SEISMIC ISOLATION OF HIGHWAY VIADUCTS THROUGH PENDULUM ISOLATORS

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Retrofit/reconstruction of 3 viaducts on the Salerno-Reggio Calabria Highway

- Built in the late 1960s with simply supported spans
- Initial retrofit design with LRB
- As built design with pendulum isolators (double concave curved surface sliders)

A total of 116 isolators of different types
Pendulum isolators (curved surface sliders according to European Standard EN 15129)

The period does not depend upon the mass

\[ T = 2\pi \sqrt{\frac{1}{g \left( \frac{1}{R} + \frac{\mu}{X} \right)}} \]

\[ K_e = W \cdot \left( \frac{1}{R} + \frac{\mu}{X} \right) \]

\[ \xi_e = \frac{2}{\pi} \cdot \frac{1}{\frac{X}{\mu R} + 1} \]

Working Principle similar to a pendulum
Pendulum isolators
(curved surface sliders according to European Standard EN 15129)

- Tested at Seismic Response Modification Device Test Facility of the University of California at San Diego, USA, at EucentraLab.in in Pavia, Italy, etc.
Typical design spectrum

Collapse Limit State
Camp model
Galdo Viaduct

Seismic isolation of highway viaducts through pendulum isolators
Pian della Mentana Viaduct

- Total length 190 m – 32 m typical span
- Seismic isolation with pendulum isolators allowed to maintain existing foundations (originally designed for seismic actions) reinforced concrete
- New steel deck was built

Before retrofit
Pia n d ella M e n t a v i a d u c t

- $T_{\text{eff}} = 2.54 \text{ s} - \xi_{\text{eff}} = 25\%$
- $R=3.1 \text{ m} - \text{Medium friction (5.5\% at } N_{Ed})$
- 4 isolators (red) with $N_{Ed}=1700 \text{ kN}$
- 10 isolators (blue) with $N_{Ed}=4300 \text{ kN}$
- Max. seismic displacement obtained through non-linear time-history analysis: 217 mm at Collapse Limit State
- Max. displacement capacity of isolators: 350 mm
Cam po del G a l d o vi a d u c t

• New viaduct, part on the existing plan and part on a new one, designed to avoid existing foundations. Curved, with an interchange, 450-470 m long, with spans from 30 m to 50 m.

Before retrofit

During construction works
Cam po d el G a l d o vi a

- R = 3.1 m
- Medium friction (5.5% at NED)
- 10 isolators (red) with $N_{Ed} = 2650 \text{kN}$
- 38 isolators (blue) with $N_{Ed} = 7700 \text{kN}$
- Max. seismic displacement obtained through non-linear time-history analyses: 179 mm at Collapse LS
- Max. displacement capacity 350 mm
Campos del Galdo Viaduct

- Use of pendulum isolators instead of LRB allowed a reduction of 18% in forces on substructures.
Casale Civile Viaduct

- New structure on a new layout
- Total length 380 m
  9 spans (36 + 4.4 x 7 + 36 m)
- Steel-concrete composite deck, with 2 steel girders, as in other 2 viaducts

Seismic isolation of highway viaducts through pendulum isolators
Casale Civile Viaduct

- **R=3.1 m - Medium friction (5.5% at \(N_{Ed}\))**
- **8 isolators (red) with \(N_{Ed} = 1700\) kN**
- **20 isolators (blue) with \(N_{Ed} = 4300\) kN**
- **12 isolators (green) with \(N_{Ed} = 5000\) kN**
Casale Civile Viaduct

- Example of results of a time-history analysis on one isolator (on pier 3)
- Max. seismic displacement: 207 mm at Collapse LS
Casale Civile Viaduct

- Use of pendulum isolators instead of LRB allowed an average reduction of 15% in forces on substructures.
Type tests at European Laboratory according to EN 15129:2009

Isolator FIP-D M 1900/700 (3100)

$N_{Ed} = 7700 \text{kN}$

Factory Production Control Tests were carried out as well, according to EN 15129.
Type tests at Eucentre

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Conclusions

- The design of the seismic isolation system was optimized. Only 5 types of isolators were used in the 3 viaducts, different for vertical load capacity.

- The substitution of LRB pendulum isolators gave significant benefits in terms of improved structural performance together with major construction economy.

- The average reduction in terms of forces on substructures was of 14% in the Piano Men t a viaduct, of 18% in the Piano dell a Ment a viaduct.
Thanks for your attention!

Seismic isolation of highway viaducts through pendulum isolators.
and next year...

Izmit Bay Suspension Bridge