ABSTRAK

Sebagai negara berkembang, Indonesia terus mendorong pembangunan infrastruktur berkelanjutan seperti jembatan, jalan, dan gedung, dengan beton bertulang sebagai material utama karena kekuatan serta fleksibilitasnya dalam desain. Namun, banyak struktur beton bertulang mengalami penurunan kinerja akibat faktor usia dan kurangnya perawatan, khususnya pada elemen balok yang berfungsi menyalurkan beban ke kolom penopang. Salah satu metode perkuatan yang efisien dan inovatif untuk mengatasi permasalahan tersebut adalah Near Surface Mounted (NSM) dengan pelat baja. Penelitian ini bertujuan untuk mengkaji pengaruh perkuatan NSM menggunakan pelat baja 3 mm terhadap perilaku lentur balok beton bertulang persegi melalui pendekatan eksperimental dan numerik berbasis metode elemen hingga menggunakan perangkat lunak GID dan ATENA. Pengujian laboratorium dilakukan pada tiga jenis balok, yaitu balok kontrol (BK), balok dengan perkuatan pelat baja lebar 20 mm (BP2D), dan lebar 40 mm (BP4D), dengan parameter uji meliputi kapasitas lentur, daktilitas, penyerapan energi, dan pola keruntuhan. Validasi model numerik dilakukan menggunakan metode Normalized Mean Square Error (NMSE), kemudian dilanjutkan dengan studi parametrik terhadap variasi kuat tekan beton serta strategi perkuatan. Penelitian ini menggunakan 11 benda uji yaitu BNK (balok tanpa perkuatan), BNP2D (balok perkuatan pelat baja tebal lebar 20 mm), BNP4D (balok perkuatan pelat baja lebar 40 mm), BNK-17, 5 (balok tanpa perkuatan dengan kuat tekan beton 17,5 MPa), BNP2-17, 5 (balok perkuatan pelat baja lebar 20 mm, kuat tekan beton 17,5 MPa), BNP4-17,5 (balok perkuatan pelat baja lebar 40 mm, kuat tekan beton 17,5 MPa), BNK-50 (balok tanpa perkuatan dengan kuat tekan beton 50 MPa), BNP2-50 (balok perkuatan pelat baja lebar 20 mm, kuat tekan beton 50 MPa), BNP4-50 (balok perkuatan pelat baja lebar 40 mm, kuat tekan beton 50 MPa), BNP-SP2 (balok dengan perkuatan pelat baja lebar 20 mm di sisi samping balok), serta BNP-SP4 (balok dengan perkuatan pelat baja lebar 40 mm di sisi samping balok). Hasil analisis menunjukkan bahwa peningkatan kuat tekan beton dan lebar pelat baja berpengaruh signifikan terhadap peningkatan kapasitas beban ultimit, kekakuan, serta penyerapan energi balok. Penempatan pelat baja pada sisi bawah daerah tarik menghasilkan peningkatan kekakuan paling efektif, meskipun sedikit menurunkan daktilitas. Balok dengan mutu beton 50 MPa dan pelat baja berlebar 20 mm menunjukkan peningkatan kapasitas beban lentur hingga 66%.

Kata kunci: struktur perkuatan, *Near Surface Mounted* (NSM), pelat baja, balok beton bertulang, perilaku lentur, studi parametrik.

ABSTRACK

As a developing country, Indonesia continues to promote sustainable infrastructure development such as bridges, roads, and buildings, with reinforced concrete serving as the primary material due to its strength and design flexibility. However, many reinforced concrete structures experience performance degradation as a result of aging and insufficient maintenance, particularly in beam elements that function to transfer loads to supporting columns. One efficient and innovative strengthening method to address this issue is Near Surface Mounted (NSM) reinforcement using steel plates. This study aims to investigate the effect of NSM strengthening with 3 mm steel plates on the flexural behavior of rectangular reinforced concrete beams through both experimental and numerical approaches based on the finite element method using GID and ATENA software. Laboratory tests were conducted on three types of beams, namely control beams (BK), beams strengthened with 20 mm wide steel plates (BP2D), and beams with 40 mm wide steel plates (BP4D). The test parameters included flexural capacity, ductility, energy absorption, and failure patterns. Numerical model validation was carried out using the Normalized Mean Square Error (NMSE) method, followed by a parametric study on variations in concrete compressive strength and strengthening strategies. This research utilized 11 specimens: BNK (unstrengthened beam), BNP2D (beam strengthened with 20 mm wide steel plate), BNP4D (beam strengthened with 40 mm wide steel plate), BNK-17.5 (unstrengthened beam with 17.5 MPa compressive strength), BNP2-17.5 (beam strengthened with 20 mm wide steel plate, 17.5 MPa compressive strength), BNP4-17.5 (beam strengthened with 40 mm wide steel plate, 17.5 MPa compressive strength), BNK-50 (unstrengthened beam with 50 MPa compressive strength), BNP2-50 (beam strengthened with 20 mm wide steel plate, 50 MPa compressive strength), BNP4-50 (beam strengthened with 40 mm wide steel plate, 50 MPa compressive strength), BNP-SP2 (beam strengthened with 20 mm wide steel plate on the beam's side), and BNP-SP4 (beam strengthened with 40 mm wide steel plate on the beam's side). The results indicated that increasing concrete compressive strength and steel plate width significantly enhanced the ultimate load capacity, stiffness, and energy absorption of the beams. Placement of steel plates on the tensile zone at the bottom of the beam yielded the most effective improvement in stiffness, although with a slight reduction in ductility. Beams with 50 MPa concrete strength and 20 mm wide steel plates demonstrated an increase in flexural load capacity of up to 66%.

***Keywords*: strengthening structure, Near Surface Mounted (NSM), steel plate, reinforced concrete beam, flexural behavior, parametric study.**