

Likuefaksi merupakan fenomena yang terjadi ketika tanah pasir jenuh kehilangan kekuatan gesernya akibat peningkatan tekanan air pori berlebih selama pembebanan gempa. Evaluasi potensi likuefaksi umumnya dilakukan menggunakan metode *simplified procedure* yang mengasumsikan kondisi *free field* sehingga tidak mempertimbangkan pengaruh fondasi terhadap likuefaksi. Oleh karena itu, diperlukan kajian yang mampu mengevaluasi pengaruh keberadaan fondasi terhadap potensi likuefaksi. Penelitian ini bertujuan untuk membandingkan potensi likuefaksi kondisi *free field* dengan fondasi tiang, mengevaluasi pengaruh variasi jarak antar tiang terhadap potensi likuefaksi, serta membandingkan hasil evaluasi menggunakan metode *simplified procedure* dengan metode numerik.

Evaluasi awal dilakukan menggunakan *simplified procedure*. Selanjutnya, analisis numerik dilakukan menggunakan PLAXIS2D dengan model konstitutif PM4SAND untuk mensimulasikan respons tanah pasir jenuh terhadap pembebanan gempa. Analisis dilakukan pada kondisi *free field* dan kelompok fondasi tiang dengan variasi jarak antar tiang pada tiga kondisi muka air tanah.

Metode *simplified procedure* memberikan estimasi potensi likuefaksi pada kedalaman 3 hingga 20 meter. Hasil ini lebih konservatif dibandingkan analisis numerik yang menunjukkan potensi likuefaksi pada kedalaman 6 hingga 20 meter. Hasil analisis numerik menunjukkan bahwa keberadaan fondasi tiang mampu menurunkan nilai *excess pore water pressure ratio* ( $r_u$ ) di sekitar fondasi dibandingkan kondisi *free field*. Pada muka air tanah 0 m, nilai rasio area  $r_u$  maksimum berturut-turut sebesar 97%, 99%, 88%, dan 75% untuk kondisi *freefield*, jarak tiang 3,2 m, 2,5 m, dan 1,5 m. Pada muka air tanah -3 m diperoleh nilai  $r_u$  sebesar 88%, 86%, 85%, dan 74%, sedangkan pada muka air tanah -6 m sebesar 60%, 57%, 58%, dan 53%. Konfigurasi jarak tiang 1,5 m menunjukkan reduksi likuefaksi paling signifikan serta laju pembangkitan tekanan air pori yang lebih lambat dibandingkan konfigurasi lainnya. Hasil penelitian menunjukkan bahwa jarak antar tiang berpengaruh terhadap potensi likuefaksi, di mana jarak yang rapat menghambat perkembangan tekanan air pori berlebih.

**Kata kunci:** Likuefaksi, PM4SAND, Analisis Dinamik, Fondasi Tiang, *excess pore pressure ratio*

### ABSTRACT

Liquefaction is a phenomenon in which saturated sandy soils lose their shear strength due to the buildup of excess pore water pressure during earthquake loading. Liquefaction potential is commonly evaluated using the simplified procedure, which assumes free field conditions and does not account for the influence of foundations. Therefore, further investigation is needed to assess the effect of pile foundations on liquefaction behavior. This study compares liquefaction potential under free field conditions and in the presence of pile foundations, evaluates the influence of pile spacing, and compares results from the simplified procedure and numerical analysis.

Initial assessments were conducted using the simplified procedure, followed by numerical simulations in PLAXIS 2D employing the PM4SAND constitutive model. Analyses were performed for free field conditions and pile groups with different spacings under three groundwater table levels.

The simplified procedure predicted liquefaction at depths of 3 to 20 m, while numerical analyses indicated liquefaction at depths of 6 to 20 m, showing that the simplified method was more conservative. Numerical results demonstrated that pile foundations reduced the excess pore water pressure ratio ( $r_u$ ) around the piles compared with free field conditions. For a groundwater table at 0 m, the maximum  $r_u$  area ratios were 97%, 99%, 88%, and 75% for the free field condition and pile spacings of 3.2 m, 2.5 m, and 1.5 m, respectively. For groundwater tables at -3 m, the corresponding values were 88%, 86%, 85%, and 74%, while for groundwater tables at -6 m, they were 60%, 57%, 58%, and 53%. Among the analyzed configurations, the 1.5 m pile spacing produced the greatest reduction in liquefaction potential and the slowest buildup of excess pore water pressure. These findings indicate that pile foundations can mitigate liquefaction effects and that pile spacing significantly influences liquefaction potential. Closer pile spacing was found to be the most effective in restraining excess pore water pressure development.

**Keywords:** Liquefaction, PM4SAND, Dynamic Analysis, Pile Foundation, Excess Pore Water Pressure Ratio.