



Geological investigation and mitigation suggestion of slumping localities in Saiha town, southern Mizoram, India

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ABSTRACT

Saiha town slumping area was triggered by cloud burst on the 16th and 17th May, 1995. Prominent transverse cracks were observed from the month of October, 2010 at the rupture surface of subsidence localities such as New Colony-I, New Colony-III, College Veng and Council Veng, Saiha. About 310 houses were affected. This could be due to high rate of percolation of rain water which developed pore pressure and weakening connection between the top and bottom layer, thus, reduced shear strength or resisting force. A continuous movement was observed till 2013, and maybe unsafe localities if not mitigate at the correct time. The present paper deals with geological field investigations as well as recommendation in terms of preventive and remedial measures.

Key words: Rock bed; Saiha; slumping; transverse crack.

INTRODUCTION

The downward rotation of regolith that occurs along a curved surface is rotational slide or slump or subsidence. This type of mass movement is common where clays are underlain by impervious strata and overlain by porous rocks which form storage reservoirs for water.¹

The immature topography, receiving higher rainfall and the thick regolith of the town caused more geological hazards like mass movement. Saiha town experienced one of the largest landslide/ mudflow in Mizoram on 16th and 17th

May, 1995 after cloud burst, and also due to no drainage system, geologically weak strata and poor vegetation (Photo plate- 1). 20 people lost their valuable lives, 13 people were seriously injured and 67 houses were completely destroyed in Saiha town.²

MATERIALS AND METHODS

Saiha is the southernmost town in Mizoram; it is the district capital of Saiha District as well as headquarters of Mara Autonomous District Council. It is located at a distance of about 315 kms from Aizawl *via* Thenzawl- Lunglei road. The town is approachable by NH-54. State highway connects it from Tuipang and from Sangau

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by seasonal road. It can also be approached by the state helicopter service. It falls under Survey of India Toposheet No. 84 B/15 and situated in between 22°29'–22°30' latitude and 92°58'–93° longitude. The specific study area - New Colony and College Veng localities are situated at the western side of Saiha town, while Council Veng at the eastern side (Fig. 1). The anticline ridge of Civil Hospital road breaks up the location of New Colony-College Veng block to Council Veng block.

Saiha town receives high rainfall with an average of 2577.29 mm per annum (Table 1), i.e. highest in the state. During winter the temperature ranges from 8 to 22°C and the temperature ranges from 18 to 27°C during summer.

The present geological investigation was based on field study.^{3,4} During geological field work, Brunton compass and Silva compass were used for measuring dip and strike amount and direction. GPSmap78sc (Garmin) used for geographical location, and measuring tape for determination of the length and wide of transverse crack. Trees, buildings, and ruler marked stick are based for measuring the rate of subsidence. Tilting angle of trees and sinking of the stick

(positioned at the contact between disturbed and undisturbed) were examined twice a day at the same time constantly for 3 weeks in the month of October, 2010. The cracks observed at the wall and floor, and conjunction between the column and the skirting of the affected buildings were also examined and measured. These short-time measurement, and field investigations during the month of December, 2011 and June, 2013 observed that a continuous movement of these slumping localities, and may be unsafe settlement area if not mitigate at the correct time.

Geologically, Saiha town is made up of Middle Bhuban Formation of Surma Group. The main rock types are shale, sandstone and siltstone. There are many local fault lines, which controlled the stream lines. Since, shale is the main rock type, it easily weathered by the action of water, then transformed into clays.⁵⁻⁷ These weathered products are observed along the stream line and along the NH-54B road section. Medium to fine grained grey to yellow bedded sandstones are mostly deposited along the stream. There is no proper bed rocks exposure. The general strike of the beds trends

Table 1. Rainfall record during 2002-2012. [Source: Department of Agriculture, Saiha]

MONTH	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
JAN	24.0	0.0	0.0	0.0	0.0	0.0	0.0	84.0	0.0	14.0	0.0
FEB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	196.0	0.0	0.0	0.0
MAR	49.0	20.3	3.0	74.0	0.0	8.0	8.0	25.0	152.0	54.2	16.0
APR	43.0	50.0	237.0	25.0	0.0	176.0	176.0	0.0	62.0	128.4	20.0
MAY	651.6	252.0	187.5	278.0	347.0	374.0	369.0	455.0	338.5	791.2	176.0
JUN	351.0	906.0	646.0	286.0	735.0	735.0	695.0	323.0	300.0	296.2	199.0
JUL	971.0	319.0	707.0	404.0	619.0	547.8	381.4	499.0	389.7	285.6	159.0
AUG	364.9	312.0	211.0	563.0	431.0	172.0	800.0	418.5	711.0	667.0	422.0
SEP	260.0	365.0	507.0	404.0	258.0	0.0	597.0	418.0	512.0	357.2	156.0
OCT	151.0	234.0	108.0	249.0	210.0	0.0	195.0	118.0	346.0	246.4	219.9
NOV	78.0	0.0	12.0	47.0	25.0	0.0	417.0	86.0	0.0	0.0	19.9
DEC	22.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0
T.T	2965.5	2473.3	2618.5	2330.0	2625.0	2012.8	3638.4	2622.5	2836.2	2840.2	1387.8
Rainy days	144	121	110	91	126	84	157	134	149	154	114

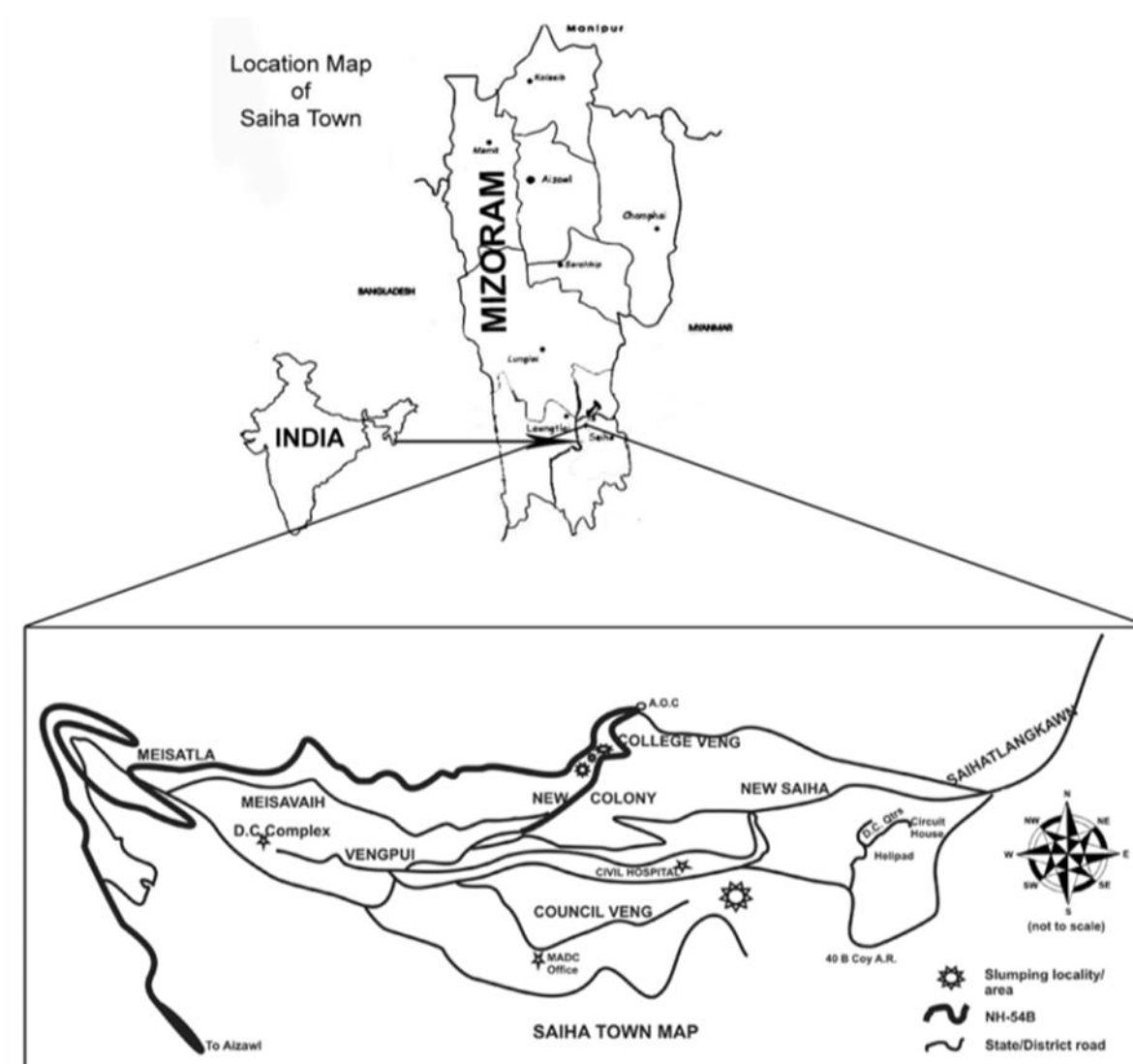


Figure 1. Location map of Saiha.

N5°W/ N5°E-S5°E/ S5°W with dip ranges from 30° to 65° either towards east or west. Development of joints and faults are abundance. But, proper beddings and outcrops were not observed at the slumping area.

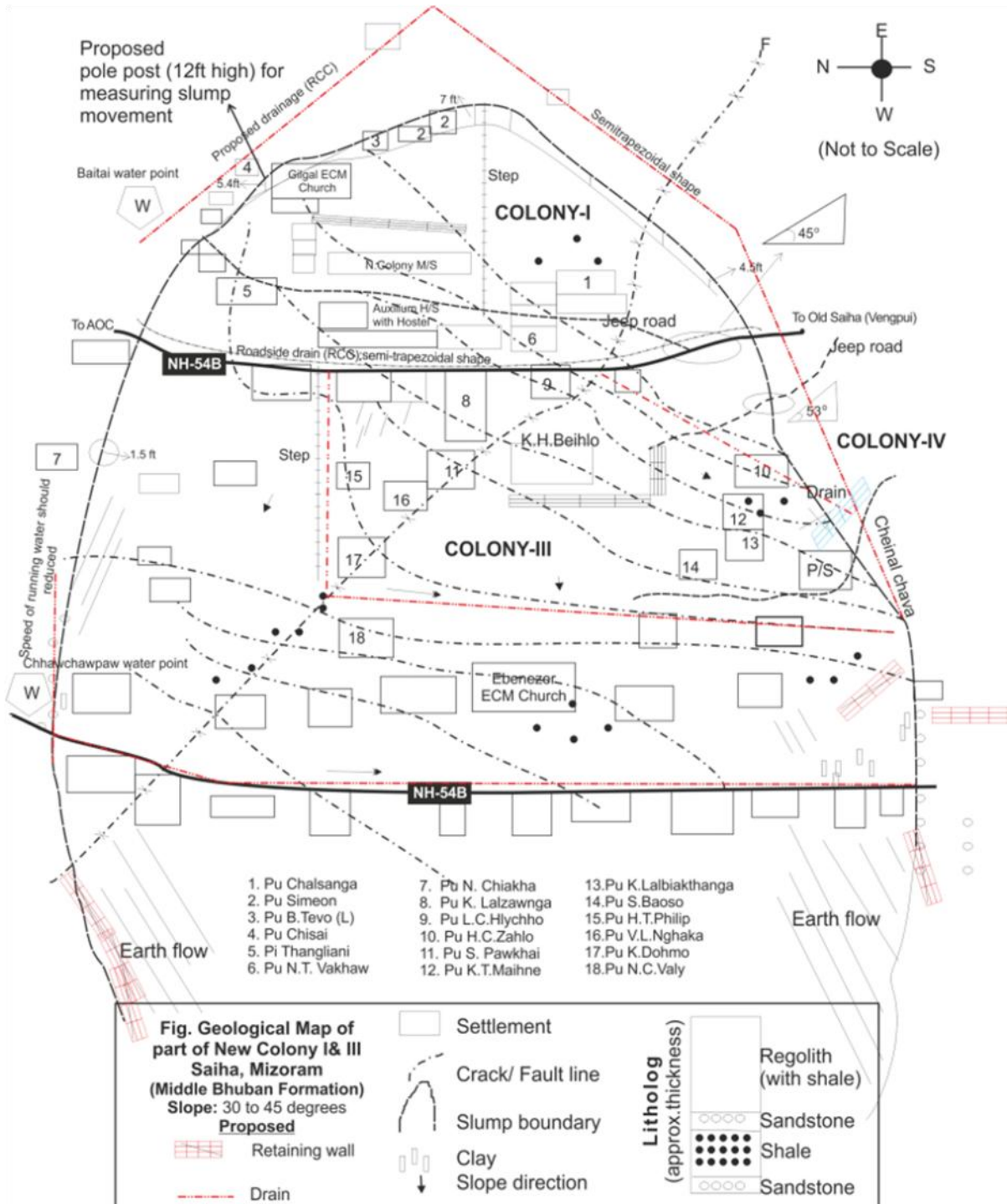
The slopes are characteristically steep, ranges from 35° to almost vertical, i.e. 90°. Because of thick regolith/ debris (2 to 20m), the slope morphology is changes. High rate of erosion at the toe regions results vertical slope. Generally, the western limbs of the anticlines are steeper than

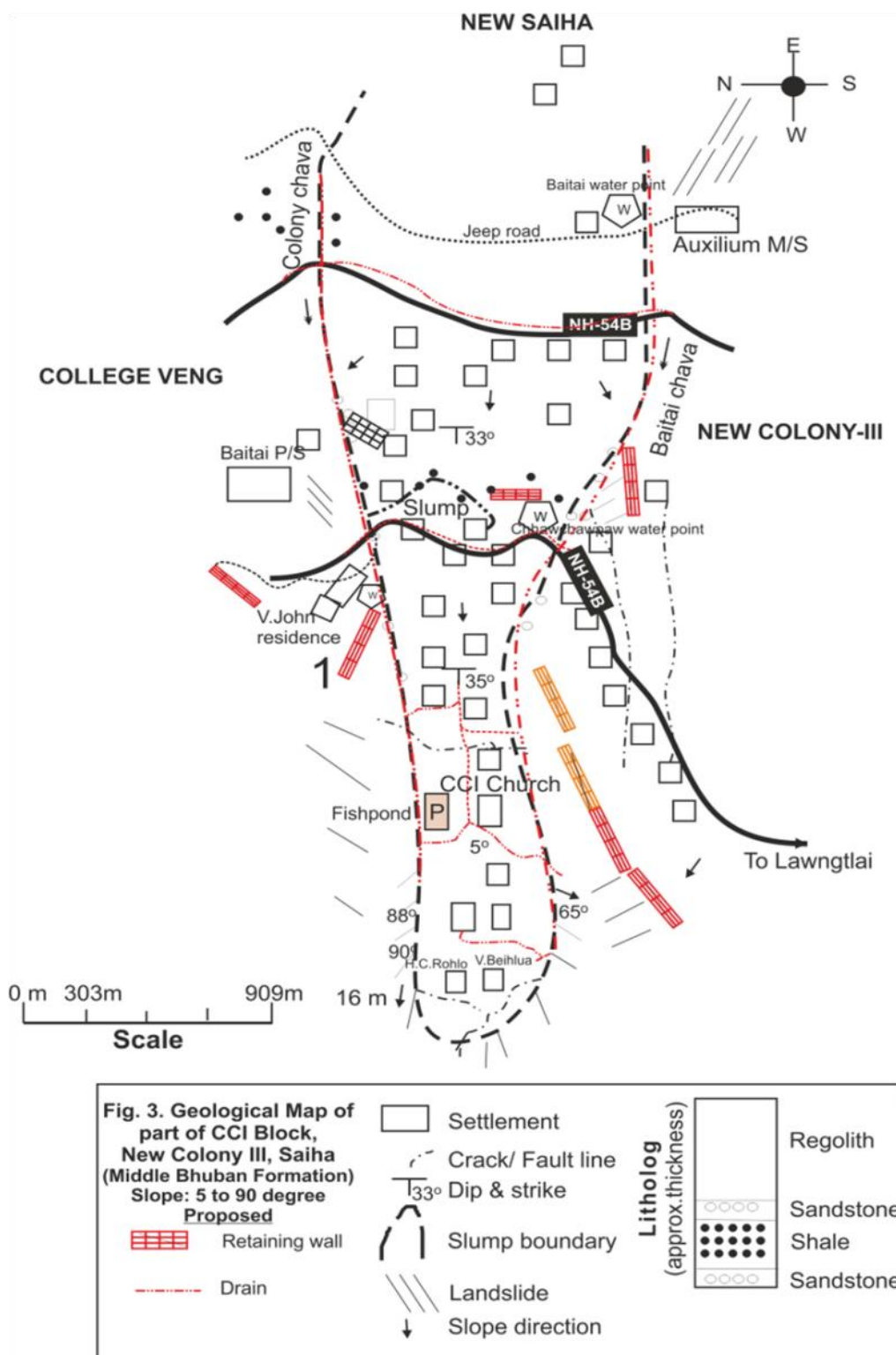
the eastern limbs.

OBSERVATIONS

1. New Colony

The slumping area covering an area of about 200 sq m, coordinates between N22°29' 26.46"-E092°58' 53.94" at the southern main scarp, and N22°29' 27.84"-E092°58' 55.32" at the northern main scarp. At the toe region, along NH-54B, it





coordinates between N22°29' 32.34"-E092°58'48.48" at 979 m in south and N22°29' 31.8"-E092°58' 54.9" in north. The height of main scarp to the down thrown ranges from 1.5 to 7 ft respectively, and the height distance between the main scarp at N22°29' 26.46"-E092°58' 53.94" (1078 m) and toe (bottom of earth flow) at N22°29'41.7" & E092°58'45.78" (881 m) is 197 m. The area comprises two village councils viz. New Colony-I and New Colony-III respectively (Fig. 2).

According to local people, the northern side of New Colony-I & III area suffered huge landslides in around 1920, again in 1960 and 1995. Transverse cracks were noticed from 23rd July, 2002. 10 transverse cracks along NE-SE & NS direction were identified during geological field work on October, 2010. About 180 houses were affected including one boarding school, i.e. Auxilium H/S, one middle school, i.e. New Colony M/S and one primary school, i.e. New Colony-III P/S, and ECM Church, Gilgal. These transverse cracks were about 1 to 13 inches wide and about 5 to 32 m (Photo plate 3). One big transverse crack (fault) along NW-SE direction was observed, which severely affected four residential houses. Reconstruction of Cheinal chava (*chava* means 'stream') was suggested to catch the drains from upper crown of the slump (Photo plate 5). ECM Church (Gilgal) situated at the border of northern slumping area was badly affected, and the District Disaster Management Authority (SDMA) ordered on the 17th June, 2013 to evacuated and dismantled the building.

There was no proper bed rock and outcrops exposed in this area. The geological structures in this area differed considerably. At the border of New Colony and College Veng, between N22°29'33.36"-E092°58'56.58" along the NH-54B road section, 13 inch thick grey sandstone intercalated with 2 inch shale bed of about 12ft thick exposed was observed. This bed strikes N80°W and dip amount was 29° due east.

The CCI College Veng block of New Colony-III area was observed as the most vulnerable disastrous subsidence area in the town due to

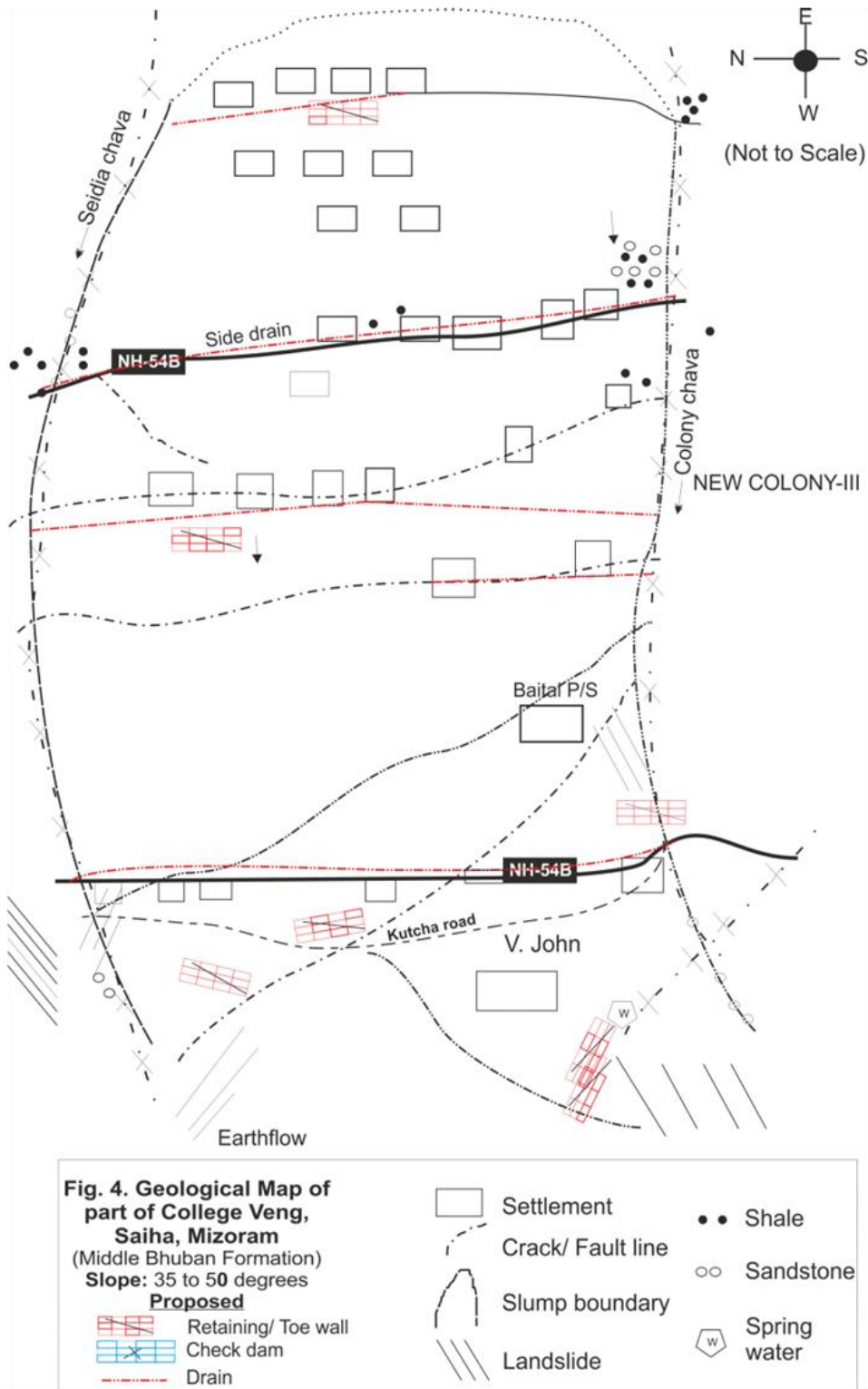
weak resisting nature at the toe portion (Fig. 3). It was situated between N22°29'30.18" & E092°59'1.74" at the crown at the height of 1075m to N22°29'41.1' & E092°58'46.86" at the toe at the height of 880 m. No bed rock was observed, only thick regolith about 24m. The fishpond of about 70 sq m situated near CCI church may increase the gravitation force. The resisting force at the toe region was weak due to high erosion, thick regolith and no proper bedding. 4 transverse cracks of about 1 to 6 inches wide, along NW-SE direction were observed at the toe region. 2 houses situated near the coordinates between N22°29'37.44" & E092°58'51.24" at the height of 968 m are highly vulnerable to sliding shown in Fig. 3. After suggestion with detailed geology², DRDA Saiha constructed check dams at the toe region in the year 2012. These check dams observed as 'positive' i.e. decreasing the rate of slumping at this respective area (Photo plate 4).

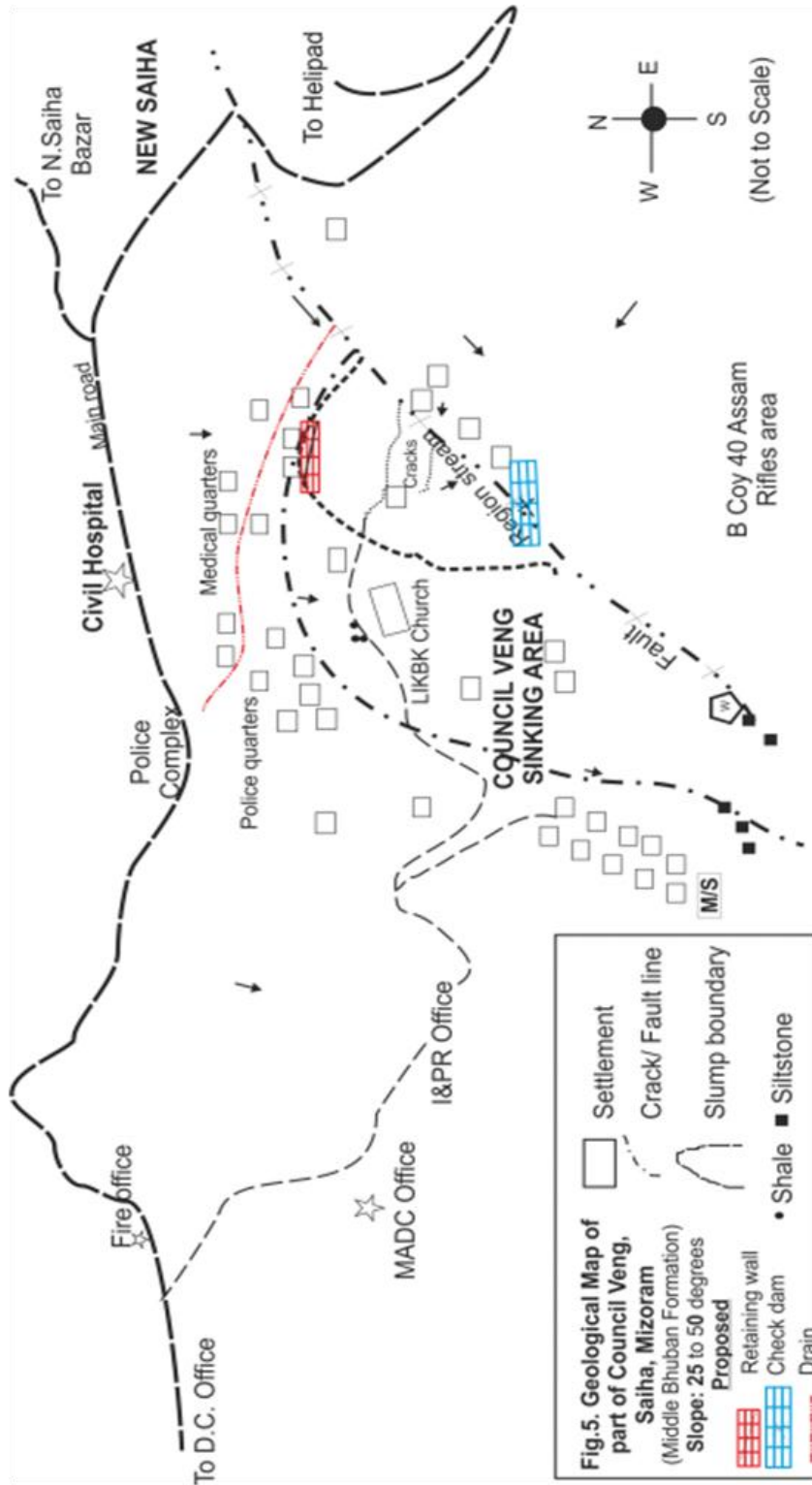
2. College Veng

About 60 houses affected by slumping in College Veng area (Fig. 4). The area is situated between N22°29'32.16" & E092°59'2.7" at the crown at 1081m to N22°29'36.66"-E092°58'57" at the toe. 6 transverse cracks along NS, NE-SE, EW & NW-SE directions were observed. These transverse cracks are about 1 to 5 inches wide. At Seidia chava, at N22°29'35.94" & E092°59'5.94" at 1056 m, there was an exposure of shale bed along the NH-54 road striking N20°E and dip 17° W, this type of rock bed exposed again at N22°29'38.2' & E092°58'43.87" at 881 m striking N50°E and dip amount is 13°W. After suggestion⁴, check dam was constructed at Seidia chava at the side of V. John residential compound. The check dam was also observed as positive. Garbion wall type was suggest at above the bridge to increase toe resisting force, and to prevent slump along the road of National Highway situated at the height of about 80 m.

3. Council Veng

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Photo plate 1. Largest mass movement at Saiha in May 1995.



Photo plate 2. Some of the cracks observed at the settlement of New Colony & College Veng slumping areas.

Laldinpuia



Photo plate 3. One of the affected School, Govt. Primary School, New Colony-III.



Photo plate 4. Check dam at the toe of College Veng - New Colony area, constructed by DRDA, Saiha.



Photo plate 5. Proposed reconstruction of Cheinal chava drain, and breast wall at New Colony- I & III locality.

Council Veng subsidence area was noticed from 1989, and again in 1995. About 40 houses are affected in this subsidence. The main scarp situated at $N22^{\circ}29'16.92''$ & $E092^{\circ}58'58.8''$ at the height of 1136 m and the toe at $N22^{\circ}29'9.6''$ & $E092^{\circ}58'55.32''$ at 1020 m (Fig. 5). On September 2010, an area of about 20 sq m slumping was observed, destroyed one kutch house.

There was no proper rock bed in the area. About 7 ft siltstone was exposed at the toe, at $N22^{\circ}29'8.4''$ & $E092^{\circ}58'54.78''$ at 1020 m near Region stream striking $N42^{\circ}W$ and dip $20^{\circ}E$. Bluish weathering shale of about 3 ft thick was observed at $N 22^{\circ}29'14.04''$ & $E092^{\circ}58'56.04''$ at

the height of 1126 m near the LIKKB church. One transverse crack was observed along NS-direction at the toe of Civil Hospital hill. The height of the main scarp to the nearest down thrown ranges from 8 to 20 ft.

To prevent infiltration of water and erosion in this area, new drainage system was suggested to construct along New Colony- Er. Chohmo road- DNS – CMO office, and beneath of Hospital canteen to Project stream. To increase resisting force at the toe region, 15 x 5 m check dam was suggested at the location of $N 22^{\circ}29.195'$ & $E092^{\circ}58.979'$ at the height of 1076 m.

DISCUSSION

The rate of slumping increased during mon-

soon period, and generally slows in another season². The slumping may be due to heavy percolation of rain water into thick regolith develops pore pressure and reduced resisting force, steepness of the slope accelerate gravitational force of the soil and high erosion rate at the toe region.

No proper drainage system was developed in the study area; thus as according to the condition of the slope, geology and transverse cracks, suitable drainage system was proposed^{4,9-10}. New drainage system and reconstruction of existing side drains are recommended as the first priority in work schedule if possible, for to decrease gravity and infiltration at the high susceptible area as the map shown in figures 2, 3 & 4, and the details mentioned under the observations sub-title. To increase resisting force, breast wall, retaining wall, toe wall and check dam are suggested at the toe and even in the rupture surface.^{4,9-10} The proposed various walls like breast wall, retaining wall, toe wall and check dam are shown in figures 2, 3 & 4, respectively.

The lifespan of such recommended mitigation measures may depend on legislation. Construction of RCC building should be banned in the slumping localities. Building should be completed with suitable drainage system, house gutter and water reservoir. Implementation of building bye-law or building regulation for Saiha town was strongly suggested.

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