INTISARI

Gempa bumi yang bersumber dari *shallow crustal* dapat bersifat sangat merusak terutama bagi daerah padat penduduk di Pulau Jawa. Padatnya penduduk tersebut mengakibatkan terjadinya peningkatan mobilitas kendaraan dan mendorong pembangunan jalan tol. Namun, dikarenakan investasi jalan tol membutuhkan biaya yang sangat besar, diperlukan perencanaan yang baik untuk meminimalisir kerusakan akibat gempa bumi dan dampaknya, seperti likuefaksi. Salah satu jalan tol yang berpotensi mengalami likuefaksi adalah Jalan Tol Yogyakarta–Bawen dengan tingkat kerentanan sedang.

Peak Ground Acceleration (*PGA*) merupakan salah satu faktor penentu likuefaksi. Nilai *PGA* di lokasi penelitian didapatkan dari analisis probabilistik dan deterministik. Analisis *Safety Factor* (*SF*) dilakukan menggunakan *simplified procedure* yang diusulkan oleh Boulanger dan Idriss. Berdasarkan nilai *SF* tersebut, dilakukan perhitungan *Liquefaction Potential Index* (*LPI*) berdasarkan Iwasaki dkk., *Liquefaction Severity Index* (*LSI*) berdasarkan Sonmez dan Gokceoglu, *Lateral Displacement Index* (*LDI*) berdasarkan Zhang dkk., dan analisis s*ettlement* berdasarkan Yoshimine dkk. Setelah diketahui lapisan yang berpotensi terlikuefaksi, dilakukan analisis mitigasi menggunakan *stone column* secara empiris menggunakan metode Priebe dan secara elemen hingga (*Finite Element Method*/*FEM*) menggunakan *PLAXIS 2D*.

Nilai *PGA* yang digunakan berasal dari analisis probabilistik menggunakan LINI Bina Marga, sebesar 0,314–0,365g. Hasil analisis potensi likuefaksi, diperoleh 24 titik yang berpotensi terlikuefaksi, dengan *LPI* mulai dari rendah sampai sangat tinggi. Berdasarkan hasil analisis *LSI*, terdapat potensi kerusakan mulai dari *very low* sampai *low*. Terdapat potensi penurunan tanah mulai dari *light to no damage* hingga ekstensif. Selain itu, terdapat potensi perpindahan lateral tanah hingga 3,97 meter. Mitigasi likuefaksi dilakukan dengan *stone column* berdiameter 0,8 meter dan diperoleh jarak optimum antar pusat *stone column* sebesar 1,44 meter. Hasil analisis *FEM*, *stone column* mampu mengurangi peningkatan rasio tekanan air pori berlebih (r_u), mengurangi hilangnya *effective stress* sebesar 64,88%, mengurangi peningkatan *shear-strain* dari 0,741% menjadi 0,038%, dan nilai tekanan air pori berlebih (p_{excess}) dari -60,37 kN/m^2 menjadi -39,82 kN/m^2.

Kata kunci: Jalan Tol Yogyakarta–Bawen, *Peak Ground Acceleration*, Likuefaksi, *Stone Column*, *PLAXIS 2D*

ABSTRACT

Earthquakes originating from shallow crustal origin can be very destructive, especially for high populated areas on the Java island. The high population has resulted in increased vehicle mobility and encouraged the construction of toll roads. However, because toll road investment requires very large costs, good planning is needed to minimize damage from earthquakes and their impacts, such as liquefaction. One of the toll roads that has the potential to experience liquefaction is the Yogyakarta–Bawen Toll Road with a moderate level of vulnerability.

Peak Ground Acceleration (PGA) is one of the determining factors for liquefaction. The PGA value at the research location was obtained from probabilistic and deterministic analysis. Safety Factor (SF) analysis was carried out using the simplified procedure proposed by Boulanger and Idriss. Based on the SF value, the Liquefaction Potential Index (LPI) was calculated based on Iwasaki et al., Liquefaction Severity Index (LSI) based on Sonmez and Gokceoglu, Lateral Displacement Index (LDI) based on Zhang et al., and settlement analysis based on Yoshimine et al. After identifying the layers that have the potential to liquefy, a mitigation analysis was carried out using a stone column empirically using the Priebe method and finite element method (FEM) using PLAXIS 2D.

The PGA value used comes from probabilistic analysis using LINI Bina Marga, amounting to 0.314–0.365g. The results of the liquefaction potential analysis showed that 24 points had the potential for liquefaction, with LPI ranging from low to very high. Based on the results of the LSI analysis, there is potential for damage ranging from very low to low. There is potential for land subsidence ranging from light to no damage to extensive. In addition, there is the potential for lateral ground displacement of up to 3.97 meters. Liquefaction mitigation was carried out with a stone column with a diameter of 0.8 meters and obtained an optimum distance between the centers of the stone columns of 1.44 meters. The results of the FEM analysis show that the stone column is able to reduce the increase in the excess pore water pressure ratio (r_u), reduce the loss of effective stress by 64.88%, reduce the increase in shear-strain from 0.741% to 0.038%, and the excess pore water pressure value of -60.37 kN/m^2 becomes -39.82 kN/m^2.

Keywords: Yogyakarta–Bawen Toll Road, *Peak Ground Acceleration, Liquefaction, Stone Column, PLAXIS 2D*