Equivalent Lateral Forces

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The seismic Equivalent Lateral Forces (ELF) analysis is the most well known method for the seismic analysis of structures. Although it is quite conservative, its simplicity makes it a very popular method for seismic design.

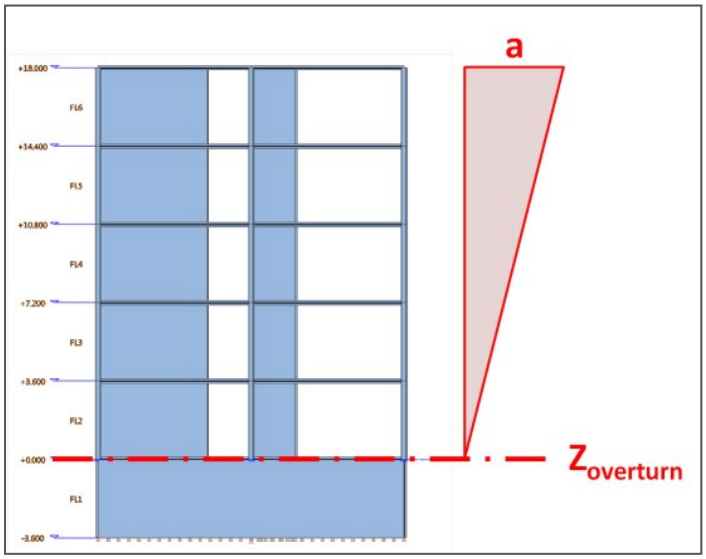
- The ELF method is a static analysis method.
- It requires the input of some data related to dynamic analysis: masses and at least one combination of mass groups.
- The calculation is based on the distribution of masses in the structure.
- The calculation of storey forces is based on the definition of storeys as well as on the reduced system, which must therefore be defined.

Calculation of the Equivalent Lateral Forces

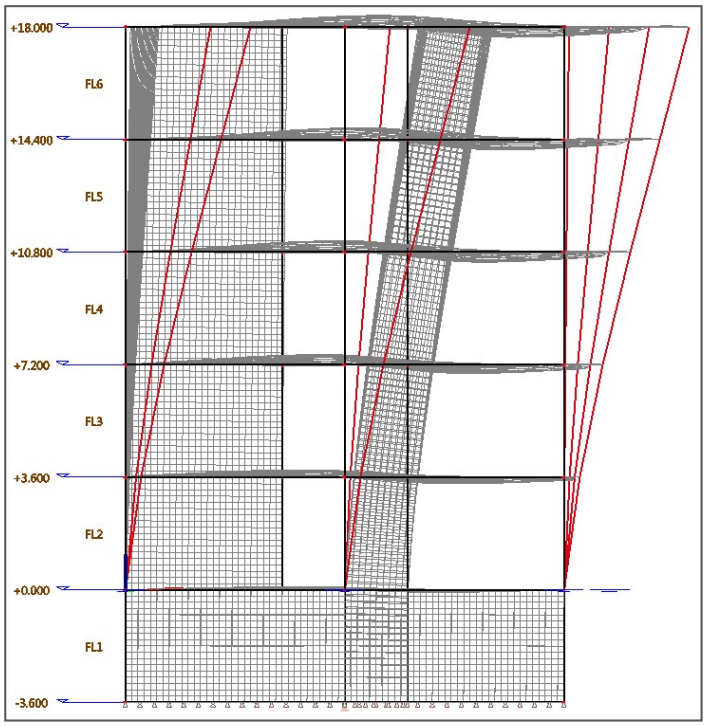
- The user is able to select from methods for calculation of equivalent lateral forces.
- These method are in compliance with the European and American standards - EN 1998 and ASCE 7-10.
- ELF are calculated in the background after a modal analysis.
- Calculated equivalent lateral forces are applied as one concentrated force at the mass centre of each storey.

Possibility to select how the acceleration is distributed in the building:

- Linear distribution of accelerations (EN 1998- 1 clause 4.3.3.2.3 eq. (4.11))
- Polynomial distribution of accelerations (ASCE 7-10 12.8.3)
- Distribution of accelerations from eigenshape (EN 1998- 1 clause 4.3.3.2.3 eq. (4.10))



Linear distribution



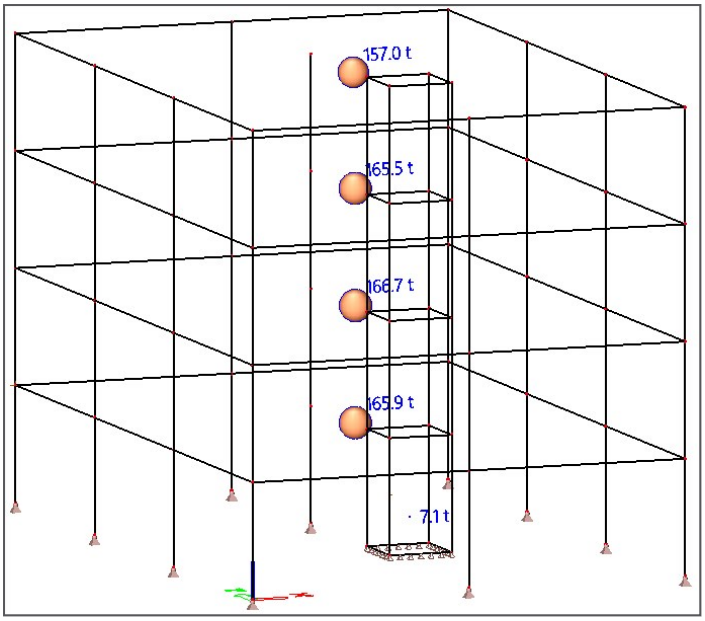
Distribution from eigenshape

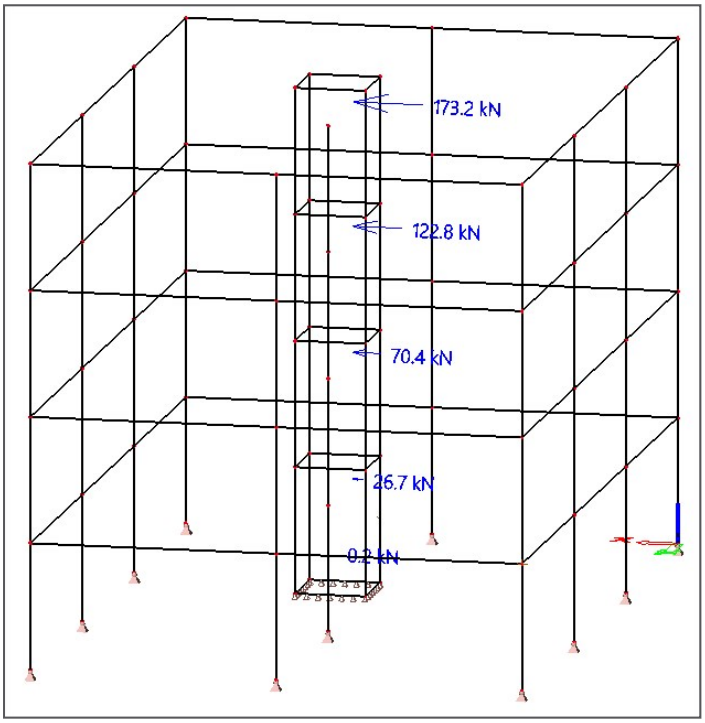
Application of the storey forces to the model

- The calculated storey forces are applied to the structure using the reduced system.
- The transformation matrices of the IRS method make it possible to "smear" the concentrated storey forces in such a way that the resultant of each storey force is applied at the mass centre of the corresponding storey. It is therefore not necessary to define diaphragms to apply storey forces.
- The loads are, however, applied in a distributed way to the entire storey, hence avoiding any numerical singularity, as would be the case if point loads would be applied in a conventional way.

Results

All standard result output can be used in SCIA Engineer, without any restriction. Also, because it is a static load case, none of the issues related to the loss of sign due to the modal superposition apply here.





Summary storey result

Storey data:
Linear calculation, Extreme: No, System: Principal
Selection: All
Load cases : EQX1

Equivalent Lateral Forces (ELF) settings

ELF method	Polynomial distribution of accelerations (ASCE 7-10 12.8.3)
Seismic force from	Selected eigenmode
Fundamental period [s]	1.28
Distribution factor k	1.39
Mode shape	1

Equivalent Lateral Forces (ELF) per storey

Name	M [t]	Zg [m]	Fx [kN]
FL1	7.1	0.993277	**0.2**
FL2	165.9	3.603689	**26.7**
FL3	166.7	7.204320	**70.4**
FL4	165.5	10.800000	**122.8**
FL5	157.0	14.354149	**173.2**
Total	**662.2**		**393.4**

Brief comparison of ELF and response spectrum method

Equivalent lateral forces

Pros
- easy to use, intuitive
- static analysis, which implies the following advantages:
- results easy to check
- signed results & concomitant results
- non-linear analysis possible (not available yet in SCIA Engineer)

Cons
- limited to regular buildings (acceptance criteria defined in the design codes)
- only fundamental mode is taken into account
- conservative (in applicable cases)

Response Spectrum Method (modal superposition)

Pros
- applicable to all types of buildings (including irregular ones)
- multiple modes taken into account
- less conservative than ELF, more realistic

Cons
- requires understanding of modal analysis
- only elastic linear analysis (2nd order possible)

Required modules

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