



Inelastic Bridge and Frame Response Comparison using Seismostruct and Zsoil Software with Flexibility based Element

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ABSTRACT

This article shows a comparison between two different software of inelastic behavior one with flexibility base element in which we do not need meshing element, because it is based on the direct stiffness method. The comparison is for a single degree of freedom model, representing a frame and bridge structures respectively by using graphical method, which allow us to diagnose the state and the ability of resistance of the studied existing structure, this is an efficient and fast method for our engineers.

Key words: inelastic response, capacity curve, flexibility base model, displacement based

INTRODUCTION

The use of displacement-based representation of an existing structure is very important for the capacity evaluation of this later. The system performance is represented by a lateral force-displacement relationship calculated using a so-called “pushover analysis” [1-2], in a pushover analysis a prescribed vertical distribution of static lateral load is applied to a structure, in order to evaluate the non-linear deformation response. Many structures exhibit a range of behavior between the development of first yielding and development of a mechanism. In this article the comparison of frame and bridge by single of degree of freedom model is done between two softwares Seismostruct [6] and Zsoil [7] in the second one we use flexibility based model [3] which allow us to have one element per member (beam or column) is used in preparing the mesh.

Conversion to ADRS format and inelastic response diagram

The inelastic diagram response, for a given ductility, is a curve in format (A-D) representing spectral acceleration A according to spectral displacement D. it is obtained by conversion of the elastic spectrum of response (A-T) into format (A-D) using equation 2.1 connecting spectral displacement and acceleration spectral by the period [4].

$$D = \left(\frac{T}{2\pi} \right)^2 A \quad (1)$$

as we know that a spectrum is divided into areas which are delimited by the means of the periodes, and that all the spectrum have four fixed periods (T_a, T_b, T_c, T_d). Knowing these periods and corresponding accelerations given by [5], we can convert the curve from A-T format to A-D by using a following equation:

$$D_i = \left(\frac{T_i}{2\pi} \right)^2 A_i \quad i = a, \dots, d \quad (2)$$

The obtained diagram (A-D) transformed into a diagram of inelastic response (A-D) by a reduction coefficient, which is obtained using rule of the equal displacements for low frequency, and by the principle of consevation of energy for the average frequency. These frequencies are empirical values [4].

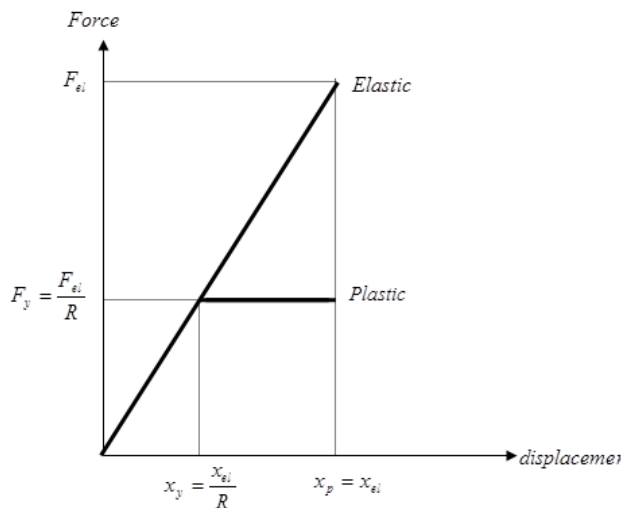


Fig. 1 Empirical rule of equal displacement

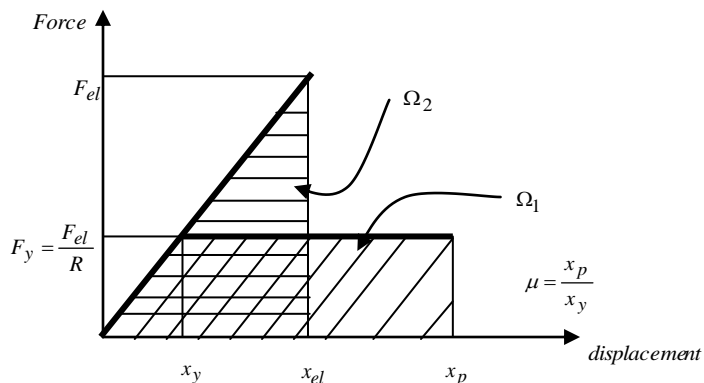


Fig. 2 Conservation energy principle

For the case of equal displacement and the principle of conservation of energy the reduction coefficient R is equal to μ and $\sqrt{2\mu - 1}$ respectively.

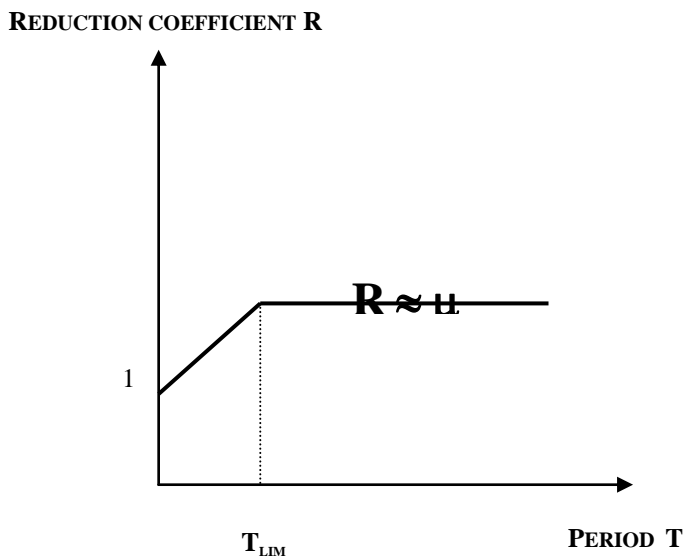


Fig. 3 Coefficient of reduction variation

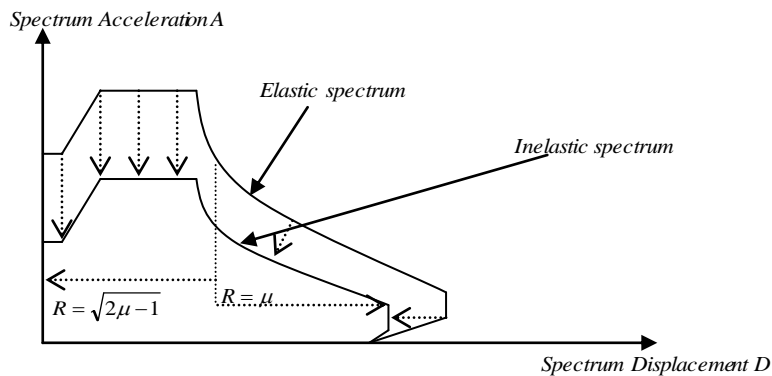
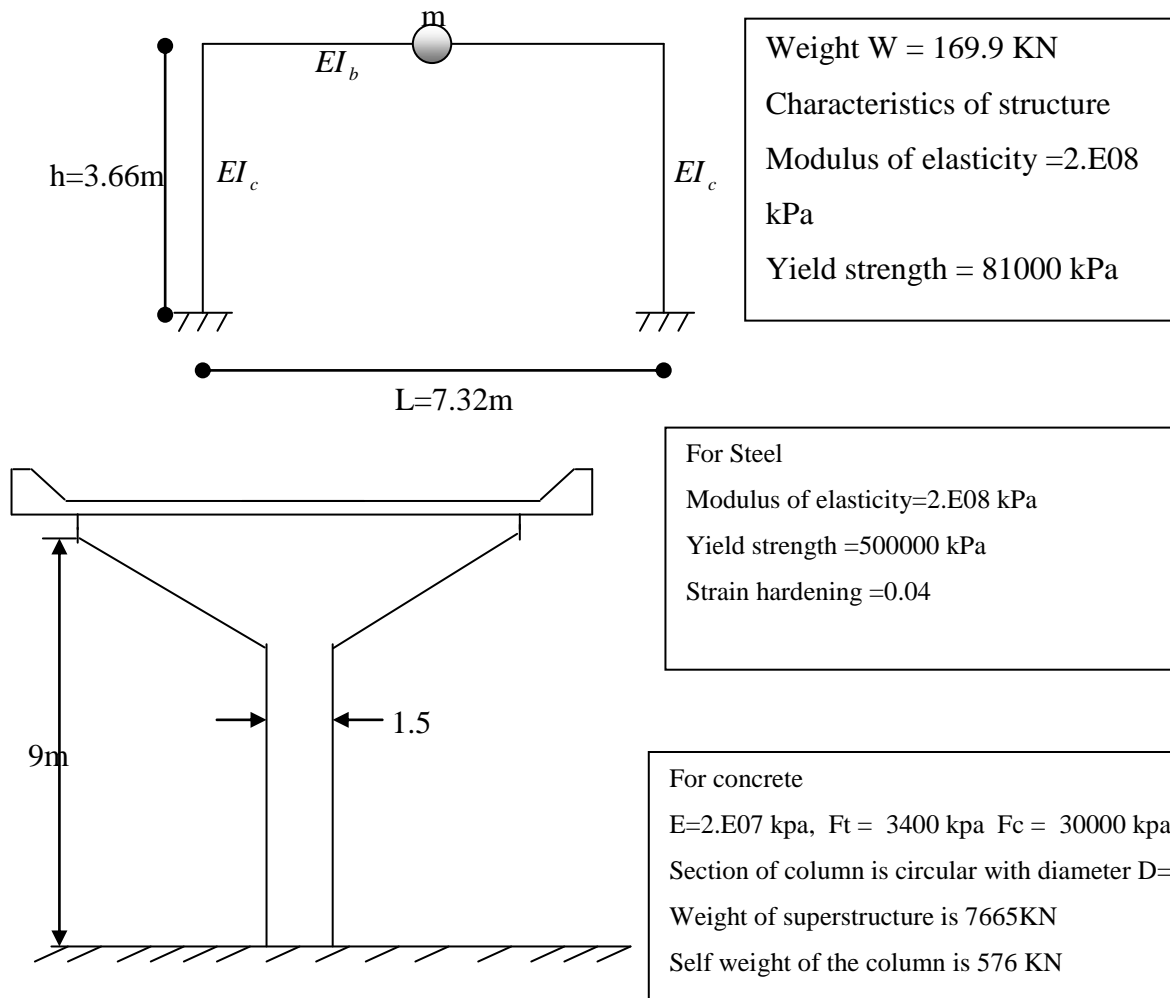


Fig. 4 Elastic and Inelastic response spectrum in ADRS format

Examples

Two examples are presented in this article frame and bridge respectively [4].



The capacity curve of frame and bridge structure using Seismostrut [6] and Zsoil [7] software are presented in figure 5.

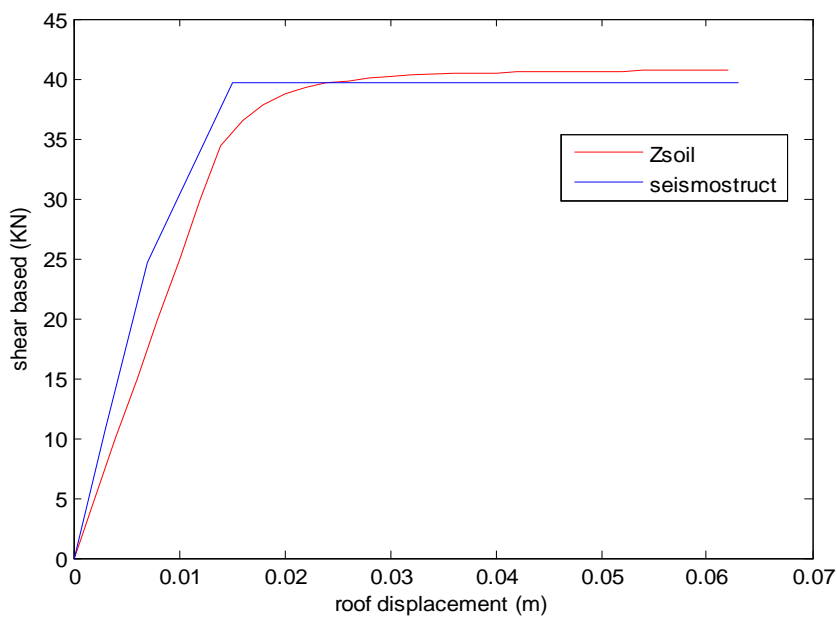


Fig. 5 Frame capacity curve

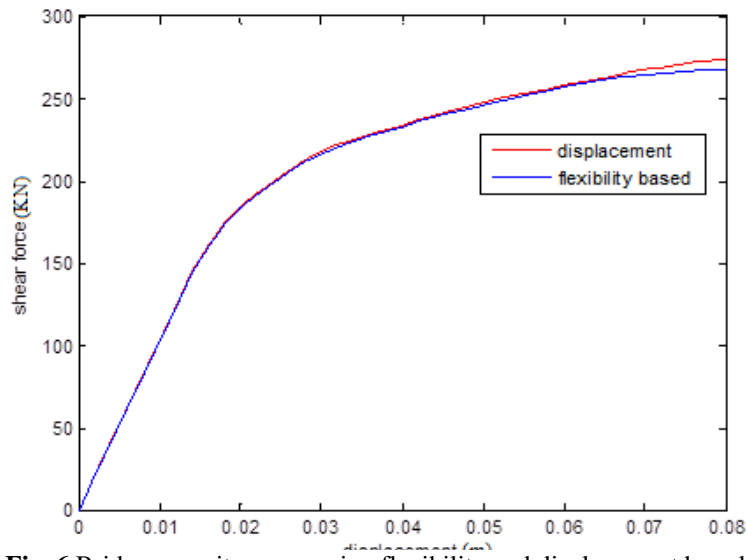


Fig. 6 Bridge capacity curve using flexibility and displacement based

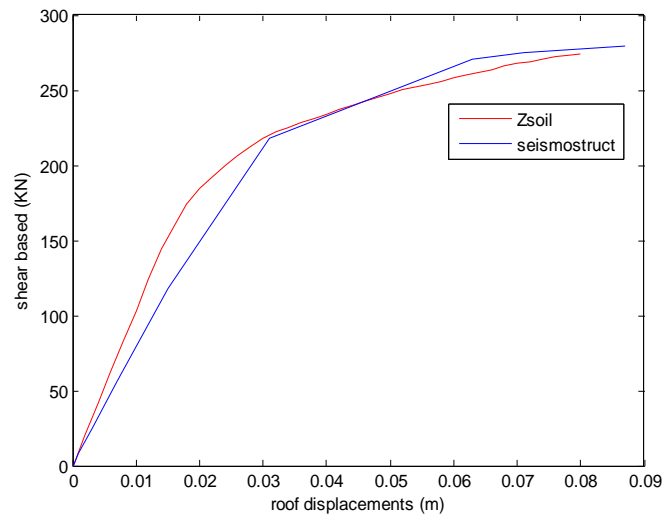


Fig. 7 Zsoil and Seismostruct of bridge capacity curve

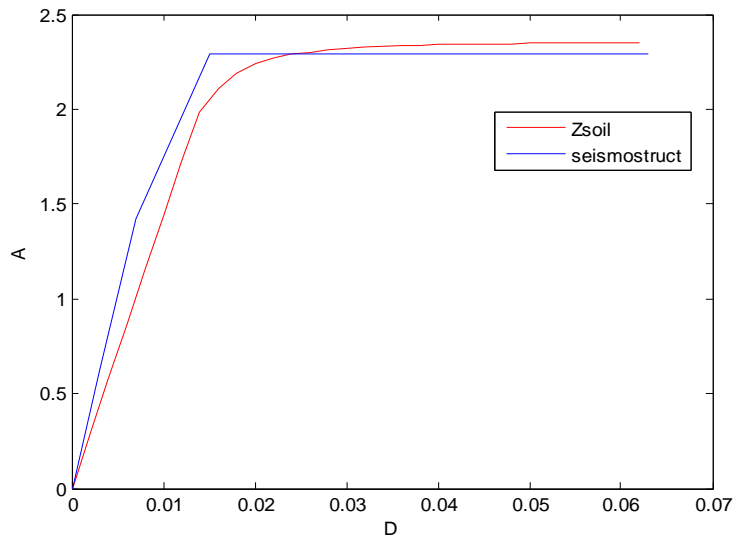


Fig. 8 Frame capacity curve in ADRS format

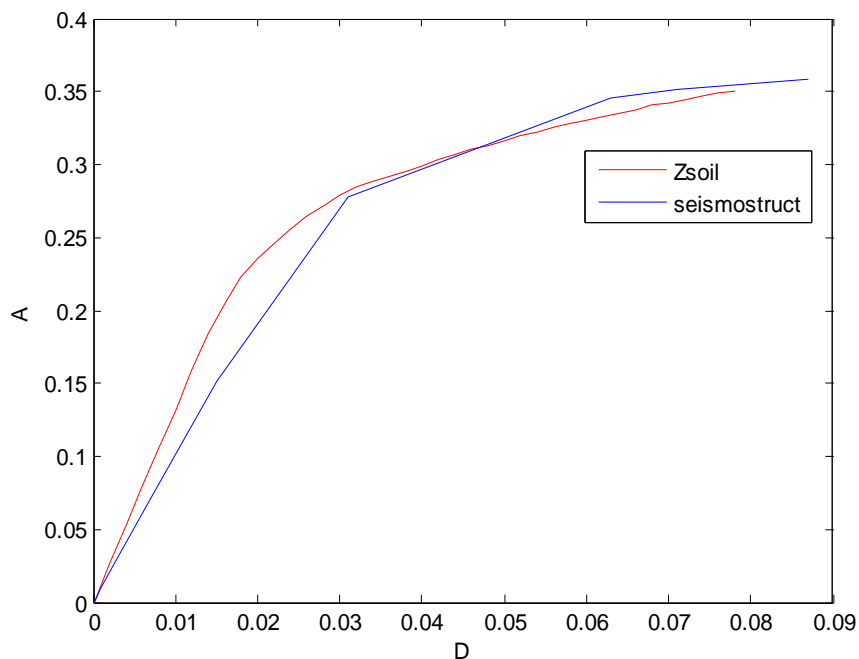


Fig. 9 Bridge capacity curve in ADRS format

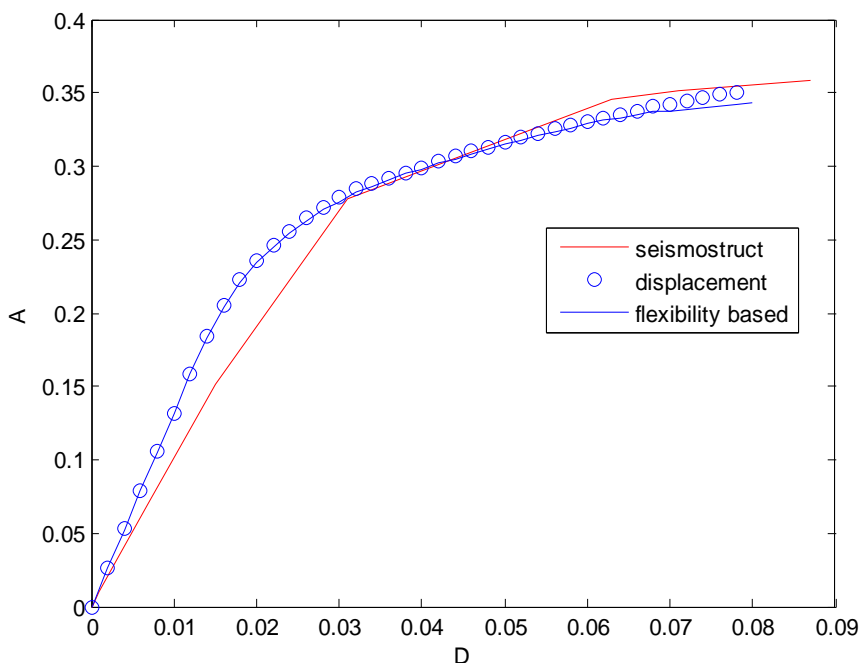


Fig. 10 Comparison of bridge capacity curve in ADRS format between displacement and flexibility base with Zsoil and Seismostruct software

ZONE: Z2 CLASS OF THE SUBGRADE: B DUCTILITY FACTOR : 3 DAMPING FACTOR : 5%

Pushover curve is converted into the capacity curve by means of these two equations:

$$A = \frac{F}{m^*} \quad \text{and} \quad D = \frac{U_N}{\Gamma_1 \Phi_{nl}}$$

At this level we have an inelastic response spectrum and a capacity curve are in uniformed format so we can trospose the two curves in the same graph.

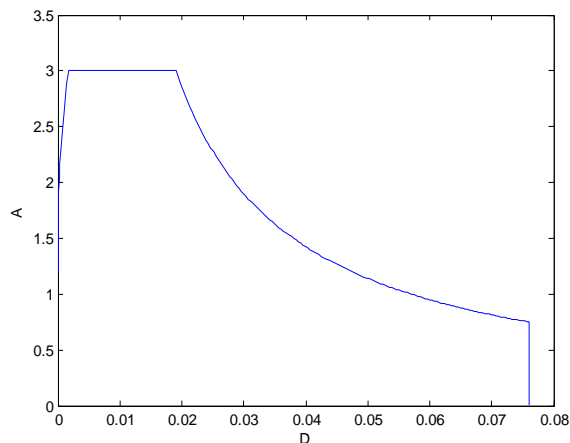


Fig. 11 Elastic response spectrum curve in ADRS format

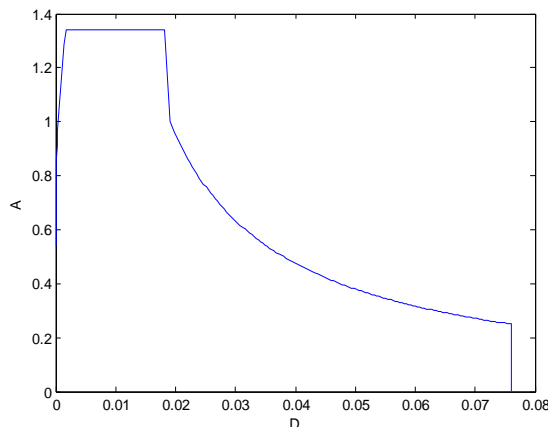


Fig. 12 Inelastic response spectrum curve in ADRS format

Characteristic in the site given by earthquake Swiss code [5]

Zone: Z2 class of the subgrade: B ductility factor: 3 damping factor: 5%

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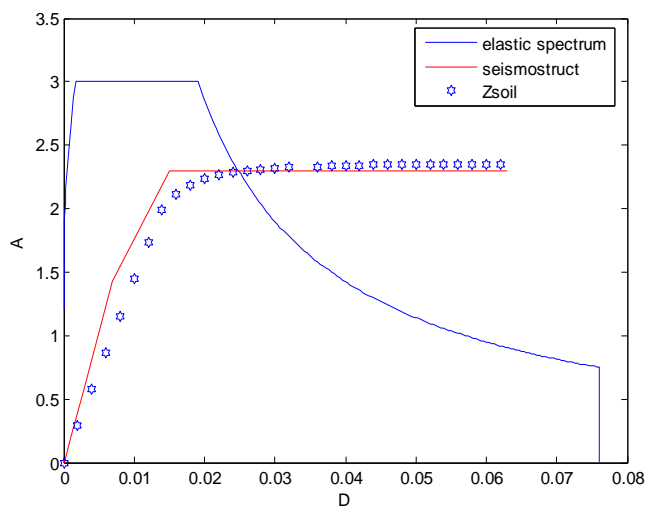


Fig. 13 Determination of performance point under inelastic response for frame structure using Zsoil and Seismostruct software

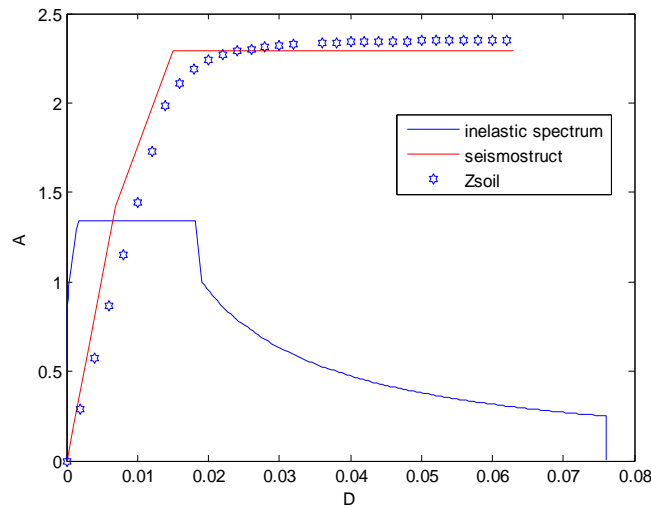


Fig. 14 Determination of performance point under inelastic response for frame structure using Zsoil and Seismostruct software

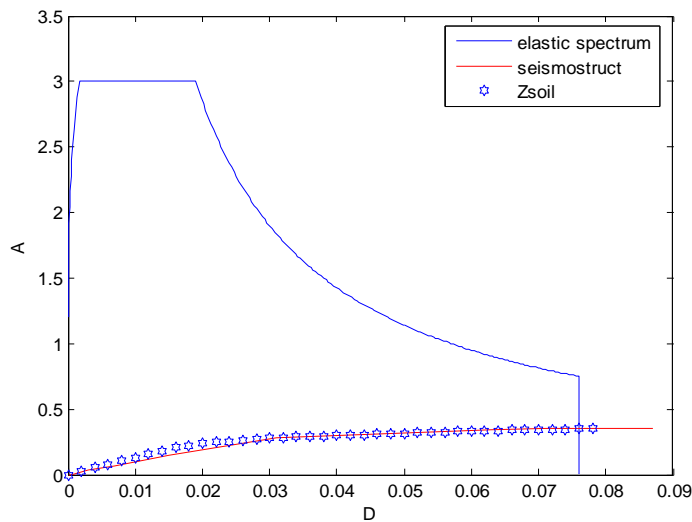


Fig. 15 Determination of performance point under elastic response for bridge using Zsoil and Seismostruct software

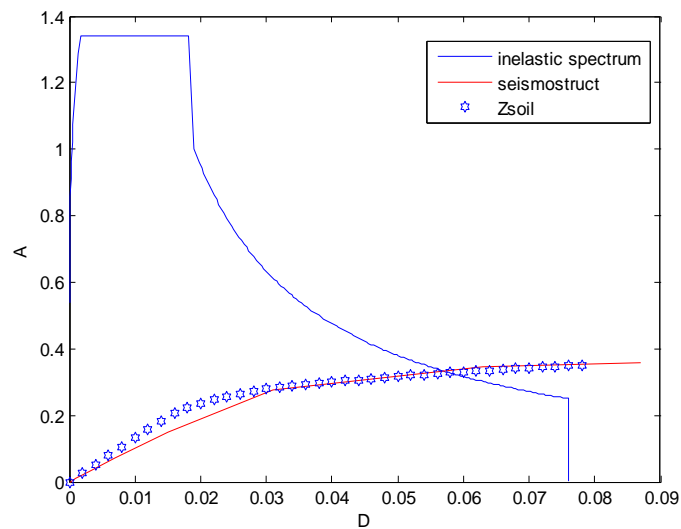


Fig. 16 Determination of performance point under inelastic response for bridge using Zsoil and Seismostruct software

RESULTS AND DISCUSSION

When we compare the results given by the two softwares Zsoil [7] and Seismostruct [6] with those given by [1] for frame structure which are $V_{by} = 40.5KN$ $V_{by} = 39.71KN$ and $V_{by} = 39.26KN$ respectively we can see that the results are very close.

For the bridge example, we can see clearly see the good coincidence of the two curves and we deduce that the results given by Zsoil and Seismostruct software are very close which are $V_{by} = 218.26KN$ and $V_{by} = 217.55KN$ respectively.

CONCLUSION

We notice the existence of intersection point between capacity curve and response spectrum response; which means, the earthquake applied to studied structures can be absorbed.

The results given in figure 6 and figure 10 show a very close results between flexibility based model and displacement based one, using Zsoil comparing with those given with Seismostruct software.

As conclusion this graphical method is one of the better tool for existing structure evaluation because it is fast, efficient, graphical and easy for our engineers, in addition the use of flexibility element drastically reduce the size of matrix and thus the equation system.

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