INTISARI

Candi Borobudur merupakan salah satu peninggalan budaya yang sudah diakui sebagai warisan dunia oleh UNESCO. Situs Candi Borobudur berada di sekitar Yogyakarta dan dikelilingi oleh empat buah gunung berapi. Candi Borobudur berada di Dataran Kedu yang merupakan pertemuan dua sungai. Lokasi Candi Borobudur berada di kawasan rawan terjadi bencana alam seperti letusan gunung berapi dan gempa bumi. Oleh karena itu Candi Borobudur perlu dipantau. Pemantauan aspek geoteknik yang dilakukan didapat informasi mengenai kondisi tanah area Candi Borobudur. Selain itu pemantauan aspek geometrik secara berkala dilakukan dengan menggabungkan dua metode geodetik yaitu metode GPS dan terestris. Pada penelitian terdahulu belum diketahui model deformasi 3D aspek geometrik yang terjadi di area Candi Borobudur. Oleh karena itu pada penelitian ini bertujuan untuk menentukan model deformasi 3D aspek geometrik area Candi Borobudur yang sesuai dengan kondisi fisis area Candi Borobudur.

Penelitian ini menggunakan data koordinat toposentrik dan ketelitian titik kontrol Candi Borobudur. Pengolahan dibagi menjadi dua skenario dan empat potongan. Perbedaan kedua skenario adalah jumlah titik yang diikutkan dalam proses perataan di setiap potongan. Empat potongan tersebut adalah potongan 1 dan 2 (Utara-Selatan) serta potongan 3 dan 4 (Timur-Barat). Analisis menggunakan uji statistik, meliputi uji *similarity*, uji *congruency*, uji global dan uji signifikansi parameter. Data koordinat toposentrik juga digunakan untuk membentuk model permukaan Candi Borobudur. Model permukaan Candi Borobudur ini selanjutnya digunakan untuk visualisasi vektor regangan 3D hasil perataan model deformasi 3D Candi Borobudur. Model deformasi 3D yang digunakan dibagi menjadi enam model, yaitu model lengkap, regangan-rotasi, rotasi, translasi, translasi-rotasi dan polinomial 3D.

Hasil penelitian ini menunjukkan nilai parameter deformasi bervariasi pada translasi, rotasi dan regangan 3D. Secara umum keenam model deformasi diterima di area penelitian, akan tetapi ada parameter yang signifikan dan tidak signifikan. Model rotasi cocok pada skenario I potongan 1 data *epoch* 2002 dan 2012 serta skenario I potongan 1 dan skenario II potongan 3 data prediksi 10 tahun. Komponen parameter translasi, rotasi dan regangan 3D signifikan di area penelitian apabila ditinjau dari hasil uji signifikansi tiap komponen. Hasil visualisasi regangan 3D berbeda dengan pola deformasi aspek fisis di Candi Borobudur. Hasil analisis geometrik 3D area Candi Borobudur terindikasi mengalami *swelling.* Akan tetapi informasi geoteknik diketahui bahwa pengaruh *swelling-shrinking* tidak terjadi di area penelitian. Perbedaan hasil antara dua metode disebabkan karena penelitian geoteknik terfokus pada struktur Candi Borobudur, sedangkan fokus penelitian ini di area Candi Borobudur. Kurang rapatnya titik kontrol Candi Borobudur dan tidak diikutsertakan besaran parameter aspek fisis dalam pemodelan memberikan hasil yang berbeda.

Kata kunci: Candi Borobudur, model deformasi 3D, regangan 3D.

ABSTRACT

Borobudur temple is one of the cultural heritage that has been verified as world heritage by UNESCO. The location of Borobudur temple is near Yogyakarta and surrounded by four volcanoes. Borobudur temple located in Kedu Plain, this area were confluence of two rivers. Borobudur temple located in high risk natural disasters areas such as volcanic eruptions and earthquakes. Because of the location in high risk disasters areas, therefore Borobudur temple should be monitored. Geotechnical aspects monitoring process obtained information on soil conditions of Borobudur temple area. Another research is geometrical aspects that held periodically combine two methods, there are the GPS and terrestrial methods. The last research do not give an information about 3D deformation model of the geometric aspect that occurs in the area of Borobudur temple. Therefore, the objective of this research is to determine 3D deformation model of geometric aspect in Borobudur temple area that suitable to the physical condition of the Borobudur temple area.

This research used toposentric coordinate and the precission of the Borobudur temple control points. Processing in this research divided by two scenarios and four blocks. The difference between two scenarios is the number of point that include in adjustment process on each block. The four blocks are block 1 and 2 (North-South) and block 3 and 4 (East-West). The analysis using statistical test that consists of a similarity, congruency, global and significance test. Toposentric coordinate data also processed to build Borobudur temple digital terrain model. This model then used for the visualization of 3D vector strain obtained from the processing of 3D deformation model of Borobudur temple. 3D deformation model that used in this research divided by six model, there were complete model, strain-rotation model, rotation model, translation model, translation-rotation model and 3D polynomial model.

The result of this research showing the varying values of deformation parameter in translation, rotation and 3D strain. In general, the deformation model acceptable in the research area, but there are significant and not significant parameters. The rotation model suitable on block 1 scenario I using 2002 and 2012 data. This model also suitable on block 1 scenario I and block 3 scenario II using 10 years prediction data. However, translation, rotation and 3D strain parameters are significant for each component in the research area. The deformation model shows that swelling happened in the Borobudur area based on polynomial 3D models and complete models of all points adjustment results. The 3D strain visualization give different compared with the illustration of physical aspect in Borobudur temple. The geotechnic aspect gave information that swelling-shrinking never happened in the area. The factors that gave different result between two methods were the geotechnic research main focus in the Borobudur structure, but this research main focus in the Borobudur temple area. Another factors were Borobudur control points not covered the area and when processed the physical parameters not included in adjustment process. So this three factors might be the factor that gave different result between two methods.

Keywords : Borobudur temple, 3D deformation model, 3D visualization.