

## **ABSTRACT**

There are several factors may cause the dam unstable such as structural instability, excessive hydraulic gradients, seepage through dam core and its foundation, sudden drawdown in reservoir, and seismic excitations. The aims of this research are: (a) to conduct an engineering geological map of Gondang dam site, (b) to analyze seepage and slope stability of main dam with and without traffic loads under three loading conditions, i.e. the right after construction, steady state seepage, and sudden drawdown conditions, (c) to analyze those cases in (b) with seismic load, and (d) to analyze the slope stability of reservoir under steady state condition (long-term flood condition) with and without seismic load and the sudden drawdown condition.

In order to achieve these objectives, an engineering geological map at a 1:5000 in scale was conducted by using Geographical Information System (GIS) tool. The slope stability analyses were performed using the computer program Slide 6.0, a software developed by Rocscience Inc. The slope stability analyses were carried out using a limit equilibrium method, while the seepage analyses were performed using finite element method with circular failure modes. The total and effective stress of soil properties parameters are used. The data such as geomorphology (slope inclination), rocks and soils engineering properties, geological structures, groundwater seepage, and landslides susceptibility were done by surface engineering geological mapping. Both rock and soil samples which analyzed to determine the engineering properties were used for reservoir slope stability analyses. Rock mass qualities and rock strengths were determined by using Geological Strength Index (GSI) classification and Uniaxial Compressive Strength (UCS).

The lithology in this study area was divided into two units, namely andesite breccia and andesite tuff-breccia units. The weathering degree of each units varied from slightly to highly weathered. Moreover, there were four engineering geological properties such as sandy elastic silt, very poor andesite breccia, poor andesite breccia and poor andesite tuff-breccia, and fair andesite breccia and fair andesite tuff-breccia covered 20%, 25%, 40%, and 15% of the research area,

respectively. The rock mass was sorted into three zones of safe cut slope such as very poor surface quality (RMR 17 – 20) had a safe cut slope angle smaller than 40°, poor surface quality (RMR 21 – 40) had safe cut slope angle about 45°, and fair surface quality (RMR 41 – 50) had safe cut slope angle around 55°. The classification of rock foundation is in fair condition and had the allowable bearing pressure varied from 1350 – 2800 kPa. On the other hand, the results of slope stability analyses of main dam showed that the dam was stable against the slope failure and the seepage through the core and its foundation as well.

The reservoir slope section F – F' and I – I' was unstable when earthquake may happen and during sudden drawdown condition. The instability of slope section I – I' was very concerned because it may affect the main dam construction. However, after design and analyses of reservoir slope section I – I' by using support systems (cantilever wall and shotcrete), the results showed that this slope was stable enough against the future failure. Therefore, the retaining wall and shotcrete were suggested to use in preventing a serious problem in the future.

**Keywords:** Geological structures, groundwater seepage, landslides susceptibility, hydraulic gradients, seismic excitation.

## SARI

Beberapa faktor yang berpotensi menyebabkan bendungan menjadi tidak stabil di masa depan seperti ketidakstabilan struktural, gradien hidraulik yang berlebihan, rembesan melalui inti bendungan dan fondasinya, penurunan tiba-tiba di reservoir, dan pengaruh seismik. Tujuan dalam penelitian ini adalah: (a) untuk melakukan peta geologi teknik situs bendungan Gondang, (b) untuk menganalisis rembesan dan stabilitas lereng bendungan utama dengan dan tanpa beban lalu lintas dalam tiga kondisi pemuatan pembebanan yaitu, setelah konstruksi, keadaan rembesan stabil, dan kondisi *drawdown* mendadak, (c) untuk menganalisis kasus-kasus pada kondisi (b) dengan beban seismik, dan (d) menganalisis stabilitas lereng reservoir dalam kondisi *steady* (kondisi banjir jangka panjang) dengan dan tanpa beban seismik dan kondisi *drawdown* mendadak.

Untuk mencapai tujuan ini, dilakukan pembuatan peta geologi teknik dengan skala 1:5000 menggunakan Sistem Informasi Geografis (SIG). Analisis stabilitas lereng dilakukan menggunakan program Slide 6.0, sebuah perangkat lunak yang dikembangkan oleh Rocscience Inc. Analisis stabilitas lereng dilakukan dengan menggunakan metode *limit equilibrium*, sedangkan analisis rembesan dilakukan menggunakan metode *finite element* dengan mode *circular failure*. Tegangan total dan efektif dari parameter sifat tanah digunakan. Data-data seperti geomorfologi (kemiringan lereng), sifat-sifat teknik batuan dan tanah, struktur geologi, rembesan air tanah, dan kerentanan tanah longsor didapatkan melalui pemetaan geologi teknik permukaan. Sampel batuan dan tanah dianalisis untuk menentukan sifat material yang digunakan untuk analisis stabilitas lereng reservoir. Kualitas massa batuan dan kekuatan batuan ditentukan dengan menggunakan klasifikasi *Geological Strength Index* (GSI) dan *Uniaxial Compressive Strength* (UCS).

Litologi di daerah penelitian dibagi menjadi dua unit, yaitu *andesit breccia* dan *andesite tuff-breccia unit*. Tingkat pelapukan masing-masing unit bervariasi dari sedikit hingga sangat lapuk. Kualitas batuan terbagi menjadi 4 yaitu, *sandy elastic silt* yang mencakup 20%, *very poor breccia* meliputi 25%, *poor andesite breccia and poor andesite tuff breccia* yang menutupi 40%, *fair andesite breccia and fair andesite tuff breccia* yang adil meliputi 15% daerah penelitian. Massa

batuan dipilah ke dalam tiga zona lereng potong aman seperti kualitas permukaan yang sangat buruk (RMR 17 – 20) memiliki sudut lereng potong aman lebih kecil dari 40°, kualitas permukaan buruk (RMR 21 – 40) memiliki sudut lereng lereng dipotong aman sekitar 45°, dan kualitas permukaan yang adil (RMR 41 – 50) memiliki sudut kemiringan potong yang aman sekitar 55°. Klasifikasi pondasi batuan dalam kondisi wajar dan memiliki tekanan bantalan yang diijinkan bervariasi dari 1350 – 2800 kPa. Di sisi lain, hasil analisis stabilitas lereng bendungan utama menunjukkan stabil terhadap kegagalan lereng, rembesan melalui inti bendungan dan fondasi.

Kemiringan reservoir bagian F – F' dan I – I' tidak stabil ketika gempa bumi terjadi dan selama kondisi penarikan tiba-tiba. Ketidakstabilan bagian lereng I – I' sangat mengkhawatirkan karena dapat mempengaruhi konstruksi bendungan utama. Setelah desain dan analisis lereng lereng bagian I – I' menggunakan sistem pendukung (dinding kantilever dan shotcrete), menunjukkan bahwa lereng ini cukup stabil terhadap kegagalan di masa depan. Oleh karena itu, dinding penahan dan shotcrete disarankan untuk digunakan dalam mencegah masalah serius di masa depan.

**Kata kunci:** Struktur geologi, rembesan air tanah, kerentanan longsor, gradien hidraulik, eksitasi seismik.