ANALISIS KERENTANAN BANGUNAN MASJID AL-IKHLAS ULAK KARANG PADANG AKIBAT BEBAN GEMPA BUMI DAN TSUNAMI MENGGUNAKAN KURVA FRAGILITAS

TUGAS AKHIR

Oleh:

WISESA DANADIPA
NIM: 2110923002

PROGRAM STUDI SARJANA TEKNIK SIPIL
DEPARTEMEN TEKNIK SIPIL
FAKULTAS TEKNIK
UNIVERSITAS ANDALAS

PADANG
2025

ABSTRAK

Kota Padang merupakan kawasan dengan tingkat kerentanan tinggi terhadap bencana gempa bumi dan bencana tsunami karena berada di zona subduksi Lempeng Indo-Australia dan Lempeng Eurasia. Masjid Al-Ikhlas yang berlokasi ±500 meter dari garis pantai difungsikan sebagai shelter sekaligus tempat ibadah, akibat adanya isu megathrust dengan kekuatan gempa hingga 8,5 magnetudo perlu dilakukan evaluasi kerentanan struktur terhadap beban gempa dan tsunami. Penelitian ini bertujuan untuk menganalisis kerentanan bangunan Masjid Al-Ikhlas akibat beban gempa bumi dan beban tsunami dengan menggunakan pendekatan kurva fragilitas untuk mengetahui probabillitas kerusakan bangunan. Peraturan yang digunakan mencakup SNI 1726:2019 untuk peraturan pembebanan gempa, SNI 1727:2020 untuk peraturan pembebanan, SNI 2847:2019 untuk desain beton struktural, dan FEMA P-646:2019 sebagai acuan desain struktur vertikal terhadap beban tsunami. Pemodelan struktur dilakukan pada struktur atas menggunakan software ETABS dengan sistem rangka terbuka (open frame). Analisis dilakukan melalui dua metode utama, yaitu analisis statik nonlinier (pushover analysis) dan analisis gabungan (pushover analysis dan nonlinear time history analysis) dengan data gempa aktual (Chi-Chi, Kobe, dan Supertition Hill) yang diskalakan dengan gempa kota Padang. Beban tsunami dihitung berdasarkan delapan komponen gaya mengacu pada peraturan FEMA P-646:2019 tentang pembebanan tsunami. Nilai-nilai maksimum perpindahan yang diperoleh dari kedua jenis beban (gempa dan tsunami) digunakan untuk membentuk Probabilistic Seismic Demand Model dan menghasilkan kurva fragilitas dengan pendekatan distribusi lognormal. Hasil analisis menunjukkan bahwa bangunan Masjid Al-Ikhlas memiliki tingkat probabilitas kerusakan yang cukup tinggi terhadap kedua skenario bencana. Pada skenario gempa bumi dengan metode pushover dengan PGA 0,6g kurva fragilitas menunjukkan probabilitas kerusakan arah X ringan sebesar 92,30%, sedang 72,99%, berat 59,50%, dan kerusakan total 27,10% dan arah Y ringan sebesar 96,99%, sedang 85,70%, berat 67,82%, dan kerusakan total 24,18% sedangkan untuk metode gabungan probabilitas kerusakan ringan sebesar 100%, sedang 99,96%, berat 40,07%, dan kerusakan total 1,20% dengan nilai PGA 0,6g bedasarkan peta gempa kota Padang SNI 1726:2019. Untuk kurva fragilitas beban tsunami dengan metode pushover dan variasi ketinggian tsunami, dengan ketinggian genangan 5 meter, probabilitas kerusakan ringan mencapai 100%, sedang 99,99%, berat 56,87%, dan kerusakan total 6,26%. Dari hasil kurva fragilitas menujukan bahwa bangunan Masjid Al-Ikhlas rentan terhadap beban gempa dan tsunami dikarenakan kerusakan sedang ≥70% dan kerusakan berat ≥40%. Hasil penelitian ini dapat menjadi acuan dalam peninjauan ulang desain struktural, serta menjadi dasar dalam perencanaan retrofit atau perkuatan bangunan demi meningkatkan kekuatan infrastruktur tanggap darurat.

Kata kunci : Kurva Fragilitas, Shelter, Probabilitas Kerusakan Bagunan, Tsunami, Gempa Bumi

ABSTRACT

The city of Padang is an area with a high level of vulnerability to earthquake and tsunami disasters because it is located in the subduction zone of the Indo-Australian Plate and the Eurasian Plate. The Al-Ikhlas Mosque, located approximately 500 meters from the coastline, serves as both a shelter and a place of worship. Due to the megathrust issue with a potential earthquake magnitude of up to 8.5, it is necessary to evaluate the structural vulnerability to earthquake and tsunami loads. This study aims to analyze the vulnerability of the Al-Ikhlas Mosque building under earthquake and tsunami loads using the fragility curve approach to determine the probability of structural damage. The regulations used include SNI 1726:2019 for earthquake loading provisions, SNI 1727:2020 for loading provisions, SNI 2847:2019 for structural concrete design, and FEMA P-646:2019 as a reference for vertical structural design against tsunami loads. The structural modeling was carried out for the superstructure using ETABS software with an open frame system. The analysis was conducted using two main methods: nonlinear static analysis (pushover analysis) and combined analysis (pushover analysis and nonlinear time history analysis) with actual earthquake data (Chi-Chi, Kobe, and Superstition Hill) scaled to the earthquake level in Padang. Tsunami loads were calculated based on eight force components referring to FEMA P-646:2019 on tsunami loading. The maximum displacement values obtained from both types of loads (earthquake and tsunami) were used to form the Probabilistic Seismic Demand Model and generate fragility curves using a lognormal distribution approach. The results of the analysis show that the Al-Ikhlas Mosque building has a relatively high probability of damage under both disaster scenarios. In the earthquake scenario using the pushover method with PGA 0.6g, the fragility curve indicates a probability of damage in the X direction of 92.30% (slight), 72.99% (moderate), 59.50% (extensive), and 27.10% (complete); and in the Y direction of 96.99% (slight), 85.70% (moderate), 67.82% (extensive), and 24.18% (complete). For the combined method, the probability of damage was 100% (slight), 99.96% (moderate), 40.07% (extensive), and 1.20% (complete) with PGA 0.6g based on the earthquake map of Padang City from SNI 1726:2019. For the tsunami load fragility curve using the pushover method and variations in tsunami height, with a 5-meter inundation height, the probability of damage reached 100% (slight), 99.99% (moderate), 56.87% (extensive), and 6.26% (complete). The fragility curve results indicate that the Al-Ikhlas Mosque building is vulnerable to earthquake and tsunami loads, as moderate damage is ≥70% and extensive damage is ≥40%. The results of this study can serve as a reference for structural design reassessment, as well as a basis for planning retrofitting or strengthening measures to enhance the resilience of emergency response infrastructure.

Keywords: Fragility Curve, Shelter, Probability Of Building Damage, Tsunami, Earthquake