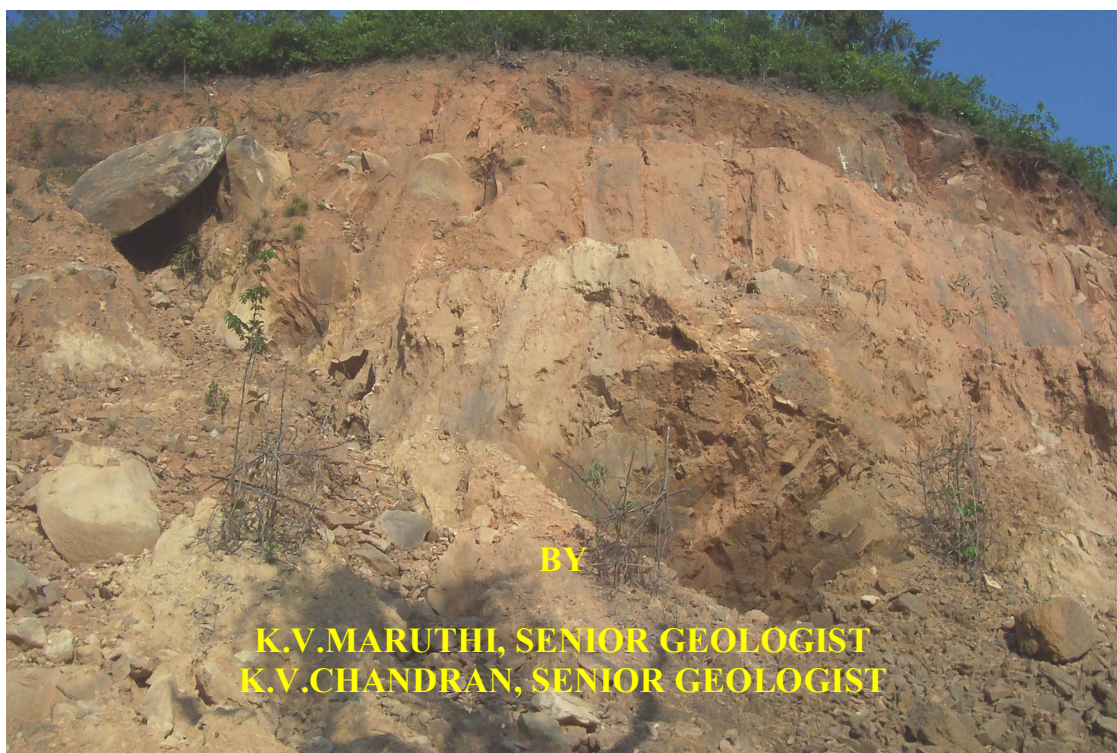


**GOVERNMENT OF INDIA
GEOLOGICAL SURVEY OF INDIA**



**DETAILED SITE SPECIFIC STUDY OF SASANWAD LANDSLIDE,
KARWAR TALUK, UTTAR KANNADA DISTRICT, KARNATAKA
(Progress Report for Field Season 2010-2012)
Code No.: EG/SR/KG/2010/059**



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**Project: Engineering Geology
State unit: Karnataka and Goa**

**BANGALORE
2012**



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कर्नाटक के उत्तर कन्नडा जिले के कारवार तहसील में ससनवाड भूस्खलन स्थान विशेष विस्तृत अध्ययन

(प्रगति प्रतिवेदन कार्य वर्ष 2010-12) (क्रमांक इजी/एस.आर/के.जी/2010/059)

द्वारा

के. वी. मारुथि, वरिष्ठ भूवैज्ञानिक
के. वी. चन्द्रन, वरिष्ठ भूवैज्ञानिक

सारांश

जून 2010 कारवार तहसील क्षेत्र में ससनवाड गॉव के पास 03 भूस्खलन हुए। यह भूस्खलन कारवार के 3 कि.मी. उत्तर पश्चिम क्षेत्र में हुए। इस भूस्खलन क्षेत्र में भारतीय भूवैज्ञानिक सर्वेक्षण द्वारा जुलाई 2010 में भूस्खलन पश्चात प्रारंभिक अध्ययन किया गया। इस क्षेत्र का स्थान विशेष पर विस्तृत अध्ययन कार्य वर्ष 2010-12 में प्रारंभ हुआ ताकि भूस्खलन की विशेषता, कारण का ज्ञान हो सके और क्षेत्र विशेष के लिए उपचारी उपाय बताए जा सकें। यह भूस्खलन उत्तर दक्षिण प्रवृत्त समुद्र तल से 69 मीटर ऊंचाई पर स्थित टीले में पाया गया जिसका ढाल लगभग 20° था। डोलेराइट डायक द्वारा अंतरवेधित ग्रेनाइट नाइस की चट्टानें इस क्षेत्र में पायी गयी हैं। इस क्षेत्र के अध्ययन हेतु 0.1 वर्ग कि. मी. क्षेत्र का 1:1000 पैमाने पर मानचित्रण तीन अनुभाग व तीन अनुदैर्घ्य काट निर्माण किया गया। जिसमें भूस्खलन की ज्यामिति का मूल्यांकन किया जा सके। इस क्षेत्र में तीन प्रकार के भूस्खलन पाए गए हैं। (i) चट्टानी भूस्खलन (2) मलवा भूस्खलन (3) संयुक्त प्रकार के भूस्खलन। अध्ययन के समय चार परिवर्तन रहित व छः परिवर्तित नमूने एकत्र किए गए। इस सभी नमूनों का धनत्व, आद्रता, विशिष्ट धनत्व, नमूने में शून्यस्थान का अनुपात, संरघ्नता, अटरवर्ग लिमिट, लिक्विड लिमिट, श्रंकेज लिमिट, प्लास्टिक लिमिट एक अ भूअभिचात्रिकी गुणों की परीक्षा की गई। साथ ही नमूनों में तन्यर्त, एकगुटता अनुपात एवं आंतरिक घर्षण का भी अध्ययन किया गया। इस अध्ययन में ज्ञात होता है कि नमूनों में बालु व गाद की मात्रा अधिक एवं क्षेत्र में पाई जाने वाली चट्टानें अत्यधिक अपरादित ग्रेनाइट नाइस है। ढाल विफलता मुख्यतः तलीय की है एवं पूर्व स्थित भ्रश क्षेत्र में ही स्थित है। अतः ससनवाड क्षेत्र के भूस्खलन का मुख्य कारण-भ्रश का प्रति अभिविन्यास है। इस भूस्खलन के अन्य कारण टीले के आसपास मानवीय कारणों में ढाल का परिवर्तन एवं अत्यधिक वर्षा है। क्षेत्र के लिए गए भूअभियात्रिकों अध्ययन, भूवैज्ञानिक कारण व कारक तत्वों की जानकारी पश्चात हर एक भूस्खलन के लिए उपचारी उपाय यथा राक बोल्टिंग, ढाल परिवर्तन, वृक्षारोपण एवं क्षेत्र से जल निकाली प्रभावी के मार्ग सुझाव गए हैं।

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K.V.CHANDRAN, SENIOR GEOLOGIST

ABSTRACT

A series of three landslides occurred in Sasanwad Village, Karwar Taluk in June 2010. The landslides have occurred at about 3 km NW of Karwar. A preliminary post disaster study was carried out by GSI in July 2010 and detailed site specific study was subsequently taken up during the 2010-12 to get insight of the slide characteristics, causative factors of landslide and to suggest remedial measures. The landslides had occurred at the westerly slope of an N-S trending mound which is 69m above MSL and having a slope around 20°. Granitic gneiss intruded by a dolerite dyke is exposed at the site. An area of about 0.10 km² was mapped on 1:1000 scale and three cross sections as well as three longitudinal sections were drawn to evaluate the geometry of the slides. Of the three slides, one pertains to a 'Rock slide', the second a 'Debris slide' and the third a 'Composite slide'. Four UDS(Un Disturbed Sample) and six disturbed samples were collected during the investigation and analyzed for various geotechnical properties viz., density, moisture content, specific gravity, void ratio and porosity; Atterbergs limits including liquid limit, plastic limit, plasticity index and shrinkage limit; Shear parameters including cohesion index and angle of internal friction and size analysis. The study reveals that the samples are high in sand-silt content and the material represents mostly a weathered product of granite/gneiss. Slope failure is essentially a 'Planar' type confined to prominent pre-existing discontinuity/ joint planes. Accordingly, the main causes for the slide at Sasanwad are inferred to be unfavorable orientation of joints in the rock. Other contributing factors include modification of slope at 'Toe' part of the slope mostly due to human interference (cut slope failures) coupled with a high incidence of rainfall. After geotechnical evaluation, analysis of geological condition at the site and factors responsible for the slides, some of the remedial measures were suggested for each slide, which include rock bolting, slope gradation, plantation and effective drainage system.



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I. INTRODUCTION

Landslides, around the world are known to take a heavy toll on life and property. Landslides also disrupt communication modes. In Karnataka, Western Ghats commonly experiences landslides every year during monsoon. With increase in population as well as anthropogenic activity, slopes are modified unscientifically leading to periodical slope failures. Anthropogenic activity includes plantation followed by settlements and constructing roads for communication. Landslides during every monsoon in Western Ghats are of great concern for general public as well as local administration.

In October 2009, Karwar Taluk witnessed large number of landslides including the most destructive and disastrous landslide which took place in Kadwad village, killing 19 people and destroying nine houses. The slide at Sasanwada occurred during the same time. GSI in their preliminary report suggested many remedial measures for Sasanwad landslide which have been subsequently implemented by the district authorities. The effective measures taken by the district authorities include grading of the slope by benches and providing proper drainage at the toe part of the slope. In 2010, in the nearby area, a rock slide took place on 17th June 2010 and the district authorities acted fast and shifted the local residents to a safe shelter and started ĀGanji Kendraā There were also reports of falling boulders on 21st June 2010 and by 23rd June, the road was blocked by district administration, the electric lines removed and slides were monitored. Preliminary post disaster study was carried out on 31st July 2010 by Geological survey of India and detailed site specific study was suggested to know the slide characteristics in detail and for proposing long term remedial measures (Maruthi et.al 2010). Accordingly, detailed site specific study was taken up as a service item during the FS 2010-12 (Code No.: EG/SR/KG/2010/059).

I.1. LOCATION: The Sasanwad landslide site (latitude 14° 49' 19.63" N and longitude 74° 10' 17.83"E) confined to Survey of India Toposheet No. 48J/1 is nearly 3 km NW of Karwar town. (Plate- 1, Photo 1,2,3,4 & 14)

I.2.PREVIOUS WORK: Preliminary post-disaster investigation of the Kadwad landslide was carried out during 2010 (Maruthi et.al.2010) wherein the causative factors, triggering

mediate corrective measures were recommended. Detailed long term remedial measures was also recommended.

I.3. SCOPE AND OBJECTIVE: The objective of the site-specific study was to evaluate the slide dimensions and morphometry, crack propagation if any, mechanism of failure, triggering mechanism, stability of the slope, risk associated with the slides in the area and to suggest appropriate long-term remedial measures or precautionary measure to stabilize the slope. For the three landslides observed at Sasanwad, the causative factors for each slide have been discussed and suggested suitable remedial measures.

I.4. NATURE AND QUANTUM OF WORK

NATURE OF WORK	Work proposed for FS2010-12	Total work Completed in Current FS2010-12
Detailed study of the landslide and slope stability analysis for identifying the Causative factors and suggesting remedial measures. Detailed mapping of 0.1 sq.km of slide area	0.1sq.km	0.1sq.km.
Geological section a) Longitudinal section on 1:1000 b) Cross section on 1:1000	3 Profiles 3 Profiles	3 Profiles 3 Profiles
SMPL a) Undisturbed b) Disturbed	As necessary	4 samples collected 6 Samples collected

I.5. ACKNOWLEDGEMENTS: The authors extend their sincere thanks to Dr.S.S.Nayak, the then Director EG Division, SU: Karnataka & Goa, GSI, Bangalore for his guidance during investigation, and to Dr. B.R.Venkatesh Director EG Division, SU: Karnataka & Goa, GSI, Bangalore for scrutiny of the report. They also extend their thanks to Director in-Charge, SU: Karnataka. & Goa, GSI, Bangalore for his encouragements and support. Thanks are due to, Deputy Commissioner, Uttar Kannada district, village accountant and asst. village accountant Sasanwad village and other district administrative staffs for providing necessary help during the field work. Thanks are also due to residents of Sasanwad village for rendering co-operation during investigation.

II. PHYSIOGRAPHY AND CLIMATE

II.1. TOPOGRAPHY AND GEOMORPHOLOGY: Sasanwad village is situated 1 km NE of Shejwad village and south of the Kali river estuary; the landslide site is confined to easterly (S55°E) slope of an N-S trending mound. The mound has an elevation of 81 m above MSL with a slope angle around 20°. The foot-hill is sparsely populated. The spur of the mound runs into marshy land near the bank of Kali River on its three sides (Photo 17). The original hill profile shows the presence of minor streams draining in to Kali River from a NE direction. Drainage in is Sub-dendritic to Trellis in pattern (Plate- 1 & 2).

OVER: Towards north, north-east and eastern sides of
rove swamps, prawn farms, rice fields, marshes and small
inlets of the estuary. The hills are covered with dense scrubby vegetation, thorny bushes, herbs,
grasses and climbers along with cashew plantations (Photo 16). The zone between lowlands and the
hills is densely populated. The houses are generally abutting the lower slopes of hills. The hill
slopes are modified for the purpose of habitation, plantation and for laying roads over a long
time. The moderately vegetated slope with shrubs and cashew plants has a low root and shoot
ratio.

II.3. CLIMATE AND RAINFALL: The area forms part of the coastal tract, limited by
Western Ghats to the east. The area in general has a tropical humid climate with hot and humid
summers between March and May. The winter months between November and February are
moderately cold. The monsoon period between June and October is quite severe. Annual rainfall
is mostly in excess of 3000 mm (Table-1, Fig-1 and Annexure-1)

Table-1: Rainfall data of Karwar rain gauge station over last decade.

Year wise Monthly rain fall at Karwar rain gauge station													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2000	0.0	0.0	0.0	0.6	471.5	991.8	1216.6	566.0	217.8	132.7	0.0	5.4	3602.4
2001	10.4	0.0	0.0	39.7	281.7	744.7	838.9	434.4	138.3	147.5	0.0	0.0	2635.6
2002	0.0	0.0	0.0	8.3	183.4	1030.3	394.0	581.0	149.2	432.4	0.0	0.0	2778.6
2003	0.0	0.0	0.6	0.0	0.2	1268.1	1174.8	555.6	272.4	66.8	0.0	0.0	3338.5
2004	0.0	0.0	0.0	0.0	271.0	732.4	678.4	664.8	273.6	123.7	69.8	0.0	2813.7
2005	0.0	0.0	0.0	91.6	56.1	956.3	1146.2	351.8	374.3	157.6	0.0	0.2	3134.1
2006	0.0	0.0	4.3	0.0	569.3	973.5	637.9	670.6	543.7	293.0	38.2	0.0	3730.5
2007	0.0	0.0	0.0	2.0	111.4	1336.9	730.6	914.4	653.3	66.9	4.1	4.4	3824.0
2008	0.0	3.3	86.3	2.7	62.7	943.3	556.2	666.8	469.8	13.4	1.5	26.1	2832.1
2009	0.0	0.0	15.0	0.0	86.6	780.9	1318.1	441.2	518.9	688.4	157.5	3.9	4010.5
2010	1.3	0.0	0.0	11.0	123.5	920.3	1381.8	617.0	575.2	306.4	403.4	3.2	4343.1
Total	11.7	3.3	106.2	155.9	2217.4	10678.5	10073.5	6463.6	4186.5	2428.8	674.5	43.2	37043.1

Data Source: Dy. Commissioner's office, Uttar Kannada Dist., Karwar

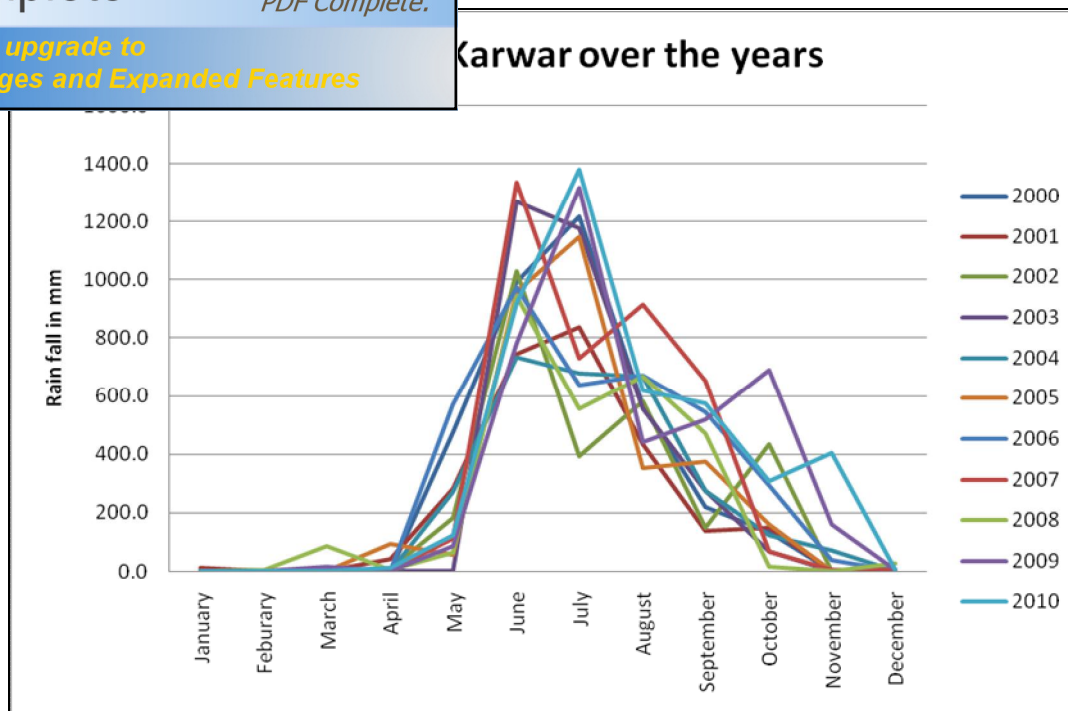


Fig 1: Rainfall data of Karwar rain gauge station over the years

II.4. GROUND WATER: The seasonal fluctuation of the water table is not high in the area. Water table is very shallow in the village, even during summer. The water table at the site was deciphered from the study of dug wells situated at the toe part of the slide (Table-2, Plate-3, and Photo-15). During the time of investigation (March 2011) depth to water table was at 1.63 to 2.40 m.

Table-2: depth to water table in the dug wells at the time of investigation

Well number	Location	Depth to water table at the time of investigation
W-1	15 m east of survey station 6 (Refer Plate-3)	2.33 m
W-2	30 m northeast of survey station 1 (Refer Plate-3)	1.63 m
W-3	25 m southwest of survey station 12 (Refer Plate-3)	2.40 m

III. GEOLOGY

The regional geology of Uttara Kannada district comprises the rocks of Sargur Group, Peninsular Gneissic Complex, older granitoids, Chitradurga Group of Dharwar super group of Archaean age and dolerites of Palaeoproterozoic age intruding these rocks. Older metamorphics of Sargur Group are represented by amphibolite. They occur as enclaves within granite. They occur as irregular sporadic lenses. The amphibolites are dark grey, fine to medium grained and schistose, rich in hornblende and plagioclase. The Peninsular Gneissic Complex is represented by granitic gneiss and granodiorite gneiss. The granite gneiss is coarse grained, comprises quartz, orthoclase & plagioclase feldspars, mica and hornblende show gneissic texture and at places with migmatitic structures. The Dharwar Supergroup of rocks and PGC-I are intruded by older granitoids locally referred as "Karwar Granite". The granite is massive, it is generally coarse grained, porphyritic, grey with pink variants, consists of quartz, potash feldspars, plagioclase and biotite mica. The Goa belt (represented by Chitradurga Group) are exposed in the area are Barcem Formation consisting of metabasalt, schistose metabasalt, BMQ and acid volcanics. The area is intruded by numerous swarms of dolerite dykes (Ramakrishna, 1967; Shafeeq ahmed, 1990; Subramanian, 1968; Subramanian, 1969).

III.2. LITHOLOGY AT SITE: Granite gneiss intruded by dolerite dyke is the main litho unit exposed at the site (Plate-3). Rock exposures are mostly seen on the distressed slope where the overburden has been removed. The landslide area is occupied by debris as well as soil material.

III.2.1.GNEISS: Gneiss is well exposed at the "Crown scarp" (Plate-3). The rock is coarse grained, light grey and foliated with gneissosity trending N24°W to N20°E. The rock is seen to have varying dips from ~ 42°easterly to near vertical. Three major sets of joints are observed (Photo 13) and the characteristics are given in Table-3.

Table- 3: The characteristics of the joints in gneisses of slide areas

Place of Observation	Joint set	Attitude	Spacing	Opening / Filling	Characteristics
Headscarp portion of slide no-1	J1	N70°W/20°NE	-	-	-
	J2	N50°W/Vertical	20-30 cm	Nil	Uneven, stained
	J3	N40°E/78°NE	10-15 cm	2mm/ soil	Smooth, uneven, stained,
	Foliation joint	N24°W/71°NE	-	-	Foliation plane
Headscarp portion of slide no-2	J1	N65°W/42°NE	-	-	-
	J2	N55°W/Vertical	20-30 cm	Nil	Uneven, stained
	J3	N45°E/78°NE	10-15 cm	2mm/ soil	Smooth, uneven, stained,

	Vertical	-	-	(Foliation plane)
Headscarp portion of slide no-3	J1	N50°W/45°NE	-	-
	J2	N50°W/Vertical	20-30 cm	Nil
	J3	N40°E/78°NE	10-15 cm	2mm/ soil
				Smooth, uneven, stained,

III.2.2.GRANITE: Minor exposures of granite are seen at the head portion above the Crown in respect of Slide No.-1 (Photo 12). The granite is massive, is generally coarse grained, porphyritic, grey in colour consisting of quartz, potash feldspars, plagioclase and biotite. An abandoned quarry is seen in the northeastern corner of the study area (Photo 18). Three sets of joints noticed in the granite and the characteristics are given in Table-5.

Table-5: The characteristics of the 3 set joints in Granite

Place of Observation	Joint set	Attitude	Spacing	Opening / Filling	Characteristics
Granite quarry (abandoned) in the northeastern corner of the study area & at Slide no-1	J1	N30°W/ 84°NE	30-60 cm	Tight	Smooth, uneven,
	J2	N80°W/78°NE	20-50 cm	Tight	Smooth, uneven
	J3	N70°E/82°NW	20-50 cm	Tight	Smooth, uneven

III.2.3. DOLERITE DYKE: A dolerite dyke trending N34°W-S34°E is exposed below the crown of the slide No. 3 at the central part. The rock is fine to medium grained, dark green to bottle green in colour and highly weathered (Photo 5 &7). Two sets of joints are noticed in the dyke rock and the characteristics are given in Table-4.

Table- 4: The characteristics of the 2 sets of joints in dyke

Place of Observation	Joint set	Attitude	Spacing	Opening / Filling	Characteristics
Near the crown in slide no.-3	J1	N45°W/ 62°NE	20-30 cm	Tight	Smooth, uneven, stained,
	J2	EW/Vertical	30-60 cm	Tight	Smooth, uneven

III.2.4. DEBRIS AND BOULDER UNIT: This unit consists of unconsolidated rock fragments of dyke and gneisses (gravel, cobble and boulder size) and sand, silt & clay. The size of Blocks dispersed all over the slide no-1 and slide no-3(Photo 6) and sporadically in slides no-2 ranges from 1.0 to 4.0 cu.m. It is seen that the clay percentage increases in the toe portion because of the gully erosion which is continuing. At the crown portion the percentage of boulders and pebbles increases considerably indicating the removal of blocks from the highly weathered gneisses.

is mainly seen on the head portion of the three landslides and an along the top portion.

III.3. WEATHERING: The depth of the weathering was estimated up to depth of 20-30 m. The role of weathering at Sasanwad landslide area has an important role in weakening of rock formations and consequent opening up of joints (Photo 7 & 9). The litho units and nature and the weathering characteristics determine: a) the amount of pore space available and the permeability of the material present in the slope b) the clay content of the material in the slope and c) the retentivity/runoff of water at the slope.

IV. LANDSLIDE CHARACTERISTICS

IV.1. SLIDE MORPHOMETRY: The slide morphometry was calculated from the plan and sections prepared in the field using Total station on 1:1000 scale. The morphometric parameters calculated for three slides are appended in Table-6.

Table-6: The morphometric parameters of three slides

	Slide 1	Slide 2	Slide 3
Maximum length of the flow from crown to frontal lobe (Lm)	38.0 m	23.0 m	36.0 m
Maximum width of the slide zone from the left flank to the right flank boundary (Wm)	68.0 m	29.0 m	88.0m
Area of the debris flow in plan	~5200 m ²	~1400 m ²	~6400 m ²
Depth of slide (A)	~ 3.0 m	~ 3.0 m	~ 4.0 m
Debris flow Volume (V)	~3900.0 m ³	~1000.0 m ³	~6400.0 m ³
Slope angle after failure took place (°)	20°-25°	20°-25°	20°-25°
Slope angle before failure took place	25° -30°	25° -30°	25° -30°
Base Length	20m	25m	32m
Scarp radius	25m	17m	31m
Scarp height	6m	18m	20m
Scarp angle	vertical	85 ⁰	87 ⁰
Run out distance	~15.0m	~45.0m	~45.0m
Cut slope angle near the toe	35°	40°	45°
Slide direction	N70°W	N70°W	N80°W

IV.2. TYPE AND SIZE OF SLIDE MATERIAL: The slide material in the slide no-1 and 2 in the zones of accumulation and depletion comprises different fractions of granite/weathered gneiss. The size of different fractions varies from huge granitic/gneissic boulders to small cobbles and pebbles and soil/clay material. The slide material in the slide no-3 in zone of accumulation and depletion comprises different fractions of weathered gneiss and weathered dyke and the size of different fractions vary from huge boulders to small cobbles and pebbles and soil/clay material (Photos 6 & 9). The slope material predominantly consists of coarse material hence it may be classified as debris following Varnes, 1978 and Cruden and Varnes, 1996.

Factors used to classify landslides mainly are type of material involved, geomorphic attributes of the slope, landslide geometry, type of movement, water content of the slid material, speed of movement of the slide, triggering mechanism etc. Landslides can either be rapid or slow or occur in a wide variety of geologic environments.

As per observation, the Slide No-1 is a "Rock fall" wherein both planar and wedge failures are noticed. The planar failure appears to have occurred along the daylighted joint trending N70°W with 20°NE dip. The overburden material might have slipped along the same daylighted plane. The wedge failure appears to have occurred along intersect of joints N50°W/ dipping vertical and N40°E/ dipping 78°NW.

The Slide No-2 is a "Composite slide" wherein both "Rock fall" and "Debris slide" are seen. The planar failure might have occurred along the daylighted joint trending N50°W/ dipping 45°NE. The high rainfall might have enabled removal of the weathered material along these planes by infiltration and the fluid might have acted as a lubricant causing reduction in the resisting force, resulting in slope failure.

The Slide No-3 classified as a "Debris slide" and the planar failure appears to have occurred along the daylighted joint trending N55°W/ dipping 42°NE.

V.SAMPLE ANALYSIS

Four Undisturbed (UDS), six disturbed samples and one rock sample were collected during investigation and analyzed for various geotechnical properties at the Geotechnical Laboratory of Geological Survey of India, SR, Hyderabad. The UDS and disturbed samples were collected mainly from the Slide No. 1 (Photo 11) since the debris material was not considerable in the adjoining slides. One representative rock sample also was collected from Slide No.-1 (Plate-3).

The undisturbed samples were analyzed for the geotechnical parameters such as density, moisture content, specific gravity, void ratio and porosity. Size analysis was carried out to know the particle size distribution. "Atterbergs limits" that includes Liquid Limit, Plastic Limit, Plasticity Index and Shrinkage Limit were determined. Shear parameters including Cohesion and angle of internal friction were also determined.

The disturbed samples were subjected to particle-size analysis and determination of Atterbergs limits.

The rock sample was analysed for density, moisture content, specific gravity, void ratio and porosity. Based on the analytical results the samples were classified. The analytical results are appended in Tables-7, 8 and 9.

Table-7: Analytical results of four undisturbed samples

Sample No.	Density gm/cm ³	Moisture content %	Specific gravity	Void ratio	Porosity	Grain size analysis				Atterbergs Limits				Shear parameters		Group Symbol	Group Name
						Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index	Shrinkage Limit %	Cohesion Index	Angle of Internal friction		
SUDS-1	1.41	3.31	2.61	0.92	0.48	4	67	19	10	36	-	-	-	0.29	28		
SUDS-2	1.32	7.47	2.62	1.13	0.53	2	49	27	22	42	28	14	22	0.32	28	SM	Silty sand
SUDS-3	1.48	1.20	2.72	0.86	0.46	6	68	17	9	38	-	-	-	0.22	31		
SUDS-4	1.32	2.85	1.32	1.05	0.51	3	66	24	7	37	-	-	-	0.29	27		

Table-8: Analytical results of six disturbed samples

Sample No.	Grain size analysis				Atterbergs Limits				Group Symbol	Group Name
	Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index	Shrinkage Limit %		
SDS-1	39	--	--	--	1	79	14	6		
SDS-2	40	29	11	21	1	45	32	22	ML	Sandy silt
SDS-3	45	36	9	34	1	64	28	7	SM	Silty sand
SDS-4	37	27	10	21	3	51	28	18	SM	Silty sand
SDS-5	38	--	--	--	2	70	21	7		
SDS-6	38	32	6	29	1	60	27	12	SM	Silty sand

Table-9: Analytical results the rock sample

Sample No.	Density gm/cm ³	Moisture content %	Specific gravity	Void ratio	Porosity
SRS-1	2.94	3.02	0.10	0.30	0.003

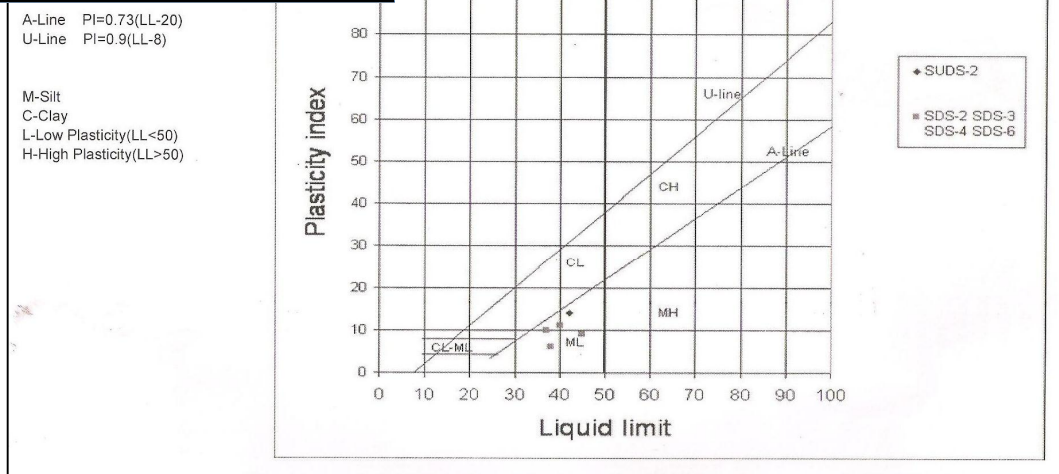


Fig-2: Plasticity chart with plasticity index for Sasanwad landslide.

V.1.DISCUSSION: As detailed before, the slides fall in the category of rock fall as well as composite slide with very little debris flow component. A sample of Gneissic rock was tested for various geotechnical parameters. The analysis has revealed that the gneissic rock at the site has a high void ratio and is non porous in nature (Table-9).

The Grain size and geotechnical parameters analysed for the four UDS samples have indicated only very little variation in their characteristics, indicating a near-homogeneity of composition of the loose and unconsolidated materials involved in the landslide. As the materials are loose & unconsolidated water infiltration during heavy rains might have acted as lubricant to dislodge masses by reducing the resisting force. One of the sample was studied for determining the Atterbergs limits and it is seen that the sample falls in $\delta M\delta$ category of Unified Soil Classification System -USCS (Bajra.M.Das 2009) (Appendix-1) characterizing only a moderate liquid limit.

The grain size parameters studied for the disturbed samples show similarity with the UDS as also the parameters determined under the Atterbergs limit. The disturbed samples also like the UDS fall in the SM category Unified Soil Classification System (USCS) (Appendix-1). However, one of the sample falls in the $\delta ML\delta$ category of Unified Soil Classification System (USCS) reflecting the presence of an inorganic silt content with $<50\%$ liquid limit. The plasticity index of the samples indicates that the material flow strength was relatively low. All the above confirms that the material involved at Sasanwad landslide is mostly a weathered product. As a convenience for comparing a variety of soils, Dr. A. Casagrande (Casagrande 1953) devised a plasticity chart (Figure 2), in which an empirical boundary known as the "A" line separates inorganic clays from silty and organic soils. Soils of the same geological origin usually plot on the plasticity chart as straight lines parallel to the A line. The larger the plasticity index the greater will be the volume change characteristics. "Fat" or plastic clays plot above the line. Organic soils, silts and clays containing a large portion of "rock flour" (finely ground non-clay

Soils of same origin.

Sasanwad slide also the samples are plotted below the ϕ - c diagram for organic clay and are also plotted as straight line indicating

VI. PROBABLE CAUSES AND TRIGGERING MECHANISM

Instability of any slope increases over a period of time due to various factors like slope modification, quality and nature of slope forming material, weathering depth and conditions, ground water table variation etc. affecting independently or simultaneously. These factors are difficult to quantify but there are a number of factors which may be operating either to increase the shear stress or to decrease the shearing resistance of the material (e.g. by decreasing the normal shearing resistance because of pore pressure increase) causing the slope failure.

VI.1.CAUSES: The probable causes of the landslides in Sasanwad are discussed below.

Slide no-1

- Human interference in the form of road construction wherein the slope was modified and the joints have daylighted on the slope face.
- Both type of transitional failures, planar & wedge are seen. Planar transitional failure is noticed along joint plane trending $N70^{\circ}W$ / dipping $20^{\circ}NE$. It was also noticed that the dip of failure plane is less than that of slope ($25-30^{\circ}$). The δ Wedge transitional failure is noticed along two joint planes $N50^{\circ}W$ /vertical and $N40^{\circ}E/78^{\circ}NW$ wherein two discontinuities intersected and wedge is formed daylighting into the slope.
- Water infiltration during heavy rains might have acted as lubricant to dislodge masses by reducing the resisting force.

Slide no-2

- Human interference in the form of road construction wherein the slope was modified.
- Planar failure occurred along the daylighted joint trending $N50^{\circ}W$ / dipping $45^{\circ}NE$. The overburden material with gneissic boulders, soil and clay slipped along this daylighted major joint plane. Water infiltration during heavy rains might have acted as lubricant to dislodge masses by reducing the resisting force.
- Even though the crown was moderately vegetated with shrubs and cashew plants, the vegetation is not having deep penetrating root system to hold the slope material intact. The crown portion on the left flank appears still unstable due to the presence of large crack (Photo 10).
- A Nala flowing at the centre of the slide could have contributed towards to the gradual weakening of the rock mass by erosion.

Slide no-3

- Human interference in the form of road construction wherein the slope was modified in the form of toe cutting (Cut slope failure).

fractured & weathered rock might have become unstable so the joints seem unfavorably oriented and have daylighted on the slope face. Flank failure occurred along the daylighted joint trending N55°W/ dipping 42°NE, the overburden material with gneissic/ dyke boulders, soil inclusive of clay component might have slipped along the daylighted major joint. Heavy rainfall might have removed the material along the joint plane by infiltrating and acted as lubricant thereby reducing the resisting force.

- Even though the crown was moderately vegetated with shrubs and cashew plants (Photo 16), vegetation is not having deep penetrating root system to hold the slope material intact. The crown portion on the right flank appears still unstable in view of presence of a large crack (Photo 10).

VI.2. TRIGGERING MECHANISM: As stated before, rainfall must have been the immediate triggering factor, as is common for almost all the landslides in the Western Ghats (Mishra & Pradhan 2010, Mishra & Dharuman 2010). Annual rainfall in Uttara Kannada district (annexure-1) is mostly in excess of 3000 mm. Most of the rainfall is received during the peak monsoon period of June to October. The Slide No-3 had occurred in October 2009 when whole of Karwar region witnessed number of landslides, including the disastrous Kadwad landslide. The District administration has taken care of the slide and Modification slope with benches were done. The Slide No. 1 & 2 was activated during 17th June 2010 after heavy rainfall for 5 days (Annexure-1).

VII. SUMMARY

Consequent upon the series of landslides in Sasanwad Village, Karwar Taluk in June 2010, a site-specific study was taken up to get insight into slide characteristics, causative factors and to suggest remedial measures. Detailed mapping on 1:1000 scale over an area of 0.10 sq.km was carried out and 3 cross sections and longitudinal section were drawn. Four UDS and six disturbed samples were collected for geotechnical analysis. After a detailed mapping, the field data and analytical results were synthesized.

1. Of the three slides recorded, Slide-1 is classified as a "Rock slide", slide-2 is "Debris slide" and the slide-3 is "Composite slide".
2. The lithounits exposed at the site includes Granite gneiss, Granite intruded by dolerite dyke. Debris and soil cover are seen on the slope.
3. The water table is shallow with depth to water at 1.63 to 2.4 m. Weathering was estimated up to depth of 20-30 m.
4. Analysis of geotechnical parameters reveals that all the all undisturbed samples show a high sand and silt contents, derived possibly by the weathering of gneissic rock.
5. The apparent causes for the failure are
 - i. Unfavorable orientation of joints in the rock
 - ii. Modification of slope at the toe due to human interference.
6. The triggering mechanism might have been the heavy antecedent rain fall.

RECOMMENDATIONS

As per the site condition and evaluation of the factors responsible for the individual slide (both the causes and triggering mechanism) the following remedial measures are proposed.

- i. Rock bolting for the exposed rocks with wire mesh.
- ii. Gradation of crown part.
- iii. Construction of retaining structure at toe.
- iv. Improving drainage connectivity and erecting of proper drain system including diversion of water from the crown with contour drains.
- v. Plantation/ afforestation have to be carried out with the native species of flora

It is suggested for the Slide no-1

- Removal of all the loose boulders and hanging boulders and the slid debris from the slope.
- While providing with rock bolts, three rows of staggered rock bolting at an angle of 45^0 from horizontal to a depth of 3.5 meters with 1.0 meter spacing is suggested.
- For arresting infiltration at the top, the slope should be provided with proper drainage with concrete lining at the base.

Similarly for the Slide no-2

- Removal of all loose boulders, hanging boulders and the slided debris from the slope,
- Grading of the hanging crown part is suggested as the crown part appears unstable due to the presence of crown cracks (Photo 8 & 10). Also since major part of the intact slope exposed is either weathered Gneiss or soil the near vertical, 8 m high crown scarp should be graded to 35^0 - 45^0 .
- A *nala* is flowing right at the centre of the slide proper drainage is required for this *nala*.
- In order to arrest infiltration at the top, the slope should be provided with proper concrete lined drainage at the base.

For Slide no-3

- Removal of all the loose boulders and hanging boulders and the slided debris from the slope is suggested as above
- The benches/berns as well as the drainage facilities provided by the District administration although has reduced the magnitude of the slide, the benches may be extended further into the hillock for at least a meter. Proper yearly maintenance including the removal of washed out debris and maintaining the bench width is recommended.
- A retaining wall to be constructed at the toe part with weep holes and suitable graded filters with following specifications: Height- 2.0 m, length-100.0 m, width-1.0m.
- Plantation in the slide zone with deep rooted plants in staggered manner is essential to stop future landslides of local nature in the slide debris. Afforestation with the native species of flora is to be prioritised. In order to restrict gully erosion on the slope with scattered debris, plantation of vetriver grass all along mid section may be done. The



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ion and will also help people in the vicinity an economical

- Stop infiltration at the top and make a proper drainage at the base (concrete lined).

(K.V.MARUTHI) Senior Geologist		(K.V.CHANDRAN) Senior Geologist
SCRUTINISED BY (Dr. B.R.VENKATESH) Director		



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PSIS OF WORK DONE

1		Title of the report		DETAILED SITE SPECIFIC STUDY OF THE SASANWAD LANDSLIDE, KARWAR TALUK, UTTAR KANNADA DISTRICT, KARNATAKA	
2		Item No.		Code No.: EG/SR/KG/2010/059	
3		Field Season		2010-12	
4		Date of commencement		19.03.2011	
5		Date of completion		29.03.2011	
6		Officers Associated with investigation and No. of days spent in the field		K.V.Maruthi, Senior Geologist K.V.Chandran Senior Geologist (10 days)	
7		Quantum of work done			
		NATURE OF WORK		Work proposed for FS2010-12	Total work Completed
		Detailed study of the landslide and slope stability analysis for identifying the Causative factors and suggesting remedial measures. Detailed mapping of 0.1 sq.km of slide area		0.1sq.km	0.1sq.km.
		Geological section a)Longitudinal section on 1:1000 b)Cross section on 1:1000		3 Profiles 3 Profiles	1 Profiles 3 Profiles
		SMPL a)Undisturbed b) Disturbed		As necessary	4 samples collected 6 Samples collected
8		Analysis carried out 1) AAS-MIBK for Au 2) ICP-AES		NA	
9		Elements analysed		NA	
		Expenditure (1) POL (2) Wages (3) Misc./Other charges		- (* Vehicle was outsourced) Rs. 6217=56 Rs. 12998=00	
10		Other information if any			
		(K.V.MARUTHI) Senior Geologist		(K.V.CHANDRAN) Senior Geologist	
(Dr. B.R.VENKATESH) Director					

Annexure-1

gauge station over the years.

Year- 2000												
Month Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.0	0.0	0.0	0.0	0.0	4.8	50.7	0.0	50.6	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	97.2	3.4	0.0	37.7	27.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	43.0	45.2	0.0	63.6	9.6	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	24.5	12.6	0.0	0.0	11.8	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	36.8	109.1	0.0	0.0	1.6	0.0	5.4
6	0.0	0.0	0.0	0.0	4.4	185.4	158.6	0.0	0.2	0.6	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	36.2	201.8	3.4	0.0	5.3	0.0	0.0
8	0.0	0.0	0.0	0.0	14.3	67.8	148.9	27.2	0.0	1.2	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	19.8	95.0	28.6	1.8	3.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	15.8	43.4	25.4	12.6	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	51.4	64.9	73.7	1.8	0.8	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	98.1	38.2	48.6	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	17.5	60.9	12.6	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	11.4	26.8	4.2	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.1	2.8	11.1	0.0	0.0	1.0	0.0	0.0
16	0.0	0.0	0.0	0.0	60.4	0.0	12.0	1.8	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	13.8	5.2	0.2	34.5	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	64.6	2.7	13.2	19.8	5.2	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	97.6	51.9	20.4	12.2	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	16.8	13.6	29.4	7.9	0.0	19.1	0.0	0.0
21	0.0	0.0	0.0	0.0	31.4	26.5	1.2	4.4	3.9	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.5	0.0	3.9	19.2	2.8	5.2	0.0	0.0
23	0.0	0.0	0.0	0.0	2.8	8.0	0.4	29.1	1.5	46.5	0.0	0.0
24	0.0	0.0	0.0	0.6	0.2	1.1	0.0	30.6	3.2	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	5.6	13.7	51.5	4.0	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	4.1	2.2	0.3	75.3	7.0	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	75.1	11.8	2.4	4.9	17.8	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	28.7	7.8	37.6	10.7	0.7	0.0	0.0	0.0
29	0.0	0.0	0.0	0.0	15.7	61.6	11.3	9.4	3.4	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	10.8	81.3	0.0	27.9	0.0	0.0	0.0	0.0
31	0.0	0.0	0.0	0.0	30.2	0.0	0.0	3.1	0.0	0.0	0.0	0.0
Total	0.0	0.0	0.0	0.6	471.5	991.8	1216.6	566.0	217.8	132.7	0.0	5.4
Annual rainfall in mm					3602.4							

Year- 2001												
Month Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	8.0	0.0	0.0	0.0	0.0	0.0	57.0	3.2	1.0	64.4	0.0	0.0



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	0	0.0	0.5	83.1	21.2	0.0	0.0	0.0	0.0				
	0	0.0	0.0	2.8	122.3	0.3	0.0	0.0	0.0				
	4	0.0	0.4	3.7	6.8	0.0	0.0	0.0	0.0				
5	0.0	0.0	0.0	0.0	0.0	0.0	42.6	27.8	0.0	0.0	0.0	0.0	
6	0.0	0.0	0.0	0.0	0.0	0.0	14.6	4.0	0.7	20.8	0.0	0.0	
7	0.0	0.0	0.0	0.0	0.0	0.0	82.9	16.2	10.2	6.6	1.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	23.4	11.0	4.1	0.0	13.6	0.0	0.0
9	0.0	0.0	0.0	0.2	0.0	0.0	20.2	67.6	11.6	0.0	14.5	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	16.2	11.0	8.2	0.0	0.9	0.0	0.0
11	0.0	0.0	0.0	6.2	0.0	0.0	16.0	15.4	1.7	0.0	0.9	0.0	0.0
12	0.0	0.0	0.0	21.4	0.0	0.0	64.2	4.0	7.4	0.0	3.2	0.0	0.0
13	0.0	0.0	0.0	11.5	0.0	0.0	12.5	13.4	3.9	0.0	1.9	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	21.8	29.0	18.2	0.0	20.6	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	17.0	10.5	5.6	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	7.9	14.0	6.0	0.0	0.2	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	3.4	8.2	20.6	2.5	1.3	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	1.2	15.5	30.5	0.0	3.2	0.0	0.0
19	0.0	0.0	0.0	0.0	1.3	8.1	18.8	29.1	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.9	19.7	2.4	5.3	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	10.8	34.9	3.1	20.8	0.5	1.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	20.2	140.0	7.1	16.2	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	75.0	6.6	30.0	1.9	7.6	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	50.5	0.0	14.7	18.4	30.4	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	32.8	20.4	60.5	11.1	0.0	0.0	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	46.4	4.6	61.6	6.5	0.0	0.0	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	2.2	4.6	61.1	2.1	3.8	0.0	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	8.0	36.0	9.8	8.9	17.7	0.0	0.0	0.0	0.0
29	0.0	0.0	0.0	0.0	29.2	109.0	75.6	0.2	1.0	0.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	1.3	58.6	65.6	2.4	66.2	0.0	0.0	0.0	0.0
31	0.0	0.0	0.0	0.0	3.1	0.0	19.6	2.2	0.0	0.0	0.0	0.0	0.0
Total	10.4	0.0	0.0	39.7	281.7	744.7	838.9	434.4	138.3	147.5	0.0	0.0	
Annual rainfall in mm					2635.6								



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Year- 2002												
Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.0	0.0	0.0	0.0	0.0	48.6	12.8	8.4	5.6	20.2	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	12.5	10.1	12.7	25.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	60.8	9.9	12.9	22.4	0.0	0.0	0.0
4	0.0	0.0	0.0	6.7	0.0	2.8	1.6	45.5	7.8	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.4	14.7	16.3	0.3	0.0	0.0
6	0.0	0.0	0.0	0.0	0.3	0.0	3.2	10.7	42.5	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	11.2	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	4.0	0.0	7.4	11.7	1.0	9.8	0.0	0.0
9	0.0	0.0	0.0	0.0	2.0	0.4	21.4	119.6	9.0	10.1	0.0	0.0
10	0.0	0.0	0.0	0.0	1.3	7.7	14.8	133.2	0.0	9.7	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	43.7	141.0	19.8	4.6	19.6	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	4.7	2.6	42.3	0.0	52.9	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	8.2	1.4	12.9	1.2	190.2	0.0	0.0
14	0.0	0.0	0.0	0.0	0.2	297.2	3.7	0.6	0.0	1.6	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	77.9	1.7	18.0	0.0	1.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	98.0	12.2	11.9	0.0	40.7	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	48.6	13.0	39.0	0.0	36.4	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	37.8	2.5	6.7	0.0	6.0	0.0	0.0
19	0.0	0.0	0.0	0.0	105.0	125.0	1.5	2.8	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	18.0	39.4	0.7	5.2	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	4.2	33.1	38.4	8.9	0.0	2.5	0.0	0.0
22	0.0	0.0	0.0	1.6	0.0	11.4	16.8	1.2	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	26.9	17.8	1.9	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	6.7	3.9	2.6	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	1.1	11.4	29.3	0.0	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	0.4	15.6	8.3	0.0	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	2.3	35.0	12.3	0.2	0.0	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	28.2	1.6	7.9	0.0	0.0	0.0	0.0	0.0
29	0.0	0.0	0.0	0.0	0.0	0.4	6.7	0.0	0.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	16.4	0.4	0.5	0.0	0.0	10.0	0.0	0.0
31	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	2.6	21.4	0.0	0.0
Total	0.0	0.0	0.0	8.3	183.4	1030.3	394.0	581.0	149.2	432.4	0.0	0.0
Annual rainfall in mm					2778.6							



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Year- 2003												
Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.0	0.0	0.0	0.0	0.0	0.0	85.8	12.9	35.5	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	36.0	21.0	4.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	38.9	10.9	16.9	3.2	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	69.2	21.4	3.6	11.4	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	97.2	105.8	1.1	2.5	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	49.9	4.3	43.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	3.0	159.5	36.6	9.5	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	26.2	20.9	10.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	19.6	25.3	12.9	14.1	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	3.7	52.9	0.0	2.7	2.6	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	37.4	34.9	1.4	0.6	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	30.4	11.2	15.6	10.2	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	52.6	7.3	2.8	3.5	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	12.2	153.2	0.8	13.4	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	69.4	66.8	13.7	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	133.4	74.8	24.2	25.3	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	95.0	12.9	5.6	25.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	83.1	1.0	15.4	2.4	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.2	39.4	6.8	69.1	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	204.6	7.2	21.5	1.6	0.8	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	107.2	1.2	30.5	0.0	32.6	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	195.8	1.8	3.5	0.0	5.2	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	14.8	41.7	5.0	0.5	8.5	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	33.6	16.2	7.2	0.6	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	11.8	16.0	8.4	18.7	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	6.0	20.4	14.0	0.0	0.0	0.0	0.0
27	0.0	0.0	0.6	0.0	0.0	87.8	23.9	2.0	0.3	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	0.0	4.4	13.4	0.0	29.9	0.0	0.0	0.0
29	0.0	0.0	0.0	0.0	0.0	4.6	12.4	3.1	0.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	0.0	18.3	7.8	29.9	0.0	0.0	0.0	0.0
31	0.0	0.0	0.0	0.0	0.0	0.0	3.0	35.2	0.0	0.0	0.0	0.0
Total	0.0	0.0	0.6	0.0	0.2	1268.1	1174.8	555.6	272.4	66.8	0.0	0.0
Annual rainfall in mm					3338.5							



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Year- 2004												
Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.0	0.0	0.0	0.0	0.0	47.6	0.0	47.8	1.6	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	82.6	10.2	24.6	0.0	1.8	14.4	0.0
3	0.0	0.0	0.0	0.0	1.0	0.0	11.5	90.8	0.0	8.7	53.4	0.0
4	0.0	0.0	0.0	0.0	0.0	1.4	6.2	45.3	0.0	62.2	0.0	0.0
5	0.0	0.0	0.0	0.0	2.4	21.0	1.2	6.4	0.0	51.0	0.0	0.0
6	0.0	0.0	0.0	0.0	13.0	35.2	31.8	6.8	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.2	3.2	0.0	13.2	4.8	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	12.0	79.8	0.0	27.0	29.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	2.4	101.7	30.2	8.1	14.3	0.0	2.0	0.0
10	0.0	0.0	0.0	0.0	2.3	72.4	9.5	24.2	43.6	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	3.0	17.5	39.2	10.0	24.8	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.8	8.7	46.2	29.4	24.1	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.8	13.0	45.1	142.5	2.7	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	19.6	22.5	12.1	34.0	0.2	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	14.5	13.3	6.7	4.1	6.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	46.2	19.5	30.2	16.9	1.7	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	6.9	15.3	22.0	29.0	0.4	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	71.6	2.2	2.0	28.4	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	26.2	2.9	15.6	8.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	19.2	0.0	46.8	2.2	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	2.2	0.0	48.3	14.2	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	2.4	0.0	12.2	1.8	61.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	2.9	0.0	20.2	13.4	2.4	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	5.0	0.0	35.4	14.8	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	1.4	7.2	7.2	15.8	0.5	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	101.5	42.4	0.6	0.5	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	0.4	38.1	19.0	4.0	42.2	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	2.7	11.4	5.5	1.3	0.0	0.0	0.0	0.0
29	0.0	0.0	0.0	0.0	0.0	1.6	15.6	0.2	11.6	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	9.8	12.8	45.6	0.0	2.2	0.0	0.0	0.0
31	0.0	0.0	0.0	0.0	2.1	0.0	60.5	0.0	0.0	0.0	0.0	0.0
Total	0.0	0.0	0.0	0.0	271.0	732.4	678.4	664.8	273.6	123.7	69.8	0.0
Annual rainfall in mm					2813.7							



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Year- 2005												
Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.0	0.0	0.0	0.0	0.0	13.2	8.8	3.5	0.4	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	19.9	28.2	20.3	0.0	0.0	0.0	0.2
3	0.0	0.0	0.0	0.0	0.0	0.0	14.8	5.1	1.6	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	8.6	6.4	12.5	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	121.7	6.5	2.5	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	1.2	28.8	5.1	42.1	0.0	0.0	0.0
7	0.0	0.0	0.0	3.2	0.0	36.3	5.0	6.4	2.5	0.0	0.0	0.0
8	0.0	0.0	0.0	5.8	0.0	12.0	2.6	35.0	1.3	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	2.4	94.6	6.8	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	2.1	3.0	18.1	10.3	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	18.4	10.3	4.3	7.7	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	17.8	124.5	0.8	33.4	38.6	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	68.7	0.0	20.2	36.9	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	5.4	39.1	4.3	23.8	32.9	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	2.5	0.0	6.1	4.8	1.6	0.0	0.0
16	0.0	0.0	0.0	58.2	0.0	24.2	0.8	0.4	6.5	6.4	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	19.2	1.9	29.9	2.1	10.6	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	81.0	20.4	57.4	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	26.3	0.9	3.4	18.0	30.2	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	90.4	58.6	0.4	52.9	0.3	0.0	0.0
21	0.0	0.0	0.0	23.6	0.0	122.8	13.1	5.5	8.9	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	234.9	54.0	8.5	43.5	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	104.2	72.3	0.5	59.6	0.0	0.0	0.0
24	0.0	0.0	0.0	0.8	0.0	23.4	145.8	0.7	9.9	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	4.5	159.0	14.6	1.8	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	11.2	3.0	14.3	14.0	1.2	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	0.0	4.1	12.6	0.0	0.0	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	0.0	15.2	37.1	0.0	0.0	0.1	0.0	0.0
29	0.0	0.0	0.0	0.0	28.5	48.8	39.4	0.0	0.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	16.4	25.5	47.7	0.0	0.0	0.0	0.0	0.0
31	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0
Total	0.0	0.0	0.0	91.6	56.1	956.3	1146.2	351.8	374.3	157.6	0.0	0.2
Annual rainfall in mm					3134.1							



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Year- 2006												
Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.0	0.0	0.0	0.0	0.0	68.7	2.0	33.9	14.8	1.2	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	70.4	26.5	8.0	1.1	27.4	31.7	0.0
3	0.0	0.0	0.0	0.0	1.6	5.8	21.8	25.6	0.0	81.3	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	35.3	5.5	5.6	0.0	48.6	5.1	0.0
5	0.0	0.0	0.0	0.0	0.0	3.8	9.5	6.2	0.0	24.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	21.8	20.2	33.8	0.0	37.0	0.4	0.0
7	0.0	0.0	0.0	0.0	0.0	5.2	11.3	16.4	0.0	9.3	1.0	0.0
8	0.0	0.0	0.0	0.0	0.0	15.3	158.2	112.8	0.0	27.9	0.0	0.0
9	0.0	0.0	0.0	0.0	0.2	5.0	10.2	22.0	0.0	36.3	0.0	0.0
10	0.0	0.0	3.3	0.0	0.0	9.0	8.1	24.9	10.4	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	15.3	16.3	26.8	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	5.1	7.4	8.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	5.2	13.5	12.9	52.1	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	16.3	15.6	102.3	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	7.9	31.8	83.7	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	3.2	50.5	73.9	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	3.2	6.2	12.2	34.6	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	49.0	136.4	18.6	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	27.9	31.9	23.5	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	14.0	3.9	3.6	0.0	0.0	0.0
21	0.0	0.0	1.0	0.0	0.0	3.6	8.6	3.7	2.5	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	20.2	15.9	28.8	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.4	0.1	8.3	1.6	36.4	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.7	335.8	43.4	0.1	0.8	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	53.4	6.8	0.0	0.8	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.6	143.0	8.7	0.0	51.4	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	3.3	65.6	42.6	0.0	3.6	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	23.7	18.7	26.7	24.4	0.0	0.0	0.0	0.0
29	0.0	0.0	0.0	0.0	7.8	69.0	1.7	0.5	0.8	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	439.8	15.2	20.9	4.5	0.0	0.0	0.0	0.0
31	0.0	0.0	0.0	0.0	91.2	0.0	15.0	0.7	0.0	0.0	0.0	0.0
Total	0.0	0.0	4.3	0.0	569.3	973.5	637.9	670.6	543.7	293.0	38.2	0.0
Annual rainfall in mm					3730.5							



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Year- 2007												
Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.0	0.0	0.0	0.0	0.0	1.1	13.0	2.0	118.1	16.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	21.8	28.0	96.4	84.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	46.8	26.4	96.1	80.2	2.8	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	2.7	55.3	47.2	63.1	21.8	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.2	22.4	103.6	10.8	0.0	2.5	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	1.2	89.8	10.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	4.8	4.2	73.6	32.9	0.0	1.6	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	24.8	28.3	9.6	0.7	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.5	18.2	9.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	34.6	33.9	4.8	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	11.3	21.7	10.6	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	38.2	0.6	0.8	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	75.8	17.4	7.6	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	21.4	10.2	6.2	3.3	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	37.6	0.3	29.0	18.6	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	103.3	9.8	0.0	22.0	0.0	0.0	0.0
17	0.0	0.0	0.0	2.0	0.0	54.2	23.8	0.0	0.6	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	71.8	0.4	0.0	25.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	29.6	3.4	5.7	5.7	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	89.4	4.3	21.0	7.8	12.1	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	30.8	9.0	32.1	2.6	11.0	0.0	4.4
22	0.0	0.0	0.0	0.0	0.0	143.2	66.8	9.4	2.1	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	2.8	205.8	62.5	58.2	10.5	1.4	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	83.6	6.9	7.2	43.8	0.4	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	44.8	17.6	3.2	26.5	0.7	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	37.2	9.7	42.2	4.5	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	0.0	23.5	60.0	16.3	0.0	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	6.4	13.0	53.8	14.8	3.8	0.0	0.0	0.0
29	0.0	0.0	0.0	0.0	85.0	71.8	38.4	18.3	34.9	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	0.8	38.1	42.4	30.2	32.9	0.0	0.0	0.0
31	0.0	0.0	0.0	0.0	16.4	0.0	44.2	50.8	0.0	0.0	0.0	0.0
Total	0.0	0.0	0.0	2.0	111.4	1336.9	730.6	914.4	653.3	66.9	4.1	4.4
Annual rainfall in mm					3824.0							



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Year- 2008												
Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.0	0.0	0.0	0.0	0.0	55.7	28.7	17.3	0.7	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.2	13.9	0.6	3.8	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.2	1.1	9.5	0.0	0.0	0.0	26.1
4	0.0	0.0	0.0	0.0	0.0	1.0	5.8	22.1	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	22.0	12.9	0.6	0.0	1.4	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	31.9	13.9	4.2	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	84.5	13.6	26.4	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	103.7	8.7	41.2	122.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	113.6	8.2	41.7	28.6	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	61.8	4.0	90.4	95.4	6.3	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	103.9	2.2	119.0	66.7	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	48.7	0.0	85.9	37.6	0.0	1.0	0.0
13	0.0	0.0	0.0	0.0	0.0	159.3	4.4	69.9	37.7	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	29.9	1.4	56.2	9.5	0.0	0.0	0.0
15	0.0	1.1	0.0	0.0	0.0	8.7	0.3	40.7	10.1	0.0	0.0	0.0
16	0.0	2.2	0.0	0.0	0.0	18.8	37.8	12.7	26.8	0.0	0.0	0.0
17	0.0	0.0	0.5	0.0	0.0	17.8	1.6	11.7	2.6	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.8	2.5	49.0	0.4	10.5	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	2.6	21.3	11.7	8.2	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	4.0	25.8	0.7	2.8	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	2.2	1.0	2.2	0.3	5.6	0.0	0.0	0.0
22	0.0	0.0	16.8	0.0	5.0	2.4	0.8	0.7	1.2	0.2	0.0	0.0
23	0.0	0.0	5.3	2.7	5.2	2.8	5.8	1.0	0.0	1.7	0.0	0.0
24	0.0	0.0	0.4	0.0	0.8	0.0	5.6	1.6	0.0	3.8	0.0	0.0
25	0.0	0.0	7.1	0.0	0.7	1.2	77.3	0.0	0.0	0.0	0.0	0.0
26	0.0	0.0	50.2	0.0	0.2	13.8	51.3	0.0	0.0	0.0	0.0	0.0
27	0.0	0.0	6.0	0.0	32.7	6.5	29.3	0.3	0.0	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	0.2	17.4	61.0	0.0	0.0	0.0	0.0	0.0
29	0.0	0.0	0.0	0.0	0.1	18.2	19.0	0.0	0.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	10.9	9.2	31.2	0.0	0.0	0.0	0.0	0.0
31	0.0	0.0	0.0	0.0	3.9	0.0	18.1	0.0	0.0	0.0	0.5	0.0
Total	0.0	3.3	86.3	2.7	62.7	943.3	556.2	666.8	469.8	13.4	1.5	26.1
Annual rainfall in mm					2832.1							



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Year- 2009												
Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.0	0.0	0.0	0.0	0.0	0.0	32.2	4.0	19.9	38.5	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	1.2	141.0	0.2	57.9	179.6	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	12.8	142.2	4.5	30.0	423.6	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	66.5	4.1	38.4	34.9	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	20.5	83.2	21.6	64.0	1.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	108.6	98.0	39.6	49.6	10.4	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	165.3	71.8	2.8	26.4	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	20.4	102.6	1.6	8.8	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	10.8	108.1	0.4	1.0	0.0	2.6	0.0
10	0.0	0.0	0.0	0.0	0.0	20.6	32.1	0.5	17.3	0.0	8.2	0.0
11	0.0	0.0	0.0	0.0	0.0	19.2	40.9	16.8	2.4	0.0	59.3	0.0
12	0.0	0.0	0.0	0.0	0.0	0.2	5.0	10.4	41.8	0.0	32.9	0.0
13	0.0	0.0	15.0	0.0	0.0	0.6	8.0	11.6	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	28.0	5.5	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	11.9	41.2	1.5	10.7	0.4	0.3	0.0
16	0.0	0.0	0.0	0.0	0.0	10.0	29.9	4.0	4.7	0.0	51.8	0.0
17	0.0	0.0	0.0	0.0	0.0	48.0	3.2	2.0	0.0	0.0	0.4	0.0
18	0.0	0.0	0.0	0.0	2.4	0.0	40.3	23.9	0.0	0.0	2.0	0.0
19	0.0	0.0	0.0	0.0	0.0	7.9	20.5	0.9	8.2	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	19.5	18.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.2	44.4	7.7	0.0	4.4	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	65.0	18.4	10.5	0.5	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	21.4	0.5	23.6	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	12.0	40.0	2.6	70.6	3.5	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	5.7	28.4	19.8	49.6	0.7	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	31.5	0.0	12.7	4.4	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	1.0	30.1	9.1	13.0	0.6	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	0.0	27.5	79.4	28.3	0.0	0.0	0.0	2.4
29	0.0	0.0	0.0	0.0	0.3	21.3	47.2	33.4	6.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	0.0	40.4	24.8	10.6	118.2	0.0	0.0	1.5
31	0.0	0.0	0.0	0.0	0.0	0.0	3.8	43.0	0.0	0.0	0.0	0.0
Total	0.0	0.0	15.0	0.0	86.6	780.9	1318.1	441.2	518.9	688.4	157.5	3.9
Annual rainfall in mm					4010.5							



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Year- 2010												
Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.0	0.0	0.0	0.0	2.0	6.0	60.2	25.4	13.2	15.4	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	150.2	8.0	10.8	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	1.2	0.0	51.5	2.2	37.5	0.0	22.7	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	25.4	52.3	45.6	33.2	7.8	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	76.2	2.7	5.4	0.0	6.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.8	26.3	5.4	32.6	0.0	25.0	0.0
7	0.0	0.0	0.0	0.0	0.0	15.8	54.4	12.2	23.6	3.2	0.6	0.0
8	0.0	0.0	0.0	0.0	0.0	70.9	14.4	18.6	17.2	0.0	7.2	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	14.2	0.0	36.4	0.0	207.4	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	9.8	7.4	28.2	0.0	12.8	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.4	24.2	13.5	0.0	1.2	3.2
12	0.0	0.0	0.0	0.0	0.0	1.0	0.6	10.6	2.2	0.0	31.4	0.0
13	0.5	0.0	0.0	0.0	0.0	13.7	17.6	11.8	6.4	1.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	49.7	9.2	1.7	5.7	0.6	0.0	0.0
15	0.8	0.0	0.0	0.0	0.0	64.1	4.2	13.9	6.6	18.4	20.8	0.0
16	0.0	0.0	0.0	0.0	0.0	63.0	57.2	12.8	28.5	1.6	7.2	0.0
17	0.0	0.0	0.0	0.0	0.0	56.0	22.9	70.0	39.0	7.9	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	57.2	71.2	49.8	0.6	12.6	0.0	0.0
19	0.0	0.0	0.0	0.0	7.8	30.8	68.4	32.5	20.0	72.2	5.5	0.0
20	0.0	0.0	0.0	0.0	0.0	10.7	140.8	20.0	0.4	34.8	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	11.6	74.4	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	14.1	64.8	19.6	20.2	18.0	0.8	0.0
23	0.0	0.0	0.0	5.3	0.0	31.4	20.2	0.0	0.0	66.3	41.4	0.0
24	0.0	0.0	0.0	0.0	0.0	44.8	9.2	17.3	70.0	17.6	4.6	0.0
25	0.0	0.0	0.0	0.0	0.0	86.6	36.0	47.3	0.0	0.6	1.0	0.0
26	0.0	0.0	0.0	0.0	0.0	112.4	36.2	52.8	11.8	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	2.7	58.0	8.7	33.9	3.2	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	0.0	15.6	34.3	20.6	51.2	0.0	0.0	0.0
29	0.0	0.0	0.0	5.2	0.0	5.9	30.6	10.2	36.8	0.0	0.0	0.0
30	0.0	0.0	0.0	0.5	0.0	100.2	119.3	6.0	8.6	3.0	0.0	0.0
31	0.0	0.0	0.0	0.0	109.8	0.0	73.0	27.8	0.0	0.0	0.0	0.0
Total	1.3	0.0	0.0	11.0	123.5	920.3	1381.8	617.0	575.2	306.4	403.4	3.2
Annual rainfall in mm					4343.1							

Appendix-1

The Unified Soil Classification System (USCS) is a soil classification system used in engineering and geology to describe the texture and grain size of a soil. The classification system can be applied to most unconsolidated materials, and is represented by a two-letter symbol. Each letter is described below (with the exception of Pt):

First and/or second letters

Symbol **Definition**

G [gravel](#)

S [sand](#)

M [silt](#)

C [clay](#)

O [organic](#)

Second letter

Letter

Definition

P poorly graded (uniform particle sizes)

W well graded (diversified particle sizes)

H high [plasticity](#)

L low plasticity

If the soil has 5% to 12% by weight of fines passing a #200 sieve ($5\% < P_{\#200} < 12\%$), both grain size distribution and plasticity have a significant effect on the engineering properties of the soil, and dual notation may be used for the group symbol. For example, GW-GM corresponds to "well graded gravel *with silt*." If the soil has more than 15% by weight retained on a #4 sieve ($R_{\#4} > 15\%$), there is a significant amount of gravel, and the suffix "with gravel" may be added to the group name, but the group symbol does not change. For example, SP-SM with gravel may refer to "poorly graded sand with silt and gravel."

Major divisions			Group symbol	Group name
Coarse grained soils more than 50% retained on No. 200 (0.075 mm) sieve	gravel > 50% of coarse fraction retained on No. 4 (4.75 mm) sieve	clean gravel <5% smaller than #200 Sieve	GW	well graded gravel, fine to coarse gravel
			GP	poorly graded gravel
		gravel with >12% fines	GM	silty gravel
			GC	clayey gravel
	sand Ö50% of coarse fraction passes No.4 sieve	clean sand	SW	well graded sand, fine to coarse sand
			SP	poorly-graded sand
		sand with >12% fines	SM	silty sand
			SC	clayey sand
Fine grained soils more than 50% passes No.200 sieve	silt and clay liquid limit < 50	inorganic	ML	silt
			CL	clay
		organic	OL	organic silt, organic clay
	silt and clay liquid limit Ö50	inorganic	MH	silt of high plasticity , elastic silt
			CH	clay of high plasticity, fat clay
		organic	OH	organic clay, organic silt
Highly organic soils			Pt	peat

Source: From Wikipedia encyclopedia

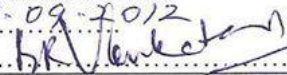
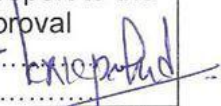


Geological Survey of India

Data sheet on report movement in connection with its scrutiny

Project/Division... *Engineering Geology* FSP No... *9.F.2010-12* Mission... *IV*
Title of the report... *Detailed Site Specific Study of Simanwadi Landslide, Karwar taluk, Uttara Kannada District, Karnataka*

Name of author(s) 1. <i>K.V. Maruthi</i> 2. <i>K.V. Chandran</i> 3. 4.	Date of submission of report to the Supervisory Officer <i>06.07.2012</i> Signature of the senior most author <i>K.V.</i>
Name of Supervisory Officer <i>Dr. B.R. Venkatesh</i>	Date of receipt of report <i>06.07.2012</i> Date of completion of scrutiny <i>14.08.2012</i> Date of handing over report to the author after scrutiny <i>14.08.2012</i> Signature <i>B.R. Venkatesh</i>
Name of author(s) To whom the report has been handed over by the Supervisory Officer <i>K.V. Maruthi</i>	Date of receipt after scrutiny <i>14.08.2012</i> Signature <i>K.V.</i> Date of resubmission <i>17.08.2012</i> Signature <i>K.V.</i>
Supervisory Officer <i>Dr. B.R. Venkatesh</i>	Date of receipt after modification <i>17.08.2012</i> Date of handing over report to the Regional Mission Head <i>21.08.2012</i> Signature <i>B.R. Venkatesh</i>
Name of Regional Mission Head <i>Dr. K.R.K. Prasad</i>	Date of receipt of report <i>27.08.2012</i> Date of handing over the report after peer review to the Project Director <i>10.9.2012</i> Signature <i>Prasad</i>
Name of Supervisory Officer <i>Dr. B.R. Venkatesh</i>	Date of receipt from the Regional Mission Head after peer review <i>12.9.2012</i> Date of handing over to author(s) <i>12.9.2012</i> Signature <i>B.R. Venkatesh</i>
Name of author(s) <i>K.V. Maruthi</i> <i>K.V. Chandran</i>	Date of receipt of report from Supervisory Officer <i>12.9.2012</i> Date of handing over report after modification to Supervisory Officer <i>17.9.2012</i> Signature <i>K.V.</i>
Name of Supervisory Officer	Date of receipt of report after

Dr. B. R. Venkatesh	modification from the author(s) 17-09-2012 Date of handing over report to Regional Mission Head 17-09-2012 Signature..  17/9
Name of Regional Mission Head Dr. K. R. K. PRASAD	Date of receipt after modification from the Project Director... 24-09-2012 Date of handing over the report to the HoD of the Region for approval 24-09-2012 Signature.. 
Name of the HoD of the Region S. C. RATH	Date of receipt of report for approval 24-09-2012 Date of approval... 25-09-2012 Date of sending back report to Project Director... 25-09-2012 Signature of the HoD. 
Name of the Project Director	Date of receipt of report after approval of HoD... 26-9-2012 Date of circulation of report..... Signature.....



GEOLOGICAL SURVEY OF INDIA

Certificate of Quality of the report

Project/ Division: *Engineering Geology* FSP No.: *EA/SR/K4/2010/059* Mission: *IV*
Title of the report: *Detailed Site Specific Study of Samaywad Landslide, Karmaveer Taluk, Uttara Kannada District, Karnataka*
Part - A

This is to certify that the following Officer(s) have carried out the above mentioned FSP and are responsible for collection of field data, carrying out required laboratory analysis, compilation and synthesis of field data, collation of the data and writing of the report as per the approved guidelines. The duration of field stay of each Officer is as against his/ her name.

Name and designation of the Officer	Total field stay during the FSP (No. of days)	Signature with date
1. K.V. Maruthi, Sr. Geo/10/134	10 days (For this study)	<i>M. G. K.V. 17/5/12</i>
2. K.V. Chandan, Sr. Geo/10/134	10 days (For this study)	<i>[Signature]</i>
3.		

Part-B — NA —

This is to certify that drilling has been carried out and completed as per the table given below:

Drilling Unit No	Date of commencement of drilling	Date of completion of drilling	Name and signature of the Director Drilling
1.			
2.			

Part-C — NA —

This is to certify that geophysical component of the item has been carried out as per the table given below

Name(s) Designation of the geophysicist	Date of commencement of work	Date of completion of work	Signature of the Geophysicist with date
1.			
2.			
Name of the Director (Geophysics)			
Signature with date			

This is to certify that the chemical analysis of the geological samples has been carried out as per the table given below

Name of the Director in charge of the Laboratory	Date of receipt of samples from the Field Officer/ party	Date of providing complete analytical results to the Field Officer/ party	Signature with date

Part -E

This is to certify that the Supervisory Officer(s) mentioned below have supervised the above item and have provided guidance to the Field Officer(s). The number of inspection visits and total duration of field visits is as per the table below. It is also certified that the work carried out under the project is of high standards, the norms of field work, lab work etc. have been followed. It is also certified that thorough scrutiny of the report for maintaining the scientific contents and its quality has been overseen

Name(s) and designation of the Supervisory Officers	No. of inspection visits	Total No. of days spent on inspection visit	Remarks	Signature with date
Shri R.Panduranga, Director	1	09*	From 1.10.2010 to 31.12.2010	Retired
Dr.S.S.Nayak, Director	1	02*	From 01.01.2011 to 15.05.2011	
Dr. H.S.M. Prakash, Director	Nil	Nil	15.05.2011 to 30.08.2011	
Shri. Muhammad Ahamed, Director	1	1	01.09.2011 to 20.10.2011	Transferred
Shri. Subir Dasgupta, Supt. Geologist	1	2	21.10.2011 to 30.01.2012	
Dr.B.R.Venkatesh, Director	Nil	Nil	01.02.2012 to till date	<i>Dr. Venkatesh</i> 21/8/12

*Supervisory officers visited Sasanwada landslide site during their inspection visit.

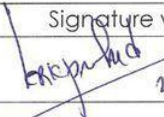


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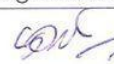
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This is to certify that the report has been thoroughly scrutinized at the Regional Mission Head level. The scientific contents and the quality of the report are certified. The report has been peer reviewed and the needful corrections have been attended to.

Name and designation of the Regional Mission Head	Signature with date
Dr. K.R.K. PRASAD, DIRECTOR (G)	 24.09.2012

Part-G

This is to certify that the report has been scrutinized at various levels and has also been peer reviewed. On being satisfied regarding the scientific content and quality of the report, the undersigned has accorded approval for its circulation.

Name and designation of the Regional HOD	Signature with date
S.C. RATH , Dy. D.G. & H.O.D .	 25.09.12

S OF SASANWAD LANDSLDIE



Photo 1: A view of Sasanwad slide no-1.



Photo 2: A view of Sasanwad slide no-2.



Photo 3: A view of Sasanwad slide no-3.



Photo 4: A view of top portion of Sasanwad slide no-2.



Photo 5: view of dyke exposure in Sasanwad slide no-3.



Photo 6: view of the Sasanwad slide no-3 from the toe of the slide.



Photo 7: Highly wetahered dyke in Sasanwad slide no-3.



Photo 9: The weathered gneiss in the slide debris in the mid slope of Sasanwad slide no-3.



Photo 11: Collection of undisturbed sample just below the crown of Sasanwad slide no-3.



Photo 8: Crown cracks observed in between Sasanwad Slide no-2 & slide no-3.



Photo10:Crown cracks observed in between Sasanwad Slide no-2 & slide no-3.



Photo 12: Granite exposure near Sasanwad Slide no-1.



Photo 13: Prominent set of joint in Gneiss outcrop on the right flank of the Sasanwad slide no-2.



Photo 14: View of road from the crown part of Sasanwad slide no-3.



Photo 15: Ground water level in the open dug well at the toe part of the Sasanwad slide.



Photo 16: Survey work in progress at the top of Sasanwad slide no-3 with lush vegetation of cashew plantation all around.



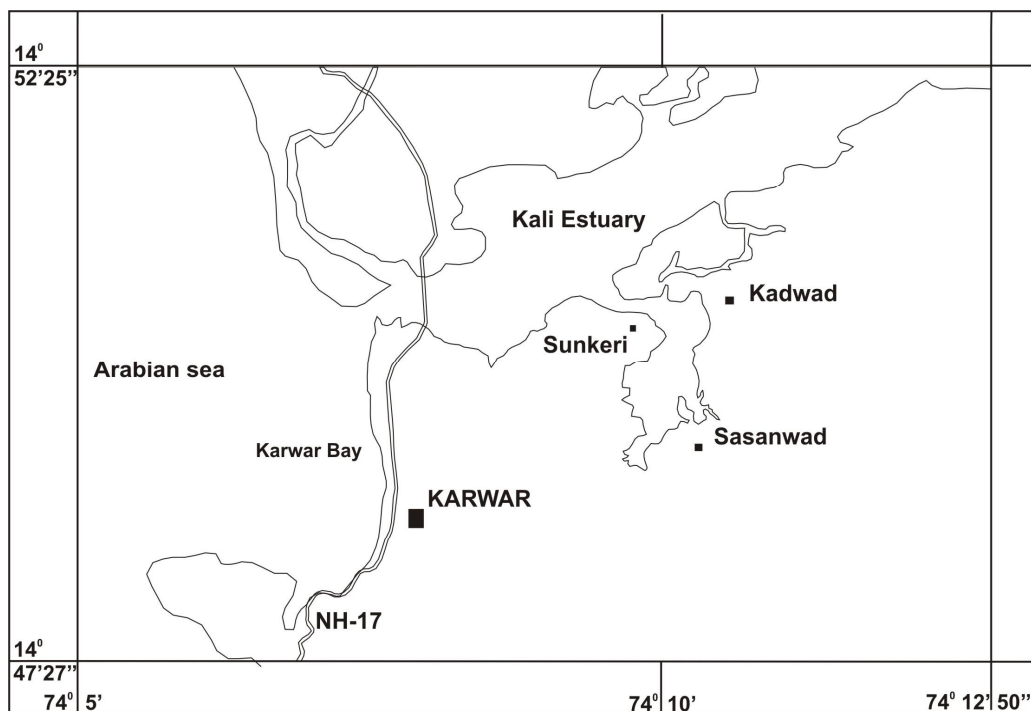
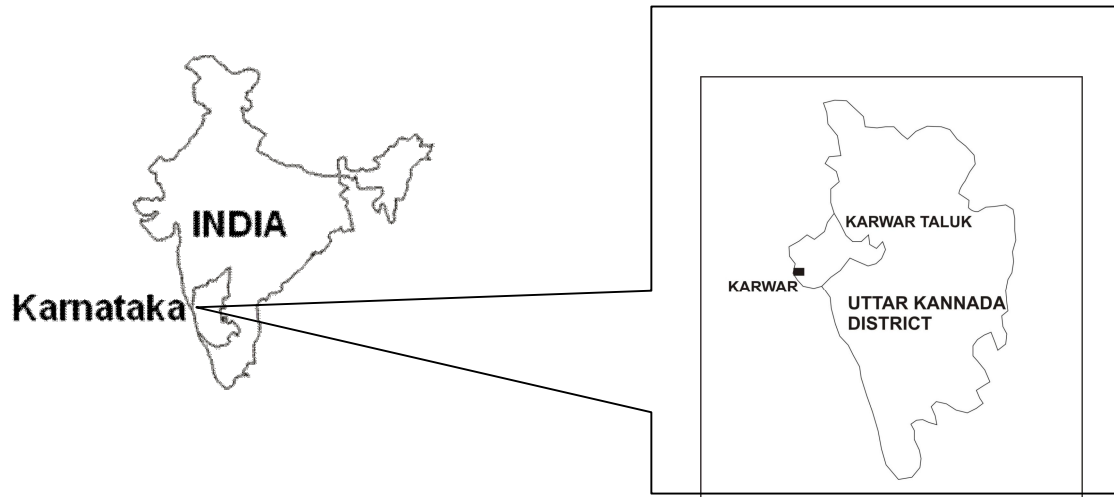
Photo 17: View of Marshy land (prawn farm) below the toe of the Sasanwad slide no-1.



Photo 18: Granite quarry (abandoned) in the north eastern corner of the Sasanwad slide study area.

PLATE-1

LOCATION MAP OF SASANWAD LANDSLIDE AREA



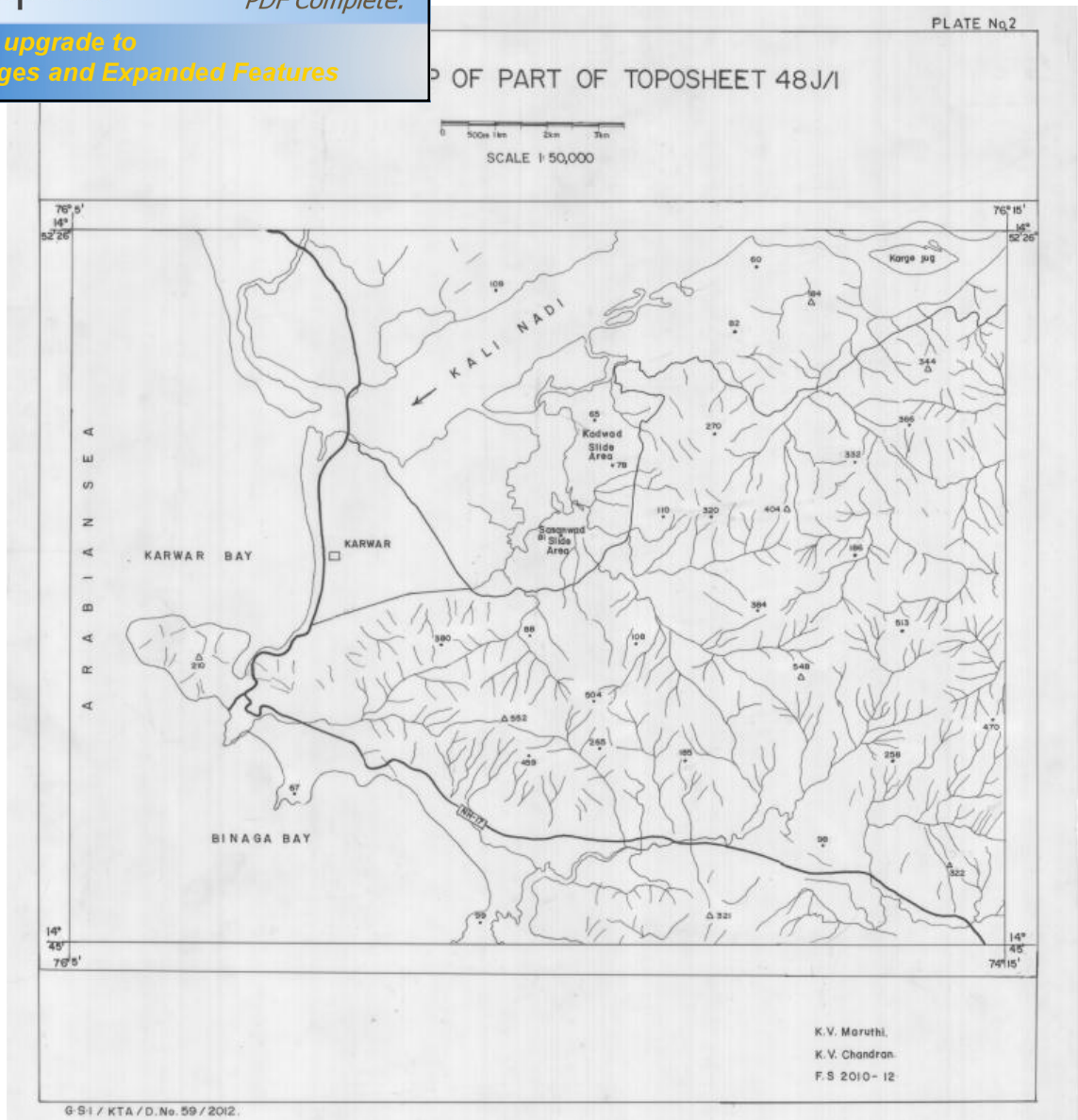
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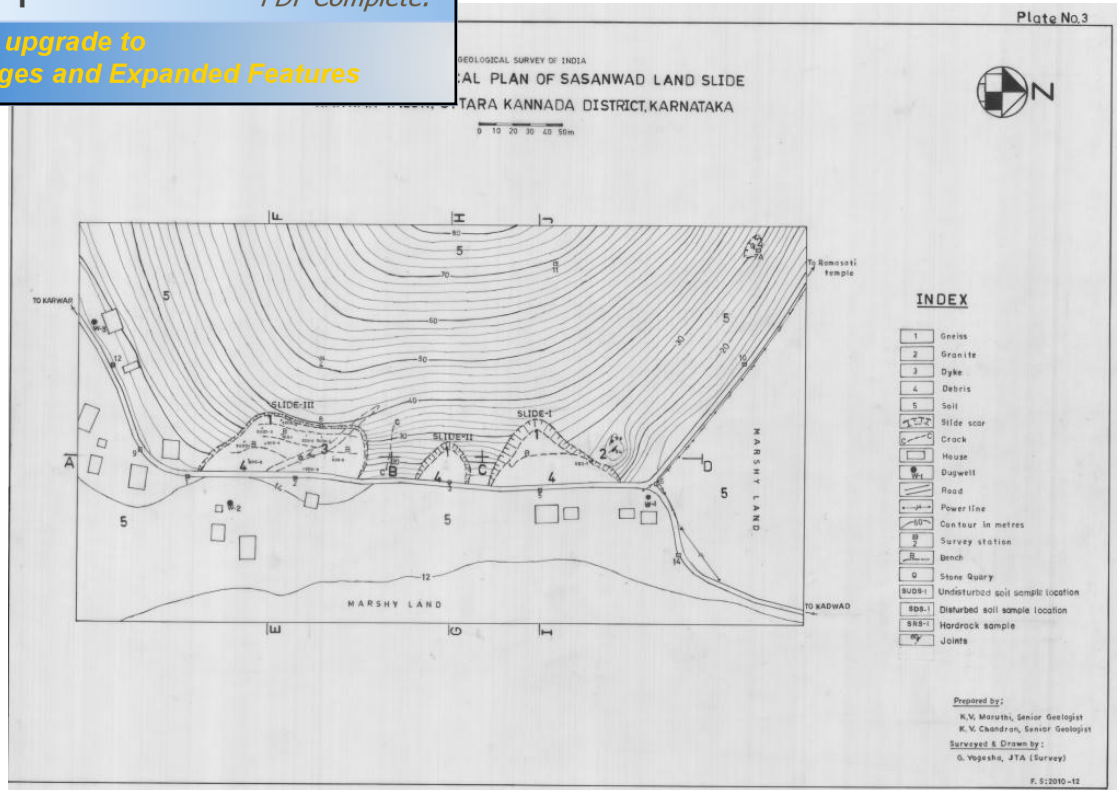


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PLATE-4

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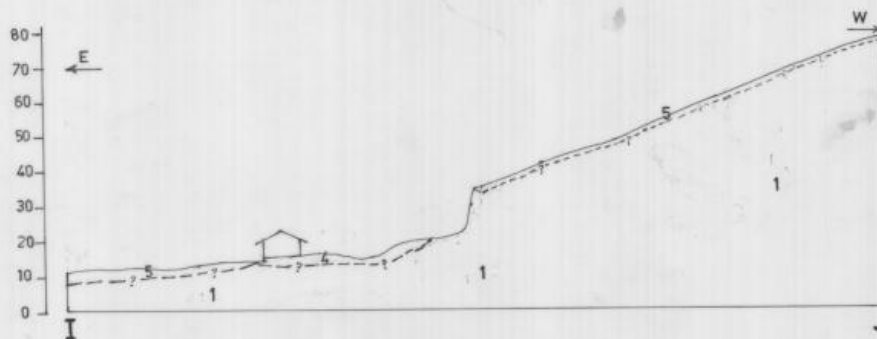
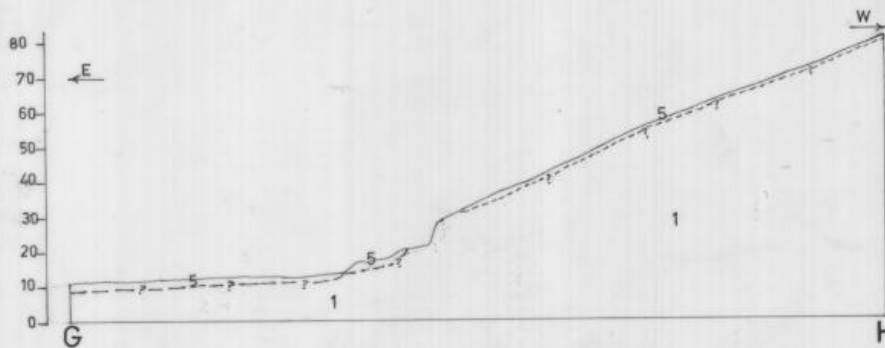
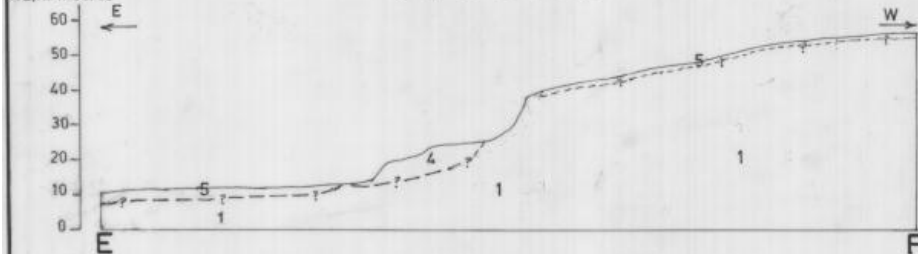
EF, GH & IJ AT SASANWAD LANDSLIDE

KARWAR TALUK, UTTARA KANNADA DISTRICT

KARNATAKA

0 10 20 30 40 50m

RL in metres



INDEX

- | | |
|---|---------|
| 1 | Gneiss |
| 2 | Granite |
| 3 | Dyke |
| 4 | Debris |
| 5 | Soil |

Prepared by:

K.V. Maruthi, Senior Geologist

K.V. Chandran, Senior Geologist

G. Yogesha, JTA (Survey)

F.S: 2010-12

DRN:YOG



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