# ABSTRAK

Perubahan pada standar desain struktur gedung membuat gedung-gedung yang ada tidak memenuhi kriteria standar baru. Struktur tersebut memerlukan perkuatan struktur agar tetap dapat melayani fungsinya. Perkuatan eksternal menggunakan *Fiber Reinforced Polymer* (FRP) merupakan sistem perkuatan yang banyak ditinjau beberapa dekade terakhir. Salah satu jenis FRP, yaitu *Carbon Fiber Reinforced Polymer* (CFRP) merupakan salah satu material yang populer digunakan karena memiliki kuat tarik paling tinggi di antara jenis lainnya. Perkuatan eksternal menggunakan CFRP sering tidak dapat mencapai kapasitas optimal karena kegagalan *debonding*, yaitu terlepasnya CFRP dari permukaan beton. Berbagai penelitian mengenai fenomena *debonding* pada perkuatan eksternal menggunakan CFRP telah banyak ditinjau. Model *bond* antara CFRP dan beton pada umumnya diperoleh melalui pengujian eksperimental maupun simulasi menggunakan *Finite Element Model* (FEM).

Metode utama dalam penelitian disertasi ini adalah pengembangan model numerik berbasis *Rigid Body Spring Model* (RBSM) dengan pengujian eksperimental sebagai penunjang. Pengujian eksperimental digunakan untuk mendapatkan respons *bond* geser dan *bond* normal tarik antara CFRP dan beton. Sebanyak masing-masing 12 spesimen diuji untuk mendapatkan respons *bond*. Model analisis sensitivitas disimulasikan untuk mendapatkan model optimal. Model optimal selanjutnya dikalibrasi terhadap hasil pengujian eksperimental balok beton dengan CFRP. Performa model terkalibrasi dianalisis dan didiskusikan.

Berdasarkan hasil pengujian eksperimental, model *bond* geser dapat dimodelkan sebagai material bilinier, sedangkan model *bond* normal tarik dapat dimodelkan sebagai material linier. Kekakuan awal model turun setelah pengimplementasian model *bond* dan akurat menyimulasikan kekakuan awal rata-rata spesimen. Berdasarkan hasil kalibrasi, properti *bond* geser dan *bond* normal tarik memiliki rasio 30% terhadap properti material beton untuk mendapatkan mode kegagalan *concrete peeling* seperti pada spesimen. Hasil studi parametrik penggunaan luasan CFRP lentur sebesar 0,034% dapat meningkatkan kapasitas balok beton menjadi 3,75 kali lipat.

Kata kunci: model *bond*, beton, CFRP, model elemen diskret, RBSM

ABSTRACT

The changes in building structural design codes make existing buildings do not meet the new standard criteria. The structure requires structural strengthening to maintain its services. Externally bonded reinforcement using Fiber Reinforced Polymer (FRP) is one of strengthening techniques that is widely reviewed in recent decades. One type of FRP, namely Carbon Fiber Reinforced Polymer (CFRP) is one of the most popular materials used because it has the highest tensile strength among other types. Externally bonded reinforcement using CFRP frequently cannot reach its optimal capacity due to debonding failure, namely the separation of CFRP from the concrete surface. Numerous studies regarding the debonding phenomenon in the externally bonded reinforcement using CFRP have been widely reviewed. Bond models between CFRP and concrete are obtained through experimental tests and simulations using the Finite Element Model (FEM).

The main method in this research thesis is the development of a numerical model based on the Rigid Body Spring Model (RBSM) with experimental testing as complementary method. Experimental tests were used to obtain the shear bond and normal tensile bond response between CFRP and concrete. A total of 12 specimens were tested to obtain the bond response. The sensitivity analysis models are simulated to obtain the optimal model. The optimal model is further calibrated to the experimental results of concrete beams with CFRP. The performance of the calibrated model is analyzed and discussed.

Based on the experimental results, the shear bond model can be modeled as bilinear material, while the normal tension bond model can be modeled as linear material. The initial stiffness of the model drops after implementing the bond model and is accurate in simulating the average initial stiffness of the specimens. According to the calibration results, the properties of shear bond and normal tension bond model have ratio of 30% compared to those of concrete material to produce concrete peeling failure mode as in the specimens. Parametric studies reveal that using flexural CFRP with an area of 0.034% can increase the concrete beam bending capacity to 3.5 times.

Keywords: Bond model, concrete, CFRP, discrete element model, RBSM