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CONSTRUCTION AND CARE OF EARTH ROADS.*

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In Illinois at the present time a great deal of attention is given to questions relating to good roads. Although there is considerable difference as to details, all agree that good roads are of some financial advantage to farmers, and add materially to the comfort and pleasure of rural life. There is a remarkable difference of opinion as to the wisdom of attempting the construction of a general system of permanently hard roads; but all are agreed that for several years to come many of the main roads will have only an earth surface, even though the state immediately enters upon a comparatively elaborate scheme of hard road construction, and that under any and all circumstances many of the roads of Illinois will always be built of the native soil. In other words, whether

*There have recently appeared in engineering journals several papers by Ira O. Baker, Professor of Civil Engineering in the University of Illinois, on various phases of the good roads question, which have differed materially from much that has recently been written upon this subject; and as Professor Baker seems to have considered the road question quite carefully, I have requested him to prepare this bulletin, addressed to the farmers chiefly, upon Earth Roads—a subject of great importance to the rural population, but one which seems to have been almost entirely overlooked by writers on good roads.

E. Davenport, *Director.*

the state is upon the eve of an era of hard road improvement or not, for a large portion of our state earth roads must, at least for a long time, continue to be the only highways, and in all parts of the state the minor roads will always be earth roads.

At certain seasons of the year earth roads can be made second to none, but at other seasons they are almost impassable. Can anything reasonable be done to improve the average earth road, either in its most favorable or in its worst condition? The object of this article is to offer some suggestions as an answer to this question. These suggestions will be grouped under three heads, viz.: I., Construction; II., Maintenance; and III., Administration. The term "earth roads" will be employed as applying to roads built of loam and clay, and subsequently sand roads will be considered.

I. CONSTRUCTION.

In the greater portion of Illinois the public highways have mostly already been opened, but it does not follow that the roads are finished as far as construction is concerned

Location.

Most of the roads in Illinois are already established, and farm buildings have been located accordingly: therefore it is not wise to waste many words on this phase of the subject. However, it may be permissible to say that in a broken country the value of a road for transportation purposes can sometimes be materially improved by going round the hill instead of over it. Again, if the road is likely to have any considerable travel, it may be wiser to spend considerable money for a right of way through the section instead of locating the road on the section line. Farther, notwithstand- the farmer's justifiable dislike of non-rectangular fields, it may be wiser for the road to run irregularly through the section instead of on the land-survey lines, particularly if by so doing a steep grade is obviated or a location is obtained where the road is upon better soil or is less liable to damage by water. These points are mentioned here as a reminder only that in the location of a road in a rough country, they should not be entirely overlooked.

Width.

In Illinois the law and practice have established the width of the road probably beyond possible change. The right of way is almost always 66 feet. The law requires that a strip equal in width to one-tenth of the right of way shall be reserved for pedestrians on each side between the property line and the ditch. This

makes the wagon way about 53 feet wide. This is probably none too much for an earth road, since the travel can be distributed over a greater width and thus prevent the surface from being cut up so much when it is soft. With the possibility of the construction of bicycle paths on the side portions, and with the possibility of the construction of electric railroads in the center portion, it is not certain that the right of way of the main roads is extravgantly wide, as is sometimes claimed.

Grades.

Of course the hills should be cut down and the hollows filled up as far as practicable. Ordinarily, and properly, the road when first opened runs down into the hollows and up over the hills; and, as time or money is available, the high places are cut down and the low ones filled up. The effect of a steep hill in limiting the amount that can be hauled over a road is so apparent to those who use and care for the road, that local authorities can be trusted to make all reasonable improvements in this line. However, it may be well to mention that the more the surface is improved the more the grades should be reduced. This needs no argument.

Embankments.

When an embankment is to be built, care should be taken that the earth is deposited in layers—the thinner the better,—so that it shall settle uniformly. These layers should be kept lower in the center than on the sides, since when built in this way the sides of the embankment are less liable to slide down. If the earth is moved with the drag-scoop scraper, care should be taken to level down each scraper full, since otherwise the earth will settle unevenly and leave the surface full of hills and hollows, which are very annoying to travel over, and when it rains the hollows are filled with water which is soon worked into mud, thus rendering the road nearly impassable. A little care in this matter is very beneficial. If the very best result is desired in the shortest time, the layers should be harrowed and rolled. The ordinary farm roller is too light for this work, and should therefore be loaded as heavily as possible with stone or other heavy material.

Drainage.

Drainage is the most important matter to be considered in the construction of earth roads. No road, whether earth or stone, can long remain good without drainage. Drainage alone will often change a bad earth road to a good one, and the best road may be destroyed by the absence of proper drainage. Water is the only agent that destroys earth roads. Water and dirt make mud, and

mud makes bad going. The dirt is always in the road, and the water comes at unpropitious times, as rain or snow. The water softens the earth, the horses' feet and wagon wheels mix and knead it, and it soon becomes impassable mud; finally the frost freezes it, and the second state of the road is worse than the first—for a time at least. Further, if the water is allowed to course down the middle of the road, it will wash away the earth and leave gullies in the surface that must be laboriously filled up by the traffic or the hand of man. No road, however well made otherwise, can endure if the water collects or remains on it. Prompt and thorough drainage is a vital essential in all road construction.

A perfectly drained road will have three systems of drainage, each of which must receive special attention if the best results are to be obtained. This is true whether the trackway be iron, broken stone, gravel, or earth, and it is emphatically true of earth. These three systems are, viz.: underdrainage, side ditches, and surface drainage.

UNDERDRAINAGE.—Many, if not most, country highways could be considerably improved by thorough subdrainage. Most roads need underdrainage even though water does not stand in the side ditches. Most people appear to think that the sole object of tile drainage is to remove the surface water, but this is only a small part of the object of the underdrainage of roads.

The most important object of underdrainage is to lower the water level in the soil. The action of the sun and the breeze will finally dry the surface of the road, but if the foundation is soft and spongy, the wheels wear ruts and horse's feet make depressions between the ruts. The first shower fills these depressions with water, and the road is soon a mass of mud. A good road can not be maintained without a good foundation, and an undrained soil is a poor foundation. A dry subsoil can support almost any load. A friend of the writer, an intelligent man and a close observer, claims that even in a dry time the easiest digging on or around a farm is just under the surface of a road having no underdrainage. His theory is that except in the road vegetation is continually pumping the water up from the subsoil and giving it out into the air, while in the road the compact surface prevents evaporation of the water in the subsoil. Therefore the road needs underdrainage more than the field.

A second object of underdrainage is to dry the ground quickly after a freeze. When the frost comes out of the ground in the spring, it thaws quite as much from the bottom as from the top. If the land is underdrained, the water when released by thawing

from below will be immediately carried away. This is particularly important in road drainage, since the foundation of the road will then remain solid and the road itself will not be cut up like untiled roads.

A third, and sometimes a very important, object of subdrainage is to remove what may be called the underflow. In some places where the ground is comparatively dry when it freezes in the fall, it will be very wet in the spring when the frost comes out—surprisingly so considering the dryness before freezing. The explanation is that after the ground freezes, water rises slowly in the soil by hydrostatic pressure of the water in higher places; and if it is not drawn off by underdrainage it saturates the subsoil and rises as the frost goes out, so that ground which was comparatively dry when it froze is practically saturated when it thaws.

The underdrainage of a road not only removes the water, but prevents, or greatly reduces, the destructive effect of frost. Frost is destructive only where there is moisture. The upheaving action of frost is due to presence of water. Water expands on freezing and loosens the soil; when thawing takes place, the ground is left spongy and wet, and the roads "break up." If the roads are kept dry they will not break up. Underdrainage helps to keep them dry.

It is the universal observation that roads in low places which are tiled dry out sooner than the untiled roads on the high land. The tiled roads never get so bad as those not tiled. There is no way in which road taxes can be spent to better advantage than in tiling the roads.

All roads, except those on pure sand, can be materially improved by tile drainage. This is the opinion of many farmers, in several communities, with whom the writer has conversed on this subject. In each community this is universally the opinion of the farmers who have had the best success in draining their own farms. The cost of tile drainage is not great, say, about 50 cents per rod or $160 per mile; and the improvement is permanent with no expense for maintenance, and the benefit is immediate and certain. Farther, tile drainage is the very best preparation for a gravel or a stone road. Gravel or broken stone placed upon an undrained foundation is almost sure to sink gradually, whatever its thickness; whereas a thinner layer upon an underdrained roadbed will give much better service. "Roads tiled without gravel are better than roads graveled without tile."

The road should be underdrained so as to keep the water level well below the road surface. In most localities this can be accom-

plished reasonably well by laying a line of farm tile 3 or 3½ feet below the road surface along one side of the roadway. It is sometimes claimed that there should be a tile on each side of the road. Some tests recently made by the Illinois Experiment Station (not yet published) seem to indicate that one line will give fairly good drainage under the most adverse conditions. The experiment consisted in the drainage of a piece of land selected as the worst that could be found in a part of the state notorious as having a large area of hand-pan which it was generally considered could not be underdrained "because the soil held water like a jug." Lines of tile were placed 2½ feet deep and 50 feet apart. The water level at a point midway between the lines of tiles was lowered 18 inches, when at the same time the water level in the undrained portion of the field was only 6 inches below the surface. In this case the surface of the ground water had a slope of 1 foot in 25 feet, but in a more porous soil the slope would be much less. Therefore a single line of tile 3 or 3½ feet deep, if of adequate size, will give nearly perfect drainage; and a second line will not materially improve it. For example, in Fig. 1, if A represents

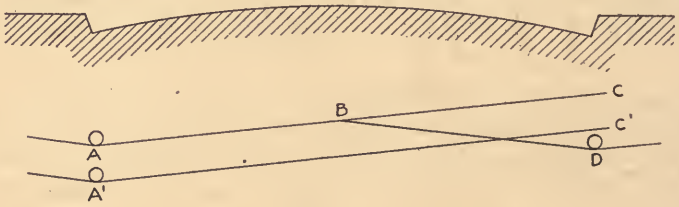

FIG. 1.

the first tile, the surface of the ground water is represented by the lines A B C. If a second line of tile, D, is laid, the water surface will be A B D, the second line draining only the comparatively small portion C B D. The diagram shows that a single line well below the surface is far better than two shallow ones. For example, lowering the tile A 6inches, lowers the water surface to A′ C′, which represents better drainage than the line A B D with the two lines.

Some writers on good roads advocate the use of a line of tile under the middle of the traveled portion, and some advocate a line on each side of the wheelway. The object sought by these tile is rapid drainage, and therefore it is urged that they should be laid near the surface. It is doubtful whether any water will reach the tile, since the road surface when wet is puddled by the traffic, which prevents the water percolating through the soil; and it is certain that in clay or loam the drainage thus obtained is of no practical

value. More than one farmer has tried to drain his barnyard by laying tile near the surface, always without appreciable effect.

While a line of tile on one side of the road is usually sufficient, there is often a great difference as to the side on which it should be laid. If one side of the road is higher than the other, the tile should be on the high side to intercept the ground water that is flowing down the slope under the surface. Sometimes a piece of road is wet because of a spring in the vicinity; or perhaps the road is muddy because of a stratum which brings the water to the road from higher ground; in either case, tap the source of supply with a line of tile instead of trying to improve the road by piling up earth.

The tile should be laid in the bottom of the side ditch, below the frost line. Of course, the tile should have a uniform grade, and a sufficient fall, and an adequate outlet. The size of the tile required will depend upon the length of the line and the grade of the ditch, but local experience in farm drainage is likely to be a better guide than any general statement that can be made here. Farm drainage is almost certain to precede road drainage in any particular locality.

It is hoped that in this day and age of the world no Illinoisan will attempt to follow several writers on good roads in the use of such substitutes for tile as the following, which are illustrated in two official publications open before the writer: "subdrains made with field stones," "subdrains made of bundles of brush," "subdrains made of logs and faggots," "subdrains made of brick."

Side Ditches.--The side ditches are to receive the water from the surface of the traveled way, and should carry it rapidly and entirely away from the roadside. They are useful, also, to intercept and carry off the water that would otherwise flow from the side hills upon the road. Ordinarily they need not be deep, and if possible should have a broad, flaring side toward the traveled way, to prevent accident if a vehicle should be crowded to the extreme side of the roadway. The outside bank should be flat enough to prevent caving. The proper form of ditch is easily made by the usual road machine or road grader. The side ditch should have a free outlet into some stream, so as to carry the water entirely away from the road. No good road can be obtained with side ditches that hold the water until it evaporates. Much alleged road work is a positive damage for this reason. Piling up the earth in the middle of the road is perhaps in itself well enough, but leaving undrained holes at the side of the road probably more than counterbalances the benefits of the embankment. A road between long artificial ponds is always inferior and is often impassable. It is

cheaper and better to make a lower embankment, and to drain thoroughly the holes at the side of the roads. Often the public funds can be more wisely used in making ditches in adjoining private lands than in making ponds at the roadside in an attempt to improve the road by raising the surface.

When the road is in an excavation, great care should be taken that a side ditch is provided on each side to carry away the water so that it shall not run down the middle of the road—as is frequently the case. Every road should have side ditches, even one that runs straight down the side of a hill. The steepest road needs the side ditch most, but often has none. Frequently the water runs down the middle of the road on a side hill and wears it into gullies, which are a discomfort and perhaps dangerous, in both wet weather and dry. The water must not be suffered to run *in* the road, but must be made to run *off* the road.

As a rule the side ditches can not have too much fall, but sometimes a ditch straight down a hill will have so much fall as to wash rapidly, in which case it is an advantage to put in an obstruction of stone or brush. In extreme cases the bottom of the ditch is paved with stones.

Surface Drainage.—The surface drainage of the traveled portion of a road is fully as important as its underdrainage, and is provided for by making the surface crowning. This subject will be discussed briefly in the next paragraph, and more fully under Maintenance in Part II. Drainage of the surface is a matter chiefly affecting the maintenance of the roads.

The Crown.

The slope from the center to the side ditch should be enough to carry the water freely and quickly to the side ditch. A crown at the center of 12 inches in 25 or 30 feet is sufficient. The better the surface is cared for, i. e. the smoother the surface is kept, the less the crown required, as will appear in the discussion on maintenance. If there is not enough crown, the water can not easily reach the side ditches, and hence the road soon becomes water soaked.

The crown can be too great. More water will stand on a very convex road than on a flatter one. If the side slopes are so steep that traffic keeps continually in the middle of the road, it will be worn hollow and retain the water instead of shedding it promptly to the side ditches. Again, if the earth is piled too high in the middle, the side slopes will be washed into the side ditches, which not only damages the road but fills up the side ditches. Farther,

if the side slopes are steep, the top of the wheel will be farther from the center of the road than the bottom, and the mud picked up by the bottom of the wheel will be carried to the top of the wheel and then dropped farther from the center of the road than it was before. Thus each vehicle acts like a plow and moves the earth from the center toward the side of the road.

The crown should be greater on steep grade than on the more level portions, since on the grade the line of steepest descent is not perpendicular to the length of the road and consequently the water in getting from the center of the road to the side ditches travels obliquely down the road. Under these circumstances, it is customary to construct "breaks," or "thank-you-ma'ams," or "hummocks" to prevent washing. These "breaks" are V-shaped ridges meeting in the center of the road with the point up hill. The object is to turn the water into the side ditches instead of allowing it to continue down the center of the road. Usually the ridges forming the branches of the V are so narrow and so high as to form a serious obstruction to the traffic. They should have a considerable breadth so that wheels can easily ascend them and so horses will not stumble over them. However, at best they are a clumsy substitute for a proper adjustment between the grade of the road and the pitch from the center of the road to the side ditch.

There has been considerable discussion as to the exact form to be given to the surface of the roadway. Some claim that it should be the arc of a circle, and others that it should consist of two planes meeting at the center and having their junction rounded off with a short curve. Each form has its defects. The circular curve is defective in that it gives too little inclination near the middle and too much near the sides, the result being that the road wears hollow in the center and permits the water to stand there. The objection to the straight sides is that they wear hollow, which interferes with surface drainage. The latter form is probably the better, but great refinement in this matter is neither possible nor important.

The proper crown can be easily and cheaply obtained by the use of the road machine or grader, of which there is a variety of excellent forms on the market. After the roadbed has been rounded with the grader, it should be rolled with as heavy a roller as is available. Rolling compacts the earth and prevents it from being cut up by subsequent traffic, and also prevents the earth from washing into the side ditches. The road should not be rounded up late in the summer or in the fall, for then the earth

thrown up in the center will not unite with the foundation—even after being rolled, unless the fall is an unusually wet one. In no case should a ridge of loose earth, and much less sods, be left in the center of the roadway. The ridge should not be formed at all, but the earth should be uniformly distributed over the roadway. However, in giving the first crown to a roadway mostly sodded over, it is nearly impossible at the beginning of the work to prevent the sods from accumulating in a ridge along the center. Under these circumstances, they should be torn to pieces and leveled down by the use of a harrow.

A common defect of earth roads is the lack of any attempt at crown. Seldom a mile is seen of which all is properly crowned. Often a cheap wood-box culvert is only half or third as long as the traveled way is wide, and hence the traffic is concentrated upon a small part of the width of the road—and that, too, is a low place where the roadbed is wettest.

II. MAINTENANCE.

Maintenance is important with any road, as no style of construction is sufficiently permanent to admit of the road's being left to take care of itself. Whether built of earth or stone, it will eventually wear into ruts and holes, the time depending upon the quality of the material, the form of construction, and the amount of the traffic. When ruts or holes have been formed, the deterioration of the road will proceed rapidly unless repairs are promptly made.

The chief object in the maintenance of an earth road is to get rid of the water as quickly and as fully as possible. In maintenance, as in construction, water is the great enemy of good roads. The secret of success in maintenance is to keep the surface smooth and the side ditches open.

The building and caring for bridges and culverts are matters of importance, but they will not be considered in this article.

Care of the Surface.

If the surface of the roadway is properly formed and kept smooth, the water will be shed into the side ditches and do comparatively little harm; but if it remains upon the surface, it will be absorbed and convert the road into mud. If all ruts, depressions, and mud holes are not filled as soon as they appear, they will retain the water upon the surface, to be removed only by gradually soaking into the roadbed and by slowly evaporating; and each passing wheel or hoof will help to destroy the road. All inequali-

ties of the surface, the depressions and the mud holes, are caused by water softening the roadbed. A hard road can not be made out of soft mud, and no amount of labor and machinery will make an earth road that will stay good unless an adequate plan is adopted to get rid of the water. Water is hard to confine and easy to let loose. It is always seeking a chance to run down hill. The chief duty of the road tender is to give it a chance to get away.

There are several machines or devices which are very effective in filling the ruts and depressions, and in keeping the surface smooth. Different tools are best under different conditions. These tools and the method of using them will be considered briefly.

In the winter there frequently come times when the road is full of holes and ruts, while the surface soil is dry and mellow. This condition occurs most frequently when the ground below the surface is frozen. If at this time a harrow is run over the road, it will fill up the ruts and holes and leave the surface smooth. This improves the road for present travel, and gives a smooth surface which will greatly decrease the deterioration of the road by subsequent rains. Often there is only a few hours in the middle of the day when the frost is out of the ground sufficiently to permit this work to be done, and therefore it is best to have each farmer harrow the road adjoining his own land. The ordinary adjustable farm harrow should be used, and the teeth should be set to slope well back. The labor required is not great, since a 12-foot harrow can be used, and then a single round is sufficient. The work comes at a time of the year when the farmer's time is usually not very valuable, and hence the expense is small. The writer has seen frequent examples of this method of treating the roads, which have proved very beneficial both in securing good roads and preserving them.

In the early spring just after the frost goes out of the ground, earth roads are usually full of deep ruts. At this time the roads can be greatly improved by running over them that tool called indifferently "road machine," "road grader," "road plane," or "road leveler." The object is simply to cut off the ridges and fill up the ruts, and thus "break the way" for travel. It is well to break the road early in the season, both to accommodate the present travel and to hasten the coming of a better condition of the road. It is much more economical to make the road smooth with the machine than to wear it down by travel.

There are many road machines on the market, all of which are most excellent for certain kinds of work to be referred to later, but most of which are too heavy and too elaborate to fit the con-

ditions just described. The machines are mounted upon four wheels, and of themselves are a considerable load over roads which are only a succession of ridges, ruts, and mud holes; and are heavier and more cumbersome than is necessary for the work now under consideration. The writer has seen a heavy stick of timber shod with a steel plate and drawn by two horses, used for this purpose with great success. He has also seen a railroad rail so used. The rail is usually 14 or 16 feet long, and is drawn by four horses. When the ground is mellow and loose after freezing and thawing, the rail will smooth the road down nicely, and do it more rapidly than the road machine, since it cuts a wider swath. One round trip is sufficient for any road. The time when the work is most advantageously done is comparatively limited, and therefore one rail should not be expected to cover too much road. If the roads are treated with the light scraper or railroad rail, they will not get so rough and hence will not require so much work later with the heavy road machine.

Second-hand railroad rails can usually be bought in the great cities of dealers in railroad material. One weighing 50 to 60 pounds per yard (that is the way the size is designated) is heavy enough. A 7-inch steel I-beam weighing 15 pounds per foot is equally good, and can always be had in the great cities of dealers in structural metal. In either case the cost is so small that one could be owned for each few miles of road.

In the late spring after the ground has settled, the roads should be prepared for summer travel by being shaped up with the "road machine" or "road grader." When this work is to be done, the ground is comparatively dry, and consequently the heavier road scraper is required and can be handled on the roads. It is somewhat unfortunate that this tool is ordinarily called a road grader, since the name has possibly led to a misconception as to an important use of the machine. As an instrument of road construction, this machine is used to give a crown to the road; but as an instrument of maintenance, it should be used only to smooth the surface and restore the original crown. Apparently some operators assume that the machine is not to be used except to increase the crown of the road. Employed in this way the crown is made too great, and a big ridge of loose earth is left in the middle of the road which only slowly consolidates and which is likely to be washed into the side ditches to make trouble there. Since the introduction of the road machine there has developed a strong tendency to increase the crown of the road unduly. Doubtless the object is to secure better drainage of the roadbed, but piling up the earth is an inadequate

substitute for tile drainage. Side slopes steeper than just enough to turn the water into the side ditches are a detriment. Other things being equal, the best road to travel on or to haul a load over is a perfectly flat one.

In smoothing the road, the road machine should be run over the ground lightly so as to smooth down the ridges and fill up the ruts. Only enough earth should be moved toward the center of the roadway to replace that washed down by the rains. The blade should stand nearly square across the road, and considerable earth should be shoved along in front of the blade so as to have enough loose earth to fill any depressions. The surplus earth should be evenly distributed along on the surface. This work should be done early—before the ground becomes hard and difficult to work, and before traffic has been compelled partially to do the work of the road leveler, and while the surface is in condition to unite with the loose earth left by the machine. Unfortunately this work is often postponed until the ground is so hard that it is impossible to do a thoroughly good job. If the ground is a little too wet for agricultural tillage it is all the better for roadmaking, since it will pack better than though it were drier. During the summer, if the road becomes very badly rutted, the road machine should be run lightly over it.

In the summer when the roads get roughed up, they can be materially improved at small expense by running over them with a harrow having the teeth down quite flat. If the roads are a little muddy, this treatment will make them dry faster and also make them much more pleasant to use after they have dried.

Finally, during the fall the roads should be repaired with special reference to getting them into good shape for the winter. Any saucer-like depressions or ruts should be filled with earth like that of the roadbed. The material should be solidly tamped into place. Holes and ruts should never be filled with stone, bricks, or coarse gravel. The hard material will not wear uniform with the rest of the road, but produce bumps and ridges, and usually result in making two holes, each larger than the original one. It is a bad practice to cut a gutter from a hole to drain it to the side of the road. Filling it is the proper course, whether the hole is dry or contains mud. The holes most requiring attention are found at the end of bridges and along the sides of small wooden box culverts.

Care of Side Ditches.

The side ditches should be examined in the fall to see that

they are free from dead weeds and grass; and late in the winter they should be examined again to see that they are not clogged with corn stalks, brush, etc., washed in from the fields. The mouth of culverts should also be cleared of rubbish, and the outlet of tile drains should be opened. Attention to side ditches will prevent overflow and washing of the road-bed, and will also prevent the formation of ponds at the roadside and the consequent saturation of the roadbed. The road care-taker should frequently go over his portion of the road, particularly during the rainy season and especially just as a heavy fall of snow is going off, for it is then that the most damage is done. Fortunately, this work will not interfere with farm work.

Care of Trees and Hedges.

Roads should have plenty of light and air. Of course a shady road is very nice on a hot day; but such a road can not be kept in good condition, since shade is nearly sure to breed mud holes. Therefore the road officials should use all possible diplomacy to have trees adjoining the road, particularly those on the south side, trimmed with reference to the benefits of the roads.

A tall hedge cuts off the view of the adjacent country, shuts out the breeze, and in a dry time keeps in the dust and in a wet time retards the drying of the road. Therefore the road officials should enforce the law concerning cutting of hedges.

Care of the Roadside.

It is hoped that the day is not far distant when in each community the roadside will be cared for so as to secure a coating of grass instead of unsightly and noxious weeds. This can be accomplished with an occasional mowing at but slight expense.

Sand Roads.

Roads on pure or nearly pure sand require very different treatment than roads on clay and loam. Dampness improves the sand road, while it damages a clay or loam road. The preceding rules for the drainage of loam or clay roads must be reversed for sand roads. Wet sand makes a better road than dry sand, and therefore draining a sand road is useless and possibly a damage. Of course, this is not true of quicksand, but there is very little, if any, of that in the roads. Roads on quicksand are improved by drainage.

Sand roads are usually nearly level and need little, if any, grading. They should not be crowned, since they do not need surface drainage. The traveled portion should be simply leveled off.

The great disadvantage of pure sand as a road material is the freedom with which the grains move one on the other. Therefore to improve a sand road encourage grass to occupy all the space possible. The roots will decrease the movement of the grains under the tread of the hoofs and wheels. It will sometimes pay to give sandy roads a heavy coat of manure to strengthen the grass. It is an advantage if low growing bushy vegetation occupies the surface clear up to the traveled way—both for the shade and for the binding effect of the roots.

Shade harms a loam or clay road, but improves a road of sand or broken stone, since it prevents the evaporation of the moisture from the roadbed. Therefore a sand road can be permanently improved by planting trees so as to shade the traveled way. They will prevent, in part, the drying effect of the winds, as well as interscept the rays of the sun.

A road on pure sand is improved temporarily by covering it with a thin layer of any vegetable fiber, as decaying leaves, straw, marsh hay, waste from sorghum mills (begasse), fibrous or string-like shavings, etc. This fibrous material soon becomes incorporated with the sand and decreases its mobility. The vegetable matter decays and wears out, and consequently the effect is comparatively temporary. The length of time such expedients will last depends upon the climate and the amount of travel. Sand roads improved with three to four inches of shredded wood (excelsior) have kept in reasonable condition for a year or two.

The only thorough and permanent improvement possible for a sand road is to add a layer of tough clay and incorporate it with the sand. This is expensive at best, and it is difficult to get the sand and clay thoroughly incorporated in the right proportions.

"Will it Pay?"

Perhaps some will say that to carry out the preceding recommendations will cost too much. All improvements and advances in civilization cost. Will the suggested improvements in construction and maintenance pay? They will make better roads, which will decrease somewhat the cost of travel; but the saving in cost of transportation and miscellaneous travel will probably not be equal to the increased cost of securing the better roads. To live in a good house costs more than to live in a poor one. Good roads are desirable for the same reason that a man buys a carriage or builds a fine house, i. e., because they are a comfort and a pleasure. Whether good roads "will pay" or not, depends

upon the relative estimate put upon money and labor on the one side and comfort and convenience of travel on the other. The man who prefers to ride in a lumber wagon because it is cheaper than a carriage, will prefer to ride in the mud instead of spending money or labor in improving the roads. It is certain that comfort and ease of travel add to the knowledge and intelligence of the citizen, and thus indirectly, but none the less certainly, add to his ability to get on in the world. A reasonable expenditure for good roads is always a good investment—financially, socially, and educationally—for any community. The construction of stone roads may or may not be a reasonable expenditure—that depends upon the local conditions,—but it is believed that there are many communities in Illinois in which an observance of any or all of the preceding suggestions would materially improve the road at a comparatively small expenditure of money or labor.

III. ADMINISTRATION.

The difficulties encountered in maintaining a well-constructed system of highways in any locally governed community have always been very great. In America the management of roads has rested upon local authorities—either counties or towns. Within the past ten years, a comparatively few miles of road in a few states have been placed under the control of state authorities; but in most of these states this control relates to the original construction, or rather reconstruction, of these roads, and not to the maintenance. Therefore at present the maintenance of the public highways in America depends wholly upon the local authorities.

It is very common for road reformers to denounce the present system of road administration. It is easy to criticise existing evils, to point out unerringly the radical defects of the present system, to condemn unsparingly the incongruities of the diversified provisions of the statute books relative to roads, and to join the general chorus of reform. Unquestionably the present system is not ideally perfect, but a practical solution of the problem—one that will meet all the conditions of the case—will be found difficult of attainment. It is probably impossible to make any radical change in the present system, and it would probably be unwise to make such changes if they could be secured. It is better and more practicable to grow gradually into a better system, by first making those changes most needed or those most easily obtained.

It would be unwise to attempt an elaborate discussion of road administration in this paper, and therefore the writer will present

only a few somewhat disconnected observations upon the general subject.

Labor *vs.* Cash Tax.

It is usually assumed that the labor-tax system is all wrong, and that the evils thereof would be escaped by paying road taxes in cash. Assuming that Champaign County is representative of the entire state, the following conclusions may be drawn from statistics collected by the writer from the township officials for the year 1900. Apparently no similar statistics have ever before been collected; and hence it can not be known how nearly Champaign County is representative; but it is believed that in most respects it represents an average for the state.

1. The poll-labor tax is not very great, being only $2.49 per mile of road. A defense of this tax is that it is practically the only tax paid by farm laborers, or "hired men." Besides many of these men, for obvious reasons, pay this tax in cash. A district road tax is levied in half of the townships. This tax may be paid in labor or cash, but is usually paid in labor, only a few non-resident land owners paying in cash. Where levied, it amounts to an average of $8.44 per mile of road, the range being from $3.51 to $13.39. Therefore in half the townships the total labor tax (the poll tax) is $2.49 per mile of road, and in the other half the total labor tax is $2.49+8.44=$10.93 per mile of road. The average cash road-tax is $23.93, varying from $11.70 to $34.70, the wide range being due to the difference in the number of new bridges built. Therefore in the townships having both the poll and the property labor-tax, the labor tax amounts to only about one-third of the total road taxes. Hence, even if the statute labor is inefficient, the inefficiency affects only one third of the road taxes.

2. Is it certain that the "farmer" is any less efficient when working out his labor tax, than the "town man" when laboring on the city streets under the cash system? Perhaps simply changing to the cash system would not improve matters.

3. If the labor-tax is inefficient, it is wholly, or at least chiefly, because of inefficient officials. City streets are maintained on the cash system. Are they cared for better or more economically than rural highways?

4. Road taxes are assessed by farmers and paid by farmers. Probably any farmer would more willingly assess himself a road tax of $2 payable in labor than $1 payable in cash. If so, then

the difference between the labor-tax and the cash-tax systems is not as great as is frequently claimed.

5. England and France are justly noted for their excellent roads, and both have the labor-tax system. Therefore it is possible to have good roads under the labor-tax system.

All of the above is intended to suggest that the much abused labor-tax system is not necessarily the cause of inferior roads, nor the cash-tax system in itself the cause of improved roads. The one thing absolutely necessary for successful road management is effective supervision of the road work. Without it neither system will accomplish much, and with it either system will do reasonably well.

Many townships in this and other states have changed from the labor-tax system to the cash-tax system, with a marked improvement in the condition of the roads,—due chiefly, if not wholly, to better administration. For in many of these cases the so-called cash-tax system is practically only a change in the method of administering the labor-tax system. Farmers desiring to do so are given an opportunity to work out their road taxes under the cash system. Under the labor-tax system those working upon the roads receive credit on their road taxes, while in the so-called cash system the laborer receives an order which is accepted as cash in paying taxes. In these cases the public sentiment that demanded road improvement secured the change from the labor-tax to the cash-tax, and, consciously or unconsciously, also secured a more efficient road administration.

There are several matters connected with the relative merits of the labor-tax and the cash-tax systems that are worthy of consideration, but it is not wise to take space to discuss them here. Among these questions are: The effect of the desire of the official to please the voter? The relative skill of the labor obtained under the two systems? The ability to get the work done at the best time? The relative advantages of continual maintenance and annual repairs?

Contract System.

It is frequently claimed that our roads would be much better if a man were employed to give his entire time to their care. This plan has some promising advantages, and is probably a necessity with broken stone roads whose maintenance requires intimate knowledge and constant attendance. Is it practicable for earth roads?

In Champaign County the expenditures in 1900 per mile of road were as follows:

1.	New "iron" bridges, exclusive of county aid—which is nearly as much more*	$16.20
2.	Drainage	6.32
3.	Tile culverts	1.32
4.	Repairs of bridges and culverts	2.93
5.	Grading (not simply smoothing and leveling)	1.43
6.	Smoothing and leveling (not grading)	2.83
7.	Mowing the roadsides	1.14
8.	Administration	2.69
	Total	$34.86

Item 1 in the above table is certainly expended by contract with specialists; and all, or nearly all, of item 2 is likewise so expended. A large part of items 3 and 4 is spent for material. Therefore, practically, only items 5, 6, and 7 remain for the subject of a contract with a special road attendant. The sum of these items is $5.40 per mile of road. Even though something be added for the labor involved in items 2, 3, and 4, the total will be so small that the road attendant under the contract system must have under his care so many miles of road that he must change his place of abode from day to day or waste a great deal of time in traveling to and from his work. Farther, he must have so many miles of road under his care that he can visit any particular piece only at long intervals; and therefore can not do the work at the most favorable time, and can not become intimately acquainted with the road. These objections have less force in the townships spending more than the average for these items. The range of the expenditures for grading, smoothing, and mowing in Champaign County is from $1.12 to $15.33. The above objections also have less force if the major part of the money is concentrated upon a comparatively small proportion of the roads of a township. All of the above is intended to show that the contract system is not universally applicable, although there may be circumstances under which it is the best method of maintaining earth roads.

The farmer who travels a particular road frequently, and in all kinds of weather, can have a more intimate knowledge of it

*In this item Champaign County is probably not representative of the state. From one point of view, it would be expected that Champaign County would spend less for bridges than other parts of the state, since it is flat, and has but a few small streams. On the other hand, there are several large dredged ditches, and the bridges over them are first class steel structures on high grade stone abutments. Therefore it is probable that this item is considerably larger than the average of the remainder of the state.

than the man who sees it only occasionally; and therefore for this reason the farmer is best able to care for the road. The plan of having the farmer work the roads is frequently compared to a railroad's occasionally sending out its clerks to care for the track. There is almost no similarity in the two cases. (1) Much of the farmer's daily work is very similar to road work; (2) the amount of labor required per mile of road is very different in the two cases; and (3) the farmer's acquaintance with the road is continuous and intimate. Besides the farmer uses the road more than anybody else, and he alone pays for it.

"The Road Taxes are Wasted."

Not infrequently it is claimed that since the road taxes produce no permanently hard roads, the money is wasted. This claim is almost wholly false. In the first place, a considerable part of all road taxes is spent for grading, drainage, tile and stone culverts, and new steel bridges,—all of which are permanent improvements which would be absolutely required by hard roads. The roads of every community are continually growing better. There has been a marvelous improvement in twenty years.

Farther, a considerable expenditure of time and money is required to prevent the roads from steadily growing worse. A man is justly commended for not suffering his house to decay for the lack of care, but the road official is severely condemned because he spends money in caring for the house already built and does not add a $10,000 Mansard roof to the cottage still in process of construction. A new coat of paint and a new roof protect the house against the attacks of wind and weather, but the road official is accused of wasting money if he protects the road against the ravages of water and traffic.

What can be Done?

1. It is believed that material improvement can be attained by paying more attention to the office of Highway Commissioner and Pathmaster. Elect only the very best men without regard to party, men who have judgment in business affairs, who have ideas on road making and maintenance, who have skill in directing the labor of others, and who will give to their official duties their best endeavor. If they do reasonably well and are continually seeking to increase their road knowledge and to improve the roads under their care, continue them in office. If not, try again to find some one who will do these things. Dignify the office by every means possible.

2. In private conversation and in public meeting, discuss ways and means of improving the earth roads. Organize for the purpose of creating interest in common earth roads. As soon as possible adopt rules for the guidance of the road officials, and then let each tax payer note whether these rules are obeyed. Do not fail to give due credit if they are; and if they are not, do not shrink from entering a respectful protest. Unless the earth roads are maintained in reasonably good condition, it is folly even to talk of constructing high priced broken stone roads.

3. Divide the roads up and allot definite sections to farmers, and publish these allotments. As far as possible require each man to care for the road nearest home and which he travels most. By private conversation and public meeting seek to stimulate pride in road making and maintenance, and try to secure the effect of competition in road work. Possibly have annual inspections and award prizes and diplomas. Railroads find annual inspections and nominal cash prizes and diplomas exceedingly effective. France has a system of gratuities for excellence in road work.

4. Permanently hard roads are very desirable if their cost is not too great, but remember that high class stone or gravel roads are not feasible unless the roadbed is thoroughly underdrained, and unless the subgrade is adequately crowned, and unless the public understands the superiority of perpetual maintenance over annual repairs, and unless the road officials are intelligent, energetic, and conscientious. Fortunately these things are the very best investments for earth roads, and good earth roads are the very best preparation for good gravel or broken stone roads.

5. Do not overlook the fact that the interest in good roads should have a broader foundation than mere commercial needs. Comfortable and easy communication between the members of a rural community and also between the rural and urban inhabitants is of great importance in the social and educational development of a community.

Finally, in the words of Professor Shaler, for a number of years the able President of the Massachusetts Highway Commission, in speaking of the roads of that state: "Those who h ave the betterment of our highways at heart should do all in their power to guide, direct, and even restrain the present movement, so that enthusiasm may be guided by business sense, to the end that we may attain a system of ways properly related to the needs of the state."