

# PREPARATORY PHASE TO THE ELABORATION OF SEISMIC RISK MAPS AT URBAN LEVEL: CASE STUDIES IN ISRAEL

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INGEGNERIA CIVILE,  
EDILE E AMBIENTALE  
CIVIL, ARCHITECTURAL AND  
ENVIRONMENTAL ENGINEERING



## Seismic vulnerability analysis of historic buildings at a territorial level



**Simplified methodologies and models**, that are  
reliable, based on empiric parameters

### Level of analysis

- Level 0: general data from inventories or censuses (ANCITEL, ISTAT...),  
typological classes definitions
- Level 1: rapid survey on typological base, more information about structural  
behaviour
- Level 2: detailed tests and surveys, damage observation, study of the buildings  
in great detail
- (Level 3: study in order to define intervention for the seismic improvement of  
the building)





## Seismic vulnerability assessment on an urban scale



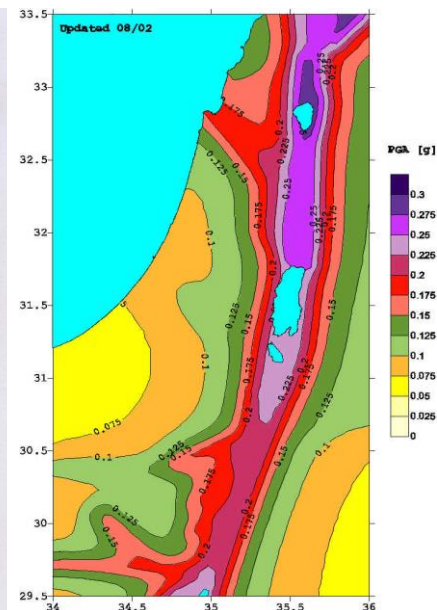
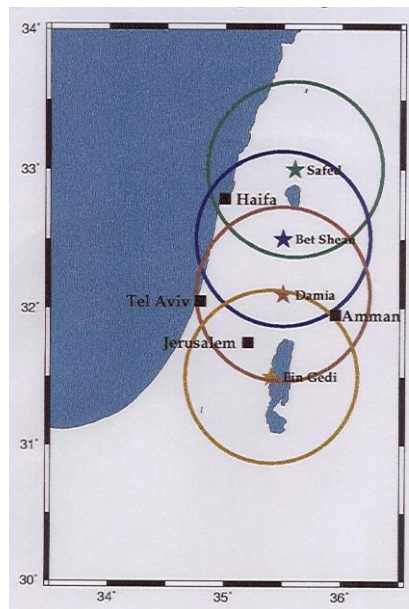
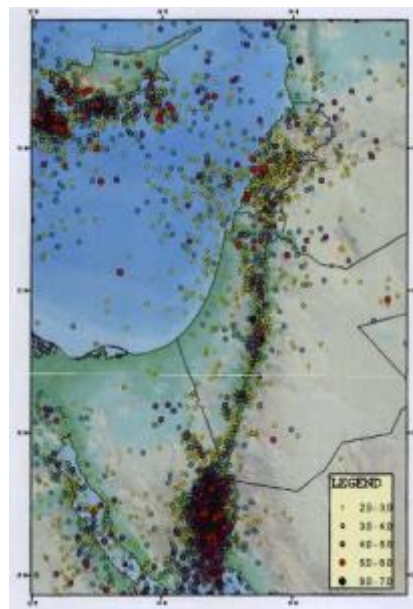
Acre



Safed



## Seismicity in Israel



a/g (PGA):

- a/g=0,045 (October 1759)
- a/g=0,057 (January 1837)
- a/g=0,073 (November 1759)

- a/g (PGA) = 0,23 (for Safed, Israeli code)
- a/g (PGA) = 0,17 (for Acre, Israeli code)

## Identification of the blocks

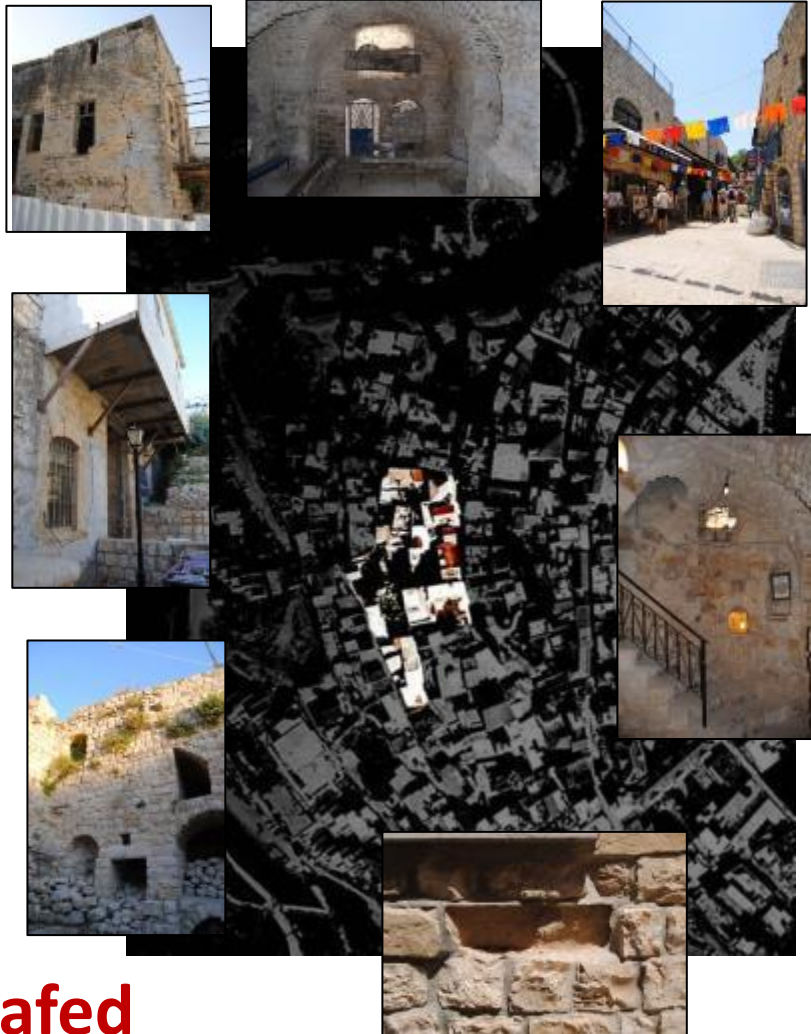


Acre is located on the Mediterranean coast (10 metres above the sea level) and it is served by a natural harbour.

Continuous stratifications took place during the centuries as a consequence of historical events which led up to the Crusader, the Arab, the Ottomans and finally (at the beginning of the 20<sup>th</sup> century) the British city.



## Identification of the blocks



**Safed**

Safed is located at an altitude of 900 metres above the sea level.

The town is developed on the contour lines and its parts are connected by stairs or ramp systems.

As a consequence of the configuration of the area, basements and underground vaulted floors are recurring.

## Activity in situ

- General reconnaissance of the blocks with the aim of subdividing the aggregate buildings into structural units;
- visual survey in order to collect all the information;
- schedule form compilation;
- photographic survey.

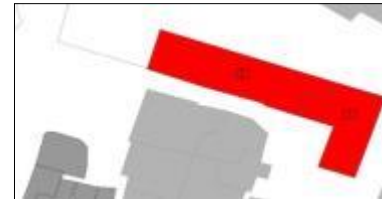




## Subdivision of the aggregate buildings into structural units



**Acre**



**Block 1**



**Block 3**



**Block 2**



## Subdivision of the aggregate buildings into structural units



**Safed**

Block 1



Block 2



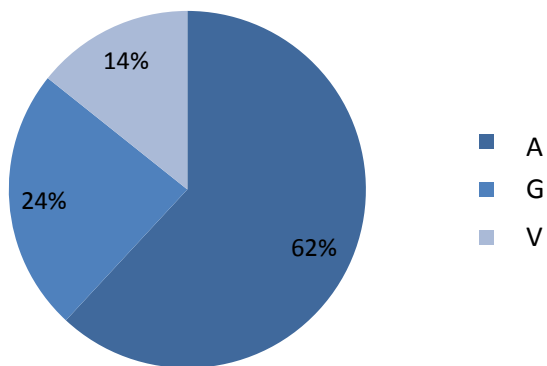




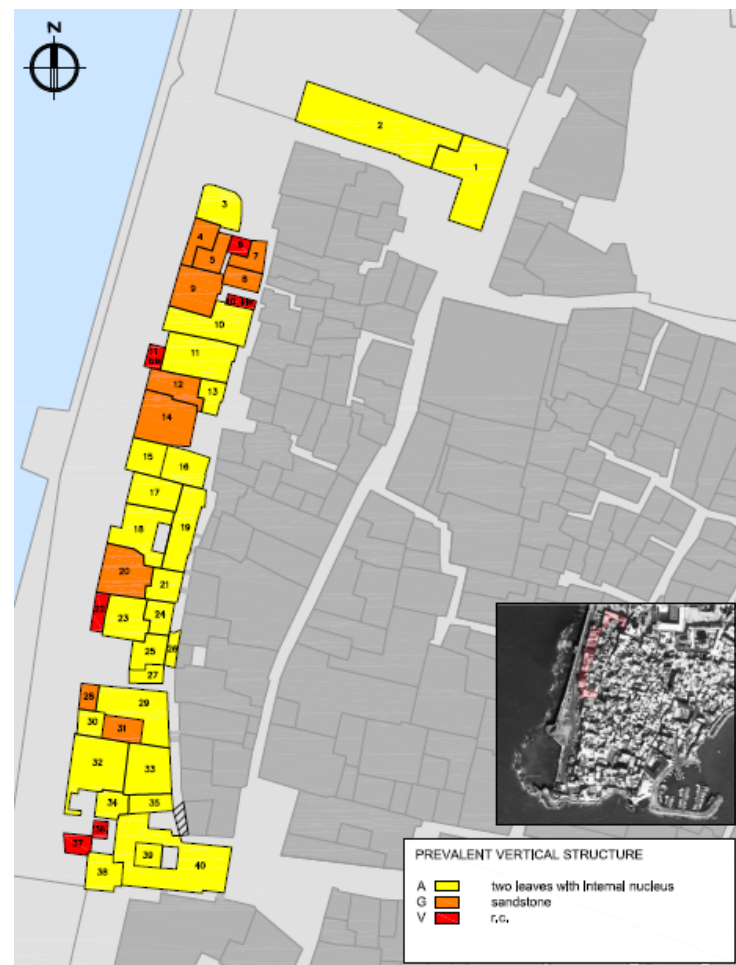
## Statistical and typological analysis of the data

### Prevalent vertical structure

PREVALENT VERTICAL STRUCTURE	n.	%
A: two leaves and internal nucleus	26	61.9
G: sandstone	10	23.8
V: r.c.	6	14.3



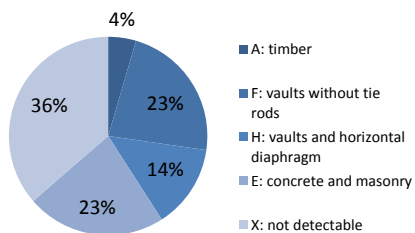
**Acre**



## Statistical and typological analysis of the data

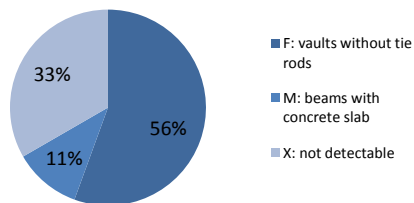
### Prevalent horizontal structure

PREVALENT HORIZONTAL STRUCTURE	n.	%
A: timber	1	4,5
F: vaults without tie rods	5	22,7
H: vaults and horizontal diaphragm	3	13,6
E: concrete and masonry	5	22,7
X: not detectable	8	36,4



### Block 1

PREVALENT HORIZONTAL STRUCTURE	n.	%
F: vaults without tie rods	10	55,6
M: beams with concrete slab	2	11,1
X: not detectable	6	33,3



### Block 2



**Safed**



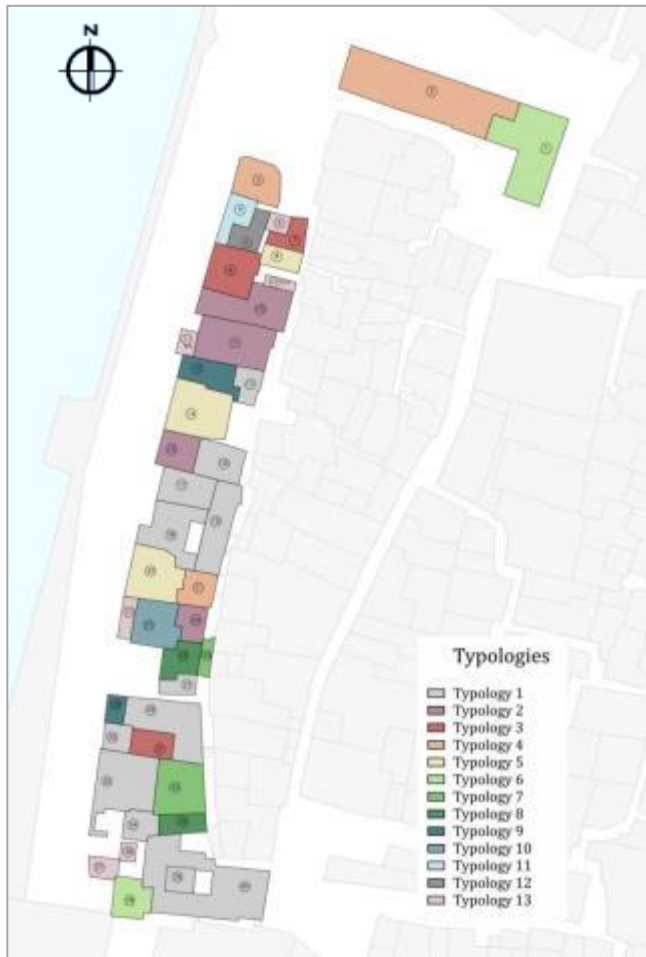
## Typologies identification

The previous analysis are important in order to understand the recurring typology and the main features of the buildings.

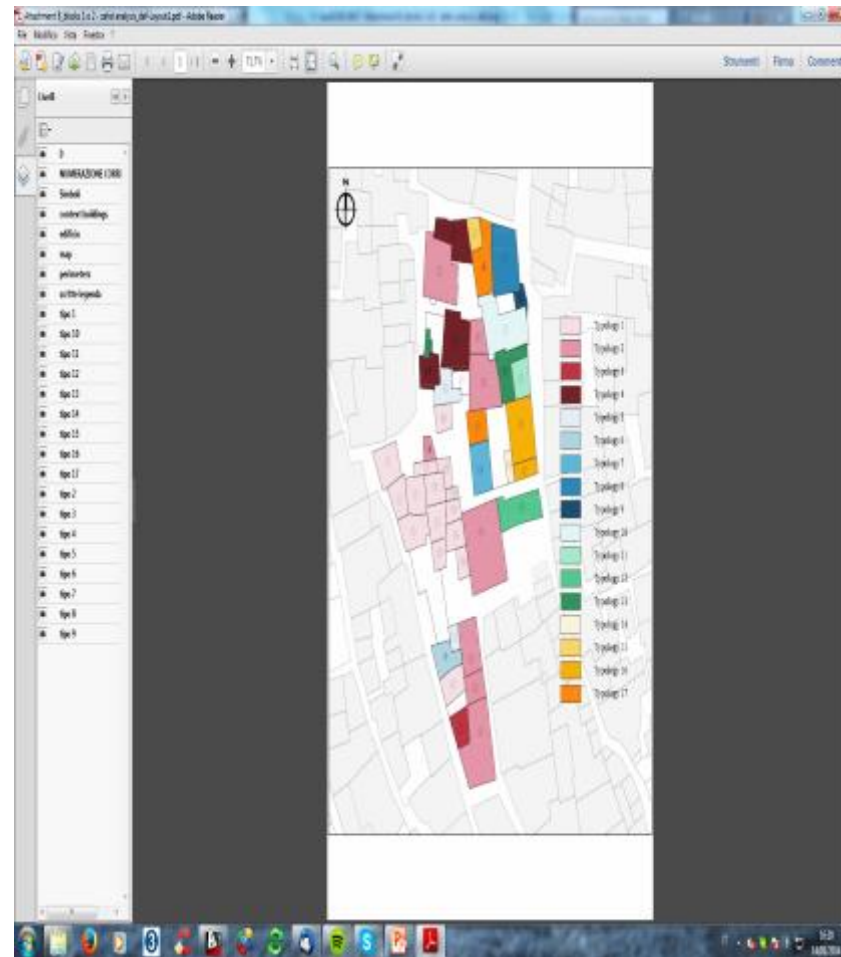
The classification takes into account different parameters:

- number of out of ground stories;
- structural typology;
- prevalent and secondary vertical structures
- prevalent and secondary horizontal structures;
- rigid and deformable horizontal structures;
- rigid and deformable roofs and number of pitches.

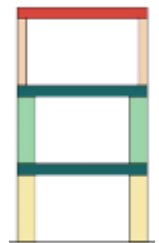
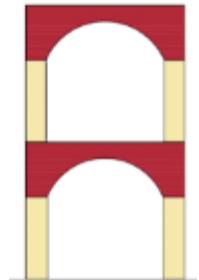
## Typologies identification



**Acre**



**Safed**





## Seismic vulnerability analysis



Vulnus provides global vulnerability assessments and it assesses the critical horizontal average acceleration level corresponding to the activation of in-plane mechanisms (I1 index) or out-of-plane mechanisms (I2 index).

## Seismic vulnerability analysis: Vulnus

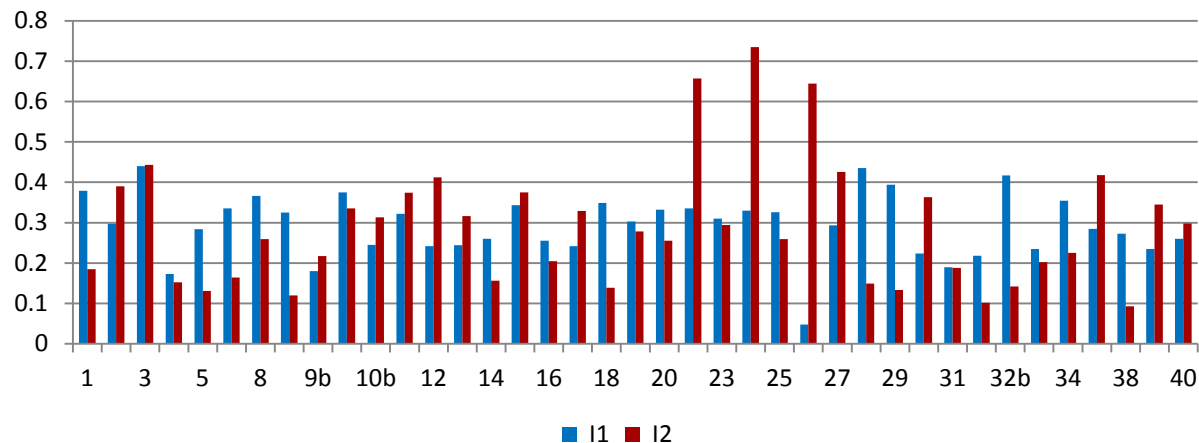
Vulnus S.U. identification



**Acre**

I1>I2 VULNERABILITY FOR OUT OF PLANE MECHANISMS

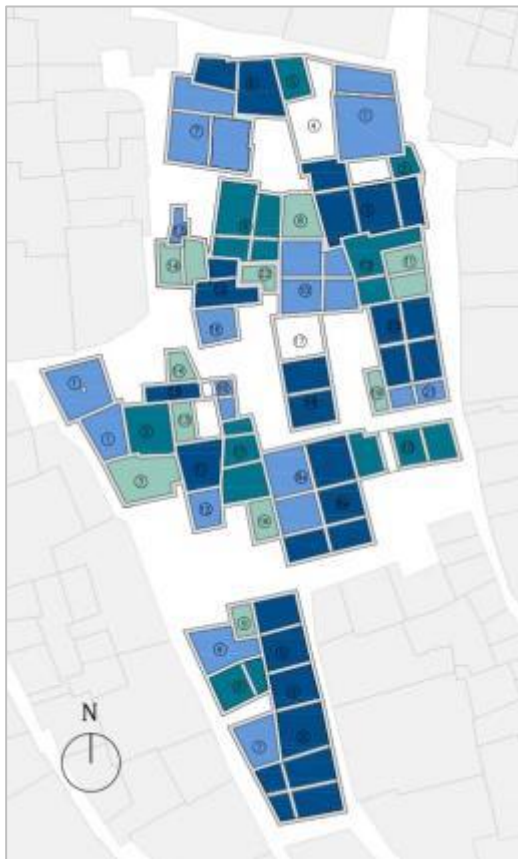
I2>I1 VULNERABILITY FOR IN PLANE MECHANISMS



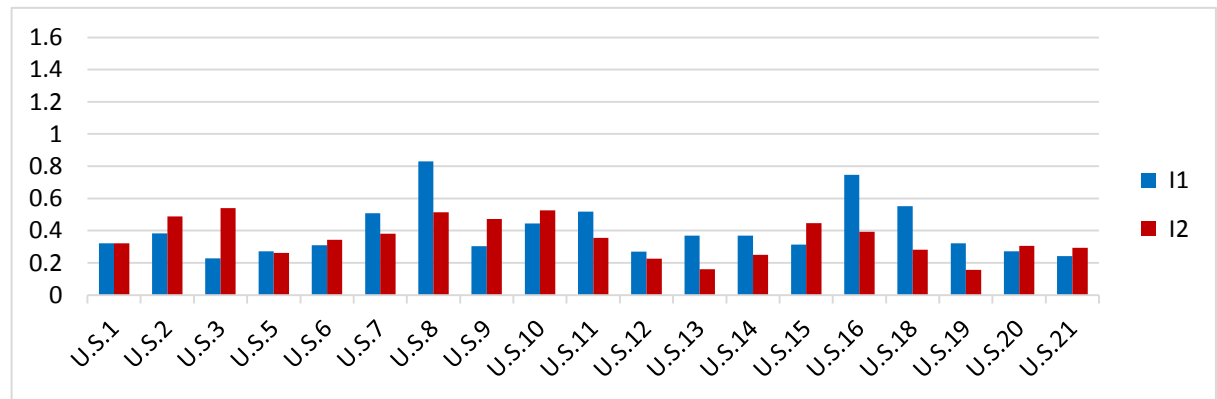


## Seismic vulnerability analysis: Vulnus

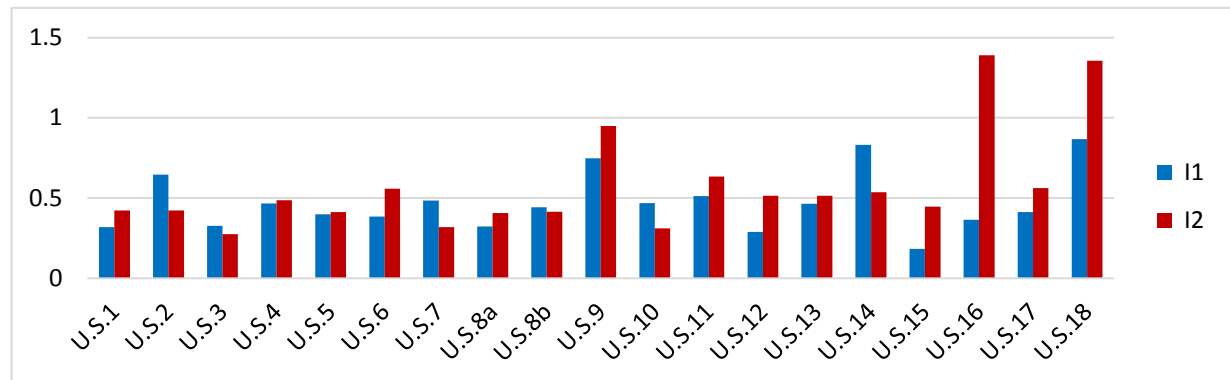
Vulnus S.U. identification



**Safed**

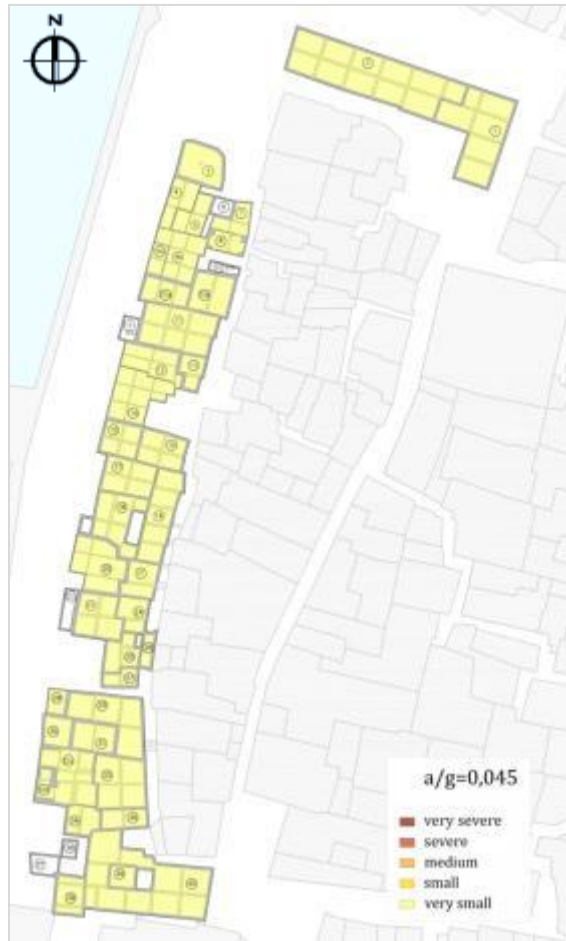


### Block 1



### Block 2

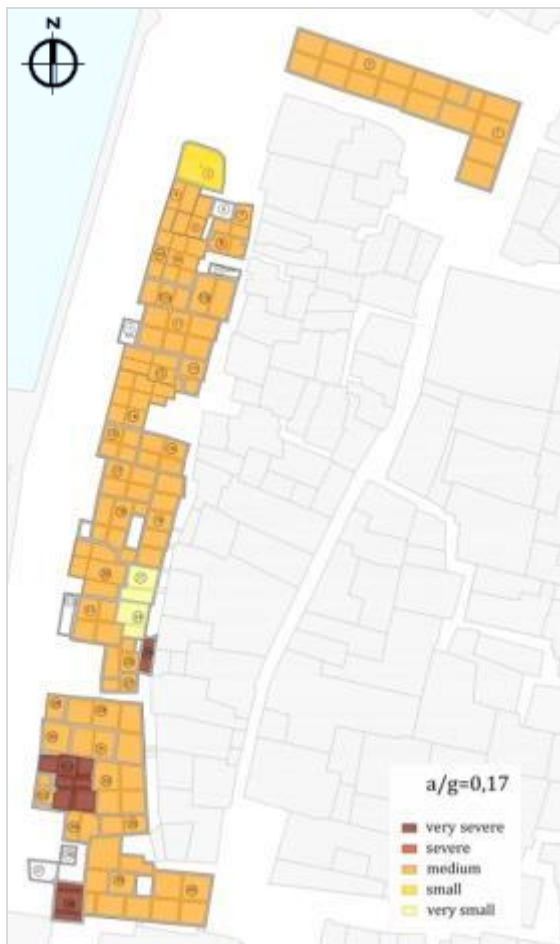
## Seismic vulnerability analysis: Vulnus



Acre

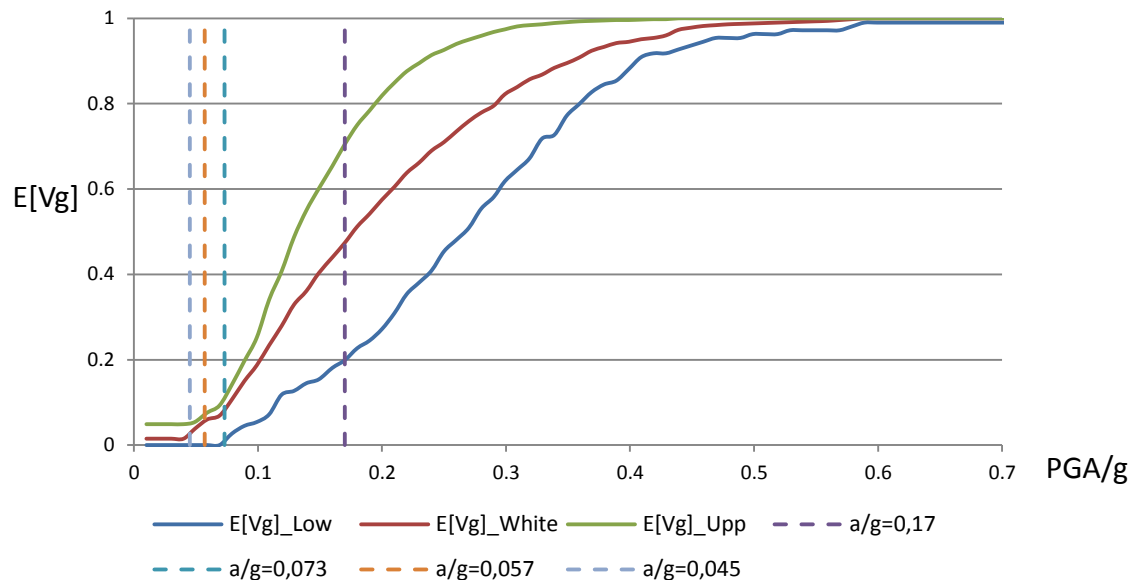


## Seismic vulnerability analysis: Vulnus



**Acre**

Fragility curves



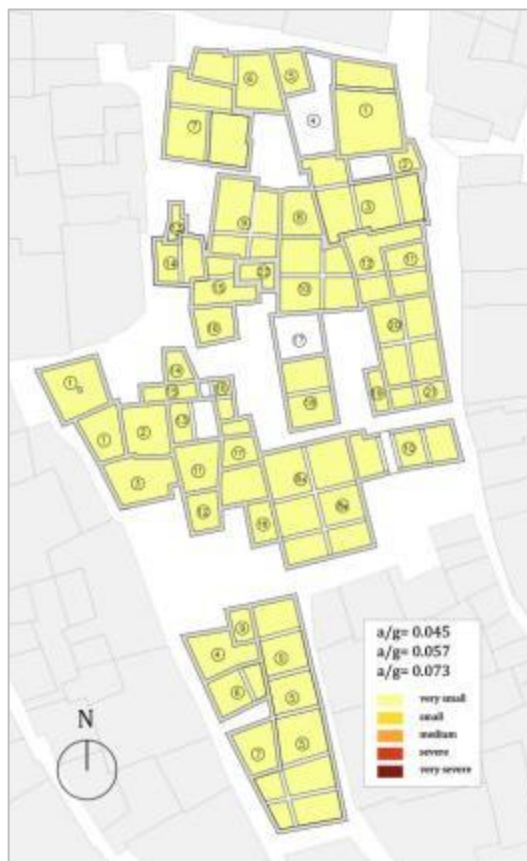
$a/g=0,045$  very small vulnerability

$a/g=0,057$  very small vulnerability

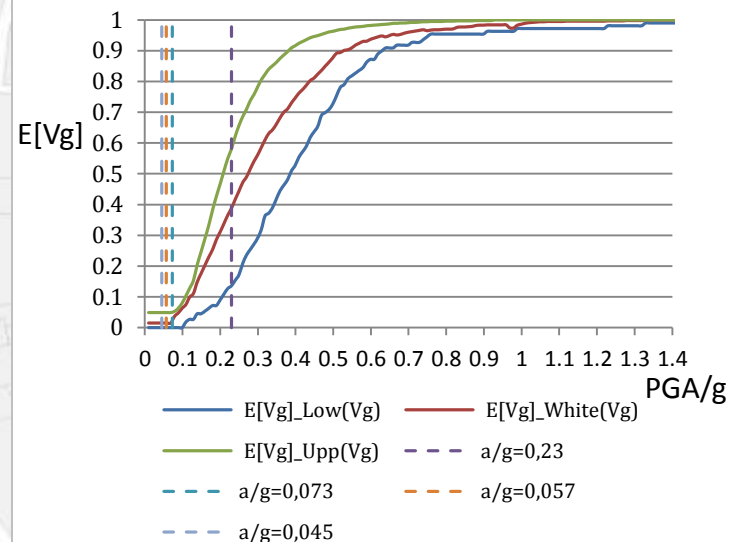
$a/g=0,073$  very small vulnerability

$a/g=0,17$  medium vulnerability

## Seismic vulnerability analysis: Vulnus



### Fragility curves

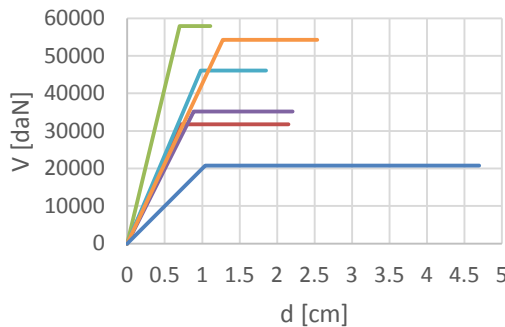
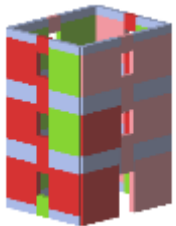
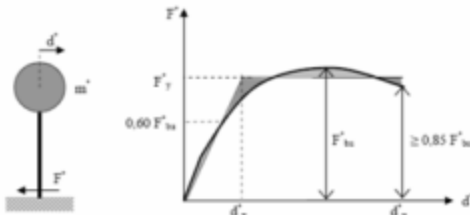
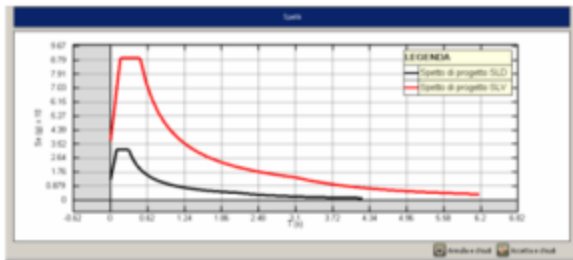


a/g=0,045 very small vulnerability  
a/g=0,057 very small vulnerability  
a/g=0,073 very small vulnerability  
a/g=0,23 medium vulnerability

**Safed**



## Global assessment

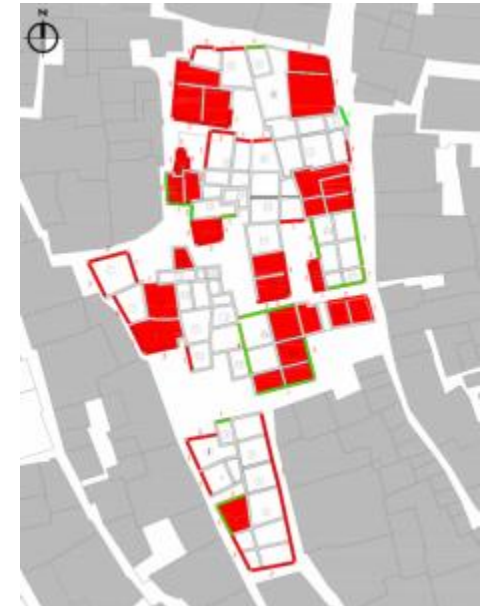
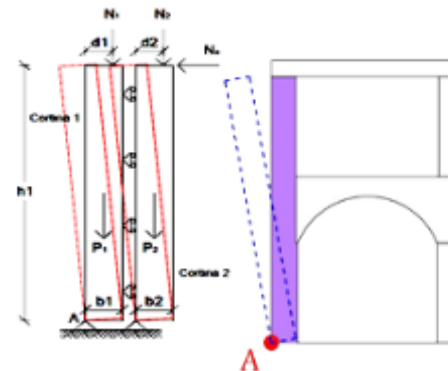


A global analysis is carried out for each typology, comparing the obtained capacity curves in order to define a vulnerability classification.

## Local mechanisms of collapse

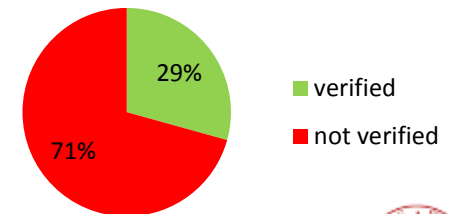


Walls identification



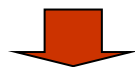
Comparison with I2 index

### Linear Kinematic analysis



## Conclusion

Seismic vulnerability analysis of historic buildings at **urban level**



Simplified methodologies and models



Rapid survey

Statistical analysis

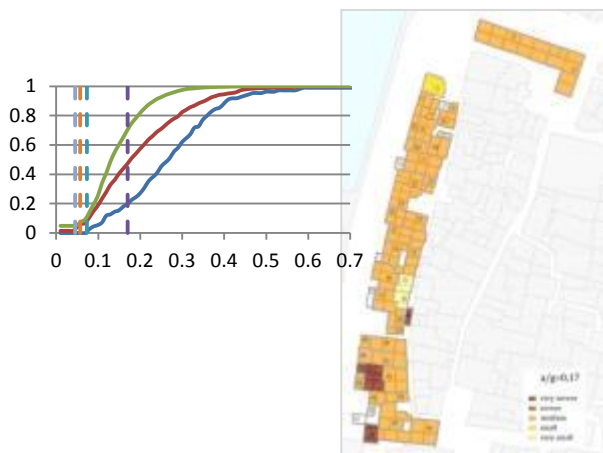
Typologies identification

Global simplified analysis

Global and local analyses for each typology



Extensibility of the vulnerability results to other buildings belonging to the same typology in other blocks of the towns



**THANKS FOR YOUR ATTENTION**

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