

УДК 550.34

КОРРЕЛЯЦИЯ СИЛЬНЫХ ДВИЖЕНИЙ ГРУНТА И ЕЕ ВЛИЯНИЕ НА ОЦЕНКИ СЕЙСМИЧЕСКОЙ ОПАСНОСТИ ДЛЯ ПРОТЯЖЕННЫХ ОБЪЕКТОВ

В.Ю. Соколов, Ф. Венцель

Геофизический институт, Технологический институт Карлсруэ, г. Карлсруэ, Германия

Аннотация. Дается описание моделей корреляции сильных движений и рассматривается влияние корреляции на оценки опасности для совокупности критических элементов в линейных системах (мосты в транспортных сетях). Анализ был проведен для случаев единичного (сценарного) землетрясения и вероятностной оценки, которая учитывает пространственное и временное распределение очагов землетрясений различной магнитуды. Для расчетов опасности использовался метод статистического моделирования Монте Карло. Показано, что выбор параметров модели корреляции сильных движений существенно влияет на оценки сейсмической опасности и вероятности повреждений разного уровня для рассмотренных объектов. Игнорирование корреляции сильных движений при подобных оценках может привести к недостоверным результатам.

Ключевые слова: сильные движения грунта, случайные отклонения, сейсмическая опасность.

Литература

- Abrahamson N.A., Youngs R.R. A stable algorithm for regression analysis using the random effects model // Bull. Seismol. Soc. Amer. 1992. V. 82. P. 505-510.
- Abrahamson N., Atkinson G., Boore D., Bozorgnia Y., Campbell K., Chiou B., Idriss I.M., Silva W., Youngs R. Comparison of the NGA ground-motion relations // Earthquake Spectra 2008. V. 24(1). P. 45-66. doi: 10.1193/1.2924363.
- Bommer J.J., Crowley H. The influence of ground-motion variability in earthquake loss modeling // Bull. Earthq. Engineering. 2006. V. 4(3). P. 231-248. doi: 10.1007/s10518-006-9008-z.
- Boore D.M., Joyner W.B., Fumal T.E. Equations for estimating horizontal response spectra and peak acceleration from western North American earthquakes: a summary of recent work // Seismol. Res. Lett. 1997. V. 68. P. 128-153.
- Brillinger D.R., Preisler H.K. An exploratory analysis of the Joyner-Boore attenuation data // Bull. Seismol. Soc. Amer. 1984. V. 74. P. 1441-1450.
- Brillinger D.R., Preisler H.K. Further analysis of the Joyner-Boore attenuation data // Bull. Seismol. Soc. Amer. 1985. V. 75. P. 611-614.
- Cheng C.T., Lee C.T., Lin P.S., Lin B.S., Tsai Y.B., Chiou S.J. Probabilistic earthquake hazard in metropolitan Taipei and its surrounding regions // Terrestrial, Atmospheric and Oceanic Sciences (TAO). 2010. V. 21(3). P. 429-446. doi: 10.3319/TAO.2009.11.11.01(TH).
- Crowley H., Bommer J.J., Stafford P.J. Recent developments in the treatment of ground-motion variability in earthquake loss model // J. Earthq. Engineering. 2008. V. 12(S). P. 71-80. doi: 10.1080/13632460802013529.
- Douglas J. Earthquake ground motion estimation using strong-motion records: a review of equations for estimation of peak ground acceleration and spectral ordinates // Earth Sci. Rev. 2003. V. 61. P. 43-104.
- Douglas J. Errata and additions to «Ground motion estimation equations 1966-2003» // Report BRGM/RP-54603-FR. 2006.
- Ebel J.E., Kafka A.L. A Monte Carlo approach to seismic hazard analysis // Bull. Seismol. Soc. Amer. 1999. V. 89. P. 854-866.
- Johnson M.E. Multivariate statistical simulation. Wiley series in probability and mathematical statistics / Los Alamos National Laboratory. Los Alamos, NM, 1987.
- Joyner W.B., Boore D.M. Methods for regression analysis of strong-motion data // Bull. Seismol. Soc. Amer. 1993. V. 83. P. 469-487.
- Lee R., Kiremidjian A.S. A loss analysis method and evaluation for correlated bridges in a transportation network // Proceedings of First European Conference on Earthquake Engineering and Seismology, Geneva, Switzerland, 3-8 September, 2006. Paper 1663.
- Liao W.I., Loh C.H. Preliminary study of the fragility curves for highway bridges in Taiwan // J. Chinese Institute of Engineers. 2004. V. 27(3). P. 367-375.
- Loh C.H., Jean W.Y. Seismic zoning on ground motion in Taiwan area // Proceedings of 14th International Conference on Soil Mechanics and Foundation Engineering, Germany, 6-12 September, 1997. P. 71-79.
- Mander J.B. Fragility curve development for assessing the seismic vulnerability of highway bridges / University at Buffalo, State University of New York, MCEER Research Progress and Accomplishments, Research Summary 1997-1999. 1999. <http://mceer.buffalo.edu/publications/resaccom/99-sp01/chl0mand.pdf>
- McVerry G.H., Rhoades D.A., Smith W.D. Joint hazard of earthquake shaking at multiple locations // Proceedings of the 13th World Conference on Earthquake Engineering, Vancouver, Canada, August 1-6. 2004. Paper 646.
- Musson R.M.W.. Determination of design earthquakes in seismic hazard analysis through Monte Carlo simulation // J. Earthq. Engineering. 1999. V. 3(4). P. 463-474.

Park J., Bazzurro P., Baker J.W. Modeling spatial correlation of ground motion intensity measures for regional seismic hazard and portfolio loss estimations // Applications of Statistics and Probability in Civil Engineering. London: Taylor & Francis Group, 2007. P. 1–8.

Rhoades D.A., McVerry G.H. Joint hazard of earthquake shaking at two or more locations // Earthquake Spectra. 2001. V. 17(4). P. 697–710. doi: 10.1193/1.1423903.

Sokolov V., Wenzel F. Influence of spatial correlation of strong ground-motion on uncertainty in earthquake loss estimation // Earthquake Engineering and Structural Dynamics. 2011a. V. 40 (9). P. 993–1009. doi: 10.1002/eqe.1074.

Sokolov V., Wenzel F. Influence of ground-motion correlation on probabilistic assessments of seismic hazard and loss: sensitivity analysis // Bulletin of Earthquake Engineering. 2011b. V. 9(5). P. 1339–1360. doi: 10.1007/s10518-011-9264-4.

Sokolov V., Wenzel F., Jean W.Y., Wen K.L. Uncertainty and spatial correlation of earthquake ground motion in Taiwan // Terrestrial, Atmospheric and Oceanic sciences (TAO). 2010. V. 21(6). P. 905–921. doi: 10.3319/TAO.2010.05.03.01(T).

Stergiou E., Kiremidjian A.S. Treatment of uncertainties in seismic risk analysis of transportation systems // The John A Blume Earthquake Engineering Center. 2006. Report 154.

Strasser F.O., Abrahamson N.A., Bommer J.J. Sigma: issues, insights, and challenges // Seismol. Res. Lett. 2009. V. 80(1). P. 40–56. doi: 10.1785/gssrl.80.1.40.

Tsai C.C.P., Chen Y.H., Liu C.H. The path effect in ground-motion variability: an application of the variance-component technique // Bull. Seismol. Soc. Amer. 2006. V. 96. P. 1170–1176. doi: 10.1785/0120050155.

Wang M., Takada T. Macrospatial correlation model of seismic ground motions // Earthquake Spectra. 2005. V. 21(4). P. 1137–1156. doi: 10.1193/1.2083887.

Wesson R.L., Perkins D.M. Spatial correlation of probabilistic earthquake ground motion and loss // Bull. Seismol. Soc. Amer. 2001. V. 91. P. 1498–1515. doi: 10.1785/0120000284