Geological and Technical analisys of the pilot area of Pianazzola (Chiavenna, SO, Italy)

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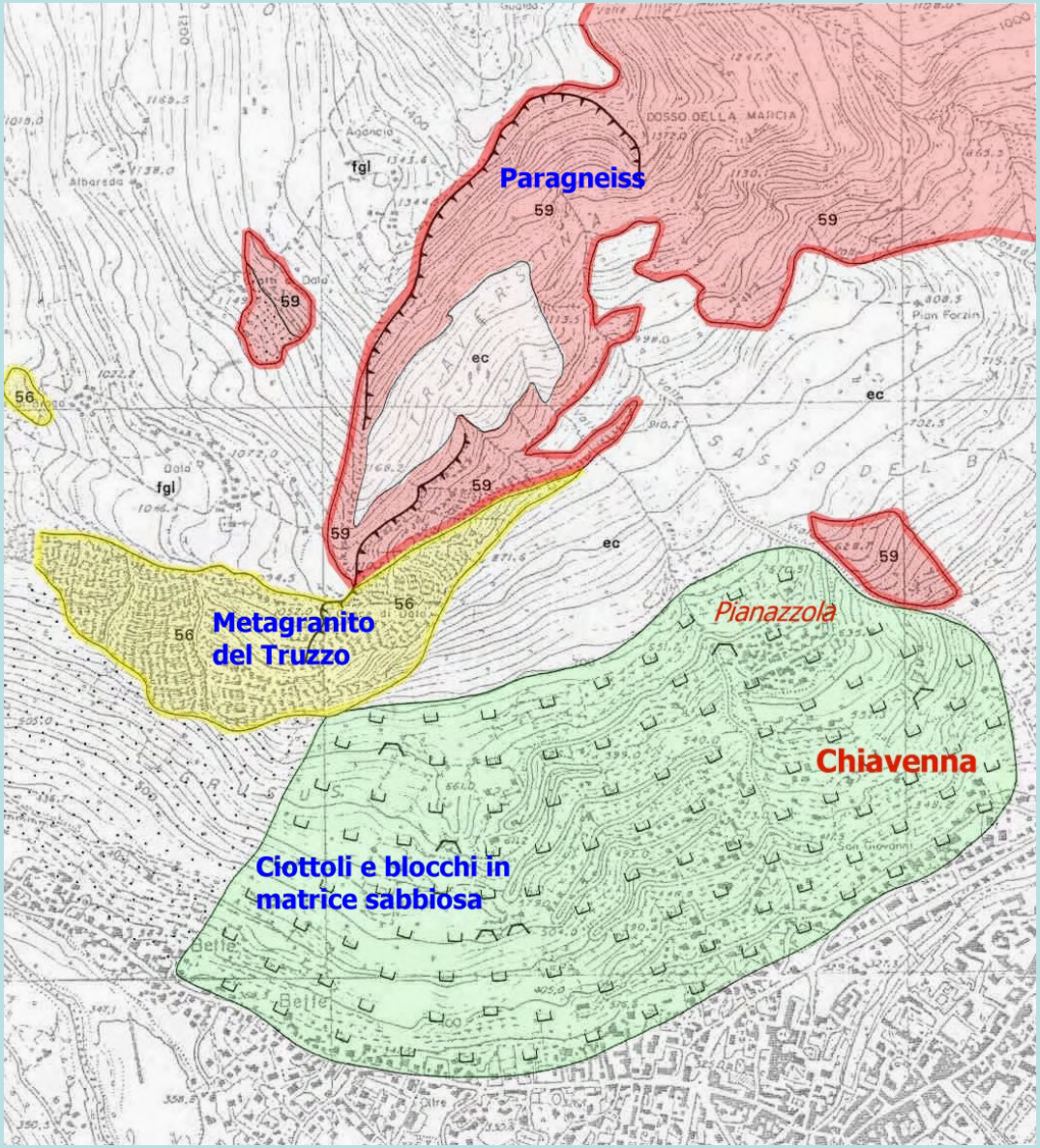
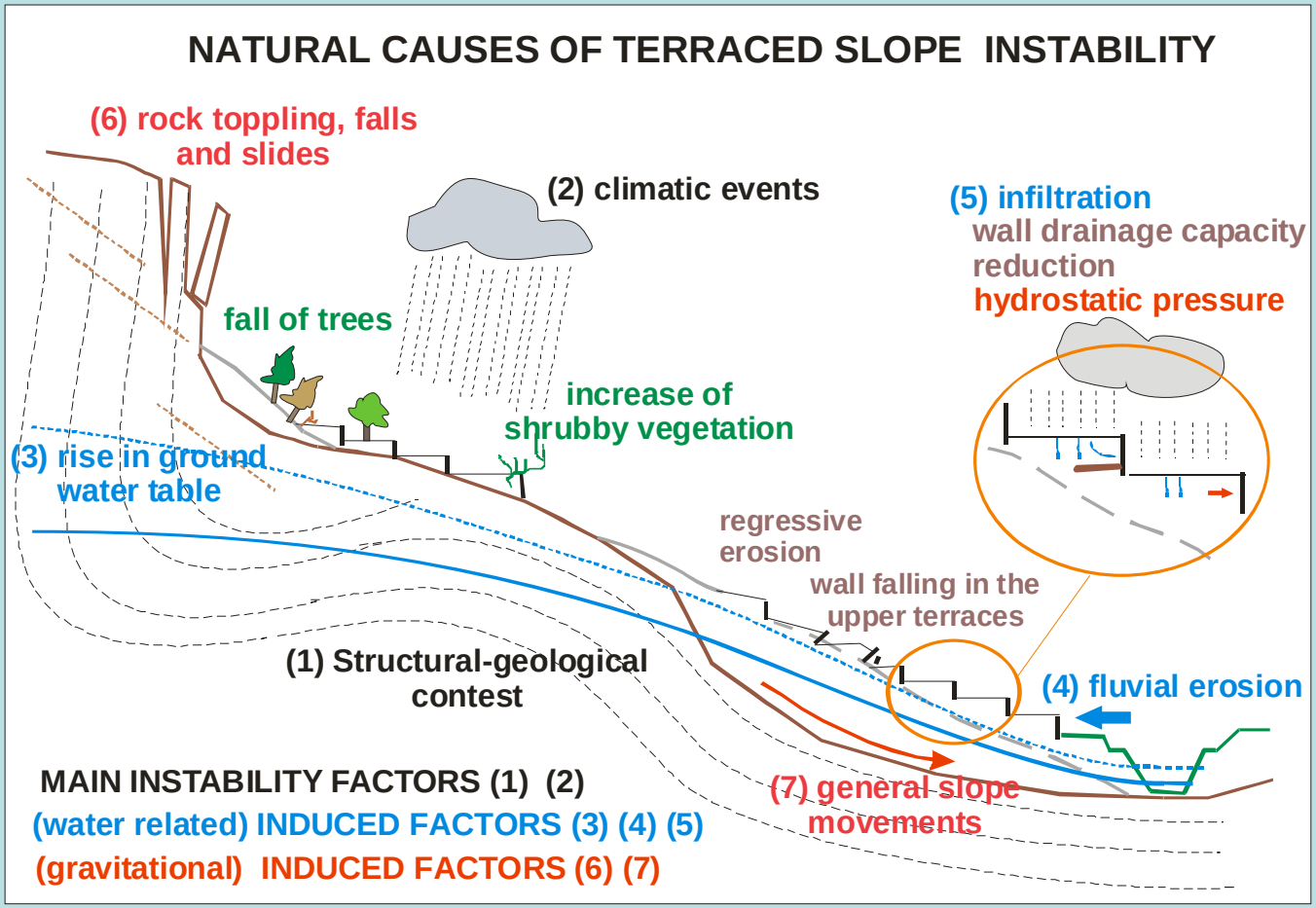
Geological sketch



The pilot area (light green) is located on an ancient landslide deposit.

It is in the western sector of the city of Chiavenna (SO)

- Perform the technical anaysis of terraced slope
- Study infiltration process on terraced slope
- Evaluate its effect on dry stone wall deformation and slope instability.



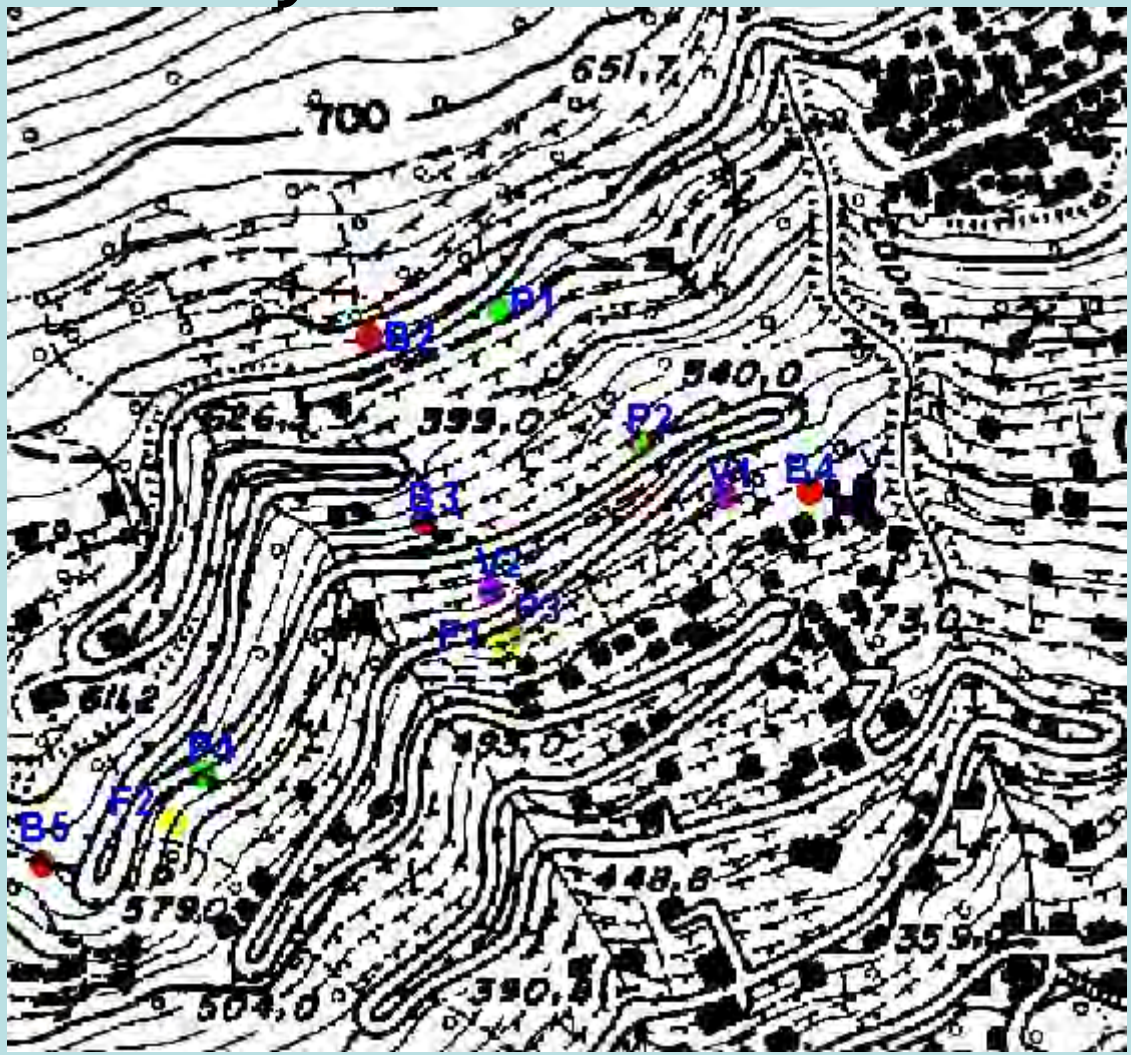
In situ surveys and tests

Permeability tests

Soil specific weight

Soil water content

Soil sampling for laboratory test



Test sites selected according to soil use (bush, grass, vineyard, fruit tree) and spatial distribution

Permeability tests

Double ring infiltrometer

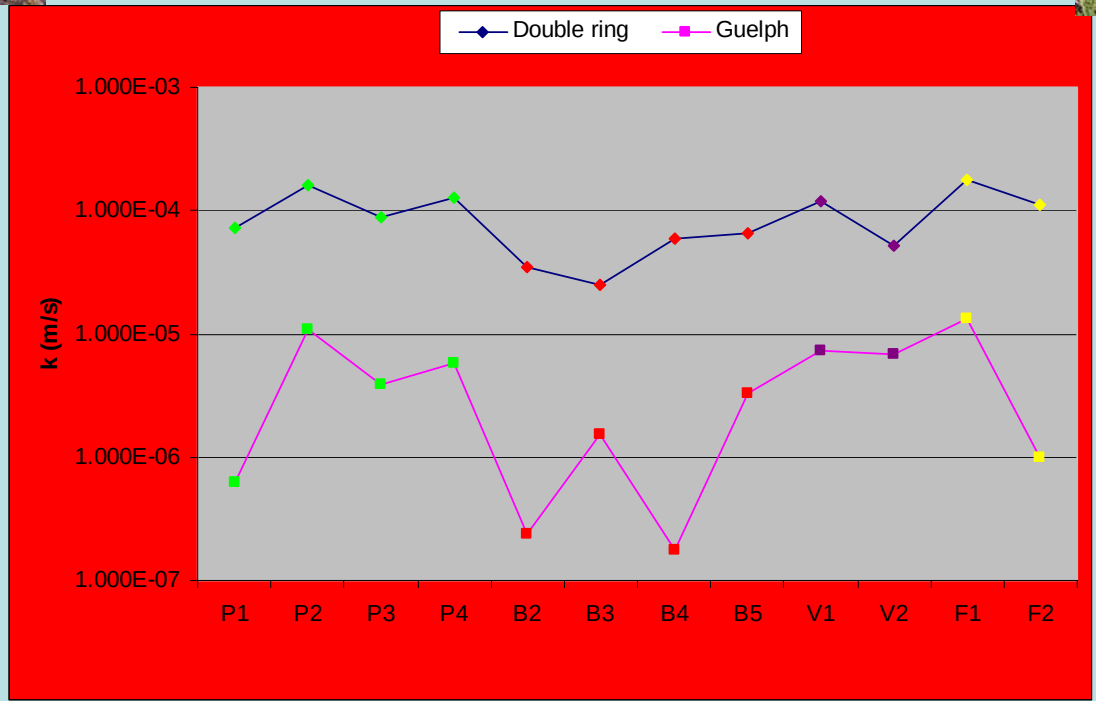
Guelph permeameter

Standard tests

-Soil hydraulic conductivity

-Scale effect

-Relationships with soil use and soil physical parameters



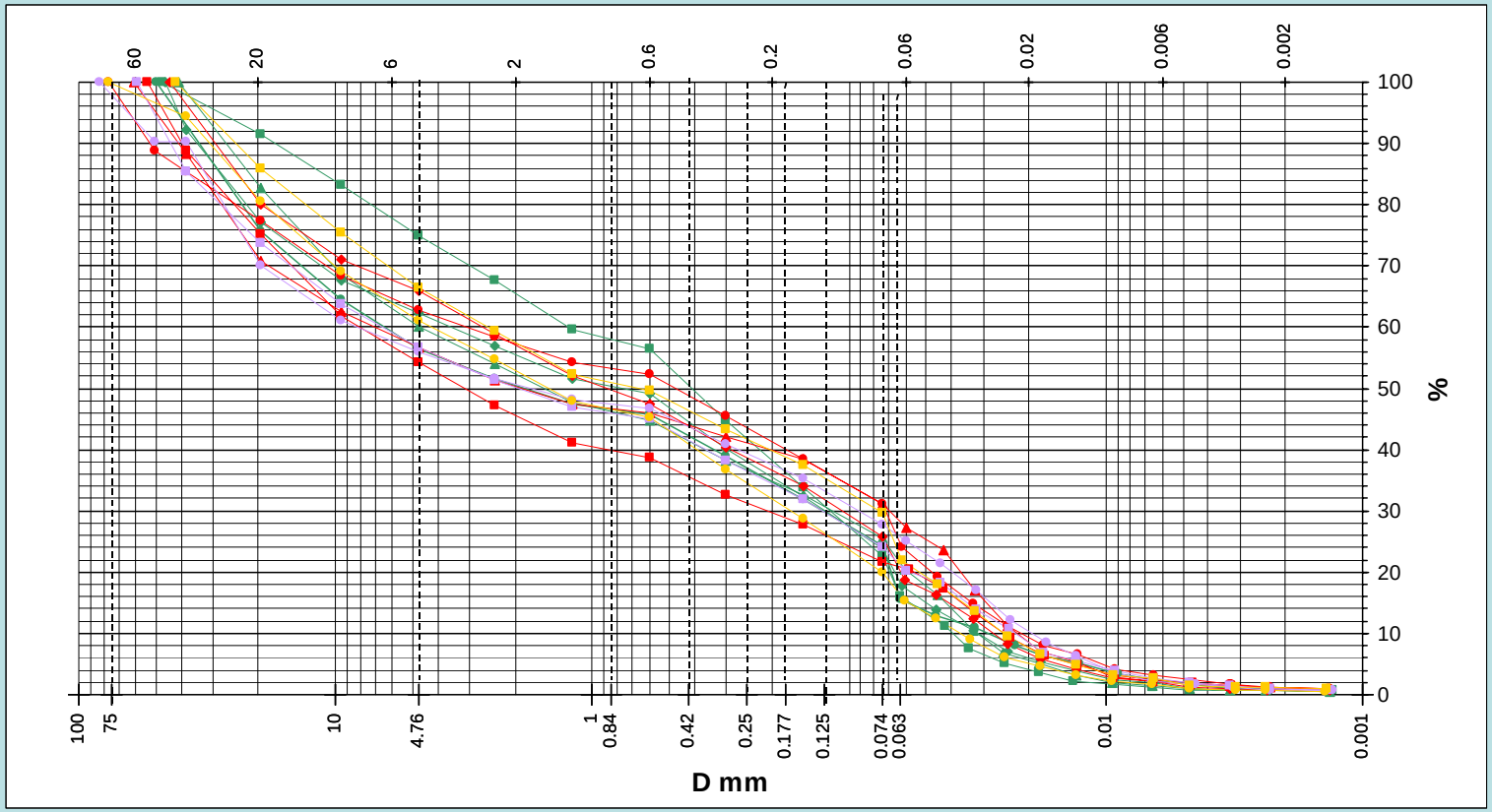
Laboratory tests

Physical properties:

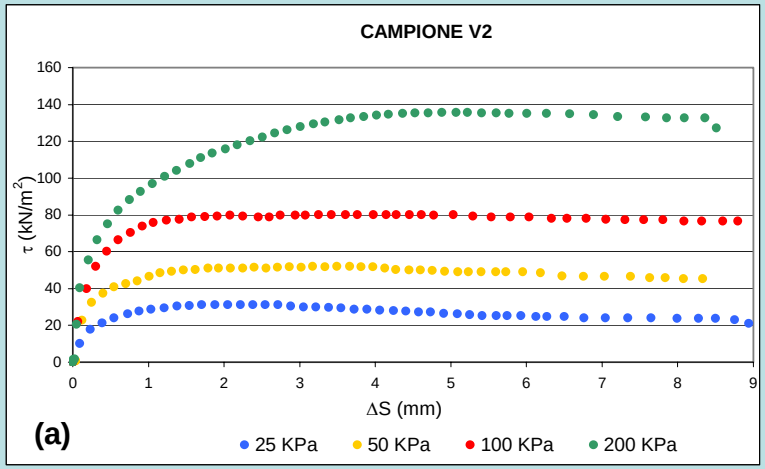
Grain size distribution

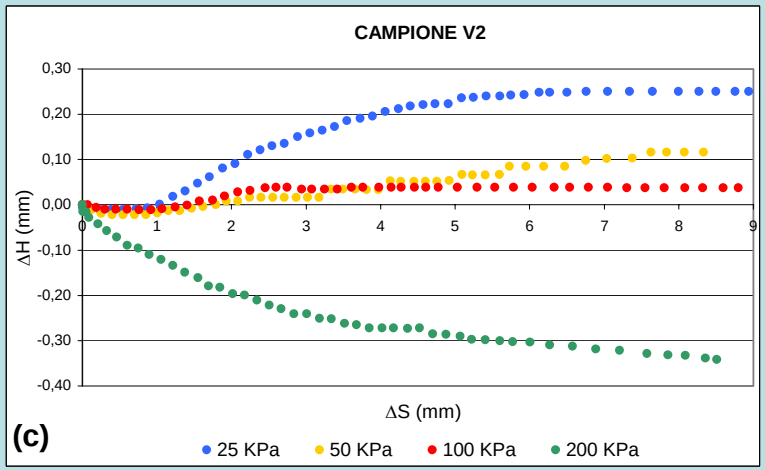
- High percentage of sand and gravel
- no clay

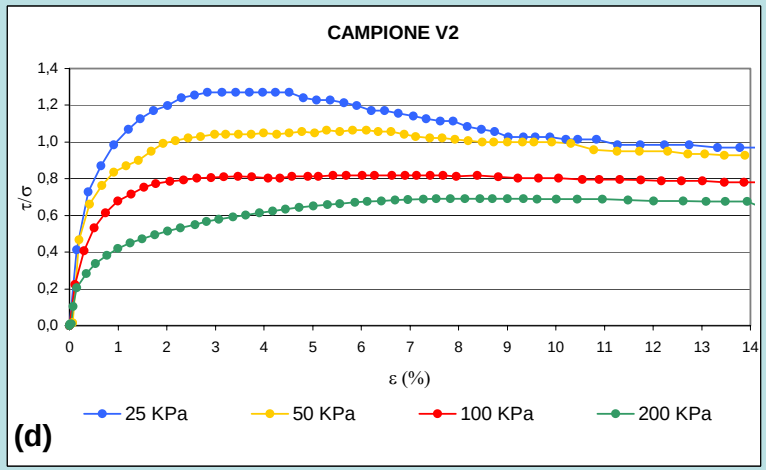
- γ_0 = 14.3 – 16.7 kN/m^3
- γ_D = 13.7 – 15.3 kN/m^3
- W = 4.7 – 13.3 %
- o.c. = 8.8 – 13.9 %



- Direct shear tests







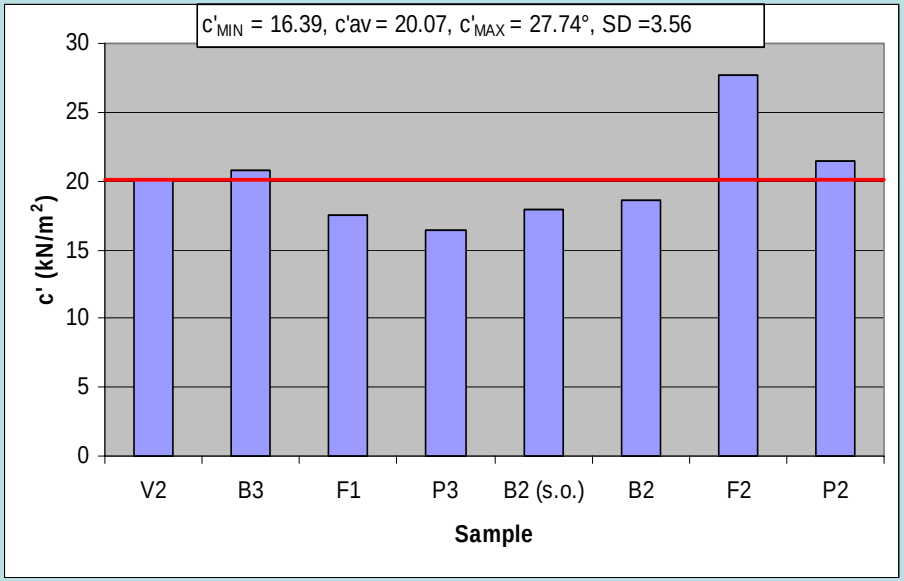
SAMPLE	SOIL USE	CLASSIFICATION U.S.C.S.	ORGANIC CONTENT (%)	γ_0 (kN/m³)	γ_D (kN/m³)	c' (kN/m²)	ϕ' (°)
V2	Vineyard	GM	11.57	14.32	13.73	20.10	30.76
B3	Bush	GM	8.86	15.5	14.62	20.83	28.02
F1	Fruit Tree	SM	11.61	16.68	15.3	17.50	28.92
P3	Grass	SM	12.56	14.32	12.65	16.39	27.75
B2 (s.o.)	Bush	GM	0.00	15.89	14.52	17.92	29.66
B2	Bush	GM	13.95	15.89	14.52	18.54	34.15
F2	Fruit Tree	SM	11.88	14.03	12.85	27.74	32.39
P2	Grass	SM	9.31	13.44	12.56	21.51	30.34

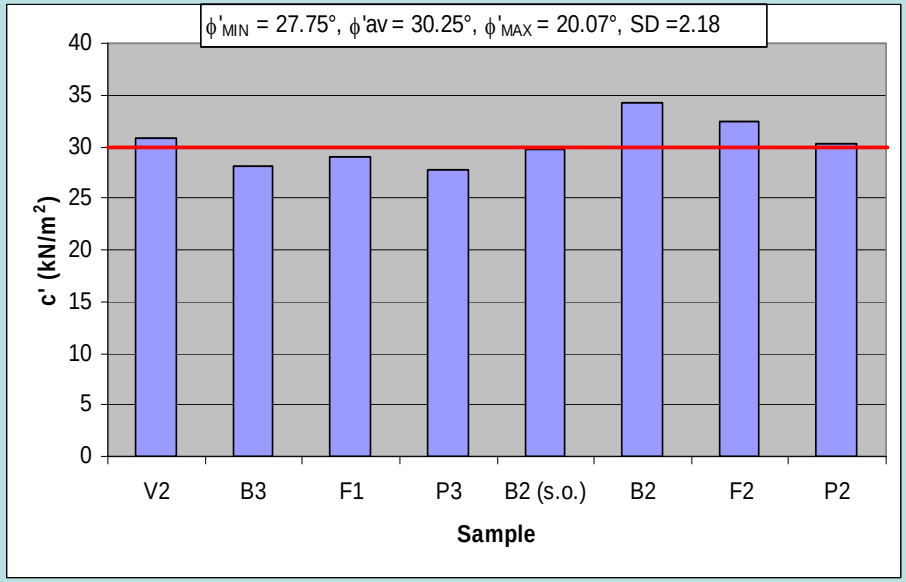
$c' = 16 – 28\ kN/m^2$

$c'_{av} = 20.07\ kN/m^2$; SD = 3.56

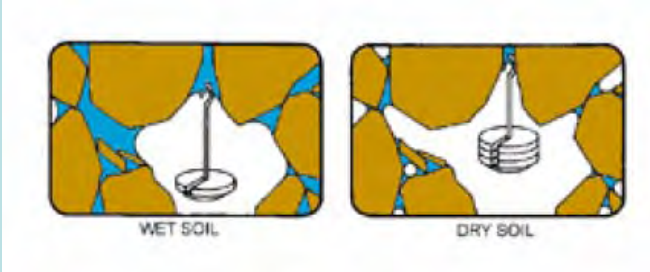
$\phi' = 28° - 34°$

$\phi'_{av} = 30.25°$; SD = 2.18





The tensiometer allowed a direct measure of the “soil suction”, the force required to remove water from the soil.

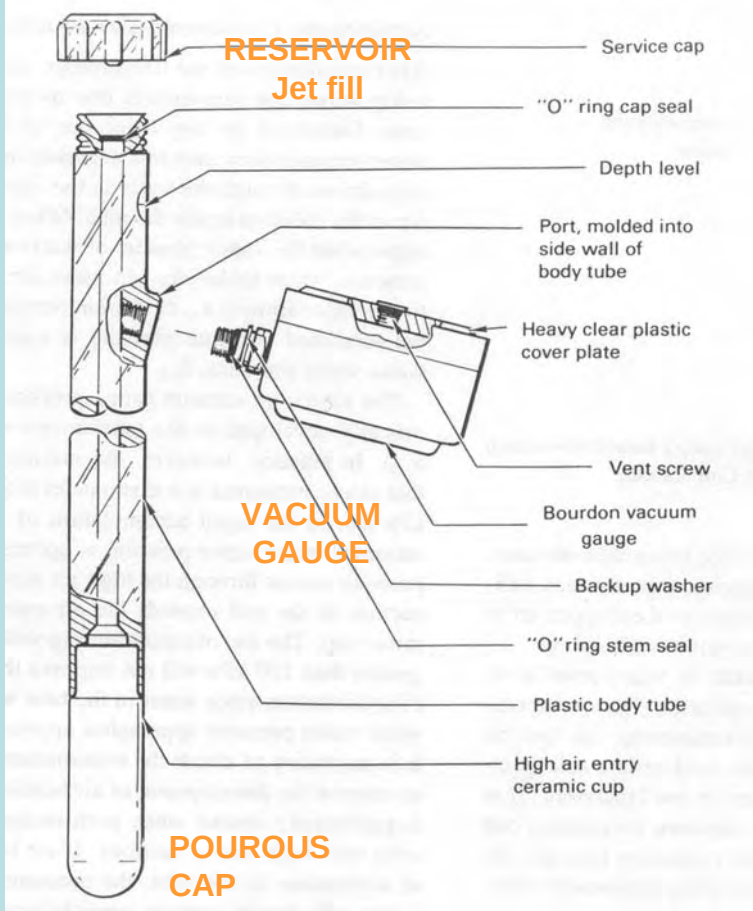


This parameter controls the water flow in vadose zone.

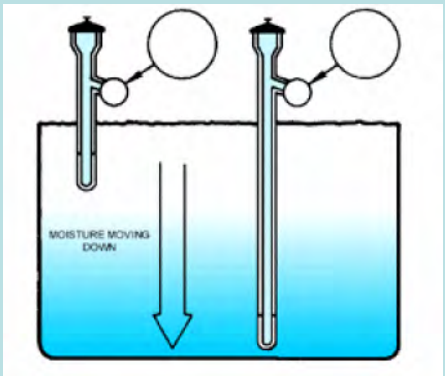
$(u_a - u_w)$ → **Soil suction**: pore-air pressure – pore water pressure

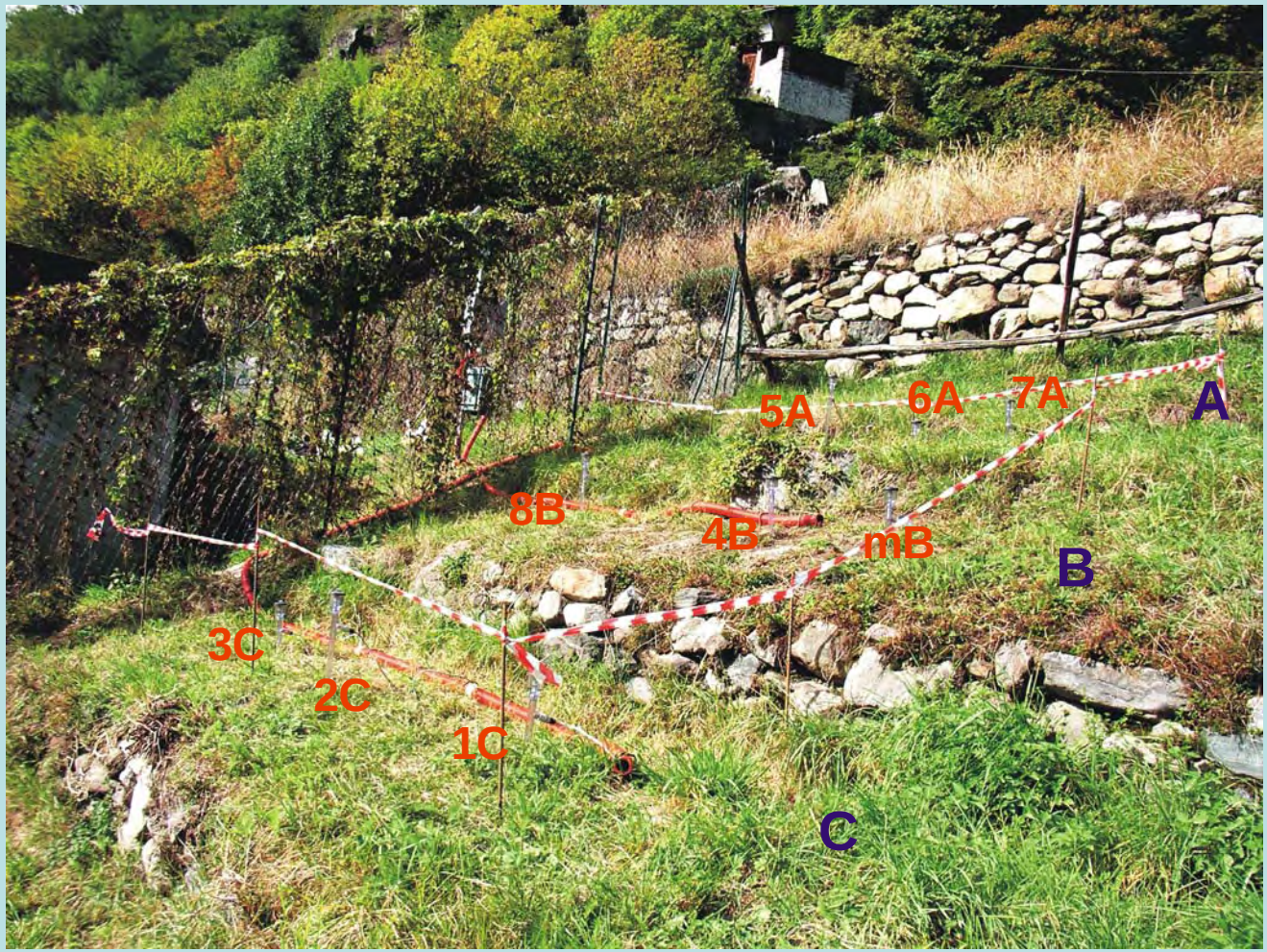
USE

- Study the infiltration capacity of soils
- Analyse groundwater effect on soil mechanical behaviour
- Mantain accurate control of soil moisture during plant growth
- Develop effective irrigation practice.

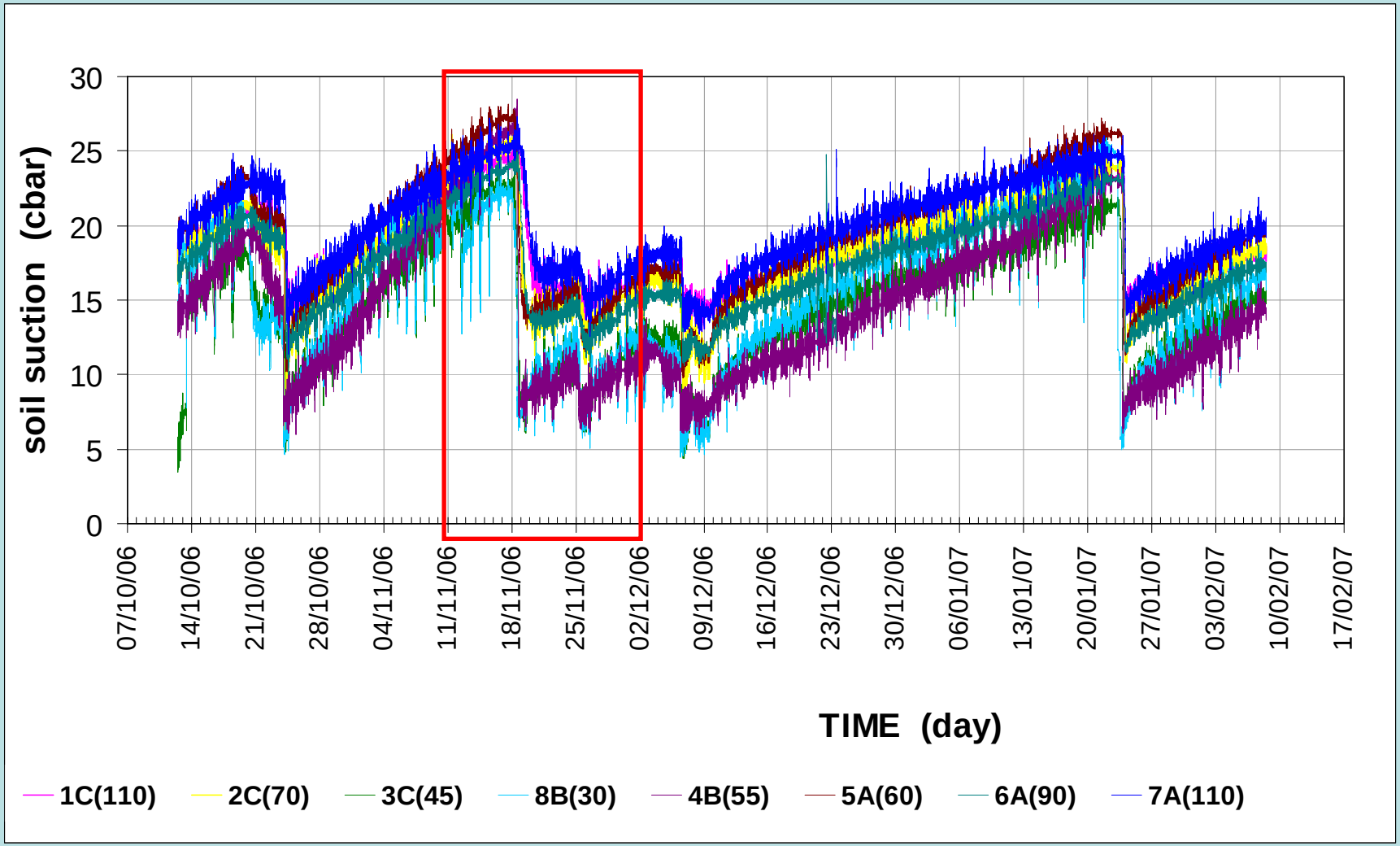


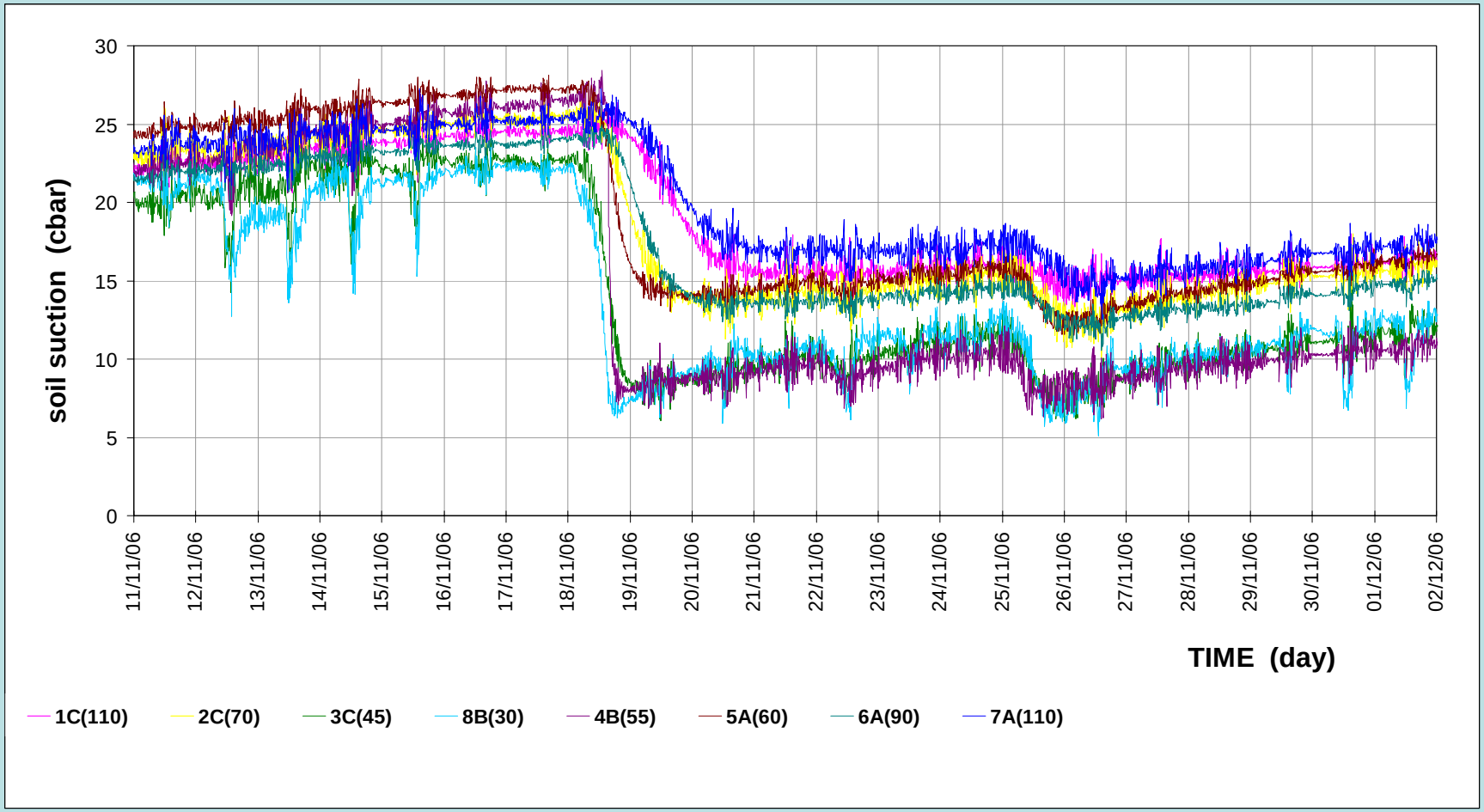
Monitoring system



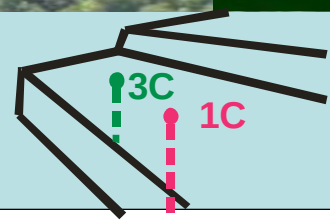


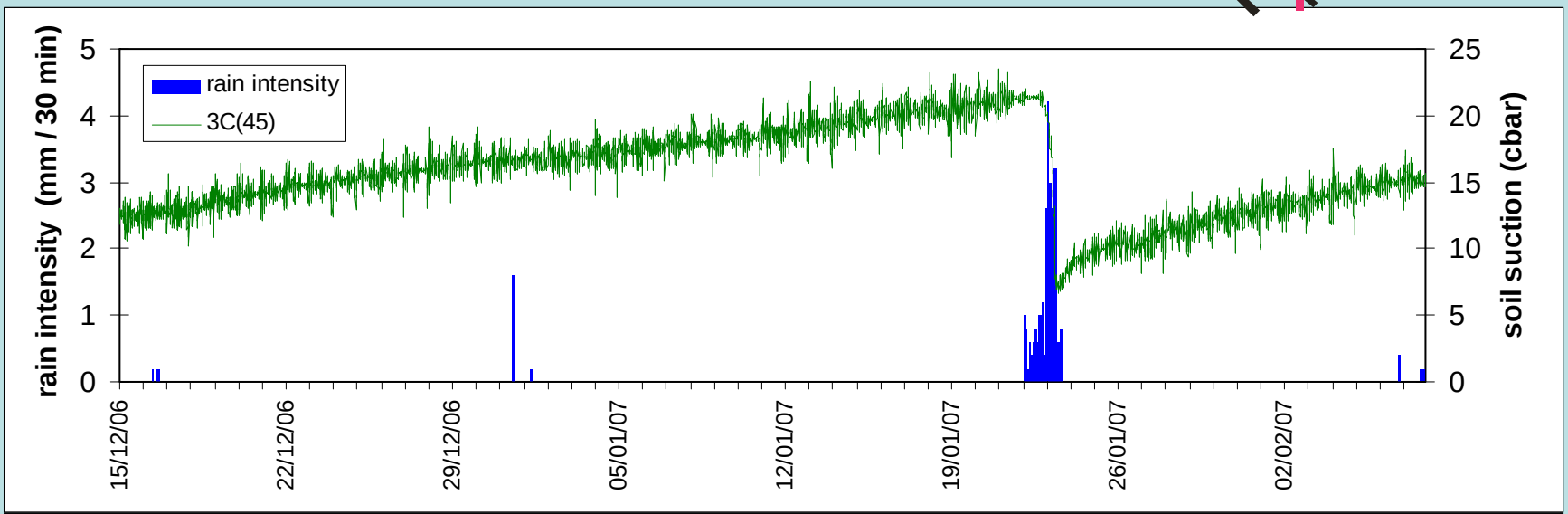
Monitoring period

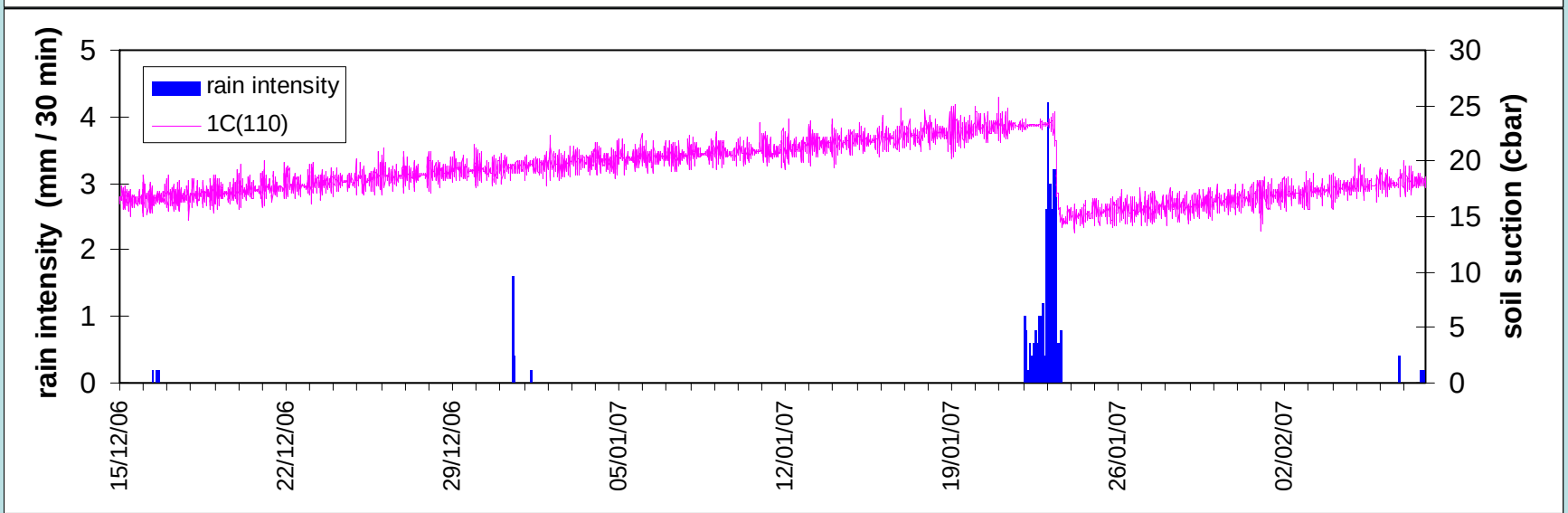



soil suction (cbar)
30
25
20
15
10
5
0
11/11/06
12/11/06
13/11/06
14/11/06
15/11/06
16/11/06
17/11/06
18/11/06
19/11/06
20/11/06
21/11/06
22/11/06
23/11/06
24/11/06
25/11/06
26/11/06
27/11/06
28/11/06
29/11/06
30/11/06
01/12/06
02/12/06
TIME (day)
1C(110)
2C(70)
3C(45)
8B(30)
4B(55)
5A(60)
6A(90)
7A(110)

Influence of depth in rainfall event

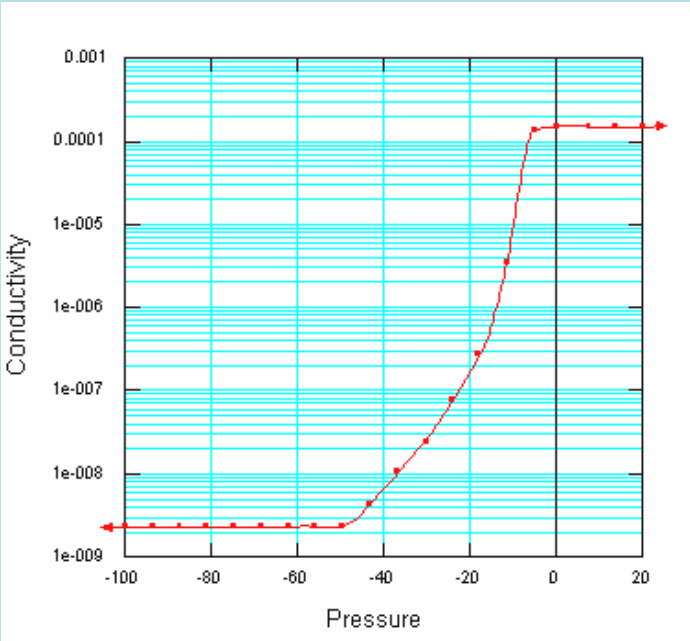




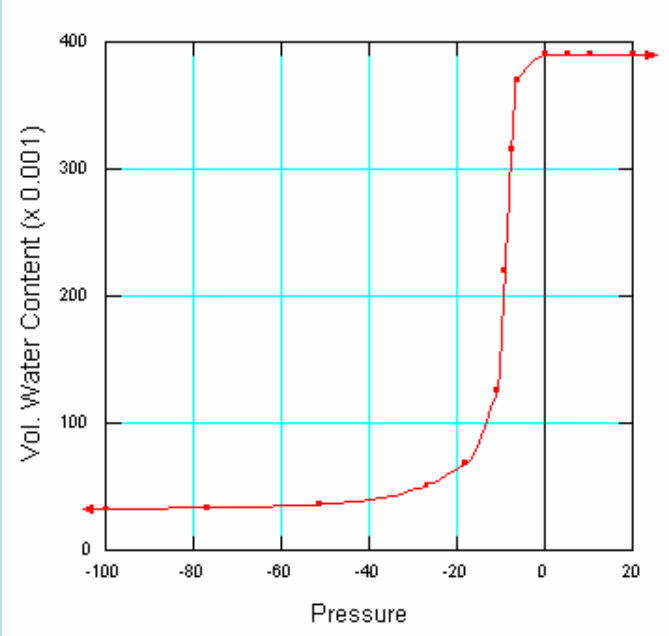


Experimental data - physical properties of soils - hydraulic conductivities

Hydraulic conductivity curve



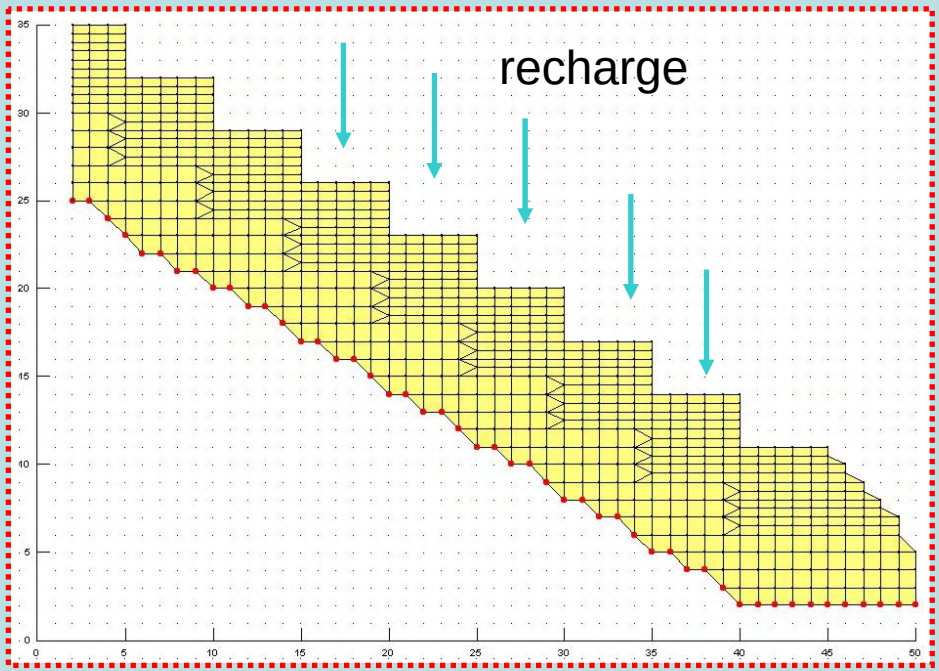
Soil water characteristic curve

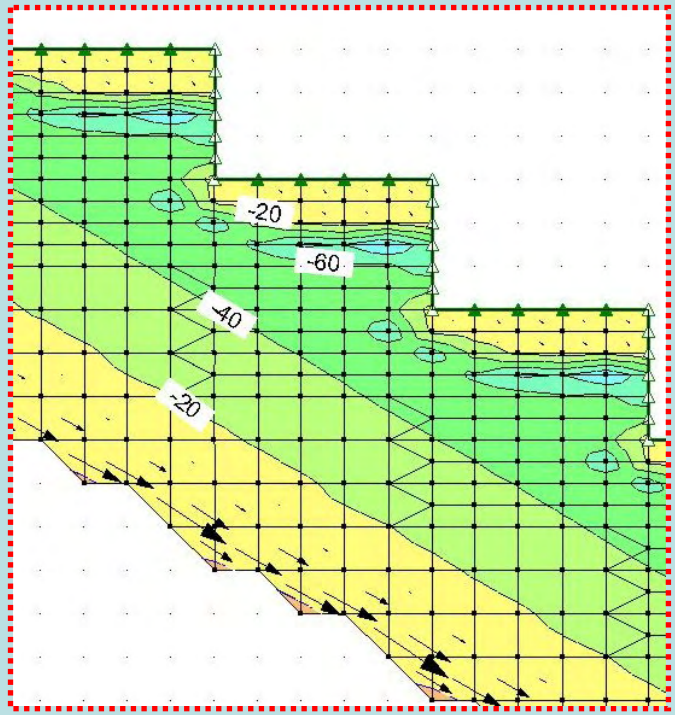


Numerical modeling

Unsaturated and saturated flow

The calibrated model allows to make previsions on soil moisture content and pore water pressures changes under different conditions of recharge

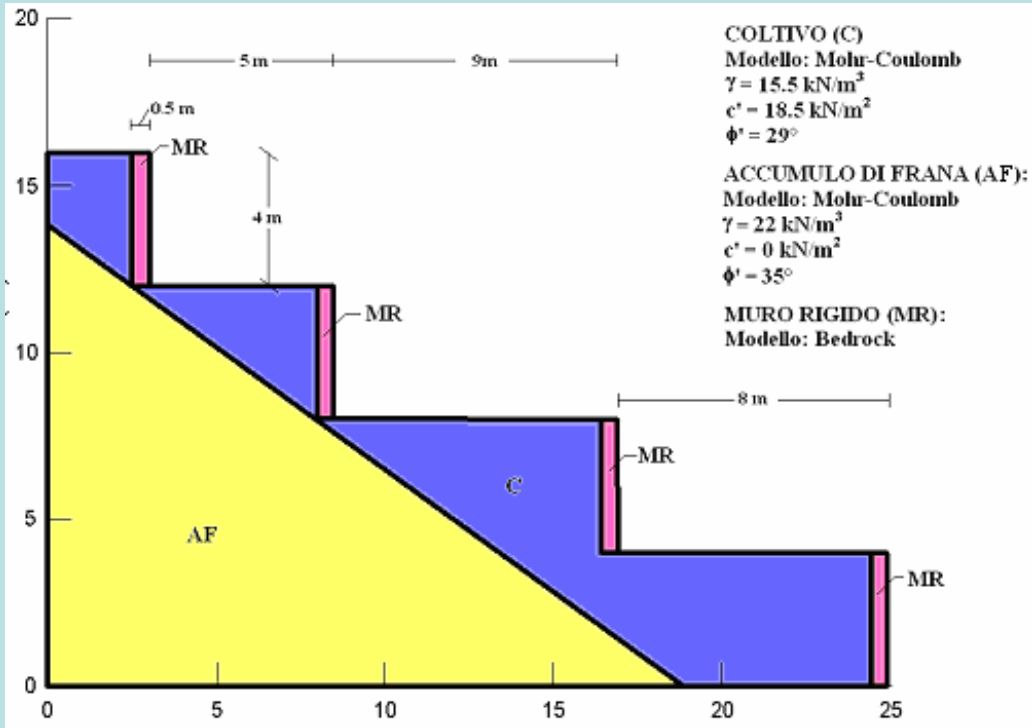


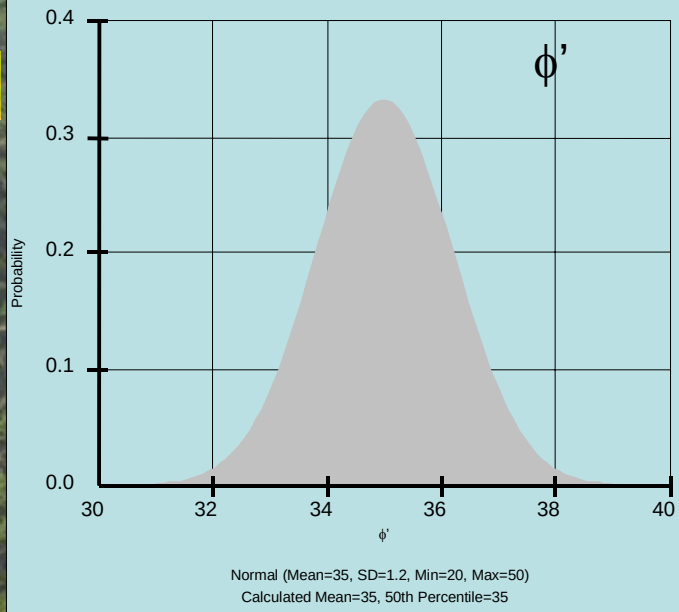


Data can be used for:
- planning agricultural activities
- geotechnical analysis
    1) at the pilot area scale (factor of safety)
    2) at the single terrace scale (numerical modeling)

1) factor of safety

use of limit equilibrium method

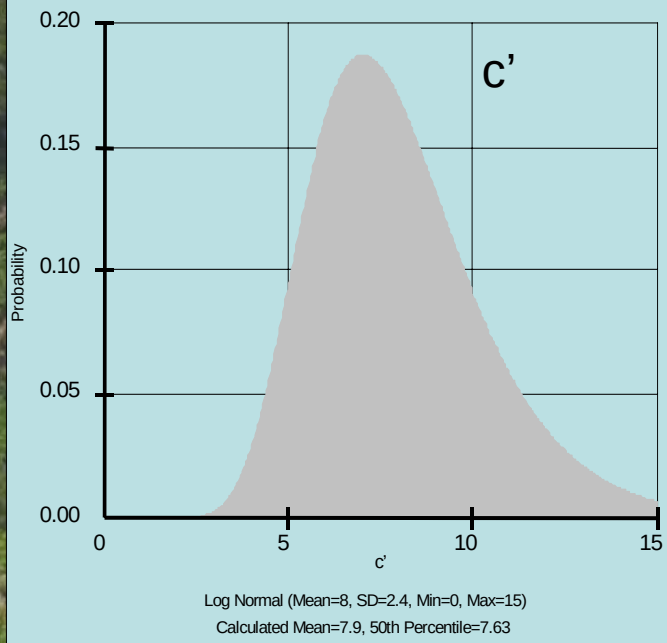


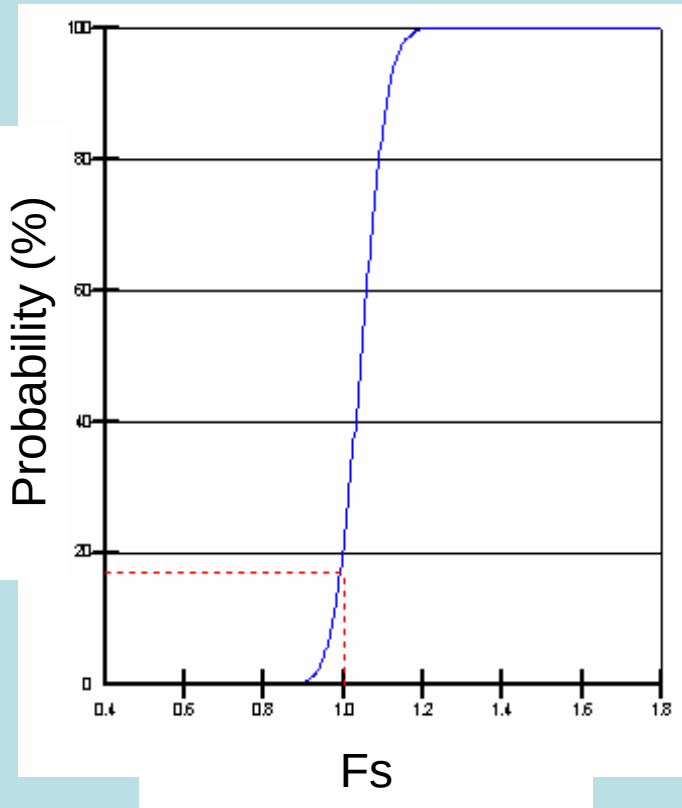


PROBABILISTIC ANALYSIS

-) ϕ': normal distribution, $\phi'_{MIN} = 20°$, $\phi'_{AV} = 35°$, $\phi'_{MAX} = 50°$, SD = 1.2;

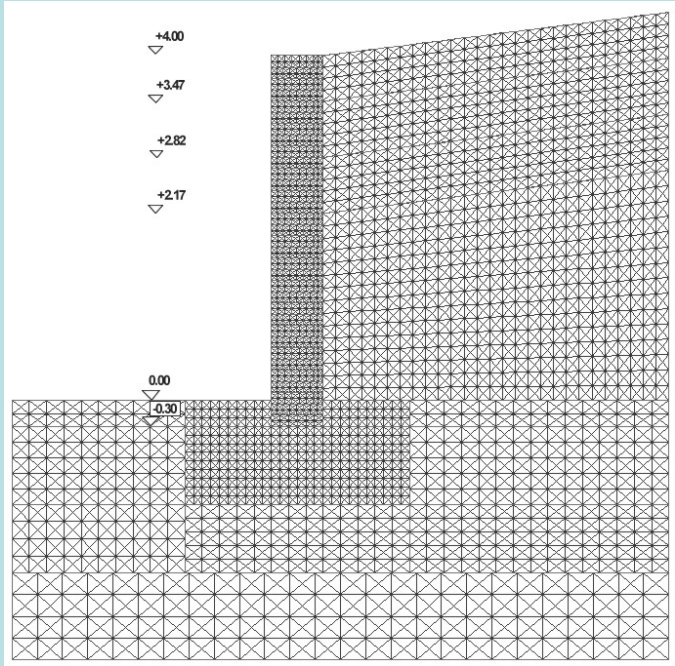
-) c': log–normal distribution, $c'_{MIN} = 0$ kN/m^2, $c'_{AV} = 10$ kN/m^2, $c'_{MAX} = 15$ kN/m^2, SD = 2.4

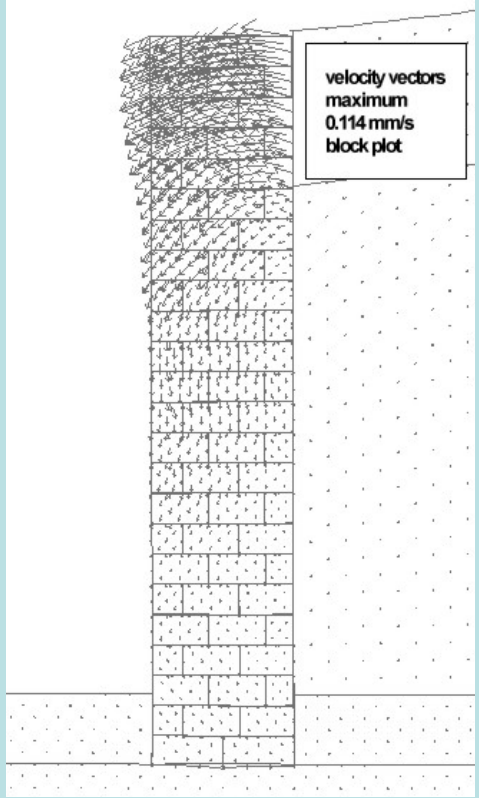


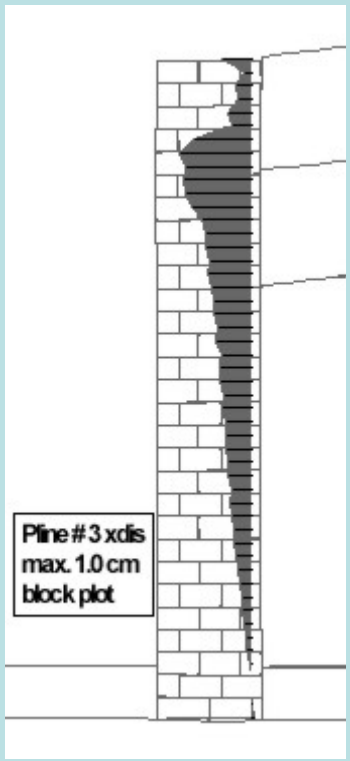


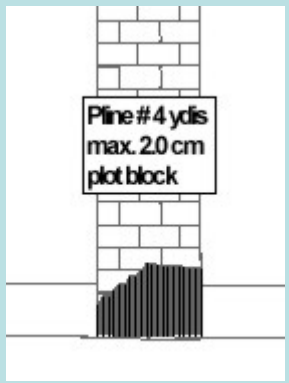
2) Numerical modeling

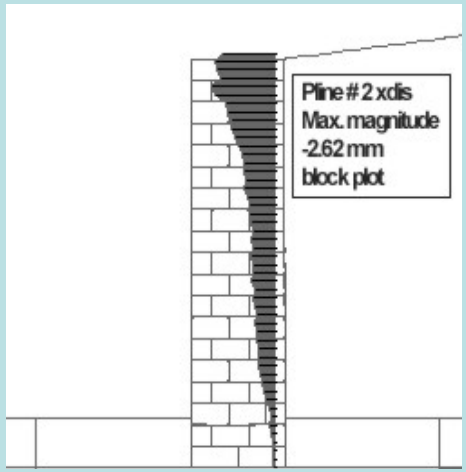
Factors influencing wall deformation and stability











Mechanical properties of dry stone wall? (stone size and roughness, wall texture...)

Conclusions

- The technical characterization of the pilot area has been “completed” obtaining interesting information on soil behaviour from an hydrological and geotechnical point of view

- Combining instrumental data and groundwater flow numerical modeling, different solution (analytical, statistical) can be used to analyse terraces stability all over the pilot area.

- A particular interest on processes, their measures and modeling, is always active and it is necessary to improve the reliability of the adopted solutions

Thank for your attention!

Thank also to all the colleagues who worked or are still working in the area:

Mauro Baldini, Emanuele Catelli,
Federico Mazza, Davide Roveda,