



Data Preparation from Pre-processing to Post-processing for Pushover Analysis Related to Eurocode 8

Mourad Belgasmia

Department of Civil Engineering Setif1 University, Algeria, 19000
 mourad.belgasmia@yahoo.fr

ABSTRACT

The article present different steps of data preparation for pushover analysis of a simple 3D model building as an illustration. The design spectrum for the building was obtained from Eurocode8 using the local soil properties and the peak ground acceleration according to Eurocode8, pushover analysis may be used to verify the structural performance of newly designed buildings and of existing buildings.

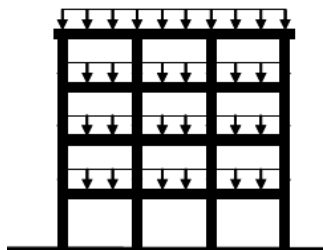
Key words: Design spectrum, Demand spectrum, Pre-processing, Post-processing, Plastic response

INTRODUCTION

The nonlinear pushover analysis consists of applying monotonically increasing constant shape lateral load distributions to the structure under consideration. The structure model can be either 2D or 3D. In particular, Eurocode 8 [1] states that for buildings with plan regularity, 2D analysis of single plane frames can be performed, while for buildings with plan irregularity a complete 3D model is necessary. Given that the nonlinear methods are particularly interesting for existing buildings, which are rarely regular, a 3D model is required in most cases.

DATA PREPARING

The structural element models and the resulting structural model of the overall building are very similar for pushover and nonlinear time-history analysis. The only difference lies in the need to have cyclic models for the time-history analysis. The initial steps of both nonlinear procedures are identical: construction of the nonlinear frame model and application of the gravity loads. The gravity loads remain constant during the nonlinear analysis (both static and dynamic). The application of the gravity loads is schematically shown in figure 1. The value of the constant gravity loads is given by EC8. This initial step is quite important because it may change the initial state of the structure.



$$G_k + P_k + \sum_i (\psi_{2i} Q_{ki})$$

Fig. 1 Gravity load

Data preparation for pushover analysis requires specification of the following data [2]:

- Control phase:
 - Activating driver(s)
 - Setting control data for each driver
- Preprocessing phase:
 - Introducing masses to the FE model of the structure, (see next section).
 - Selecting and labeling control node i.e. node where target displacement is set.

The example concerns a simple reinforced concrete 3D frame representing the skeleton of a two-storey building (with stiffness of the wall neglected) [3].

For sake of presentation simplicity there is one reinforced concrete section assumed in all members with dimension $0.4 \times 0.3\text{m}$, made of concrete characterized by $f_c = 25\text{MPa}$, $f_t = 1.8\text{MPa}$, reinforced by symmetric reinforcement $10\%25$ as shown in figure 2.

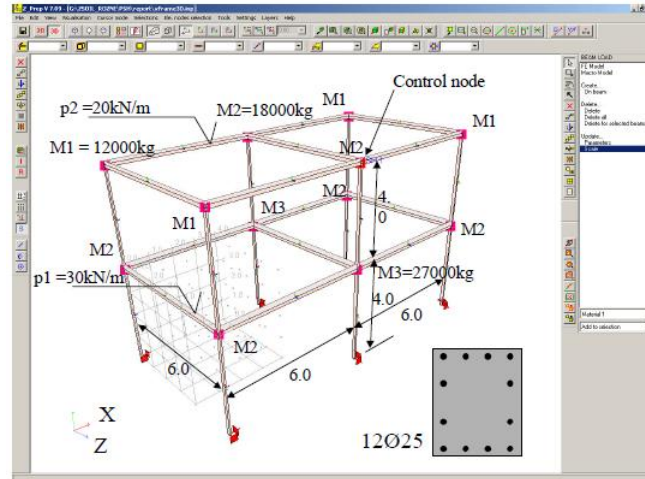


Fig. 2 Example of finite element model

Other data to be defined are:

- Nonlinear solver settings (use Control / Control)

The only data taken into account during pushover analysis are:

- Tolerance for solid phase (Right hand Side) RHS
- Absolute max. nr of iterations -if reached, the step length reduction is performed

- Pushover settings: (use Control / Pushover)

- Label can be given to ease identification of the given set in case of multiple use in one job,
- Mass filtering (if on) will be performed in specified direction
- Direction, the vector introduced will be used to set: pushover force direction, control displacement direction, and mass filtering (if activated).
- Force pattern- selection between Modal , Uniform or Triangular, see Window

MODELING OF MASSES

There is different possibilities to model masses present in the structure. They include:

- Element masses

They are related to the material density and geometry of the structural element itself. In each element type they have to be defined as a part of material model attached to the element. Their existence at a given instant of the analysis is controlled by the element itself.

- Added masses

They can be added independently from element description, their activity (existence) can be controlled by existence and load functions. They can be attached to:

- A node (by specifying total nodal mass),
- An edge or existing beam and truss (by specifying linear mass density),
- A face of a shell (by specifying surface mass density).

POST-PROCESSING

After running computational part of pushover analysis, seismic demand assessment can be done automatically under Menu/Results/Pushover results option. Each of the available actions will invoke EXCEL spreadsheet containing numerical results together with their graphical presentation:

- View MDOF capacity curve (for the single driver or multiple selection of drivers, irrelevant to active demand spectra) [4], see figure 3.
- View SDOF capacity curve and demand spectra (for the single driver or multiple selection of drivers and for the active demand spectra), see figure 4.
- View Report (for the single driver or multiple selection of drivers and for the active demand spectra), EXCEL table containing results as shown in figure 4 will be created.
- Seismic demand activation and edition.

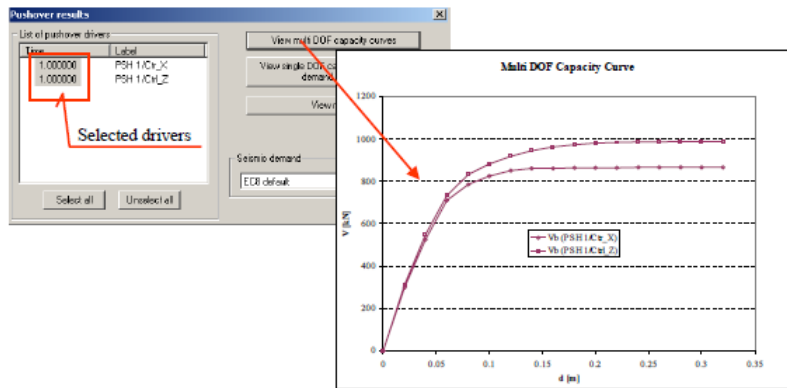


Fig. 3 Multi degree of freedom capacity curve

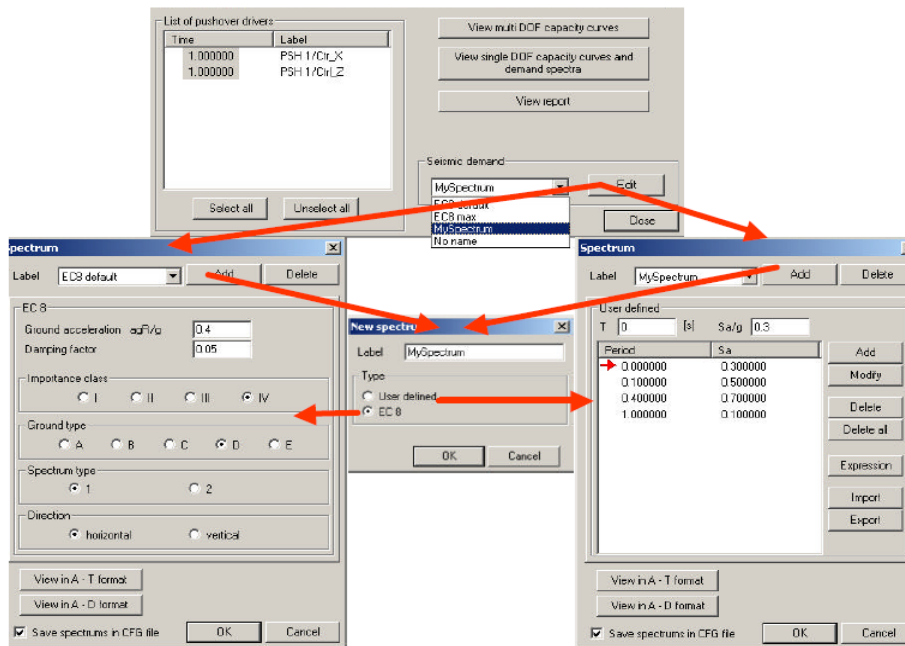


Fig. 4 Single degree of freedom demand spectra

Having set the elastic demand spectrum, inelastic demand spectrum related to given capacity spectrum can be set leading to evaluation of displacement demand (or target displacement). Typical relations between demand spectrum and capacity spectrum are shown in the figure 5. All cases concern results of pushover.

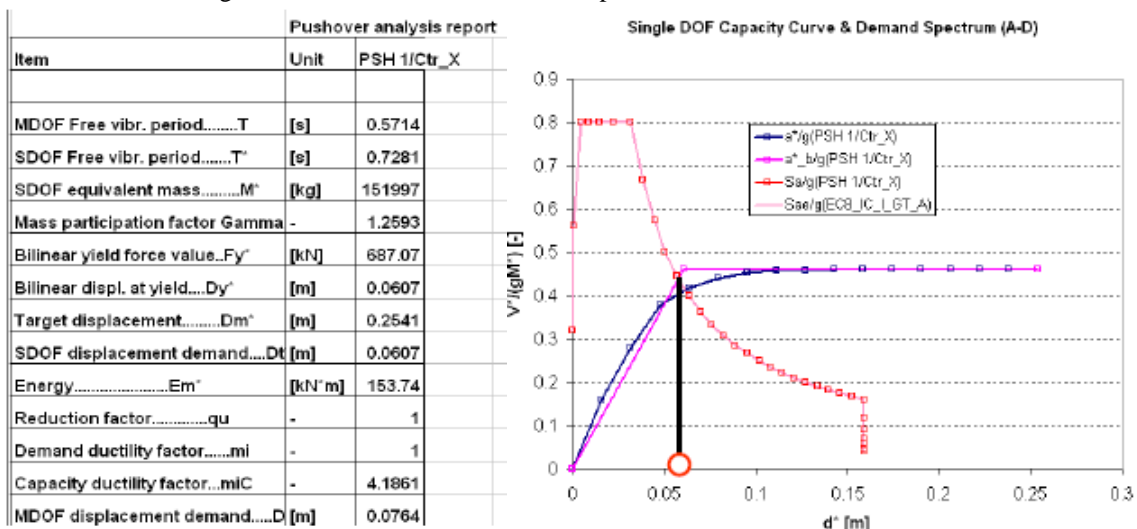


Fig. 5 Elastic response in the range of seismic demand (no reduction of demand spectrum)

Both cases Figure 5 and 6 are successful, in the sense that target displacement was found within the initially assumed range of analysis $D_t < U_{max}$. If so, evaluation of the structural performance at the state corresponding to the evaluated value D_t can be performed. In figure 6 plastic response [5] (target displacement) found within the range of capacity spectrum ($D_t < D_m$).

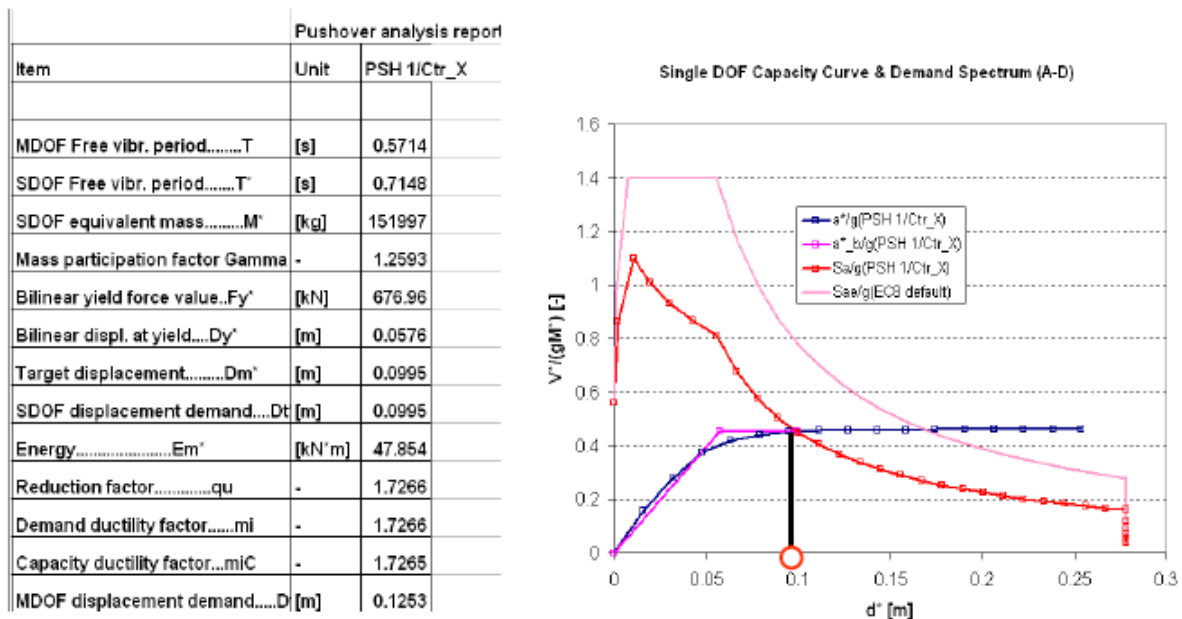


Fig. 6 Plastic response with ductility reduced demand spectrum

CONCLUSION

This article allow us to deduce that the model must have nonzero mass (masses are defined as element and/or nodal), and control node must be set during preprocessing.

The initial step is quite important because it may change the initial state of the structure, in a reinforced concrete building; for example, the gravity loads typically induce cracking in beams and apply high axial forces on columns.

After running pushover driver use Post-processing/Pushover Result to perform seismic demand assessment automatically

REFERENCES

- [1]. Eurocode 8: Design of Structures for Earthquake Resistance, European Committee for Standardization, 2003.
- [2]. Th. Zimmermann, A. Truty, A. Urbanski, K. Podles. Z-Soil user manual, Zace Services Ltd, 1985-2006.
- [3]. A. Urbański, E. Spacone, M. Belgasmia, J.L. Sarf, Th. Zimmermann Static Pushover Analysis in Z_Soil. PC & related EUROCODE 8 regulations Zace Services Ltd, Report 070202 January 2007
- [4]. S. Moussaoui and M. Belgasmia. Static Nonlinear Analysis Case Study. European Journal of Advances in Engineering and Technology, 2018, 5(3): 156-161.
- [5]. T. Vidic, P. Fajfar, M. Fischinger. Consistent Inelastic Design Spectra: Strength and Displacement. Earthquake Engineering and Structural Dynamics, 1994, 23:502-521.