LIMITING SOIL MOISTURE VARIATIONS

HAZARD

GEOTECHNICAL DROUGHTS

IMPLEMENTATION STEP

CONSTRUCTION

RENOVATION

BUILDING IN OPERATION

AREA OF ACTION

FOUNDATIONS

OUTDOORS

COST

€ € €

low **medium** high

LEVEL OF SKILL

medium

Clay is a rocky material with plastic properties that changes its consistency on contact with water. Clay soils tend to change volume according to their water content: they swell in the presence of water and shrink in the event of drought. When a building is constructed on clay soil, it is advisable to install devices to control the water content of the soil in order to limit the damage caused by clay swelling and shrinkage (shrink-swell).

IMPACTS

Installing devices to regulate water content helps to **reduce differential soil movements** by homogenising and limiting the penetration or evaporation of water under and around the building. Depending on their moisture content, clay soils swell and shrink in different ways, leading to heterogeneous settling of the soil, which in turn can lead to disorders affecting the entire building:

- **Structural work**: cracking of structures, disconnection of structural elements, etc.
- **Finishing work**: distortion of openings, burst pipes, etc.
- **Exterior fixtures and fittings**: cracking and subsidence of outdoor terraces and staircases, etc.

INSTALLATION GUIDE

Various **strategies and preventive measures** can be taken to anticipate damage to buildings and regulate the water content of clay soil:

- Build a **watertight, evaporation-proof pavement** at least 1.50 m wide around the building (terrace or geomembrane).
- Collect and **drain roof water** (gutters) to prevent run-off.
- Connect rainwater and wastewater networks to the **collective network** to limit infiltration in the immediate vicinity of the building.
- **Seal** underground **pipes** to prevent leaks.
- Install a perimeter **drainage system** at least 2 m from the building.
- Install **thermal insulation** if the boiler is located in the basement.
- **Move vegetation away from the building** to limit the absorption of water by trees (distance of at least the height of the tree) and prune remaining trees regularly.
- Install a **root barrier** at least 2 m deep if the vegetation can't be removed.

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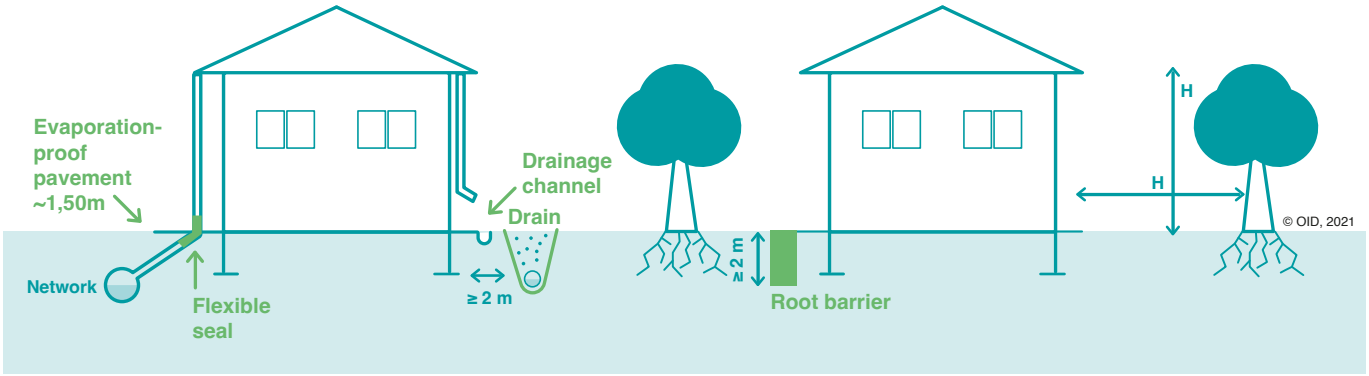
EXAMPLES OF DEVICES TO LIMIT VARIATIONS IN SOIL MOISTURE CONTENT



Source: French Ministry for Ecological Transition (2008)

WEAK POINTS AND STRONG POINTS

⊕ Water content control devices have a number of advantages: they are relatively **simple to install**, are **inexpensive** compared with other devices for limiting the damage caused by shrink-swell, and help to prevent damage to the foundations and structure of the building.

⊖ Recommendations to keep trees away from buildings to combat shrink-swell are **in contradiction with** recommendations to plant outside spaces to provide cooling shade. A trade-off needs to be made between the comfort of occupants and the risks to which the building is exposed, in order to determine whether it makes sense to plant trees close to the building.

⊕ These measures are particularly interesting for **detached houses**, which are more vulnerable to the risk of shrink-swell due to their light structure and shallow foundations.

MALADAPTATION

Maladaptation can result from the following:

Reduced soil aeration

When soil remains constantly moist, it's difficult for air to penetrate the soil, compromising aeration and the oxygen supply necessary for the survival of soil micro-organisms, which are responsible for decomposing organic matter and releasing essential plant nutrients. Problems such as root rot and the development of plant diseases can occur, reducing the overall health of the soil and the viability of vegetation.

Compaction problems

When soils remain constantly wet, they are more prone to compaction, resulting in a loss of their natural pore structure and a reduction in their permeability. This increased compaction makes it difficult for water to circulate through the soil, which can lead to drainage and flooding problems. In addition, soil compaction can hinder the growth of roots, which find it difficult to develop in a dense, compact environment that limits their ability to absorb water and essential nutrients. In addition, it can lead to uneven subsidence under the weight of the building, compromising the stability of the structure and potentially causing serious structural damage.

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MONITORING INDICATORS

ESSENTIAL RECOMMENDATIONS WORTH THINKING ABOUT

- COLLECT AND DRAIN ROOF WATER
- THERMALLY INSULATE THE BASEMENT IF A BOILER IS INSTALLED
- INSTALL A PERIMETER DRAINAGE SYSTEM AT LEAST 2 METRES FROM THE BUILDING
- PLACE A ROOT BARRIER AT LEAST 2 METRES DEEP IF THE VEGETATION CANNOT BE REMOVED

MONITOR MY ACTIONS FOR CLIMATE CHANGE ADAPTATION

+/− : Quantitative indicator ★ : Qualitative indicator

INDICATORS OF MEANS		INTERPRETATION
+/−	Percentage of pipes sealed below ground floor level 1 (%)	To be maximised
+/−	Percentage of building perimeter with an evaporation-proof pavement width greater than 1.5 m (%)	To be maximised
+/−	Percentage of essential recommendations followed (%)	The maximum number of recommendations should be implemented
+/−	Number of trees whose distance from the building is less than the height of the tree	To be minimised
+/−	Percentage of cracks wider than 1 mm and/or longer than 10 cm (%)	To be maximised
★	Water status of the foundation soil defined using a hydrometric soil survey defining the control situation*	-

INDICATORS OF RESULTS		INTERPRETATION
+/−	Comparison between water pressure and that in the control situation* (centibars)	Stabilisation over time
+/−	Number of cracks wider than 1 mm and/or longer than 10 cm	No increase in the number of cracks
+/−	Number of cracks that have widened and/or lengthened, including those wider than 1 mm and/or longer than 10 cm.	No widening of cracks
+/−	Difference in levelling between several reference points distributed over the foundations of a building at the same depth, to be compared with a control situation* (m)	The difference in level between the reference points should vary as little as possible (to avoid differential settlement of the foundations).

**The control situation is defined by the parameters set to isolate the influence of the adaptive action (similar conditions: weather, time of measurement, space, etc.).*

REGULATION / CRITERIA

- **Cracks wider than 1 mm** should be monitored more closely. The length depends on the component concerned, but it is advisable to monitor cracks of 10 cm or more (Baticopro, 2020).

TOOL

- A **crack-width gauge** is primarily designed to measure the linear opening of a specific crack, whereas a crack tester is a more comprehensive instrument that measures various crack parameters (deformation, width, length, shape, etc.), monitors the crack in several directions, and records variations over time.

- **Tensiometric probes** are used to annual monitor tensiometric data (continuous measurement in real time). Cerema is experimenting with the MACH (*MAison Confortée par Humidification*) process: when the tension in the soil reaches a critical level indicating that the soil is too dry (defined in relation to the hydrometric study), the foundation soil is moistened by injecting rainwater that has been harvested and stored. This water is diffused into the ground by gravity through several injection points distributed around the cracked façades. This stabilises buildings damaged by shrink-swell.

- **Differential levelling** is carried out using levelling tools such as spirit levels, lasers or precise levelling instruments.

FIND OUT MORE

BRGM (2009), *Rapport final du projet ARGIC (Analyse du Retrait-Gonflement des Argiles et de ses Incidences sur les Constructions)*

CEREMA (2021), *Effets des sécheresses sur les maisons individuelles et solutions de remédiation et d'adaptation*

Ifsttar and Ineris (2017), *Retrait et gonflement des argiles – Analyse et traitement des désordres créés par la sécheresse*

French Ministry for Ecological Transition (2008), *Le retrait-gonflement des argiles - Comment prévenir les désordres dans l'habitat individuel ?*

N. Pousse, J. Ponge, M. Bartoli (2022), *L'air du sol, c'est la vie de la forêt (Soil air is the life of the forest)*

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