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GOVERNMENT OF INDIA
GEOLOGICAL SURVEY OF INDIA

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(Progress Report for the Field Season 2007-08)

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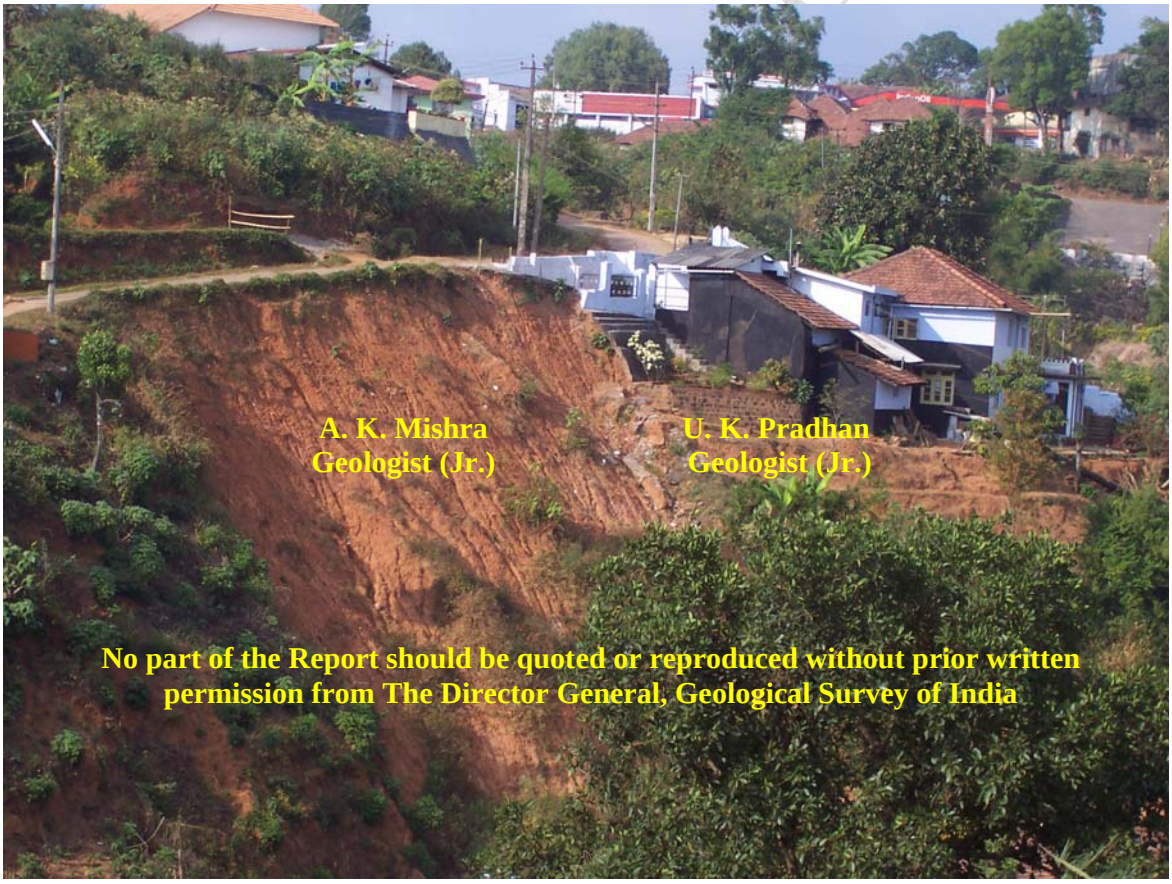

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Project: ENGINEERING GEOLOGY

State unit: Karnataka and Goa
BANGALORE

2010

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कर्नाटक के राष्ट्रीय मार्ग एवं राज्य मार्ग के घाट में भूस्खलन पर प्रतिवेदन

(क्षेत्र सत्र 2007-008 के प्रगति प्रतिवेदन)

कूट सं. : एल.एच.जेड/एस.आर./के.जी./2007/044

ए.के.मिश्रा एवं यू.के.प्रधान, भूविज्ञानी(क.)

सारांश

जुलाई, 2005 में मडिकेरी शहर में स्त्री और बच्चों सहित छह व्यक्तियों की भूस्लखन में मत्यु हुई, जिससे कर्नाटक के पश्चिमी घाट में भूस्खलनको एक आपदा के रूप में गंभीरता से देखा गया. इस हादसे से पहले न तो केन्द्र न ही राज्य प्राधिकारियों ने भूस्खलन की ओर ज्यादा ध्यान दिया था. भारतीय भूवैज्ञानिक सर्वेक्षण भारत के भूस्खलन के ग्रन्थिल अभिकरण (2004 में घोषित)ने इस हादसे का सामना करने के लिए सशक्त रूप से एवं तेजी से बहु-प्रोंग्ड कार्य आरंभ किया है.

कर्नाटक राज्य के भागों में पश्चिमी घाट के अनुभागों में भूस्खलन तालिका भूआकृति 48/आई/2, आई/3, ई/14,15,16 एवं जे/7,जे/6,जे/9, एल/13 में आरंभ किया गया था जिसका उद्देश्य भविष्य के भूस्खलन अनुक्षेत्र वर्गीकरण के लिए डाटाबेस को विकसित करना एवं भूस्खलन हादसों एवं जोखिम न्यूनीकरण पर एम.एच.ए. के कार्रवाई योजना के भाग के रूप में प्रतिरूपित करना है. क्षेत्र सत्र 2007-08 के दौरान निम्नलिखित घाट अनुभागों में कुल मिलाकर 64 आपतनों का अध्ययन किया गया.

अ) एस.एच -1 शिमोगा-मेंगलूर(आगुम्बे घाट अनुभाग) में भूस्खलन-2 अदद.
ब) एन.एच-17 मेंगलूर-मन्जेश्वर सडक अनुभाग :2 अदद(कर्नाटक-केरल सीमा)
स) एन.एच.17 होन्नवार-कुम्टा सडक अनुभाग:2 अदद
ड)मडिकेरी-मडेपल्ली-सम्पाजे सडक के बीच एस.एच.88 के रिकार्ड किए गए भूस्खलन:25 अदद
ई)मडिकेरी-सिद्दापुरेसडक के बीच एस.एच.-89 में रिकार्ड किए गए भूस्खलन: 4 अदद
फ) कारवार-कुम्बारवाडा (अन्सी घाट) के बीच एस.एच.-95 में रिकोर्ड किए गए भूस्खलन:14 अदद
ज) अराबली घाट में येल्लापुर-अन्कोला सडक में रिकार्ड किया भूस्खलन:15 अदद

प्रस्तुत अध्ययन यह दिखाता है कि ज्यादातर स्खलन छिछले मलबे स्खलन/अवसर्पण है. स्खलित वस्तुओं में गोलाश्म, चट्टानों के टुकडे एवं मिश्रोढक के सन्निक्षेप है. कट ढाल ऊँचाई में क्रोढ से टो तक एवं कोण के स्खलन में मुख्य भूमिका अदा करती है. यह देखा गया कि ज्यादातर स्खलन कट ढालों में प्रतिबंधित है जिसकी ऊँचाई 10 मी से ज्यादा है ढाल कोण में परिवर्तित होता है. कट ढाल से तुलनात्मक राहत सभी अनुभागों में निम्न से सामान्य है. उपरिभार की गहराई 0.5-10 मी में परिवर्तित होता है. पश्चिमी घाट में भूस्खलन का मुख्य कारण सडक के निर्माण के लिए चट्टान ढाल को टो कटिंग, मानवीय बस्ती का परिवर्द्धन, अपक्षीण चट्टान पिण्ड एवं निरंतर वर्षा है. पानी की बहुव्यापी उपस्थिति ठोस अपक्षीण के लिए अनुकूल है जिससे अपरूपण प्रतिरोध में काफी कमी आई है. घने अपक्षीण प्रोफाइल एवं भारी

वर्षा ऋतु के दौरान भारी वर्षा सभी स्खलनों के लिए मुख्य विमोचक है. स्खलन जो सडक कटिंग एवं मकान गठनों के ऊपर है अपक्षीण चट्टान एवं मलबे से बनाहै जबकि सडक कटिंग या ढाल के मुक्त पार्श्व की ओर उन्मुख मकानों के गठन मुख्यतया ढाल में से खोदे गए सन्निक्षेप अपरद से बने है. क्षेत्र में 200 मी मी मासिक बारिश होती है. चट्टान ढाल के टो में मकानों के अनुचित निर्माण से मदिकरे के आसपास कई भूस्खलन हुए है. स्खलन का मुख्य विमोचक कारण जमीन का उपयोग है यानि सडक का निर्माण एवं मानवीय बस्ती.

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ABSTRACT

Death of six persons including women and children in a landslide that occurred in July 2005 in Madikere town brought a sense of serious look toward the landslides as a hazard in the Western Ghats of Karnataka. Prior to this incident not much attention was paid by either the central or the state government authorities towards the land slides. Geological Survey of India as the Nodal agency for Landslides in India (declared during 2004), vigorously and swiftly started multi-pronged approach to address this hazard.

Landslide inventory of the Ghat sections of Western Ghats in parts of Karnataka state in toposheets 48I/2, I/3, E/14, 15 & 16 and J/7, J/6, J/9, and L/13 was taken up in order to develop a landslide database for future landslide zonation and modeling as a part of the action plan of the MHA on landslide Hazard and risk mitigation. A total of 64 incidences of landslides were studied along the following ghat sections of NH/SH during the FS 2007-08.

a) Landslides along NH-13, SH-1-Shimoga-Mangalore (Agumbe ghat section)- 2 nos.
b) Landslides along NH 17-Mangalore-Manjeshvar road section: 2nos. (Karnataka-Kerala border)
c) Landslides along NH 17-Honavar-Kumta road section: 2 nos.
d) Landslides recorded along SH-88 between Madikere- Madepalli -Sampaji road:25 nos.
e) Landslides recorded along SH-89 between Madikere-Siddapure road - 4 nos.
f) Landslides recorded along SH-95 between Karwar- Kumbarwada (Ansi ghat)-14 nos.
g) Landslides recorded along Arbail ghat along NH-63 between Yellapur- Ankola road-15 nos.

The present study reveals that most of the slides are shallow (<2 m depth) debris slides/slumps**.** The slided material consists of boulders, rock fragments and colluvial deposits. The cut slope height and angle plays a major role in all the slides as the sliding events from crown to toe are restricted between the cut slopes**.** It was observed that majority of the slides are restricted to the cut slopes having height more than 10m and slope angle varying from

70 -90 The relative relief from the cut slope is low to moderate at all the section and varies from 5m to 200 m with depth of overburden varying from 0.5-10 m. The general hill slope angle varies from 25-40°. The main causes of landslides in western Ghat are toe cutting of hill slope for construction of road, modification for human settlement, highly weathered rock mass and frequent rain. The ubiquitous presence of water is favorable for intense weathering of rocks causing appreciable drop in their shearing resistance. The deep weathering profile and the heavy rainfall during monsoon is the major trigger for all the slides. The slide that originate from above the road cutting and cut slopes of house formations consists of insitu weathered rock and debris whereas the slides that originating below the road cutting or the formation of the houses towards the free face of the slope are mainly the loose dumped waste material dug out from the slope. The area receives an average monthly rainfall of >200 mm during monsoon (from June –Sept). Improper construction of houses at hill slopes without giving proper remedial measures at the toe has caused many landslides around Madikere. The main triggering factors of slides are land use i.e. construction of road and human settlements.

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1. INTRODUCTION

1.1 Introduction

Landslide inventory of the ghat section of Western Ghats in parts of Karnataka state was been taken up to build data base on landslides for landslide zonation, modeling etc in order to implement the proposed action plan of the MHA on landslide hazard and risk mitigation. The item was taken up in pursuance of the code No LHZ/SR/KG/2007/044 item no. 062 of Geological Survey of India FSP 2007-08 under mission engineering geology and geotechnical investigation programme Landslide Hazard Evaluation. The landslide inventory was carried out in parts of Ghat roads of Western Ghats in Shimoga, Uttar Kannada, Coorg, Dakshina Kannada and Chikmagalur districts covering parts of toposheet nos. 48 O/3, P/11, P/15, J/5, J/6, J/7, J/9, J/10 and L/13.

1.2 Location

The Karnataka state is bounded by the Arabian Sea on the west, Goa and Maharastra in the northwest and north respectively and in the south it is bounded by Tamilnadu and Kerala state. During the FS 2007-08, landslide inventory was carried out along ghat roads in the western ghat belt (Plate-1 & 2). The western ghat belt which is known for its thickly vegetated forests and mineralisation is an irregularly elongated north-west trending belt. In Karnataka the western ghat extends from Chikmagalur district in the south to Uttar Kannada district in the north. The following ghat sections along NH and SH were covered.

a) Landslides recorded along SH-88 between Madikere-Madepalli -Sulya road: 26 nos. (Plate-3).
b) Landslides recorded along SH-89 between Madikere-Siddapure road - 3 nos. (Plate-4).
c) Landslides recorded along SH-95 between Karwar- Kumbarwada (Ansi ghat)-14 nos. (Plate-5 & 6).
d) Landslides recorded along Arbail ghat along NH-63 between Yellapur- Ankola road -11 nos. (Plate-7).

e) Landslides along NH 17-Karwar-Ankola road section: 4 nos. (Plate-8)

f) Landslides along NH-13, SH-1-Shimoga-Mangalore (Agumbe ghat section)-2 nos. (Plate-9)

g) Landslides along NH 17-Mangalore-Manjeshvar road section: 2 nos. (Plate-10)

h) Landslides along NH 17-Honavar-Kumta road section: 2 nos. (Plate-11).

1.3 Nature and quantum of work

Nature of Work	Total work envisaged	Work proposed for FS: 2007-08	Work completed
Aerial photo/Image interpretation and checking of incidences given by state governments and other incidences enroute	50 incidences	50 incidences	64 incidences

1.4 Acknowledgements

The authors are sincerely thankful to Shri A. K. Chattopodhyay, then Dy. D. G, Op: Karnataka and Goa for his support and guidance. The authors are grateful to Dr. K. Rajaram for providing support and guidance. They are thankful to Shri R. Panduranga, Director EG for his technical guidance and scrutiny of the report. Without the data provided by the district authorities, to locate the slide would have been a difficult /impossible task. In this regard authors are grateful to the authorities of Govt. of Karnataka, namely, District Commissioner, Collectors of different districts and PWD, Govt. of Karnataka.

2. REGIONAL GEOLOGY

The western ghat belt preserves an ideal succession of Bababudan Group, which is exposed in the mountainous region of Kudremukh, Agumbe and Kodachadri. The Sargur group is represented by a number of enclaves within gneisses and granites and the enclaves are quartzite, amphibolite, iron formation, garnetiferous mica schist, kyanite-staurolite schist, silimanite-garnet schist, calc-silicate rock and ultramafics. The Peninsular gneiss of this region is a complex of migmatitic gneiss and granitoids and includes biotite gneiss, hornblende-biotite gneiss and hornblende gneiss. The peninsular gneiss is unconformably overlain by Dharwar Supergroup (Bababudan Group). Bababudan group is represented by four formations namely a) Walkunje Formation b) Kudremukh Formation c) Kodachadri Formation and d) Narasiparvata Formation. The Walkunje Formation represents the lower arenaceous and argilaceous member of the Bababudan Group. Other rock members associated with it are quartzites, quartz-sericite schist, greywacke, arkose and quartz-biotite-chlorite schist. Kudremukh formation comprises amygdolar metavolcanics, amphibolite, actinolite-chlorite schist, meta gabbro and ultramafics with interbeds of quartzites, quartz-sericite schist and chlorite schist. Kodachari formation comprises of Banded magnetite quartzite and quartz-chlorite-sericite schist. The Narasiparvata formation comprises of acid porphyries, chlorite quartz schist and iron stones. Numerous dykes varying in texture from coarse to fine grained are reported from various localities. The laterite cover is extensive in the area between the coastal plains and the intermediate range of hills below the Western Ghats.

3. LANDSLIDE INVENTORY

3.1. Methodology for landslide inventory

1. The landslide data were collected from different district commissioner offices, PWDs and other district authorities.
2. Prioritisation of the landslides for inventory was carried out
3. No data could be obtained from aerial photo/imageries as the land slides are small in dimension and these are in 1:50,000 scale.
4. The most important characters and the important data to be collected were discerned as the data sheet provided by the CHQ were inadequate in many respect.
5. The check list table was prepared
6. Each slide site was studied and the measurements of various dimensions taken by using measuring tape.
7. The slides were designated a special ID to distinguish from one another and easy data interpretability. As for Karnataka state the slides were named as KA 01, KA02 etc. The date of study was taken as precedence over all other criteria for assigning the ID
8. The indexing method Date on which landslide data collected takes preference not date of occurrence or any other morphometric or independent criteria as many slides don't have the data/lacks data.
9. Photo graphs taken are more than what is provided in the report and the numbering is done as Slide no: KA01 (1), Slide no: KA01 (2)… etc. and is stored in the landslide in landslide inventory database file in .jpeg format for future reference.
10. Data entered are in excel file format as per the check list and kept in soft copy file format and the data in soft copy is provided in such to the Dy. D. G, Op: Karnataka and Goa and the Director EG for safe custody till a viable software is developed to keep the database for future reference, data base management (including, excluding and revising the database.)

3.2. Constraints & limitations

1. Many data of many slides are lacking or are approximations because the slide slopes at many places could not be conquered hence some measurements like scarp depth/width was visually estimated.
2. Scarp radius was visually estimated
3. Angle of repose and angle of failure were taken at the present slope where as the slope at the sliding might be different

4. Vertical interval and horizontal components were calculated from slide length and failure angle.
5. The size of slides in Western Ghats is small hence were difficult to pick up from the satellite imageries or Arial photo of 1:50,000 scale
6. The recent Arial photos are not available and we don't have these data in different sequence of time.
7. Weathering depth at the slide site or nearby nala sections was taken.

3.3. Description of individual slide

During the FS 2007-08, landslide inventory was carried out along ghat roads in the western ghat belt. A total of 300 line km was covered and 64 incidences of landslides were studied. Detail description of each landslides studied during this period are given below.

Photographs of each slide follow the description.

LANDSLIDES ALONG MADIKERE-MADEPALLI -SULYA ROAD SH-88

SLIDE NO: KA01

LOCATION: The slide is located at latitude 12° 24′ 49″ N and longitude 75° 44′ 21″ E in Survey of India toposheet No 48 P / 11 along SH-88, in Madikere taluk, Coorg district (2 km from Madikere town).

SLIDE DESCRIPTION: The slide is classified as a debris slide. The debris consists of boulders & rock fragments of weathered granite and colluvial deposits. The slide has occurred due to the lateral progradation of small & shallow slides along the strike of the spur. With a overburden depth of nearly 1m and weathering ~ 10m the slope forming material was weak and loose. Though houses have been constructed at the lower levels of the slope, the slope has been modified for construction of the State on this moderately vegetated slope.

MORPHOLOGICAL PARAMETER OF SLIDE

a.	Maximum length of failed mass from crown to foot	:	30 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	20 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	5 m
d.	Volume of failed mass above the failure surface	:	1500 m^3
e.	Slope angle after failure	:	80°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	41°
h.	Scar width	:	15 m
i.	Scar depth	:	5 m
j.	Direction of slide	:	S60°E

CAUSES: The contour road has been cut across the slope of the spur of the hill where both sides are drained by streams. The cut slope has exposed the toe of the slide on the road along the three sides of the slope thus increasing the instability. As the cut slope height was more at the middle part of the spur i.e. convex turn of the road, the maximum disturbing force was along this direction. The incumbent pore pressure development during monsoon triggered this slide as the slope forming debris material was highly saturated with rain water. Few old slide scars observed at the boundary of this slide were also caused due to the above reasons.

NATURE OF DAMAGE: The Madikere-Mangalore state highway (SH 88) was blocked due to the heaped debris material on the road.

RECCOMENDATION:

i) The crown part was found to be unstable hence the crown portion is to be completely removed.

ii) The geometrical modification of the slope by grading or bench to be provided with height 2m with bench width 1 m at a slope angle of <30˚.

iii) Bio geotechnical measures of slope protection like plantation of Vetiver grass along the slope will reinforce this shallow slide.

iv) Proper surface drainage and horizontal drainage is also recommended.

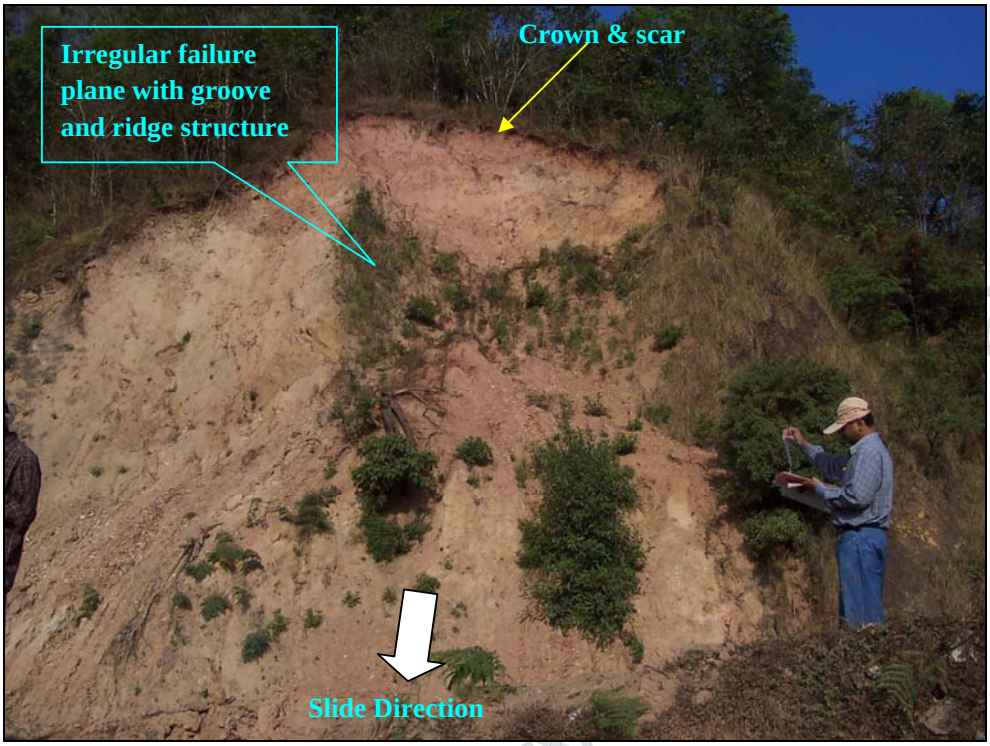

Photo-1: *The plan view of the landslide along Madikere-Mangalore road section (SH88)*

Photo-2: *The highly weathered granite gneiss boulders in the debris on the slide plane*

SLIDE NO: KA02

LOCATION: The slide is located at latitude 12° 24′ 44″ N and longitude 75° 44′ 04″ E at elevation 1034 m from MSL in Survey of India toposheet No 48 P / 11 in Madikere taluk, Coorg district along Madikere-Mangalore road (SH-88).

SLIDE DESCRIPTION: The slide is classified as a multiple source (6 sources) debris slump. It is a new slide. The debris consists of boulders, rock fragments and colluvial deposits. The material involved is weathered granite. The over burden depth is 1 m. Land used is for construction of road. The depth of weathering is 11m.

MORPHOLOGICAL PARAMETER OF SLIDE

a.	Maximum length of failed mass from crown to foot	:	60 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	9 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	3 m
d.	Volume of failed mass above the failure surface	:	810 m^3
e.	Slope angle after failure	:	80°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	40°
h.	Direction of slide	:	S13°E & S5°W

CAUSES: This slide was caused due to the blockage/obstruction of natural drainage. The mid section of the drainage was excavated for making construction space for the houses. The two small slides in the left flank of the major slide were on the cut slope at the mid section. To add to the woe the excavated material at the top of the hill are dumped in the slope. Both toe cutting and over saturation of the loose slope forming material caused this slide.

NATURE OF DAMAGE: The Madikere-Mangalore state highway (SH 88) was blocked due to the heaped debris material on the road.

RECCOMENDATION:

i). The loose material at the crown is to be removed.

ii). The natural stream is to be restored for free flow.

iii). No construction should be allowed along the flanks of the stream.

iv).Small retaining wall of 2m height may be constructed at the base.

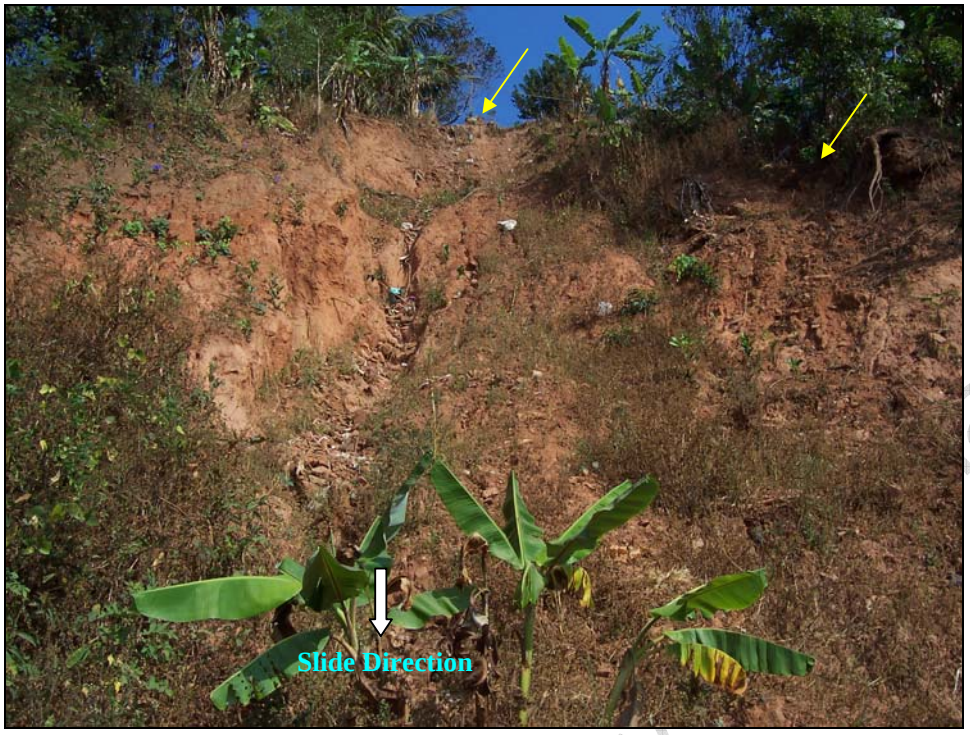

Photo-3: *The plan view of the landslide with several rills on the slide plane, the arrow mark shows the two source of the slide*

Photo-4: *The SH88 was blocked (arrow) and the slided debris was heaped up on the road*

SLIDE NO: KA03

LOCATION: The slide is located at latitude 12° 24′ 44″ N and longitude 75° 44′ 04″ E at elevation 1033m from MSL in Survey of India toposheet No 48 P / 11 in Madikere taluk, Coorg district along SH-88.

SLIDE DESCRIPTION: The slide is classified as a multiple debris slump. It is a new slide. The debris consists of boulders, rock fragments and colluvial deposits. The material involved is weathered granite. The over burden depth is 0.5 m. Land used is for construction of road. The depth of weathering is 5m.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	23m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	8m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	2m
d.	Volume of failed mass above the failure surface	:	184m^3
e.	Slope angle after failure	:	70°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	18°
h.	Scar depth	:	5m
i.	Direction of slide	:	S74°W

CAUSES: The house is located in the mid slope. The space for the construction of house has been carved out in the mid slope by excavation resulting in flattening of the slope .The loose unconsolidated dug out material was dumped in the lower slope (towards SH88).The pavement of the house was resting directly over this loose material. During monsoon of 2006 due to heavy rainfall the debris slided due to over saturation of the unconsolidated material taking with it a part of the varandah and developing concentric crown cracks all over the varandah, wall etc. To this the toe cutting of the slope at the back of the house caused the cutslope to fail and the slided debris ran into the back of the house damaging the back wall. The house was damaged due to the landslide.

NATURE OF DAMAGE: One house was damaged and SH88 was blocked.

RECCOMENDATION:

i) The house is to be shifted and relocated to safer place.

ii) The over hanging portion of the varandah is to be cleared totally as this portion is highly unstable and will slide down to SH88 in future with slight trigger.

iii) Geometrical modification of the slope with grading .

Photo 5: *The damaged house standing in the mid slope of the slide, rills formed all over the slide zone.*

Photo 6: *The arrow shows the damaged pavement with crown cracks*

Photo 7: *The land slide in the vertical cut slope with scar at the back of the house*

Photo 8: *The debris accumulation and damage to the back wall and roof of the house.*

SLIDE NO: KA04

LOCATION: The slide is located at latitude 12° 24′ 44″ N and longitude 75° 44′ 04″ E at elevation 1033m from MSL in Survey of India toposheet No 48 P / 11 in Madikere taluk, Coorg district along Madikere-Mangalore (SH88).

SLIDE DESCRIPTION: The slide is classified as a debris slump and is a new slide. The debris consists of boulders, rock fragments and colluvial deposits. The material involved is weathered granite. The over burden depth is 0.5 m. Land used is for construction of road. The depth of weathering is 5m.Circular cracks are noticed in the mid slope for a length of about 15m and opening of 1-5 cm.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	29 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	10 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	1 m
d.	Volume of failed mass above the failure surface	:	145 m^3
e.	Slope angle after failure	:	65°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	40°
h.	Direction of slide	:	N03°W

CAUSES: This slide occurred 100m west of the slide noKA03 in the same modified slope. The damaged house is located in the mid slope (Photo -10). The space for the house has been carved out in the mid slope by excavation (flattening the slope). The loose unconsolidated excavated material was dumped in the lower part of the slope (towards SH88). During monsoon of 2006 heavy rainfall caused over saturation of the unconsolidated slope material which slided down slope. The toe cutting of the slope at the back of the house caused the cutslope to fail and the slided debris ran into the back of the house damaging the back wall.

NATURE OF DAMAGE: One house damaged and Madikere-Mangalore (SH88) road was blocked.

RECCOMENDATION:

i). Geometrical modification of the slope is necessary to stabilize the slope.

ii).As the slide is a shallow slide with depth of sliding less than 2m, deep rooted plants/shrubs with high tensile strength is to be planted in the benched slope to increase its stability.

iii). Removal of loose material from the unstable crown.

Photo 9: *The debris dumped on the slope slided down on to the road, the arrow shows the undisturbed plants on the slope*

Photo 10: *The damaged house which was located along the run out path of the slide*

SLIDE NO: KA05

LOCATION: The slide is located at latitude 12° 24′ 43″ N and longitude 75° 43′ 55″ E at elevation 1033m from MSL in Survey of India toposheet No 48 P / 11 in Madikere taluk, Coorg district along Madikere - Mangalore road (SH88).

SLIDE DESCRIPTION: The slide is classified as a debris slide. It is a new slide. The debris consists of boulders, rock fragments and colluvial deposits. The material involved is weathered granite. The over burden depth is 0.3 m. Land used is for construction of road. The depth of weathering is 10m.The type of failure is slip.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	10 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	12 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	2 m
d.	Volume of failed mass above the failure surface	:	120 m^3
e.	Slope angle after failure	:	80°
f.	Slope angle before failure	:	85°
g.	Original slope angle	:	30°
h.	Scar width	:	5 m
i.	Scar depth	:	3 m
j.	Direction of slide	:	N55°W

CAUSES: A small stream was crossing the hill slope before the construction of road. During the time of the road alignment the slope modification was carried out with the cutting of the stream course with out providing an outlet. The depth of weathering along this stream section was more than the adjoining area of the slope. During monsoon of 2006 due to high recharge along this depression the oversaturated debris slided.

NATURE OF DAMAGE: The Madikere - Mangalore road (SH88) was partially blocked.

RECCOMENDATION:

i) The water flowing along the depression to be rearranged by proper drainage at the surface.

ii) Retaining wall with weep holes may be provided as the slope is at very high angle after failure.

iii) Modification of the slope with grading and benches.

iv) Removal of the unstable material.

Photo 11: *The view of the slide with the depression on the slope.*

Photo 12: *The circular failure of the slide with the exposed bedrock (weathered granite)*

SLIDE NO: KA06

LOCATION: The slide is located at latitude 12° 24′ 45″ N and longitude 75° 43′ 49″ E at elevation 1034m from MSL in Survey of India toposheet No 48 P / 11 in Madikere taluk, Coorg district along Madikere - Mangalore road (SH88).

SLIDE DESCRIPTION: The slide is classified as a debris slump. It is a new slide. The debris consists of boulders, rock fragments and colluvial deposits. The material involved is weathered granite. The over burden depth is 0.2 m. Land used is for construction of road. The depth of weathering is 10m.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	15m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	21m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	1m
d.	Volume of failed mass above the failure surface	:	158m^3
e.	Slope angle after failure	:	56°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	40°
h.	Direction of slide	:	S41°E

CAUSES: The original slope angle of this small spur is very gentle and is dissected by two small streamlets in both sides. The slope having more than one meter thick debris was cut vertical for the road and it was failed earlier due to high rainfall experienced in this area. The new slide was due to lateral progradation of the old slide on its left flank. Toe cutting during road alignment and the already induced instability of the slope after the first slide caused the slope to fail during high monsoon rain of 2006.

NATURE OF DAMAGE: The Madikere-Mangalore road was partially blocked.

RECCOMENDATION:

i) The relative height of the slope is low hence benching of the slope with a average slope angle of 45˚ will ensure its stability in long run.

ii) Deep rooted plants/shrubs with high tensile strength is to be planted in the benched slope to increase its stability.

Photo 13: Lateral progradation of the slide along SH88 cut slopes

Photo 14: Deeply weathered granite exposed in the slide plane with old slide plane

SLIDE NO: KA07

LOCATION: The slide is located at latitude 12° 25′ 0″ N and longitude 75° 42′ 45″ E at elevation 1034 m from MSL in Survey of India toposheet No 48 P / 11 in Madikere taluk, Coorg district along Madikere - Mangalore road (SH88).

SLIDE DESCRIPTION: The slide is classified as a debris slide. It is a new slide and elliptical in shape. The debris consists of boulders, rock fragments and colluvial deposits. The material involved is weathered granite. The over burden depth is 0.25 m. Land used is for construction of road. The depth of weathering is 7m.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	12 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	7 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	2 m
d.	Volume of failed mass above the failure surface	:	84 m^3
e.	Slope angle after failure	:	45°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	50°
h.	Scar width	**:**	10 m
i.	Scar depth	:	3 m
j.	Direction of slide	:	N74°E

CAUSES: The original slope angle of the spur is very gentle. The slope having more than one meter thick debris was cut vertical for the road and failed due to high rainfall experienced in this area. The crown and the toe of the slide is restricted above the road as the plant roots are still exposed in vertical position. The slope failed due to high pore water pressure development due to heavy infiltration during the monsoon.

NATURE OF DAMAGE: The Madikere-Mangalore road was partially blocked.

RECCOMENDATION:

i) The relative height of the slope is low hence benching of the slope with a average slope angle of 45˚ will ensure its stability in long run.

ii) As the slide is a shallow slide with depth of sliding less than 2 m, deep rooted plants/shrubs with is to be planted in the benched slope to increase its stability.

Photo 15: Shallow debris slide with a concave sliding plane

Photo 16: View of the slide with unaffected plants near the toe of the slide

SLIDE NO: KA08

LOCATION: : The slide is located at latitude 12° 25′ 0″ N and longitude 75° 42′ 45″ E at elevation 1034 m from MSL in Survey of India toposheet No 48 P / 11 in Madikere taluk, Coorg district along Madikere - Mangalore road (SH88), 20 m from slide no. 7 towards Mangalore.

SLIDE DESCRIPTION: The slide is classified as a debris slump. It is a new slide and elliptical in shape. The debris consists of boulders, rock fragments and colluvial deposits. The material involved is weathered granite. The over burden depth is 0.5 m. The depth of weathering is 8m.Land used is for construction of road.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	10 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	5 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	0.5 m
d.	Volume of failed mass above the failure surface	:	25 m^3
e.	Slope angle after failure	:	70°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	80°
h.	Direction of slide	:	N80°E

CAUSES: High cut slope angle, more than 3mteter depth of weathering and the old slide in the slope made it unstable. The high precipitation during monsoon of 2006 triggered the new slide.

NATURE OF DAMAGE: The Madikere-Mangalore road was partially blocked.

RECCOMENDATION:

i).The relative height of the slope is low hence benching of the slope with a average slope angle of 45˚ will ensure its stability in long run.

ii).As the slide is shallow with depth of sliding less than 2m, deep rooted plants/shrubs with high tensile strength is to be planted in the benched slope to increase its stability.

Photo 17: An angular plan view of the Lateral progradation of the old slide in its right flank

Photo 18: The concavity and convexity of the slide plane.

SLIDE NO: KA09

LOCATION: The slide is located at latitude 12° 25′ 01″ N and longitude 75° 42′ 44″ E at elevation 961m from MSL in Survey of India toposheet No 48 P / 11 in Madikere taluk, Coorg district along Madikere - Mangalore road (SH88).

SLIDE DESCRIPTION: The slide is classified as a multiple, debris slump. It is a new slide and irregular in shape. The debris consists of boulders, rock fragments and colluvial deposits. The material involved is weathered granite. The over burden depth is 0.5 m. The depth of weathering is 10m.Land used is for construction of road.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	12m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	30m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	1m
d.	Volume of failed mass above the failure surface	:	180m^3
e.	Slope angle after failure	:	80°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	20°
h.	Scar depth	:	0.5 m
i.	Direction of slide	:	N30°E

CAUSES: High cut slope angle, more than 3 meter depth of weathering and the old slide in the slope made it unstable. The high precipitation during monsoon of 2006 triggered the new slide.

NATURE OF DAMAGE: The Madikere-Mangalore road was partially blocked.

RECCOMENDATION:

i) The relative height of the slope is low hence benching of the slope with an average slope angle of 45˚ will ensure its stability in long run.

ii) As the slide is shallow with depth of sliding less than 2m, deep rooted plants/shrubs with high tensile strength is to be planted in the benched slope to increase its stability.

Photo 19: View of the landslide along the cut slope of SH88

Photo 20: Two sources of the shallow slide on the cut slope along SH88

SLIDE NO: KA10

LOCATION: The slide is located at latitude 12° 25′ 05″ N and longitude 75° 42′ 26″ E at elevation 961 m from MSL in Survey of India toposheet No 48 P / 11 in Madikere taluk, Coorg district along Madikere - Mangalore road (SH88).

SLIDE DESCRIPTION: The slide is classified as a multiple, debris slump. It is a reactivated slide and circular in shape. The debris consists of boulders, rock fragments and colluvial deposits. The material involved is weathered granite. The over burden depth is 0.3 m. The depth of weathering is 10 m.Land used is for construction of road.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	10m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	12m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	1m
d.	Volume of failed mass above the failure surface	:	$60m^3$
e.	Slope angle after failure	:	75°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	25°
h.	Scar width	**:**	10m
i.	Scar depth	:	3m
j.	Direction of slide	:	N14°W

CAUSES: High cut slope angle, more than 3mteter depth of weathering and the old slide in the slope made it unstable. The high precipitation during monsoon of 2006 triggered the new slide.

NATURE OF DAMAGE: The Madikere-Mangalore road was partially blocked.

RECCOMENDATION:

i) The relative height of the slope is low hence benching of the slope with an average slope angle of 45˚ will ensure its stability in long run.

ii) As the slide is shallow with depth of sliding less than 2m, deep rooted plants/shrubs with high tensile strength is to be planted in the benched slope to increase its stability.

Photo 21: View of the slide plane and the accumulation zone

Photo 22: Formation of striations on the slide zone

SLIDE NO: KA11

LOCATION: The slide is located at latitude 12° 25′ 10″ N and longitude 75° 41′ 35″ E at an elevation of 961 m from MSL in Survey of India toposheet No 48 P / 11 in Madikere taluk, Coorg district along SH-88 Madikere –Mangalore road.

SLIDE DESCRIPTION: The slide is classified as a debris slide with multiple sources. The debris consisting of boulders & rock fragments of weathered granite and colluvial deposits. The slided area has an overburden depth of nearly 1m and weathering ~ 8m . The slope has been modified for construction of the State Highway on this moderately vegetated slope.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	10 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	38 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	1 m
d.	Volume of failed mass above the failure surface	:	190 m^3
e.	Slope angle after failure	:	75°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	25°
h.	Scar depth	:	3 m
i.	Direction of slide	:	S48°W

CAUSES: The increase in the gradient of the slope due to the vertical cut slope for making road decreased the stability of slope. The heavy precipitation during monsoon increased the pore water pressure, the loose overburden and the weathered granite in the slope failed due to saturation.

NATURE OF DAMAGE: The SH-88 was affected as road was blocked due to slide material.

RECCOMENDATION:

i) The unstable crown should be completely removed.

ii) Making contour drainage at the top of the slopes for decreasing infiltration and sub-surface horizontal drainage i.e. inserting horizontal perforated pipes in to the slopes will act as weep holes in the vertical slopes and thus reducing the pore pressure by draining out the excess water.

Photo 23: *The plan view of the debris slide with exposed bed rock.*

Photo 24: *The plan view of the debris slide with exposed bed rock.*

SLIDE NO: KA12

LOCATION: The slide is located at latitude 12° 25′ 45″ N and longitude 75° 40′ 43″ E at elevation 889 m from MSL in Survey of India toposheet No 48 P / 11 in Madikere taluk, Coorg district along SH-88 in Madikere –Mangalore road.

SLIDE DESCRIPTION: The slide is classified as a debris slide. The debris consists of boulders & rock fragments of weathered granite and colluvial deposits. The slided area has a overburden depth of nearly .50m and weathering ~ 8m .The slope forming material was loose. The slope modification for construction of the State Highway is the only land use on this moderately vegetated slope.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	10 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	9 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	1 m
d.	Volume of failed mass above the failure surface	:	45 m^3
e.	Slope angle after failure	:	85°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	20°
h.	Direction of slide	:	N80°E

CAUSES: The increase in the gradient of the slope due to the vertical cut slope for making road decreased the slope stability. The heavy precipitation during monsoon increased the pore water pressure, the loose overburden and the weathered granite in the slope failed due to saturation.

NATURE OF DAMAGE: The Madikere-Mangalore state highway (SH 88) was blocked due to the heaped debris material on the road.

RECCOMENDATION:

i). Geometrical modification of the slope is necessary to stabilize the slope.

ii) As the slide is a shallow slide with depth of sliding less than 2m, deep rooted plants/shrubs with high tensile strength is to be planted in the benched slope to increase its stability.

iii) Removal of loose material from the unstable crown.

Photo 25: *The plan view of the debris slide with huge trees on the unstable crown.*

Photo 26: *The plan view of the debris slide*

SLIDE NO: KA13

LOCATION: The slide is located at latitude 12° 25′ 43″ N and longitude 75° 40′ 37″ E at elevation 871 m from MSL in Survey of India toposheet No 48 P / 11 in Madikere taluk, Coorg district along SH-88 in Madikere –Mangalore road.

SLIDE DESCRIPTION: The slide is classified as a debris slide. The debris consists of boulders & rock fragments of weathered granite and colluvial deposits. The slide has a overburden depth of nearly 0.50 m and weathering ~ 10m .The slope forming material was friable and loose. The slope modification for construction of the State Highway is the only land use on this moderately vegetated slope.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	6 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	17 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	1 m
d.	Volume of failed mass above the failure surface	:	51 m^3
e.	Slope angle after failure	:	85°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	20°
h.	Scar depth	:	3 m
i.	Direction of slide	:	N45°E

CAUSES: The original slope angle of this small spur is very gentle. This slope having more than one meter thick debris was cut vertical for the road and failed due to increase in pore water pressure during high rainfall experienced in this area.

NATURE OF DAMAGE: The SH-88 was affected as roads were blocked due to slide material.

RECCOMENDATION:

i) The relative height of the slope is low hence benching of the slope with a average slope angle of 45˚ will ensure its stability in long run.

ii) Deep rooted plants/shrubs with high tensile strength is to be planted in the benched slope to increase its stability.

iii) The unstable crown portion should be removed.

Photo 27: *The plan view of the debris slide with unstable crown.*

SLIDE NO: KA14

LOCATION: The slide is located at latitude 12° 26′ 26″ N and longitude 75° 39′ 05″ E at elevation 686 m from MSL in Survey of India toposheet No 48 P / 11 in Madikere taluk, Coorg district along SH-88 in Madikere –Mangalore road.

SLIDE DESCRIPTION: The slide is classified as a debris and planar slide. The debris consists of boulders & rock fragments of weathered granite and colluvial deposits. The slope forming material was loose and unconsolidated. The slope modification for construction of the State Highway is the only land use on this moderately vegetated slope. The failure has occurred in the joint plane N32°W/64°NE. The cut slope height is 7 m.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	20 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	7.5 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	1 m
d.	Volume of failed mass above the failure surface	:	75 m^3
e.	Slope angle after failure	:	80°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	20°
h.	Direction of slide	:	N12°E

CAUSES: The slope angle was enhanced due to near vertical cut slope for making road is the main cause of instability of the area. Heavy precipitation during monsoon saturated the slope forming material by increasing pore water pressure.

NATURE OF DAMAGE: The SH-88 was affected as roads were blocked due to slide material.

RECCOMENDATION:

i) The unstable crown part and slided debris material should be removed.

ii) The slope angle should be reduced to <45°.

iii) Plantation is suggested in the slope to reduce erosion and for slope stabilisation.

iv) Making contour drainage at the top of the slopes for decreasing infiltration and sub-surface horizontal drainage i.e. inserting horizontal perforated pipes in to the slopes will act as weep holes in the vertical slopes and thus reducing the pore pressure by draining out the excess water.

Photo 28: *The plan view of the debris slide with unstable crown.*

Photo 29: *The plan view of the debris slide with crown height of 4m.*

SLIDE NO: KA15

LOCATION: The slide is located at latitude 12° 26′ 13″ N and longitude 75° 39′ 34″ E at elevation 643 m from MSL in Survey of India toposheet No 48 P / 11 in Madikere taluk, Coorg district along SH-88 in Madikere –Mangalore road.

SLIDE DESCRIPTION: The slide is classified as a debris slump. The depth of weathering is 15 m and overburden depth is 0.30-0.50 m. The slope forming material was unconsolidated and loose. The slope modification for construction of the State Highway is the only land use.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	20 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	7 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	1 m
d.	Volume of failed mass above the failure surface	:	70 m^3
e.	Slope angle after failure	:	85°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	45°
h.	Direction of slide	:	S65°W

CAUSES: The slope angle was enhanced due to near vertical cut slope for making road is the main cause of instability of the area. The weathered granite and slope forming material of 1 m thick failed during heavy precipitation due to increasing pore water pressure. Slope height is also another factor for this slide.

NATURE OF DAMAGE: SH-88 was affected due to road blockage.

RECCOMENDATION:

i) The unstable crown and slided debris material should be removed.

ii) Geometrical modification of the slope.

iii) Plantation is suggested in the slope to reduce erosion and for slope stabilisation.

iv) Making contour drainage at the top of the slopes for decreasing infiltration and sub-surface horizontal drainage i.e. inserting horizontal perforated pipes in to the slopes will act as weep holes in the vertical slopes and thus reducing the pore pressure by draining out the excess water.

Photo 30: *The plan view of the debris slump*

Photo 31: *The plan view of the debris slump*

SLIDE NO: KA16

LOCATION: The slide is located at latitude 12° 26′ 14″ N and longitude 75° 39′ 33″ E at elevation 645 m from MSL in Survey of India toposheet No 48 P / 11 in Madikere taluk, Coorg district along SH-88 in Madikere –Mangalore road.

SLIDE DESCRIPTION: The slide is classified as a debris slide. The slide has a elliptical shape and is a rotational slide. The depth of weathering is 15m and overburden depth is 3m. The slope forming material was weak and loose. The slope modification for construction of the State Highway is the only land use. The rock type is weathered gneiss.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	20 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	7 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	1 m
d.	Volume of failed mass above the failure surface	:	70 m^3
e.	Slope angle after failure	:	75°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	25°
h.	Scar width	**:**	7 m
i.	Scar depth	:	2 m
j.	Direction of slide	:	S15°W

CAUSES: The slope angle was enhanced due to near vertical cut slope for making road is the main cause of instability of the area. The weathering depth of 15m and overburden depth 3m indicate the area consists of loose and friable material. The weathered granite and slope forming material failed during heavy precipitation due to increasing pore water pressure.

NATURE OF DAMAGE:The Madikere-Mangalore state highway (SH 88) was blocked due to the heaped debris material on the road.

RECCOMENDATIONS:

i) The unstable crown and slided debris material should be removed.

ii) The slope angle should be reduced to <45°. The slope height should also be reduced by 5m.

iii) Plantation is suggested in the slope to reduce erosion and for slope stabilisation. Horizontal drainage is suggested for removal of infiltrated water.

Photo 32: *The plan view of the debris slide with unstable crown*

Photo 33: *The plan view of the debris slide with unstable crown*

SLIDE NO: KA17

LOCATION: The slide is located at latitude 12° 26′ 16″ N and longitude 75° 39′ 31″ E at elevation 655 m from MSL in Survey of India toposheet No 48 P / 11 in Madikere taluk, Coorg district along SH-88 in Madikere –Mangalore road.

SLIDE DESCRIPTION: The slide is classified as a multiple debris slide. The slide is irregular in shape and is a rotational slide. The depth of weathering is 15m and overburden depth is 2 m in the slided area. The slope forming material was weak and loose. The slope modification for construction of the State Highway is the only land use. The rock type is biotite gneiss.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	20 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	50 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	2 m
d.	Volume of failed mass above the failure surface	:	1000 m^3
e.	Slope angle after failure	:	75°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	25°
h.	Direction of slide	:	S25°W

CAUSES: The slope angle was enhanced due to near vertical cut slope for making road is the main cause of instability of the area. The weathering depth of 15m and overburden depth 2m indicate the area consists of loose and friable material. The weathered gneiss and slope forming material failed during heavy precipitation due to increasing pore water pressure.

NATURE OF DAMAGE: The Madikere-Mangalore state highway (SH 88) was blocked due to the heaped debris material on the road.

RECCOMENDATIONS:

i) The unstable crown and slided debris material should be removed.

ii) The slope angle should be reduced to <45°. The slope height should also be reduced by 5m.

iii) Plantation is suggested in the slope to reduce erosion and for slope stabilisation.

iv) Horizontal drainage is suggested for removal of infiltrated water.

Photo 34: *The plan view of the debris slide with unstable crown*

Photo 35: *The plan view of the debris slide with unstable crown*

SLIDE NO: KA18

LOCATION: The slide is located at latitude 12° 26′ 12″ N and longitude 75° 40′ 08″ E at elevation 723 m from MSL in Survey of India toposheet No 48 P / 11 in Madikere taluk, Coorg district along SH-88 in Madikere –Mangalore road.

SLIDE DESCRIPTION: The slide is classified as a debris slump. The slide has an elliptical shape. The depth of weathering is 10m and overburden depth is 1.5m. The slope forming material was unconsolidated and loose. The slope modification for construction of the State Highway is the only land use. The rock type is weathered gneiss.

MORPHOLOGICAL PARAMETER OF SLIDE:

a. Maximum length of failed mass from crown to foot : 14 m

b. Maximum width of failed mass from the left flank to the right flank boundary : 10 m

c. Maximum depth of the failed mass from the surface of the slide to the failure surface : 0.5 m

d. Volume of failed mass above the failure surface : 35 m^3

e. Slope angle after failure : 80°

f. Slope angle before failure : 90°

g. Original slope angle : 25°

h. Direction of slide : N79°E

CAUSES: The original slope angle of this small spur is very gentle. This slope having more than one meter thick debris was cut vertical for the road .The cutting of the mound without giving protection at the toe decreased the stability of the slope which failed due to increase in pore water pressure during high precipitation in the monsoon experienced in this area.

NATURE OF DAMAGE: The Madikere-Mangalore state highway (SH 88) was blocked due to the heaped debris material on the road

RECCOMENDATIONS:

i) The relative height of the slope is low hence benching of the slope with a average slope angle of 45˚ will ensure its stability in long run.

ii) Deep rooted plants/shrubs with high tensile strength is to be planted in the benched slope to increase its stability.

iii) The unstable crown portion should be removed.

Photo 36: *The plan view of the debris slide with unstable crown*

Photo 37: *The side view of the debris slide with zone of accumulation*

SLIDE NO: KA18 A

LOCATION: The slide is located at latitude 12° 26′ 12″ N and longitude 75° 40′ 08″ E at elevation 723 m from MSL in Survey of India toposheet No 48 P / 11 in Madikere taluk, Coorg district along SH-88 in Madikere –Mangalore road.

SLIDE DESCRIPTION: The slide is classified as a debris slump. The slide has an elliptical shape. The depth of weathering is 10m and overburden depth is 1.5m. The slope forming material was weak and loose. The slope modification for construction of the State Highway is the only land use. The rock type is weathered gneiss.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	10 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	5 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	1 m
d.	Volume of failed mass above the failure surface	:	25 m^3
e.	Slope angle after failure	:	80°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	25°
j.	Direction of slide	:	N33°E

CAUSES: The original slope angle of this small spur is very gentle. This slope having more than one meter thick debris was cut vertical for the road .The cutting of the mound without giving protection at the toe decreased the stability of the slope which failed due to increase in pore water pressure during high precipitation in the monsoon experienced in this area.

NATURE OF DAMAGE: The Madikere-Mangalore state highway (SH 88) was blocked due to the heaped debris material on the road

RECCOMENDATIONS:

i) The relative height of the slope is low hence benching of the slope with a average slope angle of 45˚ will ensure its stability in long run.

ii) Deep rooted plants/shrubs with high tensile strength is to be planted in the benched slope to increase its stability.

iii) The unstable crown portion should be removed.

iv) Making contour drainage at the top of the slopes for decreasing infiltration and sub-surface horizontal drainage i.e. inserting horizontal perforated pipes in to the slopes will act as weep holes in the vertical slopes and thus reducing the pore pressure by draining out the excess water.

Photo 38: *The plan view of the debris slide with unstable crown*

Photo 39: *The plan view of the debris slide with zone of accumulation*

SLIDE NO: KA19

LOCATION: The slide is located at latitude 12° 25′ 59″ N and longitude 75° 40′ 18″ E at elevation 772 m from MSL in Survey of India toposheet No 48 P / 11 in Madikere taluk, Coorg district along SH-88 in Madikere –Mangalore road.

SLIDE DESCRIPTION: The slide is classified as a debris slide. The slide has an circular shape. The depth of weathering is 10m and overburden depth is 2m. The slope forming material was weak and loose. The slope modification for construction of the State Highway is the only land use. Thick coffee plantation is noticed in the area. The rock type is weathered gneiss.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	25 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	20 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	5 m
d.	Volume of failed mass above the failure surface	:	1250 m^3
e.	Slope angle after failure	:	60°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	40°
h.	Scar width	**:**	20 m
i.	Scar depth	:	5 m
j.	Direction of slide	:	N23°E

CAUSES: The slope angle was enhanced due to near vertical cut slope for making road is the main cause of instability of the area. The weathering depth of 10m and overburden depth 2m indicate the area consists of loose and friable material. The weathered granite and slope forming material failed during heavy precipitation due to increasing pore water pressure.

NATURE OF DAMAGE: The Madikere-Mangalore state highway (SH 88) was blocked due to the heaped debris material on the road.

RECCOMENDATION:

i) The unstable crown and slided debris material should be removed.

ii) Geometrical modification of the slope by reducing the slope angle.

iii) Deep rooted plants/shrubs with high tensile strength is to be planted in the slope to increase its stability and reduce erosion.

iv) Horizontal drainage is suggested for removal of infiltrated water.

Photo 40: *The plan view of the debris slide covered by plants*

SLIDE NO: KA20

LOCATION: The slide is located at latitude 12° 25′ 56″ N and longitude 75° 40′ 24″ E at elevation 772 m from MSL in Survey of India toposheet No 48 P / 11 in Madikere taluk, Coorg district along SH-88 in Madikere –Mangalore road.

SLIDE DESCRIPTION: The slide is classified as a debris slide. The slide has a circular shape. The depth of weathering is 10m and overburden depth is 2m. The slope forming material was weak and loose. The slope modification for construction of the State Highway is the only land use. Thick coffee plantation is noticed in the area. The rock type is weathered gneiss.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	15 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	10 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	2 m
d.	Volume of failed mass above the failure surface	:	150 m^3
e.	Slope angle after failure	:	42°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	50°
h.	Scar width	:	7 m
i.	Scar depth	:	2 m
j.	Direction of slide	:	N78°E

CAUSES: The slope angle was enhanced due to near vertical cut slope for making road is the main cause of instability of the area. The weathering depth of 10m and overburden depth 2m indicate the area consists of loose and friable material. The weathered granite and slope forming material failed during heavy precipitation due to increasing pore water pressure.

NATURE OF DAMAGE: The Madikere-Mangalore state highway (SH 88) was blocked due to the heaped debris material on the road.

RECCOMENDATION:

i) The unstable crown and slided debris material should be removed.

ii) Horizontal and surface drainage is suggested for removal of infiltrated water.

iii) Deep rooted plants/shrubs with high tensile strength is to be planted in the slope to increase its stability and reduce erosion.

Photo 41: *The plan view of the debris slide with unstable crown*

Photo 42: *The plan view of the debris slide with huge trees standing on the crown*

SLIDE NO: KA21

LOCATION: The slide is located at latitude 12° 24′ 54″ N and longitude 75° 44′ 24″ E at elevation 1140 m from MSL in Survey of India toposheet No 48 P / 11 in Madikere taluk, Coorg district along SH-88 in Madikere –Mangalore road.

SLIDE DESCRIPTION: The slide is classified as reactivated debris slump. The debris consists of boulders & rock fragments of weathered granite and colluvial deposits. The slide has an overburden depth of nearly 0.50 m and weathering ~ 7 m .The slope forming material was weak and loose soil. The slope modification for construction of the State Highway is the only land use on this thickly vegetated with coffee plantation area. The rock type is weathered gneiss. Two sets of Joints are noticed, J1- N15E/57NW and J2- N5W/vertical.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	23 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	10 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	1 m
d.	Volume of failed mass above the failure surface	:	
e.	Slope angle after failure	:	75
f.	Slope angle before failure	:	90
g.	Original slope angle	:	50
h.	Direction of slide	:	S52 E

CAUSES: The vertical cut slope for making road, the loose overburden and the weathered granite in the slope decreased the slope stability and the slope failed due to the heavy ingress of water during monsoon.

NATURE OF DAMAGE: The Madikere-Mangalore state highway (SH 88) was blocked due to the heaped debris material on the road.

RECCOMENDATION:

i) The protective measures proposed at the site include removal of slide material from the slope

ii) Grading of the slope with benches

iii) Providing retaining wall for a height of 4 m.

Photo 43: *Plan view of the reactivated slide with exposed weathered granite*

Photo 44: *Side view of the reactivated slide with exposed weathered granite*

SLIDE NO: KA22

LOCATION: The slide is located at latitude 12° 24′ 42″ N and longitude 75° 44′ 20″ E at elevation 1075 m from MSL in Survey of India toposheet No 48 P / 11 in Madikere taluk, Coorg district along SH-88.

SLIDE DESCRIPTION: The slide is classified as a debris slide. The debris consists of boulders & rock fragments of weathered granite and colluvial deposits. The slide is circular in shape and has an overburden depth of nearly .50m and weathering ~ 5 m .The slope forming material was unconsolidated and loose soil. The slope modification for construction of the State Highway is the only land use on this thickly vegetated with coffee plantation area.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	25 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	20 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	3 m
d.	Volume of failed mass above the failure surface	:	m^3
e.	Slope angle after failure	:	70°
f.	Slope angle before failure	:	85°
g.	Original slope angle	:	54°
h.	Scar width	**:**	10 m
i.	Scar depth	:	3 m
j.	Direction of slide	:	S42°E

CAUSES: The vertical cut slope for making road, the loose overburden and the weathered granite in the slope decreased the slope stability and the slope failed during monsoon due to movement of debris and weathered material on the surface of bed rock.

NATURE OF DAMAGE: The Madikere-Mangalore state highway (SH 88) was blocked due to the heaped debris material on the road.

RECCOMENDATION:

i) The protective measures proposed at the site include removal of slide material and unstable from the slope

ii) Grading of the slope with benches

iii) Plantation on the slope to increase the soil strength.

Photo 45: *Plan view of the debris slide with exposed weathered granite*

Photo 46: *Plan view of the debris slide with huge trees standing on the crown*

SLIDE NO: KA23

LOCATION: The slide is located at latitude 12° 24′ 40″ N and longitude 75° 44′ 17″ E at elevation 1060 m from MSL in Survey of India toposheet No 48 P / 11 in Madikere taluk, Coorg district along SH-88 in Madikere –Mangalore road.

SLIDE DESCRIPTION: The slide is classified as a rock fall. The rock type of the area is weathered biotite gneiss. The slide is elliptical in shape and has weathering depth upto ~ 5m. The slope modification for construction of the State Highway is the only land use on this thickly vegetated with coffee plantation area.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	21.5m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	12 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	1 m
d.	Volume of failed mass above the failure surface	:	240 m^3
e.	Slope angle after failure	:	80°
f.	Slope angle before failure	:	85°
g.	Original slope angle	:	55°
h.	Scar width	**:**	0
i.	Scar depth	:	0
j.	Direction of slide	:	S62°W

CAUSES: The vertical cut slope for making road has increased the gradient of the slope and disturbed the nature's equilibrium and the slope failed during monsoon due to ingress of water along joint plane.

NATURE OF DAMAGE: The Madikere-Mangalore state highway (SH 88) was blocked due to the heaped debris material on the road.

RECCOMENDATION:

i). The protective measures proposed at the site include removal of weathered material and big trees from the crown which are exerting pressure on the crown.

ii). Geometrical modification of the slope by grading or making benches.

Photo 47: *View of the rock slide with trees on the crown and slide plane*

Photo 48: *Plan view of the rock slide with trees on the crown and slide plane.*

SLIDE NO: KA24

LOCATION: The slide is located at latitude 12° 24′ 44″ N and longitude 75° 44′ 13″ E at elevation 1061 m from MSL in Survey of India toposheet No 48 P / 11 in Madikere taluk, Coorg district along SH-88 in Madikere –Mangalore road.

SLIDE DESCRIPTION: The slide is classified as a debris slump. The rock type of the area is weathered biotite gneiss. The slide is elliptical in shape and has weathering depth upto ~ 5 m. The slope modification for construction of the State Highway is the only land use on this thickly vegetated with coffee plantation area.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	25 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	15 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	2 m
d.	Volume of failed mass above the failure surface	:	375 m^3
e.	Slope angle after failure	:	80°
f.	Slope angle before failure	:	85°
g.	Original slope angle	:	55°
h.	Direction of slide	:	S62°W

CAUSES: The vertical cut slope for making road has increased the gradient of the slope and the slope failed during monsoon due to heavy ingress of water increasing the pore water pressure and decreasing the shear strength of the slope forming material.

NATURE OF DAMAGE: The Madikere-Mangalore state highway (SH 88) was blocked due to the heaped debris material on the road.

RECCOMENDATION:

i) The protective measures proposed at the site include removal of weathered and loose material from the slope

ii) Gradation of the slope to reduce the slope angle

iii) Providing retaining wall of 4m height.

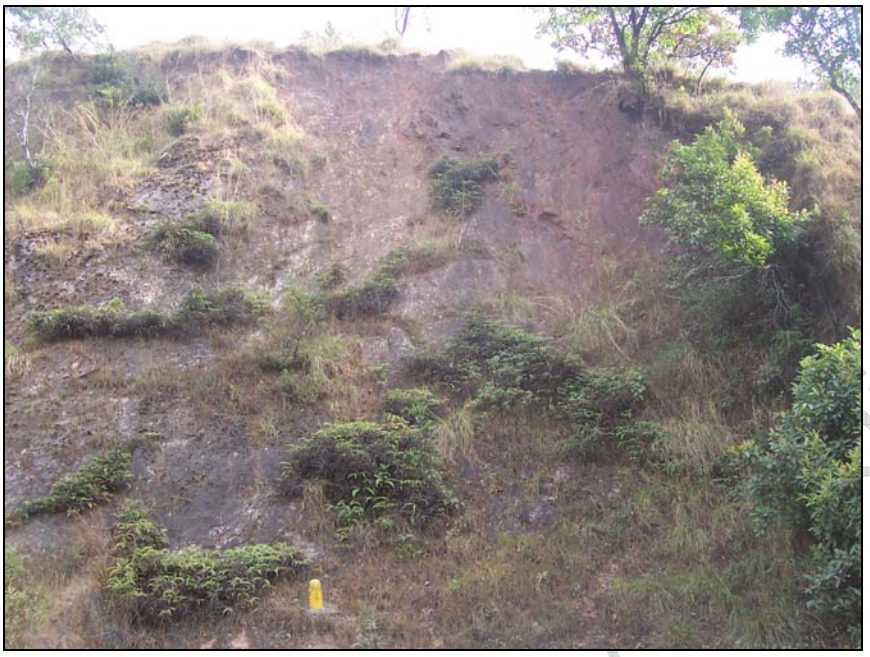

Photo 49: View of the debris slump exposing the bed rock over which it has moved.

Photo 50: *View of the debris slump exposing the bed rock over which it has moved.*

SLIDE NO: KA25

LOCATION: The slide is located at latitude 12° 24′ 45″ N and longitude 75° 44′ 12″ E at elevation 1062 m from MSL in Survey of India toposheet No 48 P / 11 in Madikere taluk, Coorg district along SH-88 in Madikere –Mangalore road.

SLIDE DESCRIPTION: The slide is classified as a slump. The rock type of the area is weathered biotite gneiss. The slide is elliptical in shape and has weathering depth up to ~ 5m. The slope modification for construction of the State Highway is the only land use on this thickly vegetated with coffee plantation area.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	10 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	12 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	1 m
d.	Volume of failed mass above the failure surface	:	60 m^3
e.	Slope angle after failure	:	75°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	49°
h.	Scar width	**:**	7 m
i.	Scar depth	:	2 m
j.	Direction of slide	:	S24°W

CAUSES: The vertical cut slope for making road has increased the gradient of the slope and the slope failed during monsoon due to heavy ingress of water increasing the pore water pressure and decreasing the shear strength of the slope forming material.

NATURE OF DAMAGE: The Madikere-Mangalore state highway (SH 88) was blocked due to the heaped debris material on the road.

RECCOMENDATION:

i) Removal of weathered and loose material from the slope

ii) Geometrical modification of the slope with grading or making benches

iii) Providing retaining wall at the toe of the slided area.

Photo 51: *The old debris slump covered by small trees*

Photo 52: *View of the debris slump which is covered by small trees*

SLIDE NO: KA26

LOCATION: The slide is located at latitude 12° 25′ 12″ N and longitude 75° 41′ 41″ E at elevation 1062 m from MSL in Survey of India toposheet No 48 P / 11 in Madikere taluk, Coorg district along SH-88 in Madikere –Mangalore road.

SLIDE DESCRIPTION: The slide which occurred on 28th July 2007 is classified as a debris slide. This is a reactivated slide. The rock type of the area is weathered biotite gneiss. The slide is circular in shape and has weathering depth up to 10m. The slope modification for construction of the houses is the land use. Crown crack is noticed for a length of 10m.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	17 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	10 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	2 m
d.	Volume of failed mass above the failure surface	:	170 m^3
e.	Slope angle after failure	:	59°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	25°
h.	Scar width	**:**	10 m
i.	Scar depth	:	2 m
j.	Direction of slide	:	S54°W

CAUSE: The vertical cut slope for making road, the loose overburden and the weathered biotite gneiss in the slope decreased the slope stability and the slope failed during monsoon due to heavy ingress of water increasing the pore water pressure and decreasing the shear strength of the slope forming material.

NATURE OF DAMAGE: The Madikere-Mangalore state highway (SH 88) was blocked due to the heaped debris material on the road.

RECCOMENDATION:

i) Removal of slide material from the slope and unstable material from the crown

ii) Reducing the slope angle by making benches or grading of the slope

iii) Providing retaining wall or gabion wall to strengthen the toe part of the slide.

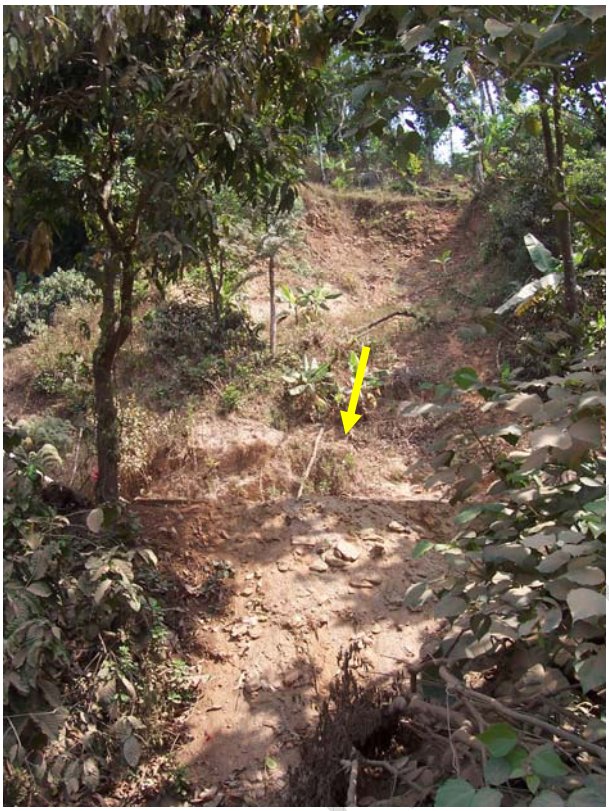

Photo53: *Plan view of the reactivated debris slide which has length of 17m*

Photo 54: *Plan view of the reactivated debris slide which has crown height of 2m.*

LANDSLIDES ALONG MADIKERE – SIDDAPURA ROAD

SH-89

SLIDE NO: KA27

LOCATION: The slide is located at latitude 12° 24′ 37″ N and longitude 75° 45′ 29″ E at elevation 1155 m from MSL in Survey of India toposheet No 48 P / 11 in Madikere taluk, Coorg district along SH-89 in Madikere - Siddapura road.

SLIDE DESCRIPTION: Slide is located in the eastern slope of NNE-SSW trending hillock with a maximum height of 1259m from MSL. The relative relief of the slope is 159m with an average slope angle of 15.91°. The slide is classified as a debris slide. The rock type of the area is weathered biotite gneiss. The slide is irregular in shape and has weathering depth up to 5m. The slope modification for construction of the state highway-89 is the only land use.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	7 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	15 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	1 m
d.	Volume of failed mass above the failure surface	:	53 m^3
e.	Slope angle after failure	:	45°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	20°
h.	Scar width	**:**	8 m
i.	Scar depth	:	2 m
j.	Direction of slide	:	S76°E

CAUSES: The vertical cut slope for making road, the loose overburden and the weathered biotite gneiss in the slope decreased the slope stability and the slope failed during monsoon due to heavy ingress of water increasing the pore water pressure and decreasing the shear strength of the slope forming material.

NATURE OF DAMAGE: The Madikere-Siddapura state highway (SH 89) was blocked due to the heaped debris material on the road.

RECCOMENDATION:

i) Deceasing the driving force by removal of load from the crown and slided material from the slope

ii) Geometrical modification of slope by grading of the slope or benching

iii) Providing retaining wall or gabion wall at the toe of the slide.

Photo 55: *Plan view of the debris slide which has crown height of 2m and crown width of around 8 m.*

SLIDE NO: KA28

LOCATION: The slide is located at latitude 12° 24′ 52″ N and longitude 75° 45′ 26″ E at elevation 1153 m from MSL in Survey of India toposheet No 48 P / 11 in Madikere taluk, Coorg district along SH-89 in Madikere- Siddapura road.

SLIDE DESCRIPTION: Slide is located in the eastern slope of NNE-SSW trending hillock with a maximum height of 1259 m from MSL. The relative relief of the slope is 159 m with an average slope angle of 15.91°. The slide is classified as a debris slide. The rock type of the area is weathered biotite gneiss. The slide is circular in shape and the weathering depth of the site is 10 m. The slope modification for construction of the state highway-89 is the only land use.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	8 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	10 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	2 m
d.	Volume of failed mass above the failure surface	:	80 m^3
e.	Slope angle after failure	:	66°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	20°
h.	Scar width	**:**	10 m
i.	Scar depth	:	4 m
j.	Direction of slide	:	N86°E

CAUSES: The vertical cut slope for making road increased the gradient of the slope, the loose overburden and the weathered material in the slope has moved over the bed rock. Heavy ingress of water during monsoon increased the pore water pressure and decreased the shear strength of the slope forming material resulting in slope failure.

NATURE OF DAMAGE: The Madikere-Siddapura state highway (SH 89) was blocked due to the heaped debris material on the road.

RECCOMENDATION:

i) Removal of load from the crown and slided material from the slope to reduce the driving force

ii) Geometrical modification of the slide by grading of the slope or benches

iii) Providing proper surface and horizontal drainage to decrease infiltration and reduce pore water pressure.

Photo 56: *View of the debris slide on the*

SLIDE NO: KA29

LOCATION: The slide is located at latitude 12° 24′ 56″ N and longitude 75° 45′ 24″ E at elevation 1153 m from MSL in Survey of India toposheet No 48 P / 11 in Madikere taluk, Coorg district along SH-89 in Madikere – Siddapura road.

SLIDE DESCRIPTION: Slide is located in the eastern slope of NNE-SSW trending hillock with a maximum height of 1259 m from MSL. The relative relief of the slope is 159 m with an average slope angle of 15.91°. The slide is classified as a debris slump. The rock type of the area is weathered biotite gneiss. The slide is irregular in shape and has weathering depth up to 10m. The slope modification for construction of the state highway-89 is the only land use.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	7 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	14 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	1 m
d.	Volume of failed mass above the failure surface	:	49 m^3
e.	Slope angle after failure	:	47°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	20°
h.	Scar width	**:**	10 m
i.	Scar depth	:	4 m
j.	Direction of slide	:	N54° E

CAUSES: The vertical cut slope for making road increased the gradient of the slope, the loose overburden and the weathered material in the slope decreased the slope stability and the slope failed due to the heavy ingress of water during monsoon.

NATURE OF DAMAGE: The Madikere-Siddapura state highway (SH 89) was blocked due to the heaped debris material on the road.

RECCOMENDATION:

i) Removal of slide material from the slope and unstable material from the crown.

ii) Proper surface and horizontal drainage is suggested to decrease infiltration and reduce pore water pressure.

iii) Plantation of deep rooted vegetation on the slope is suggested to reduce erosion and increase slope stability.

Photo 57: *Plan view of the depletion zone of the above debris slump*

LANDSLIDES ALONG ANSI GHAT

SH-95

SLIDE NO: KA30

LOCATION: The slide is located at 100 m from the 1st hair pin bend from the Kadra junction towards Ansi at latitude 14° 55′ 26″ N and longitude 74° 21′ 07″ E in Survey of India toposheet No 48 J/5 along SH-95 (Ansi Ghat) in Belgaum-Sadashivgad road in Karwar taluk.

SLIDE DESCRIPTION: The slide occurred in the south western slope of the mound in the cut slopes of the hillock trending N52°E-S52°W. The relative relief of the slope is ~200 m with a slope angle of 11.30° towards S52°W. The relative relief from the top of the hill to the road is 180 m. The slide is a reactivated rock slide in a planar failure. The Lithology of the area is weathered granite. The land is used for construction of SH-95. Three sets of joints are noticed. They are J1-S39°W/67°W, J2- N45°E/58°SE and J3-S59°E/45°S.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	12.21m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	16m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	1.5m
d.	Volume of failed mass above the failure surface	:	147m^3
e.	Slope angle after failure	:	26°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	25°
h.	Scar width	**:**	7m
i.	Scar depth	:	2.7m
j.	Direction of slide	:	N57°W

CAUSES: The original slope angle of the hillock is very gentle. The slope was cut vertical for making of road and failed due to high rainfall experienced in this area. The weathered and fractured rock slipped on a joint plane due to heavy infiltration of water during the monsoon.

NATURE OF DAMAGE: The Ansi ghat, state highway (SH 95) Belgaum-Sadashivgad road was blocked due to the heaped debris material on the road.

RECCOMENDATIONS:

i) The crown part was found to be unstable hence the crown portion is to be completely removed.

ii) The geometrical modification of the slope by grading or bench to be provided.

iii) Proper drainage to be provided for safely discharge of water away from unstable slopes and decreasing the infiltration of water.

iv) Netting with wire mesh is suggested as long term remedial measure.

Photo 58: *The plan view of the rock slide in a planar failure*

Photo59: *The biotite gneiss exposed in the failure plane*

SLIDE NO: KA31

LOCATION: The slide is located at 150m from the 1st hair pin bend from the Kadra junction towards Ansi at latitude 14° 55′ 24″ N and longitude 74° 21′ 09″ E in Survey of India toposheet No 48 J/5 along SH-95 (Ansi Ghat) Karwar- Kumbarwada road in Karwar taluk.

SLIDE DESCRIPTION: The slide occurred in the south western slope of the mound in the cut slopes of the hillock trending N52°E-S52°W. The relative relief of the slope is ~200m with a slope angle of 11.30° towards S52°W. The relative relief from the top of the hill to the road is 180m. The slide is a reactivated rock slide in a planar failure . The weathering depth is 2m. The land is used for construction of SH-95. 3 sets of joints are noticed. They are J1-S39°W/67°W, J2- N45°E/58°SE and J3-S59°E/45°S.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	8.88m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	43m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	0.6m
d.	Volume of failed mass above the failure surface	:	115m^3
e.	Slope angle after failure	:	55°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	11.30°
h.	Scar width	**:**	15m
i.	Scar depth	:	2.39m
j.	Direction of slide	:	N57°W

CAUSES:. The original slope angle of the mound is very gentle. The slope was cut vertical for the road construction and failed due to high rainfall experienced in this area. The slope failed due to heavy infiltration of water along planes during the monsoon. The loose rock material slipped along day lighted plane.

NATURE OF DAMAGE: The Ansi ghat in state highway SH- 95, Karwar- Kumbarwada road was blocked due to the heaped debris material on the road.

RECCOMENDATION:

i) The crown part was found to be unstable hence the crown portion is to be completely removed.

ii) Rock bolting is suggested to anchor the unstable blocks.

iii) Proper drainage to be made to safely discharge water away from unstable slopes

Photo 60: *The plan view of the reactivated rock slide along day lighted plane.*

Photo 61: *The plan view of rock slide along day lighted plane*

SLIDE NO: KA32

LOCATION: The slide is located at latitude 14° 55′ 39″ N and longitude 74° 21′ 19″ E in Survey of India toposheet No 48 J/5 along SH-95 (Ansi Ghat) Karwar- Kumbarwada road in Karwar taluk.

SLIDE DESCRIPTION: The slide occurred in the south western slope of the mound in the cut slopes of the hillock trending N52°E-S52°W. The relative relief of the slope is ~200 m with a slope angle of 11.30° towards S52°W. The relative relief from the top of the hill to the road is 100 m. This is a reactivated rock slide with a planar failure. The land used for construction of SH-95.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	8.46 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	18.5 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	1 m
d.	Volume of failed mass above the failure surface	:	78 m^3
e.	Slope angle after failure	:	46°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	11.30°
h.	Scar width	**:**	15 m
i.	Scar depth	:	2.4 m
j.	Direction of slide	:	S70°W

CAUSES: The slope was cut vertical for the road construction and failed due to high rainfall experienced in this area. The slope failed due to heavy infiltration of water along planes during the monsoon. The loose rock material slipped along day lighted plane.

NATURE OF DAMAGE: The Ansi ghat in state highway- SH 95 (Karwar- Kumbarwada road) was blocked due to the heaped debris material on the road.

RECCOMENDATIONS:

i) The crown part was found to be unstable hence the crown portion is to be completely removed.

ii) The geometrical modification of the slope by graded or bench to be provided.

iii) Proper drainage is to be provided for discharge of water away from unstable slopes.

iv) Soil nailing and rock bolting is suggested to protect the vulnerable planes from sliding.

Photo 62: *The plan view of the reactivated rock slide along day lighted plane.*

Photo 63: *The plan view of the reactivated rock slide along day lighted plane.*

SLIDE NO: KA33

LOCATION: The slide is located at latitude 14° 55′ 45″ N and longitude 74° 21′ 29″ E in Survey of India toposheet No 48 J/5 along SH-95 (Ansi Ghat) in Karwar- Kumbarwada road in Karwar taluk.

SLIDE DESCRIPTION: The slide occurred in the northwest slope of NE-SW trending hill which has a maximum height of 240m. The relative relief of the slope is 160m with slope angle 24.57° towards N32°W. It is a debris slide with overburden depth of .5m. The land used for construction of SH-95. This is a shallow slide with a depth of only 1m.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	9.4 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	24 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	1 m
d.	Volume of failed mass above the failure surface	:	113m^3
e.	Slope angle after failure	:	48°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	24.57°
h.	Scar depth	:	2.5 m
i.	Direction of slide	:	N8°W

CAUSES: The cutting of the slope for construction of road has increased the gradient. The incumbent pore pressure development during monsoon triggered this slide as the slope forming debris material was highly saturated with rain water.

NATURE OF DAMAGE: Karwar- Kumbarwada road in SH-95 was blocked due to the heaped debris material on the road.

RECCOMENDATION:

i) The crown part was found to be unstable due to presence of huge trees; hence the crown portion is to be completely removed to decrease the driving force.

ii) The geometrical modification of the slope by graded or bench to be provided with 2:1 height with bench width ratio at a slope angle of <40˚.

iii) Plantation on the slope is also suggested to increase the cohesiveness of soil.

iv) Retaining wall is to be constructed to protect the toe from further sliding.

Photo 64: *The view of the debris slide where plants are tilted and uprooted.*

Photo 65: *The view of the toe portion debris slide where uprooted plants and debris are accumulated.*

SLIDE NO: KA34

LOCATION: The slide is located at at latitude 14° 56′ 05″ N and longitude 74° 21′ 30″ E in Survey of India toposheet No 48 J/5 along Ansi Ghat (Karwar- Kumbarwada road) in SH-95 in Karwar taluk.

SLIDE DESCRIPTION: Slide is occurred in the western slope of N23°E-S23°W trending spur of N14°W-S14°E trending hillock which has a maximum height of 465 m. The relative relief of the slope is 420m and slope angle is 18.57° towards SouthWest. Relative relief from the top of the hill to the road is 280 m. The lithology of the area is biotite gneiss. The construction of the road (SH-95) is the only land use. The slide is a debris slide.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	12.45 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	19 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	1 m
d.	Volume of failed mass above the failure surface	:	118 m^3
e.	Slope angle after failure	:	50°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	19°
h.	Direction of slide	:	N32°W

CAUSES: The cutting of the slope for construction of road has increased the gradient. The incumbent pore pressure development during monsoon triggered this slide as the slope forming debris material was highly saturated with rain water.

NATURE OF DAMAGE: Karwar- Kumbarwada road in SH-95 was blocked due to the heaped debris material on the road.

RECCOMENDATION:

i) The crown part was found to be unstable due to presence of huge trees; hence the crown portion is to be completely removed.

ii) The geometrical modification of the slope by graded or bench to be provided with 2:1 height with bench width ratio at a slope angle of <45˚.

iii) Plantation on the slope is also suggested to increase the cohesiveness of soil.

iv) Retaining wall or gabion wall is to be constructed to protect the toe from further sliding.

Photo 66: *The plan view of the debris slide with exposed bed rock*

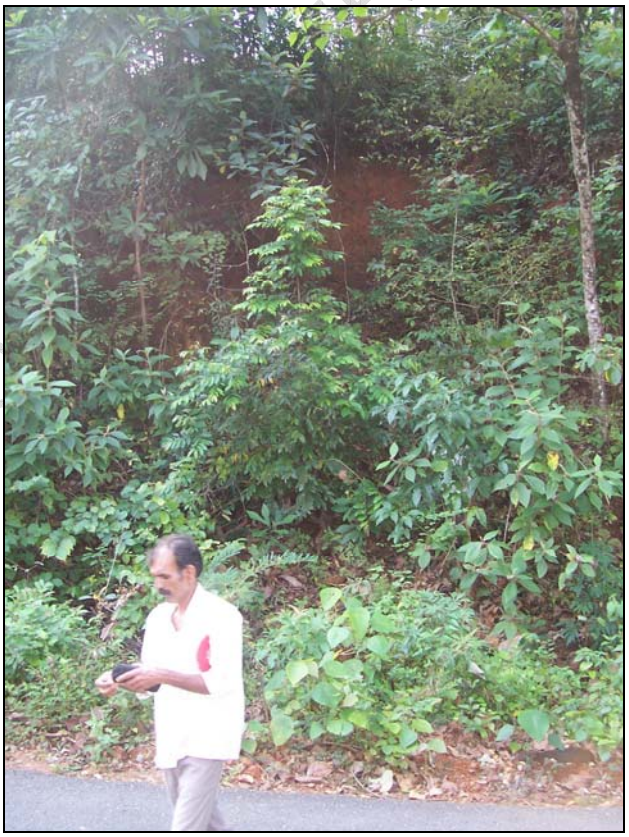

Photo 67: *The plan view of the debris slide with exposed bed rock*

SLIDE NO: KA35

LOCATION: The slide is located at at latitude 14° 55′ 55″ N and longitude 74° 21′ 41″ E in Survey of India toposheet No 48 J/5 along Karwar- Kumbarwada road (Ansi Ghat) in SH-95 in Karwar taluk.

SLIDE DESCRIPTION: Slide is located in the western slope of N23°E-S23°W trending spur of N14°W-S14°E trending hillock which has a maximum height of 465 m. The relative relief of the slope is 360 m and slope angle is 25.64° towards S45°W. Relative relief from the top of the hill to the road is 200 m. The slide is classified as debris slide. The lithology of the area is biotite gneiss. The construction of SH-95 is the only land use.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	20 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	48 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	1 m
d.	Volume of failed mass above the failure surface	:	480 m^3
e.	Slope angle after failure	:	55°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	25°
h.	Scar width	**:**	65 m
i.	Scar depth	:	4.2 m
j.	Direction of slide	:	S26°W

CAUSES: The original slope angle of the mound is very gentle. The cutting of the slope for construction of road has increased the gradient. The incumbent pore pressure development during monsoon triggered this slide as the slope forming debris material was highly saturated with rain water.

NATURE OF DAMAGE: Karwar- Kumbarwada road in SH-95 was blocked due to the heaped debris material on the road.

RECCOMENDATION:

i) Removal of slide material from the slope and unstable material from the crown.

ii) Proper surface and horizontal drainage is suggested to decrease infiltration and reduce pore water pressure.

iii) Plantation of deep rooted vegetation on the slope is suggested to reduce erosion and increase slope stability.

Photo 68: *The plan view of the debris slide with exposed bed rock*

Photo 69: *The view of the debris slide with exposed bed rock*

SLIDE NO: KA36

LOCATION: The area is located at latitude 14° 55'57"N and longitude 74° 21' 41"E in Survey of India Toposheet No 48 J/5, along Karwar- Kumbarwada road (Ansi Ghat) in SH-95 in Karwar taluk.

SLIDE DESCRIPTION: : Slide is located in the Western slope of N23°E-S23°W trending spur of N14°W-S14°E trending hillock which has a maximum height of 465 m. The relative relief of the slope is 360 m and slope angle is 25.64° towards S45°W. Relative relief from the top of the hill to the road is 200 m. The slide is classified as rock slide. The rock type of the area is biotite gneiss. The construction of SH-95 is the only land use. Two sets of joints are recorded J1: N45°W/62°SW, J2: N85°E/78°NW

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	12 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	20 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	1.5 m
d.	Volume of failed mass above the failure surface	:	180 m^3
e.	Slope angle after failure	:	70°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	15°
h.	Scar width	**:**	2 m
i.	Direction of slide	:	N65°W

CAUSES: The slope having more than one meter thick debris was cut vertical for the road and failed due to high rainfall experienced in this area. The crown and the toe of the slide is restricted above the road as the plant roots are still exposed in vertical position. The slope failed due to high pore water pressure development due to heavy infiltration during the monsoon.

NATURE OF DAMAGE: Karwar- Kumbarwada road in SH-95 was blocked due to the heaped debris material on the road.

RECCOMENDATIONS

i) The crown part was found to be unstable hence the crown portion is to be completely removed.

ii) The geometrical modification of the slope by graded or bench to be provided.

iii) Proper drainage is to be provided for discharge of water away from unstable slopes.

iv) Soil nailing and rock bolting is suggested to protect the vulnerable planes from sliding.

v) Netting with wire mesh is suggested where the joint spacing's are less.

Photo 70: *The plan view of the rock slide with exposed bed rock*

Photo 71: *The plan view of the rock slide with exposed bed rock*

SLIDE NO: KA37

LOCATION: The area is located at latitude 14° 55'57"N and longitude 74° 21' 41"E in Survey of India Toposheet No 48 J/5, along Karwar- Kumbarwada road (Ansi Ghat) in SH-95 in Karwar taluk.

SLIDE DESCRIPTION: Slide is located in the western slope of N23°E-S23°W trending spur of N14°W-S14°E trending hillock which has a maximum height of 465 m. The relative relief of the slope is 360 m and slope angle is 25.64° towards S45°W. Relative relief from the top of the hill to the road is 200 m. The rock type of the area is biotite gneiss. The slide is classified as rock slide. The construction of road (SH-95) is the only land use.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	12 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	16 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	1 m
d.	Volume of failed mass above the failure surface	:	96 m^3
e.	Slope angle after failure	:	70°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	25°
h.	Scar depth	:	2 m
i.	Direction of slide	:	N65°W

CAUSES: The slope was cut vertical for the road and failed due to high rainfall experienced in this area.. The slope failed due to high pore water pressure development due to heavy infiltration during the monsoon.

NATURE OF DAMAGE: Karwar- Kumbarwada road in SH-95 was blocked due to the heaped debris material on the road.

RECCOMENDATIONS:

i) The crown part was found to be unstable hence the crown portion is to be completely removed.

ii) The geometrical modification of the slope by graded or bench to be provided.

iii) Proper drainage is to be provided for discharge of water away from unstable slopes.

iv) Soil nailing and rock bolting is suggested to protect the vulnerable planes from sliding.

Photo 72: *The plan view of the rock slide covered with trees.*

SLIDE NO: KA37 a

LOCATION: The area is located at latitude 14° 55'57"N and longitude 74° 21' 41"E in Survey of India Toposheet No 48 J/5, along Karwar- Kumbarwada road (Ansi Ghat) in SH-95 in Karwar taluk.

SLIDE DESCRIPTION: Slide is located in the western slope of N23°E-S23°W trending spur of N14°W-S14°E trending hillock which has a maximum height of 465 m. The relative relief of the slope is 360 m and slope angle is 25.64° towards S45°W. Relative relief from the top of the hill to the road is 200 m. The rock type of the area is biotite gneiss. The slide is classified as debris slide. The construction of (road) SH-95 is the only land use.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	10 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	05 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	0.5 m
d.	Volume of failed mass above the failure surface	:	25 m^3
e.	Slope angle after failure	:	50°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	25°
h.	Direction of slide	:	N70°W

CAUSES: The vertical cut slope for making road, the loose overburden and the weathered gneiss in the slope decreased the slope stability and the slope failed because of pore water pressure developed due to the heavy ingress of water during monsoon.

NATURE OF DAMAGE: Karwar- Kumbarwada road in SH-95 was blocked due to the heaped debris material on the road.

RECCOMENDATION:

i) The protective measures proposed at the site include removal of slide material from the slope.

ii) Grading of the slope with benches

iii) Providing gabion or masonry wall for a height of 4m..

iv) Biotechnical measures is also suggested to increase the cohesiveness of soil.

Photo 73: *The plan view of the debris slump with slided material in the slope.*

SLIDE NO: KA38

LOCATION: The area is located at latitude 14° 56'03"N and longitude 74° 21' 40"E in Survey of India Toposheet No 48 J/5, along (Ansi Ghat) Karwar- Kumbarwada road in SH-95 in Karwar taluk

SLIDE DESCRIPTION: Slide is occurred in the western slope of N23°E-S23°W trending spur of N14°W-S14°E trending hillock which has a maximum height of 465 m. The relative relief of the slope 420 m and Slope angle is 18.57° towards southwest. Relative relief from the top of the hill to the road is 200 m. This is classified as reactivated rock slide. Three sets of joints are observed J1: N55°W/53°SW, J2: N45°E/62°SE and J3:S37°W/60°NE

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	50 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	70 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	01 m
d.	Volume of failed mass above the failure surface	:	1750 m^3
e.	Slope angle after failure	:	36°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	19°
h.	Direction of slide	:	N68°W

CAUSES: The vertical cut slope for making road has increased the gradient of the slope and disturbed the nature equilibrium and the slope failed during monsoon due to ingress of water along joint plane. The loose and debris material of the earlier slide increased the instability of the slope.

NATURE OF DAMAGE: Karwar- Kumbarwada road in SH-95 was blocked due to the heaped debris material on the road.

RECCOMENDATIONS:

i) The protective measures proposed at the site include removal of weathered and loose material from the crown.

ii) Soil nailing and rock bolting is suggested to protect the vulnerable planes from sliding.

iii) Horizontal drainage is suggested to remove the infiltrated water.

Photo 74: *The plan view of the rock slide*

Photo 75: *The side view of the rock slide*

SLIDE NO: KA39

LOCATION: The area is located at latitude 14° 56' 13"N and longitude 74° 21' 43"E in Survey of India Toposheet No 48 J/5, along (Ansi Ghat) Karwar- Kumbarwada road in SH-95 in Karwar taluk.

SLIDE DESCRIPTION: Slide is located in the western slope of N14°W-S14°E trending hillock which has a maximum height of 520 m. The relative relief of the slope is 460 m and slope angle is 19.48° towards S84°W. Relative relief from the top of the hill to the road is 220 m. The slide is classified as debris slide. The rock type of the area is biotite gneiss.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	14.7 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	17 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	2 m
d.	Volume of failed mass above the failure surface	:	250 m^3
e.	Slope angle after failure	:	36°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	20°
h.	Scar depth	:	4.2 m
i.	Direction of slide	:	N68°W

CAUSES: High cut slope angle and more than 2 meter of overburden increased the instability of the area. The high precipitation during monsoon triggered the slide.

NATURE OF DAMAGE: Karwar- Kumbarwada road in SH-95was blocked due to the heaped debris material on the road.

RECCOMENDATIONS:

i) As the slide is shallow with depth of sliding less than 2m, deep rooted plants/shrubs with high tensile strength is to be planted in the benched slope to increase its stability.

ii) Unstable loose material and trees from the crown should be removed.

iii) Proper drainage is to be provided for discharge of water away from unstable slopes.

Photo 76: *The plan view of the debris slide*

Photo 77: *The view of the unstable crown portion of debris slide*

SLIDE NO: KA40

LOCATION: The area is located at latitude 14° 56' 36"N and longitude 74° 21' 43"E in Survey of India Toposheet No 48 J/5, along (Ansi Ghat) Karwar- Kumbarwada road in SH-95 in Karwar taluk.

SLIDE DESCRIPTION: Slide is located in the western slope of N14°W-S14°E trending hillock which has a maximum height of 520m. The relative relief of the slope is 460m and slope angle is 19.48° towards S84°W. Relative relief from the top of the hill to the road is 160m. This is an old rock slide with both wedge and planar failure. 3 sets of joints are noticed J1:N70W/45SE, J2: NS/64E and J3: N15E/42NW. The Lithology of the area is biotite gneiss traversed by quartz veins.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	30m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	50m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	2m
d.	Volume of failed mass above the failure surface	:	1500m^3
e.	Slope angle after failure	:	45°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	20°
h.	Direction of slide	:	S70°W

CAUSES: The vertical cut slope for making road has increased the gradient of the slope and disturbed the nature equilibrium and the slope failed during monsoon due to ingress of water along joint plane. The weathered and loose rock slipped over the day lighted plane.

NATURE OF DAMAGE: Karwar- Kumbarwada road in SH-95 was blocked due to the heaped debris material on the road.

RECCOMENDATION:

i) The protective measures proposed at the site include removal of weathered and loose material from the crown.

ii) Rock bolting is suggested to protect the unstable jointed blocks from sliding.

iii) Proper horizontal and surface drainage is suggested to decrease the infiltration of water.

Photo 78: *The view of the rock slide with unstable crown.*

Photo 79*: The view of the slide plane of rock slide.*

SLIDE NO: KA41

LOCATION: The area is located at latitude 14° 58' 12"N and longitude 74° 22' 19"E in Survey of India Toposheet No 48 J/5, along Karwar- Kumbarwada road in SH-95 (Ansi Ghat) in Karwar taluk.

SLIDE DESCRIPTION: Slide is located in the eastern slope of North-South trending hillock which has a maximum height of 480m. The relative relief of the slope is 40 m and slope angle is 9.09° towards east. Relative relief from the top of the hill to the road is 10m. The slide is classified as debris slump. The Lithology of the area is biotite gneiss.

MORPHOLOGICAL PARAMETER OF SLIDE:

a. Maximum length of failed mass from crown to foot : 9.88 m
b. Maximum width of failed mass from the left flank to the right flank boundary : 22 m
c. Maximum depth of the failed mass from the surface of the slide to the failure surface : 1 m
d. Volume of failed mass above the failure surface : 109 m^3
e. Slope angle after failure : 44°
f. Slope angle before failure : 90°
g. Original slope angle : 10°
h. Scar width : 20 m
i. Direction of slide : N80°W

CAUSES: The original slope angle of the mound is very gentle. The cutting of the slope for construction of road has increased the gradient. The incumbent pore pressure development during monsoon triggered this slide as the slope forming debris material was highly saturated with rain water.

NATURE OF DAMAGE: Karwar- Kumbarwada road in SH-95 was blocked due to the heaped debris material on the road.

RECCOMENDATIONS:

i) The crown part was found to be unstable due to presence of huge trees; hence the crown portion is to be completely removed.
ii) The geometrical modification of the slope with grading
iii) Biotechnical stabilisation is also suggested to prevent slope failure.

Photo 80: *The view of the debris slump with unstable crown.*

Photo 81: *The view of the debris slump with unstable crown.*

SLIDE NO: KA42

LOCATION: The area is located at latitude 14° 56' 12"N and longitude 74° 21' 42"E in Survey of India Toposheet No 48 J/5, along Karwar- Kumbarwada road in SH-95 (Ansi Ghat) in Karwar taluk.

SLIDE DESCRIPTION: Slide is located in the westrern slope of N14°W-S14°E trending hillock which has a maximum height of 500m. The relative relief of the slope is 140m and slope angle is 29.34° towards NW. Relative relief from the top of the hill to the road is 120m. This slide is classified as complex slide as both debris and rock slide are observed. The Lithology of the area is biotite gneiss. 3 sets of joints are noticed .J1: EW/52°S, J2: EW/60°N and J3: NS/70°E.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	30 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	26.8 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	1m
d.	Volume of failed mass above the failure surface	:	402 m^3
e.	Slope angle after failure	:	70°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	30°
h.	Direction of slide	:	S58°W

CAUSES: The original slope angle of the mound is very gentle. The cutting of the slope for construction of road has increased the gradient. The incumbent pore pressure development during monsoon triggered this slide as the slope forming debris material was highly saturated with rain water.

NATURE OF DAMAGE: Karwar- Kumbarwada road in SH-95 was blocked due to the heaped debris material on the road.

RECCOMENDATIONS:

i) The crown part was found to be unstable; hence the crown portion is to be completely removed.

ii) Biotechnical stabilisation like plantation is suggested to prevent slope failure.

iii) Rock bolting and soil nailing is suggested to protect the loose day lighted jointed plane.

iv) Proper horizontal and surface drainage is suggested to decrease the infiltration of water.

Photo 82: The view of the debris slide with unstable crown.

Photo 83: The view of the rock slide.

SLIDE NO: KA43

LOCATION: The area is located at latitude 14° 56' 39"N and longitude 74° 21' 43"E in Survey of India Toposheet No 48 J/5, along Karwar- Kumbarwada road in SH-95 (Ansi Ghat) in Karwar taluk.

SLIDE DESCRIPTION: Slide is located in the western slope of N14°W-S14°E trending hillock which has a maximum height of 500 m. The relative relief of the slope 140 m and Slope angle is 29.34° towards NW. Relative relief from the top of the hill to the road is 140 m. The slide is classified as reactivated rock slide. The Lithology of the area is biotite gneiss.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	15 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	33 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	1 m
d.	Volume of failed mass above the failure surface	:	248 m^3
e.	Slope angle after failure	:	50°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	30°
h.	Direction of slide	:	S68°W

CAUSES: The vertical cut slope for making road has increased the gradient of the slope and disturbed the nature equilibrium and the slope failed during monsoon due to ingress of water along joint plane. The unprotected old slide increased the instability of the area. The weathered and loose rock mass slipped over the day lighted plane.

NATURE OF DAMAGE: Karwar- Kumbarwada road in SH-95 was blocked due to the heaped debris material on the road.

RECCOMENDATIONS:

i) The crown part was found to be unstable; hence the crown portion is to be completely removed.

ii) Rock bolting and soil nailing is suggested to protect the loose day lighted jointed plane.

iii) Proper horizontal and surface drainage is suggested to decrease the infiltration of water.

Photo 84: The plan view of the rock slide with loose boulders accumulated at the toe of the slide.

Photo 85: The side view of the rock slide.

LANDSLIDES ALONG ANKOLA- YELLAPUR SECTION

NH-63

SLIDE NO: KA44

LOCATION: The slide is located at latitude 14°53′ 58″ N and longitude 74° 39′ 08″ E at elevation 436 m from MSL in Survey of India toposheet No 48 J / 9, 61.2 milestone to Ankola in Yellapur –Arbail road, North Kanara district along NH- 63.

SLIDE DESCRIPTION: Slide is located in the western slope of NNW-SSE trending hillock which has a maximum height of 440m. The relative relief of the slope is 40 m. Slope angle is 15° towards SW. The slide is classified as reactivated debris slide. The slide is prograding towards upslope/backward. The depth of overburden is about 3m and the slope forming material is laterite and clay. The construction of road (NH-63) is the only land use.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	11.4 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	33 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	3 m
d.	Volume of failed mass above the failure surface	:	564 m^3
e.	Slope angle after failure	:	75°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	12°
h.	Scar depth	:	1.5-2.5 m
i.	Direction of slide	:	S85°E

CAUSES: The increase in the gradient of the slope due to the vertical cut slope for making road decreased the slope stability. The weathering depth of about 10m and overburden depth of 3m also affected the slope stability. The heavy precipitation during monsoon increased the pore water pressure, the loose overburden and the laterite in the slope failed due to saturation.

NATURE OF DAMAGE: The national highway NH-63 (Yellapur –Arbail road) was blocked due to the heaped debris material on the road

RECCOMENDATIONS:

i) The protective measures proposed at the site include removal of slide material from the slope and the unstable crown should be completely removed.

ii) Slope angle should be reduced to <40° by grading of the slope

iii) Plantation of deep rooted vegetation on the slope is suggested to reduce erosion and protect the unstable slope

iv) Proper surface and horizontal drainage should be provided.

Photo-86: The plan view of the debris slide with unstable crown.

Photo 87: The plan view of the debris slide with accumulation at the toe.

SLIDE NO: KA45

LOCATION: The slide is located at latitude 14°53′ 38″ N and longitude 74° 39′ 14″ E at elevation 428m from MSL in Survey of India toposheet No 48 J / 9 in Yellapur –Arbail road, North Kanara district along NH- 63.

SLIDE DESCRIPTION: Slide is located in the western slope of NNW-SSE trending hillock which has a maximum height of 440 m. The relative relief of the slope is 40 m and slope angle is 15° towards SW. The slide is classified as reactivated rock cum debris slide (complex slide). The slide is prograding along sides. The lithology of the area is laterite. The slope forming material is very less (<0.5 m).

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	15 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	52 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	1-2 m
d.	Volume of failed mass above the failure surface	:	780 m^3
e.	Slope angle after failure	:	90°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	15°
h.	Direction of slide	:	S80°E

CAUSES: Increase in the gradient of the slope due to the vertical cut slope for making road decreased the slope stability. The lack of surface drainage increased the percolation and infiltration of water into the mound. The heavy precipitation during monsoon increased the pore water pressure, the loose overburden and the laterite in the slope failed due to saturation.

NATURE OF DAMAGE: Yellapur –Arbail road in national highway NH-63, was blocked due to the heaped debris material on the road

RECCOMENDATIONS:

i) The protective measures proposed at the site include removal of huge trees standing on the unstable crown part and slided material which are resting on the slided plane .

ii) The slope angle should be reduced to <40° to increase the stability by grading of the slope.

iii) Plantation of deep rooted vegetation on the slope is suggested to reduce erosion and increase slope stability.

iv) Retaining wall of height about 4m should be provided.

Photo 88: The plan view of the complex slide

Photo 89: The plan view of the debris cum slide with accumulation at the toe.

SLIDE NO: KA46

LOCATION: The slide is located at latitude 14°53′ 31″ N and longitude 74° 39′ 18″ E at elevation 424 m from MSL in Survey of India toposheet No 48 J / 9 in Yellapur –Arbail road, North Kanara district along NH- 63.

SLIDE DESCRIPTION: Slide is located in the eastern slope of NNW-SSE trending hillock which has a maximum height of 400 m. The relative relief of the slope is 140 m and slope angle is 15° towards NE. Highly weathered granite with kaolinisation on the slope of the slide zone is observed. The total slide zone surface is irregular and drained with small rills and gullies. The slides look to be stabilised due to the high vegetation cover in the slide slope. The present topography of the cut slopes has both concave and convex geometry. The slide is classified as multiple, reactivated debris slide.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	20 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	167.82 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	4 m
d.	Volume of failed mass above the failure surface	:	6713 m^3
e.	Slope angle after failure	:	45-80°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	15°
h.	Direction of slide	:	N52°E

CAUSES: The original slope angle of this spur is very gentle. This slope was cut vertical for construction of road which decreased the stability of the slope. The compressive strength of the weathered granite is very week and kaolinised clay lenses in the surface exposes the weak zones and the slope failed due to increase in pore water pressure during high rainfall experienced in this area.

NATURE OF DAMAGE: Yellapur –Arbail road in NH-63 was blocked due to the heaped debris material on the road.

RECCOMENDATIONS:

i) The slope angle should be reduced to <40°.

ii) Deep rooted plants/shrubs is to be planted in the graded slope to increase its stability.

iii) The unstable crown portion should be removed.

iv) Retaining wall of height about 4m should be provided.

Photo 90: The side view of the debris slide

Photo 91: The plan view of the debris slide

Photo 92: The side view of the debris slide

Photo 93: The kaolinised clay lenses in the surface of the debris slide

SLIDE NO: KA47

LOCATION: The slide is located at latitude 14°53′ 28″ N and longitude 74° 39′ 20″ E at elevation 424 m from MSL in Survey of India toposheet No 48 J / 9 in Yellapur –Arbail road, North Kanara district along NH- 63.

SLIDE DESCRIPTION: Slide is located in the eastern slope of NNW-SSE trending hillock which has a maximum height of 400 m. The relative relief of the slope is 40 m and slope angle is 15° towards SW. Relative relief from the top of the hill to the road is 20 m. The slide is classified reactivated debris slide. The vegetation cover in the slide zone indicates an age of slide to be more than 2 years.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	17 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	24.7 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	1-2 m
d.	Volume of failed mass above the failure surface	:	420 m^3
e.	Slope angle after failure	:	70-80°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	15°
h.	Direction of slide	:	S84°E

CAUSES: The original slope angle of this spur is very gentle. This slope was cut vertical for construction of road which decreased the stability of the slope. Due to the cutting of the mound, the toe portion became vulnerable. The slope forming material became saturated due to increase in pore water pressure during high rainfall experienced in this area.

NATURE OF DAMAGE: Yellapur –Arbail road in NH-63 was blocked due to the heaped debris material on the road

RECCOMENDATIONS:

i) The slope angle should be reduced to <40° by grading of the slope.

ii) The unstable crown portion should be removed.

iii) Proper surface drainage should be provided to minimize water infiltration.

iv) Retaining wall of height about 3m should be provided.

Photo 94: The plan view of the debris slide

Photo 95: The plan view of the debris slide

SLIDE NO: KA48

LOCATION: The slide is located at latitude 14°53′ 21″ N and longitude 74° 39′ 21″ E at elevation 409 m from MSL in Survey of India toposheet No 48 J / 9 in Yellapur –Arbail road, North Kanara district along NH- 63.

SLIDE DESCRIPTION: Slide is located in the eastern slope of NNW-SSE trending hillock which has a maximum height of 400 m. And relative relief of the slope is 160 m. Slope angle is 16.22° towards East. Relative relief from the top of the hill to the road is 20 m. The slide is classified as reactivated, multiple debris slide. The slope forming material is soil and depth is about 1m. The construction of road (NH-63) is the only land use.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	20 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	230 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	1.5 m
d.	Volume of failed mass above the failure surface	:	3450 m^3
e.	Slope angle after failure	:	45°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	17°
h.	Scar depth	:	5 m
i.	Direction of slide	:	S17°E

CAUSES: The increase in the gradient of the slope due to the vertical cut slope for making road decreased the slope stability. The lack of surface drainage increased the percolation and infiltration into the mound. The heavy precipitation during monsoon increased the pore water pressure, the loose overburden and the weathered granite in the slope failed due to saturation.

NATURE OF DAMAGE: Yellapur –Arbail road in NH-63 was affected due to slided material.

RECCOMENDATION:

i) The protective measures proposed at the site include removal of huge trees standing on the unstable crown and slide material which are resting on the slided plane should be completely removed

ii) The slope angle should be reduced to <40° to increase the stability by grading of the slope

iii) Plantation of deep rooted vegetation on the slope is suggested to reduce erosion and increase slope stability.

iv) The retaining wall has been provided for certain distance and it should be increased to for the entire width of the slide.

Photo 96: The view of the debris slide with unstable crown

Photo 97: The side view of the debris slide

SLIDE NO: KA49

LOCATION: The slide is located at latitude 14°52′ 47″ N and longitude 74° 39′ 23″ E at elevation 305 m from MSL in Survey of India toposheet No 48 J / 9 in Yellapur –Arbail road,, North Kanara district along NH- 63.

SLIDE DESCRIPTION: Slide is located in the eastern slope of NNW-SSE trending hillock which has a maximum height of 400 m. The relative relief of the slope is 200 m and slope angle is 21.8° towards E. Relative relief from the top of the hill to the road is 40 m. The slide is classified as reactivated multiple slide. The overburden depth is about 3m and consists of weathered granite and soil.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	15 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	32.3 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	2 m
d.	Volume of failed mass above the failure surface	:	485 m^3
e.	Slope angle after failure	:	45°
f.	Slope angle before failure	:	68°
g.	Original slope angle	:	22°
h.	Scar depth	:	5 m
i.	Direction of slide	:	N61° E

CAUSES: The increase in the gradient of the slope due to the vertical cut slope for making road decreased the slope stability. The remedial measures were not provided for the earlier slide, so the slide prograded laterally. The heavy precipitation during monsoon increased the pore water pressure, the loose overburden and the weather granite in the slope failed due to saturation.

NATURE OF DAMAGE: Yellapur –Arbail road in NH-63 was blocked due to the heaped debris material on the road.

RECCOMENDATIONS:

i) The protective measures proposed at the site include removal of huge trees standing on the unstable crown and slide materials which are resting on the slided plane should be completely removed.

ii) The slope angle should be reduced to <40° to increase the stability by grading of the slope.

iii) Plantation of deep rooted vegetation on the slope is suggested to reduce erosion and increase slope stability.

iv) The retaining wall has been suggested for the entire width of the slide.

Photo 98: The view of the debris slide with unstable crown

Photo 99: The view of the debris slide with unstable crown

SLIDE NO: KA50

LOCATION: The slide is located at latitude 14°52′ 27″ N and longitude 74° 39′ 18″ E at elevation 312 m from MSL in Survey of India toposheet No 48 J / 9 in Yellapur –Arbail road, North Kanara district along NH- 63.

SLIDE DESCRIPTION: Slide is located in the eastern slope of North-South trending hillock which has a maximum height of 400 m. The relative relief of the slope is 140m and slope angle is 15.64° towards NE. Relative relief from the top of the hill to the road is 20m. The slide is classified as reactivated multiple slide. The overburden depth is about 3m and consists of weathered granite and soil.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	18 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	53 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	1.5 m
d.	Volume of failed mass above the failure surface	:	715 m^3
e.	Slope angle after failure	:	52°
f.	Slope angle before failure	:	60°
g.	Original slope angle	:	16°
h.	Direction of slide	:	S70°E

CAUSES: The increase in the gradient of the slope due to the vertical cut slope for making road decreased the slope stability. The remedial measures were not provided for the earlier slide, so the slide prograded laterally. The heavy precipitation during monsoon increased the pore water pressure, the loose overburden and the weather granite in the slope failed due to saturation.

NATURE OF DAMAGE: Yellapur –Arbail road in NH-63 was blocked due to the heaped debris material on the road

RECCOMENDATIONS:

i) Unstable crown and slided material which are resting on the slided plane to be completely removed

ii) Slope angle should be reduced to <40° by grading of the slope to increase the stability.

iii) Plantation of deep rooted vegetation on the slope is suggested to reduce erosion and increase slope stability.

iv) Making contour drainage at the top of the slopes and inserting horizontal perforated pipes in to the slopes will act as weep holes in the vertical slopes and thus reducing the pore pressure by draining out the excess water.

v) The retaining wall has been suggested for the entire width of the slide.

Photo 100: The side view of the debris slide with unstable crown

Photo 101: The plan view of the debris slide with steep slope angle.

SLIDE NO: KA51

LOCATION: The slide is located at latitude 14°52′ 22″ N and longitude 74° 39′ 18″ E at elevation 310 m from MSL in Survey of India toposheet No 48 J / 9 in Yellapur –Arbail road, North Kanara district along NH- 63.

SLIDE DESCRIPTION: Slide is located in the eastern slope of N-S trending hillock which has a maximum height of 400 m. The relative relief of the slope is 160 m and slope angle is 15.64° towards Southeast. Relative relief from the top of the hill to the road is 20 m. The slide is classified as reactivated, multiple debris slide. The overburden depth is about 3m and consists of weathered granite and soil.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	20 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	68 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	3.5 m
d.	Volume of failed mass above the failure surface	:	2380 m^3
e.	Slope angle after failure	:	68°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	16°
h.	Direction of slide	:	N73°E

CAUSES: The increase in the gradient of the slope due to unscientific cutting of hills for making road resulting in greater instability of hill slopes. Proper remedial measures were not provided for the earlier slide, so the slide prograded laterally. The slope forming materials in the slided area tend to be loose and non-cohesive due to prolonged weathering. The heavy and intensive period of precipitation during monsoon increased the pore water pressure, the loose overburden and the weather granite in the slope failed due to saturation.

NATURE OF DAMAGE: Yellapur –Arbail road in NH-63 was affected due to slided material.

RECCOMENDATIONS:

i) Removal of unstable crown and debris which are resting on the slided plane are likely to slide again during monsoon and therefore should be completely removed.

ii) Slope angle should be reduced to <40° grading of the slope to increase the stability

iii) Plantation of deep rooted vegetation on the slope is suggested to reduce erosion and increase slope stability.

iv) The retaining wall has been suggested for the entire width of the slide.

v) Making contour drainage at the top of the slopes and inserting horizontal perforated pipes in to the slopes will act as weep holes in the vertical slopes and thus reducing the pore pressure by draining out the excess water.

Photo 102: The plan view of the reactivated debris slide.

Photo 103: The side view of the reactivated debris slide.

SLIDE NO: KA52

LOCATION: The slide is located at latitude 14°47′ 47″ N and longitude 74° 36′ 1″ E at elevation 310 m from MSL in Survey of India toposheet No 48 J / 9 in Arbail-Ankola road, North Kanara district along NH- 63.

SLIDE DESCRIPTION: The slide is classified as reactivated, multiple debris slide and slump. The slope forming material is soil. The Lithology of the area is phyllite. The slide is a surface slide with depth <1 m. The slide has a width of 300 m. Numbers of slides are joined together laterally. Some are new slides and others are reactivated slides. The construction of road (NH-63) is the only land use.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	20 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	300m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	0.5 m
d.	Volume of failed mass above the failure surface	:	1500 m^3
e.	Slope angle after failure	:	70°
f.	Slope angle before failure	:	80°
g.	Original slope angle	:	20°
h.	Direction of slide	:	Varies all along the road

CAUSES: The steeping of the slope due to unscientific cutting of hills for making road resulting in greater instability of hill slopes. Remedial measures were not provided for the earlier slide, so the slide prograded laterally. The slided area has materials that tend to be weak and non-cohesive due to prolonged weathering. The heavy and intensive period of precipitation during monsoon increased the pore water pressure, the loose overburden and the weather phyllite in the slope failed due to saturation.

NATURE OF DAMAGE: Arbail-Ankola road in NH-63 was blocked due to slided material.

RECCOMENDATION:

i) Removal of unstable crown part and slided material.

ii) Slope angle should be reduced to <40° by grading of the slope or benches to increase the stability.

iii) Plantation of deep rooted plant/shrub on the slope is suggested to reduce erosion and increase slope stability.

iv) Making contour drainage at the top of the slopes for decreasing infiltration and sub-surface horizontal drainage i.e. inserting horizontal perforated pipes in to the slopes will act as weep holes in the vertical slopes and thus reducing the pore pressure by draining out the excess water.

Photo 105: The side view of the reactivated debris slump with steep slope angle

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SLIDE NO: KA53

LOCATION: The slide is located at latitude 14°42′ 59″ N and longitude 74° 30′ 46″ E at elevation 310 m from MSL in Survey of India toposheet No 48 J / 10 in Yellapur –Hillur road, North Kanara district along NH- 63.

SLIDE DESCRIPTION: The slide is classified as debris slide. The slope forming material is soil. The Lithology of the area is laterite. The slide is a surface slide with depth <1 m. The lithology of the area is laterite. The depth of weathering is about 10m. The shape of the slide is irregular. The construction of road (NH-63) is the only land use.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	12 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	7 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	2 m
d.	Volume of failed mass above the failure surface	:	84 m^3
e.	Slope angle after failure	:	45°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	20°
h.	Direction of slide	:	N80°W

CAUSES: The steeping of the slope due to unscientific cutting of hills for making road resulting in greater instability of hill slopes. The absence of adequate drainage at the surface allows more rain water to infiltrate. The slided area has materials that tend to be weak and non-cohesive due to prolonged weathering. The heavy and intensive period of precipitation during monsoon increased the pore water pressure, the loose overburden and the weak laterite in the slope failed due to saturation.

NATURE OF DAMAGE: Yellapur –Hillur road in NH-63 was affected due to sliding material.

RECCOMENDATION:

i) Removal of unstable crown and modification of slope angle by grading of the slope or benches

ii) Slope angle needs to be trimmed to 40-45° to increase the stability.

iii) Plantation of deep rooted plant/shrub on the slope is suggested to reduce erosion and increase slope stability.

iv) Making contour drainage at the top of the slopes for decreasing infiltration of water and sub-surface horizontal drainage i.e. inserting horizontal perforated pipes in to the slopes will act as weep holes in the vertical slopes and thus reducing the pore pressure by draining out the excess water.

Photo 106: The side view of the debris slide showing steep slope angle.

Photo 107: The side view of the debris slide showing steep slope angle.

SLIDE NO: KA54

LOCATION: The slide is located at latitude 14°43′ 4″ N and longitude 74° 30′ 47″ E at elevation 310 m from MSL in Survey of India toposheet No 48 J / 10 in Yellapur –Hillur road, North Kanara district along NH- 63.

SLIDE DESCRIPTION: The slide is classified as debris slide. The slope forming material is soil. The Lithology of the area is laterite. The slide is a surface slide with depth <1 m. The Lithology of the area is laterite. The depth of weathering is about 10m. The shape of the slide is irregular. The construction of road in NH-63 is the only land use.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	12 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	7 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	2 m
d.	Volume of failed mass above the failure surface	:	84 m^3
e.	Slope angle after failure	:	45°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	25°
h.	Direction of slide	:	S12°E

CAUSES: This man induced rotational failure was caused by steep cutting of hill slopes for making road resulting in greater instability of slopes. The absence of adequate drainage at the surface allows more rain water to infiltrate. The slided area has materials that tend to be weak and non-cohesive due to prolonged weathering. The heavy and intensive period of precipitation during monsoon increased the pore water pressure, the loose overburden and the weak laterite in the slope failed due to saturation.

NATURE OF DAMAGE: Yellapur –Hillur road in NH-63 was affected due to slided material.

RECCOMENDATIONS:

i) Removal of unstable crown part

ii) Slope angle needs to be trimmed to 45° to increase the stability.

iii) Bio-engineering, plantation of deep rooted plant/shrub on the slope is suggested to reduce erosion and increase slope stability.

iv) Making contour drainage at the top of the slopes for decreasing infiltration and sub-surface horizontal drainage i.e. inserting horizontal perforated pipes in to the slopes will act as weep holes in the vertical slopes and thus reducing the pore pressure by draining out the excess water. Retaining wall is suggested at the toe of the slope.

Photo 108: The plan view of the debris slide showing steep slope angle.

Photo 109: The side view of the debris slide showing steep slope angle.

LANDSLIDE ALONG KARWAR- ANKOLA ROAD

NH-17

SLIDE NO: KA55

LOCATION: The slide is located at latitude 14°36′ 27″ N and longitude 74° 21′ 40″ E at elevation 67 m from MSL in Survey of India toposheet No 48 J / 6 in Ankola –Hiregutti road, North Kanara district along NH- 17.

SLIDE DESCRIPTION: The slide is classified as multiple, reactivated debris slide. The slope forming material is lateritic soil. The Lithology of the area is laterite. The slide is a sallow slide with depth 2 m. The depth of weathering of the slided area is 15 m. The shape of the slide is circular. The construction of NH-17 is the only land use.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	20 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	43 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	2 m
d.	Volume of failed mass above the failure surface	:	860 m^3
e.	Slope angle after failure	:	75°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	22°
h.	Direction of slide	:	N28°E

CAUSES: This slide is a man induced slope failure, caused due to steep cutting of hill slopes for making road resulting in greater instability of slopes. The remedial measures were not given for the earlier slide and the slided area has materials that tend to be weak and non-cohesive due to prolonged weathering. The absence of adequate drainage at the surface allows more rain water to infiltrate. The intensive period of precipitation during monsoon increased the pore water pressure, the loose overburden and the weak laterite in the slope failed due to saturation.

NATURE OF DAMAGE: Ankola –Hiregutti road road in NH-17 was blocked due to the heaped debris material on the road.

RECCOMENDATIONS:

i) Removal of unstable crown and debris present at the slided area.

ii) The slope angle needs to be trimmed to <45° to increase the stability.

iii) Bio-engineering, plantation of deep rooted plant/shrub on the slope is suggested to reduce erosion and increase slope stability.

iv) Making contour drainage at the top of the slopes for decreasing infiltration and sub-surface horizontal drainage i.e. inserting horizontal perforated pipes in to the slopes will act as weep holes in the vertical slopes and thus reducing the pore pressure by draining out the excess water. Retaining wall is suggested at the toe of the slope.

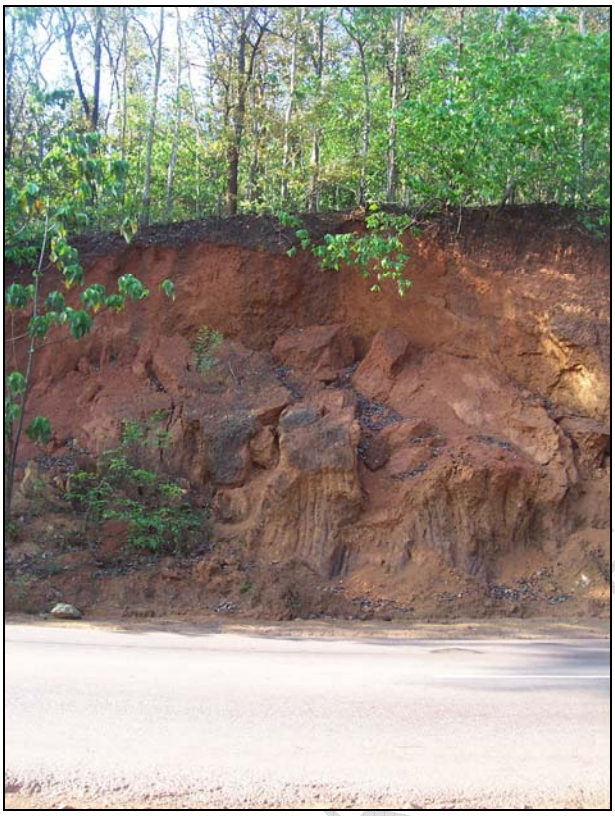


Photo 110: The side view of the debris slide showing steep slope angle.

Photo 111: The side view of the debris slide with slided material at the toe.

SLIDE NO: KA56

LOCATION: The slide is located at latitude 14°36′ 25″ N and longitude 74° 21′ 42″ E at elevation 26 m from MSL in Survey of India toposheet No 48 J / 6 in Ankola –Hiregutti road, North Kanara district along NH- 17.

SLIDE DESCRIPTION: The slide is classified as debris slide. The slope forming material is lateritic soil. The Lithology of the area is laterite. The slide is a sallow slide with depth 2m.The depth of weathering of the slided area is 15 m.The construction of road in NH-17 is the only land use.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	7 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	17 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	2 m
d.	Volume of failed mass above the failure surface	:	119 m^3
e.	Slope angle after failure	:	75°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	25°
h.	Direction of slide	:	N36°E

CAUSES: This slide is a man induced slope failure, caused due to steep cutting of hill slopes for making road resulting in greater instability of slopes. The absence of adequate drainage at the surface allows more rain water to infiltrate. The intensive period of precipitation during monsoon increased the pore water pressure, the loose overburden and the weak laterite in the slope failed due to saturation.

NATURE OF DAMAGE: Ankola –Hiregutti road road in NH-17 was blocked due to the heaped debris material on the road

RECCOMENDATIONS:

i) Removal of unstable crown and debris present at the slided area.

ii) The slope angle needs to be trimmed to 40-45° to increase the stability.

iii) Bio-engineering, plantation of deep rooted plant/shrub on the slope is suggested to reduce erosion and increase slope stability.

iv) Making contour drainage at the top of the slopes for decreasing infiltration and sub-surface horizontal drainage i.e. inserting horizontal perforated pipes in to the slopes will act as weep holes in the vertical slopes and thus reducing the pore pressure by draining out the excess water. Retaining wall with weep holes is suggested at the toe of the slope.

Photo-112: View of the debris slide with slided material

SLIDE NO: KA57

LOCATION: The slide is located at latitude 14°36′ 25″ N and longitude 74° 21′ 43″ E at elevation 28m from MSL in Survey of India toposheet No 48 J / 6 in Ankola taluk, North Kanara district along NH- 17.

SLIDE DESCRIPTION: The slide is classified as reactivated, multiple, debris cum rock slide. The failure surface is planar. The slope forming material is soil. The Lithology of the slided area is gabbro. The slide is a sallow slide with depth 2m.The construction of NH-17 is the only land use.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	20m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	58m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	2m
d.	Volume of failed mass above the failure surface	:	1160m^3
e.	Slope angle after failure	:	70°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	22°
h.	Direction of slide	:	W

CAUSES: The steeping of the slope due to unscientific cutting of hills for making road resulting in greater instability of hill slopes. The remedial measures were not provided for the earlier slide and the slided area has materials that tend to be weak and non-cohesive due to prolonged weathering. The heavy and intensive period of precipitation during monsoon increased the pore water pressure, the loose overburden and the weather rock in the slope failed due to saturation.

NATURE OF DAMAGE: Ankola –Hiregutti road in NH-17 was blocked due to the heaped debris material on the road

RECCOMENDATIONS:

i) Removal of unstable crown and debris from the slide area.

ii) Geometrical modification of the slope by grading of the slope or benches, the slope angle should be reduced to <40° to increase the stability.

iii) Bio-engineering and plantation of deep rooted plant/shrub on the slope is suggested to reduce erosion and increase slope stability.

iv) Making contour drainage at the top of the slopes for decreasing infiltration and sub-surface horizontal drainage i.e. inserting horizontal perforated pipes in to the slopes will act as weep holes in the vertical slopes and thus reducing the pore pressure by draining out the excess water.

Photo-113: view of the debris slide with slided material

SLIDE NO: KA58

LOCATION: The slide is located at latitude 14°32′ 13″ N and longitude 74° 23′ 57″ E at elevation 28 m from MSL in Survey of India toposheet No 48 J / 6 in Karwar- Ankola road, North Kanara district along NH- 17.

SLIDE DESCRIPTION: The slide is classified as debris slide. The failure surface is slip. The slope forming material is soil. The Lithology of the slided area is laterite. The slide is a sallow slide with depth 2 m. The construction of NH-17 is the only land use.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	10 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	20 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	2m
d.	Volume of failed mass above the failure surface	:	200 m^3
e.	Slope angle after failure	:	70°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	22°
h.	Direction of slide	:	N56°E

CAUSES: Steepening of slopes due to cutting of the hill slopes for making of new road or widening of existing road resulting in instability of hill slopes. Improper drainage system at the surface allows more water to infiltrate down ward. Loose and non-cohesive material present at the area due to prolonged weathering and intensive rainfall for a long period during monsoon increased the pore water pressure and the slope forming material failed due to saturation.

NATURE OF DAMAGE: Karwar- Ankola road in NH-17 was blocked due to the heaped debris material on the road.

RECCOMENDATIONS:

i) Removal of unstable crown and debris from the slide area.

ii) Geometrical modification of the slope by grading or benches, the slope angle should be reduced to <40° to increase the stability.

iii) Bio-engineering and plantation of deep rooted plant/shrub on the slope is suggested to reduce erosion and increase slope stability.

iv) Making contour drainage at the top of the slopes for decreasing infiltration and sub-surface horizontal drainage i.e. inserting horizontal perforated pipes in to the slopes will act as weep holes in the vertical slopes and thus reducing the pore pressure by draining out the excess water.

Photo-114: view of the debris slide with slided material

LANDSLIDE ALONG AGUMBE GHAT

SH-1

SLIDE NO: KA59

LOCATION: The slide is located at latitude 13°29′ 48″ N and longitude 75° 4′ 52″ E at elevation 589 m from MSL in Survey of India toposheet No 48 O / 3 in Tirthahalli taluk, Shimoga district along SH- 1in Agumbe - Udupi road.

SLIDE DESCRIPTION: The maximum height of the hill is 647 m. The average relative relief of the area is nearly 523.5m.The slide is classified as rock slump. The rock type of the slide area is metabasalt. Three sets of joints are recorded in the slide area.J1:N38E/68E, J2: N65E/71E, J3:N40W/54NE and foliation is N20W/58E. The slope forming material is soil. The lithology of the slided area is laterite. The slide is a surface slide with depth 0.5 m. The construction of road (NH-17) is the only land use.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	15 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	45 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	0.5 m
d.	Volume of failed mass above the failure surface	:	168 m^3
e.	Slope angle after failure	:	75°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	35°
h.	Direction of slide	:	W

CAUSES: This slide was caused mainly due to steep cutting of the hill slopes for making new roads. Prolonged weathering of the exposed rock resulted in loose, fragmented and non-cohesive material, which failed due to intensive precipitation during monsoon.

NATURE OF DAMAGE: Agumbe - Udupi road in SH-1 was affected due to sliding material.

RECCOMENDATIONS:

i) Removal of unstable crown and huge trees standing on the crown to decrease the load.

ii) The slope angle should be reduced to <40° to increase the stability.

iii) Bio-engineering and plantation of deep rooted plant/shrub on the slope is suggested to reduce erosion and increase slope stability.

iv) Retaining wall with weep holes is suggested at the toe of the slide.

Photo 115: The side view of the debris slump

Photo 116: The plan view of the debris slump

SLIDE NO: KA60

LOCATION: The slide is located at latitude 13°29′ 51″ N and longitude 75° 4′ 41″ E at elevation 590 m from MSL in Survey of India toposheet No 48 O / 3 in Tirthahalli taluk, Shimoga district along SH- 1 in Agumbe - Udupi road.

SLIDE DESCRIPTION: The maximum height of the hill is 647 m. The average relative relief of the area is nearly 523.5m. The slide is classified as debris slide. The rock type of the slide area is meta-basalt. Two sets of joints are recorded in the slide area.J1:N12E/31SW, J2: N65E/79SW. The slope forming material is soil. The lithology of the slided area is laterite. The slide is a surface slide with depth 0.5m.The construction of road (NH-17) is the only land use.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	12.5 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	14 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	<1 m
d.	Volume of failed mass above the failure surface	:	88 m^3
e.	Slope angle after failure	:	34°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	30°
h.	Direction of slide	:	N27°W

CAUSES: This slide was caused mainly due to steep cutting of the hill slopes for making new roads. Prolonged weathering of the exposed rock resulted in loose, fragmented and non-cohesive material, which failed due to intensive precipitation during monsoon.

NATURE OF DAMAGE: Agumbe - Udupi road in SH-1 was affected due to sliding material.

RECCOMENDATIONS:

i) Removal of unstable crown and huge trees standing on the crown to decrease the load.

ii) The slope angle should be reduced to <40° to increase the stability.

iii) Bio-engineering and plantation of deep rooted plant/shrub on the slope is suggested to reduce erosion and increase slope stability.

iv) Retaining wall with weep holes is suggested to at the toe of the slide.

Photo 117: The plan view of the debris slide

Photo 118: The side view of the debris slump

LANDSLIDES ALONG MANGALORE-MANJESHVAR ROAD SECTION

NH 17

SLIDE NO: KA61

LOCATION: The slide is located at latitude 12°51′ 19″ N and longitude 74° 52′ 1″ E at elevation 589 m from MSL in Survey of India toposheet No 48 L / 13 in Mangalore taluk, Dakshina Kannada district along NH- 17in Mangalore-Manjeshvar road section .

SLIDE DESCRIPTION: The trend of the hillock N4°E-S4°W with an average slope angle 5.71° towards west. Relative height of the slope is 30 m and cut slope height 10m. The slide is classified as old debris slump. The slide is elliptical in shape. The Lithology of the slide area is laterite. The weathering depth of the area is about 15 m.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	11 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	49 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	1 m
d.	Volume of failed mass above the failure surface	:	270 m^3
e.	Slope angle after failure	:	80°
f.	Slope angle before failure	:	75°
g.	Original slope angle	:	6°
h.	Direction of slide	:	N59°W

CAUSES: This slide is a man induced slope failure, caused due to steep cutting of hill slopes for making road resulting in greater instability of slopes. The absence of adequate drainage at the surface allows more rain water to infiltrate. The intensive precipitation for a long period during monsoon increased the pore water pressure, the loose overburden and the weak laterite in the slope failed due to saturation.

NATURE OF DAMAGE: Mangalore-Manjeshvar road section in NH-17was affected due to slided material.

RECCOMENDATIONS:

i) Removal of unstable crown part and debris present at the slided area.

ii) The slope angle needs to be trimmed to <40° to increase the stability.

iii) Making contour drainage at the top of the slopes for decreasing infiltration and sub-surface horizontal drainage i.e. inserting horizontal perforated pipes in to the slopes will act as weep holes in the vertical slopes and thus reducing the pore pressure by draining out the excess water.

Photo 119: The plan view of the debris slump with unstable crown

Photo 120: The plan view of the debris slump with steep slope angle

SLIDE NO: KA62

LOCATION: The slide is located at latitude 12°51′ 42″ N and longitude 74° 52′ 0″ E at elevation 17 m from MSL in Survey of India toposheet No 48 L / 13 in Mangalore taluk, Dakshina Kannada district along NH- 17 in Mangalore-Manjeshvar road section.

SLIDE DESCRIPTION: The slide is classified as debris slump. The slide is circular in shape. The Lithology of the slide area is laterite. Clay mineral is noticed on the surface of the laterite. Laterite is very coarse grained with brown colour. The cut slope height is 10m.The weathering depth of the area is about 10m.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	12m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	25m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	3m
d.	Volume of failed mass above the failure surface	:	450m^3
e.	Slope angle after failure	:	70°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	10°
h.	Direction of slide	:	S85°W

CAUSES: This slide is a man induced slope failure, caused due to steep cutting of hill slopes for making road resulting in greater instability of slopes. The absence of adequate drainage at the surface allows more rain water to infiltrate. Formation of weak, non-cohesive material due to prolonged weathering and intensive precipitation during monsoon increased the pore water pressure, the loose overburden and the weak laterite in the slope failed due to saturation.

NATURE OF DAMAGE: Mangalore-Manjeshvar road section in NH-17 was affected due to slided material.

RECCOMENDATIONS:

i) Removal of unstable crown and debris present at the slided area.

ii) The slope angle needs to be trimmed to <40° to increase the stability.

iii) Making contour drainage at the top of the slopes for decreasing infiltration and sub-surface horizontal drainage i.e. inserting horizontal perforated pipes in to the slopes will act as weep holes in the vertical slopes and thus reducing the pore pressure by draining out the excess water.

iv) Soil nailing is also suggested to stabilise the slope.

Photo 121: The plan view of the debris slump with steep unstable crown

Photo 122: The side view of the debris slump with steep slope angle

LANDSLIDES ALONG HONAVAR-KUMTA ROAD SECTION

NH 17

SLIDE NO: KA63

LOCATION: The slide is located at latitude 14°17′ 09″ N and longitude 74° 26′ 58″ E at elevation 2 m from MSL in Survey of India toposheet No 48 J /7 along Hovavar- Kumta road in NH- 17 in Honavar taluk, Uttar Kannad district.

SLIDE DESCRIPTION: The slide is classified as old, multiple, debris slide. The slide is irregular in shape. The Lithology of the slide area is laterite. Laterite is very coarse grained with brown colour. The retaining wall has been constructed in half the area. The weathering depth of the area is about 20 m.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	20 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	400 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	3 m
d.	Volume of failed mass above the failure surface	:	12000 m^3
e.	Slope angle after failure	:	75°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	25°
j.	Direction of slide	:	N30°E

CAUSES: This slide is a human induced slope failure caused due to steep cutting of the hill for making road resulting in instability. Protection given for the earlier slide was not adequate to stabilise the slope. The height of the exiting retaining wall is too short and it does not provide any protection as the slope angle is greater that the height of retaining wall. No protection was given at the unstable crown portion, so the crown continues to slide and prograded up slope and sideways.

Adequate surface drainage is not present and running water infiltrated downward. Prolonged weathering led to formation of weak and non-cohesive slope material which failed due to intense precipitation during monsoon.

NATURE OF DAMAGE: Hovavar- Kumta road in NH- 17 was affected due to slided material.

RECCOMENDATIONS:

i) Removal of unstable crown and debris present at the slided area.

ii) The slope angle needs to be trimmed to <40° to increase the stability.

iii) Making contour drainage at the top of the slopes for decreasing infiltration and sub-surface horizontal drainage i.e. inserting horizontal perforated pipes in to the slopes will act as weep holes in the vertical slopes and thus reducing the pore pressure by draining out the excess water.

iv) The height of the existing retaining wall should be increased by 1m and retaining wall with weep holes should be provided for the entire width of the slide.

Photo 123: The plan view of the reactivated, debris slide with unstable crown. No protection at the crown

Photo 124: The plan view of the reactivated, debris slide with no protection at the mid slope and is likely to slide again

Photo 125: The plan view of the reactivated, debris slide with unstable crown

Photo 126: The side view of the reactivated, debris slide with steep slope angle

SLIDE NO: KA64

LOCATION: The slide is located at latitude 14°17′ 42″ N and longitude 74° 26′ 1″ E at elevation 1m from MSL in Survey of India toposheet No 48 J /7 along Hovavar- Kumta road in NH- 17 in Honavar taluk, Uttar Kannad district.

SLIDE DESCRIPTION: The slide is classified as old, multiple, debris slide. The slide is classified as surface slide as depth is 1m.The slide is irregular in shape. The Lithology of the slide area is laterite. Laterite is very coarse grained with brown colour. The weathering depth of the area is about 20 m.

MORPHOLOGICAL PARAMETER OF SLIDE:

a.	Maximum length of failed mass from crown to foot	:	20 m
b.	Maximum width of failed mass from the left flank to the right flank boundary	:	75 m
c.	Maximum depth of the failed mass from the surface of the slide to the failure surface	:	1 m
d.	Volume of failed mass above the failure surface	:	750 m^3
e.	Slope angle after failure	:	75°
f.	Slope angle before failure	:	90°
g.	Original slope angle	:	25°
h.	Direction of slide	:	N15°E

CAUSES: This slide caused due to steep cutting of the hill slope for making road resulting in instability. Remedial measures were not provided for the earlier slide. No protection was given at the unstable crown portion, so the crown continues to slide and prograded up slope and sideways.

Adequate surface drainage is not present and running water infiltrated downward. Prolonged weathering led to formation of weak and non-cohesive slope material which failed due to intense precipitation during monsoon.

NATURE OF DAMAGE: Hovavar- Kumta road in NH- 17 was affected due to slided material.

RECCOMENDATIONS:

i) Removal of unstable crown and debris present at the slided area.

ii) The slope angle needs to be trimmed to <40° to increase the stability.

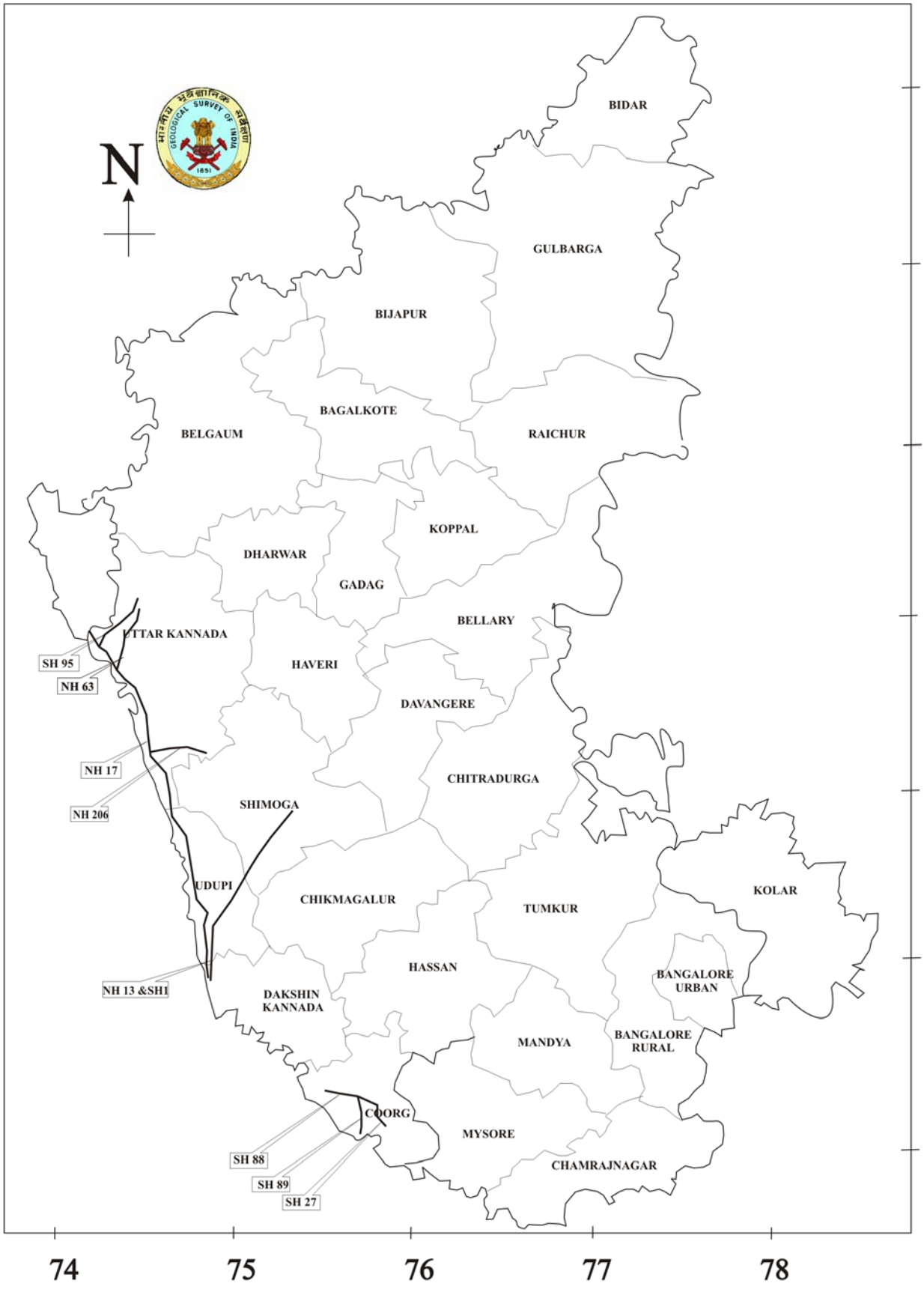
iii) Making contour drainage at the top of the slopes for decreasing infiltration and sub-surface horizontal drainage i.e. inserting horizontal perforated pipes in to the slopes will act as weep holes in the vertical slopes and thus reducing the pore pressure by draining out the excess water.

iv) Retaining wall with weep holes should be provided for the entire width of the slide.

Photo 127: The side view of the reactivated, debris slide with unstable crown

Photo 128: The side view of the reactivated, debris slide with steep slope angle

LANDSLIDE INVENTORY INDEX MAP ALONG NH AND SH OF GHAT ROADS IN KARNATAKA



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