4.2.1 Concept of New Duong Bridges

Then, an alternative offer may be reconstruction of the bridge. The most conceivable plan could be that the railway is raised at the place of the present bridge, and the road is through a new road bridge to be separately constructed at an appropriate location near and parallel to the present bridge.

In this plan the new road bridge can be use as the temporary pier for construction works of the railway bridge, the deck level of which shall be raised.

The characteristics of construction of the new bridges can be summarized as follows:

1) The existing bridge is reinforced and be raised by 2 m.

2) The existing bridge will be moved on at the new piers to have made high.
The pier height in this case can be assumed to be the same as that of Ho Bridge, which has the clearance of 3.4 m under the deck.

3) After resuming the railway bridge, the new road bridge will be constructed.

4.2.2 Alternatives of New Road Bridge

As the alternatives of New Road Bridge, several types of bridges are compared and truss type is considered to be the best choice.

4.2.3 Conceptual Design of New Bridge

The conceptual design of the new bridges is shown in **Figure A 25.4.1** on the following page.

4.2.4 Preliminary Cost Estimate

A preliminary rough estimate of construction expenses are as follows:

(1) Construction of New Road Bridge

1)	Superstructure:	US$ 11.6 million
2)	Substructure:	US$ 2.2 million
3)	Sub-total:	US$ 13.8 million

(2) Raising of Existing Railway Bridge

1)	Superstructure:	US$ 3.3 million
2)	Substructure:	US$ 0.7 million
3)	Sub-total:	US$ 4.0 million

(3) Total: US$ 17.7 million

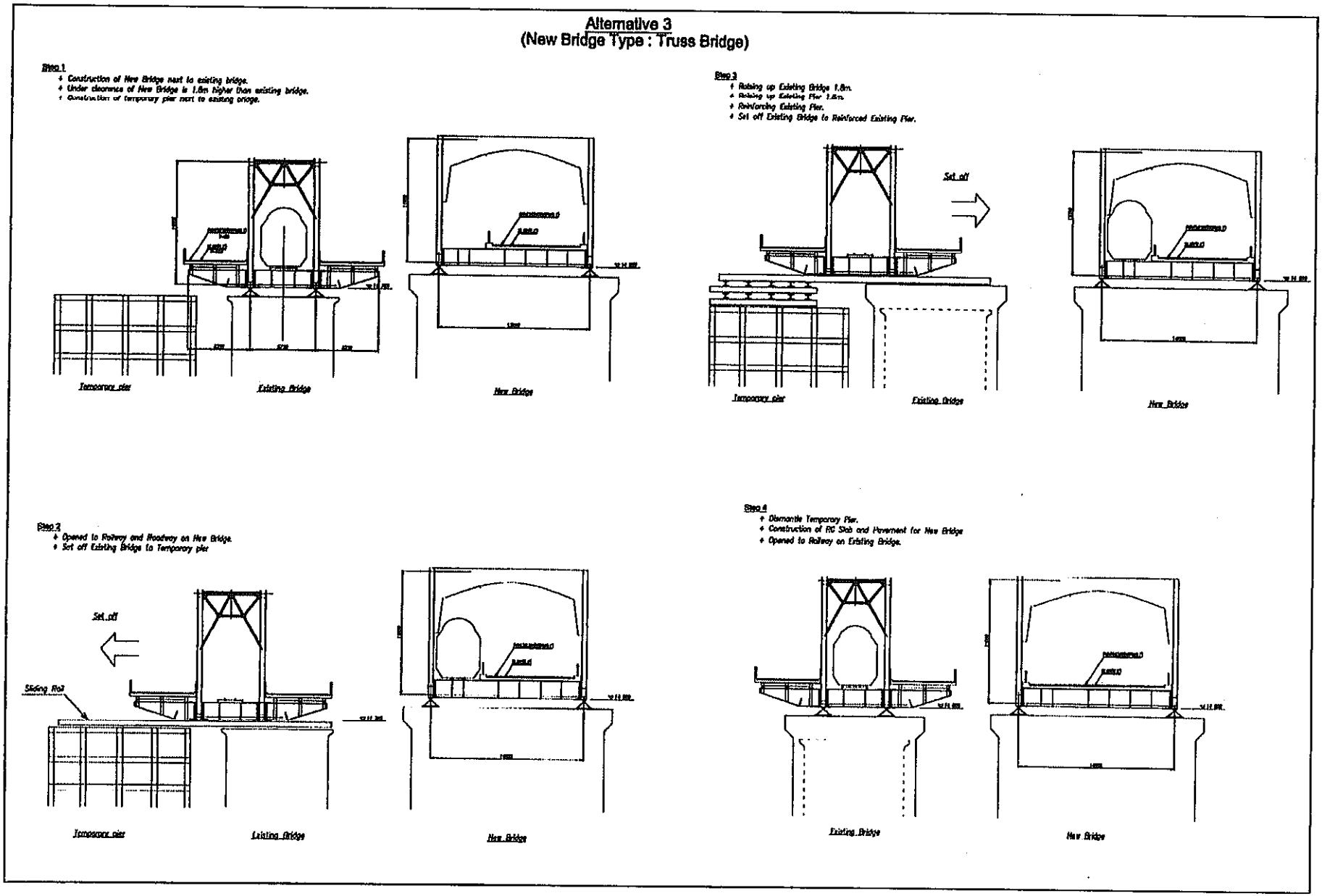


Figure A 25.4.1 General Arrangement of New Duong Bridge (Road Bridge: Truss)

Source: Study Team