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PREVENTION AND TREATMENT OF CONSTRUCTION DAMAGE TO SHADE TREES[1]

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Construction of homes and other buildings results in injury to a great many valuable shade trees every year. Most injury of this kind is caused through a lack of knowledge concerning the protection and care needed by established trees. In the majority of cases it can be prevented.

Careless construction practices can cause root and branch breakage or wounds on roots, stem, or branches of a tree, all of which are usually obvious at the time damage occurs. In many instances, however, construction damage may not appear until later, when the tree is placed under stress. Then foliage may suddenly wilt or become off-color, bark may become loosened in places, suckers may appear at the base of the tree or along main branches, and branches may start to die back, eventually causing stag-heading such as shown in Figure 1. Increased susceptibility to drought or winter injury and to disease or insect attack may also result from damage which occurred during construction.

Occasionally, a damaged tree may be saved and restored to a healthy condition. However, prevention of construction damage is more economical than attempts to correct it later.

When construction is planned on a property which contains shade trees, each tree should be evaluated. If a tree is an undesirable species because of its shape, size, or lack of longevity, if it is very susceptible to disease or insect attack, if it will require excessive care and maintenance, or it if is a poor specimen with considerable dieback or other injury, it should be removed or replaced later with a tree that is more desirable. If a tree is young, it may be safely moved to another location during construction operations and returned to the same or another desirable location at a later date. If a tree is established and a good specimen of a desirable species, it should be given adequate protection and care throughout construction and afterwards.

Causes and Prevention of Construction Damage

Most established trees will not tolerate any appreciable disturbance of the root system without showing some adverse effects. Damage can be caused by lack of water, excess water, mechanical breakage or injury, changes in pH (a measure of soil acidity), soil compaction, or a lack of nutrients. Normal building operations may result in the creation of one or more of these conditions.

The most common type of construction damage involves soil aeration. All tree roots must be provided with an adequate supply of air in order to carry on the normal processes of respiration and metabolism. Any change which results in reduced soil-air circulation, such as flooding or compaction of soil, may result in suffocation of roots. Such a change can be brought about by placing heavy machinery or building materials over the root system, raising the grade, raising the water table, decreasing drainage, or in some other way decreasing the volume or circulation of air within the soil.

Shade tree species vary in their tolerance to

reduced soil aeration. Some, such as white oak, beech, tulip tree, linden, and the conifers ("evergreens"), are highly sensitive to changes in soil aeration; others, such as sugar maple, honeylocust, and ash, are fairly tolerant; whereas willow, elm, poplar, sycamore, ailanthus, and pin oak will tolerate heavy or poorly drained soils without showing ill effects. Few, if any, species, however, will withstand extensive changes in aeration of soil around the root system without being injured.

One of the most effective damage-prevention methods (although not always possible) is to put up a barrier or fence composed of snow fencing, lath, boards, or logs surrounding the tree at approximately the drip-line of the branches. Such a fence will protect the above-ground portion of the tree as well as the highly sensitive root system. Where the installation of such a barrier is either impossible or highly impractical, one or more of the following types of damage may occur, and the preventive measures suggested should be followed if applicable.

Soil Compaction

Compaction of soil under trees due to movement of heavy machinery, trampling, or piling of building materials, reduces aeration of soil around the root system and can cause suffocation of tree roots. A good way to avoid this is to use not more than one roadway for the movement of trucks and equipment. Excavation dirt and construction materials should be confined to an open area and workmen should be cautioned against trampling or otherwise compacting the soil under trees.

Grade Changes

Raising the grade. Earth fills, which raise the grade, cause many changes in soil aeration, drainage, and soil microflora. Clay fills may result in reduced aeration, lower nitrogen, high pH, and improper drainage (Fig. 1). In the case of a shallow earth fill (not more than four inches), the use of a porous topsoil as fill may be all that is required to prevent damage.

Deeper fills are more likely to cause damage and require that some provision be made for aeration, watering, and fertilization of the original root system (Fig. 2). The following practices should be employed when deep fills are planned:

- Remove vegetation to prevent decomposition and buildup of gases below the layer of fill.

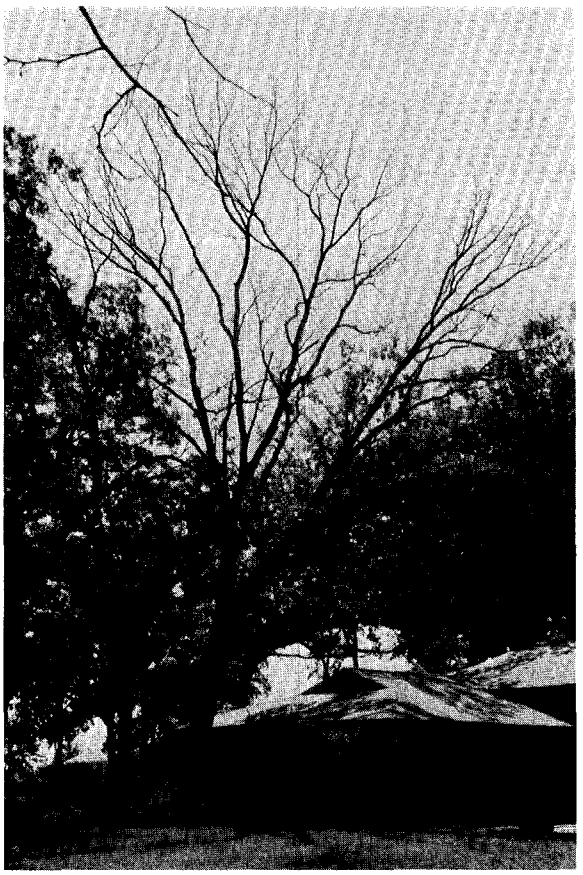

Fig. 1. Stagheading and dieback of white oak due to placement of earth fill over the root system.

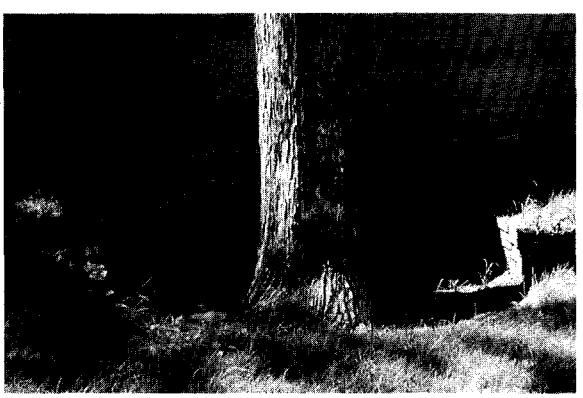

Fig. 2. Inadequate aeration system. This white oak was severely injured by the addition of a deep earth fill over the roots with only a large trunk well as a damage prevention measure.

- If a porous loam soil is used as fill and the fill is not more than 18 inches deep, spread several layers of 2- to 3-inch stone over the original soil surface starting with a thin layer just beyond the drip-line and building up to the height of the fill at the base of the trunk as shown in Figure 3. This will permit the movement of air, water, and nutrients to the root system. *Do not use limestone as this will cause excessive alkalinity.*
- If the earth fill is not composed of a porous soil, or if the height of the fill is over 18 inches, an aeration system should be installed as follows:
  1. Lay 4-inch field tile in a "wagonwheel" design with the outer rim of tile at or beyond the drip-line of the branches as in Figure 3. The spokes of the wheel should extend into within two feet of the trunk of the tree. The entire system should be built on a slight gradient so that drainage will occur from the base of the tree outward.
  2. A masonry or stone well, extending slightly above the proposed height of the fill, should be built around the trunk of the tree, making an air space of about two feet between the trunk and the fill.
  3. Tile should be laid loosely and tile joints covered with tar paper to prevent clogging by dirt. Vertical bell tile may be placed at intervals around the outer ring of tile as shown in Figure 4 and should extend just to the surface of the proposed fill to provide entrance for air, water, and nutrients to the underground system.
  4. The entire system should be covered by several layers of 1- to 2-inch gravel or crushed rock (not limestone) as shown in Figure 5. The gravel bed may then be covered with a layer of straw to prevent soil from infiltrating and clogging the gravel.
  5. After placement of the fill, vertical bell tile and the trunk well may be filled with 2-inch stone to prevent clogging of the tile and to reduce the chance of accidents.
  6. To maintain vigorous growth of the tree in the future, water and fertilizer may be added through the vertical bell tile and the trunk well.
  7. In the case of very large trees, additional circles and spokes of tile may be laid in the original "wagonwheel" pattern.

The construction of a well, even a large well, without providing an adequate aeration network, is seldom, if ever, sufficient to prevent damage to the root system of most trees when a deep fill is added.

Lowering the grade. A slight grade lowering of not more than two inches may not cause severe damage unless the tree has a very shallow root system. Where slight grading is necessary, the graded soil surface should be mulched with peat moss, leaf mold, or straw to retain moisture and stimulate root production.

If extensive grade lowering is essential, a retaining wall should be constructed as shown in Figure 6, or a terrace should be made as near to the drip-line as possible so that the original depth of soil covering the root system will be maintained. Removal of large amounts of topsoil from the root system of an established tree will cause irreparable damage.

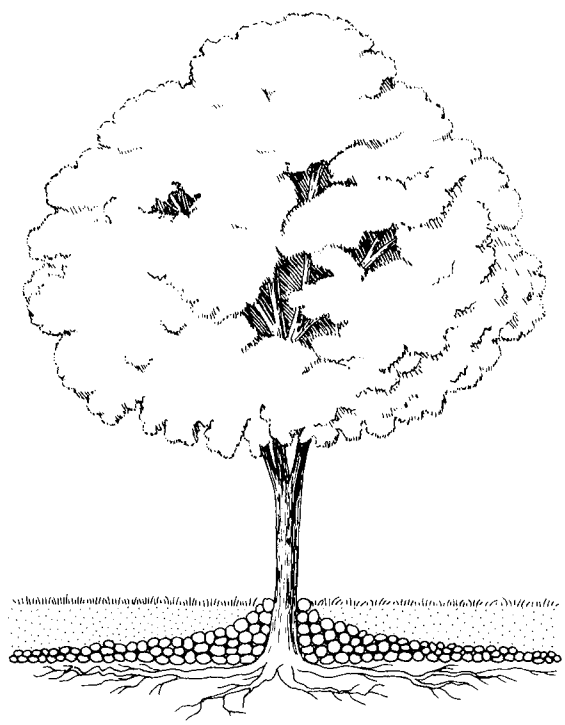

Fig. 3. Scheme for an aeration system where an earth fill of not more than 1½ feet in depth is added.

Changes in Drainage

Trenching for installation of utilities causes a reduction in the water table for a considerable distance on either side of the trench and should be carried out as far as possible from established trees.

Basement and driveway excavation is usually restricted by the size and configuration of the building site but wherever possible should be planned to avoid damage to tree roots as a result of drainage changes and mechanical injury.

Extensive grading may result in the raising or lowering of the water table in the vicinity of tree roots. If the soil around tree roots becomes drier following grading, some provision should be made for periodic watering. If grading or earth fills will cause raising of the water table and consequent reduction of soil aeration around tree roots, some provision should be made beforehand for drainage and aeration of soil around the root system.

Changes in Soil pH

Most of the common shade tree species grow best in slightly acid soil with a pH range of 4.5 to 6.5. Some species such as red oak, redbud, locust, willow, flowering crab, and sycamore will tolerate soils with a pH as high as 8.0, whereas others such as white oak, dogwood, sweetgum, hackberry, and especially pin oak may become yellow or chlorotic when soil pH rises above 6.5.

Typical symptoms of alkaline soil are reduced shoot growth and progressive yellowing of younger foliage, with leaf veins remaining dark green. Species which are sensitive to alkaline soil conditions are not able to obtain an adequate supply of iron from the soil at the higher pH levels. This deficiency is often difficult to correct, particularly if the soil is an alkaline clay. With this knowledge in mind, the contractor should avoid the use of alkaline soil as fill and should keep lime or limestone away from the root systems of shade

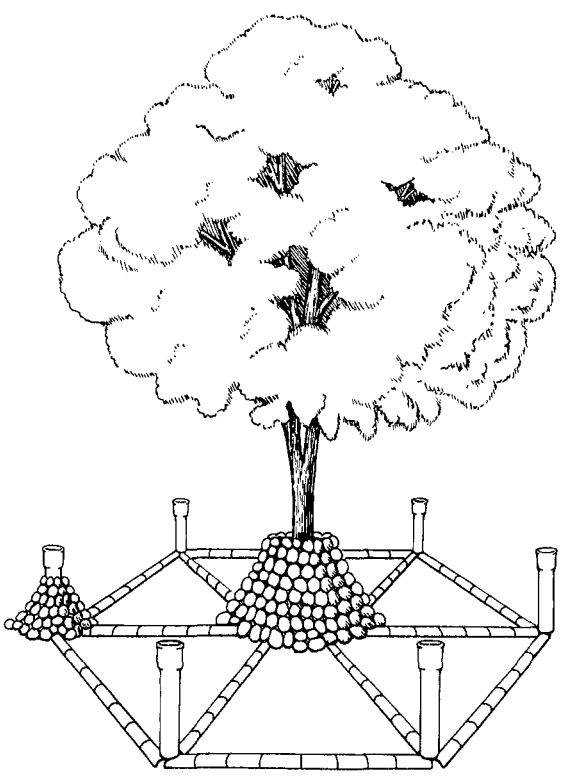

Fig. 4. Preparation of a "wagonwheel" type aeration system for deep earth fills, showing vertical bell tile and trunk well.

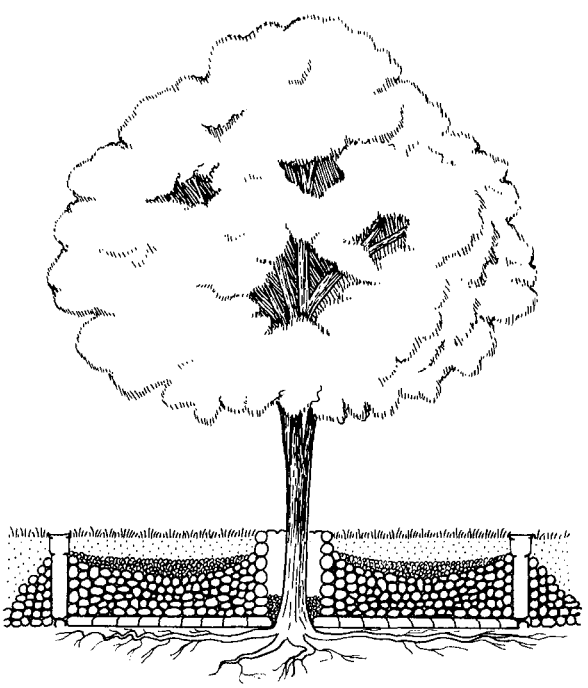

Fig. 5. Completed "wagonwheel" type aeration system for deep earth fills, showing trunk well, vertical bell tile, and layers of stone and gravel between the tile and the fill.

trees during and after construction operations.

Root Breakage or Removal

Roots may be broken or severed during construction of basements and driveways or during the installation of septic tanks, water mains, gas mains, sewage lines, or drain tile. In such cases the remaining root system would be mulched, watered, and fertilized. Wherever possible, it is best to tunnel under roots, particularly large roots, rather than sever roots when installing facilities.

If root damage or loss is extensive, portions of the crown of the tree may be removed to ease the stress placed on the reduced root system. This can be accomplished by removing some of the lower branches if the tree has not been pruned up in the past, or by thinning out the crown, removing branches which are not essential to the beauty and shape of the tree.

Mechanical Wounding

Each year, many established shade trees are severely wounded by the careless operation of construction equipment. The wounds may not be noticed until long after the building has been completed.

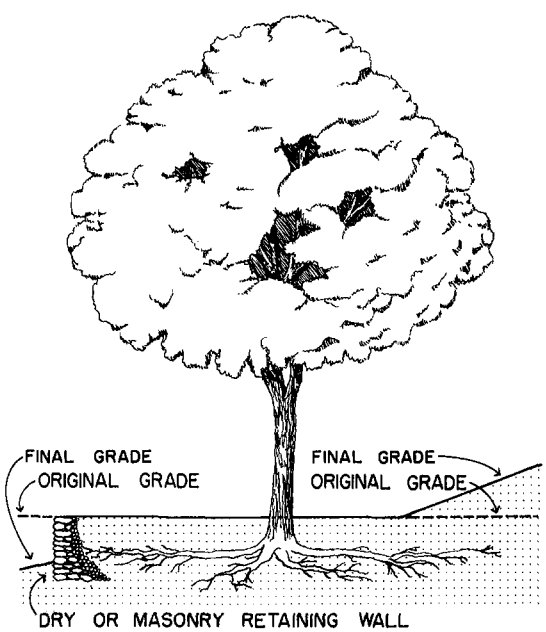

Fig. 6. Change of grade from level to sloping showing the use of a retaining wall around the tree roots.

Trunks and large, exposed roots of established trees should be covered or otherwise protected with boards or other resistant materials to prevent mechanical injury during construction. Branches which interfere with construction operations should be tied up out of the way or removed. All wounds that occur should be painted with a good wound dressing as soon as possible, since wounds provide entrances for insects and/or wood-rotting and disease organisms.

TREATMENT OF DAMAGED TREES

When symptoms of damage due to construction appear, it is often too late to correct the damage by applying treatments. If the damage is so severe that a tree is losing its shape and beauty due to stagheading and dieback, it should be removed. Dead and dying branches are hazards to life and property.

If damage is slight and if corrective measures are started early enough, damaged trees may be saved and restored to a vigorous condition. The following practices have proved effective when applied intelligently in the treatment of damaged trees.

Pruning

All shade trees should be pruned periodically to remove dead and injured branches. Trees showing symptoms of construction damage should have all dead and dying material removed and, in addition, should have all unnecessary or unsightly branches pruned out to reduce the stress on the root system. Some of the lower limbs may be removed without lessening the shape and beauty of the tree. The pruning or removal of excess branches may enhance the appearance of an established tree which has not been properly pruned in the past.

Pruning wounds should be treated with a good wound dressing immediately to keep out insects, wood-rotting fungi, and disease organisms.

Watering

Thinning out trees in wooded areas, lowering grades, trenching, and excavating cause a reduction in soil moisture around tree roots. Trees remaining in such areas may show drought symp-

toms unless some provision is made for periodic watering. Wilting and yellowing of foliage and loss of older leaves are indications of drought conditions.

Since the bulk of the root system of most shade tree species is located from one to five feet below the soil surface, light surface watering will have little effect on roots at these levels. If the soil under affected trees is porous, overnight soaking with a garden hose at weekly intervals during dry weather may prevent drought damage. If the soil has been compacted or is a nonporous clay or if a nonporous earth fill has been added, deep watering should be carried out by means of a root needle. The needle should be inserted into the soil at 4- to 6-foot intervals to a depth of one and one-half to three feet throughout the area from within two feet of the base of the tree to just beyond the drip-line of the branches.

Watering more than once a week should be avoided, since excessive watering will cause flooding and suffocation of roots.

Aeration

Trees affected by reduced aeration of the root system may show wilting, off-color foliage, general loss in vigor (with resulting increase in susceptibility to attack by insects and disease organisms), and eventual stagheading and dieback.

Where a shallow fill of not more than four inches has been placed over the root system, periodic cultivation of the fill may provide adequate aeration to enable the root system to become re-established. If the fill cannot be cultivated or has become compacted, aeration of the soil by holes two inches in diameter drilled to a depth of 12 to 18 inches at 2-foot intervals in concentric rings around the base of the tree, starting three feet from the trunk and extending just beyond the drip-line (Figure 6), may be sufficient to prevent damage. Holes should be filled with gravel or peat moss to permit continued aeration of the original root system. Another very effective method of aeration is the forcing of air or air and water into the soil with a root needle.

If an impervious clay has been used as fill or if the fill is deeper than six inches, as much of the fill as possible should be removed immediately, if this can be accomplished before severe damage has occurred, particularly where white oak or other trees sensitive to reduced aeration are involved. If replacement of the fill is necessary, an aeration network such as that previously described should be installed before the fill is replaced.

All common shade tree species have a buttressing root system; that is, the trunks of shade trees flare out at the base and some of the larger roots can be distinguished at the ground line. If no buttress roots are evident, and the base of the trunk is not enlarged at the ground line, it is very likely that an earth fill has been added and damage can be expected.

Mulching

Most trees grow best in a porous, well-aerated soil having high moisture retention. When soil under trees is disturbed by grading or compaction, water absorption and retention are reduced and the soil may become hard and impervious to water and air. The application of a good mulch such as a partially decomposed leaf litter, peat moss, vermiculite, or even straw will increase the moisture-absorbing and holding capacity of the soil and aid in maintaining tree vigor.

Fallen leaves and ground litter which are removed to reduce fire hazard or beautify grounds may be composted and later used as mulch or top dressing.

Fertilization

The root systems of established trees become adjusted to a certain balance of air, water, and nutrients in the soil. When soil around a tree is disturbed, or when roots of the tree are injured as a result of construction operations, this balance may be upset, with resulting loss in vigor of the tree. Periodic fertilization is usually recommended to restore injured trees to a vigorous condition. Two methods of fertilizer application: surface or broadcast feeding and deep feeding, have given satisfactory results.

1. **Surface feeding.** Although three elements: nitrogen, phosphorus, and potassium are considered essential for plant growth, recent research in Illinois has shown that surface application of nitrogen alone often results in satisfactory stimulation of weakened or deficient trees.

Nitrogen moves both vertically and laterally in the soil and may be broadcast on the soil surface beneath trees, then watered in with a hose or sprinkler. Best results were obtained with 13 pounds of urea (45% nitrogen) or 18 pounds of ammonium nitrate (33.5% nitrogen) per 1,000 square feet of soil surface. This is equivalent to 6 pounds of available nitrogen per 1,000 square feet.

2. **Deep feeding.** One method of deep feeding is to place dry fertilizers in holes in the soil. Phosphorus and potassium fertilizers applied to the soil surface are not available to most nutrient-absorbing roots of trees. To become available, these materials must be placed in the soil occupied by plant roots. Holes can be punched in the soil with a punch bar or drilled with an auger attached to an electric drill. Holes should be 12-15 inches deep. They are placed at 2-foot intervals in a series of parallel lines 2 feet apart throughout the area to be fertilized (Fig. 6). The following quantities of fertilizer source materials should be placed in each hole: superphosphate (0-20-0), 2 level tablespoons, and muriate of potash (0-0-60), 1 level tablespoon; **or** 10-10-10 (NPK), ½ cup.

A second method of deep feeding is injecting solutions into the soil with a hydraulic pump and a soil needle. The fertilizer materials must be completely soluble in water. The materials can be purchased from garden supply stores. The readily available water-soluble fertilizers are mixtures containing nitrogen, phosphorus, and potassium in the following proportions: 20-20-20, 23-19-17, or 25-10-20. Fertilizer solutions are injected into the soil at a depth of approximately 18 inches. Injection sites are placed at intervals of 2½ feet. Place 25 pounds of fertilizer in 200 gallons of water and 1.2 gallons of this solution in each injection site.

Pesticide Spraying

Established shade trees in a vigorous condition are usually resistant to attack by most insects and disease organisms. Trees weakened as a result of construction damage, however, are often subject to invasion by bark beetles, boring insects, wood-rotting fungi, or canker and dieback organisms. Although fertilization, pruning and watering will help restore injured trees to a vigorous growing condition over a period of years, it may be advisable to apply protective sprays of fungicides or insecticides during the period of recovery. This is true particularly in the case of trees such as elm, birch, locust, ash, and dogwood, which are subject to bark beetle or borer attack. Spray recommendations may be obtained from the appropriate state or federal agency dealing with plant pests in each state.

Responsibility

Construction damage is much easier to prevent than to try to correct later. It is the job of the builder or contractor to make sure that precautions are taken to protect established shade trees from injury during construction. The buyer or homeowner should insist that the proper procedures are followed to preserve his trees in the best possible condition, even though these procedures may add to the cost of construction.

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