No.

ROAD DEVELOPMENT AUTHORITY
MINISTRY OF HIGHWAYS AND ROAD DEVELOPMENT
THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

THE DETAILED DESIGN STUDY ON THE OUTER CIRCULAR HIGHWAY TO THE CITY OF COLOMBO

FINAL REPORT
(FOR NORTHERN SECTION 1)
MAIN TEXT
2 of 10

February 2008

JAPAN INTERNATIONAL COOPERATION AGENCY

Oriental Consultants Company Limited

Pacific Consultants International

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PREFACE

In response to the request from the Government of the Democratic Socialist Republic of Sri Lanka, the Government of Japan decided to conduct the Detailed Design Study on the Outer Circular Highway to City of Colombo in the Democratic Socialist Republic of Sri Lanka (Northern Section 1) and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a Study Team headed by Dr. Masaaki TATSUMI of Oriental Consultants Co., LTD. and Pacific Consultants International to Sri Lanka, four times between October 2006 and December 2007.

The Study Team held discussions with the concerned officials of the Government of Sri Lanka and conducted the field surveys in the study area. Upon returning to Japan, the Study Team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the concerned officials of the Government of Sri Lanka for their close cooperation extended to the Study.

February 2008

Eiji HASHIMOTO
Vice President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

February 2008

Mr. Eiji HASHIMOTO,
Vice President
Japan International Cooperation Agency (JICA)
Tokyo, JAPAN

We are pleased to submit to you the Final Report of the Detailed Design Study on the Outer Circular Highway to the City of Colombo (Northern Section 1).

This study was conducted by Oriental Consultants Co., Ltd. in association with Pacific Consultants International under a contract to JICA, during the period from October 2006 to February 2008. In conducting the study, we have completed the Detailed Design of the project.

We wish to take this opportunity to express our sincere gratitude to the officials concerned of JICA, Ministry of Foreign Affairs of Japan, Japan Bank for International Cooperation, Infrastructure Development Institute, Ministry of Highways and Road Development of Sri Lanka, Road Development Authority, Embassy of Japan in Sri Lanka, JICA Sri Lanka Office and JBIC Representative Office in Colombo for their cooperation assistance throughout the Study.

Finally, we hope this report will contribute to further promotion of the project.

Very truly yours,

Masaaki TATSUMI
Team Leader,
Study Team of the Detailed Design Study
on the Outer Circular Highway to the City of Colombo

OUTER CIRCULAR HIGHWAY TO THE CITY OF COLOMBO (OCH)

LOCATION MAP

PROJECT SUMMARY

◆ Project objectives

The Outer Circular Highway to the City of Colombo (OCH) Project was aimed to relieve traffic congestion in the Gampaha, Colombo and Kalutara districts. From 1998 to 2000, a feasibility study (F/S) was carried out by the JICA Study Team to and it was proposed that the Government construct a 51.26-km circular highway. Consequently, the scale of the OCH Project was reduced to approx. 29km length, consisting of the 2nd and 3rd sections of the F/S. The study was started in 2001 but suspended after preparing draft basic design report in 2002. Subsequently, the study was resumed partially from the section that confirmed that it is possible to carry out site survey and basic design for entire OCH and detailed design for OCH Southern Section was completed. The detailed design in this stage of the study was for an 8.3-kilometer from A1 road to the south bank of the Kelani River (i.e., the Northern Section 1).

◆ Study methodology

2001-2002

1) Preparatory work in Japan (analysis of related documents, examination of basic study policies, preparation of inception report)
2) First field study (review of FS report, execution of topographical surveys and surveys on natural and other conditions, basic design)
3) First work in Japan (preparation of draft basic design report)
4) Second field study (submission of draft basic design report)

2004-2005

5) Preparatory work in Japan (preparation of progress report)
6) Third field study (supplementary surveys, execution of surveys on natural conditions, environmental surveys, and surveys of traffic volumes, basic design)
7) Second work in Japan (detailed review of FS, examination of soft ground countermeasures)
8) Third work in Japan (preparation of basic design report)
9) Fourth field study (definitive plan, detailed design, construction plan, cost estimation, etc.)
10) Fourth work in Japan (preparation of interim report)
11) Fifth field study (preparation of PQ documents, tender documents, project implementation & and road operation plans)
12) Fifth work in Japan (preparation of draft final report)
13) Sixth field study (explanation and submission of the draft final report)
14) Sixth work in Japan (preparation of final report)

2006-2007

15) Preparatory work in Japan (preparation of progress report)
16) Seventh field study (supplementary surveys, execution of surveys on natural conditions, environmental surveys, definitive plan, detailed design, construction plan, etc.)
17) Seventh work in Japan (study for design and construction concepts, preparation of interim report)
18) Eighth field study (detailed design, construction plan, cost estimate, preparation of PQ documents, tender documents, project implementation & and road operation plans)
19) Eighth work in Japan (preparation of draft final report)
20) Ninth field study (modification of detailed design, modification of bridge design, modification of project cost estimation, modification of P/Q documents
21) Ninth work in Japan (preparation of draft final report 2, modification of bridge design, modification of construction plan)
22) Tenth field study (explanation and submission of the draft final report 2)

2008

23) Tenth work in Japan (preparation of final report)

◆ Project outline

The entire Project is divided into two sections with three construction packages as follows:

- ☐ Northern Section 2: STA.0-600 to STA.8+200 (CKE - A1)
  *Basic Design – completed, Detailed Design – not covered in this study
- ☐ Northern Section 1: STA.8+200 to STA.16+500 (A1 - AB10)
  *Basic Design – completed, Detailed Design – conducted in the present study
- ☐ Southern Section: STA.16+500 to STA.28+500 (AB10 - A4)
  *Basic Design and Detailed Design - completed

◆ Project evaluation

The social and environmental problems has been mitigated due to reduction of hauling volume by the application of the Gravel Compaction Pile (GCP) method as soft soil countermeasure, and the adoption of viaducts on sections with deep layers of soft ground or high embankments

◆ Conclusion and recommendations

The Southern Highway is now on the peak of construction process and the construction of the OCH Southern Section is to commence shortly. Furthermore, it is expected that the CKE will also be taken up sometime in the near future. In order for these highways to function as intended, the realization of the OCH Northern Section 2 is extremely important. It is therefore hoped that the Sri Lankan Government will continue with its sincere efforts to obtain the understanding of local residents regarding the implementation of this project.

OUTLINE OF THE STUDY

- Study Term: July 2001 – February 2008 (suspended from February 2002 to May 2004)
- Counterpart Agency: The Road Development Authority of the Ministry of Highways & Road Development of Sri Lanka (hereinafter referred to as the “RDA”)

1. Objectives

The Outer Circular Highway to the City of Colombo (OCH) Project was aimed to relieve traffic congestion in the Gampaha, Colombo and Kalutara districts. From 1998 to 2000, a feasibility study (F/S) was carried out by the JICA Study Team to and it was proposed that the Government construct a 51.26-km circular highway, which would consist of four sections and connect seven high-priority trunk roads radiating from Colombo as well as a number of intercity expressways.

This study is to carry out detailed design and prepare draft tender documents for two sections (2 and 3), which are about 29 km in length, of the four sections originally proposed in the F/S. It was also decided that basic and detailed designs for a provisional four-lane road be prepared keeping in mind that the OCH will be widened to a six-lane highway in the future.

The basic and detailed design study of OCH would be conducted in accordance with the Scope of Work (S/W) and Minutes of Meeting (M/M) signed and exchanged between the Sri Lankan Government and JICA on 20th February 2001, however, the study was suspended after preparing draft basic design report in January 2002 because the protest of residents made implementation of the field survey impossible.

After That, the study was resumed partially from the section that confirmed that it is possible to carry out site survey and following study was completed. (refer to LOCATION MAP and 1.3. OCH Project Chronology)

- Basic design for entire OCH and detailed design for OCH Southern Section (12-km section south of the Kelani River -June 2004 - July 2005)

- detailed design study for OCH Northern Section 1 (8.3-km section from A1 to Kelani River - October 2006 – February 2008)

The detailed design for the OCH Northern Section 1 was prepared, and includes establishment of design requirements, construction work plans, cost estimates, and bidding documents.

2. Design and Construction Concept

OCH's Northern Section 1 extends from Kandy Road (A1) in Kadawatha to AB10 on the left bank of the Kelani River in length of 8.3km, connecting with the Southern Section of the OCH. The A1 Interchange (A1IC) is located in paddy area and the main carriageway around the A1IC is designed with a high embankment in order to cross over the existing A1 Road. In the Biyagama area, the ground is low-lying and soft, resulting in the height of the embankment of the OCH being high here as well.
In the case where the replacement method is applied as a soft soil countermeasure, which is the original concept proposed in the basic design stage of the OCH, all soft soil including peat is removed and replaced with gravel. The estimated total haulage from carrying and dumping material would reach about 4.7 million cu.m. and a large number of trucks would be required for this operation.

It was planned to apply the replacement method against soft ground in the OCHNS1 and the OCHSS, however, in order to reduce the impact on the social environment during construction, the RDA strongly requested to consider other methods which could reduce the amount of earthwork volume much more. The JICA study team compared some alternatives including the application of viaduct instead of embankment structures, and selected the most suitable alternative which make the construction cost increase 20% but reduce haulage 60% as compared with the original method.

In addition, the Sri Lanka side requested the application of a JBIC STEP (Special Term for Economic Partnership) loan, as Japanese technology will provide advantages regarding soft soil countermeasures and rapid construction in congested and/or narrow areas. According to the request the above, some proposals that satisfy their requests were studied by the JICA Study Team and the optimal proposal was determined through discussions with Sri Lanka side again.

3. Outline of Detailed Design

The detailed design for the Northern Section 1 covers the following:

(1) Roads

Geometric structural design for the OCH and its interchanges/ramps, embankments, cut soil structures, soft soil coutermeasures, and traffic safety facilities.

(2) Bridges

Design of five highway bridges, six ramp bridges, and five overpasses. Note that the design of bridges except the Kelani River Bridge and overpass bridge were conducted at the basic design level. The basic design for both a concrete structure and a steel structure were carried out for A1 IC bridge including the main carriageway and ramps.

(3) Structures

Design of underpass culverts, drainage culverts, ditchs, retaining walls, and other structures.

4. Construction Work Plan

The construction process of OCHNS1, which is influenced by viaducts and Kelani River Bridge construction, is planned to require three years thanks to reducing the total amount of haulage drastically.

5. Environmental Study

The Supplementary Environmental Impact Assessment (SEIA) Report for deviation in Biyagama area was reviewed and confirmed the consistancy with the JICA guideline. The Draft Environment Management Plan (EMP) and Environmental Monitoring Action Plan (EMAP) for the OCH were prepared and the Resettlement Implementation Plan (RIP) was also reviewed to reflect present conditions and future plans.

6. Project Cost Estimates

The project costs was estimated referring to the unit prices in Sri Lanka and the Japanese standards for cost estimate.

7. Road Maintenance & Operation

In view of a previous study of the present operating and maintenance (O&M) conditions for existing roads, the Study team conducted the preliminary examinataion regarding a road operation plan for the OCH.

8. Draft Tender Documents

Tender documents were prepared by referring to other similar projects and to various standards and are as listed below.

Volume I:	Instructions to Bidders etc.
Volume II:	Conditions of Contract
Volume III:	Technical Specifications
Volume IV:	Bills of Quantities
Volume V:	Data Provided by the Employer (survey data, geological data, climate data, etc.)
Volume VI:	Drawings (incl. ROW, soil profile, and utilities)

9. Implementation Program

The Study team proposed a project implementation plan that will require one year of pre-construction preparation (including the signing of the loan agreement) and three years of actual construction work.

10. Conclusion and Recommendations

In this study, social and environmental problems has been mitigated due to reduction of hauling volume by the application of the Gravel Compaction Pile (GCP) method as soft soil countermeasure, and the adoption of viaducts on sections with deep layers of soft ground or high embankments.

On the other hand, the Southern Highway is now on the peak of construction process and the construction of the OCH Southern Section is to commence shortly. Furthermore, it is expected that the CKE will also be taken up sometime in the near future. In order for these highways to function as intended, the realization of the OCH Northern Section 2 is extremely important. It is therefore hoped that the Sri Lankan Government will continue with its sincere efforts to obtain the understanding of local residents regarding the implementation of this project.

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Abbreviations

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1	ADB:	Asian Development Bank
2	B/D:	Basic Design
3	BOI:	Board of Investment (of Sri Lanka)
4	BS:	British Standards
5	CBR:	California Bearing Ratio
6	CEA:	Central Environmental Authority (of Sri Lanka)
7	CKE:	Colombo-Katunayake Expressway
8	CKdE:	Colombo-Kandy Expressway
9	CMC:	Colombo Metropolitan Council
10	CMR:	Colombo Metropolitan Region
11	DS	Divisional Secretariat
12	EIA:	Environmental Impact Assessment
13	EIRR:	Economic Internal Rate of Return
14	EMAP:	Environmental Management Action Plan
15	EMP:	Environmental Management Plan
16	ESD:	Environmental and Social Division
17	ERD:	Department of External Resources, Ministry of Finance and Planning (of Sri Lanka)
18	F/S:	Feasibility Study
19	GCP:	Gravel Compaction Pile (Method)
20	GOSL:	Government of Sri Lanka
21	GPS:	Global Positioning System
22	HFL:	High Flood Level
23	HSR:	Sri Lanka Highway Schedule of Rate
24	IC:	Interchange
25	ITI:	Industrial Technology Institute (of Sri Lanka)
26	JBIC:	Japan Bank for International Cooperation
27	JICA:	Japan International Cooperation Agency
28	MOF:	Ministry of Finance and Planning (of Sri Lanka)

29 MOH: Ministry of Highways and Road Development (of Sri Lanka)

30 MSL: Mean Sea Level

31 NEA: National Environmental Act

32 OCH: Outer Circular Highway

33 OCHNS: Outer Circular Highway Northern Section

34 OCHSS: Outer Circular Highway Northern Section

35 ODA: Official Development Assistance

36 OP: Overpass

37 O&M: Operation and Maintenance

38 PBC: Performance-Based Contracting

39 PBM: Performance-Based Maintenance

40 PC: Prestressed Concrete

41 PCU: Passenger-Car Unit

42 PMU: Project Management Unit

43 PQ: Prequalification

44 PSP: Private Sector Participation

45 RDA: Road Development Authority (of Sri Lanka)

46 RIP: Resettlement Implementation Plan

47 ROW: Right of Way

48 SD: Survey Department (of Sri Lanka)

49 SEIA: Supplemental Environmental Impact Assessment

50 SH: Southern Highway (same as STDP)

51 SLEA: Sri Lanka Expressway Authority

52 SLLRDC: Sri Lanka Land Reclamation and Development Corporation

53 SLR: Sri Lanka Rupees

54 STDP: Southern Transport Development Project

55 STEP: Special Term for Economic Partnership

56 UP: Underpass

57 VPD: Vehicle per Day

CHAPTER 1

GENERAL

CHAPTER 1 GENERAL

1.1. Introduction

Based on an agreement between the Japan International Cooperation Agency (JICA) office in Sri Lanka and the Road Development Authority (RDA), the detailed design for Northern Section 1 of the OCH commenced in October 2006 and is to be completed in February 2008. This section will connect the Southern Section of the OCH with A1 and thereby link the Colombo-Kandy Road with the Southern Transport Development Project (STDP).

After completion of the detailed design for OCH Southern Section, several problems regarding the STDP appeared. Based on this experience and recent circumstances in Sri Lanka, the RDA informed the JICA Study Team about its concerns for the OCH Project and they are as follows:

- Difficulties with the haulage of soft soil replacement materials, borrowed materials, and quarry materials on public roads due to severe negative social and environmental impacts.
- Difficulties with finding dumping sites for disposal materials from soft soil replacement.
- The possibility a shortage of borrow materials due to the recent construction boom around Colombo.

In addition, the RDA has requested the JICA Study Team to examine the possibility of adopting a viaduct for certain sections in order to reduce the quantities of borrow materials and soft soil spoilage.

Taking into account the above RDA requests, the JICA Study Team made adjustments to the design and construction concept that includes the application of viaducts and soft soil countermeasures that eliminate spoilage (gravel compaction piles or GCP). As a result of this, another recommendation plan was proposed for OCH Northern Section 1 (OCHNS1), and the design and construction concept for OCHNS1 finalized based on this recommendation in discussions with the RDA.

Finally, during the execution of the detailed design (viaducts: basic design), the Sri Lanka side also requested the application of a STEP (Special Terms for Economic Partnership) loan for the OCHNS1 in order to apply Japanese technology that will provide advantages regarding soft soil countermeasures and rapid construction in congested and/or confined areas. In accordance with this request, proposals satisfying STEP loan conditions were examined by the JICA Study Team and an optimal proposal, which adopted a low-noise and low-vibration type of GCP and steel viaducts, adopted through discussions with the Sri Lanka side (see **Chapter 3** for details).

1.2. Objectives

The objectives of this stage of the Study are as follows:

- Execution of the detailed design for OCHNS1, including the preparation of draft tender documents and an implementation program for the application of a JBIC ODA loan. (Note, however, that the introduction of a viaduct represents a substantive deviation from the scope of work and therefore only conceptual designs will be prepared for these structures.)

- Implementation of technology transfer concerning the detailed design of roads and bridges to RDA counterparts.

1.3. Area

The detailed design Study area extends from the Kaduwela IC to the Kadawatha IC of the OCH (or STA.8+200 – STA.16+560), or OCHNS1.

1.4. Scope

In order to achieve the abovementioned objectives for OCHNS1, the JICA Study Team shall execute the following:

- Engineering Surveys
  - Supplementary topographic survey
  - Supplementary soil and geotechnical survey
  - Supplementary hydrological survey
  - Supplementary materials survey
- Supplementary Environmental Study
- Detailed Design
- Construction Plan
- Bill of Quantities and Cost Estimates
- Draft Tender Documents
- Implementation Program

1.5. Schedule

The Study began in October 2006 and is to be completed after an 18-month period with submission of the Final Report in February 2008. The workflow of the Study is as shown in Fig. 1.1.2. Note that the design and construction concepts for OCHNS1 were amended at the request of the Sri Lanka side in April 2007 in order to avoid potential construction difficulties, and the concept again amended later at the request of the Sri Lanka side in order to apply a STEP loan.

1.6. Structure

The detailed design of the Study is to be carried out jointly by the RDA and the JICA Study Team within the framework of cooperation as indicated in **Fig. 1.6.1**. Below, a description of the functioning of said framework is given.

The JICA Advisory Committee, which consists of members from the Infrastructure Development Institute of Japan, is responsible for providing technical supervision to JICA Headquarters. From an engineering point of view, the Advisory Committee is to advise the JICA Study Team in order to expedite the resolution of technical issues that may arise in the course of the Study.

The MOH of Sri Lanka is to organize a Steering Committee, which is to be composed of the relevant organizations so that the interests of stakeholders are represented, and to provide the necessary information and cooperation for the smooth implementation of the Study. The Steering Committee, exclusive of JICA, shall assist the MOH in making the necessary arrangements for land acquisition and resettlement of affected residents so that the OCH can be constructed properly and smoothly.

Finally, in addition to the Steering Committee, a Technical Committee, consisting of engineers and the relevant expert directors, is to be established in the RDA.

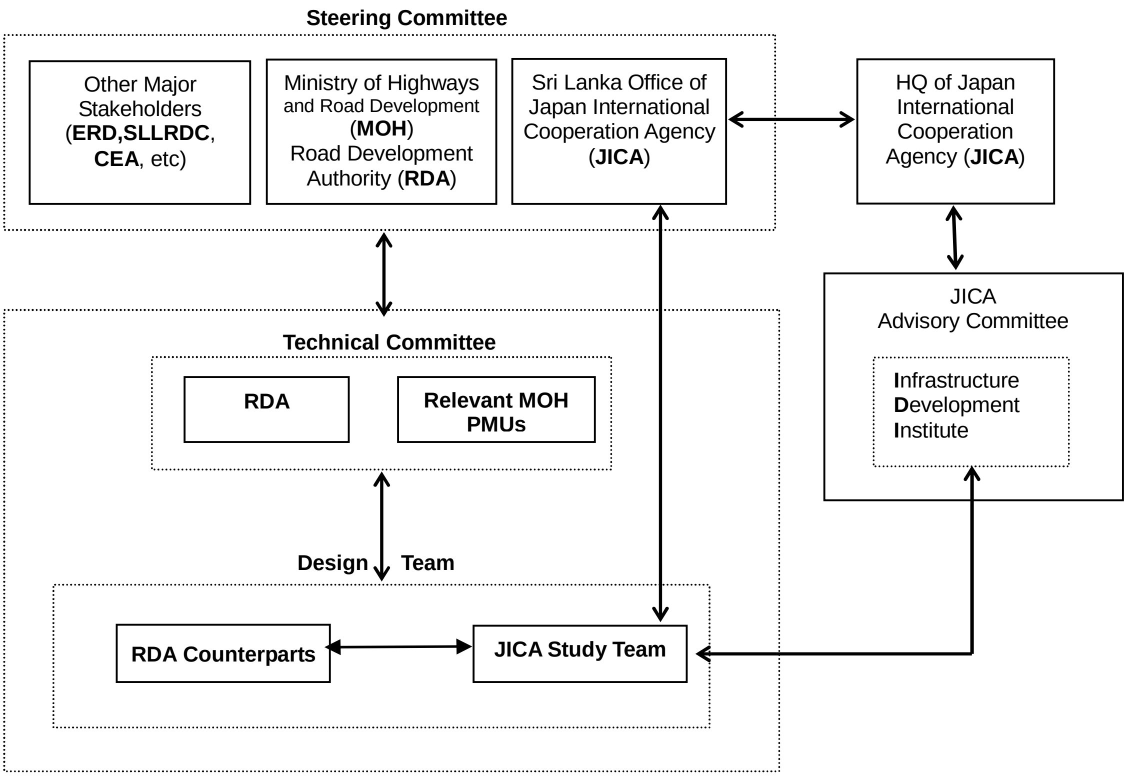
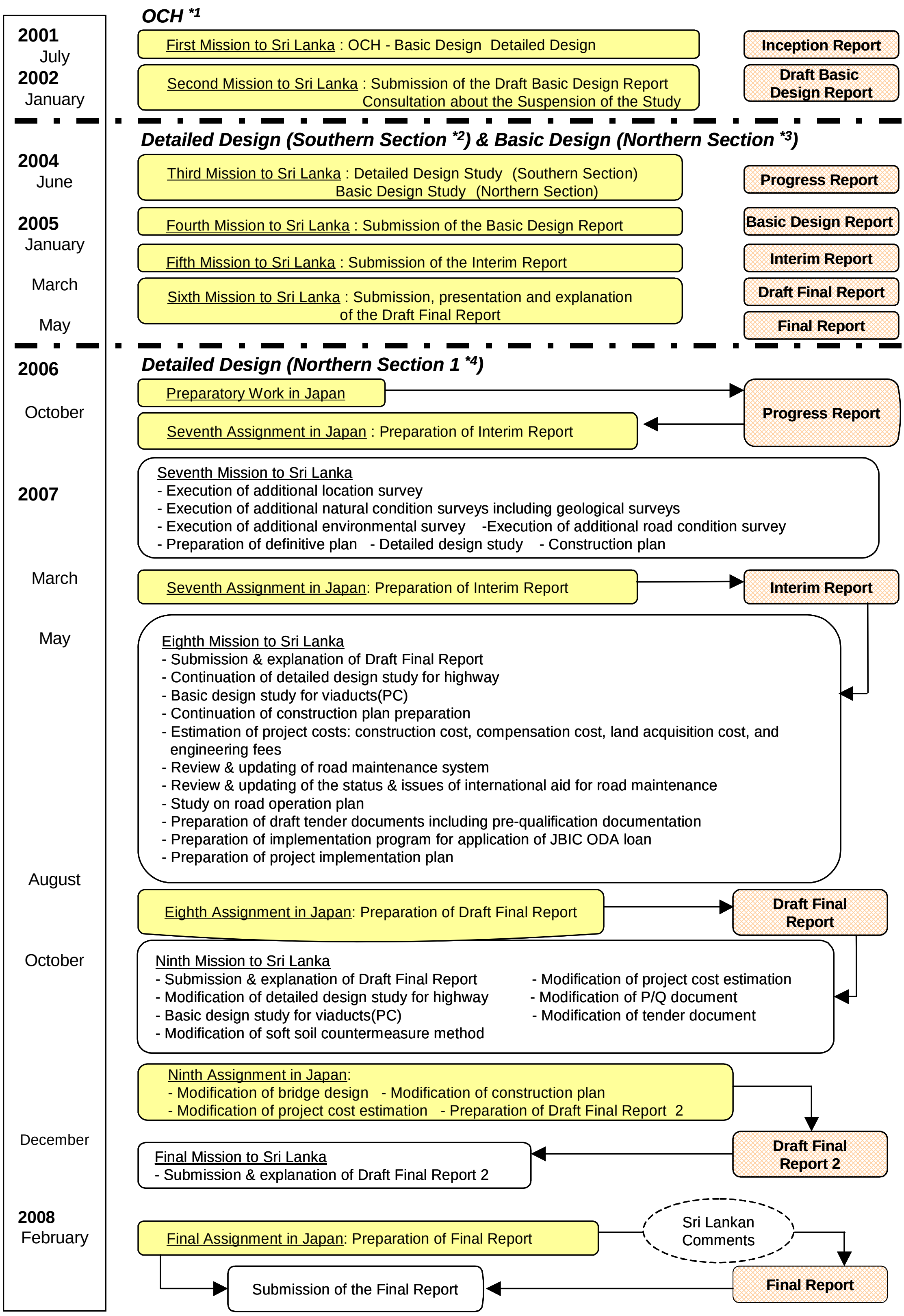


Fig. 1.6.1 Framework of Cooperation



*1 OCH（STA.0-600 - STA.28+300） *2 Southern Section（STA.16+560 - STA.28+300）
*3 Northern Section（STA.0-600 - STA.16+560） *4 Northern Section 1（STA.8+200 - STA.16+560）

Fig. 1.6.2 Study Flow

1.7. OCH Project Chronology

A brief chronology of important events of the OCH Project in its execution up to the present time is given below.

- 1998 - 2000

A Feasibility Study (FS) for the OCH was carried out by a JICA Study Team, and the proposed OCH alignment was to cover approximately 51km length (Kerawalapitiya – Kadawatha – Kaduwela – Kottawa – Bandaragama – Panadura).

After completion of the F/S, the 1st Section was incorporated into the Southern Transport Development Project, which is being funded by JBIC, and the 4th section was rejected due to the upgrading of the parallel Rt. A8 and because it was not considered to have sufficient merit for the foreseeable future.

Consequently, the scale of the OCH Project was reduced from approx. 51km to approx. 29km length, consisting of the 2nd and 3rd sections of the F/S.

- May 2001

The EIA Report for the OCH from Kerawelapitya to Kottawa was approved by the Central Environmental Authority (CEA) of Sri Lanka and had a three-year period of validity. In its conditional letter of approval, the CEA recommended a deviation of the trace from station 17+000 to station 21+800, in order to reduce resettlement impacts by shifting the OCH alignment from an existing residential area to marshland.

- 2001 - 2002

The Detailed Design Study for the OCH Project commenced in June 2001, with the scope of the Study to include Basic and Detailed Design for a 29km section from Kerawalapitiya to Kottawa of the original 51km route. Note that the Study included in its scope the deviation at Kaduwela section in accordance with the conditions of approval by the CEA together with a Supplemental Environmental Impact Assessment (SEIA).

On the other hand ground surveys, including topographic and geological surveys necessary for proceeding with the detailed design, could not be carried out at most sections due to protests from residents. As a result, after the completion of the Basic Design, the Study was suspended in an Agreement concluded between the Sri Lankan side (ERD, MOH, RDA) and Japanese side (Embassy of Japan, JICA) at the end of January 2002, pending a situation that would allow for the smooth implementation of the necessary site surveys.

- 2002 - 2004

In accordance with the above-mentioned Agreement, the RDA carried out public consultations in view of convincing residents of the need and importance for an expressway in Sri Lanka. With these consultations, other controversial subjects also arose, particularly regarding possible alternative alignments. In regards to this, the JICA Study Team supported the activities of the RDA by preparing relevant technical papers in a timely manner to deal with each of the subjects deliberated on.

- May 2004

The validity of approval for the OCH EIA Report for entire section, which was initially May 2004 was extended until May 2007.

It was determined that site surveys could be carried out smoothly after the successful completion of a topographic survey by the Survey Department of the Sri Lankan

Government on the OCH Southern Section (OCHSS), which is approx. 12km long and south of the Kelani river. The RDA and JICA therefore agreed to resume the Study and that it could consist of a Supplemental Basic Design for alignment and condition variations, Detailed Design for the OCHSS, and technical cooperation for the OCH Northern Section (OCHNS), witch is approx. 17km long and north of the Kelani River.

- June 2004

The Detailed Design for the OCHSS and the Supplemental Basic Design for the OCHNS were recommenced.

- November 2004

The SEIA Report for the deviating section at Kaduwela was submitted to the CEA.

- May 2005

In spite of consultations, which included the active cooperation of the JICA Study Team, understanding towards the Project by residents did not increase significantly. For example, the ratio of completion regarding the topographic survey by the Survey Department for the entire OCHNS was 75% in terms of route length and 55% in terms of the number of houses affected. On the other hand, the ratios of completion for these two factors on the section between the interchanges for A1 to AB10 were 88% and 79%, respectively. As a result, JICA concluded that it is not yet possible to execute the Detailed Design for the OCHNS.

From the direction of the President, the RDA is now to examine the feasibility of shifting the OCH alignment in the Kadawatha area, and consigned this task to the University of Moratuwa.

- July 2005

The SEIA Report for the deviating section at Kaduwela was approved by the CEA.

The Detailed Design for the OCHSS was completed.

- December 2005

The feasibility study of the OCH deviating section at Kadawatha area by a Moratuwa university concluded that the OCH deviation plan by JICA study is the most appropriate and the argument about the deviation was settled.

- September 2006

RDA and JICA agreed to recommence the study of the OCH Northern Section 1 (OCHNS1) from the middle of October. The scope of works included A1 interchange, A1 Bypass, B214 interchange in addition with OCH main lane, the detailed design of Kelani bridge, construction plan/cost estimation and draft tender documents.

- October 2006

The JICA study resumed in conformity with the above-mentioned plan. At the study start time, a survey and field survey of geology could not be carried out at about six points (about 4% of object area).

- February 2007

The SEIA Report for the deviating section at Biyagama was approved by the CEA.

- April 2007

The plan undertaking STDP soft ground countermeasure construction, it caused many problems for residents by disposal and haulage of borrow pit.

It was planned to apply replacement method against soft ground in the OCHNS1 and the OCHSS. However, in order to reduce the impact on the social environment during construction, the RDA strongly requested to consider other methods which could reduce the amount of earthwork volume much more.

The JICA study team compared some methods including the application of viaduct instead of embankment structures, and selected the most suitable method that make the construction cost increase 20% but reduce haulage 60% as compared with the replacement method.

- August 2007

Based on the alternative selected in April, the detailed design of embankment, Kelani River Bridge and the basic design of viaducts was carried out. The Draft Final Report including the drawings, construction plan, cost estimate and draft tender documents was submitted to RDA.

After that, RDA requested the Japanese Government to apply a STEP Loan for OCHNS1 expecting to apply Japanese technology which is superior for soft soil countermeasures and rapid construction in congested or narrow area.

- November 2007

The SEIA Report for the deviating section at Katawatha (A1IC) was approved by the CEA. In addition, the EIA Report for entire OCH project, which expired in May 2007 was expanded with 3 years.

- December 2007

The low-noise and low-vibration type of GCP method were applied as soft soil countermeasure, and the steel viaducts were applied to diminish the site work and shorten the construction period in congested and/or narrow areas. Based on that, JICA Study Team carried out the detailed design of earthworks & Kelani River Bridge and basic design of steel viaducts and submitted the DF/R2 with drawings, construction planning, cost estimates and draft tender documents. In addition, it was decided to remove the section between A1 and A1 Bypass (460m) from this project in order to reduce the hauling volume.

- February 2008

The detailed design of the OCH Northern Section 1 was completed.

1.8. Present Status of Other Expressway Projects

The present status of other expressway projects, which would interface with the OCH, is described below.

- CKE (Colombo-Katunayake Expressway)

Construction work has been suspended and RDA is looking for funding to restart the construction as a public-private partnership venture or via donor assistance.

- CKdE (Colombo-Kandy Expressway)

Malaysian firm is studying with RDA to carry out as a BOT project.

- STDP (Southern Transport Development Project)

The STDP is being funded by both the ADB and JBIC. Both portions of ADB and JBIC are currently under construction.

CHAPTER 2

INVESTIGATION

CHAPTER 2 INVESTIGATION

2.1. Supplemental Topographic Survey

2.1.1. Outline of Topographic Survey in 2003-2004 and 2006

With the gradual improvement of field circumstances, the RDA contracted with the Survey Department (hereinafter referred to as the "SD") and in 2003 they commenced the field survey of the section between 0+000 and 21+700, in accordance with the instructions of the Director/PMU, OCH and RDA Engineer.
However, several portions in the Northern Section from the Kelani River have not been completed due to some difficulties in field circumstances and the sections where the design criteria are not determined.
The section between station 9+300 and 16+500 was carried out by the SD in 2003-2004. The section between station 8+200 and 9+300, was carried out by the National Peoples' Forum (hereinafter referred to as the NPF) in 2006-2007. There were still sections which remained unsurveyed due to objections and also new sections required due to deviation of alignment and for additional plan survey. Therefore, the supplemental topographic surveys implemented in this Study are in **Table 2.1.1**.

Table 2.1.1 Sections to be Verified / Added

Section / Station No.	Length (m)	Remarks
8+200 to 9+300	1,100	This section was completed by the NPF in 2006-2007.
9+300 to 10+200	900	This section was completed by the SD in 2003-2004
10+200 to 10+500	300	This section was completed.
10+500 to 16+240	5,740	This section was completed by the SD in 2003-2004.
16+240 to 16+400	160	This Kelani river section was completed.
16+400 to 16+500	100	This section was completed by the SD in 2003-2004.
Total:	8,300	

Prior to the commencement of the supplemental topographic survey, the Study Team confirmed the RDA/OCH Staff members for the survey progress by the SD or NPF and their field conditions. Then, the following survey data was received from the RDA between September and December, 2006.

(1) Data of GPS Control Points, Traverse Points and Bench Marks

- Ground Survey for the Outer Circular Highway Project (Report prepared by the SD in 2004)

- GPS Coordinates-Survey Control Points Outer Circular Highway Project (Letter for the Coordinates of 3 GPS points located at A-1 interchange site from the SD in December 2006)

(2) Data of Drawings of Profiles, Cross-sections and Plans

- Drawing data between section 9+300 and 16+500 (prepared by the SD in 2004)

- Drawing data between section 8+200 and 9+300 (prepared by the NPF in 2007)

After being checked by the Study Team, the drawing data between station 9+300 and 16+500 were modified and updated by the private surveyor in 2006-2007.

2.1.2. Contract of Supplemental Topographic Survey

The supplemental topographic survey work of the Outer Circular Highway was carried out by Gamini B Dodanwela Associates (hereinafter referred to as the "Contractor"), a company of land surveyors in the City of Dehiwala close to Colombo, which was contracted by the Study Team on 7th November 2006, following approval from the JICA Head Office. The survey work, which commenced on 8th November 2006, was supervised by the Engineer of the Study Team as well as the RDA Counterparts.

2.1.3. Datum of Survey and Mapping

The survey work was conducted based on the following datum and parameters of survey and mapping:

- Datum of Vertical: Mean Sea Level (MSL)
- Grid System: National Coordinates System
- False Northing/Easting: +200 km South and +200 km West of Pidurutalagala
- Map Projection: Transverse Mercator
- Reference Ellipsoid: Everest 1830

The parameters to be transformed from the Global Positioning System (GPS) based on the World Geodetic System (WGS-84) ellipsoid to the National Coordinates System based on the Everest 1830 ellipsoid are specified in the SLD 95 decided by the SD. Hence, the Topographic Survey after the Feasibility Study for this Project in 1998 has been based on the following Transformation Parameters in the SLD 95.

Table 2.1.2 Transformation Parameters

Translations (m)	Rotations
X = 2.0553	0.198003
Y = -763.5581	1.706361
Z = -87.6682	3.46612
Scale Factor = 1.0000000315	

2.1.4. Volume of Topographic Survey

The supplemental topographic survey consisted of the verification survey in order to check the prepared drawings and the surveyed results which were done by the SD during 2003 and 2006. It also includes the additional survey for the Detailed Design.
The estimated survey volume of the section (Approx. 8.5 km) from the A-1 road to the left bank of the Kelani River (8+200 to 16+500) is in **Table 2.1.3**.

Table 2.1.3 Volume of Supplemental Topographic Survey

Work Items	Contract Volume	Progress Volume	Remarks
1. Verification Survey			
1.1 Positioning Survey of Control Points	98 points	113 points	
1.2 Leveling Confirmation	10 km	12.6 km	
2. Route Survey for Deviation Section and Additional Plan Survey			
2.1 Positioning Survey of Center Line	141 stations	165 stations	For main carriageway
2.2 Profile Leveling	2.76 km	3.30 km	ditto
2.3 Cross-section Survey	141 sections	165 sections	ditto
2.4 Plan Survey	6.98 ha	7.98 ha	ditto
2.5 Additional Plan Survey	2.22 ha	4.85 ha	For approach roads
3. Interchange & Junction Survey			
3.1 Positioning Survey of Center Line	165 stations	155 stations	
3.2 Profile Leveling	2.50 km	2.4 km	
3.3 Cross-section Survey	165 sections	129 sections	
4. River Survey			
4.1 Cross-section Survey of Kelani River	10 sections	7 sections	
4.2 Cross-section Survey of Tributaries	41 sections	38 sections	
5. Route Survey Revision Work			
5.1 Profiles	0.98 km	0.80 km	
5.2 Cross-sections	4,900 m	4,000 m	
5.3 Plans	9.8 km	8.0 ha	
6. Compilation of Existing Drawings Using Photogrammetric Maps	6.23 ha	6.80 ha	Revision & drawing work for missing areas in the plans

Notes: The contract volume has been estimated by the Study Team based on the survey results which were carried out by the SD in 2003-2004 and by the NPF in 2006.

2.1.5. Verification Survey

(1) Check survey for control traverse

Prior to the checking of control points, and after checking the Survey Report prepared by the SD in 2004, a check survey of the whole main control traverse between GPS control points was done in order to verify the horizontal accuracy of the traverse points and GPS control points. The results of the check survey are as follows:

Table 2.1.4 Check Survey for Control Traverse

Control Traverse		Traverse Lines		Angular Miss-closure	Linear Error (m)	Relative Accuracy	Remarks
From	To	Nos.	Length (km)				
GPS 07	GPS 04	7	0.938	1° 18’ 06”	3.366	1:279	Unaccepted
GPS 06	GPS 02	6	1.011	00’04”	0.911	1:1,110	Unaccepted
B 5098	GPS 01	8	1.169	00’17”	1.049	1:1,115	Unaccepted
B 5098	GPS 07	18	3.316	00’ 20”	0.056	1:59,379	Accepted
GPS 06	GPS 08	5	0.668	00’24”	0.035	1:19,275	Accepted
B 5098	B5084	28	1.172	03’59”	0.370	1:3,167	Unaccepted
B 5084	B 5083	17	1.697	02’17”	0.281	1:6,044	Unaccepted

B 5098	B 5083	41	2.631	01' 42"	0.157	1:16,724	Accepted
B 5083	B 5082	26	1.663	01' 08"	0.062	1:26,956	Accepted
B 5082	B 5081	17	1.625	00' 32"	0.032	1:50,305	Accepted
B 5081	B 5079	23	2.320	00' 19"	0.048	1:48,668	Accepted
B 5079	B 5080	9	1.275	00' 01"	0.257	1:4,952	Accepted
B 5080	B 802	6	0.412	00' 36"	0.047	1:8,778	Accepted

Souse: Survey data checked by Gamini B Dodanwela Associates.

In regards to traverse routes from B5098 to B5084, the relative accuracy being less than the requirement, a re-survey was done between B5098 and B5083 successively. In accordance with the results of the re-survey, the coordinates of B5084 (including B5084A and B5084B) was applied to the coordinate results of the re-survey. Hence, the Study Team adopted the coordinates revised for the following Six (6) GPS control points, after the RDA approved them.

Table 2.1.5 Discrepancy of Former and Revised Coordinates

Point No.	Former Coordinates (a)		Revised Coordinates (b)		Difference (m)	Remarks
	Easting (m)	Northing (m)	Easting (m)	Northing (m)	$\sqrt{(aE-bE)^2+(aN-bN)^2}$	
B5084	110593.576	198869.081	110593.467	198868.986	0.145	
B5084B	110520.536	198886.231	110520.408	198886.075	0.202	
GPS 01	110360.906	200432.054	110361.803	200432.460	0.985	
GPS 02	110465.261	200391.044	110466.171	200391.460	1.001	
GPS 03	110651.044	200751.456	110651.942	200751.853	0.982	
GPS 04	110957.007	201176.929	110957.876	201177.346	0.964	

Souse: Survey data checked by Gamini B Dodanwela Associates.

The following coordinates have been checked or revised by the method of control traverse in 2006-2007. The location of GPS control points observed by SD is shown in **Fig. 2.1.1**.

Table 2.1.6 Coordinates and Elevation of GPS Control Points

No.	Coordinates		Elevation (MSL)	Remarks
	Easting (m)	Northing (m)	(m)	
B5098	110561.219	199735.382	20.169	Result of Survey Department in 2004
B5098B	110494.373	199713.723	23.935	Ditto
B5084	110593.467	198868.986	27.382	Ditto
B5084B	110520.408	198886.075	24.199	Ditto
B5083	111047.95	198022.297	33.364	Ditto
B5083B	111014.842	197936.629	31.320	Ditto
B5082	111468.846	196759.910	16.989	Ditto
B5082A	111334.831	196727.608	17.555	Ditto
B5081	111657.085	195967.51	4.041	Ditto
B5081A	111848.517	196272.661	5.152	Ditto
B5079	111986.504	194309.263	3.648	Ditto
B5079A	112067.624	194176.512	4.118	Ditto
B5079B	111944.208	194436.717	11.194	Ditto
B5080	111451.761	193250.035	5.374	Ditto
B5080B	111696.696	193286.283	5.254	Ditto

B802	111325.954	192924.119	5.734	Ditto
GPS01	110361.803	200432.460	8.615	Result of Gamini B Dodanwela Associates in 2007
GPS02	110466.171	200391.460	8.888	Ditto
GPS03	110651.942	200751.853	10.327	Ditto
GPS04	110957.876	201177.346	11.962	Ditto
GPS05'	110843.419	201298.185	17.929	Ditto (This point is not the same position as GPS05.)
GPS06	110141.084	200821.759	13.084	Result of Survey Department in 2006
GPS07	109963.494	200698.870	14.168	Ditto
GPS08	110071.299	200249.979	9.167	Ditto

Souse: Survey data checked by Gamini B Dodanwela Associates in 2007.

(2) Check Leveling

This survey checked the respective GPS control points and traverse points based on the elevation of known bench marks (SD BM 4).
As a rule, the limit of closing error for check leveling was applied as follows:

$$20 \text{ mm } \sqrt{S} \quad (\text{ S: length of leveling route in km})$$

A round-trip type of leveling route was carried out from the SD BM 4. The check leveling has been connected to the BM 8 which was established for the Feasibility Study in 1999. The elevation results of GPS control points checked in 2006 are in **Table 2.1.7**.

Table 2.1.7 Result of Leveling Routes Checked in 2006-2007

Point No.	Known/given Elevation (a) (m)	Checked Elevation (b) (m)	Difference (a-b) (m)	Remarks
SD BM 4	10.880	–	–	This is a given BM.
B5080	5.374	5.377	0.003	
B5079	3.648	3.664	0.016	
B5081	4.041	4.086	-0.045	
B5082	16.989	17.022	-0.033	
B5083	33.364	33.401	-0.037	
B5084	27.382	27.401	0.019	
B5098	20.169	20.214	-0.045	
GPS 08	N/A	9.167	–	Newly installed in 2006
GPS 06	N/A	13.084	–	Newly installed in 2006
GPS 07	N/A	14.168	–	Newly installed in 2006
BM 8	12.318	(12.281)	(0.037)	This is an existing BM on F/S in 1999.
GPS 01	8.509	8.615	-0.106	The checked elevation was applied for this Supplemental Topographic Survey.
GPS 02	8.786	8.888	-0.102	Ditto
GPS 03	10.207	10.327	-0.120	Ditto
GPS 04	11.747	11.962	-0.215	Ditto
GPS 05'	N/A	17.929		

Souse: Survey data checked by Gamini B Dodanwela Associates.

The leveling routes checked by the Contractor are shown in **Fig. 2.1.2**.

(3) Reference Points Survey

For the Reference Points Survey of Control Points, buildings/houses and other structures to be checked on the plans at a scale of 1:1,000 prepared by the SD in 2003 and NPF in 2006, the Study Team instructed the Contractor on the respective positions on the existing plans of which the horizontal accuracy should be verified.
These coordinate results compared with the coordinates on the plan drawings have been verified by "Accuracy Control for the Reference Points Survey". (See the attached **Table 2.1.8**)
As far as these results were checked, almost all of the horizontal positions of the control points were judged to have an accuracy of less than 0.5m on the plan, excluding some different measurement positions at the sites.

Table 2.1.8 Accuracy Control for the Reference Points Survey

Ref No.	Cordinates in Plan		Checked Cordinates		Discrepancy	Remarks
	North (m)	East (m)	North (m)	East (m)	d◿ (m)	
1	199718.963	110283.080	199719.052	110282.959	0.150	Corner of Masonry Well
2	199729.543	110295.366	-	-	-	Survey Station Missing
3	199711.739	110335.139	199711.789	110335.012	0.136	Building Corner
4	199550.339	110307.824	-	-	-	Building Demolished
5	199481.517	110321.309	199481.606	110320.671	0.644	Building Corner - Different Position
6	199509.411	110375.788	199509.524	110375.836	0.123	Survey Station
7	199491.736	110384.714	199491.792	110384.421	0.298	Building Corner
8	199462.076	110384.526	199462.120	110384.226	0.303	Building Corner
9	199383.235	110394.631	199382.087	110395.440	1.404	Building Corner - Different Position
10	199350.112	110408.847	-	-	-	Building demolished
11	199338.332	110379.399	199338.329	110379.299	0.100	Survey Station
12	199182.330	110403.941	199183.181	110404.210	0.893	Building Corner - Different Position
13	199179.350	110421.625	199179.349	110421.487	0.138	Survey Station
14	199109.837	110430.825	199110.098	110430.736	0.276	Building Corner
15	198993.930	110509.720	198994.004	110509.796	0.106	Building Corner
16	198983.610	110519.666	198983.612	110519.576	0.090	Survey Station
17	198895.787	110565.685	-	-	-	Not allowed to survey
18	198886.191	110520.520	198886.231	110520.536	0.043	GPS Pt. B5084B
19	198869.081	110593.576	198869.081	110593.576	0.000	GPS Pt. B5084
20	198501.136	110697.711	-	-	-	Not allowed to survey
21	198447.780	110705.875	-	-	-	Survey Station Missing
22	198285.767	110827.815	-	-	-	Survey Station Missing
23	198256.850	110811.292	198256.847	110811.303	0.011	Building Corner
24	198220.501	110871.902	198220.446	110872.047	0.155	Building Corner
25	198172.882	110822.042	-	-	-	Survey Station Missing
26	198096.690	110818.295	-	-	-	Survey Station Missing
27	198089.440	110838.909	198089.405	110839.093	0.187	Building Corner
28	198088.299	110859.086	198088.356	110859.112	0.063	Building Corner
29	198015.772	110924.829	-	-	-	Not allowed to Survey
30	198026.184	110897.849	-	-	-	Not allowed to Survey
31	197992.097	110896.540	-	-	-	Not allowed to Survey
32	197943.894	110915.826	-	-	-	Not allowed to Survey
33	197936.629	111014.842	197936.629	111014.842	0.000	GPS Pt. B5083B
34	197816.429	111020.176	197816.431	111020.192	0.016	Fence Corner
35	197817.895	111030.931	-	-	-	Survey Station Missing
36	197679.430	111019.244	197678.571	111018.812	0.962	Building Corner - Different Position
37	197674.583	111074.398	197675.119	111073.439	1.099	Building Corner - Different Position
38	197667.029	111084.978	-	-	-	Survey Station Missing
39	197602.856	111046.554	197603.281	111044.989	1.622	Building Corner - Different Position
40	197534.962	111111.278	197535.110	111111.617	0.370	Building Corner

Ref No.	Cordinates in Plan		Checked Cordinates		Discrepancy	Remarks
	North (m)	East (m)	North (m)	East (m)	d◿ (m)	
41	197502.180	111108.612	-	-	-	Survey Station Missing
42	197400.900	111163.010	-	-	-	Survey Station Missing
43	197197.995	111304.050	-	-	-	Survey Station Missing
44	197211.624	111198.150	197211.598	111198.079	0.076	Survey Station
45	197009.316	111373.698	197009.255	111373.756	0.084	Survey Station
46	196930.048	111422.069	-	-	-	Survey Station Missing
47	196877.825	111396.379	196877.832	111396.364	0.017	Survey Station
48	196822.717	111313.655	-	-	-	Survey Station Missing
49	196836.588	111356.643	196836.665	111357.373	0.734	Building Corner - Different Position
50	196813.363	111368.381	196813.309	111367.719	0.664	Building Corner - Different Position
51	196727.608	111334.831	196727.608	111334.831	0.000	GPS Pt. B5082A
52	196759.910	111468.846	196759.910	111468.846	0.000	GPS Pt. B5082
53	196666.028	111404.545	196665.686	111405.568	1.079	Building Corner - Different Position
54	196662.547	111488.392	196662.326	111489.720	1.346	Building Corner - Different Position
55	196558.107	111462.194	196558.951	111462.537	0.911	Building Corner - Different Position
56	196553.116	111490.735	-	-	-	Survey Station Missing
57	196499.035	111532.115	196499.038	111532.113	0.004	Survey Station
58	Not shown in		196407.850	111553.478	-	Pylon Corner
59	the drawing		196402.603	111556.217	-	Pylon Corner
60	196375.395	111580.941	196375.402	111580.943	0.007	Survey Station
61	196375.358	111600.709	-	-	-	No such detail on ground
62	196222.871	111715.301	196222.833	111715.273	0.047	Survey Station
63	196216.020	111722.162	196215.695	111722.171	0.325	Corner of Earth Well
64	195967.510	111657.085	195967.510	111657.085	0.000	GPS Pt. B5081
65	196001.992	111745.592	-	-	-	Survey Station Missing
66	196002.668	111766.170	-	-	-	Survey Station Missing
67	195990.999	111782.672	195991.067	111782.710	0.078	Pylon Corner
68	195986.885	111792.054	195987.194	111791.690	0.477	Pylon Corner - Different Position
69	194983.376	111973.244	-	-	-	Survey Station Missing
70	194818.596	111911.397	-	-	-	Survey Station Missing
71	194808.819	111899.085	194808.820	111899.348	0.263	Building Corner
72	194744.995	111921.707	194744.990	111921.874	0.167	Building Corner
73	194736.850	111929.095	194736.773	111929.179	0.114	Survey Station
74	194598.254	111932.301	194599.952	111932.010	1.723	Building Corner - Different Position
75	194597.643	111898.781	194597.441	111898.851	0.214	Survey Station
76	194534.400	111906.187	194534.279	111906.234	0.130	Survey Station
77	194498.341	111872.723	194498.300	111872.754	0.051	Boundary Corner
78	194465.515	111831.168	194465.637	111830.241	0.935	Building Corner - Different Position
79	194436.604	111944.175	194436.717	111944.208	0.118	GPS Pt. B5079B
80	194309.263	111986.504	194309.263	111986.504	0.000	GPS Pt. B5079
81	194314.670	111860.760	-	-	-	Survey Station Missing
82	194317.414	111833.692	194317.437	111833.705	0.026	Boundary Corner
83	193849.705	111635.011	193850.141	111634.979	0.437	Building Corner - Different Position
84	193736.482	111541.347	-	-	-	Survey Station Missing
85	193667.231	111552.249	-	-	-	Survey Station Missing
86	193695.133	111552.954	193695.198	111553.165	0.221	Building Corner
87	193671.597	111536.595	193671.666	111536.882	0.295	Building Corner
88	193575.483	111520.897	193575.563	111521.451	0.560	Corner of Masonry Well - Different Position
89	193249.718	111377.731	193249.757	111377.728	0.039	Building Corner
90	193232.950	111265.545	193232.951	111265.552	0.007	Building Corner
91	193206.333	111367.794	193206.329	111367.747	0.047	Building Corner
92	193216.477	111259.713	193216.477	111259.713	0.000	GPS Pt. B5080A
93	193250.035	111451.761	193250.035	111451.761	0.000	GPS Pt. B5080
94	193286.283	111696.696	193286.283	111696.696	0.000	GPS Pt. B5080B

2.1.6. Route Survey for the Deviated Section and Additional Plan Survey

(1) Route Survey for the Deviated Section

In accordance with the changes of carriageway alignment, the following sections to be deviated were re-surveyed and added onto the drawing data:

Table 2.1.9 Method of Surveying and Drawing on Deviated Section

Sections		Length (m)	Method of Surveying and Drawing
From	To		
12+520	12+780	260	Indicated new center on drawings of cross-sections and plans
12+800	13+760	960	Expanded from cross-sections and plans on the drawings
13+780	16+260	2480	Re-surveyed all cross-sections and plans
16+280	16+380	100	Section by river cross-section survey (Kelani River)
16+400	16+500	100	Re-surveyed all the cross-sections and plans

The sections between 13+780 and 16+260, 16+400 and 16+500 were re-surveyed due to the escalation of position gap from Station 13+780.

(2) Additional Plan Survey

In order to add supplementary plans into the existing ones, the necessary areas for details design have been surveyed and compiled based on the "Legend of OCH Topographic Plan" specified by the JICA Study Team and RDA.
Contour lines on the plans were generated using on the 3-D data files on DEM (Digital Elevation Model) software. Afterwards, the irrational contour lines were checked on the plans and modified. The details of the drawings prepared are given below:

- Drawing scale: 1/1,000
- Index contour: 5 m
- Intermediate contour: 1 m
- Half interval contour: 0.5 m

2.1.7. Route Survey for the Interchange and Junction Site

The route survey in A1 interchange site had been carried out accordingly after checking the control traverse data and the drawing data which was received from the SD and NPF through the RDA during the Study since December 2006.

In the route survey of sections between 8+200 and 9+280, the main carriageway and bypass route has already been carried out based on the coordinates of design alignment by the NPF without supervision by the Study Team in 2006-2007.
Hence, the route survey in this Study was implemented based on the alignment coordinates of the Ramps in the Interchange site, carried out by the Contractor and supervised by the Study Team.
However, a discrepancy (about 1m) turned up in the coordinates on the drawing data between 8+200 and 9+280, as mentioned in the said verification survey for the GPS control points. Naturally, as the center lines of main carriageway and bypass done by

NPF were also shifted from position of the correct arraignment, these center lines have been modified on the plan drawings based on the correct coordinates grid.

The route survey for the Ramps of section between 15+900 and 16+200, which has been carried out based on the alignment of the Ramps.

The details of the route survey section are as follows:

Table 2.1.10 Details of Route Survey Section

Section on Main Carriageway		Total Length (km)	Number of Cross-section	Survey Intervals (m)	Remarks
From	To				
8+200	9+300	1.58	89	20	Width: 80m
15+900	16+200	1.17	65	20	Width: 60m
Total:		2,75	154		

2.1.8. River Survey

(1) Cross Section Survey of Kelani River for Bridge Design

The river survey of the Kelani river was done using a small boat and a weighted measuring tape in order to measure the depth of the water, and using the Total Station in order to navigate the boat on cross-section lines from both river banks.
The river survey for the bridge design was carried out in accordance with the following specifications on 28th January 2007:

- Number of sections: 5 sections
- Measuring width: Approx. 200 m
- Interval of measuring points: Approx.10 m
- Base line: Line between Station 16+260 and 16+400.

(2) Cross Section Survey of Kelani River for Hydraulic Analysis

The river survey for the hydraulic analysis was carried out in accordance with the following specifications on 28th January, 2007:

- Number of sections: 2 sections
- Measuring width: Approx. 140 m
- Interval of measuring points: 10 m.

(3) Cross Section Survey of Tributaries for Hydraulic Analysis

The river survey for the hydraulic analysis was carried out in accordance with the following specifications during the end of January in 2007:

- Number of sections: 38 sections
- Measuring width: Approx. 50 m and/or depend on the river bank width
- Interval between cross-sections: Approx. 100 m
- Interval of measuring points: 10m and topographical terrains.

2.1.9. Route Survey Revision Work

The revision work for drawings consisting of profiles, cross-sections and plans was carried out after the existing survey results prepared by the SD and NPF were inspected.
The main details to be revised and/or modified on existing drawings of cross-sections and plans are as follows:

Table 2.1.11 Main Details on the Revised Drawings

Sections/stations		Main Details of Revision Work
From	To	
8+200	9+300	Shifted all the horizontal position of plan drawings based on the corrected coordinates of the existing 4 GPS control points.
8+200	9+300	Partially modified unnatural portions of contour lines on the plans.
9+300	10+200	Reversed left and right sides on cross-sections toward the direction increased stations.
10+980	13+280	Reversed left and right sides on cross-sections toward the direction increased stations.
9+700	10+500	Plotted spot heights on plans from cross-section data.

2.1.10. Compilation of Existing Drawings Using Photogrammetric Map Data

Due to objections and other difficulties in regards to some sections since 2001, those sections could not be completed until the end of 2006 when the Study Team decided to partially complement using the digital photogrammetric map data at a scale of 1:1000 prepared by the SD.
Their sections were modified after being compared and checked against the topographical features and/or spot elevations on both plans.
In addition, the drawings of profiles and cross-sections in their sections have been prepared based on the compiled plans. In conclusion, the sections complemented by the photogrammetric map data are shown in the **Table 2.1.12**.

Table 2.1.12 Sections Objected to by Inhabitants during the Study Period

Sections		Area (ha)	Land Use	Remarks
From	To			
(0+140)	(0+320)	(0.70)	Residential area	Surveyed after agreement with inhabitants at the Bypass site in March 2007
8+840	9+000	0.72	Residential area	Compiled from photogrammetric map data
(9+640)	(9+700)	(0.35)	Residential area	Surveyed after agreement with inhabitants in December 2006
(10+020)	(10+060)	(0.15)	Residential area	Surveyed after agreement with inhabitants in December 2006
10+200	10+500	5.22	Residential area	Compiled from photogrammetric map data
11+120	11+260	0.60	Residential area	Compiled from photogrammetric map data
Total:		6.54		

Note: The horizontal and vertical accuracy in those sections has not been verified at the sites, because the inhabitants could not agree to the survey as proposed by the RDA and Study Team. As far as the Study Team was able to compare with the photogrammetric map data and the plans prepared by the ground survey, the relative accuracy of height has been estimated at approximately 1.0 meter on the drawings under favorable land conditions.

2.1.11. Final Products

The Study Team received the following final products from the Contractor after approval by the Director/PMU OCH and the JICA Study Team.

Table 2.1.13 Final Products

Final Products	Qty'	Remarks
1) Field measuring data	1 Ls	These are possessed by the Contractor
2) Computation data	1 Ls	These are possessed by the Contractor
3) Drawings of plan	1 Ls	
4) Drawings of profiles and cross-sections	1 Ls	
5) Description card of GPS/BM points	1 Ls	
6) Diagram of traverse survey and leveling	1 Ls	
7) Table of accuracy control	1 Ls	
8) CD-R of all CAD data	2 sets	
9) CD-R of all numerical data	2 sets	Data files
10) Final reports	3 sets	

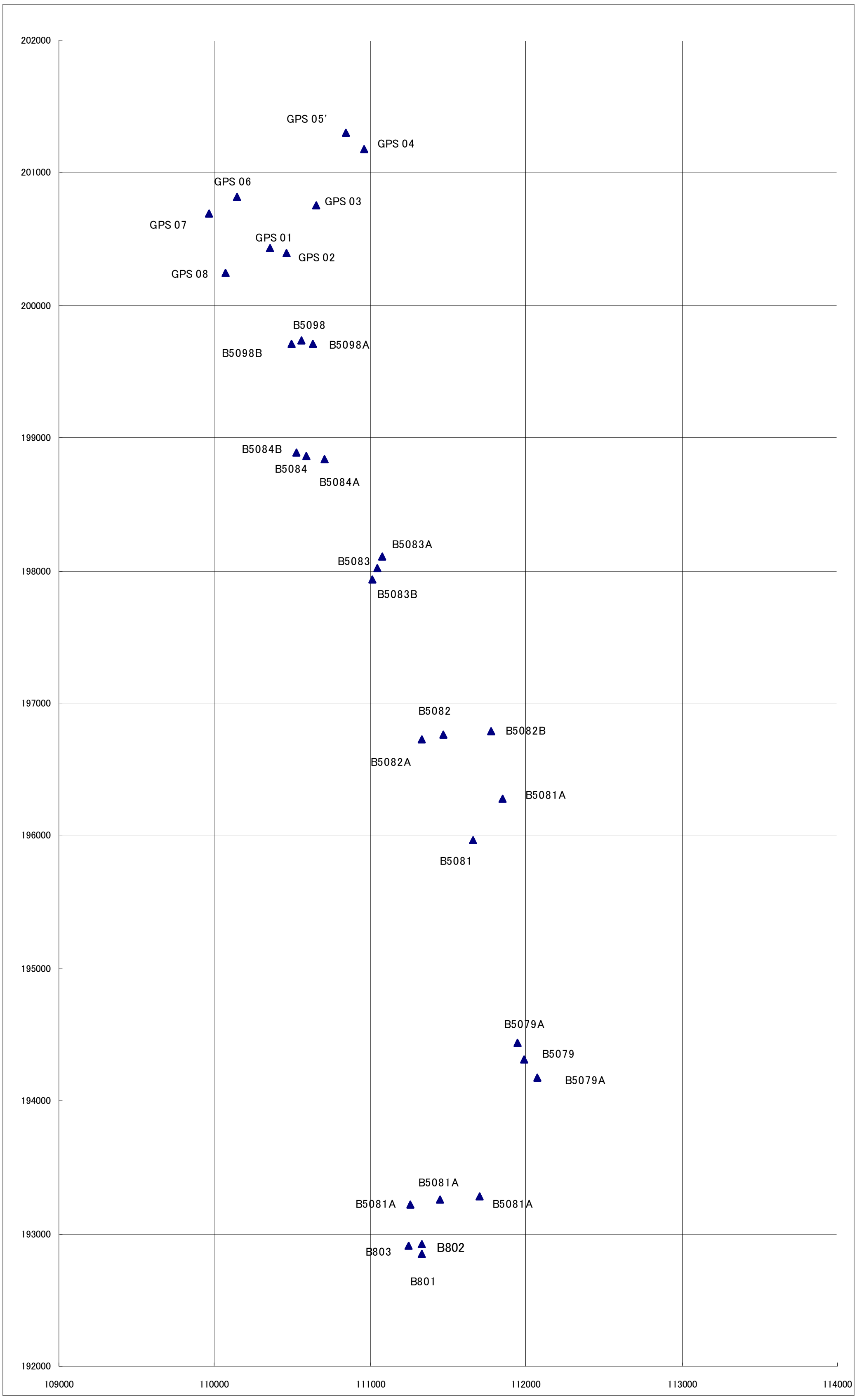


Fig. 2.1.1 Location of GPS Control Points

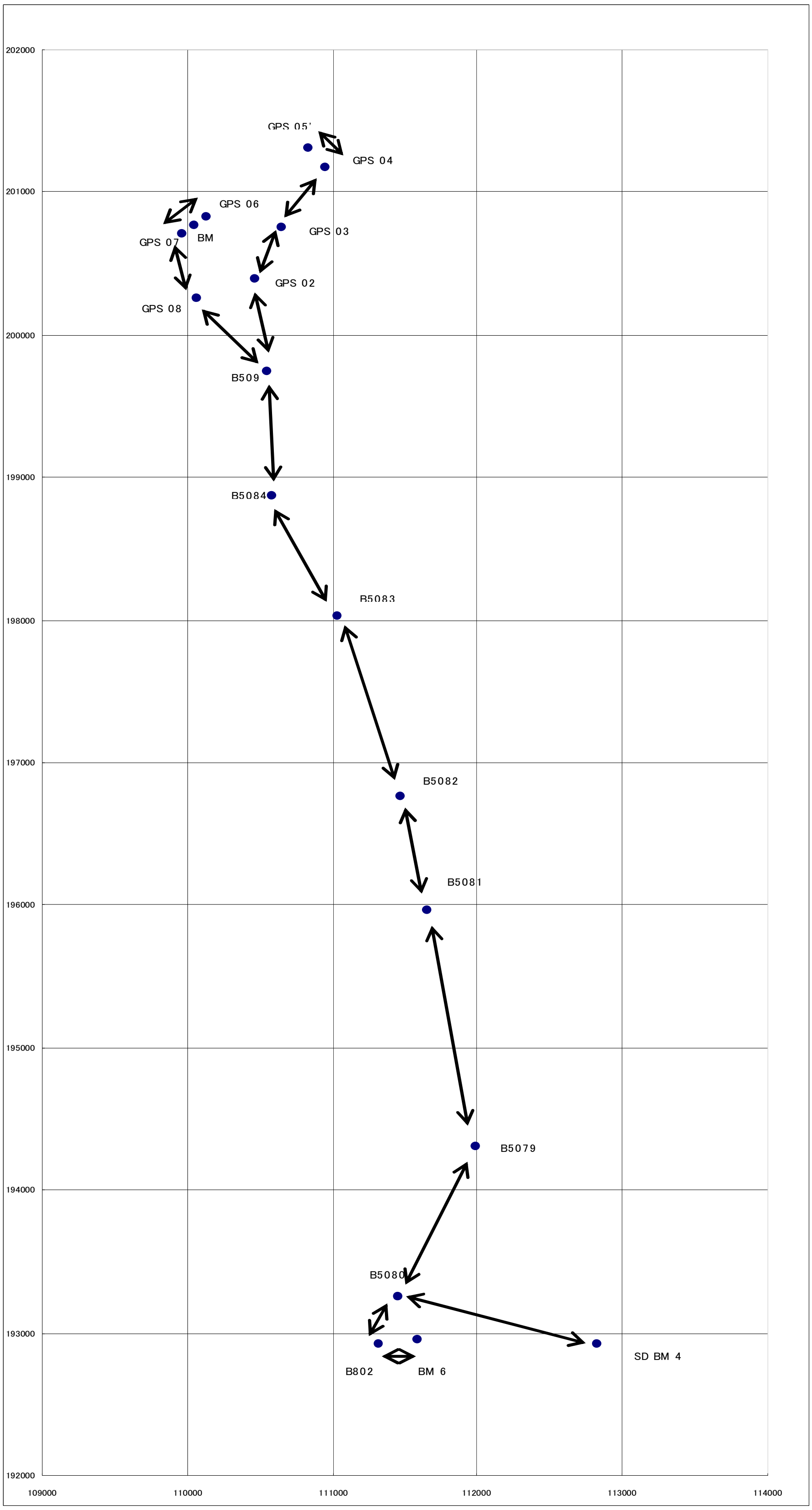


Fig. 2.1.2 Leveling Routes Checked in 2006-2007

2.2. Geotechnical and Materials Survey

2.2.1. Geomorphology and Geology

(1) General Geomorphology

The geomorphological map of the central and southern parts of Sri Lanka is shown in **Fig. 2.2.1**. In terms of geomorphology, this area consists of a peneplain located on top of Precambrian rock and can be divided into three geomorphologic surfaces based on altitude as follows:

- Highland Surface (more than 500 meters above sea level)
- Intermediate Surface (more than 300 meters above sea level)
- Lowland Surface (less than 300 meters above sea level)

The Highland Surface occupies the highest mountainous areas in Sri Lanka, and includes plains, basins and plateaus. Many peaks rise above plains such as the Monadnock. Major peaks include Mt. Pidurutalagala (2,524m) and Mt. Kirigalpotta (2,395m). The Highland Surface can be further divided into three sub-surfaces based on altitude and are as follows:

- Upper Surface (more than 2,000 meters above sea level)
- Middle Surface (more than 800 meters above sea level)
- Lower Surface (more than 500 meters above sea level)

The Upper Surface includes the Nuwara Eliya Plain and Horton Plain. The Middle Surface includes the Uva Basin and Hatton Plateau and the Lower Surface the Kandy Plain.

As for the Intermediate Surface, it is distributed widely as peneplains surrounding Highland Surfaces. It can be divided into two sub-surfaces based on altitude and is as follows:

- Upper Surface (more than 400 meters above sea level)
- Lower Surface (more than 300 meters above sea level)

The Upper Surface consists of gently sloping mountains and hills, while the Lower Surface consists of gently sloping hills and flat plateaus.

Finally, Lowland Surface consists of gently sloping hills and flat plateaus less than 300 m in height. Lowland Surfaces can be divided into two sub-surfaces based on climatic difference and are as follows:

- Dry Zone
- Wet Zone

Generally a Dry Zone is covered with thin soil and there are many Inselbergs (island hills), while the Wet Zone is covered with thick soil with few Inselbergs. The remainder of the geomorphologic units consists of coastal plain, river plain, coastal terrace, and sand dunes on the coast. The distribution of these units is concentrated and their land area small.

(2) General Geology

A geological map of Sri Lanka is shown in **Fig. 2.2.2** and is divided into Coastal Regions and Central Highland. The Coastal Regions are nearly flat, with rivers flowing through plains that have reached their base level of erosion. This region narrows on the eastern and southern sides of the island, and widens along the west side and northern half of the island. The Central Highlands comprise the southern central part of the island, with mountains in excess of 2,300m. Most of the island consists of crystalline and foliated metamorphic rock of the Precambrian era with only a narrow fringe of more recent sediment (Jurassic, Miocene and Quaternary) along the coast.

Table 2.2.1 Stratigraphy of Sri Lanka

ERA	SYSTEM	EPOCH	FORMATION
CENOZOIC	QUATERNARY (1.8 m.y.)	RECENT PLEISTOCENE	Younger Group: Alluvium Older Group: Terrace Deposit
CENOZOIC	TERTIARY (65 m.y.)	MIOCENE (24 m.y.)	Limestone, Sandstone, Shale and Others
MESOZOIC	CRETACEOUS	（142 m.y.）	Dolerite Dykes
MESOZOIC	JURASSIC	（205 m.y.）	Sandstone and Mudstone
PRECAMBRIAN		（2500 m.y.）	WANNI COMPLEX (WC) VIJAYAN COMPLEX (VC) KADUGANNAWA COMPLEX (KC) HIGHLAND COMPLEX (HC)

m.y.= million years

The Precambrian Complex is divided into four series: 1) Highland Complex (HC), 2) Kadugannawa Complex (KC), 3) Vijayan Complex (VC), and 4) Wanni Complex. The characteristics of these complexes are described below.

I. Highland Complex (HC)

The Highland Complex occupies the Central Highlands and extends from the southwest to the northeast of the island. The age of HC rock is about 2,000 to 3,000 m.y. old and consists of granulite facies metasediment, quartz-feldspathic, and chamockitic gneisses.

II. Kadugannawa Complex (KC)

These rocks are surrounded by the HC and occupy a distinct well-defined area around Kandy. They are long, upright, and boat-shaped and consist mainly of biotite hornblende gneisses and amphibolites concordant with each other.

III. Vijayan Complex (VC)

The Vijayan Complex occupies lowland east of the HC, and consists of granitic gneiss, granitoid rock, migmatite and calc-silicate rock. The age of VC rock is estimated to be about 1,100 m.y. old.

IV. Wanni Comlpex (WC)

The Wanni Complex is located in lowland west of the HC, and consists of granodioritic to granitic migmatite, granitoid rock, and charnockitic gneiss. WC rock is of a lower metamorphic grade than that of HC rock, but there is no clear structural break between the two, although several N - S zones of shearing are present between them. The age of WC rock is estimated to be between 1,000 m.y. and 1,100 m.y. old.

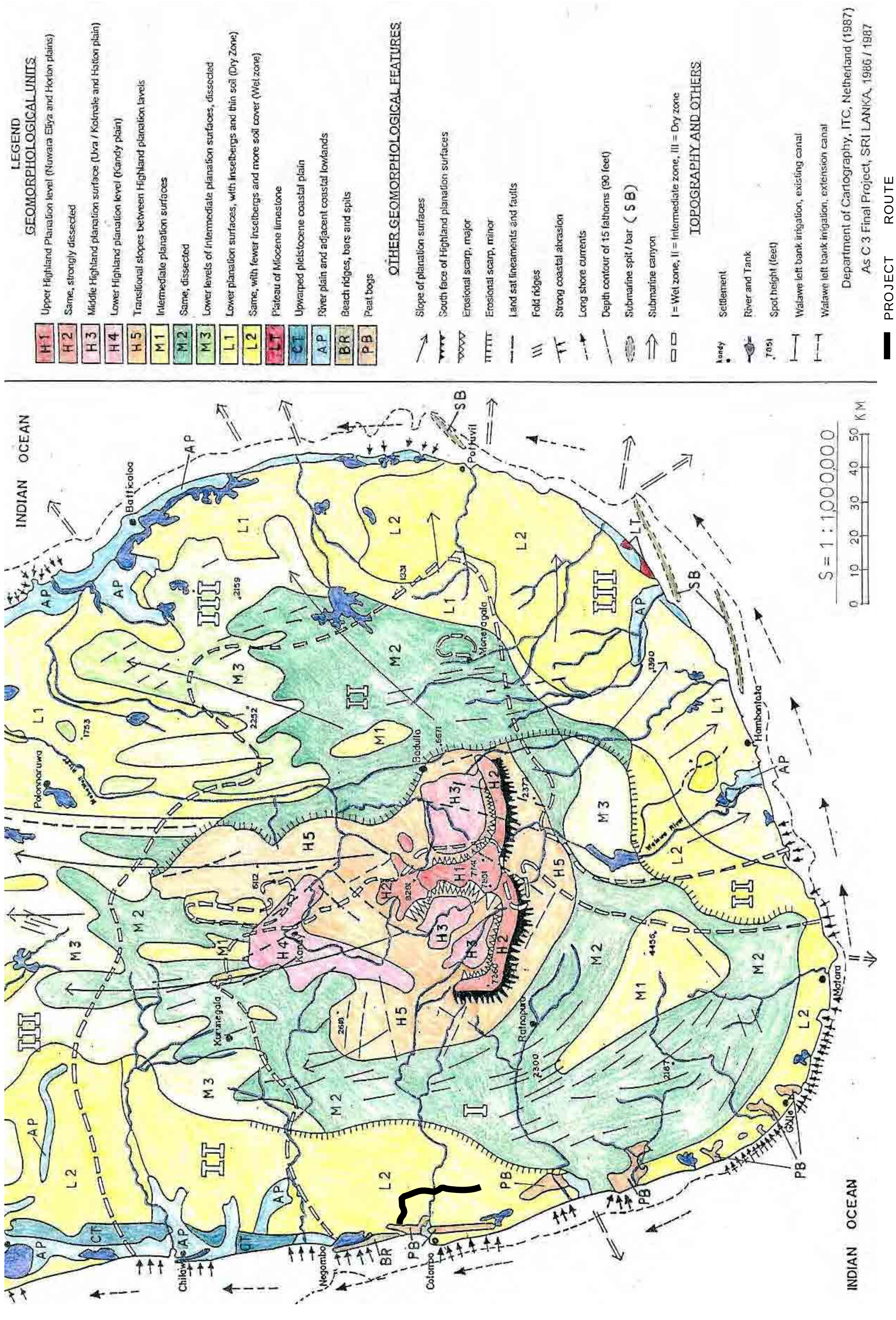


Fig 2.2.1 Geomorphological Map

S = 1:100,000

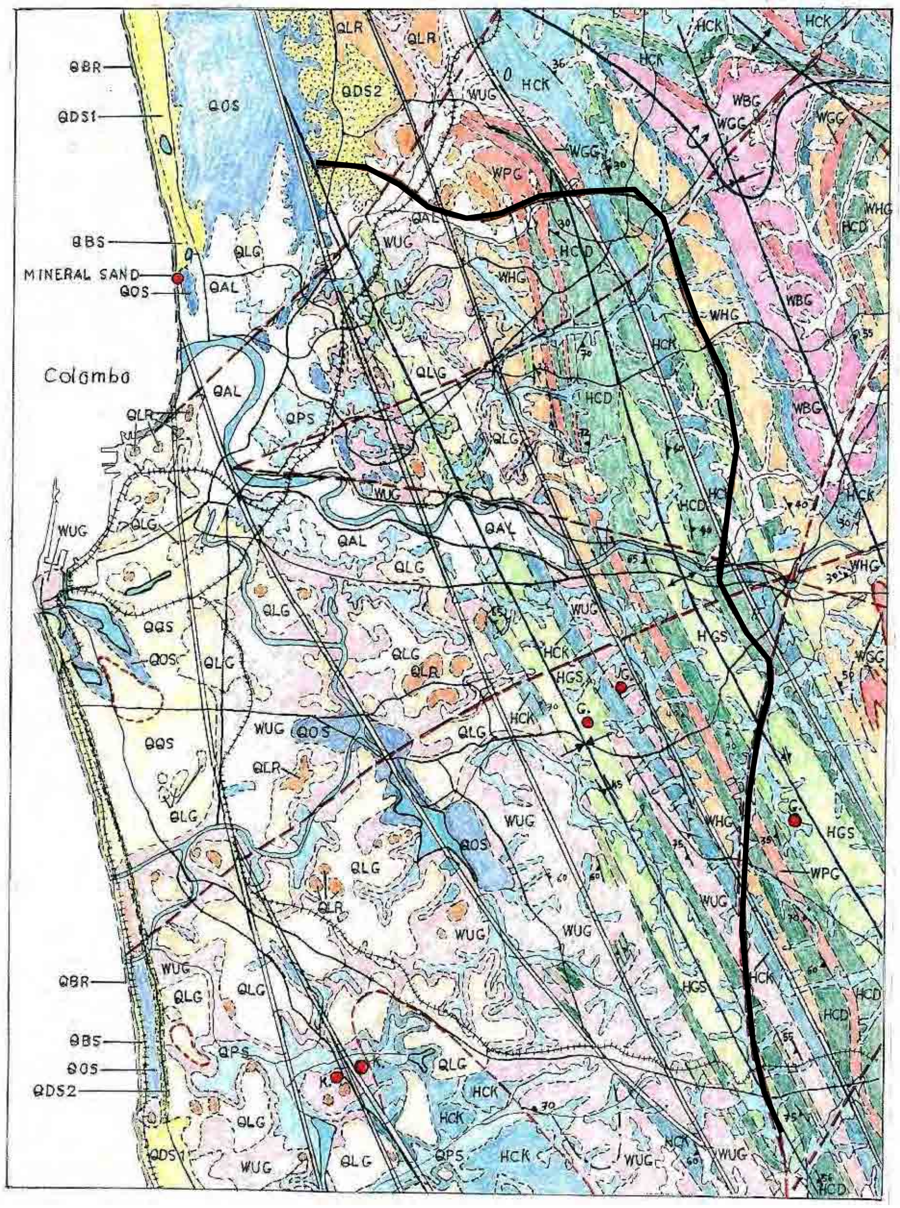


Fig 2.2.2 Geological Map

LEGEND OF GEOLOGICAL FORMATION

SUPERFICIAL DEPOSIT

- QLR — LATERITE
- QLG — SANDY LATERITIC GRAVEL

QUATERNARY (0 – 2 M. Y.)
RECENT AND PLEISTOCENE DEPOSIT

- QAL — ALLUVIUM (SAND, SILT, CLAY)
- QPS — PADDY CLAY (ORGANIC CLAY)
- QOS — LAGOONAL AND MARSH DEPOSIT (ORGANIC SILT, CLAY AND PEAT)
- QBS — BEACH SAND
- QDS1 — DUNE SAND
- QDS2 — OLD BEACH SAND OR OLD DUNE SAND
- QBR — BEACH ROCK (CALCAREOUS CEMENTED BEACH SAND)
- QQS — QUARTZ SAND

PRECAMBRIAN METAMORPHIC ROKS
WANNI COMPLEX (1000 –1100 M.Y.)

- WGG — GRANITE GNEISS
- WPG — PEGMATITIC GNEISS
- WHG — HORNBLENDE – BIOTITE GNEISS
- WBG — BIOTITE-HORNBLENDE GNEISS
- WUG — UNDIFFERENTIATED GNEISS

HIGHLAND COMPLEX (2000 – 3000 M.Y.)

- HGS — GARNET-SILLIMANITE-BIOTITIE GNEISS, GRAPHITE, SCHIST
- HGG — CALC-SILICATE GNEISS GRANULITES
- HCD — CORDIERITE GNEISS
- HCK — CHARNOCKITIC GNEISS

LEGEND OF SYMBOLS

GEOLOGICAL SYMBOLS

- GEOLOGICAL BOUNDARY
- INFERRED FAULT
- INFERRED SHEAR ZONE
- AXIAL TRACE OF ANTI-FORM AND PLUNGE
- AXIAL TRACE OF SYN-FORM AND PLUNGE
- OVERTURNED ANTIFORM
- OVERTURNED SYNFORM
- STRUCTURE FORM FROM AIR PHOTOGRAPHS
- 50 STRIKE AND DIP OF FOLIATION
- EXTENT OF MATERIAL (SILICA, SAND, GRAVEL)
- MINERAL OCCURRENCE (KAOLIN, GRAPHITE, ETC.)

OTHER SYMBOLS

- MAIN RIVER
- LAGOON AND LAKE
- MAIN ROAD
- RAILWAY
- PROJECT ROUTE (OCH)

BY THE GEOLOGICAL SURVEY AND MINES BUREAU OF SRI LANKA (1996)

2.2.2. Geotechnical Survey

(1) Content and Work Volume of Survey

The ground conditions for Sta. 08+200 km to Sta. 16+560 km of OCH have been investigated for Detailed Design this time.

For this geological survey, 147 boreholes have been completed to drill with a rotary drilling machines for the 8 km alignment of OCH, A1 bypass road and A1 Inter Change road, together with 45 auger boreholes and 20 locations of field vane tests. Of these boreholes, 14 water observation holes were established at the hilly area.

The quantities carried out for this geological investigation are tabulated in **Table 2.2.2** and details of each borehole, auger hole, field vane share tests and water standpipes are shown in **Table 2.2.3** to **Table 2.2.6**. Those investigation points are shown in **Fig. 2.2.3**.

Table 2.2.2 Summary of Quantities for Geological Investigation

Soil and Geotechnical Survey			
	Boring and Sampling (147 Locations)		
a)	Rotary Core Boring (Type A fo Rock)	m	190.2
b)	Rotary Wash Boring (Type B for Soil)	m	1694.1
c)	Hand Auger Boring (Type C for soil and Weathered rock)	m	160.2
d)	Undisturbed sampling (Fixed position with thin wall sampler)	Nos	26
e)	Water standpipe installation	Nos	13
f)	Ground water sampling	Nos	13
In-Situ Tests			
a)	Standard Penetration Test	Nos	1429
Vane Shear test			
a)	Vane shear test (20 Locations)	m	60
Laboratory Tests (physical)			
a)	Particle Size (hydro, sieve) (bh-226+AH-8)	Nos	234
b)	Moisture Content (AH-8+BH-225)	Nos	233
c)	Specific Gravity	Nos	48
d)	Atterberg Limits	Nos	221
e)	Bulk Density	Nos	23
f)	Ignition Loss	Nos	24
g)	Chemical test for Soil (pH, CI, Alalnity, Ca)	Nos	3
h)	Apparent Specific Gravity (for rock)	Nos	9
i)	Chemical Tests for Water (pH, CI, S04, Na, Ca, Ms_4, K, OH	Nos	13
	Co_3, HCO_3, Alkalinity)		
Laboratory Tests (mechanical)			
a)	Unconfined Compression (for Soil)	Nos	25
b)	Standard Consolidation	Nos	11
c)	Long-term Consolidation	Nos	7
d)	Proctor Compaction (for Auger Hole)	Nos	8
e)	Labo CBR (for auger hole)	Nos	8
f)	Unconfined Compression (for Rock)	Nos	13
g)	Organic content	Nos	20

Table 2.2.3-1 Details of Boreholes

No.	Type of Hole	Borehole No.	Chainage	Ground Elevation (m)	Coordinates		Ground Water Level (m)	Total Depth (m)
					X	Y		
		NS1						
1	SPT	BH-10	STA 9+106, L-30	22.619	110 306.742	199 845.772	14.10	20.00
2	SPT	BH-12	STA 9+415, R-113	8.443	110 204.852	199 615.310	1.80	12.00
3	SPT	BH-13	STA 9+415 R-25	15.343	110 290.988	199 633.045	4.00	15.00
4	SPT	BH-14	STA 9+415, L-25	14.359	110 340.050	199 643.065	4.20	23.00
5	SPT	BH-15	STA 9+520, CL	22.432	110 337.932	199.535.438	9.00	26.60
6	SPT	BH-16	STA 9+700, CL	8.536	110 380.811	199 360.617	1.80	10.50
7	SPT	BH-18	STA 9+900, CL	10.382	110 435.196	199 168.131	3.00	12.90
8	SPT	BH-30	STA 11+110, CL	21.840	110 893.745	198 061.010	4.30	25.10
9	SPT	BH-35	STA 11+400, CL	23.713	111 008.454	197 783.837	2.50	22.00
10	SPT	BH-38	STA 11+850,CL	9.307	111 157.769	197 359.426	1.60	15.20
11	SPT	BH-39	STA 11+950,CL	10.372	111 193.418	197 265.437	1.60	15.45
12	SPT	BH-40	STA 12+050,L-30	7.535	111 258.058	197 184.027	0.30	9.00
13	SPT	BH-41	STA 12+050, CL	9.598	111 230.207	197 172.904	1.30	5.70
14	SPT	BH-42	STA 12+160,CL	15.854	111 272.826	197 071.552	8.40	21.50
15	SPT	BH-44	STA 12+400, CL	7.708	111 372.914	196 853.390	0.00	15.70
16	SPT	BH-47	STA 12+850, CL	9.779	111 563.949	196 447.586	2.70	14.10
17	SPT	BH-48	STA 12+850, R-28	4.882	111 538.342	196 434.974	0.70	15.05
18	SPT	BH-60	STA 14+100, CL	1.786	111 893.988	195 296.442	0.00	10.00
19	SPT	BH-62	STA 14+410, L-32	1.910	111 940.820	194 936.324	0.10	7.40
20	SPT	BH-65	STA 12+160, CL	3.214	111 895.353	194 727.533	0.40	10.50
21	SPT	BH-67	STA 14+765, CL	19.739	111 876.513	194 583.749	10.70	21.45
22	SPT	BH-76	STA 15+946, R-30	2.012	111 514.110	193 463.138	0.25	8.95
23	SPT	BH-78	STA 15+946, R-30	3.622	111 457.975	193 484.517	3.20	9.00
24	WSP+WS	BH-11	STA 9+110, L-125	21.235	110 401.038	199 858.362	8.00	22.00
25	WSP+WS	BH-20	STA 10+080, L-98	19.033	110 584 566	199 026.512	5.60	17.00
26	WSP+WS	BH-31	STA 11+132, R-55	27.026	110 855.004	198 011.947	8.65	18.50
27	WSP+WS	BH-34	STA 11+260, R-135	38.996	110 831.214	197 863.390	8.90	23.00
28	WSP+WS	BH-46	STA 12+555, L-125	18.545	111 550.438	196 789.409	NE	6.00
29	WSP+WS	BH-64	STA 14+550, R-123	21.087	111 777.926	194 804.973	8.70	21.00
30	WSP+WS	BH-66	STA 14+725, R-32	19.124	111 850.752	194 627.539	10.70	24.00
31	SPT+UD	BH-01	STA 8+165,CL	10.428	110 114.442	200 759.416	1.10	3.55
32	SPT+UD	BH-02	STA 8+250,CL	9.134	110 114.442	200 680.292	0.65	7.80
33	SPT+UD	BH-03	STA 8+350, CL	8.834	110 142.719	200 584.391	0.60	3.30
34	SPT+UD	BH-04	STA 8+450, CL	8.488	110 162.724	200 486.442	0.70	9.70
35	SPT+UD	BH-05	STA 8+550, CL	8.061	110 180.207	200 388.013	0.30	9.60
36	SPT+UD	BH-06	STA 8+865, CL	7.741	110 200.271	200 274.756	0.00	8.15
37	SPT+UD	BH-07	STA 8+740, CL	7.608	110 213.352	200 200.951	0.75	6.40
38	SPT+UD	BH-08	STA 8+850, CL	7.010	110 232.544	200 092.631	0.20	2.40
39	SPT+UD	BH-17	STA 9+800, CL	6.521	110 407.110	199 264.130	0.10	8.60
40	SPT+UD	BH-24	STA 10+535, CL	8.391	110 653.346	198 572.169	0.10	4.00
41	SPT+UD	BH-25	STA 10+600, CL	8.879	110 679.623	198 512.839	0.10	6.00
42	SPT+UD	BH-26	STA 10+700, CL	9.236	110 721.278	198 421.722	0.05	8.00
43	SPT+UD	BH-27	STA 10+800, CL	11.781	110 784.618	198 331.685	0.05	11.20

Table 2.2.3-2 Details of Boreholes

44	SPT+UD	BH-28	STA 10+800, L-35	10.477	110 795.925	198 347.129	0.00	9.45
45	SPT+UD	BH-29	STA 10+950, CL	16.067	110 830.794	198.197.148	1.50	25.00
46	SPT+UD	BH-37	STA 11+750, CL	10.121	111 124.307	197 453.535	0.10	12.12
47	SPT+UD	BH-43	STA 12+350, CL	5.618	111 351.255	196 898.550	0.20	14.20
48	SPT+UD	BH-49	STA 13+000, CL	3.079	111 620.711	196 307.279	5.00	17.60
49	SPT+UD	BH-50	STA 13+100, CL	2.924	111 656.340	196 213.812	0.00	6.45
50	SPT+UD	BH-51	STA 13+200, CL	2.696	111 690.312	196 119.776	0.00	10.90
51	SPT+UD	BH-52	STA 13+300, CL	2.545	111 722.542	196 025.097	0.00	11.20
52	SPT+UD	BH-53	STA 13+400, CL	2.379	111 653.039	195 929.856	0.00	12.70
53	SPT+UD	BH-54	STA 13+500, CL	2.160	111 781.813	195 834.053	0.00	12.70
54	SPT+UD	BH-55	STA 13+600, CL	1.224	111 808.806	195 737.757	0.00	10.75
55	SPT+UD	BH-56	STA 123+700, CL	1.726	111 833.902	195 641.025	0.00	11.10
56	SPT+UD	BH-57	STA 13+800, CL	1.616	111 855.630	195 543.388	0.00	13.80
57	SPT+UD	BH-58	STA 13+900, CL	1.690	111 837.703	195 445.049	0.00	12.70
58	SPT+UD	BH-59	STA 14+000, CL	1.751	111 888.089	195 346.133	0.00	12.90
59	SPT+UD	BH-61	STA 14+340, CL	–	111 909.687	195 007.010	0.00	10.00
60	SPT+UD	BH-69	STA 15+130, CL	1.550	111 795.309	194 228.164	0.20	16.70
61	SPT+UD	BH-70	STA 15+233, CL	1.804	111 763.733	194 130.114	0.30	15.00
62	SPT+UD	BH-71	STA 15+300, CL	2.051	111 741.094	194 066.988	0.40	14.00
63	SPT+UD	BH-72	STA 15+400, CL	1.124	111 704.785	193 973.960	0.50	10.60
64	SPT+UD	BH-73	STA 15+500, CL	1.939	111 664.910	193 882.342	0.40	7.40
65	SPT+UD	BH-75	STA 15+860, CL	4.028	111 516.673	193 554.216	0.00	4.65
66	SPT+UD	BH-77	STA 15+946, CL	3.943	111 543.078	193 558.824	2.70	5.40
67	SPT+UD	BH-79	STA 16+000, CL	0.507	111 468.677	193 422.718	0.60	8.00
68	SPT+UD	BH-80	STA 16+100, CL	1.447	111 442.412	193 327.037	0.00	10.70
69	SPT+UD	BH-81	STA 16+170, CL	5.264	111 425.317	193 259.276	4.40	21.60
70	SPT+UD	BH-82	STA 16+240, CL	5.456	111 408.417	193 190.843	5.40	30.70
71	SPT+UD	BH-83	STA 16+300, CL	–	111 397.667	193 131.520	0.00	11.10
72	SPT+UD	BH-84	STA 16+360, CL	–	111 388.754	193 072.192	0.00	14.10
73	SPT+UD	BH-85	STA 16+415, CL	–	111 382.141	193 017.590	2.40	26.30
74	SPT+UD	BH-86	STA 16+490, CL	–	111 375.547	192 942.885	2.10	22.35
75	SPT+UD	BH-87	STA 8+647 ,R	7.783	110 178.752	200 289.280	0.00	15.15
76	SPT+UD	BH-88	STA 8+850, CL	7.879	110 230.228	200 256.982	0.00	5.80
77	SPT+UD	BH-89	STA 8+786, R-32	7.661	110 190.017	200 149.748	0.60	3.15
78	SPT+UD	BH-91	STA 10+192, R	23.349	110507.894	198884.834	10.50	12.65
79	SPT+WSP+WS	BH-19	STA 10+020, CL	21.983	110 473.535	199 060.487	9.28	15.50
80	SPT+WSP+WS	BH-32	STA 11+258, CL	31.07	110 956.101	197 915.639	3.60	6.90
81	SPT+WSP+WS	BH-36	STA 11+650, CL	15.354	111 091.917	197 648.170	2.70	12.45
82	SPT+WSP+WS	BH-45	STA 12+518, CL	17.653	111 424.639	196 752.634	9.50	12.70
83	SPT+WSP+WS	BH-63	STA 14+535, CL	14.14	111 902.744	194 812.158	10.70	20.45
84	SPT+WSP+WS	BH-68	STA 14+843, CL	18.747	111 862.100	194 501.011	9.80	30.00
85	SPT+WSP+WS	BH-74	STA 15+730, CL	13.956	111 568.708	193 673.169	NE	3.70
		A1						
86	SPT+UD	BH-01	STA 0+290,CL	0.702	110 145.996	200 032.133	0.70	13.45
87	SPT+UD	BH-02	STA 0+390, CL	10.931	109 971.147	200 290.883	1.60	15.45
88	SPT+UD	BH-03	STA 0+800,CL	7.804	110 351.034	200 359.654	0.45	12.37
89	SPT+UD	BH-04	STA 1+210, CL	8.968	110 613.134	200 674.976	0.50	10.45
90	SPT+UD	BH-05	STA 0+290,CL	11.200	109 875.948	200 315.906	0.55	4.65
91	SPT+UD	BH-06	STA 0+527, CL	7.913	110 128.478	200 261.328	0.45	11.80
92	SPT+UD	BH-07	STA 1+500, CL	9.948	110 774.263	200 918.588	0.70	2.25

Remarks

SPT	Standard Penetration Test
UD	Undisturbed Sampling
WSP	Water Standpipe Installation
WS	Water Sampling
SS	Soil Sampling

Table 2.2.3-3 Details of Boreholes

NO.	Borehole No	Coordinates		Ground Elevation (m)	Ground Water Level (m)	Total Depth (m)
		X	Y			
1	AD BH-01	110 211.031	200 226.170	7.464	0.00	6.80
2	AD BH-02	110 230.752	200 147.284	7.297	0.00	7.20
3	AD BH-03	110 229.330	200 113.165	7.208	0.00	9.55
4	AD BH-06	110 154.680	200 029.940	6.976	0.00	13.30
5	AD BH-07	110 200.353	200 059.026	6.868	0.00	6.70
6	AD BH-08	110 208.299	200 099.532	7.255	0.00	7.60
7	AD BH-12	110 122.371	200 040.846	6.881	0.00	10.00
8	AD BH-13	110 320.708	200 221.161	7.332	0.00	5.60
9	AD BH-14	110 280.953	200 202.121	7.517	0.00	11.60
10	AD BH-15	110 241.548	200 224.499	7.453	0.00	7.50
11	AD BH-16	110 257.172	200 167.587	8.736	0.00	10.50
12	AD BH-17	110 248.801	200 137.308	7.730	0.00	7.70
13	AD BH-19	111 845.093	195 593.224	1.581	0.00	20.20
14	AD BH-20	111 866.310	195 488.027	1.359	0.00	15.45
15	AD BH-21	111 882.484	195 387.578	1.766	0.00	11.50
16	AD BH-22	111 895.306	195 280.713	1.745	0.00	16.50
17	AD BH-23	111 775.976	194 167.363	1.478	0.00	16.80
18	AD BH-24	111 751.116	194 096.255	1.708	0.00	12.60
19	AD BH-25	111 727.151	194 029.800	2.402	0.70	12.55
20	AD BH-26	111 686.713	193 931.275	1.397	1.00	9.20
21	AD BH-27	111 480.487	193 458.340	1.623	0.70	9.60
22	AD BH-28	111 462.300	193 376.796	5.281	4.10	17.25
23	AD BH-29	111 512.883	193 480.293	1.824	1.05	10.65
24	AD BH-30	111 497.520	193 413.340	0.923	0.35	5.90
25	AD BH-31	111 483.797	193 356.082	4.687	3.70	14.70
26	AD BH-32	111 470.255	193 497.707	4.000	3.00	11.85
27	AD BH-33	111 439.947	193 433.323	0.614	0.00	10.00
28	AD BH-34	111 412.835	193 358.964	1.197	0.00	12.00
29	AD BH-35	111 399.165	193 311.997	2.235	0.30	17.20
30	AD BH-36	111 432.164	193 296.262	1.089	0.00	10.20
31	AD BH-37	111 415.467	193 224.855	5.253	4.70	21.60
32	AD BH-38	110 218.544	200 298.738	7.701	0.30	12.20
33	AD BH-39	110 183.352	200 249.618	7.629	0.00	14.25
34	AD BH-40	110 197.056	200 179.806	7.788	0.40	6.75
35	AD BH-41	110 224.892	200 072.311	8.627	1.20	6.70
36	AD BH-43	110 175.395	200 037.918	6.992	0.10	11.65
37	AD BH-44	110 260.984	200 212.778	7.589	0.00	9.60
38	AD BH-45	110 266.792	200 182.121	7.283	0.00	14.65
39	AD BH-46	111 852.932	195 555.513	1.665	0.00	15.45
40	AD BH-47	111 859.818	195 521.703	1.534	0.00	20.65
41	AD BH-48	111 877.040	195 424.764	1.745	0.00	18.35
42	AD BH-49	111 892.584	195 315.560	1.740	0.00	22.90
43	AD BH-50	111 783.799	194 190.209	1.431	0.00	19.90
44	AD BH-51	111 709.567	193 990.157	3.048	0.80	11.00
45	AD BH-52	111 523.382	193 522.991	3.876	2.40	6.00
46	AD BH-53	111 488.826	193 532.553	3.503	2.00	7.60
47	AD BH-54	111 455.033	193 466.607	3.113	3.50	17.80
48	AD BH-55	111 424.987	193 394.600	0.346	0.60	13.50
49	AD BH-63	111 175.287	197 312.408	10.167	2.80	19.20
50	AD BH-64	111 211.475	197 219.364	11.157	3.05	11.30
51	AD BH-65	111 249.375	197 126.902	11.966	4.40	10.65
52	AD BH-66	111 330.076	196 943.816	5.862	0.50	13.70
53	AD BH-67	111 603.029	196 351.839	2.796	0.00	19.50
54	AD BH-68	111 909.720	195 047.120	3.415	1.35	5.10
55	AD BH-69	111 804.010	194 256.795	1.593	0.60	23.30

Table 2.2.4 Detail of Auger Holes

NO.	Type of Hole	Auger hole No.	Chainage	Ground Elevation (m)	Coordinates		Ground Water Level (m)	Total Depth (m)
					X	Y		
1	SS	NS1, AB-01	STA 8+200, CL	9.332	110 095.688	200 726.680	1.00	3.50
2	SS	NS1, AB-02	STA 8+300, CL	8.803	110 129.982	200 632.653	2.50	4.00
3	SS	NS1, AB-04	STA 8+500, CL	8.200	110 171.394	200 437.209	0.00	3.50
4	SS	NS1, AB-08	STA 9+106, CL	24.748	110 277.314	199 840.514	NE	3.00
5	SS	NS1, AB-09	STA 9+340, CL	9.870	110 300.834	199 711.423	1.20	5.00
6	SS	NS1, AB-10	STA 9+520, CL	22.432	110 337.932	199 535.438	NE	4.00
7	SS	NS1, AB-12	STA 9+850, CL	6.764	110 420.820	199 216.068	0.00	5.00
8	SS	NS1, AB-13	STA 10+020, CL	21.983	110 473.435	199 060.487	NE	5.00
9	SS	NS1, AB-16	STA 10+745, CL	9.882	110 740.606	198 381.094	1.00	4.50
10	SS	NS1, AB-17	STA 10+880, CL	13.827	110 800.162	198 260.133	1.00	4.50
11	SS	NS1, AB-18	STA 11+258, CL	31.070	110 956.101	197 915.739	1.00	3.50
12	SS	NS1, AB-19	STA 11+400, CL	23.834	111 008.509	197 783.807	1.00	3.00
13	SS	NS1, AB-20	STA 11+530, CL	19.389	111 055.751	197 662.449	1.00	3.05
14	SS	NS1, AB-21	STA 11+700, CL	11.873	111 108.085	197 500.885	1.00	3.00
15	SS	NS1, AB-22	STA 11+800, CL	10.027	111 140.896	197 406.896	1.00	3.50
16	SS	NS1, AB-24	STA 11+950, CL	8.112	111 221.121	197 276.688	0.00	3.00
17	SS	NS1, AB-25	STA 12+160, CL	15.845	111 272.855	197 071.588	NE	2.00
18	SS	NS1, AB-27	STA 50+100, CL	17.530	111 424.849	196 752.789	NE	2.05
19	SS	NS1, AB-28	STA 12+650, CL	9.215	111 483.536	196 630.093	3.40	4.00
20	SS	NS1, AB-29	STA 12+725, CL	6.582	111 514.016	196 560.690	4.00	4.00
21	SS	NS1, AB-30	STA 12+800, CL	7.213	111 544.331	196 492.110	NE	2.50
22	SS	NS1, AB-31	STA 12+800, R	4.051	111 518.679	196 480.908	0.00	5.00
23	SS	NS1, AB-33	STA 13+050, CL	2.524	111 639.047	196 280.426	0.00	4.50
24	SS	NS1, AB-35	STA 13+250, CL	2.479	111 706.653	196 072.698	0.00	4.00
25	SS	NS1, AB-37	STA 13+450, CL	1.973	111 767.721	195 881.980	3.00	4.00
26	SS	NS1, AB-39	STA 13+650, CL	1.693	111 821.650	195 689.514	0.00	3.05
27	SS	NS1, AB-41	STA 13+850, CL	1.513	111 865.295	195 494.295	0.00	3.50
28	SS	NS1, AB-43	STA 14+050, CL	1.778	111 893.908	195 296.531	0.00	4.00
29	SS	NS1, AB-44	STA 14+160, CL	1.982	111 903.680	195 186.882	0.00	2.50
30	SS	NS1, AB-46	STA 14+250, CL	5.951	111 906.079	195 096.980	0.00	3.00
31	SS	NS1, AB-47	STA 14+250, L-32	1.596	111 940.094	195 098.187	1.00	4.50
32	SS	NS1, AB-49	STA 14+410, CL	6.521	111 908.740	194 936.993	0.00	3.00
33	SS	NS1, AB-50	STA 14+655, CL	5.931	111 891.410	194 692.629	0.00	3.50
34	SS	NS1, AB-51	STA 14+765, CL	19.739	111 876.513	194 583.749	0.00	3.00
35	SS	NS1, AB-52	STA 14+843, CL	18.405	111 863.186	194 508.855	0.00	2.50
36	SS	NS1, AB-56	STA 15+450, CL	1.631	111 685.174	193 927.813	NE	4.00
37	SS	NS1, AB-58	STA 15+550, CL	0.927	111 674.922	193 822.870	NE	3.00
28	SS	NS1, AB-59	STA 15+600, CL	3.727	111 623.124	193 791.449	0.00	1.00
39	SS	NS1, AB-60	STA 15+600, L-33	3.262	111 623.094	193 777.528	1.00	4.00
40	SS	NS1, AB-62	STA 16+455	–	–	–	3.00	3.00
41	SS	A1, AB-01	STA 0+260,CL	11.578	109 8046.275	200 320.427	1.00	4.00
42	SS	A1, AB-02	STA 0+450, CL	9.124	110 028.186	200 271.752	1.00	5.50
43	SS	A1, AB-04	STA 0+100, CL	8.335	110 502.935	200 408.008	4.00	4.00
44	SS	A1, AB-05	STA 1+010, CL	8.416	110 485.916	200 520.703	1.00	4.00
45	SS	A1, AB-07	STA 0+620, CL	10.300	110 799.716	201 032.929	2.50	2.00

Table-2.2.5 Location of Field Vane Shear Test

AH No	Location	Elevation
NS1		
AB-03, (FV-01)	STA 8+400, CL	8.582
AB-05, (FV-02)	STA 8+600, CL	7.881
AB-06, (FV-03)	STA 8+800, CL	7.248
AB-11, (FV-04)	STA 9+750, CL	6.531
AB-15, (FV-05)	STA 10+650, CL	9.002
AB-23, (FV-06)	STA 11+850, L-25	8.872
AB-26, (FV-07)	STA 12+300, CL	5.941
AB-32, (FV-08)	STA 12+950, CL	2.808
AB-34, (FV-09)	STA 13+150, CL	2.609
AB-36, (FV-10)	STA13+350, CL	2.453
AB-38, (FV-11)	STA 13+550, CL	1.595
AB-40, (FV-12)	STA 13+750 CL	1.621
AB-42, (FV-13)	STA 13+950, CL	1.691
AB-45, (FV-14)	STA 14+160, L-40	1.914
AB-48, (FV-15)	STA 14+340, L-32	2.079
AB-54, (FV-16)	STA 15+180, CL	1.288
AB-55, (FV-17)	STA 15+350, CL	2.630
AB-61, (FV-18)	STA 16+050, CL	1.271
A1		
AB-03, (FV-01)	STA 0+100, CL	7.737
AB-06, (FV-02)	STA 0+410, CL	9.550

Table-2.2.6 Location of Water Standpipe

BH No	Location
BH-11	STA 9+110, L-125
BH-19	STA 10+080, L-98
BH-20	STA 10+080, L-98
BH-21	STA 10+210, CL
BH-31	STA 11+132, R-55
BH-32	STA 11+258, CL
BH-34	STA 11+260, R-135
BH-36	STA 11+650, CL
BH-45	STA 12+518, CL
BH-46	STA 12+555, L-125
BH-63	STA 14+535, CL
BH-64	STA 14+550, R-123
BH-66	STA 14+725, R-32
BH-68	STA 14+843, CL
BH-74	STA 15+730, CL

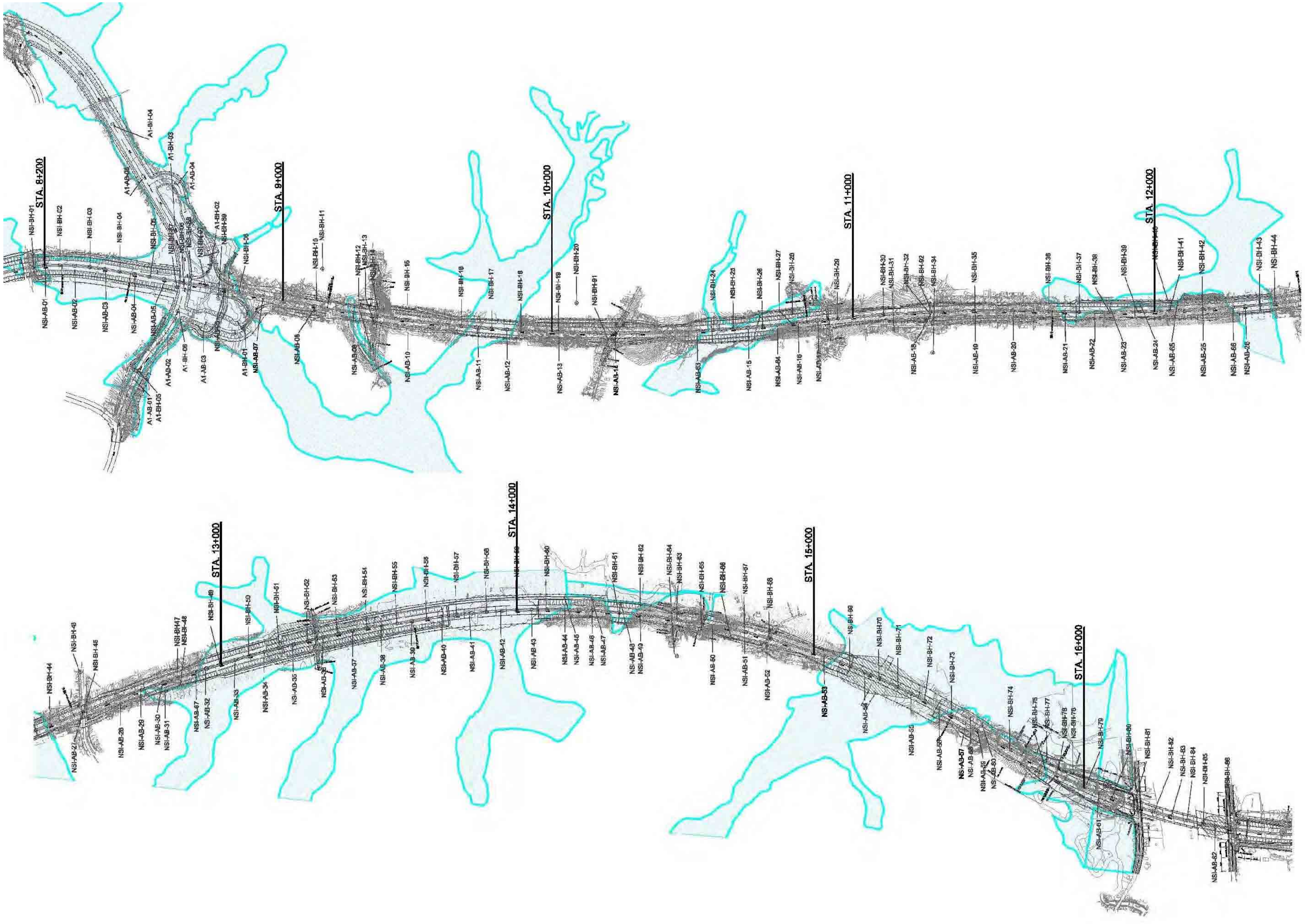


Fig. 2.2.3 Borehole Location Map

(2) Results of Geological Survey

1) Result of Drilling Survey

The crystalline metamorphic rock known as Highland Complex (HC) forms the base rock of the route. On this base rock, completely weathered rock such as gravel with sand and clay is distributed, which is covered with residual soil such as sand, silt and clay with gravels. In valley and plain areas, alluvial sand, alluvial clay and peat or organic clay is distributed. Some roads that cross the valley areas consist of embankment materials, and the thicknesses of these formations are as follows:

Table 2.2.7 Thickness of Formations

Symbol	Formation	Thickness (m)	
		Max.	Min.
B	Fill	3.00	0.50
Pt	Peat	3.00	0.50
Oc	Organic Clay	6.00	0.50
Ac	Alluvial Clay (Inorganic Clay)	4.00	0.50
Acs	Alluvial Sandy Clay	4.00	0.50
As	Alluvial Sand	7.50	0.50
Rs	Residual Soil	15.00	0.50
Wr	Completely Weathered Rock	17.00	1.00
Br	Wethered to Fresh Rock	-	-

(a) Description of Geological Formation

I. Fill (B)

This formation is located on roads crossings in valley areas. The general thickness of this formation is about from 0.5 meters to 2.0meters, and is reddish brown to dark brown in color. The faces indicate lateritic clay, sandy clay and gravelly clay, and the consistency is loose or soft.

II. Peat or Organic Soil (Pt or Oc)

This formation is distributed in marshes and valleys and can be mainly found between Sta. No. 9+740 and Sta. No. 9+880, between Sta. No. 12+260 and Sta. No. 12+380, Sta. No. 12+940 and 14+160, Sta. No. 15+080 and 15+540, and also between Sta. No.16+050 and 16+220 on the route. Especially peat is distributed between Sta. No. 12+940 and 14+160 and between Sta. No. 15+080 and 15+540. The general thickness of this formation is about from1 to 5 meters and 1 to 2 meters for organic clay and peat respectively. It shows dark brown to black in color. This formation contains many organic materials and its consistency is very soft.

III. Alluvial Clay (Ac)

AC is distributed in valley and plain areas and is usually about 2 to 3 meters in thickness. It is generally soft and has N-value under 4. And it is dark gray to dark brown in color and its faces indicate silty clay or clayey silt. At some areas, there are Ac layers under Pt or Oc layers. These are generally medium or hard and have N-value 4 or more. And it is gray to brownish gray in color and its faces indicate clayey silt or silty clay.

IV. Alluvial Sandy Clay (Acs)

Acs is also distributed in valley and plain areas and is usually about 2 to 3 meters in thickness. It is generally soft and has N-value under 4. And it is dark gray to dark brown in color and its faces indicate sandy clay or sandy silt. At some areas, there are also Acs layers as well as Ac layer under Pt or Oc layers. These are generally medium or hard and have N-value 4 or more. And it is gray to brownish gray in color and its faces indicate sandy silt or sandy clay.

V. Alluvial Sand (As)

As is distributed under alluvial clay in valley and plain areas and is usually about 3 to 5 meters in thickness. The color of As varies from gray to brown, and its faces indicate fine sand or medium sand with fine content such as silt or clay. Its relative density is generally loose to medium.

VI. Residual Soil (Rs)

RS is distributed on slopes and tops of hills and can also be found under alluvial soil. It is usually about 3 to 10 meters thick, and can be of various colors such as yellow, pinkish gray or gray, which corresponds to the mineral composition or degree of weathering of the base rock. The faces indicate a silty clay or sandy clay with gravel. Rs consistency is medium to stiff on the slopes of hill, but at some places, is soft at the foot of hills.

VII. Completely Weathered Rock (Wr)

Wr is distributed under residual soil and is usually about 5 to 10 meters thick. Near hills, however, thickness can reach about 15 meters. The color of Wr is also various and can be yellow, gray, white or brown. The faces indicate silty fine sand with gravel or sandy silt, which sometimes contains granules of quartz, feldspar and mica. Relative density is medium to very dense.

VIII. Weathered and Fresh Rock (Br)

Fr is distributed under completely weathered rock and mainly consists of granitic gneiss. Fr is encountered in drilling work as a continuous core of hard rock usually 15 to 50 cm in length. This rock is moderately to slightly weathered but is a good base rock for serving as a bearing layer.

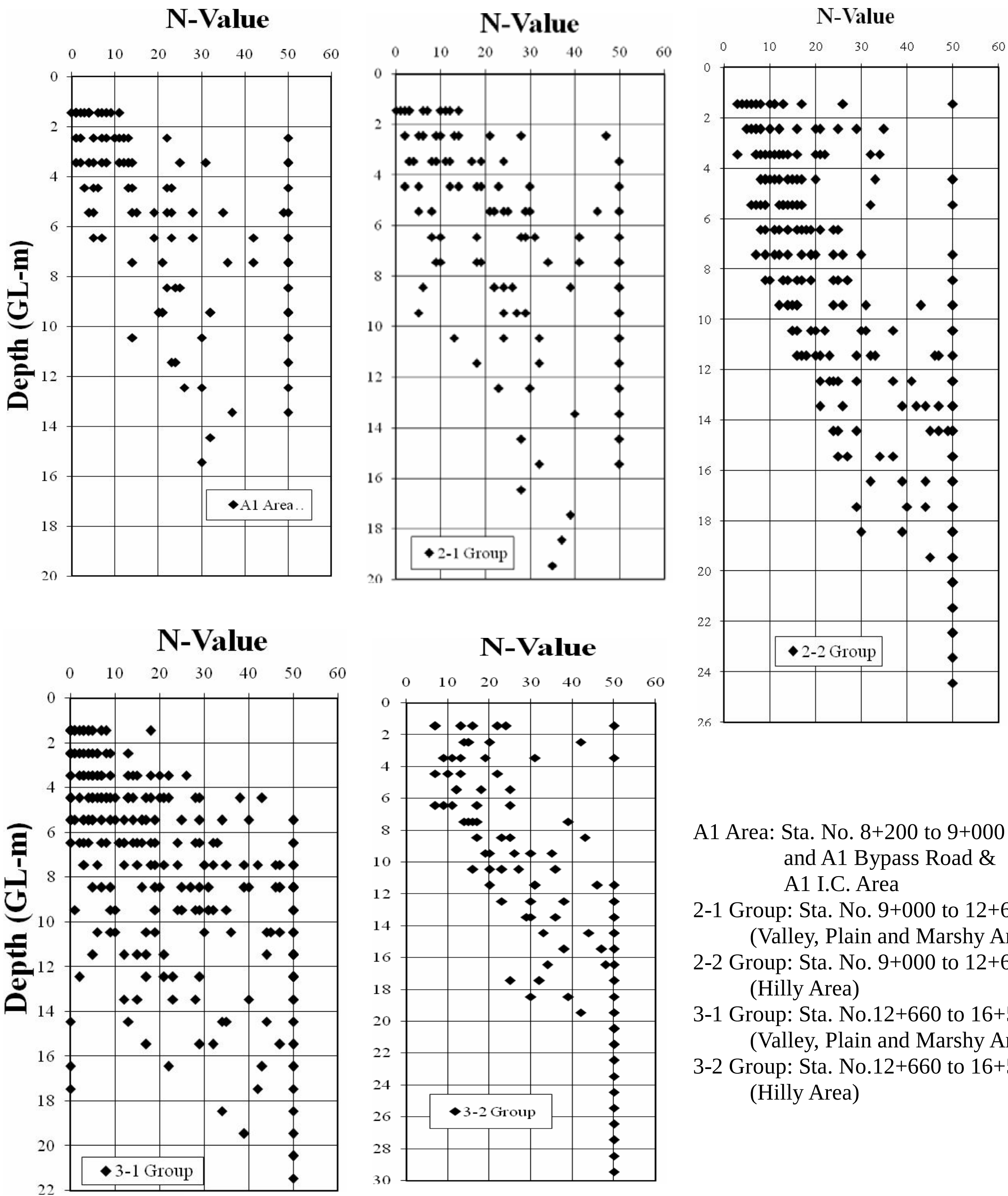
2) Results of Standard Penetration Test (SPT)

The N-value of each geological formation is shown in **Table 2.2.7**.

Table 2.2.8 Results of SPT

Item	Formation	N-Value
B	Fill	1 to 5
Pt	Peat	0 to 1
Oc	Organic Clay	0 to 4
Ac	Alluvial Clay (Inorganic Clay)	0 to 10
Acs	Alluvial Sandy Clay	2 to 15
As	Alluvial Sand	3 to 40
Rs	Residual Soil	5 to 30
Wr	Completely Weathered Rock	3 to 50
Br	Wethered to Fresh Rock	-

The N-values of alluvial clay, alluvial sand, residual soil and completely weathered rock are is distributed in wide range, and vary according to deposition conditions. Of the alluvial soils, dense gravelly sand has maximum N-value, while loose sand with high moisture content has minimum N-value. As for residual soil, gravelly soil on hills has maximum N-value and soft soil located under alluvial soil has minimum N-value. In the case of weathered rock, gravelly sand with its original rock texture has maximum N-value, while highly weathered clayey soil has minimum N-value. N-values of all fresh rock is more than 50 because it can not be penetrated.
N-value distributions to depth along the OCHNS1 are plotted area by area as shown in **Fig. 2.2.4** and **Fig. 2.2.5**.



A1 Area: Sta. No. 8+200 to 9+000
and A1 Bypass Road &
A1 I.C. Area
2-1 Group: Sta. No. 9+000 to 12+660
(Valley, Plain and Marshy Area)
2-2 Group: Sta. No. 9+000 to 12+660
(Hilly Area)
3-1 Group: Sta. No.12+660 to 16+500
(Valley, Plain and Marshy Area)
3-2 Group: Sta. No.12+660 to 16+500
(Hilly Area)

Fig. 2.2.4 SPT N-value Distribution to Depth

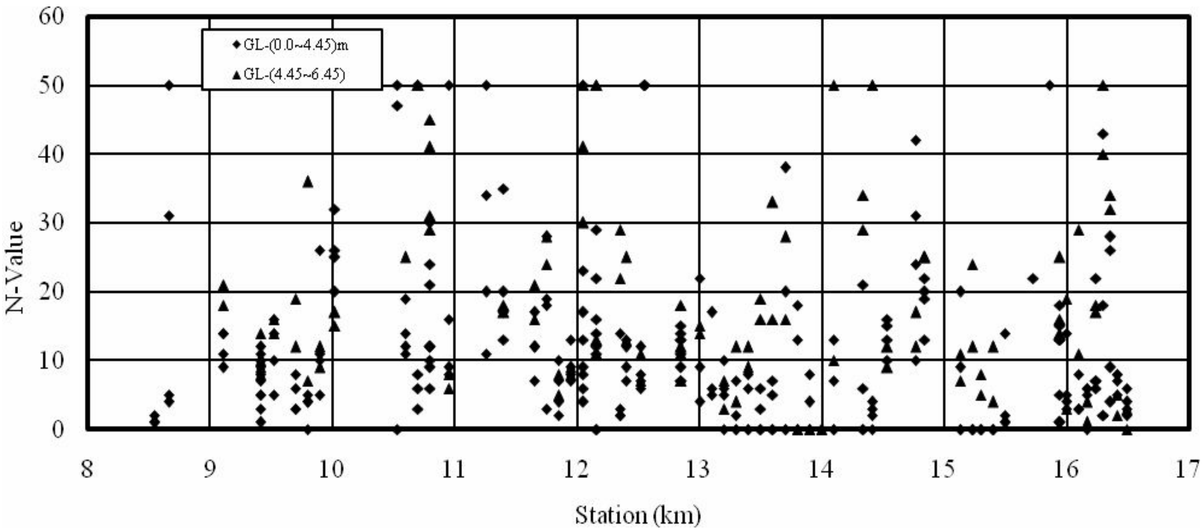


Fig. 2.2.5 SPT N-value Distribution along OCHNS1 (shallower than 6 meters)

3) Geological Profile along the Route

A geological profile was prepared based on the results of drilling work, field vane shear tests and auger boring result. These profiles are shown in Fig. 2.2.6 to Fig. 2.2.9 and the Appendix Geological Profile. The geological conditions of OCHNS1 are described below.

I. Sta. No. 8+200 – Sta. No. 9+000 (800m)

On this section, there are paddy fields. Under the top soil, alluvial clay and sandy clay are distributed in about 3 meter thick underlain by completely weathered rock layer. In this completely weathered rock layer, the depth at which it has more than 50 N-value of SPT are around G.L.-5 to -10 meter. It can be firm bearing layer for structures such as bridge.

II. Sta. No. 9+000 – Sta. No. 12+660 (3,660m)

This section is mainly located in a hilly area and small valleys. At small valleys, soft soils are deposited such as alluvial clay, sandy clay and organic clay in 2 to 5 meter thick. At each top of the hills, there are many houses along the road. These hills consist of residual soil 2 to 15 meters in thickness and completely weathered rock 4 to 20 meters in thickness. The residual soil consists of clayey sand or sandy silt and its N-value ranges from 5 to 30. The weathered rock consists of gravelly clayey soil and its N-value ranges from 10 to 50. Between Sta. No. 11+750 and Sta. No.12+080, alignment OCH is running parallel with the toe of the hill.

III. Sta. No. 12+660 – Sta. No. 14+500 (1,840m)

This section is located mainly in a marshy area, ground level of which is about 1 to 2 meters above sea level. Very soft peat and organic clay are identified in this section. The alluvial formation consists of peat, organic clay, sandy clay is 3 to 7 meters in thickness. Over the whole section, there are organic clay and peat formation about 1 to 3 meters thick on the surface of the valley plain, and it is very soft with a high moisture content. The thickness of the layers is over 6m within a particular 300m section between Sta. No.

13+750 and Sta. No. 14+050. And also in the rainy season most of this area is soaked in the water.

IV. Sta. No. 14+500 – Sta. No. 15+700 (1,200m)

This section consists of hilly area and plain area. The altitude of hilly area composed of residual soil is about 10 to 20 meters above sea level. At the plain area between Sta. No. 14+080 and Sta. No. 15+540, very soft alluvial clay, organic clay and peat are distributed in 4 to 6 meters thick. In this particular plain section, it is also soaked in the water in the rainy season.

V. Sta. No. 15+700 – Sta. No. 16+500 (800m)

This section is located in a hilly area and plain area beside the Kelani River. Hilly area near Sta. No. 15+700 consists of residual soil and fresh rock. And the left section between Sta. No. 15+900 and Sta. No. 16+500 consists of soft organic clay, peat and alluvial clay in 5 to 10 meters thick besides the right bank of Kelani River which consists of alluvial sand and gravel layer in 6 to 17 meters thick.

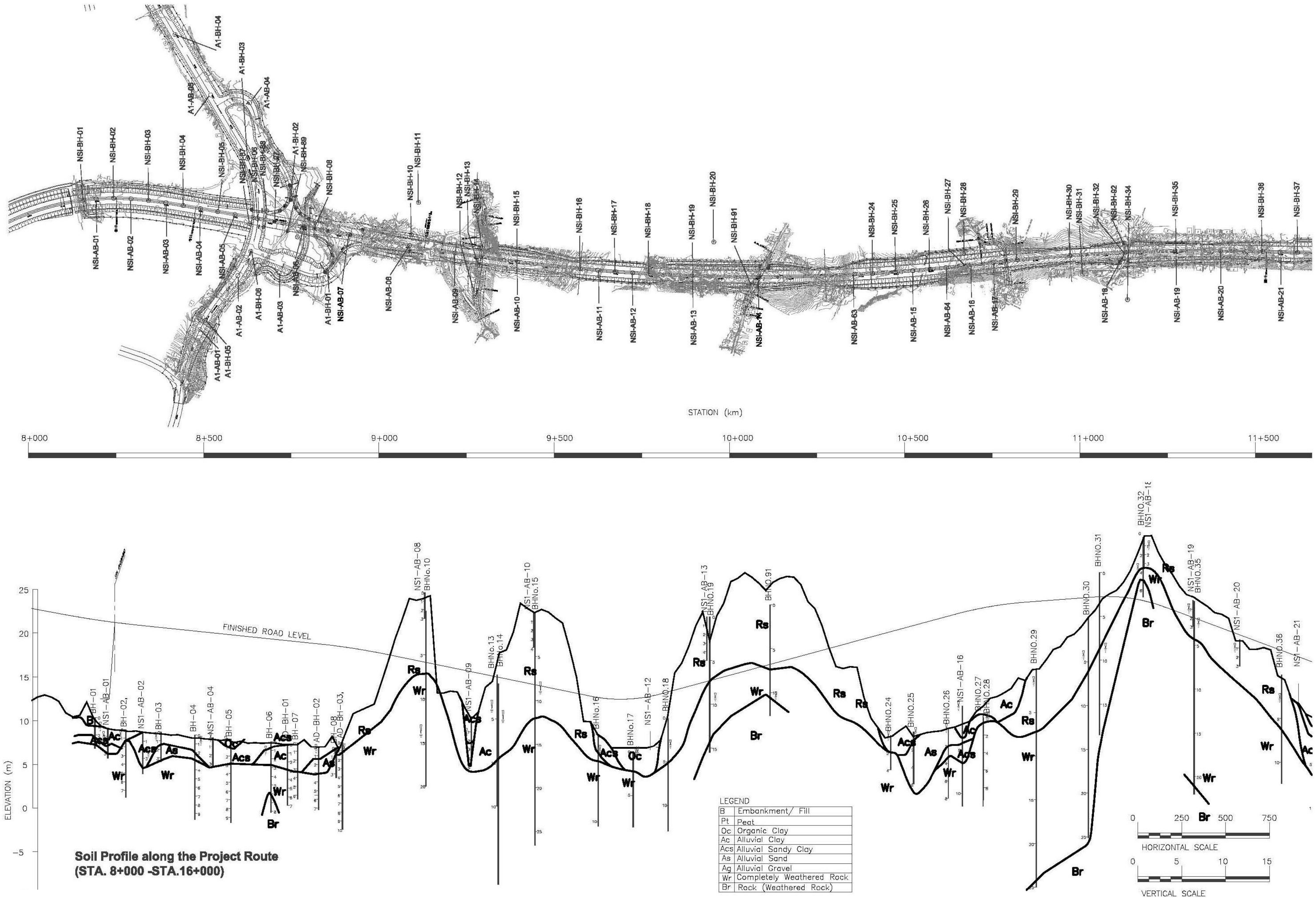


Fig 2.2.6 Geological Profile along the OCHNS1

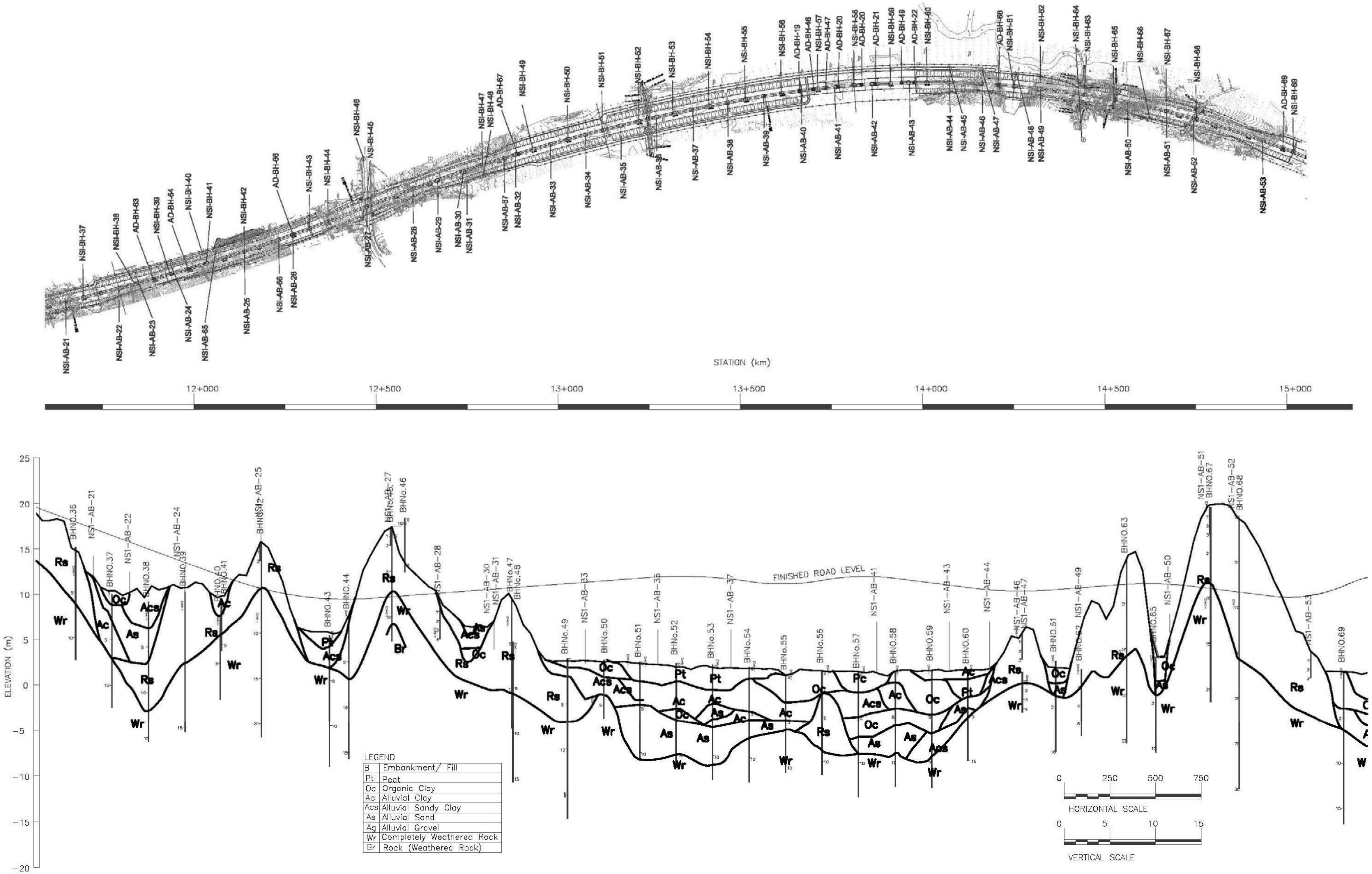


Fig 2.2.7 Geological Profile along the OCHNS1

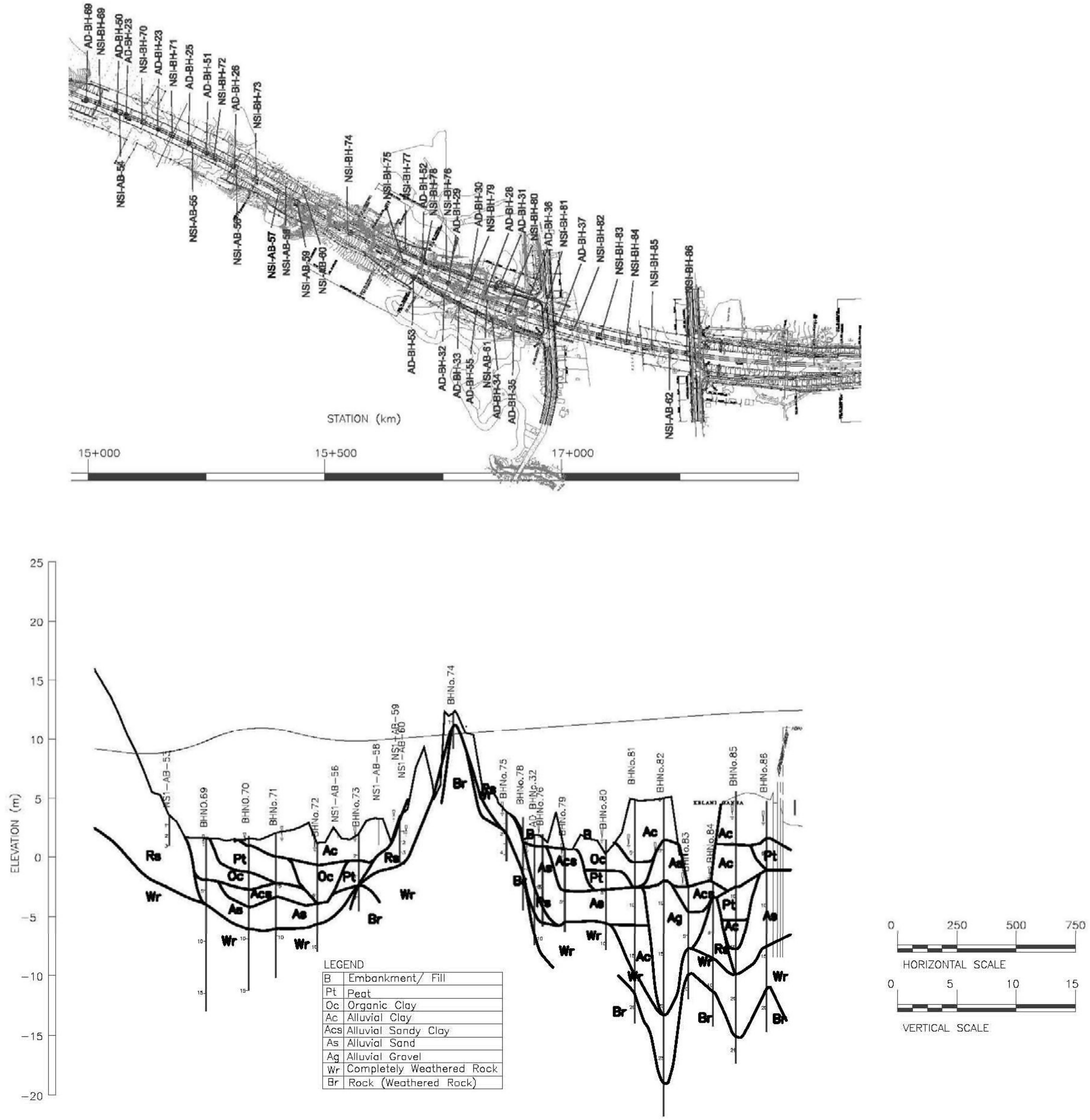


Fig 2.2.8 Geological Profile along the OCHNS1

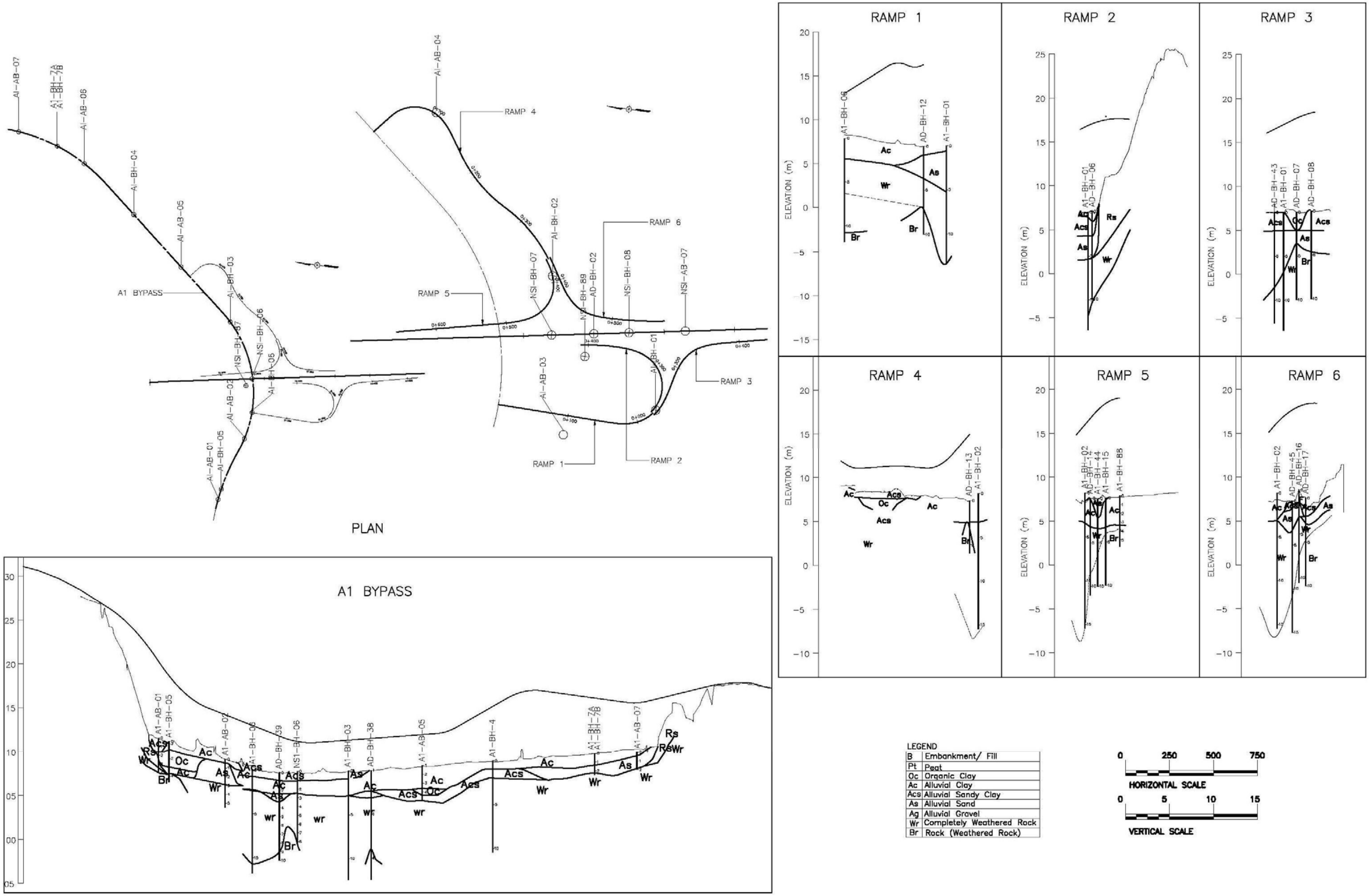


Fig 2.2.9 Geological Profile along the OCHNS1

4) Result of Field Vane Shear Test

Field Vane shear test has been carried out in the soft soil layer such as peat, organic clay and alluvial clay to obtain in-situ shear strength of soft soil. Vane shear strength (Cu(fv)) distributions to along the OCHNS1 are plotted as shown in **Fig. 2.2.10**.
Cu(fv) values of soft soil are plotted at each depth between 5kN/m2 and 15kN/m2.

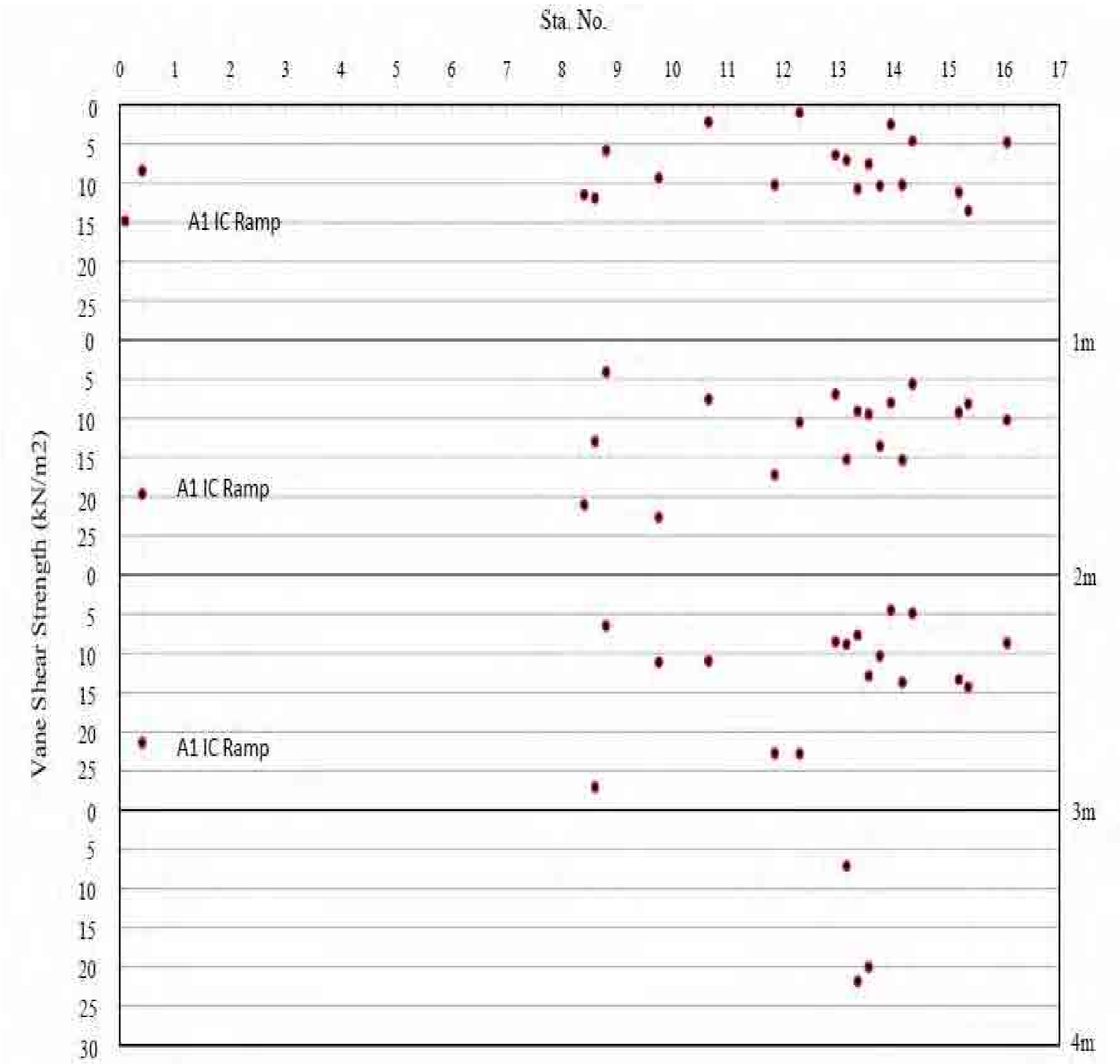


Fig. 2.2.10 Vane Shear Strength along the OCHNS1

5) Result of Laboratory Test

From boring and vane share test results, it seems that the treatment of very soft peat, organic clay and alluvial clay is very important to construct road embankment. Along the OCHNS1, peat and organic clay are mainly found at the plain and valley areas between Sta. No. 13+140 to Sta. No. 16+170. A comparison of the physical properties of peat, organic clay and alluvial clay is shown in **Table 2.2.9**.

Table 2.2.9 Comparison of Peat and Clay Physical Properties

Item		Peat	Organic Clay	Clay	Sandy Clay
Wet Density	(g/cm3)	1.6 - 1.7	1.6 - 1.7	1.4 - 1.6	2.0 – 2.1
Moisture Content	(%)	20 - 200	30 - 200	20 - 200	10 - 90
Ignition Loss	(%)	10 - 30	10 - 50	< 25	< 15
Specific Gravity	GS	2.1 - 2.5	2.3 - 2.6	2.3 - 2.7	2.4 - 2.7
Void Ratio	e	1 – 2	1 - 3	1 - 2	1 - 2

According to comparison result of soil properties (**Table 2.3.9**), the properties of peat samples tested in this study are very similar to that of organic clay. It means peat samples tested is not so-called “peat”, it can be considered that it is peaty clay. However numbers of samples of peat is not so much to conclude the properties of the whole peat layer distributed along the OCHNS1. And also it should be considered that the soil properties especially mechanical properties can change a lot due to change of water content because investigation work including soil sampling was carried out in the dry season. It was very easy to change the water content of soil samples especially for the high water content soil such as peat, organic clay and alluvial clay. Therefore it is necessary to stand at conservative side when selecting the soil parameters of peat and also other soils for design.

Summary of physical property, mechanical property, chemical and water quality test results are attached to this report as Appendix. Those distributions along the OCHNS1 are plotted as shown in **Fig. 2.2.11** to **Fig. 2.2.15**.

(3) Geotechnical Consideration

Very soft peat and organic clay and also alluvial clay is distributed at the plain area between Sta. No. 13+140 and 16+170. And also most of this section is usually soaked in the water in the rainy season every year. So it can be recommended that at least for some portions of this section, viaduct is more preferable than embankment structure from geological and geotechnical point of view.

It is assumed that alluvial clay, alluvial sand, residual soil and some part of completely weathered rock would be inadequate to ensure the bearing capacity of structures because of their low N-values of SPT.

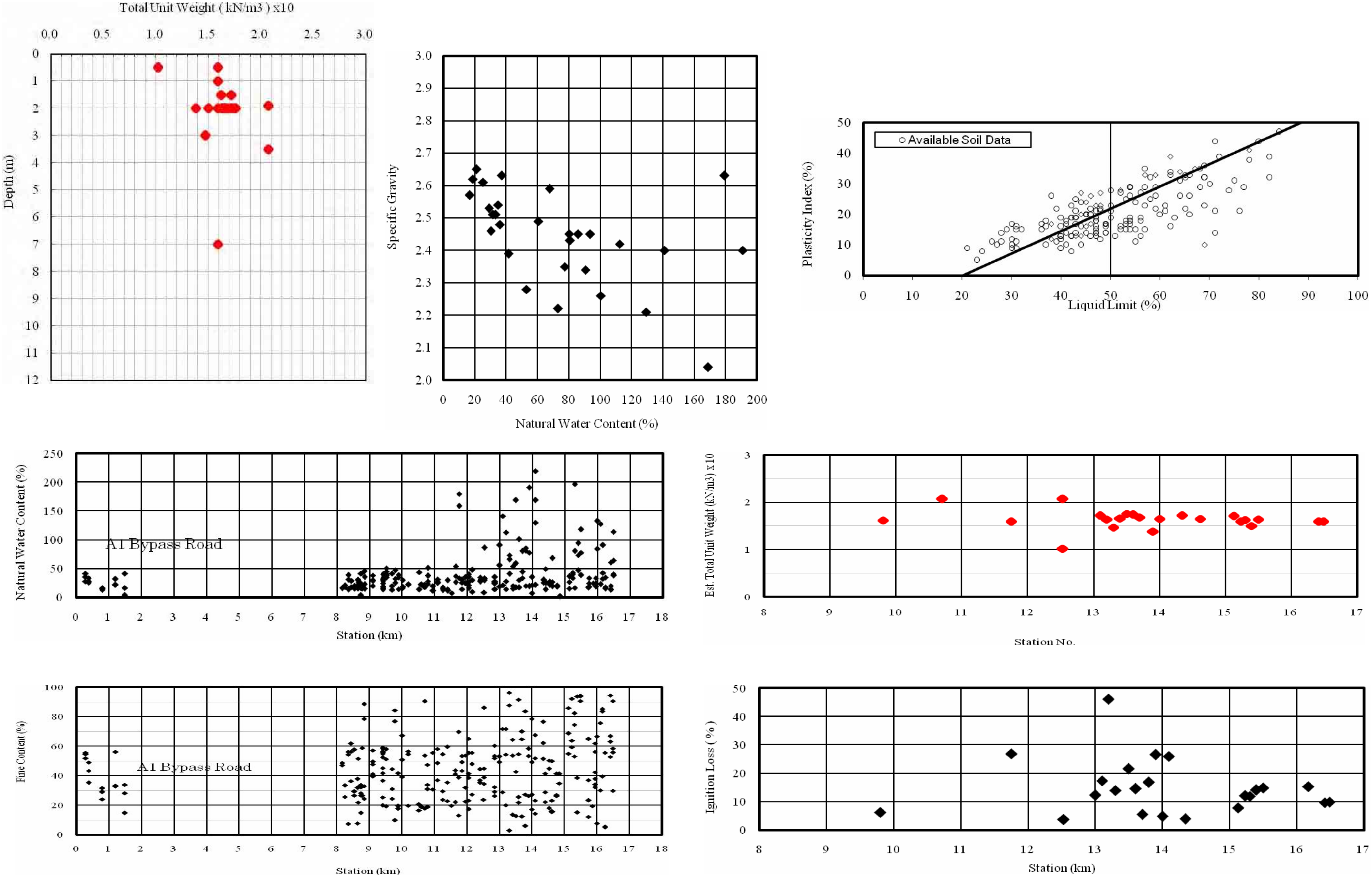


Fig. 2.2.11 Laboratory Test Result (Physical Property Test)

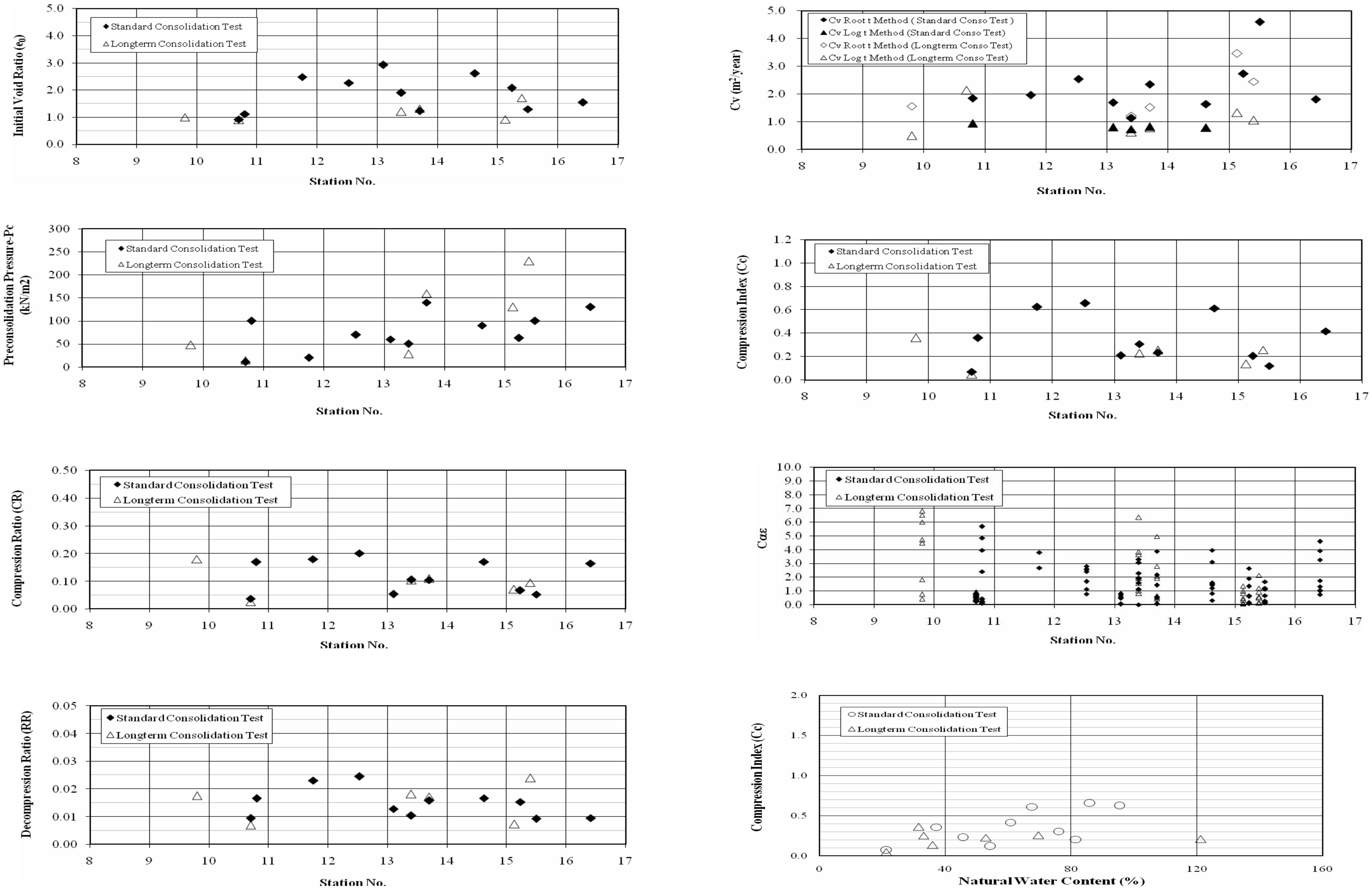


Fig. 2.2.12 Laboratory Test Result (Consolidation Test)

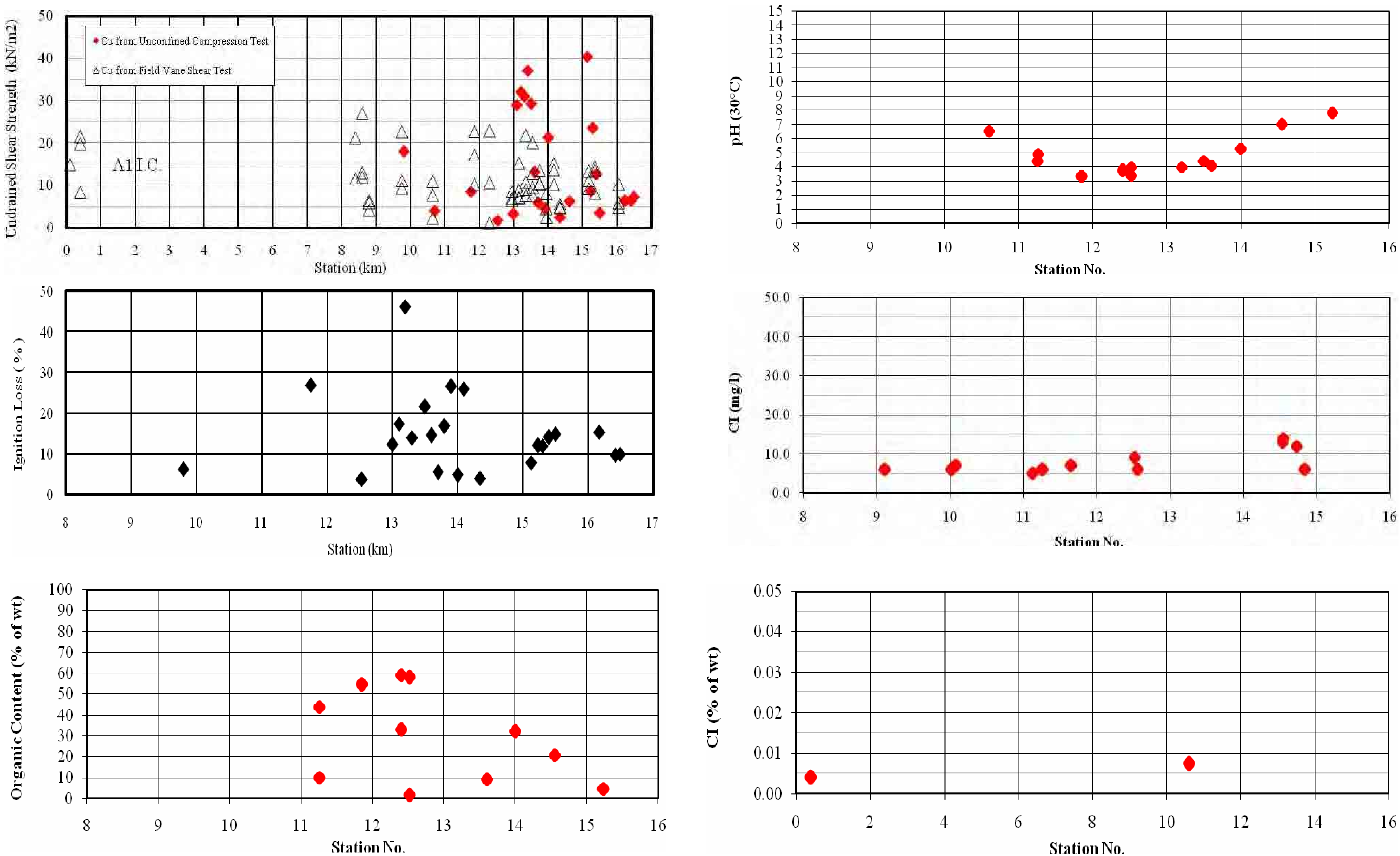


Fig. 2.2.13 Laboratory Test Result (Unconfined Compression Test and Chemical Test of Soil)

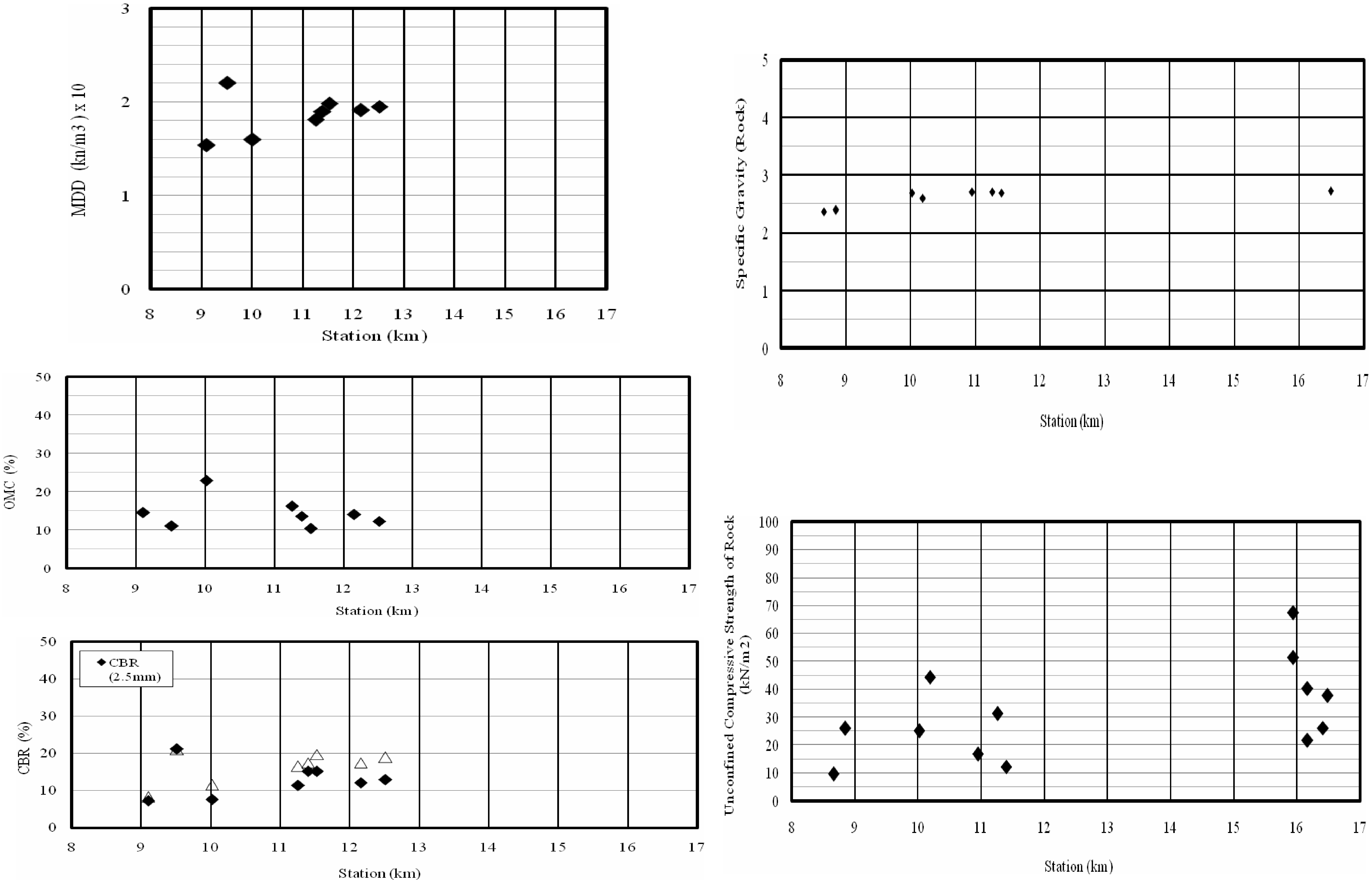


Fig. 2.2.14 Laboratory Test Result (Excavated Material , Soil and Rock)

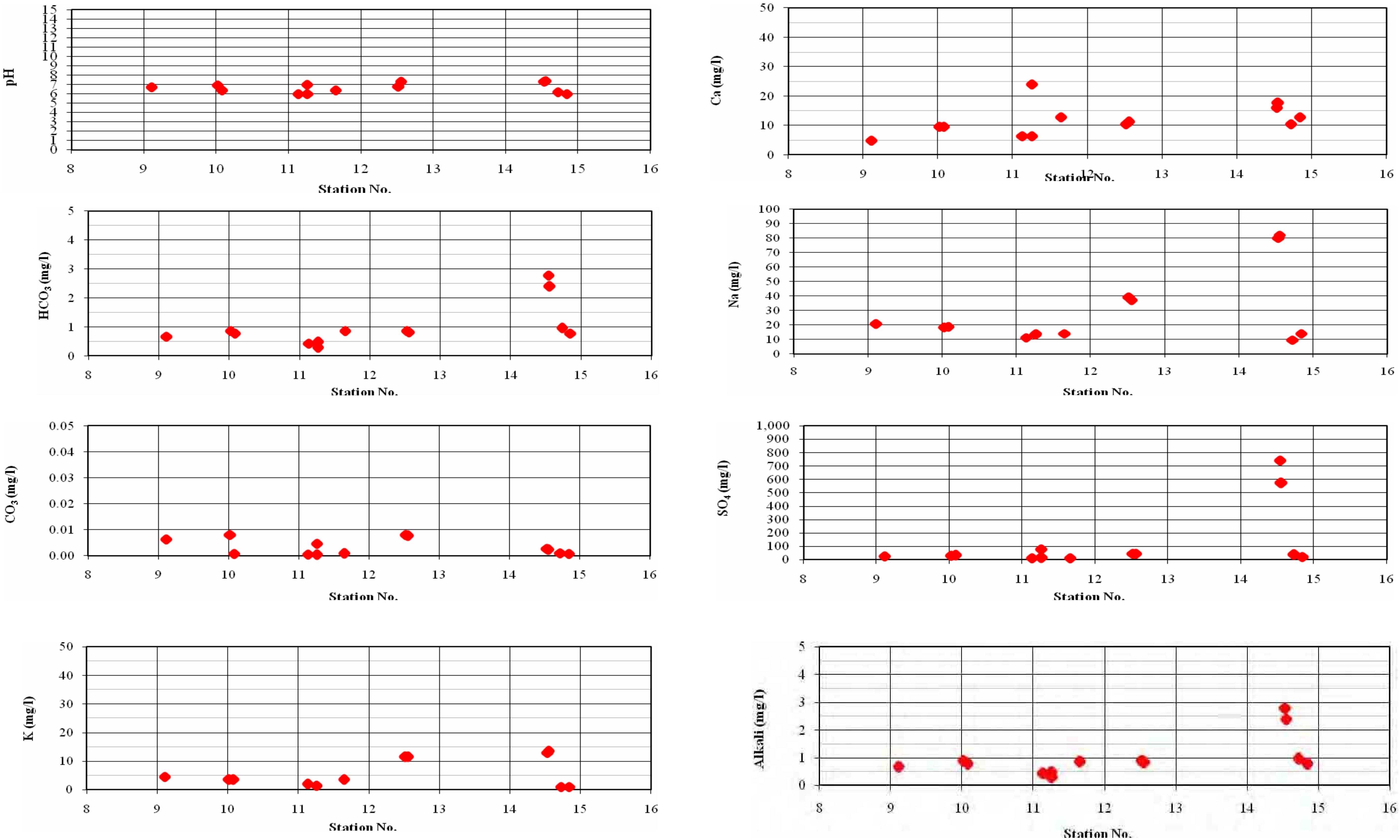


Fig. 2.2.15 Laboratory Test Result (Chemical Test of Underground Water)

2.2.3. Material Survey

In 2005, for the detailed design stage of Southern Section of OCH, geological field reconnaissance was carried out for the entire route, including the Southern Section and Northern Section of OCH (or OCHSS and OCHNS), and eighteen borrow pit sites and 12 quarry sites were selected.

According to the material survey report, expected quantities of rock to be extracted are about 25 million m^3. On the material for embankment, expected quantities of borrow material to be extracted are about 9 million m^3. Those quantities are enough to cover the requirement for both of OCHSS and OCHNS.

However, according to the latest information, the other borrow pits and quarry to cover the required volume of embankment material and gravels for OCHNS1 has been surveyed.

Due to above reason, the other 7 borrow pits and 7 quarry sites were surveyed to understand the quality and properties of rock and soil covering the wide area from project site. Those were chosen from existing borrow pits/ quarry and undeveloped natural hills/ mountains. The quantities for material survey carried out in this study are shown in **Table 2.2.10**. The location of surveyed borrow pits and quarries are shown in Table2.2.11 and **Table 2.2.12**.

Table 2.2.10 Quantities of Material Survey

Material Survey				
1	**Field Survey for Potential Borrow Pits & Material Quarries**			
a)	Rotary Wash Boring (Type-B for soil)	m	1,100.00	71.4
b)	Test Pit	No	5,000.00	7
c)	Block Sampling	No	1,000.00	7
2	**In-Situ Tests**			
a)	Field density	No	750.00	7
b)	Standard Penetration Test	No	250.00	66
3	**Laboratory Tests (physical)**			
a)	Particle Size (hydro, sieve)	No	1,000.00	32
b)	Moisture Content	No	400.00	58
c)	Specific Gravity	No	1,750.00	33
d)	Atterberg Limits	No	1,000.00	55
e)	Bulk Density	No	1,000.00	7
f)	Dry Density	No	1,000.00	7
g)	Effective Porsotiy (for rock)	No	750.00	7
h)	Chemical Tests for Soil (pH, CI, Alkalinity, Ca)	No	4,000.00	7
4	**Laboratory Tests (mechanical)**			
a)	Proctor Compaction	No	1,500.00	18
b)	CBR	No	5,000.00	19
c)	Unconfined Compression (for rock)	No	2,000.00	7
d)	Slaking	No	3,000.00	7
e)	Abrasion resistnace	No	3,500.00	7

Table 2.2.11 Location of Surveyed Borrow Pits

BH No	Location	Coordinates	
		N	E
BP-01	Delgoda	0197738	0118244
BP-02	Diddeniya	0186923	0125677
BP-03	Pathegama	0187145	0125863
BP-04	Puwakpitiya	0193475	0132450
BP-05	Halbarawa	0179804	0121187
BP-06	Dedigama	0188803	0118192
BP-07	Uduwa	0174818	0123118

Table 2.2.12 Location of Surveyed Quarries

No	Location	Coordinates	
		N	E
Q-01	W.A.Perera, Athurugiriya	0187842	0110666
Q-02	W.A.Perera, Walipillawa	0185621	0118732
Q-03	W.A.Perera, Dadigamuwa	0189268	0116873
Q-04	Lanka Quarry	0176326	0117782
Q-05	C & A	0163081	0115122
Q-06	Senok	0231478	0124251
Q-07	Bitumin Lanka	0233726	0127312

(1) Results of Materials Survey

Estimate of Quantity of Materials

The quantity of materials was estimated based on field reconnaissance and drilling work. The estimated quantity for borrow pits is shown in **Table 2.2.13** and the estimated quantity for quarries shown in **Table 2.2.14**. And estimated dumping volume surveyed together with borrow pits and quarries also is shown in **Table 2.2.15**. And all the locations of borrow pits, quarry and dumping sites are shown in **Fig. 2.2.16**.

Table 2.2.13 Expected Volume of Soil from Borrow Pits

Site No.	Location	Owenership/ Tel-No.	Distance from C.L /km	Type of site	Type of Material	Area/ m^2	Quantity / m^3	Year of investigation
B1	Lenagala,Panagoda		13.0	Operating Pit	RS	20,000	300,000	
B2	Godella,Kotalawala		1.5	Natural Hill	RS	50,000	None	
B3	Pelahela		11.0	Operating Pit	RS	20,000	None	2001
B4	Namaluwa,Atigala		19.0	Operating Pit	RS	30,000	None	
B5	Kanattagoda		9.5	Operating Pit	RS	40,000	None	
B6	Demalagama		14.0	Operating Pit	RS	400,000	300,000	
B7	Udamapitigama		11.0	*Natural Hill	RS	10,000	600,000	
B8	Udamapitigama	Unknown	11.3	Operating Pit	RS	5,000	None	
B9	Udamapitigama	Mr.Jayasinga	11.5	Operating Pit	RS	10,000	None	
B10	Kalukodayawa	Mr.MAH Alvis/2455620	7.5	**Natural Hill	RS	10,000	100,000	
B11	Karadahena,Weliwita	Government/ (UDA)	3.0	Abondon Pit	RS	75,000	200,000	
B12	Malwana	Mr.Carlo Fernando/2453470	8.5	**Natural Hill	RS	140,000	300,000	2004
B13	Beddegeramulla,Migoda	Mr.Gnanarathna	10.0	Operating Pit	RS	50,000	500,000	
B14	Maeliya,Ja-Ela	Mr.Neel/0776002699	9.0	Operating Pit	RS	160,000	None	
B15	Maeliya,Ja-Ela	.....Do....	9.0	Natural Hill	RS	10,000	None	
B16	Maeliya,Ja-Ela	.....Do....	9.0	Natural Hill	RS	200,000	None	
B17-1	Nawalamulla	Mr.Indika/0714884647	9.0	Operating Pit	RS	65,000	None	
B17-2		.....Do....	9.0	Operating Pit	RS	65,000	None	
B18	Waga-Meepe	.....Do....	18.0	Operating Pit	RS	40,000	300,000	
B19	Dekatana	Mr. M.D.S. Wijerathna	13.0		RS		150,000	
B20	Suduwella	Mr.Gunawardena	30.0		RS		5,000	
B21	Puwakpitiya	Mr. Subasinghe/0716851541	26.0		RS		60,000	
B22	Diddeniya Estate	Mr. Subasinghe/0716851541	16.0		RS		200,000	
B23	Halbarawa	Mr. Indika Koralage/0714884647	27.0		RS		300,000	
B24	Dadigama	Mr. Subasinghe/0716851541	9.0		RS		30,000	2007
B25	Uthuru Uduwa(Near Padukk	Mr. Nihal/0712333888	32.0		RS		200,000	
B26	Delgoda	Mr. Subasinghe/0716851541	9.0		RS		40,000	
B27	Dideniya	Mr.A.D. Abeyawardena/0777343236	16.0	Abondon Pit	RS	52,610	450,000	
B28	Kosgama	Mr.A.D. Abeyawardena/0777343236	23.0	Abondon Pit	RS	14,164	400,000	
B29	Puwakpitiya, Higurala	Mr.A.D. Abeyawardena/0777343236	26.0	Abondon Pit	RS	10,117	50,000	
B30	Samanebeddha	Mr.A.D. Abeyawardena/0777343237	17.0	Abondon Pit	RS	8,094	50,000	
B31	Ahugammana	Mr.Laxman/0777345083	14.0	Operating Pit	RS	50,586	300,000	
B32	Kanduboda	Mr.Mendis/ 0112403473	8.0	Rock Quarry	RS	40,000	150,000	
B33	Pitiyagedara, Bemmulla	Mr.Sunil Munasingha/0334928610	18.0	Operating Pit	RS	30,000	100,000	
B34	Yagoda		13.0	Operating Pit	RS	10,000	None	
B35	Yagoda, North		12.0	Natural Hill	RS	20,000	None	
B36	Dompe	Mr.R.P.Wijepala / 0112409424	14.0	Abondon Pit	RS	12,000	100,000	
B37	Meepawita-1	Mr.Frank Perera/ 0115657604	12.0	Rock Quarry	RS	40,000	100,000	
B38	Meepawita-2	Mr.Ajith/ 0723614813	12.0	Abondon Pit	RS	22,200	200,000	
						Σ	5,485,000	m3

Northern Section 1 Σ 2,490,000 m3
Sourthern Section Σ 2,995,000 m3

Table 2.2.14 Expected Volume of Rock from Quarries

Site No	Location	Ownership/ Tel.No.	Distance from C.L. (km)	Type of site	Type of material	Area/ (m2)	Quantity/ (m3)	Year of Investi-gation
Q1	Udugoda, Pahala Bomiriya		5.5	O.Q	Massive Diorite	40,000	500,000	2001
Q2	Arangala		2.5	O.Q	Granitic Gneiss	40,000	700,000	
Q3	Leyland Rd, Panagoda		12.0	O.Q	Dioritic Gneiss	30,000	300,000	
Q4	Leyland Rd, Panagoda		12.5	O.Q	Dioritic Gneiss	20,000	100,000	
Q5	Lenagala Watta, Panagoda		13.5	O.Q	Dioritic Gneiss	2,000		
Q6	Lenagala Watta, Panagoda		13.0	O.Q	Dioritic Gneiss	60,000	300,000	
Q7	Walgama		2.5	O.Q	Pegmatite	10,000	50,000	
Q8	Walgama		3.0	O.Q	Fine Gneiss	30,000	300,000	
Q9	Bunwalakanda, Putupagala		15.0	O.Q	Dioritic Gneiss	3,000	-	
Q10	Kanduboda	Jayantha Sandra / 2403807	8.0	O.Q	Granitic Gneiss	10,000	150,000	2004
Q11	Koratota, Nawagama	Sriwaka Metal Cutter / 0777313160	6.0	O.Q	Dioritic Gneiss	150,000	300,000	
Q12	Ambagaspitiya, Attanagala	KNUJ Chandrakumara / 0332279254	17.0	O.Q	Pink Coarse Granite	10,000	300,000	
Q13	Lenagala Watta, Panagoda	Premasiri Wijesundara/ 0714004261, 0602175360	11.0	O.Q	—	—	100,000	2007
Q14	Kanduboda	Mr.Anura/ 0112403910	8.0	O.Q	Granitic Gneiss	1,000	10,000	
Q15	Kanduboda	Mr.Mendis/ 0112403473	8.0	O.Q	Granitic Gneiss	40,000	1,200,000	
Q16	Pananwala	Ajantha Metal Crusher/ 0714778088	11.0	O.Q	Granitic Gneiss	20,000	700,000	
Q17	Pelhela,Dekatana	Fumihiko Engineering/0714723297	13.0	O.Q	Granitic Gneiss	20,000	100,000	
Q18	Koragahawatta, Karagala	Mr.Daminda Abesignha/ 0777312650	16.0	O.Q	Granitic Gneiss	20,000	400,000	
Q19	Ahugammana	Mr.Laxman/0777345083	13.5	O.Q	Granitic Gneiss	50,586	400,000	
Q20	Oruthota South		10.0	O.Q	Pink Coarse Granite	10,000	40,000	
Q21	Mabima	K.A.Dayarathne/ 785455486	2.0	O.Q	Granitic Gneiss	12,000	200,000	
Q22	Mabima	Nawaloka Construction	2.0	O.Q	Granitic Gneiss	20,000	550,000	
Q23	Mabima	Mr.Ranjith Gunasinghe/ 112351235	2.0	O.Q	Granitic Gneiss	12,000	600,000	
Q24	Mabima	Mr.Chandana/Mr.Narada	0.5	O.Q	Granitic Gneiss	12,000	150,000	
Q25	Arangala	W.A.Perera	5.0	O.Q	Granitic Gneiss	32,000	520,000	
Q26	Welipillawa	W.A.Perera	8.5	O.Q	Granitic Gneiss	85,000	2,720,000	
Q27	Dadigamuwa	W.A.Perera	10.0	O.Q	Granitic Gneiss	49,000	1,170,000	
Q28	Talagala	Lanka Quarry	28.0	O.Q	Granitic Gneiss	81,000	1,940,000	
Q29	Paragastota	C&A	40.0	O.Q	Granitic Gneiss	49,000	2,330,000	
Q30	Kotadeniyawa	Senok	50.0	O.Q	Granitic Gneiss	324,000	12,950,000	
Q31	Kithulwalana, Mirigama	Bitumin Lanka	50.0	O.Q	Granitic Gneiss	142,000	6,800,000	
						Σ	35,880,000 m3	

(yellow)	Northern Section 1	Σ	4,800,000 m3
(green)	Sourthern Section	Σ	7,060,000 m3

Note : O . Q - Operating Quarry

Table 2.2.15 Expected Dumping Volume of Dumping Sites

Site No.	Location	Owenership/ Tel-No.	Distance from C.L /km	Type of site	Area/ (Hectare)	Volume (x1,000 m3)	Year of Investi-gation
D1	Kaduwela	Mr.P.D.Nirmala Sanyakumari, Welay Handiya,Kaduwela /0776723412	3	Abandon Clay Mine	15	-	2007 Design Review Report
D2	Pahala Bomiriya	Mr.Wasantha Lenorole,No.45, Pahala Bomiriya, Kaduwela /0773529084	5	Abandon Clay Mine	5	-	
D3	Ranale	Mr.Udaya Kuruppuarachchi, 337, Jalthara, Ranala /0777276604	6	Abandon Clay Mine	7	-	
D4	Atigala	Mr.M Jinadasa,166F, Pahala Hanwella, Hanwella /0114922711	10	Abandon Clay Mine	10	-	
D5	Malwana	Mr.Colvin Perera,76/D,Samanbedda Rd, Malwana /0112535915/ 0773242508	7	Abandon Clay Mine	10	200	
D6	Kalukodayaya	.....Do....	7	Abandon Clay Mine	5	100	
D7	Udamapitigama	.....Do....	11	Abandon Clay Mine	5	100	
D8	Lunukotuwawatta, Malwana	.....Do....	8.5	Abandon Clay Mine	20	400	2007
D9	Malwana	Mr.Chamli Perera/0112450323/ 723276346	5.5	Abandon Clay Mine	2	40	
D10	Yabaraluwa	Mr.A.D. Abeyawardena/0777343236	3.5	Abandon Clay Mine	None	None	
D11	Walgama	Mr.Seelawansha /0112535983	6.5	Abandon Clay Mine	2	40	
D12	Malwana	Mr.Chamli Perera/0112450323/ 723276346	7.5	Abandon Gem Mine	5	100	
				Σ	86	980	m3

(yellow)	Northern Section 1	Σ	980 m3
(green)	Sourthern Section	Σ	- m3

Note that the quantities of borrow material estimated include that from current operational pits and therefore overall quantities would decrease in the future depending on the time of commencement of the construction.

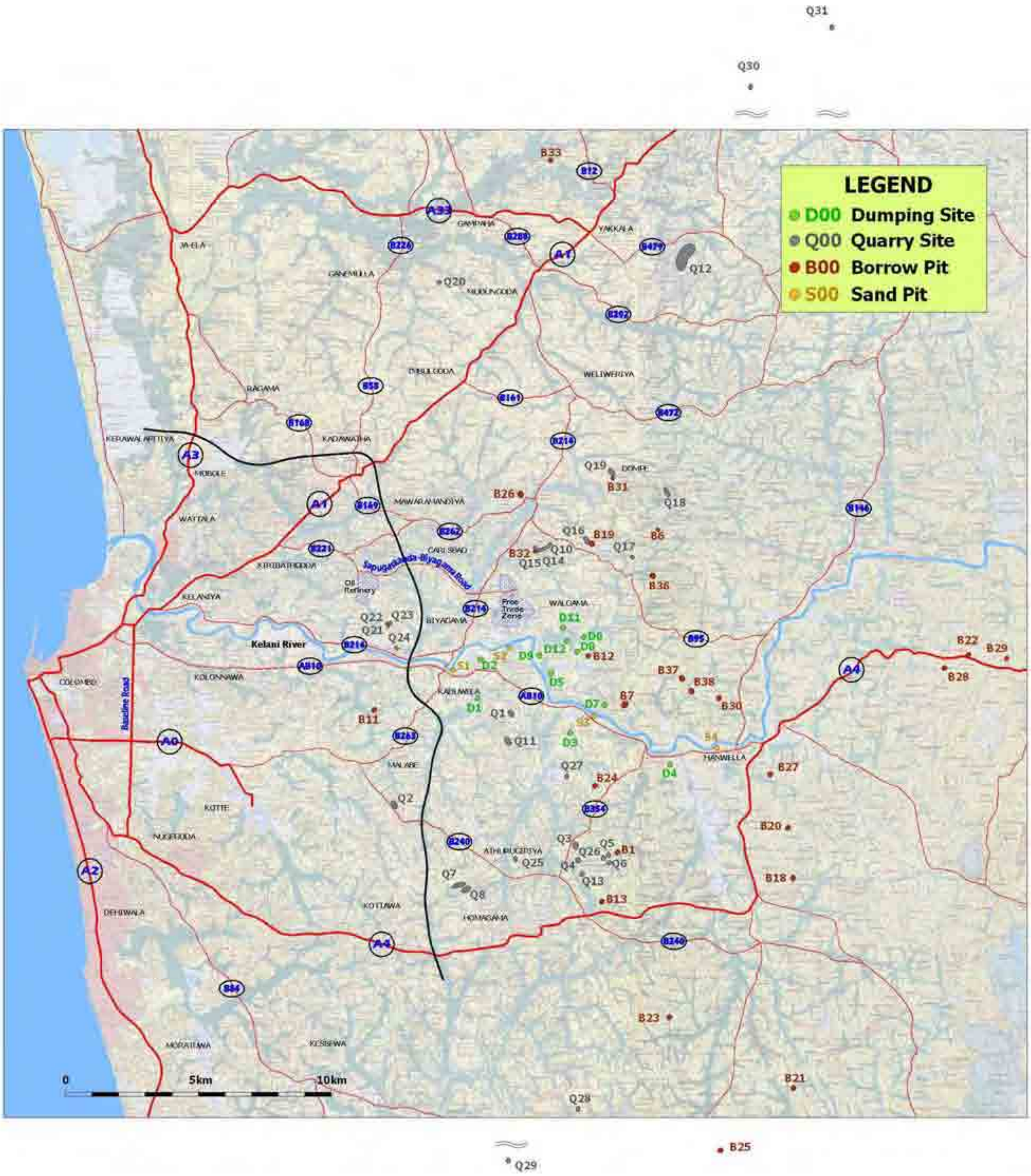


Fig. 2.2.16 Location Map of Borrow Pits, Quarry and Dumping Sites

(2) Results of Laboratory Testing

The results of the laboratory test of soils from 7 borrow pits and rocks from 7 quarries are shown in **Table 2.2.13** to **Table 2.2.16** and **Fig. 2.2.17** to **Fig. 2.2.18**. Test samples for embankment materials are obtained via test pitting. These materials (residual soil) consist of silty sand with gravel.

The engineering properties of soils from 7 borrow pits surveyed in this study are summarized as follows:

- LL: varies from 31% to 69% (from 36% to 88%)
- PL: varies from 21% to 50% (from 20% to 55%)
- Gravel Content: varies from 1% to 85% (from 3% to 30%)
- Fine Content: varies from 5% to 50% (from 1% to 71%)
- OMC*: varies from 10% to 25% (from 8% to 26%)
- MDD*: varies from 1.48 g/cm^3 to 2.06 g/cm^3 (from 1.47 g/cm^3 to 2.13 g/cm^3)
- CBR for 95% of MDD: varies from 5% to 50% (from 9% to 40%)

*Note: OMC (Optimum Moisture Content), MDD (Maximum Dry Density),
Fine Content: Weight percentage of passing the sieve size of 0.074 mm.
The values in the parenthesis show the result of OCH Southern Section.

Due to sieve analysis result, grain distribution curves of soils from 7 borrow pits are described as shown in **Fig. 2.2.17**. As for the most of soils, fine content of them show the values less than 50%. These are classified into sandy soil. However some of soils are showing the values more than 50% of fine content. It means some soils from borrow pits are classified into fine soil which is generally not preferable as construction materials Therefore soil type and grain size should be checked before and during construction after the contractor decided the borrow sites for the project.

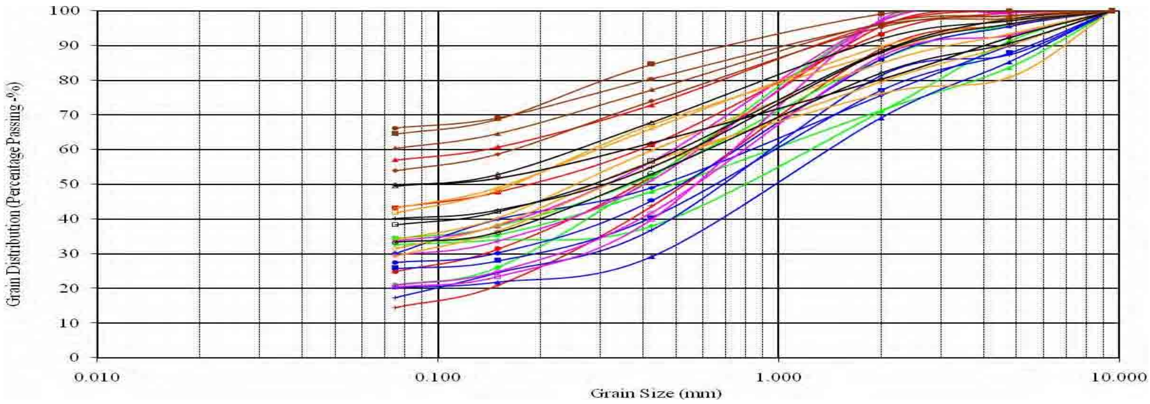


Fig. 2.2.17 Grain Distribution Curves of Soils from 7 Borrow Pits

The conditions of rocks as construction materials for the road is as follows:

● Compressive Strength	>30N/mm2
● Specific Gravity	>2.45
● Water Absorption	<3.00%

According to the laboratory test results of rocks 7 quarries, the average values for 7 rock samples are as follows:

● Compressive Strength (N/mm2)	AV. Value = 43.32 (53.47)
● Specific Gravity	AV. Value = 2.750 (2.724)

● Water Absorption (%) AV. Value = 0.54 (0.42)

*Note: The values in the parenthesis show the result of OCH Southern Section.

It seems that quality of rocks fulfill the requirement as construction materials for the road. However quality of granitic gneiss distributed in this area is changing depending on weathered conditions so that quality of rocks should be checked before and during construction as well.

Table 2.2.16 Summary of Laboratory Test for Soils from Borrow Pits

Source	Borehole No	Depth	Discription	Soil Type	Natural moisture content (%)	Bulk Density (kN/m3) x10	Dry Density (kN/m3) x10	Specific Gravity	Grain Size Analysis 4.75	2	0.425	0.15	0.075	Atterberge's Lmit LL %	PL %	PI %
DELGODA 01	1	0.00-0.45				1.61	1.43		92.27	80.29	61.89	51.83	49.67	67	34	33
		1.00-1.45			21.16			2.53						75	50	25
		2.00-2.45	Sandy Silt	ML	21.31				100	96.11	72.88	60.73	57.02	47	41	6
		3.00-3.45			18.97			2.6						51	37	14
		4.00-4.45	Claye Sand	SC	18.59				99.44	93.27	61.37	47.75	43.31	42	21	21
		5.00-5.45			17.64			2.55						51	37	14
		6.00-6.45	Silty Sand	SM	5.49				99.86	95.51	52.36	31.38	24.64	47	31	16
		7.00-7.45			6.88			2.55						40	28	12
		8.00-8.45	Silty Sand	SM	5.95				95.92	89.06	43.75	20.9	14.44	44	29	15
		9.00-9.45			6.24			2.5						42	31	11
		10.00-10.45			6.66											
DIDDENIYA ESTATE 02	2	0.0-0.45				1.77	1.65									
		1.00-1.45			13.55			2.4						58	32	26
		2.00-2.45	Silty Sand	SM	11.58				91.22	70.86	36.03	33.97	32.67	54	31	23
		3.00-3.45			17.72			2.47						48	32	16
		4.00-4.45	Silty Sand with Gravel	SM	18.3				83.63	71.26	47.94	35.37	33.39	49	31	18
		5.00-5.45			18.37			2.35						44	30	14
		6.00-6.45	Claye Sand	SC	16.96				95.96	85.99	52.6	37.91	34.44	56	24	32
		7.00-7.45			14.43			2.59						44	30	14
		8.00-8.45	Silty Sand	SM	4.01				100	97.22	51.98	26.13	21.04	NP	NP	NP
		9.00-9.45			14.1											
PATHEGAMA 03	3	0.00-0.45	Silty Sand	SM	11.1	1.81	1.63		89.95	75.65	49.01	39.94	30.17	NP	NP	NP
		1.00-1.45			9.4			2.33								
		2.00-2.45	Claye Sand	SC	13.46				85.19	69.14	29.17	21.83	20.30	49	23	26
		3.00-3.45			10.4			2.5								
		4.00-4.45	Silty Sand	SM	8.65				87.78	77.07	40.43	27.94	25.79	55	35	20
		5.00-5.45			12.62			2.07								
		6.00-6.45	Silty Sand	SM	9.67				95.49	85.98	45.36	30.22	27.52	48	29	19
		7.00-7.45			13.4			2.05								
		8.00-8.45	Silty Sand	SM	10				87.29	81.32	36.87	36.94	17.29	NP	NP	NP
		9.00-9.45			13.19											
PUWAKPITIYA BORROW PIT 04	4	TOP				1.88	1.7									
		1.00-1.45			8.49			2.59								
		2.00-2.45	Silty Sand	SM	8.31				99.3	96.93	51.26	33.64	29.57	41	28	13
		3.00-3.45			10.36			1.94						38	25	13
		4.00-4.45	Silty Sand	SM	8.69				100	97.16	56.62	38.11	33.75	42	30	12
		5.00-5.45			5.33			2.61								
		6.00-6.45	Silty Sand	SM	7.16				99.6	97.49	39.91	23.41	20.3	36	33	3
		7.00-7.45			6.28			2.5								
		8.00-8.45	Silty Sand	SM	5.01				92.9	86.92	41.84	24.87	20.87	31	26	5
		9.00-9.45			8.96			2.61								
HALBARAWA BORROW PIT 05	5	TOP				1.77	1.65									
		1.00-1.45			8.6			2.2						45	28	17
		2.00-2.45	Silty Sand	SM	19.91				90.2	79.53	55.23	36.62	29.29	48	31	17
		3.00-3.45			11			2.54						45	32	13
		4.00-4.45	Silty Sand	SM	23.01				96.3	89.66	66.15	49	43.14	53	38	15
		5.00-5.45			13.48			2.52						43	34	9
		6.00-6.45	Silty Sand	SM	18.17				98.1	87.96	67.23	48.34	41.79	46	33	13
		7.00-7.45			10.08			2.51						48	42	6
		8.00-8.45	with Gravel		16.75				80.9	76.17	56.54	38.3	31.5	37	24	13
		9.00-9.45			12.34			2.5								
		10.00-10.45	Silty Sand	SM	13.04				93.4	84.94	59.82	40.35	33.95	NP	NP	NP
DADIGAMUWA BORROW PIT 06	6	TOP	Silty Sand	SM		1.58	1.47		92.27	80.29	61.89	51.83	49.87	41	33	08
		1.00-1.45						2.45						41	26	15
		2.00-2.45	Silty Sand	SM					97.04	91.89	67.87	52.86	49.48	40	31	9
		3.00-3.45						2.39						38	27	11
		4.00-4.45	Claye Sand	SC					97.54	88.39	56.62	42.14	38.38	42	20	22
		5.00-5.45						2.58								
		6.00-6.45	Silty Sand	SM					90.61	82.04	53.05	36.17	33.28	47	32	15
		7.00-7.45						2.55								
		8.00-8.45	Silty Sand	SM					96.18	88.04	54.97	42.61	40.18	52	40	12
		9.00-9.45						2.52						42	37	5
UDUWA BORROW PIT 07	7	TOP				1.71	1.45									
		1.00-1.45			8.46			2.52						66	42	24
		2.00-2.45	Sandy Silt	ML	12.54				98.51	95.29	74.02	58.71	53.95	48	32	16
		3.00-3.45			14.68			2.61						60	38	22
		4.00-4.45	Silt	MH	12.32				98.63	96.42	77.29	64.63	60.42	64	38	26
		5.00-5.45			13.52			2.33						59	36	23
		6.00-6.45	Silt	MH	12.19									67	46	21
		7.00-7.45			14.23			2.31						54	35	19
		8.00-8.45	Silt	MH	11.56				99.82	99.13	84.57	68.81	64.50	65	46	19
		9.00-9.45			12.69			2.05						68	43	25
		10.00-10.45	Silt	MH	11.06				97.66	95.93	80.34	69.17	66.20	65	41	24

Table 2.2.17 Summary of CBR and Proctor Compaction Test Result

Borehole No	Depth	Discription	Soil Type	CBR (%)	PROCTOR COMPACTION	
					Maximum Dry Density (kN/m3) x 10	Optimum Moisture content (%)
1	0.00-1.00			12.25	1.71	17.6
	1.00-1.50			10.13		
2	0.0-0.40			13.10	1.82	13.1
	1.00-1.50			19.13	1.66	16.6
	0.00-0.50	Silty Sand	SM	21.50	1.92	11.2
3	0.50-0.90			32.00	1.97	11.0
	0.90-1.5	Claye Sand	SC	9.08	1.87	14.0
4	0.00-0.70			33.25	1.96	12.50
	0.70-1.20	Silty Sand	SM	5.25	1.85	14.40
	1.20-1.50			13.38	1.86	13.20
5	000-1.50			6.13	1.51	24.80
	0.00-1.50	Silty Sand	SM	9.50	1.68	17.00
	0.00-1.50			10.75	1.74	15.30
6	0.00-0.70			21.88	1.48	23.4
	0.70-1.20	Silty Sand	SM	8.00	1.84	13.7
	1.20-1.50			19.00	1.63	15.2
7	1.00-1.20			9.75	1.77	14.7
	1.20-1.50	Sandy Silt	ML	26.25	1.91	12.3
	0.00-1.50			50.25	2.06	9.8

Table 2.2.18 Summary of Chemical Test Result of Soil from Borrow Pits

Borrow Pit No.	Depth		Chemical Test			
	GL - (m)	EL (m)	pH at 30°C	Cl as % of wt	Alkalinity as % of wt	Ca as % of wt
01 Delgoda	4.00	0.45	5.00	0.0096	0.0032	0.0004
02 Diddeniya Estate-01	5.00	0.45	5.40	0.0016	0.0005	0.0020
03 Diddeniya Estate-02	8.00	0.45	5.10	0.0032	0.0090	0.0008
04 Puwakpitiya	7.00	0.45	5.20	0.0024	0.0032	0.0002
05 Halbarawa	5.00	0.45	5.50	0.0016	0.0025	0.0004
06 Dedigamuwa	6.00	0.45	5.30	0.0048	0.0070	0.0003
07 Uduwa	6.00	0.45	5.60	0.0048	0.0032	0.0007

Table 2.2.19 Summary of Laboratory Test Result of Rocks from Quarries

Location	Sample No.	Water Absorption (%)	Specific Gravity	LAAV (%)	Effective Porosity (%)	Unconfined Compression (N/mm2)	Slaking Durability (%)
1. W.A.Perera ,Athurugiriya	Q1-A	0.67	2.70	44.74	0.62	44.64	99.00
2. W.A.Perera ,Walipillawa	Q1-B	0.61	2.71	45.84	1.00	65.96	99.20
3. W.A.Perera ,Dadigamuwa	Q1-C	0.11	2.82	55.28	1.47	34.43	99.20
4. Lanka Quarry	Q4	0.73	2.71	32.27	0.19	52.89	99.20
5. C & A	Q5	0.61	2.69	41.92	1.08	26.63	99.40
6. Senok	Q6	0.52	2.77	31.58	0.34	33.66	99.20
7. Bitumin Lanka	Q7	0.53	2.85	40.86	1.20	45.04	99.40

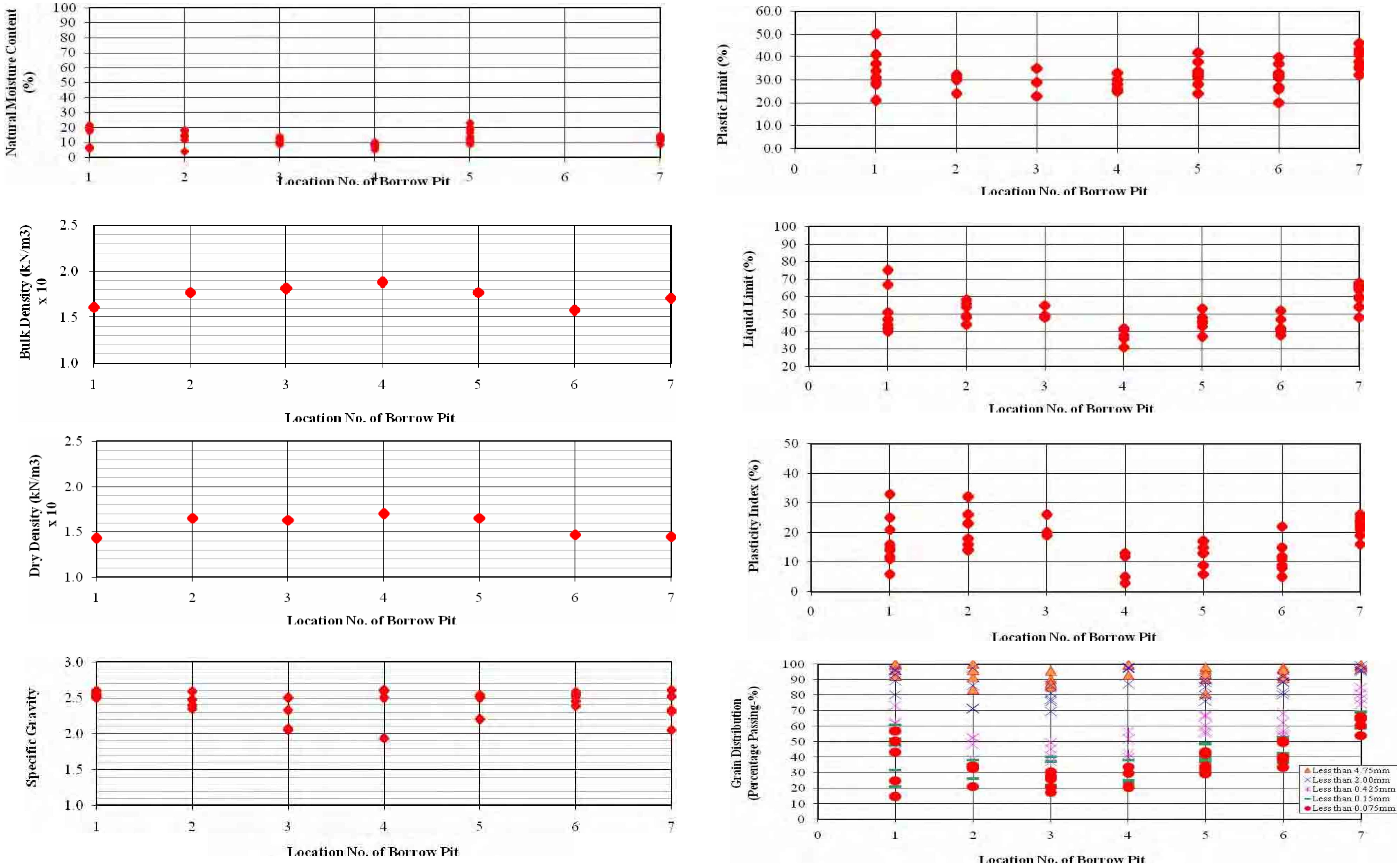


Fig. 2.2.18 Physical Property Test Result of Soils from Borrow Pits

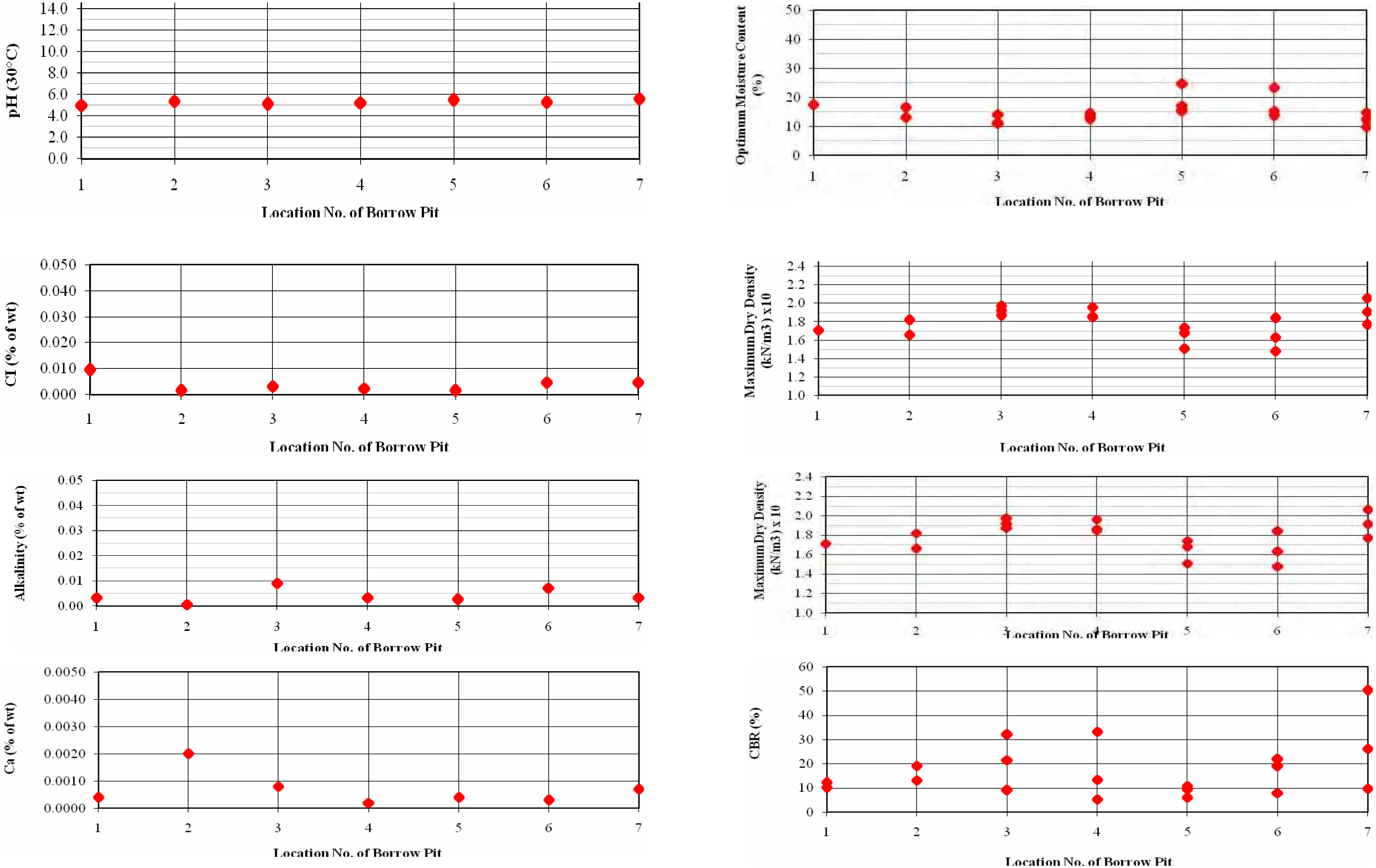


Fig. 2.2.19 Chemical Test, CBRP and Proctor Compaction Test Result

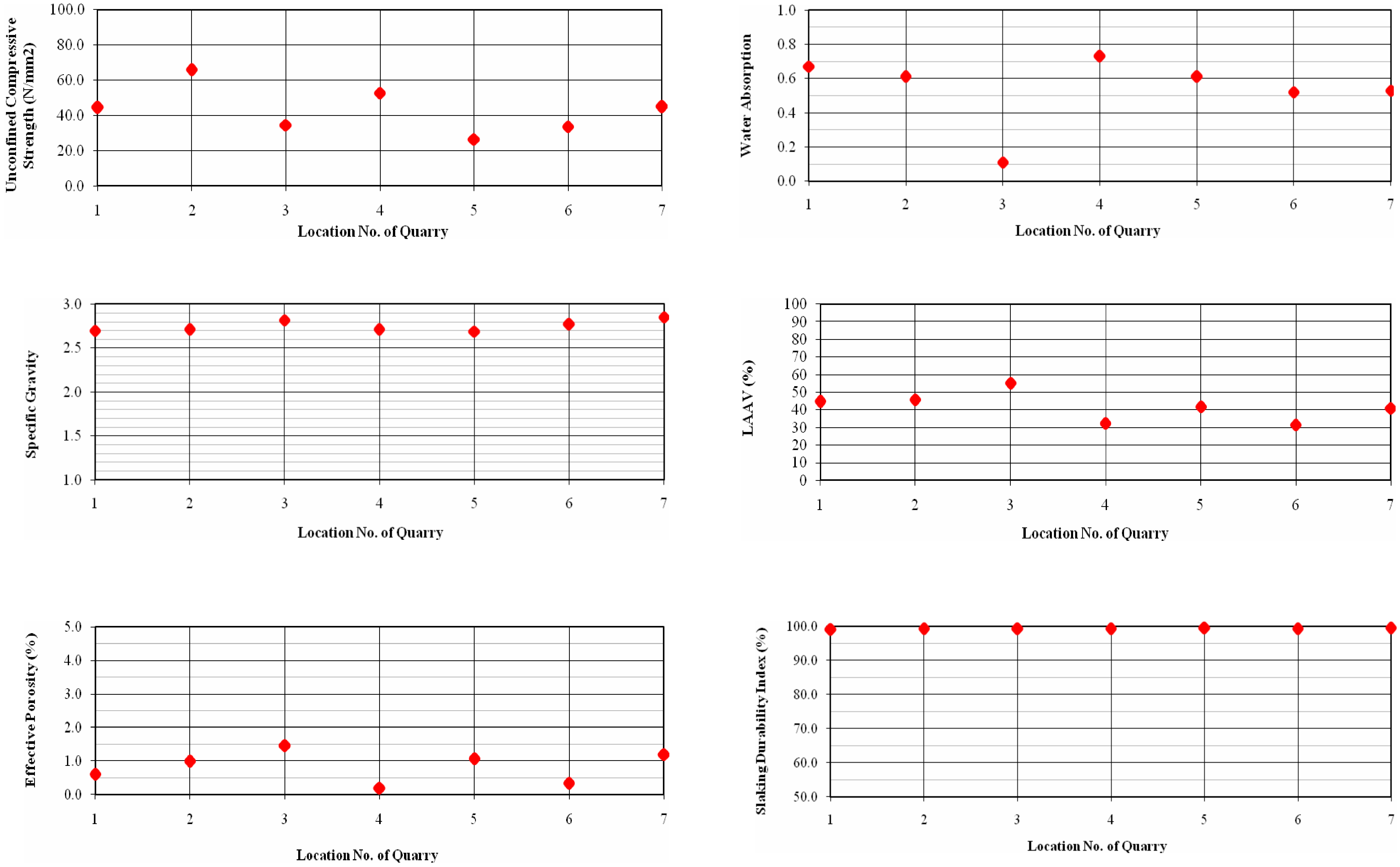


Fig. 2.2.20 Laboratory Test Result of Rocks from Quarry

CHAPTER 3

DESIGN & CONSTRUCTION CONCEPTS

CHAPTER 3 DESIGN & CONSTRUCTION CONCEPTS

3.1. General

OCH's Northern Section 1 extends from Kandy Road (A1) in Kadawatha to AB10 on the left bank of the Kelani River, connecting A1 with the Southern Section of the OCH. The A1 Interchange (A1IC) is located in paddy area and the main carriageway around the A1IC is designed with a high embankment in order to cross over A1 Bypass, which shall be planed exceeded level from high flood level of 50 years return period. In the Biyagama area, the ground is low-lying with soft soil and high flood level is much higher under influence from Kelani River, resulting in the height of the embankment of the OCH being high here as well.

In the case where the replacement method is applied as a soft soil countermeasure, which is the original concept proposed in the basic design stage of the OCH, all soft soil including peat is removed and replaced with gravel. The estimated total haulage from carrying and dumping material would reach about 4.7 million cu.m. and a large number of trucks would be required for this operation.

In this chapter, the issues surrounding the replacement method, which is the most conventional and economical way to deal with soft soil, are examined. Next, alternative options are proposed to reduce negative social and environmental impacts and compared with the Original Design (or replacement method) in order to determine the most suitable option. Finally, the design and construction concept for Northern Section 1 is finalized based on discussions with the RDA. The selected construction method is the proposal that adopted GCP (Gravel Compaction Pile) method as soft soil countermeasure which is possible to reduce a volume of disposal and borrow material and adopted the viaduct at the place where is deep soft ground layer and high embankment due to the same reason.

At the stage carried out the detailed design (viaducts: basic design) based on the selected construction method, the Sri Lanka side the application of a JBIC STEP (Special Term for Economic Partnership) loan, as Japanese technology will provide advantages regarding soft soil countermeasures and rapid construction in congested and/or confined areas. According to the request the above, some proposals that satisfy their expectations were studied by the JICA Study Team and the optimal proposal was determined through discussions with Sri Lanka side again.

3.2. Outline of Northern Section 1

3.2.1. Horizontal Alignment

The horizontal alignment for the OCH in Biyagama, which was shifted to paddy area after the feasibility stage in order to minimize land acquisition and resettlement impacts, is affected by flooding from the Kelani River as a result of this shift. The A1IC and A1 Bypass are also located in paddy area for the same reasons. Due to the characteristics of paddy areas and surrounding topography, it is necessary that soft soil countermeasures be implemented and high embankments constructed. The horizontal alignment of Northern Section 1 is as shown in **Fig. 3.2.1**.

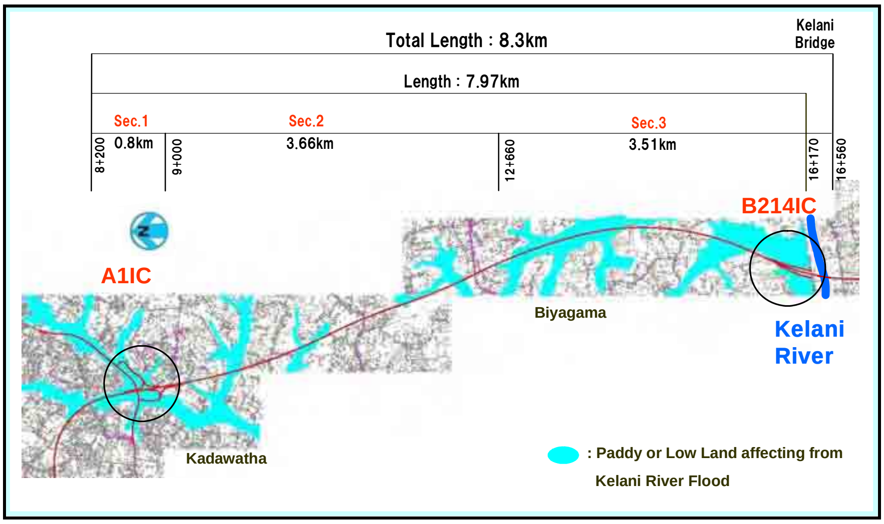


Fig. 3.2.1 Horizontal Alignment

3.2.2. Vertical Alignment

Fig. 3.2.2 shows the vertical alignment of Northern Section 1 together with the existing road crossings and 50-year return period flood level. The vertical alignment is determined based on the clearance needed for the existing A1 Road and A1 Bypass around Sta.8+500 and the flood level of the Kelani River that affects the area south of Sta.12+500. These factors are the cause for the embankment on this section of the OCH being high.

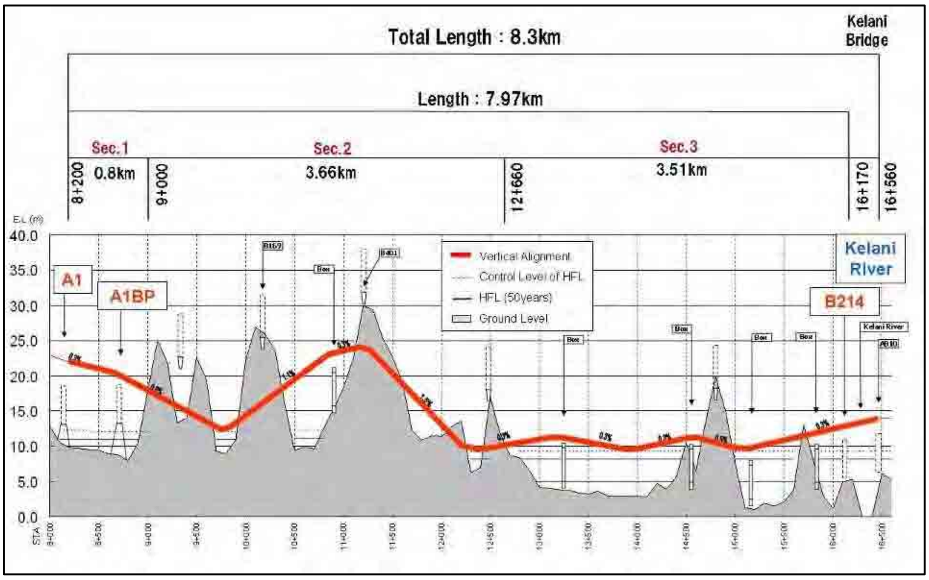


Fig. 3.2.2 Vertical Alignment of Northern Section 1

3.3. Examination of Original Design (Embanked Structure)

The basic design for the OCH envisaged it as essentially an embanked structure, with the replacement method described in **Chapter 5** adopted as the countermeasure for soft soil. The basic design (hereafter referred as to the Original Design) is analyzed and the practicality of its construction checked.

3.3.1. Division into Sections

Northern Section 1 is divided into 3 sections to account for the defining characteristics of the Original Design (see **Fig. 3.2.1** and **3.2.2**). That is, large amounts of borrow and disposal material need to be hauled for Section 1 and 3, as they pass through low-lying areas with soft soil, while for Section 2 the volume of cut and fill is almost equal and soft soil countermeasures are less quantity as the area is not too much marshy. Section 1 is divided into a further 4 sections because of its complexity (see **Table 3.3.1** and **Fig. 3.3.1**).

Table 3.3.1 Composition of Section 1

	Summary
①	OCH : Sta.8+178 – Sta.8+687
②	OCH : Sta.8+687 – Sta.8+970
③	IC Ramps
④	A1 Bypass

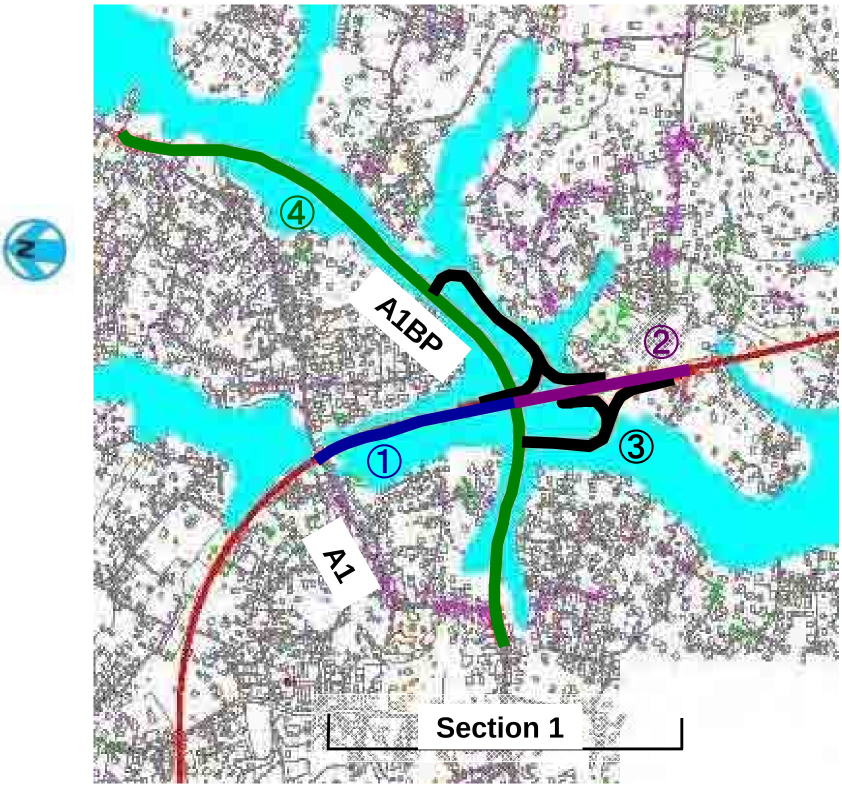


Fig. 3.3.1 Composition of Section 1

3.3.2. Earthwork Volume

Earthwork includes disposal, quarry and borrow material for the construction of each the sections and have been estimated as shown in **Table 3.3.2**. According to the results, it is necessary to transport 2.3 million and 2.0 million cu.m. of material for Section 1 and Section 3, respectively, while only 0.3 million cu.m. need to be hauled for Section 2. This means that it is important to consider the hauling of Section 1 and Section 2. Note that a further breakdown for the subsections of Section 1 is given in **Table 3.3.3**.

Table 3.3.2 Earthwork Volume for Northern Section 1

Item		Section 1	Section 2	Section 3	Total
Earthwork (x1000m^3)	Embankment	898	461	1,028	2,387
	Cutting	8	407	99	514
	Disposal	642	85	471	1,198
	Quarry	807	156	637	1,600
	Borrow pit	890	54	929	1,873
Haulage Volume		2,339	295	2,037	4,671

Table 3.3.3 Breakdown of Earthwork Volume for Section 1

Item		① Sta.8+200 – A1BP	②A1BP – Sta.9+000	③A1IC Ramp	④A1 Bypass	Total
Earthwork (x1000m^3)	Embankment	288	144	230	236	898
	Cutting	0	0	0	8	8
	Disposal	138	108	198	198	642
	Quarry	170	134	246	257	807
	Borrow pit	288	144	230	228	890

3.3.3. Construction Plan

(1) Location & Capacity of Sites for Materials & Disposal

As mentioned above, large volumes of material and spoilage have to be transported during the construction of Northern Section 1 and the locations and capacities of the relevant sites are therefore important. The candidate locations for dumping, quarry and borrow sites are as shown in **Fig. 3.3.2**. Based on this and current road conditions, it is expected that A1 will be used for Section 1 and the Sapugaskanda – Biyagama Road and B214 will be used for Section 2 and 3 for the hauling of materials.

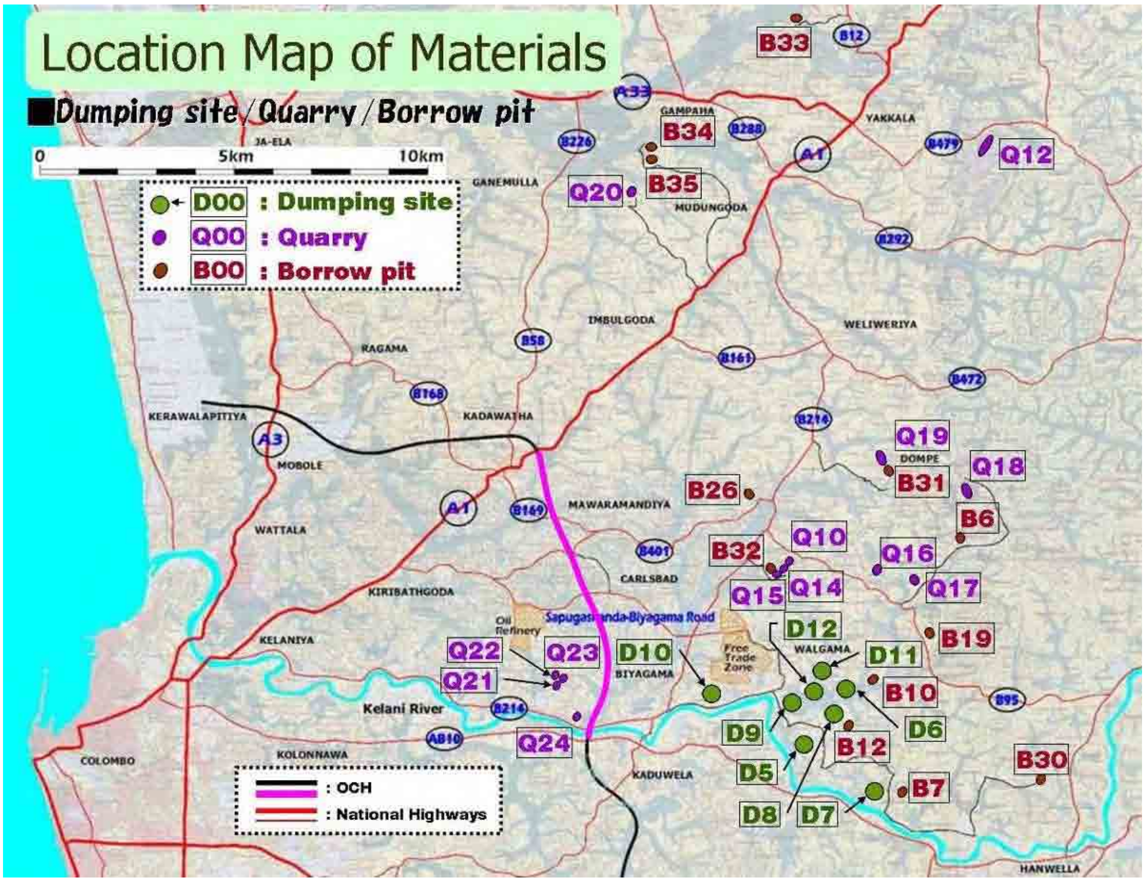
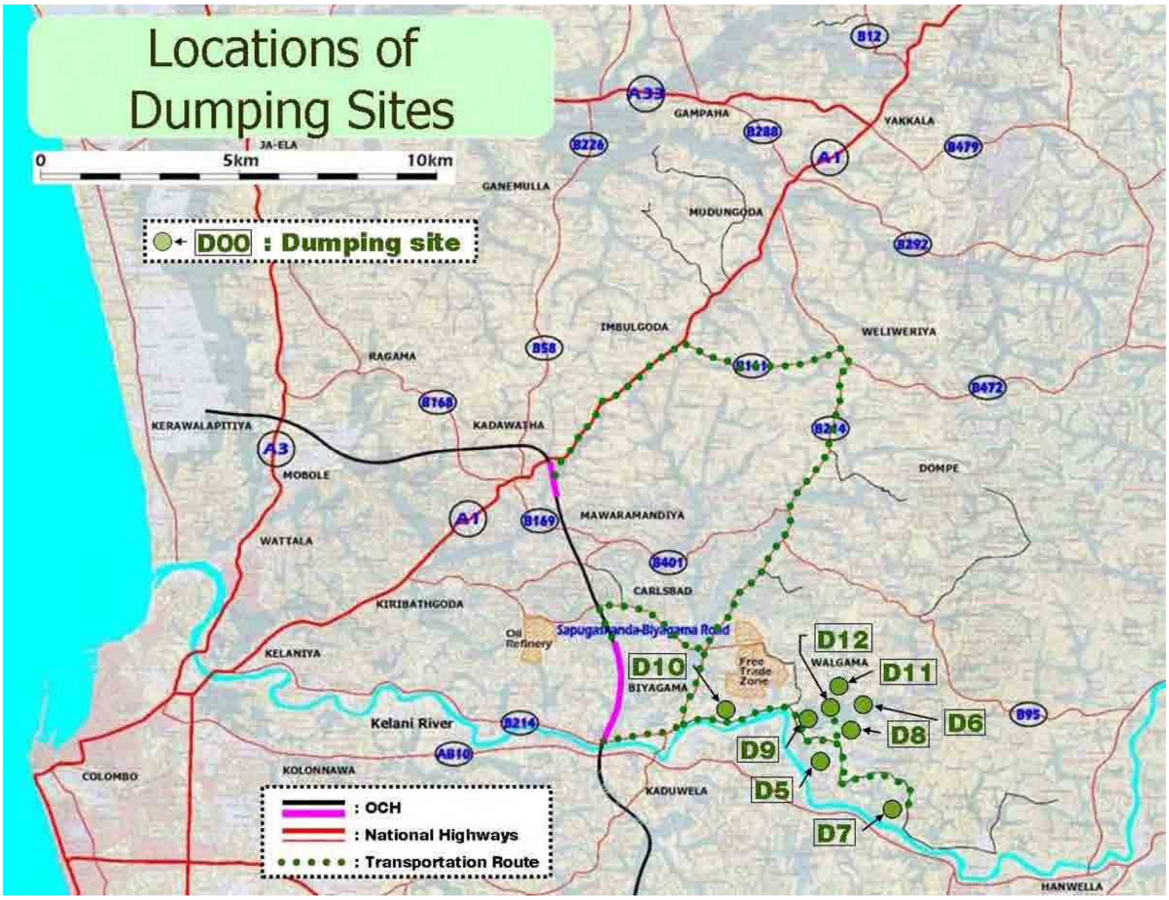


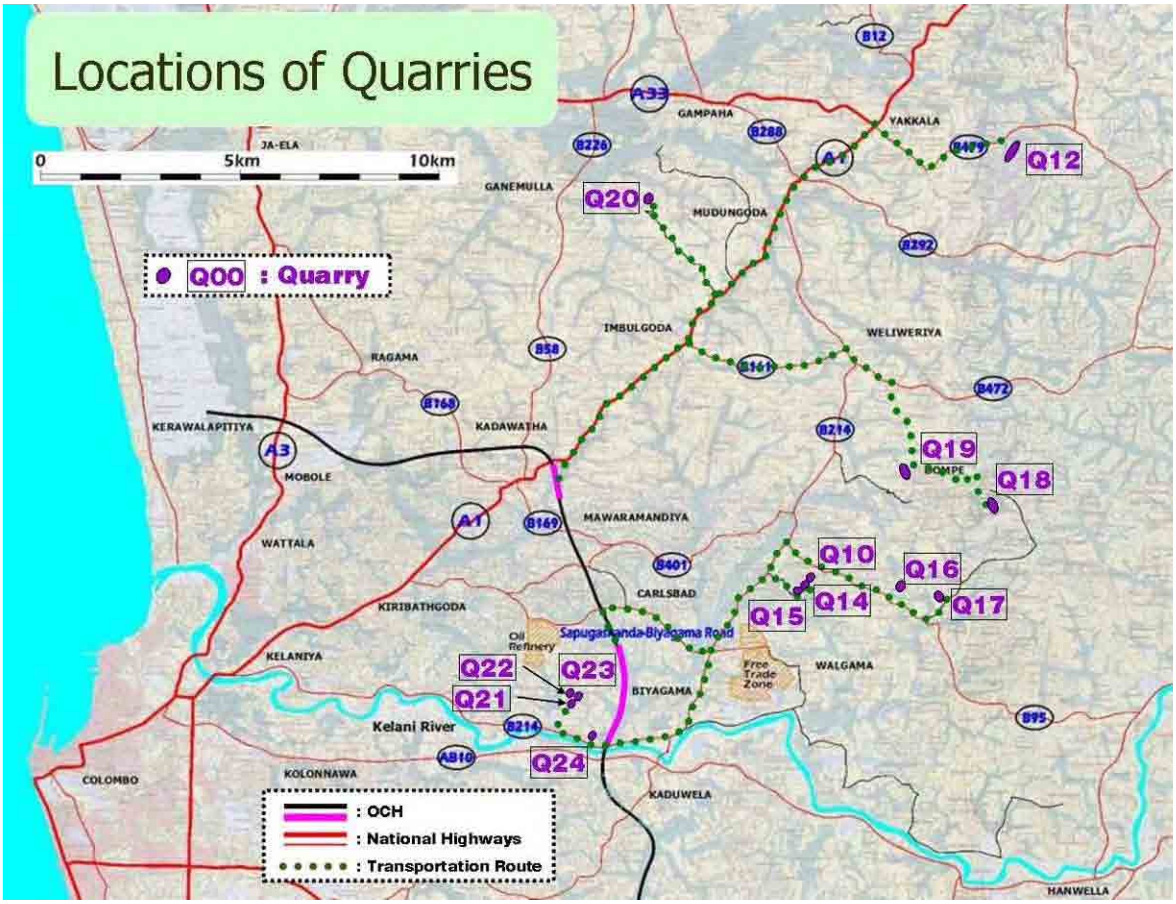
Fig 3.3.2 Location Map of Sites for Materials & Disposal

The transportation routes, capacity of sites (for dumping, quarries and borrow pits), and the average road distance from sites to the OCH are as shown in **Fig. 3.3.3**, **Fig. 3.3.4**, and **Fig. 3.3.5**. Generally, the distance from a site to Section 1 is much farther than that of a site to Section 2 or 3. Note that there is sufficient capacity at the dumping, quarry, and borrow sites; although, the surplus between existing and required capacity for dumping and borrow materials is small. On the other hand, in the case of quarries, there is a large surplus of capacity.



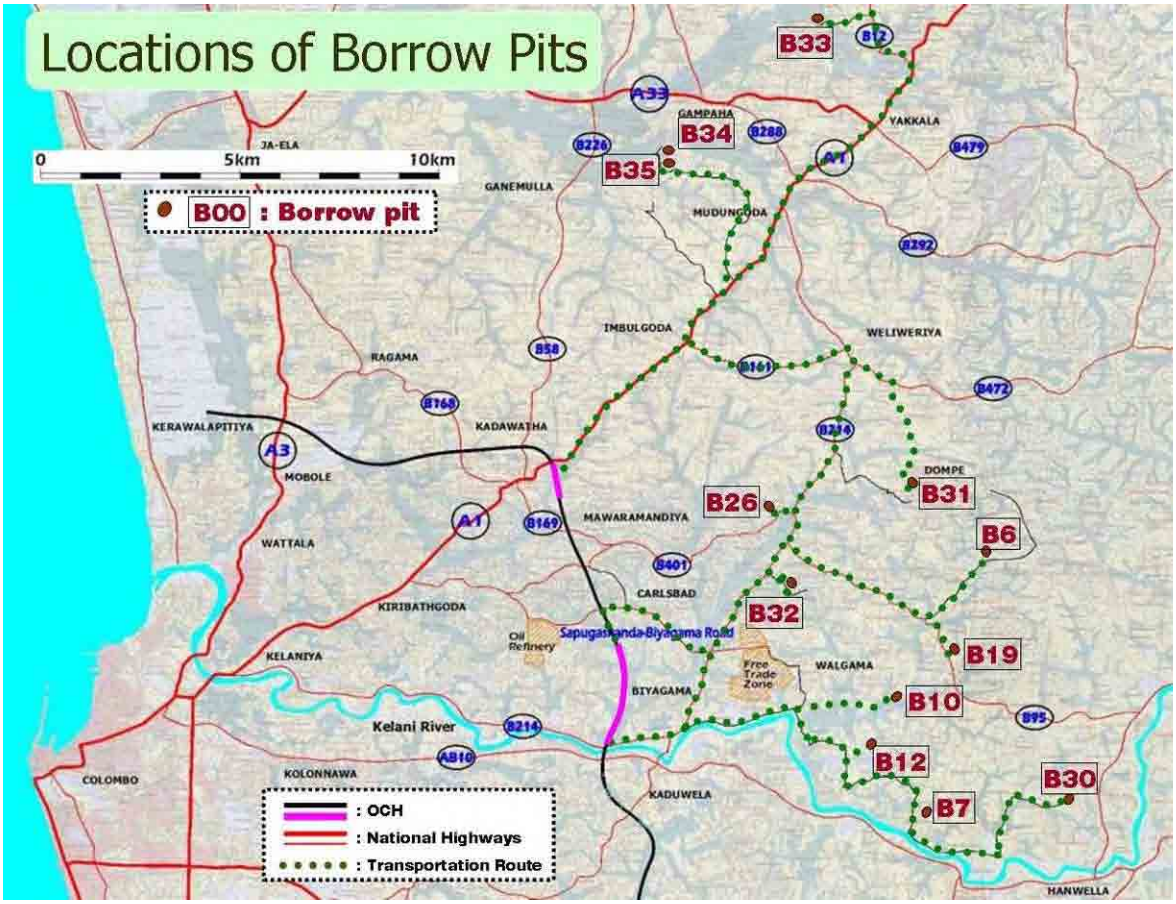
Section 1				Section 2,3			
Disposal Volume (× 1,000m³)			642	Disposal Volume (× 1,000m³)			556
Disposal Volume (× 1,000m³)							1,198
Site No.	Distance from OCH (km)	Area (ha)	Volume (× 1,000m³)	Site No.	Distance from OCH (km)	Area (ha)	Volume (× 1,000m³)
D6	27.0	5.0	100	D5	7.0	10.0	200
D9	24.0	2	40	D7	11.0	5.0	100
D10	22.0	10	400	D8	8.5	20.0	400
D11	25.0	2	40				
D12	26.0	5	100				
Sub Total			680	Sub Total			700
Total Available Capacity (× 1,000m³)							1,380

Fig. 3.3.3 Location & Capacity of Dumping Sites



Section 1				Section 2,3			
Required Volume (× 1,000m³)			807	Required Volume (× 1,000m³)			793
Total Required Volume (× 1,000m³)							1,600
Site No.	Distance from OCH (km)	Area (ha)	Volume (× 1,000m³)	Site No.	Distance from OCH (km)	Area (ha)	Volume (× 1,000m³)
Q12	17.0	1.0	300	Q10	8.0	1.0	150
Q18	16.0	2.0	400	Q14	8.0	0.1	10
Q19	13.5	5.0	400	Q15	8.0	4.0	1,200
Q20	10.0	1.0	40	Q16	11.0	2.0	700
				Q17	13.0	2.0	100
				Q21	2.0	1.2	200
				Q22	2.0	2.0	550
				Q23	2.0	3.0	600
				Q24	0.5	1.2	150
Sub Total			1,140	Sub Total			3,660
Total Available Capacity (× 1,000m³)							4,800

Fig. 3.3.4 Location & Capacity of Quarries



Section 1				Section 2,3			
Required Volume (×1,000m³)			890	Required Volume (×1,000m³)			983
Total Required Volume (×1,000m³)							1,873
Site No.	Distance from OCH (km)	Area (ha)	Volume (×1,000m³)	Site No.	Distance from OCH (km)	Area (ha)	Volume (×1,000m³)
B6	21.0	4.0	300	B7	11.0	1.0	600
B19	20.0		100	B10	7.5	1.0	100
B26	14.0		40	B12	8.5	14.0	300
B31	14.0	5.0	300	B30	17.0	0.8	50
B32	16.0	4.0	100	B32	8.0	4.0	50
B33	18.0	3.0	150				
B34	13.0	1.0	30				
B35	12.0	2.0	100				
Sub Total			1120	Sub Total			1,100
Total Available Capacity (×1,000m³)							2,220

Fig. 3.3.5 Location & Capacity of Borrow Pits

(2) Construction Schedule

The total period scheduled for construction for the Original Design is almost 4 years (see **Fig. 3.3.6**), with the transportation of materials to and from Section 1 and 3 being on the critical path. The traffic volumes for transporting Section 1 material are 70 trucks/hr for spoilage, 80 trucks/hr for quarry material, and 90 trucks/hr for borrow material, with total traffic being 240 trucks/hr (round-trip). In the case of Section 3, the total number of daily round-trips by construction trucks is 210, while it is 190 vehicles for Section 2. Because of the large volume of materials that need to be transported, as well as the congestion that on existing roads, the construction period is long (i.e., 4 years).

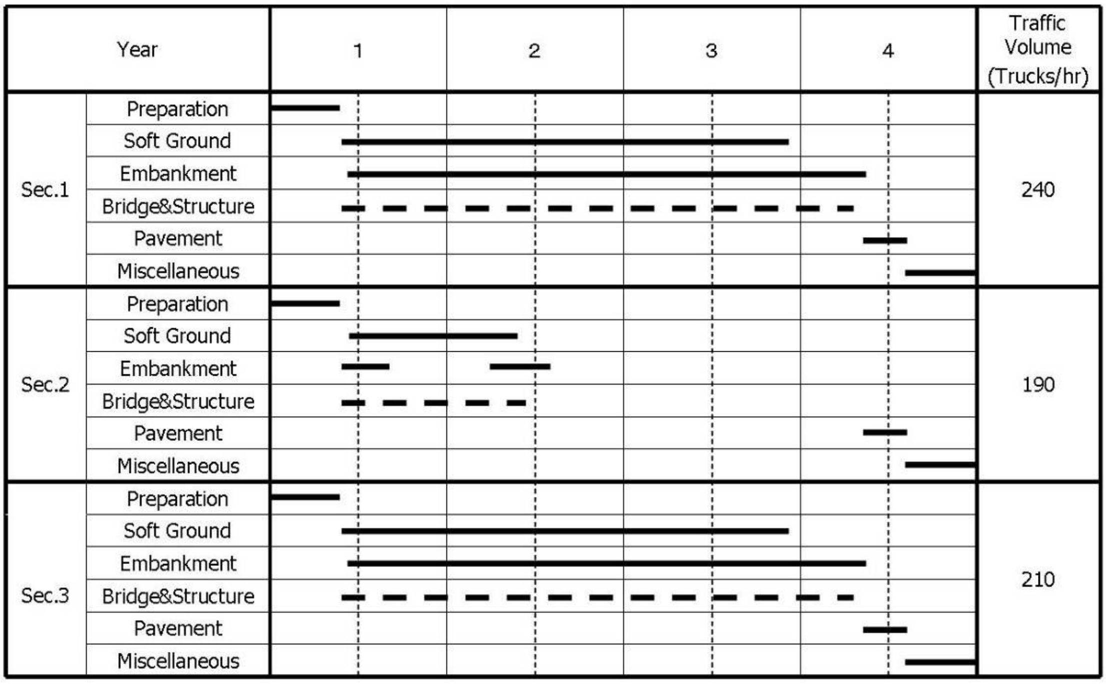


Fig. 3.3.6 Construction Schedule

3.3.4. Summary of Issues

The results of the examination of the Original Design are summarized in **Table 3.3.4**. Construction work for Section 2 is expected to be completed in 2 years and can then be utilized for the construction of Section 1. On the other hand, it will be necessary to transport materials for Section 1 for the initial two years during the night, as congestion on A1 is severe during the day. This, of course, will cause undesirable social impacts. On the other hand, B214 will be used for haulage of Section 2 and 3. This also difficult to avoid undesirable social impact in spite of the capacity of B214 will be enough for transport during the day. Moreover, it is expected that negative impacts to the social and natural environment along the entire OCH will occur as the material to be mined or disposed of is large as is the number of transport trucks. Therefore, reducing the amount of material or spoilage, together with the number of trucks, will be most effective way to reduce undesirable social impact.

Table 3.3.4 Summary of Issues

<table>
<tr><th colspan="2">Design & Issue</th><th colspan="2">Sec.1(incl. IC•Bypass)</th><th colspan="2">Sec.2</th><th colspan="2">Sec.3</th></tr>
<tr><td rowspan="3">Original Design</td><td>Disposal (x1000m³)</td><td colspan="2">642</td><td colspan="2">85</td><td colspan="2">471</td></tr>
<tr><td>Quarry (x1000m³)</td><td colspan="2">807</td><td colspan="2">156</td><td colspan="2">637</td></tr>
<tr><td>Borrow pit (x1000m³)</td><td colspan="2">890</td><td colspan="2">54</td><td colspan="2">929</td></tr>
<tr><td rowspan="8">Issue</td><td>Dumping site</td><td>Share with Sec.2,3</td><td>Av.Dist. 25km</td><td>Sufficient</td><td>Av.Dist. 10km</td><td>Sufficient</td><td>Av.Dist. 8km</td></tr>
<tr><td>Quarry</td><td>Sufficient</td><td>Av.Dist. 16km</td><td>Sufficient</td><td>Av.Dist. 7km</td><td>Sufficient</td><td>Av.Dist. 5km</td></tr>
<tr><td>Borrow pit</td><td>Share with Sec.2,3 (partial)</td><td>Av.Dist. 17km</td><td>Sufficient</td><td>Av.Dist. 12km</td><td>Sufficient</td><td>Av.Dist. 9.5km</td></tr>
<tr><td>Main transport route</td><td colspan="2">A1 , B214</td><td colspan="4">Sapugaskanda – Biyagama Road , B214</td></tr>
<tr><td>Traffic volume (2008)</td><td colspan="2">A1 : 36,600 cars/day</td><td colspan="4">B214 : 21,800 cars/day</td></tr>
<tr><td rowspan="2">Operation of construction trucks</td><td colspan="2">A1: Daytime use not possible due to lack of road capacity</td><td colspan="4">Daytime use possible</td></tr>
<tr><td colspan="2">Disposal : 70
Quarry : 80
Borrow pit : 90
(trucks/hr)
After completion Sec.2, will be used as access road</td><td colspan="2">Disposal : 50
Quarry : 100
Borrow pit : 40
(trucks/hr)
Timing for transport of borrow pit materials different</td><td colspan="2">Disposal : 50
Quarry : 65
Borrow pit : 95
(trucks/hr)</td></tr>
<tr><td>Quantity</td><td colspan="2">Desirable to reduce quantity</td><td colspan="2">No problem</td><td colspan="2">Desirable to reduce quantity</td></tr>
</table>

3.4. Examination of Alternatives

To reduce the impacts described above, alternative construction design and concepts are examined. First, the gravel compaction pile method (hereafter referred to as GCP or Alt.0) is proposed to be the basic soft soil countermeasure instead of the replacement method, and aims to reduce disposal volume to zero (see details in **Chapter 5**). In addition to the adoption of GCP, the utilization of viaducts on Section 1 and 3 instead of embankments is proposed to reduce the amount of quarry and borrow materials with Alt.1, 2, and 3 representing minimum, medium, maximum viaduct application. Note that high priority viaduct application consists of the high embankment of Section 1, which has no peat or organic clay (refer to Fig. 3.5), and Section 2 because of its large amounts peat or organic clay (refer to Fig. 3.5). The type of viaduct to be used will be pre-stressed concrete in this examination.

3.4.1. Selection of Alternatives

A total of four alternatives, in addition to the Original Design, are prepared with the objective of reducing the volume of materials and spoilage, and are described below and summarized in **Table 3.4.1**.

Alt.0: Same as the Original Design except it applies the GCP method instead of the replacement method so as to reduce spoilage to zero.

Alt.1: This alternative, which is a plan for minimum viaduct application, will reduce borrow material volume for Section1 via the use of 928m of viaduct (323m of main carriageway & 605m of ramp: refer to ②, ③ in **Fig 3.4.1**). Moreover, the section from A1IC to the A1 Bypass is to be constructed simultaneously.

Alt.2: This alternative, which is a plan for medium viaduct application, will reduce the borrow material of Section 3 via the use of 877m of viaduct (refer to ⓑ, ⓒ, ⓓ in **Fig.3.4.2**), as well as incorporate the viaduct of Alt.1. On the other hand, the section from A1IC to the A1 Bypass will be completed after the remainder of Northern Section 1 in order to mitigate negative impacts from the transportation of borrow and spoilage

Alt.3: This alternative, which is a plan for maximum viaduct application, will reduce the borrow material from Section 1 via the use of 1807m of viaduct (792m of main carriageway, 605m of ramp, 410m of bypass: refer to ①, ②, ③, ④ in **Fig.3.4.1**) and from Section 3 via the use of 1407m viaduct (refer to ⓐ, ⓑ, ⓒ, ⓓ in **Fig.3.4.2**). In addition, the entire Northern Section 1 will be completed in 3 years.

Table 3.4.1 List of Alternatives

	Summary	Soft Ground Counter-measures	Viaduct Section			①A1-A1BP Construction timing
			Sec.1	Sec.2	Sec.3	
Original Design	Embanked Structure	Replacement	40m (A1BP)	None	50m (River)	Simultaneous
Alt.0	Review the Soft Ground Countermeasure	GCP	40m (A1BP)	None	50m (River)	Simultaneous
Alt.1	Viaduct Construction Minimum Case	GCP	②A1BP-9+000:323m ③IC Ramp :605m	None	50m (River)	Simultaneous
Alt.2	Viaduct Construction Medium Case	GCP	②A1BP-9+000:323m ③IC Ramp :605m	None	877m (A)	Later
Alt.3	Viaduct Construction Maximum Case	GCP	①A1 – A1BP :469m ②A1BP-9+000:323m ③IC Ramp :605m ④A 1 B P :410m	None	1,407m (B)	Simultaneous

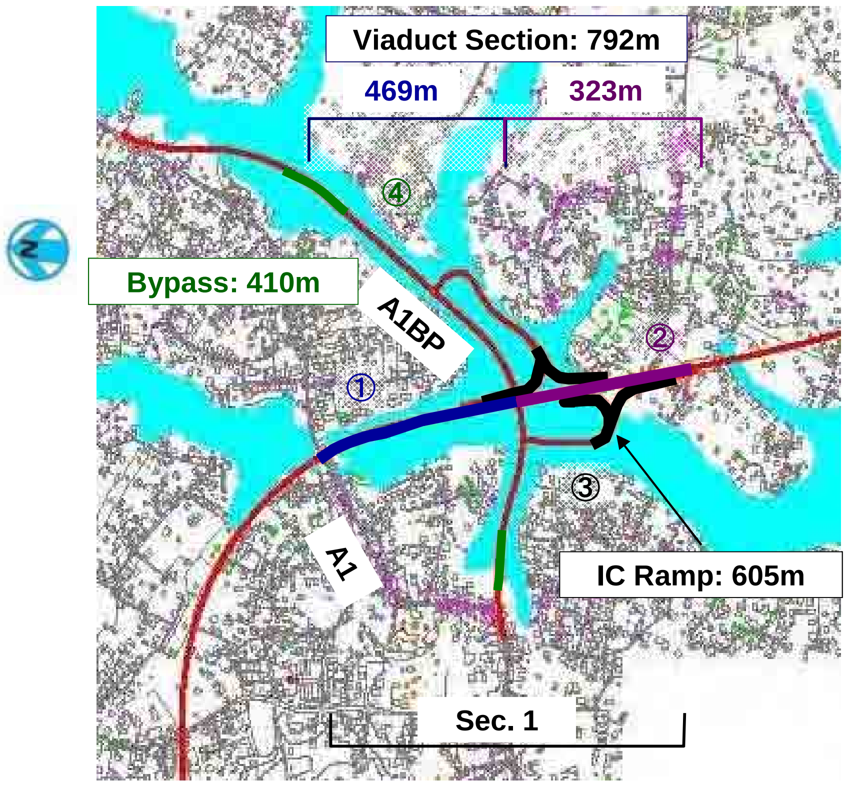


Fig. 3.4.1 Layout for Section 1

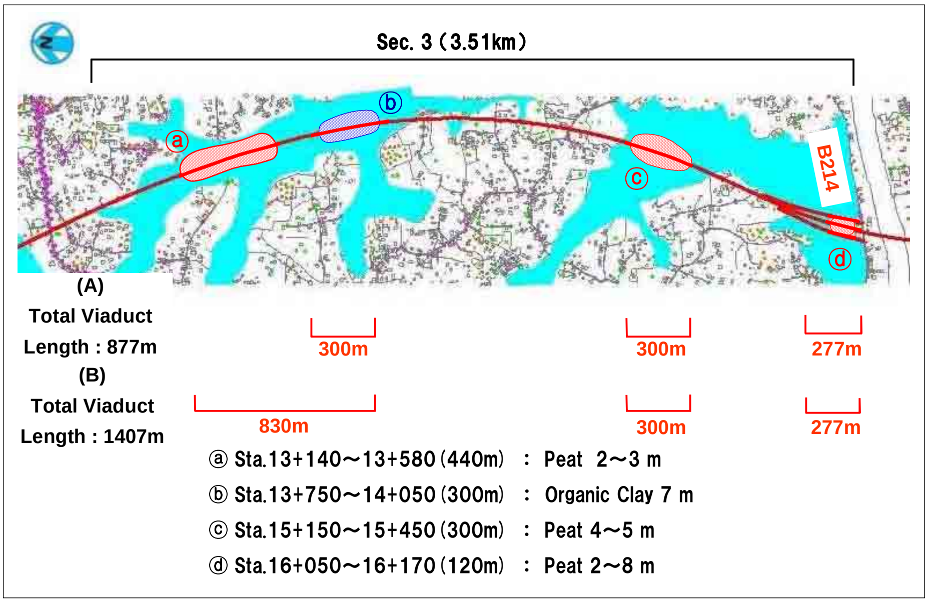


Fig. 3.4.2 Layout for Section 3

3.4.2. Comparison of Alternatives

The earthwork volumes for each alternative are as shown in **Table 3.4.2**. Note that with the use of GCP there will essentially be no spoilage; although, there will be a small amount of spoilage for Alt.2 when replacing peat in order to build a temporary service road for construction work. Gravel will be used to construct 1-meter gravel mats to replace soft soil and is part of the GCP method. Obviously, as the amount of viaduct increases, the amount of gravel and borrow material declines. Alt.3, which has the largest amount of viaduct, results in total haulage decreasing by 80%, while Alt.2 and Alt.1, which are number 2 and 3 in terms of viaduct length, result in haulage decreasing by 61% and 52%, respectively (see **Fig. 3.4.6** for details).

Table 3.4.2 Earthwork Volume of Alternatives

Alter-native	Comparison Item	Sec.1 (Including IC•Bypass)					Sec.2	Sec.3	Total (x1000m³)
		① A1 – A1BP	② A1BP – 9+000	③ IC Ramp	④ A1BP	Total			
Original Design	Disposal	138	108	198	198	642	85	471	1,198
	Quarry	170	134	246	257	807	156	637	1,600
	Borrow pit	288	144	230	228	890	54	929	1,873
Alt.0	Disposal	0	0	0	0	0	0	0	0
	Quarry	67	53	103	103	326	101	319	746
	Borrow Pit	288	144	230	228	890	54	929	1,873
Alt.1	Disposal	0	0	0	0	0	0	0	0
	Quarry	67	0	62	103	232	101	319	652
	Borrow Pit	288	3	91	228	610	54	929	1,593
	Viaduct Ext.	–	323m	605m	–	–	–	50m	–
Alt.2	Disposal	0	0	0	0	0	0	57	57
	Quarry	(67)	0	62	103	165 (67)	101	239	505 (67)
	Borrow Pit	(288)	3	91	228	322 (288)	54	551	927 (288)
	Viaduct Ext.	–	323m	605m	–	–	–	877m (A)	–
Alt.3	Disposal	0	0	0	0	0	0	0	0
	Quarry	0	0	62	70	132	101	117	350
	Borrow Pit	0	3	91	113	207	54	337	598
	Viaduct Ext.	469m	323m	605m	410m	–	–	1,407m (B)	–

Note 1 : ( ) Volume for A1 – A1BP Construction Work
Note 2 : Replacement method used for some of the soft soil in Alt.2 due to trafficability for bridge construction

3.4.3. Comparison of Construction Cost

The estimated construction cost of each alternative is as shown in **Table 3.4.3**. These costs include the expenditure necessary for maintaining roads to be used by the construction trucks, such as pavement patching and spraying water, together with a 10% contingency, but exclude engineering fees and land acquisition and long-term RDA maintenance costs. As compared to the Original Design, the construction cost of Alt.0 and Alt.1 will result in approximately a 14% and 15% increase, respectively, while the construction costs of Alt. 2 and Alt.3 will increase by about 20% and 31%, respectively. **Fig. 3.4.3** gives a breakdown of the construction costs by section and alternative, indicating the trends in expenditures for soft soil countermeasures, embankments, and viaducts. Note that a viaduct costs about twice as much as an embanked structure.

Table 3.4.3 Construction Cost of Alternatives

	Sec.1	Sec.2	Sec.3 (Incl. Kelani Bridge)	Total	Rate
Original Design	49.8	29.5	70.2	149.5	-
Alt.0	58.3	32.3	80.3	170.9	114.3%
Alt.1	59.5	32.3	80.3	172.1	115.1%
Alt.2	59.5	32.3	86.9	178.7	119.5%
Alt.3	71.2	32.3	91.8	195.3	130.6%

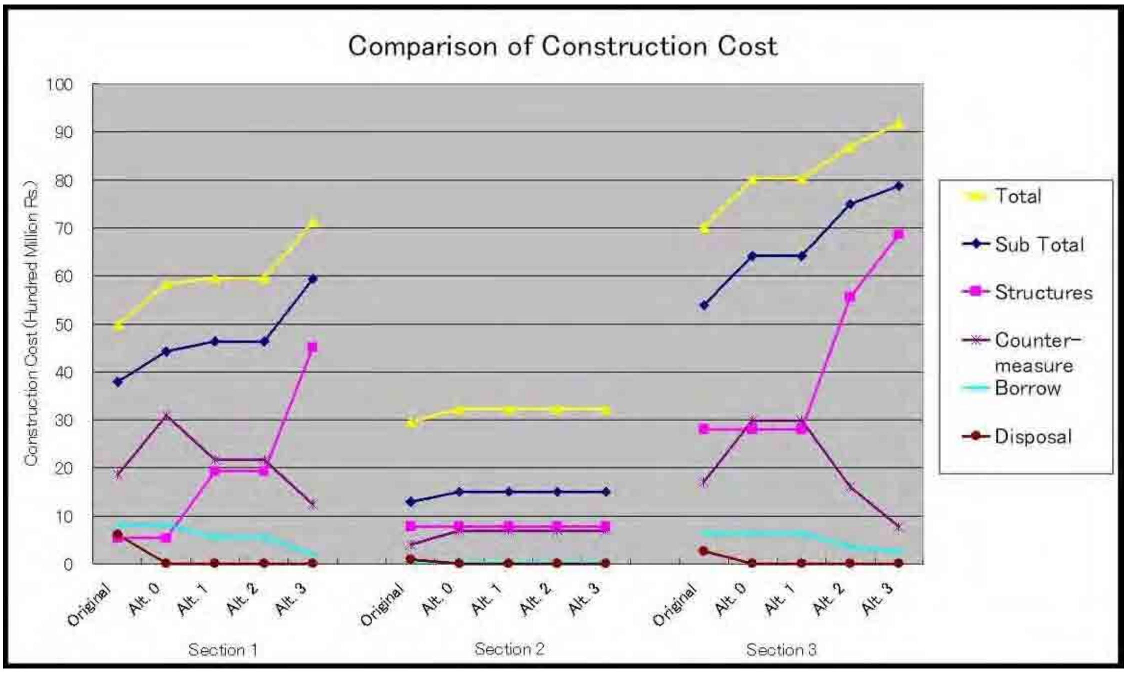


Fig. 3.4.3 Breakdown of Construction Costs by Alternative

3.4.4. Comparison of Construction Schedule

The construction schedule and number of construction trucks per hour for each alternative are as shown in **Fig. 3.4.4**. The period of construction will be shortened with the utilization of GCP and viaducts. However, even in the case of Alt.3, which has the largest amount of viaduct, a three year construction period will still be necessary due to the time required to build the Kelani River Bridge. Note that the construction period of Alt.2 will also be 3 years, as the section between the A1 Road and A1 Bypass will be constructed at a later time (or, 1 year after the completion of the remaining sections of Northern Section 1). As for Alt.0 and Alt.1, they will require 3 years 9 months and 3 years 6 months, respectively, to be completed and their longer schedules are due to the shorter lengths of viaduct.

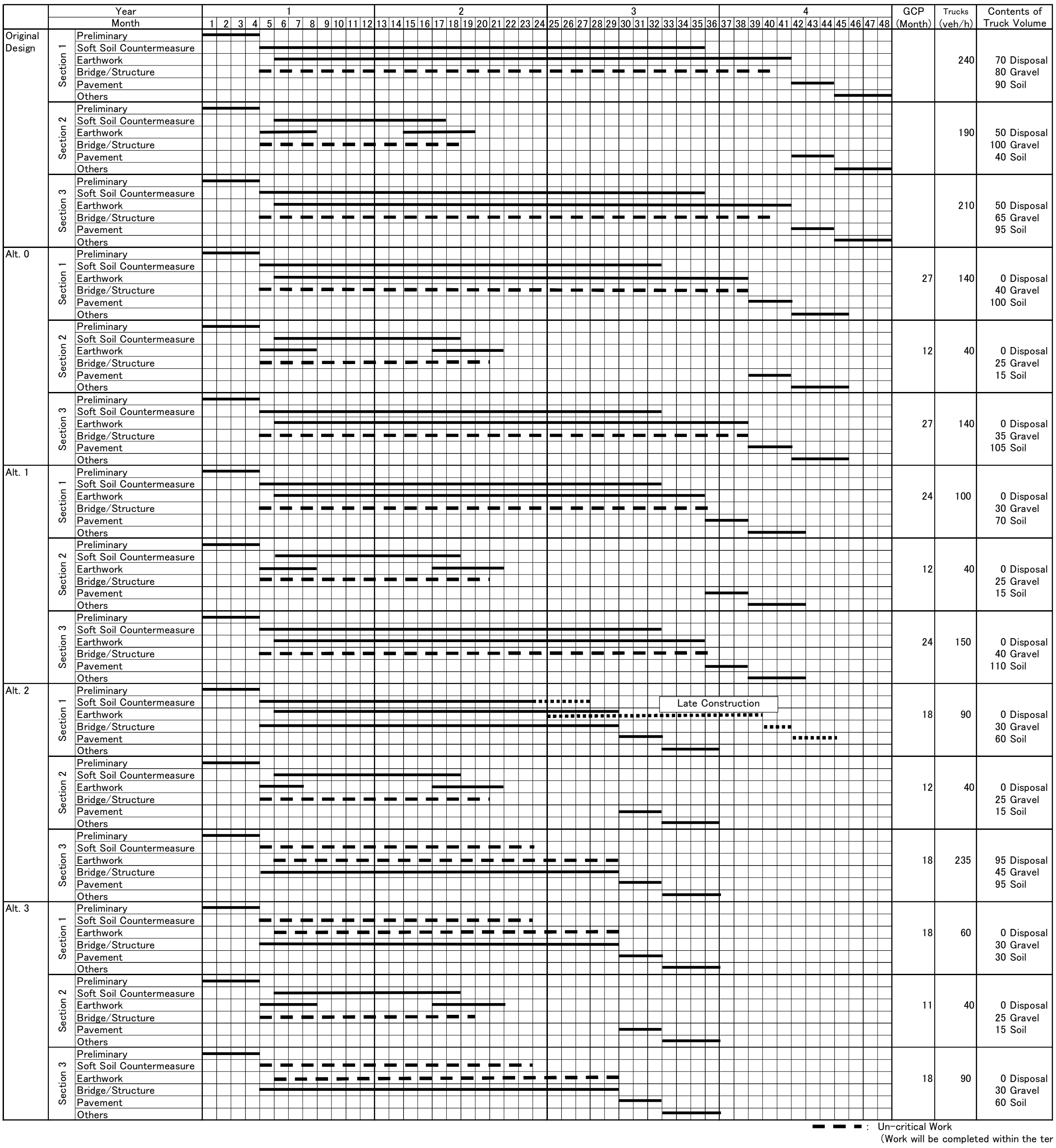


Fig. 3.4.4 Construction Schedule of Alternatives

3.4.5. Comparison of EIRR

Taking into account the increase in costs and the required construction time, the EIRR for each alternative was calculated. As **Fig. 3.4.5** indicates, Alt.2 maximizes economic return. That is, although there is an increase in construction cost, Alt.2 has a higher EIRR than the Original Design due to this cost being offset by a greater increase in benefits (such as time and vehicle operating cost savings) being realized at an earlier date. The other alternatives have a lower EIRR because of a poorer balance between costs and benefits. For example, Alt.0 has the lowest EIRR as costs will go up significantly but the construction schedule is only shortened by a mere 3 months to 3 years 9 months. On the other hand, Alt.1 has a better EIRR because it will result in the construction schedule being shortened by 6 months and its costs are almost the same (0.8% greater) as that of Alt.0. Alt.2 costs again are only slightly larger (5.2%) than that of Alt.0, but the construction schedule is reduced by a full year, while Alt.3 is about 10% costlier than Atl.2 but does not result in any savings in construction time.

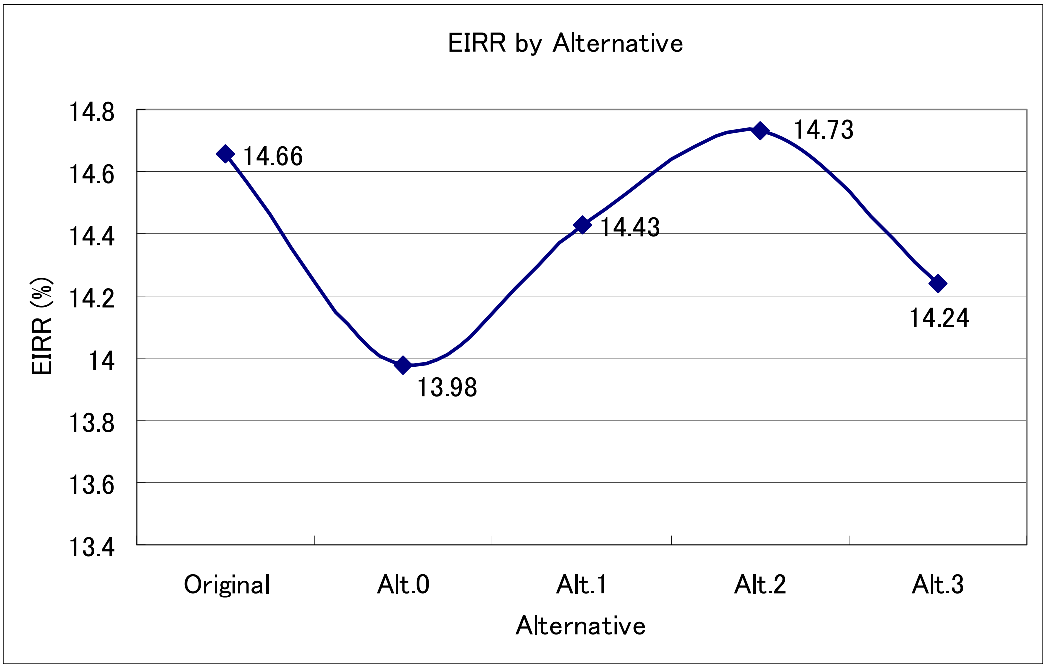
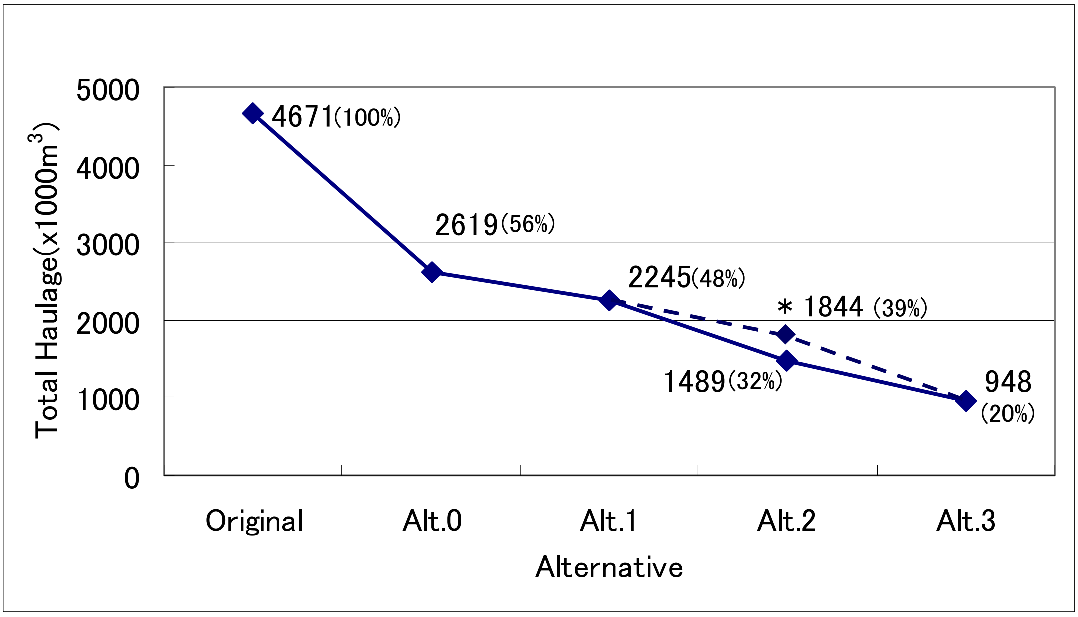


Fig. 3.4.5 EIRR by Alternative

3.4.6. Comparison of Haulage

The variation in total haulage for each alternative is as shown in **Fig. 3.4.6**. Note that total haulage can be reduced by up to 80% as compared to the Original Design by adopting Alt.3. In the case of Alt.2 61% of haulage can be eliminated, while for Alt.1 and Alt.0 the total reduction is 52% and 44%, respectively. As stated previously, the greater the amount of viaduct the lesser the amount to be hauled.



( ):% rate as compared to Original Alternative
* : Cost if section to connect Kadawatha Interchange with A1 included

Fig. 3.4.6 Haulage by Alternative

3.4.7. Selection of Most Suitable Alternative

Table 3.4.4 shows the overall results of the comparison of the alternatives and the conclusions derived from that are listed below.

Table 3.4.4 Overall Comparison of Alternatives

Name of Alternative	Soft Soil Counter-measures	Viaduct Section			Haulage	Social Environmental Aspect	Constr. Period (yrs)	Cost		EIRR (%)
		Sec.1	Sec.2	Sec.3	Total (x1000m³)			Total (Bn. Rs.)	Rate (%)	
Original	Replace-ment	40m (A1BP)	None	50m (River)	4671	-	4	14.95	100.0	14.66
Alt.0	GCP	40m (A1BP)	None	50m (River)	2619	-	3.75	17.09	114.3	13.98
Alt.1	GCP	OCH: 323m I C: 605m B P: 0m	None	50m (River)	2245	-	3.5	17.21	115.1	14.43
Alt.2	GCP	OCH: 323m I C: 605m B P: 0m	None	OCH : 877m I C : 278m	1489 (1844)	GOOD	3+(1)	17.87	119.5	14.73
Alt.3	GCP	OCH: 792m I C: 605m B P: 410m	None	OCH : 1407m I C : 278m	948	GOOD	3	19.53	130.6	14.24
Alt.2'	GCP	OCH: 323m I C: 605m B P: 0m	None	OCH : 2057m IC : 278m	499 (809)	GOOD	3+(1)	19.48	130.3	-
Alt.3'	GCP	OCH: 792m I C: 605m B P: 410m	None	OCH : 2057m IC : 278m	488	GOOD	3	20.83	139.3	-

Note 1 : Shaded row indicates selected alternative for design concept
Note 2 : GCP – Gravel Compaction Pile Method
Note 3 : Cost excludes expenditures for contingency, land acquisition & consultancy fees

1. Although the replacement method is the most conventional soft soil countermeasure, there will be substantial negative social and environmental impacts during construction due to the great number of construction trucks and large-scale mining and disposal, which requires the hauling of materials in the Original Design 1.8 to 4.9 times that of the alternatives under consideration.
2. Taking into consideration the availability of material, reliability, popularity, and cost, the GCP method is proposed to be the best soft soil countermeasure for reducing spoilage and quarry material and should be used instead of the replacement method. Note that GCP is applied across all of the alternatives.
3. In addition to reducing spoilage and quarry material with the GCP method, borrow material is reduced by adopting viaducts, which vary in amount from alternative to alternative. Alt.2 is recommended by the JICA Study Team for the design and construction of Northern Section 1 for the following reasons:

   - It optimizes the economic viability of the project via the maximization of the EIRR, which is slightly higher than that of the Original Design due to a shorter construction schedule and greater benefits that outweigh the additional costs of viaducts (resulting in an increase of cost of about 20% over the Original Design).
   - The construction period is the same as Alt.3 if the section from A1 to A1 Bypass is constructed later, and construction cost is about 10% less.
   - Total materials for haulage will be cut by 61% as compared to the Original Design and will thereby significantly reduce negative social and environmental impacts. Although this reduction is lower than that of Alt.3, the cost of Alt.3 results in the EIRR being lower than of Alt.2 and thereby produces a lower return on investment.
   - The resulting decrease in materials to be hauled will result in the number of construction vehicles to decline to one-third of that for the Original Design, meaning that daytime operation will be acceptable on all transport routes (including A1).

Based on the above reasons and discussions with the Sri Lanka side, Alt.2 was proposed to be adopted with the A1-A1 Bypass section to be constructed at a later date. Note that an additional geological survey was also carried out for the viaducts of Alt.2.

3.5. Preparation of Optimal Proposal

Based on the foregoing, preparation of an optimal proposal was started by carrying out the detailed design (added PC viaduct: basic design) for Alt.2 (hereafter referred to as Alt.2 D/D). Subsequent to that, the following 3 items were taken up regarding Alt.2 D/D and the results incorporated and renamed as Original Design 2:

- Whether the A1-A1 Bypass is to be included in the project scope of work.
- The re-examination of viaduct sections based on updated geological survey data.
- Re-examination of soft soil countermeasures.

In addition, the Sri Lanka side requested the application of a JBIC STEP (Special Term for Economic Partnership) loan, as Japanese technology will provide advantages regarding soft soil countermeasures and rapid construction in congested and/or confined areas. In accordance with this, proposals that apply Japanese Technology based on the Original Design 2 were examined by the JICA Study Team. After comparing these proposals, an optimal proposal was prepared and finalized in deliberations with the Sri

Lanka side.

3.5.1. STEP Loan Conditions

The purpose of a STEP loan is to utilize and transfer advanced Japanese technologies and know-how under the following conditions:

(1) Interest/Repayment period

- Interest Rate: 0.2%/year
- Repayment period: 40 years (10 years grace)

(2) Procurement of Contractor:: Prime contractor must be Japanese firm

(3) Country of Origin of Goods and Services to be procured under STEP:

- No less than 30% of the total amount of the contract must be for goods and/or services from Japan

3.5.2. Setting of Original Design 2 for examination of Optimal Proposal

(1) Base Design for Original Design 2

Original Design 2 is prepared in this section by refining its base, or Alt2. D/D. In **Table 3.5.1,** the Original Design, Alt.2, and Alt.2 D/D are compared. As the results for Alt.2 D/D indicate, disposal volume increases slightly due to the application of the replacement method for soft ground under box culverts. Although it is possible that all the construction will be completed in 3 years, the construction of the section between A1 and the A1 Bypass will require an additional half year in order to avoid the haulage of overly large quantities of material (see **Fig. 3.5.1**). Note that the total construction cost of Alt.2 D/D, which is estimated at Rs. 17.7 billion, is slightly lower than that of Alt.2 at about Rs. 17.9 million.

Table 3.5.1 Summary of Detailed Design

		Original Design (B/D)	Alt.2 (26th April 2007)	D/D (30th Sep. 2007)
Disposal (x1000m^3)		1,198	57	96
Quarry (x1000m^3)		1,600	505 (67)	338 (39)
Borrow pit (x1000m^3)		1,873	927 (288)	1027 (235)
Bridges / Viaducts / Ramps	No.	4	11	11
	Length (m)	349	2,438	2,496
Overpass	No.	6	5	5
	Length (m)	286	226	226
Main Method of Soft Soil Countermeasure		Replacement	GCP	GCP
Construction Period (Yrs)		4	3 + (1)	3 + (0.5)
Project Cost (Bn. Rs.)		14.95	17.87	17.698

Note : ( ) Volume for A1 – A1BP Construction Work

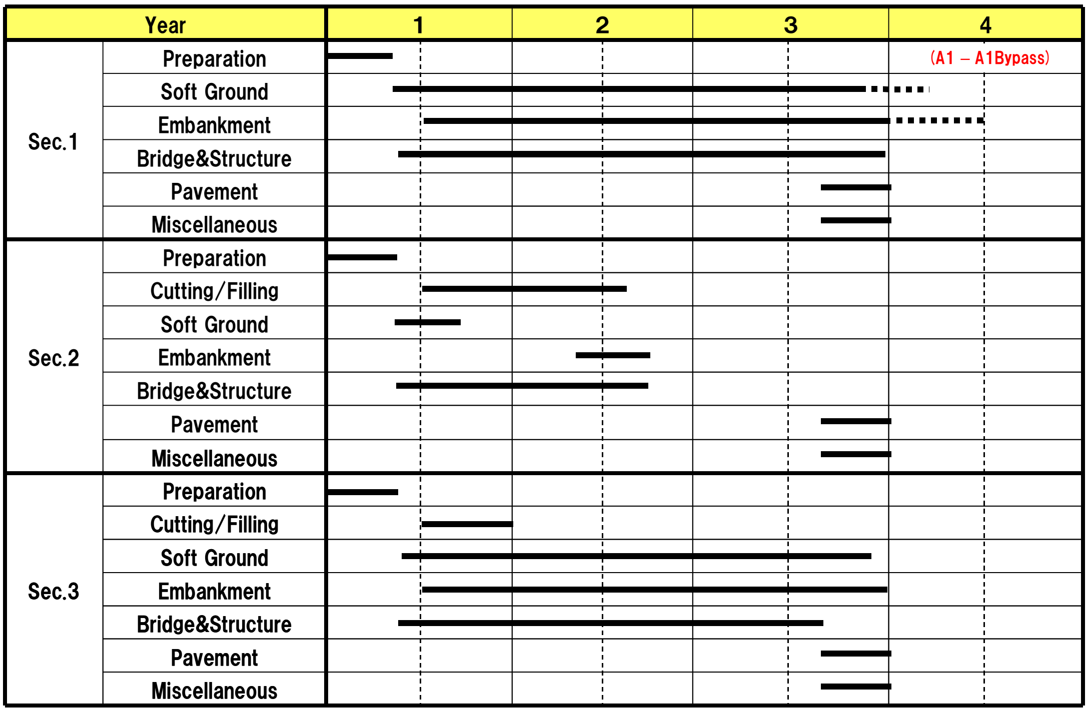


Fig. 3.5.1 Construction Schedule

(2) Removal of A1-A1 Bypass from Project

Taking into consideration the large volume of earthwork for the section between A1 and the A1 Bypass (**Table 3.5.2**) and the need to minimize social impacts from haulage, it will take three and half years to complete the construction of Northern Section 1. On the other hand, only the section from the A1 Bypass to the OCH Southern Section will be utilized at the opening of Northern Section 1. Given this, and based on the deliberations between the Sri Lanka side and JBIC Appraisal Mission in August 2007, it has been decided to remove the A1-A1 Bypass Section from the project. **Table 3.5.3** shows the number of construction trucks and the total period for material haulage for the A1 interchange area for the following 3 cases: Case-1: Later, Case-2: Simultaneous, Case-3: Removal. By removing this section, the number of months with over 50 construction trucks per hour will be shortened to 23 from 31-35, and construction cost will be reduced by Rs. 700 million. In the future, it is possible to construct the A1-A1 Bypass section with fewer social impacts by using the existing portion of the OCH. Thus, it is concluded that it is appropriate to remove the A1-A1 Bypass section from the project and this result is to be incorporate into Original Design 2.

Table 3.5.2 Haulage Volume (Unit: 1,000m^3)

	A1－A1BP	A1BP -9+000	IC,Ramp	A1BP	Total
Disposal	0	0	0	0	0
Quarry	(39)	0	35	43	78 (39)
Borrow pit	(235)	0	147	370	517 (235)
Viaduct	－	322m	506m	－	－

Table 3.5.3 Comparison of Construction Schemes

Case	Construction between A1-A1BP	Const. Period (Years)	Operation of Construction Trucks on A1		Cost Reduction
			Maximum Trucks/hr	Total Month	
1	Latter (D/D)	3.5	50～68	35	0
2	Simultaneous	3	50～74	31	0
3	Removal	3	50～60	23	Approx.700 Mn. Rs.

(3) Reflection of Additional Geological Survey Results

Owing to an additional geological survey in August 2007, it is emerged that the peat and organic clay layers were wider than thought. Therefore, the Second Biyagama Viaduct was extended from 315m in Alt.2 D/D to 420m for Original Design 2 (see **Fig. 3.5.2**). Note that the vertical alignment of the main carriageway around the bridge was also amended to account for a change in beam clearance due to the extension, together with the soft soil countermeasure being revised slightly, and the results reflected in Original Design 2.

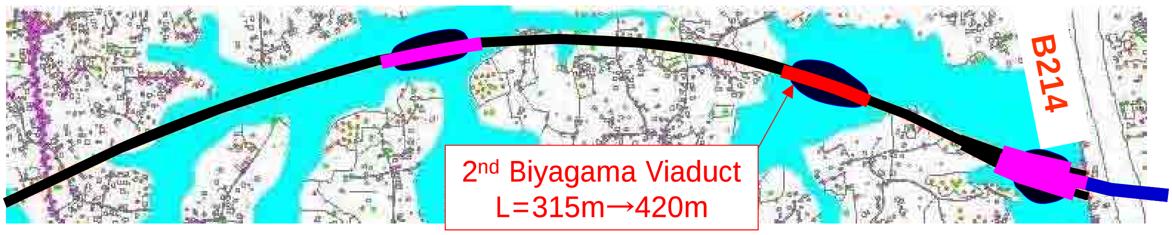


Fig. 3.5.2 Extension of 2nd Biyagama Viaduct

(4) Setting of Original Design 2 for Examination of Optimal Proposal

In addition to the preceding results, the soft soil countermeasure under box culverts is changed from replacement in Alt.2 D/D to GCP in Original Design 2, in order to further reduce spoilage due to the difficulty in securing dumping sites. Note, however, that a little spoilage will still remain as replacement is being applied to the narrow valley area at Sta.9+250 on Section 2 because of the difficulty in applying GCP. As the result of this, the total earthwork volume of Original Design 2 is a little less than 1.3 million m^3 and is only 27% of that of the Original Design.

Taking all of the above analysis into account, an outline of Original Design 2 is shown in Table 3.5.4. As the table shows, the construction period is three years and the cost of construction is about Rs. 17.2 billion and is the most suitable alternative for the project and its optimization is considered below.

Table 3.5.4 Summary of D/D & Adjusted D/D

		Original Design (B/D)	Alt.2 (26th April 2007)	Alt2. D/D (30th Sep. 2007)	Original Design 2 (11th Oct. 2007)
Haulage (x1000m3)	Disposal	1,198	57	96	6
	Quarry	1,600	505 (67)	338 (39)	266
	Borrow pit	1,873	927 (288)	1027 (235)	987
	Total %	4,671 100.0%	-	-	1,259 27.0%
Bridges/ Viaducts/ Ramps	No.	4	11	11	11
	Length (m)	349	2,438	2,496	2,601
Overpass	No.	6	5	5	5
	Length (m)	286	226	226	226
Main Method of Soft Soil Countermeasure		Replacement	GCP	GCP	GCP
Construction Period (Yrs)		4	3 + (1)	3 + (0.5)	3
Project Cost (Million Rs.)		14,950	17,870	17,698	17,194

Note : ( ) Volume for A1 – A1BP Construction Work

3.5.3. Comparison & Selection of Optimum Proposal

In this section, the content of Original Design 2 is optimized in order to present a final design proposal for the project. In accordance with the request from the Sri Lanka side to apply Japanese technology, which will provide advantages regarding soft soil countermeasures and rapid construction in congested and/or confined areas., the following technologies are recommended by the JICA Study Team:

1. The adoption of low-noise and low-vibration type of GCP method as a soft soil countermeasure because the Project is facing to residential area.
2. The adoption of steel viaducts which is able to save site work and to reduce construction period and then it is possible to facilitate rapid construction in congested and/or confined areas.

Concerning Item 2, the Study Team has proposed three possibilities for steel viaducts and they are compared in Table 3.5.5, with their locations indicated in Fig.3.5.3.

Case-1: Steel structure for main carriageway and ramp viaducts in A1IC area.

Case-2: Steel structure for First and Second Biyagama Viaduct.

Case-3: Steel structure for Kelani River Bridge and Kelani River Access Viaduct.

Table 3.5.5 Cases for Rapid Construction in Congested or Confined Areas

No.	Category			Length (m)	Case-1 (Steel at A1IC)	Case-2 (Steel at Biyagama)	Case-3 (Steel at Kelani River Area)
1	A1IC	Main Carriageway		322	Steel	PC	PC
2		Ramp		506	Steel	PC	PC
3	Biyagama	Main Carriageway	1	315	PC	Steel	PC
5			2	420	PC	Steel	PC
6	B214IC	Ramp		408	PC	PC	PC
7	Kelani River Access			275	PC	PC	Steel
8	Kelani River			355	PC	PC	Steel
9	Overpass			226	PC	PC	PC
Construction Cost (Million Rs.)					18,538	18,690	20,038

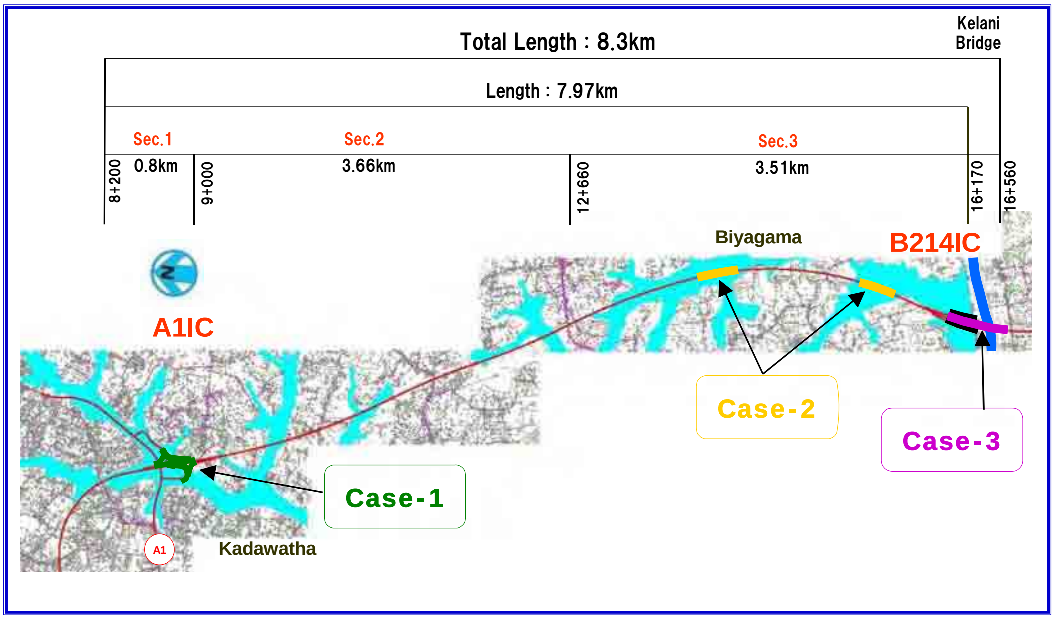


Fig. 3.5.3 Locations of Steel Viaducts

After deliberation with the Sri Lanka side regarding the above comparison of the different cases for steel viaduct construction, Case-1 was selected as the optimal proposal for the following reasons:

- The increase in project cost for Case-1 is the smallest of all the cases.
- The difficulty of transporting material to site is expected to be similar for the A1IC area of Case-1 and the Biyagama Area of Case-2 and 3.
- There will be a big advantage regarding the reduction of the amount and weight of material to be transported to site and will provide leeway for an already tight schedule at the A1IC area of Case-1..
- It is aesthetically preferable to apply curved steel ramp viaducts in the A1IC area of Case-1 rather than in the Biyagama area of Case-2 and 3.

Furthermore, it was confirmed that Case-1 will satisfy the requirements for a STEP loan roughly when the following items are considered as part of the Japanese portion.

- The purchasing and transportation of low-noise, low-vibration GCP equipment with the operating cost to be borne by the Japanese side on site.
- The material, fabrication, transportation, erection and painting cost for steel girders.
- The cost of Japanese engineers and technicians in connection with the overall project (assumed to be 2-5% of total construction cost).
- Overhead (assumed to be 7% of total construction cost).

3.5.4. Detailed Design Result

The summary of final result based on the Case-1 above shows in **Table 3.10**. Basic design is carried out for the viaducts of the A1IC area, Biyagama area, and the approach bridge of the Kelani River Bridge. On the other hand, detailed design is executed for the earthworks, the Kelani River Bridge, and other structures. Based on the design, the construction cost and project cost are estimated and the draft tender document is prepared.

Table 3.10 Final Result

			Bridge Type	Total Length (m) (Number of Bridges)	Design Level
Earth Work	A1 ~ A1BP		-	469	(Removed)
	A1BP ~ AB10		-	6122	D/D
Bridge	A1IC	Main Carriageway	Steel-I Girder	322 (1)	B/D
		Ramp	Steel-Box Girder	506 (4)	B/D
	Biyagama	Main Carriageway	PC-I Girder	735 (2)	B/D
	B214 IC	Ramp	PC-I Girder	408 (2)	B/D
	Kelani River Access		PC-I Girder	275 (1)	B/D
	Kelani River		PC-I Girder	355 (1)	D/D
	Overpass		PC-I Girder	226 (5)	D/D

Detailed design result based on case-1 is as shown in **Table 3.11**. In addition, it is confirmed that the result will satisfy the requirements for a STEP loan.

Table 3.11 Detailed Design Result

No.	Category			Length (m)	Original Design 2 (Adjusted D/D) (exclude A1-A1BP)	Case-1 (Steel at A1IC)	Detailed Design Result (Based on Case-1) 20.Dec.2007
1	A1IC	Main Carriageway		322	PC	Steel	Steel
2		Ramp		506	PC	Steel	Steel
3	Biyagama	Main Carriageway	1	315	PC	PC	PC
5			2	420	PC	PC	PC
6	B214IC	Ramp		408	PC	PC	PC
7	Kelani River Access			275	PC	PC	PC
8	Kelani River			355	PC	PC	PC
9	Overpass			226	PC	PC	PC
(A) Total Construction (Million Rs.)					17,194	18,538	18,702
(B) Japan Portion of Steel and GCP							4,006
(C) Japanese Engineer & Technician : (A) x (2~5%)							374~935
(D) Overhead : (A) x 7%							1,309
(E) (B) + (C) + (D)							5,689~6,250
(F) (E) / (A) (%)							30.4~33.4

Note, finally, that in the draft tender documents prepared by the JICA Study Team that the proposal of design alternatives will be accepted only for basic-design level viaducts at the time when construction bids are made.

CHAPTER 4

HIGHWAY & INTERCHANGE DESIGN

CHAPTER 4 HIGHWAY & INTERCHANGE DESIGN

4.1. Introduction

In this chapter, the detailed design of highway, interchange and bypass for Northern Section 1 of the OCH and the local road affected by construction of the OCH are described. The design was conducted based on the result of the Basic Design executed in 2005. The alignments of the highways, interchanges and some local roads are modified according to mainly the new topographic data carried out at site from 2003 to 2007, the amendment of the approach road class and the installation of toll plaza on the ramps.

4.2. Summary of Geometric Design Criteria

The summary of geometric design criteria for OCH main carriageway, interchange, and local road which is adopted in the detailed design is herewith introduced. The design standard adopted for detailed design for OCH is compiled in separate volume.

Table 4.2.1 Summary of the Geometric Design Criteria for OCH Northern Section 1

Item		Desirable Value	Criteria	Absolute Value	Adoption (Northern Section 1)
Design Speed		80km/h			
Min. Radius to Horizontal Curve		400m	280m	230m	700m
Min. Horizontal Curve Length		480m	240m		772m
Min. Transition Curve Length			70m		229m
Min. Radius Without Transition Curve			2000m		2000m
Min. Radius Without Superelevation		5100m	3500m		5500m
Max. Gradient			4%	5 – 7%*	2.551%
Min. Vertical Curve Length			70m		200m
Min."K" value of Vertical Curves	Crest		45		109
	Sag		31		70
Crossfall of Carriageway		2.5%			
Crossfall of Outer Shoulder		4.0%			
Max. Superelevation			6%		6%
Values of Superelevation related to Horizontal Curve (Design Speed 80km/h)		Less than 710m: 6.0% 710m to 790m: 5.5% 790m to 900m: 5.0% 900m to 1030m: 4.5% 1030m to 1190m: 4.0% 1190m to 1400m: 3.5% 1400m to 1680m: 3.0% More than 1680m: 2.5%			
Max. Ratio for Superelevation Development			1/200		1/333
Max. Composite Gradient			10.5%		6.014%
Stopping Sight Distance			140m		142m**
Traffic Lane Width		3.5m			
Outer Shoulder Width		3.0m			
Marginal Strip Width (at Shoulder and Center Median)		0.75m			
Right (Inner) Shoulder		1.25m***			
Center Median Width		4.5m** / 3.0m** (without marginal strip)			

*: Limit Length is regulated **: Ultimate Stage: 6 lanes ***: Initial Stage: 4 lanes

Table 4.2.2 Summary of Geometric Design Criteria for Interchange

<table>
<tr><td colspan="4">Interchange Standard</td><td colspan="3">Type 2, Class 1</td><td rowspan="4">Remarks</td></tr>
<tr><td colspan="4">Design Speed of Ramp (Main Carriageway)</td><td colspan="3">V = 40 km/ h (80km/h)</td></tr>
<tr><td colspan="4" rowspan="2">Elements</td><td colspan="3">Reference Value</td></tr>
<tr><td>Criteria</td><td>Absolute Value</td><td>Adoption (Northern Section 1)</td></tr>
<tr><td rowspan="6">Horizontal Alignment</td><td colspan="2">Min. Radius of Curve</td><td>m</td><td>50</td><td>40</td><td>50</td><td></td></tr>
<tr><td colspan="2">Min. Parameter of Spiral Curve</td><td>m</td><td>35*</td><td>-</td><td>50</td><td>*Min. length 35m</td></tr>
<tr><td colspan="2">Min. Radius of Curve Omitting Transition Curve</td><td>m</td><td>140</td><td>-</td><td>200</td><td></td></tr>
<tr><td colspan="2">Min. Parameter at Exit Ramp Nose</td><td>m</td><td>60</td><td>50</td><td>-</td><td></td></tr>
<tr><td colspan="2">Min. Radius of Curve at Exit Ramp Nose</td><td>m</td><td>160</td><td>-</td><td>300</td><td></td></tr>
<tr><td colspan="2">Minimum Curve Radius without Superelevation</td><td>m</td><td>900</td><td>-</td><td>1000</td><td>Normal Crossfall 2.5%</td></tr>
<tr><td rowspan="8">Vertical Alignment</td><td rowspan="2">Max. Gradient</td><td>Expressway Side</td><td>%</td><td>6</td><td>Up Slope 6
Down Slope 7</td><td>5.366</td><td></td></tr>
<tr><td>National Highway Side</td><td>%</td><td>6</td><td>Up Slope 7
Down Slope 8</td><td>2.5</td><td></td></tr>
<tr><td rowspan="2">Min. K-Value of Vertical Curve</td><td>Crest</td><td>m</td><td>7</td><td>5</td><td>12</td><td></td></tr>
<tr><td>Sag</td><td>m</td><td>10</td><td>7</td><td>11</td><td></td></tr>
<tr><td colspan="2">Min. Vertical Curve Length</td><td>m</td><td>40</td><td>35</td><td>40</td><td></td></tr>
<tr><td rowspan="3">Min. K-Value at Ramp Nose</td><td>Crest</td><td>m</td><td>15</td><td>10</td><td>16.404</td><td></td></tr>
<tr><td>Sag</td><td>m</td><td>17</td><td>12</td><td>-</td><td></td></tr>
<tr><td>Curve length</td><td>m</td><td>60</td><td>40</td><td>60</td><td></td></tr>
<tr><td colspan="3">Normal Crossfall</td><td>%</td><td colspan="3">2.5</td><td></td></tr>
<tr><td colspan="3">Crossfall of Outer Shoulder</td><td>%</td><td colspan="3">2.5</td><td></td></tr>
<tr><td colspan="3">Max. Superelevation</td><td>%</td><td>6.0</td><td></td><td>6.0</td><td></td></tr>
<tr><td colspan="3">Values of Superelevation related to Horizontal Curve</td><td></td><td colspan="3">Less than 160m: 6.0%
160m to 210m: 5.0%
210m to 280m: 4.0%
280m to 360m: 3.0%
More than 360m: 2.5%</td><td></td></tr>
<tr><td colspan="3">Max. Composite Gradient</td><td>%</td><td>11.0</td><td></td><td>7.616</td><td></td></tr>
<tr><td colspan="3">Stopping Sight Distance</td><td>m</td><td>45</td><td></td><td>45</td><td></td></tr>
<tr><td colspan="3">Traffic Lane Width</td><td>m</td><td colspan="3">3.5</td><td></td></tr>
<tr><td colspan="3">Outer Shoulder Width</td><td>m</td><td colspan="3">2.5</td><td></td></tr>
<tr><td colspan="3">Marginal Strip Width
(at Shoulder and Center Median)</td><td>m</td><td colspan="3">0.5: Shoulder / 0.75: Median</td><td></td></tr>
<tr><td colspan="3">Right (Inner) Shoulder</td><td>m</td><td colspan="3">1.0</td><td></td></tr>
<tr><td colspan="3">Center Median Width</td><td>m</td><td colspan="3">2.5 / 1.0 (without marginal strip)</td><td></td></tr>
</table>

Note: The setting of the maximum vertical gradient for ramps (including loop portions) must be considered maximum composite gradient.

Table 4.2.3 Summary of Geometric Design Criteria

Item		Unit	Contents of Geometric Design Criteria								Remarks (RDA Standards Reference
			A			B		C	D,E		
Road Class		-	A-0 (6-lane)	A-1 (4-lane)	A-2 (4-lane)	B-2 (4-lane)	B-3 (2-lane)	C (2-lane)	D (S-lane)	E (S-lane)	-
Type of Road		-	R0	R1	R2	R2	R3	R4	R5		Clause 3.1
Terrain			Flat	Flat /Rolling	Flat /Rolling	Flat /Rolling	Flat /Rolling	Flat /Rolling /M	Flat /Rolling /Mountainous		-
Designed Traffic Volume		PCU /day	72,000-108,000	40,000-72,000	25,000-40,000	25,000-40,000	18,000-25,000	300-18,000	<300		Table 2.6
Design Speed	Rural	km/h	80	80(70)	80(70)	80(70)	70(60)	60(40)	50(30)		Clause 2.5 / Table 2.6
	Urban	km/h	70	70	70	70	60	50(40)	40(30)		
Lane Width		m	10.5x2 3.5/lane	7.4x2 3.7/lane	7.4x2 3.7/lane	7.0x2 3.5/lane	3.5x2 3.5/lane	3.5x2 3.5/lane	3.5x1 3.5/lane		Table 3.3 -modified through discussion
Cycle Lane		m	1.5x2	1.5x2	1.5x2	1.5x2	1.5x2	-	-		Included to outer shoulder width
Outer Shoulder Width (Cycle lane included)		m	3.0x2	3.0x2	3.0x2	3.0x2	3.0x2	1.5x2 (2.4x2)	1.5x2 (1.8x2)	1.2x2 (1.8x2)	Primary width considering existing conditions for C,D,E class road
Median Width Including Inner Shoulder Width		m	1.20	1.20	1.20	1.20	-	-	-		Table 3.3
Drain (minimum)		m	0.90x2	0.90x2	0.90x2	0.90x2	0.90x2	0.90x2	0.90x2		Table 3.3
R.O.W. (Drain Widths Excluded)		m	28.2 (30.0)	22.0 (23.8)	22.0 (23.8)	21.2 (23.0)	13.0 (14.8)	10.0 (11.8)	8.3 (10.1)		Future width for C,D,E class road
Crossfall of Carriageway		%	2.5	2.5	2.5	2.5	2.5	3.0	3.0		Table 3.1
Crossfall of Outer Shoulder		%	4.0	4.0	4.0	4.0	4.0	3.0	3.0		Table 3.2
Minimum Radius		m	255 (185)	255 (185)	255 (185)	255 (185)	185 (130)	130 (55)	90 (30)		Clause 5.2.4/ Table 5.3
Minimum Radii with Adverse Crossfall of 2.5%	Open	m	1440 (1105)	1440 (1105)	1440 (1105)	1440 (1105)	1105 (810)	810 (565)	360 (205)		Clause 5.2.5/ Table 5.4
	Built up	m	1120 (860)	1120 (860)	1120 (860)	1120 (860)	630 (440)	630 (280)	280 (160)		
Maximum Gradient		%	4	4(6)	4(6)	5 (7)	5 (7)	7(10)	9(10)		Clause 6.2.1/ Table 6.1
Minimum Gradient	Rural	%	0.5	0.5	0.5	0.5	0.5	0.5	0.5		Clause 6.2.3
	Urban	%	0.3	0.3	0.3	0.3	0.3	0.3	0.3		
Stopping Sight Distance (SSD)		m	140(115)	140(115)	140(115)	140(115)	115(85)	85(45)	65(30)		Clause 4.2/ Table 4.2
Minimum Vertical Curve Length (for appearance criteria)		m	70(60)	70(60)	70(60)	70(60)	60(50)	50(40)	50(30)		Clause 6.3.2.2/ Table 6.4
Maximum Superelevation on Curvature		%	6								Clause 5.2.1/ Table 5.1

4.3. Typical Cross Section

Initially, the cross-section of the OCH will have four lanes on both directions, while the OCH will ultimately have six lanes.

Detailed design for Northern Section 1 of OCH was carried out on four lane cross sections.

The typical cross-sections for OCH main carriageway are shown as **Fig. 4.3.1**.

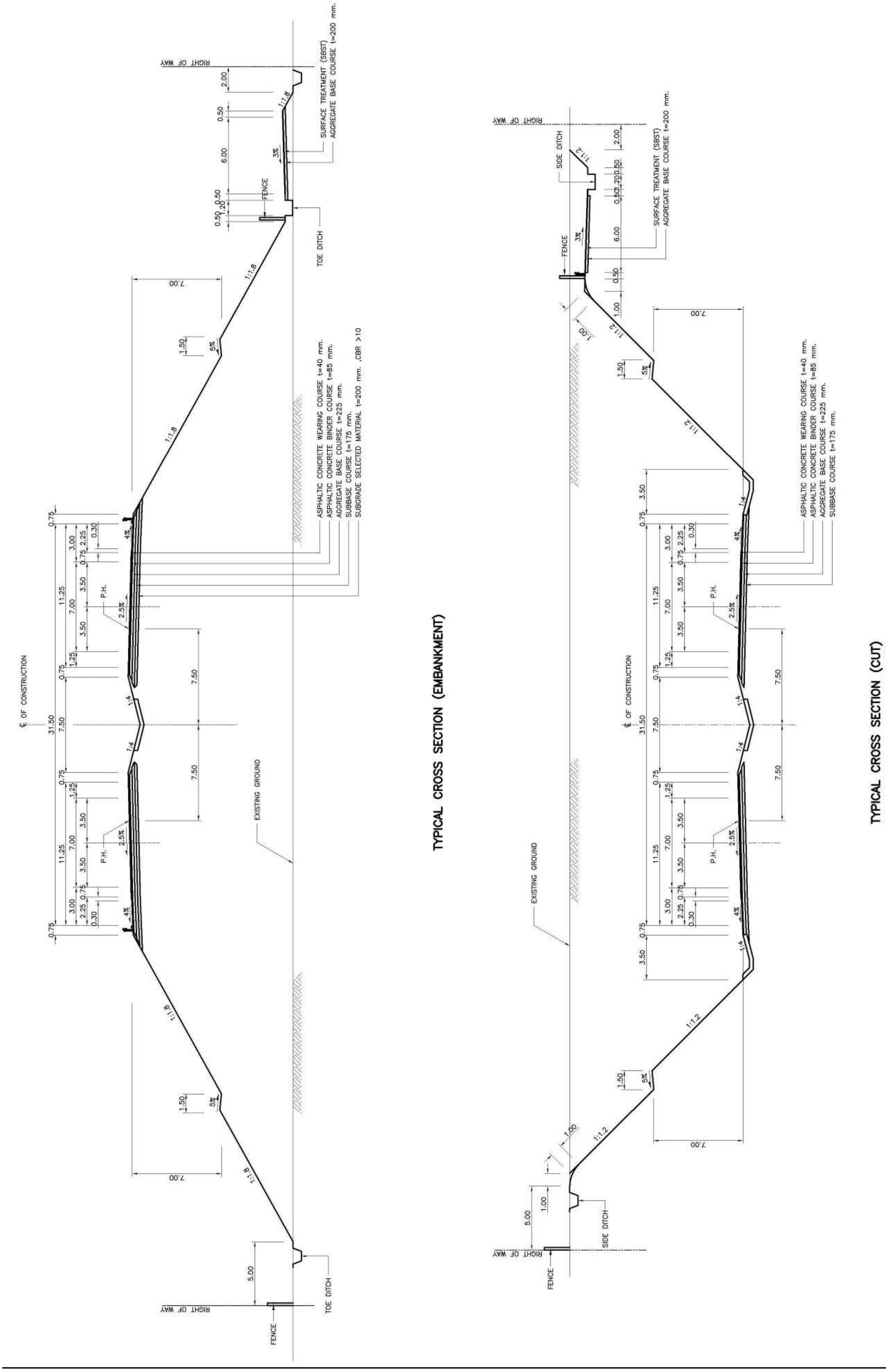


Fig. 4.3.1 (1) Typical Cross Section for OCH

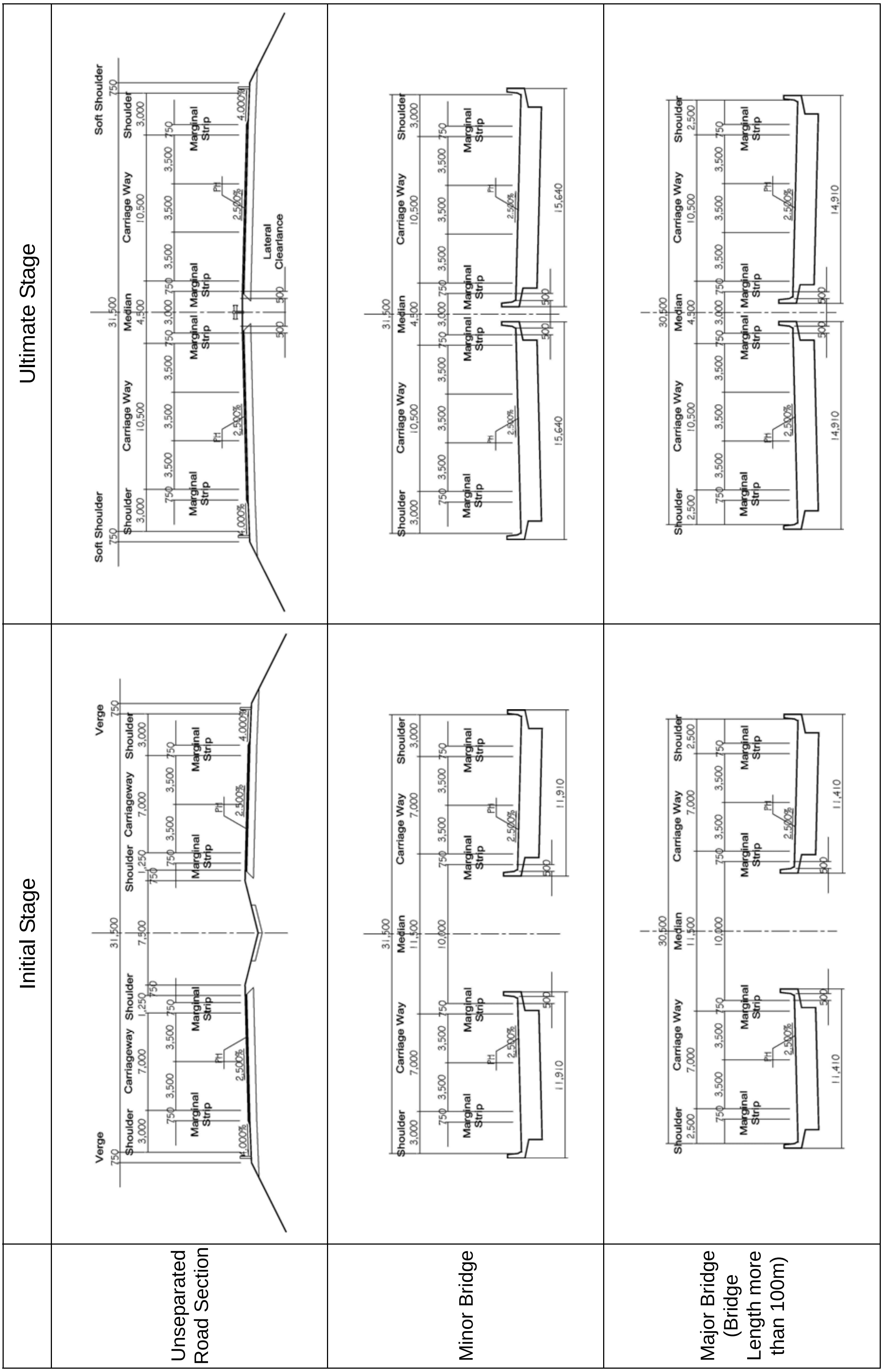


Fig. 4.3.1 (2) Typical Cross Section for OCH

4.4. Highway Design

4.4.1. Horizontal Alignment

The Horizontal Alignment for Northern Section 1 of the OCH was selected taking into account the request from RDA to minimize the land acquisition of residential area during the basic design period.

The alignment for Northern Section 1 of the OCH is shown in **Fig. 4.4.1 - Fig. 4.4.3**

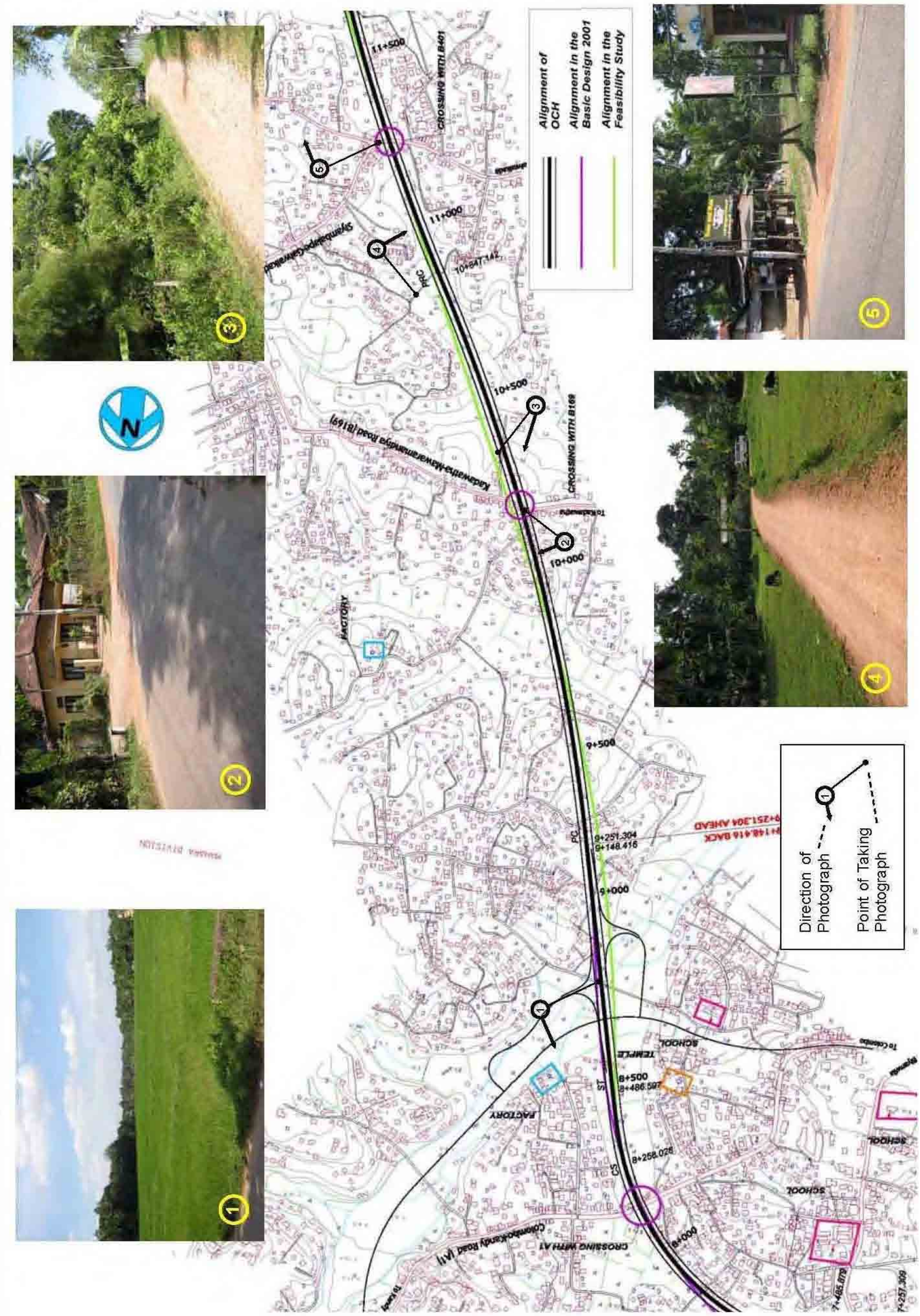


Fig. 4.4.1 Alignment for Northern Section 1 of the OCH – Mahara Division, Biyagama Division

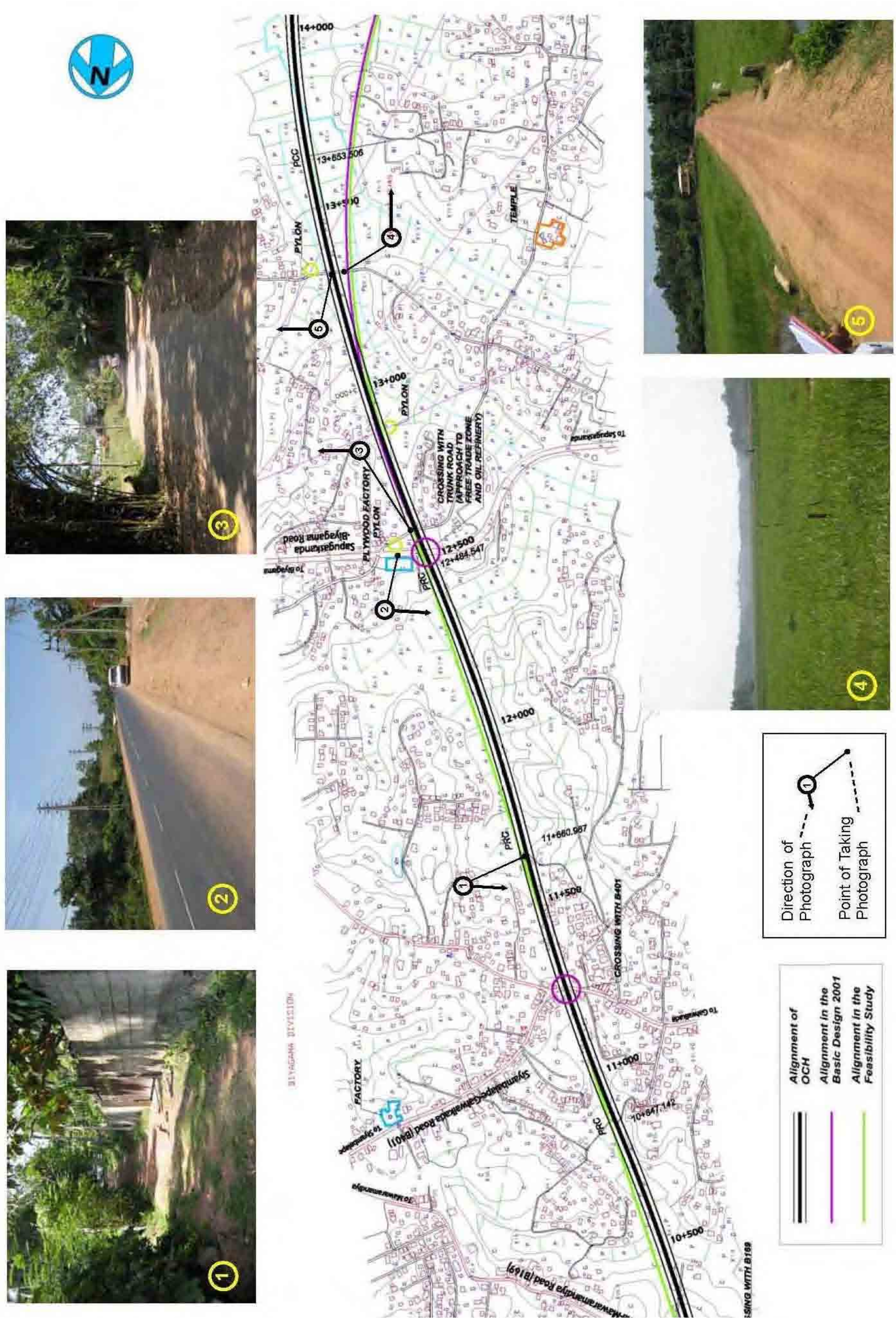


Fig. 4.4.2 Alignment for Northern Section 1 of the OCH – Biyagama Division

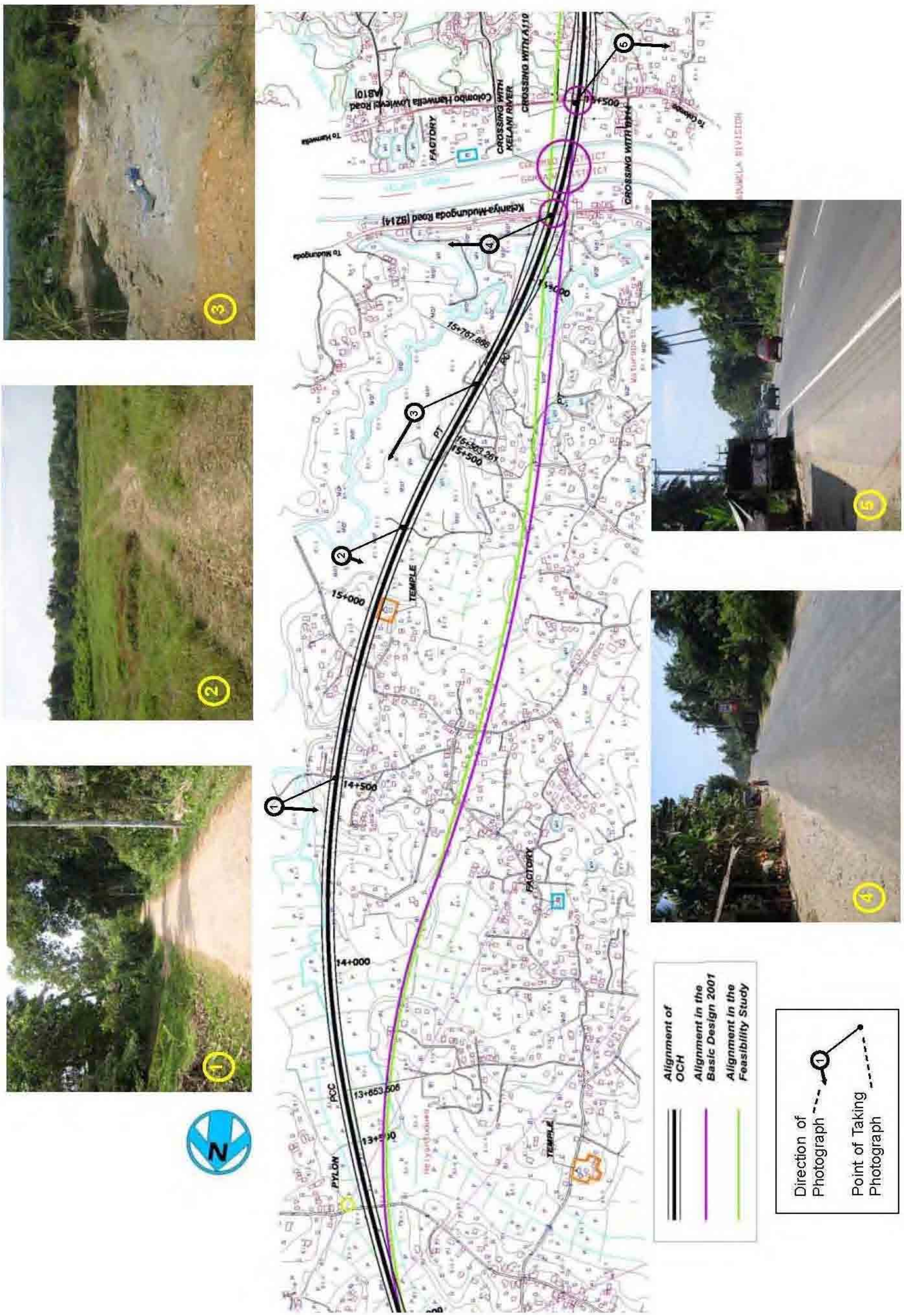


Fig. 4.4.3 Alignment for Northern Section 1 of the OCH – Biyagama Division, Kaduwela Division

4.4.2. Vertical Alignment

The selected vertical alignment for the Northern Section 1 of the OCH designed during the basic design period has been modified according to the topographic survey data which was carried out by survey department from 2003 to 2007 and additional survey data by JICA Study Team at this stage.

(1) Concept of Alignment Setting

The concepts to determine the optimal vertical alignment are as follows:

- Minimum embankment height in order to reduce construction costs as much as possible.
  - To be free from 50-year return period flooding (100-year return period for Kelani River).
  - Embankment: keep 30cm from H.F.L. to the bottom of the subbase course
  - Viaduct: keep the free board, which is 120cm for Kelani River and 30 cm for the tributary, from H.F.L. to the bottom of the slab
- Secure minimum vertical clearance for underpasses.
  - A&B Class Roads : 5.1m
  - C&D Class Roads : 4.8m (5.1m when not affect to Vertical Alignment)
  - E Class Roads : 4.5m
  - Select appropriate overpasses and underpasses to lower OCH embankment height. (detours for minor roads could be up to 500m if necessary)
- Minimum vertical gradient of 0.3% for road surface drainage.
- Minimize Land Acquisition.
- Secure the height of approach road over the Annual Flood Level (A.F.L)

(2) Control Points for Setting the Vertical Alignment

The vertical alignment is determined taking into account the control points where the critical position and elevation to secure the vertical clearance of OCH or approach road and high flood level.

List of control points is shown as **Table 4.4.1** and selected vertical alignment for Northern Section 1 of the OCH is shown as **Fig. 4.4.4.**

Table 4.4.1 List of Control Points for OCH Northern Section 1

Serial No	Location	Description	Road Class	Existing Pavement Lane Width	Existing Pavement Shoulder / Sidewalk	Future Widening Provision Lane Width	Future Widening Provision Shoulder / Sidewalk	Future Widening Provision Drain, Median	UP / OP	Type of Structure	Width of OP	Span of UP	Existing Ground Level	New Proposed Level	HFL	Vertical Clearance	Deck Thickness	Min. Proposed Height	FRL (OCH) at Control Point	Difference (Margin)	Remarks
1	7+860	Local Feeder Road	D			3.5	1.5*2 (1.8*2)		UP	Box Culvert	-	9.0	14.2	17.00	11.0	4.80	0.90	23.780	23.815	0.035	
2	8+160	Colombo - Kandy Road (A1)	A	3.5*2	1.5*2	6.5*2+2.4*2	(1.5+2.0)*2	1.2	UP	Bridge	-	(50.0)	12.3	12.67	11.0	5.10	3.00	21.290	21.681	0.391	
3	8+687	A1 Bypass	A			7.4*2	3.0*2	1.2	UP	Bridge	-	18.0+21.0	7.6	12.24	9.7	5.10	1.70	19.346	19.354	0.008	
4	8+807	Shramadana Mawatha	C	4.0	1.0*2	3.5*2	1.5*2 (1.8*2)		UP	Box Culvert	-	10.9	7.1	9.30	9.7	5.10	2.30	17.383	18.855	1.472	
5	9+410	Gonahena - Ihalabiyanwila Road	C	4.0	1.0*2	3.5*2	1.5*2 (1.8*2)		OP	Bridge	10.0	-	16.2	22.37	11.2	5.10	1.90	15.219	15.141	0.078	
6	9+766	(Point of Sag)													11.2			12.328	12.573	0.245	
7	10+211	Kadawatha-Mawaramandiya Road (B169), Manakada Road	B-3	6.0	1.0*2	3.5*2+1.5*2	1.5*2		OP	Bridge	13.0	-	25.4	26.78	11.2	5.10	2.10	19.734	16.751	2.983	
8	10+913	Galwala Road	D	4.0	-	3.5	1.5*2 (1.8*2)		UP	Box Culvert	-	7.6	14.8	17.19	11.2	4.80	0.70	23.496	23.596	0.100	
9	11+244	Siyambalape - Galwalkada Road (B401)	B-3	3.5*2	1.5*2	3.5*2+1.5*2	1.5*2		OP	Bridge	13.0	-	29.6	31.51	8.2	5.10	2.00	24.264	23.905	0.359	
10	12+393	(Point of Sag)													8.2			9.328	9.574	0.246	
11	12+531	Sapugaskanda - Biyagama Road (Approach to Free Trade Zone)	B-2	4.0*2	3.0*2	7.0*2+1.5*2	1.5*2	1.2	OP	Bridge	21.2	-	17.3	17.63	8.2	5.10	2.00	10.383	9.888	0.495	
12	12+885	High Tension Power Line Crossing	-						OP	Embankment					8.2				10.950	Relocation	
13	13+075	High Tension Power Line Crossing	-						OP	Embankment					8.2				11.520	Relocation	
14	13+334	Siriketa Road	D	3.0	1.0*2	3.5	1.5*2 (1.8*2)		UP	Box Culvert	-	7.4	2.7	4.73	8.2	4.80	0.70	11.033	12.089	1.056	
15	13+385	High Tension Power Line Crossing	-						OP	Embankment					8.2				12.013	Relocation	
16	13+591	(Point of Sag)													8.2			9.328	11.262	1.934	
17	13+755	(Viaduct)													8.2+0.3			11.005	11.958	0.953	
18	14+070	(Viaduct)													8.2+0.3			11.005	11.025	0.020	
19	14+245	(Point of Sag)													8.2			9.328	10.462	1.134	
20	14+623	Bandaranayaka Mawatha	D	4.0	-	3.5	1.5*2 (1.8*2)		UP	Box Culvert	-	7.4	3.3	4.78	8.2	4.80	0.70	11.089	11.273	0.184	
21	14+842	Jayanthi Mawatha	C	4.0	1.0*2	3.5*2	1.5*2 (1.8*2)		OP	Bridge	10.0	-	19.0	18.31	8.2	5.10	1.90	11.156	10.378	0.778	
22	14+983	(Point of Sag)													8.2			9.328	9.784	0.456	
23	15+130	(Viaduct)													8.2+0.3			11.005	11.021	0.016	
24	15+227	Private Road for Brick Clay Mining	E	2.0					UP	Bridge	-	35.0	1.5	2.50	8.2	4.50	2.30	9.505	12.214	2.709	
25	15+445	(Viaduct)													8.2+0.3			11.005	11.130	0.125	
26	15+496	(Point of Sag)													8.2			9.328	11.038	1.710	
27	15+836	Private Road	E			3.5	1.2*2 (1.8*2)		UP	Box Culvert	6.8	-	5.3	4.50	8.2	4.50	0.70	10.633	12.024	1.391	
28	15+895	(Viaduct - Mudun Era Crossing)													8.2+0.6			11.381	12.207	0.826	
29	16+184	Kelaniya - Mudungoda Road (B214)	B-2	3.5*2	1.5*2	7.0*2+1.5*2	1.5*2	1.2	UP	Bridge	-	35.5	5.3	5.44	8.2	5.10	2.30	13.049	13.104	0.055	
30	16+300	(Bridge - Kelani River Crossing)													8.5+1.2			10.455	13.463	3.008	
31	16+505	Colombo - Hanwella Low Level Road (AB10)	A-2	3.7*2	1.8*2	7.4*2+1.5*2	1.5*2	1.2	UP	Bridge	-	35.5	6.1	6.10	8.2	5.10	2.30	13.705	13.958	0.253	
32	A1IC R1 0+134	Shramadana Mawatha	C	4.0	1.0*2	3.5*2	1.5*2 (1.8*2)		UP	Box Culvert	-	10.9	7.4	9.03	9.7	5.10	1.05	16.277	16.305	0.028	
33	B214IC R1 0+227	(Viaduct - Mudun Era Crossing)													8.2+0.6			11.225	11.241	0.016	
34	A1BP 0+289	Sunethararama Mawatha	D	4.0	-	3.5	1.5*2 (1.8*2)		UP	Box Culvert	-	7.4	11.0	12.28	9.7	4.80	0.70	18.569	18.710	0.141	
35	A1BP 0+694	(Point of Sag)													9.7			11.043	11.044	0.001	
36	A1BP 1+287	Bandaranayaka Mawatha	D	4.0	-	3.5	1.5*2 (1.8*2)		UP	Box Culvert	-	7.4	9.5	10.43	9.7	4.80	0.70	16.721	16.811	0.090	

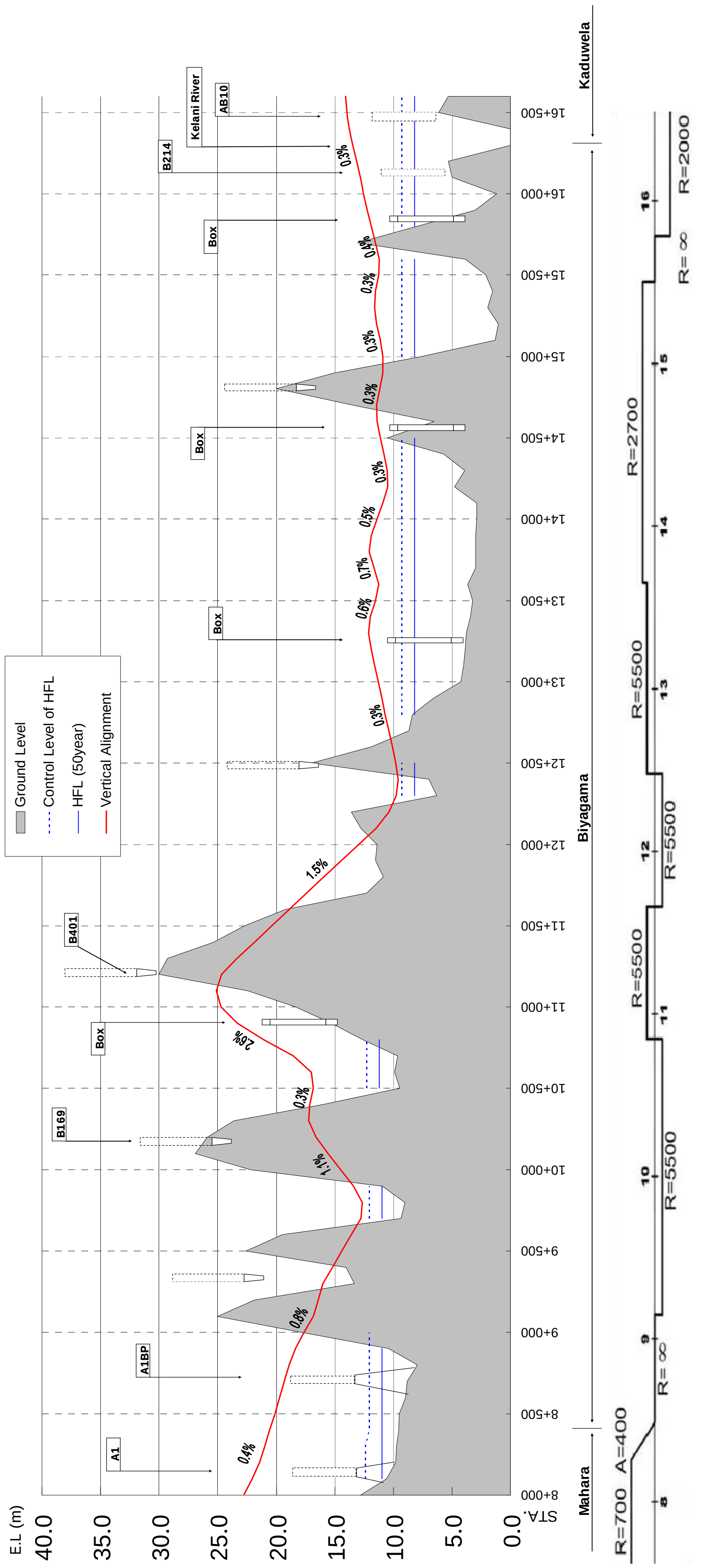


Fig. 4.4.4 Vertical Alignment for OCH Northern Section

4.5. Interchange Design

4.5.1. General

The summary of interchanges for Northern Section 1 of the OCH is as follows. Each interchange will enable to access the OCH with the major national highway, A1 bypass (newly constructed) and B214 road respectively.

Table 4.5.1 Summary of Interchanges

National Road or Expressway	Crossing Location (Chainage)	Status/Improvement		Remarks
		Existing	Future	
A1 (Bypass Road)	8+520 to 9+135	-	Initial Four Lane	Two Quadrant Cloverleaf
B214	15+730 to 16+200	Two lane asphalt paved road	Widening to Four Lane	Half Diamond

4.5.2. Interchange Layout

(1) A1IC

In the basic design stage in 2004, Two Quadrant Cloverleaf Type with At Grade Intersection has been selected taking into account of various aspects, particularly the social impact and cost effectiveness. Due to avoiding residential area, A1 bypass road was planned to traverse through the paddy area.

The horizontal alignments of ramps basically have been followed to basic design alignments, which were determined to minimize the land acquisition, except the ramp-1. The horizontal alignment of ramp-1 (Colombo side ramp) was shifted towards the main carriageway to accommodate the local road crossing. However, the vertical alignments of all ramps have been modified due to the modification of vertical alignment of OCH and the installation of toll plazas on the both ramps.

(2) B214IC

The half diamond type interchange is selected to access B214 road as designed in basic design. Both of ramp noses of the on and off ramp will be placed at the same chainage of OCH main carriageway in order to solve design difficulties of the bridge, which will be constructed near the nose point. The vertical alignment of ramps was changed taking into account of the installation of toll plaza.

4.5.3. Toll Collection Facilities

RDA is planning that OCH and STDP shall be toll road and will adopt the Interchange toll collection (closed collection) with variable rate for travel distance. Following to the scheme, it is required to install toll plaza on both ramps (on and off) of OCH.
For standardisation of toll facilities, it is expected to establish the unity design standard

by the RDA. In the Study, the JICA Study Team designs only earthwork and structure of toll plaza by Japanese Standard as follows. Designs of pavement and toll collection facilities will be carried out by other parties after establish unity design standard.

The toll gate is defined as a facility installed to toll roads for collecting toll fare charged from vehicles. It is also able to regulate the illegal access to main carriageway. Then, the toll plaza is defined as expanded road area to install the toll gate and toll collecting facility.

At the interchange toll plaza, 200m radius of horizontal curve is applied as the minimum radius, and 2.5% is applied as the maximum gradient. The number of lanes at the toll gate is provided based on the traffic volume, average service time (6 seconds at entry and 14 seconds at exit as the experience of Japanese Expressway in case of variable rate system) and level of service (judged by average queue, which is generally adopted 1.0 vehicle) as shown in **Table 5.3.2**. **Table 5.3.3** shows the designed number of lanes at the each toll gate.

Table 4.5.2 Possible Traffic Capacity and Service Time at the Toll Gate (veh/hour)

Service Time (Sec.) / Nos. of Lanes	6 (Entry Gate)	8	10	14 (Exit Gate)	18	20
1	300	230	180	130	100	90
2	850	640	510	360	280	250
3	1,420	1,070	850	610	480	430
4	2,000	1,500	1,200	860	670	600
5	2,590	1,940	1,550	1,110	860	780
6	3,180	2,380	1,910	1,360	1,060	950
7	3,770	2,830	2,260	1,620	1,260	1,130
8	4,360	3,270	2,620	1,870	1,450	1,310
9	4,960	3,720	2,980	2,130	1,650	1,490
10	5,560	4,170	3,330	2,380	1,850	1,670

Average queue = 1.0 vehicle

Table 4.5.3 Number of Lanes at the Toll Gate

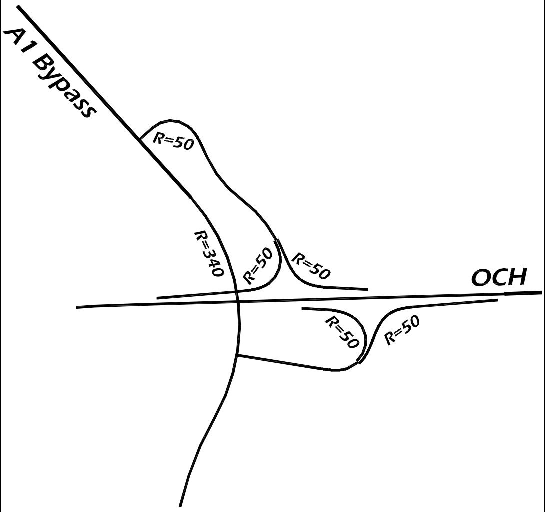
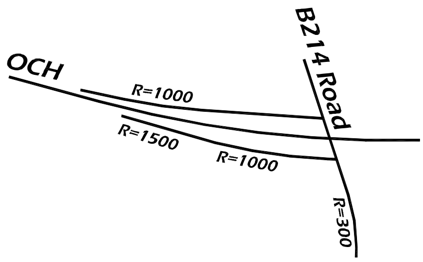
IC	Direction		Traffic Volume (pc/h)	Number of Lanes
A1 IC	Entry (ON)	To North	574	2
		To South	952	3
	Exit (OFF)	From North	476	3
		From South	1,008	5
B214 IC	Entry (ON)		308	2
	Exit (OFF)		259	2

At the time for designing the toll facilities at B214 IC, It is required to note that the toll gates area will be affected by high flood water and consideration to avoid submergence of machinery will be necessary. (Machinery shall install approximately 1.5m above the floor level of toll booth to avoid 50 years flood water -8.2m)

4.5.4. Summary of Interchange

The configuration and summary of interchanges are shown in **Table 4.5.4**.

Table 4.5.4 Summary of Interchanges for Northern Section1 of OCH

Serial No.	4			5		
Name (tentative)	A1			B214		
Alignment						
Type of Interchange	Two Quadrant Cloverleaf			Half Diamond		
Location	Eldeniya (Kadawatha), Mahara Division / Ihala Biyanwila North, Biyagama Division, Gampaha District			Mabima East / Biyagama South, Biyagama Division, Gampaha District		
Connecting Road	A1 Bypass Road			B214 Road		
	National Highway Design Speed 70km/h			National Highway Design Speed 70km/h		
Ramp	Class A	Design Speed: 40km/h		Class A	Design Speed: 40km/h	
	Minimum Radius of Horizontal Curve			Minimum Radius of Horizontal Curve		
	OCH Side	R=50m		OCH Side	R=1000m	
	Connecting Road Side	R=50m		Connecting Road Side	-	
	Maximum Gradient			Maximum Gradient		
	OCH Side	Up	4.69%	OCH Side	Up	5.33%
		Down	4.69%		Down	5.37%
	Connecting Road Side	Up	2.50%	Connecting Road Side	Up	-
		Down	2.50%		Down	-
	Land Area (incl. Main Carriageway, A1 Bypass)	Approx. 221,000 m^2		Land Area (incl. Main Carriageway)	Approx. 52,000 m^2	

4.6. A1 Bypass Design

As mentioned in **4.5.2**, A1 interchange shall be connected with A1 Bypass road which will newly be constructed and mainly go through the paddy area to avoid the land acquisition in the residential area. A1 bypass will be extended for 2.0 km and have 2 at-grade intersections connecting with the existing A1 road at both end and other 2 at-grade intersections to access with the interchange ramps. A1 bypass will be connected with A1 road, which is ongoing development presently, at the beginning and end section of A1 bypass.

A1 bypass is classified A class road as same as existing A1 road and designed based on the geometric design standard (initial 4 lanes but 6 lanes width was provided at the crossing point with OCH main carriageway).

4.6.1. Horizontal Alignment

The horizontal alignment of A1 bypass passed through the paddy area where the A1 interchange will be constructed and was selected in consideration with the minimization of the land acquisition in the residential area.

4.6.2. Vertical Alignment

To reduce the embankment volume, the vertical alignment of A1 bypass was designed as low as possible. But based on the decision in basic design stage, the minimum height of A1 bypass is subject to the H.F.L as same as OCH main carriageway. The 6% gradient, which is the highest value for design speed of 70km/h, was applied at the beginning section since the crossing point with existing A1 road is extremely higher than the paddy area.

4.7. Approach Road

Some existing roads crossing the OCH, A1 Bypass and Interchange Ramps are planed to be secured the function of access roads, which are hereinafter called the approach road. The location of the crossing point and the crossing type (overpass or underpass) are determined according to the relation between the vertical alignment of the main carriageway of the OCH and the height of the existing road.

The design of approach road is carried out based on the geometric design criteria depend on each road class shown in separate volume "Design Standard for Outer Circular Highway Project" and also based on the Road Condition Survey Results.

4.7.1. List of Approach Road

The total 13 approach roads are planed to secure the road access according to the existing road survey. The horizontal and vertical alignments of the existing road were retained as much as possible, but the alignment and height of some existing roads are shifted to secure the vertical clearance and to avoid the land acquisition in the residential area. The road class for each road was reconfirmed and indicated by RDA at this stage. The list of approach roads includes road class is as shown in **Table 4.7.1**.

Table 4.7.1 List of Approach Road

No.	Station	Description (Name of the Road)	Road Class	Type
1	0+100 (A1BP)	Shramadana Mawatha (A1 Connection)	C	-
2	0+285 (A1BP)	Sunethararama Mawatha	D(E)	UP
3	1+293 (A1BP)	Bandaranayaka Mawatha	D	UP
4	8+805	Shramadana Mawatha (Main Carriageway Crossing)	C	UP
5	9+415	Gonahena - Ihalabiyanwila Road	C	OP
6	10+210	Kadawatha - Mawaramandiya Road (B169), Mankada Road	B-3	OP
7	10+917	Galwala Road	D	UP
8	11+261	Siyambalape - Galwalkada Rd (B401)	B-3	OP
9	12+518	Sapugaskanda-Biyagama Road (Approach to Free Trade Zone)	B-2	OP
10	13+327	Siriketa Road	D	UP
11	14+619	Bandaranayaka Mawatha	D(E)	UP
12	14+843	Jayanthi Mawatha	C	OP
13	15+840	Minor Road	E	UP

Note: UP: Underpass, OP: Overpass

4.7.2. Summary of Typical Cross Section Elements

The width of typical cross sections of the approach road is in **Table 4.7.2**. Note that the width of the shoulder and drain are different between overpass and underpass.

Table 4.7.2 Typical Cross Section Elements of Overpass

Class	Carriageway (C)	Shoulder / Sidewalk (S: incl. Cycle Lane)		Median (M)	Cycle Lane (L)	Extra (D)		R.O.W ( ): incl. drain widths	
		Earth work	Structure			Earth work (Drain)	Structure (Curb and Parapet Wall)	**Earth work**	Structure
B-2	7.0x2	3.0x2	3.0x2	1.20	(1.5x2)	0.9x2	0.45x2	**21.2 (23.0)**	22.1
B-3	3.5x2	3.0x2	3.0x2	-	(1.5x2)	0.9x2	0.45x2	**13.0 (14.8)**	13.9
C	3.5x2	1.5x2 (2.4x2)	1.5x2	-	-	0.9x2	0.45x2	**10.0 (11.8)**	10.9
D	3.5	1.5x2 (1.8x2)	1.5x2	-	-	0.9x2	0.45x2	**6.5 (8.3)**	7.4

Table 4.7.3 Typical Cross-Section Elements of Underpass

Class	Carriageway (C)	Shoulder / Sidewalk (S: incl. Cycle Lane)		Median (M)	Cycle Lane (L)	Extra (D)		R.O.W ( ): incl. drain widths	
		Earth work	Structure			Earth work (Drain)	Structure	**Earth work**	Structure
A-1	10.5x2	3.0x2	3.0x2	1.20	(1.5x2)	0.9x2	-	**28.2 (30.0)**	28.2
A-2	7.4x2	3.0x2	3.0x2	1.20	(1.5x2)	0.9x2	-	**22.0 (23.8)**	22.0
C	3.5x2	1.5x2 (2.4x2)	1.5x2	-	-	0.9x2	-	**10.0 (11.8)**	10.0
D	3.5	1.5x2 (1.8x2)	1.5x2	-	-	0.9x2	-	**6.5 (8.3)**	6.5
E	3.5	1.2x2 (1.8x2)	1.2x2	-	-	0.9x2	-	**5.9 (7.7)**	5.9

Notes:
1. All dimensions are in meters.
2. These dimensions should be read in conjunction with the typical cross-section for the relevant types of roads. (**Fig. 3.4.3**)
3. The shoulder width indicated for the roadway in brackets are in accordance with RDA standards, and would be considered for future development of the respective roads.

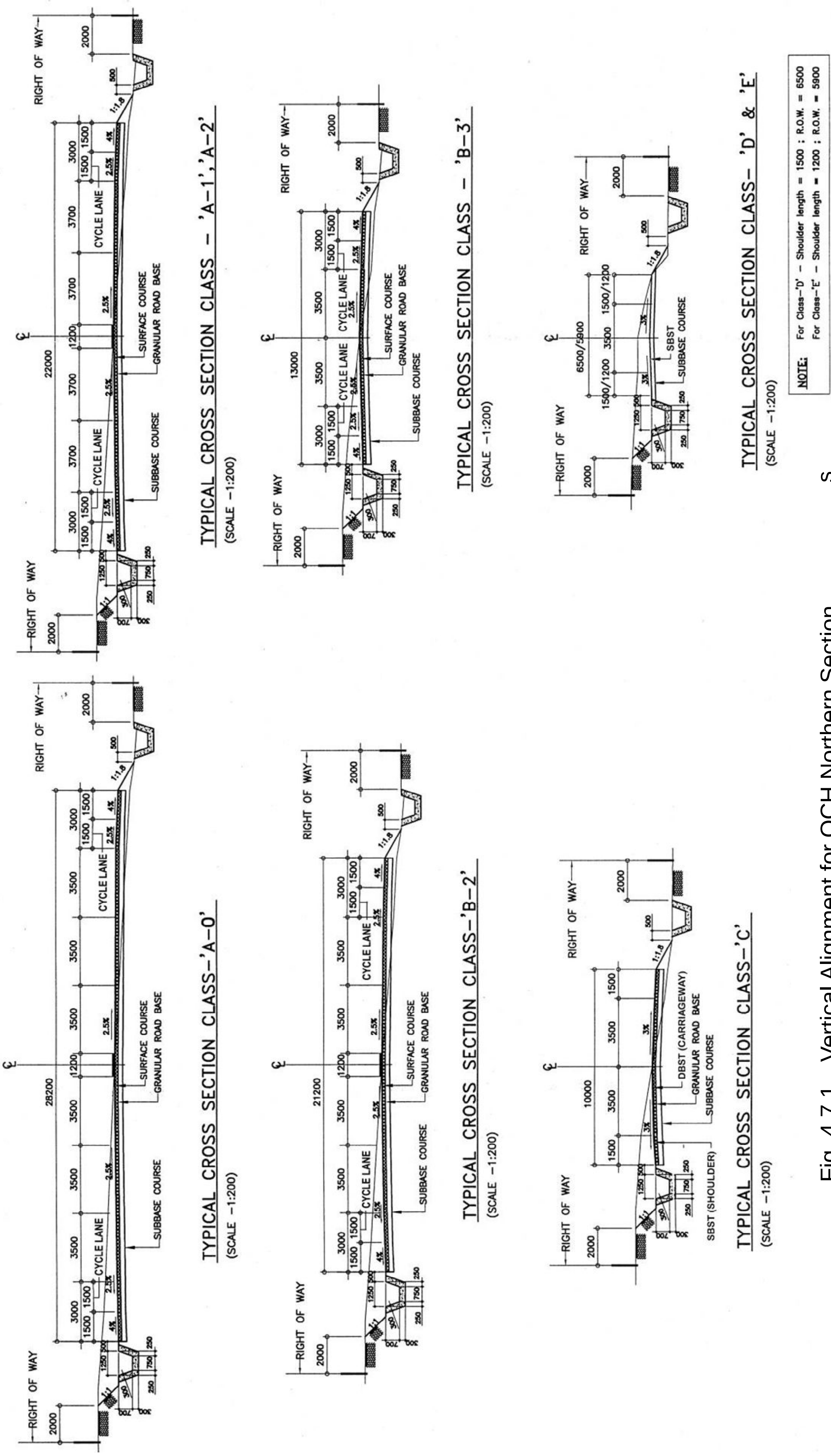


Fig. 4.7.1 Vertical Alignment for OCH Northern Section

4.7.3. Alignment Setting for Approach Roads

On the Basic Design stage, since the site survey has been suspended at approx. 70% of OCH corridor due to the protest from the residents, the alignment setting for each approach road has been carried out based on the aerial topographic maps scaled 1/1000.

In this detailed design stage, the alignment setting of each approach road has been revised based on the topographic survey data carried out on site by survey department and the Study Team. The road class and alignment of approach road are finalized through the discussion between the Study Team and RDA.

The alignment settings were done based on the policies as follows:

- to follow the existing alignments as much as possible (except C,D and E)
- to meet the requirement to conform to RDA Geometric Design Standards as much as possible
- to satisfy the requirements at least up to the existing level as the compensation
- to minimize the cost and social impact
- to set better comparing to the present alignment if possible
- to adopt existing level temporary alignment due to avoid resettlement with consideration of future alignment, which satisfied design standard depends on road class.

Details and considerations for alignment setting for each approach road are explained as follows.

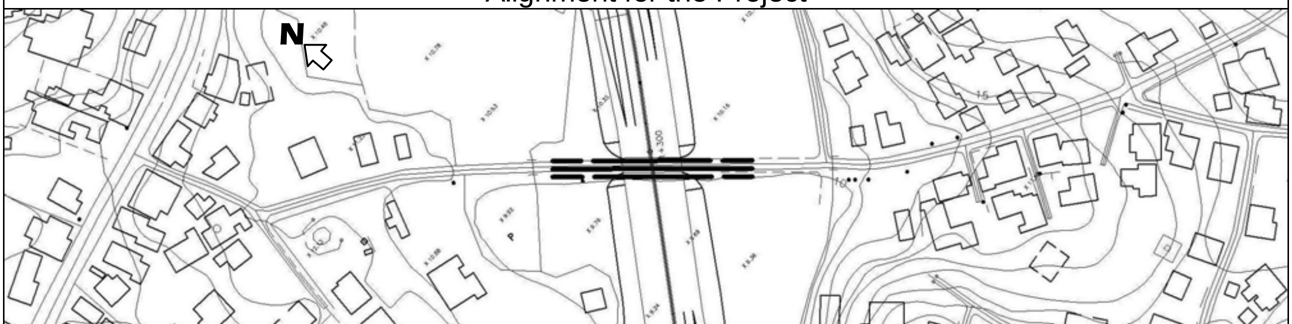
(1) No.1: STA.0+100 (A1 BP)

<table>
<tr><td colspan="2">Name of Road: Shramadana Mawatha</td></tr>
<tr><td colspan="2">Road Class C: Design Speed 50 km/h (Terrain: Rolling), Road Width: 10m (2 lanes)</td></tr>
<tr><td>Future Consideration</td><td>Alignment for the Project</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>• Alignment for Design Speed 50km/h (R_{min}=90m, i_{max}=9%)
• Horizontal alignment will be bended to far away from A1 Bypass due to obtain road length to connect to the road at middle area of the hill.</td><td>• Primary connection using 30m radius horizontal alignment and 10% gradient road to avoid houses (Design speed 30km/h).
• 10m road width for 2 lanes will be adopted taking into consideration of intersection with A1 road and steep gradient.</td></tr>
</table>

(2) No.2: STA.0+285 (A1 BP)

Name of Road: Sunethararama Mawatha	
Road Class D: Design Speed 40 km/h (Terrain: Rolling), Road Width: 6.5m (1 lane)	
Future Consideration	Alignment for the Project
	
• Alignment for Design Speed 40km/h (R_{min}=55m, i_{max}=10%) • It is impossible to touch existing road before intersection near temple. (Gradient will be over 10%)	• Primary connection using 13m radius horizontal alignment to avoid houses (Vehicle should slow down as at intersection - Design speed under 20km/h). • 4m road width will be adopted taking into consideration of existing condition (Culvert width is 6.5m).

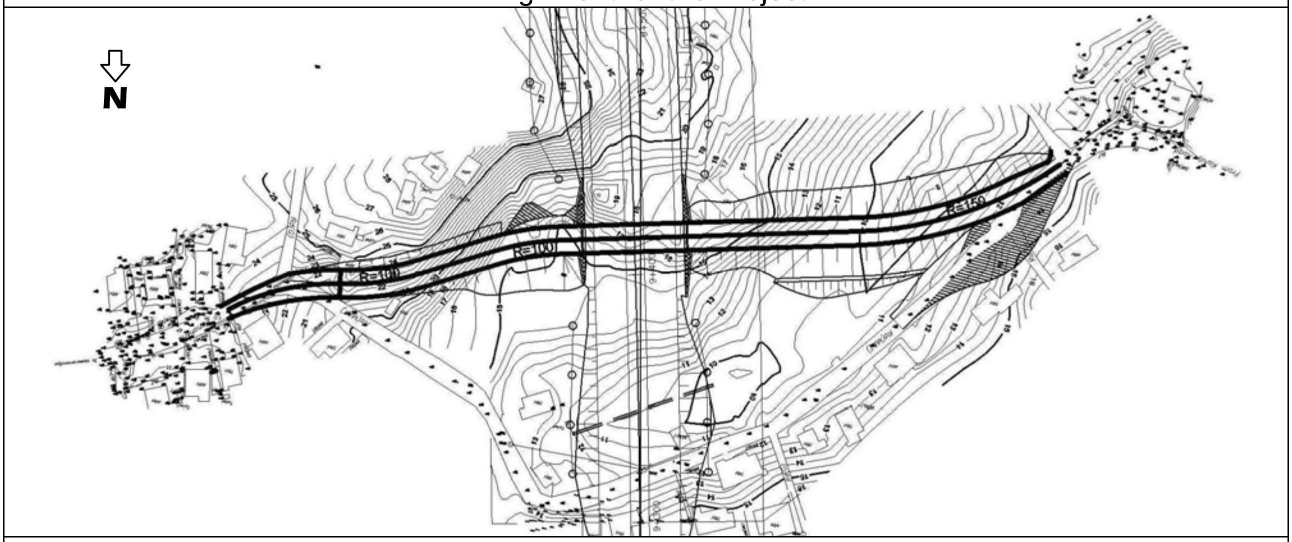
(3) No.3: STA.1+293 (A1 BP)

Name of Road: Bandaranayaka Mawatha
Road Class D: Design Speed 40 km/h (Terrain: Rolling), Road Width: 6.5m (1 lane)
Alignment for the Project

• Existing alignment (Design speed 40km/h satisfied) • Only box culvert will be constructed on the Project (Culvert width is 6.5m).

(4) No.4: STA.8+805

Name of Road: Shramadana Mawatha	
Road Class C: Design Speed 50 km/h (Terrain: Rolling), Road Width: 10m (2 lanes)	
Future Consideration	Alignment for the Project
	
• Alignment for Design Speed 50km/h (R_{min}=90m, i_{max}=9%) • Crossing point with ramp can not shift to north side due to secure clearance of local road.	• Primary connection using 30m radius horizontal alignment at 2 sections to avoid houses (Design speed 30km/h). • Design speed 50 km/h can be adopted at main carriageway and ramp crossing section. • Crossing point with ramp can not shift to north side due to secure clearance of local road. • 10m road width for 2 lanes will be adopted also at primary connected portion taking into consideration of small curvature of the road.

(5) No. 5: STA.9+415

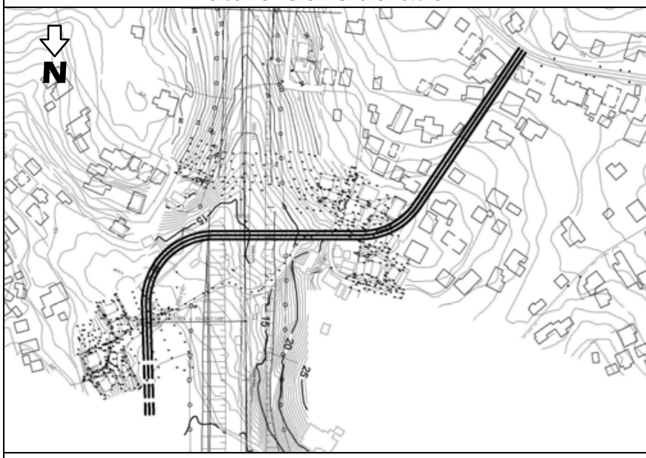
Name of Road: Gonahena - Ihalabiyanwila Road
Road Class C: Design Speed 50 km/h (Terrain: Rolling), Road Width: 10m (2 lanes)
Alignment for the Project

• Alignment for Design Speed 50km/h (R_{min}=90m, i_{max}=9%) • 10m road width for 2 lanes will be adopted

(6) No.6: STA.10+210

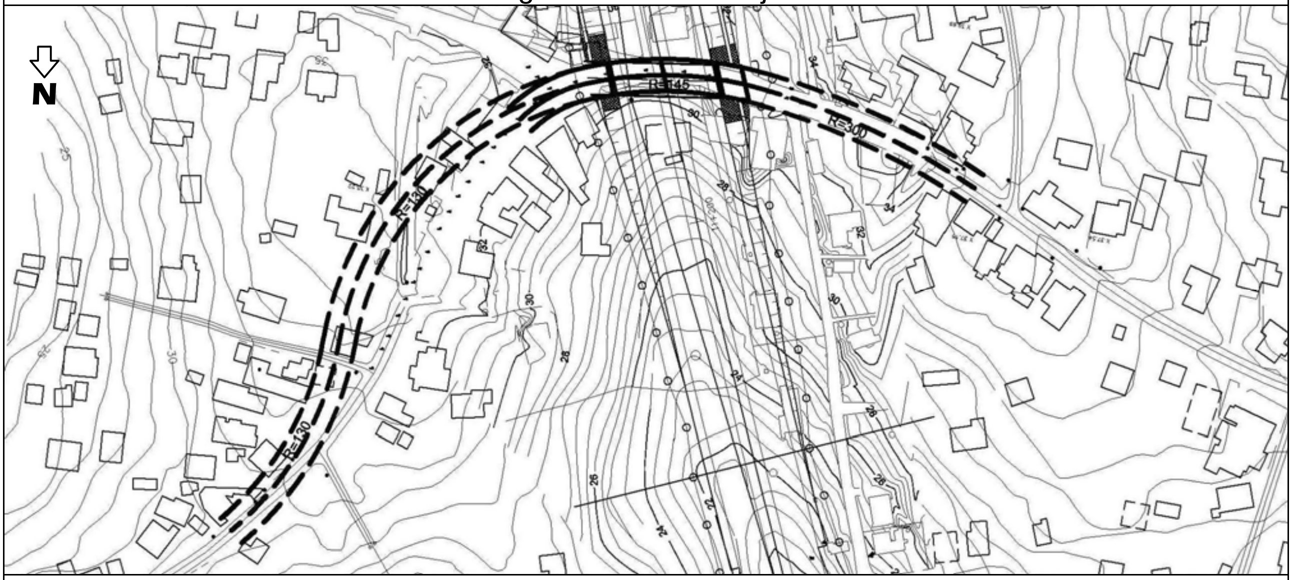
Name of Road: Kadawatha - Mawaramandiya Road (B169), Manakada Road
Road Class B-3: Design Speed 60 km/h (Terrain: Rolling), Road Width: 13.0m (2 lanes)
Alignment for the Project

• Alignment for Design Speed 60km/h (R_{min}=130m, i_{max}=7%) • 13.4m road width for 2 lanes will be adopted

(7) No.7: STA.10+917

Name of Road: Galwala Road	
Road Class D: Design Speed 40 km/h (Terrain: Rolling), Road Width: 6.5m (1 lane)	
Future Consideration	Alignment for the Project
	
• Alignment for Design Speed 40km/h (R_{min}=55m, i_{max}=10%) • It is difficult to connect to higher class road with 40km/h design speed at east side.	• Primary connection using 30m radius horizontal alignment at east side (Design speed 30km/h). • Primary construction area will limit within first crossing point with existing road to avoid houses at west side. • 6.5m road width for 1 lane will be adopted

(8) No.8: STA.11+255

Name of Road: Siyambalape - Galwalkada Rd (B401)
Road Class B-3: Design Speed 60 km/h (Terrain: Rolling), Road Width: 13.0m (2 lanes)
Alignment for the Project

• Future Alignment for Design Speed 60km/h (R_{min}=130m, i_{max}=7%) is shown by brake line. • Only overpass bridge will be constructed on the Project (Bridge width is 13.0m) and will be able to connect to existing road at design speed 40km/h (R_{min}=55m).

(9) No.9: STA.12+518

Name of Road: Sapugaskanda – Biyagama Road (Approach to Free Trade Zone)
Road Class B-2: Design Speed 70 km/h (Terrain: Rolling), Road Width: 21.2m (4 lanes)
Alignment for the Project

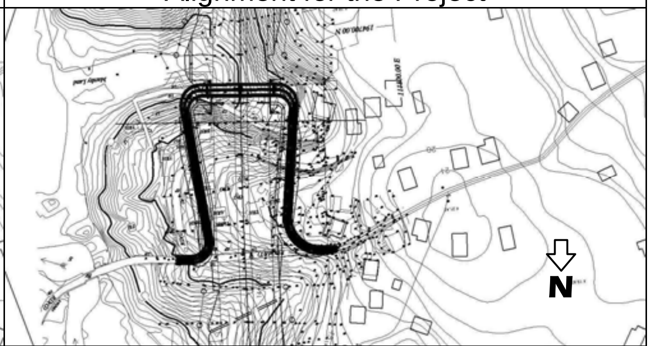
• Future Alignment for Design Speed 70km/h (R_{min}=185m, i_{max}=7%) is shown by brake line. • Only overpass bridge will be constructed on the Project (Bridge width is 21.2m). • Bridge surface should be changed from normal cross fall to superelevation in the future.

(10) No.10: STA.13+327

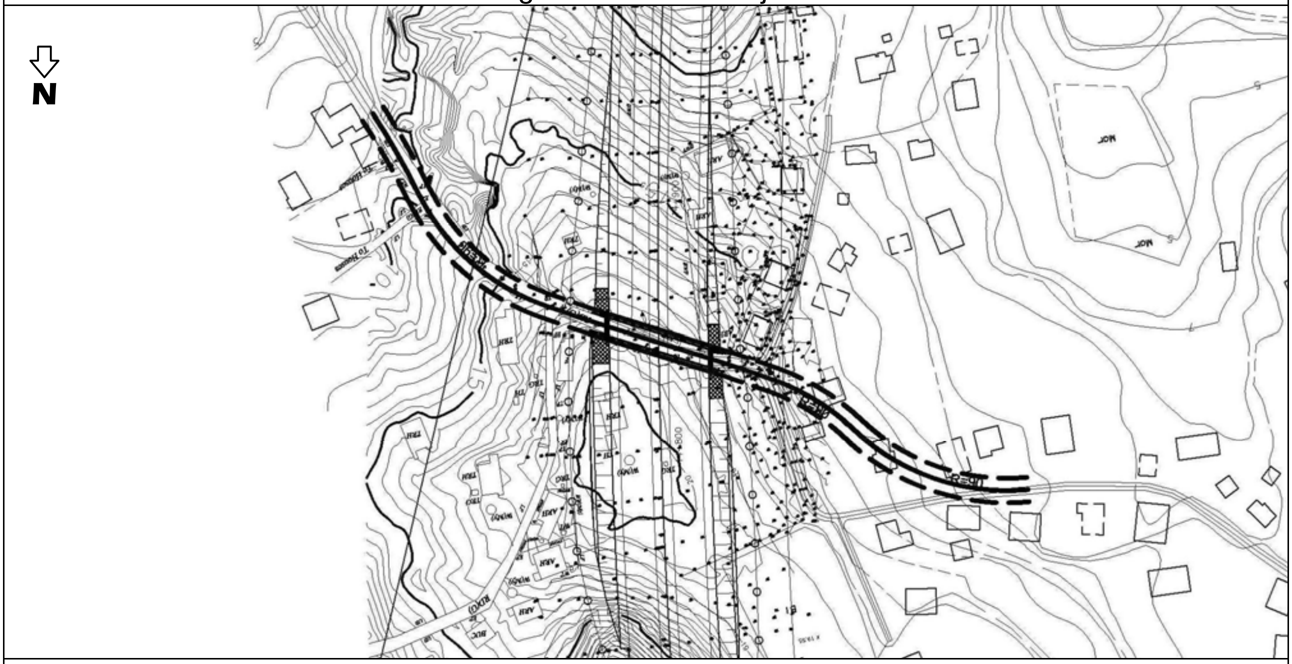
Name of Road: Siriketa Road
Road Class D: Design Speed 40 km/h (Terrain: Rolling), Road Width: 6.5m (1 lane)
Alignment for the Project

• Alignment for Design Speed 40km/h (R_{min}=55m, i_{max}=10%) • 6.5m road width for 1 lane will be adopted

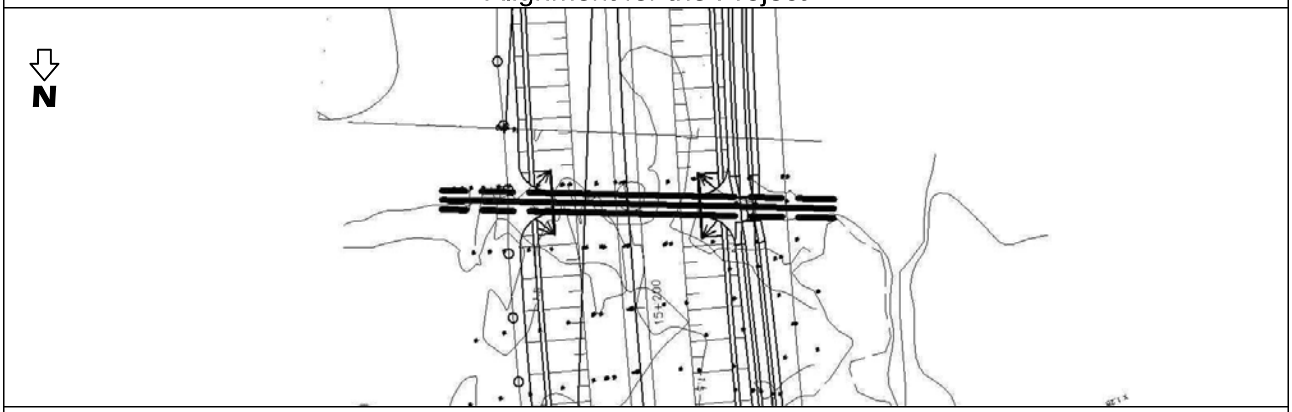
(11) No.11: STA.14+619

Name of Road: Bandaranayaka Mawatha	
Road Class D: Design Speed 40 km/h (Terrain: Rolling), Road Width: 6.5m (1 lane)	
Future Consideration	Alignment for the Project
	
• Alignment for Design Speed 40km/h (R_{min}=55m, i_{max}=10%) • Bridge or culvert will be required at east end. • West end will be cut section and will affect to many houses.	• Primary connection using 10m radius horizontal alignment to avoid houses (Vehicle should slow down as at intersection - Design speed under 20km/h). • 4m road width will be adopted taking into consideration of existing condition (Culvert width is 6.5m).

(12) No.12: STA.14+843

Name of Road: Jayanthi Mawatha
Road Class C: Design Speed 50 km/h (Terrain: Rolling), Road Width: 10m (2 lanes)
Alignment for the Project

• Future Alignment for Design Speed 50km/h (R_{min}=90m, i_{max}=9%) is shown by brake line. • Only overpass bridge will be constructed on the Project (Bridge width is 10m).

(13) No.13: STA.15+233

Name of Road: Private Road for Brick Clay Mining
Road Class E: Design Speed 40 km/h (Terrain: Rolling), Road Width: 5.9m (1 lane)
Alignment for the Project

• Existing alignment (Design speed 40km/h satisfied) • Only box culvert will be constructed on the Project (Culvert width is 5.9m).

Note: Viaduct was adopted for main carriageway at this section, and this approach road was omitted from the Design.