UNIVERSITAS
GADJAH MADA
Studi Eksperimen, Numeris, dan Semi Analitis Perangkat Peredam Eksternal Modifikasi Dinamis Metallic Bar Yielding Passive Damper dengan Material BjTP 280
Bintang Gunindra Aryandaru, Prof. Ir. Iman Satyarno, M.E., Ph.D.
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

INTISARI

Pemenuhan standar desain seismik tinggi merupakan aspek krusial untuk diterapkan pada struktur bangunan. Penggunaan perangkat peredam eksternal pasif tipe *hysteretic damper* berbasis *metallic yielding* menjadi solusi struktural yang efektif guna mendisipasi energi gempa. Penelitian ini mengkaji performa perangkat *metallic bar yielding passive damper* menggunakan material baja tulangan polos BjTP 280 yang ekonomis, mudah diinstalasi, dan dapat diganti.

Penelitian ini bertujuan menganalisis parameter seismik meliputi energi disipasi, *equivalent viscous damping ratio* (EVDR), kapasitas tahanan lateral, *displacement*, kekakuan, rasio simpangan, serta daktilitas dari empat variasi geometri bar melalui pendekatan eksperimen, numeris, serta semi analitis. Keempat model benda uji (Model A, B, C, dan D) merupakan batang baja pejal BjTP 280 non-prismatik hasil bubutan dengan perbedaan profil pengecilan diameter (*tapered*) dan panjang pada zona lelehnya didesain secara spesifik untuk memusatkan deformasi plastis. Tiga tahapan analisis digunakan: eksperimen (uji tarik BjTP 280 dan pembebanan lateral siklik kuasi-statik), pemodelan numeris (elemen C3D8R, *nonlinear geometry*, plastisitas *combined hardening* Chaboche), serta semi analitis (metode integrasi numerik inkremental batang kantilever non-prismatik domain elastoplastis).

Hasil evaluasi menunjukkan EVDR spesimen: Model A 35,20% (eksperimen), 32,08% (numeris), 40,14% (semi analitis); Model B 45,16% (eksperimen), 29,77% (numeris), 37,73% (semi analitis); Model C 43,02% (eksperimen), 30,62% (numeris), 34,93% (semi analitis); dan Model D 21,23% (eksperimen), 12,70% (numeris), 25,83% (semi analitis). Sementara itu, rasio simpangan tiap spesimen, yakni Model A 39,06% (eksperimen), 38,97% (numeris), 41,09% (semi analitis); Model B 44,17% (eksperimen), 31,73% (numeris), 30,91% (semi analitis); Model C 37,93% (eksperimen), 37,85% (numeris), 39,94% (semi analitis); dan Model D 31,67% (eksperimen), 31,22% (numeris), 29,59% (semi analitis). Pemodelan numeris mampu memprediksi kapasitas ultimit dengan deviasi rendah, meski selisih di titik leleh akibat celah antarkomponen pada eksperimen tetap terjadi. Pendekatan semi analitis mampu memprediksi kekakuan awal dan gaya leleh secara presisi, tetapi mengalami peningkatan deviasi di titik ultimit karena idealisasi kurva simetris tanpa memperhitungkan asimetri histeresis aktual.

Kata kunci: *Equivalent Viscous Damping Ratio*; Energi Disipasi; *Metallic Bar Yielding Damper*; Pembebanan Siklik; Baja BjTP 280.

UNIVERSITAS
GADJAH MADA
**Studi Eksperimen, Numeris, dan Semi Analitis Perangkat Peredam Eksternal Modifikasi Dinamis Metallic
Bar Yielding Passive Damper dengan Material BjTP 280**
Bintang Gunindra Aryandaru, Prof. Ir. Iman Satyarno, M.E., Ph.D.
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

ABSTRACT

Building structures with high seismic design standards must be fulfilled. The application of passive external hysteretic dampers based on metallic yielding serves as an effective structural solution for dissipating seismic energy. This study investigates the performance of metallic bar yielding passive dampers using BjTP 280 plain reinforcing steel, which is economical, easy to install, and replaceable.

This research aims to analyse seismic parameters, including dissipated energy, equivalent viscous damping ratio (EVDR), lateral resistance capacity, displacement, stiffness, drift ratio, and ductility of four bar geometry variations through experimental, numerical, and semi-analytical approaches. The four test specimens (Models A, B, C, and D) are lathe-machined, non-prismatic solid BjTP 280 steel bars with different tapered profiles and lengths in their yielding zones, specifically designed to concentrate plastic deformation. Three stages of analysis were employed: experimental (BjTP 280 tensile tests and quasi-static cyclic lateral loading), numerical modelling (C3D8R elements, nonlinear geometry, Chaboche combined hardening plasticity), and semi-analytical (incremental numerical integration method for non-prismatic cantilever bars in the elastoplastic domain).

The evaluation results indicate the EVDR of the specimens as follows: Model A 35.20% (experimental), 32.08% (numerical), 40.14% (semi-analytical); Model B 45.16% (experimental), 29.77% (numerical), 37.73% (semi-analytical); Model C 43.02% (experimental), 30.62% (numerical), 34.93% (semi-analytical); and Model D 21.23% (experimental), 12.70% (numerical), 25.83% (semi-analytical). Meanwhile, the drift ratio for each specimen is: Model A 39.06% (experimental), 38.97% (numerical), 41.09% (semi-analytical); Model B 44.17% (experimental), 31.73% (numerical), 30.91% (semi-analytical); Model C 37.93% (experimental), 37.85% (numerical), 39.94% (semi-analytical); and Model D 31.67% (experimental), 31.22% (numerical), 29.59% (semi-analytical). Numerical modelling was able to predict the ultimate capacity with low deviation, although discrepancies at the yield point due to inter-component gaps in the experimental setup still occurred. The semi-analytical approach precisely predicted the initial stiffness and yield force, but it experienced increased deviation at the ultimate point due to the idealisation of a symmetrical curve without accounting for actual hysteretic asymmetry.

Keywords: *Equivalent Viscous Damping Ratio; Energy Dissipation; Metallic Bar Yielding Damper; Cyclic Loading; BjTP 280 Steel*