WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY

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RURAL HIGHWAYS

OF

WISCONSIN

BY

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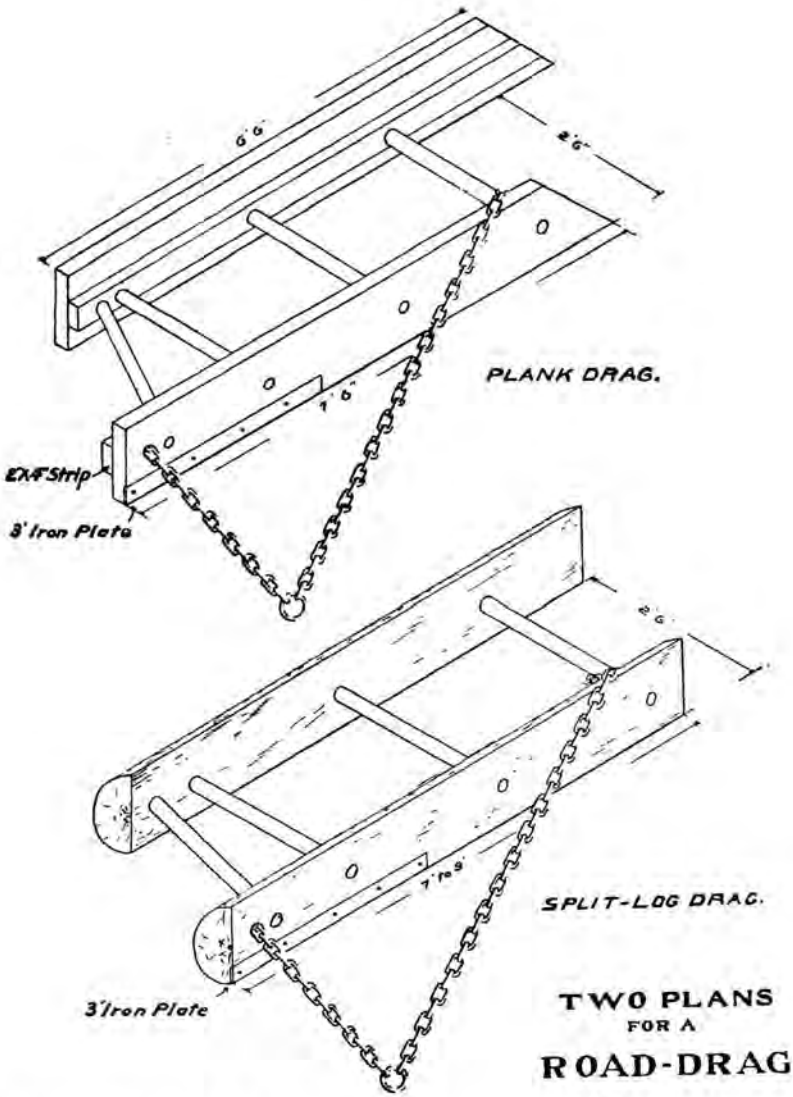

TWO PLANS FOR A ROAD-DRAG

Directions for using the split log drag:

After each rain drive along each wheel track at least once, with the drag in position to throw the dirt to the center of the road. Put a cleated platform over the connecting bars and ride on the drag, shifting your weight as needed to leave the dirt in the low places. Haul at an angle of 45 degrees. Gradually widen the strip dragged as the road improves. Read the text on this in the chapter on maintenance.

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PREFACE.

The improvement of the rural highways of this state is a problem whose proper solution is of the highest importance to the people. It is becoming quite generally recognized that road building and maintenance are as much special vocations requiring special training as are any other engineering occupations. This volume makes no pretense of being anything but the most preliminary statement of problems that exist and no attempt is made to give detailed directions for building roads in any particular localities Such directions must be to a large extent valueless because of the infinite variety of local conditions with reference to which the materials must be treated. Rather the purpose has been to give a few of the most fundamental principles and leave the working out of the local details to later opportunity or to local road officials.

The first part is a summary of the principles of making roads. In this free use has been made of the publications of the highway departments of the various states, and credit is given in each case. Those which have been especially helpful are the reports of the highway commissioners of Maine, New Jersey, Ohio, and Iowa.

The second part is a summary of highway conditions in this state, and a digest of the laws of those states having the most progressive road legislation. Credit is given in the text or foot notes wherever it is possible to do so. The thesis of Professor F. G. Young and Bulletin No. 4 of the Ohio Highway Commission deserve special mention as sources of information re-

garding the laws of the various states. In the most important cases, however, the laws themselves were referred to.

Since the magnitude of the subject of roads must necessarily limit a discussion which attempts to cover a wide range and compel it to be incomplete and elementary in its character, it is felt that no apologies are necessary for such defects in this volume. The logical following up of this subject by any state department demands special recognition of the work and special funds appropriated for the purpose. The present volume is to be regarded as simply an initial expression of the importance of the subject and of the considerable interest in country roads which has recently been awakened.

The Geological and Natural History Survey is perhaps the best situated at present of any department of the state government to take up this matter, as it is directly concerned with all road materials and has already published a bulletin (Bulletin X. E. R. Buckley, 1903) entitled "Highway Construction in Wisconsin," which deals chiefly with pavements. The people of the State need for the bettering of the rural highways information regarding methods of road construction and education in their use, which can best be provided through the organization furnished by the Survey

In the preparation of this report the assistance and valuable suggestions of the Director of the Survey, Dr. E A. Birge, and of President Van Hise, have been of the greatest assistance.

"It was by the highways that both travelers and goods generally passed from place to place. And these highways appear to have been far worse than might have been expected from the degree of wealth and civilization which the nation had even then obtained.....

"One chief cause of the badness of the roads seems to have been the defective state of the law. Every parish was bound to repair the highway which passed through it. The peasantry were forced to give their gratuitous labor six days in the year. If this was not sufficient hired labor was employed, and the expense met by a parochial rate. That a route connecting two great towns, which have a large and thriving trade with each other, should be maintained at the cost of the rural population scattered between them is obviously unjust; and this injustice was particularly glaring in the case of the great North road which traversed very poor and thinly inhabited districts, and joined very rich and populous districts.... This grievance attracted the attention of Parliament, and an act, the first of many turnpike acts, was passed.... This innovation, however, excited many murmurs. A change was at length effected, but not without much difficulty. For unjust and absurd taxation to which men are accustomed is often borne more willingly than the most reasonable impost which is new." ....

Macaulay's History of England.—Roads in 1685.

RURAL HIGHWAYS OF WISCONSIN.

INTRODUCTION.

The fundamental purpose of a highway is to provide a ready means of intercourse between various points along its length, both to permit the people to enjoy social and educational privileges, and to permit the marketing of produce. Conditions are gradually becoming such in our state that the use of roads for the purpose of hauling heavy loads of produce to market is much less than their use for hauling light loads and making quick trips for pleasure or business.

The permanent improvement of a road must be regarded as an investment of public funds. On the one side of the account we find that there is interest to pay on the cost of such a road. There is also the increased cost of maintenance which a permanent road requires. To balance this must be set off the actual saving in heavy hauling, the interest on the increased value of land along the road, and the value to the farmer of the increased accessibility of church, school and other social and educational advantages. In the form of a ledger account it is as follows:

PERMANENT ROADS.

Debtor to	*Creditor by*
Interest on Investment	Saving in heavy Hauling.
Increased cost of Maintenance	Increase in land Values.
	More easy access to market, church, school and social advantages.

It is evident at once from an inspection of this balance that as a commercial proposition only the more heavily travelled of the roads in the state of Wisconsin will at the present time justify permanent improvement by the construction of macadam.

The factors on the credit side of this account are very difficult to estimate, for instance, the actual saving in heavy hauling. If the average man is asked how much saving in heavy hauling a good road will permit him to make, he will figure the number of days time for team and man which could be saved and multiply it by the rate of wages per day. If he is asked if he would be really willing to pay this, he hesitates because he realizes at once that his heavy hauling on the roads is a minor part of his time and is frequently done when teams would otherwise be idle and himself and men without particular employment. The factor of the increased value of land should probably in part be included under the value of the increased accessibility of church, school, and such interests, as the increased value is partly due to the greater desirability of the location on account of such accessibility.

From the foregoing statements the value of a permanently improved road is seen to depend very largely upon the means of ready intercourse which it furnishes at all seasons of the year for light traveling, and the consequent enjoyment of the advantages of church, schools, etc. Many portions of the state are thickly enough settled to make permanent improvement of the roads an economic necessity, particularly along the more traveled routes, but the majority must continue to be dirt roads for a long time. As a consequence, the present problem before the people of the rural communities is not so much the construction of permanent roads as the construction of earth roads in the best possible and cheapest manner. At the present time there is enough money being spent by the rural districts to have the best earth roads it is possible to construct, *if the money were only wisely expended,* and still have a good

part of their highway funds to put into building permanent roads.

In the past the 'good roads movement' won for itself considerable opposition because it went ahead of conditions and advocated the construction of permanent highways without considering whether the local situation warranted such expenditures or not. Owing to this fact it becomes advisable to state that it is not the purpose of this little volume to urge the building of permanent roads by all rural communities in the state. It is urged that they be built where conditions warrant, *but also urged that they be not built where conditions do not warrant.* The main idea which it is hoped will be gained from its pages is that incomparably better roads than we have can be built for money at present being spent, and that it is the duty of the state to do all in its power to aid rural districts in constructing these better roads that they are already paying for. It is not proposed to advocate any scheme for unnecessary expensive road building, or anything that will cause an unwarranted increase in the taxes which are already regarded as too high in many towns.

PART I

ROAD BUILDING AND MAINTENANCE.

CHAPTER I.

WHAT CONSTITUTES A GOOD ROAD.

In this chapter are presented in a general way the essentials of a good road. These essentials are taken up later on in a specific manner, showing how they may be obtained.

The definition of a good road is in no essential part different from the definition of any other good structure which a man may build. If a man desires to build a home he considers first the matter of a good location, next he considers its proper construction upon approved plans, and third, he takes up the matter of maintaining it in good condition so long as he chooses to live there. The same elements may be taken as the foundation for the definition of a good road. A good road is first, properly located; second, well constructed; and third, maintained in good condition.

Proper Location for a road consists in putting it in such a position that people using it can reach their destinations with the least time and effort. The general direction of the road should therefore be as straight as possible consistent with proper grades. To secure a good grade will often necessitate bending very much from a straight line between the points it is desired to connect, but the road should be finally located so that when it is completed the length and grade will be balanced so well that a minimum of effort will be required to go from one end to the other. The two chief factors of a good location are therefore *proper grades* and *proper direction.*

Proper Construction of a road can be secured only by considering the fundamental principles which govern it. The first necessity in proper construction is a good *foundation.* This may consist, and practically always does consist, of firm, well drained earth. Above this foundation the road must have sufficient *crown,* or rounding up in the middle, to readily carry the water off the surface into the side ditches. The *surface* should be composed of as impervious material as can be obtained, in order that when given sufficient crown it may carry the water off to the sides instead of allowing it to seep down into the foundation. In short, the function of the surface of the road is primarily that of a roof. Besides the *foundation, crown,* and *surface* of the road there must be also proper *drainage.* In most places roads are sufficiently drained by proper ditches along the side, but where these are not sufficient to keep the water out of the road they must be supplemented by drains laid under the road. These four factors of proper construction are considered in detail in chapter III.

Maintenance is a term which, in its application to dirt roads, is understood by comparatively few of those who have charge of such highways. This is the common term which, on a railway, is used to include all work that is necessary to keep the road-bed in first class shape, and is always looked after in railroad organization by a department separate from the one which does the construction. In relation to country roads maintenance may be defined as continuous care which does not permit the formation of ruts and pitch holes, or other damage to the condition of the road. The one thing which Wisconsin roads need most at present is some attempt at *maintaining* them.

The maintenance of a road is, as is naturally to be expected, much cheaper than its construction in the first instance. At present most dirt roads are reconstructed every few years and no attempt made to do anything with them between these times of reconstruction. The difference in cost is quite fairly represented by what is at present being paid for earth roads in

this state and the cost of maintaining them, as shown by experience in other states. In Wisconsin the people are spending on country roads an average of more than thirty dollars per mile every year. Where proper methods of maintenance are used, as in parts of some other states, dirt roads are readily kept in excellent condition for from three to ten dollars per mile per year, depending upon the nature of the road. This difference between three-to-ten dollars and thirty dollars is approximately representative of the cost of roads according to the two systems:—construction with no maintenance averaging thirty dollars a year for every mile of road, as in this state, and where maintenance is practiced after the roads are once constructed, the cost being from three to ten dollars per year.

CHAPTER II.

LOCATION OF ROADS.

There are several things which must be considered in the location of a road. The first of these is the length of the road necessary to accomplish a given air line distance. In a flat prairie country the best location is a straight line between the two points it is desired to connect. When it is desired to locate a road in hilly country the problem becomes one in which many factors are concerned, chief of which are the increased cost of construction, steeper grades, and the difficulty of maintaining roads where these steep grades exist.

The problem of the primary location of roads is not an important one in this state, as roads are to a large extent already located. Only in the unsettled northern portions of the state are new roads being laid out to any extent. For this reason the subject of location becomes rather one of relocation. When permanent improvement of a road is contemplated the profitableness of relocation must be considered. Roads at present are to a large extent located on land division lines, chiefly section lines. In case a main traveled road goes about two sides of a level square section of land it may be econominal to relocate the road so that it passes in a diagonal direction through the section. A four-rod road on two sides of a section of land occupies sixteen acres, while a road four rods wide in a diagonal direction through the section occupies approximately eleven acres of land. The diagonal road, therefore, will result in a saving of about five acres. The length of the diagonal road is only

about one and four tenths miles as compared with the length of two miles of the road on the two sides of the section. To the saving in land and the saving in distance thus effected must be added the saving of the cost of constructing six-tenths of a mile, which is made by relocating the road on the diagonal. If the road were to cost two thousand dollars a mile this saving would be twelve hundred dollars. The saving in land would vary from five to one hundred and fifty dollars an acre. The final factor, which should usually be the determining one, would be the value to the community of the convenience of having a shorter distance to travel, and must depend upon the amount of traffic which goes over the road.

Relocation in rolling or hilly country. In any but flat country the problem in locating a road becomes more complicated than the preceding case. In a hilly country the length of the road must be adjusted to four principal considerations; length, cost of construction, location of suitable bridge sites, and the securing of proper grades.

In planning a road the amount of earth work required in cutting down the hills and filling the depressions should be made to cost a sum proportional to the cost of constructing the greater length which would be required to go around hills and depressions in order to avoid the necessity of cuts. In many towns in the state expensive cuts and fills have been made to secure suitable grades along section lines where a new right of way not many rods distant could be bought and a good round sum paid for it, and then a practically level road constructed at a total cost less than the sum paid for the present cuts and fills.

In case it is necessary to cross streams suitable bridge sites will often determine the proper location of the road, as the location of a bridge a few hundred feet up or down stream from any point in a valley may effect a saving of a considerable percentage in the cost of a bridge. If the cost of the bridge cannot be cut down by such a change it might often occur that a

site far more suitable could be obtained in which the security of the bridge from wash-outs would be much greater. If possible the stream course should be straight above the bridge. A bridge should not be located on a bend in a stream if it is possible to avoid doing so.

Grades. The grade of a road is commonly expressed in the number of feet of rise in one hundred feet of horizontal distance. A road with one foot of rise in one hundred feet of length is said to have a grade of one per cent; a road of two feet of rise a grade of two per cent; a road of ten feet of rise in one hundred a grade of ten per cent, and so on.

"The horizontal pull which a horse can exert depends upon its weight, its form or build, the method of hitching, the foothold afforded by the surface, the speed, the length or duration of the effort, the rest time between efforts, and the tax upon the future efficiency of the horse. The chief of these are the weight, the speed, and the length of the effort. With reasonably good footing a horse can exert a pull equal to one-tenth of his weight at a speed of 2½ miles an hour (3⅔ feet per second) for ten hours per day for six days per week and keep in condition. This is a common rate of exertion by farm horses in pulling plows, mowers, and other agricultural implements. Most horses can exert a tractive power equal to half their weight, at a slow walk for about one hundred feet. On the road in emergencies, as in starting the load or in overcoming obstacles, a horse may be expected to exert a pull equal to half his weight, but at this rate he would develope a day's energy in about two hours; and consequently if he is expected to work all day, he should not be called upon to exert his maximum power except for a short time. Similarly, a horse can exert a draft equal to one quarter of his weight for a longer time. The working tractive power of a horse may be taken as one tenth of its weight, with an ordinary maximum of one quarter, and in great emergencies a maximum of one half its weight."*

*Roads and Pavements, Baker, 1903, pp. 31–32.

The Missouri Agricultural Experiment Station has made a number of very practical experiments on the amount of pull exerted in drawing a load of constant weight over various kinds and conditions of roads and fields. The following table is a portion of that given in their Bulletin No. 52. In the experiments they used the same load upon two different sets of wheels:—standard size with 44 inch front wheels and 55 inch rear wheels, and the low size with 24 inch front wheels and 28 inch rear wheels. The wheels were of steel construction with six-inch tires, and the difference in weight was such that the total weight of wagon and load with the high wheels was 3762 pounds and with the low wheels 3362 pounds.

TABLE I.

KIND OF ROAD.	CONDITION OF ROAD.	NUMBER OF POUNDS PULL.	
		High wheels.	Low wheels.
Gravel road	Level, dry, with one inch of sand and some loose gravel.	158.9	185.3
Macadam street	Clean and in fair condition	108.0	117.4
Cinder track	Dry and not firm	113.1	120.0
Dirt road	Frozen solid, ¼ inch sticky mud on top.	189.2	233.8
	Dry and hard, in good condition.	130.0	132.0
Timothy & bluegrass sod.	Dry and firm, level	248.1	300.6
	Wet and spongy	325.2	472.6
Corn stubble	Dry, with small ridges	335.7	445.6
Plowed ground	Freshly plowed and dry	475.0	628.0

This table gives the pull necessary to draw the wagon and a net load of two thousand pounds over the surfaces named. If the pull be taken as one-tenth the weight of the team, according to the above quotation from Baker, to pull the loads used in these experiments on gravel roads would require a team weighing 1589 pounds with the standard wheels and 1853 pounds with low wheels. On macadam the team would only need to weight 1080 pounds. On the plowed ground, however,

with standard wheels it would take a team weighing 4750 pounds to pull this load with the ordinary effort which should be required of a horse. Even supposing the team were to exert for a short distance a pull equal to one quarter of its weight, it would need to weigh 1900 pounds.

The results in the above table were obtained from experiments conducted on level ground. If it were desired to pull these loads up grade the pull would, of course, be much greater. According to Baker, if a horse can pull 1000 pounds on a muddy level road, it can pull

2000 pounds in spongy earth roads,
3000 pounds on best earth roads,
6000 pounds on macadam roads,
10,000 pounds on asphalt,
20,000 pounds on iron rails.

Table II, which is arranged from Baker, gives the percentage of the load for level ground which a horse can pull up grades of different degrees of steepness.

TABLE II.

Load which a horse can draw on a grade in terms of percentage of the load on the level, when exerting a uniform force equal to one-tenth of its weight.

Rate of grade, per cent.	Iron rails.	Sheet asphalt.	Broken stone.	Earth Road.		
				Best.	Spongy.	Muddy.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
0	100	100	100	100	100	100
1	30	45	56	62	75	91
2	16	27	36	50	57	67
3	10	18	25	37	44	54
4	7	12	17	27	33	43
5	4	8	12	20	25	33
6	3	6	8	14	18	25
7	2	4	6	10	12	18
8	1	2	4	6	8	11
9	1	1	2	3	4	5
10	.....	.....	.....	.....	.....	.....

A very important fact appears in this table. That is, the smoother and harder a road is the more gentle the grades must

be. For instance, on a muddy earth road of one percent grade a horse can draw 91% of what he could draw on a level road of the same kind. On the best earth road he could draw 62% and on macadam only 56%. This is due to the fact that the greatest part of the effort in drawing a load over a muddy road is consumed in squeezing the mud out from under the wheels in order to secure a solid bottom for the wheel to roll upon. The resistance which a load offers to being drawn is divided into (1) *rolling resistance,* which is that just mentioned, and is due to the sinking of the wheel in the surface of the road, causing the load to be continually drawn up an incline, as it were; (2) *axle friction;* (3) *resistance of the air.* It is evident from this that axle friction and resistance of the air are but a very small part of the resistance to overcome on a muddy road, and the rolling resistance is nearly all of it. Consequently the added draft in pulling a load up a slight incline on a muddy road is not so great in proportion to the draft on a level stretch as it is on a hard surfaced road. On a macadam surface the rolling resistance is decreased very decidedly and the other factors make up a proportionately larger amount.

A road is only as good as its poorest part. If a team is able to haul three tons on the level part of the road and only one ton up a certain grade at the end, their load is limited to one ton. Consequently, as far as heavy hauling is concerned, the expense necessary to put the level part in shape so that more than three tons could be hauled is of no use until the hill is put in shape so that the three tons can be hauled over that also. It is poor economy, therefore, to build a level portion of a road in good shape without making the grade such that the load hauled on the level can be pulled up the hills with the extra effort which a team is capable of exerting for a short space of time.

It appears from the foregoing that the maximum grade that should be permitted in the location of a road must depend upon the nature of the surface the road is to have. The maximum

grades established in different countries and states are of interest in this connection:—

"In France the standard is; on national roads, not exceeding 3 per cent; department roads, not exceeding 4 per cent; and subordinate roads, not exceeding 6 per cent. On the great Alpine road over the Simplon Pass, built under the direction of Napoleon Bonaparte, the grades average 1 in 22 (4½%) on the Italian side, and 1 in 17 (5.9%) on the Swiss side, and in only one case become as steep as 1 in 13 (7.7%).

"In great Britain, the celebrated Holyhead Road, built by Telford through the very mountainous district of North Wales, has an ordinary maximum of 1 in 30 (3-1-3%), with one piece of 1 in 22 (4½%) and a very short piece of 1 in 17 (5.9%), on both of which pieces special care was taken to make the surface harder and smoother than on the remainder of the road."[1]

New York maximum grade is 5 or 6%.

New Jersey maximum grade is 6%.

Michigan maximum grade is 6%.

On steep grades the velocity and consequent cutting power of the water which must be taken care of in storms is greatly increased. For this reason, also, grades must be kept as low as possible. The maintenance of roads becomes too expensive to be practicable after a certain limit is reached.

"In such a climate as that of Ohio and with material of the character of that of the limestone occurring in Ohio, the limit of grade on which a fair macadam surface may be maintained is about eight and three-fourths per cent, or in other words five degrees. In approaching this limit the cost of maintenance increases very rapidly, and above that limit a fair macadam surface of limestone cannot be maintained at a reasonable cost. The washing of violent rains, the action of horses' hoofs in drawing up hill, and the effect of

[1] Baker, page 62.

locked wheels on a down grade disturb the bond of the surface. Anyone can see the loosening of the constituent parts of the surface on heavier grades, as evidenced by the loose and rounded stones occurring on the heavier grades of any well constructed road." [1]

From what has preceded in this chapter it will readily appear that the proper location or relocation of a road is a problem in which a careful account of many factors must be taken. When such a thing is contemplated the services of the most practical highway engineer obtainable should be secured without fail. In many states where they have such an officer this matter is considered of such vital importance that all locations must by law be made according to directions of the state engineer in charge of highways, and only after careful surveys have been made.

[1] State of Ohio, Highway Deparment, Bulletin No. 2, p. 4.

CHAPTER III.

METHODS OF CONSTRUCTION AS APPLIED TO DIFFERENT KINDS OF SOILS.

Any road may be regarded as composed of two principal parts, the foundation and the surface. Either of these parts may be composed of several members according to the design of the road which is being constructed. The bottom foundation of all roads must be of earth or of bed rock, providing that is close enough to the surface. The fundamental principle of Macadam was that any ordinary soil if properly compacted and drained would sustain any amount of traffic put upon it, and he laid great emphasis, therefore, upon proper drainage. The methods of construction applied to roads built of various kinds of materials are dependent almost entirely upon the necessity for securing the right kind of drainage for the material used. Most of the dirt roads in Wisconsin are sufficiently well drained by ordinary side ditches, if these are kept clean so as to offer free passage for the water. In many cases, however, particularly in clay country where springs abound, and often where bed rock is near the surface, it is necessary to use underground drains in order to keep the foundation of the road sufficiently dry. It is impossible with any sort of a road covering, unless it is built strong enough to act as a bridge, to keep a proper surface over wet ground. The importance of this matter of drainage cannot be over-emphasized. *Water must be kept out of the foundation* of the road or no good surface of any kind will be possible.

Fig. 1. Sand road showing effect of removal of trees and brush and consequent drying out of the road.

Fig. 2. Sand road freshly covered with straw

FOUNDATION MATERIALS.

The common road materials in use in Wisconsin may for the purpose of this discussion be conveniently divided into foundation materials and surface materials. In discussing the foundation it is sufficiently accurate to divide soils into sand, loam and clay, which materials need no definition for the purpose of this discussion. The *surface materials* are these common soils, with shale, gravel, crushed stone and a few miscellaneous materials used in particular localities such as shells, slag, cinders, etc. Of these materials shale may possibly require definition. In common usage, Wisconsin shales are the clayey layers which are found in practically all of the great sand-stone areas in the south central and western parts of the state. These materials are here considered as foundation material and later as surfacing material, on pages 23 to 32.

Sand. Sand is the best foundation material for a road because of its porous nature and easy drainage, but it is not good for both surface and foundation. In districts where the soil is very sandy the only way to secure a really passable road is to cover the sand with some other material, such as clay or shale for an earth road, and gravel or crushed stone for a permanent road. But this is impossible to accomplish at once in any town possessing many miles of sandy road, and as a consequence the sand roads must be treated in the best manner possible to keep them hard. Since sand is always harder when it is damp, sand roads should be so constructed as to prevent their rapid drainage, and if possible to keep them moist all the time. For this purpose the growth of bushes, grass and trees close to the roadway should be encouraged wherever possible. The grading, if any at all is necessary, should be just barely sufficient to prevent puddles forming. On plate II figure 1, a photograph of a sandy road in Trempealeau County is shown. In the foreground is a wide expanse of barren

sand, which shows very well the almost bottomless nature of this road in dry weather. In the middle distance at the right side of the picture where the weeds and grass have grown closer to the road it is much less cut up than the more traveled track in the center which is not in any way protected by the grass.

In many parts of the state a temporary makeshift is employed which gives quite good satisfaction. This is to cover the road with straw, marsh hay, sawdust, or some such material. The photographs shown in plate II figure 2, and plate III figure 1, give a fairly good idea of the appearance of roads that have been thus treated.

Clay. In building a road of clay an entirely different method must be used from that necessary in sandy country; one might almost say a method which is just the reverse of that used in sandy country. The one desirable thing for a clay road is to get the water off, and to get it off as quickly and as completely as possible. For this purpose the road must be given a high crown in the middle and provided with deep wide ditches at the side. The trees, brush and grass should be kept well cut away from the sides in order to permit the surface to dry up as quickly as possible after a rain. It may be mentioned here that this clearing away of the brush and weeds is advantageous also in preventing the accumulation of snow drifts on the road in the winter time. The best thing possible for all clay roads would be a liberal use of the split log drag, shown in the frontpiece and described on pages 43 to 45.

Cross-sections of the proper forms of grade for clay and loam roads are shown in figures 1 and 2, plate IV. As commonly constructed with the road machine, roads in clay country are left in the form shown in figures 3 and 4. Grass and weeds readily start to grow along the side of the wheel tracks, which are soon deepened by the travel. The grass catches and holds the dust and mud, soon forming with the sides of the rut an effectu l dam which prevents the water reaching the side

Fig. 1. Sandy road in Trempealeau county. This road was covered with straw about a year before the photograph was taken

Fig. 2. Crushed stone road which has been compacted by the travel. Notice the loose character of the stones outside the beaten track.

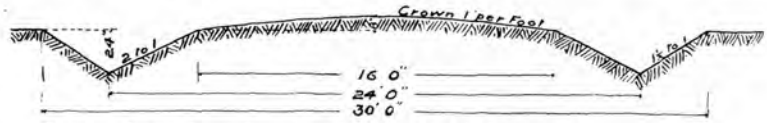


Fig. 1. Proper form of cross section for a road in loamy soil.

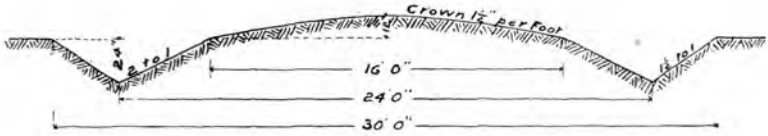


Fig. 2. Proper form of cross section for a road in clay soil.

Fig. 3. Second ditch and false shoulder as often left in regrading. Correct form shown at the right.

Fig. 4. Ditches as commonly left by grader (blade at A). Proper form and last cut shown by position of blade at B.

Fig. 5. Neglected road. Dotted line shows original form.

Fig. 6. Flat-topped road. A very poor form which is occasionally seen.

Fig. 7. Cross section of a road with side slopes into the ditches too steep. When a wagon is on one side, as at A, the weight is too much on one wheel and this wheel is sure to make a rut.

Fig. 8. Road graded too wide and flat. Proper form shown by dotted line.

of the road. The ruts thus become nothing more than water channels or puddles which hold the water and soften the ground up so that the wheels readily cut deeper. The side ditches are quickly filled by the giving in of the steep sides left by the road machine, and the whole form of the road becomes that shown in figure 5. A round or two with the road machine to turn back this steep wall of the ditch toward the side of the road, giving it a gentle slope, is all that is necessary to keep the ditch well formed, as shown in figure 1. If, after forming the road as in figure 4, where the last position of the blade of the grader is shown at A, a steeper cut is made with the blade at B, two good results will be attained; the best dirt thrown up on the surface where it should be, and a good ditch made.

A less common form of cross section given to the roads is that shown in figure 6. By this method the road is given a flat top with deep, steep walled ditches at each side of the roadway. This flat top is soon cut up by the travel and hollowed out so that it simply serves as a third ditch along which the water runs just as readily as it does along the side ditches, and the road is cut up almost as easily as though no attempt had been made to drain it. Figures 7 and 8 show other forms of cross section which are poorly made.

In most districts ditches such are shown in figures 1 and 2 are sufficient to keep the foundation of the road properly dried out, but in many cases under-drains are necessary. These under-drains should be laid with relation to the surface. If the road is along a hillside and is kept damp by seepage from above the road a single drain along the damp place on the uphill side of the road will often be sufficient to keep the road firm and solid. In rare cases it may be necessary to use a line of drain pipe at each side of the roadway where the soil is very damp and spongy. The figures on plate V show the positions of tiling for various conditions and the way the drains carry the water out of the soil. The following extract is taken from a

bulletin of the Wisconsin Agricultural Experiment Station written by Professor King.*

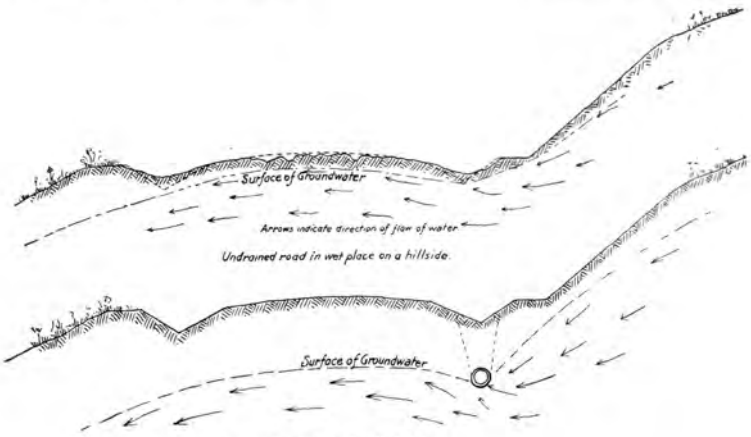
Depth of under drainage. "Where under drainage is needed the drain should not be less than three to four feet deep, and this is especially true if heavy traffic is to be maintained over it.

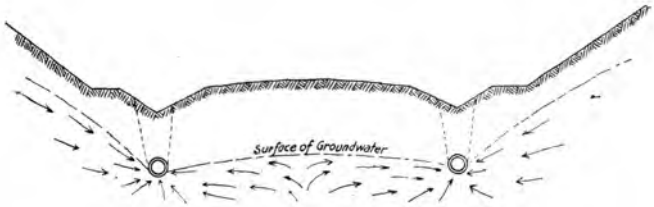
No one thinks of walking on the yielding surface of the water of a lake or stream, but let it be covered with a sufficiently thick layer of ice and it then makes the best kind of a roadbed. The drained ground beneath the road surface must be sufficiently thick to float on the soft soil beneath any load which may be driven along it, just as the ice floats its burden."

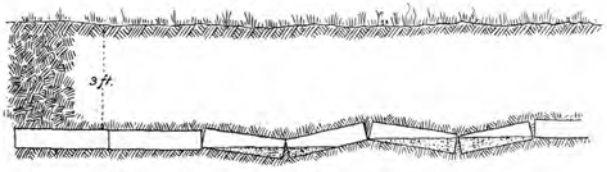
Fall of the drain. "The fall of the drain will usually conform somewhat nearly to the grade of the readbed, but should not be less than two inches in 100 feet, if this can be secured. It will, however, be necessary sometimes to lay the drain on a slope less than this, even as low as ½ inch in 100 feet. In all cases care should be exercised to lay the tile on a trade, not allowing them to drop anywhere below or rise above a rigidly maintained grade line. If they are not laid in this manner water will stand in the sags and behind the bends, and in these places the tile may become filled with silt." (See figure 5, plate V).

Outlet of the drain. "The drain should be turned out to the side of the road whenever there is an opportunity for doing so, that is, whenever there is a natural line of drainage leading across the road which will answer for the purpose. The free end of the drain is best made of one length of cast iron sewer pipe eight feet long, because this will not be injured by freezing nor easily broken. There should be a free fall at the end of the tile and it is better that the opening should be protected by some sort of metal grating or screen to prevent animals from running in in dry times."

*University of Wisconsin Agricultural Experiment Station. Bulletin No. 79, pages 19-21.







Figures showing some of the principles of drainage.

Size of tile. "Tile three inches in diameter is the best to use for the reason that, in case the grade is very small, slight errors in laying the line cannot carry the entire opening of the tile above or below the grade line and hence permit the drain to be entirely closed by silt."

Kind of tile. "Where the tile can be laid two feet or more below the surface of the road ordinary drain tile which are well burned, straight, smooth inside and having the ends cut squarely off so that they may fit closely together are best. Great care should be taken in placing the tile to turn them until the ends fit very closely all the way around, and then to fix them rigidly there. This care is needed in order to prevent silt from being washed in at the joints.

Where the tile must come less than two feet below the surface it will be safe either to use the vitrified drain tile or else second quality sewer tile not likely to be disintegrated by frost."

Loam. Loamy soils are intermediate in character between sand and clay, and may be passed over with a bare mention. As a rule loamy soil must be treated more nearly like clay soil than like sand. The proper cross section for a road in loamy soil is shown in figure 1, Plate IV.

Swamp Soils. It is difficult to build a satisfactory road from the muck and peat which are the soils found in the numerous swamps of Wisconsin. The only way to secure a passable road is, as in the case of sand, to cover the road with some other material. If it can be properly drained, clay, gravel or crushed rock may be used to form a very satisfactory surface. Otherwise, corduroy must be used.

SURFACE MATERIALS.

The materials used for road surfaces in country districts are the common soils, sand, loam and clay, with shale, gravel and crushed rock.

Sand. As a surface material sand is of value as a thin covering for clay roads. The sand mixes quite thoroughly with

the clay and prevents the absorption of as much water as clay alone will absorb, thus serving to turn more of the storm water into the ditches and prevent its seeping through the road surface. Clay is composed of very fine grains which, when mixed with sand in proper proportions, fill up the tiny spaces existing between the sand grains. Clay will sometimes absorb as much as 60% of its volume of water; sand will absorb from 25% to 40%. A proper mixture of the two, however, will not absorb nearly as much as the sand alone. A clay road treated in this manner is harder and less dusty than one without sand.

Clay and Shale. These two materials are only different in that shale, as commonly used on the roads, is nothing more than clay mixed with a little sandstone. For the same reason that sand is a valuable material to put on clay roads, clay or shale is valuable to put on sand roads. Clay on sand roads is also beneficial in that it makes a firmer surface for the road when it is dry than sand does.

The proper thickness to which clay or shale should be put on a sand road in order to give good results must depend to a large extent on local conditions. In some cases three inches of firmly packed clay or shale on sand will wear for a long time, but if there comes any lengthy period of damp weather the wheels are almost certain to cut through into the sand and ruin the usefulness of the clay as a covering. The best results are usually given by covering the sand with about six inches of clay and then putting an inch or two of sand over this. This thin covering of sand aids in turning the water off the roads into the ditches in just the same way as it does on a road made entirely of clay, and serves to prevent the softening and consequent cutting up of the road by the wheels of the wagons passing over it.

Gravel. The gravels of Wisconsin may be conveniently divieded into two classes, river gravel and pit gravel. The river gravels, as a rule, lack a proper amount of clay necessary to fill the spaces between the pebbles and form with them a com-

pact, impervious surface capable of shedding water. The pebbles have been rolled and washed by the stream until all the finer material has been carried away. If stream gravel is all that is available a proper amount of clay must be mixed with it to make it pack well in the road. If it can be obtained, low grade iron ore makes a much better cementing material than clay for mixing with gravel.

The pit gravels are mixed with sand, or clay, or both. They are usually, also, more angular than the rounded stream gravels and so wedge together better in the road under the roller and the wagon wheels and make a more solid surface. Care should be taken to pick out all large stones at the pit, to see that all sand pockets are rejected, and to be sure that the gravel contains the proper amount of clay for binding material. If there is too much clay the road will soften in wet weather, and if too little the road will "ravel," i. e., the pebbles will be kicked out of the surface by the horses on account of the lack of sufficient binding material to fill the spaces between the pebbles and hold them tightly. The road will thus be reduced to a useless mass of pebbles. The amount of binding material necessary will vary. If the pebbles are all about the same size 25% of the mass should be binding material, but as the pebbles are almost always of assorted sizes, and the smaller help fill the spaces between the larger, an ordinary gravel should not have more than about 15% of clay and sand. If more than this is present it should be removed by screening. Oftentimes by testing different parts of a pit, gravel of the proper composition can be found, and screening made unnecessary. If gravel is compact enough to stand in straight walls in the pit and requires loosening with a pick it is usually all right.

Crushed Rock. In the larger part of Wisconsin there is plenty of rock available for crushing. There is limestone in plenty in the eastern and southern parts, granite in the central and northern parts and hardheads over almost the whole state.

The relative values of different kinds of rock for road metal

has been tested in several ways. The two tests of most practical value are the *wearing* test and the *cementation test.* In the wearing test a certain number of pieces of standard size are rotated for a definite time in a steel cylinder and the amount of dust worn off the pieces weighed. In the cementation test the powdered rock is moistened and made into a little cylinder. This cylinder is then broken by the blows of a hammer falling the same distance for each blow, and the cementing power of the rock measured by the number of blows the rock is able to resist without breaking. The resistance to wear offered by many Wisconsin rocks has been tested by the State Geological and Natural History Survey under the supervision of E. R. Buckley. The following table from his report on Highway Construction gives the relative wearing qualities of some Wisconsin rocks when used for road metal.

TABLE III.

Report of wearing tests on crushed rock.

Name of sender.	Kind of stone.	Per cent. of wear.	Rank.
Montello Granite Co	Granite	2.16	3
Wisconsin Granite Co	Quartzite	3.50	8
F. Powell	Limestone	9.86	16
Horlick's L. & S. Co	Limestone	7.02	15
G. H. Chaffee, Sparta	Flint	2.10	2
Richwood Crushed Stone Co., Watertown	Limestone	3.90	12
Waupaca Crushed Granite & Stone Co.	Granite	1.80	1
Sheboygan Lime Works	Limestone	6.46	14
M. Maxon, Waukesha	Trap.	2.90	6
C. F. Smith, Appleton	Limestone	3.46	9
Menom. Falls-Lannon Stone Co., Lannon, Wis	Limestone	4.04	13
Marblehead Lime Co	Limestone	3.90	11
Sheboygan L. & S. Co	Fieldstone.	3.88	10
Rice Lake	Quartzite	2.36	7
Utley	Rhyolite.	3.04	4
Berlin	Rhyolite.	2.76	5

Wisconsin Geol. and Nat. Hist. Survey, Bulletin X., 1903. Buckley, p. 294.

The cementing property is important because it is this which causes a road made of crushed rock to become hard and smooth upon being travelled. The cementing property is due to the ability of the fine dust, into which rock is worn by the wheels, to set like cement into a more or less solid mass upon being

moistened and packed. As this fine dust is continually being washed off the road by the rain and blown away by the wind it must be replaced by the new dust worn off the stones by the wheels. If a very hard surface material, such as trap rock or granite, is put on a road which is comparatively little travelled, the result is that there is not enough dust formed to replace that blown and washed away and the surface "ravels" and becomes a mass of loose stones. On the other hand if a soft stone, such as some lime stones, is used for the surface of a heavily travelled road more dust is formed than is carried away, so that it forms a layer over the surface and makes disagreeable dust or mud, according as the weather is dry or damp. The kind of rock used on the surface of a road must accordingly be determined to a considerable extent by the amount of travel.

The cementing tests on the powder of different Wisconsin rocks have not been very satisfactory, as they do not agree among themselves. A table of their relative merits is therefore not given. In general it may be said that limestone, flint, and dark igneous rocks have good cementing qualities, while quartzite and light colored igneous rocks, such as granites, have poorer cementing qualities. These last two are very hard and may do well as surface material where travel is heavy. Many granites, however, have fairly high cementing qualities.

The proper size of crushed stone to use for a macadam surface depends partly upon the strength of the rock used. Each stone in the surface should be strong enough to support, without breaking, the weight which the wheel of a loaded wagon will put upon it. If the stones are too small to do this they will grind up rapidly under the traffic. If a relatively weak stone such as a soft limestone is used, the smaller stones should be at the bottom and the larger ones at the top. If a hard stone is used, the larger ones should be at the bottom and the smaller at the top, as the smaller stones make a more even surface and

should be used there when they are strong enough to bear the weight put upon them.

The usual sizes to which crushed stone is separated are 2½ inch, 1 inch, and ½ inch, or screenings. If soft limestone is used the 1 inch pieces should go on the bottom and the 2½ inch pieces should be used for the surface; if hard rock, either granite or trap or hard limestone, is used the one inch pieces should go on the top. In both cases the screenings are spread over the top in a thin layer to fill the spaces between the larger stones.

BUILDING GRAVEL AND CRUSHED STONE ROADS.

In making a gravel or crushed stone road the fundamental parts of a road must not be forgotten—the *foundation* and the *surface*. Care must be taken to see that the foundation is solid and well drained, and the surface must be well compacted so that it will act as a roof. It is a waste of good money to attempt to make a solid surface over a damp place in the road by dumping gravel or crushed rock on it, as it quickly pounds into the mud which is very shortly ready to swallow up more. The methods of applying gravel or crushed stone to secure this good roof are essentially the same and are therefore described together.

Both gravel and crushed stone may be spread upon a well drained, well crowned earth road without any further preparation and in time will be beaten down by the traffic into a fairly good surface. This packing process is hard on teams and vehicles, however, as well as wasteful of the material, which is kicked to one side by the horses. It is more economical in the long run to exercise a little more care and spend a little more money in the preparation.

After the roadbed is properly drained and graded a trench should be prepared as deep and wide as the surface material is to be applied. The material from the trench should be placed along the side to form straight vertical shoulders, as shown in

figure 1, plate VI. The bottom of this trench should be thoroughly rolled in order to be sure the dirt is well packed and will not settle after the gravel or crushed stone is put on. The roadbed is then ready for the surface material.

The gravel or crushed stone is usually hauled on an ordinary wagon provided with dump boards and dumped in heaps. On a country road where the width surfaced is comparatively narrow the loads are dumped into a continuous ridge and for the most part spread with shovels when spread at all. This can often be done more quickly and cheaply by running a road machine over it, using shovel work only to trim up the surface after the machine has done what it can. The materials are also applied in automatic spreader wagons, of which there are various types. These wagons leave an even layer of rock of any desired thickness.

After the layer of rock or gravel is spread evenly it is ready to roll. It is best to attempt to roll only a thin layer—3 to 5 inches—at one time, as it is impossible to thoroughly compact a thick layer with any ordinary roller. If the layer is too thick only the top will be compacted, and when the road gets older it will settle more or less unevenly. The rock should be properly wet during the rolling in order to get the best results. This wetting prevents crushing and grinding the rock by the roller, and washes the screenings into the open spaces between the larger stones so as to make a solid mass.

When the first layer is rolled down solid the second layer can be dumped upon it, spread as before, and rolled. If the material is crushed rock, after the surface layer is packed a half inch or so of screenings should be spread and rolled, so as to pack the small pieces into the openings between the larger stones.

If no roller is available and it is necessary to depend on the travel to pack the surface, the material should be spread in layers as stated above and sufficient time allowed for each layer to be thoroughly compacted before the next is added.

The people should be compelled to drive over all the surface and not allowed to travel in a single track. This can be done by placing obstructions, such as logs or boulders, in suitable positions to enforce their taking a new track after one is beaten down. These obstructions should be moved as often as necessary in order to compel the teams to pack the whole width of the roadbed. After one layer is beaten down in this way the second can be added and packed in the same manner. A road built without the use of a roller is shown in fig. 2, plate III.

After rolling the road should present a crowned surface, as shown in figure 2, plate VI, somewhat more flat than for an earth road, in the slightly arched center of which is a strip of well compacted crushed rock or gravel. On each side of the crown should be good slopes into the ditches, and good clean ditches to quickly carry the water away. Under this crown should be a thickness of earth which is well protected from moisture, so that it will always be firm. It should be protected from moisture from below—if there is any likelihood of water reaching it from that direction—by drain tile la'd deep enough to be effective; and from moisture from above by a hard compact surface of gravel or macadam. A good gravel road such as is common in the eastern part of the state is shown in figure 1, plate XVI.

Cost of Gravel and Macadam. The cost of these roads depends upon the price of labor and material, and the distance the material must be hauled. From the replies to the list of questions sent to town clerks, table XVI on page 79 is made showing the average cost of gravel and macadam roads by counties from which reports came. In many of these cases excessive prices are paid for the gravel. Some owners of gravel pits are reported to be charging 20 cents and even 25 cents per load. Considering the small loads that most farm wagons are equipped to carry in working road tax, it is not to be wondered at that gravel roads are reported costing as high as ten dollars per rod. With gravel costing 30 cents to 35 cents per cubic yard *delivered on the road which is being constructed* the cost

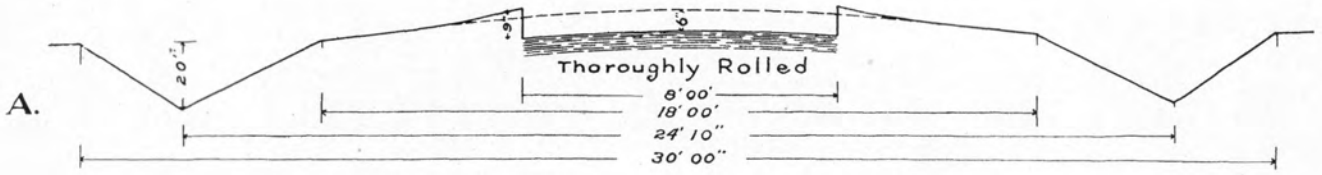


Fig. 1. Cross section of road graded and trenched ready for the laying of gravel or macadam. Notice the square shoulders raised above the finished surface.

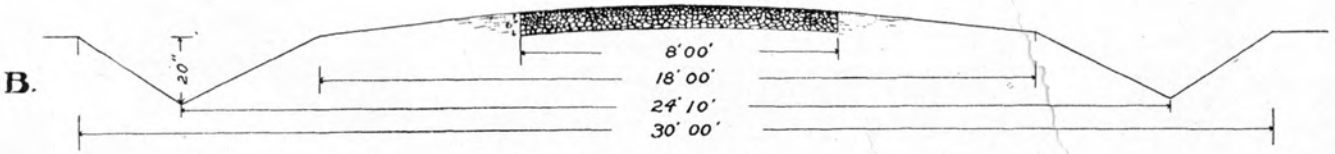


Fig. 2. Cross section of finished gravel or macadam road.

of a well constructed gravel road should be about $300 to $350 per mile, aside from the grading. This is evident from the number of yards necessary for a 6′ road 6″ thick, as given in the following table taken from the 1902 report of the New Jersey Highway Commission.

TABLE IV.

TABLE IV.—Showing number of cubic yards of gravel required in the construction of one mile of gravel road, of widths varying from 6 feet to 20 feet, and depth from 6 to 12 inches. *These within quantities should be multiplied by 1½ to give the number of cubic yards of loose gravel required to make the within depths of compact gravel.*

Feet wide.	Road 6 inches deep.	Road 7 inches deep.	Road 8 inches deep.	Road 9 inches deep.	Road 10 inches deep.	Road 11 inches deep.	Road 12 inches deep.
	Cubic yds.	Cubic yds.	Cubic yds.	Cubic yds.	Cubic yds.	Cubic yds.	Cubic yds.
6.....	586	684	782	880	977	1,075	1,173
7.....	684	798	912	1,026	1,140	1,254	1,368
8.....	782	912	1,042	1,173	1,303	1,434	1,564
9.....	880	1,026	1,173	1,320	1,466	1,613	1,760
10.....	977	1,140	1,303	1,466	1,629	1,792	1,955
11.....	1,075	1,254	1,434	1,629	1,792	1,971	2,151
12.....	1,173	1,368	1,564	1,792	1,955	2,151	2,364

Since the cost of roads depends mainly upon the local price for material, it is impossible to give a general statement that could be applied to any locality. A fair price for crushed stone at the quarry is from 60 to 90 cents per cubic yard for limestone. The city of Madison owns its quarry and makes its own crushed rock at a cost of 60 cents per yard. The rock used is a medium hard limestone. For rocks that are harder and more difficult to crush, such as granite and trap, a considerably higher price must be paid. As such rocks are not so widely distributed as limestone the freight rates will be greater in the average. To such a price, which should include loading on cars at quarry, must be added freight and unloading charges and cost of hauling. In a favorable location a mile of limestone macadam 6 feet wide and 6 inches thick can be built for $800. Twelve hundred dollars is probably nearer the average cost of such roads in country districts, however.

MISCELLANEOUS ROAD COVERINGS.

Experiments have been tried in several states with tar as a road material. It has been very successful when used on a clean crushed rock surface. Its use on country roads is still rather too experimental in nature to warrant any extended description and the interested reader is referred to Circular No. 47 of the Office of Public Roads Inquiry, U. S. Department of Agriculture at Washington. It is suggested that tar may be a valuable material to use in some districts where the roads are very sandy and clay is not to be obtained within an economical hauling distance. If any one desires to try it in this state the writer will be glad to assist in every way possible, and would like to hear of any such experiments that are being made or have been made in the past.

Corduroy. In the swamp lands of the state there are many soft springy places which cannot be avoided in laying out a road. These have usually been crossed by the use of corduroy, and it would be hard to devise a better method which would be cheap enough to be useful. A few suggestions in regard to its construction may be of assistance, however. The logs used should not be large. If they are, too much timber is required. Three to five inch poles are usually just as serviceable as larger ones. These should be laid on stringers placed lengthwise of the road. The stringers serve to keep them even, as one log cannot sink below its neighbors without depressing the stringer, in which case all the logs will sink to the same depth. If possible the logs should be laid so that they will be under water all the time. It is a well known fact that logs in the bottom of a marsh are preserved perfectly for hundreds and probably thousands of years. The wood will not decay nearly so readily as when exposed so that the air gets at it. If the logs cannot be laid low enough so as to keep them under water, they should at least be burried completely, ends and all, by a covering of dirt preferably sand. This serves to keep out the air and

much better than to leave part of the logs exposed according to the usual custom.

Other Surface Materials. There are many materials which are suitable for a road surface which are obtainable only in particular localities. These are applied in much the same way as gravel or crushed stone, but ordinarily do not give as good results. Such materials are slag, cinders, shells and mine tailings. Cinders are usually too soft and too dusty for use on an ordinary road which has any considerable amount of travel. Mine tailings are usually very fine and are objectionable on account of the dust they make, but their cheapness makes them valuable in the mining districts. Aside from these, low grade iron ore makes a most excellent covering, being much the same as clay in its behavior. There are iron ore deposits in many parts of the state which are too low grade to use for smelting which would make excellent roads if used for this purpose.

CHAPTER IV.

ROAD MACHINERY.

Graders. In the use of road machines the importance of having men to run them who are thoroughly familiar with their use, and know the form in which the surface of the grade should be left, cannot be emphasized too strongly. The custom, altogether too common, of having three teams with a driver for each one, and two men to control the blade is about as wasteful as could be devised. Each driver is afraid his team will pull more than its proper share and the result is that the six horses do not accomplish the work that four should do. If a traction engine could be rented to pull the grader the cost of the work would usually be very decidedly decreased.

The longer a man handles a road machine the more proficient he becomes and the more valuable his services. The same rule is applicable to teams. Where teams are continually being changed and new ones unfamiliar with the work take the place of those that drop out on account of having finished working their tax, no team has a chance to become thoroughly familiar with the work and either accomplishes only a small part of what it should or is worried and fretted out of all proportion to the work accomplished.

"The common custom of grading only the width of the traveled track and leaving a shoulder of earth on the outside which prevents the water from leaving the roadway (See fig. 3 plate IV), or of working this shoulder of sod and weeds

up into the road to be turned into soft mud under the influence of rain and travel, cannot be too strongly condemned, and any foreman or road overseer who persists in such practice should be kept entirely away from repair work. The grader should be run the full width of the roadway so as to provide a continuous slope from the middle of the road to the ditch on the side, and if this shoulder of earth has been scraped into the ditches by being thrown outward it must be hauled away and the ditches properly cleaned. * * * It is much better and more economical to maintain one experienced crew in a township than half a dozen crews made up of men and teams picked up at random to work out the statute labor tax. One season's work with the same force under competent direction will convince any thoughtful supervisor of the wisdom of keeping up one regular repair crew under the control of a competent road builder." *

The only time a road machine should be used is in the spring or summer. If, as in many towns, the road is turnpiked in the fall, the dirt does not have time to pack down before it freezes. As a consequence it is porous and full of water and when the frost comes out in the spring the newly made road becomes a sea of mud which is speedily tramped out to the sides. The grading is then ready to be done over again. One thing that should be carefully guarded against is the formation of secondary ditches as shown in figure 3 plate IV. The right side of the figure shows the proper way to leave the grade and the left shows the way many roads are left.

The prices on road machines are widely different. The Highway Commissioner of Maine gives the following table of prices paid by the towns in his state for different makes of machines. A large part of the variation in price is due to different sizes, weights, etc., of the machines, but some of the difference is doubtless due to difference in bargains.

* Bull., 1 Minn. Highway Commission, p. 16.

TABLE V.

NAME OF MACHINE.	No. used.	PRICE.	
		Lowest.	Highest.
American Champion	327	$125	$375
Western Reversible	41	110	350
Austin-Western	5	200	235
Austin	12	210	350
Climax	57	125	275
Victor	16	150	350
Acme	10	200	235
Indiana Reversible of Fort Wayne	7	165	250
National Reversible	4	100	205
Buckeye	2	250	
Aurora	2	210	225
Eureka	1	150	
Great Western	1	200	
McCormick	1	250	
Penrock	1	250	
Patten	1	250	
Machines no name reported	64		

One town reports "price confidential."

The cost of running a road machine is given by the Maine Commissioner as varying from $2.00 to $35.00 per day with an average of $10.42 for 373 replies to his question. The average length of road turnpiked per day was .842 of a mile. These figures will give the careful highway supervisor some idea of the work he is getting done in comparison to what is done in other districts.

Scrapers. The scrapers in common use are the "wheeler" and the "slip" or drag scraper. The wheeler holds from 9 to 17 cubic feet, and the slip from 5 to 7 feet. This small capacity—about ¼ of a yard—limits the efficient use of the slip to hauls of very short length, usually not much greater than the width of the road. Where the haul is greater the wheeler should be used as it is almost as quickly loaded and carries from 1-3 to 1-2 cubic yard; or, stated differently, from 50 to 100 per cent more work can be done with this than with the slip at not appreciably greater cost. The wheeler also has the advantage of giving a better grade as it spreads the dirt and does not leave it all in a heap like the slip. Up to hauls of 300 feet the wheeler is usually cheaper than wagon haulage because of the quickness with which it is loaded, but beyond

that wagons should be used. The slip is often used to load wagons by providing a slide up which it can be run on to the box and using a long evener so that the horses can walk on each side of the wagon. If any considerable amount of dirt is to be moved it is cheaper to provide one of these and load with a team than it is to load with shovels.

The relative cost of earth work when built with wheelers and slips is given in the following tables from Baker's "Roads & Pavements."

TABLE VI.

Cost of moving earth with drag scoop-scraper.

Per cubic yard.

ITEMS.	25 FT. HAUL.		50 FT. HAUL.		100 FT. HAUL.		200 FT. HAUL.	
Character of earth.	Loose.	Hard.	Loose.	Hard.	Loose.	Hard.	Loose.	Hard.
	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.
Loosening earth.....	1.25	2.50	1.25	2.50	1.25	2.50	1.25	2.50
Filling scrapers	1.25	1.50	1.00	1.50	1.00	1.25	1.00	1.00
Hauling.....	5.83	6.50	7.00	7.70	8.75	9.62	10.00	11.00
Leveling	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Superintendence.....	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
Wear and tear.....	0.25	0.38	0.33	0.50	0.42	0.63	0.53	0.80
Water boy	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Total cost.....	9.83	12.13	10.83	12.95	12.67	15.25	14.03	16.55

TABLE VII.

Cost of moving earth with wheel scrapers.

Per cubic Yard.

ITEMS.	LENGTH OF HAUL IN FEET.							
	Using scraper No. 1. 9 cubic ft. capacity.			Using scraper No. 3. 16 cubic ft. capacity.				
	100	200	300	400	500	600	700	800
	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.
Loosening	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Filling scrapers	1.25	1.00	1.00	1.80	1.80	1.80	1.80	1.80
Hauling	5.83	7.00	8.00	7.77	8.77	9.77	10.77	11.77
Leveling	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Superintendence	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
Wear and tear.....	0.41	0.53	0.75	0.53	0.64	0.75	0.86	0.97
Water boy	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Total cost.....	9.99	11.08	12.25	12.60	13.71	14.82	15.93	17.04

Rollers. These are little used on earth roads in Wisconsin and their value is little appreciated. It is just as important in the construction of a good earth road that it should be left in a hard compact condition as it is in making a gravel or stone road. If the dirt is rolled thoroughly it is much less subject to rutting than if left loose. The roller packs the soft spots and shows them up so that more material can be added and the road left even surfaced and evenly hard in all places. The usefulness of the roller in building stone and gravel roads is better understood, but it may be mentioned that for these harder surfaces the rolling should begin at the shoulders and progress inward toward the center.

Harrows. One implement that should be more used than at present is the common steel toothed harrow. It aids in smoothing the rough surface left by the grader or scrapers and is also useful in filling the ruts that may form in the newly made surface. For this last purpose it is not so good as the split-log drag which is described in the chapter on maintenance, but it is very useful if the split-log drag is not at hand.

Other Implements. Plows, wagons, shovels, wheelbarrows, etc., need no description. Many forms of patent spreading dump-wagons are on the market and are particularly useful in spreading gravel or crushed stone.

The elevating grader is used in some states where they have long stretches of level or slightly rolling country in which they wish to throw up grades of some considerable height, but it is too expensive a machine to be used under the system of road work existing in Wisconsin.

CHAPTER V.

ROAD MAINTENANCE.

One of the causes for the high cost of and poor results shown for the money spent on Wisconsin roads is the almost total lack of any idea of the necessity of *maintaining* the road after once constructed. The valuable old maxim, 'a stitch in time saves nine,' is altogether too rarely applied, either by cities with reference to their streets and pavements, or by towns and counties with reference to their roads. Any one who is familiar with conditions can tell numerous instances of where a few shovels of dirt or a few hour's work applied in time would have prevented a serious washout or the destruction of a road almost beyond repair which later cost much time and effort to replace. If the truth could be ascertained it is highly probable that it would appear that the greater part of the great sum of over two millions, which roads are at present costing the people, is spent in rebuilding roads that could have been kept in good shape by a much smaller amount if the work had been done in time.

Section System. The ideal way of maintaining a road is that used by the railroads—the section system—in which a man is given charge of a certain stretch and required to keep it in first class shape. The more progressive parts of the country are already beginning to care for their roads in this way. The following letter, quoted by the Highway Commissioner of

Maine, gives a good account of how one man carried out this principle and the success he met.

"Ordinarily, the chief work done by country people on highways is repairing the damage consequent upon neglect. Why this neglect? Simply because the people are trying to follow old, obsolete methods poorly adapted to these times of intense business energy and economy.

Much may be learned from the methods employed in maintaining the railroads. The means adopted to keep up our highways would be considered extravagant for them. The principle of economy forces them to a better system—one of constant and continuous work of repairing.

In the spring of 1894, with the purpose of adopting better methods for road management, I asked the people of my town for the office of road commissioner, and being elected to that office I proceeded to institute a system of continuous inspection and repairs. Being familiar with all the roads of the town and the uses to which they were put, I divided them into sections and made choice of the men who should have charge of and keep each section. My next task was to see other men and endeavor to enthuse each with some spirit of improving. They were reminded that the value of their farms depended upon the condition of the road. They were assured that the roads were to be improved, and urged to use their best endeavors in inaugurating reform in our method of road management.

Each man was furnished with a good new shovel and a pass book in which to charge for each and every hour he spent upon the road. He was instructed to go over each section as soon as the ground was bare of snow, or as soon as the water began to flow to see to it that the water was kept off the road; to go over the road every day if necessary while the snow was going and during the rainy season, for it is then that the most damage is done; and that when so passing over the road he should remedy all slight defects where a few

shovelfulls of earth or gravel would prevent a bad mud-hole later on. These men were told that the old way of working the roads once a year had been abandoned, and that it was expected that a few hours work each week, when it would not seriously interfere with their farm work, would accomplish all that was expected.

The main road through the town, six miles long, not only takes the travel of the other roads, but is the thoroughfare by which the inhabitants of other towns reach the city with their produce, lumber, wood, and a great deal of heavy trucking. The best farmers live along this road and have enough business of their own without caring for a section of the road. Because of this, and for various other reasons, I conceived the idea of employing one man to keep this road, and therefore engaged a faithful man with his horse, the town furnishing a cart.

He was employed from spring till fall, and his instructions were to begin at one end and work one mile each day, covering the entire route each week, and fixing the worst mud-holes (and there were many), using the best road material at hand; and at the close of each day to pass over the mile worked, gathering the loose stones, putting them where they would give no more trouble.

I will say here that the maintenance of this road was and had been a great burden to the town, and its condition was far from satisfactory to the traveling public. When the man employed learned what was expected of him he shrank from the task, saying, "What can I do to keep this road when a large gang of men with great expense failed to keep it?" He was only persuaded to make the attempt by the assurance that the responsibility and any bad results would rest on the commissioner.

There was much ridicule and prejudice against this system of management for a time. The man employed was instructed not to participate in any discussion of the subject,

not to answer questions relative to the road or his work upon it, and to refrain from talking about the matter generally on penalty of being discharged. Other people talked and ridiculed, but the work went on, and after a few weeks the condition of the road improved and people noticed the fact. They also discovered that the expense was not large; that all the work done was remedying defects and at the same time preventing greater ones. And so the work went on and the prejudice died out. At the next annual town meeting the people without opposition continued the system, and at the last town meeting elected the road commissioner for three years with the same system of road management.

The general results are that much better roads are secured at less expense, and the tax rate for highways has been reduced each year, as the roads grew better, and as we learned to maintain them free from damage at less cost.

I will say that we do something more for the roads than is here indicated. What we do is for maintaining or holding them, and at the same time improving. But these roads should be built according to modern ideas of road construction; so we set apart a portion of the road fund for permanent improvement, building up for each year a piece or section of the main road in a thorough manner and of good material, and constructing culverts of stone in a permanent way. After the road is put in good condition one man can easily keep and care for a long stretch.

Very truly yours,

(Signed) J. O. SANFORD,
Vermont Board of Agriculture.

Stamford, Vt., November 10, 1896."

A few general principles as to the care of roads are here given. They are all dependent on the fact that water is the one great foe to good roads of any kind except sand, and a sand road is not properly to be classed with good roads.

Keep ruts and pitch-holes filled, always with the *same kind of material* as that of which the road is composed, in order to force the water to run quickly into the ditches.

Keep weeds, grass and brush cut away from the sides to permit rapid drying.

Keep the ditches and culverts free from obstruction by dead weeds, etc., to permit the water to run away before it has time to soak into the foundation and soften it.

Keep loose stones, etc., off the surface.

Split-log drag. One of the best and cheapest methods of maintaining a clay or gravel road is to use the split-log drag. This implement is figured as the frontpiece to this volume as it is one of the most important single factors in the betterment of our dirt road conditions. Its construction is evident from the illustration. The principle on which it works is familiar to any one who has ever made mud pies. It depends upon the fact that clay which has been thoroughly mixed with water will bake into a hard compact mass on drying. The drag is used right after a rain when the ground is full of water, and it works up about half an inch of well puddled clay toward the center of the roads. The back log, not being shod, acts as a sort of packer to press down the puddled surface left by the front log. The ruts are thus filled with wet packed material which is further packed by the wheels and eventually baked on drying into a hard compact mass.

The following suggegstions for using the drag are taken from the monthly bulletin of the Missouri Board of Agriculture for April, 1906.

1st. *"The length of the chain, which is regulated by slipping it backward or forward through the hole in ditch end of drag.* The length of the chain regulates the hold taken on the earth. To make the chain longer is equivalent to putting weight on the drag. If your drag is too heavy shorten the chain."

2d. *"The position of the snatch hook, which attaches the double-trees.* To move much dirt or cut small weeds hitch the hook close to the ditch end of the drag and stand as nearly on the end of the front slab as is safe. Drive very slowly when thus hitched. This one hitch seems to be the hardest to learn. The others suggest themselves."

3d. *"Position of the driver on the drag.* To move dirt see above. In a soft spot stand on rear slab. On a hard spot stand on front slab and drive slowly. If the drag clogs with straw, weeds, sod or mud, step to a point as far as you can get from ditch end of the drag. To drop dirt in a low place step quickly from ditch end to other extreme. To fill a low place or mud hole nicely is the severest test of skill with a drag."

"I suspect you will become thoroughly disgusted when you first make the effort. But remember it will not be the fault of the drag if you fail."

4th. *"Presence or absence and sharpness or dullness of the steel.* The steel may project half an inch below the wood at the ditch end of the steel, but should come up flush with the wood at other end of the steel. After a clay or gumbo road has been dragged four or five years the soil becomes so tough and putty-like that one must study it closely to know what to do. Some times I use sharp edge of steel; sometimes dull edge (holes are bored in both edges of steel so that I can turn it up side down and use same bolt holes), and some times the plain wood."

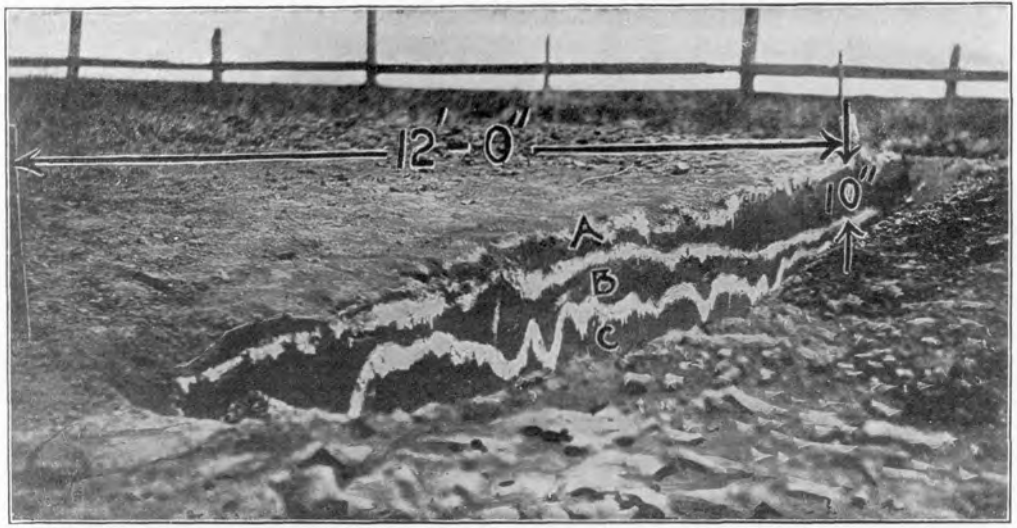
"This can be learned only by experience and you have several years in which to study the problem."

"I hope these details and fancy points will discourage no one. Never forget that the poorest drag used in the poorest manner by a man who wants to learn will surely improve the highway."

The effect of proper use of the road drag is shown in plates VII and VIII. The second road (plate IX) is located in

Fig. 1. Road in Waupaca county. Low place which has not yet been graded and dragged with the "split-log."

Fig. 2. Same road showing the effect of use of the "split-log" drag.



A trench dug across a road which had been cared for with a "split-log drag." The original surface with the deep ruts is shown at C; the old surface before the "split-log drag" was used is shown at B; and the present surface, showing the amount of dirt brought in by the "split-log drag," at A. The middle of the road is at the farther end of the trench at the right side of the picture. Photograph used by courtesy of the Iowa Highway Commission.

Waupaca county and was one of the worst stretches in the c ıntry round about. It was low and almost always wet and soft. The road supervisor, Mr. Chas. W. Gibson, believed that he could better it and so graded it up with his road machine and conscientiously dragged it after every rain. The cost ·f putt.ng a very bad stretch of road in this shape may be of interest to other road supervisors and is here given.

The road was a single wagon track with brush growing right to the ruts to begin with. This brush was cut out and the road plowed. When the sods had dried they were shaken out and thrown to one side. Three teams and four men then took a grader and turnpiked the ¾ mile that was to be fixed. It took them one day and a half to do all this. After each rain, Mr. Gibson himself took three horses and a split-log drag and went over it several times. He estimated that he had spent a total of about three days time dragging. From this record it is evident that the total cost of making three-quarters of a mile of the best dirt road to be seen in the state was only about $25.00. After this the dragging alone will keep it in good shape and will cost not to exceed $6.00 per mile per year. When it is considered that the average road tax available throughout the state is over $30.00 per year for every mile, it is evident that our roads should be in far better condition than they are now. The way such a road stands heavy traffic is indicated in the following extract from a letter from Mr. Gibson received late in October.

"The road is in as good shape as when you saw it in July. Although there is much heavy traffic continually passing over it which together with the heavy rains of late caused me some uneasiness, nevertheless it stands the wear. It has been subjected to a severe test in that practically all the heavy hauling of potatoes to market from below our place to the amount of many loads a day has gone over it. Yet it stands the wear nicely."

Mud and Dust. Besides providing a smooth hard surface for the road, the use of some system of maintenance obviates, to a large extent, the mud and dust nuisances. Roads are muddy because ruts are allowed to form and hold water. This water softens the track, lets the wheels cut deeper and make ruts that can hold more water and thus make more mud. This mud is carried up by the wheels in chunks and dries in this form. After the road dries out the travel mashes these dry chunks and the sides of the ruts into fine dust. If the road is kept in good shape so that no water can stay on its surface, this alternate formation of mud and dust cannot take place.

Wide tires. The following statement regarding wide tires is taken from Bulletin No. 3 of the Ohio Highway Commission.

"A housewife that purchases a fine and costly gown, and then without any attempt at protection to the same, engages in kitchen or dairy work, will by all be considered very extravagant and foolish. This mistreatment is no more unwise or foolish than to subject a costly and well constructed macadam road to the destructive agency of heavily weighted, narrow tires.

Tests have again and again been made that prove, without a doubt, that wide tired wagons are of lighter traction or draft than those equipped with narrow tires. There is no disputing the fact that a wide tired wagon on bad roads, rutted by narrow tires, will be of heavy draft, for the reason that the wide tires require force to overcome the condition due to the action of narrow tires. Part of the expenditure of force required in moving loads on wide tired wagons over roads rutted by the use of narrow tires is due to the corrective effect of the broad tires on the bad conditions resultant from use of narrow tires and is properly a credit entry on the side of good roads.

The action of the wide tire, in a measure, takes the place of the improvement resultant from the use of the road roller. *Narrow tires on heavily loaded wagons are road destroyers.*

Rolling snow roads. From report of Maine Highway Commissioner.

The same loads carried on wide tires are road improvers."

Relative to the proper relation of size of load to width of tire the Pennsylvania Department Agriculture gives the following rule.

"The maxium weight that should be allowed per inch of width of tire should be 550 pounds. The width of tire should be increased proportionately with the increase in weight of load. *It must be understood that the width of tires do not affect the traction on hard roads, only the condition of their surface and cost of maintenance."**

Snow Roads. The greatest trouble with winter roads is the difficulty that drifting snow presents. The most common method of breaking a road after a heavy storm is to go over it with the pointed snow plow made of two planks set in the shape of a letter V. Good results are also obtained with a common steel toothed harrow or disc.

In many places they are using with marked success a large roller to pack the snow. One of these rollers is shown in plate IX from a plate in the 1905 report of the Maine Highway Commissioner. The cost of rolling is from 25 to 50 cents per mile. "The rolling must begin when there is from eight inches to a foot of snow on the road and each additional eight to twelve inches must be rolled. If side drifts are encountered they must be leveled. The rollers are ordinarily built twelve feet wide, thus making a double track road on any part of which teams can turn out for passing. After being compacted the snow freezes and becomes very solid and in consequence does not melt away as rapidly in the spring as does the loose snow along the side of the road. On this account the traveled part of the road lasts longer than the sides and therefore it is not necessary to drive in the ditches in the spring. As the snow melts over the ditches first, they are ready to take care of the surface drainage instead of the middle of the road acting as the gutter.

* Penn. Dept. of Agriculture, Bull. 69, p. 19.

The snow must drift less, too, on a rolled road than on one broken out by shoveling and piling on the sides. By the latter method each storm drifts the road full to the height of the snow which has been thrown out on either side. By rolling the road no snow is thrown out and consequently the drifting is less."*

*Report of Maine Highway Commission. 1905.

CHAPTER VI.

CULVERTS AND BRIDGES.

In a short pamphlet of this nature it is impossible to take up in any complete way the subject of country highway bridges and culverts. The subject of bridge and culvert construction is a very important one, however, and a few statements as to the general principles which may be of benefit to town officers are here given in a very preliminary manner. Later on the Engineering College of the State University intends to take up this matter definitely and prepare and publish standard plans and specifications for short span bridges and culverts, particularly those built of reinforced concrete.

At present it is very difficult for town officers to know whether or not the prices which they are paying for such structures are excessive; they are necessarily unfamiliar with such a complicated engineering subject as bridge construction and are therefore usually at the mercy of the bridge agents and other interested parties. The state should by all means have a highway officer whose duty it would be to aid towns and counties in such technical matters.

Size of Opening. Size of opening is the only difference between a bridge and a culvert. Some states have adopted a classification, naming as culverts all structures with an opening of less than 4 feet. An important feature in the planning of a bridge or culvert is a careful estimate of the amount of water for the passage of which it is necessary to provide. This is

always done by railroad companies in planning their structures and should be done for every highway structure as well. At present, however, this point is little appreciated by those who have the deciding power in determining the size and kind of structure to be built.

The amount of water that will come from a certain drainage area and flow through any culvert or under any bridge in a given amount of time is not to be determined with any high degree of accuracy, as it depends upon too many factors. However it can be determined sufficiently close to prevent such common occurrences as putting in a bridge of forty foot span where a ten foot span would be sufficient, or putting in a ten foot span where forty is needed. The factors upon which the quantity of water depends are (1) *area of drainage basin,* (2) *maximum rainfall per hour,* (3) *slope of the surface,* (4) *character of the soil—porous or compact.* It is evident that some of the more important of these factors are practically unknown. Even the most carefully kept weather records give the rainfall per day and not for each shower, which is the point of importance in determining the amount of water to be provided for. The amount of water which the soil will absorb may vary from a small percentage to almost the whole amount of the rainfall, depending upon its state of porosity at the time of the shower. However, certain satisfactory rules are used by the railroads, and any town or county constructing a bridge of any large size should secure, if possible, the estimate of a competent engineer who is familiar with rules concerning the size of opening required. Oftentimes this may be unnecessary, particularly for streams which are spanned by railroad bridges, as the highway bridge can be made to correspond to that of the railroad in size of opening. If the services of an engineer cannot be obtained some idea of the amount of water can be obtained by noting the high water mark as given by those who have lived longest in the locality and measuring the area of the cross section of the water in the valley at this place. This should be done where

the valley is narrow and the banks steep, so as to be as nearly as possible like the opening under a bridge.

Location of Bridges and Culverts. Although the location of bridges and culverts which are at present in use cannot profitably be changed, these structures are being almost continually replaced, and the structures with which they are being replaced are quite often of a better and more permanent character. In replacing any such structure the matter of securing a better location should be considered. A bridge which is correctly located will be more stable and less likely to settle or be washed out. The factors to be considered in choosing a location are:

1. The providing of a good solid foundation for the abutments.

2. Securing a place where the stream channel is as little subject to change as possible.

3. Placing the bridge or culvert so that the water can go through it without any change in direction.

The first factor is satisfied in most cases by a simple shifting of a few yards up or down stream in order to avoid quicksands. The second factor of a good location is secured by placing the bridge in such a position that the water comes to it in a channel which is straight for at least fifty yards up stream. According to this a bridge should not be located on a bend if it is possible to avoid it. If it is located so that the water has to change its direction the bridge or culvert is exposed to the eddies or washing of water where it turns to go through and is much more subject to washing out than one which is located properly. For this reason it is often advantageous to locate culverts in a diagonal direction across the road in case it is necessary to permit the water to flow alongside of the road for any distance.

CULVERTS.

Culvert Materials.—The common materials which are used for culverts are wood, vitrified tile, steel or cast iron tubing, concrete and stone. Wood is hardly worthy of consideration as

ordinarily used without any treatment to preserve it. The life of the ordinary wooden culvert is too short and it must be replaced so often that when the cost of its maintenance is considered it is more expensive than the more permanent forms.

Tile Culverts.—Double strength vitrified pipe is very satisfactory for small culverts, providing it can be laid deep enough so that it will not be crushed by traction engines and other heavy loads. This depth will, of course, vary in different circumstances. If the road is of macadam or gravel construction and does not rut, twelve inches between the top of the pipe and the surface of the road will be sufficient—if too heavy engines or rollers are not used. In the case of a clay road, which ruts deeply and is poorly cared for, there should be at least two feet of earth over the top of the pipes. The failure of tile culverts is due also to the fact that they are so often laid improperly. The following rules should be followed carefully in laying tile culverts: (1) The trench should be cut rounding on the bottom so that pipes rest solidly at all points along their length on the undisturbed earth. (2) The joints should be filled with cement mortar to prevent the escape of water through them, which might wash away the earth surrounding the pipe. (3) The ends of the tile where they project at the sides of the road should be protected with a wall of some sort, at least of plank or loose stones placed around them, but preferably of masonry or concrete. If built in this manner a tile culvert is a good permanent improvement to the road and not one which will have to be renewed every few years.

Steel and Iron Culverts.—Steel pipe culverts are of less value than cast iron because they are much more subject to rust. Another objection to steel culverts is that they are usually made of very light steel and although they are well able to support the load upon them when they are new, they are so reduced in strength by the rust of a few years that they must be replaced. Cast iron culverts rust out much more slowly and usually give very good service. The cost of these

cast iron culverts, however, is in almost all localities higher than that of carefully built tile or concrete culverts. In cases where careless methods of construction of tile or concrete culverts are the rule the cast iron culverts will probably give much better satisfaction. Where tile culverts are properly constructed they are more permanent and cheaper in first cost than the cast iron.

The cast iron culverts are made in two general forms: The solid cast tubes and the sectional three-piece forms which usually have a triangular cross section. Of these triangular forms the ones which nearest approximate a circular cross section are the best, since it is undesirable to have the section of the culvert grow smaller as the water rises higher in it. The triangular form will accommodate a large amount of water when the water is low, and as the water rises the space becomes narrower and the water is held back, instead of having provided for it a wider channel of flow as it rises. The prices given by the manufacturers of the rounding forms and the triangular forms are given on page 66. The rounding forms must be made heavier to stand the same weight and are therefore more expensive, but the same size will carry more water than the corresponding size in a triangular form.

Stone Culverts.—In many parts of the state where large flat stones are available stone culverts can be constructed at a relatively low cost and make a good permanent feature of the road. They should ordinarily be provided with a stone floor and an apron wall at each end extending down into the soil at the side of the road to prevent them from under-mining and washing out. In the eastern and southern parts of the state are many limestone quarries from which large flagstones can be secured to make the tops, thus doing away with the necessity of constructing an arch.

Concrete Culverts.—Concrete culverts are probably the best and most permanent that can be constructed. They are easily made by any intelligent road supervisor after a little instruc-

tion from one who is familiar with concrete work. If properly made they are better the older they get.

It has been found that by imbedding steel "reinforcing bars" in the lower part of a flat sheet or beam of concrete where cracks first develop in breaking, that such beams can be made much stronger. This principle is used very extensively and large structures are made of this "reinforced concrete."

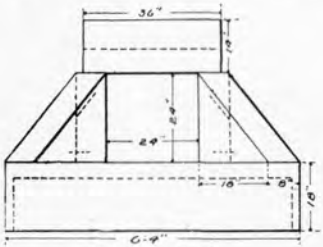
In building culverts or bridges of concrete they can either be built with arched tops without reinforcing or with flat tops using reinforced bars. In smaller types of culverts it is cheapest and most satisfactory to make them of the arched type, as this does away with the extra expense of putting in the reinforcing bars. The small extra amount of concrete which is necessary is not sufficiently great to offset the extra labor and cost of putting in reinforcing bars. For the larger types—those with an opening of over two feet—it is often more economical to use the flat topped forms and the reinforced construction. Plate X shows one of the standard forms of flat topped reinforced concrete culverts prepared by the Iowa Highway Commission. They have made standard plans for various sizes of these culverts up to 24 foot span, which show, as in this particular plate, the amount of reinforcement required and just where it is placed. The College of Engineering of the State University plans to make standard designs for such culverts and bridges for use in this state. For the small arched top culverts forms may be made quite cheaply in the manner described on page 68. The best form for small culverts which I have seen, however, is one which was exhibited at the road school held at Ames by the Iowa State Highway Commission. The makers of this mould, C. W. Overturf & Co., of Dumont, Iowa, have very kindly furnished the accompanying cut, figure 1, and the table of sizes, amounts of materials needed, and price of mould. The mould is composed of a sheet of heavy galvanized steel bent into cylindrical shape and held together along the edges by bolts which are removed after the concrete has set, the steel being then

LOADING

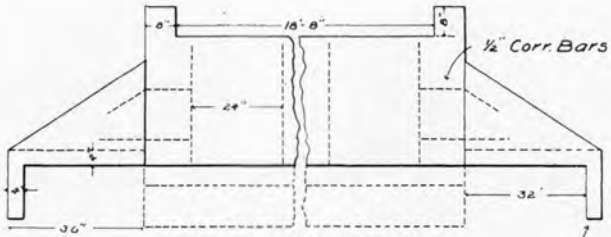
ULL - 100 lbs. per sq. ft.

CLL - 20-ton Roller

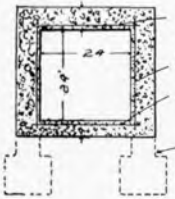
DL - 500 lbs. per sq. ft.



END VIEW



ELEVATION



CROSS SECTION

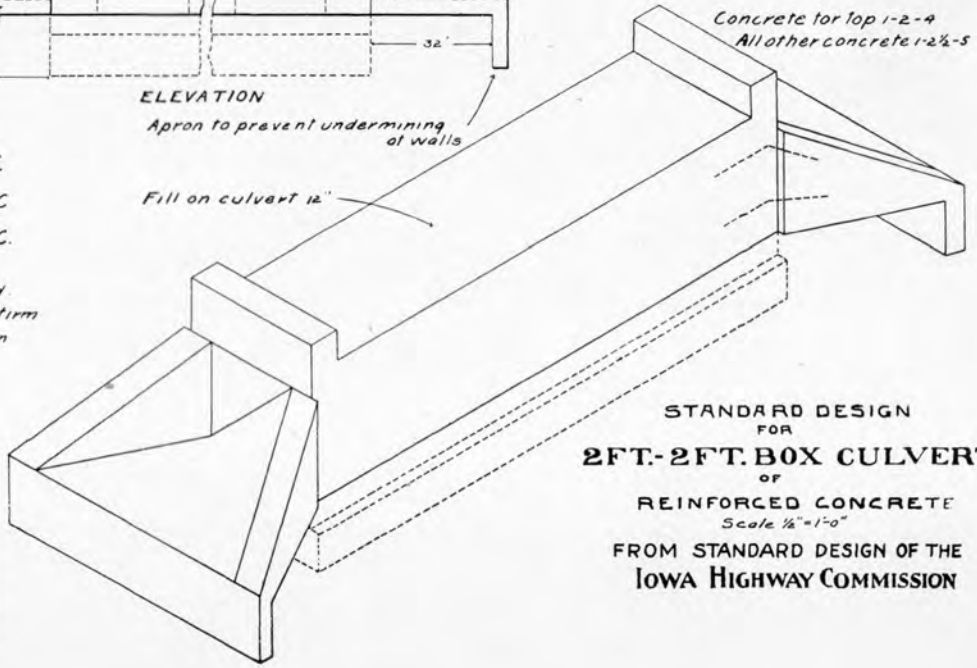


TABLE OF QUANTITIES

Item	For Culvert As shown.	For Each Add'l Foot in Length
Concrete 1-2-4	32.7 Cu. Ft.	1.6 Cu. Ft.
" 1-2½-5	83.6 " "	3.0 " "
Cement	5.7 Bbls	0.23 Bbls.
Sand	1.9 Cu Yds	0.08 Cu. Yds.
Broken Stone Pebbles	4.0 " "	0.16 " "
Corr. Bars ½" x 30"	60 Bars.	3 Bars
Corr. Bars ½ x 24"	8 "	
Total Corr. Bars	166 Ft =	141 Lbs.

STANDARD DESIGN FOR 2FT.-2FT. BOX CULVERT OF REINFORCED CONCRETE

Scale ½" = 1'-0"

FROM STANDARD DESIGN OF THE IOWA HIGHWAY COMMISSION

rolled into a more compact form to separate it from the walls so that it can be easily pulled out. This makes practically a concrete pipe culvert in a single piece.

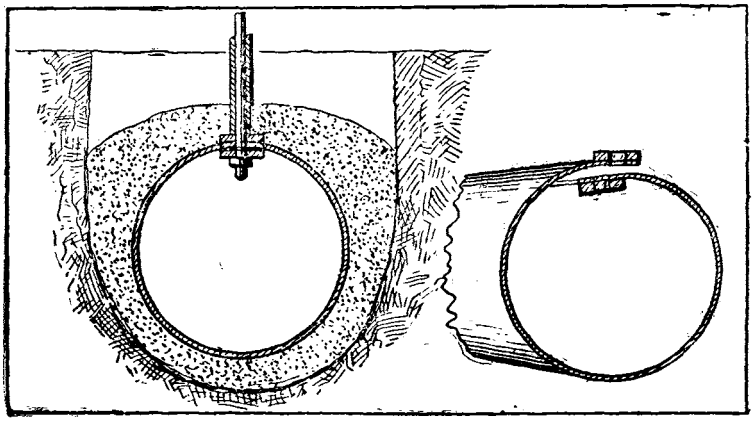


Fig. 1.—Overturf steel mold for concrete culverts.

TABLE VIII.

MATERIALS REQUIRED FOR DIFFERENT SIZED CULVERTS MADE WITH THE OVERTURF MOLD.

"These figures are made on the basis of 18-ft. culverts, with coping to extend two feet from waterway through culvert, and concrete in proportion of one part cement and seven parts gravel or sand."

Diameter of culvert.	Thickness of bottom.	Thickness of sides.	Thickness of top.	Amt. of sand required.	Amt. of cement required.	Width to dig trench.
8-inch	3 inches	4 inches	4½ inches	30 cu. ft.	465 lbs..	16 inches.
11-inch	3 inches	4 inches	5 inches	36 cu. ft.	558 lbs..	19 inches.
13-inch	3 inches	5 inches	6 inches	48 cu. ft.	744 lbs..	23 inches.
15-inch	4 inches	5 inches	6 inches	59 cu. ft.	915 lbs..	25 inches.
19-inch	4½ inches	5½ inches	6½ inches	85 cu. ft.	1,317 lbs..	30 inches.
22-inch	4½ inches	5½ inches	6½ inches	90 cu. ft.	1,395 lbs..	33 inches.
37-inch	5 inches	6 inches	7 inches	124 cu. ft.	1,922 lbs..	49 inches.

"Under ordinary conditions, with cement at 65c. per hundred pounds, the cost of this kind of concrete work is close to 14c. per cubic foot of concrete used, and as cement in the proportions mentioned does not increase the bulk of gravel, to estimate the cost of any sized culvert, completed, multiply the estimated amount of gravel in cubic feet by .18—this will give

the cost completed. Multiply by .11 to get the cost of material, by .14 for cost of material on ground, and by .04 to get cost of labor."

TABLE IX.

DIAMETER, WEIGHT AND PRICE OF OVERTURF MOLDS.

Diameter of mold.	Gauge of steel.	Weight per foot.	Price per foot.
Eight inch	20	3 lb.	$0.75
Eleven inch	20	5 lb.	.85
Thirteen inch	20	6 lb.	1.05
Fifteen inch	18	9 lb.	1.25
Nineteen inch	16	13 lb.	1.55
Twenty-two inch	16	17 lb.	1.75
Twenty-seven inch	14	25 lb.	2.65
Thirty-six inch	14	40 lb.	3.40

For culverts over two feet in diameter the use of these collapsible moulds is less advantageous than the use of the square wooden moulds, with which steel reinforcing bars can be applied, and with which therefore less concrete is needed.

CONCRETE.

A matter of fundamental importance in concrete work is the kind of cement used. Cements are ordinarily classed as portland and natural. The portland cement is made by burning and grinding together certain definite proportions of pure limestone and clay. This results in a product of uniform strength. The natural cements are made by burning and grinding certain naturally impure limestones which are approximately of the proper composition. As these natural cement rocks are never even in their composition, the cement manufactured from them is for this reason never as even in its qualities as the portland cement. Consequently portland cement is the only kind which can be depended upon to give sufficiently uniform results to make it worth while using it in bridge and culvert work.

Concrete is made by mixing together cement and crushed rock; or cement, sand and gravel. There is so little advantage in using crushed rock in place of gravel that in ordinary cases

the one which is most easily obtainable should be used. If either can be had at the same price the crushed rock should be used. The gravel or crushed rock should have enough of small particles or of sand so that the spaces between the larger pieces will be completely filled. If they are not completely filled there will be vacant spaces left which will weaken the concrete. The custom is to use about one part of small material to two parts of coarse.

If gravel is used it is very important that all clay and loamy material be screened out. This can be done on an ordinary plaster's screen at an expense which will be well repaid by the better character of the concrete produced. This screening also enables sand to be mixed with the gravel in more exact proportions.

Mixing.—Concrete may be mixed either by machinery or by hand. In mixing by hand a tight board platform is used to spread the material on. The dry sand is laid in a long heap and cement spread evenly over the top of it. Pairs of shovelers working opposite then turn the sand and cement over in such a manner as to mix it thoroughly. This process should be gone through with a number of times so that the cement will be thoroughly mixed with the sand. After it is thoroughly mixed the heap should be moistened and mixed again until it is of the same consistency throughout. The broken stone and gravel is then put on and mixed with the mortar.
Iowa Highway Commission recommends a wet mixture (which is one containing all the water it will hold) for ordinary use especially where the slab of concrete is to be thin. The forms must be practically water tight for such a wet mixture, however, or the water will escape and carry with it considerable cement.

If there is much concrete work planned it is economical and also better to use a mixing machine as the resulting concrete is more uniform.

Filling the Forms.—After it is thoroughly mixed the concrete can be shoveled into the forms. The mixing board should

if possible be so close by the forms that the concrete can be shoveled in directly without the necessity of using wheelbarrows. It should be deposited in layers of 6 inches inches thickness and thoroughly rammed into place so as to fill the forms tightly and leave no open spaces in the finished work. It should not be thrown any considerable distance as this will cause the heavy pieces to settle and will therefore destroy the uniformity of the mixture. When work is left unfinished over night the surface should be left as rough as possible so that the new concrete will make a good bond. At the beginning of the next day's work the surface should be cleaned and wet and a little cement sprinkled over it.

The strength of concrete, and consequently its durability, depends upon four factors: (1) the quality of the cement, (2) texture, (3) the proportion of cement used, and (4) the density of the concrete. To insure uniform *quality* portland cement should be used for the reason stated above. A concrete of the proper *texture* is secured by mixing the sand and gravel, or the large and small sizes of crushed stone so that the spaces between the larger pieces are completely filled. The *proportion of cement* used is a matter of choice. The *density* of the concrete depends upon the mixture used and somewhat upon the care with which it is tamped into the mould. The following table gives the strength of portland cement mortars of various compositions.

TABLE X.

STRENGTH OF PORTLAND CEMENT MORTARS IN COMPRESSION. AGE 4 MONTHS. (*Watertown Arsenal*).

PROPORTIONS BY VOLUME.		Compressive strength pounds per square inch.
Cement.	Sand.	
1	1	4,370
1	2	2,506
1	3	1,812
1	4	830
1	5	532
1	6	169

From this table it appears that the strength of a mortar of one part of cement to three of sand—a "1:3 mixture"—is over twice that of a mortar having one part of cement to four of sand. If concrete of differing strength is needed for different parts of structures, such mixtures are used as will give the strength required. The Iowa Highway Commission gives the following proportions as a guide for general practice:

For arches and flat tops for culverts;

1 part cement, 2 parts sand, 4 parts broken stone; or
1 part cement, 1½ parts sand, 4 parts screened gravel.

For wing walls, or piers or abutments:

1 part cement, 3 parts sand, 6 parts broken stone; or
1 part cement, 2 parts sand, 5 parts screened gravel.

Where a gravel concrete is used engineers ordinarily require about ten per cent additional cement to be used over broken stone concrete."

In determining what the cost of a concrete structure will be it is necessary to know the amounts of material which go to make up a cubic yard of finished concrete work. Cement should be measured in its packed bulk, not as loosely poured out. A sack of cement is just about 95 per cent of a cubic foot.

Table XI gives the proportions of cement, sand and stone to make a cubic yard of concrete.

TABLE XI.

QUANTITIES OF MATERIALS FOR ONE CUBIC YARD OF RAMMED CONCRETE
Cement=3.8 cubic ft. per barrel.

PROPORTIONS BY VOLUME.			PROPORTIONS BY BBL. AND CU. YD.		
Cement.	Sand.	Stone.	Bbl. cement.	Cubic yards of sand.	Cubic yards screened gravel or broken stone.
1	2	4	1.75	0.44	0.88
1	2½	5	1.3	0.46	0.92
1	2	5	1.19	0.47	0.94

In making small culverts where the mixing is done by hand four men can work to advantage and should mix and put in place seven or eight cubic yards in ten hours, providing the forms are already built and the materials are close by the work.

BRIDGES.

The materials of which bridges are made are wood, steel, stone, and concrete. A large proportion of the highway bridges at present being erected are of steel. Lumber has been so high as almost to prohibit its use as a bridge material and the use of concrete has not become so common as the merits of the material warrant. It is difficult for any custom in bridge building to be changed because of the large number of people who must be convinced of the value of the change. There are over four thousand town and county officers having to deal with bridge construction and the adoption of any new method must necessarily be slow. However, it is to be hoped that the use of concrete will extend more rapidly.

Causes of Failure of Bridges.—When one stops to consider the matter it is strange what a small number of bridges can be named that have "died a natural death" from decay. Even the old wooden bridges that one remembers, which ordinarily rot out in the course of fifteen years, were almost all destroyed by floods or by undermining before their period of usefulness was ended by natural decay. There are three chief causes for the failure of a bridge. These are, (1) *natural decay,* (2) *floods which lift the bridge bodily and carry it away,* and (3) *poor abutments* which are easily undermined by a moderate freshet, letting the bridge down and destroying it. Of these three causes the blame for a very large portion of bridge destruction is due to poorly constructed abutments. The common practice in building abutments is so well stated in a letter which was received from a gentleman of Orfordville, Wisconsin, that it is here quoted:

"I enclose a table (table XIV) which I hope will give you an idea of what we are doing in the line of bridges. I will

say that bridge No. 1 was built in quicksand by laying a plank on the sand, then building cement abutments on the plank with the expectation that they would settle into the sand enough to give a good foundation. This answered very well as long as we had no heavy rains, but the heavy rains of last August undermined the abutments, they toppled over and the bridge went into the ditch. Bridge No. 6 is being built in its place.

This same rain undermined the "mud sill" at one end of bridge No. 2 to a depth of five feet, allowing that end of the bridge to settle about three feet. This was raised with jack screws and the excavation filled with rock. We have now concluded that the only practical foundation for these small bridges when they must be built in mud or quick-sand is the "tubular pier," consisting of steel tubing well sunk into the soil with pile driven inside and the space filled with thin cement. As suggested in your former communication, the mud sill bridges were used at the suggestion of the bridge firm and to the sorrow of the tax payers.

However, I wish to say before closing that I am not a member of the town board, and never have been, consequently have had nothing to do with these bridges, but am a tax-payer and have watched these matters quite closely. We know that no farmer would think of building a $600.00 building on "mud sills," especially if the building were to span a stream, but when it comes to building bridges when the town foots the bill, we have a different proposition."

In the same manner as strong emphasis was laid upon the necessity for having a solid foundation for a road, so must strong emphasis be laid upon the necessity of having good foundations for bridges. If the foundations of a bridge are so constructed that the water can undermine them easily, or can wash out behind them leaving the bridge standing in the midst of a stream with no approaches, the tax-payer can figure on the fact that taxes to the amount of the cost of this bridge have been thrown away, as it will soon have to be replaced.

Steel Bridges.—In letting the contract for the construction of an ordinary steel highway bridge it is impossible for the ordinary town board to draw up proper specifications. For those who are interested in looking up this matter it is suggested that they can refer to the specifications for highway bridges which are issued by the American Bridge Co. These specifications are those which are used by that company in their bidding and insure a bridge of good grade. Other bidders should be made to furnish material and designs of an equal grade in puting in competitive bids.

It is advisable that counties and towns should adopt some standard form for the ordinary small bridges, such as the Engineering College of the State University plans to provide at an early date. With such standard plans it will be unnecessary to have special designs drawn for each span, and bidders will be placed on an equal plane with regard to the material which they must furnish.

As many bridges made of steel I beams are being erected the following table published by the state engineer of New York is here given in order to impart an idea of the depth and weight of beams necessary for spans of various lengths. If plank floor is used the depth need not be quite so great, as the depths given are for concrete or stone slab floors. The spans are designed to support a 10 ton traction engine or road roller.

TABLE XII.

SHOWING SIZES AND WEIGHTS OF I BEAMS TO BE USED FOR VARIOUS LENGTHS OF SPAN FOR BRIDGES OR CULVERTS, USING STONE OR CONCRETE SLABS.

Depth of I beam. Inches.	Width of flange in inches.	Weight of I beam per foot of length. Pounds.	Thickness of web of I beam. Inches.	Limiting Lengths of Spans.	
				I beams spaced 2 feet between centers.	I beams spaced 3 feet between centers.
				ft. in.	ft. in.
5	3	9¾	0.21	4 6	3 6
5	3⅛	12¼	0.36	5 0	4 0
5	3 5/16	14¾	0.50	5 6	4 0
6	3 5/16	12¼	0.23	6 6	5 0
6	3 7/16	14¾	0.35	7 0	5 6
6	3 9/16	17¼	0.48	7 6	6 0
7	3 1/16	15	0.25	8 6	7 0
7	3¾	17½	0.35	9 0	7 6
7	3⅞	20	0.46	9 6	7 6
8	4	18	0.27	11 0	8 6
8	4 1/16	20½	0.36	11 6	9 0
8	4 3/16	23	0.45	12 0	9 6
8	4¼	25½	0.54	12 6	10 0
9	4 5/16	21	0.29	13 6	11 0
9	4 7/16	25	0.41	14 6	11 6
9	4⅝	30	0.57	15 6	12 6
9	4¾	35	0.73	16 6	13 6
10	4 1/16	25	0.31	16 6	13 6
10	4 3/16	30	0.46	17 6	14 0
10	4 5/16	35	0.60	18 6	15 0
10	5⅛	40	0.75	19 6	16 0
12	5	31⅓	0.35	21 0	17 6
12	5 1/16	35	0.44	21 6	18 0
12	5¼	40	0.46	22 6	19 0
15	5½	42	0.41	27 6	23 0
15	5 9/16	45	0.46	28 6	23 6
15	5⅝	50	0.56	29 6	24 6

Stone Bridges.—Stone bridges are gaining in favor in the state wherever building stone suitable for such purposes is obtainable. Owing to their greater cost than wooden bridges, they have been comparatively little used up to recent years, but the desire for permanent structures and the increased cost of lumber have both aided in promoting the use of stone. Stone bridges are as permanent as any structure can be made, if properly built. If any large sum of money is to be invested in such an undertaking careful plans should be made and the construction inspected in order to see that the masons are doing their work in such a way that it will last. Bridges which were built by the Romans nearly two thousand years ago are still in use, and if stone bridges are constructed carefully today there is no limit which can be set upon their length of life.

Concrete Bridges.—The use of concrete as a bridge building material has been developed comparatively recently. The whole subject of reinforced concrete is relatively new and it is not strange, therefore, that so few highway bridges are built of this material. A properly built concrete bridge is, as a general thing, cheaper than stone, and while more expensive than steel, is a structure which grows better with age rather than rusting out as steel is bound to do. Owing to the desirability of issuing this bulletin at as early a date as possible it was found impossible to prepare designs or to give exact information as to proper methods of construction of concrete bridges here. These will be given in the previously mentioned plans to be made by the Engineering College. The concrete for use in bridge structure is prepared as indicated on pages 58 and 59 for concrete culverts.

LIFE AND COST OF BRIDGE AND CULVERT MATERIALS.

Life of Bridges and Culverts.—Any statement of the life of ordinary materials for bridge and culvert construction must be largely guess work in which the factor of experience comes in to make the guess valuable. The common practice of railroads would make the life of the ordinary wooden bridge about

fifteen years, providing it is not washed out by high water. The ordinary highway wooden bridge, however, is very often subject to destruction on account of insecure foundations which are washed out long before the bridge has had time to decay.

Wooden culverts are subject to very rapid decay and are ordinarily replaced every three or four years.

Steel bridges are much more durable than wood and it is difficult to set any limit upon their life which will be even approximately accurate. Under favorable circumstances a bridge may last 75 years. The ordinary, light, flimsily constructed highway bridge, is not likely to last more than fifty years even if well cared for. The main cause of steel bridges giving away is the fact that they are so often erected upon easily destroyed abutments. If the abutments are secure the difficulty then comes in keeping free from moisture the covered portion of the bridge immediately under the floor. The floor of the bridge provides shade and protection so that dampness is almost continuously present, and this dampness rusts the steel rapidly. The life of the bridge can be prolonged if it is properly painted every few years. In repainting the bridge care should be taken to see that all the rust scale is cleaned off and the clean surface exposed.

Steel culverts are much shorter lived than bridges because of being continually surrounded by dampness. One steel culvert company estimates the life of their steel tubing at 35 years, and this estimate is undoubtedly made as favorable to their culvert as it could be. Cast iron culverts are longer lived and and are often sold under a guarantee of 25 years.

Culverts and bridges constructed of tile, stone and concrete are in the highest sense permanent. If they are properly constructed and cared for they improve in stability with age.

Costs of Bridges and Culverts. It is impossible to give any general statement of the cost of wooden culverts and bridges, as the materials and labor vary so widely in price in different parts of the state. It was not found possible during the prepar-

ation of this bulletin to obtain detailed costs of bridges in Wisconsin. The following prices for cast iron sectional culverts were furnished by the manufacturers. The Isham-Miller is a round form and the other is triangular.

TABLE XIII.

The Isham Miller Co., Butternut, Mich.		The Beach Mfg. Co., Chalotte, Mich.	
Diameter.	Price per foot.	Diam.	Price per foot.
10 inch	$1 25	10 inch	$1 70
15 inch	1 75	14 inch	2 50
20 inch	2 75	16 inch	3 00
25 inch	4 00	18 inch	3 50
30 inch	4 75	25 inch	5 00
35 inch	6 00	30 inch	7 50
45 inch	7 50	36 inch	9 00
		48 inch	13 00
F. O. B. cars at factory. Discount: not quoted.		Net F. O. B. factories. Discount 50 per cent.	

Table XIV which accompanied the letter quoted on page 60 gives the cost of steel bridges of various lengths and types in Rock County, Wisconsin. By referring to the letter on page 60 it is noticed that bridge No. 1 was washed out and is being replaced by No. 6. The reason for the increase of span from 16 feet to 38 feet is not given, nor the reason for thus magnifying the cost from less than $200.00 to $800.00 or $900.00. Even though the length of bridge No. 1 might have been too small to accomodate all the water, it is doubtful if an increase in length of nearly 200% was necessary.

TABLE XIV.

Bridge.	Type.	Length.	Width.	Foundation.	Cost.
No. 1..	Steel stringers.	16 ft.....	16 ft.....	Cement abutments.	$56.25 for steel alone.
No. 2..	Steel truss.....	40 ft.....	13 ft.....	Steel legs resting on "mud sill."	$575.00 including plank but no backing at end nor grading.
No. 3..	Steel truss.....	40 ft.....	16 ft.....	Tubular piers..	$695.00 including plank but no backing nor grading.
No. 4..	Steel truss.....	30 ft.....	16 ft.....	Tubular piers..	$695.00 including steel backing and steel wings.
No. 5..	Steel truss.....	30 ft.....	16 ft.....	Cement abutments.	$435.00 for steel alone; $219.00 for abutments.
No. 6..	Steel truss.....	38 ft.....	16 ft.....	Tubular piers...	$1,360.00 for the two bridges including steel backing and wings; no plank or grading. These last two bridges are under construction at the present time.
No. 7..	Steel truss.....	46 ft.....	16 ft.....	Tubular piers...	

"They are all warranted to carry 100 lbs. per square foot or 1,600 lbs. per running foot. Our township buys its plank by the carload at $25.00 per M; this is oak plank known as 'swamp oak.'"

The cost of two steel bridges in Marquette County is here given by Mr. W. W. Johnson of Packwaukee:—

1. Nine stringers of 8 inch I beams, spaced 22 inches; span 26 feet; no truss; cost of bridge delivered including railing	$92.00
Cost of abutments	76.00
Three inch plank for flooring and extra plank for engines	42.00
Total	$210.00

2. Stringers, 7 inch I beams; 9 foot span; cost of bridge delivered including railing	$60.00
Cost of stone abutments pointed with cement and caps to retain embankments	68.00
Plank	18.00
Total	$146.00

The following figures for some Wisconsin concrete culverts are also given by Mr. Johnson.

Culvert No. 1 Stone walls, laid dry, pointed with mortar made of one part portland cement and three parts sand; the arch immediately over the form composed of two inches of the same mixture, and then filled up with a mixture of 7 gravel and sand to 1 portland cement. Finished with two inches of a mixture composed of two parts coarse sand to 1 of cement. Retaining walls on each end of the same proportion.

Cost of stone	$ 6.00
5 barrels cement	10.00
Sand and Gravel	2.00
Work	10.00
Total	$28.00

This culvert was then covered with three inches of sand and six inches of clay. The form on which this was built was made of 6 inch lengths sawed from a log and halved these half rounds being covered with two-by-fours. The whole was supported on legs under which blocks were placed to be knocked out when the cement had set. A larger sized culvert of the same plan is being built in the same town on a form made by using felloes of a wagon wheel covered with plank. This size of culvert will cost about $18.00 more than the smaller size built on logs. The width of the larger is 4 feet 8 inches. Mr. Johnson did not give the length of the culverts or the size of opening of the smaller one.

These costs are not so detailed and therefore not so valuable

as the following tables from the 1906 Manual of the Iowa Highway Commission.

TABLE XV.

FLAT TOP CULVERTS OR BRIDGES.

County.	No.	Span.	Reinforcement.	Cost.
Blackhawk	4 bridges..	26 ft. clear		$3,150 00
	2 bridges..	23 ft. clear	1 per cent X sec. area*	2,480 00
	1 bridge ..	20 ft. clear	1 per cent. sec. area	460 00
Boone		14 ft. clear	2,000 lb. I beams, 7 I. s	271 00
Bremer	4 bridges..	12 to 16 ft	R. R. rails and ¾ in. to 1¼ in. steel rods ave. 5 ft. span	125 00
Greene		16 ft		400 00
		5 ft	60 lb. R. R. rails	195 00
Dickinson		5x5 ft.	Top ¾ in. round rods 2 in. c. to c cu. yd	6 00
Humboldt		4 ft	30 ft. long	165 00
Hamilton		2x2.	38 ft. long, barbed wire	76 40
		2x2	40 ft. long, barbed wire	79 90
Poweshiek		4 ft.	60 ft. long, steel bars concrete $7.50 per yard	750 00
Story		4x6	16 ft. roadway	300 00
Washington		3 ft.	3 in. gas pipe 18 in cc	190 00
Woodbury		6 ft.	60 ft. long, bars and wire mesh. ing	600 00

*This means that the cross-section of the reinforcing bars is one per cent. of the total area of the cross-section of the reinforced concrete slab.

TABLE XVI.

ARCHED TOP CULVERTS OR BRIDGES.

County.	No.	Span.	Reinforcement.	Cost.
Blackhawk		17.5 feet	1 per cent sec. area, Thatcher bars	$1,200 00
Bremer	6	6-8feet	Barbed wire ave	7
Hamilton		6x5 feet 3 in	40 feet long, 200 lb. barbed wire	28
		5x6 feet 4 in	40 feet long, barbed wire	30
		3x4 feet 6 in	40 feet long, 120 lb. barbed wire	30
Story		5 feet		370 00
Tama		3-6	$.45 per cu. yd	
Woodbury		12 feet 8¾ in. x 22 ft. 6 in	Johnson	
		20 ¾ in. x 14 feet.	Johnson	800 00
Worth		16 feet.	None	210 00
		8 feet	None	75 00

TABLE XVII.

BRICK AND STONE ARCHES.

County.		Cost.
Boone	Brick arch, 5 ft. span, 50 ft. long	$350 00
	Stone arch, 5 ft. span, 30 ft. long	164 00
Union	Brick arch, 6x6—20 ft. long, $13 00 per ft	260 00
	Brick arch, 6x6—26 ft. long, $15.00 per ft	328 00

"*Cost of Concrete Work.* Particular attention is called to the range in prices as given for the different counties. This may be accounted for in a measure by the variation in price of the materials delivered, and also the relative difficulty of pursuing the work under conditions imposed by the location of the structures. However, these reasons are not altogether satisfactory when the range of prices is so wide. For instance, one county reports the work to cost 35c per cubic foot, which means $9.45 per cubic yard. A good example of the reasonable cost of concrete work under favorable circumstances is the reinforced concrete bridge reported from Boone county. The abutments and wing walls are about seven feet high and eighteen inches wide on top, with a batter of about ½" to the foot on the outside. The top is a 14" slab of concrete with a clear span of fourteen feet reinforced with seven 6" I beams having their ends imbedded in either abutment. There is a 16 foot roadway with a 10" felloe-rail on either side and a two-rail gas pipe railing. Sand and gravel cost $1.00 per cubic yard and cement $2.00 per barrel plus haulage. The structure completed cost $271.00."

"The following itemized statements of concrete work are taken from a paper read before the Iowa Good Roads Association by Henry Haag, supervisor of Greene County:—

TABLE OF ITEMIZED COSTS.

8 ft. by 8 ft. Reinforced Concrete Culvert.

Foundation required piling and three feet of excavation below bed of stream.

40 yards river gravel hauled 3½ miles at 75c	$30.00
40 bbl. Portland cement at $2.00	80.00
7 pcs. 7-inch I beams, 1,070 lbs. at $1.00	10.70
800 lbs. old junk, rods and bars at 60c per hundred	4.80
28 Stub piling, 10 feet, at 50c. each	14.00
3 men and team two days driving piling at $6.00	12.00
4 men excavating two days at $1.50	4.50
Use of lumber and wastage in forms	15.00
Hauling piles, pile driver, lumber, cement and tools	8.00
Filling in bridge and completion, 2 men and team one day	4.50
2 men 1 day taking off forms and false work at $1.50	3.00
	$225.50

"The cost of the concrete in this bridge was $6.00 per yard, there being 33 yards of concrete in the bridge as follows:—

Foundations contained	232 cu. ft.
Walls and wings	393 cu. ft.
Slab floor	220 cu. ft.
Wheel guard	43 cu. ft.
	887 cu. ft. or 33 yds.

"The following is the cost of different items per yard:—

Cement	$2.40
Labor	1.75
Steel	.45
Gravel	.90
Lumber	.50
	$6.00

TABLE OF ITEMIZED COST.

7 ft. by 8 ft. Reinforced Concrete Culvert.

Foundation on blue clay three feet below bed of stream.

8yds. pit gravel donated and used in foundations.	
50 yds. river gravel at $1.00	$50.00
65 bbls. portland cement at $2.00	130.00
Kahn trussed bars for reinforcing slab floor	50.00
2,400 lbs. old junk rods, bars and angles at 60c.	14.40
Excavation, 2 teams, 3 men, 3 days at $8.00	24.00
Lumber, use of, wastage for forms	20.00
Considerable bridge lumber that we had on hand was used, joists, etc., not damaged and no charge was made against the work.	
Building forms	10.00
4 men, 6 days, at $2.00, mixing concrete	48.00
Man and team at $3 00 hauling water, gravel and cement to mixing board, 6 days	18.00
2 men 1 day, taking off forms	4.00
Team hauling lumber and tools back	3.00
Filling in dirt on and around bridge after completion, 2 teams one day at $3.00	6.00
Total cost	$385.40

"The cost of the concrete in this bridge was $7.30 per yard, there being 53 yards of concrete in the bridge, as follows:—

Foundations contained	220 cu. ft.
Walls and wings	612 cu. ft.
Wheel guard	85 cu. ft.
Hand rail	100 cu. ft.
Slab floor	396 cu. ft.
	1,413 cu. ft. or 53 cu. yds.

"The following is the cost of the different items per yard:—

Cement	$2.35 per yard
Gravel	1.00
Labor	2.30
Steel	1.15
Lumber	.50

While it was not possible to obtain much information as to the cost of bridges in Wisconsin each town board will know what their structures are costing them and can compare costs with the figures given here for these Iowa bridges and culverts In making such comparisons the length of life of the structures whose costs are compared must be continually kept in mind.

CONTOURS.

In dealing with bridges, culverts and general drainage problems as well as in location of roads, the lay of the surface of the country is of such great importance that a short explanation is given to show the common method of indicating the irregularities of the surface. The accompanying cut, fig. 15, is taken from one used by the United States Geological Survey in explaining the use of contour lines. The figure includes an ordinary view as seen by the eye and a map of the same object. The contours which are shown on the map are lines on the surface which are drawn so that all points on a single line are at an equal distance above some level surface, which is usually taken as sea level, as indicated in the figure by the level of the water. A conception of the way these lines appear can be obtained if the water in the bay were imagined to rise by 50 ft. intervals, stopping long enough at each interval to enable the shore line to be traced. All points in this shore line would evidently be at the same level. A succession of lines thus drawn covering the country as closely as desired enables one who understands such a map to tell at once the slope of the ground, whether it is steep or gentle, and the extent of the drainage area of any stream. It is evident that where the surface of the land is steep, as on the face of the hill, the water would not go shoreward much in rising the 50 feet between contours and the contours would consequently be close together. While in places where the slope of the land is gentle the water would move shoreward a much longer distance in rising the 50 feet and the contours would be a much greater distance apart on the map.

Therefore in reading a contour map it is evident that widely spaced contours indicate gentle slopes while closely spaced contours indicate steep slopes.

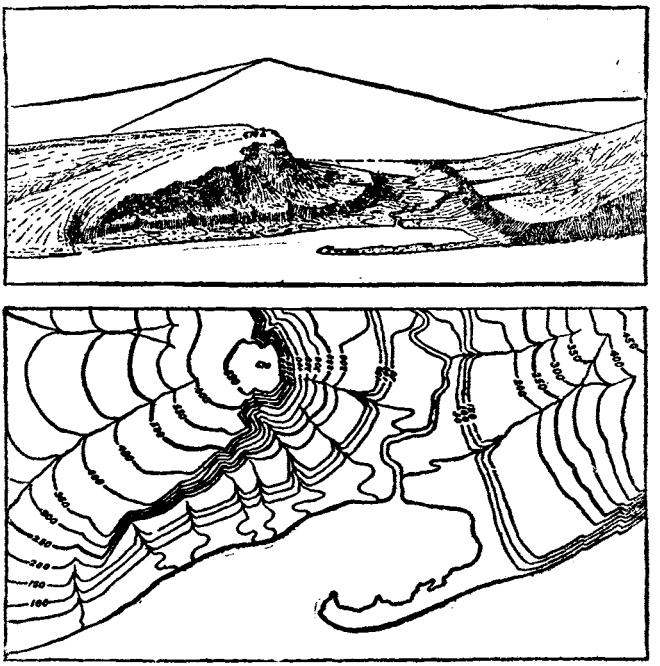


Fig. 2.—Cut showing a view of hills and a stream valley with a contour map below. From U. S. Geological Survey.

Such maps have been made of a considerable area in the southern part of the state by the United States Geological Survey, and it is hoped for the purpose of aiding in good road work that they may be extended rapidly to cover the whole state. They are usually made, however, only on condition that the state appropriate money to pay for half the expense.

PART II.

CONDITIONS IN WISCONSIN AND ROAD LAWS IN OTHER STATES.

CHAPTER I.

PRESENT HIGHWAY CONDITIONS IN WISCONSIN.

In the beginning of the present study of the road situation in Wisconsin the fact was taken into consideration that the largest part of the roads of the state must continue to be made of the ordinary soil of the districts through which they pass. As a consequence the first thing to be undertaken was to find out the methods of construction which were being used and the conditions of the roads which were the results of these methods. For the purpose of actually seeing the roads, a trip was made over a considerable part of the central and southern portions of the state and the roads and methods of construction inspected. As any such trip must necessarily be very limited as to the amount of territory covered, and as the knowledge desired was of a more general nature than could be obtained on such trip, letters were sent out to various persons.

The first letter sent out was addressed to every town clerk in the state, and enclosed a list of eighteen questions. Replies were received on first request from 700 of the town clerks. On the second request practically all of the remainder replied, giving reports from all but 167 of the 1135 town clerks. As these replies were sent in, for the most part, without even being furnished return postage, a strong indication is given of the interest of the town clerks in road conditions in the state and in any movement towards bettering these conditions.

One of the requests sent to the town clerks was that they return names of the prominent farmers in their town who

would be able to give information as to the effect of roads upon land values, etc. Later on letters were sent out to 2000 of the persons whose names were thus turned in. On a single request replies were received from about half of these.

A request was sent to the Fourth Assistant Postmaster General, Mr. DeGraw, who very kindly furnished a list of the names and addresses of all rural free delivery carriers in the state, and also sent out a circular letter to them requesting that they answer promptly the questions sent to them concerning roads. Of the 1450 carriers in the state only 316 have not replied.

The answers to these questions sent out, aggregating in number some 3000 letters, have been carefully worked over and totals, averages, and generalizations made in so far as was possible. Where a question is omitted in the following statement it is due to the fact that the question is of such a nature that answers to it can not be tabulated or any average or general results taken from them, such as questions regarding the location of roads, materials, etc.

QUESTIONS ADDRESSED TO TOWN CLERKS.

1. *How many miles of public roads in your town?*

Of those answering, 896 replied to this question. The total mileage given was 49,061, an average of 54.7 miles per town. At this average the total road mileage of the state would be about 63,000.

2. *What are the most heavily traveled roads?*

The answers to this question cannot be averaged or any general statement made from them.

3. (*a*) *How many miles of earth roads have been graded?*

A total mileage of 25,895 was given by the replies to this question.

(*b*) *How many miles have been surfaced with gravel?*

7,665 miles are reported to have been graveled

(c) *How many miles have been surfaced with crushed stone?*

The 94 towns reporting macadam roads give a total of 359.. miles. It will be noticed that this mileage of macadam road is less than that given later in the replies to the R. F. D. Carriers' questions. It is possible that some gravel roads were returned as macadam by the carriers but the discrepancy is probably due to the few answers from town clerks, as compared to the number received from carriers. The following table gives the average cost per rod of gravel and macadam in each county reporting.

TABLE XVI.

County.	Average cost Gravel, per rod.	Average cost Macadam, per rod.	County.	Average cost Gravel, per rod.	Average cost Macadam, per rod.
Adams	.....	.....	Manitowoc	$1 22	$2 00
Ashland	$3 62	$3 25	Marinette	2 00	.....
Barron	50	.....	Marquette	9 08	.....
Bayfield	.....	.....	Milwaukee	63	2 00
Brown	1 42	3 81	Monroe	1 06	6 25
Buffalo	1 29	8 50	Oconto	1 35	.....
Burnett	1 66	.....	Oneida	81	.....
Calumet	2 66	7 66	Outagamie	1 51	1 25
Chippewa	75	6 25	Pepin	16	.....
Clark	1 35	.....	Pierce	1 39	2 50
Columbia	1 75	2 02	Polk	81	.....
Crawford	.....	.....	Portage	1 00	4 08
Dane	1 53	6 55	Ozaukee	69	4 70
Dodge	1 29	3 75	Price	75	.....
Door	2 07	1 50	Racine	1 82	18 17
Douglas	.....	1 40	Richland	91	3 75
Dunn	94	10 00	Rock	2 07	3 93
Eau Claire	1 08	1 07	Rusk	57	.....
Florence	.....	.....	Sauk	3 00	6 06
Fond du Lac	1 75	2 68	Sawyer	.....	.....
Forest	75	.....	Shawano	95	1 50
Grant	7 37	6 12	Sheboygan	2 20	2 50
Green	.....	5 00	St. Croix	1 00	.....
Green Lake	1 29	.....	Taylor	2 08	.....
Iowa	.....	.....	Trempealeau	2 46	6 83
Iron	5 00	.....	Vernon	3 66	6 75
Jackson	45	.....	Vilas	.....	.....
Jefferson	3 17	3 00	Walworth	1 16	4 05
Juneau	6 25	.....	Washburn	.....	.....
Kenosha	1 49	.....	Washington	1 43	6 00
Kewaunee	1 57	.....	Waukesha	1 25	.....
La Crosse	2 50	.....	Waupaca	97	.....
Lafayette	10 00	.....	Waushara	79	.....
Langlade	88	.....	Winnebago	.....	1 50
Lincoln	1 25	.....	Wood	.....	.....
Marathon	1 21	1 06			

These averages are of course for all different styles, thicknesses and widths of roads that are built, but they are indicative of the amount of money which the people of different counties put into permanent roads when they once start to build them.

4. *Is the general character of the roads of your town level, rolling or hilly?*

No generalizations possible.

5. *Is the soil upon which your roads are built clay, sand or loam?*

No generalization possible.

6. *List road machinery owned by the town.*

State totals are:

Steam road rollers	1
Horse road rollers	16
Stone crushers	33
Road machines	2,454
Wheel scrapers	1,813
Drag scrapers	10,449
Patent dump wagons	22

7. *What road rollers or stone crushers are owned by private parties, cities or villages in your boundaries?*

Replies to this question were too meager to be of any significance.

8. *What material exists in your town suitable for surfacing roads?*

No generalizations were possible from the answers to this question.

9. (a) *During what months of the year is most road work done?*

629 towns do their road work before the end of July. 20 towns do all their road work after the end of July. 234 towns distribute their work throughout all the working months of the year.

(*b*) *What are the usual methods of building or repairing dirt roads?*

No generalizations were possible from the answer to this question.

(*c*) *Are dirt roads ever rolled after working?*

Of the 867 replies to this, 81 were yes and 788 no.

(*d*) *What do you think has been the general effect of using a road machine?*

Of the 800 answers to this question 745 reported "Good" and 55 "Bad."

(*e*) *Has any one in your town used the "split log drag?"*

Only 56 towns reported the use of the drag.

10. *How much money did your town receive from the county for road purposes in 1905?*

The towns answering this question reported $37,368 as being received from the county.

For bridge purposes in 1905?

The total reported under this was $175,355..

11. (*a*) *What was the total highway tax levied in your town in 1905?*

The replies to this question were not sufficiently definite and complete to admit their tabulation, so the records in the office of the Secretary of State were examined and the total highway tax reported there by the county clerks found to be $2,028,683. This amount divided by the number of miles as given in the answers to question 1, gives an average of $32.20. In addition to this regular highway tax there was available for road work in 1905 the poll tax and considerable sums which were appropriated out of the town general fund and which were therefore not reported as highway tax to the Secretary of State. The poll tax was paid as follows. By cities, $9,508; by villages, $10,957; by towns, $143,209; a total of $163,674. According to the census of 1900 the population of the cities was 875,868; of villages, 94,466; of towns, 1,098-708; a total of 2,069,042. The proportion of voters by this

census was given as 27%. According to this the number of rural voters in 1900 was about 296,000. Hence, it appears that 296,000 rural voters pay $143,209 poll tax, or in other words, at one dollar each about one-half of the voters of rural communities pay 87% of the poll taxes of the state.

(*b*) *How much was spent in building stone or gravel roads in 1905?*

(*c*) *How much was spent for bridges?*

(*d*) *What proportion of the highway taxes is paid directly in labor?*

The replies to these three questions were so incomplete and the records in the possession of town clerks evidently so scanty, that nothing could be determined from them as to the amount for the whole state. The record of highway expenditures is evidently kept in only the most general manner.

(*e*) *Are highway expenditures concentrated on heaviest traveled roads or distributed so that every man gets his own road fixed?*

Replies to this question indicated that 662 towns of the 879 reporting distributed the work, while only 217 made any attempt to concentrate the work in places where most needed.

12. *Would you favor the formation of a highway division in the Geological Survey to furnish free of charge to towns requesting it expert advice and supervision in the matter of building and maintaining permanent roads.*

Of the 734 replies to this question 642 were favorable and 92 unfavorable.

13. *What proportion of wagons in your town have three inch tires or wider?*

The average of the replies sent in gave 62% of the wagons of the state as having wide tires.

14. *Have you ever tried harrowing or rolling snow in your town?*

Of the 880 reporting 62 towns have tried this and find it a very good plan, while 818 have not tried it.

QUESTIONS ADDRESSED TO RURAL FREE DELIVERY CARRIERS.

1. *Name.*

2. *Location of route.*

3. *Length of route.*

By the 1,117 replies to this question a total length of route of 27,552 miles was reported, an average of 24.66 miles As there are 1450 R. F. D. Carriers in the state according to this average, the total length of road travelled by them would be 35,757 miles.

4. *How many miles of macadam roads?*

The number of miles reported by the carriers in reply to this question was 418, which is greater than that reported by the town clerks, but as a greater number of carriers reported on the question it is evident that this number is nearer right.

Gravel roads? 6,024 miles.

Clay roads? 5,311 miles

Sandy roads? 13,806 miles.

The sum of these various kinds of roads leaves 1,963 miles of the reported total length of route unclassified.

5. *Give conditions of the road at various seasons of the year.*

No generalizations possible from the replies to this.

6. *Has the "split log drag" been used on your route?*

64 reported that it had been used.

7. *How many days in the last year were roads so bad as to prevent the covering of the whole of your route?* [*Do not count obstructions from snow.*]

The average for the 1,300 replies received to this question was 1.53 days.

8. *How many days in the last year have roads been so bad as to prevent their use by loaded wagons?*

Of the 1,020 replies the average given was 17.02 days.

By unloaded wagons?

The average of 1,020 replies was 3.8 days.

It will be noted that this question was so worded as to in-

clude only the days in which heavy wagons and light travel were absolutely cut off from use of the roads. The number of days during which the roads were very bad would be much greater than this.

9. *Tell what parts of the roads were worse and give reasons.*

No generalizations possible from replies to this.

10. *What is the general nature of the road work along your route?*

No generalizations possible from replies to this

11. *How many wooden bridges on your route?*

The total of the replies received gave 9,543.

Iron bridges? 2,652.

Concrete culverts? 2,291

Iron pipe culverts? 1,211.

Tile drain culverts? 4,953.

The replies to this question indicated that there are nearly four times as many wooden bridges as steel bridges, and that tile as culvert material is by long odds the favorite.

12. *How many teams per day pass over the first part of your route when roads are in good condition?* The average of 800 reports was 60.4.

Over farthest part? The average of 728 reports was 24.4.

When roads are in bad condition how many teams per day pass over the first part of the route? Average of 786 reports was 25.5.

Over farthest part? Average of 728 was 9.95.

This question was replied to by a fairly large percentage of the carriers, but in asking the question it was recognized that any such estimate as could be made would be only a rough estimate at best. The averages for the whole state, however, are significant as agreeing in the fact that about 60% of the travel upon rural highways is cut off when roads are bad. The effect of this diminished travel upon the conditions of life must be very considerable.

13. *How long does it take you to cover your route when roads are good?*

The average of 1,112 replies received to this question was 5.94 hours.

When roads are bad? The average of 1,100 replies was 7.58 hours.

The average time wasted by each carrier when the roads are bad is 1.64 hours.

14. *How much longer route do you think you could cover with the same ease as you cover your present route if roads were always in first class condition?*

The average of 1,100 replies was 2.86 miles. When it is considered that according to this average, which is the estimate of the carriers themselves and therefore not likely to be excessive, the rural mail service could be extended over routes aggregating a total of 4,100 miles without any increased expense whatever to the government or to anybody, if the roads were kept in the condition they ought to be, the importance of keeping roads in good condition can be very strongly appreciated.

15. *What would you think of a plan such as they have in other states whereby the State Geological Survey should maintain a highway division to give advice and instruction in road building to towns free of charge?*

Of the 1108 replies to this 1106 were unqualifiedly favorable. Two replies were doubtful and might be taken unfavorable.

QUESTIONS ADDRESSED TO FARMERS.

1. *Name.*

2. *Location of farm.*

3. *Number of acres in farm.*

There were 753 answers to this question giving an average of 181.5 acres.

4. *Distance from town.*

There were 738 replies giving an average of 5.6 miles.

5. *How many tons per horse can you haul on your road?*

(*a*) *In summer?*

709 replied giving an average of 1.06 tons.

(*b*) *In fall?*

685 replied giving an average of 1.02 tons.

(*c*) *In winter on sleigh?*

591 replied giving an average of 1.67 tons.

On wagon?

654 replied giving an average of 1.08 tons.

(*d*) *In spring?*

638 replied giving an average of .47 tons.

These averages are from a large number of replies and the amount of the load which can be hauled must be, therefore, fairly representative. These figures show that in the winter time about 60% more can be hauled on sleighs than can be hauled on wagons in the other seasons of the year when roads are good, and in spring less than 50% of the ordinary load can be hauled.

6. *How many days work per year for one team and man does your heavy hauling on the road require?*

The average of 614 replies was 39 days.

7. *How much could this time be shortened if roads were always in good condition?*

The average of 461 reports was 15 days.

What would be the actual cash value of this time saved?

The average of 461 reports was $42.

8. *How much time in the year do you estimate you spend on the road with a light rig, such as going to church, lectures, fairs, children driving to school, etc.?*

The average of 573 reports was 59 days.

What proportion of such light driving which you would otherwise do are you compelled to forego by the bad condition of the roads?

The average of 311 reports was 19 days.

9. *How much would you be willing to pay to have the roads always in good condition, so as to be able to do such light driv-*

ing at any time you choose as far as conditions of roads are concerned?

The average of 312 reports was $36.

10. *How much per acre, if any, would the value of your farm be increased if you had a first class road to town?*

The average of 438 reports was $8.

Would this be a fair average of the increase in value of the farms in your town if they were all located on first class roads? If not, what would be the average?

The average of 202 reports was $8.

11. *How many days in the year are your roads so bad as to prevent hauling loads?*

The average of 530 reports was 41 days.

How many on which light driving is impracticable?

The average of 435 reports was 24 days.

Would it be to your advantage to be able to market your produce at such times?

403 yes, 118 no.

12. *Has the present law remitting taxes on wide tired wagons acted as a very strong incentive to their use in your town?*

436 yes, 270 no.

Do you think it would be more effective to have a law such as they have in Iowa to remit one quarter of the road tax for hauling all loads over 800 *pounds on tires at least three inches wide?*

364 yes, 311 no.

13. *Are road taxes in your town paid in labor?*

617 yes, 120 no.

14. *If road taxes were paid in cash and the roads worked by contract, what proportion of the present tax in your town would produce as good results as the present system?*

The average of 470 replies was 58%.

15. *Do you think it would be advisable to substitute for the present office of County Surveyor a County Engineer, capable of advising town and county officers as to the kind and size of bridges, culverts and other permanent improvements best*

suited for the particular localities where they were to be placed, besides performing the duties of a County Surveyor?

528 yes, 200 no.

16. *Do you favor the plan which has been adopted in half the states of the Union of having the state and county both aid the town in building permanent roads, thus having the cities and railroads pay a share of the cost?*

682 yes, 53 no.

17. *Would you favor turning the heavily traveled roads over to the county to maintain, and giving the county about one mill as a tax to do the work with?*

539 yes, 190 no.

18. *Do you think the road overseers of your town would desire to have a two-weeks' course given in the construction of roads, concrete culverts, etc., at Madison, somewhat after the plan of the two weeks' farmers course now given every winter?*

253 yes, 379 no.

Do you think any considerable portion of them would want to attend it?

236 yes, 392 no.

Would you think it advisable for the town board to pay part of their expenses to get them to go?

342 yes, 304 no.

19. *Would you be in favor of having the next legislature appropriate money to have a careful study of roads made in every county and general plans made for their improvement; and for the purpose of instructing town officers and road overseers in the best methods of using the funds they have to spend on roads, making standard plans for bridges, etc., and otherwise aiding the towns by technical advice?*

551 yes, 137 no.

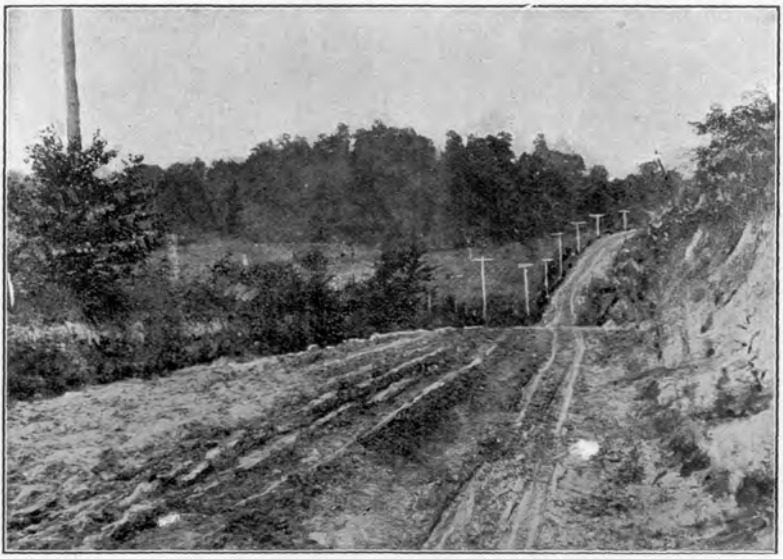


Fig 1.

Fig. 2.
These two photographs show roads which are located along the sides of valleys in Southwestern Wisconsin, and the deep cuts which are necessary to secure good grades. The valley at the left in both pictures would have afforded a location with natural gentle grades

CONDITIONS OF WISCONSIN ROADS.

From the information secured from the trip about the state, from general knowledge and from the letters just previously mentioned, it is evident that the conditions of Wisconsin roads vary in all degrees from good to extremely bad. In some road districts all the principles of proper location, construction and maintenance have been sadly violated. In most road districts only the larger part of them have been violated. In almost no road district in the state has all the road work been done upon correct principles. If the road is properly constructed it is almost sure to be poorly maintained. However, conditions may be divided for convenience of description into poor and good conditions, the former being described first.

BAD CONDITIONS.

Poor location. As described on page 7 the first necessity for a good road is proper location. This is one of the requisites which many Wisconsin roads lack. Even in very hilly districts some attempt has been made to make the roads follow section lines. This condition of affairs is well stated in a letter which was received from a farmer in Burnett county. He says, "Another thing is laying out roads. This thing of following arbitrary lines and climbing hills at an angle of forty-five degrees will never give good roads. I have lived in hillier counties, but never had to climb such hills as where they lay roads on section lines."

One of the first results of this poor location is that money is used in attempting to cut down the steep hills and fill up the sharp depressions. In one case seen west of Richland Center, which is shown in figs. 1 and 2, plate XI, a road followed along the side of a valley in approximately a straight line across the irregularities of the surface, which were quite sharp. This road was in comparatively good shape so far as grade was con-

cerned, but it had been made so by an almost continuous series of cuts and fills. This road was but a short distance from the valley bottom, where a right of way could have been purchased and a road with less irregularity of grade constructed for a small fraction of what the cuts and fills on the present road must have cost.

The poor location of many Wisconsin roads also makes them subject to being washed out during heavy showers. The roads are so located with respect to drainage lines that it is almost impossible for the ordinary bridge or culvert, as too often constructed, to withstand the action of water for more than a very few seasons.

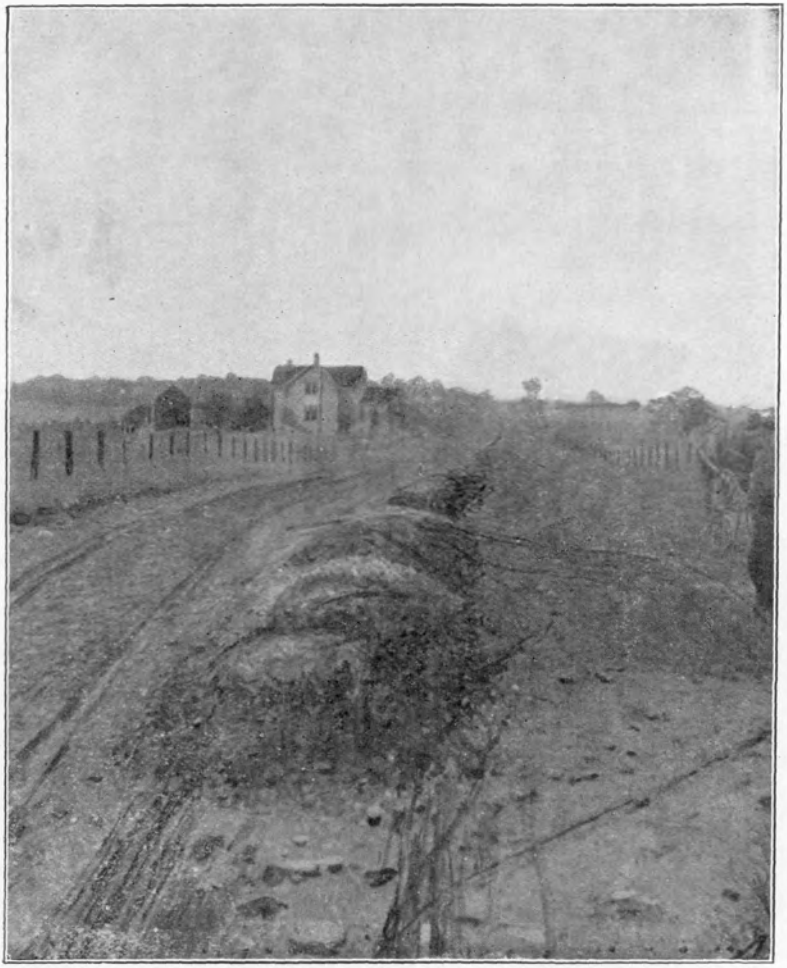
Poor construction. In constructing a country road it is the common practice to heap the dirt up in the center together with such sods, weeds, and small brush as happen to be in the way, making a windrow in the center of the road which is very carefully avoided by all teams. The surface of the road is left soft and irregular with a fond hope that eventually it will pack down into a good solid road-bed. This practice is followed for earth roads, and for gravel roads as well.

The result of leaving the sod and weeds in the middle of the road is to make the soil even more porous than it would be if the clean earth alone were thrown up by the grader, and as a consequence, when the teams are compelled to travel upon this high portion of the road by the impassability of the other parts it has become nothing more or less than a big sponge of decaying vegetable matter and soil. It is speedily floated to the sides of the road and ruts formed which hold water and rapidly disintegrate the foundation.

The throwing aside of the sod and similar material and the use of a common harrow to level the surface will benefit most newly constructed earth roads. If a roller is available, earth roads can be made very good to start with without waiting for travel to pack them down, but under present circumstances the idea that a new road is always a bad road is very decidedly justified.

Fig. 1. A flat-topped clay road in Clark county. The ruts appearing in the picture are wheel tracks in a thick layer of dust.

Fig. 2. Flat-topped clay road in Clark county showing how such a road ruts when wet.



Clay road covered with gravel which is left just as dumped by the wagons, with no attempt to spread it, so that teams can drive over it.

Figs. 1 and 2, plate XII, give pictures of a road which is constructed so that its cross section is like that indicated in fig. 6, plate IV. This type of construction has altog ther too flat a top, the result being that as soon as the road is worn a little bit in the middle the water has no means of running to the ditch, and the middle of the road therefore catches and holds all the water which falls upon it and the ditches are of no use. The same road is shown in fig. 2, after it has been wet and cut up by the traffic.

Plate XIII, gives a icture of a gravel road which had been constructed for about a month. On the day visited it consisted of two very soft muddy tracks on either side of a heap of gravel about two feet high and with such steep sides as to make it dangerous to drive across, to say nothing of attempting to drive lengthwise over it. The teams had traveled on both sides of this road and will continue to do so until compelled by the absolute impassability of the rest of the road to use the graveled way and pack it down. This gravel could have been spread out even roughly, and at very slight expense, and made into a much more valuable improvement of the road.

When gravel roads are built without the use of a roller it is customary to let the teams beat down a single traveled way, and travel in that to the neglect of the uncompacted material outside of this traveled portion. Very much better results and more permanent gravel roads can be constructed in this way if obstructions such as logs or boulders are placed—as some towns do at present—so that the travel is forced to beat new tracks until the whole road has been traveled upon and compacted.

In laying culverts they are frequently built close to the surface of the road so that they are sure to be cut by wheels before they are a year or two old. They are left without any protection at the ends so that sooner or later the gradual washing away of the soil will leave them unsupported, to fall and break.

Poor drainage. Relative to this subject the following is quoted from a letter from a road supervisor:— "The country in general makes roads without ever trying to get water off them. For instance, I was road overseer on a new piece of road this year. The town board came along and told me they would let a job on a certain date on the swamp. As they were using the funds of my district without leave I said to make the outlet first and as much road ditch as the funds would allow, but they let the job on the road ditch and put off the outlet until some other time." There are probably not many instances of such flagrant disregard of the fundamental principles of drainage, but there is certainly a lack of attempt to see that the roads are properly drained. If one were to drive over almost any road in the state after a shower he would find several puddles and places where the water was running across the road.

Poor drainage and the consequent soft condition of the road are often times due to improper use of the grader in repairing the road. Secondary ditches are often made instead of the main ditches so that the water does not reach the main ditch to flow away, but is left standing alongside of the road and near enough by, so that it can do considerable damage. A section of such a road is shown in fig. 3, Plate IV

Lack of maintenance. Country roads are not alone in suffering from a lack of continuous maintenance, city streets being almost as badly off in this regard as are the ordinary roads. The chapter on maintenance shows the good effect and desirability from every point of view of some system of maintenance. The chief function of maintenance is to keep water out of the road. The effect of its lack is shown in the two figures on plate XIV. The first one shows a road which is ordinarily very good, with a small amount of water standing in very shallow ruts and puddles. As the wheels of the vehicles pass through these puddles they continually cut them deeper until the water dries up. When the next shower comes the ruts are cut deeper still, until the water again dries out. After

Fig. 1. Clay road in Calumet county with shallow ruts filled with water just after a shower.

Fig. 2. More heavily traveled clay road one-half mile from road at left showing effects of allowing water to stand in ruts.

Fig. 1. Sandy road in Trempealeau county covered with shale, in which the sandstone was left in large pieces.

Fig. 2. Gravel road in Washington county with sod and coarse gravel heaped in the center with the road machine.

a very few showers the road gets to be in the condition shown in the second figure. But a very few cents expended in using a split log drag would have sufficed to fix up the road shown in the first figure so that the water could not stand on the surface, and the rapid deterioration of the road to the condition shown in the second figure entirely stopped. The road in the second figure is almost bad enough to require reworking with the grader at a cost of $15.00 to $30.00 per mile, where a dollar would have fixed a mile if it had been done when the road was in the condition shown in the first figure.

The two photographs on plate XV show roads which could have been kept in extremely good condition with a very slight amount of attention and which were both quite bad on account of the lack of this attention. The first one is a sandy road which has been covered with shale in which large pieces of the sandstone were left. If a little trouble had been taken in order to secure shale free from sandstone blocks this would have made an excellent road.

The second figure shows a road which was built through a natural gravel pit. The gravel had been turned up from the sides towards the center with a road machine, but the sod had been piled up with the gravel so that it made a bad ridge about a foot in height all along the middle of the road. No attempt had been made to throw the large loose stones off the road, and as a consequence it was very rough.

It is a continual surprise to any one who has never seen any system of maintenance practiced to see the good effects produced at a very small cost. In the last road described much benefit would result to the road if while it was moist a split log drag were used upon it. In some places the sod would be too tough for the drag to take hold upon it and it might be necessary to clean the sod off with a road machine, but if the ground were thoroughly moist the split log drag, if run so as to drag the material to the side of the road, would clear off most of the sod and all of the loose pebbles. If this were done

it would be a pleasure to travel over such a road instead of being a discomfort.

Politics in road work. One thing which has interfered materially with good road work in Wisconsin is very well expressed in a letter received from a farmer by the Maryland Highway Division. He stated that in his county "they mix politics and large rocks and have no good roads." If this condition were confined to Maryland we should have abundant reason to congratulate ourselves, but in the blank headed, "Remarks on Local Conditions" in the questions sent out to 2000 farmers of the state, there is a very large number of replies indicating that politics and roads are pretty intimately mixed in Wisconsin as well as Maryland. Statements of the character of this — 'any good friend of our town chairman can become overseer no matter whether he knows whether the road is to be made with a spade or a needle'—are common. One man makes the statement that in his town 'the office of highway commissioner is one of the strongest means of working politics that there is, and that the office of highway commissioner is given to the strongest workers for the officers elected. By the cancelling of poll tax, and returning the highway tax to the town clerk as worked out, when, as a matter of fact, the tax payer has worked but a small part of his tax on the road, and by similar practices, the highway officers are enabled to keep strong friends for election day.' Such statements of conditions as the last are not taken from irresponsible people but are sober sane expressions of opinion of persons who are interested in a proper application of their tax money.

GOOD CONDITIONS.

Previously we have been discussing the bad conditions in the Wisconsin highway situation. It must not be understood, from this however, that there is no good to be found, no highway commissioners who are using proper methods, and no public interest in the construction of good roads. Many highway commissioners are beginning to show a keener interest in pro-

per methods of construction and the people who pay for the roads are beginning to show a public spirit that is very promising for the future.

In several counties of the state the people in the cities and the surrounding towns are coöperating to build good roads. The city and town of Baraboo have been doing especially good work along this line. They have taken advantage of the law which requires the county to pay half of the cost of road construction. The following quotation from a letter from the clerk of the town of Baraboo illustrates the plan which they have followed:—

"In 1903 we purchased a stone crusher and began in earnest the permanent improvement of our highways. Our plan is to each spring vote an appropriation of $1,000.00 for this purpose, said appropriation to be used with an equal sum from the county, as provided by Chapter 312, Laws 1901. The section of the road to be improved is decided upon and the expense of grading provided for by the following condition which is always attached to this appropriation, viz, 'that it shall go to the main traveled highway leading into the city of Baraboo that will raise the largest cash subscription for permanent improvement, provided said subscription is not less than a thousand dollars.' So far the subscriptions have run from $1,500.00 to $2,500.00 per annum.

Enclosed you will find a crude plat of the town which shows you how our highways center in the city of Baraboo and how the stone roads are radiating from the city. The city meets us with macadam when we come to the city limits with a stone road. All work is done upon a cash basis and usually under the immediate direction of the superintendents. The superintendents report to the chairman every week; bills are paid every two weeks. Some portions of work are sometimes let by contract to the lowest bidder.

Yours truly,

FRANKLIN JOHNSON."

Other towns in the state are working on plans somewhat similar to that used in the town of Baraboo. In Lafayette county one town is preparing to take up a comprehensive scheme of road improvement, outlining a certain amount of work and attempting to accomplish some part of it each year. In Racine county one town appointed a special commissioner to investigate road conditions and determine the best methods of construction to apply to their town and map out a course of work that should be followed through a term of years. In Waukesha and Milwaukee counties much good work in building permanent roads has been done and, in fact, from Door county south to the state line some very good roads have been built with the abundant gravel which is found almost everywhere in that part of the state. Plate XVI shows a good gravel road and a permanent stone culvert built in the eastern part of the state.

In concluding this chapter on Wisconsin conditions I would state as a general fact, true in the main throughout the state, that the people are not suffering from extremely bad roads, but they are enduring moderately bad roads when *the money which they are paying is sufficient, if properly handled, to pay for good roads.*

Fig. 1. A good gravel road in Sheboygan county.

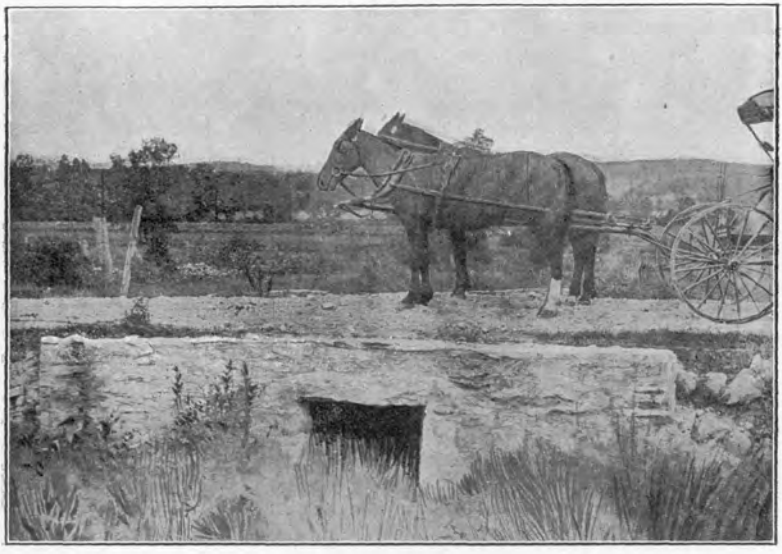


Fig. 2. Good permanent stone culvert in the town of Wabeka, Washington county.

CHAPTER II.

ROAD LAWS AND CONDITIONS IN OTHER STATES.

In any county or state where there is considerable interest in building good roads or where good roads have been built, such conditions have been brought about by control of the highways by some large unit of government. In Europe the roads are for the most part constructed and cared for by the national and provincial governments, only short local stretches off the main lines of travel being left to neighborhood control. In this country wherever any extensive movement for the construction of permanent highways in rural districts has developed it has been under state control. At present twenty-two states have some form of state control and state aid for road building. The movement for state control was not started until 1891—15 years ago—and fact that it has been in this comparatively short time adopted in nearly half the states of the Union is a strong indication of the favor with which it has been received. Wisconsin is the only state north of the Ohio river and east of the western boundary of Minnesota and Iowa which has not yet adopted such a system.

In view of the lively interest which the people of Wisconsin are beginning to take in road matters, and the probability that this interest will ultimately lead to state control and state aid for building country roads, digests of the laws adopted by some of the states are given in order that their experience may

be used as a guide. The outlines of the plans of the different states are largely taken from Bulletin No. 4 of the Ohio Highway Commission. However copies of the laws have been directly referred to, particularly in the case of New York, New Jersey, Michigan, Iowa and Minnesota.

The various provisions of the laws are collected under the following heads in order to facilitate comparisons.

1. Date of beginning of state aid and general duties of State Highway Officer.
2. Right of petition for state aid.
3. The officer or body petitioned.
4. Total state aid fund.
5. Limitations on state aid.
6. Apportionment of the cost of state aid roads.
7. Manner of doing work under state aid.
8. Securing right of way.
9. Duty of making surveys.
10. Repairs and maintenance of state aid roads.
11. Machinery furnished by state.
12. Powers of state highway officer.
    - —over road supervisors.
    - —over distribution of state aid fund.
    - —over maintenance of state aid roads.
    - —over street railways on state aid roads.
    - —over automobiles, bicycles, etc.
    - —to compel town and county officers to furnish uniform detailed accounts of highway and bridge expenditures.
13. County Supervisor for roads.
14. Legal width of roads built by state aid.
15. Wide tire laws.
16. Public meetings of local highway officials.

Where any of these heads is omitted in describing the conditions in any state the inference to be drawn is that there is no law in regard to this. The laws of New Jersey, Massachusetts, New York and Maryland are given in special full-

ness as these are the states which have had most experience with this plan and whose laws are the outcome of more extended practical knowledge of the problems arising in connection with state aid.

NEW JERSEY.

E. C. HUTCHINSON.....*Commissioner of Public Roads.*
R. A. MEEKER.....*State Engineer and Supervisor.*

In a list of states aiding the building of country roads New Jersey is given the first place as it was the first state to adopt such a plan. The movement for state aid was started there shortly after 1872, due to the efforts of the Board of Agriculture. In 1891 the first state aid law was passed by the legislature. It provided for the construction of improved roads and promised state aid for this purpose to the amount of one-third the cost of construction. This early law has been modified by almost every successive legislature and an increasing amount of money appropriated at each session.

Date and duties. In its final form the road law of New Jersey is the product of the Legislature of 1905.

The right of petition. The right of petition lies in the governing body of any township, town, borough, village, or of any municipality governed by a board of commissioners. Such governing body may be petitioned by the owners of two-thirds the linear frontage on any public road asking them to request state aid for that road.

The office or body petitioned. State highway commission.

Total state aid fund. Since the passage of the state aid law New Jersey has built roads each year to the amount given in table below. The total cost given includes state, county and town money.

1892.....	10.55	miles costing	$61,985.55
1893.....	27.34	miles costing	218,194.39
1894.....	32.28	miles costing	224,088.12
1895.....	46.33	miles costing	320,770.59

1896.....	60.82	miles costing	331,615.78
1897.....	66.665	miles costing	342,166.68
1898.....	84.554	miles costing	319,777.64
1899.....	114.46	miles costing	478,628.39
1900.....	75.782	miles costing	489,541.20
1901.....	109.376	miles costing	511,644.96
1902.....	154.745	miles costing	794,033.86
1903.....	152.92	miles costing	832,546.38
1904.....	107.717	miles costing	820,521.74
Total.....	1,043.529	miles costing	5,745,515.28

The cost of roads has ranged from $1,554 per mile (for a gravel road) to $25,500 per mile, averaging $5,505 per mile. The cheapest macadam road cost $4.282 per mile.

The annual state appropriation at present is $250,000.00 with $400,000 as the limit to the amount of state funds which can be appropriated in any one year.

Limitations on state aid. State aid is extended on the same terms to all political units in the state excepting cities. The limitation to the amount of contracts which can be let in any county depends on the tax rate and is ½ of 1% of the assessed valuation for the preceding year.

Apportionment of the cost of state aid roads. The state pays 33⅓%, the petitioning unit pays 66⅔% in case it is not the land owners who petition. If the land owners petition the state pays 23⅓%, the land owners 10% and the town or county pays 66⅔%.

Manner of doing work under state aid. All work is done by contract, bids being advertised for by the board of county commissioners. All bids are subject to the approval of the state highway commission.

Duty of making surveys. All surveys for proposed improvements are made under the direction and at the expense of the county board of supervisors but no survey is made without the consent of the state highway commissioner. This is to prevent the making of useless surveys. Copies of surveys must be deposited with the state highway commission.

Repairs and maintenance of state aid roads. The county board is required to keep in good repair all roads improved under the act providing for state aid and can be compelled to do this by mandamus proceedings instituted by any freeholder.

Powers of state highway officer—

—over road supervisors. The state commissioner has full power to appoint whom he sees fit as overseers of construction for roads receiving state aid. These supervisors were originally to be paid by the county but the law of 1905 requires them to be paid by the state alone. The state highway commissioner may summarily dismiss such supervisors whenever he thinks they are incompetent or inefficient.

—over distribution of state aid fund. The annual state appropriation is distributed among the counties by the state highway commissioner in such a manner as to him seems fair and equitable. When petitions filed call for more aid than the annual amount of appropriation, the Governor and the commissioner apportion the sum amongst the counties in proportion to the cost of the roads constructed therein for each year.

—over maintenance of state aid roads. The local supervisors having charge of the maintenance of roads built with the aid of the state can be discharged by the state commissioner when their work is not properly done.

County supervisor. After the first state aid road is built the county board of supervisors must appoint a county supervisor of roads.

Wide tires. A rebate in road taxes may be given by the town for all tires over 4 inches in width. This rebate must not exceed $1.00 for each wheel.

MASSACHUSETTS.

W. E. McCLINTOCK.....
JOHN H. MANNING..... } *Highway Commission.*
HAROLD PARKER.....

Date and duties. In 1892 the legislature passed a law under which the Governor with the advice and consent of the council appointed three persons as a highway commission. This commission was to investigate matters of road construction and maintenance, find cost of the same, investigate the geology of the state in relation to road materials, and to prepare maps and plans showing routes recommended for improvement. In 1894 the scope of the commission was enlarged by requiring them to compile statistics relative to roads and to furnish engineering service and advice to towns and counties desiring it.

Right of petition for state aid. Any city, county, or town can petition to have a road taken in charge by the state.

Whom petitioned. State highway commission.

Total state aid fund. The first appropriation for the state aid fund was $4,000.00. The next year this was raised to $300,000.00 and reached a maximum of $800,000.00 in 1897. Since then the annual appropriation has been $520,000.00 to $550,000.00.

Limitations on state aid. Any town, city, or village may receive state aid. No county may have state aid in any one year for the construction of over 10 miles of highway.

Apportionment of the cost of state aid roads. The state pays the whole cost but the county must repay one quarter within six years of the time of construction.

Manner of doing work under state aid. The work is done under contracts let by the state commissioner. The county or town petitioning for the road has the right to put in a non-competitive bid on the construction. This privilege was extended in order that towns might by this means be influenced

to provide themselves with proper equipment, and by building roads under the supervision of the state commission learn how to properly construct them and so be in a position to go ahead independently and build other roads beside state aid roads.

Duty of making surveys. The surveys must be made by the body petitioning for state aid and copies of the surveys must be filed with the petition.

Repairs and maintenance of state aid roads. The maintenance of state aid roads is in charge of the state highway commission. The expense of maintaining state aid roads to a maximum of $50 per annum is borne by the towns. All costs above this are paid by the state.

Machinery furnished by the state. Under certain restrictions county commissioners will be furnished by the state with such steam rollers, crushers and other road machines as the commission may deem necessary.

Powers of state highway officer—

—over distribution of state aid fund. The apportionment of the amount of road to be constructed in the different counties rests entirely upon the decision of the highway commission and is limited to ten miles in one county unless the governor and council approve.

—over street railways on state aid roads. The highway commission has jurisdiction as to digging up or placing any structure upon state aid roads.

—over automobiles, bicycles, etc. Authority and jurisdiction as to registration and other matters relative to the use of automobiles and motor cycles was given to the commission by the legislature of 1903 and amended in 1905. Annual revenue to the state from this law is about $50,000.00.

—to compel town and county officers to furnish uniform detailed accounts of highway and bridge expenditures. Authority to compel the local road authorities throughout the state to furnish information regarding public roads and bridges is given to the commission.

Width of road built by state aid. State roads are built from 12 to 18 feet in width of hard surface.

Public meetings. The commission is required to hold each year at least one public meeting in each county for the discussion of questions relating to public roads.

VERMONT.

CHARLES W. GATES.....*State Highway Commissioner.*

In 1892 the general assembly authorized the appointment of a commission to make an examination of the highway system of the state and report upon it to the next legislature. One sentence of this report is quite significant. "A large proportion of the highway tax of this state is expended in repairing damage done to hill roads by storm waters."

Date and general duties. In 1894 the commission was made permanent and the duty laid upon them to investigate modern methods of road building.

Total state aid fund. A state tax of five cents on each dollar of the "grand list" was levied. The "grand list" is about 1% of the assessed value of the property so that the tax amounts to about 1/20 of 1%. In 1904 this amounted to $91,795.00.

Apportionment of the cost of state aid roads. Funds are distributed to the localities in proportion to their road mileage.

Powers of state highway officer—

—over road supervisors. The state highway commissioner has supervision—through the town commissioner—of expenditures of all state appropriation for highway improvement.

Public meetings. Meetings of local road commissioners are held throughout the state each year.

CONNECTICUT.

JAMES H. MACDONALD.....*State Highway Commissioner.*

Date and general duties. In 1895 the general assembly provided for the appointment of three highway commissioners. The demands by the towns for state aid have been so far in advance of state appropriations that in 1905 the requests were scaled down to 37% of what was asked for in order to bring them within the amount appropriated. This large amount of state aid requested is no doubt due to the fact that the state pays such a large proportion of the cost.

Right of petition for state aid. Any town can petition for state aid.

Whom petitioned. The highway commission.

Total state aid fund. The first annual appropriation in 1895 was $75,000.00. In 1897 it was increased to $100,000.00, in 1899 to $175,000.00. In 1901 the annual appropriation was increased to $225,000.00.

Limitations on state aid. Only towns are benefited by state aid. The limit of state money to be expended in any town in one year is $4,500.00. The money is divided in proportion to the amounts requested.

Apportionment of the cost of state aid roads. At first the state paid ⅓, the county ⅓ and the town ⅓ of the cost of construction. This has been so amended that the state pays ⅔ of the cost when the assessed valuation of the town exceeds $1,000,000.00 and ¾ when it is below $1,000,000.00.

Manner of doing work under state aid. Work is done by contract and the specifiations are prepared by the state highway commissioner. The town authorities have joint power with the highway commissioner as to approval of bids and contracts. All work under a limit of $1,000.00 may be built by the town without advertising for competitive bids.

Duty of making surveys. The surveys were originally to be prepared by the town board, but the legislature of 1905 gave

the authority for making surveys into the hands of the state commissioner.

Repairs and maintenance of state aid roads. The maintenance of roads constructed by state aid is left to the towns.

Machinery furnished by state. The highway commissioner is given authority, when he and the selectmen deem it wise, to purchase stone crushers for use in towns remote from railroad facilities.

Powers of state highway officers—

—over road supervisors.

The state highway commissioner has the power to appoint inspectors of construction who are paid by the state.

—over distribution of state aid fund.

The commissioners are given discretion as to the granting of state aid for improvements costing less than $500.00.

—over maintenance of state aid roads.

In case the selectmen of the town neglect to make needed repairs on state aid roads after a month's notice, the highway commissioner has authority to take charge of the maintenance of the road and to make the needed repairs.

NEW YORK.

HENRY A. VAN ALSTYNE.....*State Engineer and Surveyor*
EDMUND F. VAN HOUSEN.....*Deputy State Engineer and Surveyor.*

Date and general duties. In 1898 the New York legislature passed a bill known as the Higby-Armstrong Good Roads Law. Under this law the state engineer was instructed to investigate methods of road construction and determine the best methods for the various sections of the state. He was required to furnish advice relative to the improvement of the roads free of charge to highway officers and other interested persons.

Right of petition for state aid. The right to petition for state aid lay originally with the board of supervisors of any county but was later extended to a majority of the owners of linear frontage on any road.

Whom petitioned. The state engineer.

Total state aid fund. The first appropriation for state aid was $50,000.00. This appropriation rapidly grew until in 1904 $1,108,265.00 were expended by the state. The counties met this expenditure with a total expenditure on their part of $2,032,855.00.

Apportionment of the cost of state aid roads. One-half the cost of state aid roads is paid by the state. The other half is distributed as follows: in case the movement originated with the county it is required to pay 35%, and 15% is paid by the township. In case the petition originates with the property owners the county pays 35% and 15% is assessed upon the lands benefited in proportions determined by the town assessors. The construction of the roads is carried on in the order of receipt of the final resolution of approval.

Manner of doing work under state aid. Work is done under contracts let by the state engineer. By law 10% of the monthly estimates is retained from the contractor until the work is completed satisfactorily. It is also provided that after a county board has once passed a resolution appropriating money for a road such resolution can not be rescinded. Any town or county, through its supervisors, may bid on the construction of any piece of road within its territory.

Securing right of way. The county board is required to secure the right of way for the proposed improvement.

Duty of making surveys. Surveys and maps are made by the state engineer.

Repairs and maintenance of state aid roads. The maintenance of improved highways is in charge of the supervisors of the county.

Powers of state highway officer—

—over distribution of state aid fund.

The state engineer is empowered to withhold funds due to the counties when they have not taken proper care of the roads already built for them with state aid.

—over maintenance of state aid roads.

In the event of neglect by the county commissioners to keep state aid roads in proper repair, the state engineer is empowered to cause such repairs to be made at the expense of the county.

—over street railways on state aid roads.

The use of state aid roads by street railways is under the regulation of the state engineer.

—to compel town and county officers to furnish uniform detailed accounts of highway and bridge expenditures.

The state engineer is given authority to demand information from local road authorities with which to compile the statistics which he is required to make up.

County supervisor. When state aid roads have been built in any county the state engineer may at his discretion refuse to grant petitions for any further state aid until the county board shall have appointed a county engineer. Such county engineer must forward to the state engineer reports on the conditions of the highways in each town of his county. He has charge of the work of repairing roads, constructing and repairing bridges, and is required to make surveys and maps of the roads in his county.

Width of road built by state aid. State aid roads have an improved surface of not less than eight feet nor more than sixteen feet.

Public meetings. The state highway engineer is required to hold at least one public meeting in each county every year for the discussion of highway questions.

After the passage of this law the demand for state aid from the various counties increased very rapidly. It soon became evident that no appropriations consistent with the ordinary revenues of the state would be sufficient to provide the aid requested. As a consequence the legislature of 1903 passed a resolution to amend the constitution permitting the issuing of

$50,000,000.00 in bonds for the purpose of obtaining funds for highway construction. This was concurred in by the 1905 legislature and approved by the people at the general election of 1905 by an overwhelming majority. This resolution provides that the bonds shall be issued only as required and also provides for a sinking fund of at least 2% per annum aside from the interest. Such an enormous debt imposed upon the people by themselves by a great majority of the votes cast is a strong proof of the good which the people of New York conceive to have been done by money appropriated by the state for highway purposes.

MARYLAND.

WILLIAM BULLOCK CLARK.....*Superintendent and State Geologist.*
WALTER W. CROSBY.....*Chief Engineer.*

Date and general duties. In 1898 the general assembly passed a law providing for the investigation of road construction in Maryland. The work was placed in charge of the state geological survey commission. They are charged with the distribution of literature and giving of lectures upon road subjects and making of tests upon road materials.

Right of petition for state aid. The right of petition lies in the county boards of commissioners. The owners of ⅔ the linear frontage on any road of not less than a mile in length may petition the county commissioners. If these petitioners bind themselves to pay 10% of the cost of the road the county commissioners are required to petition for state aid.

Whom petitioned. The highway commission.

Total state aid fund. The sum of $200,000.000 is annually appropriated for state aid in highway construction.

Limitations on state aid. The county commissioners can not be required to expend on state aid roads more than 25% of the road levy of the county.

Apportionment of the cost of state aid roads. The amount of state aid in any county is proportional to the road mileage. The state pays one-half the cost of construction. If any county

does not avail itself of its share such share is reapportioned among the counties desiring it.

Manner of doing work under state aid. The work is done under contracts let by the county commissioners, but if bids are too high they may build in some other manner. All contracts are subject to the approval of the state highway engineer.

Securing right of way. State aid appropriations are not to be used for the purpose of acquiring the right of way for any road improvement.

Duty of making surveys. Surveys and specifications are prepared by the state commission.

Repairs and maintenance of state aid roads. The counties are responsible for the repair and maintenance of state aid roads. Such repairs must be satisfactory to the state commissioner and the county officers can be compelled by mandamus proceedings to keep the roads in proper condition.

Powers of state highway officer—

—over road supervisors. The immediate supervision of the work is in charge of the state commission and supervisors are paid out of the state appropriation.

—over distribution of state aid fund. The highway commission can withhold state aid funds from counties not complying with their requirements.

—over maintenance of state aid roads. State aid roads must be maintained in a manner satisfactory to the highway commission which is empowered to withhold funds if the work is not satisfactory.

MAINE.

PAUL D. SARGENT.....*Commissioner of Highways.*

Date and general duties. The first state aid law was passed in 1901. In 1905 a law requiring the appointment of a state highway commissioner was passed. This commissioner is required to compile statistics on roads, conduct investigations

relative to roads, distribute maps and publications, and by lecturing and otherwise to disseminate knowledge throughout the state on the subject of road construction and maintenance and also concerning bridges and side walks.

Right of petition for state aid. The officers of any city, town, or organized plantation may petition for state aid.

Whom petitioned. Petitions are made to the board of county commissioners who petition the secretary of state.

Total state aid fund. The first appropriation for state aid was $15,000.00 in 1902; in 1903 this was made $20,000.00 and in 1904 it was increased to $40,000.00.

Limitations on state aid. Towns and cities may receive state aid for construction of any piece of work costing more than $100.00 and less than $300.00.

Apportionment of the cost of state aid roads. The state pays ½ the cost of improvments whose cost is within the limits named in the last paragraph.

Manner of doing work under state aid. The manner in which work shall be done is left to the choice of the towns and counties.

Powers of state highway officer—

—to compel town and county officers to furnish uniform detailed accounts of highway and bridge expenditures. All township and county officers are required to furnish information upon request to the commissioner of highways.

Wide tires. The town may remit not over $3.00 of road tax to users of 6 inch tires.

Public Meetings. The highway commission is required each year to hold a meeting in each county of the state for the discussion of questions pertaining to the highways.

PENNSYLVANIA.

JOSEPH W. HUNTER.....*Highway Commissioner.*

Date and general duties. In 1903 the state highway department was formed by the legislature of the state. The department was charged with the compilation of statistics and information as to the mileage, character, and condition of the state highways. Methods of road construction were to be investigated and standards established. Advice and information was to be furnished free of charge to road officials whenever required.

Right of petition for state aid. The township supervisors with the approval of the majority of the assessed valuation of real estate can petition county commissioners and through the courts compel the county commissioners to petition for state aid.

Whom petitioned. The state highway department.

Total state aid fund. The total sum of $6,500,000.00 was appropriated at the time of the formation of the highway department. Of this sum $500,000.00 was available during each of the first two years, $1,250,000.00 the third year, the same for the fourth year, and $1,500,000.00 each in the fifth and sixth years.

Limitations on state aid. State aid is appropriated among the counties in proportion to the road mileage. If any part of the apportionment for a county is not applied for within two years, it is to return to the state treasury and be reapportioned. State aid is limited to highways outside of the corporate limits of any city or borough.

Apportionment of the cost of state aid roads. Of the total cost of the improvement two-third is to be paid by the state, one-sixth by the county and one-sixth by the township. This was later amended so that the state is required to pay three-fourths of the total and the town and county each one-eighth. Roads which pass through boroughs and connect state aid roads may receive aid to the extent of three-fourths of the cost.

Manner of doing work under state aid. The state commissioner is empowered to advertise for bids and let contracts without consulting the local officials. All contracts are to be signed by the state highway commissioner and approved by the attorney general.

Duty of making surveys. Surveys and estimates of cost are made by the state highway department.

Repairs and maintenance of state aid roads. 10% of the total state appropriations for state aid is set aside for maintenance.

Powers of state highway officer—

—over automobiles, bicycles, etc. The highway department is charged with the duty of issuing all automobile licenses in the state.

—to compel town and county officers to furnish uniform detailed accounts of highway and bridge expenditures. The highway department is authorized to demand reports upon road conditions from all local road officials.

MICHIGAN.

HORATIO S. EARLE.....*State Commissioner of Highways.*

Date and general duties. An amendment to the state constitution was submitted to the voters in April 1905 and adopted by a large majority. This amendment enabled the state to appropriate money to aid in highway building and the legislature thereupon passed a law creating a highway commission.

Right of petition for state aid. Towns or counties may petition.

Whom petitioned. The state highway commission.

Total state aid fund. The first appropriation for the year of 1905 was $30,000.00 and $60,000.00 was appropriated for 1906. $10,000.00 of each appropriation is available for running expenses of the office of the commissioner.

Limitations on state aid. The law is intended to benefit country roads alone. Not less than one or more than two miles of road in any one township is eligible for state aid in one year.

Apportionment of the cost of state aid roads. This state has a unique plan for the application of state aid. Set specifications for different types of roads are drawn up. Any town or county may go ahead and build such a road and if the specifications are followed the town or county is entitled to a certain "reward". This "reward" is so adjusted as to be approximately one-third of the cost of the road. The specifications for the different roads are roughly as follows: maximum grade 6%, width not less than 18 feet between ditches, properly drained, and having a hard wagon track not less than 9 feet wide made in two courses. A road with 5 inches of gravel on clay and sand calls for a reward of $250.00 per mile. One with eight inches of gravel applied in two layers calls for a reward of $500.00 per mile. One with three inches of gravel on four inches of crushed stone, or three inches of crushed stone on four inches of gravel calls for a reward $750.00 per mile. Macadam roads not less than nine inches thick laid in two courses call for a state reward of $1,000.00 per mile.

Repairs and maintenance of state aid roads. Repairs are left in the hands of local authorities.

Powers of state highway officers—

—over distribution of state aid fund. The decision as to whether a road is built well enough to merit the state reward is entirely in the hands of the commissioner.

County supervisor. Upon vote of the people any county in the state can adopt the county highway system. The county board of highway commissioners, not exceeding five, is elected by the people and the term of office is a certain number of years proportional to the number of commissioners. If there are five commissioners, one is elected for two years, one for four years, one for six years, one for eight years and one for ten years and after that each commissioner shall be elected for the full term of ten years. If there are two com-

missioners the term of office is four years with terms arranged in a corresponding manner. The board of supervisors fixes the compensation of such commissioners. This board of county commissioners may lay out new roads, change the width, or straighten the line of any road. They may take any road they choose as a county road upon notifying the township highway commissioner, and are given authority to "grade, drain, construct, gravel or macadam, or to place thereon any other form of improvement which in their judgment may be best, and may extend and enlarge such improvements. They shall have authority to construct bridges and culverts on the line of such roads and to repair and maintain such bridges and culverts." They determine the amount of tax to be raised for county highway purposes each year, which, however, may not exceed a limit of two mills on the dollar tax of the assessed valuation.

This county system has been very efficient and useful in Michigan. The highway commissioner made the statement that he would be pleased if all counties in the state were under this law as much better work was done and more interest was taken in highway questions.

Width of road built by state aid. State reward roads are not less than nine feet wide.

Wide tires. On affidavit to the effect that all loads over 800 pounds have been hauled on tires of 3 inches or wider, a rebate is granted of ¼ of the road taxes, the total rebate not to exceed 3 days of road work to any one person.

Public meetings. The highway commissioner is required to hold meetings in each county at least once each year. The presence of town and county highway officers at these meetings is required, and their time and expenses at the rate paid when they are working upon the roads are to be paid by the towns which they represent.

IOWA.

A. MARSTON.....*Dean of Engineering, Ames College.*
C. F. CURTISS.....*Dean of Agriculture, Ames College.*
F. H. MACDONALD.....*Assistant in Charge of Roads.*

Date and general duties. In 1904 the Iowa legislature passed a law appointing the State Agricultural College at Ames as the highway commission. The duties of the commission were defined as "the devising and adopting of plans for highway construction and maintenance suited to the several needs of the different sections of the state." For the education of highway officers and students the commission was directed to carry on practical demonstrations of road construction, as well as to disseminate knowledge on the subject in any other feasible way. They were also directed to afford supervision by practical road builders for road demonstration and road work.

Total state aid fund. No money is appropriated for state aid in road building, but $5,000 per year is appropriated for carrying on the work as defined in the duties of the commission. This commission has been doing some good work although they have been very seriously handicapped by the lack of proper funds.

Wide tires. Persons paying road taxes are entitled to a rebate of ¼ of their total tax not to exceed $5 to any one person, upon making affidavit before the town clerk that all loads of 800 pounds or over have been hauled upon tires at least three inches wide.

The Iowa highway commission has done some very good work in making designs for standard forms of concrete culverts and bridges for use in the various parts of the state. Considerable of their work with regard to the use of concrete for highway purposes is quoted on other pages.

ILLINOIS.

EDMUND J. JAMES.....
JOSEPH R. FULKERSON..... } *State Highway Commission.*
LAFAYETTE FUNK.....
A. N. JOHNSON.....*State Highway Engineer.*

Date and general duties. The Illinois highway commission was formed in 1905, consisting of three persons who serve for a term of two years. They are authorized to investigate methods of construction, materials and other matters relative to the construction of highways in the state and are to furnish advice to local authorities free of charge.

Total state aid fund. $25,000 was appropriated for the expenses of the office and the construction of a few object lesson roads in different parts of the state. Illinois gives aid to local road authorities by furnishing free of charge stone which is crushed at the state prisons. Towns having such material furnished to them must make use of it according to the specifications of the state highway engineer or have their supply cut off.

Power of state highway officer to compel town and county officers to furnish uniform detailed accounts of highway and bridge expenditures. All local highway officers are required by law to furnish the state highway commission with such information as it may ask for regarding local conditions.

OHIO.

SAM HUSTON.....*State Highway Commissioner.*

Date and general duties. The seventy-sixth General Assembly of Ohio passed an act in 1904 establishing a state highway department. The state highway commissioner was appointed by the governor for a term of four years. Assistants and office help were also provided for in the law.

The duties of the department were to investigate road building throughout the United States and road materials of Ohio, and to prepare and distribute bulletins and reports on the subject of road improvement.

Right of petition for state aid. County commissioners (or land owners through the county commissioners) can petition for state aid.

The officer or body petitioned. The state highway department.

Total state aid fund. No appropriations were made to carry out the provisions of the act in 1904, but an appropriation of $16,400 was made for 1905, of which $6,400 was for the office expense and $10,000 for state aid.

Limitations on state aid. State aid money is divided equally among the counties.

Apportionment of the cost of state aid roads. Of the cost of permanent roads built with state aid, 25 per cent is paid by the state, 50 per cent by the county, 10 per cent by the towns and 15 per cent by the property fronting on the road to be improved.

Manner of doing work under state aid. All work is done by contract, bids being advertised for and contracts let by the highway department. All contracts are subject to the approval of the county commissionrs.

Powers of the state highway officer to compel town and county officers to furnish uniform detailed accounts of highway and bridge expenditures. Local road authorities are required by law to furnish the highway department data as to mileage, cost, maintenance, condition and character of roads under their supervision.

Wide tires. It is unlawful to haul more than 2,000 pounds on tires narrower than three inches. County commissioners are empowered to employ persons to see to the enforcement of this law.

MINNESOTA.

GUSTAVE SCHOLLE, *President*.....
GEORGE W. COOLEY, *Secretary*..... } *State Highway Commission.*

Date and general duties. In April 1905 a law was approved providing for the appointment of a state highway commission consisting of three members who were to appoint a secretary not one of the three, who was to be a civil engineer and practical road builder and to be known as the State Engineer. The commission was directed to investigate and determine the location of road materials in the state, ascertain the most improved methods of construction, investigate the most improved highway laws in other states, and make recommendations as to the needs of the state in regard to roads and highway legislation. The commission was directed to prepare rules for the construction of state roads.

Right of petition for state aid. County boards are the only ones empowered to petition for the establishment of a state road.

The officer or body petitioned. The state highway commission.

Total state aid fund. An annual tax of one-twentieth of a mill on each dollar of assessed valuation was provided as the state road and bridge fund. This amounts to about $80,000 at present. Aside from this tax $6,000 was appropriated for the running expenses of the highway commissioner's office.

Limitations on state aid. It was provided that no county should receive more than 3 per cent nor less than ½ of 1 per cent of the total bridge and highway fund in one year. In apportioning the funds the commission was directed to take into account the area of the county, the amount of money expended by it in road construction, and *the extraordinary expense connected with the development of new territory.* This last provision is one which appears in the laws of no other state, but

which is very much to be commended, especially in a state which has so much undeveloped territory as has Minnesota.

Apportionment of the cost of state aid roads. The amount appropriated to any one county was not to exceed ⅓ of the cost of the permanent roads built during the year.

Manner of doing work under state aid. The county board receives bids on all work to be done with state aid, or may appoint a superintendent to do the work under county charge.

Duty of making surveys. Surveys are to be made by the state engineer when practicable but if he is unable to do so the county board may employ the county surveyor or some other competent man to make the surveys and report to the state engineer.

Repairs and maintenance of state aid roads. Nothing is said in the Minnesota law regarding the maintenance and repair of roads built with state aid. In this respect the law is weak, as one of the most important features of state aid is the use of the power to compel the towns or counties to do some careful maintenance work and thus teach them how to care for roads in a proper manner.

Powers of state highway officer over distribution of state aid fund. If any road being built under state aid does not come up to the specifications of the state engineer the state's proportion of the cost of construction shall be withheld.

By the terms of the law "road" is defined to include all bridges upon the highway. It is provided that not more than ⅓ of the state money shall be expended for bridges in any one year.

WASHINGTON.

CHARLES W. CLAUSEN, *State Auditor*.....
G. Y. MILLS, *State Treasurer*..... } *State Highway Board.*

Date and general duties. In 1905 the state of Washington provided for a state highway board composed of the auditor, the treasurer, and the state engineer. The latter is appointed

by the governor for a term of two years at a salary of $2,500 and must be an experienced engineer and surveyor.

Right of petition for state aid. The money for state aid is not distributed upon petition but according to appropriations made for specific roads.

Total state aid fund. $10,000 was appropriated for office expenses and $134,000 for aid in constructing ten roads which were specified in the law. These appppropriations were for two years.

Apportionment of the cost of state aid. The state pays ⅔ and the county ⅓.

Manner of doing work under state aid. Work is done by contract under bids advertised for by the county commissioners. Any contract may be rejected by the state highway engineer.

Securing right of way. State aid funds are not to be used in securing right of way for any state aid road, such right of way being provided by the county.

Duty of making surveys. Surveys are made by the county board at the expense of the county and submitted to the highway commissioner.

Repairs and maintenance of state aid roads. The roads are maintained and repaired by the counties in which they were located.

Powers of state highway officer over distribution of state aid fund. When funds are appropriated to build any road the allotment to each county in which the road lies is to be determined by the state highway board.

GENERAL PROVISIONS.

The laws of all the states having a state highway officer provide that he is to have charge of the relocation or construction of state aid roads. Most states provide that originally roads must be laid out by the county or town officers, but when the state appropriates money for their improvements they must be relocated, if necessary according to the surveys of the state officer.

As a resume of the present status of the movement for state control of highways, the following table has been prepared. The chief sources of information for this are a thesis on "Tendencies in Recent American Road Legislation" by Prof. F. G. Young of the University of Oregon, and Bulletin 4 of the Ohio Highway commission.

State.	Beginning of state highway department.	State highway officers.	Total appropriation in		State's share of road costs.
Maine	1901	Highway Commissioner	1904	$40,000	⅓
New Hampshire	1903	State Engineer	1905	125,000	¼ to ¾
Vermont	1892	Highway Commissioner	1904	91,795	⅓
Massachusetts	1893	Highway Commissioner	1905	549,450	¾
Rhode Island	1902	Board of Public Roads.	1905	125,000	All
Connecticut	1895	Highway Commissioner	1904	225,000	⅔ or ¾
New York	1898	State Engineer	[1]1904	1,108,265	½
New Jersey	1892	Com. & State Engineer.	1905	250,000	⅓
Delaware	1904	Highway Commissioner	1904	30,000	½
Pennsylvania	1905	Highway Commissioner	1905	[2]6,500,000	¾
Maryland	1898	Geol. Survey & Engineer	1904	200,000	½
North Carolina[3]	1901	Com'r. of Agriculture & State Geologist			
Ohio	1904	Highway Commissioner	1905	17,400	¼
Indiana	1904	([4])			
Michigan	1905	Highway Commissioner	1905	35,000	½
Illinois[5]	1905	Highway Com. & Engineer.	1905	25,000	
Minnesota	1905	Highway Commissioner	1905	86,000	⅓
Iowa[5]	1904	Highway Commissioner	1904	1,000	
Missouri[6]	1906				
California	1904	Highway Com. & Engineer.	1904	25,000	Builds certain roads.
Utah[7]	1903	State Engineer			
Colorado	1905	State Engineer	1905	150,000	Builds certain roads.
Washington	1905	Highway Board & Eng'r	1905	144,000	Builds certain roads and pays ⅔.
Idado[8]					

[1] After 1904 the funds are supplied as needed by a $50,000,000 bond issue, and no appropriations are made except for support of the office of the state engineer,

[2] This amount is to be expended in six years.

[3] The Commission is an advisory board and is carrying on educational work.

[4] A special commission was appointed to study situation and recommend laws to next legislature. The roads and materials have been studied by the Geological survey.

[5] These commissions are carrying on educational work preparatory to state aid operations later on. The Iowa appropriation is for two years.

[6] In the summer of 1906 a state conventiou was held at Chillicothe under the auspices of the state agricultural department to request the coming legislature to appropriate $1,000,000 for state aid and establish a highway department.

[7] The state engineer was instructed to prepare plans for state aid.

[8] The state builds certain roads by direct appropriation, paying part or all the cost as conditions vary.

CHAPTER III.

DESIRABLE CHANGES IN THE PRESENT ROAD SYSTEM.

Larger road districts. The road system of the state of Wisconsin is in some particulars fundamentally wrong in that it fails to promote a public spirited interest in the general good condition of the highways. At present the roads of a large majority of the towns are divided into many small districts comprising in some cases, but a mile of road. This is done with the idea that better work will be accomplished—the farmer having but a short distance to go to his work—and that he will take a greater interest in a road which passes his front door. The result of this minute subdivision of the towns is that those parts of the town which have the best soil and the most prosperous farmers have a disproportionately large share of the road tax to work out, while the poorer parts of the town where the soil is not so rich and the roads are perhaps hilly and steep have had to maintain their roads on a considerably smaller tax. This short sighted view that the farmer is concerned only with what passes his own front door and has no interest in the road which does not, has resulted in a very strong prejudice against the payment of road taxes in money. As one man stated to me:—"If we pay our road taxes in cash the town commissioner would go into that other side of the town and use our money to fix up those fellows' roads. We have worked hard for our money here and built ourselves good roads. Let those fellows over there do the same thing."

In his apparently just and fair statement of conditions this man has failed to take account of the fact that his farm was in a rich level part of the town, while "those fellows over there" lived in a rocky, hilly place and naturally could not be expected to be as prosperous nor to build as good roads as could be built on the level even if they had as much tax to spend. This idea that one part of the township is not responsible for the condition of the roads in another part is not in accord with the fundamental reason for the existence of governments. Governments exist in order to protect the weaker members of society. If a man through sickness or misfortune is unable to support his family the government steps in and from the taxes it has collected from people who are better off than he keeps that family from starving. On the same principle it protects the weak against the encroachments of the strong in innumerable ways. According to the same principle still more locally applied all the labor in a road district may be used in any part of that district where the road needs repairing. The injustice of requiring each farmer to maintain the road by his own farm would be promptly appreciated, especially by the man who had a steep hill to care for or a bridge to put in. For the same reason that the town puts in bridges and that the road district maintains a steep hill which is all upon one man's farm, should the town also use its road funds as a unit which can be expended anywhere within its territory. In this way only will good roads be secured.

This distribution of funds where most needed regardless of who pays the tax is a step in the right direction which is badly needed and which will bring about a more healthy public spirit with regard to roads.

Permanence of road officers. The present system under which road officers are appointed by the town board and usually changed each year makes impossible the proper building and maintaining of country roads. As the road overseer has no prospect of remaining in office for more than a single year he can have no strong incentive to make a particular study of

the needs of roads under his charge or to become at all deeply interested in their welfare. A man will do good or poor work according as he is interested in what he is doing. Consequently the roads of the state are an infallible indication of the degree of interest which the road overseers have taken in them.

In the list of questions which were sent out to 2,000 farmers the question was asked as to whether it would be advisable to hold a road school for a week each year, in which the highway officers could become acquainted with the best methods of road building. The replies to this question were in the majority negative because, as was stated, the road overseers would not have sufficient interest or incentive to attend. Many of the replies suggested that if road overseers were to be continued in office for a number of years it would be a profitable venture for the town to pay their expenses in order to have them attend such a school, but that under present conditions it would be useless.

Another condition which the short term of the road overseer brings about is that it is impossible for the work of the town to be adequately planned for a term of years and carried out according to this plan. Each man has before him simply the problem of fixing up the roads so that they will be passable for a year, without any reference to what will be done the next season. This is an extremely expensive method of doing work. In order to produce good results some well thought out plan must be followed the same in road building as in any other project.

The present system also makes possible the sorry condition that when a road fixed up by one man according to his ideas does not agree with the ideas which his successor holds the successor in too many cases proceeds to tear it up and rebuild it according to his own notion in order to show the other fellow how a road should be built in a 'real proper' manner. This is a condition of affairs which could not be tolerated in any other business as it entails too great a waste of money. The situation is well expressed, and in very

conservative language in the following letter from Mr. Paul C. Wilson of the Grassland Stock Farm of Menomonie: "I doubt very much if 50 per cent. of the road overseers are appointed because of any special fitness for the job. I have seen right here in our own town men appointed as overseers who, if they had kept the office for a few years, might have benefited the roads, but after one year were retired and the one appointed to fill the place took the same piece of road and undid all the work of his predecessor, and he in turn let out. This does not tend to keep up a permanent improvement."

Cash tax. The cash tax system is one which has been voted upon in practically every town in the state, with the result that almost all the towns are still paying their highway taxes in labor. People must be brought to see the value of the cash tax, however, before they can hope to have roads that are properly built with the money which they can afford to pay. A letter from a road overseer states that "tax-payers never seem to want to work when the overseer wants them to, and it often takes as much money to arrange for the farmers to do the work as the work itself amounts to when they get upon the road." It is a strong objection to the labor tax system that the road overseers have no real authority. If the overseer has an interest in the work he is glad enough to get the farmers to come with their teams and men, so that he does not want to offend them by requiring too strenuous labor. On account of the political nature of his appointment he does not desire to create enemies for the one who appointed him by requiring more work than the farmer is willing to give. Of course there are many towns in which this is not true and in which the overseer faithfully requires a good day's work and the full amount of the tax to be worked out, but these towns are not so large a majority as they should be.

Another objection to working out the road tax is the character of the work done. Road work is too often regarded as an "annual picnic," as one man called it, and the object of getting the road fixed regarded as secondary to

pleasant associations with the neighbors. One town chairman writes, "We are at present working on the old district plan but we intend the coming season to pay taxes in money and have one road commissioner for the town. It has been my experience as chairman of the town for the last six years that we can get more than double the work by job work for cash." Another correspondent writes, "Our town has followed the cash system for several years and I think we get from four to ten times the beneficial results from the same tax levy." Another writes, "We worked on the cash system one year in our town and accomplished more in that year than in any two years before or after."

A last objection to the labor system is that the number of hours labor required are less than would be required under the cash labor system. Under the present system only eight hours of labor make a day, and this eight hours is customarily cut short at both ends and in the middle so that it is frequently but six. One man 'has a large number of cows to milk and his hired man has left him,' and another man 'has to go to town to get a piece of machinery for the next day's work,' and so on through the whole list of excuses that every road overseer knows.

The payment of highway taxes in cash does away with the difficulties mentioned. (1) It makes possible the securing of labor just when it is needed without regard whether any particular farmer is able to come or not. (2) It gives the overseer complete authority over his men, as he can discharge them if they do not render satisfactory service. (3) It improves the character of this service for the simple reason that the men know they can be discharged. (4) The length of the day can be made ten hours for road work the same as any other class of farm labor.

The need of trained men. Under the present system road overseers are almost necessarily incompetent. This is no reflection upon the intelligence or purposes of these officers, but it is a strong reflection upon the system. The building of a country

road in a proper manner is about as complicated a piece of engineering as is commonly met with and the farmer cannot ordinarily, from the very nature of things, be a man who is specially trained for this type of work. Highway building and maintenance requires as high an order of skill as railway building and maintenance, and yet there are not many farmers who hold themselves capable of building and maintaining a railroad. Under the present system it is difficult to secure men who have had any training in road building. Men who have made any special study of this matter are very rare as yet in this country and in order to make them available they must be educated.

Because the enormous sums of money which the people are expending on roads are entrusted to the management of men who have no training for their work we see the present bad results every time we drive over the ordinary country road. This waste of money is estimated by replies from the 2000 letters sent out to farmers in the state at from 50% to 90% of the total highway tax. As seen on page 87 the average estimate is that 58 per cent of the highway tax if paid in cash would do the same work that is being done at present. It is also evident that of this 58 per cent, which is the real value of the tax, a considerable part is wasted by poorly directed efforts. As this tax at present amounts to over $2,000,000.00 the lowest estimate of the waste, which seems to be very conservative, would make the annual loss to the farmers of the state over $1,000,000.00. The need for trained men and the present results due to not having them is stated very well in the following letter from Mr. Schinoldt of Taylor county:—"I emigrated from Germany, made a farm here, and have lived on this farm twenty-three years and one half. I have seen in these years hundreds of thousands of dollars of tax payers' money expended on the roads in town and county, but after all our roads are still as bad as ever. *Not the scarcity of money,* but the *system* is to blame for this state of affairs. We need men in charge of road building and road maintenance who are *trained* for this sort of work and *understand what to do in a*

proper way, and who should *hold their positions for a succession of years.* Take the road business from the town boards newly elected every spring and make a thoroughly state and county institution. Let us have a state road commissioner, county and town road engineers all *well trained* men and not elected but appointed from the state, and then let them work systematically. *Not money alone makes good roads or makes the roads better, but skill in plans and labor."*

Road accounts. From the replies to the letters sent out to town clerks it is evident that the accounts of the highway expenditures of the towns are kept in very poor fashion. In few instances were the books so kept that the total cost of any particular piece of macadam or gravel road could be given, to say nothing of giving any detailed account of the other expenditures. So long as the accounts are kept in this way it is of course impossible to tell whether money is being expended carefully or thrown away with an extravagant hand. If there is a certain amount of money available and it is spent—which is about the extent of the record of expenditures which is kept at present—no comparison of costs can be made, and one road overseer may take ten times as much to do a piece of work as the overseer in the next district uses on a similar job. The importance of careful accounting in even a small business does not need to be emphasized, but in a large undertaking such as the highway business of the people of Wisconsin has become, in which over $2,000,000.00 is expended annually, the accounting becomes of much greater importance. If a highway department is established in the state it should be one of its functions to see that town highway accounts are kept in some good form.

Section system. In no place in the state, so far as I have been able to learn, is there any provision for continuous care for roads. The laws should be so modified as to very strongly encourage this as there is no single change which will effect such a saving of people's money as the application of some such system as that described in the chapter on maintenance.

County road system. The advantage of having a large unit of road control, such as the county, lies in the fact that it has a larger amount of money to expend and can therefore afford to have men who are trained in their work and can keep these men continually busy and get better results cheaper than is possible in the ordinary town. It is the same principle as that upon which the wholesale dealer works. By securing his goods in large quantities he is able to get them much cheaper than the retail dealer and can therefore sell them at a lower price. In case an engineer is hired to do a single piece of work in a town he may charge ten to twenty dollars a day, whereas a competent man could be obtained by the county for about half the smaller sum. This county system has been used in New York and Michigan for a number of years and in these states has given the very best of satisfaction. The highway commissioner of Michigan stated that much more and better work could be done under the county system than under the township system.

Automobiles. There is a very strong, and one must confess, to some degree justifiable prejudice in many parts of the state against the building of good roads because of the fact that as soon as good roads are built automobiles drive the farmers off and compel them to use the back roads. The automobile is here to stay, and before many years will undoubtedly be adopted by farmers themselves the same as the bicycle has been. Most drivers of automobiles are very considerate when they meet a frightened team, but there is unfortunately too large a proportion of "road hogs", as they are well called, who think it is a good joke to scare some staid farm horse into jumping the fence and smashing the farmer's rig. These few thoughtless automobilists have brought strong disfavor upon all owners of automobiles. Something must be done by the state to protect the farmers so that the roads will be safe for them to travel upon after they are improved before any comprehensive program for improvement can be successfully carried out. How-

over this is not a problem which can properly be discussed in this place. It is sufficient here to mention the fact that something should be done.

State aid. The working of the plan of state aid in other parts of the country is given in Chapter II, Part II, and the fact that without exception it has been successful and is enthusiastically supported by the people wherever adopted is the strongest argument for its adoption in Wisconsin. The Legislature of 1905 passed a joint resolution to amend the constitution, making possible the appropriation of money for state aid in road building. This joint resolution must be considered by the legislature of 1907 and if passed by them must be voted upon by the people before any money can be appropriated in Wisconsin to aid in building roads.

The effect of the adoption of such a system in Wisconsin can be judged by its effect in other states. Where the plan has been adopted the public spirit of the citizens has been aroused and their interest in the good condition of the roads excited to such an extent that large sums have been spent in improving the roads. According to most careful estimates the people have had more returned to them in the increased value of the land than the improving of the roads has cost. The investment of these sums has therefore been amply justified, even though the roads had had to be built without state aid, and directly by the country districts through which they passed.

Railroads in many states have been so keenly interested in the building of roads that they have sent out experts and trains of machinery to build sample roads in districts along their lines. As a railroad official said at the buildng of one of these object lesson roads, 'his railroad served the country for not over five miles on each side of its track [it was a southern railroad] and if good roads were built in the country it would serve the people within a distance of 25 or 30 miles. This would mean to his railroad an increase in business of several hundred per cent.' In the same way are cities interested in the building of good country roads. The merchants of the cities in several parts of

the state have given ample subscriptions for the purpose of aiding in building roads to attract the trade of the country districts to them. While they have done this partly from philanthropic motives, no doubt there has been also back of their giving, the knowledge that they would receive this money back in the profits on increased sales of goods. It may at first sight appear to the ordinary dweller in a city who is not in trade that he is in no way benefited by the expending of taxes raised upon his property for the building of country roads, but this is entirely wrong as a moment's consideration will show. During the National Good Roads Convention at the St. Louis World's Fair one speaker computed for the benefit of his audience that the city of St. Louis paid each year in excess freight upon goods delivered to them from the surrounding country in farm wagons a sum of $250,000. He stated that this sum was paid by the city rather than by the farmers because of the well known fact that the consumer pays the freight. In other words, the farmer must make a living and if it costs him a dollar more to haul a load of potatoes to town over a bad road than it would over a good road the persons who buy those potatoes must pay a dollar extra in order to give the farmer that which he has a right to demand for his labor. For these reasons, therefore, the application of state money to road building is justified, even in the consideration of actual cash returns to the cities and railroads as well as to those by whose farms the roads pass

The giving of state aid is also justified for the reason that it educates the farmer in the value of good roads and teaches him to build them for himself. This has been the case in every state where such a course has been pursued. State aid has not been sufficiently extensive to pay for its share of all the roads which the farmers desired and as a consequence after once experiencing the benefits of good roads they have gone ahead and built them at their own expense without waiting for state money. Nowhere in the United States have good roads been built to any extent where the total cost has been borne by the farmers themselves. Some such means as state or

county aid has been necessary to get up sufficient interest so that people will build good roads, but after once started they have almost always gone much farther than state aid could follow.

The present situation in Wisconsin with regard to money for state aid is different from that in any other state in the Union. For several years it has been found to be possible to pay all the expenses of the state government from the general fund and consequently no state tax has been levied. It is highly probable that this will be continued in the future and therefore, if the system of state aid is adopted, the money thus made available would be in effect a gift from the state to the local communities. So far as known in no other state do such conditions exist.

From this statement of conditions it is at once evident that the people of Wisconsin are losing a most excellent opportunity if they do not demand of their legislators that laws be passed adopting the plan of state aid in this state.

CHAPTER IV.

ADVANTAGES OF MAKING SOME OF THESE CHANGES IN THE PRESENT HIGHWAY SYSTEM OF THE STATE.

In conclusion there is here given a short summary statement of the advantages to be gained by the adoption of some of the changes mentioned in the last chapter.

Town highway commissioners. If the plan is adopted whereby a single highway commissioner in each town is chosen for some considerably longer term to have charge of the road work and all expenditure of road funds, the following advantages will be gained. His term of office will be so lengthened that it will pay him to familiarize himself with the best methods of road building. He can make adequate plans for the improvement of all the roads in the town, and be secure enough in his position so that he can carry them out without interruption By his long term of office he will be sufficiently removed from politics so that he will be able to demand more and better labor from the farmers who may be engaged, and in these ways he can save to the town a considerable percentage of money which they are now expending by applying it in a way which will give them the good roads which are at present being paid for but not received.

Highway accounts. If the expenditures for highway purposes are required to be kept in more detailed form comparisons between the results being obtained by the highway commissioner in one town and those obtained by the commissioner

in the neighboring town working under similar conditions can be readily made by any tax payer. If reports of such expenditures are published, as they should be every year, the tax payer will be in a position to know definitely whether his money is being wasted or expended in a careful manner.

Cash tax. If road taxes are paid in cash it will permit the application of better methods of road work. Road gangs can be kept together long enough so that they become familiar with their work and highly efficient, with no need of changing them and substituting untrained men and teams for those which have more experience. Under the cash system roads can be *maintained;* men can be hired at any time needed, or continually, if desired, to look after certain stretches of road and prevent their becoming so bad as to need any extensive repairs or rebuilding.

County system. Under the county road system, which from the experience of other states is undoubtedly the best one that can be adopted, each particular piece of road machinery can be placed in charge of a man who has had experience in using it and can therefore secure better results and do more work than the ordinary inexperienced operator such as we have under the present system. Roads running in heavily travelled lines through the county can be constructed and maintained, and uniformity of plan pursued throughout so that the road will be uniformly good instead of being, as at present, good in one overseer's district, bad in the next and impassable in the third, and so on, depending on the interest of each local overseer and the difficulties he has to meet.

In the vicinity of large towns the traffic sometimes becomes so great that the taxes of a single road district are not sufficient to keep the roads in repair. This is beginning to be noticed in some parts of this state already. The road district finds it impossible to keep its roads in as good condition as it used to before the traffic became so heavy. Under the county system the cost of constructing and maintaining these roads is placed where it belongs, upon the shoulders of the whole county,

for it is the whole county which uses the road and which therefore should pay for its construction and maintainance.

Under the county system, also, a competent highway engineer can be hired to devote all his time to supervision of county roads and planning and constructing bridges and other improvements which the county may have in hand.

State aid. The benefits of state aid are so many and so important that it is difficult to make a satisfactory summary statement. State aid is of incalculable benefit in creating a proper public sentiment concerning the highways. Under it the people are moved to demand that they have the good roads to travel over which they are entitled to, but which they know very little about in the conditions prevailing under our present system. State aid will be useful to the farmers of the state in furnishing object lessons of proper road construction and maintenance, for if state aid is granted the maintenance of such roads should be placed in direct charge of the county and good regulations for their care rigidly enforced by the state.

A final advantage of state aid in Wisconsin is that the revenues of the state are in such condition that the money could come from the general fund and would not necessarily call for an increased state tax levy.

PUBLICATIONS

OF THE

Wisconsin Geological and Natural History Survey.

The publications of the Survey are issued as (1) bulletins, which are numbered consecutively, (2) biennial reports, and (3) hydrographic maps. These publications are independently paged and indexed, no attempt being made to group them in volumes.

1. Bulletins.

The bulletins are issued in three series:

Scientific Series.— The bulletins so designated consist of original contributions to the geology and natural history of the state, which are of scientific interest rather than of economic importance.

Economic Series.— This series includes those bulletins whose interest is chiefly practical and economic.

Educational Series.— The bulletins of this series are primarily designed for use by teachers and in the schools.

The following bulletins have been issued:

Bulletin No. I. Economic Series No. 1.

On the Forestry Conditions of Northern Wisconsin. Filibert Roth, Special Agent, United States Department of Agriculture. 1898. Pp. vi, 78; 1 map. *Out of print.*

Bulletin No. II. Scientific Series No. 1.

On the Instincts and Habits of the Solitary Wasps. George W. Peckham and Elizabeth G. Peckham. 1898. Pp. iv, 241; 14 plates, of which 2 are colored; 2 figures in the text. Sold at the price of $1.50 in paper and $2.00 bound.

Bulletin No. III. Scientific Series No. 2.

A Contribution to the Geology of the Pre-Cambrian Igneous Rocks of the Fox River Valley, Wisconsin. Samuel Weidman, Ph. D., Assistant Geologist, Wisconsin Geological and Natural History Survey. 1898. Pp. iv, 63; 10 plates; 13 figures in the text. *Out of print.*

Bulletin No. IV. Economic Series No. 2.

On the Building and Ornamental Stones of Wisconsin. Ernest Robertson Buckley, Ph. D., Assistant Geologist Wisconsin Geological and Natural History Survey. 1898. Pp. xxvi, 544; 69 plates, of which 7 are colored, and 1 map; 4 figures in the text. Sent on receipt of 30 cents.

Bulletin No. V. Educational Series No. 1.

The Geography of the Region About Devil's Lake and the Dalles of the Wisconsin, with some notes on its surface geology. Rollin D. Salisbury, A. M., Professor of Geographic Geology, University of Chicago, and Wallace W. Atwood, B. S., Assistant in Geology, University of Chicago. 1900. Pp. x, 151; 38 plates; 47 figures in the text. ***Out of print.***

Bulletin No. VI. Economic Series No. 3. Second Edition.

Preliminary Report on the Copper-bearing Rocks of Douglas county, and parts of Washburn and Bayfield counties, Wisconsin. Ulysses Sherman Grant, Ph. D., Professor of Geology, Northwestern University. 1901. Pp. vi, 83; 13 plates. Sent on receipt of 10 cents.

Bulletin No. VII. Economic Series No. 4.

The Clays and Clay Industries of Wisconsin. Part I. Ernest Robertson Buckley, Ph. D., Geologist, Wisconsin Geological and Natural History Survey. 1901. Pp. xii, 304; 55 plates Sent on receipt of 20 cents.

Bulletin No. VIII. Educational Series No. 2.

The Lakes of Southeastern Wisconsin. N. M. Fenneman, Ph. D., Professor of General and Geographic Geology, University of Wisconsin. 1902. Pp. xv, 178; 36 plates; 38 figures in the text. ***Out of print.***

Bulletin No. IX. Economic Series No. 5.

Preliminary Report on the Lead and Zinc Deposits of Southwestern Wisconsin. Ulysses Sherman Grant, Ph D., Professor of Geology, Northwestern University. 1903. Pp. viii, 103; 2 maps; 2 plates; 8 figures in the text. ***Out of print.***

Bulletin No. X. Economic Series No. 6.

Highway Construction in Wisconsin. Ernest Robertson Buckley, Ph. D., State Geologist of Missouri, formerly Geologist, Wisconsin Geological and Natural History Survey. 1903. Pp. xvi, 339; 106 plates, including 26 maps of cities. Sent on receipt of 30 cents.

Bulletin No. XI. Economic Series No. 7.

Preliminary Report on the Soils and Agricultural Conditions of North Central Wisconsin. Samuel Weidman, Ph. D., Geologist, Wisconsin Geological and Natural History Survey. 1903. Pp. viii, 67; 10 plates, including soil map. Sent, paper bound, on receipt of 10 cents; cloth bound, 20 cents.

Bulletin No. XII. Scientific Series No. 3.

The Plankton of Lake Winnebago and Green Lake. C. Dwight Marsh, Ph. D., Professor of Biology, Ripon College. 1903. Pp. vi, 94; 22 plates. Sent, paper bound, on receipt of 10 cents; cloth bound, 25 cents.

Bulletin No. XIII. Economic Series No. 8.

The Baraboo Iron-bearing District of Wisconsin. Samuel Weidman, Ph. D., Geologist, Wisconsin Geological and Natural History Survey 1904. Pp. x, 190; 23 plates, including geological map. Sent, paper bound on receipt of 10 cents; cloth bound, 20 cents.

Bulletin No XIV. Economic Series No. 9.

Report on Lead and Zinc Deposits of Wisconsin. Ulysses Sherman Grant, Ph. D., Professor of Geology, Northwestern University. 1906. Pp. ix, 100; 8 plates; 10 figures in the text; and an atlas containing 18 maps. Sent on receipt of 20 cents.

Bulletin No. XV. Economic Series No. 10.

The Clays of Wisconsin and Their Uses. Heinrich Ries, Ph.D., Assistant Professor of Economic Geology, Cornell University. 1906. Pp. xii, 259; 30 plates, including 2 maps; 7 figures in text. Sent on receipt of 18 cents.

Bulletin No. XVIII. Economic Series No. 11.

Rural Highways of Wisconsin. W. O. Hotchkiss, B. S., Instructor in Geology, University of Wisconsin; in charge of Economic Geology, Wisconsin Geological and Natural History Survey. 1906. Pp. xiv, 135; 16 plates; 2 figures in the text. Sent on receipt of 10 cents.

In Press.

XVI. The Geology of North Central Wisconsin. Samuel Weidman, Ph. D., Geologist, Wisconsin Geological and Natural History Survey.

XVII. The Raised Beaches of Eastern Wisconsin. J. W. Goldthwait, Ph. D., Instructor in Physical Geography, Northwestern University.

2. Biennial Reports.

The Survey has published four biennial reports, which relate to administrative affairs only and contain no scientific matter.

First Biennial Report of the Commissioners of the Geological and Natural History Survey. 1899. Pp. 31.

Second Biennial Report of the Commissioners of the Geological and Natural History Survey. 1901. Pp. 44.

Third Biennial Report of the Commissioners of the Geological and Natural History Survey. 1903. Pp. 35.

Fourth Biennial Report of the Commissioners of the Geological and Natural History Survey. 1904. Pp. 42.

3. Hydrographic Maps.

There have been prepared hydrographic maps of the principal lakes of southern and eastern Wisconsin. This work is in charge of L. S. Smith, C. E., Assistant Professor of Topographic and Geodetic Engineering, University of Wisconsin.

The maps are as follows:

		Size of Plate, Inches.	Scale, Inches per mile.	Contour Interval. Feet.
No. 1.	Lake Geneva	17 5x10.8	2	10
No. 2.	Elkhart Lake	15.5x13.1	5	10
No. 3.	Lake Beulah	22 5x20 0	6	10
No. 4.	Oconomowoc-Waukesha Lakes	29.8x19.1	2	10
No. 5.	The Chain of Lakes, Waupaca	21.7x20 6	6	10
No. 6.	Delavan and Lauderdale Lakes	22. x16 8	4	10
No. 7.	Green Lake	26 0x17.8	3.2	20
No. 8.	Lake Mendota	23 7x19 5	6	5
No. 9.	Big Cedar Lake	18.0x13.5	2.9	10
No. 10.	Lake Monona	17.6x17.3	4	5

In all of these maps the depth of the lakes is indicated by contour lines, and by tints in all except No. 1. They are sent on receipt of 15 cents each, except Nos. 4 and 8, for which 20 cents are required. They may be had either mounted in a manilla cover, or unmounted.

All correspondence relating to the Survey should be addressed to

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