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The Value of Oil in Road Improvement



An Oil-Made Road.

BY

Albert Dickens

MANHATTAN

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Introductory

At the meeting of the Board of Regents of the Kansas State Agricultural College, held in July, 1905, the writer was instructed to take charge of the experimental road work, authorized by the legislature of 1905 in section 74, of Senate Bill 664, as follows:

74. For the State Agricultural College, to make experiments with crude oil for the improvement of the public roads of the State, one-half to be expended west and one-half east of the sixth principal meridian, and the report of the results to be made to the governor for publication: For the year 1905 and 1906, \$1250, and the year 1907, \$1250, or so much thereof as may be necessary.

Acknowledgement is due my assistant, Mr. Robert E. Eastman, for careful work in constructing and observing the road at Manhattan; and Mr. J. L. Pelham, student assistant, for efficient and conscientious work done at Maple Hill and Garden City. Acknowledgement is due also Supt. E. E. Marshall and the Board of Managers of the State Reformatory at Hutchinson; County Clerk W. McD. Rowan and the Board of Commissioners of Finney county; Vice-president H. U. Mudge of the Rock Island Railroad; and General Manager Hurley and Industrial Commissioner Wesley Merritt of the Santa Fe Railroad, for valuable cooperation and assistance.

The Value of Oil in Road Improvement

By Albert Dickens

The work in testing the value of Kansas oil in road improvement began with some preliminary laboratory tests of samples of oil of different grades and from various sources. These tests indicated that the residuum from the refineries was much superior to the crude oils. The value for road making seems to depend upon the amount of asphaltum and similar substances that the oil contains. The laboratory tests indicated that one gallon of the residuum was equal in road-making qualities to from two to four gallons of the various crude-oil samples. The Board of Regents having directed that the two roads built in 1905 be located at Hutchinson and Manhattan, the matter of freight charges was important and the residuum was selected for the test.

THE HUTCHINSON ROAD

A road one-fourth of a mile in length just west of the Reformatory was selected for the test. The soil is a very fair sample of the sandy loam of the Arkansas Valley. At the date of its selection, August, 1903, no rain had fallen for ten days and the sand was several inches deep. Loads, consisting of fifty bushels of grain, made an exceedingly heavy load for a heavy draft team. A good carriage team required considerable urging to pull the carriage faster than a walk. In constructing this sample road the city of Hutchinson established a uniform grade, set the grade stakes, and furnished a road grader and teams for operating it. The Reformatory officials furnished men and teams for hauling soil for finishing the grade and for applying the oil.

Superintendent E. E. Marshall has recorded data as to the condition of the road. After the grading was completed and the road bed, where fills were required, was well firmed, the entire road — a fourth of a mile in length, and thirty feet wide — was plowed to a depth of about four and one-half inches and thoroughly pulverized with a harrow and disc. A disc (set straight) was run before the sprinkling tank to open small furrows, and a harrow followed the sprinkling tank to thoroughly mix the soil and oil.

The residuum could not be readily applied with the common sprinkling device of the street sprinkler, but a simple arrangement

consisting of a curved piece of four-inch pipe attached to the tank and connected at a right-angle with an eight-foot piece of similar pipe, in which were drilled, at a distance of one and one-half inches, holes three-eighths of an inch in diameter, worked very satisfactorily. A common gate valve in the T coupling gave control of the supply.

The oiling was done the first days of October, and the oil was not heated. The tank used held 500 gallons, and with the teams walking at a moderate gait, the tankfull would cover the road, about 8800 square yards, once. The harrow followed each application; and when one gallon to each square yard had been applied the soil seemed nearly saturated to the depth of plowing-4½ inches. After harrowing the last time a heavy float was used to smooth the surface, and in a week the road was sufficiently firm to allow rolling, a 12-ton paving roller being used, and going over the road several times until it seemed to be thoroughly **firm**. The road was closed for a week after the rolling and was then used by all kinds of heavy traffic. It was firm but not hard. A sharp-shod horse left the caulk marks plainly outlined, but did not tear up the soil, even when driven at a quick trot. November 1 this road was very good, at a time when the adjoining road was very sandy.

One reason for building the sample roads the fall of 1905 was in order that the effect of freezing weather might be noted. **The** Hutchinson road was not noticeably affected; it would seem that the coating of oiled soil kept the underlying soil sufficiently dry to prevent serious heaving by frost.

In June, 1906, the surface of the road, on becoming dry, carried a coat of dust, varying from one-half inch in the places where the grade required cutting to an inch and more in places where a fill was required. Another application of oil was made, varying in amount with the depth of dust, but averaging about one-half gallon per square yard. This was lightly harrowed, and after two days was floated well.

This road is at the present time a most excellent one. The grade is good: slightly over an inch to the foot; and so well-rounded that all water runs off quickly. At the time the section begun in 1905 received the second application, another section of this road was oiled. This was so deeply worked by the traffic that no plowing was required, the disc and harrow sufficing to put it into good condition for oiling. At the time of application the weather was hot and dry, so slightly more than one gallon per square yard was required to saturate the four or five inches of

dry sandy soil. This was harrowed and floated, but lacked the rolling, and has not yet reached the degree of excellence the first section has maintained since the second oiling.

A section of road consisting of two blocks of fairly well-graded street and of a considerably heavier soil was given a coating of oil with no preparation except smoothing it with the float. Less than one-half gallon per square yard was used, and the road was very considerably benefited; the dust was not troublesome during the summer and fall, and the rain-fall was well carried off; but after continued wet weather heavy traffic cut this road quite badly; whereas the sections where the oil was worked in to a depth of four or more inches were not injured.

THE MANHATTAN ROAD

In August, 1905, the road east and extending south of the Agricultural College to the Manhattan City Park was prepared for oiling. This road is built of heavy black soil for the greater part of the length, one block of the road being noticeably lighter. In front of the College grounds the road, for many years, has been notoriously bad in wet weather. This road was well rounded, with wide and shallow ditches, and the center rising thirty inches above the inside of the ditch. The section for oiling was twenty-four feet wide; the grade was two and one-half inches to the foot, which was slightly reduced by heavy rolling and frequent dragging. It was a matter of frequent comment that this road was "too round." This road has proved very satisfactory; all sorts of heavy traffic, including many loads of loose hay, has gone over it constantly.

In the laboratory tests this black soil did not seem to mix well with oil and it was coated with sand an inch in depth. In order to accommodate traffic this road was oiled in two sections. The first oiled was the heavier soil; and this was well worked to a depth of nearly four inches. The disc and harrow were used, as at Hutchinson, and the road was well rolled with a heavy horse roller before it was opened to traffic. Nine-tenths of a gallon to the square yard was applied on this section. The second section oiled was not worked so deeply. It had been very firmly packed by heavy loads during the oiling of the first section, and was worked only about two inches in depth. Six-tenths gallon per square yard was applied. Both sections have been greatly improved by oiling, but the first section has been uniformly better than the second.

In May, 1906, the second section became very dusty. Before oil was secured it was so coated with deep dust that traffic

shunned it. Even at its worst it did not blow badly, and when in June a second application was given it soon became a very fine road. The first section was somewhat dusty, but the oiled crust had not been cut through in any place.

Traffic over this road has been exceptionally heavy. The coal for the College is hauled by heavy teams, and although the contractor's wagons are, by agreement, equipped with wide tires it often happens that the arrival of a number of cars at once compels them to hire extra teams with narrow-tired wagons. During the week between December 28 and January 4 the weather was the most trying, nearly the entire week being damp with five-tenths inch of rain. The heavy loads, many weighing three to three and one-half tons, did not seriously injure the road; in no case was the crust on the first section cut through. The output of a stone quarry, and the cement, sand and other material used in College buildings, has all been hauled over this road, making as severe a year's test as could well be given. The soil below the oiled layer was thoroughly wet by heavy rains immediately preceding the oiling, and some heaving was noticed when the ground thawed in the spring. The crust was not frozen hard, but the under-soil froze to a considerable depth. A floating and rolling after the ground thawed served to put the road in good condition. The road has been given some considerable attention; after each rain it has been smoothed with the drag; and because of street's opening upon the road it has sometimes been necessary to reverse the drag and float the collected mud to the side of the road.

The oiled road has been compared with a well-graded, well-dragged earth road built of a better draining soil. The oiled road has required less care than the earth road, and there have been several days after each heavy rain when the earth road has been far from good while all the time the oiled road has been in such condition that heavy carriages and light loads have been drawn at a good trot. The worst condition that has been observed during the year has been following the light snow-fall which melted the following forenoon. The water standing on the surface and mixing with the surface dust made the road disagreeably sloppy until the wind dried out the road, but all the time the bed was firm and hard. Somewhat the same conditions have followed after long continued drizzling rains. Heavy rains have been quickly drained from the surface.

A short section of road built on a clay hill that has always washed badly has tested the value of oil in preventing washing. In June, 1906, this was plowed to a depth of six inches and several applica-

tions of oil, amounting to nearly three gallons per square yard, were thoroughly worked in. It has proved satisfactory in every way. After rolling and floating July 1st it has been in constant use and is in every way a very fine road. The following copy of notes may be of interest:

NOTES ON BEHAVIOR OF OILED ROAD AT MANHATTAN

November 20, 1905. Road in good condition, fairly compact; sharp-shod horses leave distinct mark of caulks, unshod horses only light mark.

November 27. Road in fine condition, November 23. 1.1 inches of rain-fall, nearly all drained off road; gutters showed some oil. The afternoon of November 25 the road was well dragged with King drag and rolled with the horse roller weighted to about three tons. Heavy teams with narrow tires cut in two inches morning of November 25, dragged ruts well-filled. Road in fine condition for light driving.

December 31. Tests made with heavy load: 6000 pounds of stone on oiled road show slightly heavier draft than on smooth, unoiled dirt road. The greatest difference in the record is at the start. Less difference in draft where wide-tired wagon was used.

January 19, 1906. Sleet on January 13, two-tenths inches of rain. Road in use; sleet cut up and ground into surface. When sun came out the road became very sloppy, and very disagreeable for one day, after which the drag put it into excellent condition.

February 10. After a light snow but a very sunny morning the water stood in large drops on the oiled surface; road did not become sloppy.

February 18. After one inch of rain on February 14 and 15 the road was dragged, and on February 17 was in excellent condition; was slightly muddy on February 16, but carriage teams trotted without apparent effort and loads did not cut badly. February 18, in good condition.

March 7. After ninety-five hundredths inches of rain on March 5, road in good condition without the drag: drag put in good, smooth surface; very little mud.

April 10. After fifty-five hundredths inches of rain on April 8 the road was not at all muddy; heavy loads of stone—one 7000 pounds—cut through the crust and necessitated some dragging to fill the ruts.

May 10. Road quite dusty. Fair crust below dust; three places cut through with pick showed crust two to three inches evidently well saturated with oil. Dust probably an inch deep.

June 1. Dust very bad on south end, where about six-tenths gallon was applied; less dusty on north end. Dust apparently heavy; does not blow so far as the dust on unoiled roads.

June 25. One gallon per square yard applied to the south section; slightly over one-half gallon per square yard applied to the north section. Both sections harrowed and floated.

July 1. Road in very fair condition, slightly oily.

July 10. Road in very fine condition, hard and smooth.

August 5. Rain of 1.95 inches yesterday. Road in fine condition; earth roads adjoining very muddy: much too wet to drag.

August 25. Rain of 1.15 inches yesterday: road in fine condition: load of stone hauled by heavy team on narrow tires, did not cut through except in a few spots where mud from side street had accumulated (load weighed 8500 pounds).

September 18. Rain Festerday—3.1 inches; seemed to run off as fast as it fell; road in fine condition this morning.

November 19. Twenty-four hundredths inch melted snow; road quite sloppy where side streets join and some water, standing on surface of the best section; road hard; teams trotting without apparent effort.

November 25. Rain-fall one inch yesterday; road in good condition to-day.

December 30. Three-tenths inch rain yesterday; misty for three days; road slightly sloppy but firm and good, while earth road is too wet to drag.

THE MAPLE HILL ROAD.

The Board of Regents having decided that the roads built in 1906-07 should be located at Maple Hill and Garden City, one-half mile of road south and west of Maple Hill, in the Mill Creek valley, in soil that is frequently called "gumbo" and which has been very bad in wet weather, was selected. The grading and preparation was done by the township and the Maple Hill Commercial Club. The oiling was done the first week in September, 1906; the oil was well worked in to a depth of about four inches, about 1.4 gallons used per square yard, rather more than the average being put in the center of the road. Traffic was kept off for ten days. Since that time the road has been subjected to heavy traffic. October 17, when inspected, it was a very fine piece of road, and January 1, after a week of moist weather, it was in particularly good condition. No work of any kind has been done on this road since its completion, early in September, and it has evidently borne all traffic without cutting through the crust of oiled earth. This half-mile was built at less cost than roads at other points; it was nearer the point of unloading and the weather being fine and warm the oil was easily pumped from the tank car to the sprinkler. The residuum used cost 90 cents for a 42-gallon barrel f. o. b. Maple Hill, amounting in all to \$150. The cost of sprinkling, working in, floating and supervision, including board of team and teamsters, cost slightly less than \$100. This oiled road, 16 feet wide, cost at the rate of about \$500 per mile besides the grading. A member of the Maple Hill committee on good roads, who has been interested sufficiently to make frequent observations, reports under date of January 5:

MAPLE HILL, KAS., January, 5, 1907.

ALBERT DICKENS, Manhattan, Kansas.

Dear Sir: The half-mile of oil road that Mr. Pelham put in here last fall according to your directions is in elegant condition and has been tested thoroughly this winter, and has never been touched since Mr. Pelham left it last fall. I consider it by far the best piece of road for the money I ever saw,

Yours very truly,
R. T. UPDEGRAFF.

THE GARDEN CITY ROAD.

The "sand-hill" road south of the Arkansas river, near Garden City, is probably as bad a stretch of road as can be found anywhere. The sand is rather coarse, and when dry works up to a considerable depth. In the summer of 1905 the County Commissioners used one car-load of crude oil on a section of this road. When I visited the road early in the spring of 1906 the effect of the oil was apparent; it had to a degree kept the sand moist and the road was somewhat less bad than the other sections. Compared with the residuum afterward used, the crude oil evidently lacked the binding properties of the residuum. On this first trip to Garden City I met Mr. Bullard, who informed me that some three years previous a Colorado refinery had sent him ten gallons of residuum and asked him to use it in road experiment. He leveled a space ten feet square and poured the residuum upon it, taking no pains to work it into the sand. Guided by Hon. Wm. Kinnison I found the place where the residuum had been applied and we found a considerable section which, though undermined by wind and sand-rats, was of the consistency of a soft sandstone. The appearance of the sand indicated that a much greater quantity of oil would be required than at any other location where we had built experimental roads, and the appropriation being small the County Commissioners agreed to bear one-half the expense of a trial mile, located about three miles from town. This is about the center of the strip of sand-hills and the worst of the strip. Considerable temporary improvement has been made at both ends by hauling old hay, straw or manure upon the sand. This mile had had but little of these. The road was built of the clean sand, and the quantity of oil required was very much greater than had been used elsewhere. The oiling was done in sections a quarter-mile in length, the quantity varying with the condition of the sand. In one place the oil penetrated sixteen inches, and in many places twelve to fourteen, being absorbed by the sand until a layer of moist firm sand was reached. The quantity used varied, the north section, 400 yards long by 4 yards wide, receiving an average of 3.7 gallons per square yard.

The second required 4.3 gallons per yard. This section was graded before being oiled; the sand was dried to a greater depth than the section that had been oiled and worked in. The sand floated upon the surface and the road again was oiled to secure a grade.

The third section received an average of 4.7 gallons per square yard. The fourth or south section was the deepest, and coarsest

sand on the road. The oil penetrated to an average depth of 8 inches—6.06 gallons per square yard was applied. It was found to be practically impossible to close this road to traffic. It was clearly better than the unoiled track, and the temporary fences were of no avail in keeping off the heavily loaded wagons. The oiling was completed October 20, and December 15, when the road was last inspected, it was vastly better than other portions of the road, but was badly cut into ruts. The horse tracks were quite **firm** and some teamsters insisted that even with **ruts** and all it was a “mighty fair road.” Driving horses and saddle horses travelled easily. In some few places an excessive amount of oil had been applied, but this was remedied by floating dry sand into these spots. A road drag was built and the filling of the ruts was begun. It seems now highly probable that even with constant teaming, by keeping the ruts filled, this will ultimately become a very fair road.

THE MANHATTAN DRIVING CLUB TRACK

During the winter of 1905-'06 the owners and drivers of roadsters in and near Manhattan came to appreciate the excellence of the half-mile of oiled road. For a considerable time it was the only half-mile in the vicinity where a horse could be driven at a fast gait.

The directors of the Manhattan Driving Club early announced their intention of oiling their track. The soil of which this track is built varies from a fairly heavy loam to a very sandy loam, and in some places a light silt, deposited by the river at high water, is present. Before oiling, the track was so poor that no horses were trained there. The only assistance the College rendered was in an advisory way; but the effect of the oiling has been watched with interest. About 270 42-gallon barrels were used, which allowed somewhat less than one gallon per square yard. The oil was harrowed in and the track afterward well rolled with a heavy roller. The rolling was finished July 2, and July 4 a matinee was held. The track was not in good condition; it **was** somewhat “cuppy,” and considerable quantities of the oily soil were thrown over the drivers. August 22 to 24 the Club held a race meeting and the track was in very fair condition. The opinions of drivers varied somewhat as to the quality of the track. Some thought it rather slower than hard clay tracks, but practically all agreed that it was a good track, so far as keeping horses' feet and legs in condition was concerned. The track has continued to improve. Quite recently Mr. C. B. Michael, a well-known trainer of long experience, said in an interview: “It is a

first-class training track; the cushion is always there; and there is no danger of the dust cushion being blown away by the first high wind; and it does not require floating after every rain to renew the dust cushion. It is especially good, I believe, for winter and early spring training. Last Friday, after it had been raining all week and the roads were too sloppy to allow jogging, the track was in fine condition. Soon as it stopped raining we could drive as fast as we cared to hurry them. I am not sure as to the chance for breaking records; it may not be quite so fast as a harder track, but I believe it will give less trouble for trainers in keeping their horses' feet, legs and muscles in condition." It is my opinion that this track will require another application of oil the coming spring. I think one-half gallon per square yard will be ample. It is the only oiled road that has had no heavy traffic over it in bad weather, and it is very fine **for driving; it is firm** and somewhat elastic.

OILING MACADAM

One of the most satisfactory uses made of oil has been the oiling of one of the macadam drives. The limestone of which the College drives are built is quite soft and wears badly. Rains and winds remove the dust, and ruts form. In preparing one part of a drive for oiling the teamster misunderstood directions and used a harrow instead of a float. The result **was a** surface of small stones, the harrow working the binding course in below the surface. Sand was used to level the surface and this was well oiled, slightly more than a gallon per square yard being used. It is a very satisfactory surface; it is much less noisy than the macadam alone, and evidently very much easier for the horse. The draft was somewhat heavier when the coating was first applied, but it is becoming smooth, firm, dustless, and nearly noiseless. A section of macadam oiled upon the last course some four months after the completion of the road has given satisfaction. The road has not worn appreciably, although on a slope where wear would be soon noticed. Less than one-half gallon per square yard was used. The surface is smooth and the cost of the oil will in all probability be saved very many times in the increased life of the road, and its desirability greatly increased by the comparative freedom from dust.

SUMMARY

The durability of oiled roads and their need of further applications of oil must be learned by further observations. I believe that the object lessons offered by the samples built will be a considerable factor in advancing the cause of good roads. It seems

to me advisable that sufficient funds be provided to secure definite information concerning the durability of the roads now made.

The residuum from the refinery contains the roadmaking material and has been more successful than crude oil.

The thorough mixing of the earth and oil to a sufficient depth to form a waterproof crust is necessary. For heavy traffic, not less than six inches is desirable; for light driving, three or four inches should be sufficient.

Oil roads will probably require some future application, but it now seems that the amount required will decrease annually as roads become smoother. The use of oil for city streets might occasion some dissatisfaction because of oil sticking to shoes, but careful cleaning of shoes will obviate this trouble.

The residuum first used in 1905 cost one and one-half cents per gallon at the refinery, freight making it cost nearly three cents at Manhattan. Residuum used in 1906 varied from eighty-six cents to one dollar per barrel f. o. b. Maple Hill, Hutchinson, Manhattan, and Garden City. Cost of applying varied with distance, price of labor, temperature and convenience in unloading from fifty to one hundred dollars per car. Cost of road varied from \$525 to \$1300 per mile.

ESTIMATE

One mile, 1760 yards by **6** yards wide (10,560 square yards), at two gallons per square yard (**506** barrels at **\$1** per barrel), **\$506**. Cost of application within three miles of railroad, **\$154**. Total, \$660.

LOCATION.	Kind of soil.....	Preparation.....	Date of oiling....	Amt. of oil per sq. yd., gallons.....		Date of oiling....	Amt. per sq. yd., gallons....		Condition 1 month after oiling.....	Condition 6 months after oiling.....	Condition 1 year after oiling.....	Cost of grade and preparation	
				sq. yd.	gal.		yd.	cents				Cost per mile, road 18 feet wide, oil and application.....	
Manhattan, Section No. 1.....	Very heavy black loam.	Disced 4½ inches.	Oct. 1905.	0.9	3	Jun. 1906.	0.5	1½	Good.	Somewhat dusty.	Very good.	\$ 450	\$ 50
Manhattan, Section No. 2.....	Heavy loam.....	Disced 2 inches.	Oct. 1905.	0.6	2	Jun. 1906.	1.0	2½	Fair.	Very dusty.	Good.	500	40
Manhattan, Section No. 3.....	Clay, <i>hill side</i>	Plowed 6 inches.				Jun. 1906.	3.0	7½	Good.	Very good.		800	150
Manhattan Macadam Drive.....	Macadam road.....	Clean surface.				Jun. 1906.	0.5	1½	Good.	Very good.		125
Manhattan Drive.....	Macadam surfaced with sand.	Smooth the sand.*				Jun. 1906.	1.0	2½	Good.	Very good.		250	250†
Hutchinson Section No. 1.....	Very sandy loam....	Plowed 4½ inches.	Oct. 1905.	1.0	3½	Jul. 1906.	0.5	1½	Good.	Slightly dusty.	Very good.	500	200
Hutchinson Section No. 2.....	Very sandy loam.....	Disced 4 inches.				Jul. 1906.	1.0	2½	Fair.	Good.		300	50
Hutchinson Section No. 3.....	Medium heavy loam.	Surface smooth.				Jul. 1906.	0.4	1	Good.	Only fair.		125	25
Maple Hill.....	Very heavy black soil.	Plowed 4 inches.				Sept. 1906.	1.4	4	Very Good.			425	50
Garden City Section No. 1.....	Sandy.....	Graded slightly				Oct. 1906.	3.7	11	Fair.			1100	20
Garden City Section No. 2.....	Very sandy.....	None necessary.				Oct. 1906.	4.3	13	Fair.			1350	20
Garden City Section No. 3.....	Extremely sandy.....	None necessary.				Oct. 1906.	4.7	14	Fair.			1475	20
Garden City Section No. 4.....	Nearly pure sand.....	None possible.				Oct. 1906.	6.06	19	Fair.			2000	20

*Sand cost 2½ cents square yard spread. †Sand.