INTISARI

Evaluasi kinerja seismik bangunan merupakan bagian penting dari konsep *Performance-Based Seismic Design/Evaluation* (PBSD/PBSE) yang menekankan pemenuhan level kinerja tertentu, mulai dari *Operational* hingga *Collapse Prevention*. Pendekatan ini tidak hanya menilai apakah struktur mampu bertahan setelah gempa, tetapi juga mengevaluasi sejauh mana bangunan dapat tetap berfungsi sesuai kebutuhan operasionalnya. Oleh karena itu, *viscoelastic damper* (VED) dihadirkan sebagai salah satu perangkat disipasi energi yang berperan penting dalam mengendalikan respons inelastis struktur, menjaga keamanan penghuni, serta memastikan bangunan mencapai target level kinerja yang ditetapkan. Penelitian ini secara khusus menerapkan pendekatan PBSE pada Gedung *Smart and Green Learning Center* (SGLC) UGM untuk mengkaji efektivitas VED dalam meningkatkan ketahanan seismik terhadap skenario gempa besar (BSE-2E).

Dalam pemodelan numerik, VED dimodelkan secara eksplisit menggunakan pendekatan histeretik Bouc–Wen yang mampu merepresentasikan perilaku nonlinier perangkat redaman. Analisis dilakukan melalui *Nonlinear Time History Analysis* (NLTHA) dengan input sebelas rekaman gerakan tanah yang telah disesuaikan terhadap spektrum target berdasarkan SNI 1726:2019 dan ASCE 41-17. Selanjutnya, validitas model diverifikasi melalui perbandingan kurva histeresis gaya–perpindahan serta akumulasi energi disipasi hasil simulasi dengan data eksperimen terdahulu. Validasi perlu dilakukan guna memastikan bahwa model numerik sesuai dengan hasil eksperimen, sehingga dapat digunakan untuk menilai kinerja global struktur SGLC dalam menghadapi gempa besar.

Hasil validasi menunjukkan kesesuaian yang baik antara model numerik dan data eksperimen, dengan peningkatan energi disipasi sebesar 74.1% untuk VED tipe 17 mm dan 72.8% untuk tipe 22 mm dibandingkan model tanpa VED. Hasil analisis memperlihatkan bahwa simpangan puncak model tanpa VED hampir mencapai 2% (*Life Safety*), sedangkan model dengan VED terkendali di bawah 1.5%. Rerata simpangan antar lantai model dengan VED konsisten berada di bawah 1% sesuai kriteria *Immediate Occupancy* menurut FEMA 356, sementara model tanpa VED berada relatif kritis mendekati batas 1%. Selain itu, deformasi VED tetap jauh di bawah batas izin material sebesar 300%, sehingga perangkat dapat beroperasi dalam kondisi linier dan aman. Integrasi VED terbukti mampu meningkatkan disipasi energi, mengurangi deformasi struktur, serta menjaga kinerja seismik gedung pendidikan pada tingkat keamanan yang lebih tinggi.

Kata kunci: *seismic device, viscoelastic damper, VED, bouc-wen, nonlinear time history analysis*

ABSTRACT

Seismic performance evaluation of buildings is an essential aspect of the Performance-Based Seismic Design/Evaluation (PBSD/PBSE) framework, which emphasizes the fulfillment of specific performance levels, ranging from Operational to Collapse Prevention. This approach not only assesses whether a structure can withstand earthquakes but also evaluates the extent to which the building can remain functional in accordance with its intended operational needs. Accordingly, the viscoelastic damper (VED) is introduced as an energy dissipation device that plays a crucial role in controlling the inelastic response of structures, safeguarding occupants, and ensuring that the building meets the targeted performance levels. This study specifically applies the PBSE approach to the Smart and Green Learning Center (SGLC) at Universitas Gadjah Mada to examine the effectiveness of VEDs in enhancing seismic resilience under a major earthquake scenario (BSE-2E).

In the numerical modeling, the VEDs were explicitly represented using the Bouc–Wen hysteretic model, which is capable of capturing the nonlinear behavior of damping devices. The analysis was carried out through Nonlinear Time History Analysis (NLTHA) using eleven ground motion records that were spectrum-matched to the target spectra in accordance with SNI 1726:2019 and ASCE 41-17. The validity of the model was further verified through a comparison of force–displacement hysteresis curves and the cumulative dissipated energy obtained from the simulations with those from previous experimental studies. This validation was necessary to ensure that the numerical model accurately reflects experimental behavior, thereby providing a reliable basis for evaluating the global seismic performance of the SGLC under major earthquakes.

The validation results demonstrate a good agreement between the numerical model and experimental data, with an increase in energy dissipation of 74.1% for the 17 mm VED and 72.8% for the 22 mm VED compared to the structure without VEDs. Structural analysis further reveals that the peak interstory drift of the model without VEDs nearly reached 2% (Life Safety level), whereas the model with VEDs was effectively controlled below 1.5%. The average interstory drift of the VED-equipped model consistently remained below 1%, satisfying the Immediate Occupancy criteria according to FEMA 356, while the model without VEDs was relatively critical, approaching the 1% threshold. Moreover, the deformation demand on the VEDs remained well below the material deformation limit of 300%, ensuring that the devices operated within a linear and safe range. Overall, the integration of VEDs proved effective in enhancing energy dissipation, reducing structural deformation, and maintaining the seismic performance of the educational building at a higher level of safety.

Keyword: *seismic device, viscoelastic damper, VED, bouc-wen, nonlinear time history analysis*