

Comparison of the performance of two different approaches for damage detection on framed structures

C. Iacovino¹, R. Ditommaso¹, M.P. Limongelli² and F.C. Ponzo¹

¹ School of Engineering, University of Basilicata, Potenza, Italy

² Politecnico di Milano, Department of Architecture, Built environment and Construction engineering, Milano, Italy
 chiara.iacovino@unibas.it; r.ditommaso@unibas.it; mariagiuseppina.limongelli@polimi.it; felice.ponzo@unibas.it

Summary

In this work results retrieved from the application of a curvature evolution based method and an interpolation error based method are compared. The first method is based on the evaluation of the curvature variation (related to the fundamental mode of vibration) over time and compares the variations before, during and after the earthquake. The Interpolation Method is based on the detection of localized reductions of smoothness in the Operational Deformed Shapes (ODSs) of the structure between the reference and the inspection phases.

METHODOLOGIES

Curvature evolution based method

- Use of a band-variable filter able to extract the nonlinear response of each mode of vibration.
- Detection of curvature variations in three significant instants: (A) an instant before the earthquake (assumed as reference), (B) the time-instant where the damaging structure exhibits the minimum values of the fundamental frequency and (C) an instant after the earthquake (Figure 1).

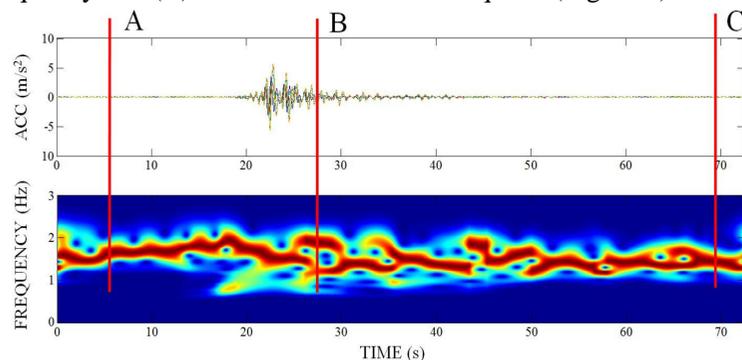


Figure 1. Normalized S-Transform and selection of the instants A, B and C

Interpolation method

- The damage feature is defined in terms of the error related to the use of a spline function in interpolating the ODSs of the structure: statistically significant variations of the interpolation error between two successive inspections of the structure indicate the onset of damage (Figure 2).
- In this case the damage feature is calculated as the difference between a reference and an inspection configuration.

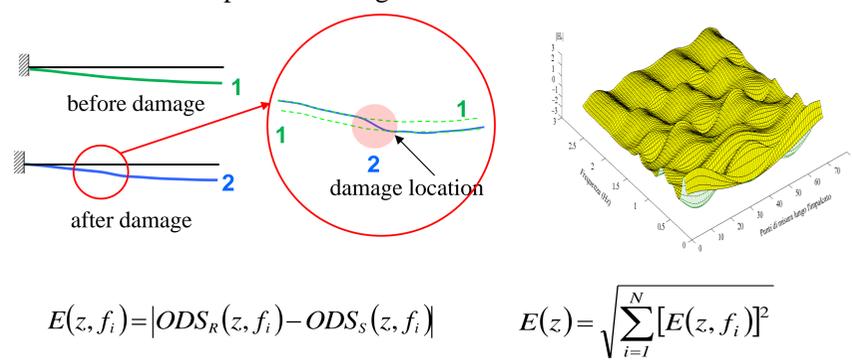


Figure 2. The Interpolation Damage Detection Method (IDDM)

APPLICATION

- The two methodologies have been applied to nonlinear numerical dynamic models of reinforced concrete framed structures characterized by 5 and 8 floors with regular geometric configuration and designed only for gravity loads (Figure 3).
- The numerical campaign was performed using natural accelerograms compatible with the Italian Seismic Code for a soil type B (Figure 4).

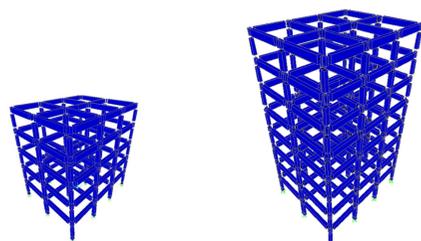


Figure 3. Nonlinear numerical models analyzed

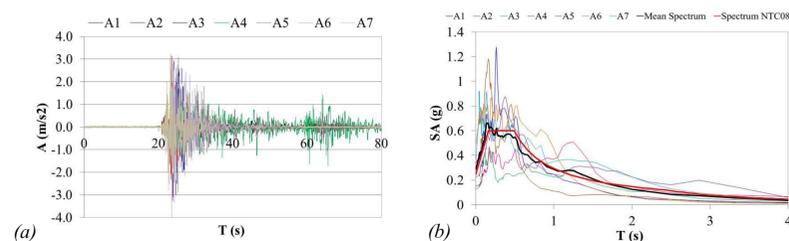


Figure 4. (a) Seven natural accelerograms; (b) Response spectra relating to natural accelerograms

RESULTS

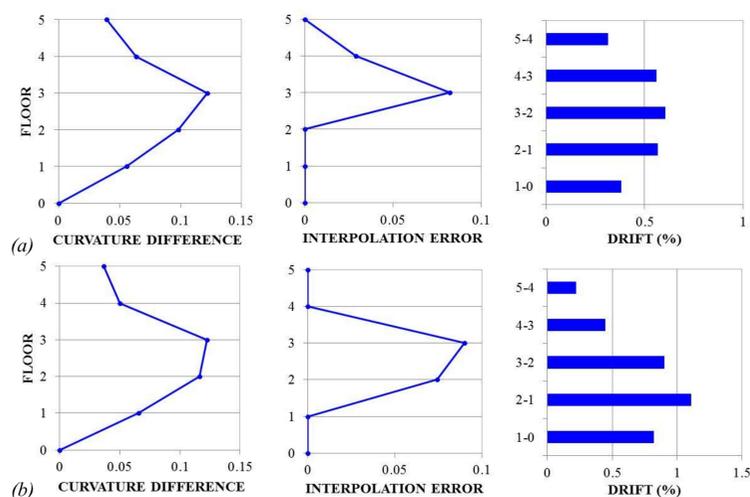


Figure 5. Curvature difference among floors, variation of the interpolation error and interstory drift for the structure with 5 floors: (a) accelerogram A1, (b) accelerogram A4

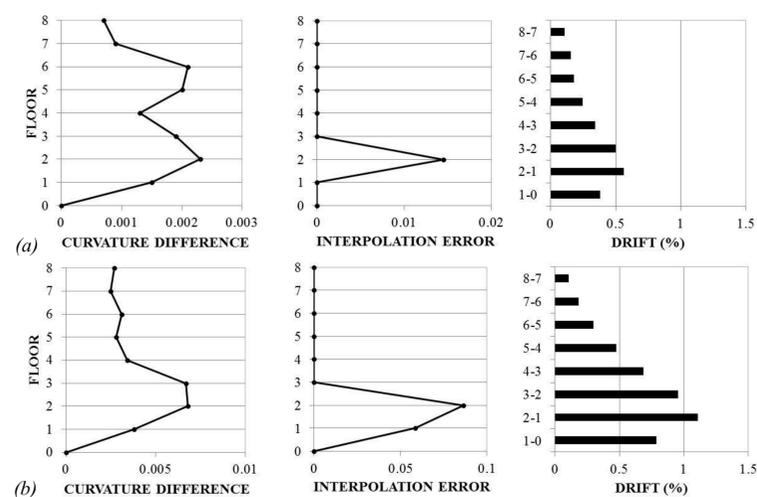


Figure 6. Curvature difference among floors, variation of the interpolation error and interstory drift for the structure with 8 floors: (a) accelerogram A1, (b) accelerogram A4

CONCLUSIONS

- ✓ Possibility to localize damage in a framed structures subjected to strong motion earthquakes through analysis of features related to the variation of curvature.
- ✓ Both the curvature evolution based method and the Interpolation method (IDDM) avoid problems related to the double integration needed to estimate the modal curvature.
- ✓ Both methods allow to localize, in a fast and intuitive way, structural damage after an earthquake inducing a non linear structural behaviour.

ACKNOWLEDGEMENT

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