19Jan 2016　土木学会
岩盤力学委員会岩盤斜面研究小委員会

ネパールの道路防災と シンズリ道路斜面対策工事

㈱安藤・ハザマ　猪狩哲夫

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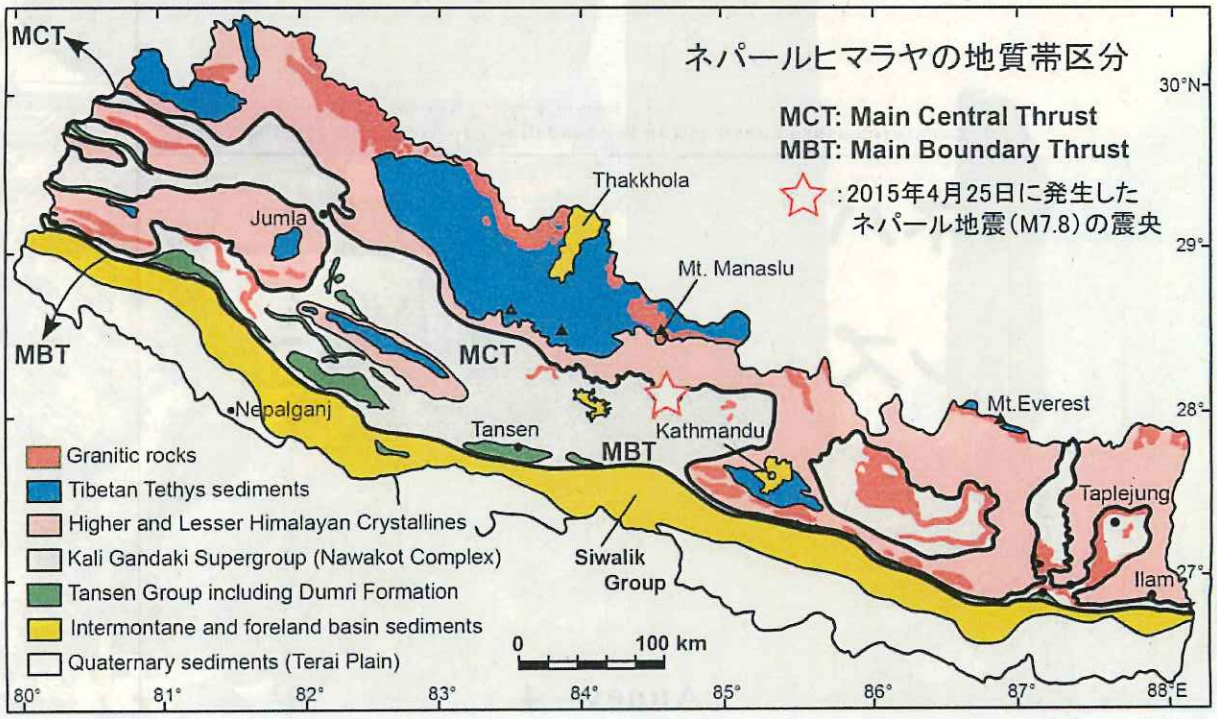
ネパールとは

- 東西850km　南北190km　147,000ｋm^2　北海道の2倍、九州の4倍
- 標高　67m～8,848m
- 気候帯　すべての気候帯を有する珍しい国
- 人口　26.5百万人(2011年国勢調査)
- 産業　農業76%（産業別人口）
- 年降水量　100～5,000mm/yr
- 行政区画　7開発地域　14県　76郡（郡は行政区画ではなく地方行政組織）
- 宗教　ヒンドゥ教　80%
- GNI(国民総所得)　USD730程度(名目GNP/人口)（2013）
- 国家予算　Nrs　8,200億　うち1/4は外国からの借款・贈与(2015-2016)
- LDC(後発開発途上国）and LLDC(内陸開発途上国)

ネパールの地質と地震



Sakai et al., 2013

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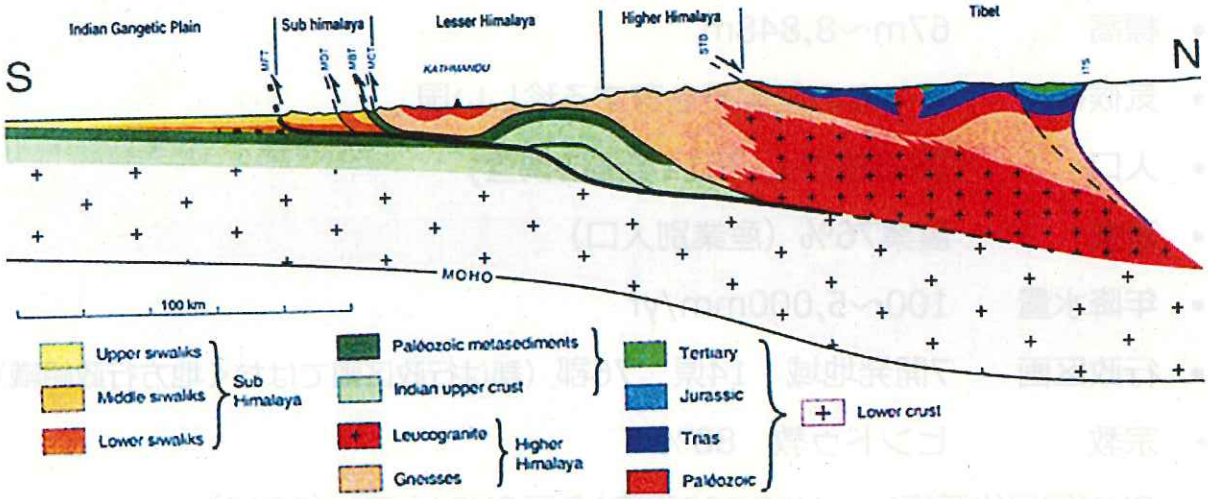
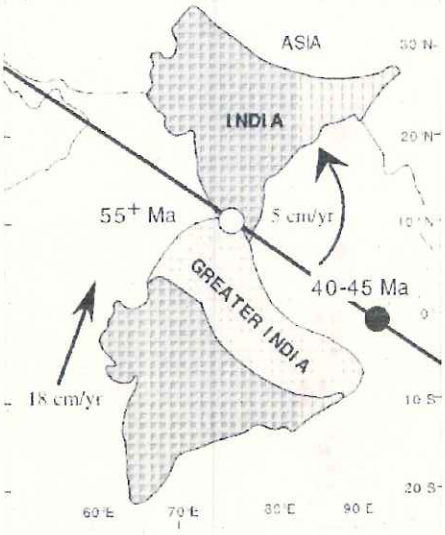
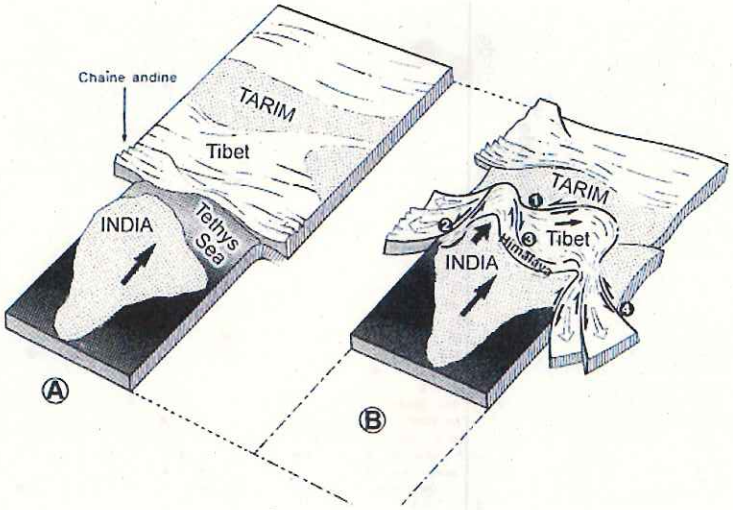


Geological Section (Pandy et al; 1995)



(酒井2005)



(Mattauer1989)

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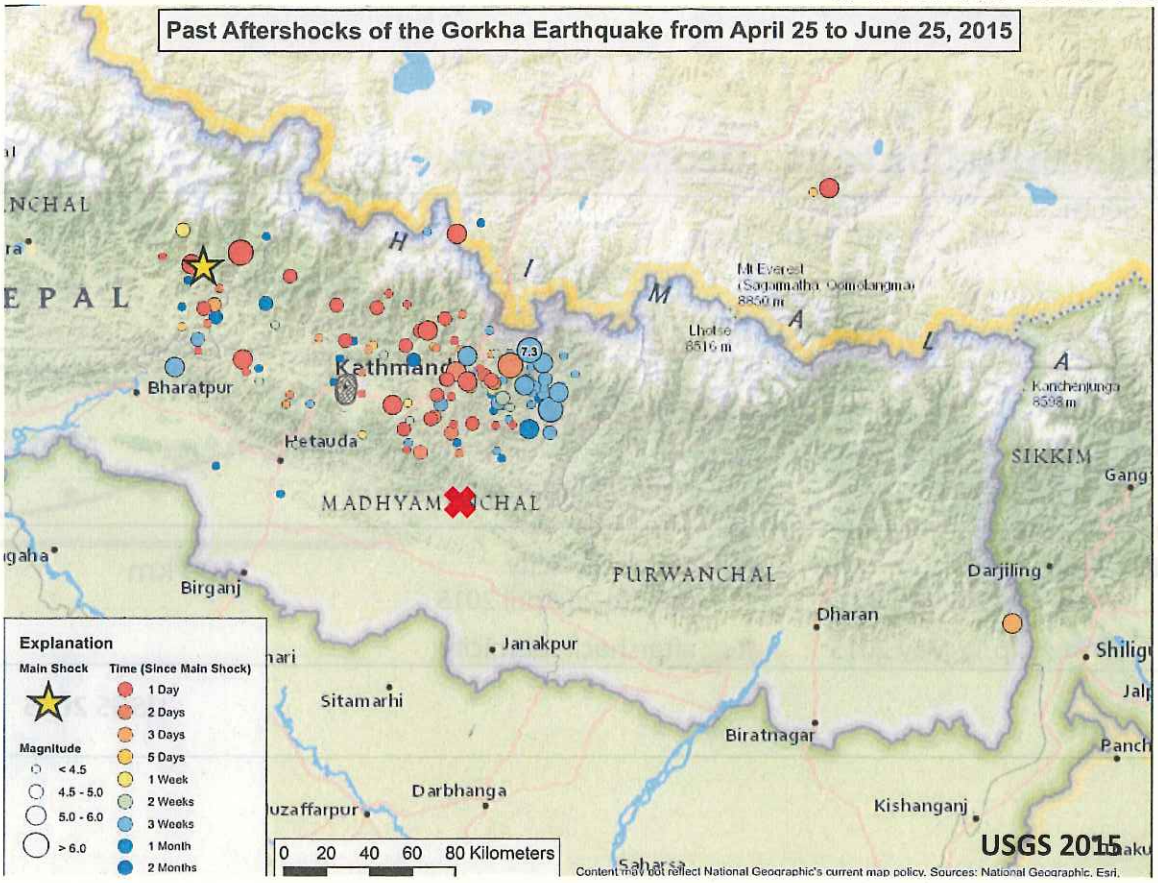

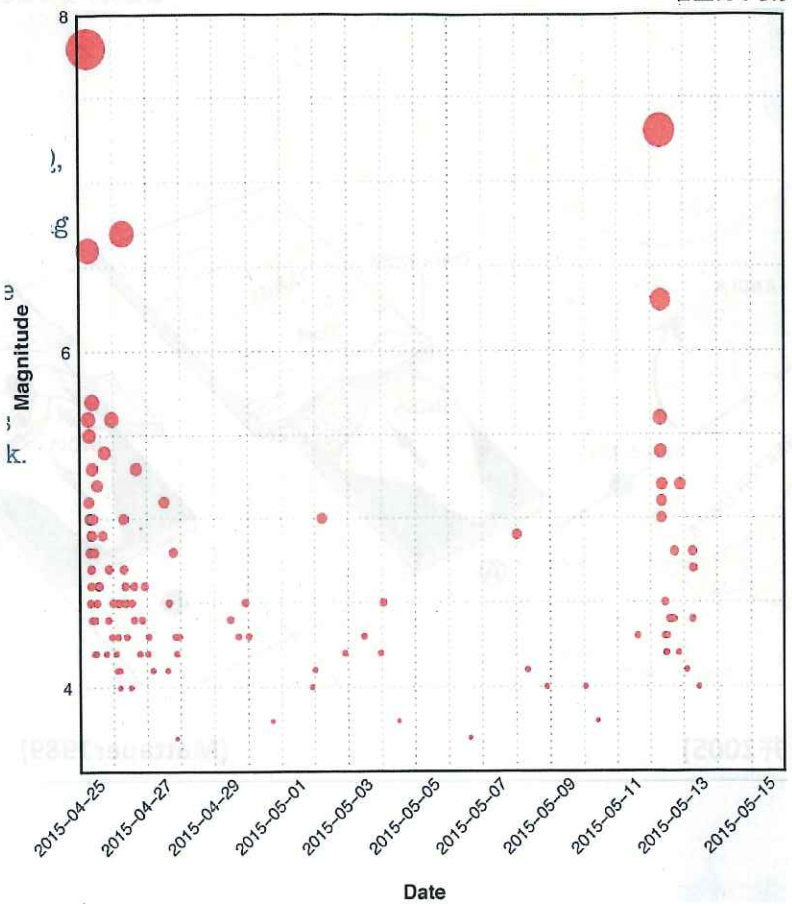

USGS 2015

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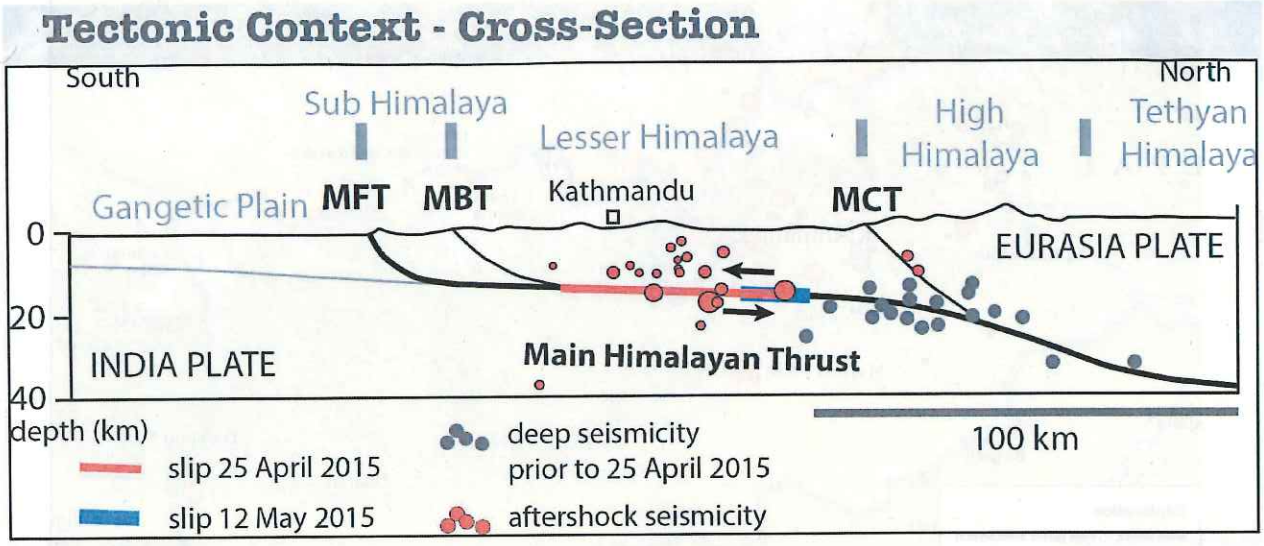
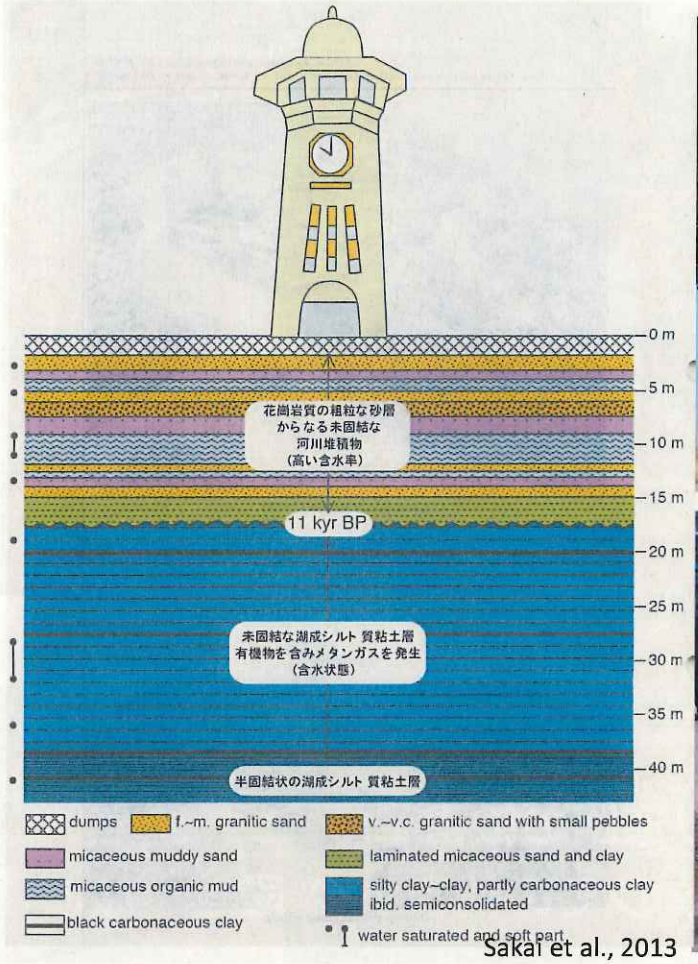
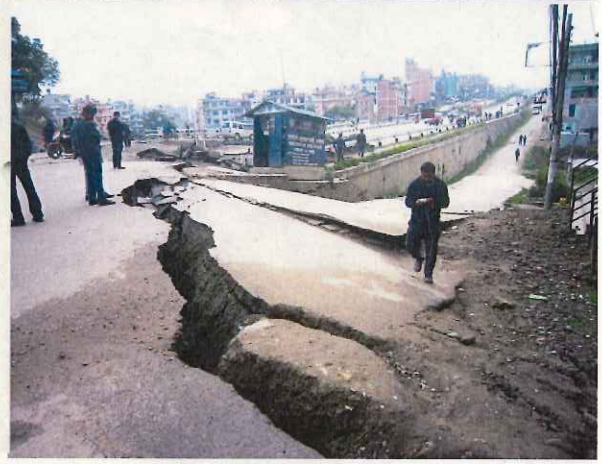
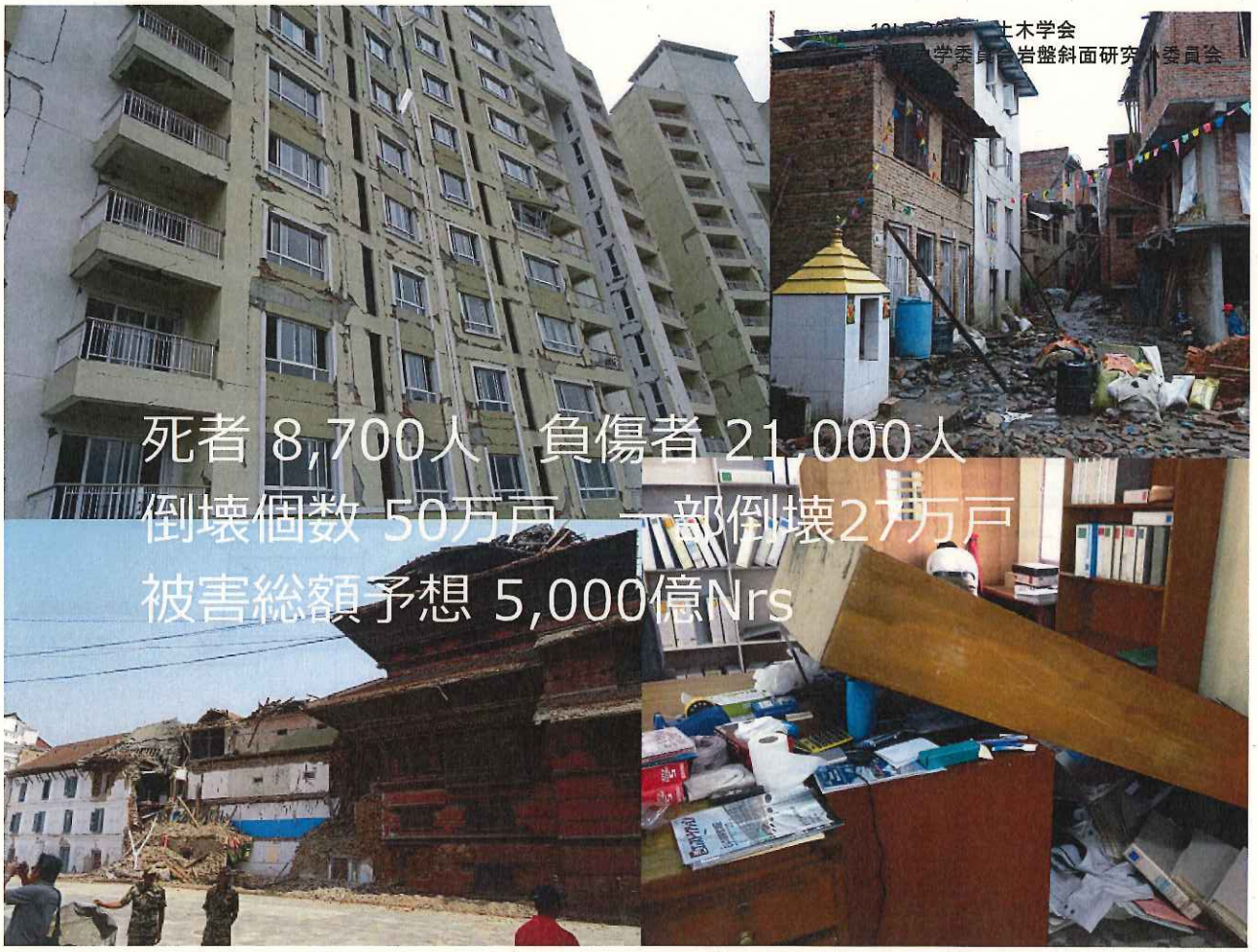


USGS 2015



Sakai et al., 2013





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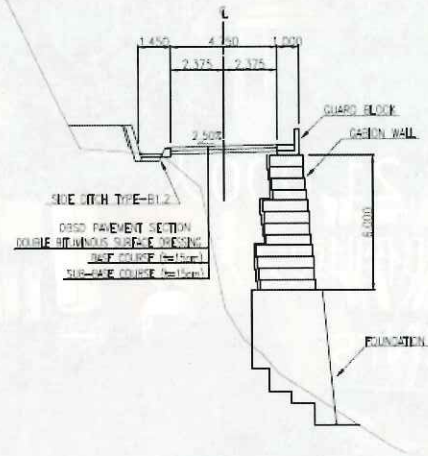
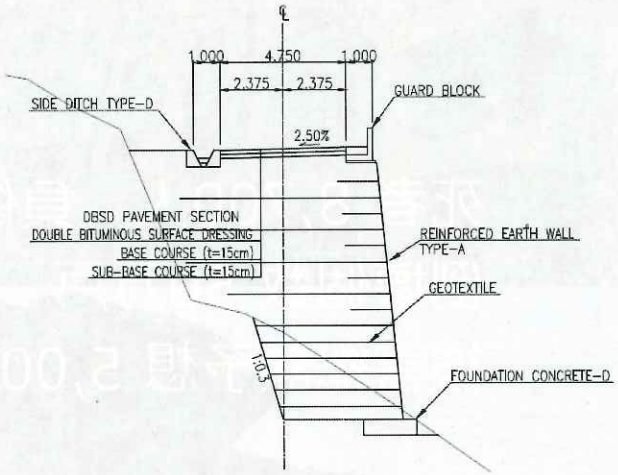


ギャビオン擁壁構造

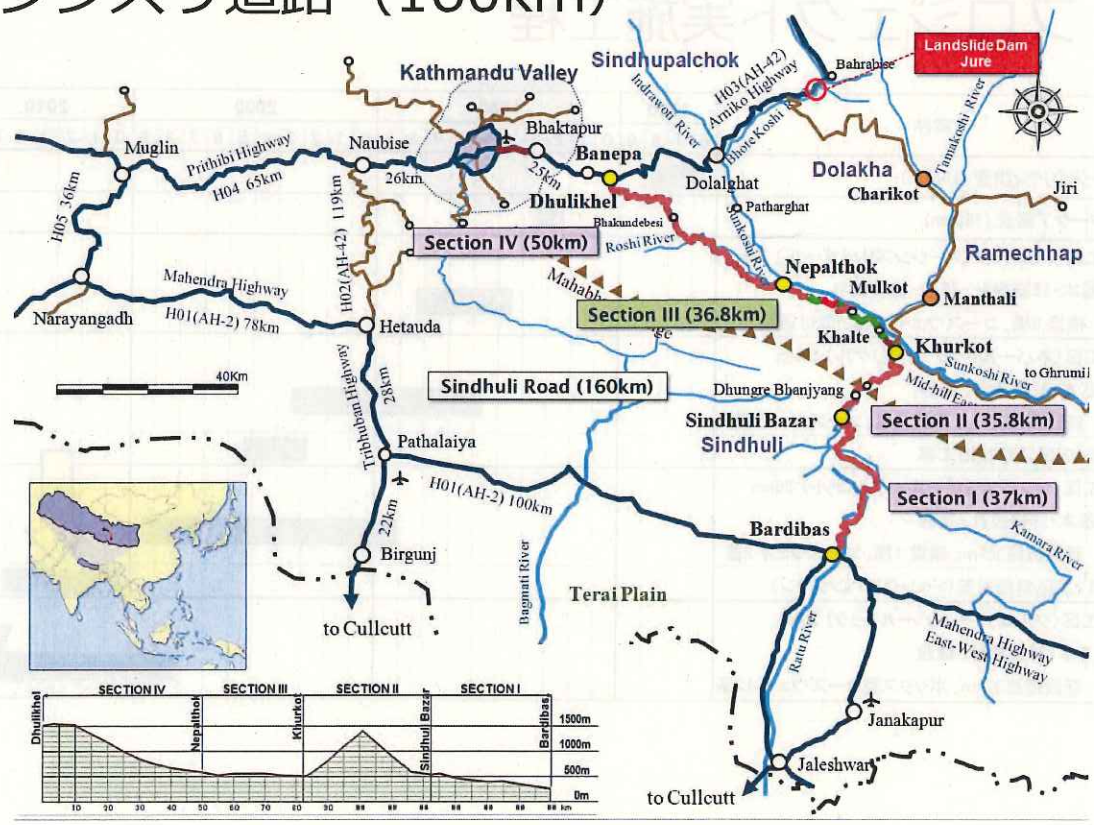


補強土壁構造

日本政府開発援助　最大級の無償資金協力
構想から50年　計画から30年　工事20年

事業実施機関　国際協力機構　JICA
施主　ネパール国公共インフラ交通省道路局
コンサルタント　日本工営株式会社

シンズリ道路（160km）



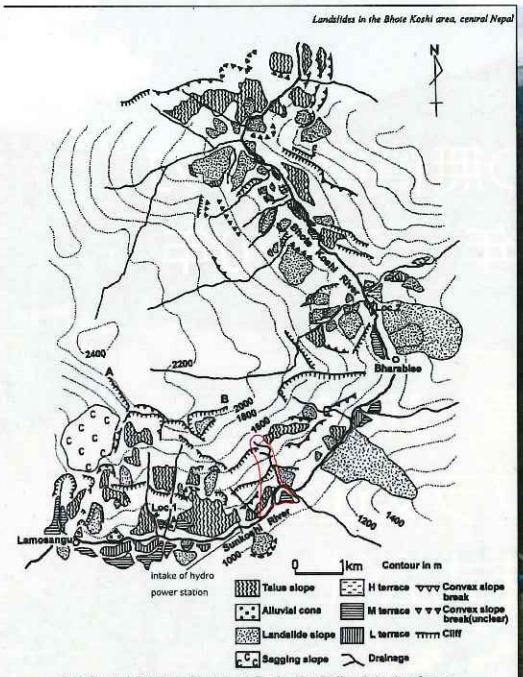


Fig. 2: Geomorphological map of the study area (Loc. 1 and Loc. 2 indicate the locations of outcrops

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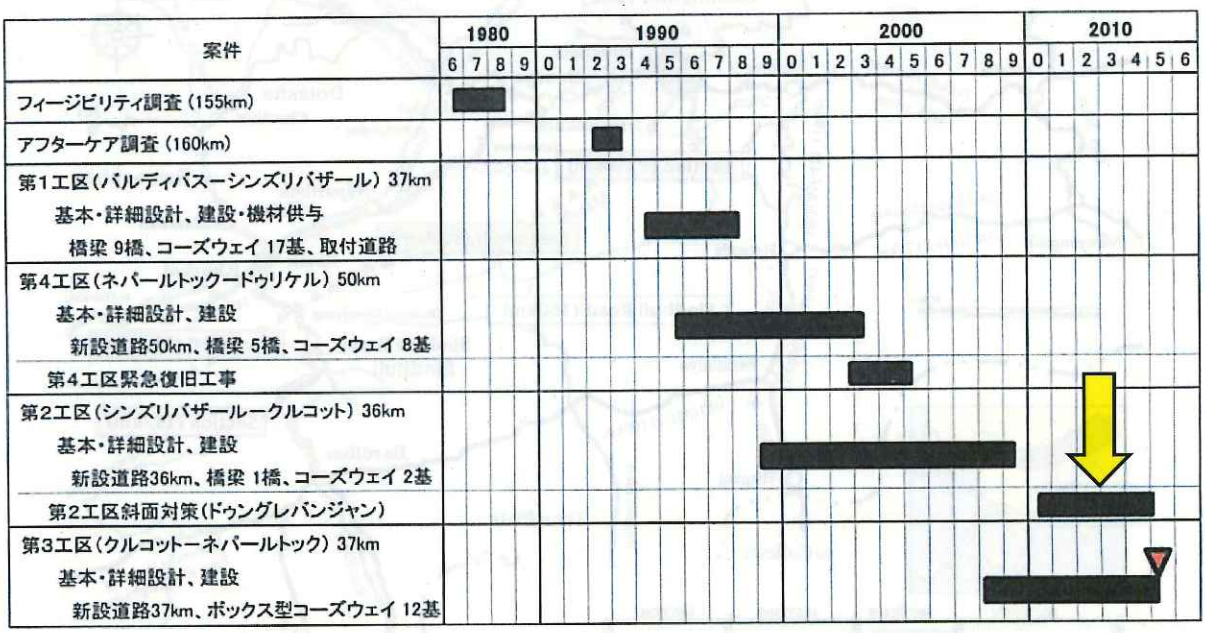
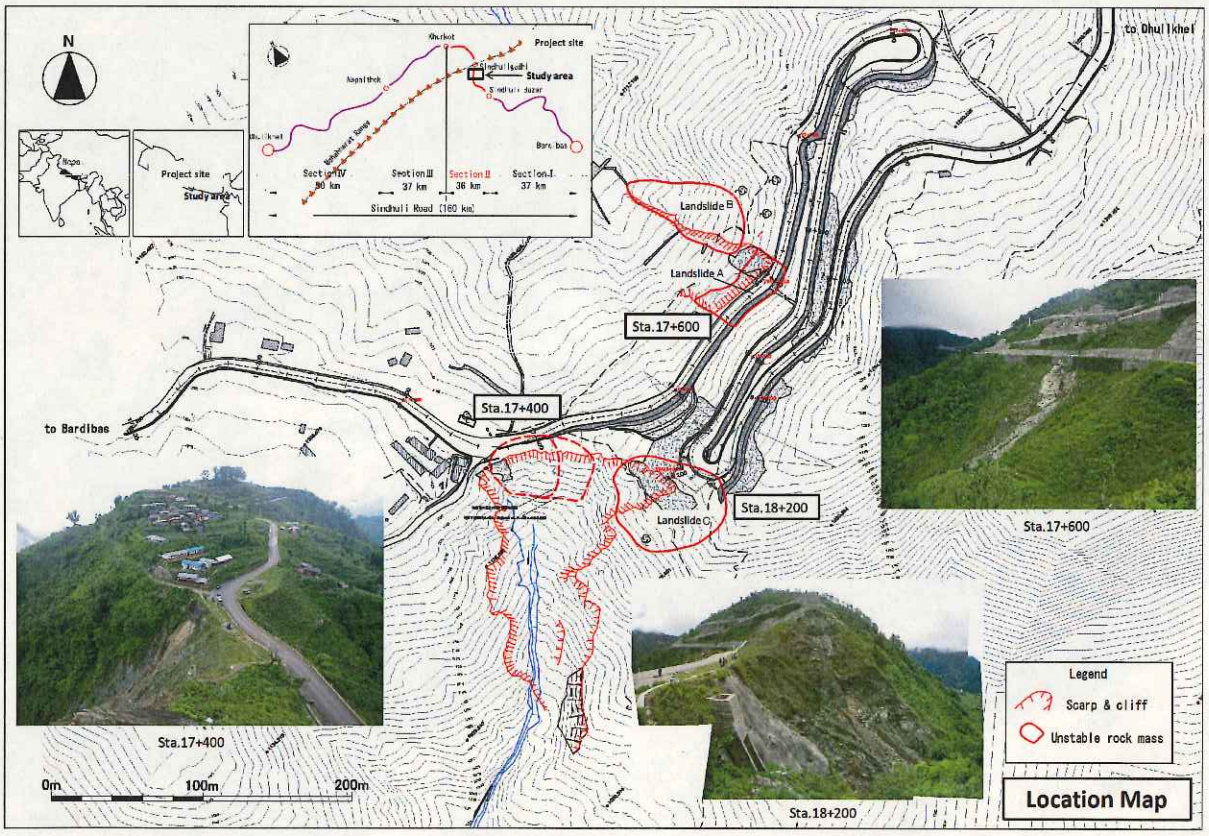
プロジェクト実施工程



シンズリ道路主要工事数量

		第1工区	第2工区	第3工区	第4工区	合計
延長	km	37.0	36.0	37.0	50.0	160
土工事	千 m^3	146	1,000	686	1,026	2,858
コンクリート工事	千 m^3	9	106	87	66	268
ギャビオン	千 m^3	36	122	120	28	306
練石積擁壁	千 m^2		157	113	132	402
用排水工	千 Lm	8	48	56	74	186
簡易舗装	千 m^2	14	170	180	289	653
橋梁	橋	9	1		5	15
		鋼橋5、RC橋10　総延長1,030m				
コーズウエイ	基	5	3	12	19	39
		ボックス型14、越流/穴あき25、　総延長2,390m				
のべ工事従事者数		コンサルタント30名　施工会社54名　ネパール人580万人日				

シンズリ道路斜面対策工事



Locations of Slope Works
Road Re-Alignment
Anchor Work
High Intensity Net
Embankment Work
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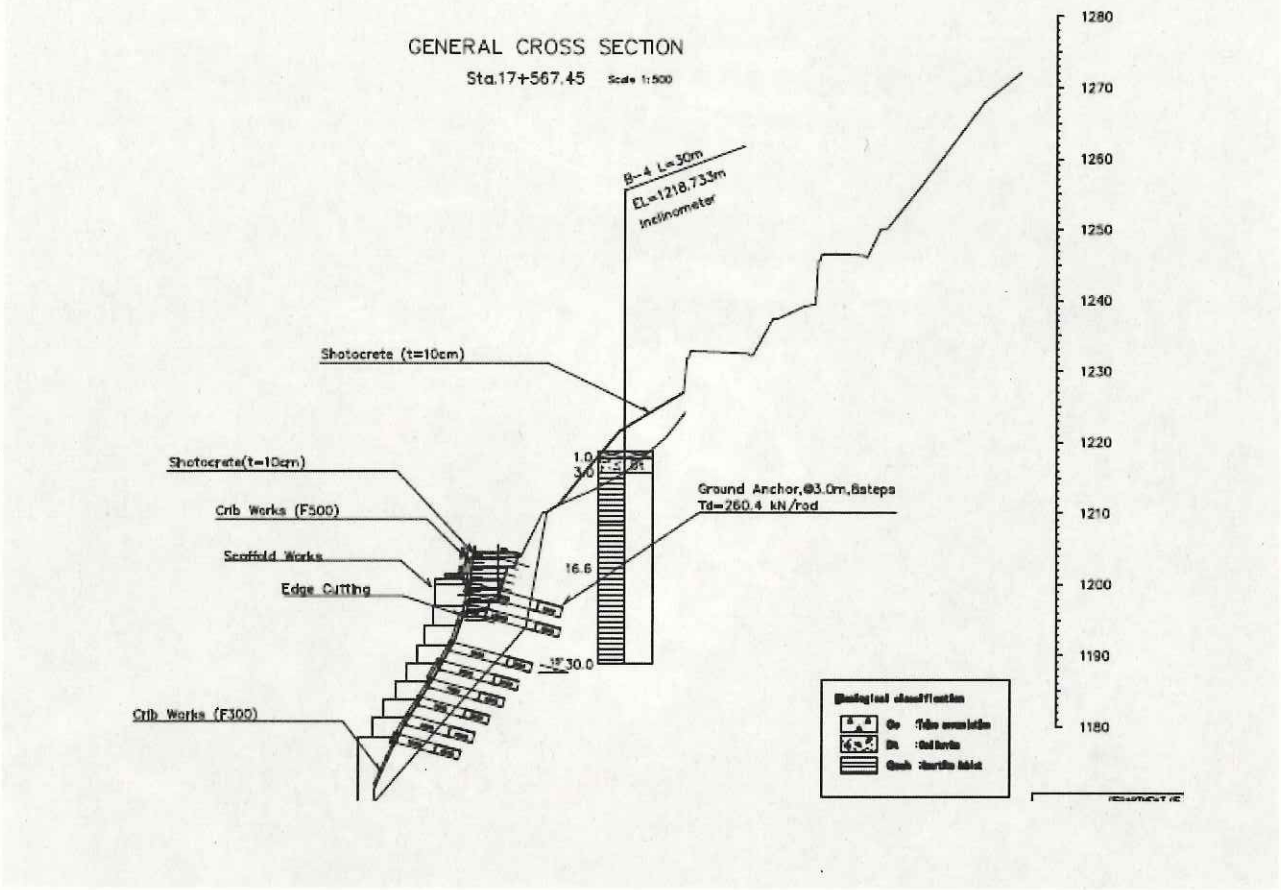

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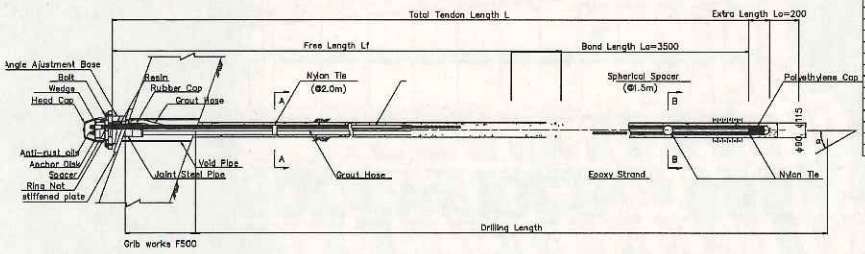
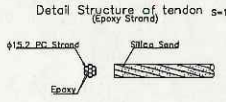
Structure of Anchor Tendon



Wedge	φ29　L=52	2	SCM415 equivalent
Anchor Disk	M100xP4L=64	1	S45C equivalent
Ring Nut	φ113　h=30	1	S45C equivalent
Head Cap	L=156	1	Aluminum Alloy
Spacer	φ65x3	1	High Density Polyethylene
Joint Steel Pipe	L=220	1	SS400 Steel Gas Pipe, Galvanization
Angle Ajustment Base	P170-N,170-N,B170-N	1	
Stiffened Plate	φ280x22,φ143	1	SS400, Galvanization
Water Stop Resin	A Size	1	Formed Resin
Rubber Cap	φ84　L=65	1	Polychloroprene
Spherical Spacer	φ59		High Density Polyethylene
Polyethylene Cap	L=126	1	High Density Polyethylene
Seal	L=150	2	Polyolefin(including Vinyl Tape)
Tape	L=500		Glass Fiber Reinforced Polyester Film
Nylon Tie			Nylon
Epoxy Paint		0.020	1 can per 50 anchors
Grout Hose	L=	1	the Length of Tendon
Filler	1.0Kg	1	

Sections Scale 1:10

Detail Structure of tendon (Epoxy Strand) S=1:4

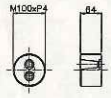


Type	Name	Outside Diameter mm(Film Thickness)	Tensile Load kN(kgf)	Yield Load kN(kgf)	Strain %
SWPR7B	15.2	16.4 (0.4 ~ 1.2mm)	over 261(26,600)	over 222(22,600)	over 3.5

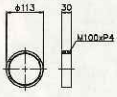
The value measured at the crown of the Strands.

Wedge Scale 1:10 (corresponding SCM415)

Anchor Disk Scale 1:10 (corresponding S45C)

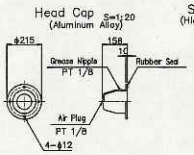


Ring Nut S=1:10 (S45C Equiv.)



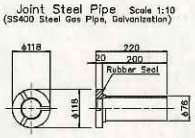
A-A
Boring Diameter φ90, φ115
Grout Hose φ21.5
Nylon Tie
Epoxy Strand φ15.2
Polyethylene Sheath φ23.5
B-B

Head Cap S=1:20 (Aluminum Alloy)



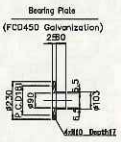
Spacer Scale 1:10 (High Density Polyethylene)

Joint Steel Pipe Scale 1:10 (SS400 Steel Gas Pipe, Galvanization)

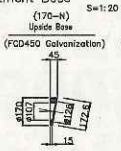


Angle Ajustment Base S=1:20

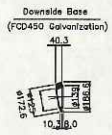
Bearing Plate (FCD450 Galvanization)



(170-N) Upside Base (FCD450 Galvanization)

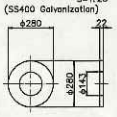


Downside Base (FCD450 Galvanization)

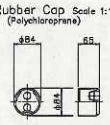


Boring Diameter φ90, φ115
Grout Hose φ21.5
Epoxy Strand φ15.2
Spherical Spacer

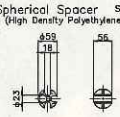
Stiffened Plate S=1:20 (SS400 Galvanization)



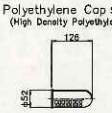
Rubber Cap Scale 1:10 (Polychloroprene)



Spherical Spacer Scale 1:10 (High Density Polyethylene)



Polyethylene Cap Scale 1:10 (High Density Polyethylene)



スーパーフローテック工法
φ15.2mm　2本より線

DEPARTMENT OF ROADS Ministry of Physical Planning,Works and Transport Management THE PROJECT FOR COUNTERMEASURE CONSTRUCTION AGAINST THE LANDSLIDES ON SHINDIMULI ROAD SECTION II	
STRUCTURE OF ANCHOR WORKS SAT 17+600	Drawing No. A-10
Date: August 2012	Scale: As Shown
Designed by:	Approved by:
NIPPON KOEI CO., LTD. Consulting Engineers, Japan	

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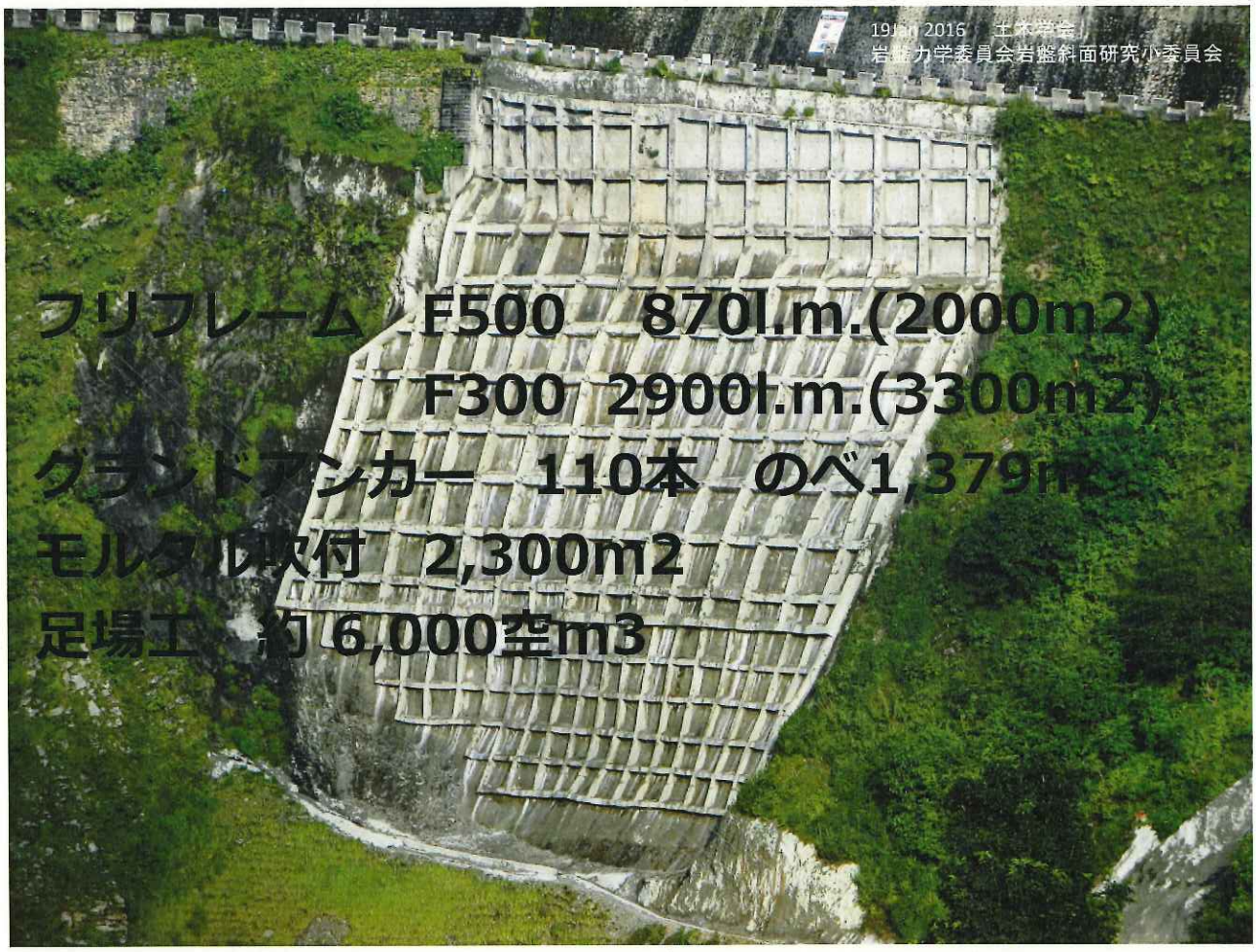
ネパール国で初の・・・・・・
Ground Anchor工法の採用
フリフレーム工法の採用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フリフレーム　F500　870l.m.(2000m2)
F300　2900l.m.(3300m2)
グランドアンカー　110本　のべ1,379m
モルタル吹付　2,300m2
足場工　約6,000空m3

ON JOB Training

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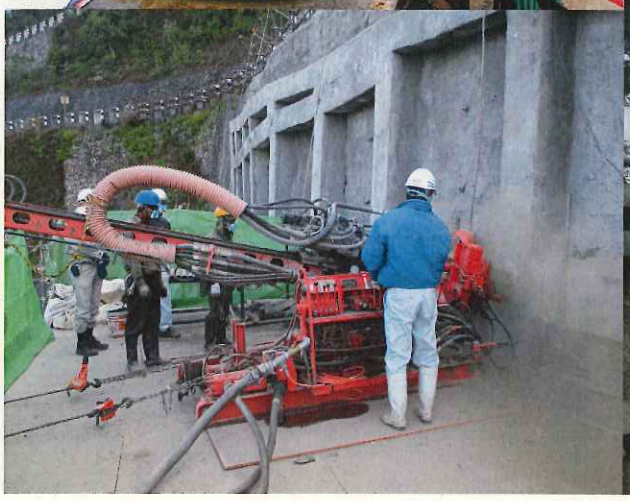

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Before & After 1

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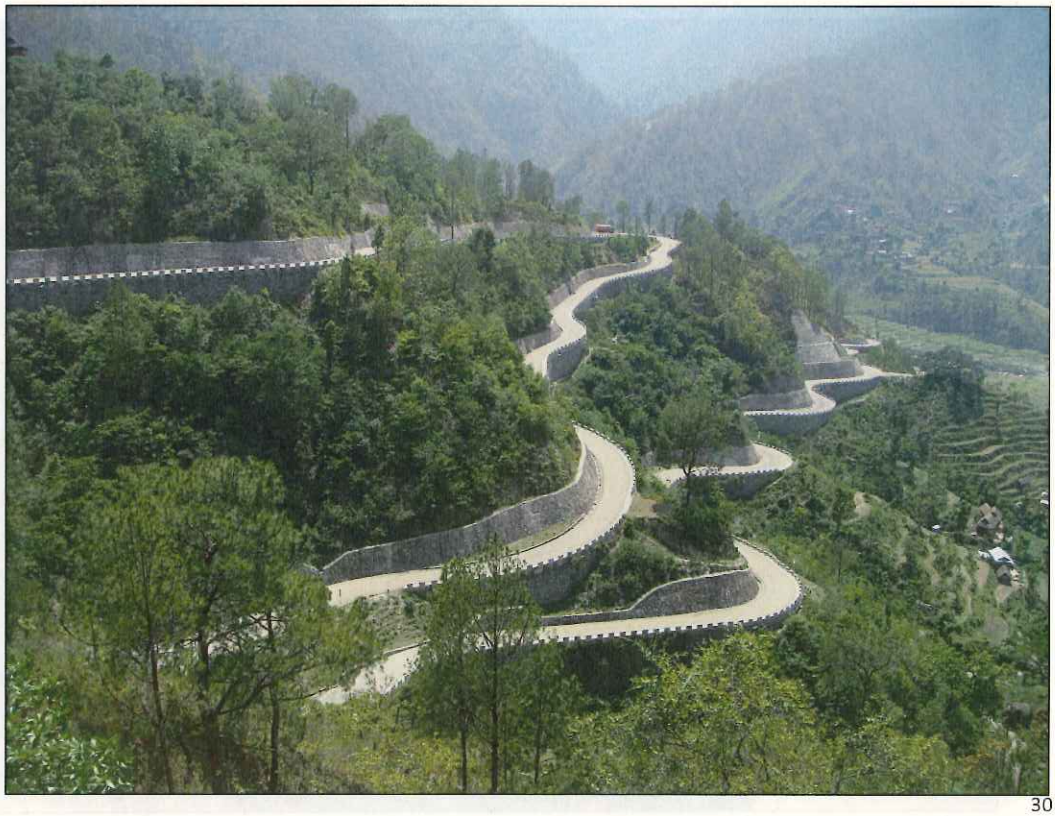
Before & After 1



Before & After 2

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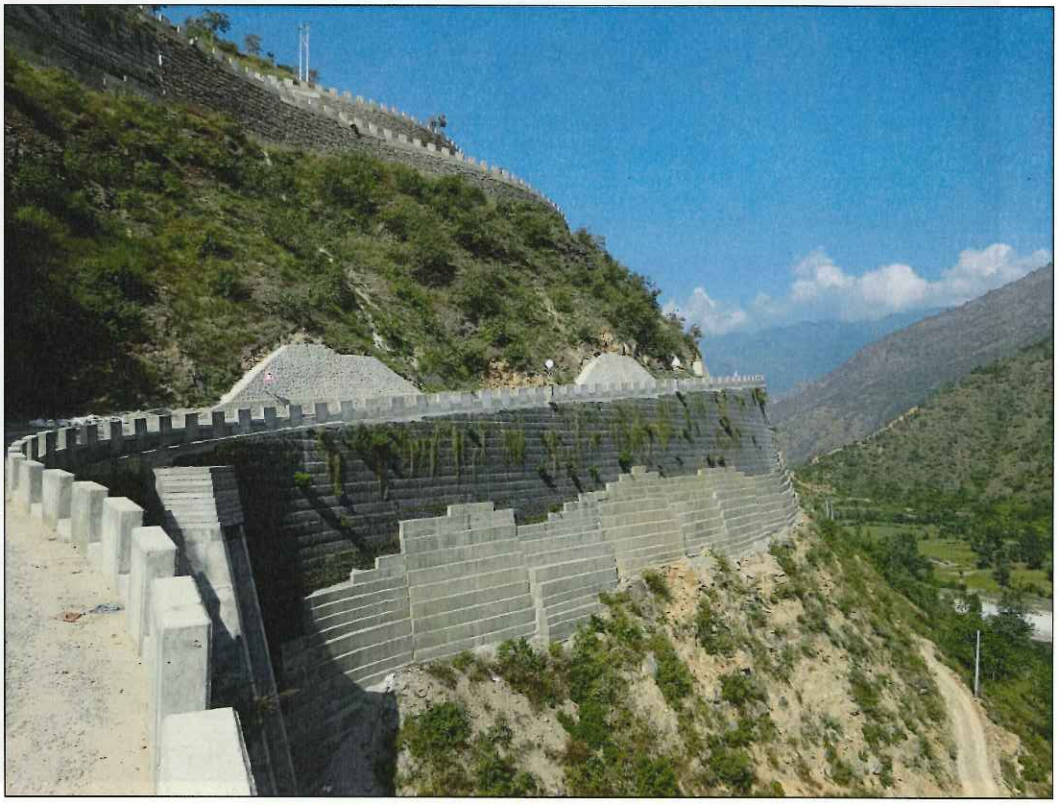
Before & After 3



Before & After 3

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Before & After 3

Before & After 4

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Before & After 4

2015年 ISRMのNational Groupに加盟
初のISRM国内シンポジウムを開催

NSRM
Nepal Society for Rock Mechanics

1st National Conference of
Nepalese Society for Rock Mechanics

Rock Engineering Practice in Infrastructure Development in Nepal

22nd March, 2015
Kathmandu, Nepal

NSRM

Nepal Society for Rock Mechanics

~~1st National Conference (22 March,2015)~~

Rock Engineering Practice in Infrastructure Development in Nepal

Program Schedule

Inaugural Session	
09:30 to 10:00 Hrs	Registration
10:00 to 10:05 Hrs	Welcome Speech by NSRM President, Mr. Prem Krishna K.C
10:05 to 10:15 Hrs	Short speech about NSRM and its objectives by Dr. Krishna Kanta Panthi
10:15 to 10:30 Hrs	Address by ISRM Vice President, Dr. Zhou Yingxin
10:30 to 11:15 Hrs	**Keynote Speech** of Prof Bjørn Nilsen, NTNU, Norway titled **"Basic Norwegian Procedures for Tunnel Planning, Design and Construction"**
11:15 to 11:45 Hrs	Tea/ Coffee Break
Technical Session I	
11:45 to 12:15 Hrs	Presentation by Er. Naresh Man Shakya/Prakash Chandra Ghimire titled **"Rock slope stability assessment practice in Nepalese highways"**
12:15 to 12:45 Hrs	Presentation by Dr. Igari Tetsuo titled **"Protection of slope stabilities in Sindhuli Road Project"**
12:45 to 1:15 Hrs	Presentation by Mr. Narayan Gopal Ghimire titled **"Rock-mechanical Investigation in Budhigandaki dam Site, Gorkha"**
1:20 to 2:15 Hrs	Lunch
Technical Session II	
2:15 to 2:45 Hrs	Presentation by Dr. Pawan Kumar Shrestha titled **"Estimating tunnel strain in weak and schistose rockmass under state of in-situ stress anisotropy"**
2:45 to 3:15 Hrs	Presentation by Dr. Krishna Kanta Panthi titled **"Predicting stress induced brittle failure in tunnels"**
Closing Session	
3:15 to 3:30 Hrs	Distribution of Token of Appreciation to presenters and sponsors by NSRM President
3:30 to 3:40 Hrs	Vote of Thanks by NSRM General Secretary Mr. Prakash Chandra Ghimire
3:40 to 4:00 Hrs	Closing and Hi-Tea

19Jan 2016　土木学会
岩盤力学委員会岩盤斜面研究小委員会

DOR's Position to deal with Rock slopes:

- Geo-environment and Social Unit (GESU): a specialized advisory unit on Geo-tech at centre
- Around 20 Geo-technical Engineers
- Limited mapping tools on rocks
- Generalized geo-technical manual with guidelines on rock slope stability analysis is available
- Geo-technical training to field engineers anually
- No adequate software available except SWEDGE (DIPs and other software- not available)

Way forward:

- Strengthen (GESU) with :
  - > trained geo-tech engineer,
  - > buy software such as DIPS
  - ➢ enough tools such as Clarr Compass, Schmidt hammer, point load testing equipments etc.
- Carry out dedicated training on rock slope stability to DOR Engineers who are supposed to work at rock slopes ;
- Support to Nepalese Engineering Institutes in Capacity building in rock slopes; and
- Establish collaboration with organizations such as NSRM.