Karakteristika prigušenja grupe seizmičkih izolacionih ležajeva, u modularnom projektovanju, za mostove i vijadukte

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U ovom radu predstavljena je karakteristika prigušenja i kako se ista određuje kroz modeliranje i numeričku simulaciju grupe seizmičkih izolacionih ležajeva u modularnom dizajnu za mostove i vijadukte.

Ključne reči: Karakteristika prigušenja, Seizmička izolacija, Mostovi, Vijadukti

2. UVOD

Kod modularnog projektovanja seizmičke grupe izolacionih ležajeva za mostove i vijadukte, (sl. 1), analiziranih u ovom radu, elementi komponenti koji imaju ulogu prigušivanja kretanja nadgradnje mosta rasipanjem kinetičke energije su:

1. Elastomerni izolator, obezbeđuje viskoelastično prigušivanje i ima viskozno prigušenje ekvivalentno tipu gume koji se koristi:
 - meka: $G = 0,4 \text{ N/mm}^2$, $\xi = 10\%$,
 - standardna: $G = 0,8 \text{ N/mm}^2$, $\xi = 10\%$, i
 - tvrda: $G = 1,4 \text{ N/mm}^2$, $\xi = 16\%$.
2. Sferni ležajevi, obezbeđuju prigušenje suvim trenjem $\mu = 0,02$,

3. Sistem koji se sastoji od šest hidrauličnih amortizera, raspoređenih u geometrijskoj konfiguraciji u skladu sa kinematičkom šemom Stjuart platform (Stewart platform), obezbeđuje viskozno prigušivanje, koeficijent viskoznog prigušenja svakog prigušivača može se podesiti promenom površine otvora za prolaz fluida između dve komore cilindra.

U zaključku, jedini stavka koji ima funkcionalno podesivi parametar je šest hidrauličnih sistemskih amortizera, a podesivi parametar je viskozni koeficijent prigušenja svakog hidrauličnog prigušivača.

Slika 1. Sistem koji se sastoji od šest hidrauličnih amortizera (Stewart platform)

2. ODREĐIVANJE KARAKTERISTIKA PRIGUŠENJA

Prigušujuća grupu seizmičkih izolacionih ležajeva se procenjuje na osnovu rasute (disipativne) energije tokom perioda seizmičkog kretanja koja je data veličinom područja histerezisa dijagrama sila-pomeranje.

U cilju dobijanja dijagrama sile i pomeranja, napravljen je virtuelni model i simuliran je rad seizmičke grupe ležajeva izolacije, u modularnom dizajnu, za mostove i vijadukte. Simulacija je urađena za različite vrednosti viskoznog koeficijenta prigušenja hidrauličnih amortizera kao i za različite pravce seizmičkih pokreta u odnosu na grupu ležišta; reprezentativni pravci su Ox i Oy respektivno. U simulaciji je postavljeno pomeranje gornje ploče u odnosu na donju ploču i sila koja je potrebna da bi se postiglo pomeranje koje se smatra kao zbir svih disipativnih sila u pravcu kretanja.

Karakteristike komponenti simulirane grupe su:

1. Elastomerni izolator ALGA HDS300x96,
 $G = 0,4 \text{ N/mm}^2$; $k = 0,29 \text{ kN/mm}$; $V_{\max} = 500$;
 $V_{\text{din}} = 210 \text{ kN}$; $s_{\max} = 200 \text{ mm}$;

2. Sferni ležaj MAGEBA KA 1.0, $\mu = 0,02$;
 $V_{\max} = 1000$, $V_{\text{din}} = 300 \text{ kN}$, $p = 180 \text{ N/mm}^2$;

3. Hidraulični amortizeri (prigušivači) ACE, HB-70-100-EE-P, hod- 100 mm , $F_{\max} = 50 \text{ kN}$

Dobijeni rezultati su prikazani u nastavku.

2.1. Pomeranje duž Ox ose

Velika ploča se smatra nepokretnom, a mala ploča se pomera translatorno duž ose Ox prema zakonu $x(t) = 100 \cdot \sin(\pi \times t + \pi) \text{ mm}$. Na vrhu male ploče deluje vertikalna sila intenziteta 210 kN . Rezultati sile potrebne za pomeranje, merene u N , za različite vrednosti koeficijenta prigušenja c hidrauličnih prigušivača su prikazani na slikama 2 do 6.

Slika 2. Pomeranje duž Ox ose i sila koja deluje na gornju ploču.

Figure 3. $F_d(t)$ i $F_d(x)$ za $c = 0 \text{ Ns/mm}$

Slika 4. $F_d(t)$ i $F_d(x)$ za $c = 50 \text{ Ns/mm}$ Slika 5. $F_d(t)$ i $F_d(x)$ za $c = 100 \text{ Ns/mm}$ Slika 6. $F_d(t)$ i $F_d(x)$ za $c = 500 \text{ Ns/mm}$

2.2. Pomeranje duž Oy ose

Velika ploča se smatra nepokretnom, a mala ploča se pomera translatorsno duž ose Oy prema zakonu $y(t) = 100 \cdot \sin(\pi \times t + \pi) \text{ mm}$. Na vrhu male ploče deluje vertikalna sila intenziteta 210 kN .

Rezultati sile potrebne za pomeranje, merene u N , za različite vrednosti koeficijenta prigušenja c hidrauličnih prigušivača su prikazani na slikama 8 do 11.

Slika 7. Pomeranje duž Oy ose i sila koja deluje na gornju ploču.

Slika 8. $F_d(t)$ i $F_d(y)$ za $c = 0 \text{ Ns/m}$

Slika 9. $F_d(t)$ i $F_d(y)$ za $c = 50 \text{ Ns/m}$

Slika 10. $F_d(t)$ i $F_d(y)$ za $c = 100 \text{ Ns/m}$ Slika 11. $F_d(t)$ i $F_d(y)$ za $c = 500 \text{ Ns/m}$

3. ZAKLJUČAK

1. Ponašanje grupe seizmičkih izolacionih ležajeva, u modularnom projektovanju, za mostove i vijadukte u smislu rasipane energije ne zavisi od pravca seizmičkog kretanja.
2. Dispersija energije po ciklusu, Sl. 12, praktično varira linearno sa viskoznim koeficijentom prigušenja hidrauličnih amortizera.

Slika 11. Rasuta (disipativna) energija (c)

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- [3] Brochures ALGA
- [4] Brochures SOMMA.
- [5] Brochures MAGEBA
- [6] Brochures SKF.
- [7] Brochures ACE.

Damping Characteristics of the Seismic Isolation Bearings Group, in Modular Design, for Bridges and Viaducts

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In this paper we present the damping characteristic and how to determine it through modelling and numerical simulation of the seismic isolation bearings group in modular design for bridges and viaducts.

Keywords: Damping characteristic, Seismic isolation, Bridges, Viaducts

1. INTRODUCTION

In the modular bridge and viaduct seismic grouping and seismic isolation group, analysed in the present paper, the component elements which have the role of damping the motion of the bridge superstructure by dissipating the kinetic energy are:

1. The elastomeric insulator, provides viscoelastic damping and has a viscous damping equivalent to the type of rubber used:
 - soft: $G = 0,4 \text{ N} / \text{mm}^2$, $\xi = 10\%$,
 - standard: $G = 0,8 \text{ N} / \text{mm}^2$, $\xi = 10\%$,
 - hard: $G = 1,4 \text{ N} / \text{mm}^2$, $\xi = 16\%$.
2. Spherical bearings, provides dry friction damping $\mu = 0,02$,

3. A system consisting of six hydraulic shock absorbers Fig.1, arranged in a geometric configuration according to the cinematic scheme of the Stewart platforms, provides viscous damping, the viscous damping coefficient of each damper being adjustable by changing the passage hole area between the two chambers of the cylinder.

In conclusion, the only item that has a functionally adjustable parameter is the six hydraulic dampers system and the adjustable parameter is the viscous damping coefficient of each hydraulic damper.

Figure 1. System consisting of six hydraulic shock absorbers (Stewart platform)

2. DETERMINING THE DAMPING CHARACTERISTICS

The damping of the seismic isolation bearings group is assessed by the dissipated energy during a period of seismic motion that is given by the magnitude of the hysteresis area of the force-displacement diagram.

In order to obtain the force-displacement diagram, a virtual model was constructed and simulated the operation of the seismic isolation bearings group, in modular design, for bridges and viaducts. The simulation was done for various values of the viscous damping coefficient of the hydraulic dampers and also for the different directions of the seismic movement in relation to the bearing group; the representative directions being Ox and Oy respectively. In the simulation, a displacement of the upper plate was imposed relative to the lower plate and the force required to achieve the displacement considered as the sum of all dissipative forces in the direction of motion was measured.

Characteristics of the components of the simulated group are:

1. Elastomeric isolator ALGA HDS300x96,
 $G = 0,4 \text{ N/mm}^2$; $k = 0,29 \text{ kN/mm}$;
 $V_{\max} = 500$; $V_{\text{din}} = 210 \text{ kN}$; $s_{\max} = 200 \text{ mm}$;

2. Spherical bearing MAGEBA KA 1.0, $\mu = 0,02$;
 $V_{\max} = 1000$, $V_{\text{din}} = 300 \text{ kN}$, $p = 180 \text{ N/mm}^2$;
3. Hydraulic dampers ACE, HB-70-100-EE-P, hod-
 100 mm , $F_{\max} = 50 \text{ kN}$

The results obtained are presented below.

2.1. Displacement by the Ox axis

The large plate is considered fixed and the small plate translates along the Ox axis following the law $x(t) = 100 \cdot \sin(\pi \times t + \pi) \text{ mm}$. On top of the small plate acts a vertical force of 210 kN . The results for the force required for displacement, measured in N , for various values of the dampening coefficient c of the hydraulic dampers are shown in Figure 2 to 6.

Figure 2. Displacement by the Ox axis and acting force on the upper plate.

Figure 3. $F_d(t)$ and $F_d(x)$ for $c = 0 \text{ Ns/mm}$

Figure 4. $F_d(t)$ and $F_d(x)$ for $c = 50 \text{ Ns/mm}$ Figure 5. $F_d(t)$ and $F_d(x)$ for $c = 100 \text{ Ns/mm}$ Figure 6. $F_d(t)$ and $F_d(x)$ for $c = 500 \text{ Ns/mm}$

2.2. Displacement by the Oy axis

The large plate is considered fixed and the small plate translates along the Oy axis following the law $y(t) = 100 \cdot \sin(\pi \cdot t + \pi) \text{ mm}$. On top of the small plate acts a vertical force of 210 kN .

The results for the force required for displacement, measured in N , for various values of the dampening coefficient c of the hydraulic dampers are shown in Figure 8 to 11.

Figure 10. $F_d(t)$ and $F_d(y)$ for $c = 100 \text{ Ns/m}$

Figure 11. $F_d(t)$ and $F_d(y)$ for $c = 500 \text{ Ns/m}$

3. CONCLUSION

1. The behavior of the seismic isolation bearings group, in modular design, for bridges and viaducts in terms of dissipated energy does not depend on the direction of seismic motion.
2. The energy dissipated per cycle, Fig. 12, practically varies linearly with the viscous damping coefficient of the hydraulic dampers.

Figure 12. Dissipated energy (c)

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