INTISARI

Perkembangan dan pembaharuan standar mengikuti perkembangan teknologi tak dipungkiri menyebabkan struktur yang dibangun sesuai standar lama tidak memenuhi persyaratan teknis standar baru. Salah satu metode perkuatan atau *retrofitting* elemen struktural eksisting yang sering dilakukan yakni dengan *concrete jacketing, steel jacketing*, dan FRP *(fiber reinforced polymer) jacketing*. FRP *jacketing* menawarkan beberapa kelebihan dibandingkan metode *jacketing* lainnya dengan kekuatan yang tinggi, ringan, tahan terhadap korosi, mudah dalam pemasangan dan memerlukan sedikit bekisting dan perancah. Salah satu material FRP di antaranya *glass fiber reinforced polymer* (GFRP) yang merupakan alternatif yang lebih ekonomis dibanding *carbon fiber*. Beberapa penelitian terkait perkuatan beton menggunakan GFRP telah dilakukan. Akan tetapi, penelitian-penelitian tersebut belum membandingkan keakuratan antara hasil analisis dan pola kegagalan metode analisis eksperimen, teoritis, dan numerik.

Dengan demikian, penelitian ini dilakukan untuk meneliti pengaruh kekangan 3 lapis GFRP terhadap karakteristik beton dalam menahan beban desak, baik secara eksperimental, analisis teoritis, maupun simulasi numerik. Eksperimen dilakukan dengan menggunakan silinder beton ukuran 150 mm × 300 mm mutu 25 MPa yang dilapisi dengan 3 Lapis GFRP arah serat homogen 0°. Total digunakan empat buah spesimen dalam penelitian ini dengan variasi silinder kontrol dan silinder dengan dilapisi 3 lapis GFRP masing-masing 2 buah silinder uji. Dari hasil pengujian desak, kurva tegangan-regangan dapat diperoleh yang kemudian dibandingkan dengan kurva hasil analisis teoritis dan numerik. Simulasi numerik dilakukan dengan Abaqus CAE di mana beton dimodelkan sebagai elemen solid, dengan *concrete damage plasticity* dan GFRP dimodelkan sebagai *shell* dengan Hashin *damage*.

Berdasarkan hasil eksperimen, beton dengan kekangan 3 lapis GFRP menghasilkan tegangan ultimit (f'_{cc}) sebesar 46,97 MPa, regangan ultimit (ε_{cu}) sebesar $1{,}30\times10^{-2}$, dan perbedaan kurva antar spesimen sebesar 2,98%. Analisis teoritis menghasilkan nilai perbedaan kurva terhadap hasil eksperimen sebesar 9,44%. Di sisi lain, analisis numerik yang dilakukan dengan hasil konvergensi ukuran *mesh* 5 mm dan sudut dilasi 40°, menghasilkan nilai perbedaan kurva sebesar 34,50%. Nilai perbedaan ini dapat diturunkan menjadi 11,56% dengan menggunakan persamaan Mander modifikasi untuk beton terkekang. Pola kerusakan analisis numerik menghasilkan pola yang mirip dengan eksperimen yakni beton mulai rusak tetapi fiber belum putus saat pengujian dihentikan. Berdasarkan hasil tersebut, analisis numerik dapat memberikan hasil yang cukup akurat untuk memprediksi perilaku desak silinder beton dengan kekangan GFRP.

Kata kunci: Beton; Kekangan GFRP; Kuat Desak; Simulasi Numerik; Pola Kegagalan

ABSTRACT

The development of standards in line with technological advancements inevitably result in structures built according to older standards not meeting the technical requirements of new standards. One common method of strengthening or retrofitting existing structural elements is through concrete jacketing, steel jacketing, and FRP (fiber reinforced polymer) jacketing. FRP jacketing offers several advantages over other jacketing methods, including high strength, light weight, corrosion resistance, ease of installation, and minimal formwork and scaffolding requirements. Among FRP materials, glass fiber reinforced polymer (GFRP) is a more economical alternative compared to carbon fiber. Several studies on strengthening concrete using GFRP have been conducted. However, these studies have not yet compared the accuracy between the results of the analysis and the failure patterns of experimental, theoretical, and numerical analysis methods.

hus, this study was conducted to investigate the effect of 3-layer GFRP confinement on the characteristics of concrete in resisting compressive loads, using experimental methods, theoretical analysis, and numerical simulations. The experiment was conducted using concrete cylinders of size 150 mm × 300 mm with a strength of 25 MPa, wrapped with 3 layers of GFRP with homogeneous fiber orientation at 0°. A total of four specimens were used in this study, with variations of control cylinders and cylinders wrapped with 3 layers of GFRP, each consisting of 2 test cylinders. From the compressive load tests, stress-strain curves were obtained and compared with the curves from theoretical and numerical analysis. Numerical simulations were performed using Abaqus CAE, where concrete was modeled as a solid element with concrete damage plasticity, and GFRP was modeled as a shell with Hashin damage.

Based on experimental results, concrete with 3 layers of GFRP confinement produces an ultimate stress (f'_{cc}) of 46.97 MPa, an ultimate strain (ε_{cu}) of 1.30×10^{-2}, and a curve difference between specimens of 2.98%. Theoretical analysis results in a curve difference compared to experimental results of 9.44%. On the other hand, numerical analysis, conducted with mesh size convergence of 5 mm and dilation angle of 40°, results in a curve difference of 34.50%. This difference can be reduced to 11.56% by using the modified Mander equation for confined concrete. The damage pattern from numerical analysis shows a pattern similar to the experiment, where the concrete begins to fail but the fiber has not broken when the test is stopped. Based on these results, numerical analysis can provide sufficiently accurate results for predicting the compressive behavior of concrete cylinders with GFRP confinement.

Keywords: *Concrete; GFRP Confinement; Compressive Strength; Numeric Simulation; Failure Pattern*