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Displacement based vs Force based time history analysis and capacity curve under two types of load of an Existing structure in 2D model

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ABSTRACT

The goal of this article is to study the seismic response of 2D model for an existing reinforced concrete building, analyzed using both displacement-based and force-based formulations for time history non-linear analyses according to Eurocode8.And comparison with uniform and modal load distribution using non-linear static analysis with flexibility based (force based) formulation.

Key words: Displacement-based, Force-based formulations, Time history analyses, Non-linear, Static non-linear

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INTRODUCTION

Recent versions of Z_Soil software include advanced models for frame analysis. In particular, nonlinear beams with fiber section models are available. The cross section is divided into fibers and the constitutive laws of each fiber is assigned from the constitutive law library available in [1]. Both displacement-based and force-based formulations are available. Force-based elements [2]**Error! Reference source not found.** are exact within the classical Euler-Bernoulli beam theory. As for geometric linearities, these are considered in the general framework of the program and thus follow a corotational approach [3].

An applications is presented, which concern the study of seismic response of an existing reinforced concrete building in order to compare displacement based and force based formulation time history analyses according to EurocodeC8.And the pushover analysis comparison of 2D model between uniform and modal load distribution.

FLEXIBILITY BASED FORMULATION

The element formulation is based on force interpolation functions strictly satisfy element equilibrium and, thus, belongs to the category of flexibility-based elements. The use of exact force interpolation functions in the element requires fewer elements for the representation of the non-linear behavior of a structure [4].

in the case of time history analysis [5] propose to take the maximum response, if we apply to structure less than 7 earthquakes.

There are no doubt advantages in using nonlinear analyses vs using linear methods. Most importantly, nonlinear analyses allow designers to follow more closely the nonlinear response of buildings and bridges to the design earthquakes corresponding to the ultimate and collapse limit states.

LOAD PATTERN AND CAPACITY CURVE

The Nonlinear Static Procedure (pushover) is based on the capacity spectrum method. It consists of the following to develop the relationship between base shear, V_b, and roof (N^{th} floor) displacement, commonly known as the pushover curve. In [5] we Consider at least two lateral load distributions: uniform load model pattern see figure 1a and figure 1b. When capacity curve and the target displacement are obtained, this displacement is for single degree of freedom (SDOF) system, it must be transformed to multi degree of freedom (MDOF) system see figure 2.

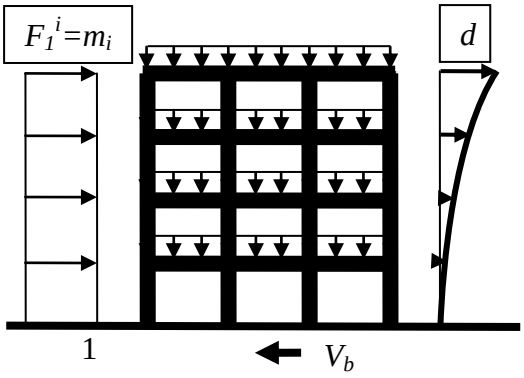

Fig. 1a Uniform load distribution 1

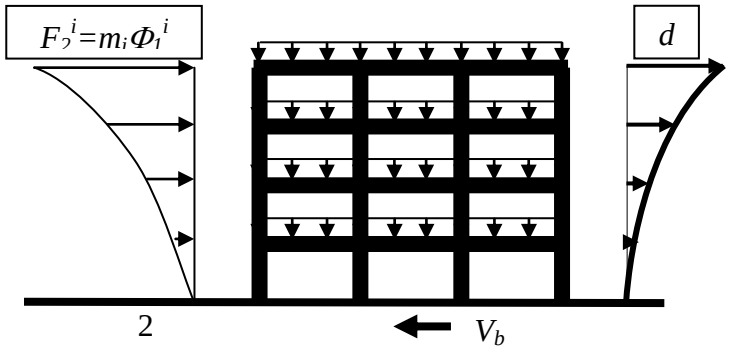

Fig. 1b Modal load distribution 2

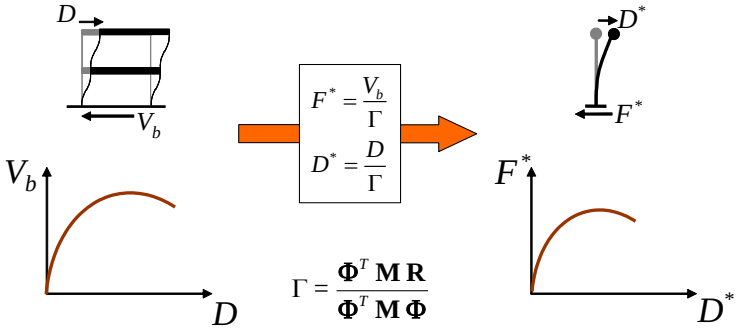

Fig. Error! No text of specified style in document. Capacity curve: transformation from response of MDOF to equivalent SDOF

RESPONSE OF EXISTING BUILDING TO GROUND ACCELERATION

The response of a single 2D frame is studies. Its model with force-based elements in [1] is shown in Fig.3 the model is obtained using force-based elements; six displacement-based elements in every beam and column were needed to converge to the solution obtained with force-based elements. One force-based element per column is used, while three elements were used throughout this paper for the beams, because of the different reinforcement near the columns.

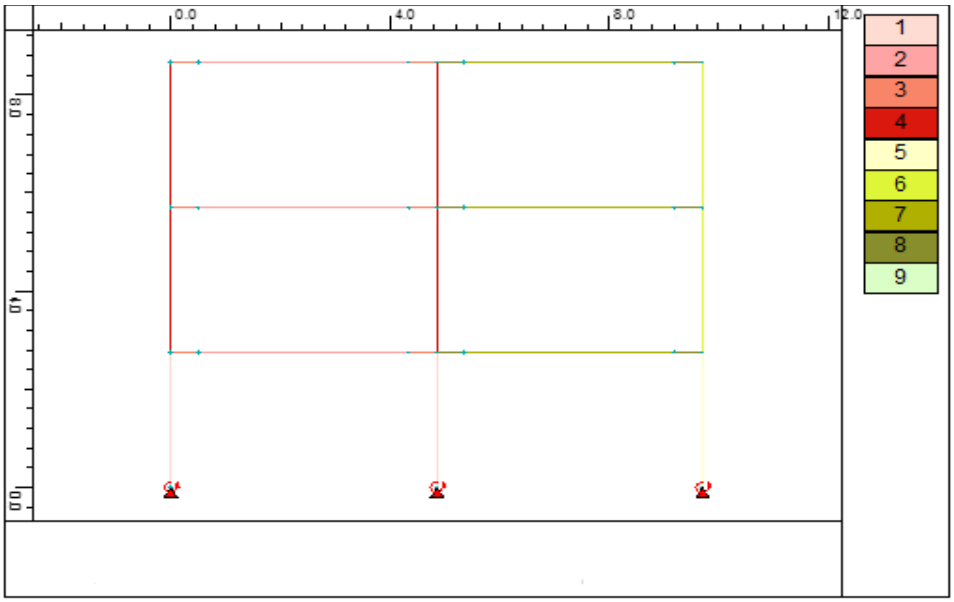

Fig. 3 2D frame model

Error! Reference source not found.4 and figure 5 show the response of 2D frame at each floors (three) to the El Centro earthquake using force based element (flexibility base element) and displacement based element respectively.

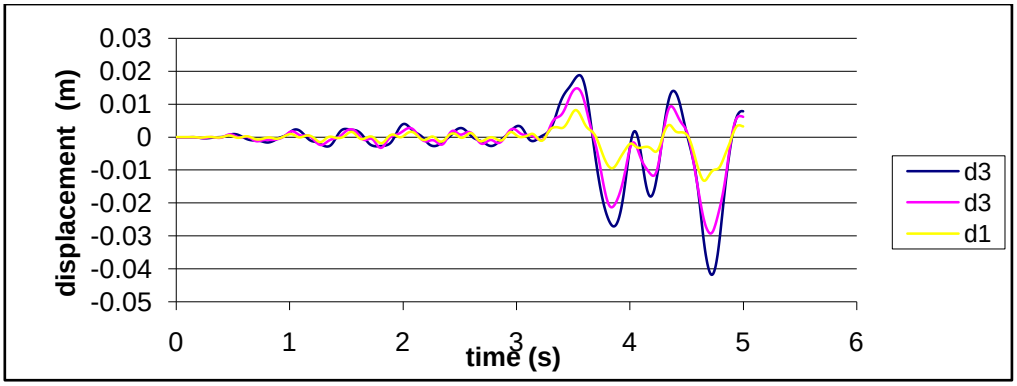

Fig. 4 Response of 2D frame model to El Centro Earthquake using Force-based elements: (displacement history of three floors)

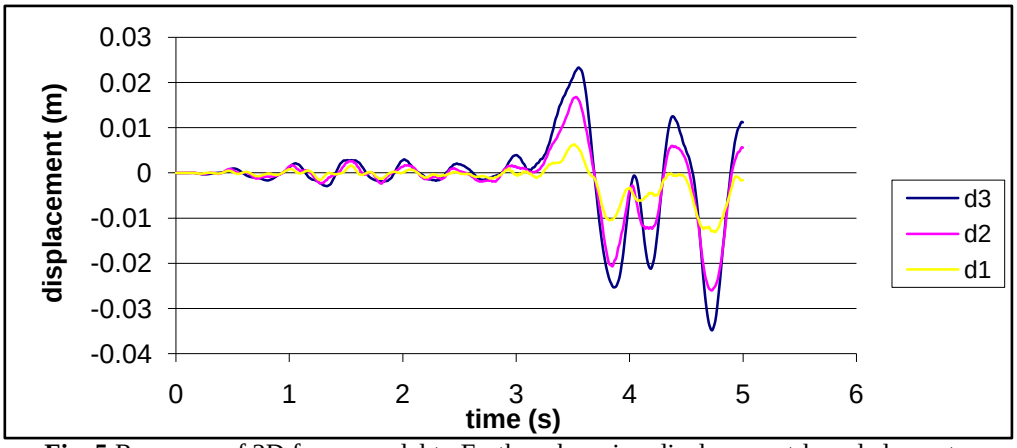

Fig. 5 Response of 2D frame model to Earthquake using displacement-based elements: (displacement history of three floors)

Error! Reference source not found.6 and figure 8 show the interstory drift of 2D frame under uniform load and modal load pattern using flexibility base element. Target displacement for single degree of freedom system is represented in figures 7 and figure 9 for the two patterns load (uniform and modal). The last figure 10 gives the position of the target displacement of multi degree of freedom in a capacity curve of the building.

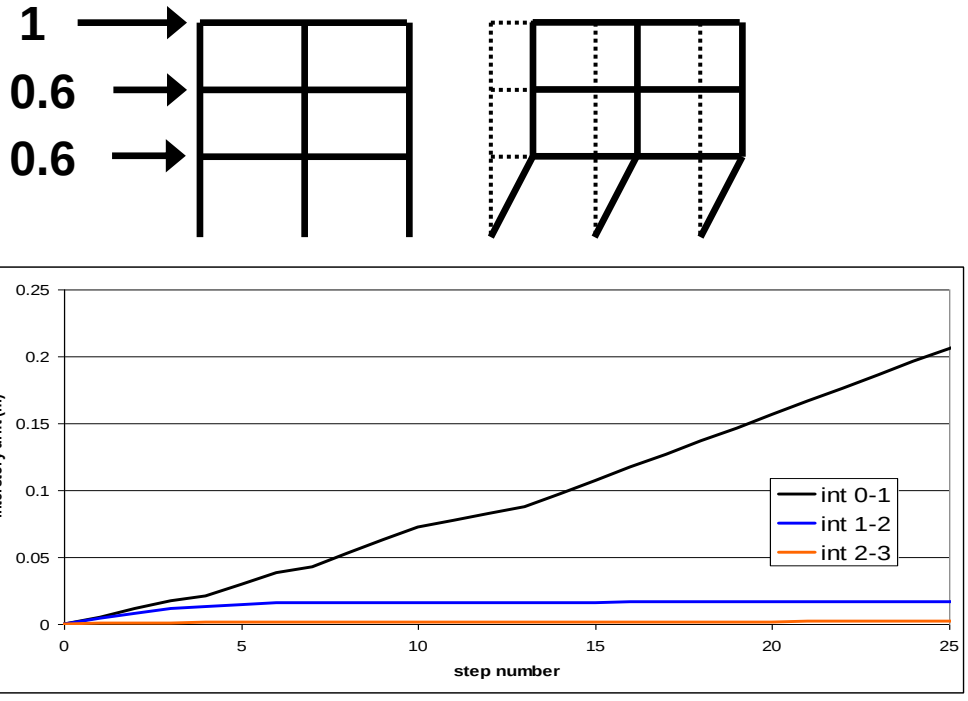

Fig. 6 Interstory drift floor of 2D frame model using Force-based elements under uniform load

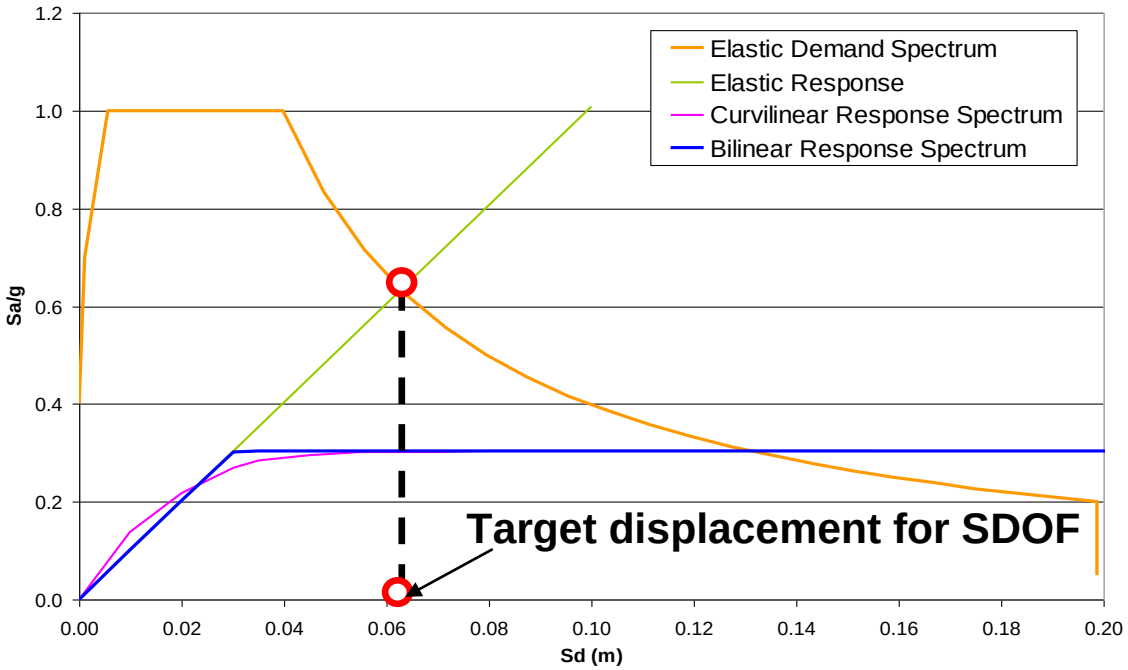

Fig. 7 Target displacement of 2D frame model using Force-based elements under uniform load

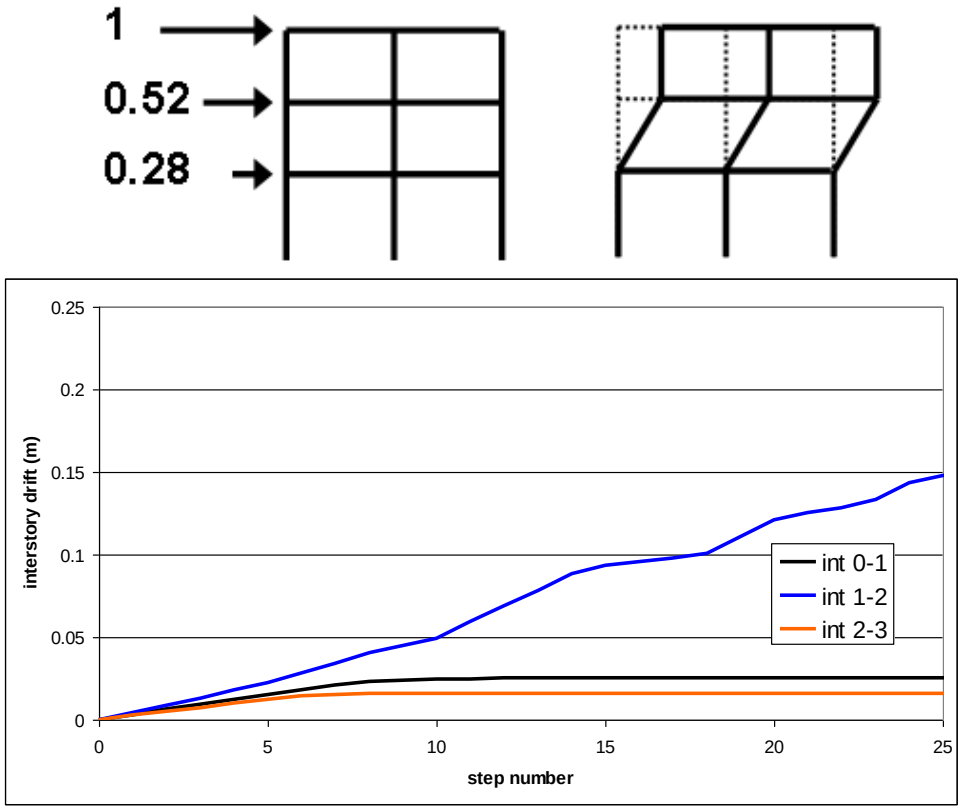

Fig. 8 Interstory drift floor of 2D frame model using Force-based elements under modal load

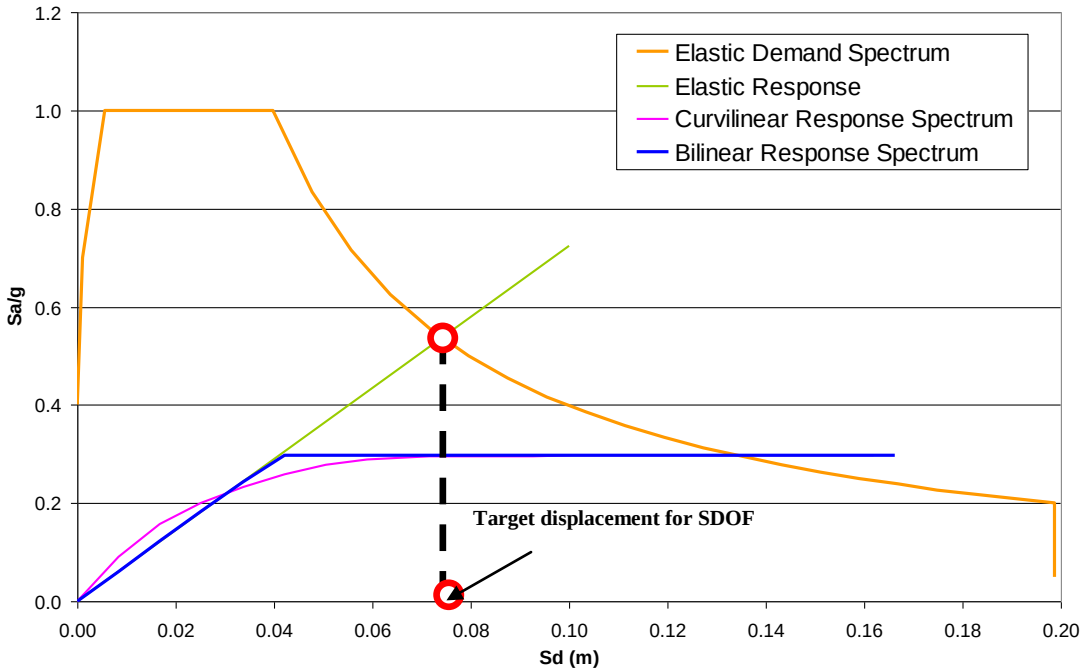

Fig. 9 Target displacement in single degree of freedom (SDOF) of 2D frame model using Force-based elements under modal load

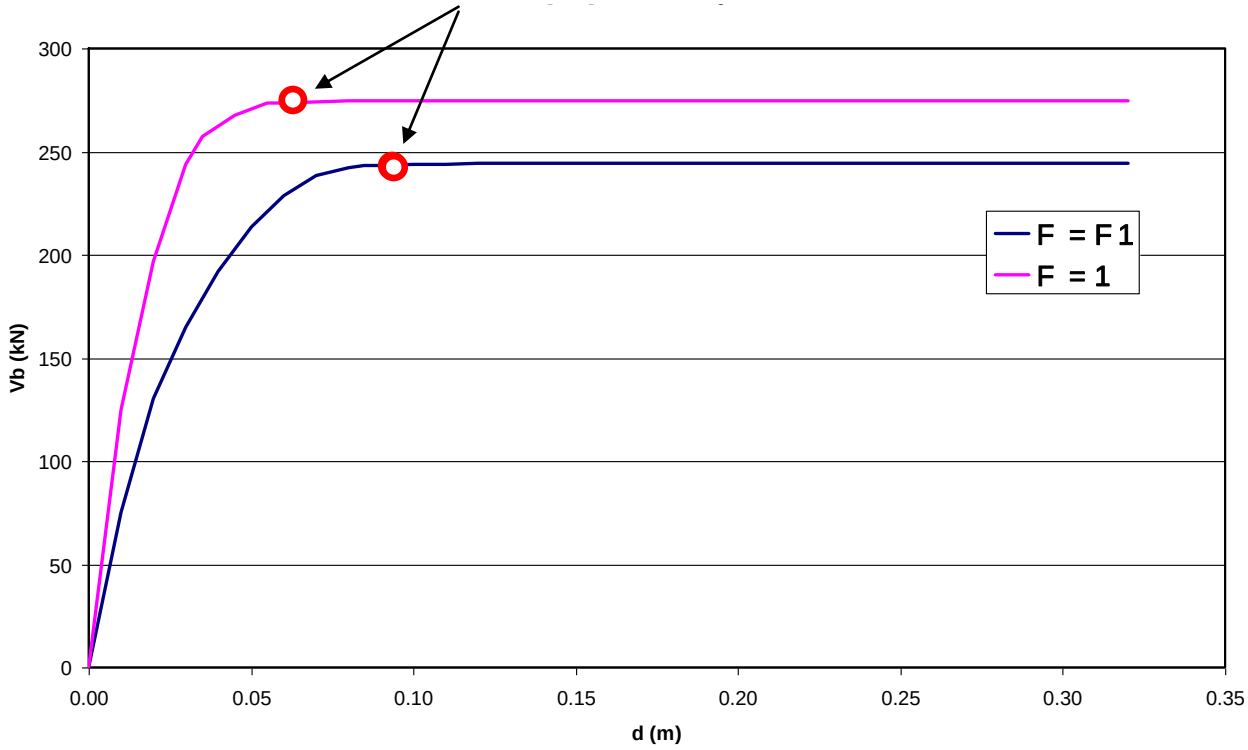

Fig. 10 Target displacement for MDOF using force base element

CONCLUSION

We can notice that the response at each top floor of the existing structure under the El Centro earthquake, are very close each other comparing between flexibility based and force based formulation.

In the capacity curve of figure 10 the strength is different when we apply to the structure different type of load ; because of coupling in failure mode which are shear and bending and this is du also to the plastic hinges which appear in different places and as consequences we have different strength for different applied load.

There are no doubt advantages in using flexibility based element and nonlinear analyses vs using linear methods. Because this formulation (flexibility based) requires fewer elements for the representation of the non-linear behavior of a structure, and gives a good numerical results without difficulties. This (flexibility based formulation) can be used with graphical method like non-linear static analysis [6], Most importantly, nonlinear analyses allow designers to follow more closely the nonlinear response of buildings and bridges to the design earthquakes corresponding to the ultimate and collapse limit states.

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