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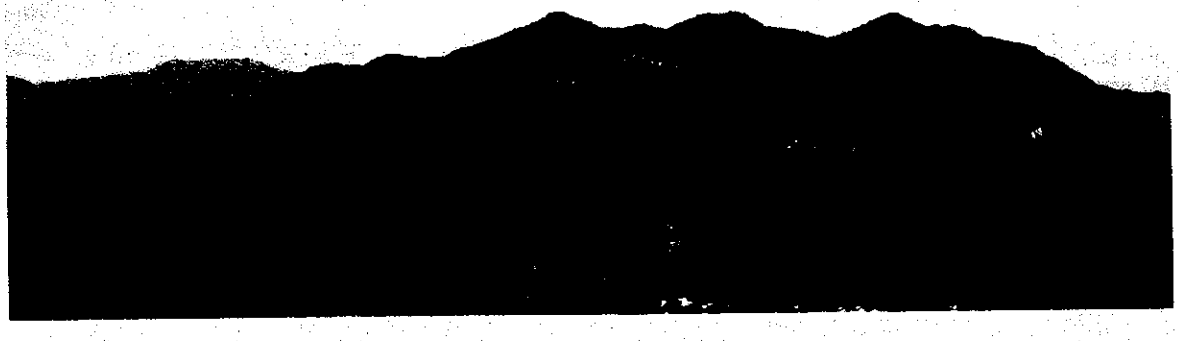
No. 32

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

HIS MAJESTY S GOVERNMENT OF NEPAL
MINISTRY OF PHYSICAL PLANNING AND WORKS
DEPARTMENT OF ROADS

THE FEASIBILITY STUDY ON THE CONSTRUCTION OF KATHMANDU-NAUBISE ALTERNATE ROAD IN THE KINGDOM OF NEPAL



FINAL REPORT

VOLUME III: APPENDIX

MARCH 2001

NIPPON KOEI CO., LTD.

THE FEASIBILITY STUDY ON THE CONSTRUCTION OF KATHMANDU-
FINAL REPORT VOLUME III: APPENDIX
MARCH 2001
NIPPON KOEI

CURRENCY EQUIVALENTS
(Average of July 1st to December 31st, 2000)

1USD	=	72.57 NRs (Nepalese Rupee)
1USD	=	109.76 JPY (Japanese Yen)
1USD	=	42.34 TLB (Thailand Baht)

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MINUTES OF MEETING
ON
THE INCEPTION REPORT
FOR
THE FEASIBILITY STUDY
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THE CONSTRUCTION OF KATHMANDU-NAUBISE ALTERNATE ROAD
IN
THE KINGDOM OF NEPAL

BETWEEN MINISTRY OF WORKS AND TRANSPORT
DEPARTMENT OF ROAD
AND
JAPAN INTERNATIONAL COOPERATION AGENCY
THE STUDY TEAM

Ananda Khanal

Mr. Ananda Prased Khanal
Director General
Department of Roads
Ministry of Works and Transport
His Majesty's Government of Nepal

Mr. Tatsuya Masuzawa
Team Leader
The Study Team
Japan International Cooperation Agency

Witnessed by,

Mr. Hideki Okamura
Team Leader
The Advisory Team
Japan International Cooperation Agency

MINUTES OF MEETING

In accordance with the Scope of Works agreed upon on 17th December 1999 between Japan International Cooperation Agency (hereinafter referred to as "JICA") and the Ministry of Works and Transport (hereinafter referred to as "MoWT"), Department of Roads (hereinafter referred to as "DoR"), Inception Report for the Feasibility Study on the Construction of Kathmandu-Naubise Alternate Road in The Kingdom of Nepal (hereinafter referred to as "the Study") was submitted by the Study Team of JICA to the DoR on 3rd April 2000. Discussions were held between the Study Team and concerned DoR officers on 7th April 2000, wherein Mr. Tatsuya Masuzawa, Leader of the Study Team, along with other members of the Study Team conducted a briefing of the Report and explained general approach and methodology to be followed for the Study.

After a series of discussion between the Study Team and DoR, the following subjects were confirmed and agreed upon by DoR and the Study Team.

1. Submission of the Inception Report

   The Study Team submitted 20 copies of the Inception Report on 3rd April 2000 to DoR in accordance with the Scope of Works for the Study. DoR acknowledged the receipt of the Report.

2. Explanation of the Inception Report

   The Study Team explained Contents, Methodology, Staffing and Schedule of the Study in line with the Inception Report.

3. Explanation of Environmental Study

   The Study Team presented proposed work flow of the environmental study for the Study in accordance with the attended flow chart (Appendix-1).

4. Item Confirm

   4.1 Contents of the Inception Report

   The Contents, Methodology and Schedule of the Study were basically agreed by DoR through the meeting.

   4.2 The Environmental Study

i) The task assignment between DoR and the Study Team

DoR and the Study Team confirmed their each tasks and responsibility as follows;

The Study Team: The Study Team conducts preparation of draft documents required for the Environmental Impact Assessment (EIA) application procedure in Nepal.

DoR : DoR is responsible for finalization of all official documents necessary for the EIA application procedure in Nepal, and conducts actual procedures for the application.

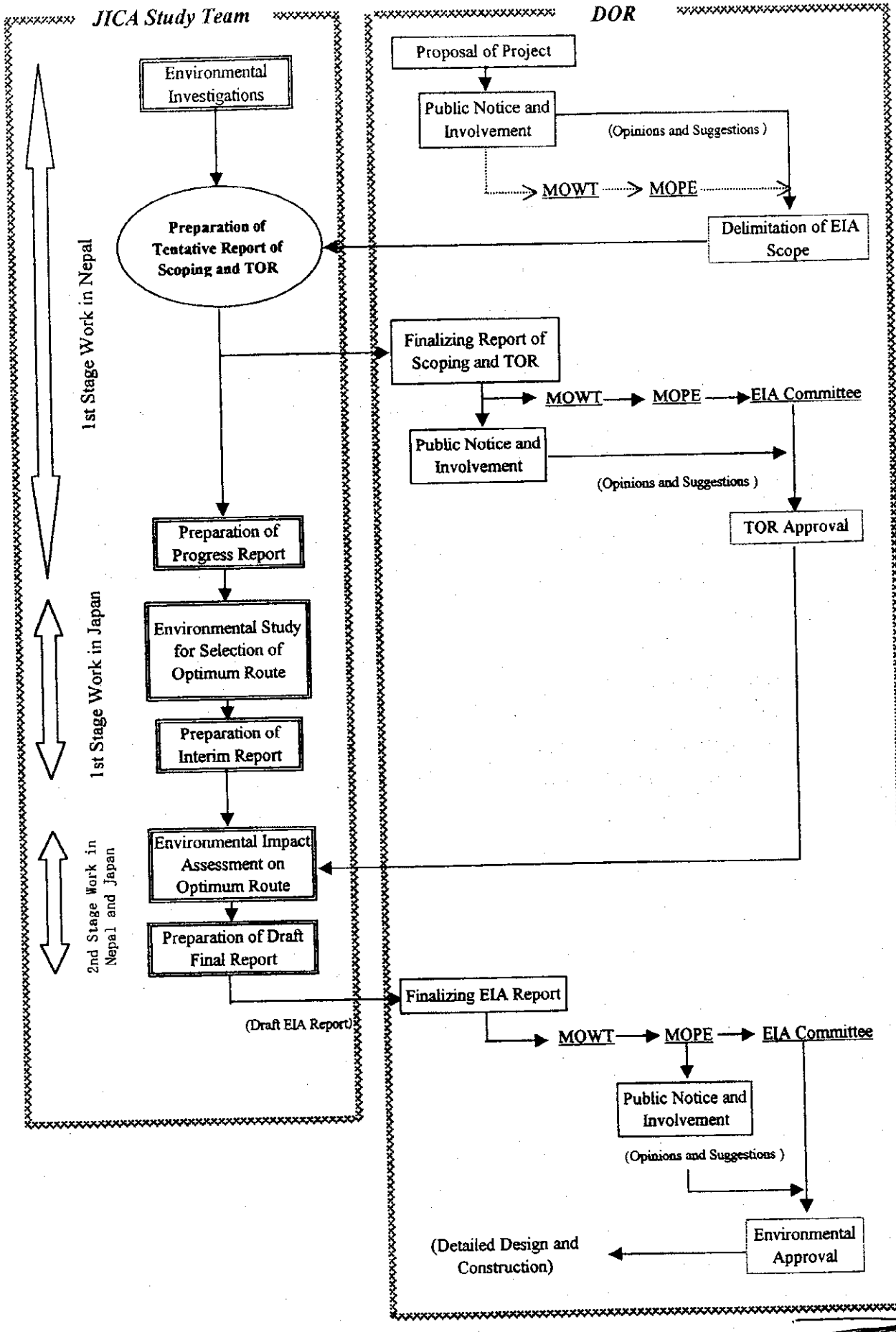
ii) Both parties confirmed the work flow shown in Appendix-1 and make best effort to obtain an approval on the ToR for the EIA within 1st stage work in Nepal.

4.3 Counterpart of DoR

It was agreed that DoR provides one counterpart from the beginning of the Study, and that the additional counterpart(s) will be provided by DoR during the study period upon request of the Study Team.

4.4 Other Undertakings of DoR

Other undertakings of DoR were agreed according to the Scope of Works agreed on 17th December 1999 by JICA Preparatory Study Team and DoR.



Proposed Work Flow of the EIA Study for the Project

LIST OF PARTICIPANTS

The Presentation of the Inception Report for the Feasibility Study on the Construction of Kathmandu-Naubise Alternate Road

7th April 2000

1. DoR

No.	Name	Position
1	A. P. Khanal	Director General
2	S. Lacoul	Deputy Director General
3	M. G. Maleku	Deputy Director General
4	T. Kimata	JICA Advisor
5	P. M. Shrestha	SMD Coordinator
6	S. P. Adhikary	CRRD-2
7	K. B. Thapa	Senior Divisional Engineer
8	G. P. Singh	Senior Divisional Engineer
9	L. N. Tripathi	Senior Divisional Engineer
10	M. B. Regmi	Engineer
11	P. R. Pant	Engineer
12	K. B. Thapa	Senior Divisional Engineer
13	R. P. Pradhanang	Senior Divisional Engineer
14	B. S. Rana	Project Manager
15	B. Shrestha	Senior Divisional Engineer
16	N. R. Adhikari	Engineer
17	S. Bhattarai	Engineer
18	K. S. Mahato	Senior Divisional Engineer
19	B. K. Shahi	Engineer
20	N. M. Patrabansh	Senior Divisional Engineer
21	B. P. Neupane	Engineer
22	S. R. Shah	Project Manager
23	R. P. Pathak	Engineer
24	S. R. Adhikari	Engineer
25	J. B. Shrestha	Senior Divisional Engineer
26	D.B. Thapa	Deputy Director General

2. JICA

No.	Name	Position	Organization
1	Hideki Okamura	Team Leader	The Advisory Team
2	Kazunori Yamaguchi	Member	The Advisory Team
3	Tatsuya Masuzawa	Team Leader	The Study Team
4	Kazuyuki Otsuka	Urban/Traffic Planner	The Study Team
5	Kentaro Okuno	Coordinator	The Study Team
6	Kazuhisa Arai	Assistant Resident Representative	JICA Nepal Office

MINUTES OF MEETING
ON
THE PROGRESS REPORT
FOR
THE FEASIBILITY STUDY
ON
THE CONSTRUCTION OF KATHMANDU-NAUBISE ALTERNATE ROAD
IN
THE KINGDOM OF NEPAL

BETWEEN
MINISTRY OF PHYSICAL PLANNING AND WORKS
DEPARTMENT OF ROADS
AND
JAPAN INTERNATIONAL COOPERATION AGENCY
THE STUDY TEAM

Mr. Ananda Prased Khanal
Director General
Department of Roads
Ministry of Works and Transport
His Majesty's Government of Nepal

Mr. Tatsuya Masuzawa
Team Leader
The Study Team
Japan International Cooperation Agency

MINUTES OF MEETING

In accordance with the Scope of Works agreed upon on 17th December 1999 between Japan International Cooperation Agency (hereinafter referred to as "JICA") and the Ministry of Physical Planning and Works and (hereinafter referred to as "MoPPW"), Department of Roads (hereinafter referred to as "DoR"), Progress Report for the Feasibility Study on the Construction of Kathmandu-Naubise Alternate Road in The Kingdom of Nepal (hereinafter referred to as "the Study") was submitted by the Study Team of JICA to the DoR on 16th June 2000. Discussions were held between the Study Team and concerned DoR officers on the same day, wherein Mr. Tatsuya Masuzawa, Leader of the Study Team, along with other members of the Study Team conducted a briefing of the Report and explained results of the study, which have been carried out during past period since the submission of the Inception Report.

After a series of discussion between the Study Team and DoR, the following subjects were confirmed and agreed upon by DoR and the Study Team.

1. Submission of the Progress Report

The Study Team submitted 20 copies of the Progress Report on 16th June 2000 to DoR in accordance with the Scope of Works for the Study. DoR acknowledged the receipt of the Report.

2. Explanation of the Progress Report

The Study Team made a presentation on Contents of the Progress Report and study results of major issues were explained by the Study Team. Several discussion on the issues was made between the DoR and Study Team subsequently.

3. Item Confirmed

3.1 Contents of the Progress Report

The Contents of the Progress Report, which includes the traffic demand forecast, design standards and possible alternative route for further study, were basically agreed by DoR through the meeting.

3.2 The Environmental Study

The DoR and Study Team confirmed that official approval by the Ministry of Population and Environment (MOPE) on the Scoping and TOR for EIA has been obtained on 14th

June, 2000 and the Study Team conducts EIA study and preparation of Draft documents according to the TOR.

3.3 Alternative Electrical Power Source for the Tunnel Alternative

The DoR requested the Study Team to add a study on the possible alternative source of electrical power for operation and maintenance of tunnel, for which wind-power and solar-power may be considered. The Study Team acknowledged the request and promised to consult with JICA on this matter.

3.4 Location of East Portal of Short Tunnel Alternative

The DoR requested the Study Team that the alternative location of the east portal of short tunnel shall be studied, since the current location of the portal will effect on the potential landslides (LS-1 and LS-2) and Bakhrigau community of Bhimduhunga VDC. The Study Team agreed on this matter.

3.5 Passenger Car Equivalents of PCU

The DoR commented that PCU shall be fixed after examination of the Passenger Car Equivalents of PCU introduced in Indian Standard. The Study Team agreed on this matter.

END OF MINUTES OF MEETING

LIST OF PARTICIPANTS

The Presentation of the Progress Report for the Feasibility Study on the Construction of Kathmandu-Naubise Alternate Road

16th June 2000

1. DoR

No.	Name	Position	Office
1	A. P. Khanal	Director General	DoR
2	M. G. Maleku	Deputy Director General	F.C.Branch
3	K.P.Pokharel	Deputy Director General	Design Branch
4	S. Lacoul	Deputy Director General	Maintenance Branch
5	H.L.Rajbahak	Deputy Director General	Mechanical Branch
6	S. P. Adhikary	R.D	CRRD-2
7	B.Karki	Senior Divisional Engineer	MRCU
8	C.Karki	Senior Divisional Engineer	RSSDU
9	H.O.Shrivastav	Senior Divisional Engineer	Road Unit
10	K.Pandey	Senior Divisional Engineer	MPPW
11	K. B. Thapa	Senior Divisional Engineer	F.C.Branch
12	K.P.Wagley	Senior Divisional Engineer	Bridge Unit
13	K.L.Joshi	Senior Divisional Engineer	TESU
14	K. B. Thapa	Senior Divisional Engineer	F.C.Branch
15	L. N. Tripathi	Senior Divisional Engineer	Pranning Branch
16	M.R.Gyawali	Senior Divisional Engineer	F.C.Branch
17	P. M. Shrestha	Senior Divisional Engineer	SMD Coordination Unit
18	S.J. Thapa	Senior Divisional Engineer	Office of DG
19	R.Bista	Senior Divisional Engineer	RMDP
20	B.Shrestha	Senior Divisional Engineer	CRL
21	R.P.Pradhanang	Senior Divisional Engineer	MEL
22	P.J.Shah	Senior Divisional Engineer	DoR
23	D.P.Ostee	Project Manager	Chinchhu Jajarkot PJT
24	S.Dali	Head	HMIS Unit
25	A.D. Shrestha	Engineer	Office of DG
26	B.Ranabhat	Engineer	Plannning Branch
27	B.Subedi	Engineer	RSSDU
28	P. Shrestha	Engineer	HMIS Unit
29	M. B. Regmi	Engineer	RMDP
30	P.Upadhaya	Engineer	HMIS Unit
31	R. P. Pathak	Engineer	Pranning Branch
32	M.L. Shah	Engineer	DoR
33	M.S.Acharya	Engineer	MEU
34	Deepak.K.C	Engineer	RMPP,FCB
35	T.Kimata	JICA Advisor	

2. DoR Counterpart

No.	Name	Position
1	B.S.Rana	Coordinator
2	S.Bhattarai	Counterpart Engineer

3. Embassy of Japan

No.	Name	Position
1	Yoshiyuki Toyoguchi	Second Secretary
2	K.M.Pradhan	Program Officer

4. JICA

No.	Name	Position	Organization
1	Yoshiyuki Arai	Assistant Resident Representative	JICA Nepal Office
2	Tatsuya Masuzawa	Team Leader	The Study Team
3	Kazuyuki Otsuka	Urban/Traffic Planner	The Study Team
4	Junji Moto	Traffic Survey/Analysis and Demand Forecast	The Study Team
5	S.Naresh	Road Design	The Study Team
6	Koichiro seki	Bridge Design	The Study Team
7	Tamito Masunari	Tunnel Design	The Study Team
8	Akichika Ishibashi	Road Disaster Protection	The Study Team
9	Takaaki Tanaka	Construction Planning /Cost Estimate	The Study Team
10	Masao Chida	Natural Condition Survey	The Study Team
11	Norihiko Inoue	Envirnment and Social Impact Assesment	The Study Team
12	Akio Morikawa	Economic and Financial Analysis	The Study Team
13	Hirotoshi Suzuki	Coordinator	The Study Team

MINUTES OF MEETING
ON
THE INTERIM REPORT
FOR
THE FEASIBILITY STUDY
ON
THE CONSTRUCTION OF KATHMANDU-NAUBISE ALTERNATE ROAD
IN
THE KINGDOM OF NEPAL

BETWEEN
MINISTRY OF PHISICAL PLANNING AND WORKS
DEPARTMENT OF ROAD
AND
JAPAN INTERNATIONAL COOPERATION AGENCY
THE STUDY TEAM

Ananda Khanal

Mr. Ananda Prased Khanal
Director General
Department of Roads
Ministry of Works and Transport
His Majesty's Government of Nepal
DIRECTOR-GENERAL

Mr. Tatsuya Masuzawa
Team Leader
The Study Team
Japan International Cooperation Agency

His Majesty's Government
Ministry of Physical Planning & Works
Department of Roads
Babar Mahal

Witnessed by,

Mr. Hideki Okamura
Team Leader
The Advisory Team
Japan International Cooperation Agency

MINUTES OF MEETING

In accordance with the Scope of Works agreed upon on 17th December 1999 between Japan International Cooperation Agency (hereinafter referred to as "JICA") and the Ministry of Physical Planning and Works and (hereinafter referred to as "MoPPW"), Department of Roads (hereinafter referred to as "DoR"), Interim Report for the Feasibility Study on the Construction of Kathmandu-Naubise Alternate Road in The Kingdom of Nepal (hereinafter referred to as "the Study") was submitted by the Study Team of JICA to the DoR on 24th August 2000. Discussions were held between the Study Team and concerned DoR officers on the same day, wherein Mr. Tatsuya Masuzawa, Leader of the Study Team, along with other members of the Study Team conducted a briefing of the Report and explained results of the study, which have been carried out during past period since the submission of the Inception Report.

After a series of discussion between the Study Team and DoR, the following subjects were confirmed and agreed upon by DoR and the Study Team.

1. Submission of the Interim Report

The Study Team submitted 20 copies of the Interim Report on 24th August 2000 to DoR in accordance with the Scope of Works for the Study. DoR acknowledged the receipt of the Report.

2. Explanation of the Interim Report

The Study Team made a presentation on Contents of the Interim Report and study results of major issues were explained by the Study Team. Several discussion on the issues was made between the DoR and Study Team subsequently.

3. Item Confirmed

3.1 Optimum Route Selection

There is no significant difference between the short-tunnel option and no-tunnel option in terms of cost and economic feasibility, however the short-tunnel option was slected as the optimum route road taking the following advantages of the short-tunnel option into account.

i) Higher reliability against road disasters than the no-tunnel option by bypassing fragile section.

ii) More smooth project implementation due to less environmental and social impacts

iii) Less traffic accident by shortening road length in accident prone section

iv) Necessity of highway tunnel for future road network development in a mountainous country of Nepal

The above study result was proposed by the Study Team and accepted by DoR.

3.2 The optimum Route of Section-A (Ring Road Connection)

The optimum route of Section-A (Ring Road Connection) will be determined after topographic survey in this section is completed. The route shall be determined taking following matters into consideration.

(1) minimization of land acquisition and compensation

(2) future road extension to inside of Ring Road

3.4 Alignment of Short Tunnel and Location of East Portal

According to the minutes of meeting of the progress report, the alignment of the short tunnel and location of its east portal shall be carefully determined based on the result of seismic prospecting investigation.

3.5 Seismic Prospecting Investigation

The Study Team informed that it will conduct seismic prospecting investigation using blasting at Bhimdhunga. The Study Team requested DoR's cooperation and necessary arrangement to obtain permissions for procurement of blasting material and its use. DoR accepted the request.

3.6 Future Road Network for Future Traffic Demand Forecast

DoR suggested that Kathmandu-Hetauda direct link shall be taken into account for the future traffic demand forecast of the Project Road. The Study Team agreed to take the Kathmandu-Hetauda direct link into account for the traffic demand forecast of the Project Road.

3.7 Other Contents of the Interim Report

The other Contents of the Interim Report, which includes the traffic demand forecast, design standards and environmental studies, were basically agreed by DoR through the meeting.

---------- END OF MINUTES OF MEETING ----------

LIST OF PARTICIPANTS

The Presentation of the Interim Report for the Feasibility Study on the Construction of Kathmandu-Naubise Alternate Road

24th August 2000

1. MPPW

No.	Name	Position	Office
1	D.P.Rimal	Jt.Secretary	MPPW
2	B.B.Deuja	Jt.Secretary	MPPW

2. DoR

No.	Name	Position	Office
1	A. P. Khanal	Director General	DoR
2	M. G. Maleku	Deputy Director General	F.C.Branch
3	K.P.Pokhrel	Deputy Director General	Design Branch
4	S. Lacoul	Deputy Director General	Maintenance Branch
5	H.L.Rajbahak	Deputy Director General	Mechanical Branch
6	R.Rijal	P.D	ADB Project Directorate
7	I.S.Dhakal	Senior Divisional Engineer	Maint.Division,Kathmandu
8	J.B.Shrestha	Senior Divisional Engineer	GEU
9	K.L.Joshi	Senior Divisional Engineer	TESU
10	K.B.Thapa	Senior Divisional Engineer	F.C.Branch
11	M.R.Gyawali	Senior Divisional Engineer	F.C.Branch
12	S.R.Dali	Senior Divisional Engineer	F.C.Branch
13	P.M.Shrestha	Senior Divisional Engineer	SMD Coordination Unit
14	S.J.Thapa	Senior Divisional Engineer	Office of the D.G.
15	P.J.Shah	Senior Divisional Engineer	EROM
16	R.Pradhananga	Senior Divisional Engineer	MEU
17	B.M.S.Dangole	Senior Divisional Engineer	DRO Bhaktapur
18	S.Shah	Senior Divisional Engineer	RMDP
19	S.Dali	Tr.Economist	HMIS Unit
20	A.D.Shrestha	Engineer	Office of the D.G.
21	B.Subedi	Engineer	RSSDU
22	P.Shrestha	Engineer	HMIS Unit
23	S.Poudel	Engineer	TESU
24	S.Kharel	Engineer	RMRP
25	R.D.Pathak	Engineer	Planning
26	B.L.Shrestha	Engineer	F.C.Branch
27	R.Sharma	Engineer	DRO Biratnagar
28	K.Karki	Engineer	DRO KTM
29	T.Kimata	JICA Advisor	

3. DoR Counterpart

No.	Name	Position
1	B.S.Rana	Coordinator
2	S.Bhattarai	Counterpart Engineer

4. JICA

No.	Name	Position	Organization
1	Hideki Okamura	Team Leader	The Advisory Team
2	Kazunori Yamaguchi	Member	The Advisory Team
3	Tatsuya Masuzawa	Team Leader	The Study Team
4	S.Naresh	Road Design	The Study Team
5	Akichika Ishibashi	Road Disaster Protection	The Study Team
6	Tadashi Nakayu	Natural Condition Survey	The Study Team
7	Takayuki Fujitomi	Coordinator	The Study Team

MINUTES OF MEETING
ON
THE DRAFT FINAL REPORT
FOR
THE FEASIBILITY STUDY
ON
THE CONSTRUCTION OF KATHMANDU-NAUBISE ALTERNATE ROAD
IN
THE KINGDOM OF NEPAL

BETWEEN
MINISTRY OF PHISICAL PLANNING AND WORKS
DEPARTMENT OF ROAD
AND
JAPAN INTERNATIONAL COOPERATION AGENCY
THE STUDY TEAM

Mr. Ananda Prased Khanal
Director General
Department of Roads
Ministry of Physical Planning and Works
His Majesty's Government of Nepal

Mr. Tatsuya Masuzawa
Team Leader
The Study Team
Japan International Cooperation Agency

Witnessed by,

Mr. Hideki Okamura
Team Leader
The Advisory Team
Japan International Cooperation Agency

MINUTES OF MEETING

In accordance with the Scope of Works agreed upon on 17th December 1999 between Japan International Cooperation Agency (hereinafter referred to as "JICA") and the Ministry of Physical Planning and Works and (hereinafter referred to as "MoPPW"), Department of Roads (hereinafter referred to as "DoR"), the Draft Final Report for the Feasibility Study on the Construction of Kathmandu-Naubise Alternate Road in The Kingdom of Nepal (hereinafter referred to as "the Study") was submitted by the Study Team of JICA to the DoR on 13th February 2001. Discussions were held between the Study Team and concerned DoR officers on the same day, wherein Mr. Tatsuya Masuzawa, Leader of the Study Team, along with other members of the Study Team conducted a briefing of the Report focusing on the results of the studies carried out since the submission of the Interim Report.

After a series of discussion between the Study Team and DoR, the following subjects were confirmed and agreed upon by DoR and the Study Team.

1. Submission of the Draft Final Report

   The Study Team submitted 20 copies of the Draft Final Report (including Draft Preliminary Design Drawings) on 13th February 2001 to DoR in accordance with the Scope of Works for the Study. DoR acknowledged the receipt of the Report.

2. Explanation of the Draft Final Report

   The Study Team made a presentation on contents of the Draft Final Report and study results of major issues were explained by the Study Team. Several discussions were made between DoR and Study Team for the clarification of the Study results subsequently.

3. Acceptance of the Draft Final Report

   Through the explanation and discussion on the contents of the Draft Final Report, DoR accepted the contents of the Draft Final Report in principle.

4. Preparation of Final EIA Report and its Approval

   DoR will prepare the Final EIA Report based on the draft documents prepared by the Study Team and take necessary actions for application and official approval of the EIA under its responsibility.

5. Comments from DoR on the Draft Final Report

   DoR will send its comments on the Draft Final Report to JICA by the end of February 2001

---------- END OF MINUTES OF MEETING ----------

B. TECHNICAL REFERENCES AND DATA

B-1 Result of Geological Boring Investigation

REPORT ON

Site Investigation at Proposed Bridge Sites of

KATHMANDU - NAUBISE ALTERNATE ROAD PROJECT

Prepared for

JICA Study Team
Kathmandu - Naubise Alternate Road Project
Nippon Koei
Kathmandu

Submitted by

SILT Consultants Pvt. Ltd.
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December 2000

Table of Contents

Location of Bore Holes

BH-1	3066105.490	625497.730	1307.610
BH-2	3067972.010	622815.190	1372.810
BH-3	3069021.090	615326.487	870.680
BH-4	3069166.660	613759.714	835.888
BH-5	3069080.640	612235.348	791.699
BH-6	3069038.300	612163.724	785.538

Report on Bridge Site Investigation at proposed Bridge Sites of Kathmandu - Naubise Alternate Road Project

1. INTRODUCTION

This job of investigation work was carried out for the proposed five bridges site at Kathmandu-Naubise Alternate Road Project.

Two sets of drilling rigs were mobilized to the site with necessary drilling crew and accessories for exploratory drilling works. Diamond core bits were used to get the core samples of the large boulders as well as other materials from the strata.

All together six bore holes, one at each of the probable location of the bridge site either at the bridge sites at the probable location of the left or right abutment were made to a depth of 20m to get the samples of the strata and to conduct field tests.

2. OBJECTIVE

Main objective of the investigation work is to identity and produce a real picture of stratification of the subsoil and provide their physical and strength properties and to ensure that the site is safe to construct the proposed bridge. For this purpose exploratory drilling was started and completed within two months. Professional experts of Nippon Koei has also visited the site during the field works.

3. FIELD WORKS

So as to penetrate through various strata, a double tube core barrel was used to recover the sample. Samples being non-cohesive in nature at certain location, even the double tube core barrel could not recover the sample after several trials. Dry drilling was conducted but presence of high water table disturbed in obtaining core for better core recovery. Water used for drilling operation carried the sample with it and the samples obtained are mostly that from the sludge except the samples of hard core. At various intervals, SPT (Standard Penetration Test) and DCPT (Dutch Cone Penetration Test) were carried out. The split spoon sampler carried some original sample, although the amount is in small quantity.

4. TESTS

The strata being non homogeneous and non cohesive, only following tests could be conducted, as listed below.

4.1 Field Tests

4.1.1 Standard Penetration /Dutch Cone Penetration IS 2131

4.2 Laboratory Tests

4.2.1 Physical Test
- Sieve Analysis IS 2720 (IV)
- Specific Gravity IS 2720 (III)
- Moisture Content

4.2.2 Liquid Limit & Plastic

4.3 Mechanical Tests

4.3.1 Sodium Sulphate Soundness
4.3.2 pH Measurement

5. GEOLOGY OF THE SITE

5.1 Regional Geology of the Site

In the regional geological framework, the present project lies in the "Kathmandu Complex" of the Lesser Himalayas, which merges with the central crystalline of Higher Himalayas in the north. The Kathmandu Complex is a klippe structure and found to be the thrust over Tertiary sediments (Siwalik) in the South along the regional structure known as "Main Boundary Thrust (MBT).

The Kathmandu Complex is divided into the Bhimphedi group (lower) and the Phulchoki group (upper), the two being stratigraphically continuous but distinguished by different grade of metamorphism.

Rock type of Bhimphedi group of Kathmandu Complex is of Pre-Cambrian to Lower Cambrian age and is composed of relatively high grade metasediments, gneiss and several granite intrusion. In the project area, the major type of Bhimphedi group encountered is Tistung formation consisting of phyllite, meta-sediments and minor limestone. This formation is showing a distinct decrease in metamorphic grade from bottom to top. The lower part is mostly dark phyllite with fine biotite and in general have interbands of gray to dark gray limestone.

On the contrary, the Phulchoki groups of rock of Cambrian to Devonian age is occupied by low grade meta sedimentary sequence, phyllite, metasediments and limestone at the top. The project area have mostly encountered the Chandragiri limestone of Bhimphedi group. It is comprising of brown to pale brown limestone with argillaceous coating and phyllite interbands in then.

In general, whole group of these rock assemblages, regionally forms a large internally complicated synclinal mega structure, the "Mahabharat Synclinorium" with a gentle axial plunge to the E-SE and narrow syncline wing, the Nagarjun syncline to the East.

The centre of the Synclinorium is occupied by the Kathmandu basin with fluvial to lacustrine sediments with the occasional beds and hills of youngest Plaeozoic metasediments.

Apart from this main geological formation, talus deposit are found immediately along the base of mountain while the colluvium deposit consisting mainly of limestone boulders in sand silt matrix is found occurring all along the hill slopes, high raised terraces and at some portion of cultivated land. The Lacustrine sediments with minor bands of lignite in them are seen exposed in the eastern portion of the project area.

5.2 Geology of the Bridge Site

Since the investigation for several bridge sites within the project area are carried out, the geology around each of the bridge site are briefly described.

5.2.1 Bridge Site around Bore Hole B1

The land surface around the bridge site is the cultivated alluvial land formed by Manamati river. It comprises of alluvial soil consisting of light to brown clay, gray to dark gray highly plastic clay and silty clay with fine sand. The alluvial deposit is overlying the lacustrine deposit of the Kathmandu valley. The lacustrine deposit is semi-consolidated sandy, clayey silt and clay interbedded with gravel and clayey sand. Peat and lignite upto 3m is common in this deposit.

In the borehole B1, alluvial soil is encountered up to the depth of 9m. From 9m to the bottom of the bore hole - lacustrine deposit comprising of highly plastic carbonaceous black clay and gray coloured silty clay are encounter. Ground water level is encountered at 9m.

5.2.2 Bridge Site around Bore Hole B2

The land surface around the bridge site is high raised cultivated terrace and comprise of talus to debris flow deposit without boulders. It consists of in homogenous deposit of clayey material mostly alluvial soil and lateratic clayey material without boulders. Under this deposit is the lacustrin deposit consisting of semi consolidated sandy, silty clay interbedded with gravel and clayey sand.

In the bore hole B2, talus to debris flow deposit consisting of reddish brown alluvial soil and sandy clay with fine sand are encountered up to 3m depth. From 3m to 18.35m lacustrine deposit consisting alternative layers of highly plastic carbonaceous black clay and gray colored silty clay are encountered. From 18.35m to 20.0m highly weathered brown to pale brown limestone with intermittent phyllite bands are encountered. Probably, this is the start of the bed rock. Ground water table is encountered at 4.5m depth.

5.2.3 Bridge Site around Bore Hole B3

The area around the bore hole B3 comprises of weathered phyllite group consisting of greenish gray to brown fine grained phyllite and slate interbedded with thin bands of argillaceous limestone. This deposit is underlain by Talus to debris flow deposit with big boulders and comprises of

in homogeneous deposits of clay, silt and sand with presence of big boulders at places.

The borehole log reveals that the sub surface consists of silty soil strata upto the depth of 3m. From the depth of 3m to the bottom of the bore hole highly weathered phyllitic bands with intermittent totally decomposed limestone and completely weathered limestone with highly weathered intermittent bands of phyllite in succession are encountered. The groundwater table is encountered at 12.0 m depth.

5.2.4 Bridge Site around Bore Hole B4

The area around bore hole B4 comprises of high-rise terraces consisting of Talus to debris flow deposit with big boulders. The underlying rocks of the terraces consist of weathered phyllite group comprising of greenish gray to brown fine grained phyllite with thin bands of argillaceous limestone.

The bore hole log reveals that sub surface strata upto 6m consists of silty clay with occasional presence of boulders. From the depth of 6 to 9m, the stratum consists of completely weathered phyllite where though the SPT values are reasonable higher penetration is not rejected. From the depth of 9m penetration is mostly rejected and comprises of weathered phyllite with intermittent gray colored limestone of different degree of weathering. From the depth of 15m onward, the limestone bands encountered are only slightly weathered.

Ground water table is encountered at 9m.

5.2.5 Bridge Site at Dharke (Bore Hole B5 & B6)

Bore Hole B5 and B6 located at left and right abutment of Dharke khola respectively lie in the weathered phyllite group of rock. This group of rock comprises of gray to brown, fine grained phyllite with thin bands of argillaceous limestone.

However at the foot of the mountainous, slopping terrace and elevated terraces above river bed, these group of rocks are covered by Talus to debris flow deposit with big boulders. It is mostly comprised of in homogeneous deposit of clay, silt and sand with pale brown to blush gray limestone boulders.

6. BEARING CAPACITY

The bearing capacity of five sites of proposed bridges are computed and recommended below on the basis of topography of the bridge sites, bore hole log with SPT values and test results attached herewith in the appendix.

6.1 Location B1 and B2

Samples and logs with SPT values of bore holes B1 and B2 are identical. The sample are mostly highly plastic silty clay. SPT values are subject to correction for water table and overburden. SPT values at both the bridge sites at about 12-15m is more than 29-40 blows. The higher values are due to high overburden and therefore are subject to correction. Adopt 29 as value for further computation.

The values are corrected first for the water table by with the help of equation.

$$N = 15 + 1/2\,(N' - 15)$$

where N and N' are corrected and actual blow respectively.

$$N = 15 + 1/2\,(29-15)$$
$$= 22 \text{ blows}$$

Generally, overburden correction is applicable to only granulor soils. Hence for consistence of soil and other factors adopt emperical values.

During excavator for foundation the overburden value will be zero. Hence for the purpose of further computation initial readings of SPT be considered here for reference. The minimum initial SPT value at B2 is 14 blows.

As suitable over burden correction is not available a minimum of above two values be considered for future computation as a careful and safe consideration.

The soil thus falls under stiff category with,
qu unfonfined compressive = 20 kN/m^2
Unit wt. be adopted as = 17-20 kN/m^2

6.1.1 Foundation Type

Detail tests like consolidation and shear tests which are the primary ones, are not done at this stage of study. Based on emperical tables it has a poor bearing value with probably high settlement.

In such cases open foundation is not generally recommended. Well foundation or pile foundation are the only alternatives. As well foundation is quiet expensive and time taking for construction, friction pile foundation is the optimum solution. Detail design and recommendations will be done during the detail design stage.

6.2 Location B3

Bore Hole 3 located at Mahesh khola has a overburden of 2m after which strata of weathered rock is encountered. Weathering of these strata is mainly due to the bore

holes located very close this exposed surface. Weathering should be less if the location has an off set of 5-8 m. It is therefore for final design, span of the bridge be adopted with an additional span of 5-8m longer on each side for better and safe foundation strata. This will saver the cost of foundation with shallow depth , but with higher bearing capacity in comparison to the cost with deeper depth for a suitable foundation layer. This will also save the effective stresses close to the exposed steep banks.

A suitable size of open foundation be adopted.

6.3 Location B 4

As in bore hole 4 located at Mahesh khola rock strata start from the elevation of 876.0 m. The strata are again weathered due to river water penetration. As in bore hole B3 the bridge span be designed with an offset of 5-8m, for better strata and for minimum effective stresses close to the steep river banks.

As in B 3 a suitable size of open foundation be adopted.

6.4 Locations B5/6 Dharke

At Dharke river, bed rock is exposed in the right bank at and around the level of river bed. Overburden layer exists at both banks.

Open foundation is the only solution for the type of strata and location.

6.5 Bearing Capacity for Locations B3, B4 and B5/6

The bearing capacity or the allowable bearing pressure to which the subsoil can be subjected to, can be estimated on the basis of limited data obtained from the soil exploration. SPT value N remains the most important factor and parameter to evaluate the maximum allowable bearing pressure . At locations where SPT is not possible Dutch Cone Penetration Test was carried out.

Assuming q as the uniform pressure at the depth of foundation. an analysis is done here to get the vertical pressure at a depth (equal to width of foundation, i.e., 6m) below the foundation level for preliminary design.

Stress distribution analysis for stresses at a depth of 6m below the foundation level of :

- **Abutment Foundation**

L = 7m, B = 6m (assumed for computation)
L/B = 7/6 = 1.17
m = 2z/B = (2x6)/6 = 2
I_o = 0.38 (38%)

The stress distributions at a depth of 6-7m below the foundation is only 38% of stresses developed at the foundation level and seems very low for any major geotechnical changes in the soil strata expected below the depth of investigation. Hence a depth of influence is taken as 10m below the OGL for future analysis side slope stability due to steep bank has to be checked in detail design phase.

N value is very high and occasionally it is rejected and for the sake of analysis N value is taken as 50.

Correction for water table is done with the help of following equation.

$N' = 15 + 1/2 (N - 15)$
$= 15 + 1/2 (50 - 15)$
$=$ **32 blows**

This value is further corrected for overburden as suggested by Gibbs & Holtz (1957) is as follows and, is widely adopted

$N = 35 N'/ (\delta + 7)$, for $\delta < 28$ t/m^2
In our case $\delta = 10 \times 2.1$
$= 21 < 28$ t/m^2

Assuming, r = 2.1 t/m^3 (for layer with boulders)

$N = 35 \times 32 / (21 + 7)$
$= 40.0$

But another equation for correction of water table for a raft foundation (the block is assumed to act as a raft foundation.) is

$C_w = 0.5 + 0.5 \{(D_w / D_f + B)\}$

where , C_w = Correction factor (0.5)
D_w = Depth of ground water (4m)
D_f, B = Depth & width of foundation (4 and 7m) assumed

$C_w = 0.5 + 0.5 [4/ (4+7)]$
$= 0.67$

N' corrected will be = 50×0.67
$= 33.5$

But the equation does not suggest any overburden correction.

Adopt N = 35 for further computation

Various equations are considered below to evaluate the bearing capacity.

6.6 <u>From Meyerhof, (1965)</u>

$\delta q_s = 0.31 N Þ[(B + 0.3)/B)]^2$, for B > 1.2m

where, δq_s = allowable bearing stress

N = SPT blows = 35blows

$Þ$ = Allowable settlement in mm
= 25 mm (assumed)

B = width of block
= 7 m (assumed)

q_s = $0.31 \times 40 \times 35[(5 + 0.3)/5)]^2$
= $488\ KN/m^2$
= $50\ t/m^2$

q_s = $50 + \gamma d_f$
= $50 + (2.1 - 1) \times 4.0$
= $54\ t/m^2$

where. γ = dry unit weight of soil
d_f = depth of foundation

For the higher allowable settlement bearing capacity may be increased accordingly.

6.7 <u>According to Teng W.C. (1966)</u>

The following empirical equation is used to compute the bearing capacity

$$q_{ult} = 2\ N^2\ BR + 6\ (100 + N^2)\ D_f\ R$$

Where q_{ult} = Ultimate bearing capacity in psf.

N = SPT value corrected.

R = Correction factor for the water table
= 0.5 for water table above foundation level

B & D_f = Dimensions of foundation in ft.
= 23 and 13 ft respectively

q_{ult} = $2 \times 35^2 \times 23 \times 0.5 + 6 \times (100 + 35^2) \times 13 \times 0.5$
= 79,850 psf
= $390.0\ t/m^2$

q_s with a safety factor of 5 (High value of safety factor is recommended for isolated block)
= $78\ t/m^2$

6.8 <u>Terzaghi & Peck</u>

The allowable bearing pressure based upon the foreseeable settlement of the foundation as suggested by Terzaghi & Peck (1948) is as follows:

$$q_s = 720\,(N - 3)\,(B + 1)^2/\,(2B \times R)$$

where q_s = Net allowable bearing pressure in psf. for a maximum settlement of an (1) inch.

$= 720 \times (35 - 3) \times (23 + 1)^2 / (2 \times 23 \times 0.5)$

$= 577002$ psf

$= 2816$ t/m^2

$= 563$ *t/m^2* (with a factor of safety of 5)

However this value of 563 t/m^2 worked out from the above equation looks to be in the higher range, even if it is estimated for a foreseeable settlement of 25mm only. Bearing capacity of 39 t/m^2 worked out from the Meyerhof's equation is more convincing for the settlement allowed probable different at settlement chances of which is high.. If the design practice of bridge allows higher settlement, interpolating the above-recommended value may increase the bearing capacity.

For safe design, adopt an slightly lower value of allowable stress worked out from Meyerhof. **Adopt 40 t/m^2 as allowable bearing stress for future computation considering non-uniformity of strata.**

6.9 Settlement

Potential settlement due to the additional load increment is checked by the following equation of Parry (1971).

$$S = a \times q \times B/(N \times C_D \times C_W \times C_T)$$

Where, S = Settlement in mm

a = Constant = 200 for SI units

q = Applied pressure in (0.41)MN/m^2

C_w = Correction factor for water table

C_D = Excavation correction factor

$= 1.75$

$S = 200 \times 0.41 \times 7/(25 \times 1.75 \times 0.5 \times 1)$

$=$ **26.2 mm** (tolerable)

Considering all above computations, a safe bearing capacity of 40 t/m^2 assuming an allowable settlement of 25 mm is recommended for B3, B4 and B5/6 sites at this stage of feasibility study.

BORE HOLE LOG

PROJECT : Kathmandu-Naubise Alternate Road Project
CLIENT : NK/JICA, Study Team

Bore Hole: B 1
Location: Bhimdhunga-Sitapaila

Scale	Elevation m	Depth m	Thickness m	Symbol	Classification	SOIL DESCRIPTION	Water Table m	SPT at m	No. of Blows per 10 cm 10	20	30	Total SPT Value	SPT 0 10 20 30 40 50	Scale
	1312.6													
			1.4		ML	Reddish brown alluvial soil		1	2	2	3	7		
	1311.2	1.4												
			1.4		CH	Gray to dark gray alluvial highly plastic clay								
	1309.8	2.8												
			3.2		ML	Sandy clay with medium fine sand with some suspended boulder		4	12	14	18	44		
								5	18	24	48	90		
	1306.6	6.0												
			3.0		ML	Sandy clay		7	19	34	38	81		
	1303.6	9.0					GWL							
	1302.6		1.0		CH	Plastic black clay		9.2	8	13	19	40		
		10.0						10	16	31	43	90		
			1.3		CL	Light gray sandy clay with fine sand								
	1301.3	11.3												
			1.1		CH	Gray coloured silty clay								
	1300.2	12.4						12	11	16	16	43		
								14	11	15	26	52		
			6.4		CH	Dark gray to black highly plastic clay with carbonaceous material								
								16	13	17	23	53		
	1293.8	18.8												
			1.2		CH	Ash coloured plastic clay								
	1292.6	20.0						20	18	32	45	95		
						End of Bore Hole								

BORE HOLE LOG

PROJECT: Kathmandu-Naubise Alternate Road Project
CLIENT: NK/JICA, Study Team

Bore Hole : B 2
Location: Bhimdhunga-Sitapaila

Scale	Elevation m	Depth m	Thickness m	Symbol	Classification m	SOIL DESCRIPTION	Water Table m	SPT at m	No. of Blows per 10 cm per 10 cm 10	20	30	Total SPT Value	SPT	Scale
0	1371.6												0 50 100	0
1			2.3		ML	Reddish brown alluvial soil with sand		1	9	4	6	19		1
2	1369.3	2.3						1.6	9	13	16	38		2
3	1370.0	3.0	0.7		ML	Sandy clay with medium to fine sand		3	8	10	14	32		3
4							GWL	4	7	3	4	14		4
5								5	11	17	21	49		5
6			4.8		OH	Highly plastic black clay with carbonaceous material		6.2	7	8	10	25		6
7	1365.2	7.8												7
8								8.5	9	17	26	52		8
9	1363.0	10.0	2.2		CH	Gray to dark gray highly plastic clay								9
10					OH	Highly plastic black clay with carbonaceous material								10
11	1361.8	11.2	1.2					10.8	8	10	11	29		11
	1361.0	12.0	0.8		CH	Gray coloured plastic clay								
12	1360.2	12.8	0.8		OH	Highly plastic black clay		12	13	15	17	45		12
13	1359.8	13.2	0.4		CH	Gray plastic clay								13
	1359.0	14.0	0.8		OH	Black clay		13.5	13	17	25	55		
14	1358.0	15.0	1.0		CH	Gray coloured clay								14
15								15	11	17	22	50		15
16			2.0		OH	Black clay with carbonaceous matter								16
17	1356.0	17.0												17
					ML	Gray plastic clay with some fine sand		16.8	8	15	21	44		
18	1354.8	18.2	1.2					18	48	NP		48		18
19						Highly weathered limestone with intermittent weathered phyllite									19
	1353.0	20.0	1.8		rock	(probably start of bed rock)		20	20	13 in 40 blows		20		20
20						End of Bore Hole								
21														21

BORE HOLE LOG

PROJECT: Kathmandu-Naubise Alternate Road Project **Bore Hole :** B 3

CLIENT: NK/JICA, Study Team **Location:** Bhimdhunga-Sitapaila

Scale	Elevation m	Depth m	Thickness m	Symbol	Classification	SOIL DESCRIPTION	Water Table m	SPT at m	No. of Blows per 10 cm 10	20	30	Total SPT Value	SPT 0 50 100	Scale
0	849.0													0
1			2.0		GP	Pale brown silty soil with fragments of phyllite		1	6	7	9	22		1
2	847.0	2.0						2	11	13	15	39		2
3								3	10	16	28	54		3
4								4	32	50/4		32		4
5								4.5	50/3			50		5
6			11.0		rock	Highly weathered gray phyllite with occasional bands of completely weathered course gained yellowish brown limestone		6	50/5			50		6
7								7	50/5			50		7
8								8	50/5			50		8
9								9	50/4			50		9
10								10	50/5.5			50		10
11							GWL	11	50/3			50		11
12								12	50/3.5			50		12
13	836.0	13.0						13	50/5.5			50		13
14								13.5	50/5			50		14
15								15	50/4.5			50		15
16			3.0		rock	Completely weathered coarse grained yellowish brown limestone with intermittent thin band of highly weathered phyllite		16	50/4			50		16
17								16.5	50/4			50		17
18								17.5	50/1.5			50		18
19	833.0	19.0						18.5	50/2			50		19
20					rock	Phyllite with highly weathered course grained grewish brown limestone								20
21														21

BORE HOLE LOG

PROJECT: Kathmandu-Naubise Alternate Road Project **Bore Hole:** 4

CLIENT: NK/JICA, Study Team **Location:** Bhimdhunga-Sitapaila

Scale	Elevation m	Depth m	Thickness m	Symbol	Classification	SOIL DESCRIPTION	Water Table m	SPT at m	No. of Blows per 10 cm 10	20	30	Total SPT Value	SPT	Scale
0	881.0												0 50 100	0
	880.3	0.7	0.7		GW	Dark red lateratic top soil								
1	879.6	1.4	0.7			Limestone boulder		1	1	2	2	5		1
2								2.5	3	4	6	13		2
3			3.6		GC	Reddish brown silty clay with fragments of phyllite								3
4								4	3	4	7	14		4
5	876.0	5.0						5	10	13	18	41		5
6								6	11	27	38	76		6
7			4.9		rock	Completely weathered gray phyllite	GWL							7
8	871.1	8.9						8	20	40	NP	60		8
9														9
10								10	43	50	NP	93		10
11			4.9		rock	Dark gray coloured highly weathered phyllite with occasional thin bands of occasional thin band of completely weathered course grained limestone								11
12								12	17	50	NP	67		12
13	866.2	13.8						13	34	50	NP	84		13
14			0.7			Highly weathered course grained limestone								14
	865.5	14.5												
15								15	50/2			50/2		15
16			5.5			Slightly weathered course grained gray limestone with intermittent thin bands of intermittent thin bank of highly weathered gray phyllite (max. 20cm thick)		16	50/4.5			50/4.5		16
17														17
18								18	50/5			50/5		18
19								19.5	50/2			50/2		19
	860.0	20.0												
20						End of Bore Hole								20
21														21

BORE HOLE LOG

PROJECT: Kathmandu-Naubise Alternate Road Project
CLIENT: NK/JICA, Study Team

Bore Hole: B5
Location: Bhimdhunga-Sitapalla

Scale	Elevation m 792	Depth m	Thickness m	Symbol	Classification m	SOIL DESCRIPTION	Water Table m	SPT at m	No. of Blows per 10 cm 10	20	30	Total SPT Value	SPT 0 50 100	Scale
			2.0			Completely weathered course grained limestone with thin bands of phyllite		1	15	30	35	80		
	790.0	2.0					GWL							
			3.1			Slightly to moderately weathered coarse grained gray limestone with thin interbands of phyllite		3	18	33	40	91		
	786.9	5.1												
			1.8			Highly weathered limestone with interbands of phyllite with thin interbands of limestone		5	23	5 in 45 blows		68/15		
	785.1	6.9												
			4.3			The maximum thickness of limestone band is 30cm are highly weathered		7	5	8	9	22		
								8	8	12	15	35		
	780.8	11.2												
	780.3	11.5	0.5			Dark gray silty clay								
	779.8	12.0	0.5			Weathered phyllite								
	779.3	12.5	0.5			Slightly weathered limestone								
	778.7	13.0	0.6			Weathered phyllite		10	17	20	25	62		
	778.1	13.6	0.6			Slightly weathered limestone								
								12	15	21	30	66		
								13	20	35	NP	55		
								15	9	15	25	49		
			6.4			Weathered phyllite with thin interbands of course grained slightly weathered gray limestone								
								17	10	15	28	53		
								19	13	18	30	61		
	771.7	20.0						20	14	20	35	69		
						End of Bore Hole								

BORE HOLE LOG

PROJECT : Kathmandu-Naubise Alternate Road Project
CLIENT : NK/JICA, Study Team

Bore Hole: B 6
Location: Bhimdhunga -Sitapaila

Scale	Elevation m	Depth m	Thickness m	Symbol	Classification m	SOIL DESCRIPTION	Water Table m	SPT at m	No. of Blows per 10 cm 10	20	30	Total SPT Value	SPT 0 10 20 30 40 50	Scale
0	787													0
1								1	25	29	NP	54		1
2								2	30	35	NP	65		2
3			7.0		GP	Mainly boulders of silcified limestone with a minor amount of brown silty clay and sand.		3	40	13 in 48 blows		40		3
4								4	56	NP	NP	56		4
5								5	10 in 45 blows			50		5
6	780	7.0						6	10 in 45 blows			50		6
7	779.9	7.12	0.12		CL	Highly cohesive & sticky gray to greyish black clay		7	23	22	15	60		7
8	779.0	8.0	0.88		GP	Limestone fragments		8	4	5 in 36 blows		50		8
9	778.0	9.0	1		CL-GP	Brown silty clay with minor amount of rock fragments in the matrix	GWL							9
	783.45	9.55	0.55		GP	Boulder of limestone								
10	777	10	0.45		CL	Boulders of silty clay		9.55	11	12	9	32		10
11			2.6		GP	Boulders of limestone		11	2.5 in 45 blows			50		11
12	774.5	12.55						12	2 in 40 blows			50		12
13	773.5	13.55	1.00		CL	Highly cohesive & sticky grey to dark grey clay & sticky in nature		13	15	16	13	44		13
14								14	10in 35 blows			50		14
15			3.25		GP	Boulders of limestone		15	10 in 50 blows			50		15
16	770.2	16.8						16	7.5 in 35 blows			50		16
17	769.6	17.45	0.65		GP-CL	Limestone fragment in the brown silty clay matrix		17	25	30	39	94		17
18	768.4	18.6	1.15		GP	Boulders of limestone		18	15 in 50 blows			50		18
19	767.5	19.5	0.9		GP-CL	Gravel & fragment of limestone in matrix of brown silty clay		19	11	19	40	70		19
20	767.0	20.0	0.5		GP	Boulders of limestone								20
21						End of Bore Hole								21

SILT CONSULTANTS PVT. LTD.

Kathmandu, Nepal

Test Result Summary Sheet

Project : **Kathmandu-Naubise Alternate Road**

Location : **Bhimdhunga - Sitapaila**

B. H. No. : 1

Tested by: R.S. Timilsina

Sample	Physical Test									pH value	Soundness Test	Remarks
	Percentage of					Atterberg Limits			Specific gravity			
	Gravel	Coarse	Fine	Silt	Clay	LL	PL	PI		%	% loss in wt.	
4.8 - 5.1	2.0	18.0	52.0	28.0	0.9	42.2	28.6	13.6	2.88	8.3	-	
9.9 - 10.2	-	9.0	37.0	52.2	1.8	38.6	21.5	17.1	2.61	7.9	-	
14.8 - 15.1	0.2	19.8	38.5	37.3	4.2	34.3	22.0	12.3	2.85	7.8	-	
19.8 - 20.0	5.0	3.0	24.8	57.8	5.2	32.2	12.3	18.9	2.55	8.2	-	

SILT CONSULTANTS PVT. LTD.

Kathmandu, Nepal

Test Result Summary Sheet

Project : **Kathmandu-Naubise Alternate Road** B. H. No. : 2

Location : **Bhimdhunga - Sitapalla** Tested by: R.S. Timilsina

Sample	Physical Test									pH value	Soundness Test	Remarks
	Percentage of					Atterberg Limits			Specific gravity			
	Gravel	Coarse	Fine	Silt	Clay	LL	PL	PI		%	% loss in wt.	
4.8 - 5.1	5.0	7.2	3.5	70.5	14.0	42.0	32.20	9.8	2.57	7.80	-	
8.0 -8.3	1.0	1.5	2.8	80.8	13.5	22.0	NP	-	2.59	6.80	-	
9.8- 10.1	-	1.0	5.4	80.1	13.5	27.5	NP	-	2.55	6.80	-	
14.8 - 15.1	-	-	2.8	84.2	13.0	32.0	NP	-	2.56	6.80	-	

SILT CONSULTANTS PVT. LTD.

Kathmandu, Nepal

Test Result Summary Sheet

Project : **Kathmandu-Naubise Alternate Road**

B. H. No. : 3

Location : **Bhimdhunga - Sitapalla**

Tested by: R.S. Timilsina

Sample	Physical Test									pH value	Soundness Test	Remarks
	Percentage of					Atterberg Limits			Specific gravity			
	Gravel	Coarse	Fine	Silt	Clay	LL	PL	PI		%	% loss in wt.	
0 - 4.5	-	6.0	13.7	74.2	6.1	-	-	-	2.61	-	-	
9.5	-	-	-	-	-	-	-	-	2.61	-	0.13	
14.9 - 15.1	-	-	-	-	-	-	-	-	2.61	-	0.17	
20.0	-	-	-	-	-	-	-	-	2.65	-	0.13	
25.0	-	-	-	-	-	-	-	-	-	-	0.16	

SILT CONSULTANTS PVT. LTD.

Kathmandu, Nepal

Test Result Summary Sheet

Project : **Kathmandu-Naubise Alternate Road** B. H. No. : 4

Location : **Bhimdhunga - Sitapaila** Tested by: R.S. Timilsina

Sample	Physical Test									pH value	Soundness Test	Remarks
	Percentage of					Atterberg Limits			Specific gravity			
	Gravel	Coarse	Fine	Silt	Clay	LL	PL	PI		%	% loss in wt.	
4.5 - 5.0	2.0	2.0	3.0	68.4	21.5	34.2	25.3	8.9	2.59	6.8	-	
5.5 - 8.8	2.3	2.0	1.2	85.7	8.8	28.8	NP	-	-	6.4	-	
15.0 - 15.1	-	-	-	-	-	-	-	-	2.61	-	9.25	
16.0 - 16.6	-	-	-	-	-	-	-	-	2.61	-	0.5	
19.2 - 19.3	-	-	-	-	-	-	-	-	2.63	-	0.4	
20.0	-	-	-	-	-	-	-	-	2.66	-	0.38	

SILT CONSULTANTS PVT. LTD.

Kathmandu, Nepal

Test Result Summary Sheet

Project : **Kathmandu-Naubise Alternate Road**

B. H. No. : 5

Location : **Bhimdhunga - Sitapalla**

Tested by: R.S. Timilsina

Sample	Physical Test									pH value	Soundness Test	Remarks
	Percentage of					Atterberg Limits			Specific gravity			
	Gravel	Coarse	Fine	Silt	Clay	LL	PL	PI		%	% loss in wt.	
15.0	-	42.0	34.0	24.0	-	-	-	-	2.51	-	-	
5.3	-	2.0	15.1	80.9	-	-	-	-	2.59	-	0.53	
9.9	-	-	-	-	-	-	-	-	2.62	-	0.01	
10.2	-	-	-	-	-	-	-	-	2.66	-	0.02	
18.5	-	-	-	-	-	-	-	-	-	-	0.01	

SILT CONSULTANTS PVT. LTD.

Kathmandu, Nepal

Test Result Summary Sheet

Project : **Kathmandu-Naubise Alternate Road** B. H. No. : 6

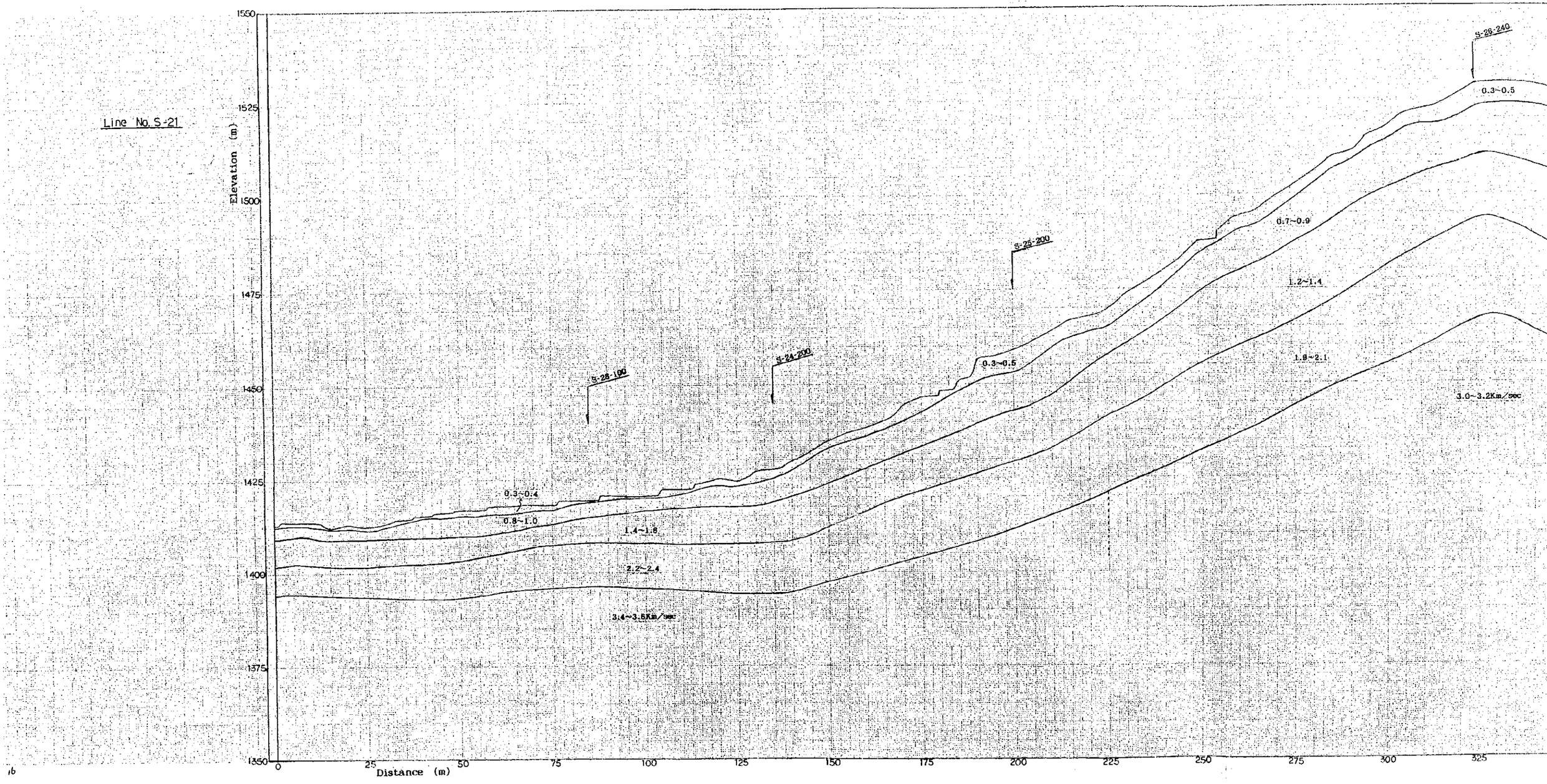
Location : **Bhimdhunga - Sitapalla** Tested by: R.S. Timilsina

Sample	Physical Test									pH value	Soundness Test	Remarks
	Percentage of					Atterberg Limits			Specific gravity			
	Gravel	Coarse	Fine	Silt	Clay	LL	PL	PI		%	% loss in wt.	
0. - 2.2	22.0	23.0	9.0	37.0	-	-	-	-	2.55	-		
4.75 - 4.8	65.0	29.2	2.8	2.0	1.0	-	-	-	-	-	0.03	
5.2	73.2	21.2	5.6	-	-	-	-	-	2.63	-	0.05	
9.2	68.5	21.8	9.7	-	-	-	-	-	2.64	-	0.06	
14.5 - 15.0	-	-	-	-	-	-	-	-	-	-	0.05	

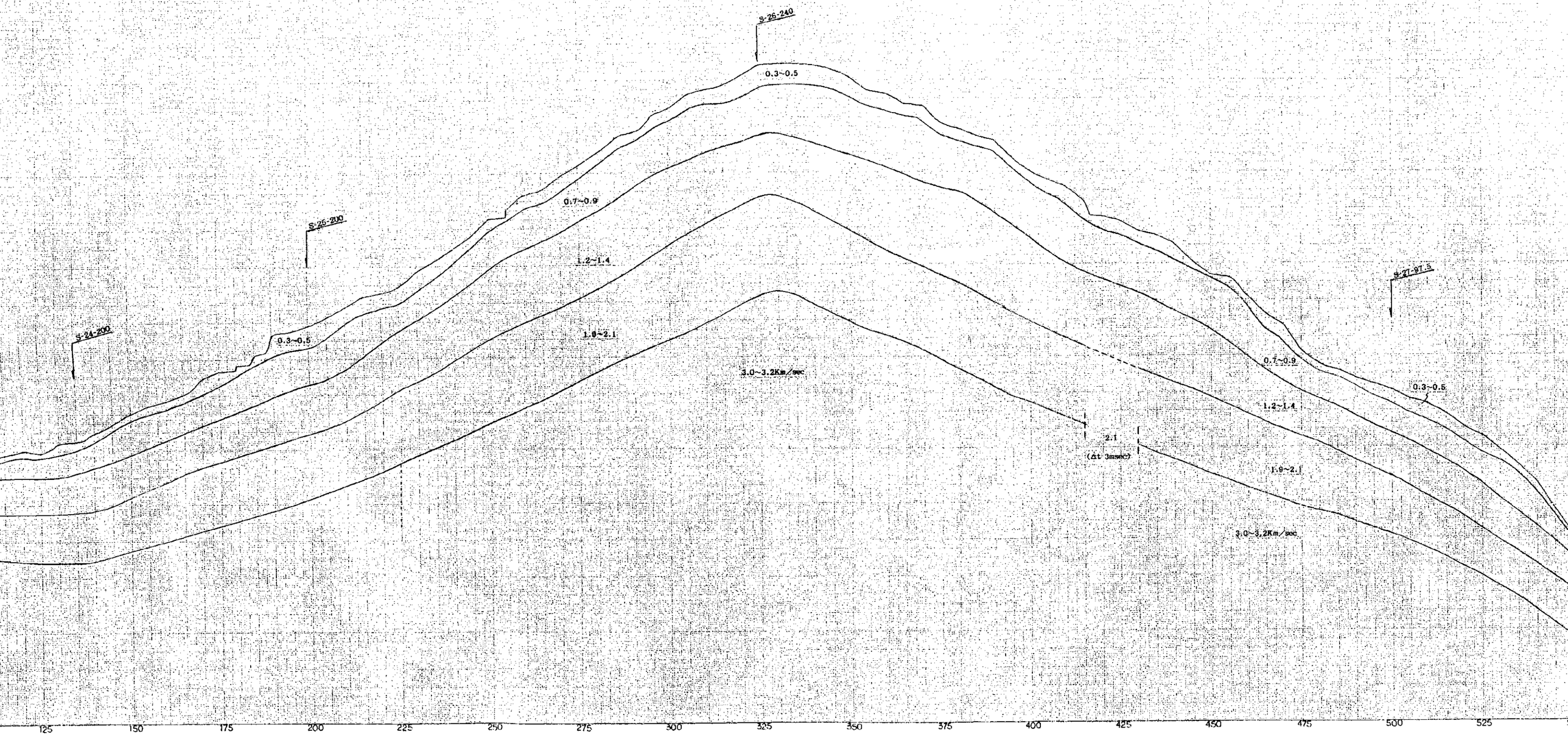
B-2 Result of Seismic Refraction Survey

S-21 LINE VELOCI

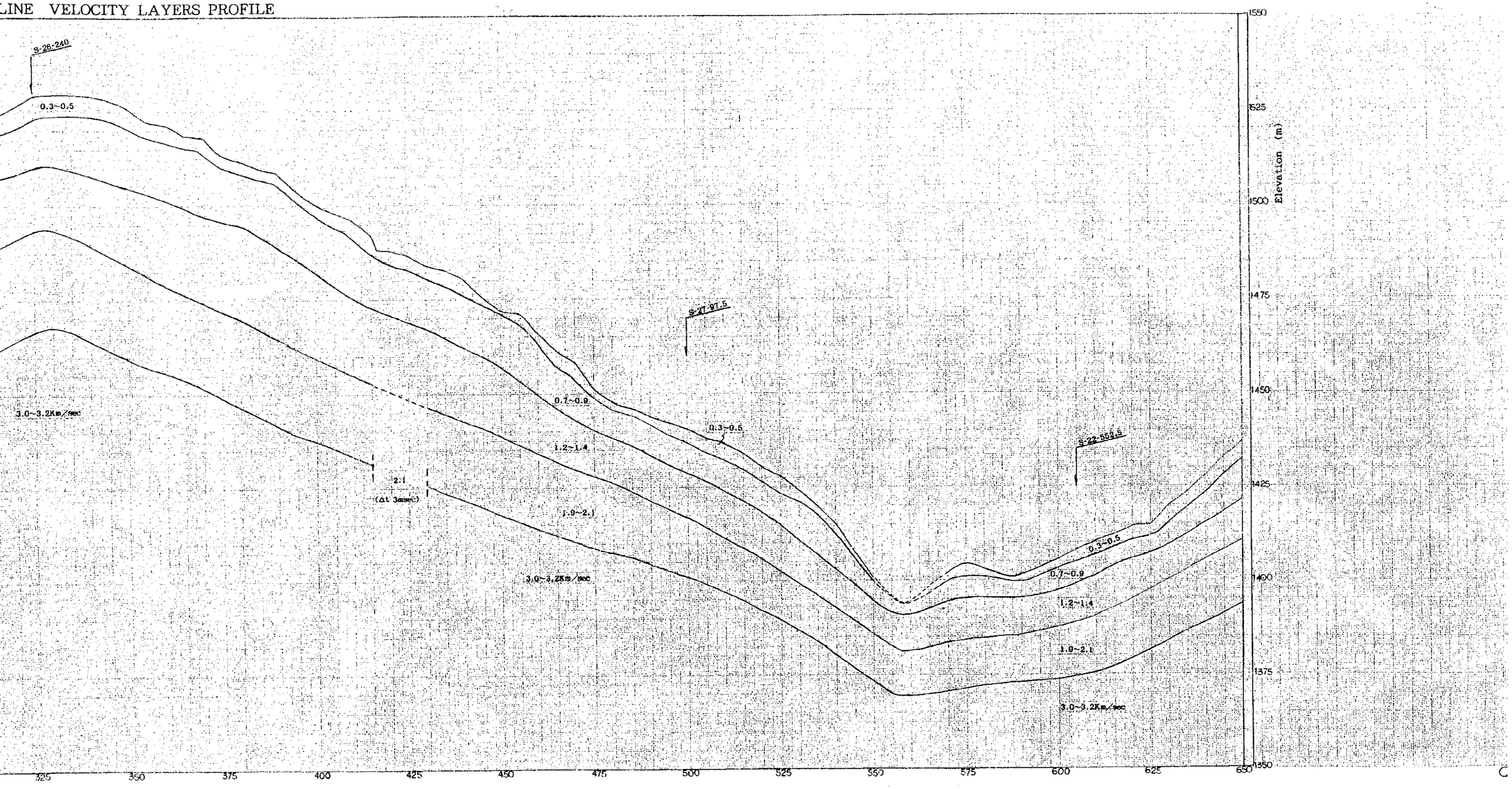
Line No. S-21



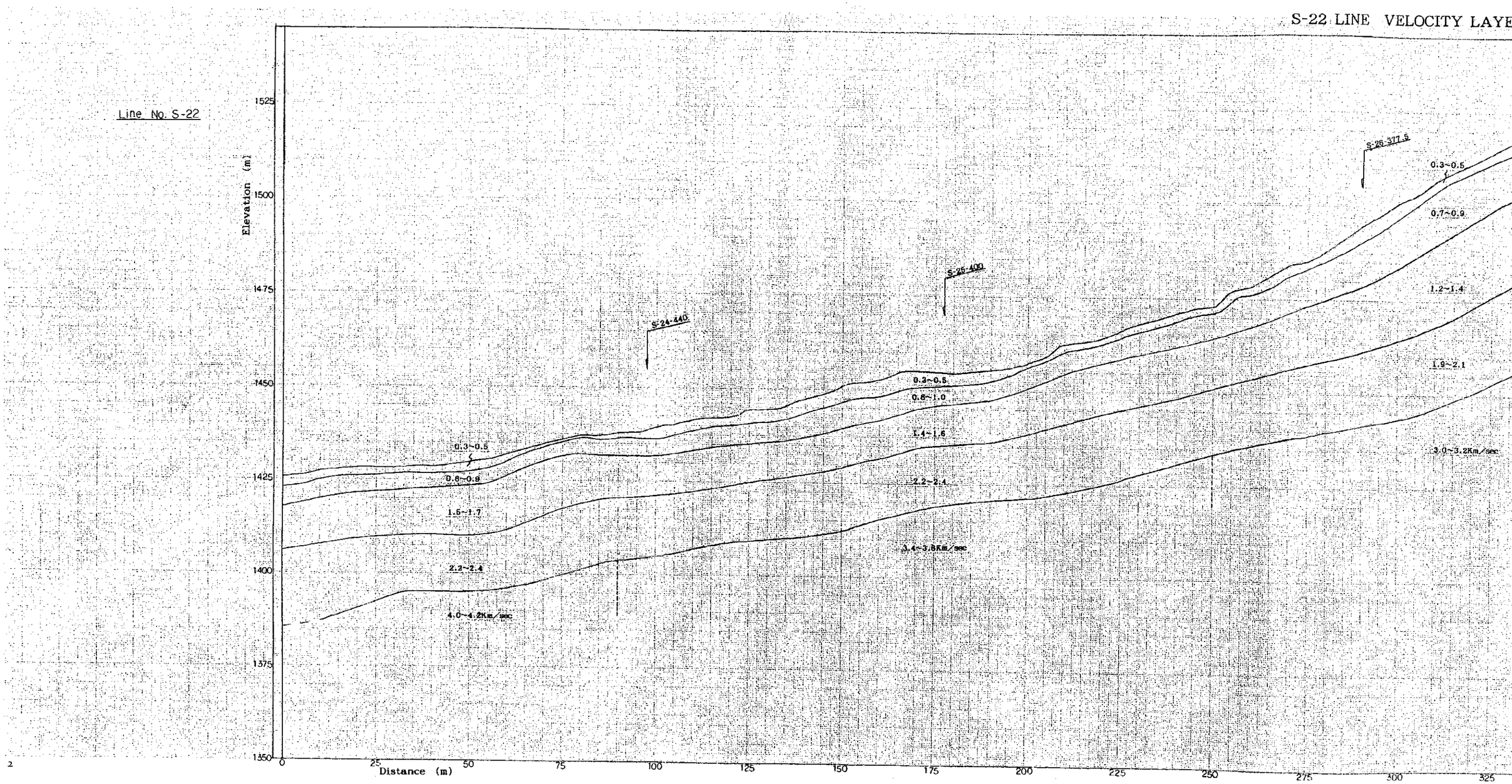
S-21 LINE VELOCITY LAYERS PROFILE



LINE VELOCITY LAYERS PROFILE



Line No. S-22


S-22 LINE VELOCITY LAYE
Elevation (m)
1525
1500
1475
1450
1425
1400
1375
1350
S-26-377.5
S-25-400
S-24-440
0.3~0.5
0.7~0.9
1.2~1.4
1.9~2.1
3.0~3.2Km/sec
0.3~0.5
0.6~1.0
1.4~1.6
0.3~0.5
0.8~0.8
2.2~2.4
1.5~1.7
3.4~3.8Km/sec
2.2~2.4
4.0~4.2Km/sec
0
25
50
75
100
125
150
175
200
225
250
275
300
325
Distance (m)

S-22 LINE VELOCITY LAYERS PROFILE