Slow mass movement in the Kangchenjunga Area, Eastern Nepal Himalaya

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Solifluction collectively represents slow mass wasting processes associated with freeze-thaw action (Ballantyne and Harris 1994, French 1996). Solifluction operates slowly, in general, at a rate of at most 1 m $year^{-1}$. Solifluction, nevertheless, contributes greatly to the evolution of mountain landscapes because of its widespread coverage on mountain slopes. Beside large coverage of periglacial environment, no efforts have yet been made in the cold region of the Nepal Himalaya, which is characterized by high relief, steep slope, and concentrated monsoon precipitation. This study attempts to quantify the rate and depth of displacement of the solifluction lobe in the uppermost part of the Ghunsa valley in the Kangchenjunga area **(Figure 1)**.

The accumulated displacement was measured using non-electric probe, i.e., glass fiber tubes at sites A and B **(Figure 1)** from 7 November 1998 to 26 November 2001. Soil auger, 1-m long and 13 mm in diameter was used to make a hole in the ground. The fiber tube in one side was tied with a small nut-bolt to prevent from uplifting by frost heaving. The side with nut-bolt was placed downward and inserted inside the ground with the help of steel pipe. The remaining gap was filled with fine soil. To obtain the displacement rate, the ground was excavated after two years and carefully scratched from one side of the fiber tube leaving another side sticking with the ground.

An improved strain probe method (Yamada and Kurashige 1996) was used to monitor continuous soil displacement from 1 December 2001 to 21 September 2002 at site B. An automatic data logger (KADEC-U of KONA System Co.), which stores data at intervals of one hour, was connected to the strain probe.

In addition, ground temperatures and soil moisture were monitored in order to understand the solifluction process. Ground temperatures of the solifluction lobes were monitored at three different depths of 6, 12 and 18 cm using data loggers (Thermo Recorder TR-52 of T & D Co.) from 24 April 2001 to 21 September 2002. Furthermore, the year-round ground temperature data taken on the mid-slope at 5433 m in altitude were used to show the general ground thermal condition. The soil moisture was measured only for 22 days from 19 April to 11 May, 2002. Soil moisture was measured by a soil moisture sensor (Theta Probe Type ML2x of Delta -T Devices Ltd) with ± 1% accuracy. Rain gauge was installed on the mid-slope at 5235 m in altitude from 21 April to 22 September, 2002 **(Figure 1)**. Precipitation data were recorded in a logger (HOBO Event of

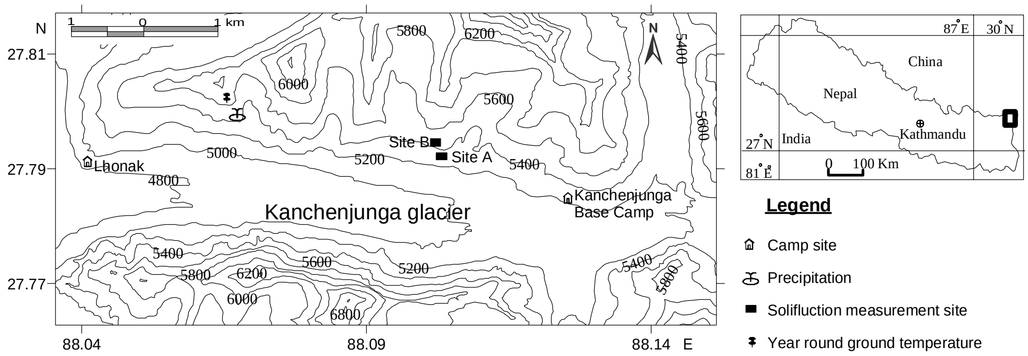

FIGURE 1. Location of the study area

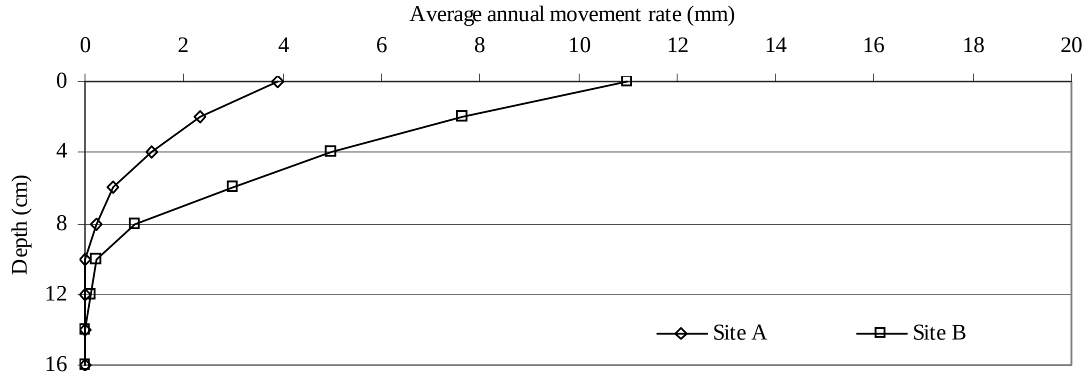

FIGURE 2. Average annual accumulated displacement rate of solifluction lobe at sites A and B

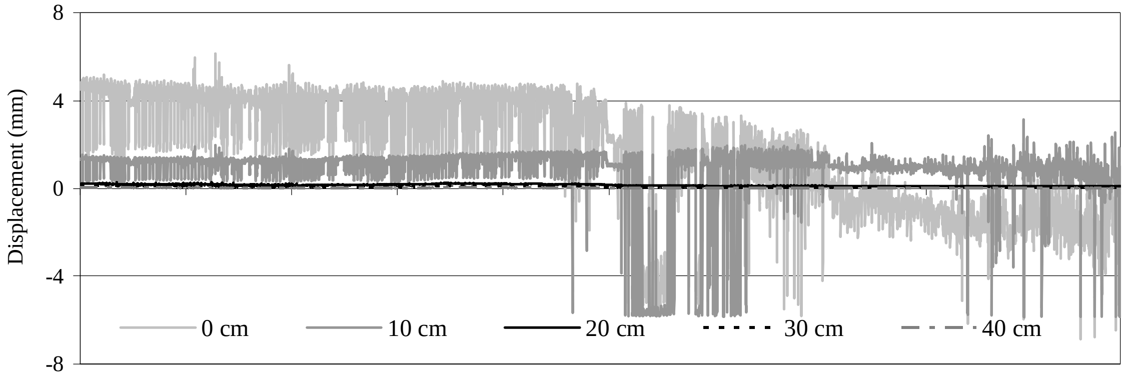

FIGURE 3. Displacement of soil at 0 cm, 10 cm, 20 cm, 30 cm and 40 cm depth from 1 December 2001 to 21 September 2002 at 5408 m (site B)

Onset Computer Co.) connected to a standard tipping-bucket rain collector.

The average movement rate of the glass fiber tubes at 5412 - 5414 m altitude with slope angle of 31° was about 11 mm/year, which was almost three times larger than that observed at 5322 - 5325 m with 22° slope angle (**Figure 2**). There was no significant difference in the depths which caused displacement at both sites. The continuous displacement near the ground surface at 5414 m shows permanent downslope movement from the middle of June. It may be attributed to high moisture supply in soil derived from precipitation. The amplitude of the displacement cycle was the largest at the ground surface, decreasing with increasing depth: the amplitude at and below 20 cm in depth is virtually zero (**Figure 3**). Although the soil moisture rises at each depth after precipitation events, the soil moisture content in general is very low. The low moisture content and the absence of freeze-thaw during monsoon period may be major factors leading to the slow rate of downslope displacement in this area.

References

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