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Kyoto University
Clarification on the Internal Structure of Landslide Dam by Microtremor array survey method

Yasuhiro Mitani (Shimane University)
Fawu WANG
Austin Chukwuekka OKEKE
Yohei KUWADA
Taiki ADACHI
Hufeng YANG
Fikri FARIS

Landslide dam
It is formed by backing up river current due to landslide.

Failure factor
① Failure due to overflow erosion
② Failure due to sliding failure
③ Failure due to progressive failure

Natural dams in the world

Formation sites of landslide dam in Japan
Formation of landslide dam centers site is related to topographic and geological conditions, natural phenomena (earthquake, heavy rain, eruption).

Past study outcome
From the aspect of topography and geology, hydrology, study of landslide dam made progress. Therefore, precision of failure and countermeasure techniques were developed.

Matter of present situation
Not understand about the internal structure of landslide dam.
Less-advanced about study of progressive failure that is depended on the internal structure of landslide dam.

Study purpose
Clarify the internal structure of landslide dam using geophysical exploration.

Occurrence distribution of Sediment disaster in Kii peninsular
Huge slope failure: 32 places
Landslide dam formation: 17 places
Five places of those are objective of urgency investigation (MLIT)

Akatsui landslide
Kurideira landslide
The total rainfall distribution figure by analysis rainfall estimation. From 5 pm of August 30th to 24 pm of September 6th.

Rainfall by typhoon No.12

Grain size distribution of materials from dam body

- Akatani: 1.87, 6.27, 13.47, 7.20, 1.56
- Kurida: 1.11, 5.29, 14.15, 12.70, 1.78

Conducted geophysical exploration on investigation area

Self-potential method
It can figure out subsurface characteristic by measuring electrical potential that occur as natural phenomenon.

Feature: Easy to use and inexpensive price, not affected by season.

Microtremor array survey (Chain array survey)
It can estimate subsurface structure of ground by extracting surface wave from micromotion of ground surface.

Feature: Easy to measure, not damaged ground.
**Self-potential method**

\[ V = V_1 - V_2 \]
- Potential difference between a pair of electrodes \( V_1 \) and \( V_2 \)
- \( V_1 \), \( V_2 \): Each electrode potential difference
- \( V_1 \): Each contact potential difference with ground of electrode
- \( V_2 \): Internal potential difference of voltmeter
- \( r_3 \): Impedance of voltmeter

**Occurrence of streaming potential by ground water flow**

Model of electric double layer

Ground water vein

Potential difference occur by negative electric charge of soil and positive electric charge of water in interfacial surface between soil and water. Area having negative electric charge is obtained due to ground water takes out positive electric charge from surrounding soil.

**Microtremor array survey method**

Microtremor placement on SPAC method can set up linear arrangement by making replacement to semi-circularity, get the phase velocity section from dispersion curve.

**Theoretical concept of spatial auto correlation method**

1. Correlativity between center point and circle point

\[ Y_{rr}(f, R, R') = \frac{1}{2\pi f} \int_{-\infty}^{\infty} \hat{S}(f, R) \hat{S}(f, R') df \]

\( \hat{S}(f, R) \): Fourier spectrum of observation waveform in center
\( \hat{S}(f, R') \): Fourier spectrum of observation waveform around point

2. Correlativity of all circumferences orientation average

\[ p(f) = \frac{1}{2\pi} \int_{-\infty}^{\infty} \hat{S}(f, R) df \]

\( p(f) \): Spatial auto correlation of frequency average

3. Compute of phase velocity from inverse function of Bessel function

\[ v(f) = \frac{2\pi f}{s_0} \sqrt{s_0^2 - (p(f))^2} \]

**Geophysical exploration loci on Akatani landslide**
SP method result on Akatani landslide

Upper figure: Topography cross section figure of survey line
Middle figure: Potential cumulative curve figure
Lower figure: Potential gradient curve figure

Chain array survey result on Akatani landslide

Placement spacing of microtremor
AA’ survey line: 3m
BB’ survey line: 3m
CC’ survey line: 3m
DD’ survey line: 1.5m
Observation time: 15 minutes

Geophysical exploration loci on Kuridaira landslide

SP method result on Kuridaira landslide

Upper figure: Topography cross section figure of survey line
Middle figure: Potential cumulative curve figure
Lower figure: Potential gradient curve figure

Geophysical exploration loci on Kuridaira landslide

Chain array survey result on Kuridaira landslide

Placement spacing of microtremor
AA’ survey line: 10m
Observation time: 15 minutes

Conclusion

Conclusion of Akatani landslide dam
• There are changing sites of streaming potential, then it can presume that those sites are ground water vein from lake.
• Surface layer of dam is soft layer and high void ratio. Layer thickness of dam internal is not showed uniformity, was deposited as disturbance state.

Conclusion of Kuridaira landslide dam
• Changing sites of streaming potential was measured near drainage during construction.
• Surface layer of dam is soft layer and high void ratio. Dip angle is gradual, dip direction trended downstream.
私たち会員企業は、地質調査業が地質、土質、地盤、地下水など、主として地中の不可視なるものを見つけることの技術情報という無体物を成果品とする知識産業であることを自覚し、優れた専門技術をもって、顧客の要望に応えるとともに、地質調査業の職業上の地位並びに社会的な評価の向上に努めます。

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