ABOUT YOUR HOUSE

UNDERSTANDING AND DEALING WITH INTERACTIONS BETWEEN TREES, SENSITIVE CLAY SOILS AND FOUNDATIONS

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Do you live in an area of Canada that has sensitive clay soils? Such areas are at risk for soil shrinkage that can lead to foundation problems. Are you wondering whether trees are a contributing factor to soil shrinkage? Here is some background information on sensitive clay soils, why problems can sometimes occur, and assistance in evaluating your circumstances. Also provided are some tips for what you can do to minimize potential problems.

Firstly, the range of potential factors contributing to foundation damage is complex (for example, amount of rainfall, soil type and cover, foundation type, age and depth, among others). Therefore all of the factors should be carefully evaluated on a situation-by-situation basis before taking any action. The amount of risk, if any, trees may contribute to soil shrinkage should be weighed against their benefits. In addition to making your home and community pleasing to the eye, trees provide many other important benefits. Trees can increase your property value; their shade helps keep cities cooler in the summer; groupings of trees can help break up harsh winds and control snow drifting in winter; the leaves of trees intercept rainfall which helps reduce and slow down the surface runoff; and trees provide wildlife with a source of food and a place to live. In short, trees are essential to the quality of life in our neighbourhoods.

Figure 1: Extent of sensitive clay soils: Ottawa and St. Lawrence River lowlands.

All Clay is not the Same

Clay is fine grained soil that shrinks and swells according to its water content; these exist throughout Canada. Sensitive clays have a higher proportion of water among their small particles. These tiny plate-like particles are arranged like a house of cards, holding each other up when the spaces between them are filled with water. When there is a severe loss of water, they collapse, leading to a reduction of soil volume and soil shrinkage. This shrinkage occurs on sensitive clay when it dries out during drought periods. In Canada, sensitive clay is primarily found in

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the Ottawa and St. Lawrence River lowlands (Fig. 1), which contain major urban areas. Clay soils in other parts of Canada, such as in the Prairies, can experience similar effects but less severely.

To find out if your home is located in an area of sensitive clay soils, consult soils mapping for your area, or consult your local municipality.

Impact of Soil Shrinkage on Foundations

Foundation damage can be caused by many factors, but sometimes is the result of the shrinkage of sensitive clay soils. Soil shrinkage is generally localized to the zone where soil water is removed and therefore results in differential settlement. Water can be removed from soil by a wide variety of mechanisms, such as excavations or other works that lower ground water levels, prolonged periods of low rainfall, or low rainfall in combination with mature trees with a high water demand. Because conventional housing construction is not designed to handle differential settlement, deformation and cracking of foundations can result. This can lead to leakage into basements, cracking and poor fitting doors and windows.

Potential Role of Trees in Soil Shrinkage

Sensitive clay soil is subject to soil shrinkage when its water content is reduced. Trees require water for many biological functions, but the function requiring the greatest quantity of water is transpiration (Fig. 2). Transpiration is the movement of water vapour from the leaves of plants to the atmosphere. The soil in which trees grow is the reservoir from which tree roots draw water.

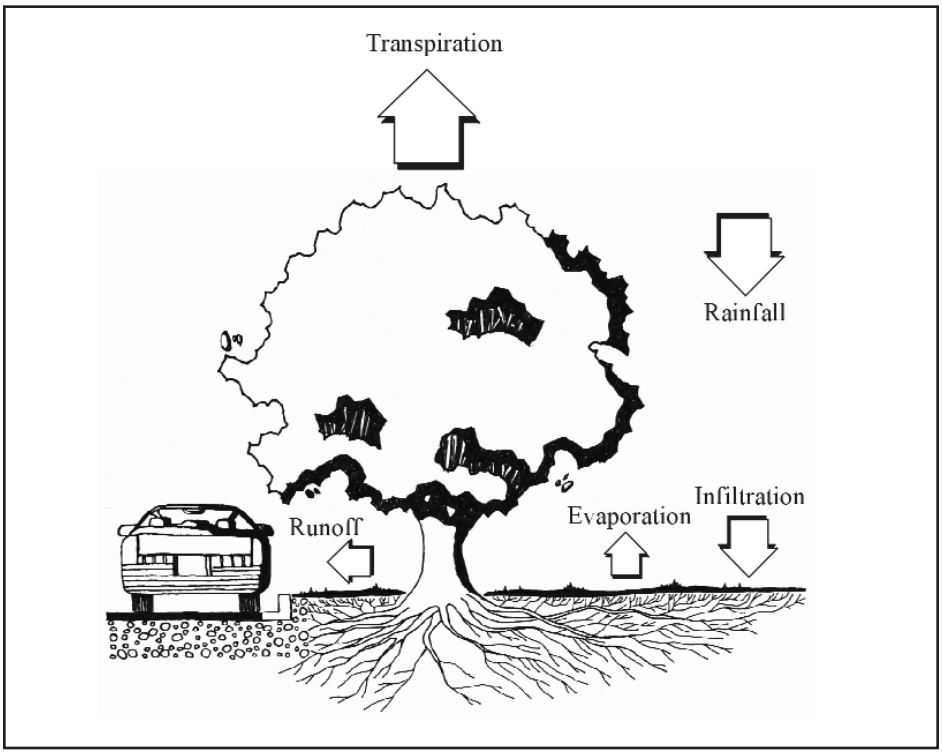

Figure 2: Main water movements in urban areas

Transpiration from trees is highest during the warm relatively dry months of June, July and August. In urban areas, particularly downtown areas, the amount of water transpired by trees is almost always more than that provided by natural rainfall, especially during the growing season. When the soil experiences a water deficit, trees can be expected to exploit all sources of water at their immediate disposal. The longer drought conditions exist, the higher the risk that trees will contribute to the shrinkage of sensitive clay soils.

The zone of influence of trees is generally related to the extent of their root growth. The lateral spread of roots is typically 2 to 4 times the height of the tree. For most tree species, 80 per cent of roots are found in the upper 30 cm of soil. Most of the remaining 20 per cent of roots are typically found within the top 1.0 to 1.5 metres of soil, with some growing to 2.0 metres, and less frequently to as deep as 3.0 metres. In clay soils and/or in urban areas where soil compaction occurs, root penetration is difficult and the percentage of roots in the upper layer can be expected to be greater than 80 per cent, and the maximum depth of deeper roots is likely to be shallower. Generally, trees take up water where the soil is in contact with the fine or small feeder roots. Once the soil dries out around the root, roots are capable of withdrawing water from surrounding soil areas, but only within an area

about 30 cm from the tips of tree roots. An understanding of the zone of influence of trees (Fig. 3, 4 and 5) demonstrates why shallow building foundations in the range of 1.5 metres deep, such as are often found in older urban areas, are at greater risk than deeper foundations in the range of 3.0 metres deep.

The zone of influence can be warped by insufficient growing conditions around the tree. When planting a tree it is important to make sure that enough rooting space is provided for the mature tree. If not enough space is provided, tree roots can be very creative in seeking out the water, air and nutrients the tree needs to grow and maintain its health. In this type of circumstance, tree roots may grow under driveways, walkways, and walls. However, once under these obstacles the roots would typically again grow toward the surface where they can best access water, air and nutrients. Localized modifications to the soil, such as a sand filled utility trench, may also provide some desirable growing conditions which may attract concentrated rooting. Although a sand filled trench would provide a low nutrient growing medium, it may provide better access to water and air than the surrounding soil, and therefore become a preferred growing area for tree roots.

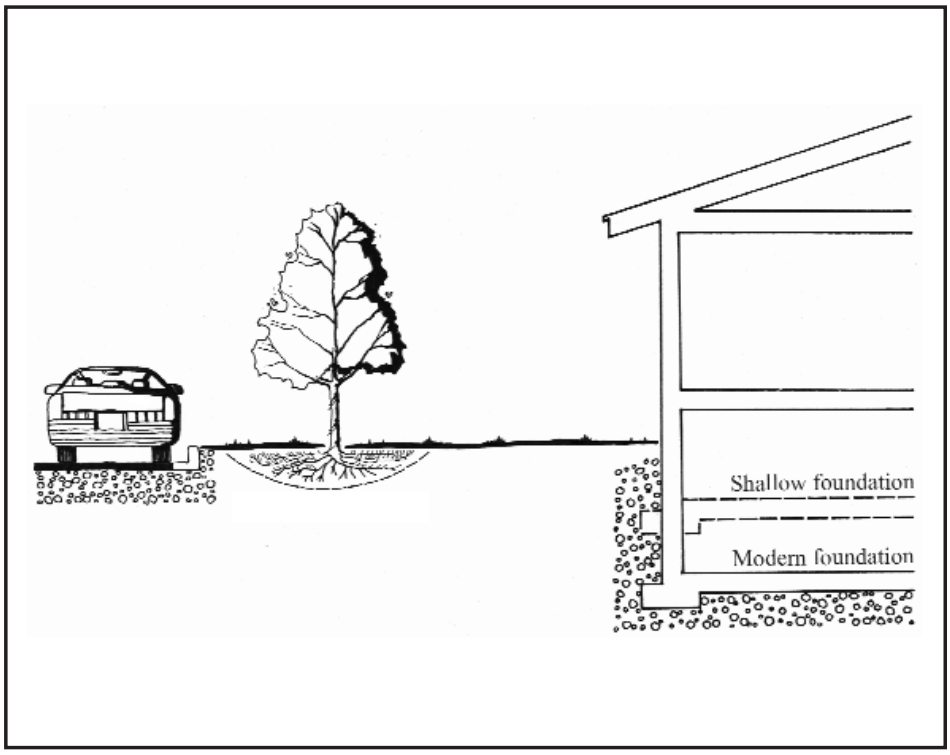

Figure 3: Relationship between a young tree and building foundation

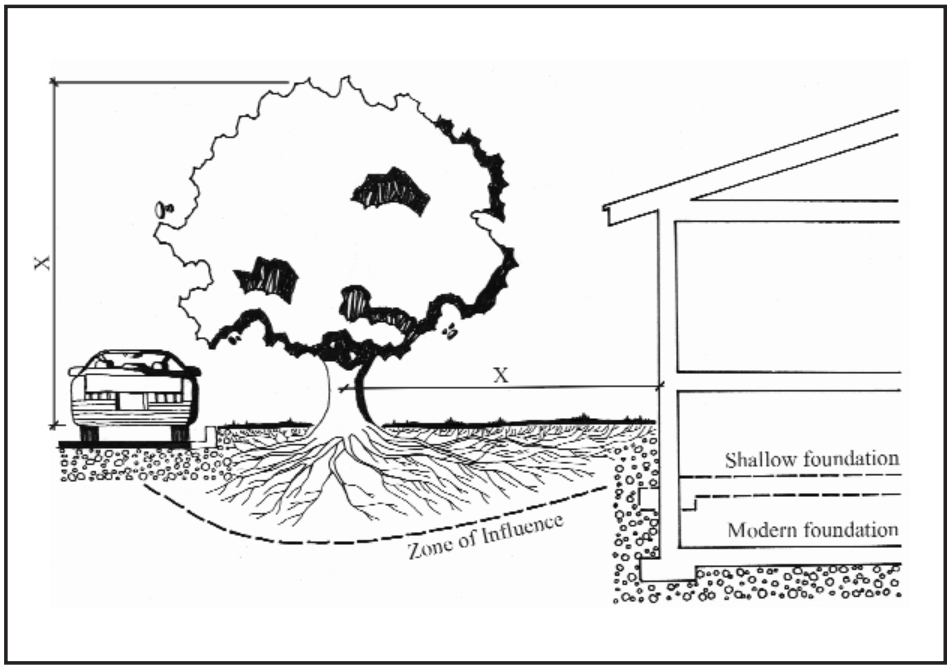

Figure 4: Relationship between a mature tree and building foundation where height of mature tree equals distance from building

Potential Problems and Assessing Risk

If your home is located on sensitive clay soil, you can reduce risk by taking proper care. This includes an evaluation of all the factors that could potentially contribute to foundation stability. The following provides a summary of some of the important factors related to soil shrinkage and foundation stability that should be evaluated. Homeowners whose properties are located in areas

Potential Problems and Assessing Risk

Tree Factors	***Type of clay*** *- If not on sensitive clay soil, the risk is reduced. If on sensitive clay, consider the following:*
	Amount of space for root growth *- If there is enough room, the risk is lower*
	Siting of tree *- If the tree's distance from the foundation is greater than the mature height of the tree, the risk is lower*
	Tree species *- (see list of high risk species below)*
	Size of tree *- If tree is mature, the risk is higher*
	Growing conditions *of tree relative to foundation (both current and historic) – e.g., a previous driveway, wall, garage, or shed may have restricted rooting in a particular direction, in which case the risk would be lower*
	Maintenance history *(watering, pruning, aeration of root zone) – If properly completed, the risk is lower*
Foundation Factors	***Age of structure*** *- If recently constructed, the risk may be lower*
	Type of structure *- e.g., unreinforced masonry rubble and concrete block foundations are more sensitive to differential movements than other foundation materials, like reinforced concrete, therefore the risk is higher*
	Sensitivity of structure *to differential movement – If structure allows for some movement, the risk is lower*
	Depth of foundation *- If foundation is deeper than 1.5 metres, the risk is lower*
	Extent of impervious surfaces *(e.g., asphalt, concrete) - If there are large areas of permeable surfaces (e.g., grass, planting beds, gravel) around the tree, the risk is lower*
Other Factors	***Who owns the tree and its parts?*** *For information in Quebec, consult the International Society of Arboriculture, Quebec Chapter, at siaq.home@sympatico.ca Elsewhere in Canada, contact the International Society of Arboriculture at isaont@bmts.com*
	Tree benefits *provided (increased property values, reduced energy costs, dust filtering, noise abatement, carbon sink, wildlife habitat, visual pleasure, etc.)*
	Health and safety *– Is there a direct threat?*

of sensitive clay soils can use this summary to help them make decisions regarding home construction techniques, siting of structures, driveways, and trees, as well as ongoing maintenance practices.

Where foundation damage involves a dispute between neighbours, a comprehensive risk assessment should be carried out by a professional. However, individual homeowners can do much to help protect themselves from potential disputes. This includes keeping an ongoing record of decisions and actions taken, for example by taking photos of changing property conditions (e.g. foundation damage, new driveways, removal of old structures or paving). Be sure to record the date and put a brief description on the back of each photograph. Keep a diary recording the date and a brief description of important maintenance work such as watering and pruning of trees, or aerating of lawns around trees.

Once this type of evaluation has been completed, you may decide to accept some tree related risk in planting or retaining a tree near a foundation if the risk is judged to be low and the tree is providing a lot of other desirable benefits. Remember that mature trees, particularly in established urban areas, are irreplaceable in our lifetimes. The main point of this evaluation is that **the removal of a tree, particularly if it is healthy and mature, should be a solution of last resort, carried out only after careful analysis of the circumstances and implementation of the tree management techniques discussed below.**

Tips for Managing a Tree's Contribution to Foundation Damage

If you determine that your property is at risk for soil shrinkage and want to avoid potential problems as much as possible, here are some tips for managing trees. As a general rule of thumb, management of trees near buildings in sensitive clay soils should begin no later than when the height of the tree is equal to the horizontal distance of the tree to the building (Fig. 4).

Watering:

Controlled watering can limit the amount of soil movement caused by drying. Controlled watering is the application of water on a regular basis to compensate for periods of low natural rainfall and/or high transpiration. Surface watering is effective, however research has shown that below ground irrigation systems can provide better results. With all watering, particularly irrigation systems, care must be taken to ensure that excess water combined with building defects do not result in water damage to homes or other structures. Because the failure of below ground irrigation systems are difficult and costly to deal with, surface watering is recommended in most cases unless it can be certain that there are good resources to monitor and maintain the system on a long term basis.

As a further note of caution, trees can receive too much water. In clay soil, where infiltration into the ground is slow, this can be a particular problem. Generally, when tree roots are sitting in water they cannot use oxygen to take up the water into the upper parts of the tree. The tree essentially drowns. Ponding water in sensitive clay soils can also lead to softening of the soil.

It is important to remember that during drought conditions of little or no rainfall, established lawn areas can become dormant and then recover when enough water again becomes available. However, trees do not have the ability to become dormant during the growing season, and therefore trees should be given priority over lawns in any watering operation. The extent of tree watering should cover the entire root system of the tree, and not just be localized around the base of the tree. The larger the tree, the greater the amount of water that should be applied. If the tree is surrounded by hard surfaces, such as buildings, roads, sidewalks, driveways, etc., transpiration will be much higher than if the tree is surrounded by soft landscaped surfaces such as grass or other trees, and therefore its requirement for water will also be much higher. It is also best to water with a slow trickle for an extended period of time, like overnight. For more information on watering, refer to the CMHC *About Your House : Water-saving Tips for Your Lawn and Garden*.

Increased water can also be provided to trees by reducing the area of non-porous paving over their roots, so that rainfall can soak into the soil and oxygen can move into soil pore spaces so that the tree can take up the water. Runoff from roofs and paved surfaces could also potentially be collected and/or diverted toward trees for use in meeting their water requirements instead of allowing the water to flow into catchbasins or manholes.

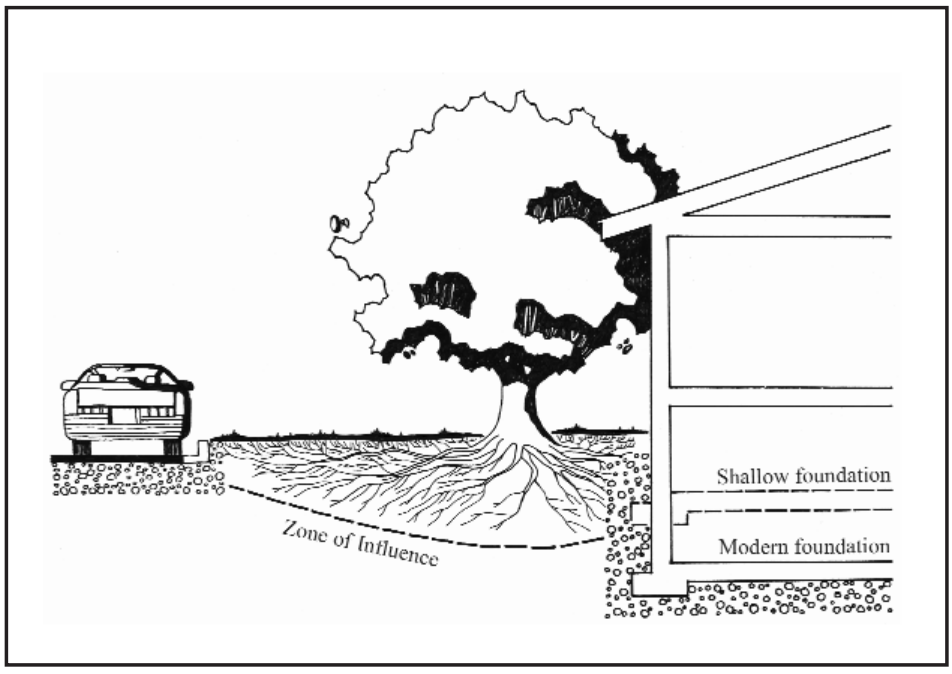

Figure 5: Relationship between a mature tree and building foundation where tree was planted close to building.

Directing Root Growth:

Tree roots will grow in the direction of least resistance and where they will have the best access to water, air and nutrients. Only a lone, open grown tree in the middle of a large healthy lawn will have generally even root development on all sides of the tree. Therefore the growing conditions around a tree can be manipulated or controlled to encourage root development away from foundations. This includes ensuring that trees have enough rooting space to meet their long-term growing requirements and periodically aerating the rooting area to increase soil oxygen and water infiltration. This may also include purposely providing poor growing conditions between trees and foundations, such as highly compacted mixed soil, vertical barriers to root growth, low nutrient soils, and/or impervious surfaces. Over-reliance on root barriers should be avoided, particularly when the quantity and quality of growing conditions on the tree side of the barrier are minimal. When designing barriers to root growth, keep in mind that the majority of the root system is near the soil surface, with very few roots growing deeper than 2 metres, and that the below ground mass is roughly proportional to the above ground mass of the tree.

Contrary to some reports, under drought conditions, tree roots cannot quickly adapt and grow into new and deeper areas where water may be available. In a water deficit situation, root growth typically ceases. However, if frequent droughts occur in an area of the country, tree roots can slowly, over many years, adapt their growth to deal better with dry conditions. Mature trees, with their massive root systems, take much longer than young trees in adapting to changing growing and climatic conditions.

Species Selection:

Tree species which have their natural habitat in a wetland or moist area (i.e., poplar, willow, elm, red maple, Manitoba maple, silver maple, bur oak), tend to have a higher requirement for water than species which are more characteristic of dry, upland areas (i.e., pine, spruce, fir, oak, beech). There are also differences in the depth of root growth among tree species. **Among those species with a lower requirement for water, pine, spruce, fir, horsechestnut, walnut, and honey locust typically have shallow root systems** with few roots deeper than about 1.5 metres, even for mature trees over 100 cm in diameter. Evergreen species in particular have been observed to have a low impact on soil shrinkage. Therefore, in areas of sensitive clay soils, water demand and root depth are two species specific characteristics which can be used to advantage when selecting new trees for planting around buildings, with water demand being a much more important characteristic than root depth.

Ironically, those species that have the lowest risk for causing soil shrinkage in sensitive clay soils are also species that do not typically grow well in poorly drained soils such as clay. Therefore, consideration should be given to modifying soil conditions and/or planting methods to compensate for this situation.

Site Selection:

When planting new trees, make sure that there is enough area with good growing conditions to provide for the root system of the mature size of the tree species planted. Good growing conditions mean good access to water, air and nutrients.

Because there are so many factors involved, the only rule of thumb that can be safely stated is that on properties with sensitive clay soils, new trees should be planted no closer to foundations than the mature, ultimate height of the species. This minimum distance is particularly important to use when tree species with a high water demand or buildings with shallow foundations are involved (see list under *Species Selection*). As Figures 4 and 5 illustrate, the closer the tree is to the building, the deeper the zone of influence relative to the foundation wall. After all factors have been evaluated (see Assessing Risk), you may decide that the benefit of having a tree close to the foundation outweighs the assessed risks, particularly if the tree is a low risk species, and proper growing conditions have been provided for the mature tree size.

Pruning:

Although not as effective as regular watering, pruning can play an important role in reducing the mass of trees, including both above ground branches and below ground

roots, and therefore the amount of water needed to meet the trees' biological requirements. This is also why mature trees have the greatest risk of contributing to soil shrinkage.

Groupings of smaller trees can also combine to produce a water demand impact similar to a mature tree. Trees can be over-pruned, thereby jeopardizing their health. Therefore, no more than 30 per cent of the trees' branches should be removed in any given year. Pruning, on a 2 to 5 year cycle, with fewer branches removed, is better for the health and appearance of a tree than more extensive pruning spread many years apart. If you are unsure about pruning, call a professional arborist. For more information on pruning, refer to the *About Your House* fact sheet *Helping Your Trees Survive Storm Damage.*

Home or Building Design:

In high risk areas, buildings can be designed to protect them from damage from soil shrinkage by deepening and reinforcing foundation walls, using adjustable columns, and the use of flexible building materials in the frame, partitions and cladding.

When to Hire an Expert:

Because of the nature and complexity of this problem, expert advice crosses many professional boundaries.

A *landscape architect* can help in determining the best locations and species to plant, as well as provide advice on how to plan or modify growing conditions to encourage root growth in more preferred directions.

An *arborist* can carry out major pruning of the above and below ground parts of mature trees in a manner which minimizes health effects on the tree. Both landscape architects and arborists can also potentially act as an expert witness in legal cases.

An *irrigation specialist* can assist in the design and installation of a watering system designed to meet the water requirements of mature trees throughout the growing season, while not causing overwetting of the soil which can lead to other problems.

A *geotechnical, soils or structural engineer* can assist in the design of structures to handle possible soil shrinkage in high risk areas, conduct forensic examinations of suspected foundation damage, and act as expert witness in legal cases.

A *lawyer* may be required if conflicts between neighbours over trees and foundation damage end up in unresolved disputes.

Resource Professionals

The following professional organizations can direct you to individuals or firms certified to practice in each province or territory.

Canadian Society of Landscape Architects: **www.csla.ca**

International Society of Arboriculture – Quebec Chapter: **www.isa-arbor.com**

Canadian Geotechnical Society: **www.cgs.ca**

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