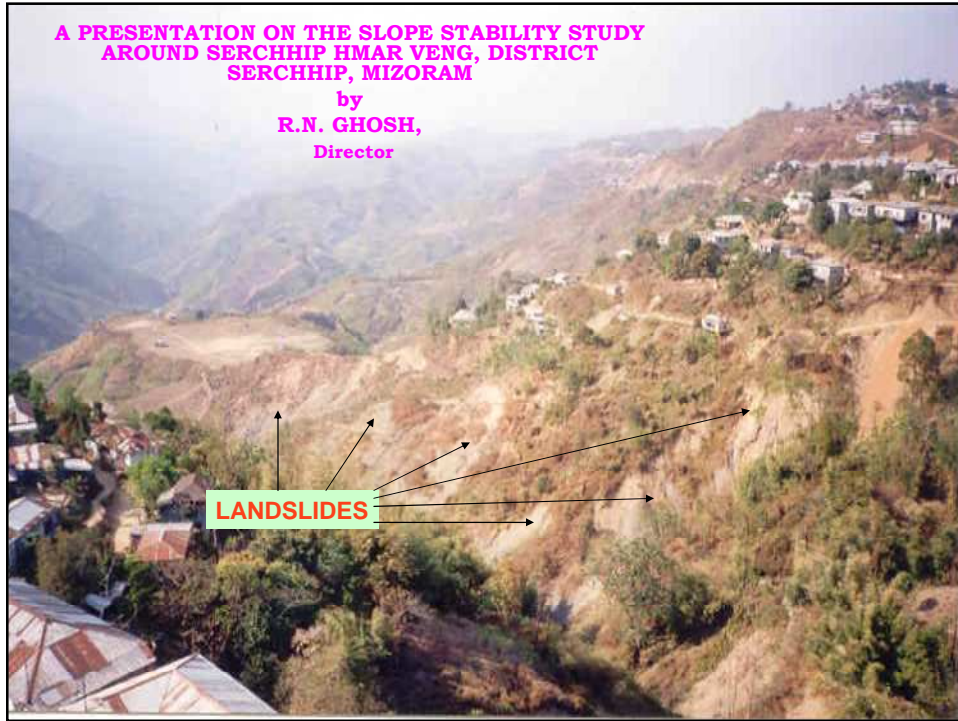


**A PRESENTATION ON THE SLOPE STABILITY STUDY  
AROUND SERCHHIP HMAR VENG, DISTRICT  
SERCHHIP, MIZORAM**

by  
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Director

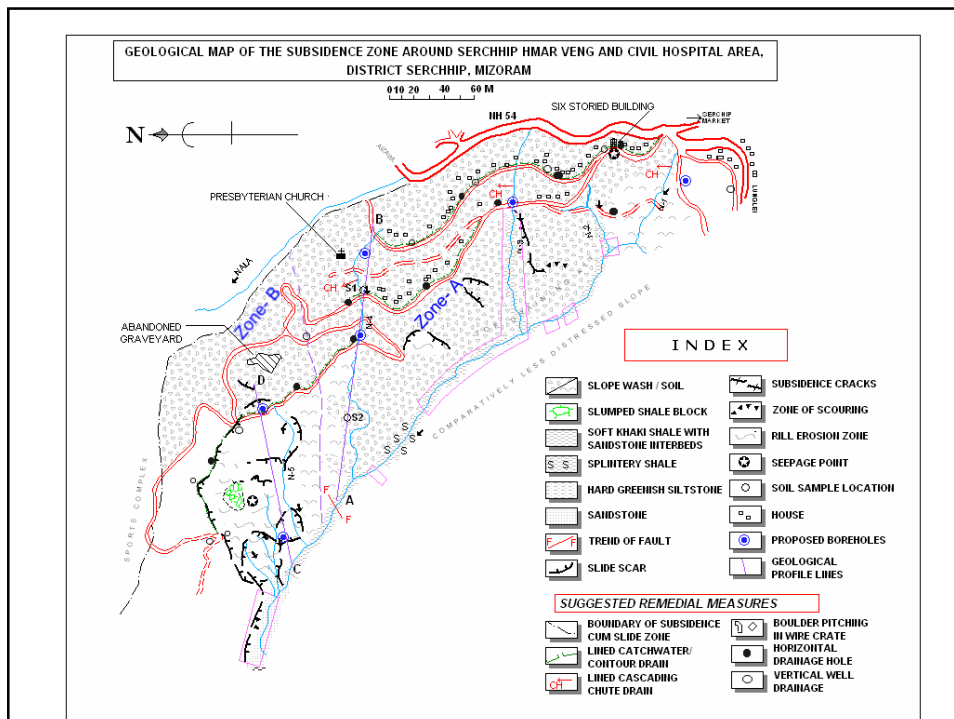


**LOCATION**

**Northwest-Southeast trending  
hillslope near Serchhip market;  
150 km South of Aizawl, District  
Serchhip, Mizoram.**

# NATURE OF THE PROBLEM

- Thickly populated hillslope (900 m X 300 m X 178m) affected by landslides and subsidences



## MAGNITUDE OF THE PROBLEM

- **Zone-A** (thickly populated southeastern part of the hillslope)
  1. Subsidence cracks on road, floor and wall of the Presbyterian Church; tilted two front pillars of the Church indicating slow creep.
  2. Few slides at different levels on the hillslope.
  3. Conspicuous scouring along the courses of the nalas draining the slope (mainly N-3 nala)

## MAGNITUDE OF THE PROBLEM

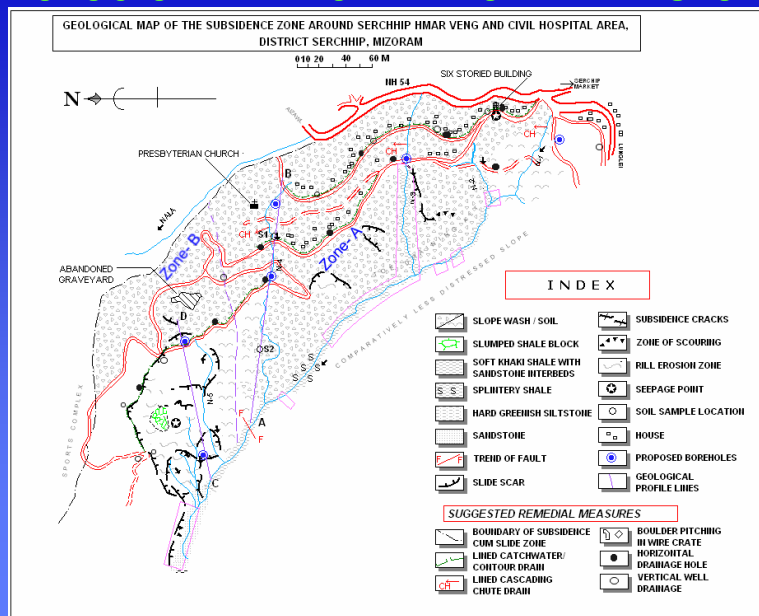
- **Zone-B** (Sparsely populated northwestern part of the hillslope)
  1. A conspicuous slide (200m X180m) with numerous minor slides; appears to be multiple rotational slips
  2. Subsidence cracks on road benches at different levels
  3. Toe erosion of the hillslope along the northwesterly flowing nala.

## GEOLOGY OF THE AFFECTED AREA

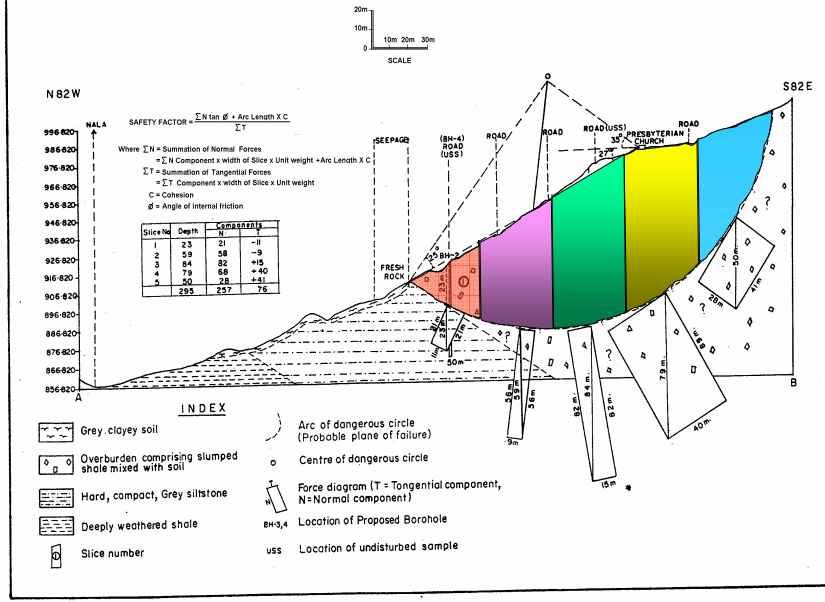
•Tightly folded soft, fragile, shale and sandstone interbeds of Middle Bhuban Formation of Bhuban Subgroup of Surma Group ( Tertiary). Affected by a few normal faults.



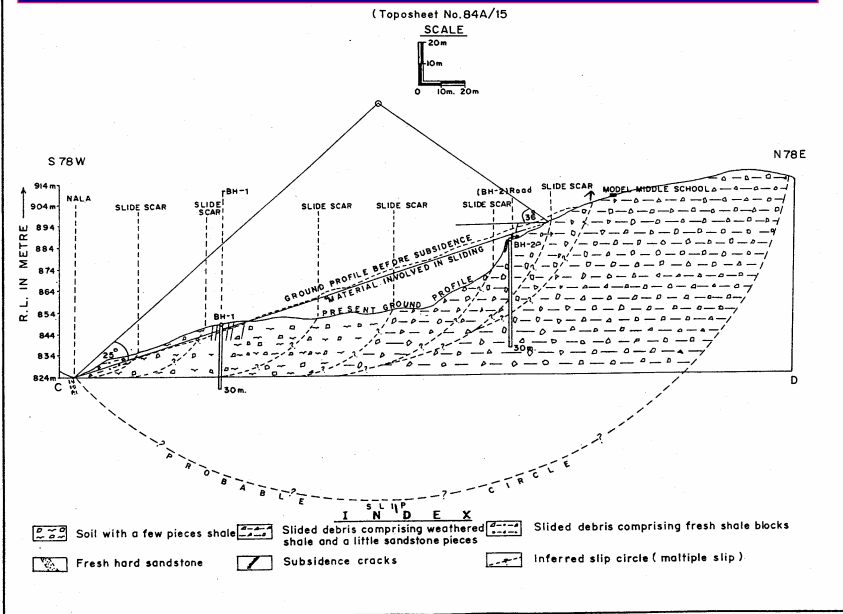
## GEOLOGICAL MAP OF AFFECTED HILLSLOPE



## STABILITY ANALYSIS OF THE HILL SLOPE ALONG GEOLOGICAL PROFILE LINE A-B, ZONE-A



## GEOLOGICAL PROFILE ALONG LINE C-D, ZONE-B



## COMPOSITION OF SLOPE FORMING MATERIALS

- Predominantly sandy clayey soil mixed with deeply weathered shale and thin sandstone interbeds.

## PURPOSE of SAMPLE COLLECTION

- Determination of shear strength parameters like angle of internal friction, cohesion, unit weight of slope forming materials at NMC and different saturation for slope stability analysis.

## UNDISTURBED OVERBURDEN SAMPLES COLLECTED

- Two samples (3 numbers each in steel tube) from the profile A-B and one sample (3 Nos. in steel tube) from the profile C-D (Plate-I&II).

## PURPOSE OF SLOPE STABILITY ANALYSIS

1. To assess the degree of slope instability and to draw the most dangerous circle along which the slope is likely to fail.
2. Determination of Factor of Safety (FS)

$$FS = \frac{\text{Resisting Force preventing movement}}{\text{Driving force causing movement}}$$

## PURPOSE OF SLOPE STABILITY ANALYSIS

1.  $FS = 1$  i.e. Both Forces are of equal magnitude; the slope is in a critical condition.
2.  $FS = <1$  i.e. Driving force is more than Resisting Force; the slope may fail at anytime/already failed.
3.  $FS=>1$  i.e., Resisting Force is more than Driving Force; the slope is comparatively safe (Overloading of crown, Earthquake Force and Saturation not considered).

## CALCULATION OF FACTOR OF SAFETY

1. **Safety Factor determined in natural moisture content.**  
Cohesion (c)=0.35kg/cm<sup>2</sup>=0.35x1000 gms/cm<sup>2</sup>  
Angle of internal friction=11° tanΦ=11°=0.1944  
Unit weight of the material=1.77 gms/c.c  
Arch length (L)=282m=282x100cm  
Width of the slice=43m=43m x 100 cm  
ΣT Forces= ΣT components x width of the slices x unit weight of the material.  
ΣN Forces= ΣN components x width of the slices x unit weight of the material x tanΦ+ Arc Length x cohesion

## CALCULATION OF FACTOR OF SAFETY

$$\text{Formula (FS)} = \frac{\sum N \tan\phi + Lc}{\sum T}$$

Where

$\sum N$  Force =  $\sum N$  components X width of the slice X unit weight x  $\tan\phi + Lc$

$\sum T$  Force =  $\sum T$  components X width of the slice X unit weight

C= Cohesion in kg/cm<sup>2</sup>

$\phi$ =Angle of internal friction

L= Arc length of the slip circle in metre.

## CALCULATION OF FACTOR OF SAFETY

### 1. Safety Factor determined in natural moisture content.

Cohesion (c) = 0.35kg/cm<sup>2</sup> = 0.35x1000 gms/cm<sup>2</sup>

Angle of internal friction ( $\phi$ ) = 11°,  $\tan\phi = \tan 11^\circ = 0.1944$

Unit weight of the material = 1.77 gms / c.c

Arch length (L) = 282m = 282x100cm

Width of the slice = 43m = 43m x 100 cm

$\sum T$  Forces =  $\sum T$  components x width of the slice x unit weight of the material.

$\sum N$  Forces =  $\sum N$  components x width of the slice x unit weight of the material x  $\tan\phi +$  Arc Length x cohesion

contd...

## CALCULATION OF FACTOR OF SAFETY

$$\begin{aligned} \text{F.S.} &= \frac{257 \times 100 \times 43 \times 100 \times 1.77 \times 0.1944 + 0.35 \times 1000 \times 282 \times 100}{76 \times 100 \times 43 \times 100 \times 1.77} \\ &= \frac{38025164 + 9870000}{57843600} = \frac{47895164}{57843600} = 0.828 \dots\dots (1) \end{aligned}$$

## CALCULATION OF FACTOR OF SAFETY

### II. Safety factor determined for the sample in almost saturated condition.

Cohesion (c) =  $0.05 \text{ kg/cm}^2 = 0.05 \times 1000 \text{ gm/cm}^2$

Angle of internal friction ( $\Phi$ ) =  $8^\circ$ ,

$\tan \Phi = \tan 8^\circ = 0.1405$

Unit weight of the material =  $2.33 \text{ gms / c.c}$

Arc length (L) =  $282 \text{ m} = 282 \times 100 \text{ cm}$

Width of the slice =  $43 \text{ m} = 43 \times 100 \text{ cm}$

## CALCULATION OF FACTOR OF SAFETY

$$\begin{aligned} \text{F.S.} &= \frac{257 \times 100 \times 43 \times 100 \times 2.33 \times 0.1405 + 0.05 \times 1000 \times 282 \times 100}{76 \times 100 \times 43 \times 100 \times 2.33} \\ &= \frac{36177106 + 1410000}{7614400} = \frac{37587106}{7614400} = 0.493 \text{ -----(2)} \end{aligned}$$

## RESULT OF SLOPE STABILITY ANALYSIS

1. Safety factor in natural moisture content = 0.828 (C=0.35 kg/cm<sup>2</sup>,  $\phi=11^\circ$ , unit weight=1.77 gms/c.c).
2. Safety factor determined in almost saturated condition = 0.493 (C=0.05 kg/cm<sup>2</sup>,  $\phi=8^\circ$ , unit weight=2.33 gms/c.c)

**Inference:** Safety factor falls conspicuously with gradual saturation (so also shear strength of the slope forming material). The slope is unsafe. Earthquake tremor accompanied by heavy rainfall may trigger slope failure.

## CAUSATIVE FACTORS OF SLOPE INSTABILITY

1. Poor shear strength of the slope forming materials both in natural moisture content and on saturation.
2. Deep scouring of the distressed hillslope by the westerly flowing nalas descending the hillslope, mainly in Zone-A.
3. Toe erosion of this hillslope by a lineament controlled northwesterly flowing nala.
4. High porewater pressure suspected from the occurrences of a few seepage points and waterlogged muddy zone at different levels on this hillslope.

## CAUSATIVE FACTORS OF SLOPE INSTABILITY

5. Slope forming material is not self draining; hence detrimental hydrostatic pressure probably the main causative factor inducing slope instability.
6. Heavy loading of the highly unstable slope by construction of numerous concrete buildings even up to six-storied building.
7. Completely barren hillslope allowing heavy infiltration of rain water into the highly unstable hillslope.
8. Waste water disposal through unlined drains on the hillslope allowing appreciable amount of seepage into the highly distressed hillslope

## RECOMMENDATIONS

- **A. Short term recommendations:**
  1. Drilling of six boreholes up to depths between 30m and 50m or 3m into fresh bedrock whichever is earlier to delineate the thickness of overburden, depth of fresh rock, depth of ground water level, confirmation of the anticipated Slip circle, installation of Piezometer, Inclinator/Tiltmeter in the Zone-A and pumping out of water from these boreholes during monsoon period.

## RECOMMENDATIONS

2. Lined cascading chute drains along the westerly flowing nalas descending the hillslope particularly in Zone-A.
3. Lined catch water drain/ contour drains along the road benches on different levels particularly in Zone-A.
4. Protection measures against scouring and toe erosion along the northwesterly flowing nala course by boulder pitching in wire crate and providing lined cascading chute drain.

## RECOMMENDATIONS

5. Filling up of subsidence cracks with sand mixed coaltar.
6. Lined drains in Zone-A for wastewater disposal.
7. Immediate afforestation of the barren hillslope.
8. Discouraging construction of any concrete building on this distressed hillslope.

## RECOMMENDATIONS

- **B. Long term recommendations**
  1. Installation of atleast two piezometers and one inclinometer/ tiltmeter in two boreholes on thickly populated hillslope.
  2. Subsurface drainage arrangement by providing eighteen numbers of horizontal drainage holes on different levels of the hillslope or thirteen numbers of vertical well drainage holes with their outlet points at appropriate levels on this hillslope.
  3. Monitoring of piezometer for ascertaining the seasonal fluctuation of ground water level and to draw the approximate seepage line.
  4. Detecting of amount of creep from Inclinometer/ Tiltmeter

## GENERAL CONCLUSION

1. Well drained slopes are inherently more stable than poorly drained slope and much more resistance to failures during severe earthquakes.
2. Horizontal drainage and vertical well drainage are very effective for draining slopes.
3. Piezometer system should be installed in all slopes which are stabilized by drainage.
4. It is required to verify the effectiveness of the system and to provide a measure of the inherent stability of the slopes under seasonal fluctuations in groundwater levels.
5. In this manner failures due to unknown groundwater conditions can be avoided

