INTEGRATED GEOELECTRICAL AND SEISMIC APPROACH FOR LANDSLIDE ASSESSMENT:A CASE STUDY IN THUNGSONG SITE,THAILAND.

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Abstract -*This research assesses the possibility of landslide risks in Thungsong Thailand using an integrated geoelectrical and seismic approach. Integrating Electrical Resistivity Tomography (ERT) and Seismic Refraction methods permits the research to map subsurface structures, determine possible slip surfaces, and evaluate soil and bedrock properties. Such results illustrate the effectiveness of these geophysical techniques in scanning regions prone to landslides, thus helping in risk management and land-use planning. This method provides an effective means of evaluating landslide risks in other areas of this sort.*

Key Words: **ERT, SRT, P-wave, Tomography, Seismic waves.**

1. INTRODUCTION

1.1. Background: It is a critical threat to human habitations and infrastructure, particularly for the areas with steep slopes and heterogeneous geological formations. Natural landslides can have a catastrophic impact, and understanding the causes and predicting future landslides is therefore vital to reduce their destructive impact. This limitation has made the integrated use of geophysical methods a prominent approach as traditional investigation methods frequently do not provide enough subsurface knowledge. Here we make use of both geoelectrical and seismic techniques to investigate the subsurface at the Thungsong site in Thailand, an area prone to landslide activity because of the geologic patchwork underneath its surface to provide a holistic image of the subsurface.

Detection and prediction of landslides are still verified difficult because of the complicated conditions of subsurface. The traditional single-method approaches might miss crucial elements. The integrated geoelectrical and seismic methods enhance the reliability of analysis, identifying potential slip surfaces and unstable areas This was the problem statement. Objectives of the Study are assessing subsurface conditions with integrated geoelectrical and seismic methods. Then they trace and locate possible landslide hazard regions and to validate each methods findings against the other for increased accuracy.

2. STUDY AREA

2.1. Geographical Setting: The chosen study site in Thungsong, Nakhon Si Thammarat Province, Thailand, is an area prone to complex topography and landslides. Thungsong is in the south of Thailand and has a tropical monsoon climate. The region has high seasonal rainfall, particularly during the southwest monsoon season from May to October, with average annual precipitation higher than 2,000 mm. Steep slopes and heavy rainfall combined result in high slope instability in the area.

The study area is encircled by rolling hills and low mountains whose elevations range from 50 to 300 meters above sea level. Heavy rainfall, in addition to the slopes, has resulted in a high number of past landslides. Main transport corridor and settlements are within the susceptible areas, making accurate landslide risk assessment more necessary.

2.2 Geological Features

The Thungsong region is composed of metamorphic and sedimentary units, predominantly shale, sandstone, and decomposed granite. The surface is covered with loamy colluvial soil which is highly permeable but tends to get waterlogged. The weak top layer makes landslides more probable, especially during periods of prolonged rainfall. Some important features are:

Soil Composition: Upper layers comprises colluvial deposits of silt, sand, and clay.

Bedrock: Siltstone and sandstone together with other sedimentary rocks that have low to moderate resistivity and seismic velocity makes the upper portions of the ground.

Fault Lines: Minor brittle faults and fissures which facilitate entry of water and decrease slope stability may be found the region.

Hydrogeological Conditions: The region is characterized by rapid oscillations of ground water having a considerable impact on slopes stability. During rain, water seeps in and increases the pore water pressure within the soil which results in lower shear strength, making the slopes prone to failure. On the other hand, lower water levels in the dry season enhances slope stability temporarily. Preliminary investigations showed some surfaces of seepage and ground water movement. These zones, delineated by geoelectrical and seismic surveys, tend to significantly destabilize the slope structure and amplify the risk of landslides, which makes them extremely decisive for reason of landslide hug susceptibility.

2.3. Landslide History

The Thungsong area has historically experienced recurrent slides particularly on the road networks as well as the settlement areas. In the monsoon seasons of 2011 and 2017, landslides occurred and infrastructure was damaged along with loss of agricultural land.Primary Factors are anthropogenic and technological modification, the intensity of rainfall, and seismic activity. All slopes that possess a high degree of soil moisture as well as those that have a low cover of colluvium are the most susceptible to landslides. The negative impacts include obstructions of roads, destruction of houses, and degradation of soil which endangers the communities.

3. LITERATURE REVIEW

Existing Research Overview: Various geophysical methods have been used in previous landslide assessment studies. Using Electrical Resistivity Imaging (ERI) can help in detecting moisture zones and detecting slip surface. This gives us insight into the elastic properties of the material below the surface (subsurface), helping us to identify weak spots. Integrated methods have higher accuracy than individual techniques [Sujitapan 2022]. Basic Structure in previous research. It's excellent that a number of the sources concentrate on studying subsurface abnormalities using seismic and geoelectrical techniques. According to study by Jongmans and Garambois (2007), combined techniques in landslide-prone areas offer a thorough assessment of hazards. However, only a small number of studies provide a thorough cross-comparative evaluation of seismic and geoelectrical measures. This study closes this gap by offering a comprehensive strategy and cross-referencing results for more precise outcomes.

4. METHODOLOGY

The study area was located in Thungsong, Thailand, where the geology is complicated and landslides frequently occur. Heavy rainfall also occurs in the region, increasing the likelihood of slope failure. The Electrical Resistivity Tomography (ERT) approximately and P-wave Seismic Refraction Tomography (SRT) surveys were undertaken along four longitudinal profiles (line 1, line 2, line 3 and line 4) in a northeast-southwest direction across the study site. Line 1 and Line 4 skirt across the slopes of known historical landslide features and are nearly parallel to Line 2 and Line

3. A second survey line (Line BH) is situated close to borehole at UTM 47P 586600E 900613N, about 600 m away from the main survey profiles (Fig. 1). Having a calibration reference is line BH, Line BH is used as a survey calibration with lithological borehole data. Consequently, the purpose of this study is to reveal the use of SRT and ERT with the 2D crossplot model to investigate internal structure and mechanisms of landslide in a remote and challenging-to-reach location. The 2D Cross-Plot Analysis is aimed to identify sliding plane in landslide areas by analysing two key parameters: P-wave velocity and resistivity. Integration of these methods conjunction with borehole data is a pioneering effort in this geological setting of landslides, particularly in areas affected by monsoonal rainfall and characterized by mountainous terrain. for the reconciliation of geophysical information with the lithological information from boreholes. This research intends to prove that combining SRT and ERT data with the 2D cross-plot model is useful in the analysis of the internal structure and processes of landslides in remote regions. In the 2D Cross-Plot Analysis, the main objective is to determine sliding planes within the landslide zones by associating the P-wave velocities with the resistivity values. The adaptation of this integrated methodology along with borehole calibration is new for the investigation of landslides in the monsoonal regions with high topography and deeply eroded landforms.

3.1. Geoelectrical Method: The Wenner-Schlumberger array was applied to resistivity imaging to provide characterization of the subsurface on high detail profiles.

3.2. Seismic Method: Seismic refraction surveys were done to evaluate the elastic characteristics of the subsurface and to differentiate the loose and compacted zones.

3.2.3.Data Collection: Resistivity data was stored with the help of a multi-electrode system along 3 survey lines.

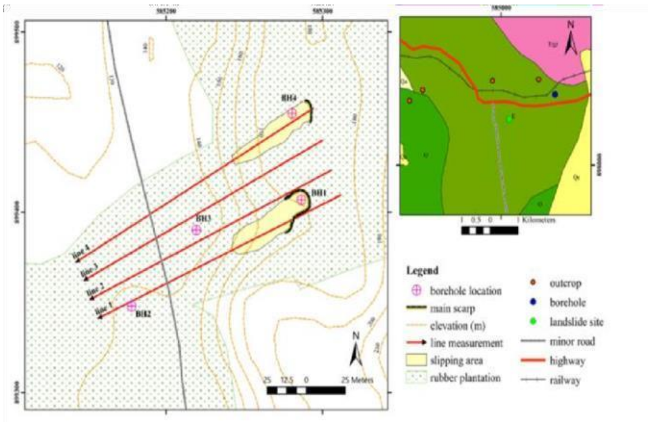

Fig 1: Map of the geophysical survey in the study area.

5. RESULT AND DISCUSSION

The subsurfaces structures along with their relation to the landslide phenomena were defined with the help of integrated geo-electrical and seismic surveys in combination with traditional geological mapping.

Geoelectrical Findings: In combination with water restivity measurements, ERT results reflect changes in resistivity that are characteristic to various geological layers. The deep resistivity measured in the high positions range, >1000 \Omega m, suggests that there are compact bedrock located below. At the same time low resistivity which is also measured near the surface <100 \Omega m, suggests that there are water saturated soils together with slip surfaces. Considerable regions of low resistivity for Line 1 and Line 4 at the depths of10-20m suggest that there are saturated layers of clay causing instability due to previous landslides.

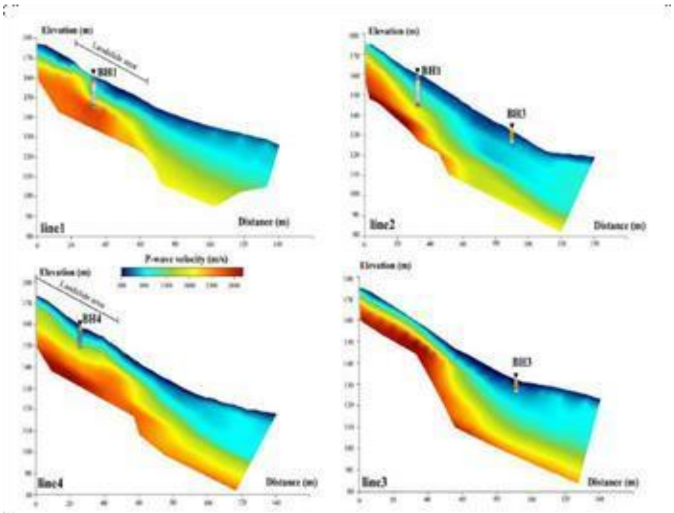

Fig 2: SRT results correlated with borehole data in this landslide area.

Seismic Findings: The results of SRT reflect the geographical distribution of velocity of the P-wave and show variations of the low-velocity zone. The low-velocity zones <1500m/s were noticed close to the bed surface out of the rock material, clay, while those situated deeper are filled with other unconsolidated materials. The greater activities >3000m/s mark the bedrock compartment. The notice of well-defined low-velocity zones placed underneath the low-velocity layers along the line together with higher velocity layers is characteristic for the slip surface positions. Integrated Analysis: By the cross-plot analysis of resistivity results of ERT.

6. CONCLUSION

Result from the Electrical Resistivity Tomography (ERT) surveying show very different resistivity values that clearly correspond to different subsurface material. Low resistivity (1000 Ωm) at deeper levels suggest compacted bedrock which will offer stability. Nearby the scarp zones, anomalous resistivity patterns suggest possible deformation and moisture ingress, aligned with past landslide occurrences. All this is realized by the SRT results interpreting. The P-wave velocities obtained from Seismic Refraction Tomography (SRT) results were well correlated with the resistivity values of ERT. Low-velocity zones (3000 m/s) are stiff, consolidated soil layers [9].

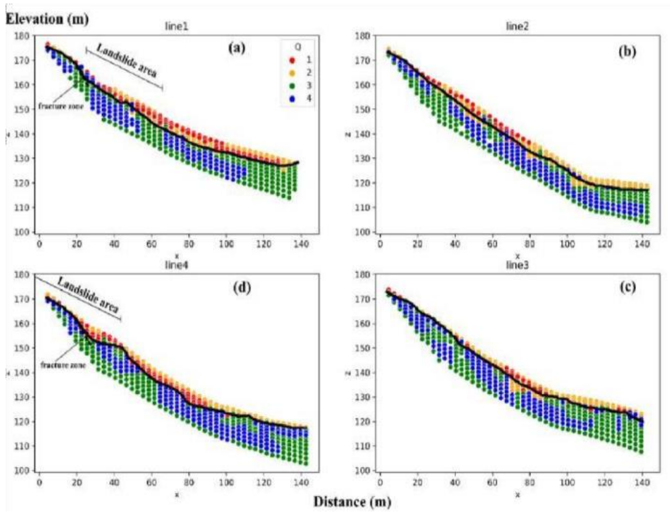

Fig 3: 2D cross plot model of P wave velocity

P-wave velocities from the Seismic Refraction Tomography (SRT) insights were correlated well with the findings of ERT. Low-velocity zones (3000 m/s) correspond to competent bedrock. In particular, Line 1 and Line 4 showed different low-velocity layers with respect to their high- velocity zones, indicating the slip surfaces. The subsurface discontinuities were further taken up to derive potential shear zones that are likely to initiate landslide movements in the seismic profiles.

The merged output of ERT and SRT results reveals a holistic understanding of the landslide mechanisms. The sliding planes were accurately demarcated by the cross-plot of resistivity and P wave velocities, highlighting its correlation with borehole data from Line BH. Integrating these two models improved identification of unstable zones and proved the efficacy of the combined geophysical approaches in terrain.

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