St. Bernard Landslide, Southern Leyte, Field Report

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1. Background

Saint Bernard is a 4th class rural municipality in Southern Leyte, Philippines. Per 2000 census, it has a population of 23,089 people in 4,746 households . Guinsaugon, one of its barangays, lies on the valley surrounded by mountain ranges on the east and western part with a population of approximately 2,000 people Agriculture is the main livelihood with rice on the plain, coconut and banana trees on the hill slopes.

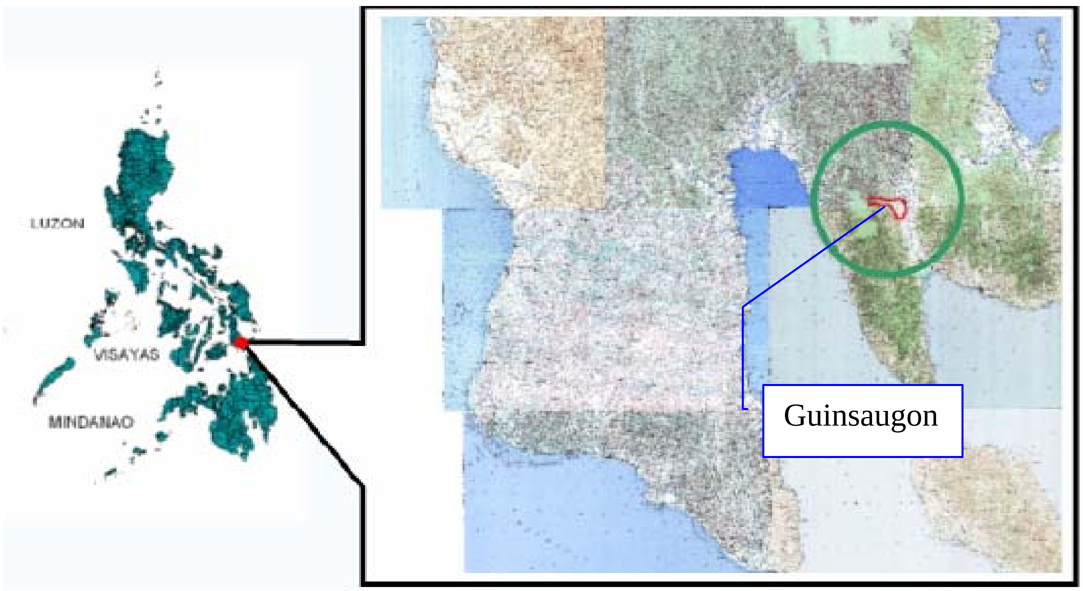

Figure 1, Location of St. Bernard, Southern Leyte

1.1 Physiography and Geology

The area is seismically active and on a geohazard zone as declared by the Mines and Geoscience Bureau, Department of Environment and Natural Resources. Fault lines traverse the mountain range in Guinsaugon and the adjoining barangays. The terrain of Guinsaguon and the surrounding barangays is steep mountains on the western part and flat on the eastern section. The foot of the mountain is characterized by many hills. At the landslide site, the slope is approximately 45º especially at the higher elevation, Figure 7. The highest peak at the landslide site is 700 meter above seal level.

Himbangan river runs from Mt. Abuyog crisscrossing to flat plains of Guinsaguon and Catmon and discharges to Cabalian Bay. Referring to the geological map, Figure 2, The upper portion of St. Bernard belongs chiefly of tuff, tuffies and tuffaceous sedimentary rocks. and the lowlands are quaternary The plain area is recent – described as alluvium, fluviatile, lacustine, paludal, and beach deposits, raised coral reefs, atolls and beachrock.

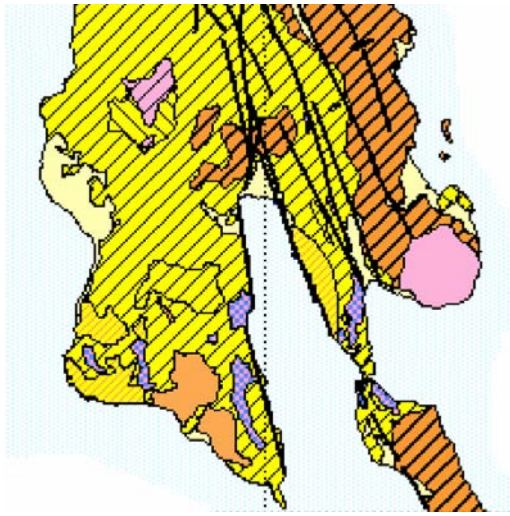

Figure 2 Fault Lines along Leyte

	Re, Recent ,Alluvium, Fluviatile, lacustrine, paludal, and beach deposits; raised coral reefs, atolls, and beachrocks
	N3 + Q1, Plioncene-Piestocene (G-H) Marine and terrestial sediments (molasses). Associated with extensive reef limestone in Bicol region, Visayas and Mindanao, with pyroclastics in western and southern Central Basin and in Northern Bicol Lowland. Predominatly marl and reworked tuff in places. Sporadic terrace gravel deposits in some coastal and fluvial tracts. Plateau red earths and/or laterites in some levated flat land surfaces. Deformation limited to gentle warping and vertical dislocation.
	N2 Upper Miocene-Pliocene (f3-g) Largely marine clastics (molasses) overlain by extensive, locally transgressively pyroclastics (chiefly tuff, tuffites) and tuffaceous sedimentary rocks. Associated with calcarenite and/or silty limestone in some parts of Luzon, central Visayas and Mindanao. Reefs limestone lenses intercalataed with dacite and andesite flows in Zamboanga (western Mindanao). Chiefly arkose and arenite in Palawan. Local bog iron; laterite deposites in some elevated near-peneplanced surfaces.
	N1 Oligecene – Pliocene (e1-f2) Thick, extensive, transgressive mixed shelf marine deposits, largely wakces, shales and reef limestone. Underlain by conglomerate and/or associated with paralic coal measures in places. Someteimes associated with basic to intermediate flows and pyroclastics within Luzon, Visayas, and Mindanao. Largely arkosic and quartzitic clastics (miogeosysnclinal type?) in southern Mindoro and Palawan. Genreally well undurated. Folded and locally intruded by quartz diorite. The ipidermal cover of many floded mountains. In some places probably includes Oilgocen (c-d)
	QV Pilocene-Quaternary Non-active cones (generally pyroxene adndesites); also dacitic and/or andesitic plugs. Basaltic dikes in Binga, Mt. Province, Luzon and in Misamis Oriental, Mindanao.
	NI Oligocene – Miocene Mostly submarine andesite and/or basalt flows. Intercalated with pyroclastis and clastic sedimentary rocks and/or reef limestone lenses. Largely confined withn the axial zones of Luzon, Visayas, and Mondanao.
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Source : Mines and Geoscience Bureau, DENR

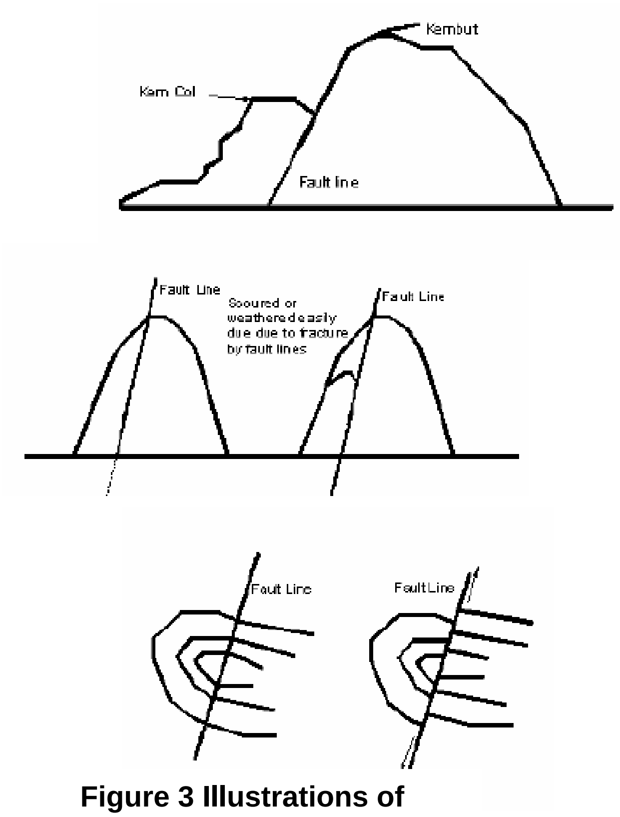

Figure 3 Illustrations of Development of Kerncol and Kernbut

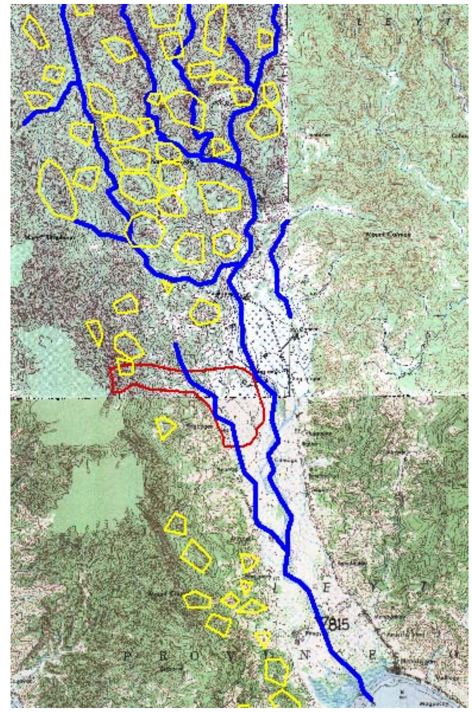

Figure 4, Topographical Map Overlaid with River Systems and Kerncol and Kernbut Around the Area

The major fault lines traverse the municipalities of Sogod, Libagon, St. Bernard and San Juan to Panaon Island. Fault lines run along the middle most stretch of the island of Leyte passing Guinsaguon at the lower tip. Please refer to Figure 4, the topographical map shows the river runs along the fault lines from north to south and the typical terrain has many kerncol and kernbut, enclosed with yellow polygons, which suggests that the area has been affected by existing active fault

1.2 Climate

The climate of Guinsaugon, St. Bernard, Figure 5 belongs to Type I – no dry season with a very pronounced maximum rainfall from November to January

The province is located within the area of less frequent tropical cyclones. Yearly typhoons affect the northern half of the island where Southern Leyte experienced heavy rains and occasional gusty winds.

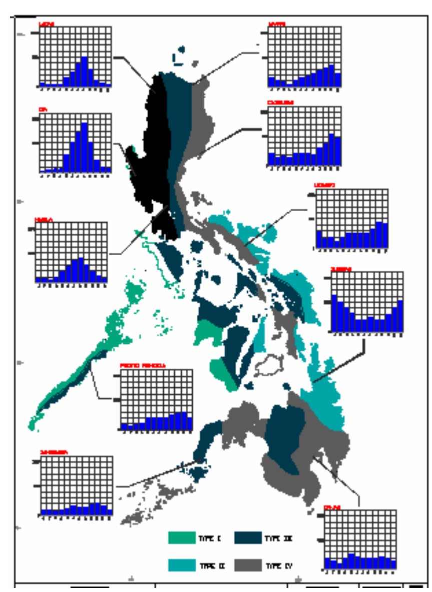

Figure 5 Climate Map of the Philippines

2. Landslide Observations

On February 17, 2006, landslide occurred in Guinsaugon, triggered by a two week heavy rainfall. The Department of Public Works and Highways requested JICA experts together with the PMO-FCSEC staff to assess and evaluate the extent of landslide and damage. On February 22 to 23, 2006, the site was investigated. The following are the conditions of the landslide area.

2.1 Damage Conditions

Affected population including the surrounding barangays were 3,850 families and 18,862 persons according to DSWD Central Office While those originating from Sug-anong, Ayahag, Guinsaugon, Magatas and Hinabian, Atuvan, Camaga and Himbangan were 654 families and 3,264 persons according to PSWD and PDCC, Southern Leyte.

Table 1 Missing and Casualties

Dead	Number	Remarks
Buried (identified and Unidentified)	139	
Missing	980	To include 248 (pupils and teachers) trapped inside the school building

Source : NDCC Update No. 16 Landslide at Guinsaugon, St. Bernard, : 28 February 2006 as of 5:00 PM

2.2 Rainfall Condition

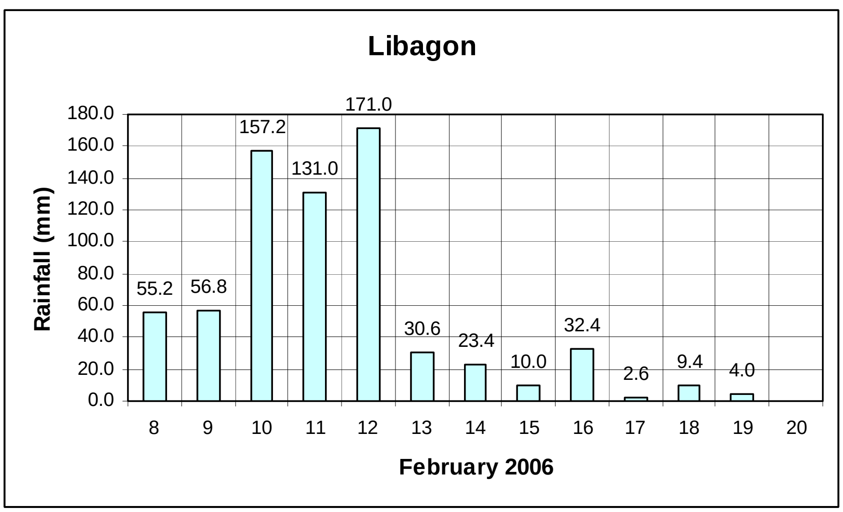

Figure 6, Rainfall Record at Libagon near the Guinsaugon

Source : PAGASA

Prior to the landslide there was antecedent continuous rainfall for two weeks in St. Bernard, Southern Leyte. Libagon raingauge, located approximately 6.8 km southwest of the landslide area (straight distance), registered 787 mm from February 1st to 20th . It peaked from 10th to 12th at 459.2 mm, on the 16th only 32.4 mm and on the 17th only 2 mm and became lighter thereafter up to the 20th. Total rainfall up to the 20th was 271 % higher than the normal compared to the mean monthly rainfall for Maasin, which is 290 mm. From 10th to 12th , there were landslides in Sogod Southern Leyte due to heavy rainfall. After five days. Guinsaguon landslide occurred.

2.3 Landslide Area Condition

The pre-landslide crown elevation was 700 m based on the topographic map with a maximum slope of 45º, mostly vegetated. It consists of sedimentary rocks such as upper Miocene, Pliocene as depicted in the geological map of Mines and Geoscience Bureau. Big boulders with tuff breccia can be found in the depositional area. Collapsed soil has high fluidity which flowed down up to 3 km, horizontal distance, see .Figures 7 and 10.

The slide area or scarp formed almost a v-cut shape, see Figure 8, approximately 300 to 400 m wide measured in between the undisturbed vegetation and approximately 50 m deep.

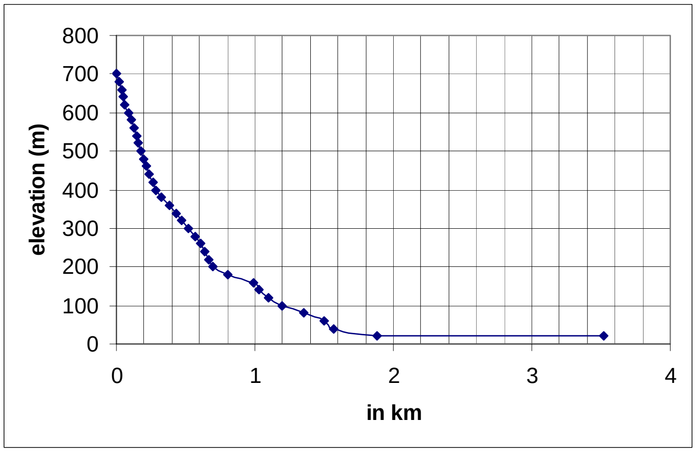

Figure 7 Slope Before the Landslide

Observation of the geological condition of the slid slope was difficult and dangerous at a very close range. From the front vantage using binocular at the rim of the depositional area, the inclined planar surface on the left is considered impermeable due to the surface runoff after the rainfall and the subsequent collapsed and the sliding of upper layer on the surface. On the right, the steep vertical unstable bed rock exhibits many cracks. Soil mass and splintered rocks spread over the slip surface and its vicinity. Rainfall, even of short duration, can generate debris flow as the boulders, rock fragments, and soil flow along with the runoff on the impermeable surface of the landslide valley. Observed for an hour was short heavy rainfall approximately 10 to 20 mm/hr caused the debris flow,

Before the heavy downpour on February 2006, there were no spring and surface flow on the slide area. Its existence after that rainfall implies that the slope in previous state has fractured cracks as it lies on the fault line, allowing infiltration and accumulation of ground water which triggered the slide.

Further, the distinction in land cover of the low ridge at the bottom of the mountain, please see Figure 8 in yellow circle, indicates that the collapse moved in high speed, ramped over and landed at a distance.

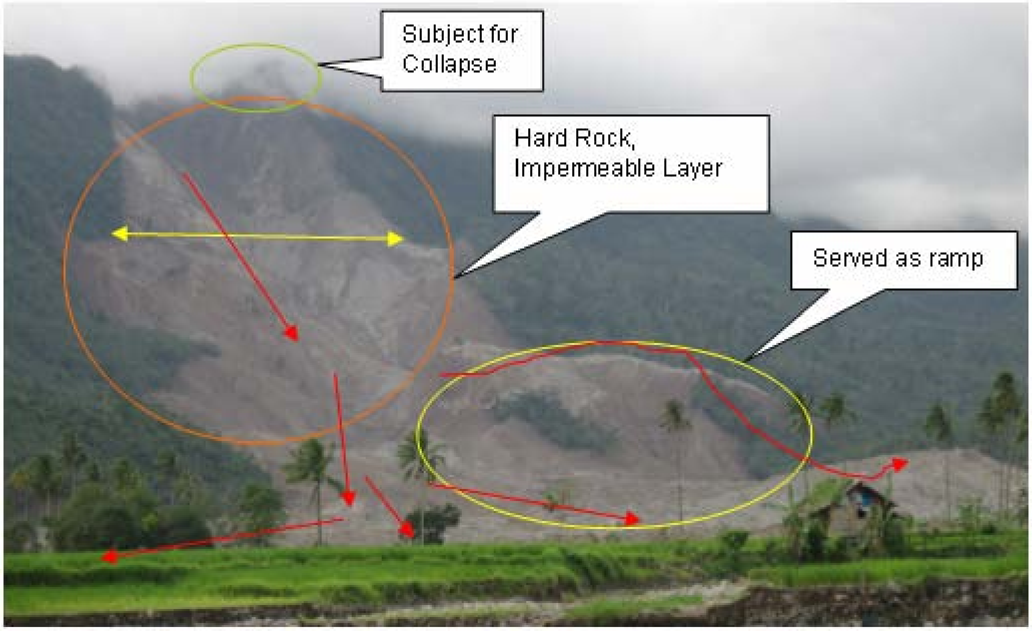

Figure 8 Aerial Perspective of the Landslide Area

2.4 Landslide Deposition Extent Condition

The extent of slide in Figure 9, measured by handheld GPS and aerial photo from the US Army, is approximately 2.6 $km^{2,}$ the area enclosed with red line. The depositional area, the shaded green area, is 1.6 km^2 reckoned from the foot of the mountain. By observation, the depth of deposition at the rim is up to 5 m, estimated from the exposed buried coconut trees and ± 10 m near the foot. If the average deposition is around 5 m, its volume is around 8 million m^3 or if the average depth is as shallow as 3m, its volume is approximately 4.8 million m^3, or roughly 5 million m^3.

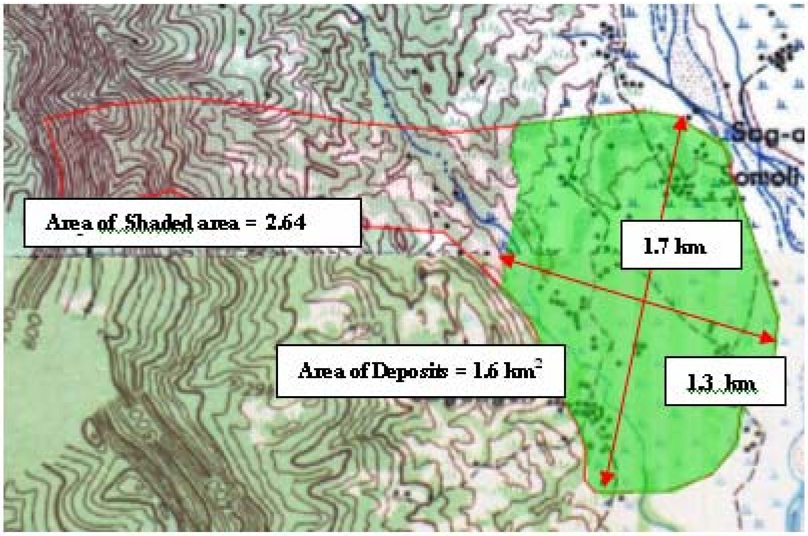

Figure 9 Overview of Sediment Deposition

The typical condition of the deposits was that the collapsed soil flowed down for more than a kilometer. Beyond 2 km and farther from the foot of the mountain, the slope is almost flat exhibiting high water content and high fluidity, which makes it difficult to proceed from the rim to the mid-depositional area.

Deposits are composed of fine sediment, big boulders containing gravel and tuff breccia. Near the river, materials are fractured rocks which differ from other locations.

Figure 10 Surface Flow

3.0 Analysis

On the mechanism of landslide. The area is a steep terrain on an active fault line. The landslide is categorized as block glide or translational slide, which moved in relatively planar surface. It was geological in nature triggered by heavy rainfall, not illegal logging as some people believed.

Prolonged and heavy rainfall penetrated through many cracks and concentrated on the impermeable layer on the left upper slide area. The underground water weakened the strength of the fractured rock and the colluvial soil on the impermeable layer due to water pressure until the mass collapsed.

Engr Jun Sacro, of DPWH Southern Leyte District Engineering Office, mentioned of a pond on top of the ridge before the slide. Pond is one of the features of landslide terrain formed by concentration of rainwater on the concave or crack due to landslide. Based on this, prior to the17th incident the area was becoming predisposed to slide.

These reports suggested the slope was potentially landslide prone as it is on an active fault line susceptible to cracks. Formation of cracks occurred before the peak rainfall on February 10-12, 2006 and then water penetrated the cracks until landslide occurred on February 17.

4. Recommendations

Entry to the disaster area is strongly discouraged during heavy rainfall due to unstable soil, rocks, strata and consequent debris flow. Monitoring of the overall conditions is essential to warn and safeguard the people.

The mechanism of the slide, the geological and topographical features inherent with the hazards should be surveyed in detail for verification and updating of the geological conditions so that areas requiring immediate attention in Southern Leyte can be identified.

As a priority consideration, the extent of the cracks mentioned in Bgy Catmon should be examined to prevent loss of lives and damages to agricultural lands in the event of impending slide.

There are still some residents at the foot of the mountains in Barangays Magatas and Catmon, just adjacent to Guinsaugon. Monitoring of rainfall, landslide and slope failure for warning system and evacuation should be set up. Residents should be trained to monitor traces and signs of impending slides through the use of gauges and conventional methods. As recommended by geologists, evacuation centers should be identified and the residents should be well aware of the procedures by engaging community participation and responsibility. Although it requires considerable resources, when feasible, relocation should be considered in the future.

Observed also was the emergency rehabilitation of road damaged by landslide. The emergency measure by the District Engineering Office to restore the traffic was cutting the foot of the slope for detour. However, this can weaken the base which holds the upper soil and rock layer.

To ensure its stability, its topography and geological structures must be scrutinized. If landslide is likely to occur, embankment of the road should be done instead of cutting new slope.

5. Acknowledgement

We wish to extend our deepest appreciation to the Katahira Engineers for assisting us in our site investigations and providing valuable inputs and materials.