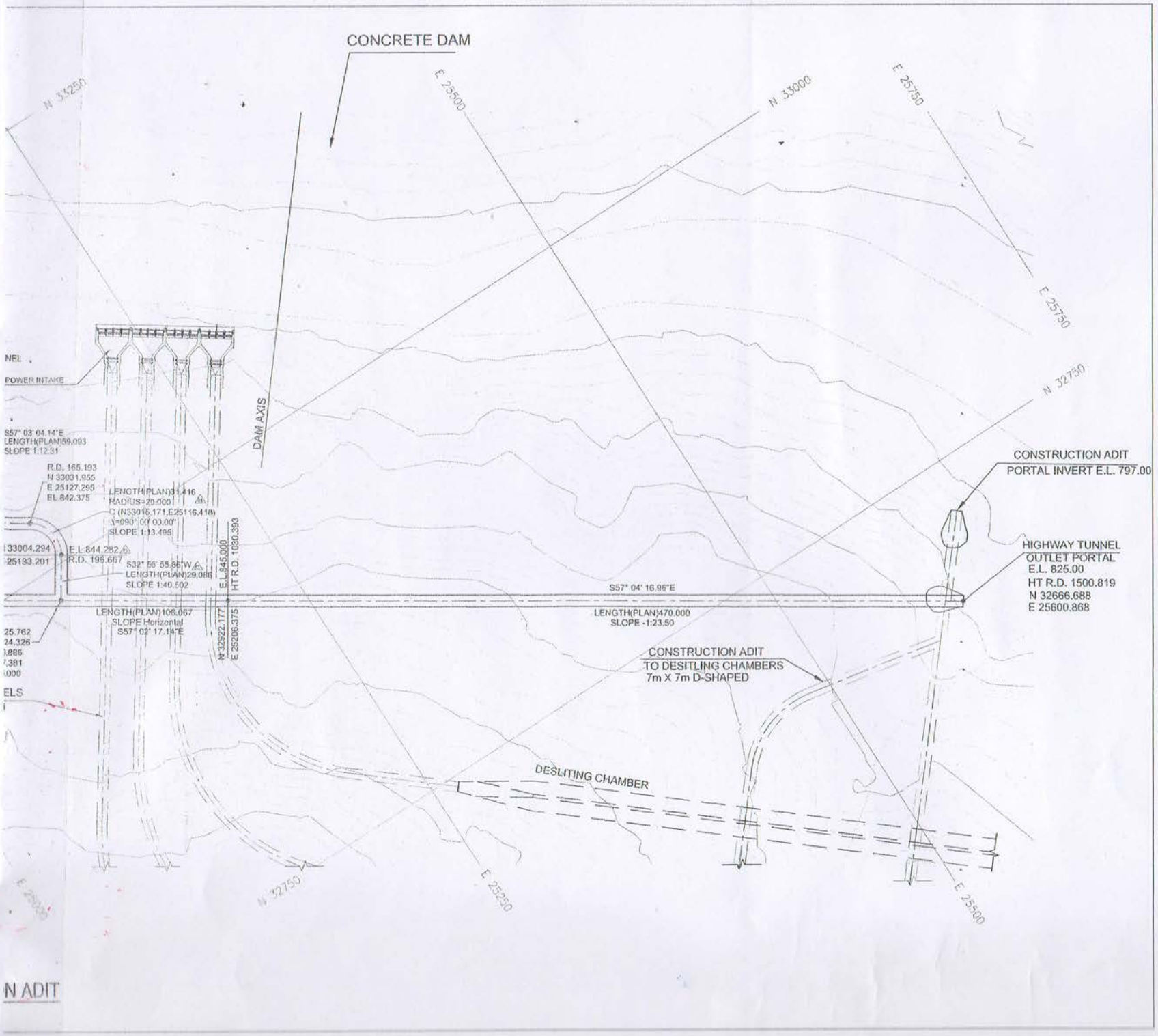
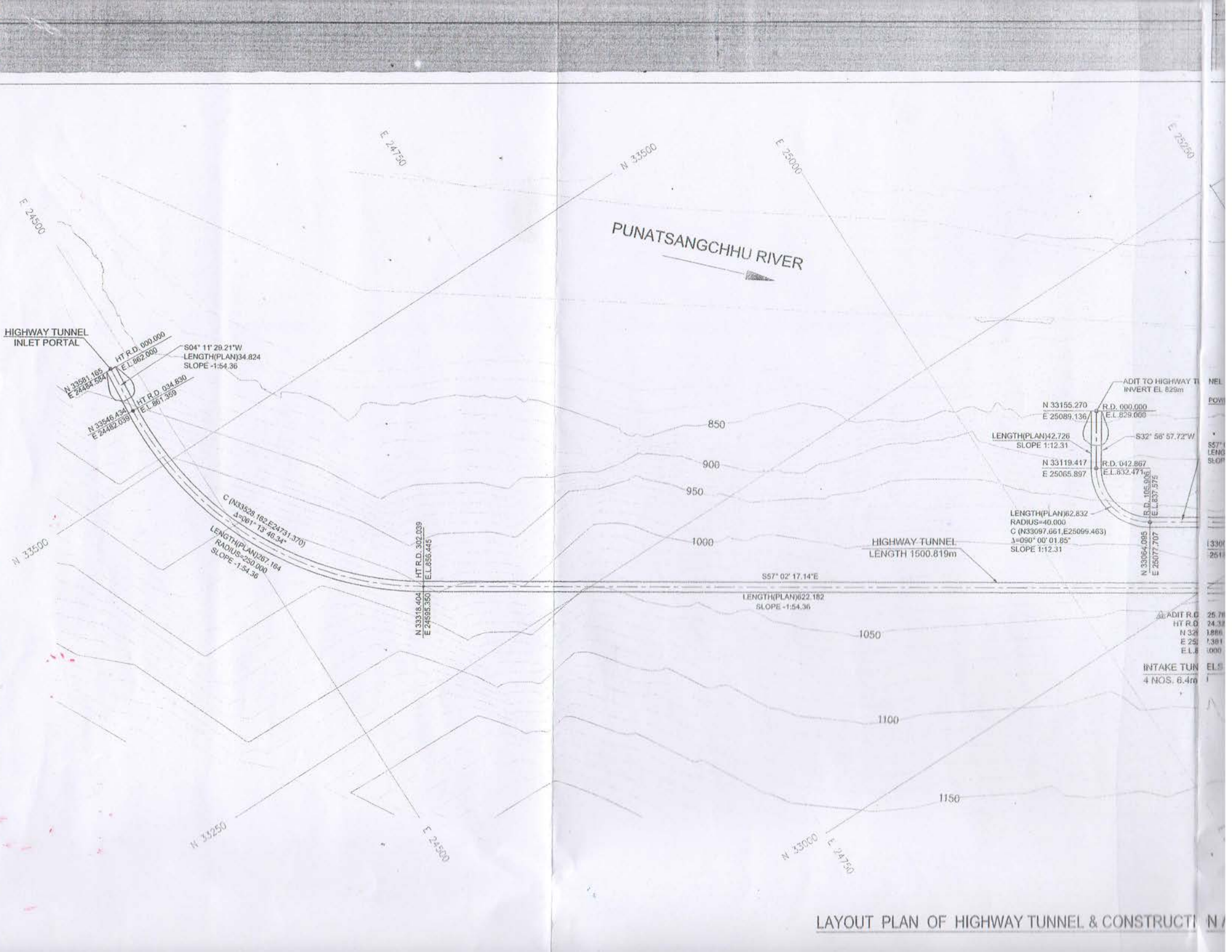
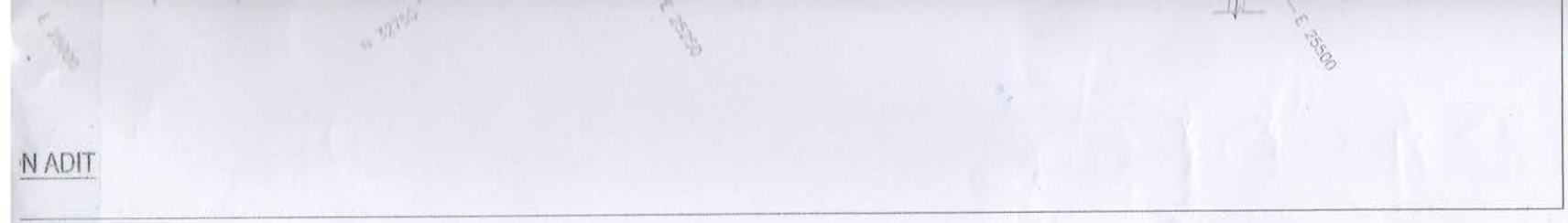
Appendix 10

プナサンチュ(Punatsanchhu)
水力開発トンネル関係図
Design Maps for Tunnel in Punatsanchhu Hydro Power Projects


CONCRETE DAM
N 33250
E 25500
N 33000
E 25750
E 25750
N 32750
DAM AXIS
NEL
POWER INTAKE
S57° 03' 04.14"E
LENGTH(PLAN)59.093
SLOPE 1:12.31
R.D. 165.193
N 33031.955
E 25127.295
EL 842.375
LENGTH(PLAN)31.416
RADIUS=20.000
C (N33016.171,E25116.418)
Δ=090° 00' 00.00"
SLOPE 1:13.495
33004.294
25133.201
E.L.844.282
R.D. 196.667
S32° 56' 55.85"W
LENGTH(PLAN)29.086
SLOPE 1:40.502
E.L.845.000
HT R.D. 1030.393
S57° 04' 16.96"E
LENGTH(PLAN)106.067
SLOPE Horizontal
S57° 02' 17.14"E
LENGTH(PLAN)470.000
SLOPE -1:23.50
N 32922.177
E 25206.375
25.762
24.326
1.886
7.381
.000
ELS
CONSTRUCTION ADIT
PORTAL INVERT E.L. 797.00
HIGHWAY TUNNEL
OUTLET PORTAL
E.L. 825.00
HT R.D. 1500.819
N 32666.688
E 25600.868
CONSTRUCTION ADIT
TO DESITLING CHAMBERS
7m X 7m D-SHAPED
DESILTING CHAMBER
N 32750
E 25250
E 25500
N ADIT



LAYOUT PLAN OF HIGHWAY TUNNEL & CONSTRUCTI N



NOTES:-

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE SPECIFIED.
2. NO DIMENSION SHALL BE MEASURED FROM THE DRAWING.
3. THIS DRAWING SHOWS THE LAYOUT PLAN OF HIGHWAY TUNNEL & ITS CONSTRUCTION ADIT ONLY.
4. FOR DETAILS OF DAM, INTAKE, DESILTING CHAMBER ETC. REFER SEPARATE DRGS.

REV.	DATE		INITIALS
			DIR
			DD
			AD
R1	JAN 2012	LAYOUT OF CONSTRUCTION ADIT REVISED BEYOND R.D. 165.193	

PUNATSANGCHHU-II HYDROELECTRIC PROJECT AUTHORITY (BHUTAN)

CONSULTANTS

WAPCOS LIMITED

(A GOVT. OF INDIA UNDERTAKING)

GOVT.OF INDIA

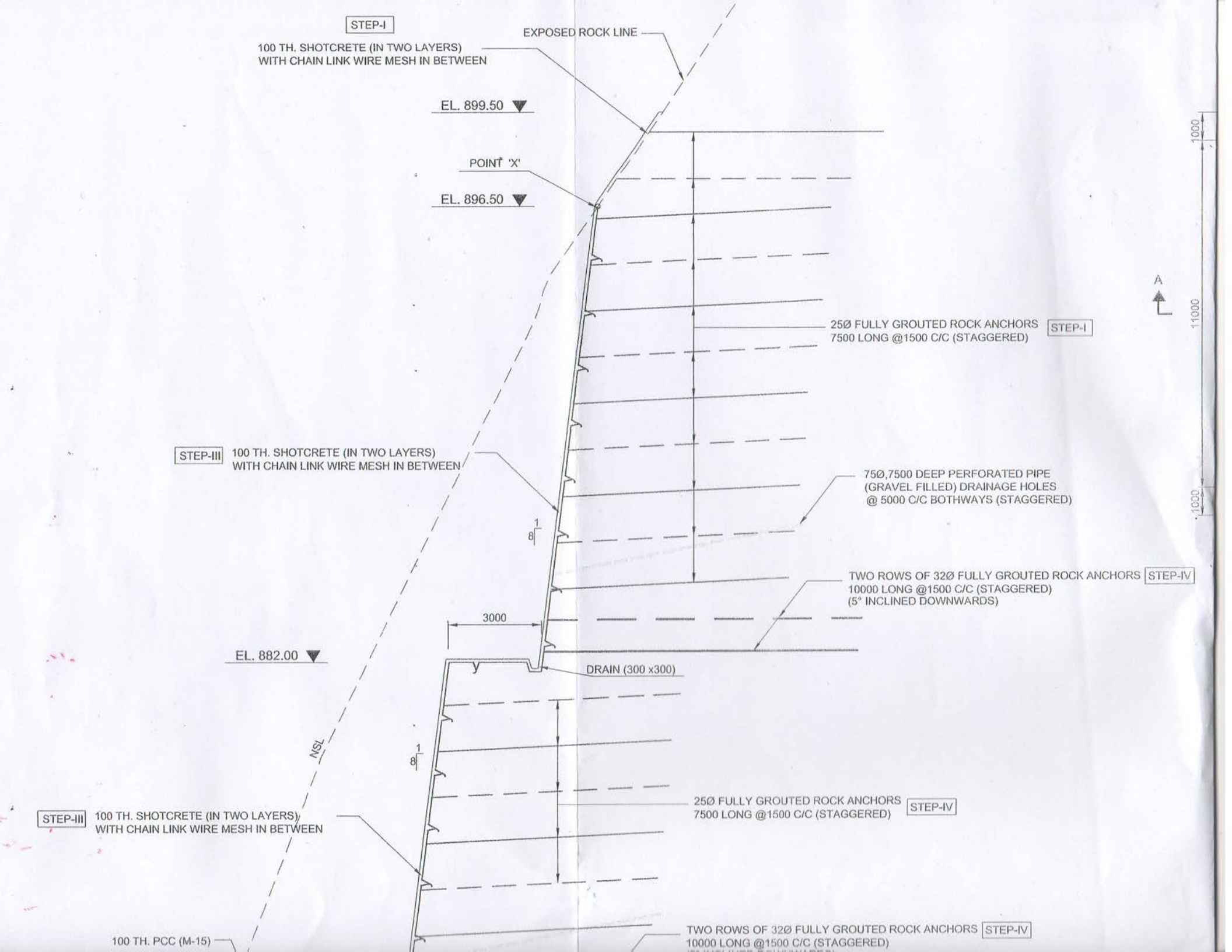
CENTRAL WATER COMMISSION

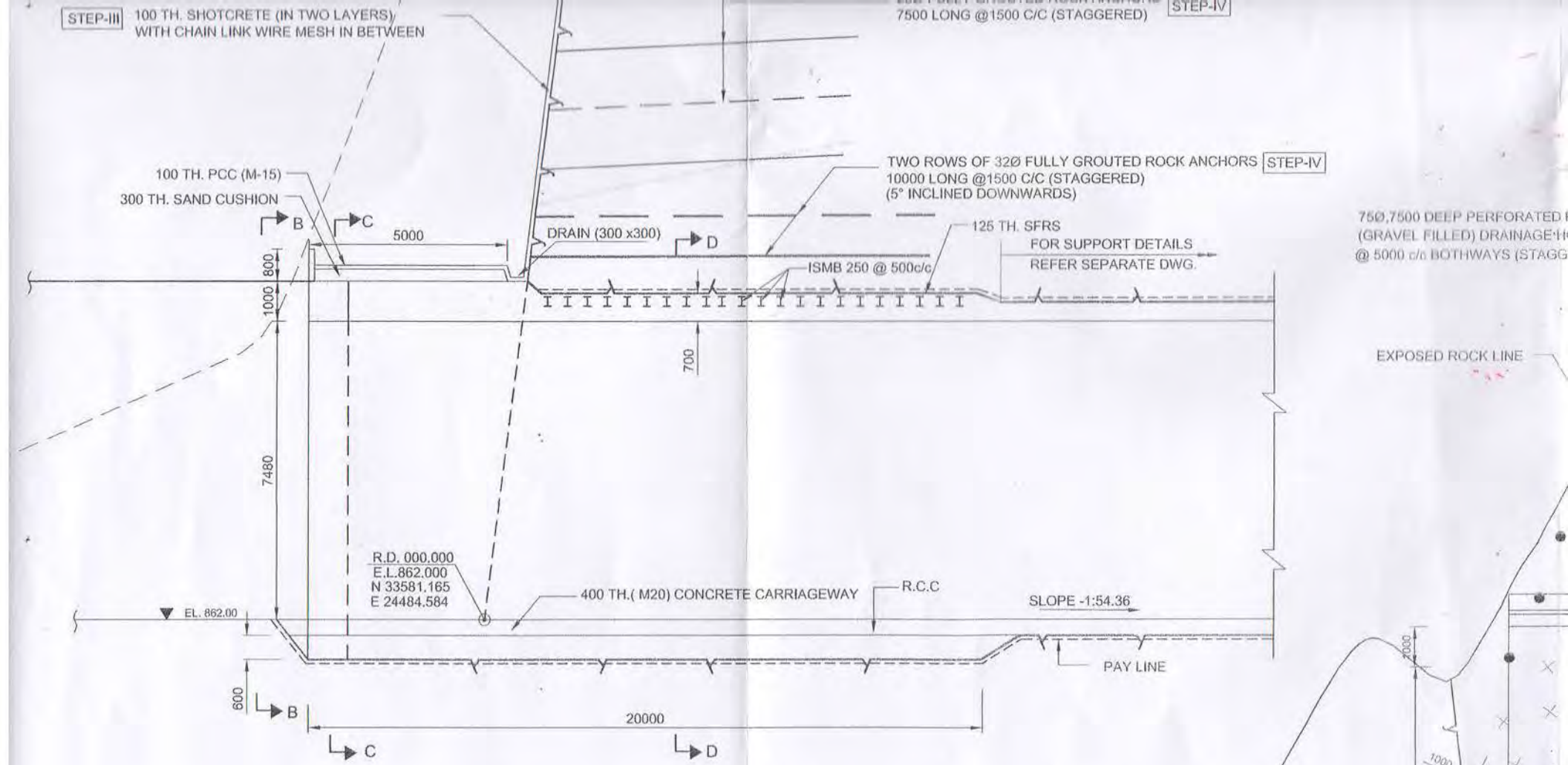
PUNATSANGCHHU-II H.E. PROJECT (BHUTAN)

HIGHWAY TUNNEL

LAYOUT PLAN

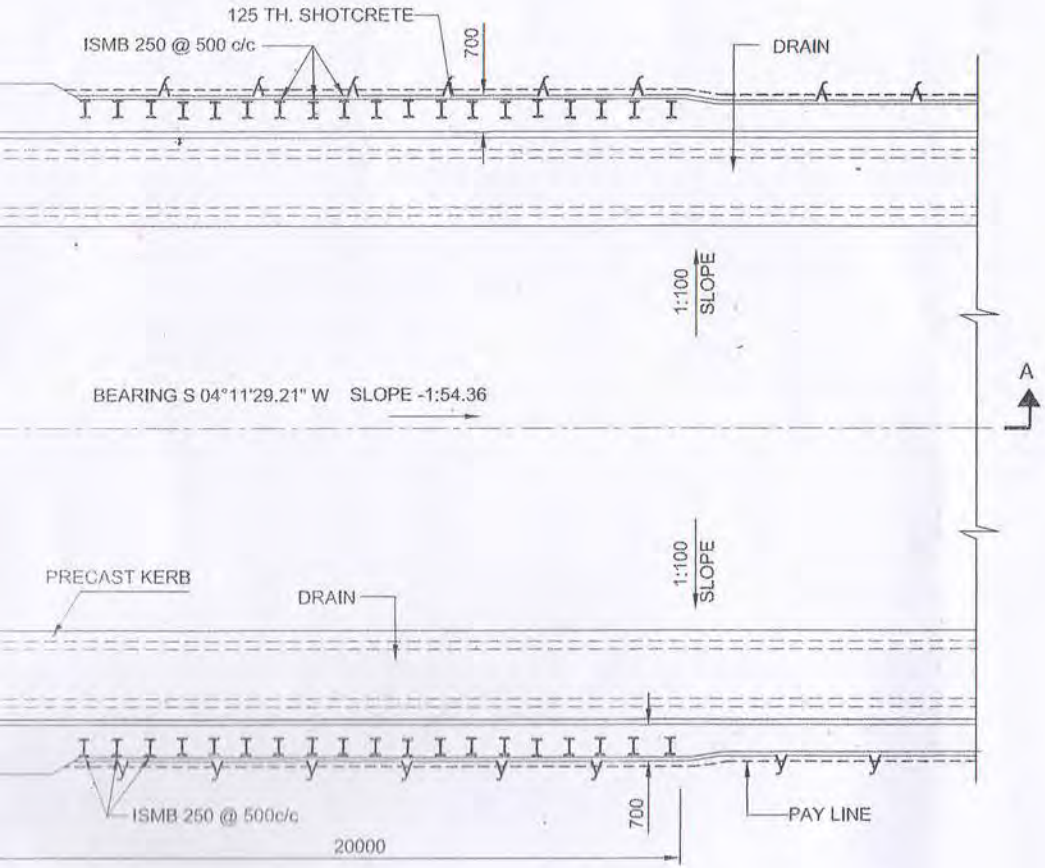
DSGN.	CHKD.	SUBM.
DRAWN		RECM.
TRCD.	INSPD.	APPD.
FILE NO. 2/79/2011 HCD (E & NE) DTE.	NEW DELHI, DEC.-2011	DRG.NO. PNSC-9810-C-501(R1)


STEP-I
100 TH. SHOTCRETE (IN TWO LAYERS)
WITH CHAIN LINK WIRE MESH IN BETWEEN
EXPOSED ROCK LINE
EL. 899.50
POINT 'X'
EL. 896.50
25Ø FULLY GROUTED ROCK ANCHORS
7500 LONG @1500 C/C (STAGGERED)
STEP-I
A
1000
11000
1000
STEP-III
100 TH. SHOTCRETE (IN TWO LAYERS)
WITH CHAIN LINK WIRE MESH IN BETWEEN
75Ø,7500 DEEP PERFORATED PIPE
(GRAVEL FILLED) DRAINAGE HOLES
@ 5000 C/C BOTHWAYS (STAGGERED)
1
8
TWO ROWS OF 32Ø FULLY GROUTED ROCK ANCHORS
STEP-IV
10000 LONG @1500 C/C (STAGGERED)
(5° INCLINED DOWNWARDS)
3000
EL. 882.00
DRAIN (300 x300)
NSL
1
8
STEP-III
100 TH. SHOTCRETE (IN TWO LAYERS)
WITH CHAIN LINK WIRE MESH IN BETWEEN
25Ø FULLY GROUTED ROCK ANCHORS
7500 LONG @1500 C/C (STAGGERED)
STEP-IV
100 TH. PCC (M-15)
TWO ROWS OF 32Ø FULLY GROUTED ROCK ANCHORS
STEP-IV
10000 LONG @1500 C/C (STAGGERED)

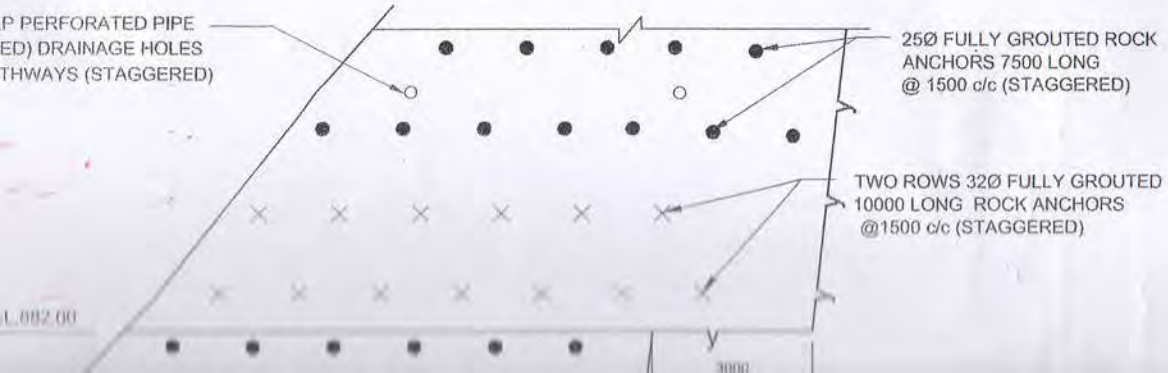


SECTION A-A

LONGITUDINAL SECTION ALONG C/L OF CARRIAGEWAY



SECTIONAL PLAN
(ALONG CENTRE LINE)

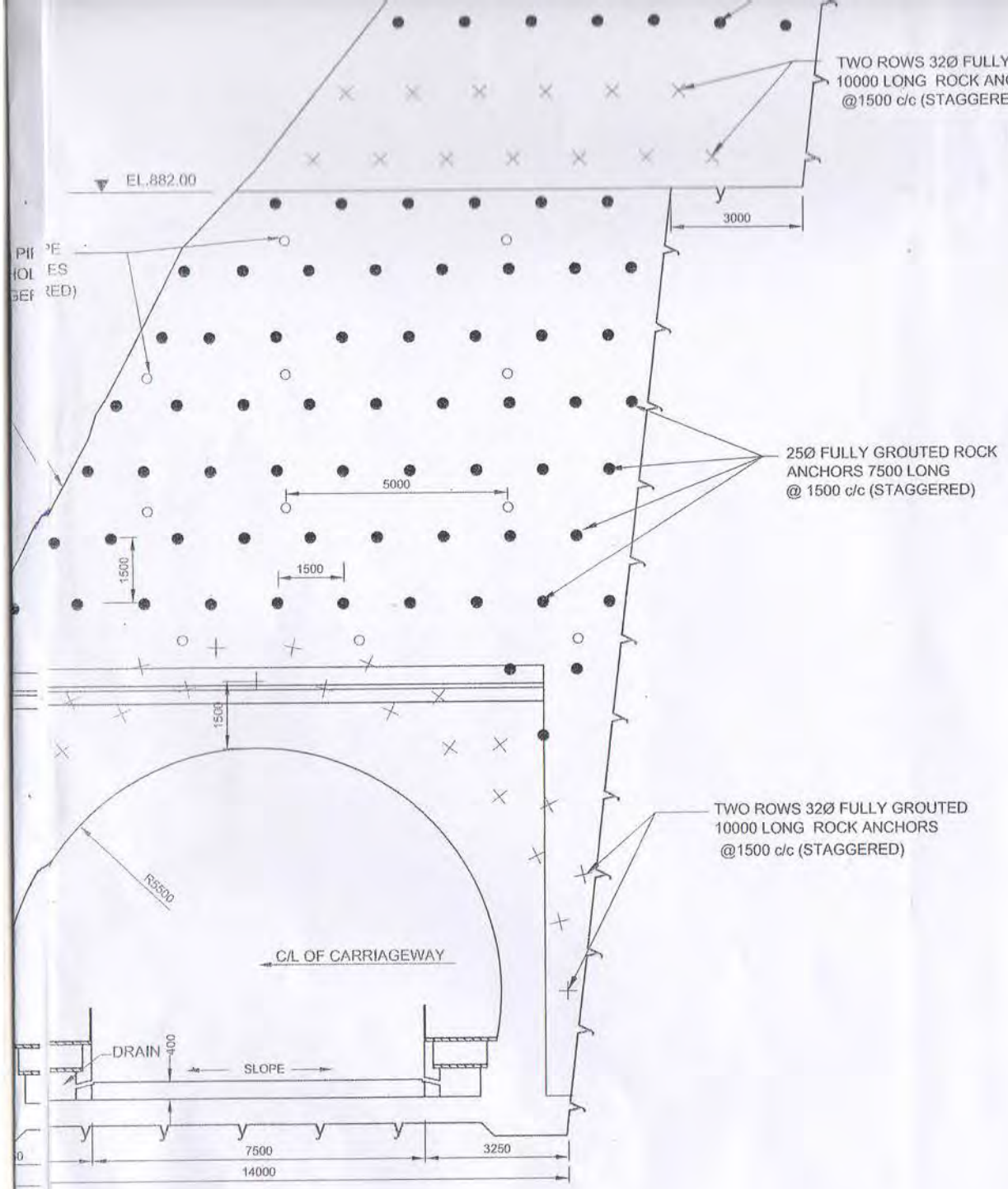


NOTES :-

1. ALL DIMENSIONS ARE IN MILLIMETRES & ELEVATIONS IN METRES.
2. NO DIMENSION SHALL BE MEASURED FROM THE DRAWING.
3. ALL DIMENSIONS/ DETAILS SHALL BE CHECKED ALONG WITH THE RELEVANT DRAWINGS BEFORE STARTING EXECUTION. DISCREPANCY, IF ANY, SHALL BE BROUGHT TO THE NOTICE OF CWC IMMEDIATELY FOR REVIEW.
4. THE DRAWING HAS BEEN PREPARED ON THE BASIS OF LETTER NO WAP/BHUTAN-LOBESA/PHEP-II/CT/2011/314-316 DATED 08 AUGUST 2011 FROM PROJECT MANAGER, WAPCOS.
5. PROPER BLASTING TECHNIQUE SHALL BE ADOPTED IN ORDER TO AVOID OVERBREAKES SO AS TO GET THE EXCAVATED SECTION AS SHOWN IN THE DRAWING.
6. SHEAR ZONES AND UNSTABLE WEDGE BLOCKS, IF PRESENT WILL REQUIRED SPECIAL TREATMENT AS PER THE INSTRUCTION OF ENGINEER-IN-CHARGE.
7. ADEQUATE SURFACE DRAINAGE SHALL BE PROVIDED AS PER SITE REQUIREMENT IN CONSULTATION WITH ENGINEER-IN-CHARGE.
8. THE SLOPES PROVIDED FOR OPEN EXCAVATION ARE ONLY INDICATIVE SUBJECT TO MODIFICATION AT SITE AS PER THE ROCK MASS/WEATHERING CONDITIONS OF EXCAVATED ROCK. GENERAL GUIDELINES FOR PROVISION OF STABLE SLOPE(FOR SHOTCRETED & ROCK ANCHORED SLOPES), UNLESS OTHERWISE SPECIFIED, SHALL BE AS BELOW:-

FRESH ROCK	1 H	: 8 V
MODERATELY WEATHERED	1 H	: 6/4 V
HIGHLY WEATHERED	1 H	: 2 V
OVER BURDEN	1 H	: 1 V

9. THE ROCK SUPPORTING MEASURES SHALL BE PROVIDED IMMEDIATELY AFTER BLASTING BEFORE BENCHING DOWN FURTHER.
10. THE LENGTH, SPACING AND DIRECTION OF THE ROCK ANCHORS ARE INDICATIVE AND MAY BE MODIFIED IN CONSULTATION WITH ENGINEER - IN - CHARGE TO SUIT THE LOCAL SITE CONDITION/ JOINT PATTERN OF ROCK MASS. THE DIRECTION OF THE ROCK ANCHOR SHOULD BE AS FAR AS POSSIBLE NORMAL TO THE JOINTS.
11. ROCK ANCHORS SHALL BE FULLY CEMENT GROUTED.
12. THE ROCK BOLTS SHALL BE RESIN END ANCHORED AND REST OF THE LENGTH SHALL BE FULLY CEMENT GROUTED.
13. RESIN/CEMENT GROUTED ROCK BOLTS SHALL BE USED AS DETERMINED BY ENGINEER-IN-CHARGE AS PER ROCK CONDITIONS.
14. THE ROCK BOLTS SHALL BE TENSIONED TO A LOAD OF 12.0 TON FOR 32Ø BOLTS.
15. ALL REINFORCEMENT (INCLUDING ANCHORS) SHALL BE OF HIGH YIELD STRENGTH COLD TWISTED BARS (GR.Fe-500) CONFORMING TO IS : 1786-2000.
16. THE CONCRETE MIX. FOR ALL RCC WORKS SHALL BE OF GRADE M:20 CONFORMING TO IS 456-2000.
17. MINIMUM CLEAR COVER FOR REINFORCEMENT SHALL BE 35 mm.
18. DEVELOPMENT LENGTH SHALL BE 57 x DIA. OF BAR.
19. LAP LENGTH SHALL BE 57 x (THINNER) BAR DIAMETER.
20. LAPPING OF BARS SHALL BE STAGGERED. REINFORCEMENT BARS NOT MORE THAN 50% SHALL BE LAPPED AT ONE SECTION.
21. SFRS AND SHOTCRETE SHALL MEET STRENGTH REQUIREMENTS AS SPECIFIED IN TECHNICAL SPECIFICATIONS.



VIEW B-B

CONFORMING TO IS 456-2000.

17. MINIMUM CLEAR COVER FOR REINFORCEMENT SHALL BE 35 mm.
18. DEVELOPMENT LENGTH SHALL BE 57 x DIA. OF BAR.
19. LAP LENGTH SHALL BE 57 x (THINNER) BAR DIAMETER.
20. LAPPING OF BARS SHALL BE STAGGERED. REINFORCEMENT BARS NO THAN 50% SHALL BE LAPPED AT ONE SECTION.
21. SFRS AND SHOTCRETE SHALL MEET STRENGTH REQUIREMENTS AS SPEC TECHNICAL SPECIFICATIONS.
22. THE SPACING BETWEEN BLOCKING POINTS SHALL NOT BE MORE T METERS.
23. THE STEEL RIBS SHALL BE CONFORMING TO IS: 2062-2006.
24. IN ADDITION TO SHOTCRETE AND STEEL RIBS, 25Ø, 4000 LONG @ 1500 C/ BOLTS MAY BE PROVIDED ABOVE THE SPRING LEVEL IN CONSULTATIO ENGINEER -IN- CHARGE.
25. WORK SHALL BE EXECUTED AS PER RELEVANT BIS CODES/TE SPECIFICATIONS.
26. THE SEQUENCE OF CONSTRUCTION SHALL BE IN FOLLOWING STEPS:-
    - STEP I APPLY SHOTCRETE AND PROVIDE ROCK ANCHORS ON ROCK SURFACES ABOVE POINT 'X'.
    - STEP II CARRY OUT OPEN EXCAVATION IN FRONT OF PORTAL.
    - STEP III WHILE BENCHING DOWN, APPLY SHOTCRETE ON EXCAVATED SURFACE AFTER EACH BLAST
    - STEP IV WHILE BENCHING DOWN, PROVIDE ROCK ANCHORS ON EXC ROCK SURFACE IMMEDIATELY AFTER SHOTCRETING
    - STEP V EXCAVATE TUNNEL AND PROVIDE SUPPORT SYSTEM IMMEDIA
27. THIS DRAWING SHOWS THE PORTAL DETAILS OF INLET PORTAL OF H TUNNEL. FOR SUPPORT DETAILS OF HIGHWAY TUNNEL REFER SEPARA OF CWC.

SHEE

PUNATSANGCHHU–II HYDROELECTRIC PROJECT AUTHORITY (B

CONSULTANTS

WAPCOS LIMITED

(A GOVT. OF INDIA UNDERTAKING)

GOVT.OF INDIA

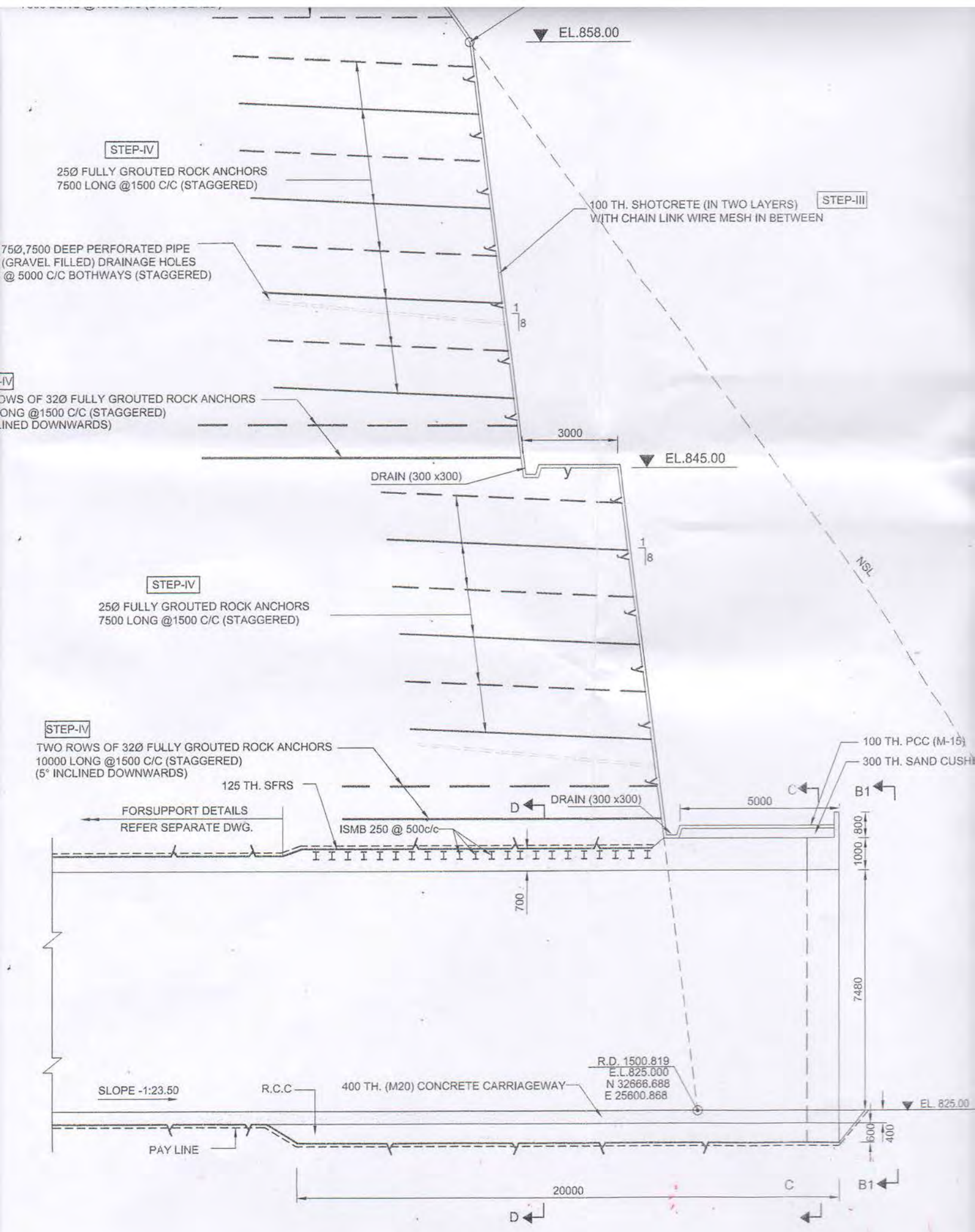
CENTRAL WATER COMMISSION

PUNATSANGCHHU–II H.E. PROJECT (BHUTA

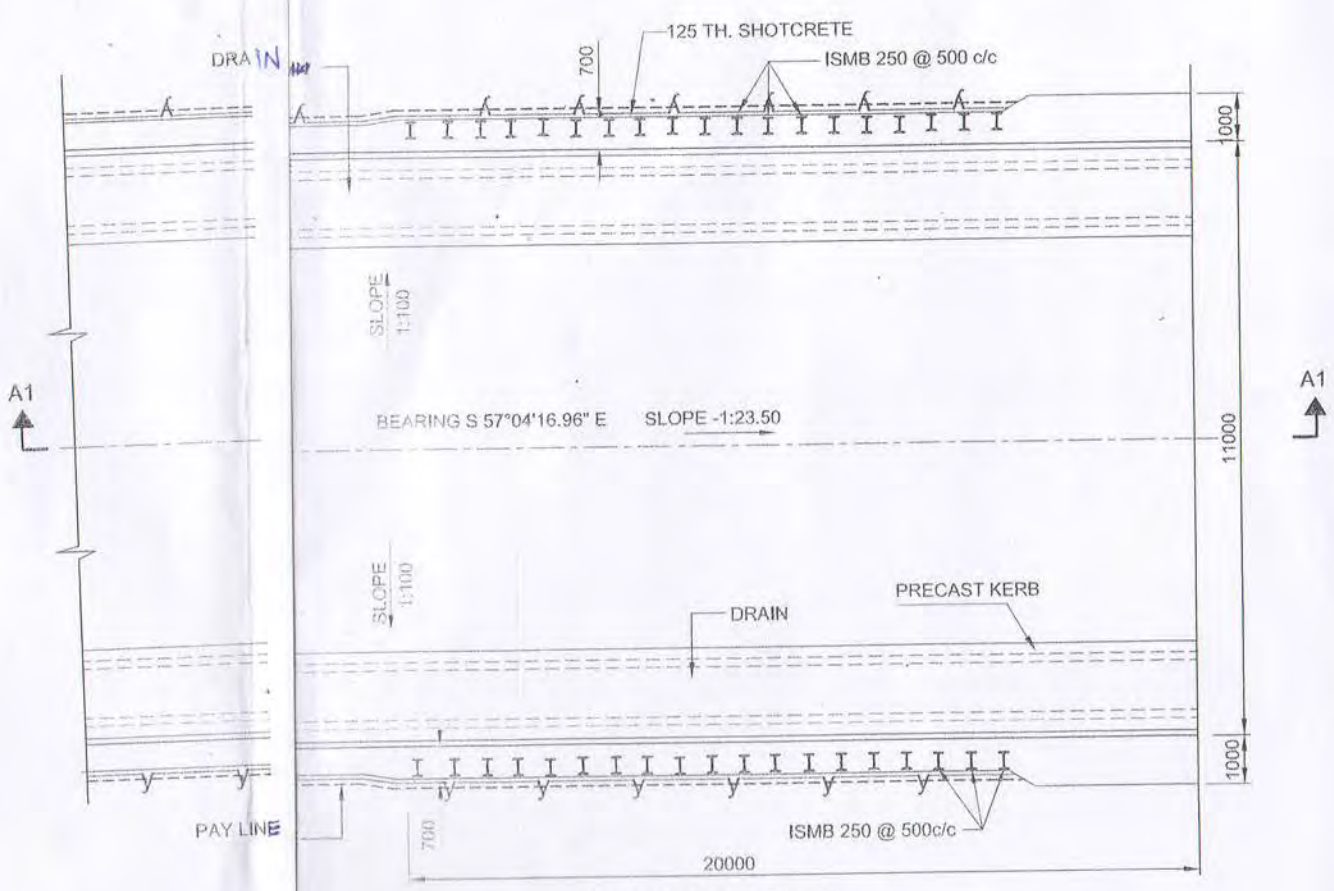
HIGHWAY TUNNEL

INLET PORTAL DETAILS

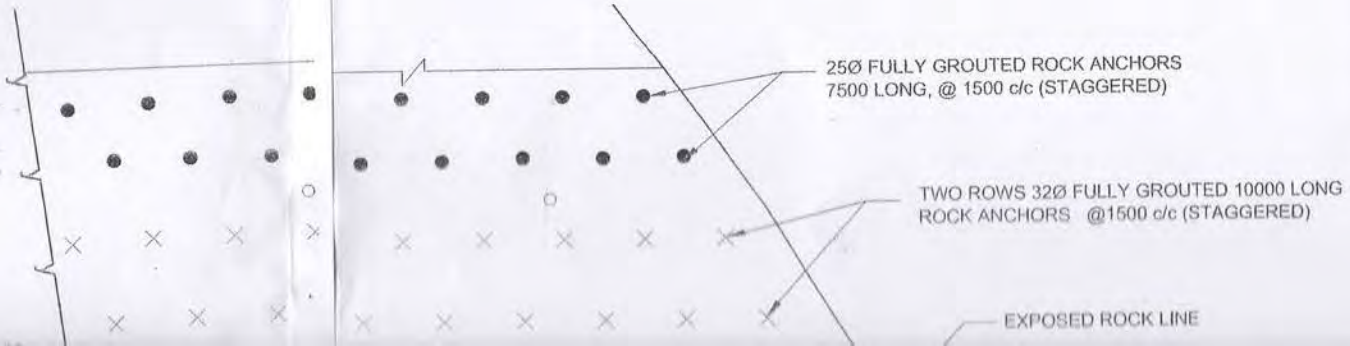
DSGN.	CHKD.	SUBM.
DRAWN		RECM.
TRCD.	INSPD.	APPD.
FILE NO. 2/79/2011	NEW DELHI DEC.-2011	DRG.NO. PNSC 9810



SECTION A1-A1

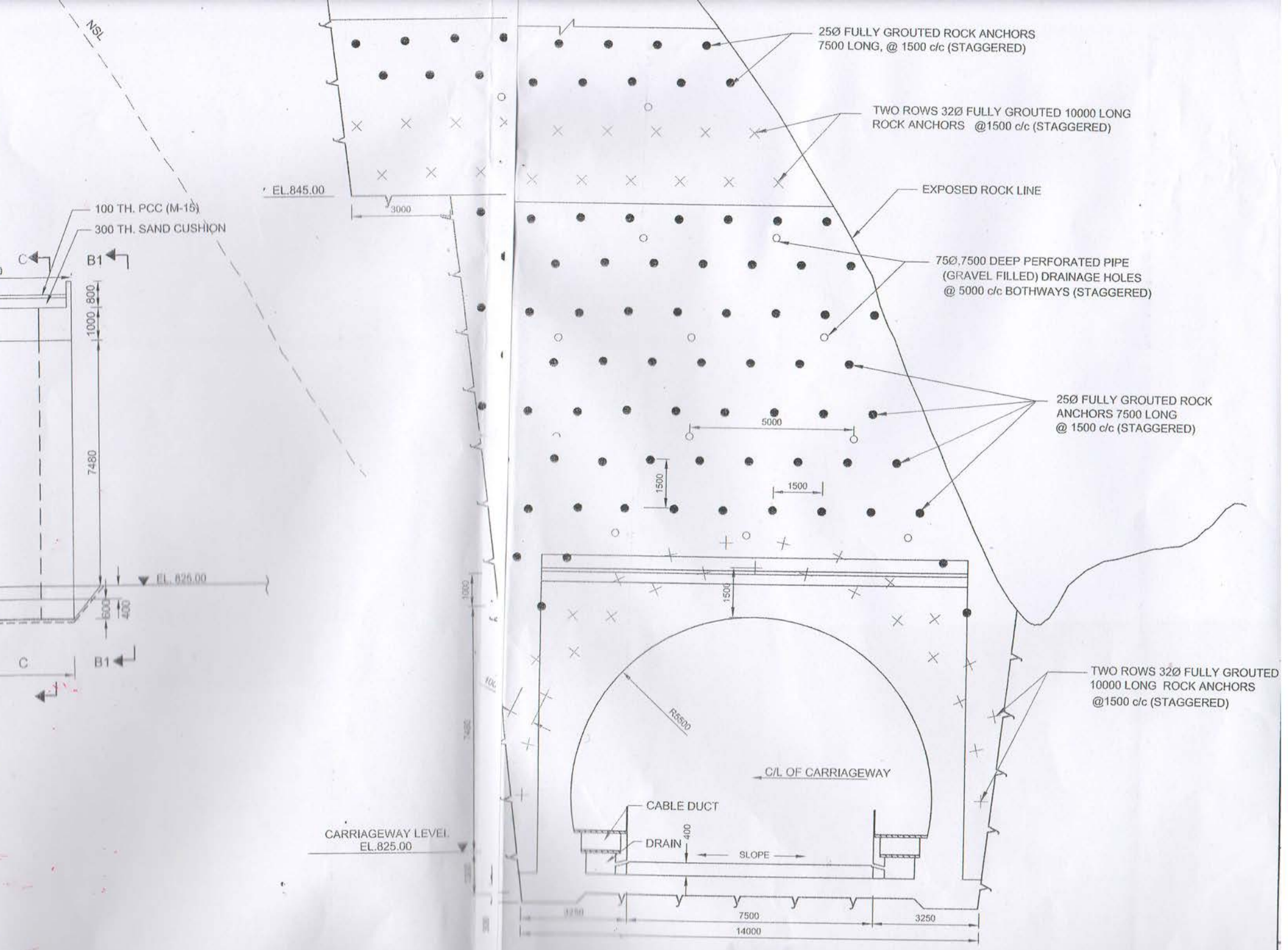


SECTIONAL PLAN
(ALONG CENTRE LINE)

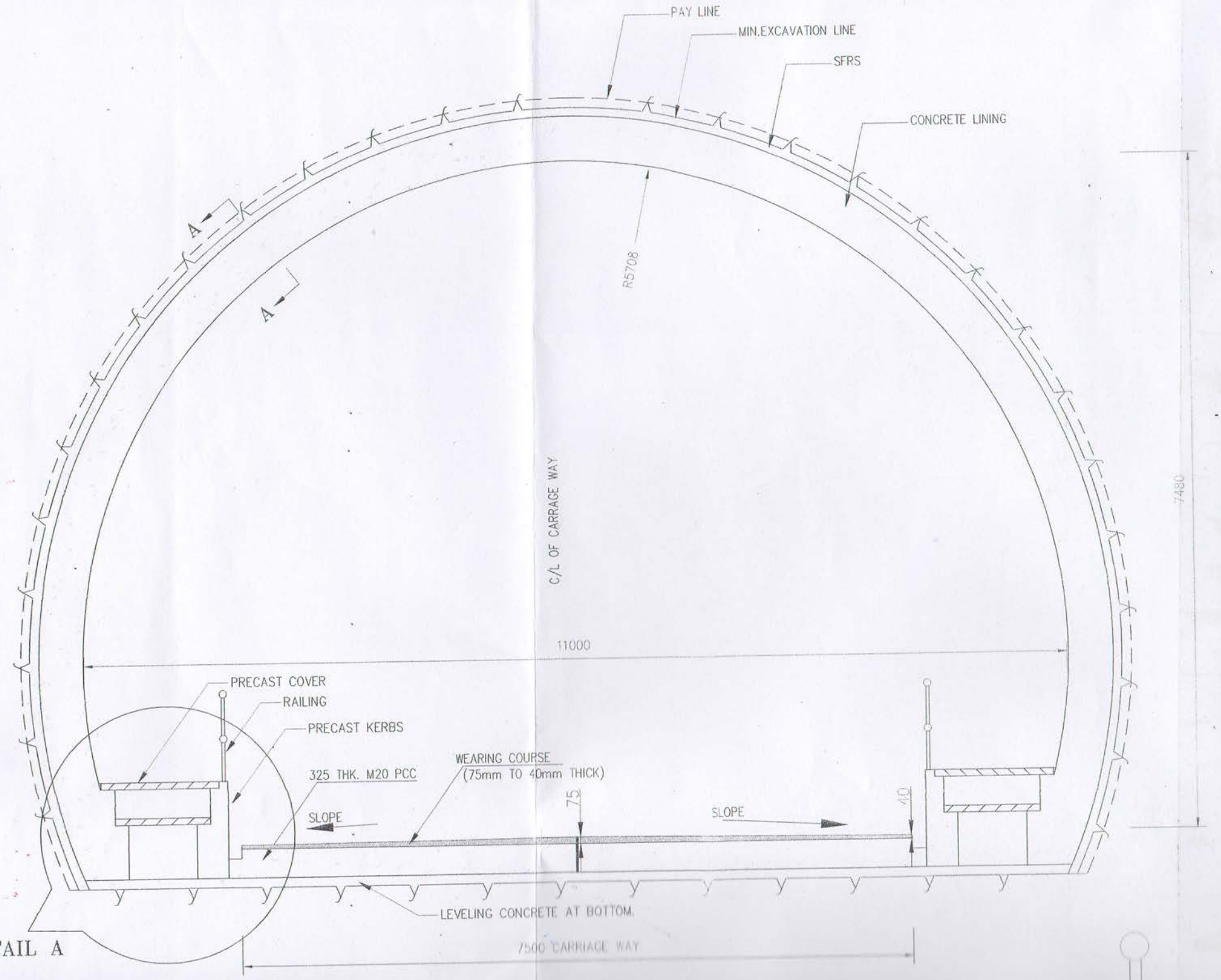


NOTES :-

1. ALL DIMENSIONS ARE IN MILLI
2. NO DIMENSION SHALL BE MEAS
3. ALL DIMENSIONS/ DETAILS S
   DRAWINGS BEFORE STARTIN
   BROUGHT TO THE NOTICE OF
4. THE DRAWING HAS BEEN
   WAP/BHUTAN-LOBESA/PHEP-II/
   PROJECT MANAGER, WAPCOS.
5. PROPER BLASTING TECHNIC
   OVERBREAKES SO AS TO G
   DRAWING.
6. SHEAR ZONES AND UNSTABL
   SPECIAL TREATMENT AS PER
7. ADEQUATE SURFACE DRAINAG
   IN CONSULTATION WITH ENGI
8. THE SLOPES PROVIDED FOR
   TO MODIFICATION AT SITE AS
   EXCAVATED ROCK. GENERAL
   SHOTCRETED & ROCK ANCH
   SHALL BE AS BELOW:-
   FRESH ROCK
   MODERATELY WE
   HIGHLY WEATHE
   OVER BURDEN
9. THE ROCK SUPPORTING ME/
   BLASTING BEFORE BENCHING
10. THE LENGTH, SPACING AND D
    AND MAY BE MODIFIED IN CO
    THE LOCAL SITE CONDITION/
    THE ROCK ANCHOR SHOULD
11. ROCK ANCHORS SHALL BE FU
12. THE ROCK BOLTS SHALL BE
    SHALL BE FULLY CEMENT GR
13. RESIN/CEMENT GROUTED R
    ENGINEER-IN-CHARGE AS PE
14. THE ROCK BOLTS SHALL BE T
15. ALL REINFORCEMENT (INC
    STRENGTH COLD TWISTED B/
16. THE CONCRETE MIX. FOR
    CONFORMING TO IS 456-2000
17. MINIMUM CLEAR COVER FOR
18. DEVELOPMENT LENGTH SHAL
19. LAP LENGTH SHALL BE 57 x (T
20. LAPPING OF BARS SHALL B
    THAN 50% SHALL BE LAPPED

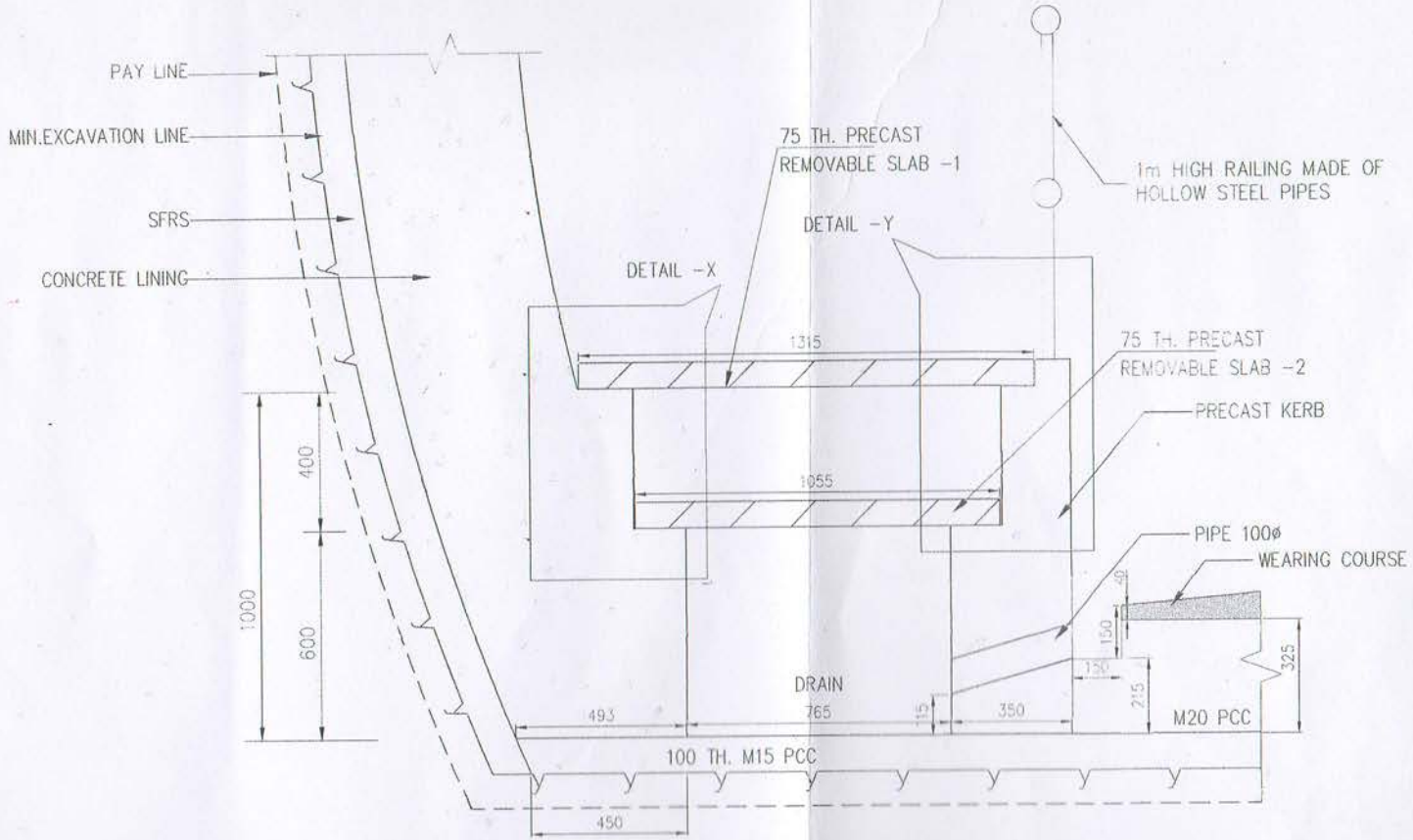

NSL
EL.845.00
3000
25Ø FULLY GROUTED ROCK ANCHORS
7500 LONG, @ 1500 c/c (STAGGERED)
TWO ROWS 32Ø FULLY GROUTED 10000 LONG
ROCK ANCHORS @1500 c/c (STAGGERED)
EXPOSED ROCK LINE
75Ø,7500 DEEP PERFORATED PIPE
(GRAVEL FILLED) DRAINAGE HOLES
@ 5000 c/c BOTHWAYS (STAGGERED)
25Ø FULLY GROUTED ROCK
ANCHORS 7500 LONG
@ 1500 c/c (STAGGERED)
5000
1500
1500
100 TH. PCC (M-15)
300 TH. SAND CUSHION
C
B1
1000
800
7480
EL. 825.00
600
400
C
B1
1500
R5500
C/L OF CARRIAGEWAY
CABLE DUCT
DRAIN
400
SLOPE
CARRIAGEWAY LEVEL
EL.825.00
3250
7500
3250
14000
TWO ROWS 32Ø FULLY GROUTED
10000 LONG ROCK ANCHORS
@1500 c/c (STAGGERED)

VIEW B1-B1

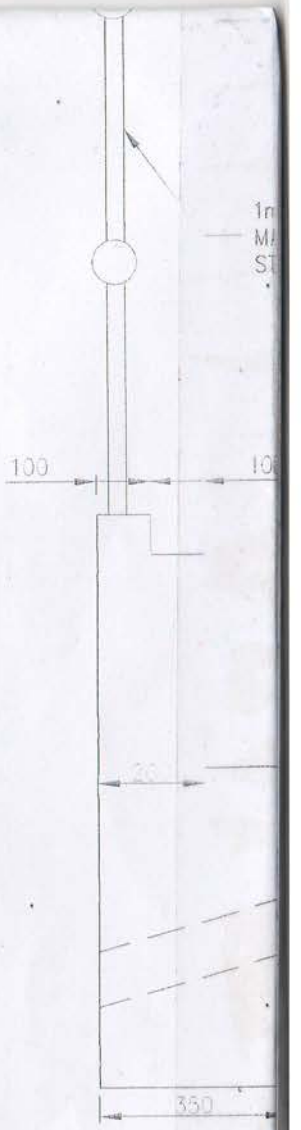

PAY LINE
MIN.EXCAVATION LINE
SFRS
CONCRETE LINING
R5708
A
A
C/L OF CARRAGE WAY
7480
11000
PRECAST COVER
RAILING
PRECAST KERBS
WEARING COURSE
(75mm TO 40mm THICK)
325 THK. M20 PCC
SLOPE
75
SLOPE
10
LEVELING CONCRETE AT BOTTOM.
7500 CARRIAGE WAY

DETAIL A

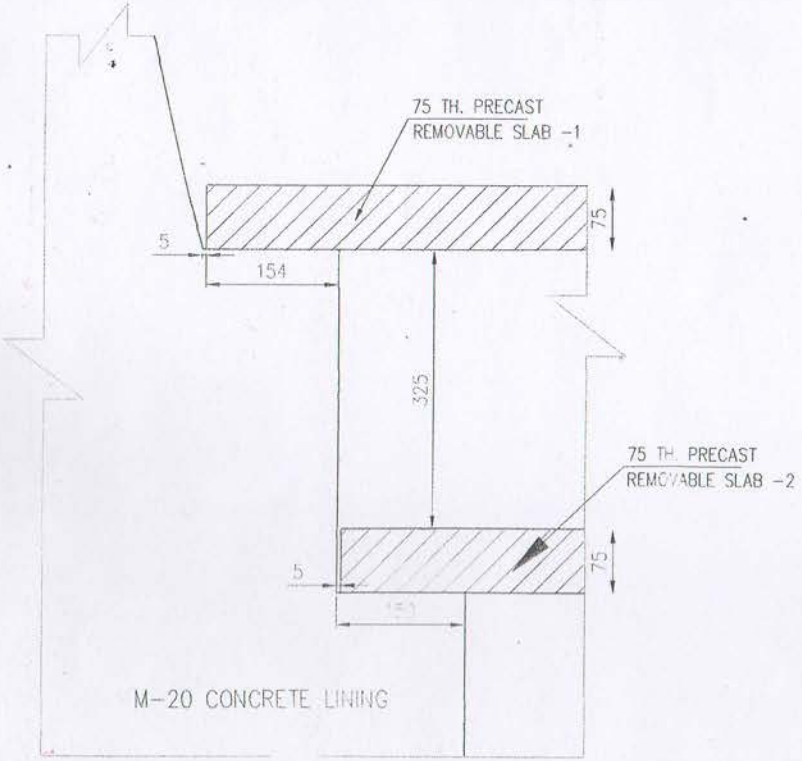
LINING DETAILS



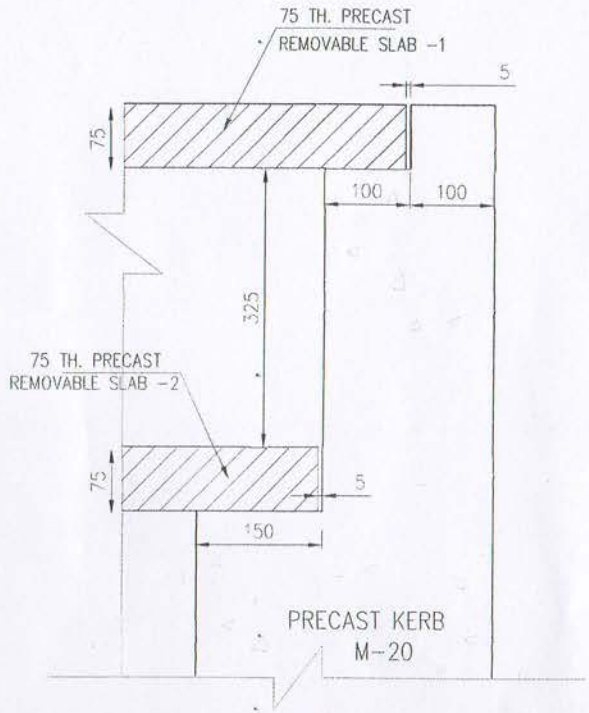
DETAIL A



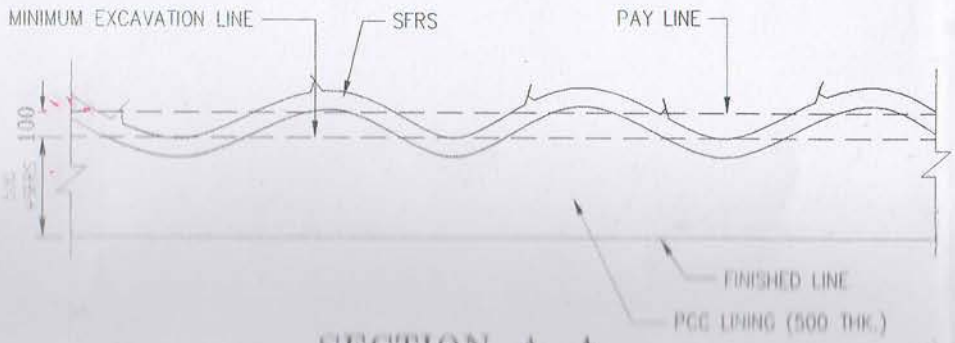
DETAIL OF



DETAIL -X



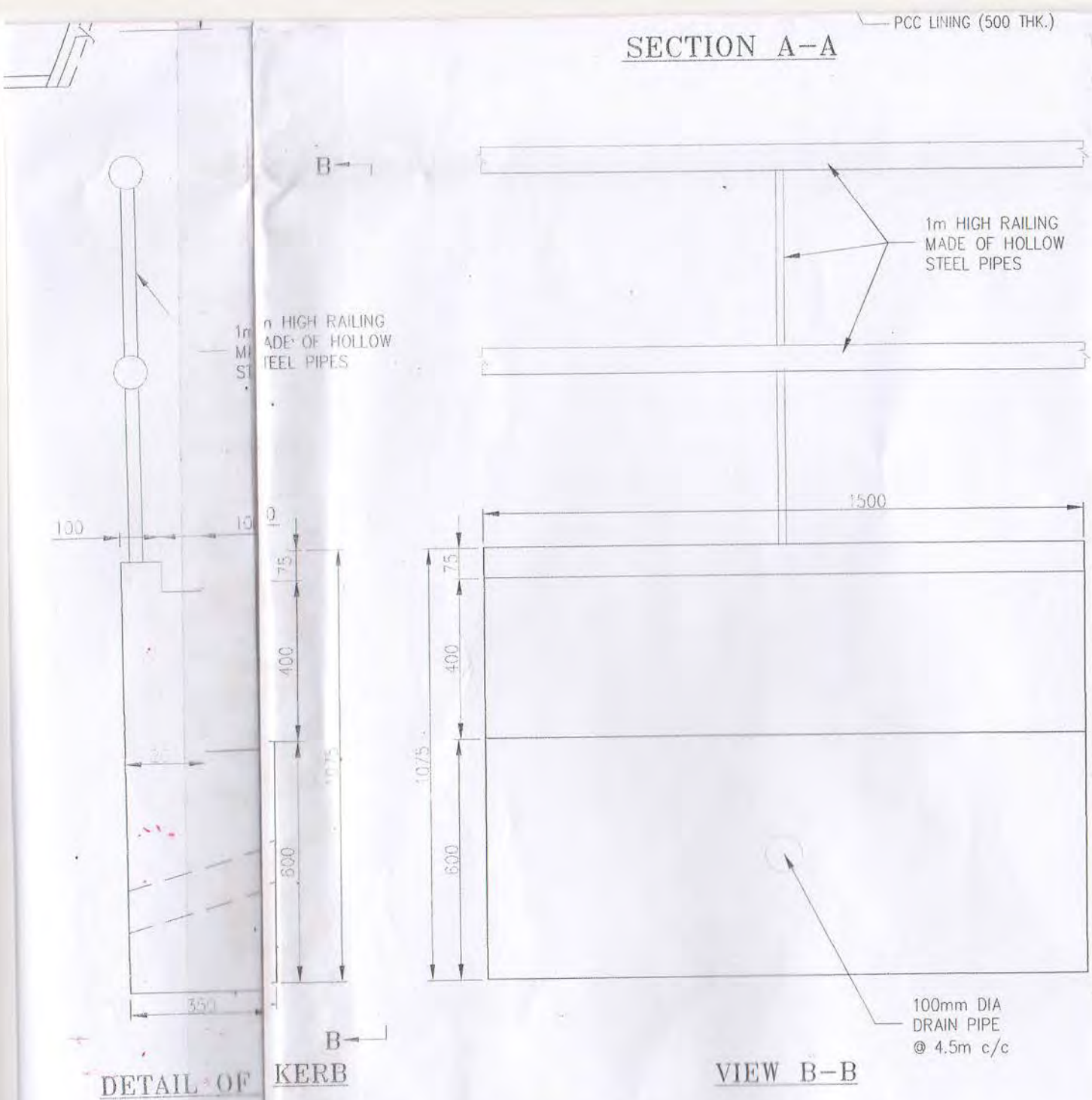
DETAIL -Y



SECTION A-A

NOTES:-

1. ALL DIMENSIONS ARE IN MILLIMETRES AND ELEVATION IN METRES.
2. NO DIMENSIONS SHALL BE MEASURED FROM THE DRAWING. ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.
3. THIS DRAWING SHOWS THE LINING DETAILS FOR HIGHWAY TUNNEL, PRECAST KERBS AND PRECAST SLABS.
4. ALL DIMENSIONS/ DETAILS SHALL BE CHECKED ALONG WITH THE RELEVANT DRAWINGS 'BEFORE STARTING EXECUTION. DISCREPANCY, IF ANY, SHALL BE BROUGHT TO THE NOTICE OF EWO IMMEDIATELY FOR REVIEW.
5. CONSTRUCTION JOINTS SHALL BE COINCIDENT WITH LONGITUDINAL AND TRANSVERSE JOINTS.



2. NO DIMENSIONS SHALL BE MEASURED FROM THE DRAWIN DIMENSIONS SHALL BE FOLLOWED.
3. THIS DRAWING SHOWS THE LINING DETAILS FOR HIGHWAY KERBS AND PRECAST SLABS.
4. ALL DIMENSIONS/ DETAILS SHALL BE CHECKED ALONG WI DRAWINGS BEFORE STARTING EXECUTION. DISCREPANC BE BROUGHT TO THE NOTICE OF CWC IMMEDIATELY FO
5. CONSTRUCTION JOINTS SHALL BE COINCIDENT WITH L TRANSVERSE JOINTS.
6. ALL PIPES AND OTHER EMBEDMENTS IN CONCRE ELECTRO–MECHANICAL REQUIREMENTS SHALL BE PR RELEVANT ELECTRICAL DRAWINGS.
7. FOR DETAILS OF LIGHTING, FIREFIGHTING, VENTILATION ARR RELEVANT ELECTRICAL DRAWINGS.
8. NECESSARY EMBEDMENT SHALL BE PROVIDED IN PRE FIXATION OF HOLLOW STEEL RAILING.
9. CONCRETE IN LINING, PRECAST KERBS AND PRECAST SL GRADE M–20 CONFORMING TO IS456–2000.
10. ALL REINFORCEMENT SHALL BE OF HIGH YIELD STRENGTH (GR.Fe–500) CONFORMING TO IS:1786–2008.
11. MINIMUM CLEAR COVER FOR REINFORCEMENT SHALL BE 15 mm I AND 25mm IN PRECAST KERBS.
12. DEVELOPMENT LENGTH SHALL BE 57 x DIA. OF BAR.
13. LAP LENGTH SHALL BE 57 x (THINNER) BAR DIAMETER.
14. LAPPING OF BARS SHALL BE STAGGERED. REINFORCEMENT BARS SHALL BE LAPPED AT ONE SECTION.

PUNATSANGCHHU HYDROELECTRIC PROJECT AUT

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

GOVT.OF INDIA
CENTRAL WATER COMMI

PUNATSANGCHHU–II H.E. PROJE

HIGHWAY TUNNEL
DETAILS OF CONCRETE LINING, KERB A

DSGN.	CHKD.	SUBM.
DRAWN		RECM.
TRCD.	INSPD.	APPD.
FILE NO. 2/79/2012 HCD (E & NE) DTE.	NEW DELHI NOV.–2013	DRG.NO.

Appendix 11

ITAによるトンネル研修資料

A Part of Training Materials
In Planning & Design in
Conventional Tunnelling

Planning & Design in Conventional Tunnelling

Two-Day Training Session for Continuing Education
17 – 18 October 2016 Thimphu – Bhutan

ITACET Foundation
Foundation for Education and Training on Tunnelling and Underground Space Use

DrukGreen

ITA AITES

Planning & Design in Conventional Tunnelling

17 – 18 October 2016. Thimphu – Bhutan

Objectives: this course aims to provide planning, design and construction elements to young professionals related to the best practice of tunnel design.

Program

Monday 17 October 2016

08.30	-	09.00	Registration of Participants
09.00	-	09.15	Welcome and opening: ITA and country representatives

Session 1: Introduction and overview on Tunnel Design

09.15	-	09.45	Public authorities and owner roles: planning and general organization
09.45	-	10.30	Design philosophy: Design and risk management
10.30	-	11.00	Coffee break
11.00	-	11.30	Specificities and stages of tunnel design
11.30	-	12.00	Geo-investigation and tunnel modeling parameters
12.00	-	12.30	Questions & Answers
12.30	-	14.00	Lunch

Session 2: Specific aspects of Tunnel Design

14.00	-	14.45	Tunnel alignment and layout planning
14.45	-	15.30	Construction methods and aspects affecting design
15.30	-	16.00	Coffee break
16.00	-	16.30	Types of tunnels and caverns
16.30	-	17.00	Design and excavation in difficult ground
17.00	-	17.30	Questions & Answers

Tuesday 18 October 2016

Session 3: Conventional Tunneling

09.00	-	09.45	Sequential excavation and design in soft ground and hard rock
09.45	-	10.30	Structural and support design
10.30	-	11.00	Coffee break
11.00	-	11.30	Work site organization in tunnel construction
11.30	-	12.00	Instrumentation and monitoring for conventional tunneling
12.00	-	12.30	Questions & Answers
12.30	-	14.00	Lunch

Session 4 : Case Studies in Conventional Tunneling

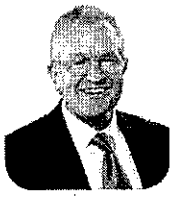
14.00	-	14.45	Design example of Tunnels for Hydropower in Alpine regions
14.45	-	15.30	Numerical analysis for design of tunnels
15.30	-	16.00	Coffee break
16.00	-	16.30	Mechanized versus conventional tunneling: Factors affecting its selection
16.30	-	17.00	Questions & Closing remarks
17.00	-	17.30	Short address by Chief Guest & award of certificate

Planning & Design in Conventional Tunnelling

17 – 18 October 2016. Thimphu – Bhutan

Training Session organizers: Druk Green power corporation, as representative of International Tunnelling Association (ITA-AITES) member nation of Bhutan and **ITACET Foundation.** The Foundation is a non-profit organization whose aim is to organize, promote and sponsor training and continuous education actions in the field of Tunnelling and Underground space use. The training activities organized by the Foundation are mainly aimed to young professionals in the field of Tunnelling and Underground space use, as engineers, geologists, consultants, administrative manager and policy makers. http://www.itacet.org

Lecturers of the seminar. *In the order of their intervention.*



Harald Wagner (Harald Wagner Consulting Engineer)>> Dr. Harald Wagner is an internationaly well-recognized Consultant for Underground Infrastructures with more than 40 years of Professional Experience in Tunnel Design, Construction and Consultancy. Harald is a Civil Engineer, M.Sc., Ph.D. Licensed Masterbuilder, Government Counsellor, appointed by President of Austrian Republic, Chartered Expert at Court, Consultant to the World Bank. A former Assistant Professor at Technical University Graz in Austria on Soil Mechanics & Foundation Engineering for Architects. Harald was Vice President of ITA and Tutor of WG 2 "Research". He contributed to "Guidelines for the Design of Tunnel Lining Segments", "Risk Management Guidelines", Report on "Long Tunnels at Great Depth", Report on "Conventional Tunnelling", etc. He is an expert Member of ITA's Executive Council, Designer & Consultant for Underground Space Use

Piergiorgio Grasso (Geodata Spà)>> Piergiorgio graduated from the 'Politecnico di Torino' of Italy in civil engineering. Piergiorgio is President & Principal Engineer of Geodata since 1984, which is a consultancy company specialised in the design and management of underground works, both in urban environments and in mountain areas. He was part of the ITA Executive Council member & an ITA past Vice President. Piergiorgio served the ITA Working Group 17 on "Long and Deep Tunnels" as its animateur & tutor. Piergiorgio is one of ITA expert and is ITACET Foundation Vice President.

Emmanuel Humbert (CETU - Centre for Tunnel Studies)>> Emmanuel HUMBERT is a graduate of the French National School for State Civil Works with a master in civil engineering. He has been working in tunnelling for almost fifteen years at CETU (Centre for Tunnel Studies) which is French government technical centre for tunnel studies and research. He has gained considerable experience in road and railway tunnel construction from the numerous tunnelling projects in which he has acted as project engineer or project manager. He has developed extensive professional skills in tunnelling design, geotechnical engineering and project and risk management. He also lectures on the topic of tunnelling and tunnel boring machines in French universities within the scope of postgraduate degrees. Emmanuel is the French representative of ITA Working Group 2, focused on research

Paolo Cuccino (SWS Engineering SpA)>> MScEng. in Geotechnical and environmental engineering at the University of Trento, Italy Paolo is Partner and Chief Operating Officer in SWS Engineering SpA. Leader of award winning, geotechnical and tunneling team, he achieved a great experience developing large national and international projects like the Brenner Base Tunnel, Underpass of High speed railway of Florence, the enlargement of highway tunnel M. Domini (enlargement of an existing highway tunnel ensuring regular traffic during work execution), HS and conventional railway projects in Turkey for TCDD (more than 800 of railway connection with 99 tunnels and more than 100 bridges), Muskrat Falls HPP in Labrador for Astaldi Canada. Innovator, researcher and as a member of some of the most influential Tunneling and geotechnical associations, he published a numerous papers related to tunneling.

Alain Poloni (Eiffage Infrastructures)>> Born in France in 1961, Alain Poloni is a civil engineer and director for major projects offers in the International department of Eiffage Infrastructures, a branch of EIFFAGE Group, a French company acting as a leader on the European market in concessions and public works sector.
He has 30 years' experience in construction field, including 18 years in international projects performed in countries like Venezuela, Turkey, Malaysia, Egypt, etc., mainly in tunnelling activities with Tunnel Boring Machine or conventional method.
Alain Poloni was in charge until April 2014 of two major projects executed in Monaco (Downward tunnel and Third Source electric substation) both using Drill and Blast technic in very urbanized areas under drastic environmental constraints. For last two years Alain Poloni is in charge for the preparation of offers for major projects located mainly in Middle East and Africa.

Paolo Mazzalai (SWS Engineering SpA) >> Prof. Paolo Mazzalai is a successful entrepreneur who has always served the scientific community with competence and passion. As an international expert in advanced engineering and construction systems, more than 30 years ago he founded SWS Engineering SpA, highly specialized in developing innovative solutions in the engineering world serving the underground and complex infrastructures construction. An International Designer of major infrastructure projects in transport (roads, highways and railways) and water (dams and river systems), Paolo Mazzalai is also the author of numerous scientific papers and a member of several Scientific and Entrepreneurial Associations. President of Confindustria of Trentino, the Industrial Association of Trentino, from 2011 to 2015, he taught for several years at the University of Padua, where he graduated in 1973 as Civil Engineer.

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ITA AITES

17 – 18 October 2016. Thimphu – Bhutan

Planning & Design in Conventional Tunnelling

Session 1: Introduction and overview on Tunnel Design
Harald Wagner, Consulting Engineer

I - Planning & general organization - Public authorities & owner roles

There is a tendency in the development of public underground infrastructure projects to fund projects either on bi- or multi-lateral bases. It is in the principle interest of both public and private owners, to achieve contractually well-structured and balanced contracts in accordance with international standards to increase transparency, as underground infrastructure projects are in particular vulnerable to corruption due to geologic uncertainties.

Through extensive training options backed up by best business practices, there is an impact of added engineering value reflected in life cycle cost and project success. The procurement phase has the greatest impact on the life cycle cost of the project, yet it is the least costly component. Contracts shall be clear and coherent with essential clauses, detailed definitions and a consistent structure. Buildings and engineering works are designed by (or on behalf of) the employer.

Risk shall be allocated to the party, which is best placed to control it, to bear it, and to deal with it. Acting as third party, contracts shall be drafted by consulting engineers who are experienced in the design and management of projects. Contracts should be complete and flexible, ranging over most needs and readily adaptable to fit requirements. The contract shall be administered by the engineer, appointed by the employer.

The stakeholders in the contract are the owner/employer, the contractor, and the engineer being the employers representative, whereas contractual clear relationships shall be established between employer and engineer as well as between employer and contractor. There shall be only an administrational relation between contractor and engineer. For the settlement of disputes a dispute adjudication board shall be established above employer and contractor.

Contracts shall be featured by harmonized terms and clauses, allowing for an application of common laws including civil laws. They shall be wide applicable under various project delivery and contracting systems. More specific provisions shall be included regarding obligations of the parties and their rights. Management procedures shall correspond with the latest developments. Late payment problems shall be tackled as well as the role of the engineer shall be updated. The foreseen dispute resolution procedure makes underground construction more effective.

The role of the employer must include the choice of most suitable conditions of contract. Upon project analysis, subject and type of contract (construction only, design & build, etc.), type of risk sharing (contractor to construct only or to be involved in the design), intended management of the contract/project, type/method of payment, shall be decided.

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Planning & Design in Conventional Tunnelling

Thimphu, Bhutan 17 - 18 October 2016

PUBLIC AUTHORITIES & OWNER ROLES

PLANNING & GENERAL ORGANIZATION

Harald Wagner, PhD, PE
Consulting Engineer
Tunnel Consultant & ITA ExCo Expert

ITACET FOUNDATION - DRUK GREEN - ITA/AITES
TRAINING SESSION
PLANNING & DESIGN IN CONVENTIONAL TUNNELLING
NAMGAY HERITAGE - BHUTAN, October 17- 18, 2016

PUBLIC AUTHORITIES & OWNER ROLES
Planning & General Organization

Harald Wagner PhD, PE
Consulting Engineer

TUNNEL CONSULTANT & ITA EXCO EXPERT

WWW.DRHARALDWAGNER.COM

CONTENT

INTRODUCTION

In the real world the struggle to define the economic future pivots on the kind of infrastructure that will be put in place to serve the coming era.

Which of the two management models, - the capitalist market and the collaborative commons - , ultimately prevails as the dominant form and which as the niche player will depend largely on the infrastructure society erects.

Jeremy Rifkin, The ZERO Marginal Cost Society 2015.

SUPPORTING AUTHORITY

WORLD BANK

The World Bank is a vital source of financial and technical assistance to developing countries around the world.

Its mission is to fight poverty with passion and professionalism for lasting results and to help people help themselves and their environment by providing resources, sharing knowledge, building capacity and forging partnerships in the public and private sectors.

International Financing

- Asian Development Bank (ADB)
  - $1 billion for 2013-16. 'New plan' after 2015 election (one priority area rural off-grid renewable energy)
- World Bank
  - $2 billion package for agriculture, energy and health
- European Union
  - 200 million from 2011-2013 for rural development, health, trade certification
  - MoU signed to start EU investment bank activities
- Finnish Financing
  - EEP Mekong, Finnfund
  - IKI financing for capacity building, forestsOther ?

World Bank Group President Jim Yong Kim visits the Myanmar Khin Dagon Township Hospital.

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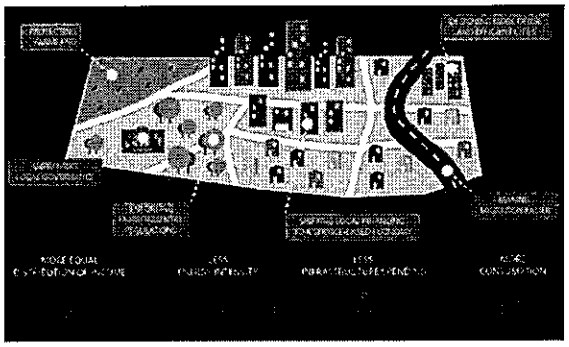
Better Infrastructure for Public Growth



Source: Urban China - Toward Efficient, Inclusive, and Sustainable Urbanization, 2014 www.worldbank.org/urbanchina

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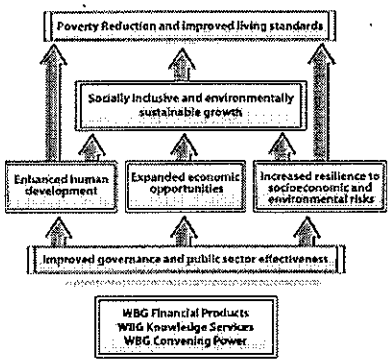
1. Poverty Reduction Framework of WBG



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2. Public Funding Programs

- The World Bank has directly or indirectly assisted in the past e.g. only 3 % of dams in developing countries.
- At present, the Bank is financing about 4 dam projects/year—half the rate of the 1970s and 1980s.
- Since 1986, the Bank has approved 39 dam projects: 33 mainly or exclusively for hydropower, three mainly for irrigation, and three for water supply or navigation.

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3. Public Infrastructure Projects

- Lending for these 39 projects, at $7.4 billion, accounts for about 3 percent of total World Bank lending in the past 10 years.
- At first, large dams were simply regarded as engineering structures—for generating electric power and improving the management of water.
- In the 1960s, cost/benefit analysis became accepted as the standard criterion for the justification of large dams, and the World Bank pioneered the modeling of river basins and new methods of economic analysis of multipurpose projects in developing countries.

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4. Energy Development

Electricity is needed for human and economic development.

An estimated **more than 400 million** Indians are without reliable access to electricity.

Poor power supply is a severe constraint on the economy → higher costs → loss of competitiveness → fewer jobs

Generation options for India are:

- Coal (already 80% of actual generation)
- Nuclear
- Limited oil and gas
- Hydropower (undeveloped potential of 120,000 MW)
- Other renewable

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5. Recognition of Social & Environmental Issues

- It was not until the late 1970s and 1980s that social and environmental impacts, previously treated as inevitable "side effects," emerged as fundamental concerns.
- The World Bank responded by adopting guidelines to integrate social and environmental concerns into the analysis of proposed projects and to avoid or mitigate the adverse consequences of large dams.

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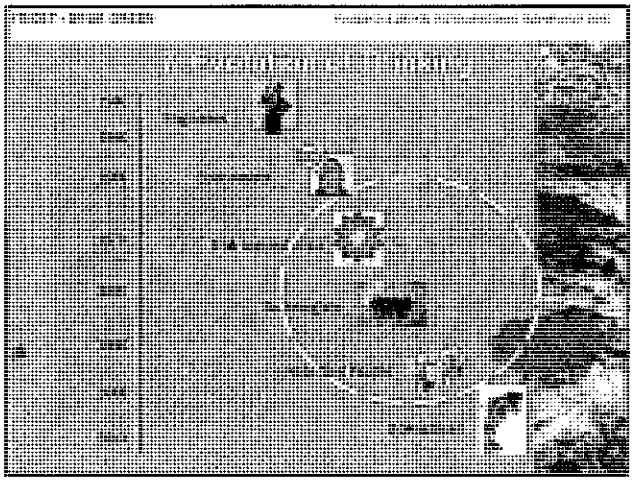
6. Environmental & Social Guidelines

- The Bank issued Guidelines on
  - dam safety in 1977;
  - involuntary resettlement in 1980, 1986, 1990 and 2001;
  - safeguards for indigenous people in 1982 and 2005;
  - natural habitat in 1986 and 1995;
  - environmental aspects of dams and reservoirs in 1989; and
  - environmental assessment in 1991.



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8. Safeguard Public Authority Policies

1. Environmental Assessment
2. Natural Habitats
3. Forests
4. Pest Management
5. Physical Cultural Resources

Plus Disclosure Policy

6. Involuntary Resettlement
7. Indigenous Peoples
8. Safety of Dams
9. Projects involving International Waters
10. Projects in Disputed Areas

Piloting Use of Country Systems

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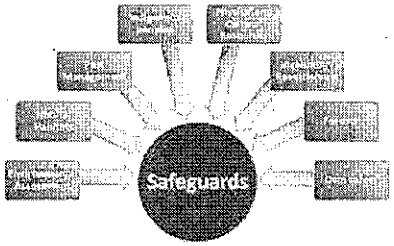
8 Principles into Safeguards



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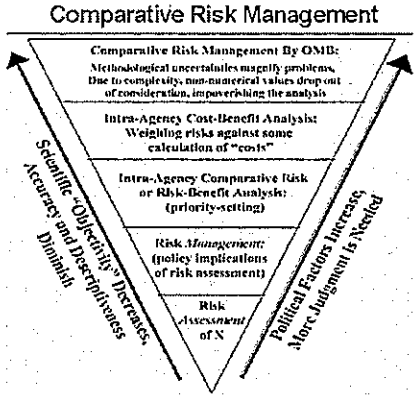
Comparative Risk Management



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Owner Commitment Role to Environment

World Bank's Partners and Owners have a commitment to ensure that people and the environment are not harmed as a result of its financing

Previous Bank emphasis: "Do no harm"
Now promoting: " Do good"

Better embody Social and Environmental Considerations
→ reduce and manage risk
→ save money and time

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9. Environmental & Social Impacts

- Impact on Flora and Fauna
- Water Quality Issue
- Construction related impacts
- Safety of workers and communities
- Impact on Physical and Cultural Resources
- Other induced impacts and cumulative impacts
- Dam safety
- Catchment Area Treatment & Other Enhancements
- Land Acquisition and its Impact
- Impacts on Indigenous people

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Challenges to Public Authorities

Standards embodied in public policies have yet to be universally adopted.

Even owners that accept them in principle, generally lack

- the regulatory framework,
- the participatory mechanisms, or
- the domestic capacities,

needed to translate the new standards into results on the ground.

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Private Financing

- The advent of private financing for public infrastructure makes the dilemma more complex and urgent.
- Knowing that influential advocacy groups oppose any public financing for large projects, many governments of developing countries are now ambivalent about seeking public support for this purpose.

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Impacts of Underground

- Impacts due to Excavation
- Impacts due to Muck or Debris disposal
- Impacts due to Construction Equipment
- Impacts of Indoor and ambient Air Quality
- Impact on Water quality
- Impact on Health and Safety

Perceptions :

- Damage on buildings
- Reduction in discharge of resources
- Reduction in productivity due to dust

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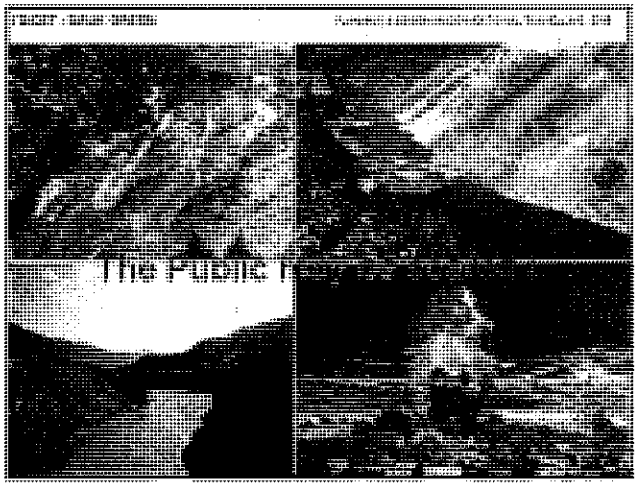
"Pay Attention" Benefits

Paying attention to Environmental & Social aspects can avoid problems and add value

- Reduces unforeseen issues/ problems
- Improves relations with local communities
- Prevents delays and stoppages
- Prevents legal disputes
- Provides good publicity
- Allows for good corporate image
- Reduces financial costs (time and money)



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10. Public supported Programs

Focus on countries with high potential for development of underground infrastructures

Investment finance; technical assistance on policy issues; capacity-building for developers

- Technical & Contracting
- Social & Environmental Practice,
- Communications

Work with State Governments on planning and regulation

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WBG supported Initiatives

Uttarakhand (Govt of Uk & THDC; Vishnugad Pipalkoti HEP)

- River Optimization study on Alaknanda
- Cumulative Impact Assessment on Alaknanda
- Minimum flow / e-flow assessment and
- Panel of Experts for Environment and Social to assist project preparation

Himachal Pradesh (Green Growth DPLs for GoHP and with SIVNL; NJHEP, Rampur HEP)

- River Optimization study on Sutlej
- Comprehensive CAT plan of Sutlej basin
- Cumulative Impact assessments
- Benefit Sharing Schemes
- Communication Strategy

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Environment & Social Sustainability
Renewable Energy Development

WBG Interventions	State's initiatives
Basin wide digital GIS based map of hydropower potential	Basin wide Monitoring protocols for hydro projects including monitoring of environment and social aspects
Cumulative Environmental Impact Assessment (CEIA) studies for the 5 key river basins and Integrated Catchment Area Treatment (CAT) plan for the Sutlej river basin	Panel of Experts for the state to oversee hydro (envmt. & social)
Local Area Development Fund (2009) to include annuities to affected communities	Mandatory e-flow @15% downstream of structure and Real time Monitoring
	Web disclosure of Families eligible for Benefit sharing and GRM

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✓ Environmental Management – New Initiatives

1. Mandatory deployment of Equipment for environment friendly construction.
2. Define minimum environment impact
3. VIDEOGRAPHY & MEASUREMENT OF NATURE RESOURCES FALLING UNDER PROJECT AFFECTED AREA
4. INSURANCE OF STRUCTURES-BASELINE SURVEY OF COMMUNITIES FALLING ABOVE TUNNEL ALIGNMENT COMPLETED
5. Involving Panel of Expert for Environment & Social to assist project preparation and in implementation
6. Involvement of Third party in implementation monitoring of EMP
7. Introduction of module based courses / Env. Engineers on Env. Mgmt.

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✓ 11. Planning to minimize Social Impact

Minimal land acquisition of private land by designing double / triple storey buildings in colony

Colony designed in such a way that nearby village population can utilize the facilities of banks, schools, dispensaries, etc.

Existing roads are used to the extent possible

Construction influenced area is to be minimized – possible no affect to habitation in the area.

Re-adjustment of project components to reduce impact (relocation of shafts and related road links).

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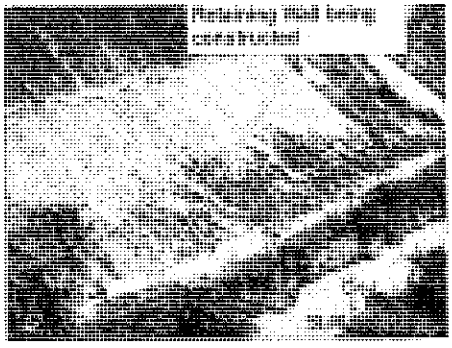
Planning reutilization of Muck for Approach Roads
Example HEP Rampur



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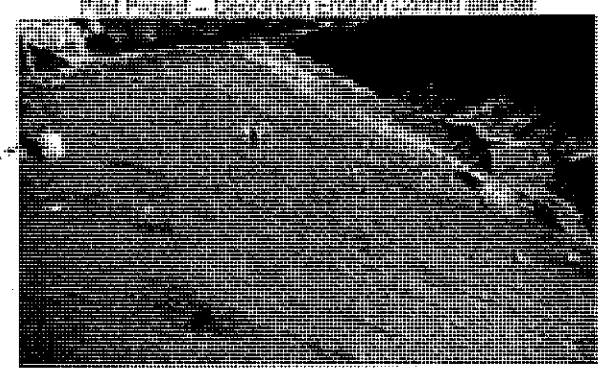
Planning muck disposal & management



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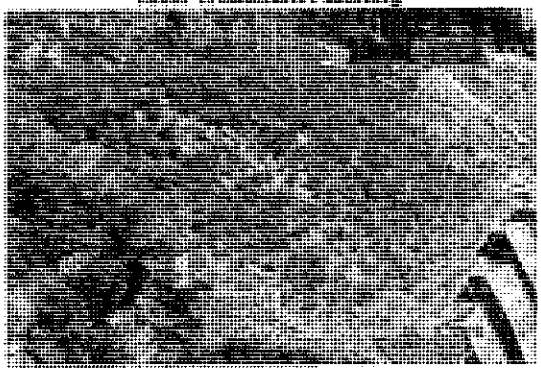
Water Treatment Planning



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Air Pollution Management

1. Sprinkling of water on unpaved roads to prevent fugitive emissions during vehicle movement.
2. Crusher used at Quarry site to be fitted with a Cyclonic Scrubber to control dust generation.
3. Fine aggregates after crushing stacked and regularly sprayed with water
4. Vehicles used in Project Area to be ensured to comply with vehicle emission norms.
5. Tunnels to be properly ventilated to disperse dust .
6. Labour camps, colonies etc to be located on Leeward side, outside impact zone of crusher and adit sites.
7. Assist in natural filtration process, landscaping, develop small garden and greenbelt around perimeter of project.

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Water Pollution Management

1. **Labour Colony**

   Sewage generated shall be disposed at Septic tank
   One community latrine shall be provided per 20 persons.
   The sewage from the community latrines shall be treated in aerated lagoons and settling tanks.
2. **Construction Water**

   The effluent generated at crushers had high suspended solids. These effluents were disposed by constructing Settling tanks at Crusher Sites
   The effluents generated in the tunnel (ground water and construction water) contains high suspended solids which shall be disposed off by constructing settling tanks.
3. **Water testing** of sources identified for drinking purposes shall be done to monitor regular disinfections

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Construction Equipment Operation

1. Equipment with modern technologies, producing low noise and in good working condition, properly lubricated and maintained, shall be deployed at Project.
2. Equipment producing considerable noises shall not be operated during Night hours.
3. Noise level monitoring of Construction equipment & vehicles shall be conducted during Construction phase. The base values of Noise level are mentioned in the EIA report and Noise levels shall be kept within permissible limits.
4. Crushers shall be provided with cyclones to control dust.
5. Continuous sprinkling of Water on Haul roads shall be ensured to control dust.

Appendix 12

プレFS調査・報告資料

Presentation for DOR,
Pre-feasibility Study

ブータン国
道路斜面管理マスタープラン調査
プロジェクト

プレF/S調査報告

2017/01/19

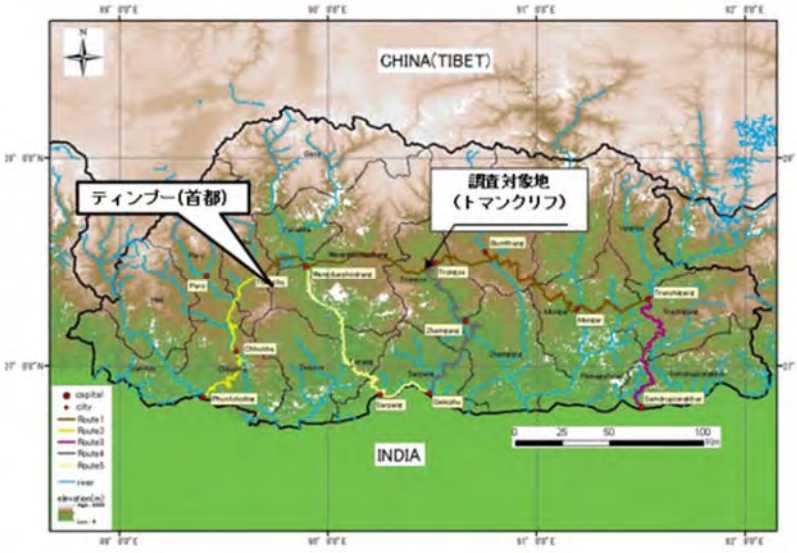
国　際　航　業　株　式　会　社
株 式 会 社 地 球 シ ス テ ム 科 学
株式会社オリエンタルコンサルタンツグローバル
ＯＹＯインターナショナル株式会社

目　　次

1. 業務概要

（1） 概要

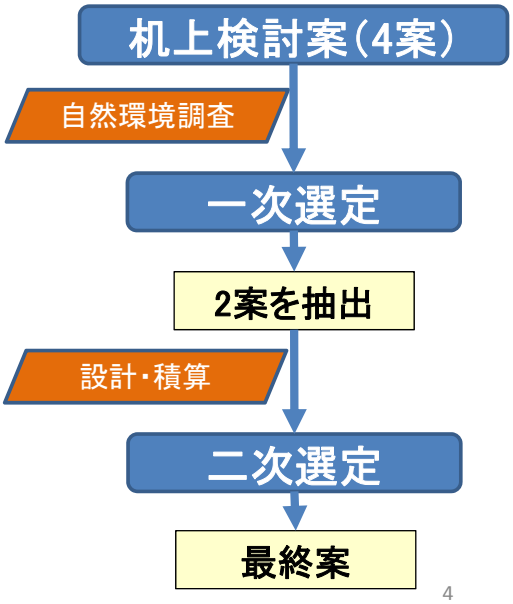
国道1号線のトマンクリフ（Thumang Cliff）における斜面対策工のプレF/S 調査を実施。



（2） 検討手順

① 既往成果の結果を踏まえ、トマンクリフの落石・岩盤崩壊に対する対策工を広い観点で模索

②机上検討案（4案）を作成し、現地調査で実現性のある2案を抽出（一次選定）、さらに設計・施工・積算の観点で比較検討し最終案を抽出（二次選定）。



③調査期間が限られているため、調査結果に不確実性があることはある程度許容する。

2. 机上検討

（1） 基本方針

- 机上検討では、道路の現線形を活用する場合と、活用しない場合（回避策）を念頭に4案を提示

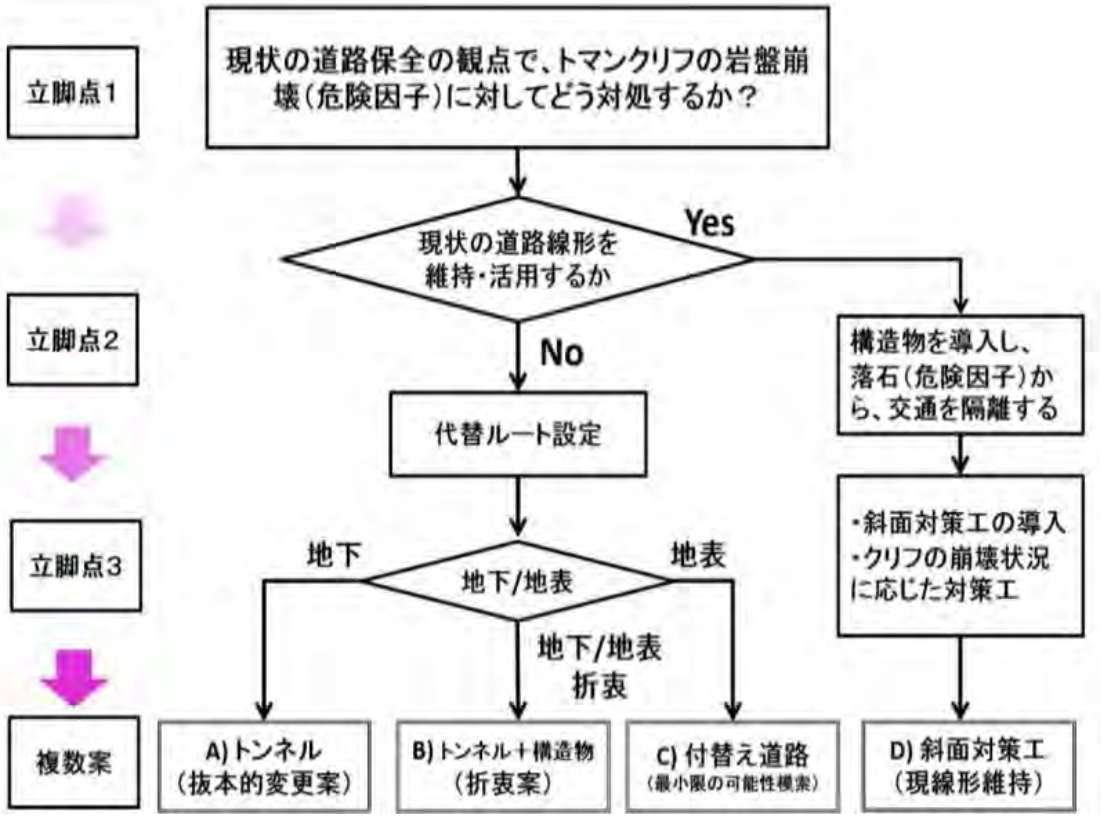
- 具体的には、以下の4案を提案する

  A案；トンネルを基本とした案（全区間トンネル）

  B案；トンネルと構造物の組合せ案（トンネル+橋梁）

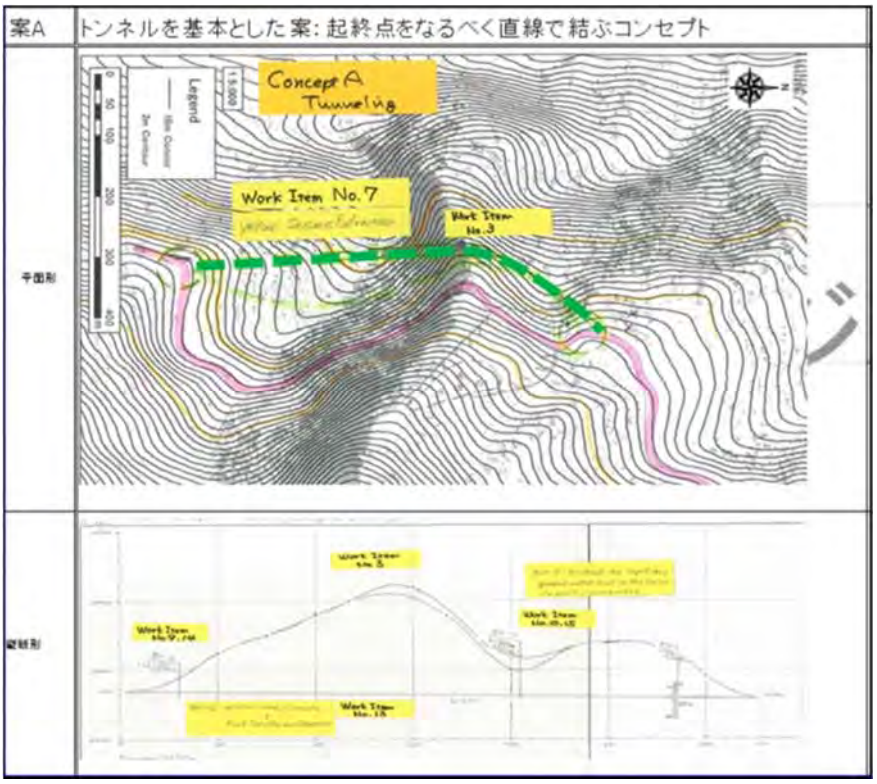
  C案；地表のルートで迂回する道路案

  D案；現状の道路線形を維持し斜面対策による案

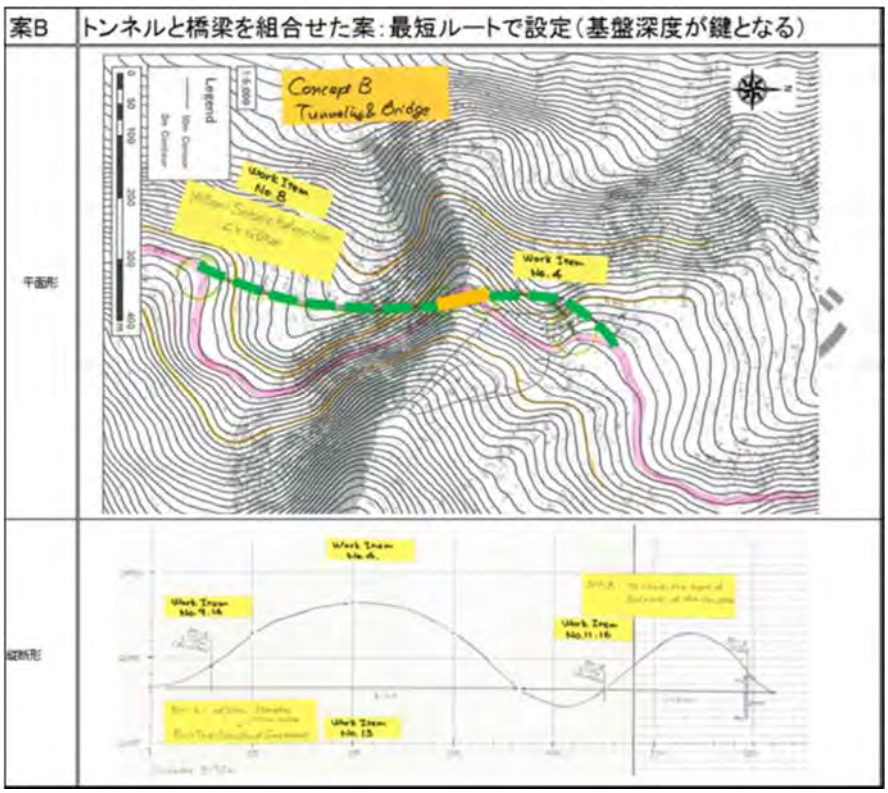


机上検討のフロー

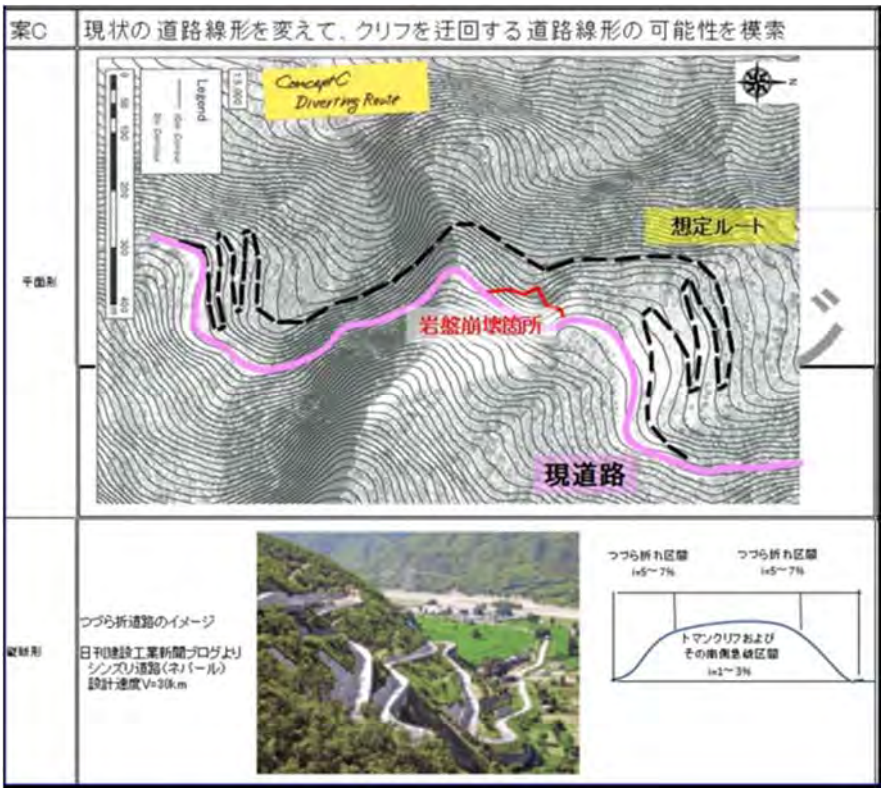
A案;トンネルを基本とした案（全区間トンネル）



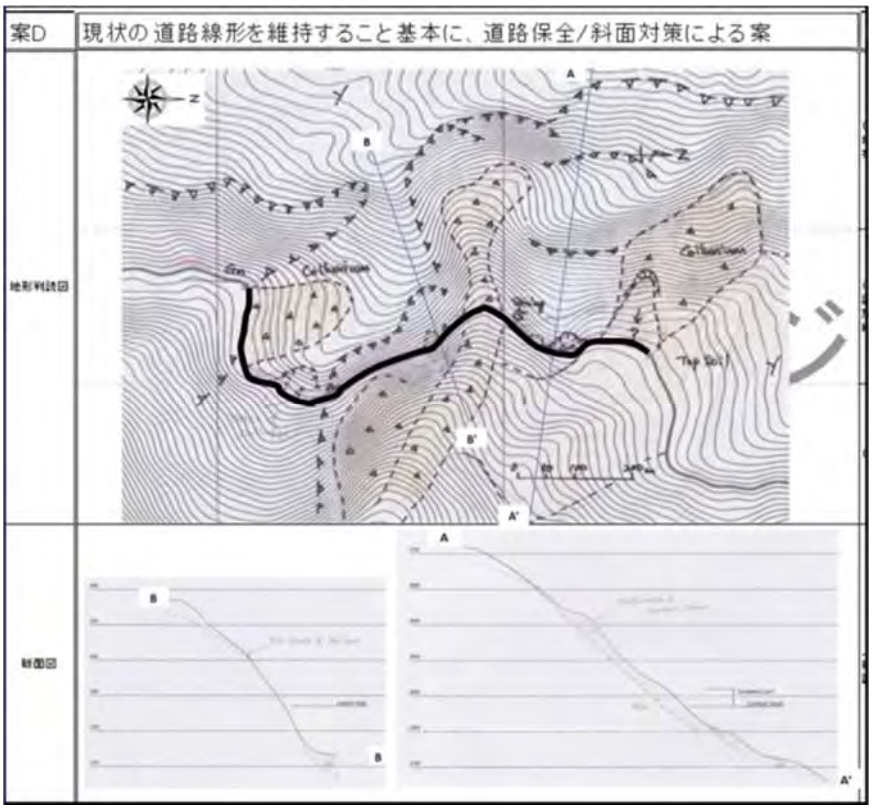
B案;トンネルと構造物の組合せ案（トンネル+橋梁）



C案；地表のルートで迂回する道路案



D案；現状の道路線形を維持し斜面対策による案

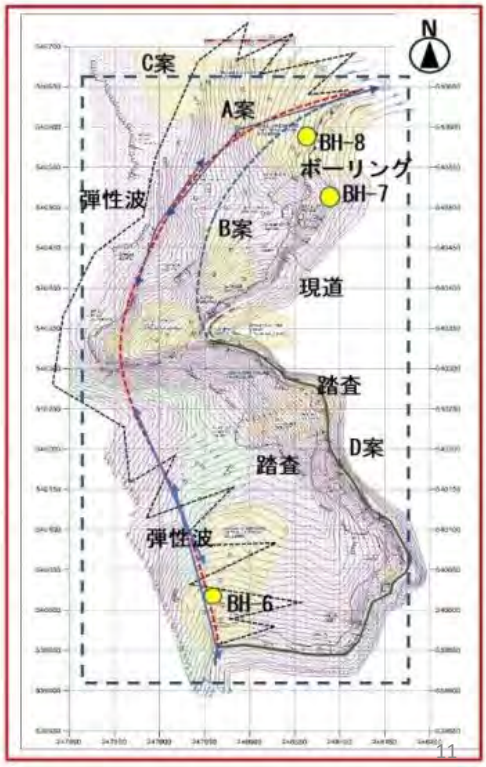


3. 自然環境条件調査

（1） 調査内容

以後の比較検討案選定作業を行うために、現地にて自然環境条件調査を実施した。

- **平面測量**：衛星画像から作成した平面図を現地測量により補足。
- **断面測量**：現道沿いの斜面11断面及びトンネルA・B案ルート沿いで実施。
- **現地踏査**：危険な急崖を除くほぼ区間全域で実施。
- **弾性波探査**：トンネルA案ルート沿いで実施。（B案ルートは未実施）
- **ボーリング調査**：トンネルルートの北側、南側坑口付近で実施。

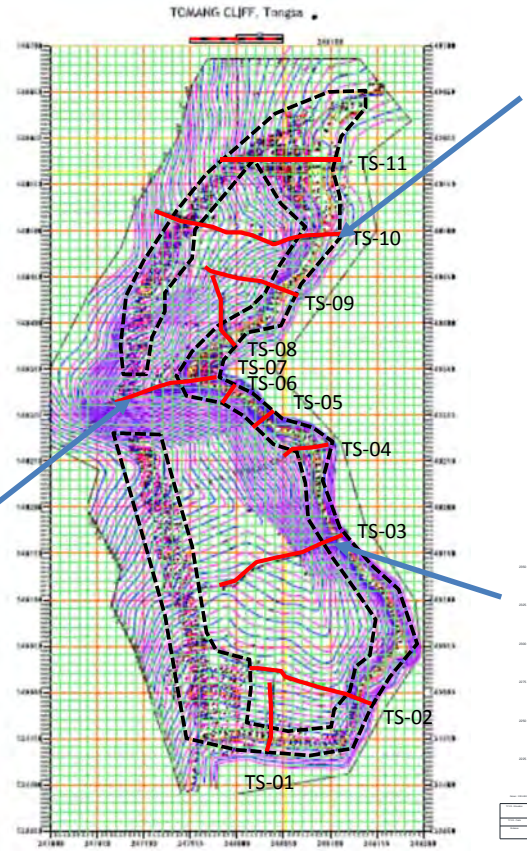


（2） 平面・断面測量結果

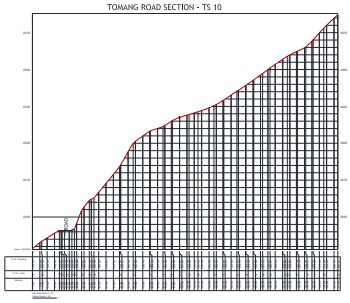
平面コンター図：
衛星画像から作成

黒破線：
現地実測範囲

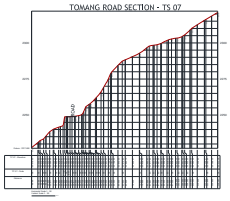
赤線：
現地断面測量線



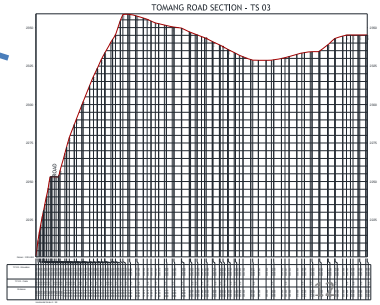
TS-10



TS-07

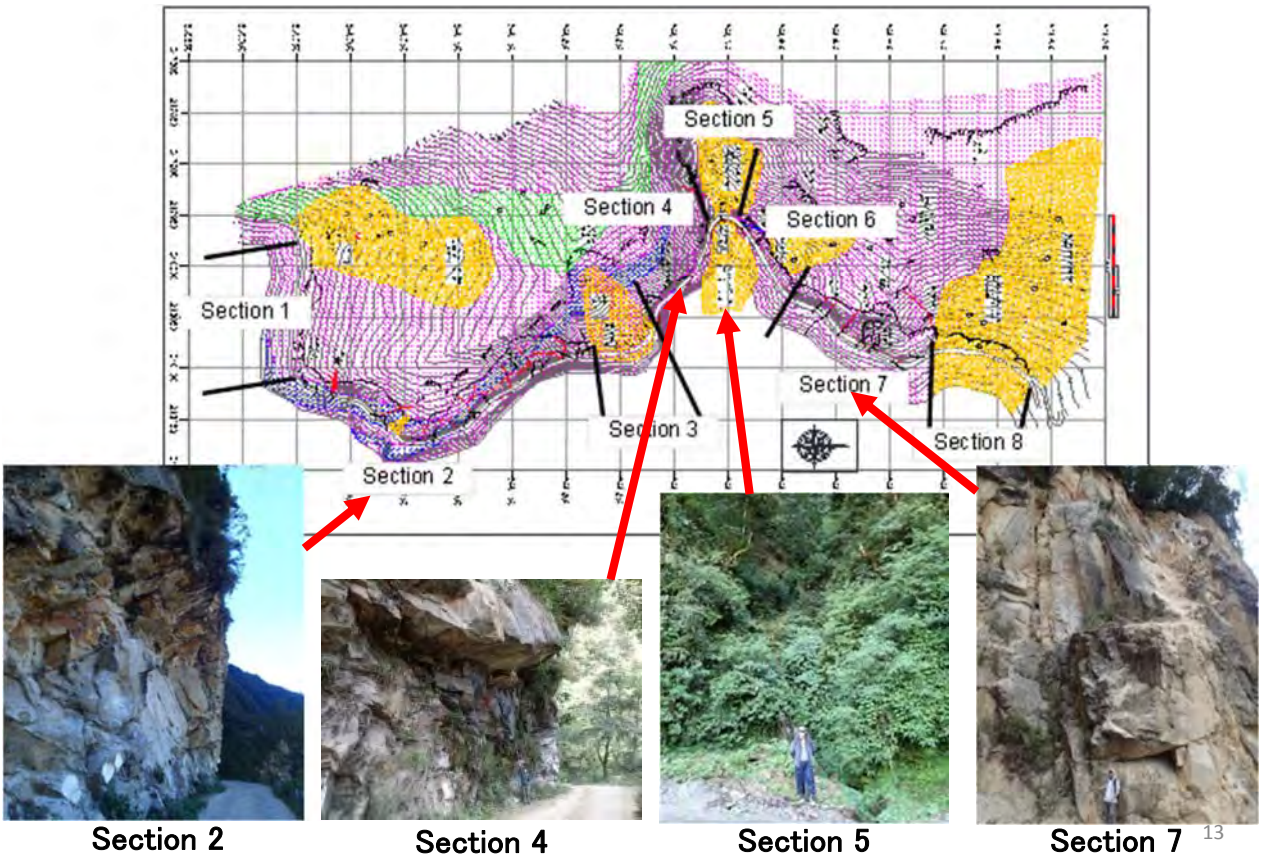


TS-03



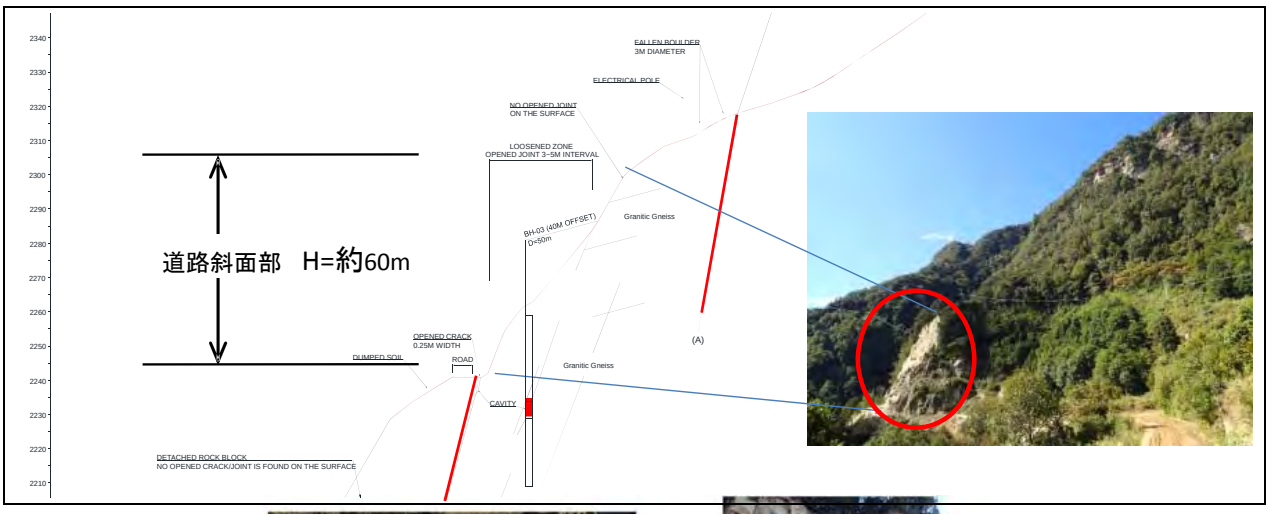
（3） 地質踏査結果

地質の分布および性状、斜面の不安定性について確認を行った。



（3） トマンクリフについて

対象道路区間で最も緩みが大きいと想定される斜面



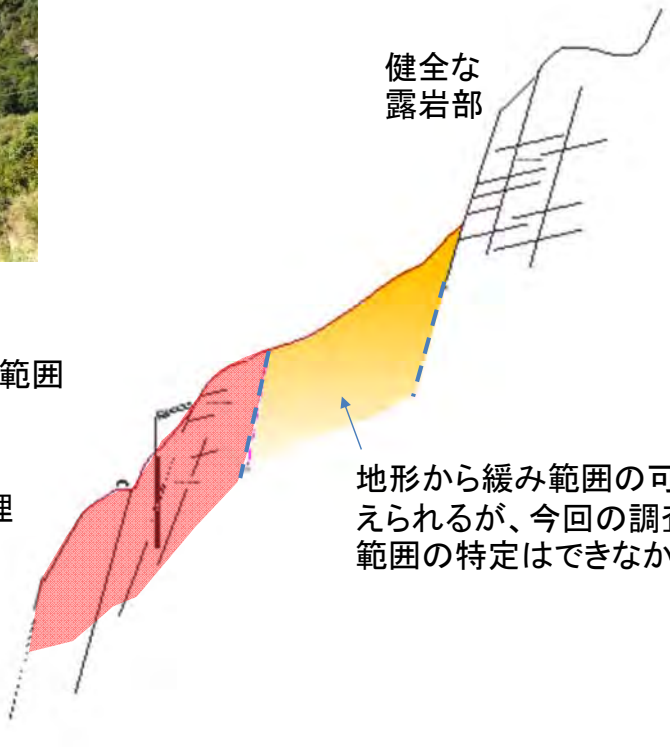
Thomang Cliff道路上の空洞

Thomang Cliff南側露頭で確認される破砕帯

（3） トマンクリフについて

想定される緩み範囲

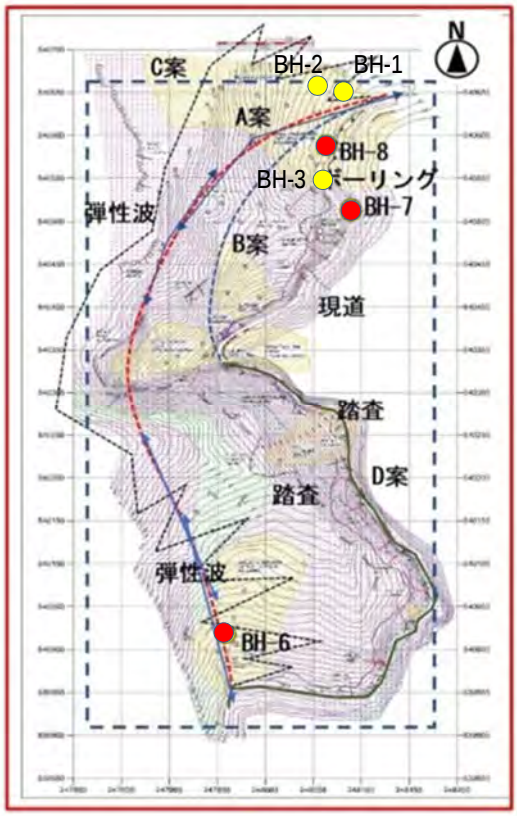
空洞
破砕帯
開口した節理

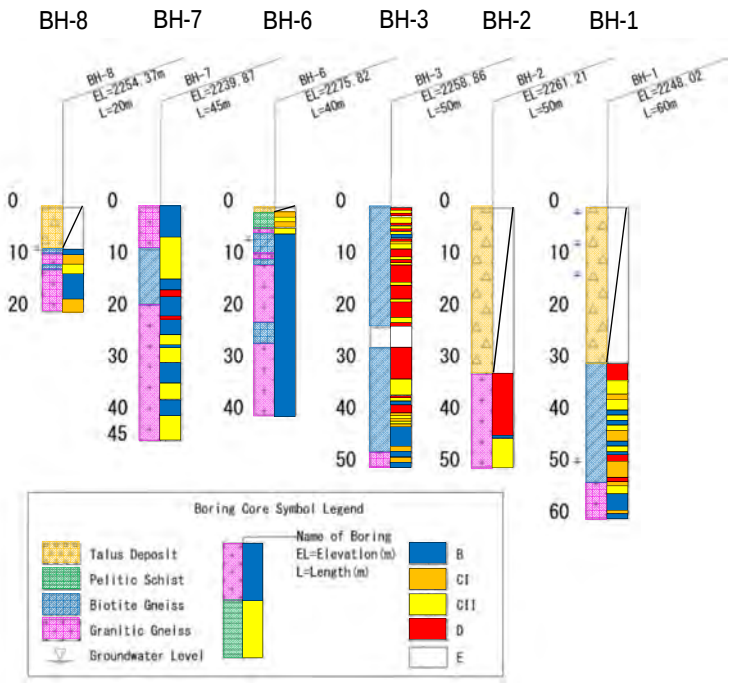


地形から緩み範囲の可能性が考えられるが、今回の調査では緩み範囲の特定はできなかった。

（4） ボーリング調査結果

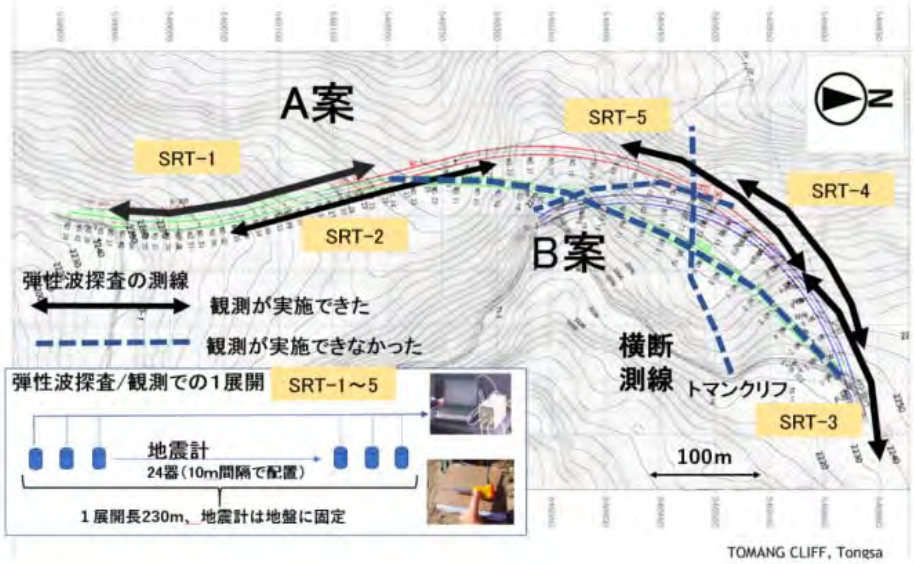
ボーリング調査によりトンネルルート上の地質状況を直接確認する。





（5） 弾性波探査

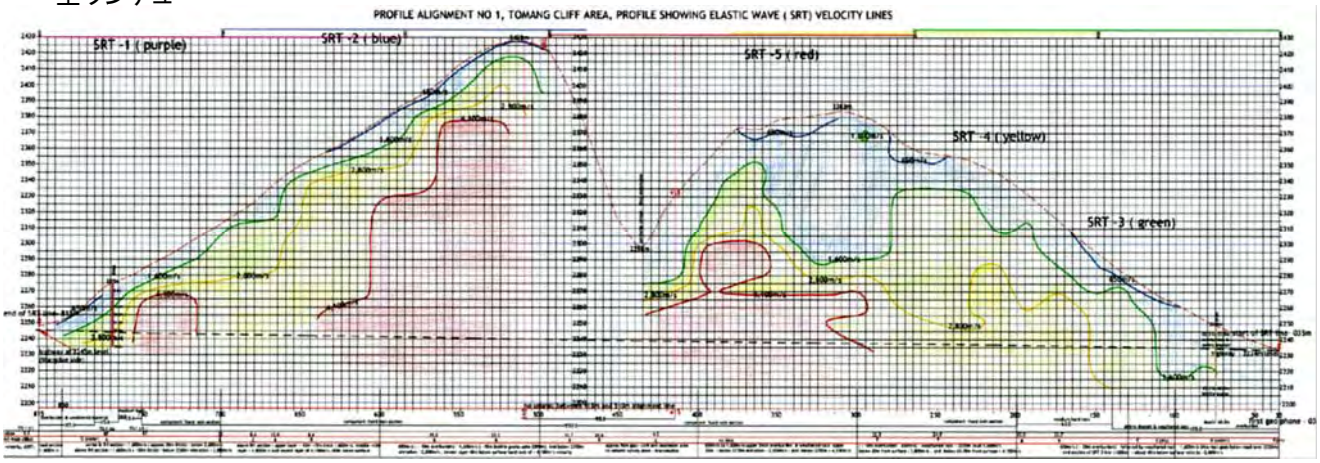
弾性波（地震波）を人工的に発生させ、地震波が地中を通る速度の差から、地中の地盤状況を推定する調査



（5） 弾性波探査

南側坑口
至ワンデュ

北側坑口
至トンサ



坑口付近：650以下～2800m/s　，　トンネル中心部：2800～4000m/s以上

（6） 調査結果とりまとめ

- 対象道路区間の北端と南端斜面は傾斜は緩いが、道路沿い斜面は70°程度の急峻な地形となる。
- 対象道路区間の中央付近に道路を横断する方向の沢地形が発達する。地形から地質的弱線が発達している可能性もあるが、今回の調査では確認することができなかった（更なる詳細調査が必要）。
- 主に、硬質な花崗片麻岩、黒雲母片麻岩、泥質片岩が分布する。
- 地表の露岩部は開口節理が発達し、またオーバーハング地形を呈し、不安定な状況である。
- トマンクリフは道路沿いの露岩斜面は、踏査やボーリングの結果から緩んだ状態であると推察される。しかしながら、背後の自然斜面まで緩み範囲が含まれるかは、今回の調査では確認できなかった。
- 今回実施した3本のボーリング調査では、片理に沿った割れ目の発達する硬質な岩石コアが採取され、計画トンネルルート両坑口付近でも、概ね健全な岩石コアが確認された。
- 弾性波探査による計画トンネルAルート沿いでの弾性波速度分布図が得られた。しかしながら、現地で確認される岩盤状況と整合しない部分もあり、今後、精査することが望ましい。

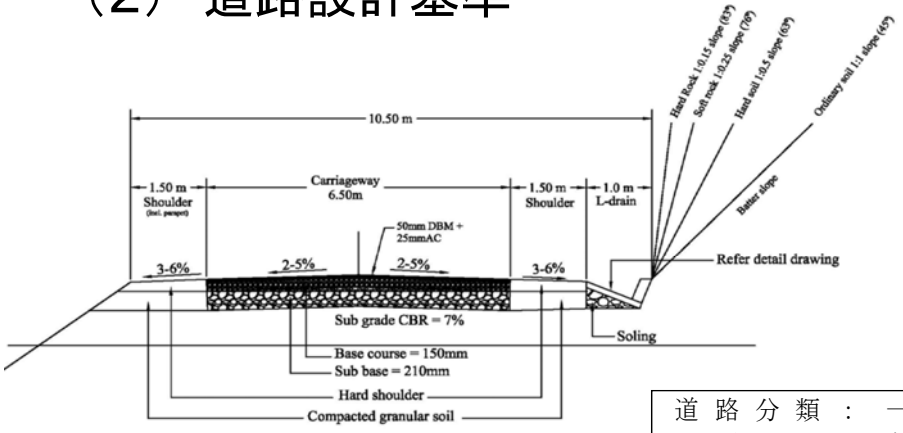
4. 現地建設事情調査

（1） 各種技術基準

道路建設に関する技術基準 （出典：JICA 調査団）

Title	Year of Issue	Authority
Guidelines on Road Classification System and Delineation of Construction and Maintenance Responsibilities	2009	MoWHS
Road pavement of Standards		DoR
Guidelines on use of Standard Work Items for Common Road Works	2010	DoR
Bhutan Schedule of Rate	2015	MoWHS
Specifications for Building & Road Works	2015	MoWHS
Indian Standard		BIS
Indian Road Congress Code		IRC
AASHTO		

（2） 道路設計基準



Primary National Highway

（出典：Guidelines on use of Standard Work Items for Common Road Works, Royal Government of Bhutan）

道路分類	：	一級国道（Primary National Highway）
地形分類	：	急傾斜地（Steep Terrain）
設計速度	：	30km/h
設計交通量	：	200 台以上/日
道路用敷地幅	：	30m
道路幅	：	6.5m
道路肩幅	：	両側 1.5m
側溝幅	：	1.0m
最小曲線半径	：	30m
舗装勾配	：	2～5%
道路肩勾配	：	3～6%
舗装タイプ	：	二層式表面処理アスファルト（DBST）
最大片勾配	：	10%
最大縦断勾配	：	7%

（3） トンネル設計基準

ブータンには<u>トンネル設計にかかる基準はない</u>。唯一の道路トンネル施工事例は国道5号線上にあり、Punatsangchhu－Ⅱ Hydroelectric Project Authorityによって建設された。設計・施工はインドの企業によるが、情報公開は拒否されたため<u>詳細な設計・積算情報は入手できなかった</u>。

Length	：	1522m
Carriage way	：	7.5m
Side walkway	：	2 X 1.5m
Higtht(Max)	：	7.5
Executed by	：	Punatsangchhu-Ⅱ Hydroelectric Project Authority
Consultant	：	Wapcos LTD
Constructed by	：	M/s Jaiprakash Associates LTD

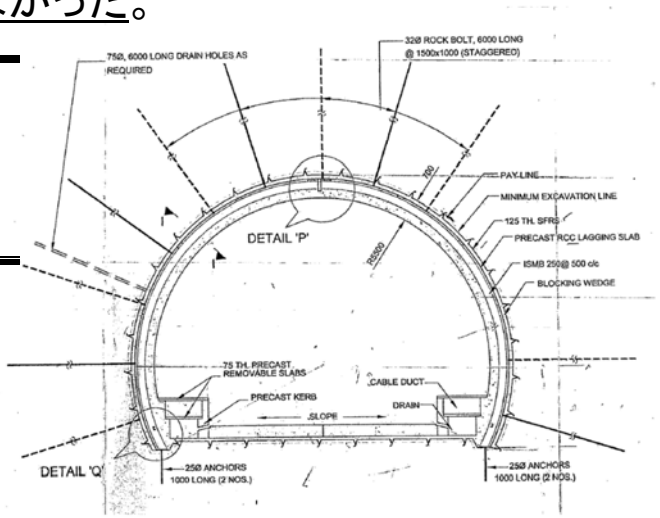


図 5.2.2 既存トンネル（国道５号線）の標準断面図 （出展：Punatsangchhu－Ⅱ Hydroelectric Project Authority より入手）

（4） 建設工事物価、建設機械調達

図5.4.1建設工事物価版, 2015

トンネル施工に関する機械の多くはブータン国内での調達が難しく、自国から輸送して使用する必要がある

主要建設機械の調達状況 （出典:JICA 既往調査報告書[*5]）

資 材 名	調 達 先		備 考
	「ブ」国内	外国より調達	
ブルドーザ	○		土工
バックホウ	○		土工
大型ブレーカー	○		土工
ホイールローダー	○		土工、資材運搬工
ダンプトラック	○		土工
トラック	○		資材運搬工
ラフタークレーン		○	上部工、下部工
グラウトミキサ		○	基礎工、上部工(PC)
グラウトポンプ		○	仮設工(アースアンカー)
ボーリングマシン		○	仮設工(アースアンカー)
モータグレーダ	○		舗装工
ロードローラ	○		舗装工
タイヤローラー	○		土工、舗装工
振動ローラ	○		土工、舗装工
タンパ	○		土工、舗装工
コンクリートミキサ	○		
空気圧縮機	○		土工
空気圧縮機	○		仮設工
発動発電機	○		
送出し資機材		○	部工
PC 桁製作用機材		○	部工
PC 桁架設用機材		○	部工

（5） 対応方針と設計基準

ブータンにはトンネルに関する設計基準がなく、唯一の国道トンネルでもDoRは技術面では直接関与しておらず詳細情報を入手できなかった。従い、本業務では、JICA「協力準備調査　設計・積算マニュアル(試行版), 2009年3月」に従い、以下の日本の諸基準を適用するものとする。

表 5.5.1 主な日本の設計基準[*7]

NO.	名 称	編集、発行所等
1	道路橋示方書（各種）	日本道路協会
2	道路構造令の解説と運用	日本道路協会
3	道路土工指針（各種指針）	日本道路協会
4	舗装の構造に関する技術基準・同解説	日本道路協会
5	舗装設計施工指針	日本道路協会
6	杭基礎設計便覧	日本道路協会
7	コンクリート道路橋便覧	日本道路協会
8	土質調査法	土質工学会
9	土質試験の方法と解説	土質工学会
10	トンネル標準示方書・同解説（各種）	社団法人　土木学会
11	コンクリート標準仕様書	社団法人　土木学会
12	港湾施設技術基準・同解説	日本港湾協会
13	漁港漁場の施設設計の手引き	全国漁港漁場協会
14	漁港構造物標準設計法	全国漁港漁場協会
15	河川砂防技術基準(案)　（各種基準案）	国土交通省
16	河川管理施設等構造令	日本河川協会
17	ダム設計基準	日本大ダム会議
18	多目的ダムの建設	全国建設研修センター
19	土地改良事業計画設計基準	農林水産省
20	土地改良事業計画作成便覧	農林水産省
21	JIS ハンドブック（各種）	日本規格化協会
22	水道施設設計指針	日本水道協会

表 5.5.2 主な日本の積算基準[*7]

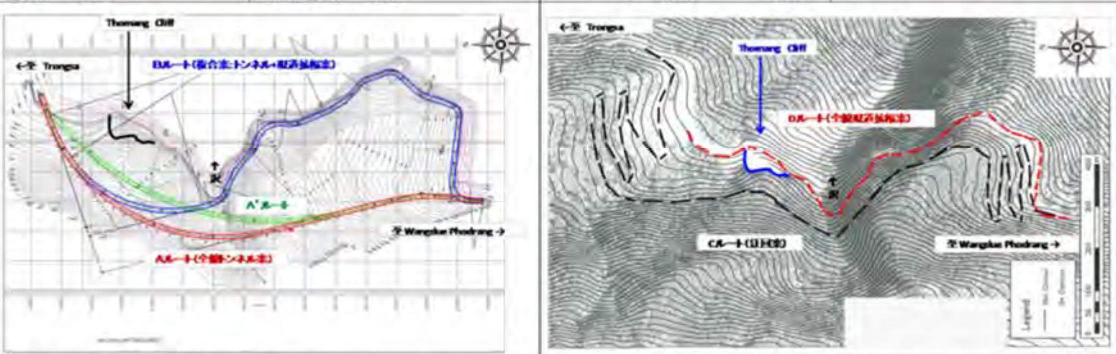
NO.	名 称	編集、発行所等
1	国土交通省土木工事積算基準	国土交通省
2	国土交通省建築工事積算基準	国土交通省
3	土地改良工事標準積算基準	農林水産省農村振興整備部
4	水道事業実務必携	全国簡易水道協議会
5	国土交通省下水道工事積算基準	国土交通省都市・地域整備局下水道部
6	港湾土木請負工事積算基準	国土交通省港湾局
7	空港土木請負工事積算基準	国土交通省航空局
8	航空無線工事積算基準	国土交通省航空局
9	橋梁架設工事の積算	(社)日本建設機械化協会
10	森林整備必携治山・林道設計編	森林科学研究所
11	国土交通省機械設備工事積算基準	国土交通省総合政策局建設施工企画課
12	建設機械等損料算定表	国土交通省総合政策局建設施工企画課
13	船舶及び機械器具等の損料算定基準	国土交通省港湾局
14	関係各省庁・独立行政法人・特殊法人制定の積算関連基準	都市再生機構、日本下水道事業団等の機構、公団、事業団等。
15	建設工事標準歩掛	財団法人　建設物価調査会
16	工事歩掛要覧	財団法人　経済調査会

5. 基本計画案（一次選定）

机上検討において提案した4案に対し、自然環境条件調査・現地建設事情調査を実施し、本事業としての基本計画案を作成・検討し、一次選定として現実的な2案を選定した。

- ・Aルート：全線トンネル案：〇採用
- ・Bルート：複合案（最短トンネル+現道拡幅案）：△採用
- ・Cルート：迂回案：×不採用
- ・Dルート：現道拡幅案：×不採用

表6.1.2　一次選定比較表　（出典：JICA調査団）


基本計画案 比較表(現地踏査後の一次選定)

項目＼ルート名称	Aルート		Bルート		Cルート		Dルート	
選定趣旨	トマンクリフの崩み領域を避けるとともに、その南側の沢をトンネルで通過するルート		トマンクリフの崩み領域をトンネル構造にて避け、トンネル延長を最も短くしたルート		トマンクリフの崩み領域を斜面上方へ避けたルート		現道を拡幅するルート	
延長	総延長 L= 0.8 km 土工延長 L= 0.1 km トンネル延長 L= 0.7 km		総延長 L= 1.1 km 土工延長 L= 0.8 km トンネル延長 L= 0.3 km		総延長 L= 3.4 km 土工延長 L= 2.0 km L= 1.4 km		総延長 L= 1.2 km 土工延長 L= 1.2 km	
概略図	[illegible]							
現地踏査結果	[illegible]		[illegible]		[illegible]		[illegible]	
走行性	[illegible]	○	[illegible]	△	[illegible]	△	[illegible]	○
施工性・安全性	[illegible]	○	[illegible]	△	[illegible]	×	[illegible]	×
環境・景観	[illegible]	○	[illegible]	△	[illegible]	△	[illegible]	△
一次選定評価	[illegible]	○	[illegible]	△	[illegible]	×	[illegible]	×

Aルート採用（○）の主な理由

- Aルートは4案中最もスムーズな平面・縦断線形で計画できまたその組み合わせも良いため、走行性が最も良い。また施工ヤードの確保、地形地質状況や周辺状況から施工性・安全性、景観・環境の点からも優れているため、採用案とする。

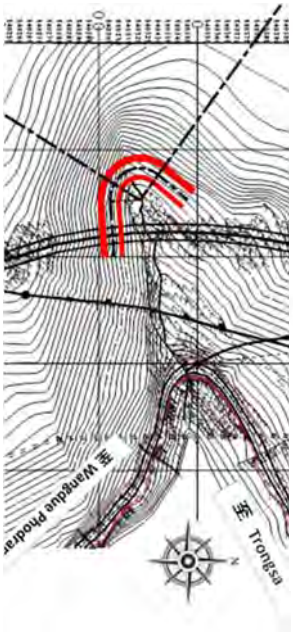
Bルート採用（△）の主な理由

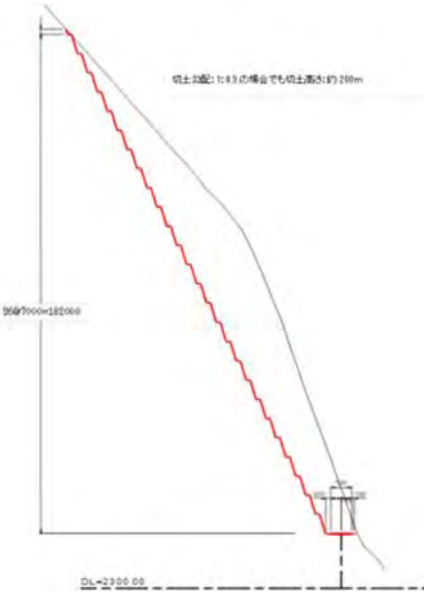
Bルートはトンネルの施工性に関してはAルートと同様であるが、現道部の施工は大規模土工となる。道路線形は現道部の線形が悪く、またトンネル部との接合部の組み合わせが悪いため走行性に劣る。課題はあるがトマンクリフの岩盤崩壊対策となるため、採用案とする。

Cルート不採用（×）の主な理由

① 起点側土地は、水力発電事業の関連施設が建設されている

② トマンクリフ南側の沢部は地形が非常に急峻で土工での通過が困難。また、薄い切土高が200m近くにもなり、非現実的である。





③ トマンクリフの緩み領域を避けると、今回検討区間の現道1.2kmに対して迂回案延長が3.4kmとなり約3倍となり現実的でないこと

Dルート不採用（×）の主な理由

トマンクリフの現道部は緩みのある不安定な状況の岩盤部に位置するため、風化（降雨、地震、交通震動等）により現道を含んでの崩壊の可能性は否定できない。（緩み領域を避けるにはトンネル案あるいは迂回案となる）

トマンクリフのり尻に生じている現道上の空洞　（出典：JICA 調査団）

6. 概略設計

一次選定で抽出された2案に対して、概略設計として基本設計図を作成した。

・Aルート：全線トンネル案

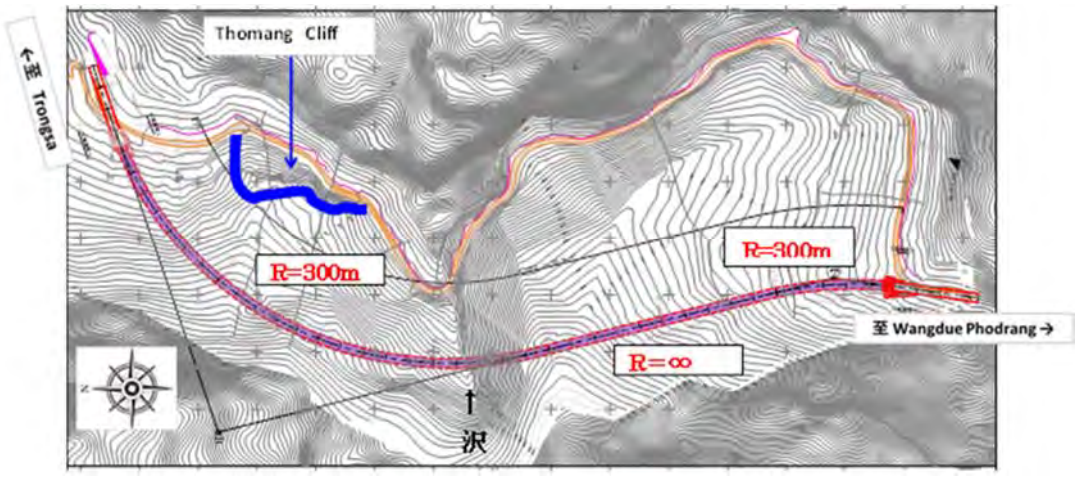
・Bルート：複合案

（最短トンネル+現道拡幅案）

図面名称		縮尺	備考
トンネル案（Aルート）			
平面図		1：2,500	
平面図		1：1,000	
縦断図	(1)、(2)	1：1,000	
地質縦断図	(1)、(2)	1：1,000	
標準横断図(1)	CⅠ、CⅡ断面	1：30	以下トンネル部
標準横断図(2)	DⅠ断面	1：30	
標準横断図(3)	DⅢ-1、DⅢ-2断面	1：30	
加背割図（1）	CⅠ、CⅡ断面	1：60	
加背割図（2）	DⅠ、DⅢ-1、DⅢ-2断面	1：60	
支保パターン図（1）	CⅠ断面　吹付け・ロックボルト工図	1：60	
支保パターン図（2）	CⅡ断面　吹付け・ロックボルト工図 鋼アーチ支保工図	1：60	輸送重量算出
支保パターン図（3）	DⅠ断面　吹付け・ロックボルト工図 鋼アーチ支保工図	1：60	輸送重量算出
支保パターン図（4）	DⅢ-1断面　吹付け・ロックボルト工図 DⅢ-1、DⅢ-2断面　鋼アーチ支保工図	1：60	輸送重量算出 注入式フォアボーリング
支保パターン図（5）	DⅢ-2断面　吹付け・ロックボルト工図	1：60	輸送重量算出 長尺鋼管先受工
複合案：トンネル+現道拡幅（Bルート）			
平面図		1：2,500	
平面図		1：1,000	
縦断図		1：1,000	
地質縦断図		1：1,000	

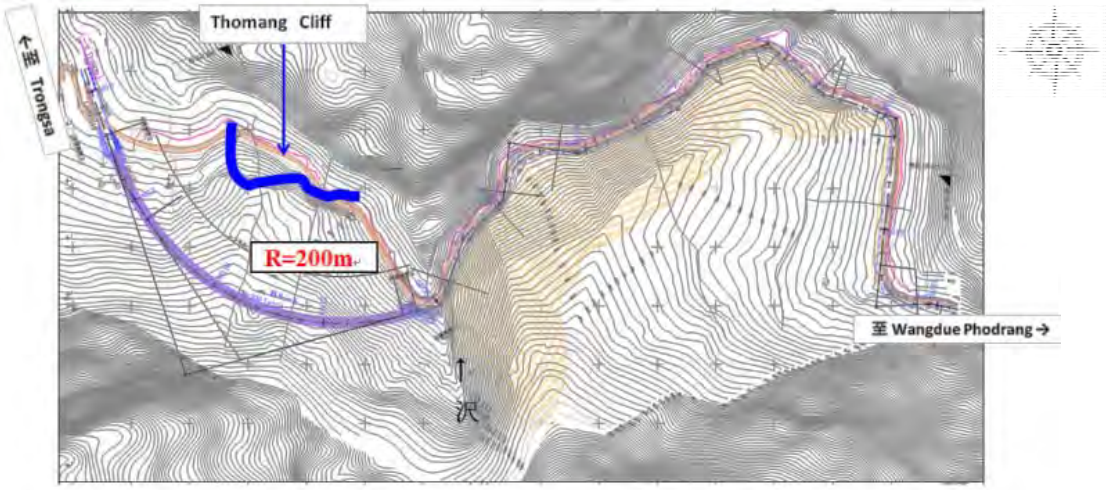
※トンネル部図面はAルート、Bルート共通

Aルート：全線トンネル案



- トマンクリフの緩み領域と沢地形をトンネル構造にて避けた全線トンネルルート
- 延長はL=840m（トンネル区間L=745m）となり、現道に対し370m短い（−30%）
- 標高は起点側（北側）が低く、単一勾配でi＝1.57%となった。これは換気上望ましい勾配3%以下を満足する。
- 北側坑口付近での施工ヤード確保できる。

Bルート：（複合案：トンネル+現道拡幅案）



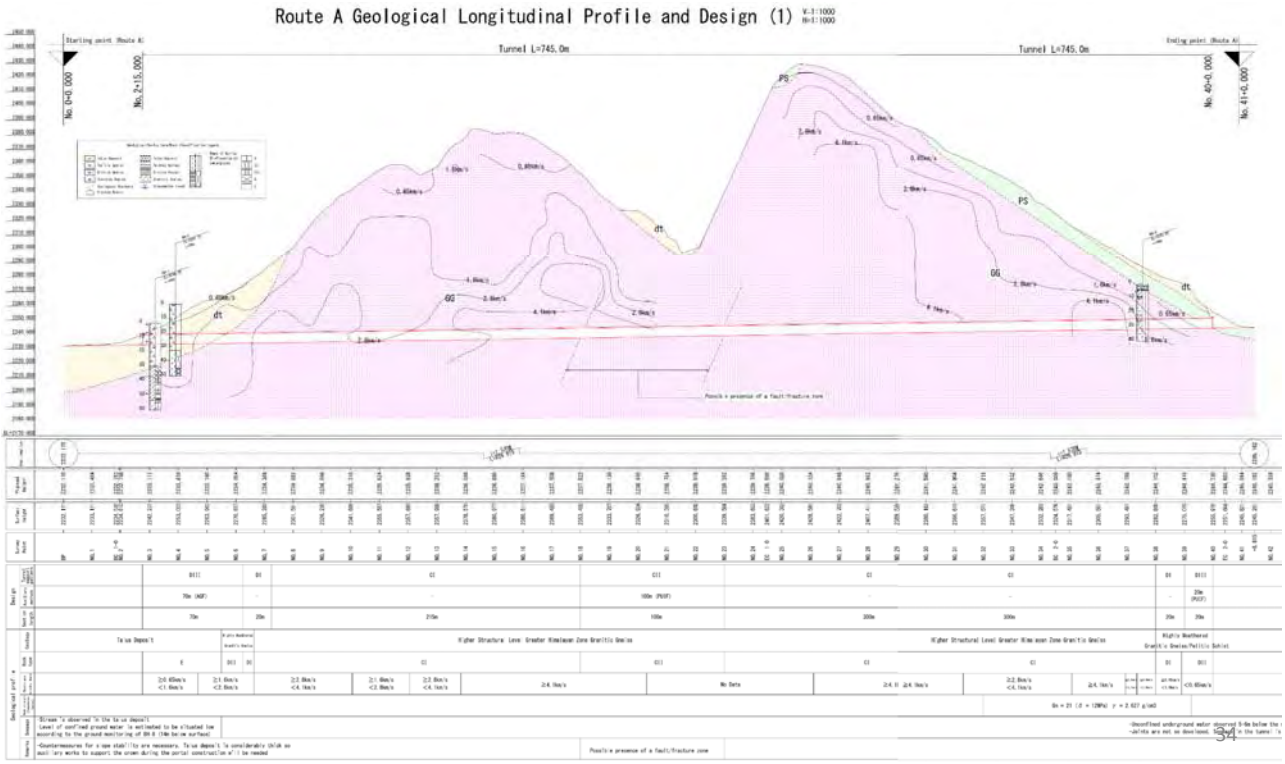
- トマンクリフの緩み領域をトンネル構造にて避け、平面線形R=200mにてその南側の沢へ接続するルート。
- トンネル延長を最も短くしたルート。
- 南側坑口からは現道の線形沿いにルートを切土工にて拡幅する。
- 延長はL=1090m（トンネル区間L=331m）となり、現道に対し120m短い（−10%）。

トンネル設計について

- 本調査において、得られた自然環境条件調査結果と本邦の技術基準や標準示方書（前述（5）設計基準）に則り、トンネル計画設計は下記のように検討・判断した。

	トンネル設計検討事項
・トンネル工法	NATM工法
・掘削方式	発破掘削 （ＣⅠ、ＣⅡ、ＤⅠ、ＤⅢ-1、ＤⅢ-2の5断面）
・掘削工法	D断面は上半先進のベンチカット工法、C断面は全段面工法（ミニベンチカット工法）
・ずり処理	ずり積作業はクローラ式バックホウ、ずり運搬はタイヤ方式
・補助工法	補助工法は両坑口部および、沢部（断層破砕帯部？）に計画している。起点側坑口部においては、地質調査結果にて、「巨礫混じり土砂が存在し、特殊な岩質（大きな崖錐、大きな断層/破砕帯等の度圧が著しい岩質）で内空変位が200mm程度以上になるもの」と想定されており、長尺鋼管フォアパイリングを計画している。断層破砕帯部と終点側坑口部は、切羽天端の安定対策として、注入式フォアポーリングを計画している

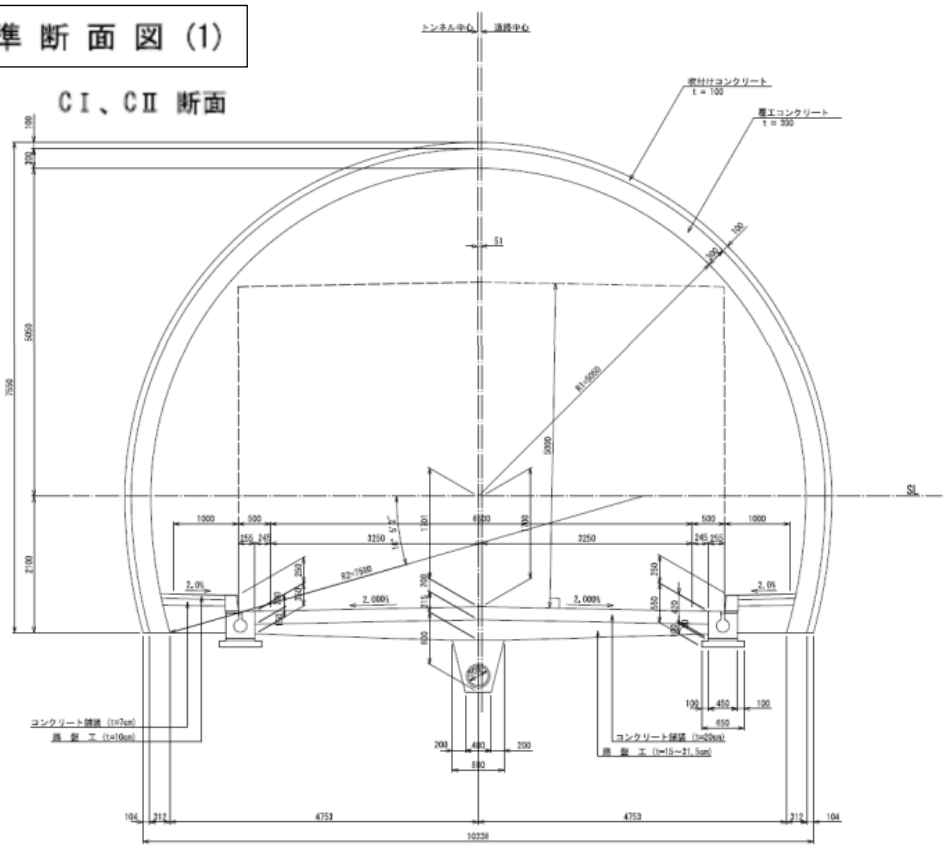
Aルート （全線トンネル案）/概略設計



Aルート （全線トンネル案）/概略設計

標 準 断 面 図 (1)

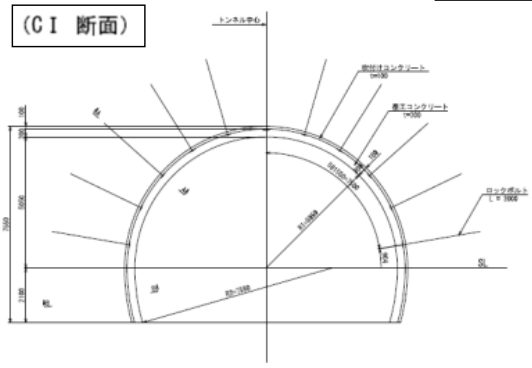
CⅠ、CⅡ 断面



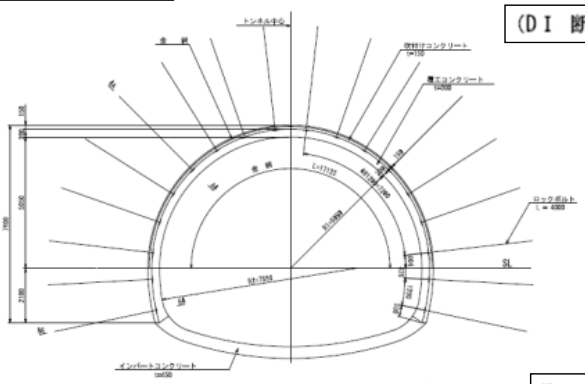
Aルート （全線トンネル案）/概略設計

支 保 パ タ ー ン 図

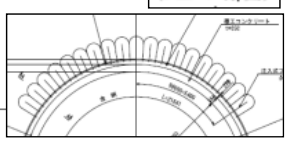
(CⅠ 断面)



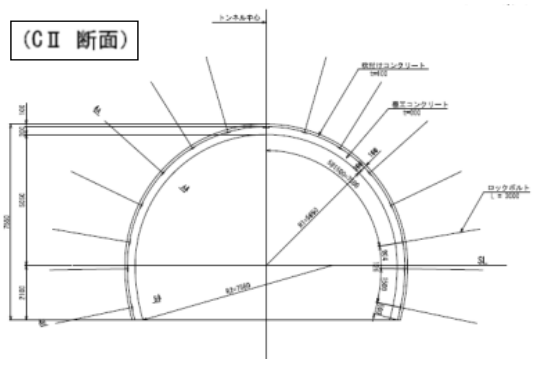
(DⅠ 断面)



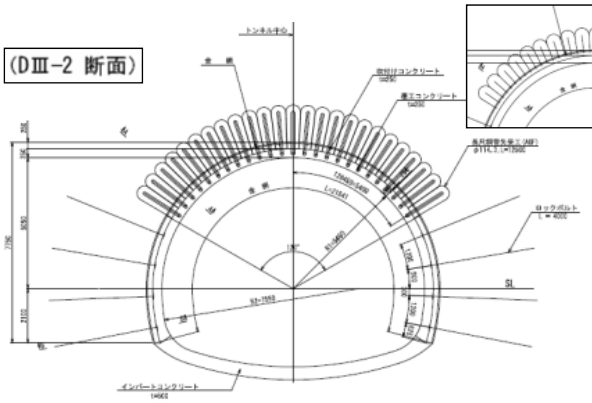
(DⅢ-1 断面)



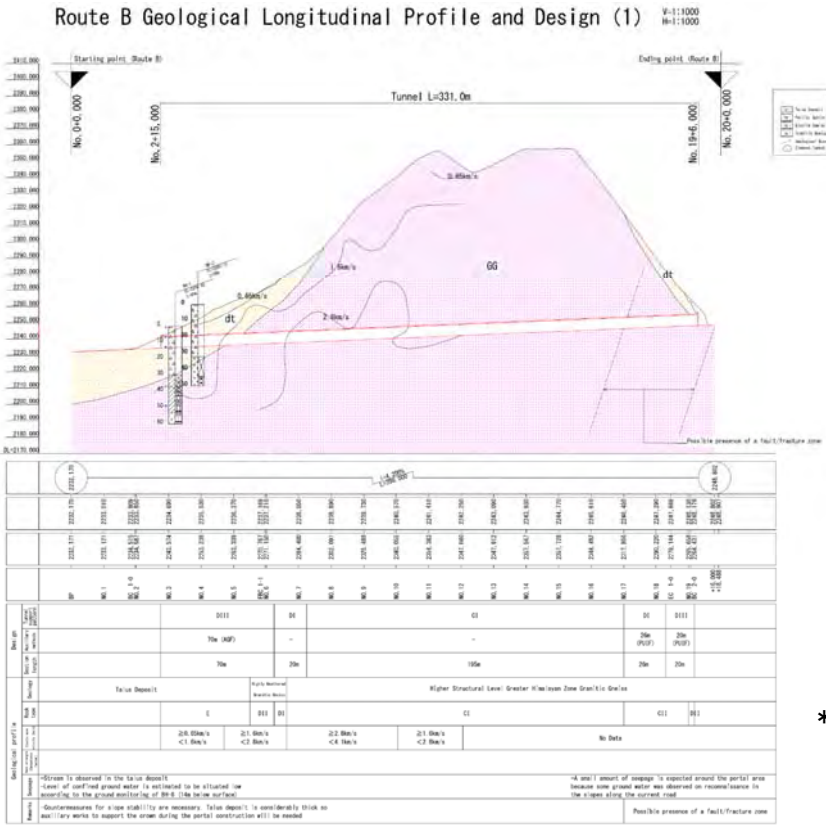
(CⅡ 断面)

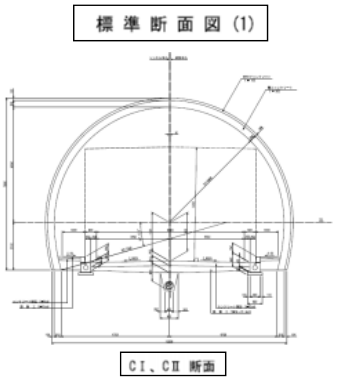


(DⅢ-2 断面)



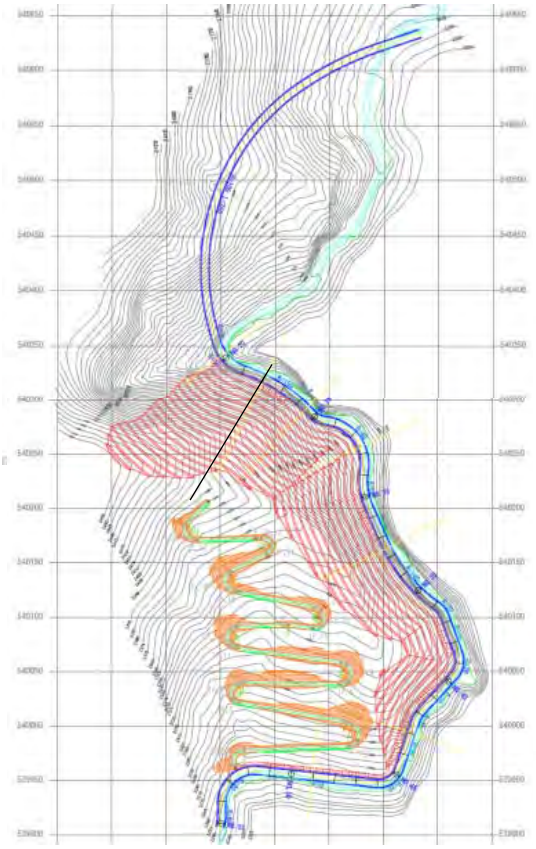
Bルート （複合案:トンネル+現道拡幅案）/概略設計

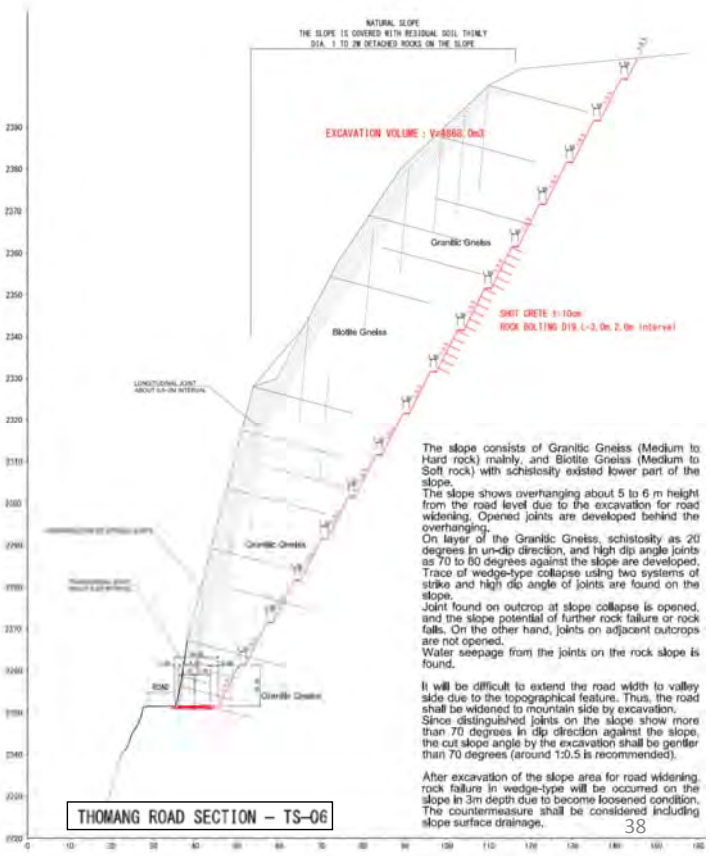




＊標準断面及び支保パターンはAルートと同じ

Bルート （複合案:トンネル+現道拡幅案）/概略設計





The slope consists of Granitic Gneiss (Medium to Hard rock) mainly, and Biotite Gneiss (Medium to Soft rock) with schistosity existed lower part of the slope.
The slope shows overhanging about 5 to 6 m height from the road level due to the excavation for road widening. Opened joints are developed behind the overhanging.
On layer of the Granitic Gneiss, schistosity as 20 degrees in un-dip direction, and high dip angle joints as 70 to 80 degrees against the slope are developed. Trace of wedge-type collapse using two systems of strike and high dip angle of joints are found on the slope.
Joint found on outcrop at slope collapse is opened, and the slope potential of further rock failure or rock falls. On the other hand, joints on adjacent outcrops are not opened.
Water seepage from the joints on the rock slope is found.

It will be difficult to extend the road width to valley side due to the topographical feature. Thus, the road shall be widened to mountain side by excavation.
Since distinguished joints on the slope show more than 70 degrees in dip direction against the slope, the cut slope angle by the excavation shall be gentler than 70 degrees (around 1:0.5 is recommended).

After excavation of the slope area for road widening, rock failure in wedge-type will be occurred on the slope in 3m depth due to become loosened condition. The countermeasure shall be considered including slope surface drainage.

7. 比較評価（二次選定）

２案に対して、概略設計・概略事業費・施工計画・留意事項等を比較検討し、最適案としてAルート（全線トンネル案）を選定した。

	A ルート	B ルート
延長	840m（現道-370m）	1090m(現道-120m)
走行性（線形計画・線形の調和）	○	△
施工性・安全性	○	△
環境・景観、メンテナンス	○	△
経済性	○	△
総合評価	○	△

表8.1.2　ルート比較表（二次選定）（出典：JICA調査団）

項目	Aルート （全線トンネル案）	Bルート （複合案：トンネル+現道拡幅案）
選定趣旨及び路線概要	・トマンクリフの緩み領域及びその南側の沢をトンネル構造にて避けた全線トンネルルート。 ・北側の基点部は、拡幅施工中の現道の方向と谷側石積み擁壁をコントロールし、平面線形R=300mにてトマンクリフの緩み領域を避け、沢部の土被りを確保（約50m：5D）した位置を通過する。直線区間を200m挟み、南側の終点部の拡幅施工中の現道の方向をコントロールし反向平面曲線R＝300mにて接続する。	・トマンクリフの緩み領域をトンネル構造にて避け、トンネル延長を最も短くしたルート。 ・北側の基点部は、拡幅施工中の現道の方向と谷側石積み擁壁をコントロールし、トマンクリフの緩み領域を避け、平面線形R=200mにてその南側の沢へ接続する。南側坑口からは現道の線形沿いにルートを計画する。
延長	**総延長：現道-370m　L＝840m** （No.0+0～No.42+0）	**総延長：現道-120m　L＝1090m** （No.0+0～No.54+10）
	土工延長　　L＝　95m （11.3%）	土工延長　　L＝759m （69.6%）
	トンネル延長　L＝745m （88.7%）	トンネル延長　L＝331m （30.4%）

表8.1.2　ルート比較表（二次選定）（出典：JICA調査団）

項目	Aルート （全線トンネル案）		Bルート （複合案：トンネル+現道拡幅案）	
走 行 性 ・線形計画 ・線形の調和	・トンネルと明かり部の取り合いはスムーズな線形が確保できる。 ・トンネル縦断勾配　i=1.57%（換気上望ましい勾配：3%以下） ・平面線形R＝300mは設計速度V＝80km/h（設計条件30km/h）をも満足するほどの良い線形である。 ・前後の線形に比べ、当該区間の線形が非常に良いため、速度抑制対策が必要となる。（現道に比べ370m（延長比30%）の短縮効果がある）	○	・北側からの南向き走行（Wangdue方向）に対しては、トンネル内のゆるい曲線（R=200m）から、明かり部の急カーブ（R=40m）となるため、平面線形上好ましくない組み合わせとなる。 ・トンネル縦断勾配 i=4.2%（換気上望ましい勾配:3%を超える勾配） ・本調査では現道拡幅を基本に考えたため、設計速度V＝30km/hの最小曲線半径R＝30mを満足していない。線形改良に応じて切土量が増加し事業費が増加する。	△

表8.1.2　ルート比較表（二次選定）（出典：JICA調査団）

項目	Aルート （全線トンネル案）		Bルート （複合案：トンネル+現道拡幅案）	
環境・景観 メンテナンス	・騒音や排気ガスはトンネル坑口に集中するものの、景観的には地山の中を通過し、良好である。（調査計画、設計、施工、維持管理の各段階で環境影響評価が必要） ・残土処理6万m3（地山）が課題。 ・照明、非常用施設の維持費用が必要。 ・舗装はコンクリート舗装にてBルート土工部に比べ長期の運用可能。	○	・切土が大きくなり、（最大高さ200m、コンクリート吹付けのり面積56千m2）地形改変の面積が大きく、周辺の景観への影響が大きい。（環境影響評価は同左：特に、調査計画段階でのアセスメント評価の検討が必要） ・残土処理129万m3が課題。 ・長大のり面の計画的な点検・維持管理が必要。（Aルートに比べ多大）	△
経 済 性	概略事業費：3,263　百万円 （3,880百万円/km）	○	概略事業費：5,255　百万円 （4,821百万円/km）対Aルート1.6倍	△
その他 特記事項	・建設残土の有効利用計画（造成等優良な土地への対応）を検討する必要有り ・北側（起点側）で事業を実施しているTangsibji水力開発（施工者HCC）の進入路や施工エリアの調整が生じる。 ・本計画区域以外の道路拡幅は、本計画と同様の幅員（W=7.5m）にて現在施工中。（完成予定2017年12月:トンネルの施工計画に織り込む必要有り）			
総合評価	比較項目全てにおいてAルートが優位となる。			

8. 今後の事業に係る提言

（1） JICA事業への提言

・有価物の有効利用
（土地利用/建設材料転換/施設材料へ）
・土捨てを減らしたい

1. 環境社会配慮の観点で

・建設発生土の有効利用について

掘削工事

掘削ズリ発生

岩石 → 石材、路盤材料、擁壁材料、その他

砂 → 活用の方向性模索
・盛土の宅地盤活用
・盛土の植生化

土/粘土 → 再利用は厳しいか？（最終処分）

2. 建設企業/海外展開の観点で

山岳トンネル施工技術に強い本邦企業 → 現地施工の機会活用

連携の機会創出

現地建設企業（H.C.C）

トンネルでは、シールドが強いが、山岳は弱い。

（2） DoRへの提言

1. 利用者安全への取組（短期）

安全利用に向けた取組
・標識/注意喚起
・啓蒙（安全速度/ライト）

2. 維持管理、保守、（長期）

「みち」を守ってきた歴史とその取組の姿勢を汲み取ってほしい.

今、ここまで来た！ 「道守の気概は変わらない。」 昔はこうだった！

将来の調査への申し送り事項として

- 自然環境条件調査　→　設計精度の向上
  1.ボーリング(トンネル中間部)
  2.弾性波探査/トモグラフィ解析(1.活用)
  3.土捨て場調査(追加)
  4.環境影響評価の実施
- 施工
  1.不確実性低減技術の活用;トンネル前方探査技術
  2.掘削ズリ活用策;盛土/宅盤/造成(平地創生)/緑化
  3.掘削ズリ活用策;石材の有効利用
  4.建設労働者の待遇改善;賃金/安全衛生(昼夜作業)

以上です！有難うございました。

現地全景(トンサから)

トマンクリフ、南側から

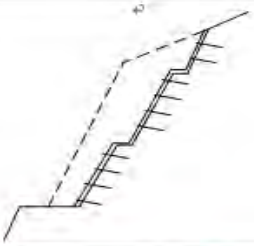
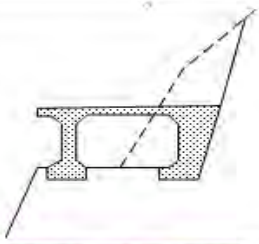
トマンクリフ

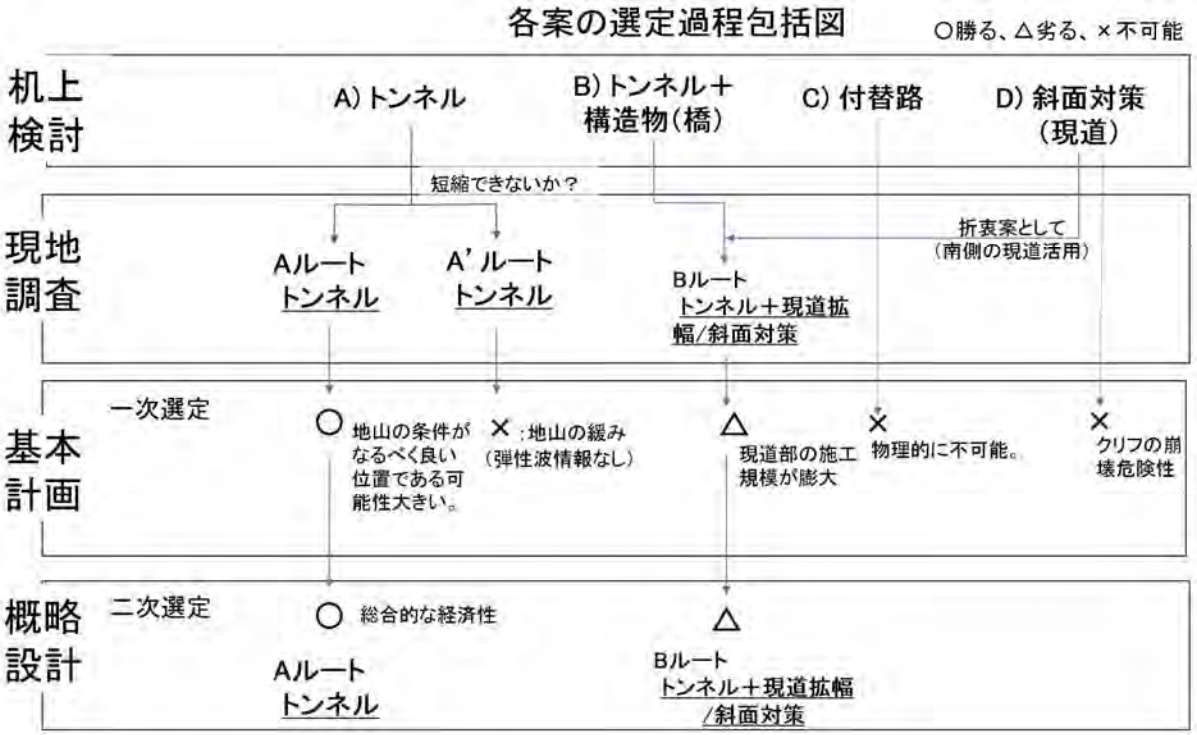
トンサの街

トンサタワー

ドチュラ峠から

表7.2.1　落石対策比較検討結果一覧表　（出典：JICA調査団）

	落石予防工（発生源対策）	落石防護工（待ち受け対策）
対策工種	切土工（不安定岩塊除去） コンクリート吹付＋鉄筋挿入工 （表層保護・風化他対策）	ロックシェッド工
対策イメージ		
対策断面		
利点 問題点	・規道を供用しながらの施工が可能（周辺集落への影響が殆どない） ・落石の初動を防止するため、比較的小さなエネルギーを対象とすることとなり、対策規模は小規模となる。 ・対策後の落石発生リスクは殆どない。	・施工時は道路を通行止めする必要あり（現道は重要アクセス道であるため周辺集落へ多大な影響を及ぼす） ・斜面上方から落下してくる大きな落石エネルギーを吸収する必要があるため、規模が大きな対策となる。 ・斜面は未対策であるため風化進行による落石発生リスクを伴う。
評価	○	△



Pre-feasibility Study for Permanent Countermeasure against the Thumang Cliff

25/Jan/2017

JICA experts team formed by

Kokusai Kogyo co.,ltd.

OYO international

Earth Science System co., ltd.

Oriental Consultants Global co., ltd.

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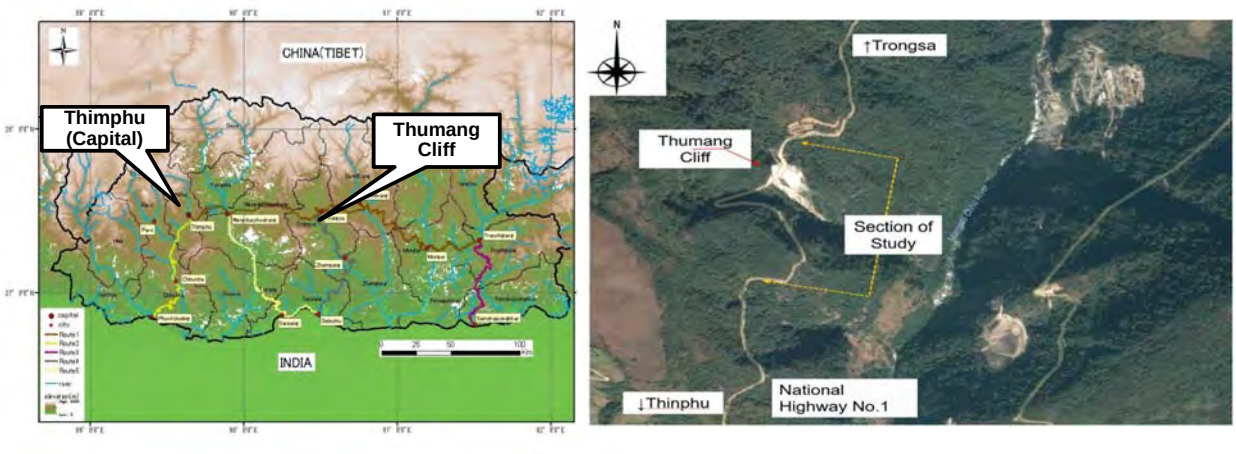
1. Summary

（1） Outline

The pre-feasible study was implemented at the Thumang Cliff for the permanent countermeasure against the Hazards of Rockfall/Slope-Failue.

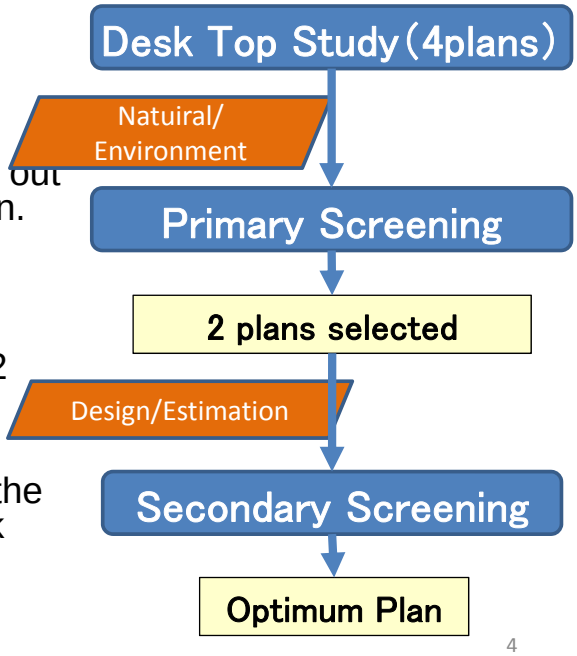


（2） Procedure of this Study

①Theme; Permanent Countermeasure has be examined against the Rockfall/Slope-Failure on the Thumang Cliff from the wide perspectives with the outcome in the previous project included.

② Practical Work
2-1 Primary: 4 Plans prepared,
2-2 Secondary: 2 viable plans screened out on the Natural/Environment investigation.
(First Screening/2 out of 4).
2-3 Design/Estimation/Construction Planning for 2 Plans
2-4 Examination/Comparison between 2

③Constraints
Some level of limitation was allowed in the Practical Work because the limited work period generated the uncertainty.

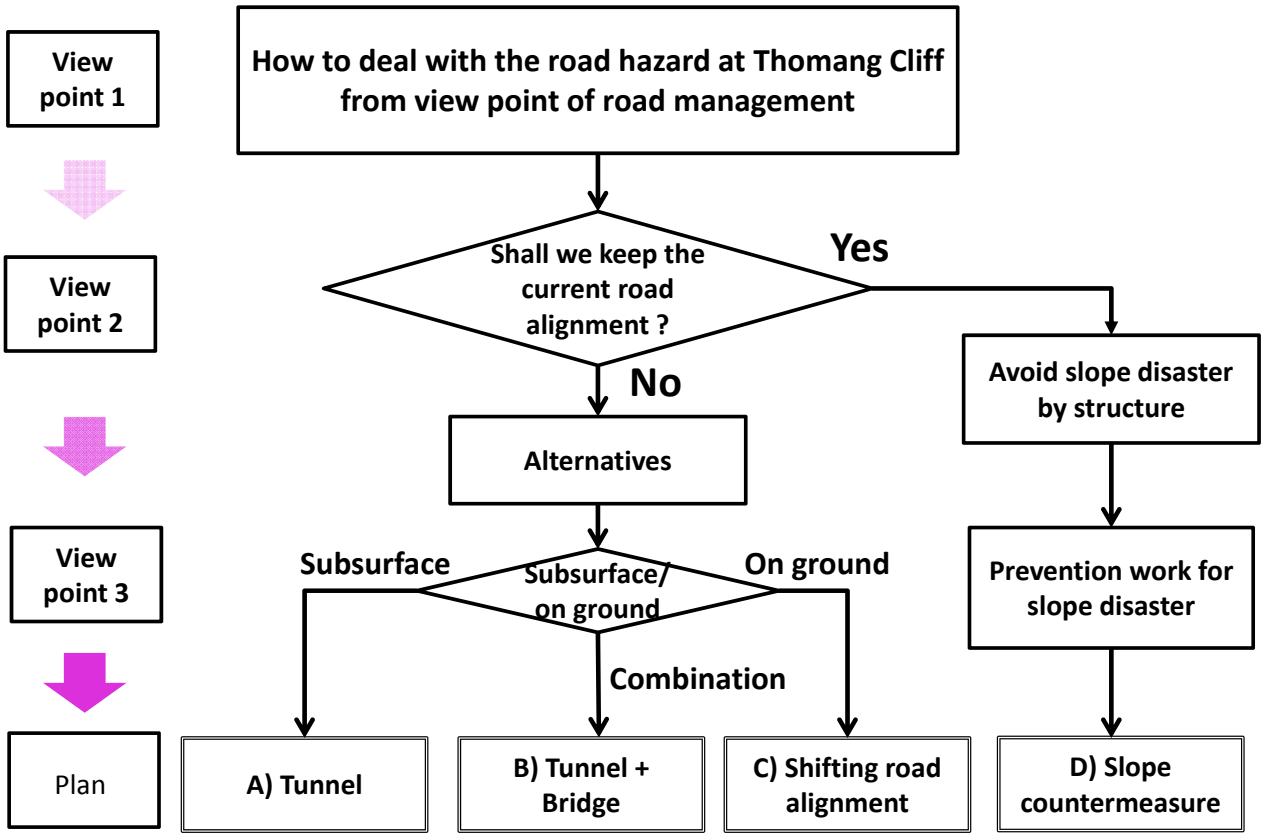


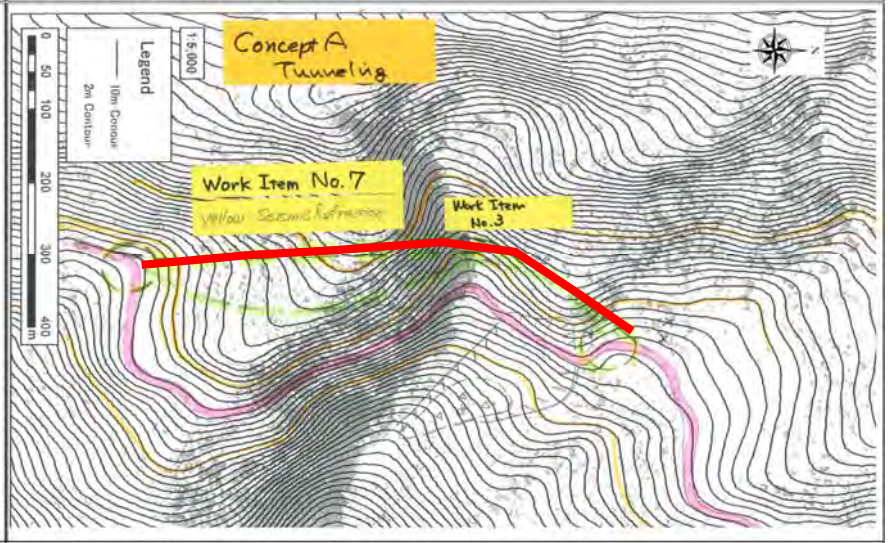
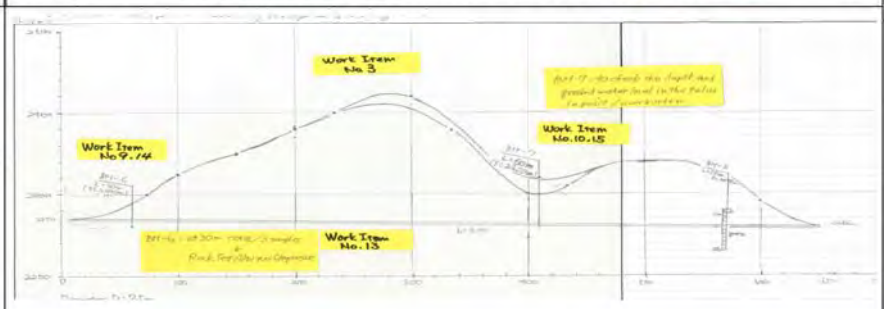
2. Desk Study

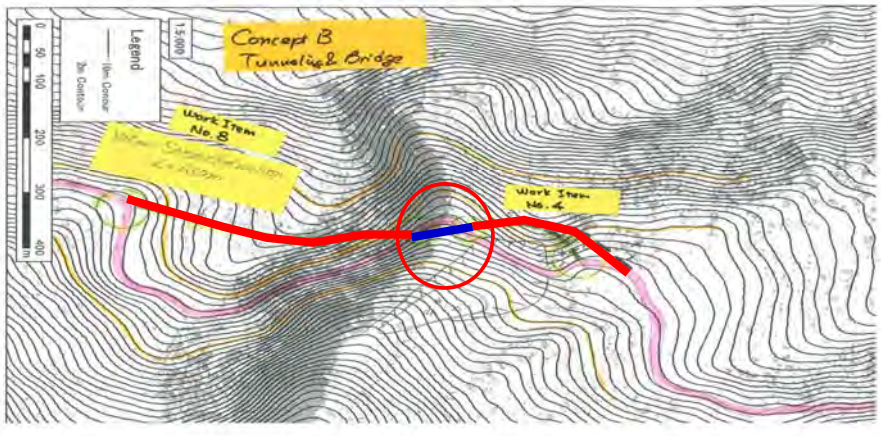
(1) Basic Policy

- In the Desk Study, 4 plans to avoid/mitigate the slope disaster risk to the road. The plans are selected in consideration of the case of making use of the existing road and in case of not use the existing road (avoidance plan).
- The following 4 plans are proposed,
  - Plan A; Tunnel on whole stretch of the road section
  - Plan B; Combination of Tunnel and Structures
  - Plan C; Diversion to avoid the road section
  - Plan D; Existing road alignment with countermeasure

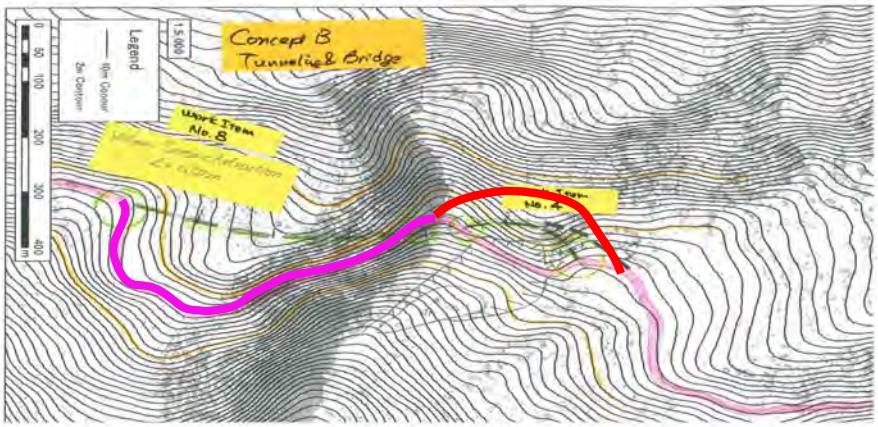
(2) Flow of selection of the plans of solution for the road disaster

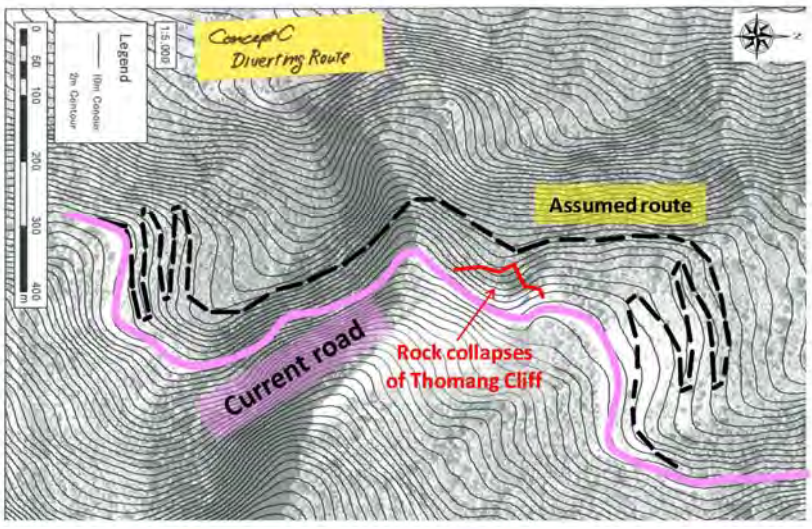
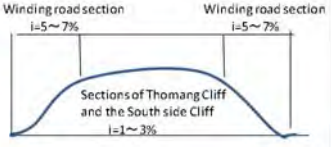


Plan A	A plan based on a Tunnel at the whole target section : The principle is to connect between the beginning and the end of the target section with a tunnel as straightly as possible.
Plane view	
Longitudinal section	

Plan B	A plan to connect tunnel(s) with a bridge: The principle is to connect between the beginning and the end of the target section as short as possible. A key issue of concern is the depth of bedrocks.
Plane view	

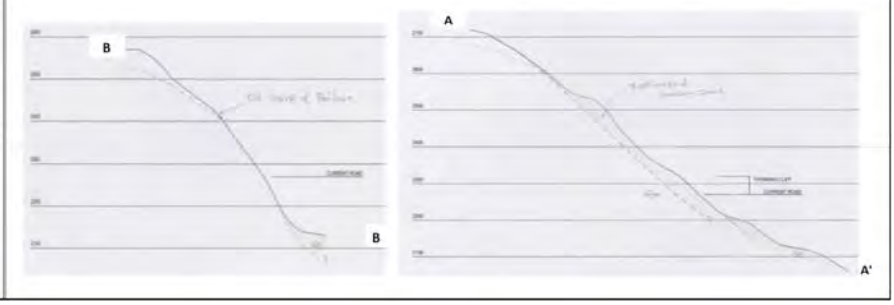
Alternative Plan B;
Existing Road + Short Tunnel

Plan B	A plan to connect tunnel(s) with a bridge: The principle is to connect between the beginning and the end of the target section as short as possible. A key issue of concern is the depth of bedrocks.
Plane view	

Plan C	Plan to make new road routes to avoid Thomang Cliff : The principle is to search and change road routes to avoid the Cliff.
Plane view	
Longitudinal section	 

An Photo Image of winding road
From: Nikkan Kensetsu Kogyo Shimbun blog

Sindhuli road in Nepal
Design speed V=30km

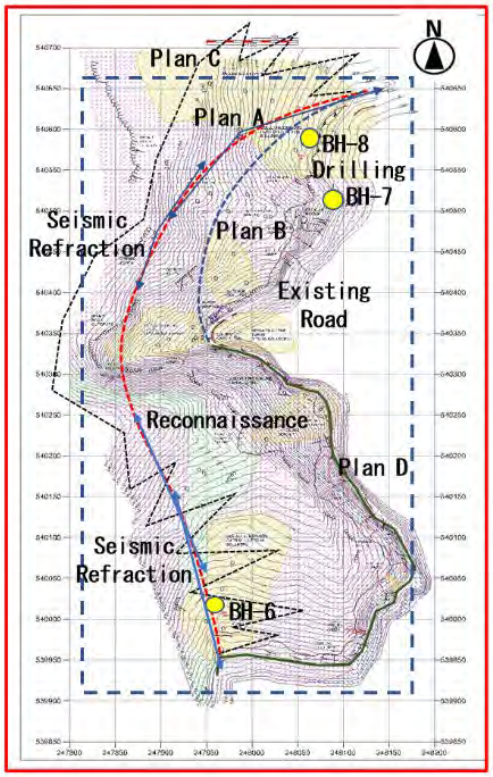
Plan D	A plan to maintain and protect the current road route with slope stability measures: The principle is to maintain the safety of the target road with slope stability work at Thomang Cliff based on utilizing the current road
Plane view	
Longitudinal section	

3. Study on Natural Conditions on the Site

（1） Contents of the Study

The study on the site was carried out to consideration of the proposed plans.

- **Topo survey**：to complement the topo map prepared by the satellite image.
- **Cross section survey:** on the tunnel alignment of Route A and 11 sections along the road
- **Site reconnaissance:** at the whole study area except inaccessible parts such as the cliffs.
- **Seismic Exploration:** on the tunnel alignment of Route A.
- **Drilling survey:** on both portals of planned tunnel.

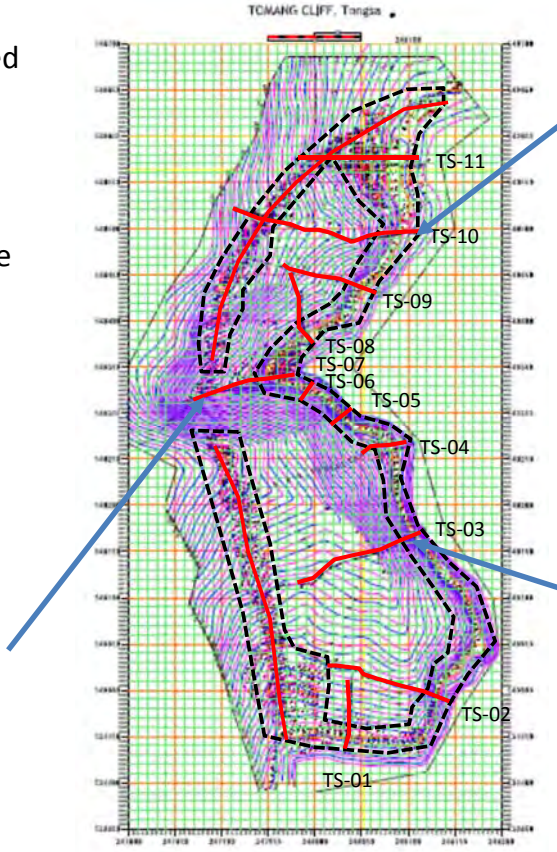


(2) Topo and Cross Section Survey

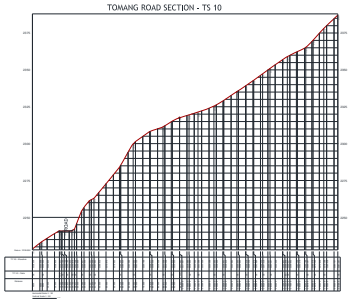
Base map prepared by the Satellite Image.

Area of Topo Survey : Break Line in Black

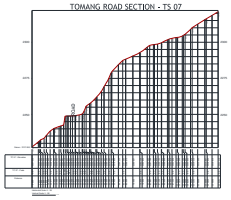
Cross Section Survey : Red Line



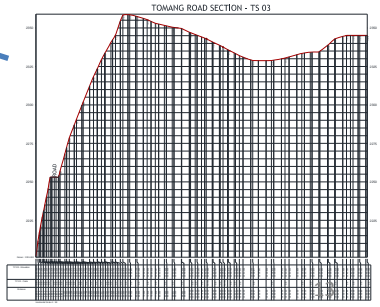
TS-10



TS-07

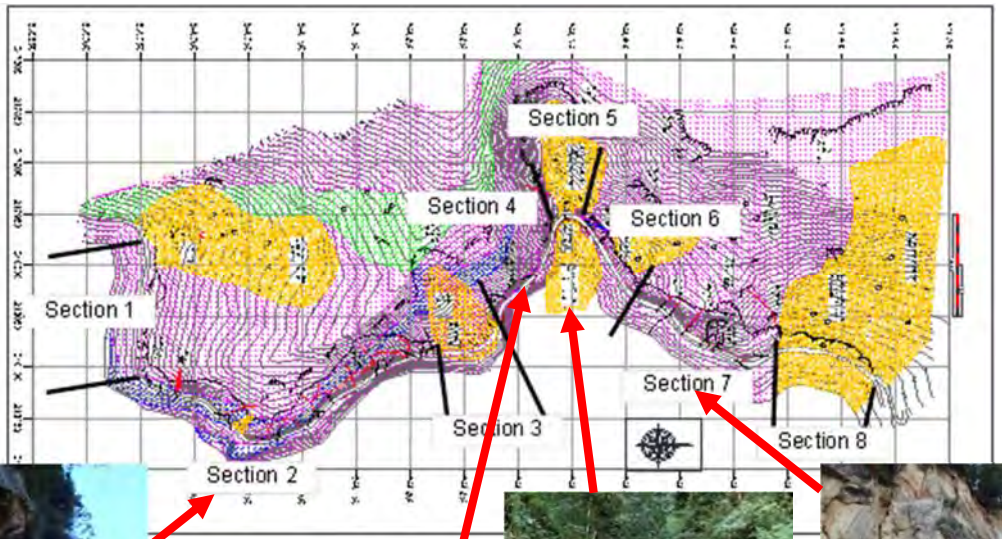


TS-03



(3) Site Reconnaissance

To check distribution and property of geology on the site, and the stability of the rock slopes



Section 2

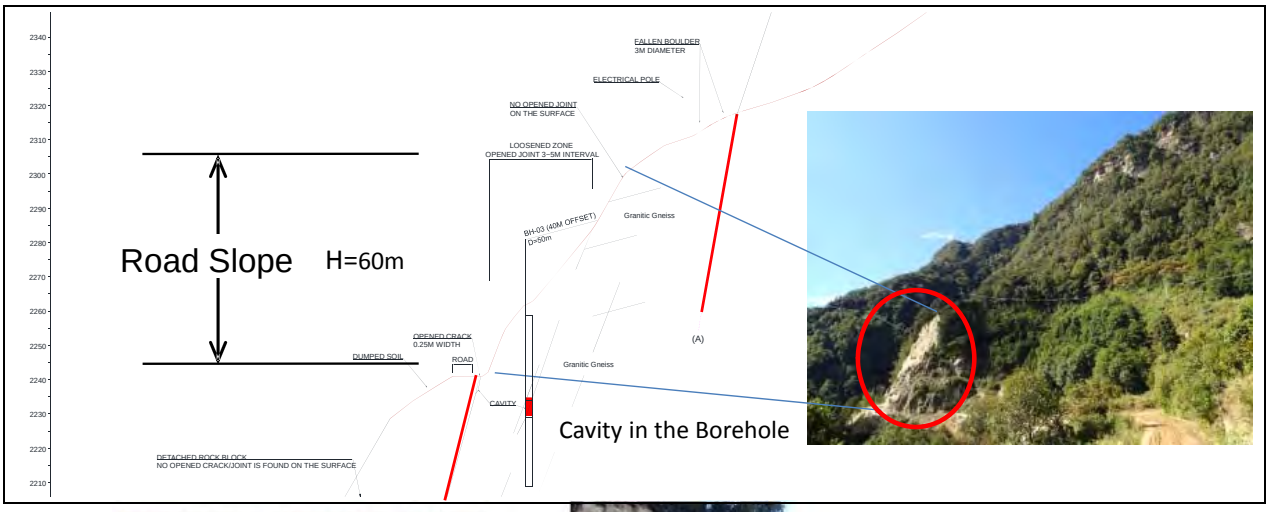
Section 4

Section 5

Section 7

（3） Thomang Cliff

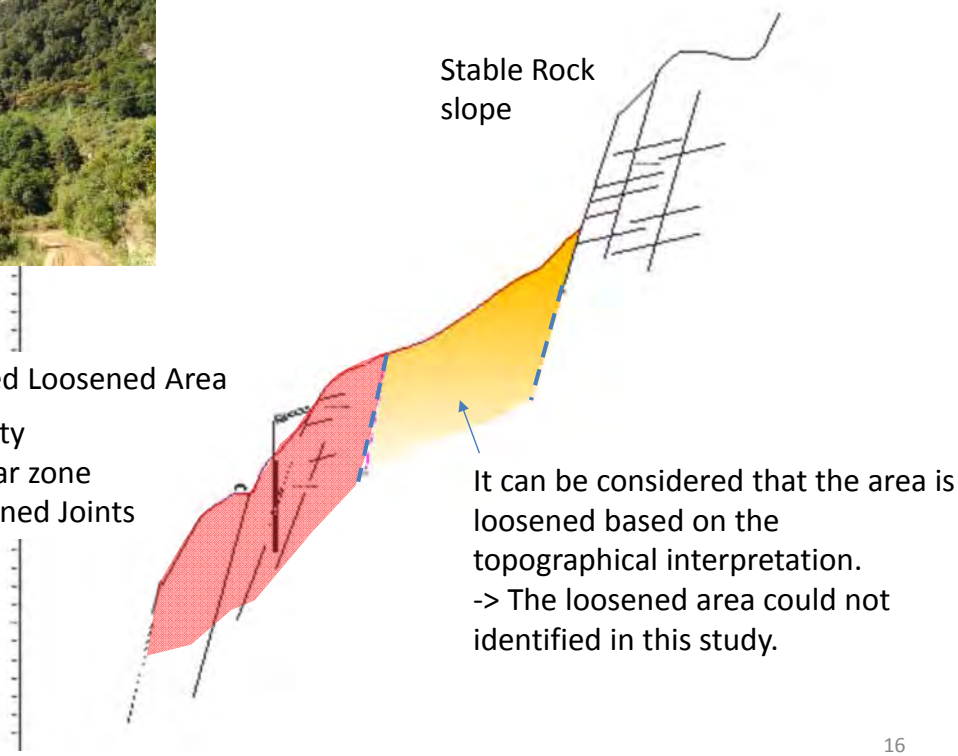
The slope which is considered as loosened area along the road section



Hole on the road in front of the Cliff

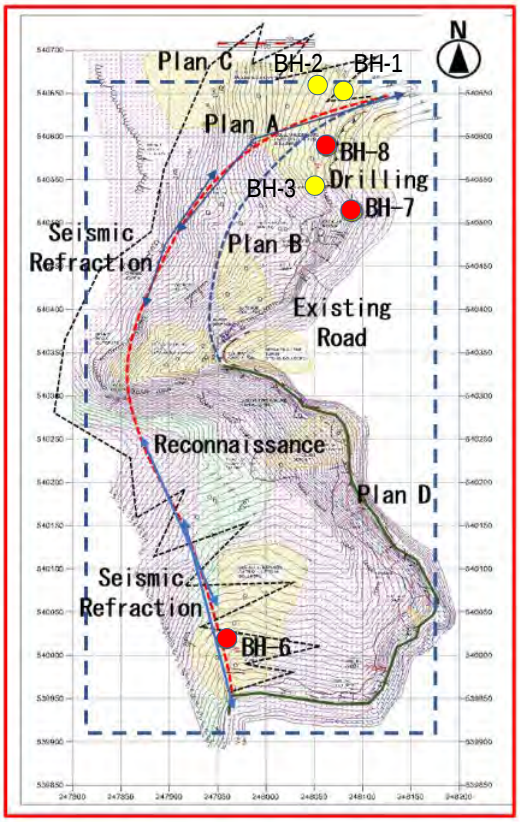
Shear Zone at Rock slope at Southern part of the Cliff

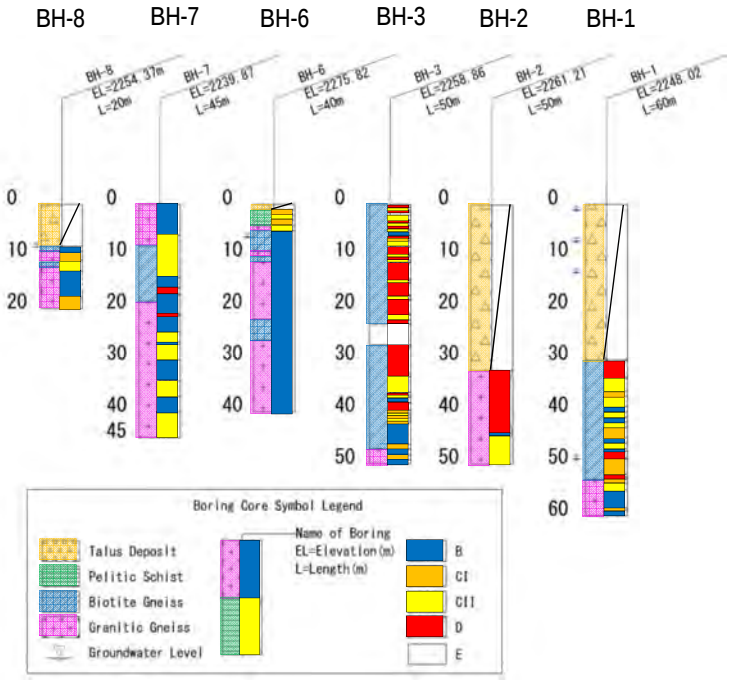
（3） Thomang Cliff 2



（4） Drilling Survey

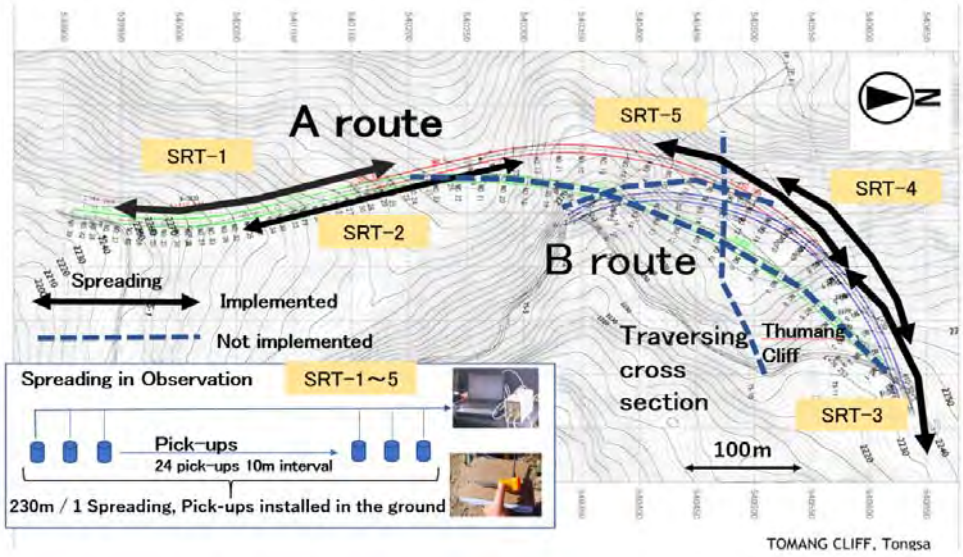
To check the geological conditions directly by the drilling survey



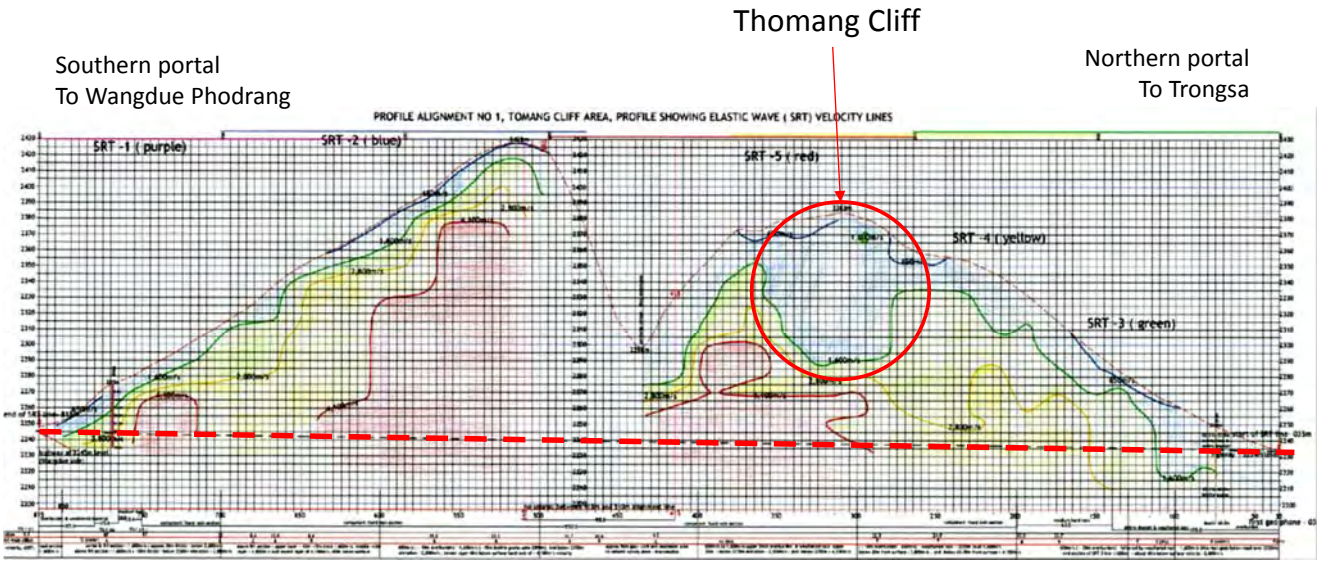


（4） Seismic Exploration

To estimate underground conditions by difference of velocity of the artificially-generated seismic wave run though the underground.



（5） Result of the Seismic Exploration



Around Portal：650以下～2800m/s ， Middle part of the tunnel：2800～>4000m/s

4. Standard and Guideline

（1） Standard and Guideline on road construction in Bhutan

Title	Year of Issue	Authority
Guidelines on Road Classification System and Delineation of Construction and Maintenance Responsibilities	2009	MoWHS
Road pavement of Standards		DoR
Guidelines on use of Standard Work Items for Common Road Works	2010	DoR
Bhutan Schedule of Rate	2015	MoWHS
Specifications for Building & Road Works	2015	MoWHS
Indian Standard		BIS
Indian Road Congress Code		IRC
AASHTO		

（2） Machinery/Material for Construction

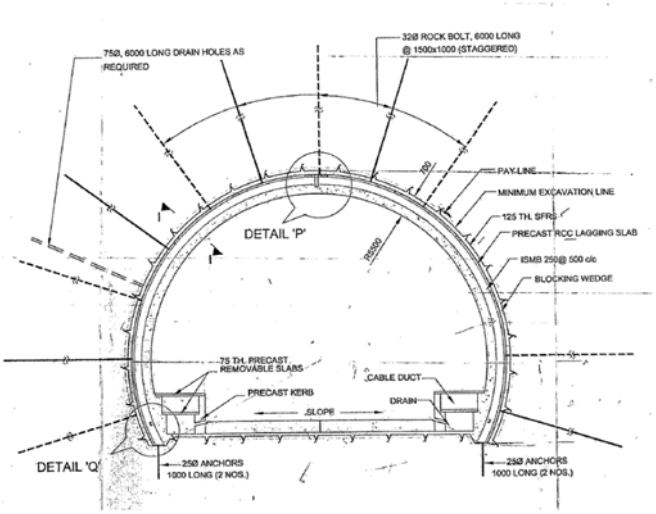
Almost machineries and materials for road construction are available in Bhutan. On the other hand, machineries for slope protection works and tunnel construction shall be imported from out of the country.

（3） Standard/Guideline for Tunnel Design

Standard/Guideline for tunnel design and quantity survey has not been prepared in the Bhutan yet.

Punatsangchhu－Ⅱ Hydroelectric Project Authority did not provide detail information on tunnel design and construction. In this study, the Japanese standard/guideline for tunnel has been applied.

Length	:	1522m
Carriage way	:	7.5m
Side walkway	:	2 X 1.5m
Higtht(Max)	:	7.5
Executed by	:	Punatsangchhu-Ⅱ Hydroelectric Project Authorit
Consultant	:	Wapcos LTD
Constructed by	:	M/s Jaiprakash Associates LTD



5. Basic Planning(Primary Screening)

Procedure

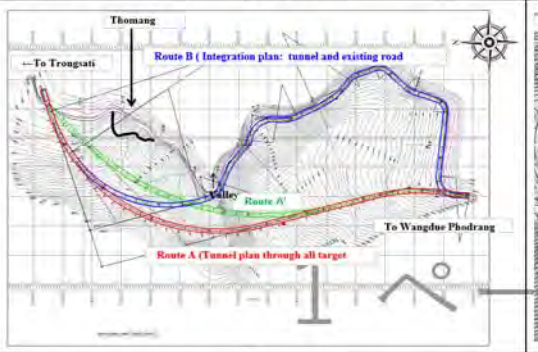
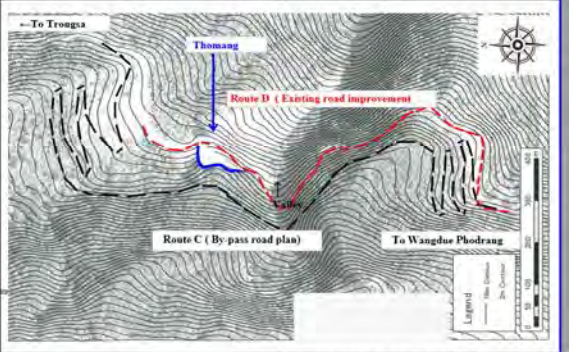
1. Examine the results from Natural Environmental Investigation and Information Gathering.
2. Compare 4 plans from Mobility, Constructability and Environmental aspects.
3. Select out the viable 2 plans to calculate the estimations

Results

- Plan A: Tunnel at whole section -> ○:Adapted
- Plan B: Combination of Tunnel and Widening -> △:Adapted (less advantageous)
- Plan C: Diverting -> × Dismissed
- Plan D: Road Widening -> × Dismissed

Table Primary Screening (Source: JET)

BASIC PLAN (DRAFT) ROUTE COMPARISON (FIRST SELECTION: Based on the result of the field survey)

Item \ Route	Route A (Tunnel plan through all target section)	Route B (Integration plan: tunnel and existing road widening)	Route C (By-pass road plan)	Route D (Existing road improvement plan)
Basic Concept of the route selection	・To avoid the loose area of Thomang Cliff and the valley at the south of Thomang Cliff by tunnel.	・To avoid the loose area of Thomang Cliff by tunnel and to utilize the current road route to minimize the tunnel construction length.	・To avoid the loose area of Thomang Cliff by making a new by-passing road at the upper side of the Cliff.	・To utilize the current road route and improve the roads.
Length of road work	Total Length L= 0.8 k m (Current road - 0.4 k m) Length of roads excluding a tunnel = 0.1 k m Length of a tunnel 0.7 k m	Total Length L= 1.1 k m (Current road - 0.1 k m) Length of roads excluding a tunnel = 0.8 k m Length of a tunnel 0.3 k m	Total Length L= 3.4 k m (Current road +2.2 k m) Length of roads = 2.0 k m Road Gradient i = 7 % 1.4 k m i = less than 7 %	Total Length L= 1.2 k m (Current road route) Length of roads = 1.2 k m (Road widening work)
Schematic map	(Design Specification) ○ Road Standard Standard of the Primary National Highway ○ Design Speed : V=30km/h ○ Road Width: W=7.5m of 2 lanes 		
Geological and geographical features from the result of the reconnaissance	・The north side of tunnel portal (Trongsa side) is located in natural slopes and entirely covered with trees and shrubs. The slopes are rather gentler compared to the surrounding slopes, which are about 30 to 40 degrees. ・The bedrocks of the area are composed of hard granite gneiss rocks and most of the slope is covered with talus deposits including boulders with 1 to 3 m diameters. ・On the slopes of the south wellhead side, the depths of the talus deposits are rather thinner and the bedrocks underneath are composed of hard granite gneiss rocks as well as the north side.	・The north side of the tunnel portal of Route B is the same location as route A. ・The south side is located in the north-side slope of a valley where the stream water flows constantly. The bedrocks of the slopes around the south side are composed of hard granite gneiss rocks. ・The lower side slopes of the current road are very steep, which are 30 to 40 degrees, and it is difficult to widen the road toward the lower slope side. ・The upper slopes of the road show both gentle slopes with 25 to 30 degrees and steep slopes with more than 70 degrees alternatively.	・The range of the loose area of the Thomang Cliff is assumedly extended up to the slope at the 3,320 m elevation. ・The south-side slope of the Thomang Cliff is extremely steep and has only shallow surface soil. The slope seems unstable, too. ・A steep slope with 60-70 degrees is extended by the more than 100m width to the valley of south of the cliff.	・An opening crack with 2m length, 4m depth and 25 cm width is observed at the shoulder of the current road to the Thomang Cliff. The area seems significantly unstable. ・Open cracks and other earth-movement phenomena are observed in the slope from the bottom to the 40 m height of the Thomang cliff at the road side. The slope seems loose and unstable conditions. ・Conditions of the area near the valley of the south of the cliff is described in the column of the Route C. ・It is extremely difficult to widen the road toward the lower side of the road because the lower side slope is very steep by 60 to 80 degrees.
Drivability of the road alignment	・The smoothest road alignment can be achieved among four route selection. ◎	・At the south side of the tunnel portal site, a loose curve of the tunnel is connected to a sharp curve of the road outside the tunnel. It is an undesirable combination as the road alignment. △	・The road is required to be a winding road to climb up by 80 m height within a short distance. Accordingly, many sharp curves of the minimum radius (R=30m) continue. Also the road is required to take the maximum gradient of 7% almost all sections of the winding road. It will be difficult for heavy vehicles to be driven on the road. △	・The same drivability can be maintained as the current road. ◎
Workability and safety for the construction	・Route A is a plan to take a shorter route toward the current road in order to shorten the length of the tunnel construction by 20 m. However, the route is assumed to get into the influential ranges of the loose area of the Thomang Cliff and thus the idea of the route was discarded. ・The construction of the tunnel work is normally started from the lower portion of the elevation, which is the north wellhead side. The terrain of the north side is relatively gentle and a construction yard can be made near the area. ・There are hillsides with unconsolidated geological structure near the north wellhead area. Accordingly auxiliary construction methods to stabilize the hillsides will be required during the construction period. ・Hillsides near the south wellhead seems geologically consolidated and better conditions for the construction work compared to the north wellhead side. ○	・The north side of the tunnel portal is same location and construction conditions as Route A. ・The south side is similar construction conditions to Route A. ・It is extremely difficult to widen the road toward the lower side from the current road. ・It will be required to cut the hillside beyond the ridge of the road is widened toward the upper side of the road and even if a concrete structure is constructed to reduce the volume of the cutting work. ・The speed control will be required for vehicles passing and passing from the north to the south on the road. △	・Regarding the cutting work to widen the current road in the South-side slope of the valley of the south of the Thomang Cliff, the cutting height will be 180 m with a cutting slope gradient of 1:0.3 and it would not be realistic for the implementation. Even if constructing a vertical concrete retaining wall is considered, the height would be 35 m and not realistic as well. Accordingly, it is too difficult to design the road construction. ・Road construction at the route C will be operated in the slope higher from the current road axis by 80 m if implemented. In case of the construction of the concrete structure, it will be further higher, too. Accordingly, it will be too difficult to construct without maintaining the current road traffic. It will be required to consider enough temporal support work such as crash fall protection and other protection methods. ×	・It is difficult to avoid the loose area of Thomang Cliff. Accordingly the safeties of roads and slopes along the road fundamentally cannot be maintained. ×
Environment and landscape	・Noises and exhaust gases are concentrated in the tunnel. ・The tunnel passes through the underground and road traffic and above noises and gases assumedly do not disturb the nature environment and landscape. ○	・The volume of the cutting work is assumed as a large scale. Accordingly it is required to consider how to deal with the excavated soil from the cutting work. ・Vegetation work and cover work at the cut faces is to be considered to maintain the natural environment and landscape. △	Cutting work should be operated for a long distance along the road aligned at the section of the winding road. Accordingly it is required to consider how to deal with the excavated soil from the cutting work. ・Vegetation work and cover work at the cut faces need to be considered to maintain the natural environment and landscape. △	Cutting work is required to operate for a long distance along the road. Accordingly it is required to consider how to deal with the excavated soil from this cutting work. ・Vegetation work and cover work at the cut faces are need to be considered to maintain the natural environment and landscape. △
Evaluation from the first selection	This is applying the tunnel construction suitable for severe terrain features and Route A is adopted in the First Selection. ○	This plan route can avoid the range of the loose area of the Thomang Cliff although many issues are to be resolved. Route B is adopted in the First Selection. △	It is difficult to design the road while securing the safety at the section of the valley of the south of the Thomang Cliff. Accordingly, this route cannot be adopted in the First Selection. ×	It is difficult to avoid the loose areas of Thomang Cliff by taking this route. Accordingly the route is regarded as dangerous and cannot be adopted in the First Selection. ×

◎ :Very good
○ :Good
△ :Conditionally applicable
× :Not recommended

Reason for adaptation (Plan A)

1. Enable to avoid the physical hazard (Rock Fall/Slope Failure)
2. Simple Alignment -> Very smooth alignment
3. Good Mobility for cars and trucks
4. Easy to secure the construction yards
5. Protection of forests and natural view (Landscape)

Reason for adaptation (Plan B)

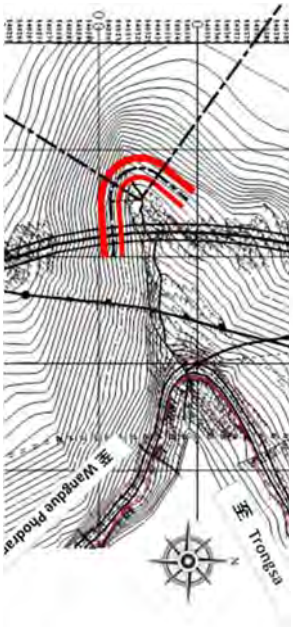
1. Enable to avoid the physical hazard (Rock Fall/Slope Failure)
2. Less advantageous factors:
   2-1. Enormous amount of excavated soil (150,000m^3)
   2-2. Complexed Alignment of Tunnel &Road

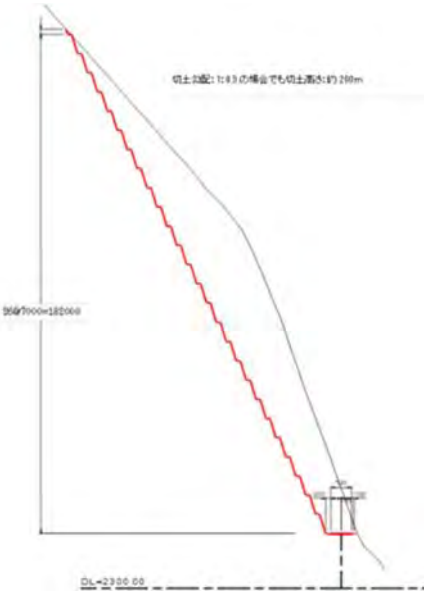
→Be subject to be compared in Secondary Screening

Reason for Dismiss (Plan C)

① The area occupied for construction of Tangsibji Hydro Energy (Around the Northern Portal)

② Steep Topology in the middle point (Steep Valley) -> Difficult to Excavate and high Slopes should be planned (about 200m high)





③ Longer than Tunnel Routes (Plan A or B) -> Length is 3.4 km (Impossible!)

Reason for Dismiss (Plan D)

Unstable basement for the Existing Road beneath the Cliff (Crack found)

There may not be impossibility of failure in future.
->Permanent Countermeasure can't be planned in such unstable part.

トマンクリフのり尻に生じている現道上の空洞 (出典:JICA 調査団)

6. Outline Design

Basic design were drawn toward the selected 2 plans (A and B) for comparison.

- Plan A: Tunnel at whole section
- Plan B: Combination of Tunnel & Widening

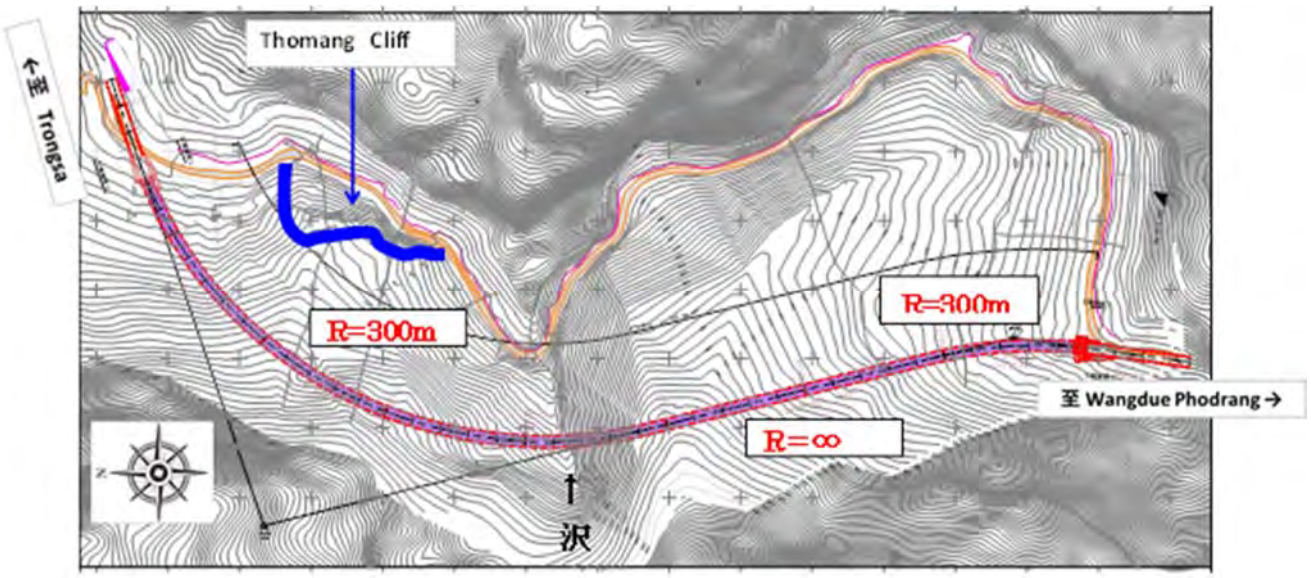
Table 7.1 Conceptual Design Drawings (Source: JET)

Conceptual Design Drawings				
			Scale	Remarks
Tunnel Plan (Route A)				
	Plane map		1:2,500	
	Plane map		1:1,000	
	Longitudinal profile map	(1), (2)	1:1,000	
	Geological longitudinal profile map	(1), (2)	1:1,000	
	Standard transverse profile map (1)	CⅠ, CⅡ Cross section	1:30	Tunnel section is listed below
	Standard transverse profile map (2)	DⅠ Cross section	1:30	
	Standard transverse profile map (3)	DⅢ-1, DⅢ-2 Cross section	1:30	
	Division of cross section of heading map	CⅠ, CⅡ Cross section	1:60	
	Division of cross section of heading map	DⅠ, DⅢ-1, DⅢ-2 Cross section	1:60	
	Tunnel support pattern map (1)	CⅠ Cross section Shotcrete/Rock bolt work map	1:60	
	Tunnel support pattern map (2)	CⅡ Cross section Shotcrete/Rock bolt work map Steel arch support work map	1:60	Weight calculation for transportation
	Tunnel support pattern map (3)	DⅠ Cross section Shotcrete/Rock bolt work map Steel arch support work map	1:60	Weight calculation for transportation
	Tunnel support pattern map (4)	DⅢ-1Cross section Shotcrete/Rock bolt work map DⅢ-1, DⅢ-2 Cross section Steel arch support work map	1:60	Weight calculation for transportation Injected forepoling
	Tunnel support pattern map (5)	DⅢ-2 Cross section Shotcrete/Rock bolt work map	1:60	Weight calculation for transportation Long steel pipe forepoling
Combination plan: Tunnel + Current Road Widening (B Route)				
	Plane map		1:2,500	
	Plane map		1:1,000	
	Longitudinal profile map		1:1,000	
	Geological longitudinal profile map		1:1,000	

※Route A and B share the same map for tunnel section

Lists of drawings prepared for comparison between 2 plans.
(This lists was included in the report.)

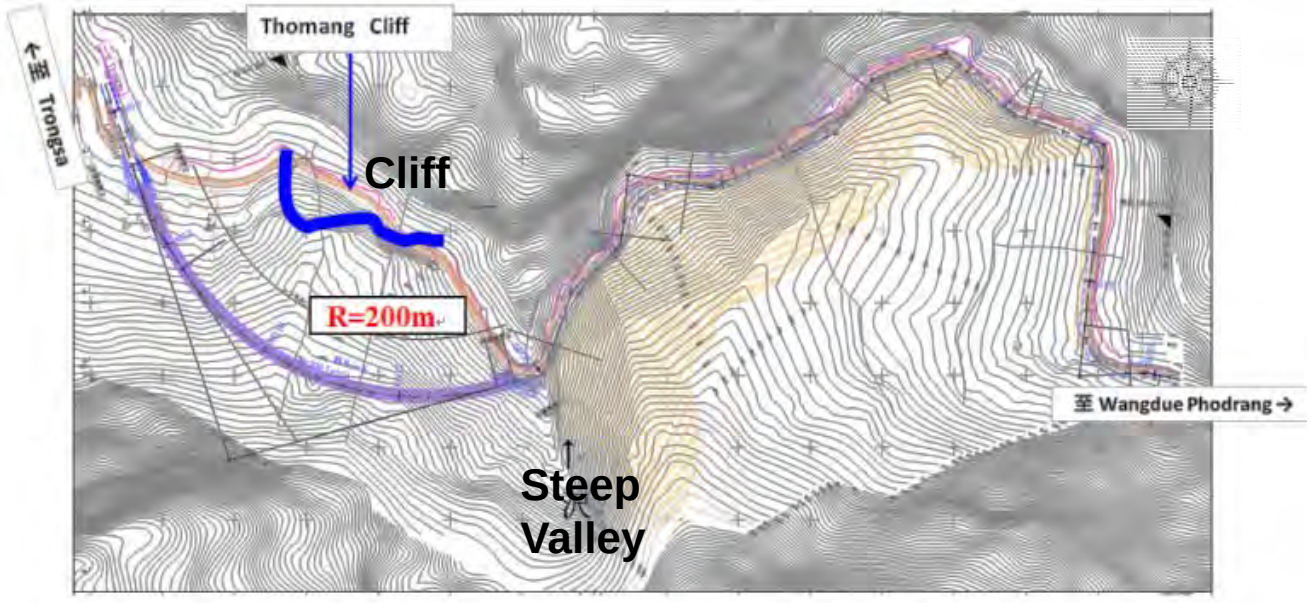
Plan A：Tunnel at whole section



Salient Features

- Whole route can avoid the loosen zone (plastic deformed) and valley topology (fractured zone predicted).
- The length became shortened by 30% at 840m. [745m in tunnel](compared to 1,210m at Existing Road)
- Inclination: 1.57% at monotonous inclination, which is satisfied condition for ventilation (3%).
- Mucking starts from Northern Portal (Trongsa side), lower than southern portal.

Plan Bルート：Combination Tunnel (Cliff) and Widening



Salient Features

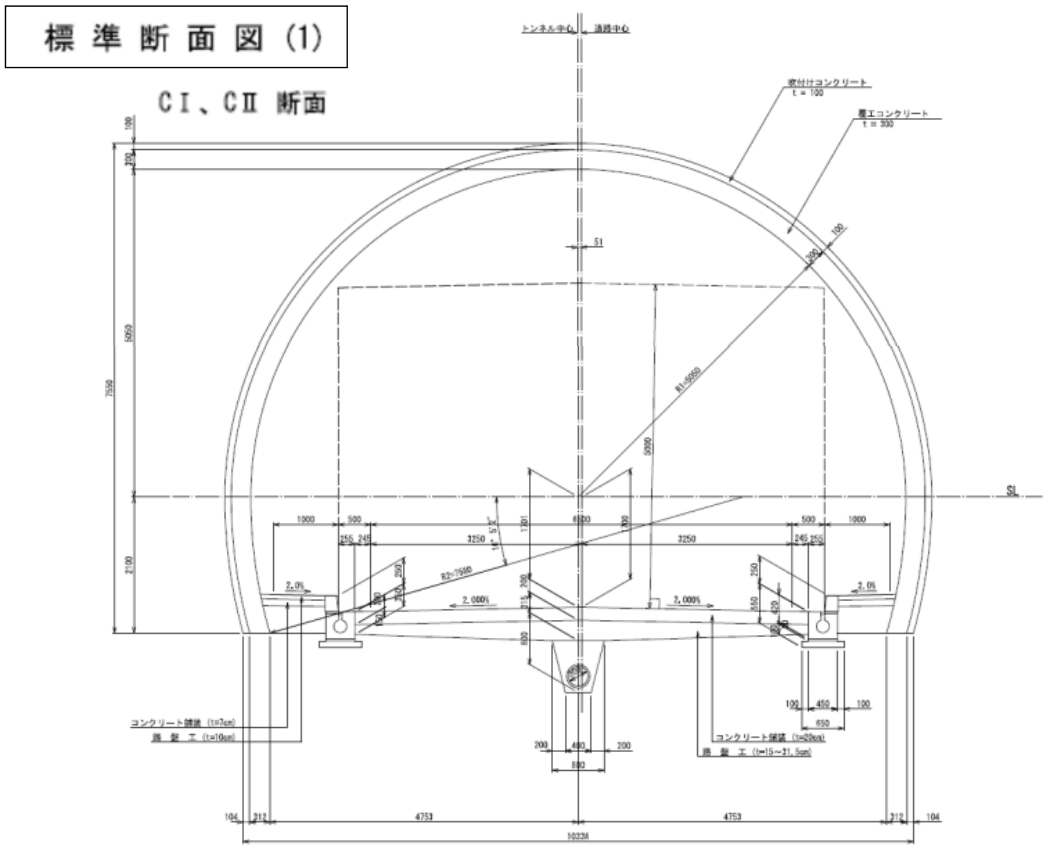
- The shortest way to avoid the hazards from Cliff.
- The curving R =200 m in the tunneling.
- Road widening in the south half section by slope cutting works.
- Total length is L=1,090m [331m tunnel included], which is 120m longer that the existing section.

Design for Tunnel

- Design is based on STANDARD SPRCIFICATIONS FOR TUNNELINGS -2006 : Mountain Tunnels (Japan Society of Civil Engineers) including the results of investigation on site

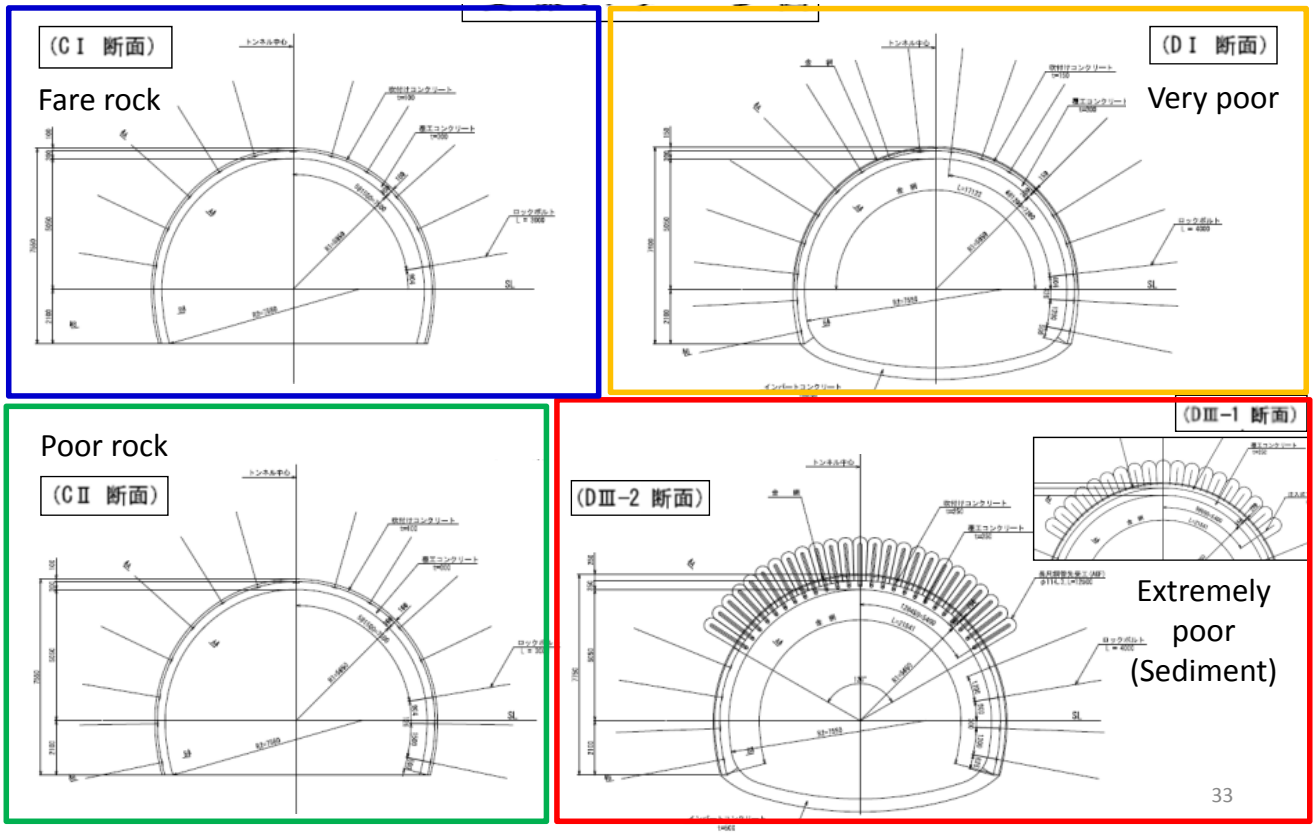
	Premise/Precondition for Design
▪Method	NATM (New Austrian Tunneling Method)
▪Excavation	Blasting and Ripping（applied for 5 pattern/CⅠ、CⅡ、DⅠ、DⅢ-1、DⅢ-2）
▪Excavation Method	Full Face Method for $C_{Ⅰ}$、$C_{Ⅱ}$ Benching Cut Method for $D_{Ⅰ}$ ～$D_{Ⅲ}$
▪Mucking	Damped by Hydraulic Excavator, Transported by Dumper Truck
▪Auxiliary	AT the portal area and the middle point (fractured zone?). 1. Steal pipe fore piling (L>200m) works is planned at north portal due to the thick sedimentation. 2. Grouting fore piling works is planned in the middle point due the fragility from the fractured zone.

Inner structures for Plan A Route

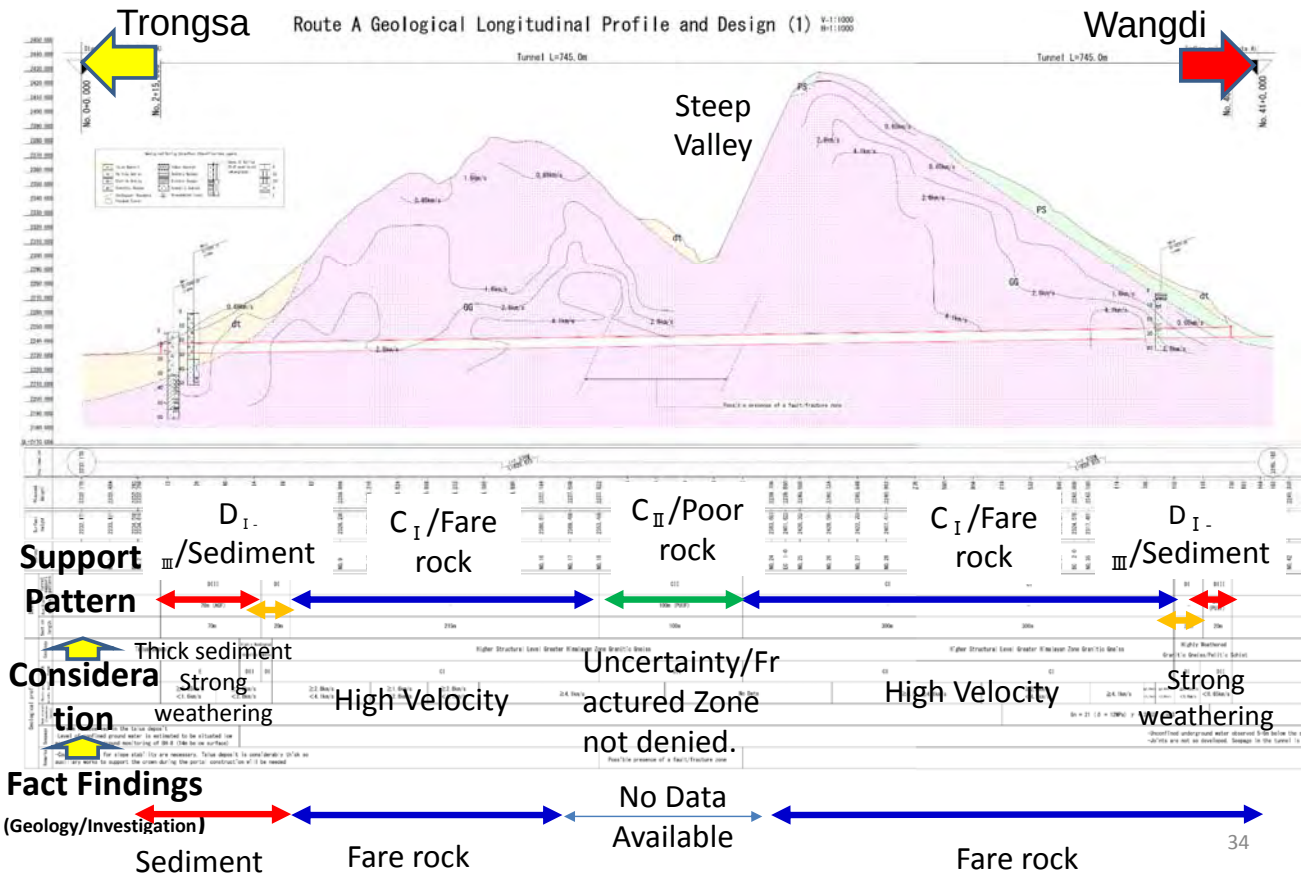


Outline Design for Plan A Route

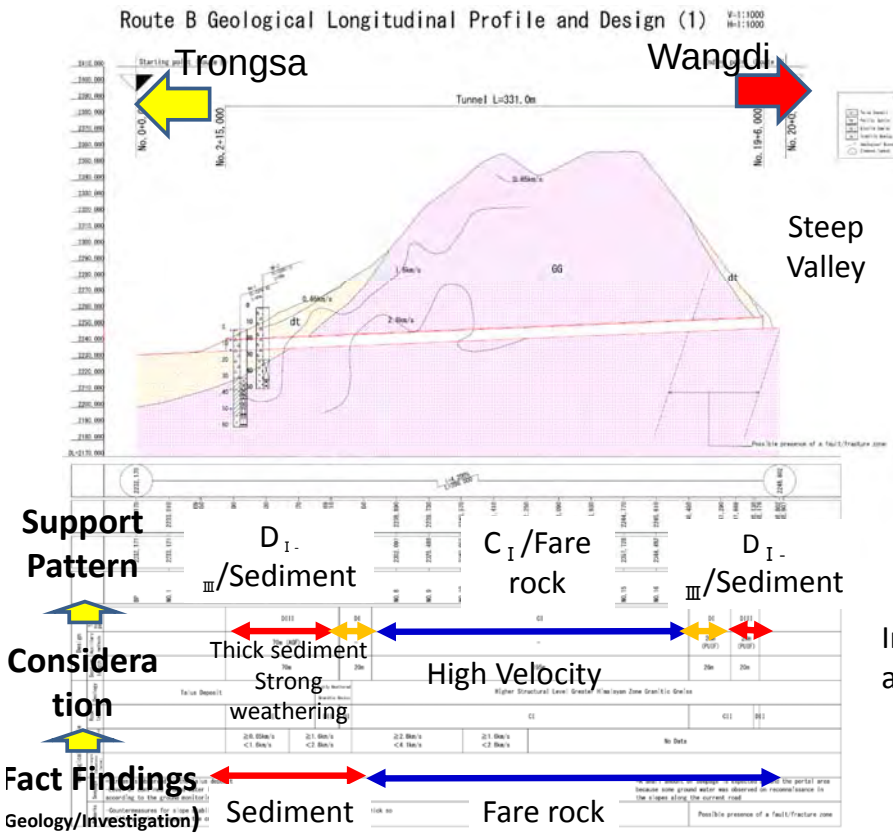
Supporting pattern for Plan A route

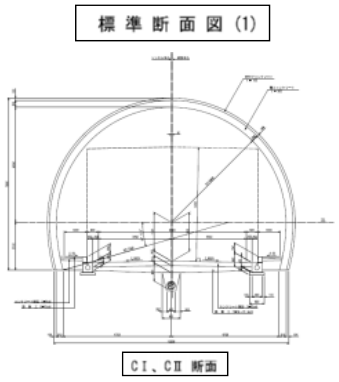


Longitudinal Geological Profile and Design at Plan A Route



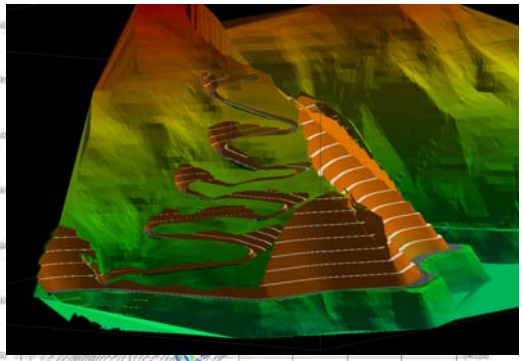
Outline Design for Plan B Route/Tunnel

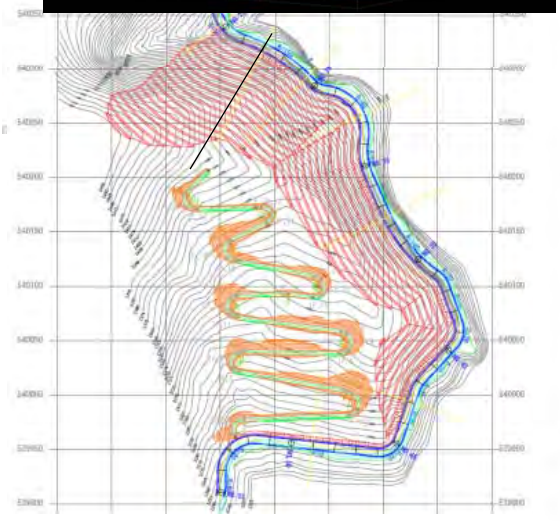




Inner structures are the same as Plan A.

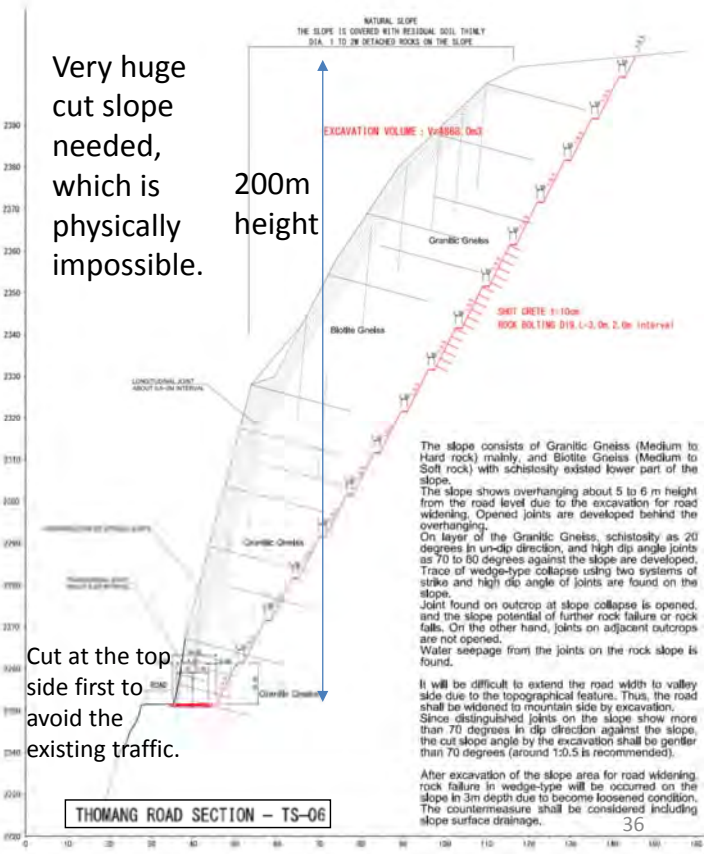
Outline design for Plan B Route/Cut Slope Stricture





Very huge cut slope needed, which is physically impossible.

200m height



Cut at the top side first to avoid the existing traffic.

7. Comparison(Secondary Screening)

1.Procedure: Design, Estimation, Construction Planning are examined for 2 plans.

2.Results: Plan A (Advantageous)

○:Advantageous

Aspects for Comparison	Plan A Route	Plan B Route
Length	840m	1,090m
Alignment/Mobility	○	△
Construction/Safety	○	△
Environment/Maintenance	○	△
Economically advantageousness	○	△
Evaluation	○	△

Comparison Table

Item	Plan A Route (Tunnel)	Plan B Route (Combination : Tunnel & Widening)
Concept Features	・Tunnel along the whole section ・Controlled by Existing Road/Gabion in the north end. ・R=300m ・Overburden 50m in the Valley. ・R=300m in the southern part	・Tunnel behind the Cliff ・Controlled by Existing Road/Gabion in the north end. ・R=200m ・Connected to the Existing Road at Valley
Length	L＝840m (Existing – 370m) (No.0+0～No.42+0)	L＝1090m (Existing – 120m) (No.0+0～No.54+10)
	Earth/Slope Works L＝ 95m (11.3%)	Earth/Slope Works L＝759m (69.6%)
	Tunnel L＝745m (88.7%)	Tunnel L＝331m (30.4%)

Comparison Table

○:Advantageous
△:Disadvantageous

Item	Plan A Route		Plan B Route	
Alignment Mobility Harmonization of the Plane alignment and vertical Alignment	・Smooth alignment between tunnel section and approaching section. ・Inclination (Vertical) i=1.57% ・R＝300m satisfies the design speed of 80km/h ・Speed Restrain needed for safety drive.	○	・Large gap in the R connectivity (R=200m in the tunnel and R=40m at Valley) is not favorable for safety drive. ・Inclination (Vertical) i=4.2% desirable for ventilation (3% at steepest) ・The existing road does not satisfy the R=30m (whose design speed is 30km/h) in some part. ・Additional cut slope will be necessitated if alignment will be improved.	△

Comparison Table

Item	Plan A Route (Tunnel)		Plan B Route (Tunnel + Widening)	
Environment, Landscape	・Landscape ○ (EIA needed) ・Exhaustion ○ ・Soil Deposit : 70,000m3 (Excavated) ・Lightning/Emergency facility needed ・Pavement: Concrete (low maintenance)	○	・Huge Slope Cut(H 200m) ・Landscape × (A=56,000m^2 for cut slopes)(EIA needed at the planning phase) ・Soil Deposit : 1.29 million m^3 ・Regular Maintenance for huge slope needed	△
Economics	Estimation：1.89 billion Nu (2.29billion Nu/km)	○	Estimation：3.10 billion Nu (2.85 billion Nu/km) × 1.6 fold against Plan A route	△
Others	・Recycling plan for excavated soil needed to create the flatten area			
	・Consideration for neighboring (Tangsibji Hydro Energy) will be needed (Approaching road and construction yard).			
	・Coordination to the road widening plan in the outer section (beyond the portals) will be needed			
Evaluation	Plan A Route is advantageous.			

8. Advices

1. Environmental Protection

1.Recycle the by-product
2.Reduce the emission

Recycling Excavated Rock/Soil

Excavation Works

Rock → Stone Material, Basement for Road Bed, Gabion etc.

Sand → Embankment for basement (housing foundation)

Soil/Clay → Embankment or Deposit (Vegetation)

2. For Safety Drive

Sign board
・Awareness to Driver to keep the speed.
・Turn-on light to inform the coming car

Thank you for hearing!

Site Overview

Cliff from southern part

Cliff

Trongsa City

Trongsa Tower

Dochhu la