UNIVERSITÀ
DEGLI STUDI
DELLA REPUBBLICA
DI SAN MARINO

UNIVERSITÀ
DEGLI STUDI
DI MODENA
E REGGIO EMILIA

Corso di laurea Triennale in Ingegneria Civile e Ambientale

Seismic soil-structure-interaction of multispan bridges with continuous deck

Sottotitolo di Seismic soil-structure-interaction of multispan bridges with continuous deck

Mario Rossi
A.A. 2017/2018

Relatore: Francesca Dezi
Co-relatore: Andrea Grilli

The paper focuses on the effects of soil-structure interaction in the seismic response of multi-spanviaducts on pile foundations. Analyses are performed by means of the substructure approach: the soil-foundation systems are studied in the frequency domain to obtain the foundation input motion and thedynamic impedance functions; inertial interaction analyses are carried out in the time domainaccounting for the material nonlinear behaviour.

Suitable lumped parameter models are introduced tosimulate the frequency dependent behaviour of the soil-foundation system. A specific procedure forselecting and scaling real ground motions is proposed and used for the definition of the spatial seismicinput. The seismic response of bridges on compliant base is compared with that obtained from fixedbase analyses discussing the significance of soil-structure interaction effects.Keywords: Bridges, Nonlinear behaviour, Soil-structure interaction, Substructure approach

Definition of case studies

Seismic design of bridges are generally performed by assuming piers fixed at the base and consideringcode acceleration response spectra, defined on the basis of local hazard and soil classification.Actually, local soil conditions and soil-foundation interaction may modify the seismic motion to suchan extent that code spectra become not conservative[1]. In this paper Soil-Structure Interaction (SSI) andsite effects on the seismic response of bridges are evaluated with reference to a set of 10-span viaductshaving different span length L (25, 50 and 75 m) and pier height H (10, 15 and 25 m) (Figure 1a). Thedeck is constituted by two I-shaped composite girders and by a 12 m wide concrete slab with meanthickness of 0.30 m.

Valore	1	A
Valore	2	B
Valore	3	C

Tabella 1: didascalia

In both the longitudinal and transverse directions the seismic action is entrusted to the piers, equippedwith lock-up devices, while multi-directional bearings are used at the abutments to exclude a dual-pathmechanism. A single layer soil deposit of type D (Figure 2a), constituted by normally consolidatedclays with properties reported in Figure 2c, is considered; the profile of the shear modulus at lowstrains G0 is shown in Figure 2a.The seismic design[2] of bridges is performed by means of a displacement-based approach byimposing different ductility demands at ultimate: in particular, circular piers of diameter 2.4 m andwith different height have been designed to achieve the ductility demand $\mu \approx 1$ (elastic behaviour),$\mu \approx 2$ and $\mu \approx 4$. The soil type D elastic displacement response spectrum of EN 1998-1 (2004) isadopted by considering a peak ground acceleration of 0.47g. The “30%-rule” is used to account for thebidirectional seismic action[3]. Foundations, constituted by groups of bored concrete piles, are designed according to hierarchyprinciples in order to avoid the pile plasticization (Figure 2d). Depending on the case study, a certainamount of the bearing capacity is entrusted to the rigid cap.

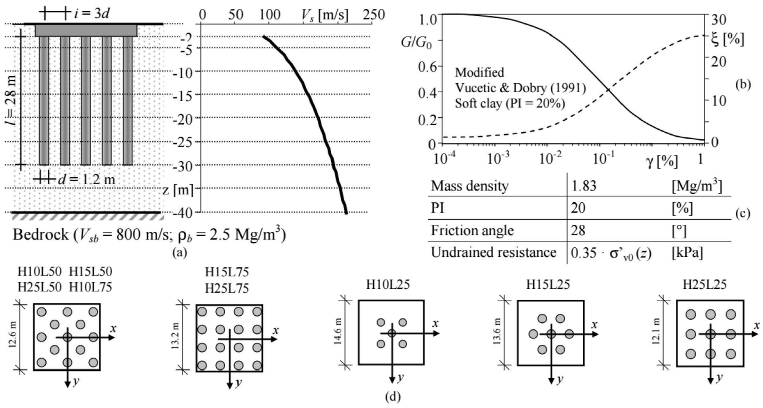

Figure 2. (a) Soil profile and Vs profile; (b) normalized shear modulus and damping ratio curves (c) soilmechanical properties and (d) pile group layouts

Conclusions

SSI effects on the seismic response of multi-span viaducts on pile foundations have been investigated,by considering bridges characterised by ductile and non-ductile behaviours. A specific procedure forthe selection and scaling of ground motions is proposed for the definition of the bidirectional seismicinput, accounting for site effects and the nonlinear soil behaviour. The seismic response of the bridgeson compliant base is compared with that obtained from fixed base analyses discussing the significanceof SSI effects. Results demonstrate that, despite bridges are founded on a very soft soil, SSI does notplay a significant role in the definition of the structural response.

References

— Baker JW and Cornell A (2006), “Correlation of response spectral values for multicomponent ground motions”,Bulletin of the Seismological Society of America 96, 215–227.
— Carbonari S, Morici M, Dezi F, Leoni G, Nuti C, Silvestri F, Tropeano G and Vanzi I (2012), “Seismic Responseof Viaducts Accounting for Soil-Structure Interaction”, 15 World Conference on Earthquake Engineering,24-28 September, Lisboa, Portugal.