MEASUREMENT OF WEAR ON GRAVEL ROADS

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SYNOPSIS

The object of this study has been to determine the loss of surfacing material from untreated traffic-bound roads and road surfaces that have been stabilized by the addition of binder-soil and calcium chloride

The scope of the work involved not only the measurement of wear but studies of surface density, moisture content, record of treatment, chemical content and gradation of materials To guard against a general shift of foundation, level measurements were taken to plates buried beneath the roadway In taking the last readings on the stabilized and treated surfaces, they were swept and the weight of loose material per mile determined These surfaces carried no loose material when first constructed

The procedure in taking wear measurements consisted of reading a level rod to an accuracy of 0 01 ft on each foot of a cross section of the maintained roadway Approximately 100,000 level readings were made The average daily traffic on the five projects studied was 395 vehicles The annual material loss from the stabilized sections, treated with calcium chloride, was 37 per cent of the amount lost from the untreated unstabilized sections The sections treated with calcium chloride without preliminary stabilizing with binder-soil lost 49 per cent as much as the untreated sections The results of the study do not indicate that the losses are proportional to the amount of traffic Variables which affect this are considered in detail in the report Readings on the buried plates showed that as much as one-third of the reduction in road surface elevation consisted of an apparent sinking of the entire road-bed, probably due to downward and outward plastic flow of the subgrade

Introduction

The consolidation of loose gravel and crushed stone surfaces with soil and moisture has been practiced for some years but recently it has come into more extensive use because the principles of soil aggregate stabilization have become better understood

The measurements of surface wear reported herein shows that the consolidated surface effects a reduction of annual loss of loose aggregate thrown off the road by traffic, by snow plows and blown away in dust In view of the large mileage of traffic-bound roads in the United States, this annual loss of material has great economic significance, both in maintenance costs and in depletion of natural supplies of aggregates

The amount of aggregate lost from traffic-bound road surfaces under different traffic and climatic conditions has been variously estimated, but little information based upon accurate measurements has been available The report of the Committee on Maintenance of the Highway Research Board for 1926[1] contains some data on the amount of gravel used on a number of sections of road over periods of three years In 1935 the Department of Engineering Research of the University of Michigan undertook a study of this problem at the request of the Calcium Chloride Association

The investigation was carried on in cooperation with five Michigan counties, each county project consisting of three contiguous sections of gravel road (generally one mile for each section) Two projects were carried on for the full period, two for the seasons of 1935-6-7, and one for 1937-8 These sections were as follows:

[1] Proceedings, Highway Research Board, Vol 6, p 355

1 *Stabilized* Three inches of new gravel was applied and stabilized by the addition of soil, moisture and calcium chloride The surface maintenance included applications of calcium chloride at the rate of about ten tons per mile per year or 1 5 lb per sq yd per year
2 *Treated* The ordinary gravel road was maintained according to usual county practice but was given surface applications of calcium chloride at the above rate
3 *Untreated* The ordinary gravel road was maintained according to usual county practice without calcium chloride treatment

A careful record was made of all new aggregate placed upon these surfaces during the period of investigation and any such additions were immediately obvious in the level readings In most cases the addition of new material was not necessary

Bench marks were established by driving spikes into telephone poles or fair-sized trees at a point about six inches higher than the roadway surface These benches were referenced to each other and to headwalls, or other permanent monuments Where an iron stake had to be used, it was checked each season By measurement with a tape, the center of the travelled way was ascertained and recorded to half a foot A reference line was established either by lining from the bench mark to a fixed distant object or better by backlining alongside the benchmark tree to a reference in the rear A lock link chain with tags at each foot was lined from the benchmark across the road with the center-line tag at the measured distance from the bench. This chain rested on the roadway surface, did not interfere with traffic and indicated the points where rod readings were to be taken

Successive observations were made at identical points and were tabulated adjacent to the previously recorded reading Any errors or discrepancies were at once obvious Approximately 500 settings of the rod were averaged into a single point on the time-wear curve of each type of roadway About 25 rod readings gave a point on the time-wear curve of a single cross section These were plotted and scrutinized for unusual behaviour before inclusion in the general wear observations

Two hundred and forty 4 by 6 by $\frac{1}{8}$-in steel plates were levelled and set on concrete beds in post holes about 1 ft 6-in deep Each was carefully lined and witnessed to the bench mark and every spring thereafter a drill was sunk to the plate and its depth measured The purpose of the plates was to indicate any major disturbance or heave They finally served admirably to indicate a plastic flow of the roadbed downward of from 02 to 03 feet

Traffic counts were taken simultaneously on all projects and in sufficient number to cover all days of the week and different seasons of the year The period of count was from 6 A M to 9 P M and these were converted to 24-hour traffic by applying a factor developed in the Ohio traffic survey, this survey showed that the traffic from 6 A M to 9 P M is approximately 88 per cent of the 24-hour traffic

Explanation of Table 1

The number of weeks observed for a given project was about the same in all types except where frost or general repairs changed the period of record

The cubic yards of apparent wear was obtained by computing the volume of loose material required for replacement of the depth lost

Loose gravel on the surface of all sections was found to contain 20 per cent less fines than new gravel Final readings on the stabilized and treated sections were taken on swept surfaces and those

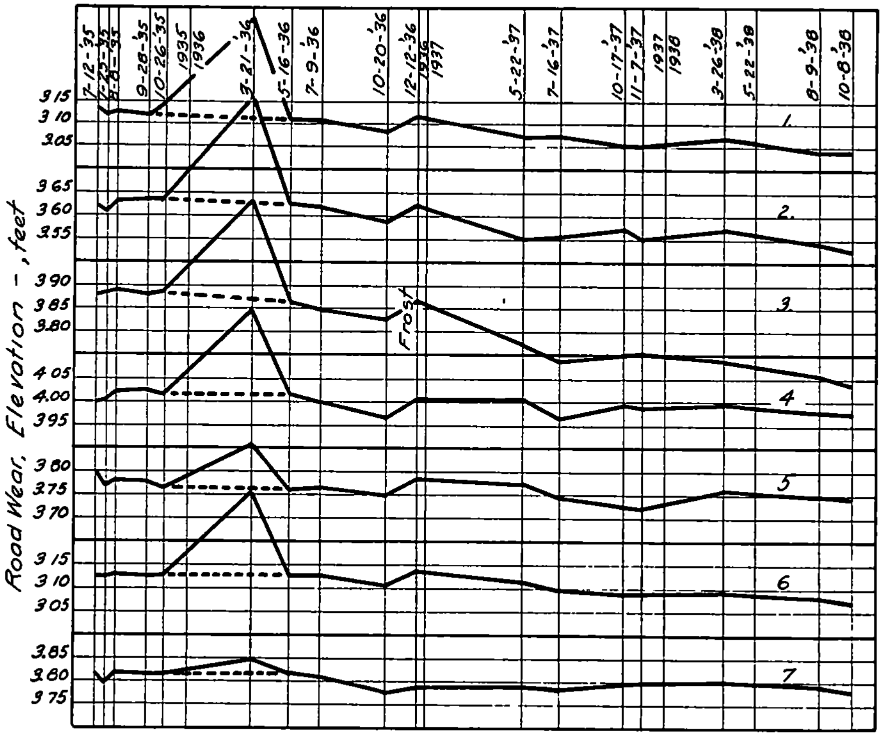

Figure 1. Typical Gravel Road Wear, Typical Stabilized Stations E. and 7-mile Road

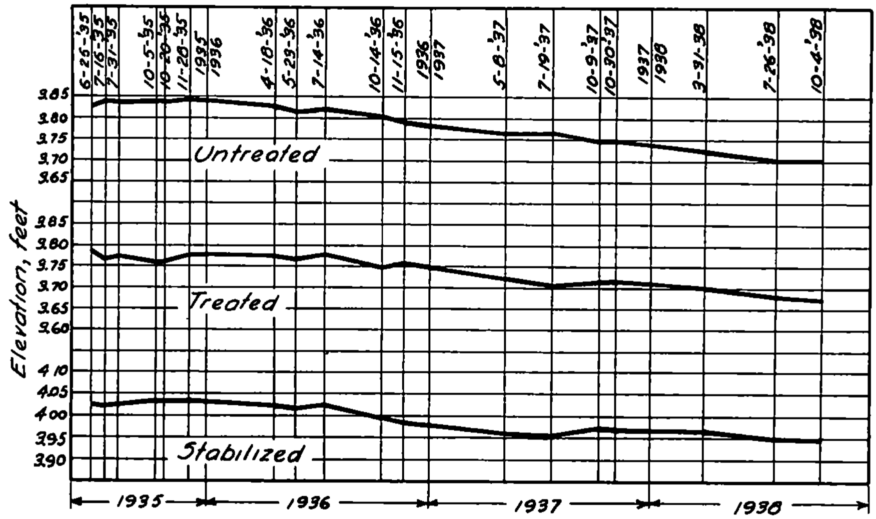

Figure 2 Summary of Wear on Gaddes Road

sections were credited with 80 per cent of the computed volume of loose gravel on those surfaces Final readings on the untreated sections were taken on top of the loose gravel and 20 per cent of the volume of loose gravel was charged as dissipated fines This latter charge was made against annual wear because of the practice of blading soil from the shoulders to replace the loss of fines The meas-

cycles with moisture and frost Such displacement must of necessity have been accompanied by lateral flow Since the material was not lost, and the movement

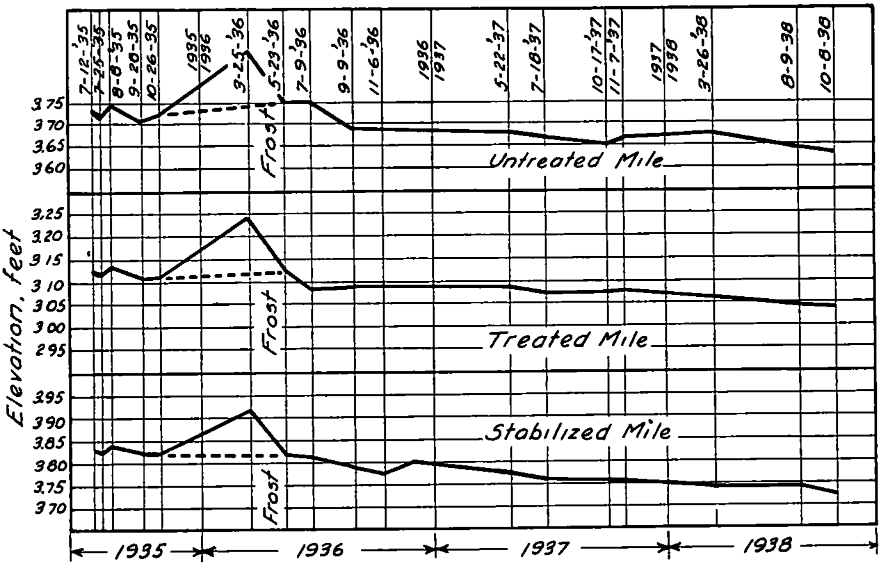

Figure 3. Summary of Wear on 7-mile Road

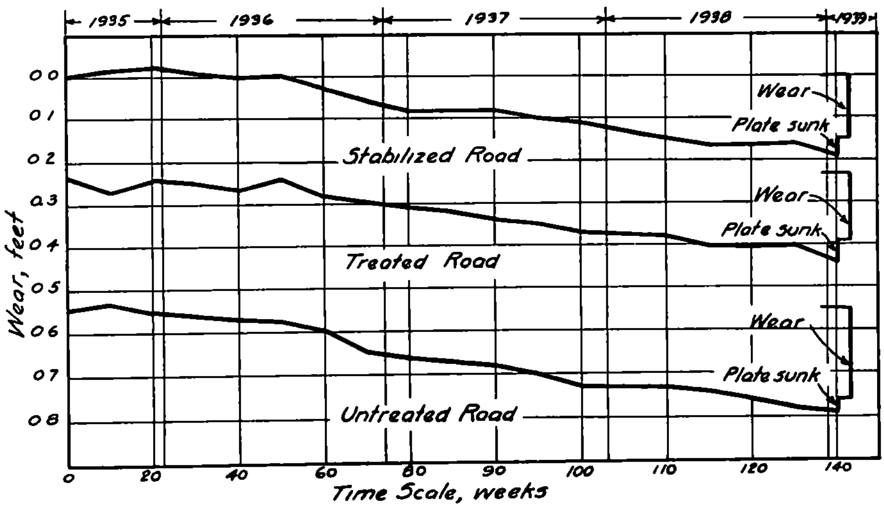

Figure 4. Average Road Wear, All Projects

ured loss of shoulder material outside of the travelled way exceeded this total

The downward movement of the plates indicated a flow rather than a compaction as the density was found to vary in

was a function of the kind of foundation material, the displacement volume was deducted from apparent wear The results of this investigation as thus computed show an annual saving of 156 cubic yards in favor of the stabilized road compared with the loose untreated road Expressed in percentage this is a saving of 63 per cent

The data are given in Table 1

form of showers varied greatly on the different projects Wind shelter and sunlight as determined by trees and brush conserved moisture on the untreated section of Seven Mile Road The direc-

TABLE 1

SUMMARY OF DATA

Location	Weeks	Apparent Surface Wear	Swept Up	Displacement	Total Loss	Annual Loss per Mile	Annual Loss per Mile per 100 Daily Traffic
		cu yd	*cu yd*	*cu yd*	*cu yd*	*cu yd*	*cu yd*
7 Mile Road·							
Stabilized	169	573 6	−21 5	−151 9	400 2	123 1	47 3
Treated	164	689 7	−51 5	−371 6	266 6	84 5	32 5[1]
Untreated	124	736 6	+17 7/yr	−55 4	681 2	303 4	116 7
13 Mile Road							
Stabilized	64	108 9	−9 4		99 6	80 9	8 8
Treated	38	111 3	−8 8		102 5	140 2	15 2
Untreated	64	308 0	+21 6/yr		308 0	271 9	29 5
Geddes							
Stabilized	171	465 5	−101 4	−66 0	298 1	90 7	46 8
Treated	171	640 3	−54 1	−66 1	520 1	158 1	81 5
Untreated	168	745 3	+19 4/yr	−19 5	725 8	244 0	125 8
McKinley							
Stabilized	121	423 8	none	−168 2	255 6	109 9	28 2
Treated	121	398 8		−135 5	263 3	113 1	29 1
Untreated	121	456 3	+77 7	−94 7	361 3	233 0	60 0
Owendale·							
Stabilized	115	230 0		−112 8	117 2	53 0	26 1
Treated	115	301 2		−58 0	226 7	102 5	50 5
Untreated	115	438 2	none	−64 1	373 9	169 1	83 3
Average							
Stabilized						91 5	23 2
Treated						119 7	30 3
Untreated						244 3	61 8[2]

[1] The treated section of Seven Mile Road was more disturbed by frost than any other The excessive displacement of the plates may have been due in part to frost action rather than plastic downward flow to which it is entirely credited

[2] This average would have been ten cubic yards higher had the untreated loose gravel section of Owendale road not been partially stabilized with clay after the first season

Interpretation of Results

The wear does not vary directly with the traffic Indeed there is an optimum minimum of rubber tire traffic necessary to compact the roadway and seal the plastic surface Local rainfall in the tions of a road and of the prevailing winds influence the loss A good mosaic, presenting a hard gravel surface, will wear less than a more friable texture Loose gravel where present on the roadway is carried off and into the ditches with the snow shoved aside in the winter

Suggested Further Research

While this is the most extensive work in wear measurements we have seen to date, it can not be considered as final nor universally applicable As in all research the techniques have been im-

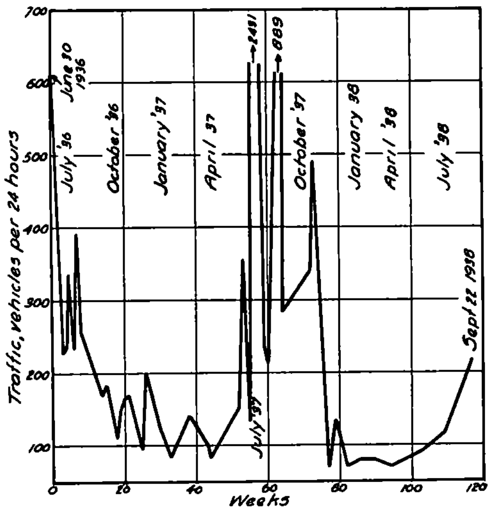

Figure 5. 'Traffic Record 7-mile Road

proved At the same time our appreciation of the significance and relative importance of data changed as our understanding grew

County roads generally carry less traffic than state routes and it is hoped that other projects may include some state trunk lines where results can be obtained in a shorter time and under a variety of climatic and soil conditions Further research in those localities where untreated roads are normally carried with less soil content than those covered by the present investigation might show greater economy in saving of materials. It is the practice in Michigan to carry some binder soil in all maintenance aggregate which tends to tighten the surface and prevent some of the loss which would otherwise occur Studies made in regions where frost does not disturb the ground would eliminate that variable By building a road on a fine wire screen, such as fly screen, laid over the subgrade, it should be possible by drilling down and making an electrical contact, to measure the rate of plastic downward flow Lateral plastic flow can be measured by observing the tilting and displacement of flat steel plates driven to grade like stakes alongside the roadway metal.

Rugosity of surface is a subject that needs, not so much investigating, as more general understanding The mosaic of stone or gravel with the interstices filled and cemented with a minimum of fines and binder presents a surface that has a high friction coefficient