

## DAMAGE DETECTION FROM DISPLACEMENT-IN-TIME FUNCTION

M.Sc. Ivana Štimac, Faculty of Civil Engineering, University of Rijeka, Croatia  
PhD. Ivica Kožar, Faculty of Civil Engineering, University of Rijeka, Croatia  
[ivana.stimac@gradri.hr](mailto:ivana.stimac@gradri.hr)

**Introduction.** Nondestructive damage detection is an important subproblem of a damage assessment. An attractive method of nondestructive testing is a measurement of dynamic characteristics of a structure. Dynamic characteristics are sensitive to changes in the mass and stiffness of the structure. Therefore, the changes in the dynamic characteristics can be used to locate the reduction in the stiffness which indicates structural damage. Changes in mode shapes are very sensitive to local damage. Many researchers have used Mode Shape Damage Detection methods (the Modal assurance criterion, the Coordinate assurance criterion, the Mode shape, the Mode shape slope, and the Mode shape curvature) to locate the damage position in the structure. [1,2,3,4,5] These methods are accurate, but many sampling points in the structure are necessary.

### Damage detection from displacement-in-time function

The dynamic testing of bridges are usually carried out by measuring dynamic characteristic due to a moving load over the bridge at one or more points. The damage detection method from displacement-in-time function is developed to avoid the need for many measurement points.

Displacement-in-time function can be measured at one point in the structure.

Numerical testing is carried out for the simply supported beam and the continuous beam with damages at different sections by using software "DARK". [6]

The displacement-in-time functions at the mid-span point are similar for both, the undamaged and the damaged structure.

Subtracting these two functions gives the *deflection difference*. As can be seen from Fig. 1(b), the maximum deflection difference is at the location of the damage.

The *deflection-in-time function slope* seeks the change in slope function of the undamaged and the damaged structure. The location of the damage is represented by a vertical jump in the slope difference function (Fig. 1 (c))

The location of the damage is assessed by the largest computed absolute difference between the *deflection-in-time function curvatures* of the damaged and the undamaged structure (Fig. 1(d)).

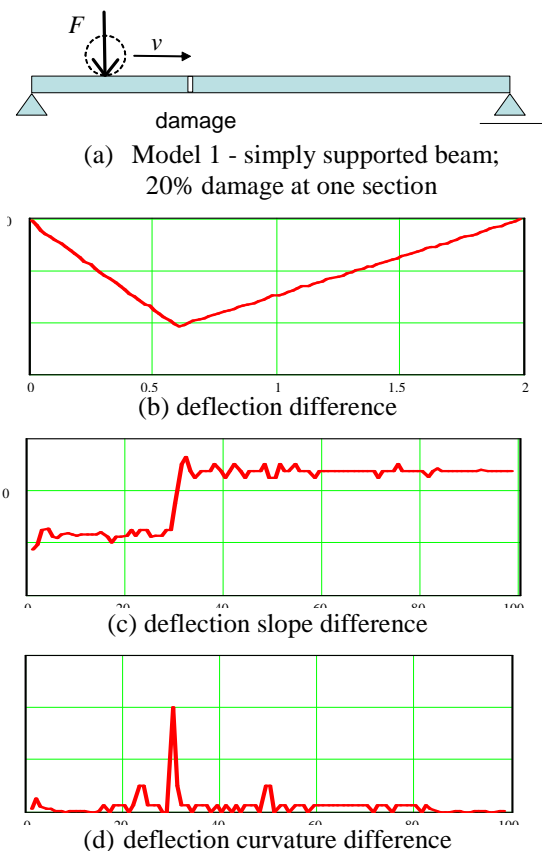


Fig. 1

The location of the damage can be found even if there are more than one damaged section (Fig. 2)

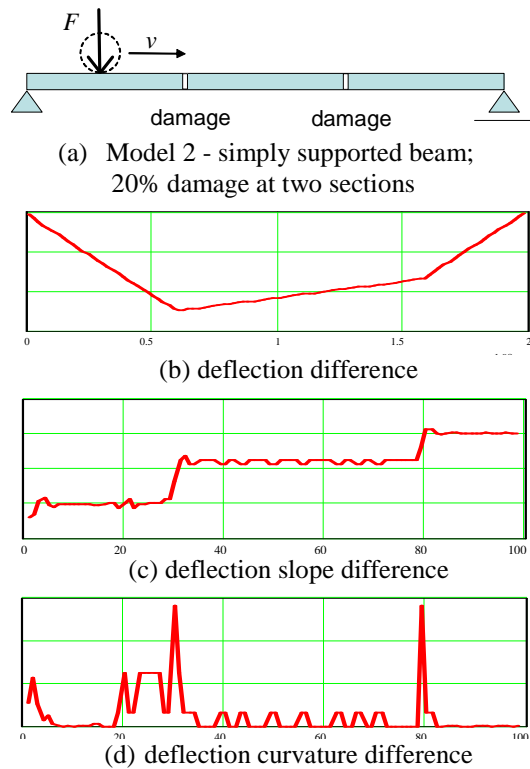


Fig. 2

However, if the damaged section is placed near a support, this method is not appropriate for detection of the position of the damage. (Fig. 3)

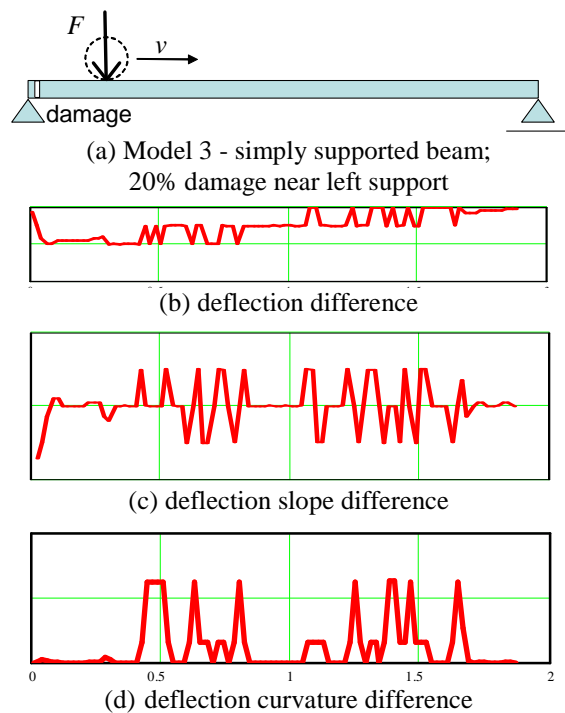


Fig. 3

On the other hand, the damages near the middle support of a continuous beam can be easily determined using the previous algorithm.

The first mid-span deflection functions are used to analyse a damaged 2-span continuous beam. (Fig. 4) In this case, the *deflection difference* is not relevant to locating the damage. The *deflection slope difference* and the *deflection curvature difference* show the exact position of the damage.

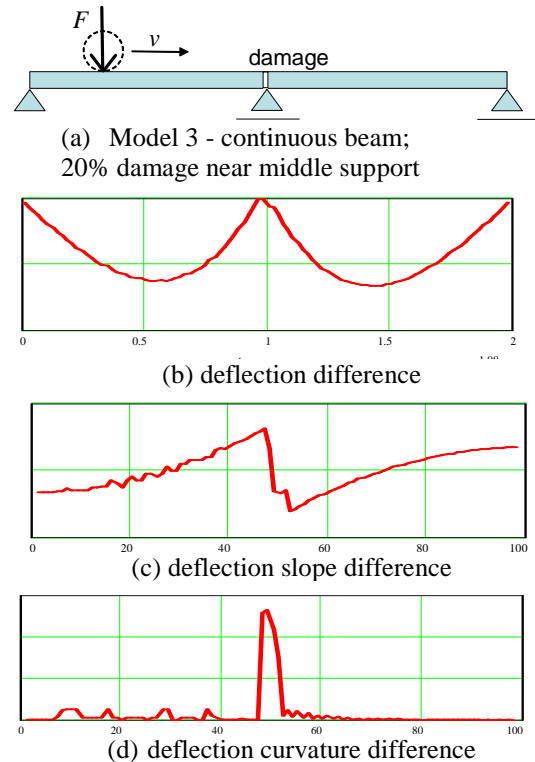


Fig. 4

## Conclusion

In the present work, a damage detection using deflection-in-time function has been outlined. They can be used for both the simply supported and the continuous beams. The deflection slope difference and the deflection curvature difference are reliable indicators for damage location, except the damage is located near the first or the last support.

## References

- [1] L. Fryba, M. Pirner: *Load tests and modal analysis of bridge*, Engineering Structures 23, 2001
- [2] A. K. Padey, M. Biswais, M. Samman: *Damage detection from changes in curvature mode shapes*, Journal of Sound and vibration 145(2), 1991
- [3] M. A.-B. Abdo, M. Hori: *A numerical study of structural damage detection using changes in rotation of mode shapes*, Journal of Sound and vibration 251(2), 2002
- [4] M. M. Abdel Wahab, and G. De Roeck: *Damage detection in bridges using modal curvatures: application to a real damage scenario*, Journal of Sound and Vibration, 226(2), 1999
- [5] J.-T. Kim, Y.-S. Ryu, H.-M. Cho, N. Stubbs: *Damage identification in beam-type structures: frequency-based method vs mode-shape-based method*, Engineering structures 25 (2003)
- [6] I. Štimac, *Analiza mostovskih konstrukcija pobudenih pokretnom masom*, Magistarska radnja, Zagreb, 2003