CHAPTER 5

PHYSICAL CONDITION OF STUDY AREA AND ENGINEERING SURVEY

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5.1 Physical Conditions of Study Area

(1) Topography

The topography is favorable throughout the entire Project Site. Flat land is spread out in the Red River delta with elevations at less than 10 m. The open area is mainly utilized for rice cultivation.

(2) Geology

Geologically, the flat terrain in Red River delta area is of alluvium or diluvium formation of Holocene or Pleistocene Ages, composed of alluvial or diluvial soils of gravel, sand, loam, silt and clay.

(3) Climate

Annual average rainfall in Hanoi is about 1,700 mm of which 80 - 85 % falls in the rainy season. The annual average number of rainy days is 140. Annual average temperature in Hanoi is 23.6 °C with its minimum of 4 °C and maximum 39.4 °C; mean humidity is 82 %.

5.2 Topographic Survey

5.2.1 Scope of Work

Topographic survey was conducted for three (3) alternative routes (See Figures 5.1.1 and 7.1.2 for alternative route locations).

The survey included:

- Plane table survey;
- Centerline / profile survey;
- Cross section survey; and
- River Cross section survey.

In performing the survey work, the following maps and aerial photographs were used:

- Topographic maps to the scales of 1/10,000 and 1/5,000 which showing three (3) alternative routes;
- A series of maps (28 copies) to a scale of 1/2,000 along the three (3) routes; and
- A series of aerial photographs along the highway corridor (scale: 1/8,000).

The requirements for the survey work were:

i) Plane table survey on the topographic maps with a scale of 1/2,000: 100 m wide along the centerline of the three alternative routes.

ii) The plane table survey at possible interchange locations.

iii) The scales of centerline/profile survey are 1/1,000 horizontal and 1/200 vertical for all the three alternative routes.

iv) The cross section surveys were performed at each 50 m interval along alternative routes with the scales of 1/1,000 horizontal and 1/200 vertical.

v) The elevations of ground surface at borings for soil investigation.

5.2.2 The Location and Descriptions of Global Position System (GPS) used for Topographic and Hydrological Surveys

<u>Reference Bench Mark 1:</u>

GPS located on the center division of National Highway No. 1 at the triangle junction toward the Red River:

Northing	:	2319281.860
Easting	:	509530.020
Elevation	:	6.318 m
Position name	:	DVD 308
DHIV	:	10-9-94

Reference Bench Mark 2:

GPS located on the top of the west dike of the Red River near the route alternative 1 alignment.

Northing	:	2322189.659
Easting	:	514804.104
Elevation	:	14.040 m
Position name	:	DVD 310

Reference Bench Mark 3:

GPS located on the top of the east dike near the route alternative 1 alignment.

Northing	:	2323493.261
Easting	:	516508.222
Elevation	:	13.611 m
Position name	:	TC 2

Reference Bench Mark 4:

GPS located along the railroad on the National Highway No. 5 near the proposed highway alignment.

Northing	:	2326044.658
Easting	:	518173.828
Elevation	:	5.137 m
Position name	:	DVD 312

5.2.3 Survey Results and Comments

Upon completion of the topographic survey, the following was produced for preliminary design:

i) 28 sheet of topographic maps to a scale of 1/2,000 which show all the salient features such as buildings, roads, power lines, rice paddy or irrigation canal dykes, fish ponds;

ii) Centerline profiles to the scales of 1/1,000 horizontal and 1/200 vertical along the centerline of SHTRR including Thanh Tri Bridge;

iii) Cross sections for each 50 m intervals along alternative routes with the scales of 1/1,000 horizontal and 1/00 vertical;

iv) Ground elevations at boring locations; and

v) Topographic survey report.

The details of the survey results are attached in the Appendix 2.

5.3 Hydrological Survey

5.3.1 Scope of Work

I. Bathymetric survey (Sounding tests)

Soundings were conducted along alternative routes to determine cross sections of the Red River.

A total of nine (9) cross sections were chosen:

i) Profiles along the centerline of two alternative routes and one river cross section between the two alternative routes.
ii) Cross sections at 100m upstream of each alternative route plus the middle cross section.
iii) Cross sections at 100m downstream of each alternative route plus the middle cross section.

II. Flow velocity survey

Soon after the soundings were completed, the velocities of the Red River were measured, using a current meter, along the centerlines of the two alternative route alignments plus one base line between the two alternative route alignments.

The locations of the flow velocity measurement for each alignment were:

- At the deepest point of the channel; and
- Two points at both sides of the deepest point in the longitudinal direction.

To determine the average velocity of the flow, the velocities at the depths of 0.2d, 0.6d and 0.8d were measured at each point (d is the depth of the water). See Appendix 2 for measurement result.

5.3.2 River Condition

The locations of the hydrological survey conducted are situated near Thanh Lan communes, where the Red River channel width becomes narrowest in the area.

On the west shore, there is a sand exploiting company that pumps up sand on to the barges at several locations in upstream and unloading at stockpile yard. The depth of the river bed at the surveyed location is rather deeper than other places.

Vegetation is observed along the west shore, and there is a sharp slope on the east side of the river which height seemed to be 2 to 3 m in height from the surface of water.

Due to an unusually large discharge of the Red River at this time of the year so that the flow velocity at the section of the river channel was very swift.

5.3.3 Hydrological Data for the Red River in Hanoi Area

There are several hydrological data available for the design of sub-structure and super-structure of the proposed Thanh Tri Bridge across the Red River, which were obtained from the Observatory for Hydrometeology and Environmental Control of the Red River and Hydrological Institute. The data include:

i) Yearly maximum water level of the Red River at Hanoi Measuring station (1945-1996).
ii) Extreme data of maximum water level (m), maximum discharge (m3/sec), and maximum velocity (m/sec) of the Red River at Hanoi Measuring Station in 1945, 1967, 1971, 1986 and 1996.
iii) Maximum water level prediction with several return period at Hanoi Measuring station.
iv) The Red River flood frequency vs. the discharge at Son Tay Measuring Station.

5.3.4 Hydrological Survey Results

(1) Hydrological Survey Report

The report presents nine (9) river cross sections to the scales of 1/1,000 horizontal and 1/200 vertical, and the flow velocities of the river channel under two alternative alignments plus cross section between the two alternative alignments as requested.

The river cross sections were used in designing the type of substructures and foundations of the bridge along with soil investigation data.

The cross section survey results were further used to determine the river bed gradient which is important factor in calculating the river-bed scouring around the bridge piers, the flow velocity and water depth at given discharge.

(2) Hydrological Data

The hydrological data obtained from the Observatory for Hydrometeorology and Environmental Control of the Red River are used for designing the substructures of Thanh Tri Bridge.

It is recommended by the Government Authorities that the return period for the design of Thanh Tri Bridge be 20 years.

5.3.5 Scour around Bridge Piers

The scour around the bridge piers is a function of the shape of the river cross section, the quantity of discharge, the depth of flow, and the river bed slope correlated with the characteristics of the bed materials, and the type & size of the piers.

It is not surprising that there are no generally accepted principles for the precise prediction of the scour around the bridge piers. Thus, the scour around the bridge piers is currently estimated by several well known theories backed up by the laboratory experiments and the field experiences.

Prior to predicting the scour depth around the Thanh Tri Bridge piers at the flood stage, the Study Team has collected the necessary, geotechnical and hydrological information and data for the estimates.

(1) The Type and Dimension of Pier

i) Type: elliptical reinforced concrete pier supported by pile foundation.
ii) Dimension: as shown in chapter 11.

(2) The River Bed Materials

i) Classification of the river bed materials: sand (SP), poorly graded.
ii) Gradation: distributed from coarse to fine.
iii) Specific gravity of the sand : 2.67.

(3) The Results of Hydrological Survey

i) Design flood level: elevation 12.5m at 20 years return period.
ii) Cross section used to determine the depth of flow: alternative route 2b & 3.
iii) River-bed slope at the proposed river crossing: i = 0.0025.
iv) Flow velocities measured by current meter along Alternative route 2b & 3: Refer to Appendix 2 (appendix table 5.1).

(4) The Prediction of Scour Depth Around the Bridge Piers

Using all information, data and values obtained, the theoretical scour depth around the Thanh Tri Bridge piers was estimated by the experimental theories which were backed up by the laboratory experiments and field experiences. As a result, it is found that the depth of scour around the bridge piers would be on the order of 6m at the flood stage of 20 years return period, using Chiew's Formula (refer to 3. Estimation of Scouring Depth around Piers in Appendix 2).

5.4 Geological and Soil Investigation

5.4.1 Scope of Work

The soil investigation consisted of the following works:

(1) Field Soil Investigation

- Borings along the proposed alternative routes: a total of nineteen (19) borings of 50 meters in depth;

- Disturbed and undisturbed soil samples: at least three (3) undistributed soil samples were required to be obtained during the drilling process from each 50m boring hole; and

- Standard penetration testing: every one (1) meter interval throughout the entire 50 depth.

(2) Search for Borrow Pit Materials

- Subbase and road embankment materials; and
- Base materials.

(3) Laboratory Soil Testing

- Disturbed and undisturbed soil samples obtained from boring holes; and
- Borrow pit materials.

5.4.2 Site Condition of Boring Locations

A total of nineteen (19) boring locations were selected along the three (3) alternative routes. The selected boring locations were identified and plotted on a topographic map with a scale of 1/25,000. See Fig. 5.1.1 for the boring locations.

As seen in the map, two boring locations were selected at the potential interchanges with National Highway No. 1 and No. 5. Also two boring locations were selected in the middle of the Red River along alternative routes, and six were selected at the river shore and riverside land where the bridge's substructures will be constructed.

Another eleven boring sites were scattered along the alternative routes outside of the river dykes where the highway embankments and viaducts will be constructed.

Care has been taken to select each boring location so as not to interfere with private or important public properties.

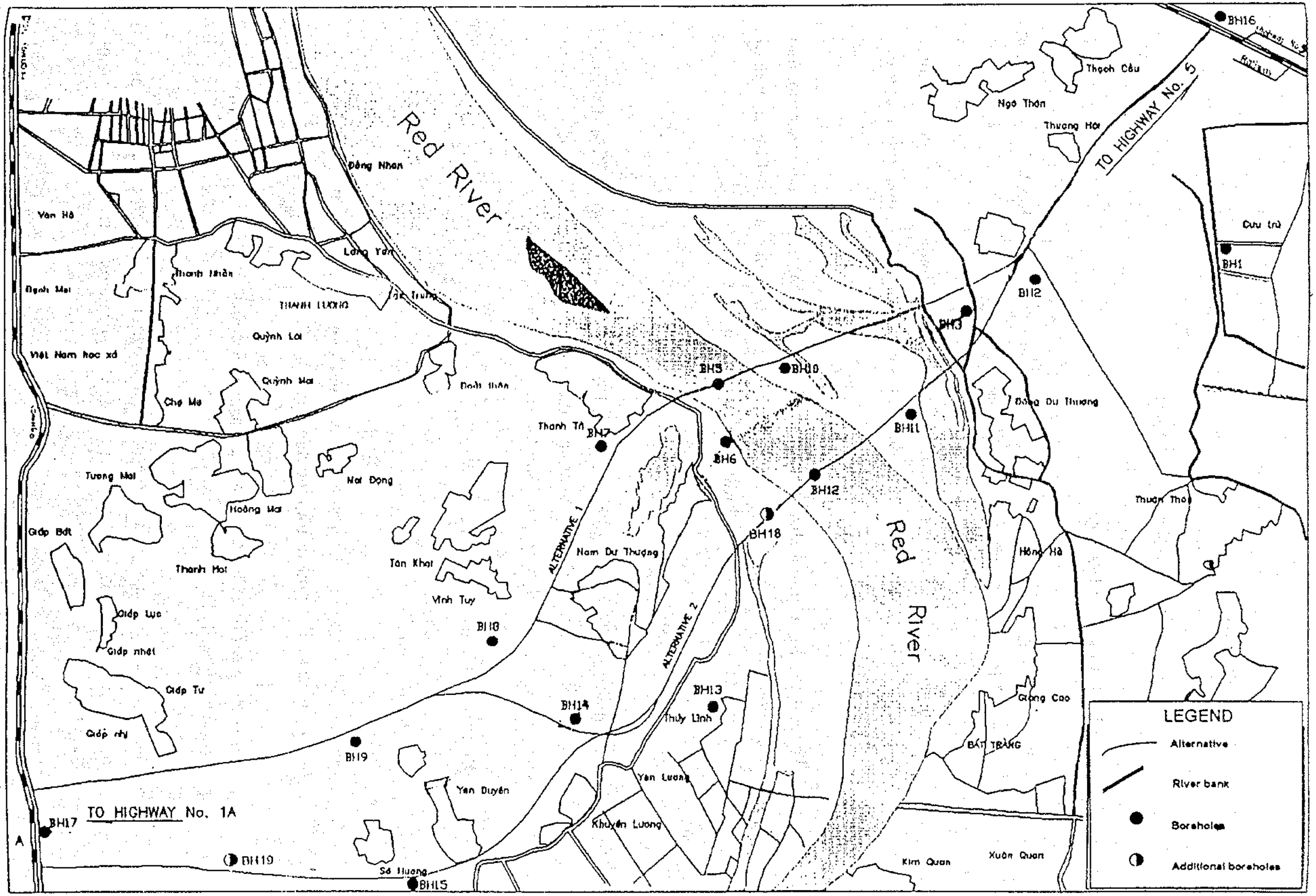


Figure 5.1.1 Plan of Borholes

5.4.3 Laboratory Soil Testings

(1) Soil Samples Obtained from Boring Holes

i) Undisturbed soil samples

Undisturbed soil samples from 19 boring holes were brought to the laboratory for testing. Nine (9) different types of soil tests were required.

The test results of water content, unit weight, specific gravity, Atterburg Limits, and grain size distribution were used for soil classification and soil properties analysis.

The test results of direct shear, unconfined compression, triaxial compression, and consolidation were used to estimate the shear strengths of soils and the degree of settlement due to the new highway overburden pressure.

ii) Disturbed soil samples

Disturbed soil samples were also obtained from each boring hole. Most disturbed soil samples were sand and gravel, and specific gravity and grain size distribution tests were performed on selected samples for engineering analysis.

(2) Borrow Materials

i) River sand

Many sand supplying companies are located along the shore of the Red River, where the sand is pumped from the middle of the river.

It was observed that the sand was used as subbase material for the improvement of National Highway No. 5.

This sand seemed to be good material for the construction of highway embankment and subbase, so the river sands from five source locations were collected and sent to the laboratory for testing.

The assigned test performed were CBR, compaction, grain size distribution and specific gravity tests.

ii) Quarry materials

Mieu Mon is located approximately 40 km southwest from Hanoi, where several quarries are located. The quarry materials are basically limestone, which are used as road base material at many construction sites in Hanoi. The Study Team obtained crushed limestone from Mieu Mon quarry and Xom Van quarry and sent them to the testing laboratory for CBR, compaction, grain size distribution and specific gravity test. The Study Team also obtained some materials from Kien Khe quarry, approximately 55 km south of Hanoi, which were also tested in the laboratory.

5.4.4 Standard Penetration Test (SPT)

Standard penetration tests were performed covering entire 50m depth of each boring hole at intervals of one (1) meter. After analyzing the test data, the depths where the N-value reached 50 or more are listed below for design purposes.

Boring No.	Ground Surface Evaluation (m)	Depth where N-Value Reached 50 or More
1	6.975	38.5 m
2	4.058	37.5 m
3	4.036	47.5 m
4	9.100	38.0 m
5	-4.270	46.5 m
6	7.325	40.0 m
7	5.562	37.0m
8	5.835	40.0 m
9	5.794	41.3 m
10	9.015	43.0 m
11	8.410	41.0 m
12	-2.900	37.5 m
13	9.607	44.0 m
14	5.795	32.0 m
15	4.679	40.0 m
16	3.717	39.0 m

17	5.436	43.5 m
18	7.431	47.0 m
19	5.396	43.5 m

5.4.5 Result of Laboratory Test

All required soils testing was completed and the necessary soils analysis was performed.

(1) Soils Classification

Using the soil test data of water content, unit weight, specific gravity, grain size distribution, and Atterburg Limit, all soil samples were classified according to the ASTM Soils Classification system.

(2) Angle of Internal Friction and Cohesion of Soils

Direct Shear, Unconfirmed Compression, and Triaxial Compression tests were conducted for undisturbed alluvium soil samples to determine the angle of internal friction, cohesion, and the density of the soils. After listing all the test results, a selected group of most reasonable values were averaged. The values obtained in the soil analysis were:

Test	Angle of Internal Friction, ϕ	Cohesion, C (kg/cm^2)
Direct Shear Test	15	0.15
Unconfined Compression	16	0.25
Triaxial Compression	12	0.26

These values were used for the slope stability of the road embankment and the ground stability analyses.

(3) Compression Index, Cc and the Coefficient of Consolidation, Cv

Consolidation tests were performed for the clay and silt soils obtained from each boring hole at different depths. When determining the Cc and Cv values, the e-log p curves and log time-consolidation curves were carefully chosen, considering the soil types, the depths, and the boring locations. From the selected curves, the values of Cc and Cv were calculated and used for settlement analysis. The values were:

Recommended Depth in Meters	Cv (cm^2/sec)	Cc
0-10	0.51×10^{-3}	0.10
10-20	0.43×10^{-3}	0.12
20-30	0.45×10^{-3}	0.14
Below 30	0.38×10^{-3}	0.28

(4) CBR Test Results on Importing Materials

Two types of importing materials are required to construct the proposed highway, base course material and embankment material. As the base course material, crushed limestone from Mieu Mon, Xom Van, and the Kien Khe quarries were selected, and as the embankment material, the Red River sand was chosen. The test results are as follows:

Source	Soil Type	CBR (Soaked)
Kien Khe	Limestone	78-100
Mieu Mon	Limestone	74-98
Xom Van	Limestone	74-96
Bai Bac	Sand	14-19.5
Phu Dong	Sand	13.5-21
Linh Nam	Sand	11.5-18

It was found that the crushed limestone have high CBR values and suitable for base course material. However, CBR value of the Red River sand was found to be rather low compared with that of crushed limestone, but strong enough to construct the highway embankment.

5.4.6 Underground Soil Strata

Analysis was made to learn the existing subsurface soil types and layer thicknesses using all the accumulated laboratory soil test data and machine boring data.

The soil encountered in the 50 meter boring depths were categorised into three soil types : alluvium soils (clay and silt), sand and fine gravel. At the Red River zone, the primary deposit between the surface and the 35 meter level was sand, underlain by fine gravel. A two or three meter layer of clay was found within the sand stratum. On the eastern side of the river, the soils consisted of 15 to 20 meters thick clay, underlain by 20 to 25 meters of thick sand, underlain by fine gravel. On the western side of the river, the upper clay deposits were thicker than on the eastern side, ranging approximately 25 to 35 meters in thickness, but containing one or two thick sand lenses, 5 to 15 meters in thickness. The clay with sand lenses is underlain by sand deposits, which is underlain by fine gravel.

5.4.7 Slope and Ground Stability Analysis

(1) The Slope Stability of the Embankment

The typical dimensions of road embankment are to be 6 meters in height and 32 meters in width at carriageways plus the center median. The slope of the embankments was set to be 1:1.5 (1 vertical to 1.5 horizontal). It is assumed that the road embankment would be constructed with the Red River sand, and that during construction, the embankment would be slightly loosened due to foundation settlement.

The slope stability calculations were made against the circular failure for the 1:1.5 slope. The physical properties of sand was found to be the angle of internal friction, $\phi = 30^\circ$ in slightly loosened condition, and cohesion, C = 1 ton / m^2. The sketch of the typical slope failure and the safety factors of the calculation results are shown on Figure 5.4.1. It was concluded that the slope would be safe if kept at 1:1.5.

(2) Ground Stability Analysis

Circular ground failure may also hazard the embankment. A sketch of typical ground failure due to the embankment load is shown in Figure 5.4.2 (a).

Calculations was made for critical cases (the least safety factor) for embankment heights of 6, 10, and 12 meters. The values used in the calculations are:

	Unit soil weight (t/m^3)	Angle of internal friction (ϕ)	Cohesion C (t/m^2)
Embankment	1.9	30	1.0
Ground	1.8	15	2.5

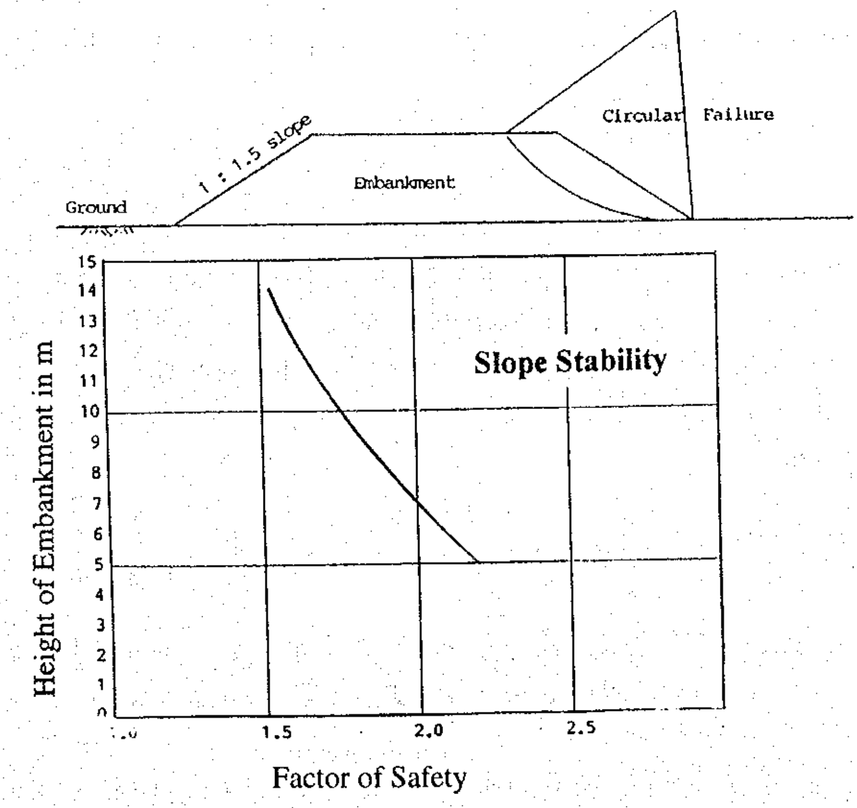
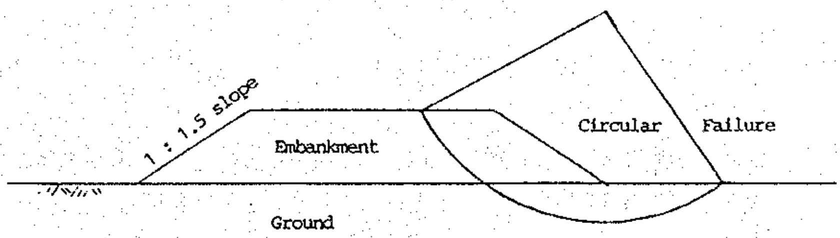


Figure 5.4.1 Slope Stability Analysis

Typical Ground Failure (a)



Ground Stability (b)

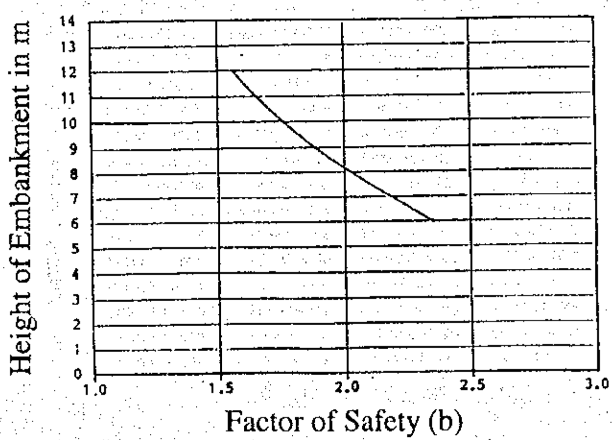


Figure 5.4.2 Ground Stability Analysis

The calculation results are shown in Figure 5.4.2 (b). As seen in the figure, the embankment height up to 12 meters would protect against potential ground failure.

5.4.8 Settlement Analysis

The stretch of land between National Highway No. 1 and No. 5 is situated on alluvium deposits, except for the Red River region. The alluvium deposits were found to be fairly compressible, and if the proposed road embankment is constructed over the deposit, settlement will likely occur. Therefore, settlement analysis is conducted to determine the extent of expected settlement and the timing of consolidation due to the embankment loading.

Two cases were considered:

Case 1. Setting the embankment height at 6 m constant, and changing the thickness of the clay layers to 10, 20, and 30 m, respectively.

Case 2. Setting the thickness of the clay layer at 30 m constant, and changing the height of the embankment to 6, 8, 10 and 12 m, respectively.

The following assumptions were made prior to the calculations:

i) Unit weight of the embankment soil would be 1.9 t/m^3 and that of the underground soil 1.8 t/m^3.
ii) Compression index, Cc, and the coefficient index Cv would be used as listed in paragraph 5.4.5 (3).
iii) Clay layers on both sides would be drained.
iv) Settlement would be estimated at the center of the embankment.

Also, the pressure increment was calculated, using the "influence values for vertical stresses in a semi-infinite mass due to an embankment loading", by J.O.Osterburg. See Figure 5.4 in Appendix 2 for the theory and chart used. Three e-log p curves were used to estimate the void ratios at the overburden pressure and the pressure increments. The curves used are shown in Figure 5.5 in Appendix 2.

The Results of Case 1 Analysis:

The results of the ground settlement analysis is shown in Figure 5.4.3. The embankment height was set at 6 m constant, but the thickness of clay layers were changed as indicated.

The Results of Case 2 Analysis:

The calculation results of the settlement vs. Consolidation time is shown in Figure 5.4.4. In this calculation, the thickness of the clay layer was set at 30 m constant, but the height of the embankment differed.

As stated in 5.4.6, the ground of the entire stretch of the proposed highway route consists of clay and a few silt layers over silty sand deposits underlying by fine gravel, except the Red River bed and the riverside land.

The clay layer of the ground from Tho Khoi village to National Highway No.5 on the east side of the river ranges approximately 15 to 20 m in thickness, and that of the ground from Yen Duyen commune to National Highway No.1 on the west side of the river ranges approximately 25 to 30 m in thickness.

These clay layers are subject to the settlement when the embankment is constructed over the ground. Currently, the embankment is designed to be 6 m in height and 32 m in top width with 1 vertical and 1.5 horizontal slope.

The settlement analysis is performed for the clay and silt layers, case by case, due to the excess overburden pressure caused by the embankment load, using the laboratory consolidation test data. The results of settlement analysis are shown on Table 5.1 in Appendix 2.

As seen from the results, where the thickness of clay layer is 30 m, the final settlement is excepted to be 36 cm and it will take 39 years, and where the thickness is 20 m and 10 m, the settlement are 30 cm and 21 cm, with consolidation time of 17 years and 4 years, respectively.

However, the initial 50% of consolidation occurs by 10 years for 30 m, 4.5 years for 20 m, and 1 year for 10 m clay thickness.

In order to expedite the degree of consolidation, the pre-loading together with vertical drain (sand drain, etc) is necessary.

The height of pre-loading embankment and the distance of vertical drains are the function of required degree of consolidation and amount of settlements to be completed.

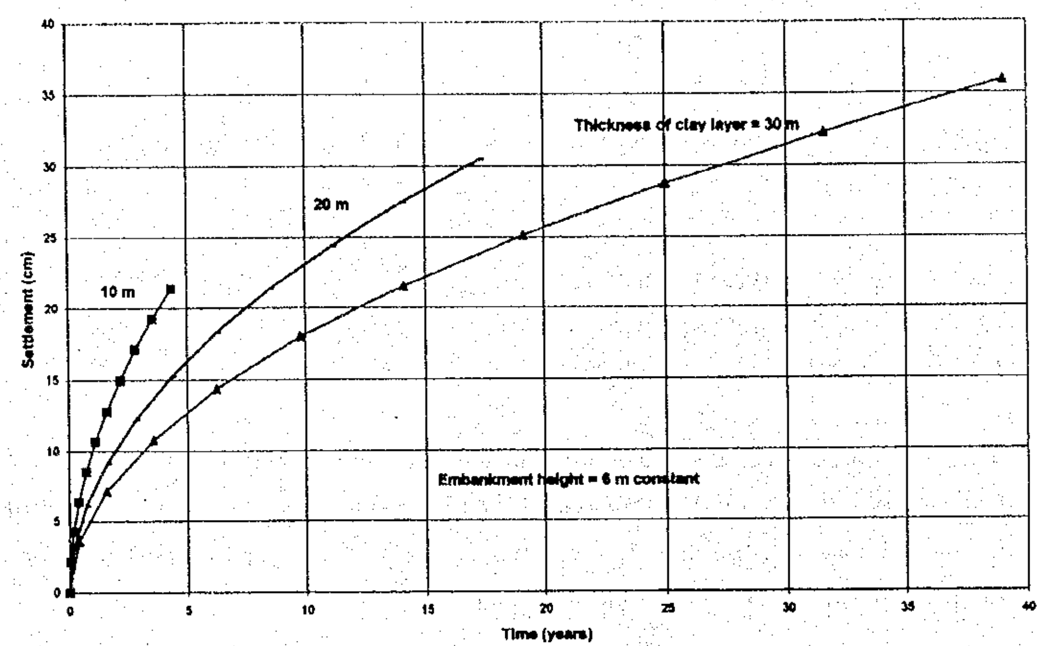


Figure 5.4.3 Result of Settlement Analysis – Case 1

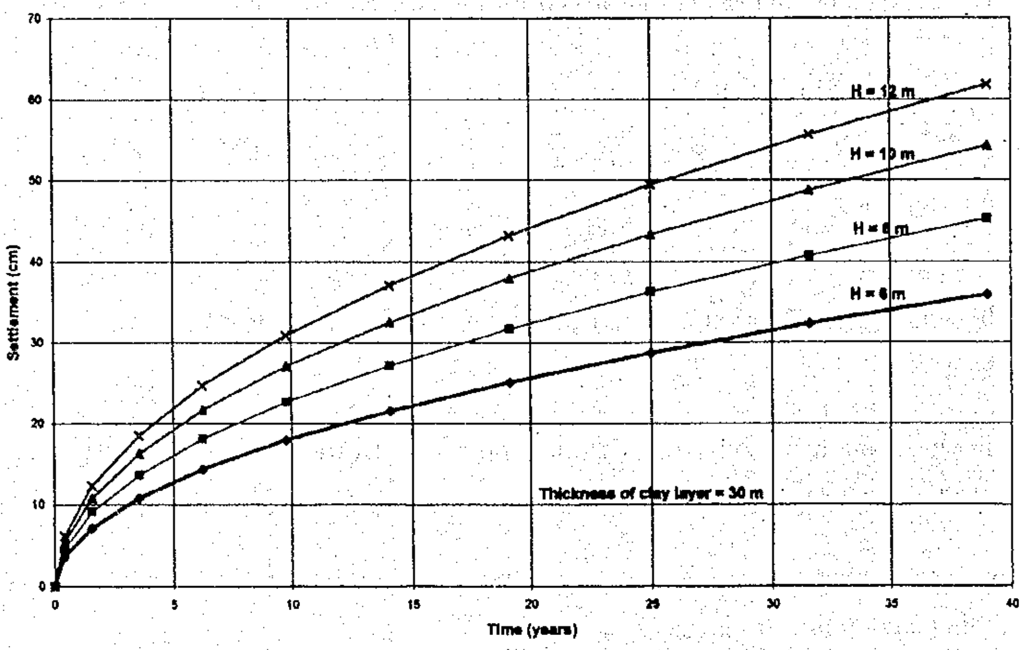


Figure 5.4.4 Result of Settlement Analysis – Case 2

This method is also expected to increase the shear strength of the ground along with expediting the settlement so that a periodical measurements of vertical and horizontal movements of the ground are a must during pre-loading period.

The expected settlements due to the pre-loading over 30 m clay layer without vertical drains are listed on Table 5.1a in Appendix 2. If the vertical drains are used, the time to reach 50-70% consolidation is to be 6 months to 1 year, depending on the size and distances of the drains.

The embankment up to 12 m in height would be safe against the slope and ground failure based on the stability and analysis.

Therefore, no specific treatment such as a counter weight loading, sheet piling, etc. along the foot of the embankment is necessary if the embankment height is less than 12 m.

5.4.9 Discussion and Recommendations

1. Based on the results of CBR tests it is recommended to use the Red River sand for the main body of the highway embankment and the quarry materials for the base course.

2. From the slope stability analysis, it was found that the slope of the embankment must be 1 vertical to 1.5 horizontal. However it is recommended to adopt 1 vertical to 2.0 horizontal considering highway maintenance problem.

3. The ground stability analysis showed that the ground will be stable up to 12 m embankment height. If pre-loading is however required to expedite the settlement, the embankment height exceeds 12 m, the general shear failure of deeper ground should also be checked.

4. Based on the results obtained from the settlement analysis, the consolidation time for 30 m of the thick clay layer requires almost 10 years for 50% consolidation, so in the location of the thick clay layer, pre-loading may be needed along with sand drain or other drain method.

CHAPTER 6
DESIGN STANDARDS

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6.1 Geometric Design Standard

6.1.1 Functions of the Southern Section of Hanoi Third Ring Road (SHTRR)

(1) System and Classification

The road network in metropolitan Hanoi is not functionally classified in hierarchies of movements and components. National highways only form radial arterial road network, Thang Long-Noi Bai Highway is designated as a part of Hanoi Third Ring Road although the first and second ring roads are distinctively functioned.

Freeways, where there is generally uninterrupted movement of vehicles and high-speed flow, do not exist although a design standard for freeways in rural areas is prepared in TCVN 5729-1997. The Hanoi Bypass, which consists of New National Highway No. 1 (New NH-1) and Duong Bridge, and forthcoming toll road development will form a freeway network for metropolitan Hanoi.

On the other hand, the public road network of Hanoi, where public roads accommodate primary movement, transition, distribution, collection, access and termination as shown in Figure 6.1.1, is formulated as a combination of radial roads and one circumferential road (locally called the inner ring road). TCVN 4054-85 specifies the design standard of public roads and highways in rural areas not only for the design of new road but also for that of upgrading and rehabilitation.

However, it should be noted that both TCVN 5729-1997 and TCVN 4054-85 specify the design standard not for urban roads but for rural roads, and that projects in urban areas will be discussed case by case.

(2) The Hanoi Bypass

The Hanoi Bypass is comprised of the New NH-1 and SHTRR as shown in Figures 6.1.2 and 6.1.3, where the SHTRR is planned to connect the southern section of New NH-1 to the northern section of New NH-1, including Duong Bridge.

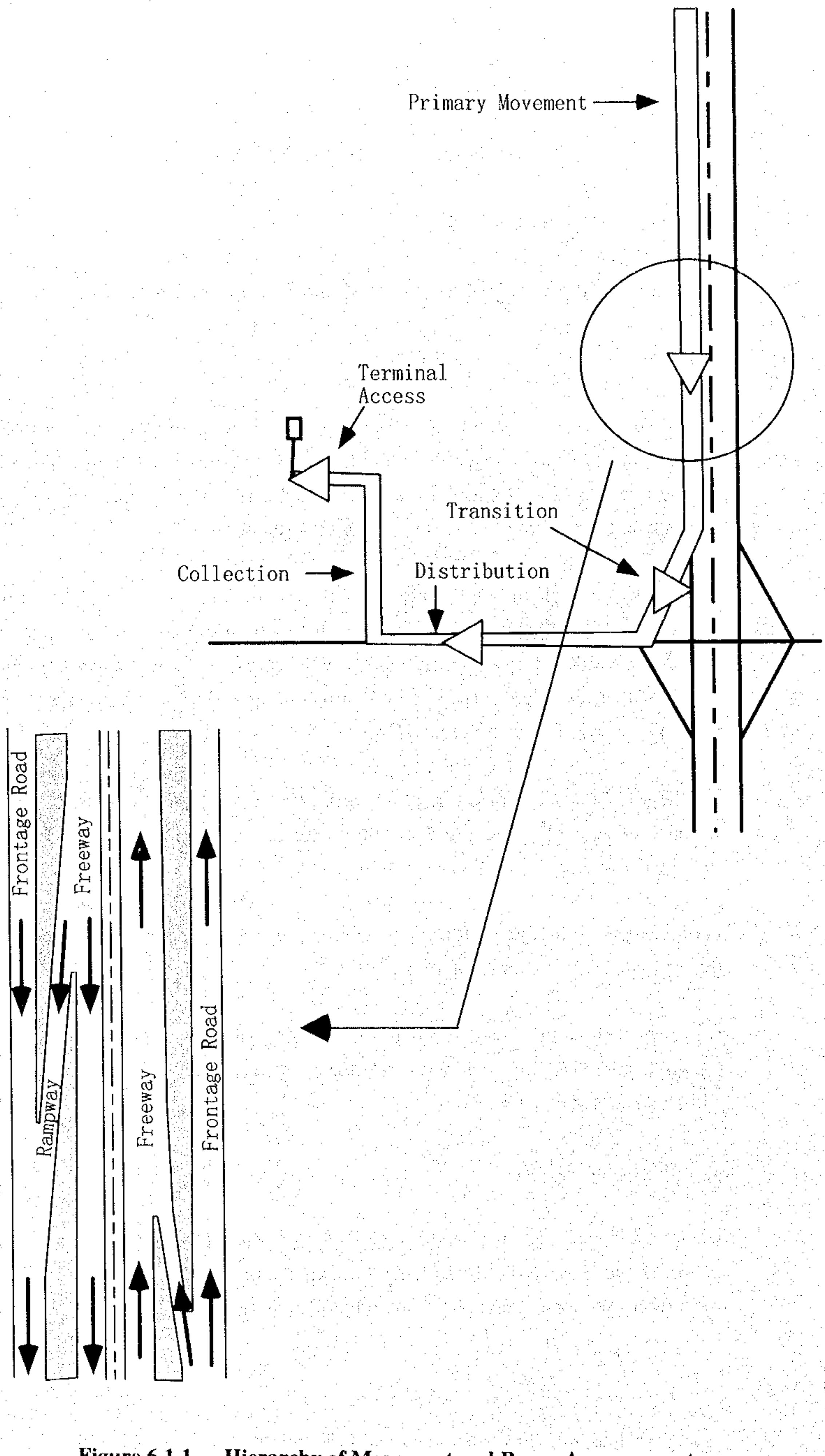


Figure 6.1.1 Hierarchy of Movement and Ramp Arrangement

The southern part of New NH-1 is planned to bypass the existing National Highway No. 1 (NH-1) in the south of Hanoi, which is designated as a 4-lane divided highway with a design speed of 100 km/h. The lane width of carriageway is 3.75 m. The project is implemented by PMU 1 under the financial assistance of the World Bank.

The northern part of New NH-1 is planned to connect National Highway No. 5 (NH-5) to NH-1 through Duong Bridge, which is designated as a 4-lane rural freeway with a design speed of 120 km/h at the 2nd stage, and 6-lane rural freeway at the 3rd stage by adding two to inner lanes. At the initial stage, one side of 2-lane carriageway is planned to be constructed and opened to public as 2-lane 2-way undivided highway with a design speed of 80 km/h. The 2nd and 3rd stage constructions are only at the planning level and no implementation plan has been made. The northern part of New NH-1 is implemented by PMU 1 under the financial assistance of ADB, while Duong Bridge is implemented by PMU 18 under the financial assistance of OECF. The lane width of 3.50 m is adopted to both projects throughout.

(3) Functional Classification as a Design Type

The SHTRR is located to connect NH-1 with NH-5 as well as a part of Hanoi Third Ring Road as shown in Figure 6.1.2, where the terrain is flat and rapid urbanization has continued for several years in spite of poor road network.

The primary function of SHTRR is to designate an urban freeway as the part of the Hanoi Bypass as shown in Figure 6.1.3 or as a part of the Hanoi Third Ring Road as shown in Figure 6.1.4.

The secondary function of SHTRR is anticipated to be the fourth bridge crossing the Red River to connect two districts, Thanh Tri and Gia Lam as shown in Figure 6.1.5. Therefore, SHTRR is also designated as an urban arterial road to strengthen road network as well as to stimulate urban development in both districts.

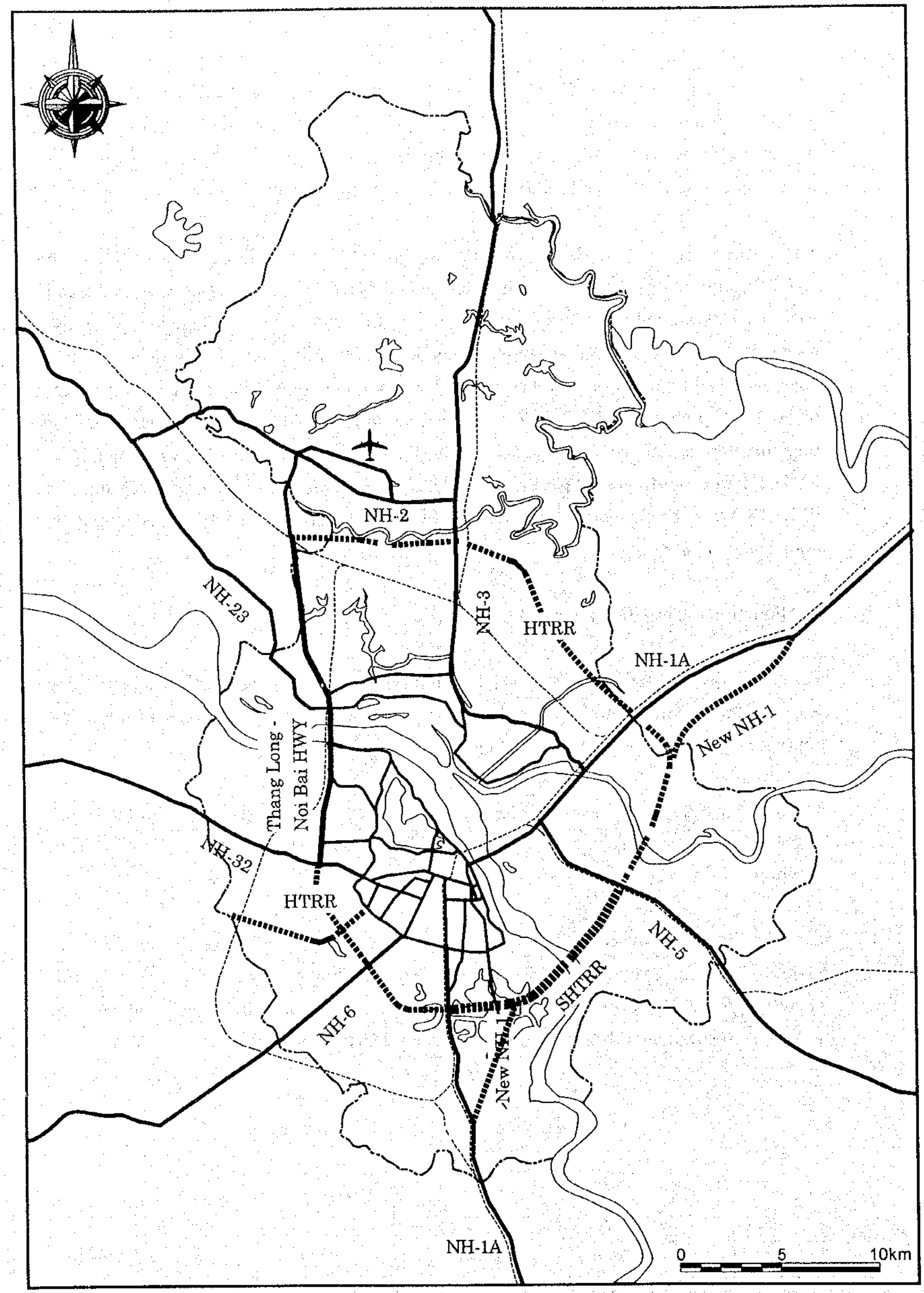


Figure 6.1.2 Major Arterial Road Network in Hanoi Metropolitan Area

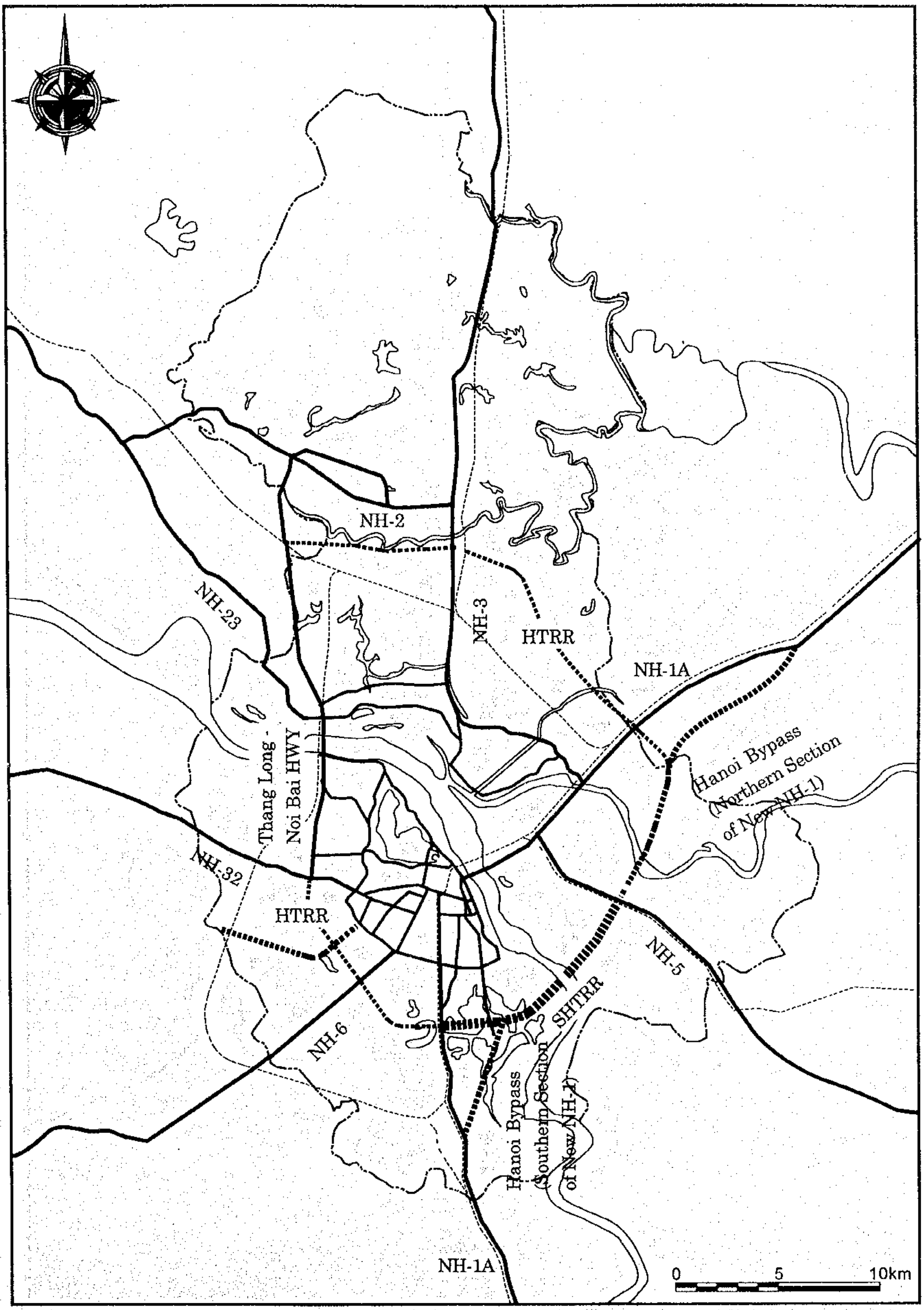


Figure 6.1.3 SHTRR Function of the Hanoi Bypass

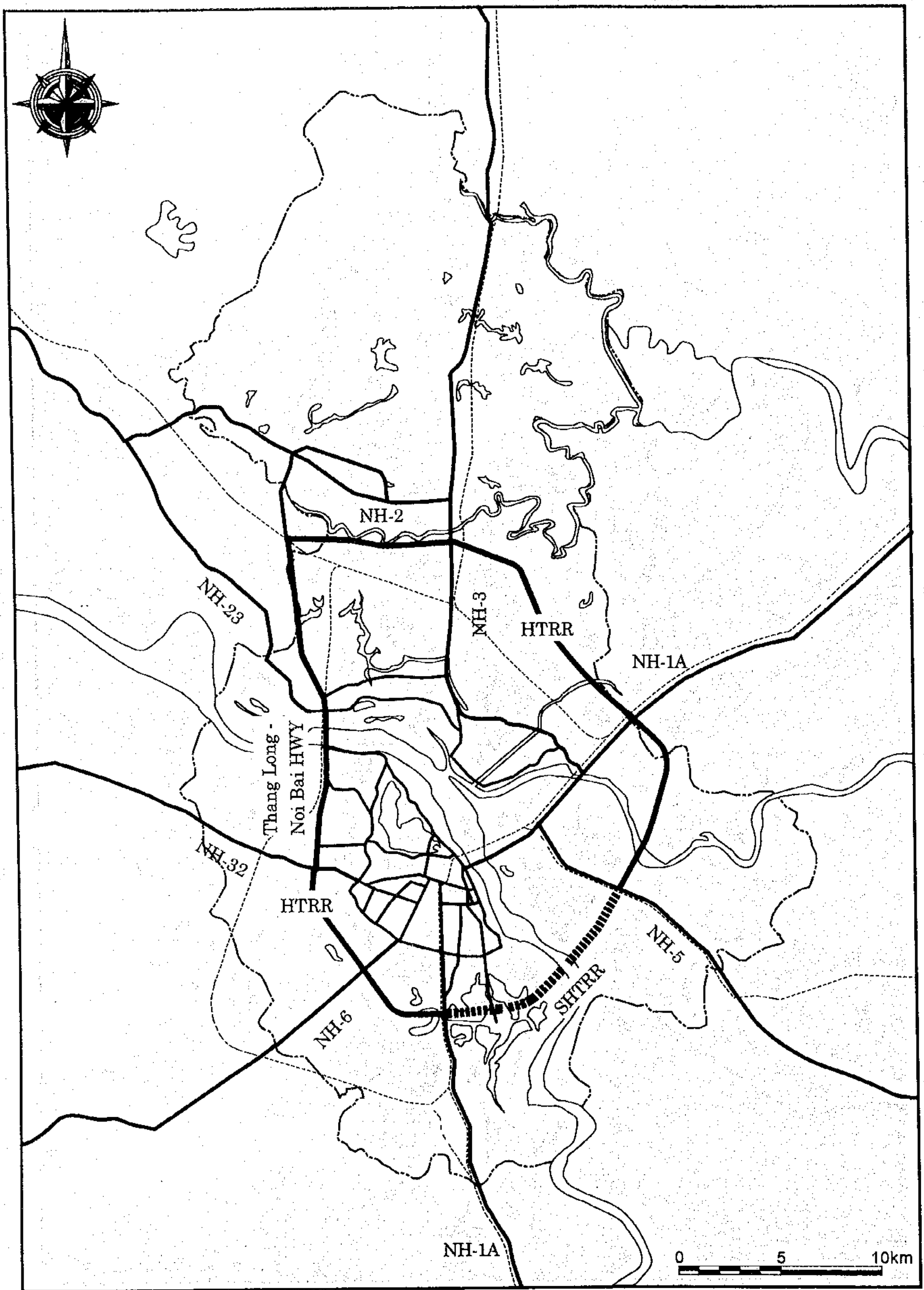


Figure 6.1.4 SHTRR Function of the Hanoi Third Ring Road

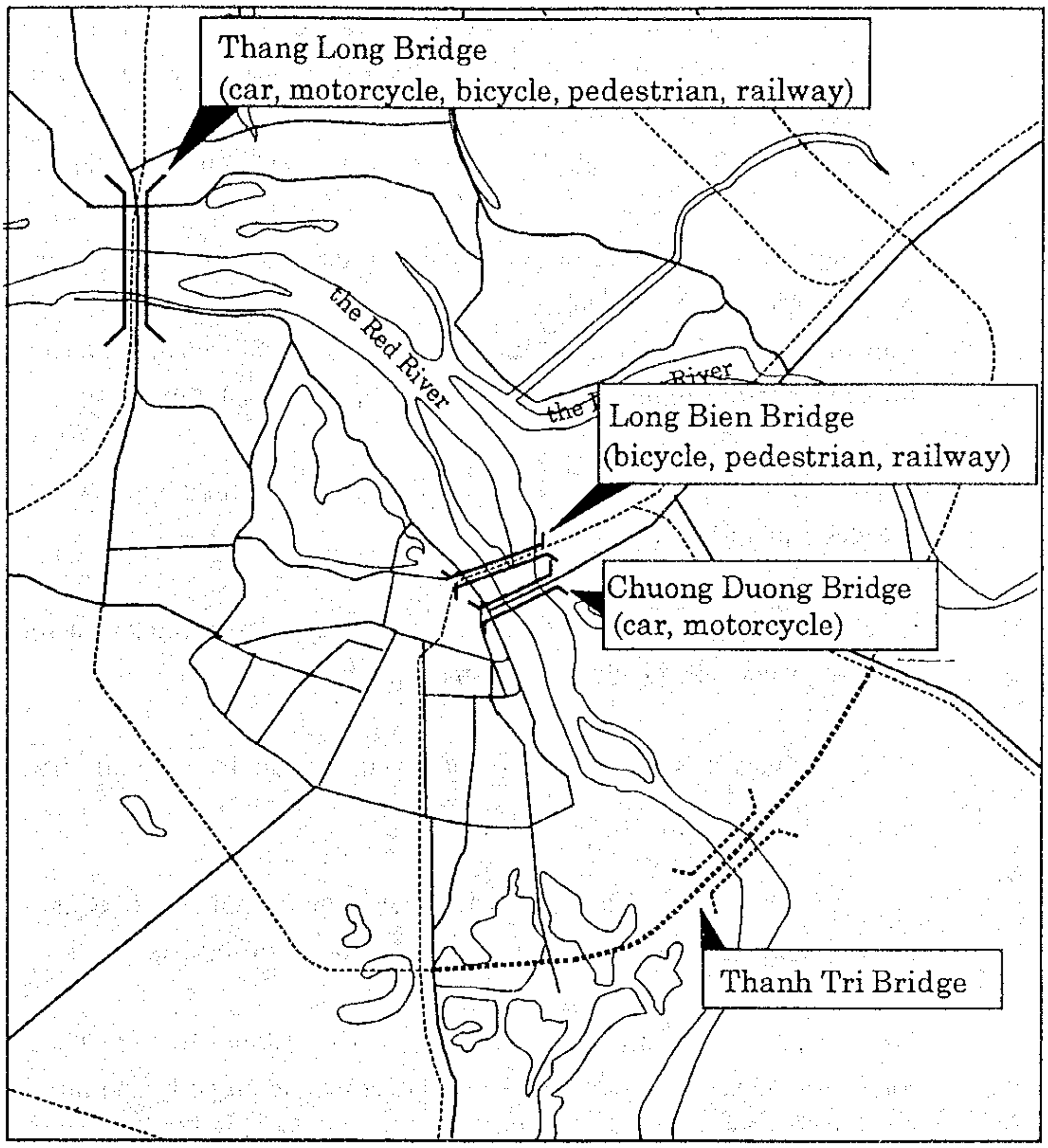


Figure 6.1.5 Bridges across the Red River

6.1.2 Geometric Design Standards

(1) Major Design Controls of Geometric Design

i) Design Speed

Design speed is the maximum safe speed that can be maintained over a specified section of road when conditions are so favorable that design features of road govern. The design speed is to be determined logically with respect to the terrain, adjacent land use, type of road and the design speed of adjoining section.

SHTRR is designated an urban freeway and becomes the part of Hanoi Third Ring Road which is planned a toll road. SHTRR is also designated to connect the southern section of New NH-1 to the northern section of New NH-1 as the Hanoi Bypass, of which design speed varies the range of 80 km/h to 120 km/h.

Although travel speed is the dominant consideration for rural freeways, urban freeways should be capable of carrying high traffic volumes. Moreover, it sometimes is necessary to compromise on physical constraints and economic limitations to fit certain elements of design within availability of right-of-way.

The followings may warrant the design speed of 100 km/h applied to the through traveled way of SHTRR:

- to install a toll plaza of barrier-gate type on the through traveled way where all vehicles stop for paying toll;

- to avert excessive eviction of local inhabitant by applying sharper curves; and

- to accommodate the entire scheme of Hanoi Third Ring Road with reasonable construction economy yet level of service.

The design speed of frontage road is assumed 40 km/h to keep the function of collector road such as good accessibility to adjoining property and mixed traffic of motorized and non-motorized vehicles.

ii) Design Vehicles

The physical characteristics of vehicles and proportions of variously sized vehicles using urban freeway are positive controls in geometric design. For purpose of geometric design, each design vehicle has larger physical dimensions and larger minimum turning radius than those of almost all vehicles in its class.

Three general classes of vehicles have been selected, namely passenger car, truck and semitrailer. The passenger car class includes sedan, wagon, van and pick-up, while the truck class includes bus, single-unit truck and so forth. The semitrailer class represents truck tractor-semitrailer combination.

Taking into consideration similar vehicular size and composition to Japan, the same design vehicles as shown in Figure 6.1.6 are assumed to be applied to the Study, and the semitrailer combination class is to apply to "Through Traveled Way", the truck to "Rampways", and the passenger car to "Frontage Road", standing on the economical viewpoint.

iii) Grades

Although the design standard of TCVN 5729-1997 for freeway in rural area specifies the maximum grade of 4 % against the design speed of 100 km/h, flatter grades less than 4 percent are deemed desirable in case of an expected mixed traffic with either heavy vehicles or slow-moving vehicles.

iv) Cross Section Elements

Lane Width

3.0 m to 3.75 m lane widths are generally used, and 3.75 m lane width is internationally accepted as the widest possible lane width because the lane wider than 3.75 m is hard to regulate traffic flow. In case of the design speed of more than 100 km/h applied to highway, 3.75 m wide lane width (12 ft in AASHTO) is desirable on both rural and urban facilities.

The lane width of 3.75 m is adopted to the Study, which complies with TCVN 5729-1997 and TCVN 4054-85 and accords with that of the southern section of New NH-1 project.

Median

A wide raised median functions not only as the portion of separating the traveled way for traffic in opposing directions but also as the space for the construction of piers of grade separation structures and overhead pedestrian crossing facilities, lighting posts, drainage on superelevated section, fence for anti-glare on horizontal curves and so forth. Minimum 2.0 m wide raised median is required to the through traveled way of SHTRR.

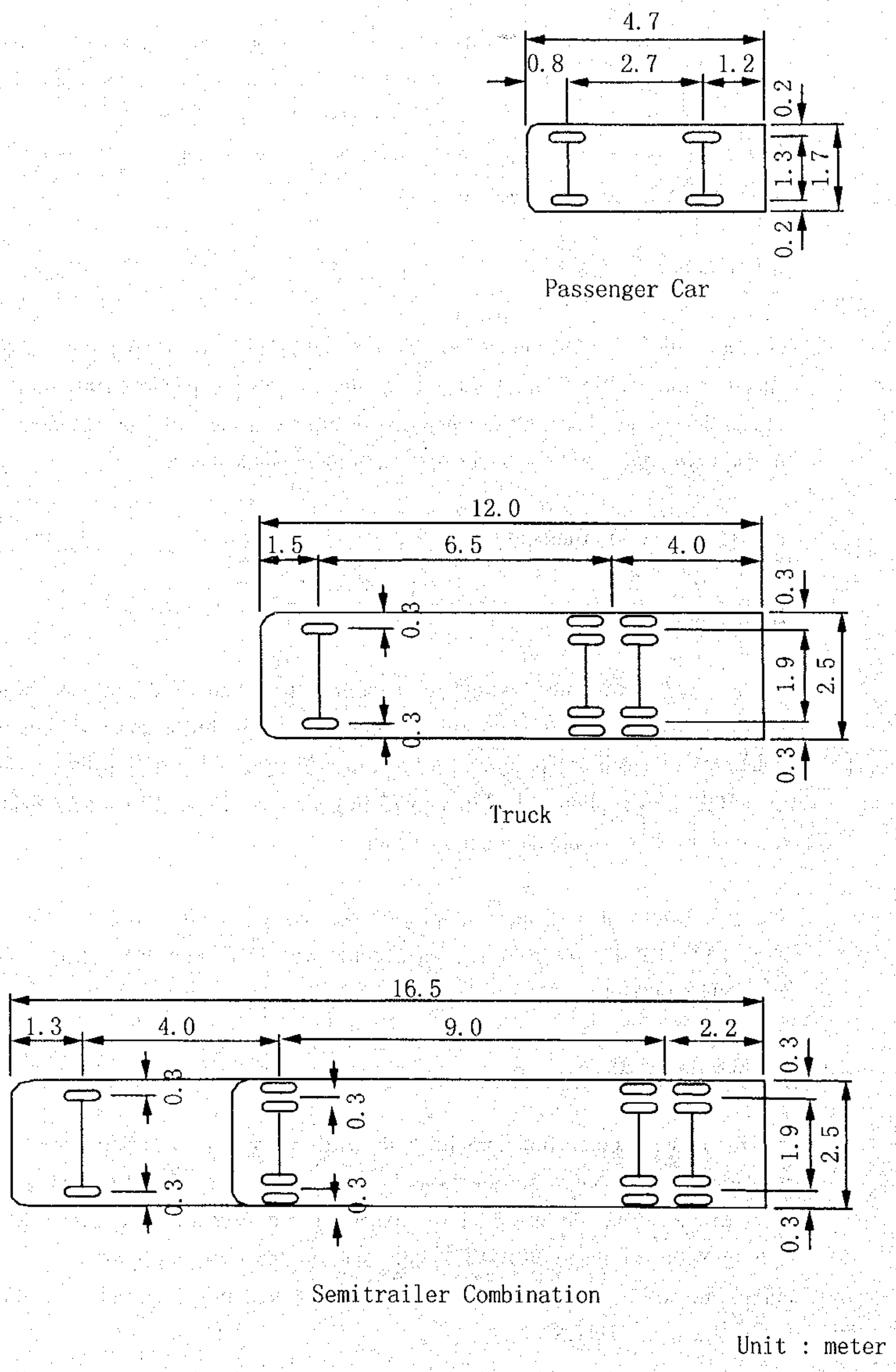


Figure 6.1.6 Design Vehicles

Outer Separation

The outer separation is the area between the through traveled way and frontage road, and provides for shoulders, sideslopes, drainage, access-control, fencing, retaining wall and ramps. It also provides a buffer zone between the through traveled way and the adjacent area, especially for noise abatement measures in sensitive areas.

8.5 m wide outer separation is installed in between the through traveled way and frontage road, while 12.5 m wide buffer zone is provided in between the through traveled way and the adjacent area.

Sidewalks and Bicycle Facilities (Cycle Path)

Pedestrian and bicyclist should be protected appropriately by motorized vehicles. One of most practical measures is to separate pedestrian and bicyclist from fast-moving motorized vehicles. The separation may contribute to increase traffic capacity of carriageway and traffic safety as well.

3 m wide sidewalk for pedestrian and separated 3 m wide cycle path are provided in the border strip.

(2) Recommended Geometric Design Standard

i) Recommended Geometric Design Criteria

Tables 6.1.1 and 6.1.2 present the summary of major criteria for geometric design recommended to the Study based upon the comparison and deliberation of Vietnamese standard, AASHTO and Japanese standard due to lack of design standard for urban freeway in Vietnam. The geometric design criteria for frontage road is to comply with TCVN 4054-85.

ii) Recommended Typical Cross Sections

Figure 6.1.7 shows the typical cross sections recommended to SHTRR. 25 m wide through traveled way may accommodate fast-moving vehicles, especially for motorcars and high capacity motorcycles. Non-motorized vehicles and small capacity motorcycles should be prohibited to enter.

8 m wide carriageway of frontage road may be used under either one way control or two ways depending upon land use along the road or U-turn facilities interval.

6 m wide border may accommodate both walkway for pedestrian and bicycle facilities. The border should also provide the important space for drainage structures, street lighting, regulatory/warning and guide signs as well as underground or aerial public utilities.

iii) Further Considerations

Since motorcycles presently dominate, and motorized traffic and motorcar ownership is very limited in Metropolitan Hanoi, the proposed through traveled way will be tentatively used by both motorcars and motorcycles.

Figure 6.1.9 gives practical variation of usage of through traveled way on Thanh Tri Bridge without little additional investment.

In case that large numbers of motorcycles should be expected initially, 4-lane with separated cycle path scheme will be adopted.

In case motorization takes place more rapidly than expected and other river crossing bridges planned in the master plan of Hanoi 2020 are not be realized, 6-lane scheme would accommodate higher volume of motorcars.

The number of lanes adopted for the formulation of typical cross sections of SHTRR including Thanh Tri bridge at this phase of the Study would still be of tentative nature. Refer to Sections 7.2.1 and 10.1.2 for inception traffic analysis and final traffic analysis in step-by-step detail respectively.

Table 6.1.1 Design Standard of SHTRR

Items	Unit	Vietnamese Standard TCVN 5729-97	AASHTO	Japanese Standard	Recommended Standard
Class of Road		Freeway Class 100	Urban Freeway	Urban Road 2 – 1	Urban Freeway
Terrain		Flat	Flat	Flat	Flat
Elements of Design					
Design Vehicle		TTSC*1)	TTSC*1)	TTSC*1)	TTSC*1)
Minimum No. of Lanes		4	4	4	4
Design Speed	km/h	100	96 (60 mph)	100	100
Stopping Sight Distance	m	160	160 (525 ft)	160	160
Minimum Horizontal Curve	m	450	437 (1432 ft)	460	450
Maximum Grade	%	5	3	3	4
Minimum Vertical Curve Sag	m	3000	3650 (120ft)	3000	3000
Minimum Vertical Curve Crest	m	6000	5800 (190ft)	6500	6000
Vertical Clearance	m	4.5	4.27 (14 ft)	4.5	4.5
Crossfall	%	2.0	2.5	2.0	2.0
Maximum Superelevation	%	7	8	8	7
Cross Section Elements					
Lane Width	m	3.75	3.66 (12 ft)	3.50	3.75
Raised Median*2)	m	1.50		1.75	2.00
Inner Shoulder	m	1.00	1.22 (4 ft)	0.50	1.00
Outer Shoulder	m	3.00	3.05 (10 ft)	1.25	3.00

Note:
*1) TTSC abbrivatesTruck Tractor – Semitrailer Combination.
*2) The width of raised median is subject to securing the space for pier of crossing grade separation structure.

Table 6.1.2 Design Standard for Ramp and Frontage Road

Items		Unit	Ramp at System Interchange	Ramp at Service Interchange	Frontage Road	
					One way	Two ways
Elements of Design						
Design Vehicle			Truck	Truck	Passenger Car	Passenger Car
Minimum No. of Lanes			1	1	2	2
Design Speed		km/h	50	40	40	40
Stopping Sight Distance		m	55	40	40	40
Minimum Horizontal Curve		m	90	50	60	60
Maximum Grade		%	7	8	7	7
Minimum Vertical Curve	Sag	m	700	450	450	450
Minimum Vertical Curve	Crest	m	800	450	450	450
Vertical Clearance		m	4.5	4.5	4.5	4.5
Crossfall		%	2.0	2.0	2.0	2.0
Maximum Superelevation		%	7	8	6	6
Cross Section Elements						
Lane Width		m	3.50	3.50	3.50	3.50
Raised Median*2)		m	2.00	2.00		
Inner Shoulder		m	0.75	0.50	0.50	
Outer Shoulder		m	1.25	1.00	0.50	0.50

Note:
*2) The width of raised median is subject to securing the space for pier of crossing grade separation structure.

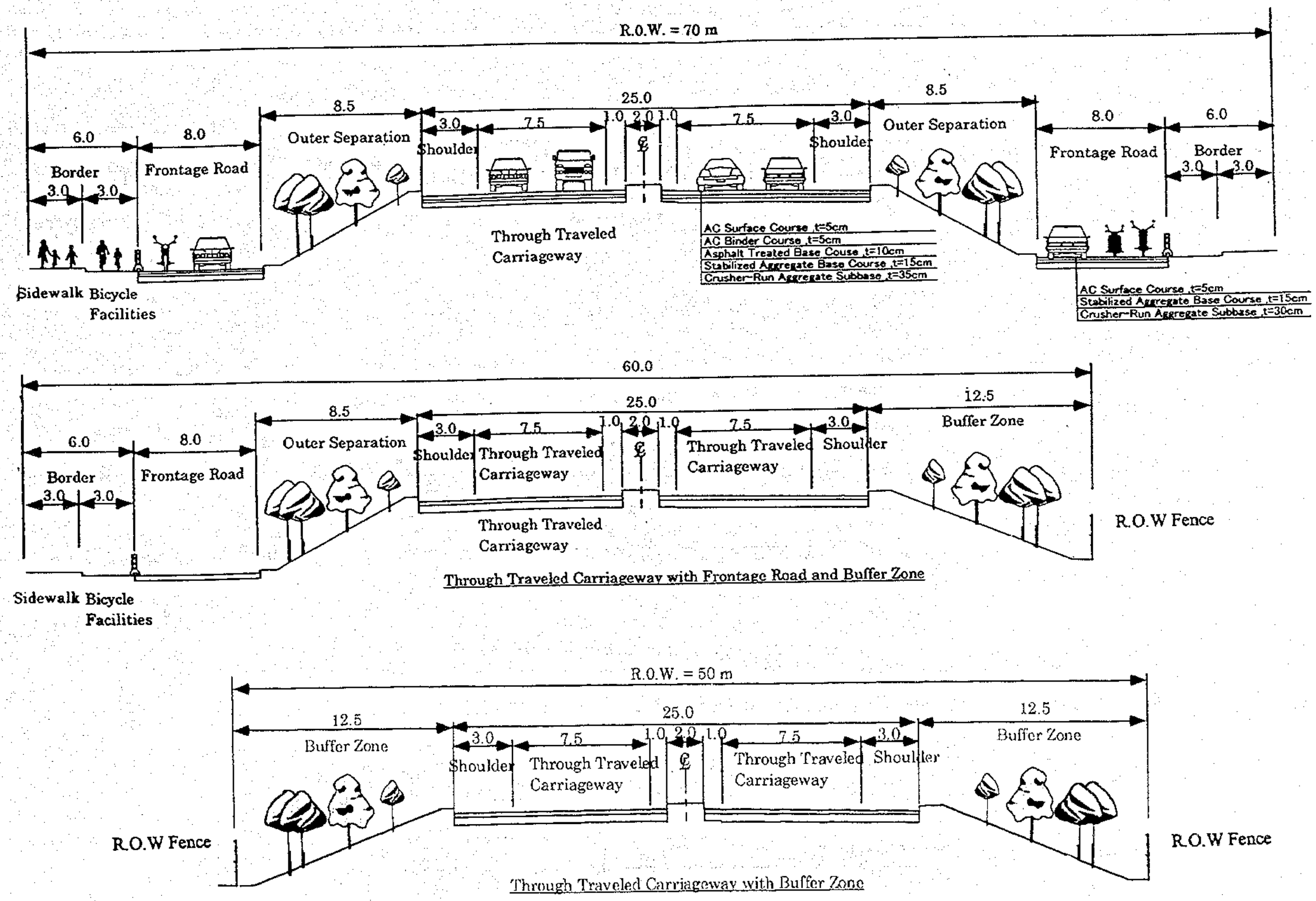
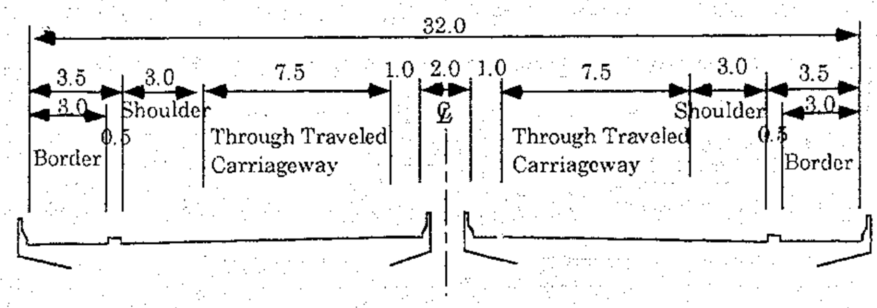
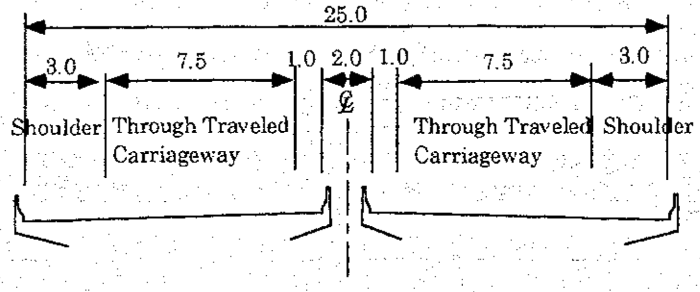


Figure 6.1.7 Typical Cross Sections for Embankment on SHTRR



Through Traveled Carriageway on Thanh Tri Bridge



Through Traveled Carriageway on Bridges except Thanh Tri Bridge

Figure 6.1.8 Typical Cross Sections for Bridges on SHTRR

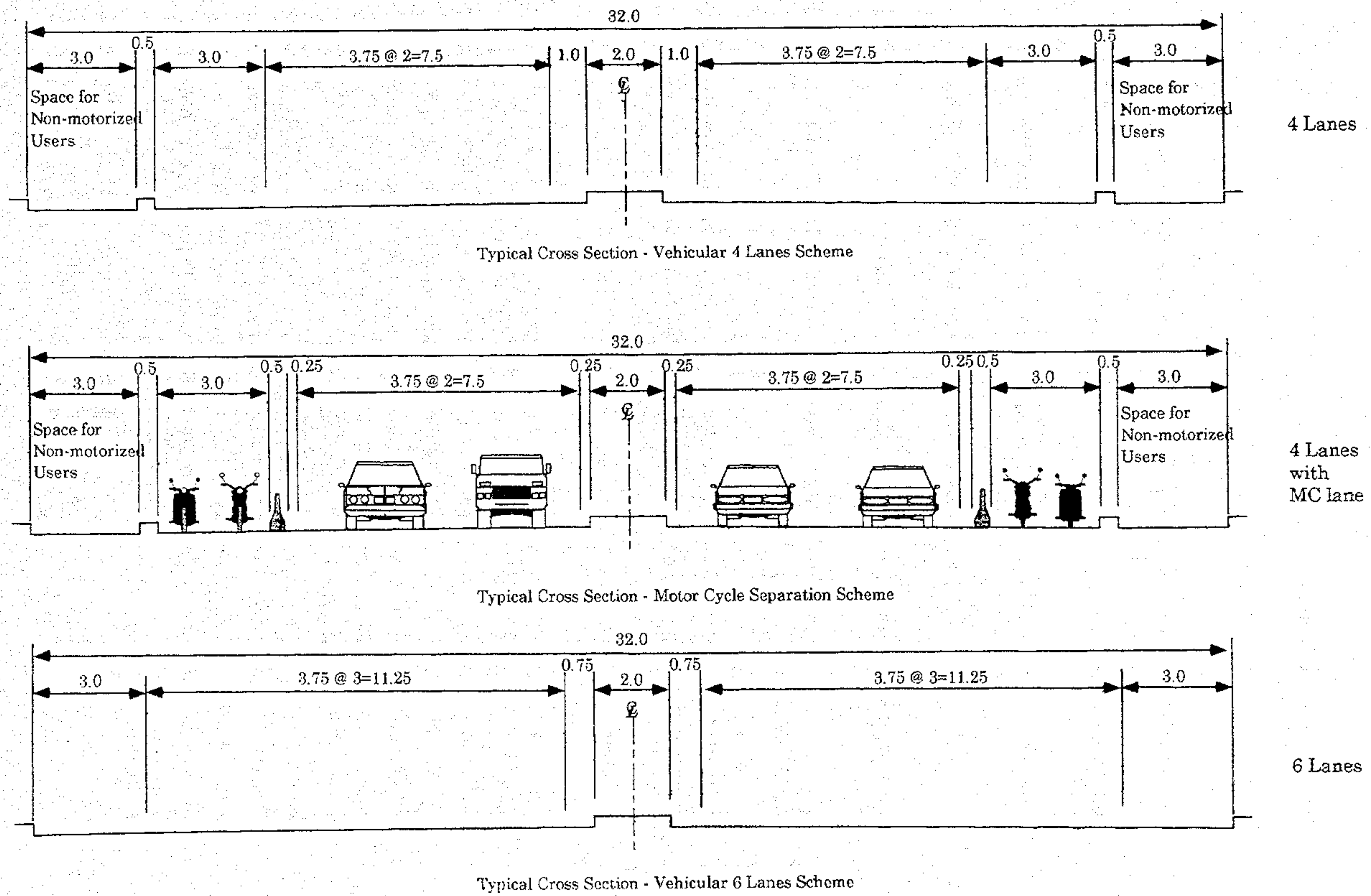


Figure 6.1.9 Typical Cross Sections for Through Traveled Way