POSITIVE BEHAVIOUR IN SEISMIC ZONES:

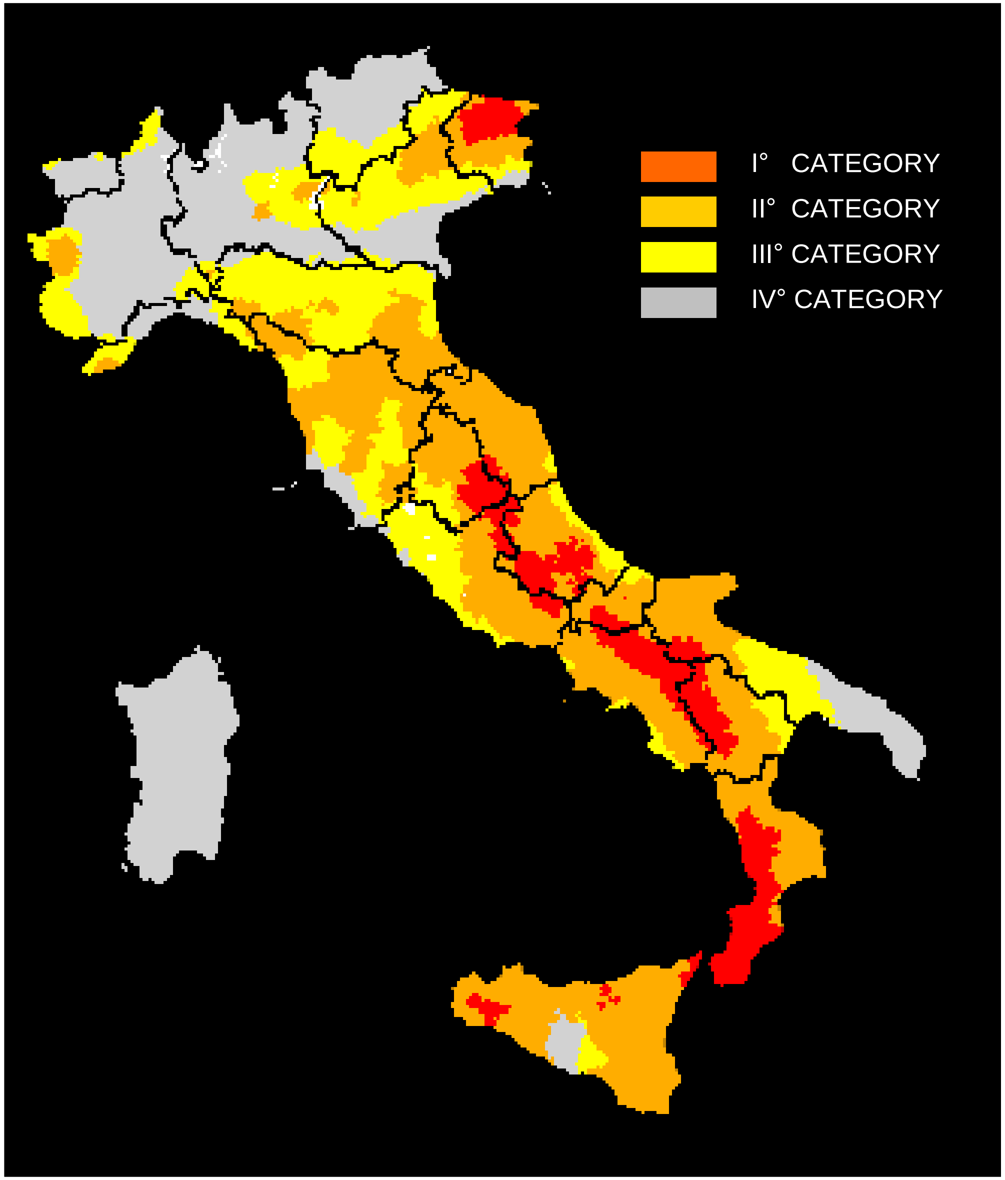
Timber as a material and as a structural framework in general, possesses intrinsic characteristics that make it appropriate if not recommendable for use in seismic areas. It has:

- **Low mass volume (weight) – providing low counteracting forces to an earthquake (weight of wood = 450 Kg/m³ 30-40 kg/m²)**
- The highest **ratio resistance/weight** amongst all existing construction materials

Wood:	**0.311**
Concrete:	**0.036**
Steel :	**0.204**
Brick:	**0.016**

- **Resistance to traction** (sussultatory movements) opposite to cement;
- **Resistance to instant loads:** +20% of breakage causing loads;
- **Possibility to create structures with a clear static function as the material is fragile and flexible** (low E, high τ) i.e. a linear ε-σ diagram (more evident in timber)
- Workable and Dissipative capacity of energy (to be secured with joints, bolt and nuts);

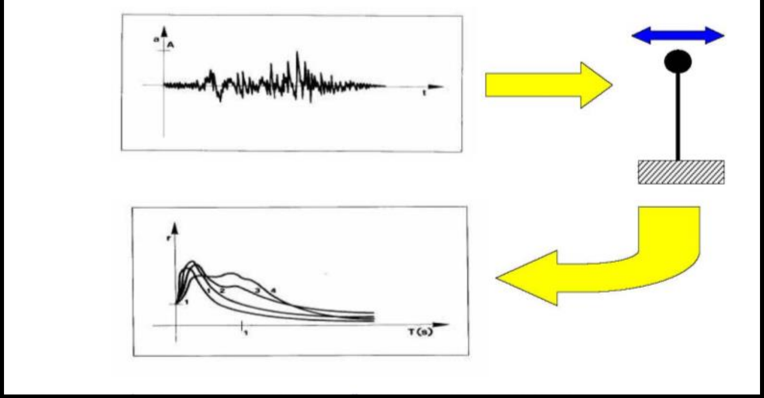
REVIEWED SEISMIC ZONE CLASSIFICATION: **OPCM n. 3274 – 3431 - 3519**



SEISMIC ZONE	ag
SEISMIC ZONE 1	0,35 g
SEISMIC ZONE 2	0,25 g
SEISMIC ZONE 3	0,15 g
SEISMIC ZONE 4	0,05 g

Elastic Response spectrum:

Is defined as the maximum response (in terms of acceleration – velocity or movement) to the seismic accelerogram of a simple accelerator with the assigned damping Y (5%) upon the variation of its frequency ω.



EFFECTS OF SEISMIC ACTIVITY:

The effects of seismic activity on the structures depend on the amount of energy of a specific earthquake, but also from the characteristics of the type of structure.

The simple oscillation can be defined as an equivalent static force that induces the movement (acceleration) times (t) of the mass in relation to the ground.

Equivalent static force $F_{se} = C_1\ mg = (1/To\ \nu) . Mg$

$C_1 \leftrightarrow$ elastic spectrum response $\leftrightarrow$ function of (**1/To ν**)

C_1 is a pure number, ratio between the maximum inertial force on the mass and the gravitational >>> **ag\g**

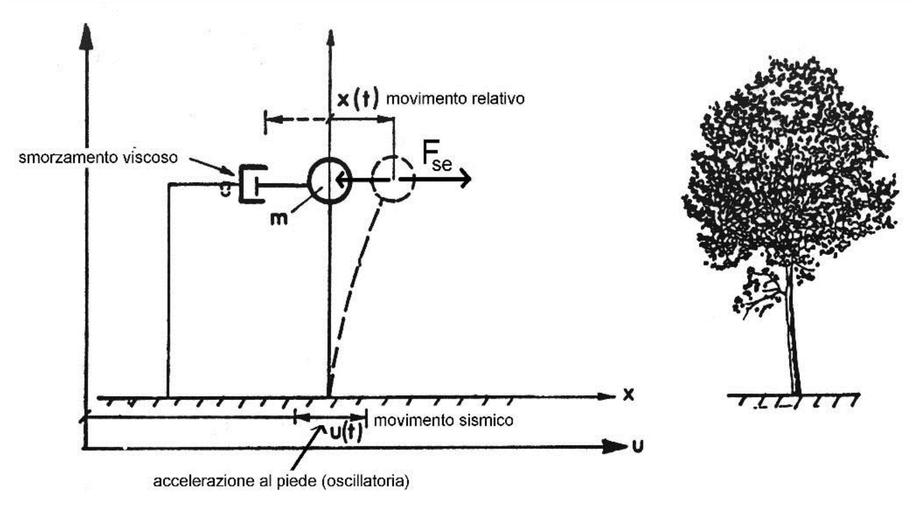
To = own oscillation period – frequency = flexibility = low E

ν = damping factor = dissipative factor = adaptability

In Dynamic Analysis (linear) the modal analysis (ways of vibrating) is used with a response spectrum based on the ratio a/g.

The (EC8) norms adopt the normal spectrum.

EFFECTS OF THE SEISMIC ACTIVITY:



"The tree is a simple oscillator!"

EC8 (structural plan in seismic zones) differentiate between the final earthquake (475 years) that can harm the structure to its limit (i.e. collapse); and the service earthquake (return time of 95 years) that does not provoke any damage or deformity to any of the services intrinsic to the structure. In this case importance is given to the dissipative capacity of the structure.

The EC8 introduces **the structural factor q**, which takes into consideration the dissipative capacity of the structure's energy via a ductile behaviour.

q is a pure number that indicates the ratio between the acceleration activity of the earthquake towards collapse and the acceleration to the elastic limit.

q allows designing the yet elastic linear design of the structure keeping in mind the none-linear plastic behaviour by dividing the ordinate of the return spectrum (the accelerations) by factor q.

<u>For the timber structures q varies from 1.5 to 5 (steel 1 >6) (concrete 1>5)</u>

However, a wooden tester subject to a gradual load with a controlled movement, reaches rupture with a linear diagram and is therefore considered "fragile", with a structural factor q = 1 more accentuated by the defects of the timber and the type of wood used. In order to each q>1, the choice of material, its mechanical characteristics and the type of joint used in the design and implementation phase are therefore important.

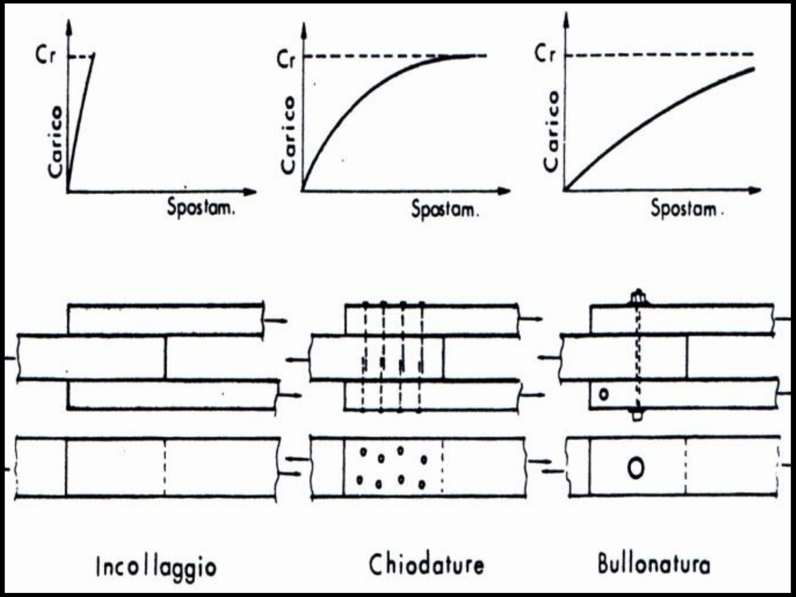
EFFECTS OF THE SEISMIC ACTIVITY:

For timber structures, one must therefore pursue the structural ductility guaranteeing rotation zones and dissipation of energy during the earthquake, able to absorb the energy transmitted by the same earthquake and avoiding fragile ruptures.

This is possible by ensuring plastic and dissipative capacity of the joints; in other words the wooden elements must be made more resistant (rigid) than the joints (i.e. opposite to steel structures, where the ductility of the posts is intrinsic to the material).

EC 8 provides references for the q values for various types of timber structures:

Semi-trapped column and rested roof:	q=1,5
Beams and pillars	q=2>>2,5
Overlapping logs	q=2
PAGANO system's beams (small) and panels	**q=5**



STRUCTURAL FACTOR q ACCORDING TO EC8:

CAT.	TYPE OF STRUCTURE	FACTOR OF THE STRUCTURE (q)
A	NON DISSIPATIVE STRUCTURES	1
B	STRUCTURES WITH LOW CAPACITY OF DISSPIATING ENERGY	1,5
C	STRUCTURES WITH MEDIUM CAPACITY OF DISSIPATING ENERGY	2,0
D	STRUCTURES WITH GOOD DISSPIPATING ENERGY	3,0 - 5

$$S_d(T) = a_g \cdot S \cdot \frac{2,5}{q}$$

Table 9.1 – Types of structures and structure factors q per category of use

CAT.	q	Example of structures
A	3,0	Nailed wall panels with glued membranes, connected via nails and bolts: rectangular structures with nailed joints.
	4,0	Portals put together with cylinder leg, pins and bolts.
	5,0	Nailed wall panels with nailed membranes, connected with nails and bolts
B	2,0	Glued wall panels with glued membranes, connected with nails and bolts; reticular structure with bolts or pin connections. So called mixed structures with seismic resistant in wood with non-loading cladding. Isostatic portals put together with cylinder leg, pins and bolts.
	2,5	Hypostatic portals put together with cylinder leg, pins and bolts.

Unless otherwise stated, the isostatic structures are to be considered as having low energy dissipation capacity, to which a structure factor not exceeding 1.5 will have to be given.