7-1-1895

An experiment in roadmaking, Bulletin, no. 30

Pettee, Charles H.

New Hampshire Agricultural Experiment Station

Bulletin 30 July, 1895

NEW HAMPSHIRE COLLEGE

AGRICULTURAL EXPERIMENT STATION

AN EXPERIMENT IN ROADMAKING

BY CHARLES H. PETTEE

NEW HAMPSHIRE COLLEGE

OF

AGRICULTURE AND THE MECHANIC ARTS

DURHAM, N. H.

NEW HAMPSHIRE COLLEGE

OF

AGRICULTURE AND THE MECHANIC ARTS

AGRICULTURAL EXPERIMENT STATION

DURHAM, N. H.

BOARD OF CONTROL

Hon. GEO. A. WASON, *Chairman*, New Boston.
Pres. CHAS. S. MURKLAND, *ex-officio*, Durham.
CHARLES W. STONE, A. M., *Secretary*, Andover
Hon. JOHN G. TALLANT, Pembroke.
HENRY W. KEYES, A. M., Haverhill.

THE STATION COUNCIL

President CHAS. S. MURKLAND, *Acting Director.*
CHAS. H. PETTEE, A. M., C. E., *Meteorologist.*
FRED W. MORSE, B. S., *Chemist.*
HERBERT H. LAMSON, M. D., *Bacteriologist.*
CLARENCE M. WEED, D. Sc., *Entomologist.*
LEIGH HUNT, B. S., *Horticulturist.*

ASSISTANTS

EDWARD P. STONE, B. S., *Assistant Chemist.*
FRED D. FULLER, B. S., *Assistant Chemist.*
RUEL S. ALDEN, B. S., *Farm Superintendent.*
RICHARD FITZGERALD, *Clerk.*

The Bulletins of this Station are sent to any resident of New Hampshire upon application.

AN EXPERIMENT WITH A COUNTRY ROAD

BY CHARLES H. PETTEE

The making of a macadamized road is not in itself an experiment. Reducing the grade or rounding up the centre of a road-bed so as to give more permanency to the road itself is not new. When, however, broken stone roads in a state are practically confined to city limits; when attention to grade is the rare exception on our country roads and correct form of surface is the exception rather than the rule, it seems to be time to institute such experiments, noting cost and results, as will determine whether the so called correct principles of road construction practiced in the larger centers of population are applicable to rural districts.

Advantage has been taken of the necessity of straightening and otherwise repairing certain portions of the highway adjacent to the college farm to carry out an experiment in road construction for the benefit of the farmers of New Hampshire who are and of necessity will continue to be the road builders in our country towns. Work was begun July 1, 1895.

LOCATION

A portion of the 1st New Hampshire turnpike between the Experiment Station building and the railway station, commencing 18 feet westerly along the turnpike from station W. (a bound thus designated in college survey of village of Durham), thence extending 300 feet easterly toward the railway station, was selected for the work.

The following conditions controlled the choice. The location was partly on a hill with a grade of one-fourteenth, or one foot rise to every fourteen in length, and thus needed to be reduced in grade. Toward the top it was well drained with only a thin soil over ledge. At the foot of the slope was a heavy,

wet soil, underlaid with ledge, which had been more or less graveled but which was always muddy in the spring. The surface was hollowing with the water running in the centre of the road. The location was central with reference to college property and needed improvement. At this point water from the college reservoir was available for sprinkling.

SURVEY

As the bounds of the road were not well defined at this point, the general course of centre line was noted for several hundred feet either side of the portion selected and a more or less com-

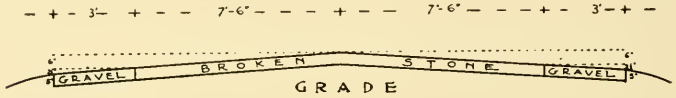

PLATE 1.—Cross-section of Road.

plete survey was made for 400 feet as follows: Ten and one-half feet were laid off either side of the centre line and stakes, three feet in length, were firmly driven opposite each other every twenty-five feet on these side lines. Levels were taken in the centre of the road between each pair of side stakes and also at side stakes themselves. The results were plotted upon cross section paper and suitable grades established, one-twentieth being the maximum allowable. The computed heights of the several stations were then transferred to the side stakes and plainly marked thereon by horizontal lines. A string twenty-one feet in length connecting the marks on two opposite side stakes would then at any time indicate the proper height of road bed at centre. As the string could be replaced at pleasure it caused no inconvenience during the construction.

Commencing at the westerly end four grades were established, level for 25 feet; grade of one-twentieth for 125 feet; of one-fiftieth for 75 feet; level for remaining distance. Plate 1 shows the cross section of completed road,—slope from centre to sides being one-fifteenth.

PLATE 2.—Foundation of Road. (From photograph.)

EXPERIMENTAL PLOTS.

Four inches of gravel were placed upon the surface of two plots, one extending 62½ feet at the westerly end and the other 112½ feet at easterly end; 125 feet of the middle were macadamized or covered with a layer of broken stone to a depth of five inches after rolling. Of this 125 feet, twenty-five, commencing at west end, had gravel foundation. The next 62½ feet had a rock foundation divided as follows: The south half was laid with flattish stone eight to ten inches deep, set on larger end, and securely wedged together by smaller stone driven into the spaces between. The north half required an average fill of about one and one-third feet and larger stone were used there, being packed together as closely as possible and spaces between filled with smaller stone and gravel. Plate 2 shows how these stone appeared before they were covered in. The smaller wedged stone of the south half of the road, forming a regular Telford foundation, had already been covered and do not show in the illustration.

Easterly from the stone foundation, for twenty-five feet in length, the south half was built up with some six inches of gravel foundation while the north half was raised an average of ten inches by clay overlaid with two inches of gravel. The last twelve and one-half feet of macadamized road were graded from three to twelve inches in depth with clay and the broken stone was placed directly on this foundation. The hardened surface was what is called light macadam, consisting of a layer of broken stone from one and one-fourth to two and one-half inches largest dimension, three and one-half inches in depth, well rolled, followed by a layer from one-half to one and one-quarter inches in diameter, two inches in depth, also well rolled. As the amount of stone dust available for surfacing was limited, a layer of good packing gravel one-half inch in depth was then added, followed by a layer of stone dust nearly one-half inch in depth and both were thoroughly rolled. During all rollings the surface was kept well sprinkled.

The crushed stone for this experiment was given by the Massachusetts Broken Stone Co. of 235 Franklin street, Boston, Mass., and was from their quarries at Salem, Mass., the

only cost to the college being the freight on the same. In table of cost, however, the regular price of the stone has been inserted. This stone ranks high according to the tests made by the Massachusetts Road Commission and many cities with complete crushing plants buy it for surfacing and even, in some cases, for all purposes.

The roller used was owned by the city of Dover, N. H. It is of stone and weighs 3700 pounds. It was kindly loaned for the purpose of the experiment by Mr. Isaac L. Lucas, Superintendent of Streets.

Of the graveled portion 62½ feet at the west end and 12½ feet east from macadamized part were graded in full with gravel drawn a distance of a little less than one mile, while the remaining 100 feet were surfaced with the same material. The grade for foundation of this last 100 feet was excavated from the side of the road. To drain the east half a ditch was dug along the south side for a distance of 160 feet, with an average depth of three and one-half feet below finished surface at centre. A three inch tile was laid and the ditch filled to within six inches of the surface with small stone, care being taken to protect the tile from crushing. The surface was covered in with gravelly loam excavated from the side ditches. To secure an outlet, a larger bell pipe was laid across the road extending a total distance of 81 feet. To obtain a suitable depth of ditch five charges of dynamite were employed and considerable rock was removed by wedges. No drainage on the north side was considered necessary.

The following table gives the details of each separate part of the work. Team work has been reckoned at $3.50 per day and day labor, $1.50. Supervision has been estimated on basis of taking a suitable number of men and teams and doing the work. On account of pressure of farm business the actual work was spread over a longer period than supervision covers.

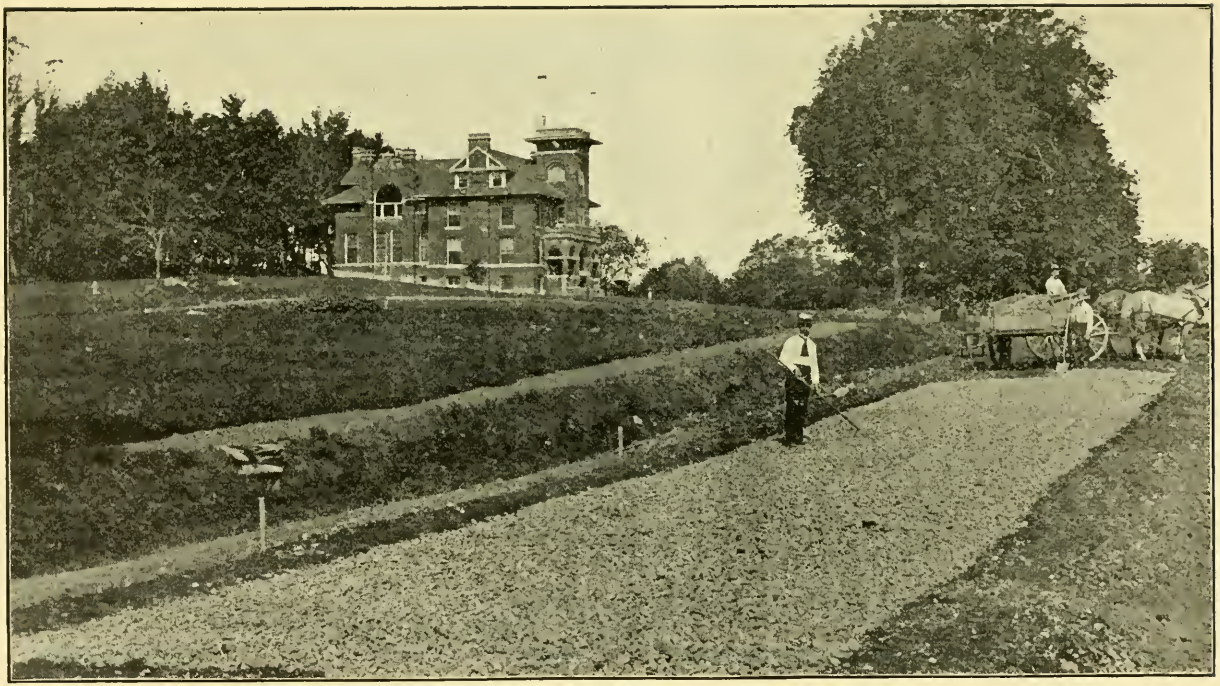

PLATE 3.—Road in Process of Construction. (From photograph.)

Grading 300 Feet of Road.

No. Cub. Yds.	Material.	Length of Haul.	Cost Cub. Yd. Hauling.	Total Cost.
26	Clay.	1-6 mile.	27 cents.	$ 7.00
43	Gravel.	9-10 "	32 "	13 65
20	Hard Pan.	20 feet.	25 "	5.00
49	Rock.	25 rods.	29 "	14 25
Labor placing rock and spreading gravel				10.50
Supervision and surveying three days at $2.00				6.00
				$ 56.40

Approximate cost of rock foundation laid, 44 cents cubic yard.

Surfacing 125 Feet of Road; Broken Stone Centre; Gravel Sides.

No. Cub. Yds.	Material.	Length of Haul.	Cost Cub. Yd. Hauling.	Total Cost on Road.
33.1	Broken Stone.	18 rods.	26.4 cents.	$ 66.78
22	Gravel.	9-10 mile.	32 "	7.00
Team getting roller and rolling, two days, at $3.50				7.00
One man spreading and sprinkling, two days, at $1.50				3 00
Supervision three days, at $2.00				6.00
				89.78

Total cost surfacing macadamized portion, 39 cents per square yard.

Total cost surfacing macadamized portion if broken stone had been increased to 50 cubic yards would have been 59 cents per square yard.

One cubic yard broken stone weighs 2500 lbs, or 1¼ tons.

33.1 cubic yards = 41.4 tons; cost per ton at station $1.40; per cubic yard $1.75.

Surfacing 175 Feet with Gravel, Four Inches in Depth.

No. Cub. Yds.	Material.	Length of Haul.	Cost Cub. Yd, Hauling.	Total Cost.
42	Gravel	9-10 mile.	32 cents.	$ 13.40
Supervision, one day, at $2.00				2.00
				15.40

Ditching 160 Feet of Road.

No. Days Labor.	Work Done.	Av. Depth Feet.	Total Cost.
4.6	160 feet side ditch.	2½	$ 6.90
4.4	81 " main "	3	6.60
2	Rock in ditch.		3.00
Dynamite			.50
160 feet three inch drain tile			2.40
81 " salt-glazed pipe			6.48
Supervision, two days, at $2.00			4.00
			29.88
			$191.46

Cost per running foot road surface, 63½ cents; per square yard, 27 cents.

Notes will be taken from time to time on the condition of the different parts of the road that comparative results may be reported later. Meantime, as a result of this experiment and of careful observation of New Hampshire country roads through a series of years, the following remarks are appended:

1st, Cost. In considering results, especially cost per square yard, it must be borne in mind that all of the road under discussion required much more than average repairs in the way of grade and drainage, as well as surfacing. On the other hand, with a less substantial foundation, the amount of broken stone advisable on the 125 foot stretch would have been increased by some twenty tons, thus increasing the surfacing cost of that portion by about twenty cents per square yard.

2nd. Permanent Work Necessary. The cost of this experiment is not presented as a model to be worked toward and not excelled, but rather as the work of an amateur who is laboring under the same disadvantages as would be found in the average farming town. It is evident that a policy of more or less permanent work every year would in an average period of ten years revolutionize the character of the roads of a town. All could be given a proper rounded form; the main ones reduced to standard grade, drained and fairly surfaced.

Experiments with macadamizing should by that time have made good headway and, with the need of ordinary repairs reduced one half by the proper construction outlined above, the towns would be in condition to rapidly push forward the

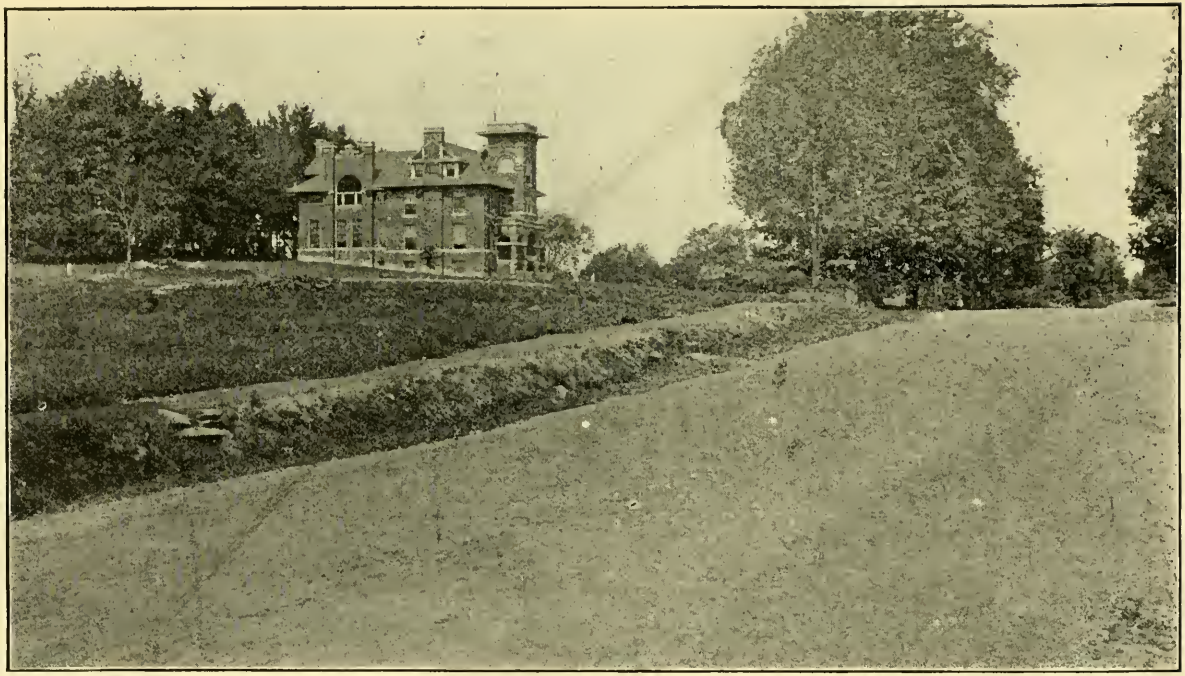

PLATE 4.—Completed Macadamized Road, with Experiment Station building in the background. (From photograph.)

macadamizing of all their main thoroughfares. All this is on the supposition of no special effort; simply the proper use of fairly generous appropriations, such as we are now accustomed to vote.

3rd, Necessary Apparatus. The apparatus not usually in the possession of a country town, necessary for the construction of a good road, either macadam or gravel, may be purchased for $600 or less, and therefore is easily within the means of even a small town. It consists essentially of a two ton horse roller, capable of being weighted to three tons, cost about $200, and a a water cart for sprinkling, cost about $350. For extensive macadamizing a steam roller is indispensible, but fair results may be obtained without its use.

4th, Grade Level. In reviewing the details of above experiment the only part which seems beyond the attainment of the average intelligent farmer is the survey. In the outlined work this was made as simple as possible, no regular cross sections being taken such as would have been necessary for contract work. Still it is too technical for the average road builder. To meet the difficulty I have devised a form of grade level, so simple that any carpenter can make one in a few hours and of such utility that suitable grades may be selected and laid out on side stakes previously placed at suitable distances (not necessarily equal distances as in the experiment) by any man of good judgment with no figuring whatever. A carpenter's level, which may be obtained at any hardware store for a dollar; a straight edge pine board; eight carriage bolts with thumb nuts for two of them; a few pieces of hard wood for sights and clamp are all the material required.

When no record is required to be kept work may be laid out with this much more expeditiously than with a level even when handled by an experienced surveyor. In ordinary road repairs it is invaluable as an aid to the eye, and even about the farm it will be found of frequent utility as in drainage, laying water pipe, plumbing walls, etc. Plate 5 gives both plan and elevation with all necessary dimensions. Grades of one-fiftieth, one-thirtieth, one-twenty-fifth, one-twentieth, one-eighteenth, one-fifteenth, one-twelfth, one-tenth, one-ninth, one-eighth,

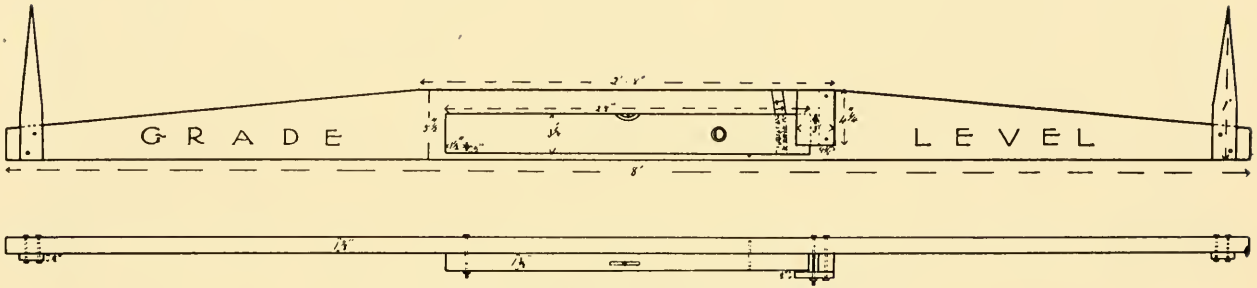

PLATE 5.—Design for Grade Level; elevation above; plan below.

one-seventh, one-sixth are indicated and others may be interpolated. The grade is read from the under side of the level. To graduate the board place level in position. Hold a pencil firmly against under side of level about two feet out from pivoted end. Swing level, allowing pencil to mark arc of circle on board. Repeat operation holding pencil about three-fourths inch farther out on level. These arcs will form limits for the graduation marks. Remove level. Lay off accurately two feet, from centre of bolt hole about which level turns, along the board parallel to edge. At this point draw perpendicular line upwards. On this line lay off proper distances for grades desired. For example for grade of one-tenth the distance would be one-tenth of two feet or two and four-tenths inches, for one-sixth it would be one-sixth of two feet or four inches, etc. Connect each of these points with centre by lines and note by marks where these lines cross one of the arcs above mentioned. Finally advance each of these marks downward along the arc the distance, say one-half inch, that the bolt hole through the level is above the base of the level. Now replace level and bring base of same in turn to each of the marks as above determined and mark along the base of the level between the two arcs with a soft lead pencil. Carefully remove all marks except the arcs and the final lines drawn across them. Place on each line the fraction indicating its grade. Two coats of shellac will complete the work. Further information about this grade level may be obtained of the writer.

5th, *Road Construction*. The four important points to be considered in constructing or reconstructing roads are as follows: grade, drainage, proper form of road foundation, surfacing. They should be considered in the order named. In common practice this order is reversed. Hence the necessity of doing over a great deal of work.

A few words on each of these points.

(*a*) Grade. Systematic efforts to reduce grades are rarely made outside of city limits. In Europe no expense is spared even among the mountains to reduce grades to at least one-twentieth. While this limit is beyond us at present, no year should be allowed to pass without the reduction in grade of

some hills in each town. Neither should work of this sort be considered complete till the standard grade is attained. The grade level will easily and accurately determine the changes that are necessary and will give data for preliminary estimates of cost of this improvement. Such work should never be undertaken till a complete plan for reduction to standard grade has been adopted. Otherwise much labor may be wasted.

(*b*) Drainage. No permanently good road surface exists without suitable drainage. Fortunately most of our roads are well drained by nature. When not so drained, if sufficient fall cannot be obtained, the road surface must be raised sufficiently to insure the desired result. This is expensive and should be avoided if practicable. Side drains, such as are described in the experiment, are usually effective. If ground contains springs, these must be directly tapped by the side drains. Side ditches must be kept open and clear.

(*c*) Foundation. The proper form of foundation of a road is seen in Plate 1, though it may be varied somewhat in detail. This form should be obtained as far as possible by the use of material near at hand. The road machine is indispensible for much of this work. The poorest material, if well covered in and drained, will make a good foundation for a country road. It will *not* make the surface. The experiment shows that rock fill, however near at hand, is expensive unless easily loaded and simply dumped in place. If rock foundation is necessary to secure drainage, this extra cost will usually prove a wise expenditure. Do not make the traveled way too narrow. This is, perhaps, the most common, though not necessary, defect of road machine construction.

(*d*) Surfacing. After forming a road it generally needs surfacing. It is not, as is usually considered, complete without. For this surface macadamize as rapidly as possible; otherwise clay or gravel a sandy road; gravel a clay road. In any case draw on some fresh material, not already worn out, that will pack with the surface and with travel. Use a sprinkler and roller. Otherwise surface late in the fall or early in spring.

6th, *Repairs*. Improvements in grade, drainage and form of

road foundation should be permanent; once attained, to be held. Surfacing is too costly to employ much before these other details are attended to. The best off-hand method of judging the work of a highway agent is by the amount of permanent work done and discrimination used in surfacing; that is, surfacing only where work will stand a reasonable time.

Men should be employed in each section of a town to make all necessary, ordinary repairs in surfacing, not once or twice a year, but as they are needed. Nothing is so costly as allowing a good road to go to pieces for lack of a little attention.

7th Records. More complete records, than are customary, of work done by highway agents should be kept for the towns. A detailed statement of payments to John Smith, Henry Jones, etc., is not sufficient. If a bridge is planked, a culvert relaid, 500 feet of road graveled two inches deep, 1000 feet rounded up with the road machine, and so on, these items should be reported with at least approximate cost of each.