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GRADE CHANGE PROTECTION FOR VALUABLE TREES
by
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Nearly everyone has noticed the death of trees around or adjacent to which grade changes have been made. Deaths from this cause are especially noticeable along the slopes of roads which have been recently constructed or realigned and in connection with operations around new buildings where grade changes are involved. Changes do not have to be great to cause serious consequences; fills of only a few inches of fine-textured soil may, and not infrequently do, cause death through a change of underground relationships.

The number of trees affected by road construction has increased materially in recent years for reasons other than increased mileage. The modern tendency in road design is to increase the radius of both horizontal and vertical curves, increase shoulder widths and road surfaces, broaden roadside and interceptor ditches, and to "roll back" road slopes instead of dressing the roadside as relatively steep inclined planes. Although such work is necessary for engineering, safety, and aesthetic reasons, there is little question but that it widens the zone influenced by the road construction. Consequently, it increases the number of trees removed or affected and widens the road scar. For this reason, if for no other, the important trees adjacent to key roads and parkways are worthy of every justifiable effort to preserve them.

The Problem.

Trees are respiratory organisms and as such absorb oxygen not only through the leaves, as is commonly known, but through the trunk and roots as well. Trees also require water for normal functioning so when anything happens to increase or decrease the normal amount of available water and air certain physiological changes are inevitable.

Another factor which affects tree health is the relationship of the tree to the delicately balanced flora and fauna of the soil, both macroscopic and microscopic. These soil organisms are not only vital factors in breaking down organic matter and making it available to the tree but they also aid in keeping the soil mechanically suitable for root growth and in other ways are highly beneficial. The soil flora and fauna are themselves immediately dependent upon sound water and air relationships in the soil. Grade changes may interrupt their functions to a serious and perhaps fatal degree so that the soil becomes, then, a medium unsuited for tree growth unless the latter is capable of adjusting itself to the altered conditions.

Some species, of course, are less susceptible to change than others, but no tree takes kindly to being deprived of its normal soil moisture or to having its

trunk and roots buried in several feet of earth, thus cutting off necessary oxygen and perhaps drowning it with an overabundance of water. We have all seen occasional individual trees the root systems of which have been buried with a thick overlay of soil for many years without apparent injury, but usually a good reason for this may be found. Perhaps the tree is of a species which is unusually well adapted to change by its ability to form new roots readily; the fill has been very gradual or of a porous nature; or natural moisture and air relationships otherwise have been maintained in a sufficient degree to minimize the physiological effect of the changed environment.

It is sometimes possible to restore a tree to health which is suffering from the effects of grade changes but too often little attention is paid to such trees until symptoms become sufficiently pronounced to attract the attention of a layman. Undersized, chlorotic, or drooping leaves, an excessive number of dead twigs or branches, excessive adventitious growth, or sloughing bark are symptomatic of serious trouble when appearing on trees affected by changes in grade. Common sense would indicate that a proper solution would be to prevent the development of these and kindred symptoms by proved precautionary measures when the grading is done.

What Trees are Worth Protecting?

Adequate treatment preparatory to grade changes is expensive and not all trees are sufficiently important to warrant the expense involved. Considerable judgment needs to be exercised in choosing trees for treatment, especially along roads. Frequently the low relative value of a tree may indicate its removal to be more sensible than any type of protective treatment.

The term "important tree" is worthy of more complete analysis than is possible in this brief paper. It is suggested, however, that in determining whether a particular tree is worthy of a protection system the following factors, which are more or less interlocking, should be evaluated:

1. Size, condition, and species of the tree. Very young or very old debilitated specimens are seldom worthy of expensive protection. Frequently it will be advisable to sacrifice badly placed young trees and to depend on replanting or volunteer growth to cover the scar. Old trees should be carefully studied to determine if the life expectancy justifies treatment. Species which are normally long-lived are, of course, worthy of more consideration than short-lived species irrespective of present size or condition.

Other factors which should be considered before treatment is given are the probabilities of windthrow and sunscald. When a new road is cut through a stand, the resulting wind tunnels and increased exposure profoundly change environmental conditions along its course. Trees which have grown up in the protection of the stand now find themselves exposed to winds of different intensity and coming from different angles. It would be unjustifiable to give complete grade protection to trees which are more than likely to be endangered through the altered conditions of exposure.

2. Probability of serious insect or disease attack. While it is rarely possible to predict with assurance that a certain tree will become prey to fatal insects or disease, the presence or absence in the locality

of insect or disease epidemics affecting the species should be carefully considered. For example, it would hardly be wise to provide an expensive protection system for an elm in the Dutch elm disease zone, a white pine in a blister rust area where no control is programmed, or trees likely to be attacked by bark beetles when new roads are cut through forest areas.

3. Presence or absence of other trees which could take the place of a removed tree. A tree growing alone is, other conditions being equal, more worthy of protection than one located on the edge of a forest or as a unit of a grove. The amount, type, and rapidity of natural regeneration also play a part in a carefully considered protection program. Trees growing close to buildings or parking areas; in playgrounds, city parks, and private lawns; or along parkways and roads through pastoral scenery have, as a rule, a higher individual value than those in forest or thickly wooded areas and consequently are worthy of more consideration.

4. Location of the tree with regard to the safety of pedestrians, vehicular traffic, buildings, etc. Trees which are dying, seriously ridden with insects or disease, structurally unsound, or obviously not windfirm, where falling trees or limbs would endanger persons, vehicles or buildings, should be removed preferably as they constitute an unwarranted hazard. Into this same category would fall trees which obscure vision at road intersections and curves or which are dangerously close to the paved surface.

5. Historical or special aesthetic considerations. Roadbuilders and designers not infrequently are confronted with the problem of preserving trees which by reason of historical association, extreme age or size, or special aesthetic value are worthy of every effort toward preservation. When planned construction work of various kinds would involve trees in this class, a change of plan or realignment may be warranted to avoid any threat to the continued existence of such specimens. If changes of plan cannot be made, such trees are worthy of the highest degree of grade protection.

6. Degree of grade changes involved. The amount of cut or fill which affects the tree under consideration will have a major bearing upon the extent of grade protection necessary to preserve it--indeed, it is one of the principal governing factors in determining whether protection is desirable at all. While it is possible and frequently desirable to provide protection for trees affected by moderate cuts and fills, if the change in grade is excessive, the expense of protection might conceivably be greater than the value of the tree in question. Sound judgment and a keen appreciation of the values at stake are needed.

Protection Principles.

Reduced to essentials, the objective in counteracting the ill effects of grade changes is to prevent as nearly as possible the upsetting of the normal balance of air, water, and other subsurface relationships. No hard and fast rules can be laid down for solving this problem because no two trees live under exactly the same en-

vironmental conditions.

The usual corrective for a raise in grade around a tree has been to build a masonry well around the trunk. Many of these wells unquestionably have been a factor in preserving the health and vitality of buried trees but too often the well has merely prolonged the tree's life for a short period. Proper protection is not so simple.

Techniques preparatory to grade changes will vary with such factors as the location, species, size, age, value, and condition of the tree or trees involved; the depth of the cut or fill and the degree of slope; the physical and chemical characteristics of the original soil and that to be used for the fill; the amount of soil moisture present; and changes in surface and subsurface drainage to be anticipated.

Raising Grades--Ideal Aeration System.

The type of treatment described below is applicable to trees of the highest individual value such as important trees in public use areas, lawns around homes or public buildings, playgrounds, etc.

The first step in a practical aeration system is the preparation of the normal ground surface including the removal of all living vegetative cover, sod, and green organic debris. It is well to cultivate all of the soil surface beneath the tree's crown, but the roots should be disturbed as little as possible unless the area has suffered considerable compaction, when it will be desirable to aerate the soil as deeply as necessary to break up the compaction layer.

Most authorities and experienced arborists believe that it is desirable at this point to fertilize trees to assist them in overcoming the inevitable changes which lie ahead although agreement is not 100 percent. Considerably more scientific investigation is required on the subject. If fertilization is deemed advisable under local conditions, a normal dosage--say three pounds per inch of trunk diameter, breast high, of a 10-8-6 or a 10-6-4 fertilizer--may be applied to a deciduous tree by any one of the standard methods so long as it is well distributed. (See Shade Tree Fertilization, Miscellaneous Circular No. 46, May 7, 1937.) Less is known of the effects of fertilizers on conifers, but it is believed that not over one-half of this dosage should be applied to the average conifer under similar conditions; indeed, chemical fertilizers should be used with considerable caution on conifers under any circumstances, particularly under wild or semiwild growing conditions.

A circular system of 4-inch porous agricultural drain tile is then laid on the ground under the drip line of the crown. In excessively wet soil or in low spots the tile preferably is laid in a very shallow ditch and is surrounded by gravel or crushed stone. Four to eight additional tile lines should be laid radiating out from the trunk and extending to the circular system so that in plan the entire system resembles the rim and spokes of a wheel. (Figure 1.) On trees of great size or under conditions of excessive moisture it may be necessary to supplement this tile system with additional circular tile lines between the tree and the drip line and in some cases outside of the drip line. The gradient of the tile lines is determined preferably by instrument to assure that there will be no dips or humps in the system and to plan for drainage away from the tree in one or more directions. Tile lines which would drain toward the tree should be omitted. All tile joints should be covered with a piece of tarred paper to keep out debris.

At a reasonable distance from the trunk a dry well is laid up with the coping flush with the final ground surface. (Figure 2.) The inside diameter of the well should be governed by the growth probabilities of the tree. A small tree needs, relatively, a greater diameter well than one which nearly has reached its anticipated girth. The well should be so constructed that the radiating tile lines start at the very bottom of the inner wall of the well and radiate outward undisturbed. As many voids as possible should be left in the walls of the well to permit an exchange of air and moisture through the porous fill which is to be placed outside of the well. Large stones, approximately even in size, are most generally used for this purpose, but brick, discarded building tile, or concrete blocks are quite satisfactory if laid up with the openings extending clear through the wall of the well. It should be noted, however, that any remnants of lime should be avoided, especially with conifers.

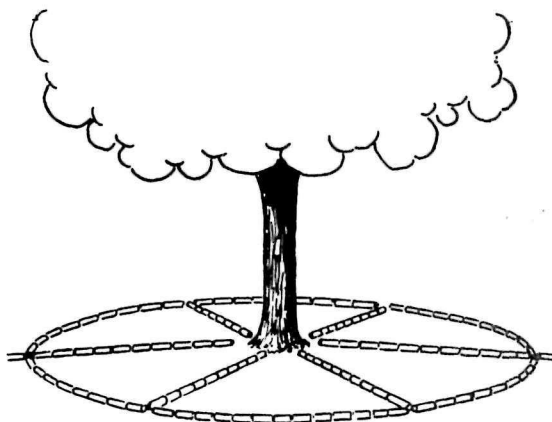


FIG. 1
HORIZONTAL TILE FIELD

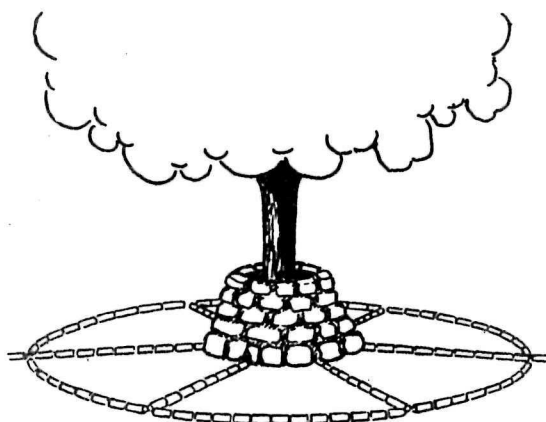


FIG. 2
CONSTRUCTION OF DRY WELL

It is a good plan to add enough rocks and gravel to the bottom of the well to just cover the drain tile openings. This will facilitate drainage and aeration and prevent the tile lines from becoming clogged with debris.

When the tree in question is so located that the open well presents a safety hazard such as might exist in a playground or similar public use area, an iron grate may be provided if the expense is warranted; a barrier fence may be built around the top of the well; or the inner wall of the well may be curved inward toward the top thus avoiding a wide space between the trunk and the well at the ground surface. Another method of avoiding the hazards of an open well is to fill it with rocks. These may be removed periodically to avoid any growth constriction and replaced in slightly different positions.

In order to permit a circulation of air through the fill at the extremities of the branch spread, provision must be made to connect the radiating and circular tile lines to the new ground surface. This is perhaps best provided by erecting vertical sections of bell tile at the intersections of the tile lines. (Figure 3.) The horizontal lines are brought together so that a 6-inch bell tile can be placed over the joint. It may be held erect during construction, bell upwards, by blocking with stones. As many sections of vertical tile should be used as are necessary to just reach the finished grade of the fill. Temporary wooden or rock plugs, placed in the mouths of vertical bell tile, will prevent the sifting in of dirt and debris while the fill is being made.

Large stones, rather evenly sized, are then laid over the entire area encompassed by the tile field and may well be extended several feet beyond. (Figure 4.) The depth of the stone layer is governed by the total depth of the fill. For example, a shallow fill of perhaps a total of two feet will permit only about one foot of stone fill, while in a deep fill a greater depth of stone may be beneficial. It is doubtful, however, whether stone fills greater than thirty inches are needed for maximum efficiency. The stone should be laid rather than dumped to permit the leaving of as many voids as possible and to prevent injury to the tile.

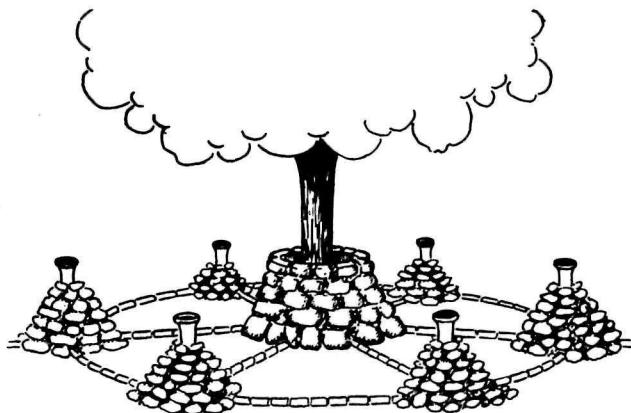


FIG. 3
VERTICAL TILES ERECTED

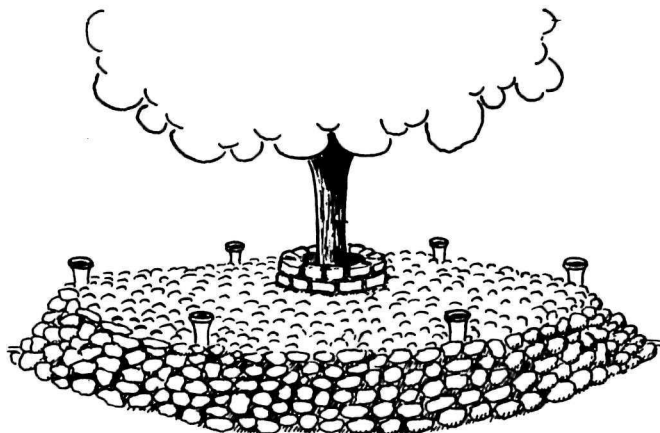


FIG. 4
PLACING OF ROCK FILL

A thinner layer of crushed rock or smaller stones may be placed over the large stones to fill the surface voids. This is followed by a thin layer of hay or straw just thick enough to prevent the future fill of soil sifting down and closing the lower voids. For conifers a layer of fallen needles could be used. Sufficient topsoil of good tilth is placed on the hay to bring the fill to the desired grade.

In order to keep the vertical tiles from filling up with debris the best method is to fill them to the ground surface with large rocks or large size crushed stone, leaving all possible voids to facilitate aeration, watering, and fertilization.

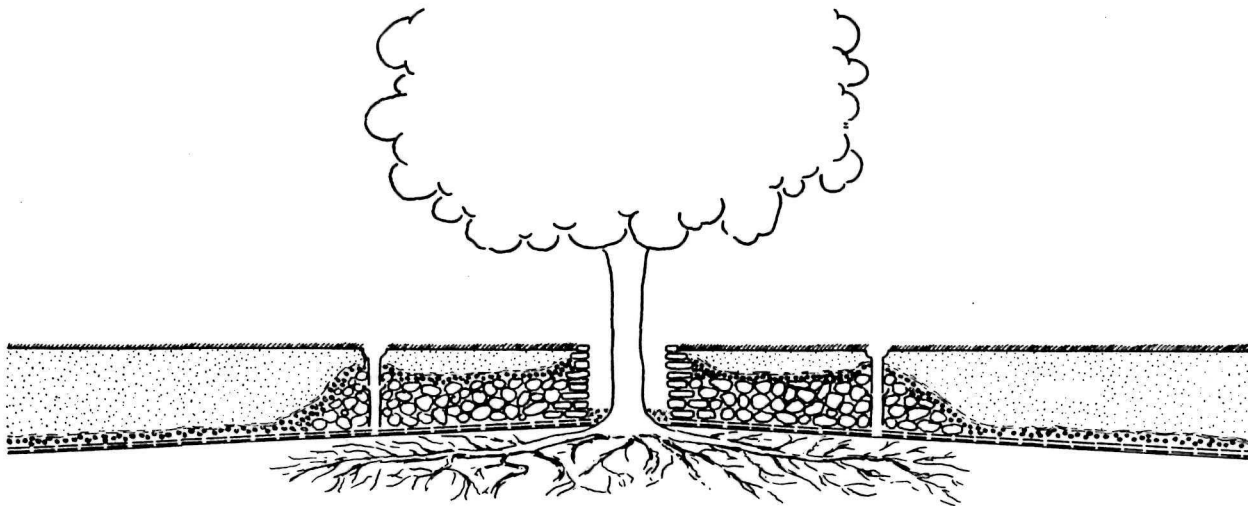


FIG. 5
CROSS-SECTION THROUGH TREE - IDEAL AERATION SYSTEM

Raising Grades--Road Slopes.

Trees growing in locations which eventually will be road slopes may be treated somewhat differently as to details but the principles involved are the same as for normal raises in grade around trees, provided the value of the trees warrants such treatment. Instead of a circular and radiating tile system, the perimeter tiles may be laid in a U-shape under the drip line of the crown with the ends of the "U" extending downhill and outward to the face of the proposed slope. Supplementary tile lines may be laid as shown in Figure 6.

The tree well is constructed essentially as described previously with the coping flush with and on the same grade as the finished slope. Vertical tiles are erected as described previously. (Figure 7.)

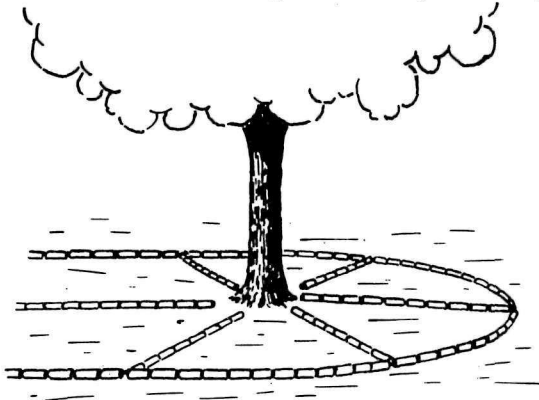


FIG. 6

TILE FIELD - TREE IN ROAD SLOPE

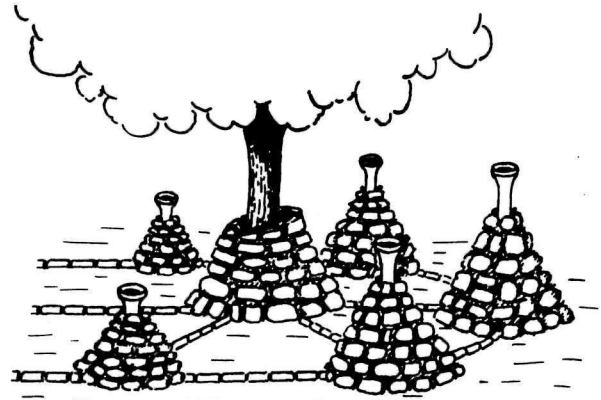


FIG. 7

WELL & VERTICAL TILES ERECTED

If any of the vertical tiles would extend into the area which will be surfaced for traffic, such vertical tiles preferably are omitted from the protection system. Some means of keeping surface road drainage away from the treated area by curbs or shallow ditches should be incorporated in the protection scheme.

The preliminary stone fill is laid the same as for a normal fill, but it is beneficial, if the appearance is not objectionable, to have some of the rock fill exposed on the slope for purposes of aeration where the final surface is graded. (Figures 8-9.)

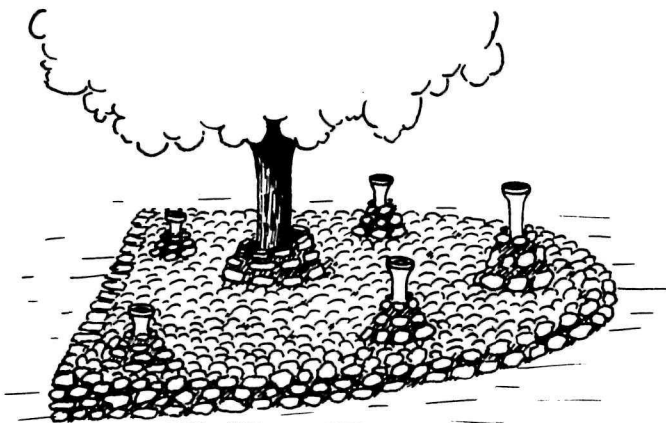


FIG. 8

ROCK FILL - DRY WALL AT LEFT

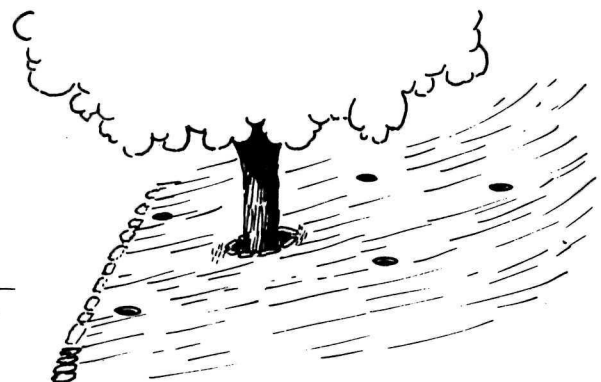


FIG. 9

COMPLETED GRADING

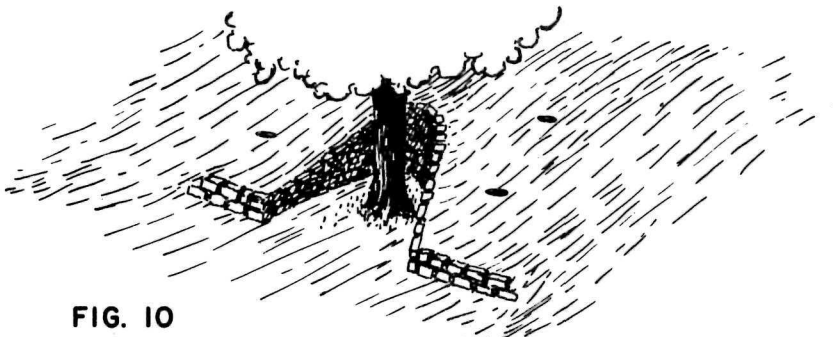


FIG. 10
MODIFIED DRY WELL - TREE IN ROAD SLOPE

A modification of this type of protection is shown in Figure 10, in which a U-shaped open well is used instead of one of circular shape. When adaptable to local conditions, this type of well is more desirable than those described previously since more of the original soil level is left undisturbed.

When valuable trees are located in or at the toe of slopes adjacent to roads or other large construction operations, any good accomplished by an aeration system may be nullified if the trunk is not protected from blasting, rolling stones, and other injuries during the construction. A tree badly scarred is an open invitation to insects and disease; hence all possible care should be exercised to prevent injuries by the erection of log or heavy board barriers on the side or sides of the trunk liable to damage. Unpreventable scars should, of course, be traced to a streamlined perimeter to promote healing and painted with a suitable tree dressing to retard or prevent decay, but most tree scars are preventable if a little judgment is used.

Raising Grades--Modifications for Economy.

When the economy of the operation or the questionable value of the tree will not permit the expense involved in the construction of an aeration system of one of the types previously described, several modifications may be adopted although it should be realized that the chances for survival of the tree are lessened thereby.

Modifications may include the elimination of the horizontal tile field, if adequate drainage otherwise is assured, (Figure 11); vertical tiles, if blind wells can be substituted, (Figure 12); the tree well, if the rock fill is brought up to the surface around the tree, (Figure 13).

Sketches illustrative of these modified systems are shown as Figures 11, 12, and 13.

Lowering Grades.

The problems presented when grades around trees are lowered are quite the opposite of those described previously. The root areas of trees which have been left standing close to an edge of a cut bank or road slopes usually are aerated sufficiently, if not excessively, but the moisture supply is reduced because of soil drying and removal of protecting surface soil and vegetation. Root cutting also is often a serious problem.

Some changes in fundamental soil relationships usually are inevitable but the effect of the changes often may be minimized or ameliorated by measures designed to prevent excessive drying of the soil, to increase the moisture-holding capacity of the soil, and to stimulate root development, particularly the deeper roots and those in the least affected part of the root system.

Excessive drying of the soil may result from three main causes: reduction of soil moisture, surface evaporation, and removal of sheltering vegetation. In most

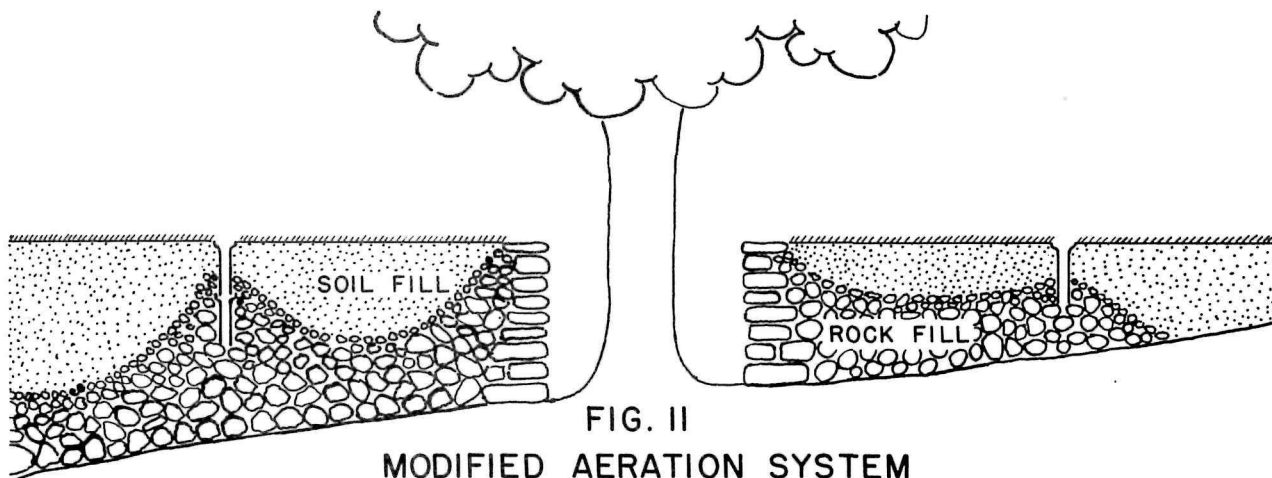


FIG. II

MODIFIED AERATION SYSTEM
HORIZONTAL TILE OMITTED

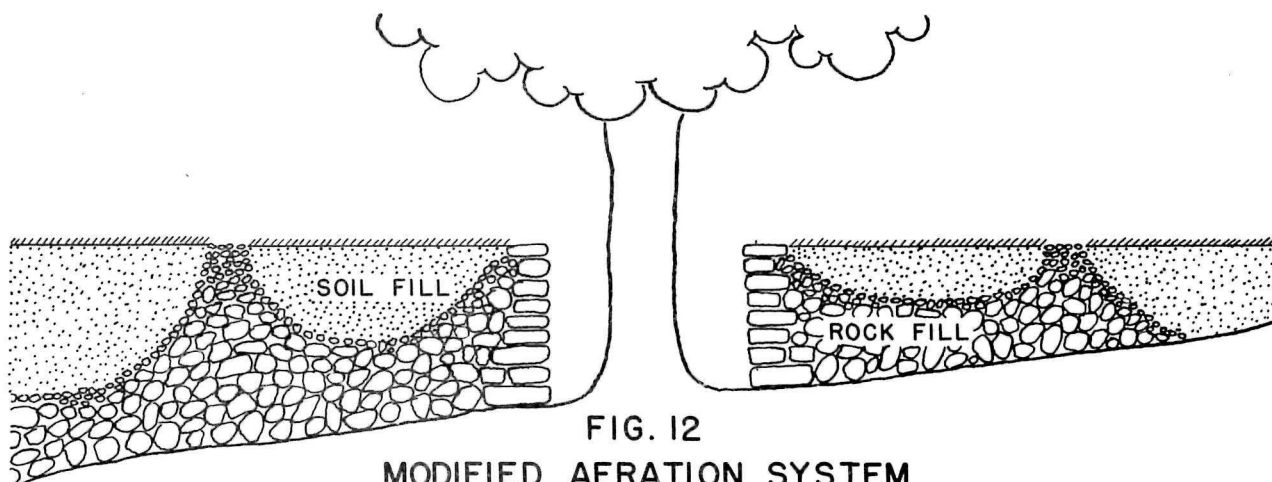


FIG. 12

MODIFIED AERATION SYSTEM
HORIZONTAL AND VERTICAL TILE OMITTED

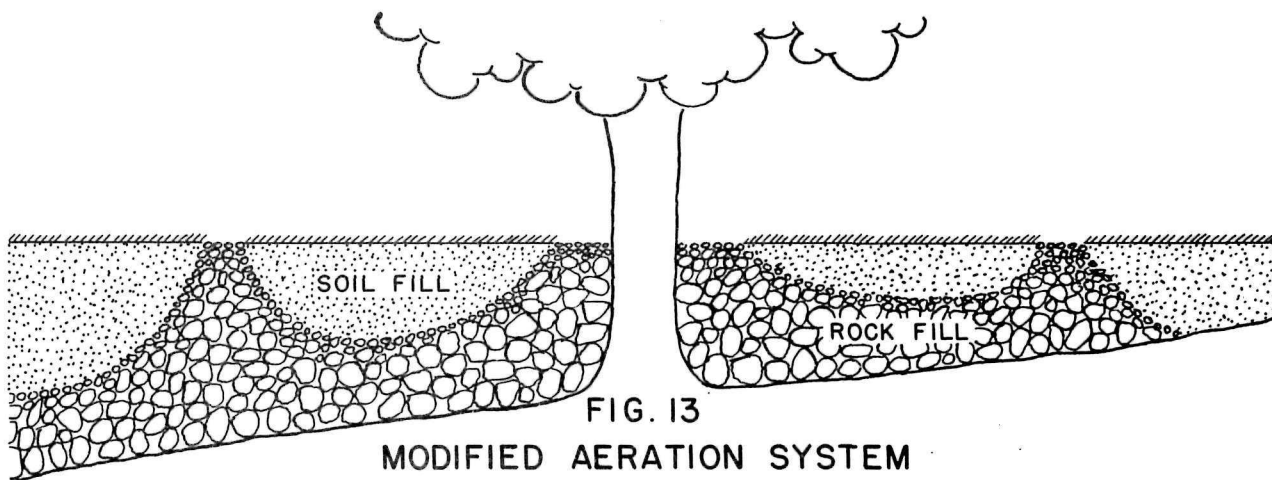


FIG. 13

MODIFIED AERATION SYSTEM
ALL TILE AND TREE WELL OMITTED

soils capable of sustaining plant life, the soil water level tends roughly to parallel the surface of the ground. It is important, therefore, that as much as possible of the normal soil level around trees be retained when the general gradient is lowered. This is a matter of close supervision at the time of the road building operation. The preservation of trees of outstanding merit, where the cost is justified, occasionally may warrant the erection of masonry retaining walls, (Figures 14, 14a), where necessary to preserve as much as possible of the normal relationship of the root system to the original ground surface.

A preferable modification of this plan, sometimes observed, is to mold the ground surface around the tree into the new general slope instead of arbitrarily cutting slope and roots to conform to a uniform gradient. (Figures 15, 15a.) In either case an extreme effort should be made to avoid cutting off an appreciable part of the root system.

The moisture-retaining capacity of the soil may be increased by providing a mixture of peat moss or leaf mold and soil for the back fill placed behind the previously mentioned walls. Mulches of leaf mold, straw, hay, etc., are extremely beneficial and, of course, the establishment of a permanent plant cover is highly desirable.

In order that the part of the root system least affected by grade changes may be better able to take over at least a part of the functions of the injured portion, practices designed to stimulate root growth frequently are beneficial. Deep fertilization, mulches, cultivation, and watering, when possible and practicable under existing conditions, will be beneficial for this purpose.

It should go without saying that all reasonable care should be exercised in operations involving changes of grade to prevent soil erosion by the planting of trees and shrubs, surfacing with protective mulches, sodding, and similar measures designed to hold the soil and cover the construction scars.

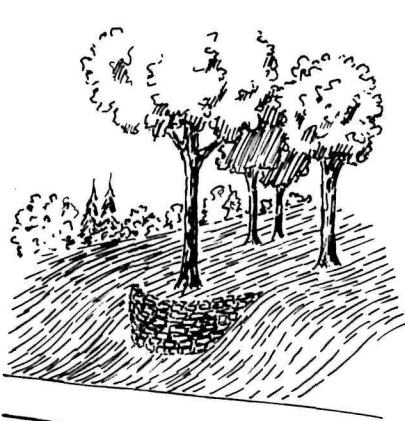


FIG. 14 A

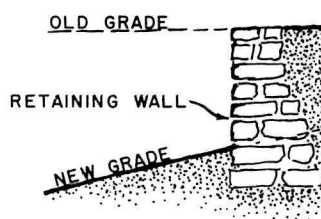


FIG. 14
MODIFIED AERATION SYSTEM
USE OF RETAINING WALL

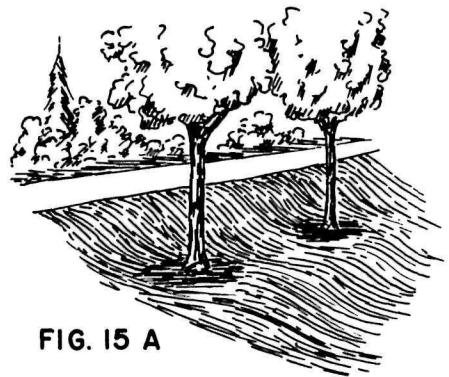


FIG. 15 A

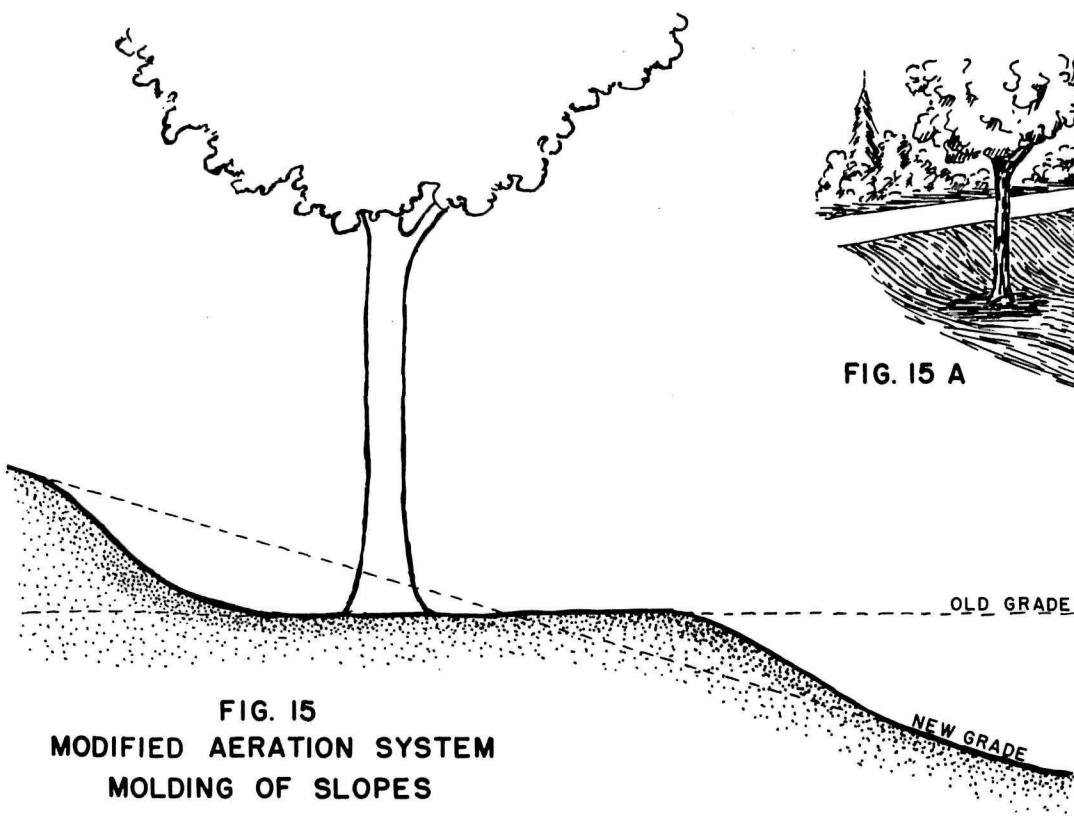


FIG. 15
MODIFIED AERATION SYSTEM
MOLDING OF SLOPES