A SURVEY AND PLANS FOR A SIXTEEN-FOOT, SINGLE COARSE GRAVEL ROAD

THESIS FOR THE DEGREE OF B. S.

G. M. Coan A. J. Grossman

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SUPPLEMENTARY
MATERIAL
IN BACK OF BOOK

A Survey and Plans
for a
Sixteen-foot, Single Coarse Gravel Road

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By

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INTRODUCTION

This thesis consists of a survey for, and design of a single course gravel road from the north quarter section corner of section thirty-one of Meredian Township, Ingham County, to the Townline Road running along the south side of said township. This road would be an extension of the road known as South Cinder Drive.

CENTER LINE SURVEY

The center line of the road was to be run directly along the quarter section line of section 31 of Meredian Township. The North quarter section stone was chosen as the point of beginning, and the stone one-half mile south served as a point to establish the line. As a fence ran down the line, it was necessary to run an offset line of ten feet to the east. To accomplish this, the transit was set up over the North quarter post and sighted on the post one-half mile south, and a ninety degree angle was carefully turned off; this was repeated a number of times to get it very accurately, then a post was set the distance of ten feet to the east. The transit was then set up over this point and sighted back on the original point, and the process of turning off the ninety degree angle repeated. The line was then run south, and when a point opposite the one-half mile point was reached the distance to the original mark was checked and it was ten feet so we continued the line for a half mile more to the Townline Road on the south line of Meredian Township.

At intervals of one hundred feet from point of beginning stakes were set and numbered to serve as points for taking cross section notes and for points to be used in the taking of topography.

ESTABLISHING BENCH MARKS

As a basis for establishing bench marks, the Coast and Geodetic bench mark No. 17C was used. This bench mark is located in the northeast corner of the school yard which is southwest of the southwest section corner of Meredian Township.

A line of levels was run from this point to the line of our road and several bench marks were established along the right of way to serve as checks while taking cross sections. For bench marks large stones, solid posts and a nail driven in a notch in the side of a tree were used.

TOPOGRAPHICAL SURVEY

All topographical notes were taken by use of angles and stadia. Instead of using South as zero, North was taken and the angles turned off in a clockwise direction. All objects that came within 100 feet on each side of the center line were recorded, and shown on the plan view. As this is all farm land there was very little topography. What there was, consisted of fences, a few trees, and the outline of two large muck holes which extended on both sides of the road. One extended only a short distance to the east of the center line, while the other extended only a short distance to the west of the center line.

CROSS SECTIONS

Using one of the bench marks that was established as a point of beginning, cross sections were taken at every 100 foot station and at all points where a marked change in elevation occurred along the center line. The cross sections were taken for the proposed width of the right of way, or a distance of 50 feet on each side of the center line, and at as many intermediate points as deemed necessary.

To obtain the distance out from the center line that the elevations were taken, the distance was measured by the use of a tape run out from the center line and perpendicular to it. These cross section notes were used to draw up the cross sections at every 100 foot mark or other necessary points so that the volume of earth that would have to be moved could be computed.

SOIL SURVEY

In order to determine whether the soil along the cross section of the proposed road was suited for the foundation of the road and for the fills, a soil survey was made. This consisted of taking a sample of soil from the proposed right of way wherever there was a distinct change in the texture of the soil. Where there was to be a cut, a soil auger was used to obtain a sample of soil from the grade elevation of the proposed road. Where the soil was below the grade elevation, a hole twelve to fifteen inches was dug and the soil scraped from the sides was used for the sample.

A soil analysis was then made on each of these samples. The results obtained from each soil analysis are on the following page. In the two large muck holes, the depth of the muck along the cross section of the proposed road was also found by using a soil auger. The greatest depth found was 17.8 feet. This data was used in computing the amount of muck excavation and also the amount of soil required to replace the excavated muck.

REPORT ON SUBGRADE SOIL.

Stations From	Stations To	% of Sand	% of Silt	% of Clay	Moisture Equivalent %	Volumetric Shrinkage in %	Capillary Moisture in %	Liquid Limit in %	Plastic Limit in %	Remarks
0 + 00	5 + 00	56.8	25.4	17.8	24.06	12.59	46.36	27.56	21.36	Poor Foundation Silty Clay
5 + 00	11 + 00	51.2	23.0	25.8	30.67	11.11	40.55	38.15	26.13	Poor Foundation Silty Clay
11 + 00	16 + 00	87.0	5.8	7.2	18.56	0.00	28.95	20.06	0.00	Good for Foundation
16 + 00	23 + 00	69.8	11.8	18.4	23.32	9.02	25.34	26.28	21.13	Good for Foundation
23 + 00	26 + 80	47.0	39.0	14.0	33.20	22.19	32.33	36.56	15.34	Poor Foundation Silty Clay
33 + 50	35 + 50	59.6	14.0	26.4	15.92	10.84	35.25	20.82	14.05	1½ feet deep Good for Foundation
32 + 50	38 + 55	50.8	14.4	36.4	21.31	23.17	37.65	24.93	13.36	Capillary Moisture too high - poor
42 + 50	52 + 50	62.6	16.0	21.4	23.06	7.32	30.68	26.91	0.00	Good for Foundation
Borrow Pit		83.5	6.7	9.8	16.50	0.00	34.32	15.63	0.00	Good Foundation Material

Stations not accounted for are muck and the soil above the clay is to be removed and soil from borrow pit substituted.

EARTHWORK

After the grade was established the cross sections were plotted and their areas determined with a planimeter. The typical cross section of the road is as follows:

1. Sixteen foot roadway.
2. Four foot shoulders on each side.
3. Slope from edge of shoulder to bottom of ditch, 1 on 4.
4. Slope from bottom of ditch to surface of ground, 1 on 1½.
5. All ditches two feet wide at the bottom, bottom of ditch being two feet below grade line.

The volume of cut and fill was computed by the end area method allowing twenty per cent for shrinkage.

A Mass Diagram was made in order to compute the amount of overhaul.

Station	End Area Square Feet		Volume Cubic Feet		% Shrinkage	Computed Volume Cubic Feet		Mass Ordinate
	Cut	Fill	Cut	Fill		Cut	Fill	
0 + 00	0.00				20			
1 + 00	10.80		540.00		20	540.00		+ 540.00
2 + 00		57.90		2355.00	20		2826.00	-2286.00
3 + 00		182.80		12035.00	20		13442.00	-15728.00
3 + 50		195.00		9445.00	20		11334.00	-27062.00
4 + 00		142.90		8447.00	20		10136.40	-37198.40
4 + 60		138.40		8439.00	20		10126.80	-47325.20
5 + 00		116.40		5096.00	20		6115.20	-53440.40
6 + 00		131.20		12380.00	20		14856.00	-68296.40
7 + 00		68.70		9995.00	20		11994.00	-80290.40
8 + 00		34.30		5150.00	20		6180.00	-86470.40

Station	Cut	Fill	Cut	Fill	Shrinkage	Cut	Fill

Station	End Area Square Feet		Volume Cubic Feet		% Shrinkage	Computed Volume Cubic Feet		Mass Ordinate
	Cut	Fill	Cut	Fill		Cut	Fill	
8 + 70	11.30			805.00	20		966.00	-87436.40
9 + 00	2.80		212.00		20	212.00		-87224.40
10 + 00	35.50		1955.00		20	1955.00		-85269.40
11 + 00	93.70		6450.00		20	6450.00		-78819.40
12 + 00	200.00		14685.00		20	14685.00		-64134.40
12 + 50	328.90		13223.00		20	13223.00		-50911.40
13 + 00	318.10		16425.00		20	16425.00		-34486.40
14 + 00	202.80		26045.00		20	26045.00		- 8441.40
15 + 00	153.00		17790.00		20	17790.00		+ 9348.60
16 + 00	107.80		13040.00		20	13040.00		+22388.60
17 + 00	70.80		8930.00		20	8930.00		+31318.60

Station	End Area Square Feet		Volume Cubic Feet		% Shrinkage	Computed Volume Cubic Feet		Mass Ordinate
	Cut	Fill	Cut	Fill		Cut	Fill	
18 + 00		18.60	2610.00		20	2610.00		+33928.60
19 + 00	18.20			40.00	20		48.00	+33880.60
20 + 00	41.50		2985.00		20	3582.00		+37462.60
21 + 00	15.40		2845.00		20	2845.00		+40307.60
22 + 00		66.90		2575.00	20		3090.00	+37217.60
23 + 00		48.90		5790.00	20		6948.00	+30269.60
24 + 00	53.20		215.00		20	215.00		+30484.60
24 + 50	102.90		7805.00		20	7805.00		+38289.60
25 + 00	134.60		11875.00		20	11875.00		+50164.60
26 + 00		29.50	5255.00		20	5255.00		+55419.60
26 + 80		138.80		6732.00	20		8078.40	+47341.20

Station	End Area Square Feet		Volume Cubic Feet		% Shrinkage	Computed Volume Cubic Feet		Mass Ordinate
	Cut	Fill	Cut	Fill		Cut	Fill	
27 + 00		248.20		3870.00	20		4624.00	+42717.20
28 + 00		233.40		24080.00	20		28896.00	+13821.20
28 + 50		222.20		11390.00	20		13678.00	+ 143.20
29 + 00		210.00		10805.00	20		12966.00	-12822.80
29 + 50		186.10		9903.00	20		11883.60	-24706.40
30 + 00		163.20		8732.00	20		10478.20	-35184.60
30 + 50		166.50		8242.00	20		9890.40	-45075.00
31 + 00		169.90		8410.00	20		10092.00	-55167.00
31 + 50		112.30		7055.00	20		8466.00	-63633.00
32 + 00		38.50		3770.00	20		4524.00	-68157.00
32 + 50	76.00		938.00		20	938.00		-67219.00

Station	Cut	Fill	Cut	Fill	Shrinkage	Cut	Fill	Overhaul
33 + 00	190.50		6662.00		50	[illegible]		

Station	End Area Square Feet		Volume Cubic Feet		% Shrinkage	Computed Volume Cubic Feet		Mass Ordinate
	Cut	Fill	Cut	Fill		Cut	Fill	
33 + 00	190.50		6662.00		20	6662.00		-60557.00
33 + 40	402.90		11868.00		20	11868.00		+48689.00
34 + 00	503.40		27189.00		20	27189.00		-21500.00
34 + 50	234.60		18450.00		20	18450.00		- 3050.00
35 + 00	279.30		12847.00		20	12847.00		+ 9797.00
35 + 50	301.60		14522.00		20	14522.00		+24319.00
36 + 00	207.60		12730.00		20	12730.00		+37049.00
37 + 00	82.70		14515.00		20	14515.00		+51564.00
38 + 00		39.40	2165.00		20	2165.00		+53729.00
38 + 55		125.60		4537.00	20		5443.00	+48286.00
39 + 00		189.00		7796.00	20		9355.20	+38930.80

Station	End Area Square Feet		Volume Cubic Feet		% Shrinkage	Computed Volume Cubic Feet		Mass Ordinate
	Cut	Fill	Cut	Fill		Cut	Fill	
39 + 30		220.90		6149.00	20		7378.80	+31552.00
39 + 60		252.70		7104.00	20		8624.80	+22927.20
40 + 00		332.10		17544.00	20		23052.80	- 125.60
40 + 60		334.10		20019.00	20		24022.80	-24148.40
41 + 00		335.50		13392.00	20		16070.40	-40218.80
41 + 30		260.00		8633.00	20		10359.60	-50578.40
41 + 60		184.50		6667.00	20		8000.40	-58578.80
42 + 00		90.40		8247.00	20		9896.40	-68475.20
42 + 35		31.70		2136.00	20		2663.20	-70138.40
43 + 00	77.30		1807.00		20	1807.00		-68331.40
44 + 00		4.40	3645.00		20	3645.00		-64686.40

Station	Cut	Fill	Cut	Fill	% Shrinkage	Cut	Fill	Mass Ordinate
	Cut Area (Square Feet)		Volume (Cubic Feet)			Cumulative Volume (Cubic Feet)		

Station	End Area Square Feet		Volume Cubic Feet		% Shrinkage	Computed Volume Cubic Feet		Mass Ordinate
	Cut	Fill	Cut	Fill		Cut	Fill	
45 + 00		74.50		3945.00	20		4734.00	-69420.40
46 + 00		109.50		9200.00	20		11040.00	-80460.40
46 + 50		37.50		7325.00	20		8790.00	-89250.00
47 + 00	59.50		1145.00		20	1145.00		-88109.40
48 + 00	148.50		10420.00		20	10420.00		-77689.40
49 + 00	124.90		13670.00		20	13670.00		-64019.40
50 + 00		4.10	6040.00		20	6040.00		-57979.40
51 + 00		29.61		1685.00	20		2022.00	-60001.40
52 + 00	9.00			1030.00	20		1236.00	-61237.40
52 + 50	77.30		4390.00		20	4390.00		-56847.40
52 + 80	00.00		3865.00		20	3865.00		-52982.40

Station	Muck Excavation		Fill to Replace Muck	
	End Area Square Feet	Volume Cubic Feet	Shrink-age %	Computed Volume Cubic Feet
26 + 80	00.00			
27 + 00	78.70	3935.00	20	4722.00
28 + 00	234.60	15665.00	20	18795.00
28 + 50	383.60	15450.00	20	18540.00
29 + 00	387.00	19265.00	20	23118.00
29 + 50	954.80	33545.00	20	40213.00
30 + 00	1061.50	50415.00	20	60498.00
30 + 50	930.20	49792.00	20	59750.20
31 + 00	271.40	30040.00	20	36048.00
31 + 50	94.50	9147.00	20	11076.40
32 + 00	35.00	3238.00	20	3885.60
32 + 50	00.00	875.00	20	1050.00
38 + 55	0.00			
39 + 00	120.00	2700.00	20	3240.00
39 + 30	429.00	8235.00	20	9882.00
39 + 60	651.00	16200.00	20	19442.00

Station	Muck Excavation		Fill to Replace Muck	
	End Area Square Feet	Volume Cubic Feet	Shrinkage %	Computed Volume Cubic Feet
40 - 00	780.00	29020.00	20	34824.00
40 - 60	822.25	48067.00	20	57680.00
41 - 00	1020.50	36855.00	20	44226.00
41 - 30	968.80	29840.00	20	35808.00
41 - 60	720.00	25332.00	20	30398.40
42 - 00	192.00	18240.00	20	21888.00
42 - 35	0.00	3360.00	20	4032.00

SUMMARY OF EARTHWORK

Total Cut	11864.69 cubic yards
Total Fill	11553.34 cubic yards
Twenty percent shrinkage allowance 11,553.34 × 130 =	13864.01 cubic yards
Available cut for fill	11864.69 cubic yards
Fill yet required	1999.32 cubic yards
Excavated muck	16639.35 cubic yards
Fill required to replace muck	19967.22 cubic yards
Total fill to be obtained from borrow pit	21966.55 cubic yards

11553.34
2310.67
13864.01

16639.35
3327.87
19967.22

SECURING RIGHT OF WAY

It is possible to secure the 100 foot right of way from station 0 + 00 to 26 + 44 for 100 dollars an acre. The total 100 foot right of way from station 33 + 5 to 52 + 80 is owned by James Hulett, Sr. This right of way will come about 50 feet from his line fence. The land for this right of way cannot be secured unless this 50 foot strip from station 33 + 5 to 52 + 80 is also bought for 100 dollars an acre. By buying this strip along with the right of way, Mr. Hulett will also sell for the same price the 50 foot strip from station 26 + 44 to 33 + 5 which is yet required to have the complete right of way.

This 50 foot strip which is not used for the right will be given to Mr. Wells, whose land joins this piece, as a part-payment for the soil obtained from his land. This is to be on a basis of 100 dollars an acre for the land and 28 cents per cubic yard for the soil.

S P E C I F I C A T I O N S

SUB-BASE

All soil within one foot of the grade line which is indicated as unsuitable for a foundation shall be removed and placed at least one foot below the grade line of the road. It shall be replaced with a suitable soil. No payment will be made for the work here specified, but compensation therefor shall be considered as included in the contract price for excavation.

REMOVAL AND DISPOSAL OF MUCK.

All muck shall be removed on both sides of the center line to the point where the side slope hits the original soil. It shall be spread uniformly in these two low places outside the right of way. This work shall be done at the contract unit price per cubic yard for excavation.

BORROW EXCAVATION

The quantity of borrow excavation, measured as prescribed in the Standard Road and Bridge Specifications, Division 2, Section 6, shall be paid for at the contract unit price per cubic yard for Borrow Excavation.

MISCELLANEOUS EARTHWORK

All excavation and embankment called for at intersecting roads, driveways, and inlet and outlet ditches shall be included in the earthwork quantities.

DITCHES

All ditches are to be turned out at break where fill is more than two feet, there being no ditches through the marches or where the fill is more than two feet. The bottom of ditches at all points shall be two feet below grade line.

SODDING

Sodding shall consist of sodding all side slopes over five feet in depth. The contract unit price per square yard for sodding shall be payment in full for the work here specified.

SEEDING

Seeding shall consist of seeding all shoulders and side slopes less than five feet in depth. This work shall be paid for at the contract unit price per mile for seeding.

OVERHAUL

Overhaul in excess of one-half mile (after deducting one thousand feet free haul) will be paid for at the contract unit price per yard mile. Overhaul less than one-half mile (after deducting one thousand feet free haul) will be paid for at the contract unit price per yard station.

GOVERNMENT CORNERS

All government markers or the two quarter section markers and the half mile marker must be preserved.

GUARD RAILS

Guard rails shall be placed where shown on plans, being designed and installed according to the specifications shown in back.

UNFORESEEN CONDITIONS

Any unforeseen conditions arising shall be performed by the contractor working on the job and shall be paid for on the basis of direct expense plus ten per cent for profit.

SPECIFICATIONS IN GENERAL

All specifications must conform to those of the Michigan State Highway Department which are shown in the back.

1500—9-10-29

MICHIGAN
STATE HIGHWAY DEPARTMENT

1926

Standard Road and Bridge Specifications

Reprinted—September, 1929.

DIVISION 2—EARTHWORK

DIVISION 2—EARTHWORK

Description.—Earthwork shall consist of all clearing and grubbing, removal of structures and obstructions as indicated or directed, roadway excavation, borrow excavation, embankment, overhaul, disposal of surplus and unsuitable materials, preparation of subgrade, placing of sub-base, shaping of shoulders, ditches and slopes, trimming and finishing, fine grading, grading of all intersecting roads, driveways and approaches, and any other items necessary to complete the grading of the roadway in conformity with the lines, grades and cross sections given on the plans.

SECTION 1—CLEARING

1. **Description.**—Clearing shall consist of cutting and properly disposing of trees, stumps, brush and other vegetation, occurring within the right of way, which interfere with excavation and embankment or are considered objectionable.

2. **Construction Methods.**—All trees, brush, shrubs and other vegetation which occur within the limits of cuts or within the limits of fills less than three (3) feet in depth and which are not designated on the plans or by the engineer to be saved shall be cut off at a height to be easily grubbed but not more than three (3) feet above the ground.

All trees, brush, shrubs and other vegetation which occur within the limits of fills three (3) feet or more in depth shall be cut off at the ground level.

Outside of the slope stake lines and within the right of way, all trees, brush and other vegetation which are designated on the plans or by the engineer as objectionable and all hardwood stumps shall be cut off level with the ground.

The contractor shall carefully protect from damage or injury during clearing operations all trees, shrubs and other plants which are designated on the plans or by the engineer to be saved.

All trees must be felled toward the center of the highway, where merchantable timber shall then be cleaned of limbs and tops. All clear and sound logs having a length of twelve (12) feet or more and all timber from which pulp wood, posts, poles, ties or cordwood can be made shall be considered as merchantable timber and shall be sawed into lengths as directed by the engineer and neatly skidded along the road for the use of the abutting property owner, provided, however, that the contractor will not be required to cut logs into less than twelve (12) foot lengths, pulp wood and ties into less than eight (8) foot lengths, and posts into less than seven (7) foot lengths.

All stumps, brush, waste logs, limbs, tops and other debris resulting from the clearing or occurring within the right of way shall be piled and burned in the center of the roadway in such a manner as not to injure or endanger public or private property or be of objectionable appearance. Such burning shall be done only at times when standing timber or cut over lands will not be endangered by fire. In no case shall stumps, brush, waste logs, limbs, tops and other debris be left in windrows or piles along or within the right of way.

3. **Method of Measurement.**—Clearing shall be measured in acres computed on the basis of units 100 feet in length multiplied by the average width of each unit within the lines between which clearing has been required. So far as possible the 100 foot units shall be coincident with the survey stations.

4. **Basis of Payment.**—If the contract contains a separate estimate and unit price for "Clearing," the contract unit price per acre shall be payment in full for all work specified in this Section. Otherwise, the contract price for Earth Excavation shall be considered as including payment for the item of clearing.

SECTION 2—GRUBBING

1. **Description.**—Grubbing shall consist of removing from the ground and properly disposing of brush, roots, stumps, logs, rubbish and other materials occurring within the right of way, which are not suitable to be left in the road foundation or are considered objectionable in appearance.

2. **Construction Methods.**—Within the slope stake lines, all logs and other timber more than three (3) inches in diameter, brush, roots, stumps and rubbish or other material not suitable for road foundation which occur within two (2) feet of the proposed road grade shall be pulled or otherwise removed.

Outside of the slope stake lines and within the right of way, all pine and other resinous stumps and their roots shall be pulled or otherwise removed to a depth of at least one (1) foot below the ground, and all brush, except such groups as are ordered left by the engineer, shall be pulled or grubbed.

All holes resulting from the removal of stumps or brush outside the slope stake lines shall be filled with earth and levelled off.

The contractor shall carefully protect from damage or injury during grubbing operations all trees, shrubs and other plants which are designated on the plans or by the engineer to be saved. All brush, roots, logs, timber, rubbish and other debris shall be disposed of in the same manner as specified under "Clearing." If, in the opinion of the engineer, it is impracticable to burn a portion of the material grubbed, it may be disposed of by placing it in neat piles at least three hundred (300) feet outside of the right of way, providing that the contractor obtains and files with the Department written permission from the owner of the property upon which the material is piled.

3. **Method of Measurement.**—Grubbing shall be measured in square rods computed on the basis of units 100 feet in length multiplied by the average width of each unit within the lines between which grubbing has been required. So far as possible the 100 foot units shall be coincident with the survey stations.

4. **Basis of Payment.**—If the contract contains a separate estimate and unit price for "Grubbing," the contract unit price per square rod shall be payment in full for all work specified under grubbing. Otherwise, the contract price for Earth Excavation shall be considered as including payment for the item of grubbing.

SECTION 3—ROADWAY EXCAVATION

1. Description.—Excavation shall consist of the removal and satisfactory disposal of all material necessary for the preparation and construction of the roadbed, embankments, slopes, side ditches, gutters, trenches, waterways and approaches to intersecting roads and private entrances taken from within the limits of the work; the removal and satisfactory disposal of all surplus and unsuitable materials encountered in the roadbed; the replacement of any such unsuitable material with satisfactory material; the breaking up of all gravel, macadam, concrete or other surfacing material which may be in place on the old roadway and the satisfactory disposal of same as hereinafter specified.

2. Classification of Excavation.—All excavated materials will be classified under either Earth Excavation or Rock Excavation unless otherwise specified. Ledge rock in place which requires blasting for removal and boulders of one-half (½) cubic yard or more in volume will be classified as Rock and all other materials as Earth. Old pavement will not be classified as Rock.

3. Construction Methods.—In general, all suitable materials removed from the excavation shall be used in forming the necessary embankment, subgrade and shoulders and in such other places as may be directed. All rocks and boulders uncovered in excavation or found in the right of way shall be placed in embankments as fill material, provided that the embankments are of such depth that these rocks or boulders can be covered with at least six (6) inches of earth. As far as possible, all such rocks or stones shall be placed under the shoulders and not under the metal.

All grass, weeds and other vegetation shall be cut and properly disposed of before the ground is broken for excavation or any embankment made thereon.

During the excavation of the roadway, the sides of the roadbed shall be kept lower than the center and the surface shall be maintained at all times in such condition as will insure adequate drainage.

The excavation shall be conducted in such manner as will insure against removing or loosening any material outside of the required slopes, and any such material which is removed must be replaced in a manner satisfactory to the engineer. In blasting rock, side slopes shall be left with a reasonably uniform face.

Where excavation is in rock, the rock shall be removed from the roadbed to a general level of the rock at least one (1) foot below the elevation of subgrade, with no points of rock projecting above the general level nearer than six (6) inches to the elevation of subgrade, and a fill of suitable material shall be made over this surface.

All intersecting roads, approaches and driveways shall be properly graded as directed by the engineer.

4. Method of Measurement.—All roadway excavation shall be measured in its original position and the volume computed by the method of average end areas. Measurement shall not include any excavated material used for purposes other than those designated, except as provided in Section 4, Division 1 under "Use of Materials Found in the Work." Measurement shall not include any material excavated beyond the limits of the required slopes, except as provided under "Borrow."

5. Basis of Payment.—This work will be paid for at the contract unit price per cubic yard for "Earth Excavation" or "Rock Excavation", which price shall be payment in full for all work specified under Roadway Excavation and also for all items of work specified under the general heading of Earthwork for which no separate unit prices are included in the contract. Such payment shall include full compensation for all equipment, tools, labor and incidentals necessary to complete the work.

SECTION 4—EMBANKMENT

1. Construction Methods.—Embankments shall be formed of good sound earth, stone or gravel and carried up full width. Materials shall be deposited in layers of not more than one (1) foot in thickness and each layer shall be thoroughly compacted by dragging and rolling with a tamping roller or by some other method satisfactory to the engineer. When embankments are to be constructed on existing embankments or hillsides, the slopes which the new embankments will cover shall be plowed deeply or deep steps cut therein before the filling is done, in order that the old and new material may bond together.

All portions of the present travelled way within the limits of the new subgrade which will be within one (1) foot of the surface of the completed subgrade shall be thoroughly broken up to a depth of not less than six (6) inches.

When embankments are constructed of stone and earth, the stone shall be properly distributed and the interstices completely filled with earth. No stone four (4) inches or more in diameter will be permitted within six (6) inches of the subgrade.

All top soil or loam encountered in the cut shall be placed in the shoulders and slopes of embankments as far as possible.

In winter grading, frozen lumps of earth shall not be placed nearer than twelve (12) feet to the center line of the grade and objectionable quantities of snow and ice shall be removed from the surface covered by the embankment prior to making the embankment.

Whenever considered necessary by the engineer, fills shall be built to an elevation above the grades given on the plans an amount sufficient to allow for settlement and insure a completed roadbed at proper elevation, and this provision for settlement shall in no wise be considered as a change in plans.

2. Method of Measurement and Basis of Payment.—The work specified under "Embankment" will not be paid for directly but the payment for "Earth Excavation," "Rock Excavation," or "Borrow" shall include compensation for such work.

SECTION 5—DISPOSAL OF SURPLUS AND UNSUITABLE MATERIAL

1. Construction Methods.—If more material is taken from the cuts than is required to construct the embankments as shown on the plans, the excess material shall be used in uniformly widening the embankments or shall be deposited where the engineer may direct. The placing of unsightly piles of surplus material on the sides of the road will not be permitted.

No excavated material shall be wasted without permission and when so wasted it shall be disposed of as directed by the engineer.

The debris resulting from the removal of old pavement or drainage structures, if considered by the engineer as unsuitable for use in the construction and if no specific directions for its disposal are included in the plans or contract, shall

be placed in neat piles at least three hundred (300) feet outside of the right of way and the contractor shall file with the Department written permission from the property owner for such disposal.

All muck, peat or other unsuitable material occurring within eighteen (18) inches of the surface of the required subgrade shall be removed and such material shall not be placed in embankments but shall be spread uniformly in low places outside of the slope stake lines, or otherwise disposed of in workmanlike manner as directed by the engineer, provided, however, that shoulders and slopes may be built of a mixture of sand and muck in the proportion of two (2) parts or more of sand and to one (1) or less of muck.

All logs of six (6) inches diameter or more occurring in the roadway and commonly classed as "Corduroy" shall be removed if they occur within three (3) feet of the proposed subgrade. All brush and other material smaller than six (6) inches found embedded with the corduroy shall be removed and properly disposed of with the corduroy as specified under "Clearing," Section 1 of this Division.

2. **Basis of Payment.**—No payment will be made for the work specified in this section but compensation therefor shall be considered as included in the contract prices for Excavation, Borrow or the items covering the construction of drainage structures, except as follows:

(a) If the contract contains a separate estimate and unit price for "Removing Old Pavement," this contract unit price per square yard shall be considered payment in full for the removal and satisfactory disposal of all old pavement as specified herein.

(b) If the contract contains a separate estimate and unit price for removal and disposal of "Corduroy," the contract unit price per linear foot of material six (6) inches or more in diameter shall be considered payment in full for the removal and disposal of all such corduroy, and also for the removal and disposal of all brush and material smaller than six (6) inches found embedded with the corduroy.

SECTION 6—BORROW EXCAVATION

1. **Description.**—Borrow excavation shall consist of materials, suitable for making embankments as hereinbefore described, obtained from borrow pits indicated on the plans or designated by the engineer.

2. **Construction Methods.**—Borrow shall only be resorted to when the materials of excavation, suitable for use in the embankments and grade, are insufficient for making such embankments and grade, in which case additional material shall be secured from borrow pits designated by the engineer. All necessary borrow pits will be secured by the Department at no expense to the contractor, unless otherwise specified.

No material shall be removed from borrow pits until they have been cross sectioned and measured by the engineer and the contractor shall notify the engineer of the opening of any borrow pit sufficiently in advance to permit of such cross sections and measurements being made.

All borrow pits shall be left in a neat and suitable condition to facilitate the accurate measurement of the material used and shall be properly drained.

3. **Method of Measurement.**—Borrow Excavation shall be measured in its original position and the volume of material moved will be computed by the method of average end areas or such other method as may be recognized as standard engineering practice.

4. **Basis of Payment.**—If the contract contains a separate estimate and unit price for "Borrow Excavation," the contract unit price per cubic yard shall be payment in full for all work specified in this section. If no such unit price is stipulated, the quantity of borrow excavation, measured as prescribed above, shall be paid for at the contract unit price for "Earth Excavation."

SECTION 7—OVERHAUL

1. **Description.**—Overhaul shall be considered as the distance through which any excavated material is moved in excess of the limits of free haul as stipulated below.

2. **Method of Measurement.**—The limits of free haul for roadway excavation shall be determined from a mass diagram by fixing on the volume curve two points, one on each side of the neutral grade point, one in excavation and the other in embankment, such that the distance between them equals 1,000 feet and the included quantities of excavation and embankment balance, and all materials within this free haul limit shall be eliminated from further consideration.

The distance between the center of gravity of the remaining mass of excavation and center of gravity of remaining embankment, less the limit of free haul as above described, shall be the length of overhaul, and the quantity of overhaul shall be determined by multiplying the yardage in the remining mass as above described by the length of the overhaul in 100 foot stations.

The distance between the center of gravity of the mass of borrow excavation and the center of gravity of the resulting embankment, less the limit of free haul as above described, shall be the length of overhaul for borrow excavation, and the quantity of overhaul shall be determined by multiplying the yardage of the mass of excavation by the length of the overhaul in 100 foot stations.

3. **Basis of Payment.**—If the contract contains a separate estimate and unit price for "Overhaul," the contract unit price per yard station shall be paid in addition to the contract price for excavation or borrow.

SECTION 8—SUBGRADE

1. **Description.**—On all contracts which include surfacing operations, the preparation of the subgrade shall consist of trenching the earth grade as prescribed on the plans and fitting it to receive the surface or base course material.

2. **Construction Methods.**

(a) **Formation of Subgrade.**—Rough grading shall be completed as far in advance of the surfacing operations as possible and the earth grade shall be prepared as stipulated in Section 11 of this Division at least one-half (½) mile ahead of the surfacing operations, except that on contracts which include roadway excavation as well as surfacing, the surface of the earth grade need not be trimmed closer than two-tenths (2/10) foot above or below the profile for the earth grade.

The earth grade shall be trenched and all tile, rock or gravel drains necessary for the proper drainage of the subgrade shall be installed. The subgrade shall then be trimmed to conform to the lines, grades and cross section to receive the road metal and shall be rolled with a roller of an approved type weighing not less than three (3) tons. Rolling may be omitted upon the orders of the engineer if the material in the subgrade can not be compacted under the roller. The subgrade thus formed shall be maintained in a smooth and compacted condition until the road metal shall have been placed.

No base course or surfacing material shall be placed on the subgrade until the subgrade has been checked and approved by the engineer.

(b) Subgrade Mats.—If the material composing the subgrade for gravel or crushed stone roads is such that it might impair the quality of the base course material by mixing with it during the construction operations, the engineer may order the surface of the subgrade covered with marsh hay, cedar bark, wet straw, fine brush or suitable soil. This material shall be evenly spread over the subgrade in such quantities as the engineer may direct.

3. Basis of Payment.—The contract unit price for Excavation or Fine Grading shall be payment in full for all work stipulated in this section except as follows:

If the contract contains a separate estimate and unit price for placing subgrade mats, such unit price shall be considered payment in full for furnishing and placing such mats. If the contract does not contain an estimate and unit price for placing subgrade mats, the furnishing of materials in stock piles along the road for such mats, if ordered by the engineer, shall be considered and paid for as extra work. The labor of taking such materials from stock piles and constructing the mats as directed shall be done by the contractor without extra compensation.

SECTION 9—SHOULDERS

1. Description.—On all contracts which include surfacing, shoulder work shall consist of building, shaping, compacting and maintaining until acceptance that portion of the roadbed hereinbefore defined as shoulders.

2. Construction Methods.—The shoulders shall be constructed of good sound earth or other approved material and rolled with a roller weighing not less than three (3) tons, or otherwise compacted as directed by the engineer, and when completed shall have the cross section shown on the plans.

In the construction of gravel or broken stone roads, the shoulders shall be built, during the preparation of the subgrade and before any surfacing material is placed, to a height not less than the edge thickness of the first course before it is compacted. The inside edges of the shoulders shall be true in alignment and shall be maintained by suitable boards placed vertically against them. The boards shall be removed after the first course of stone or gravel has been spread and before any rolling is done. Before the second course is spread, sufficient material shall be added to the shoulders to bring them to a height equal to the height of the second course before it is compacted, and such that the shoulders when rolled shall have the cross section shown on the plans.

Should the contractor prefer, he may build the shoulders at one operation, before any surfacing material is placed on the subgrade, so that when compacted they will conform to the cross section shown on the plans. However, if the shoulders are so built, they shall be reshaped after the first course is rolled and before the second course is spread.

3. Basis of Payment.—No payment will be made for the work specified in this Section but compensation therefor shall be considered as included in the contract unit prices for Excavation or Fine Grading.

SECTION 10—SUB-BASE

1. Description.—Sub-base shall consist of approved gravel, stone, slag or sand placed in the excavation made by the removal of unsuitable subgrade materials where indicated on the plans or where directed and as specified herein.

2. Materials.—Gravel, stone and slag shall meet the requirements of Section 4, Division 12 for "Gravel for Sub-Base," "Stone for Sub-Base" and "Slag for Sub-Base," respectively. Sand shall meet the requirements of Section 3, Division 12 for "Sand for Sub-Base."

3. Construction Methods.—Unsuitable subgrade materials shall be removed and the excavation shaped uniformly and thoroughly compacted. The sub-base material shall be spread evenly and thoroughly compacted in layers of not over six (6) inches in thickness, and all interstices shall be filled with gravel, stone or slag screenings or other approved material. The sub-base shall be built to the elevation required for subgrade. All compacting shall be done with a roller weighing not less than ten (10) tons, or such other method as may be approved by the engineer.

4. Basis of Payment.—This work will be paid for at the contract unit price per cubic yard for "Sub-Base," which price shall be payment in full for all excavation, furnishing the materials (unless otherwise specified), and constructing the sub-base complete as specified herein.

SECTION 11—TRIMMING AND FINISHING EARTH GRADE

1. Description.—When the contract includes grading but not surfacing, the work of leveling, trimming and otherwise completing the earth grade ready for acceptance shall be included under this heading.

2. Construction Methods.—All irregularities shall be made smooth, all hollows and depressions filled, all slopes, ditches and waterways shall be smoothed and trimmed and the entire roadway shall be thoroughly compacted and made uniformly smooth and true to the lines, grades and cross sections required. No stones over four (4) inches in diameter or other unsuitable material shall be left within six (6) inches of the surface of the grade.

All debris and rubbish resulting from the construction work or occurring within the right of way shall be cleaned up and properly disposed of. Any rocks and stones less than one-half (½) cubic yard in size, which cannot be placed in embankments as specified in Section 3 of this Division, shall be disposed of as directed by the engineer, provided, however, that an average of fifty (50) cubic yards per mile for the entire project will be the maximum quantity of rock and stone required to be so cleaned up without additional compensation.

3. Basis of Payment.—No payment will be made for the work specified in this Section but compensation therefor shall be considered as included in the contract price for Excavation except that the disposal of surplus rock and stone as defined above will be paid for as extra work.

SECTION 12—FINAL TRIMMING AND CLEANING UP

1. **Requirement.**—Previous to acceptance of the work as complete, the shoulders, slopes, ditches and waterways shall be trimmed and made compact, uniform, smooth and true to line, grade and cross section. All debris and rubbish and all loose rocks and stones from six (6) to eighteen (18) inches in diameter resulting from the construction work or occurring within the right of way shall be cleaned up and properly disposed of. Any such rocks and stones, which cannot be disposed of as specified in Section 3 of this Division, shall be disposed of as directed by the engineer, provided, however, that an average of fifty (50) cubic yards per mile for the entire project will be the maximum quantity of rock and stone required to be so cleaned up without additional compensation. All weeds in the right of way shall be cut and burned by the contractor before final acceptance of the project. The above operations incidental to trimming and cleaning up will be considered incidental to the contract and not paid for as excavation.

2. **Basis of Payment.**—No payment will be made for the work specified under this heading, but compensation therefor shall be considered as included in the contract prices for Excavation, except that the disposal of surplus rock and stone as defined above will be paid for as extra work.

SECTION 13—FINE GRADING

1. **Description.**—Fine grading shall consist of the operations specified under Sections 8, 9 and 12, when the other operations required under Excavation and Embankment have been completed under a previous contract and when the contract includes an estimate and unit price for Fine Grading.

2. **Construction Methods.**—The work shall be done in accordance with the above specifications for "Subgrade," "Shoulders" and "Final Trimming and Cleaning Up."

3. **Basis of Payment.**—If the contract contains a separate estimate and unit price for Fine Grading, the contract unit price per station shall be payment in full for all work specified in this Section, provided, however, that the maximum amount of excavation, including trenching, required under this item shall not exceed thirty (30) cubic yards per one hundred (100) feet. Any excess above this amount shall be paid for as extra excavation and any haul of over one thousand (1,000) feet shall be paid for as overhaul.

MICHIGAN STATE HIGHWAY DEPARTMENT

1926 - STANDARD ROAD AND BRIDGE SPECIFICATIONS

DIVISION - 4

Section 2 - One Course Gravel Surface

1. DESCRIPTION

This item shall consist of a single course of gravel constructed as specified herein on the prepared subgrade and conforming in all respects to the lines, grades and cross sections shown on the plan.

2. MATERIAL

The gravel shall meet the requirements of Section 4, Division 12, for "Gravel for Gravel Surfacing." (Unless otherwise shown on the plans or in the proposal.)

3. CONSTRUCTION METHODS

(a) Placing and Compacting. - The gravel shall be spread uniformly in a single layer on the prepared subgrade to such a depth that when compacted it will have the thickness shown on the plans. Over-size stone must be removed from the gravel at the pit. The placing of gravel on the road which contains over-size stone and then removing the over-size stone by means of forking or other methods will not be permitted. To secure a proper thickness of the layer, the contractor shall use side boards and center board of a height equal to the required depth of the loose layer and shall spread the gravel flush with the tops of those boards and to the required crown. The gravel shall be of a uniform mixture and density when placed on the road and, after it has been uniformly spread, it shall be harrowed with a spike tooth harrow and floated with a road drag or grader until the surface is free from waves and irregularities. This harrowing and floating, alternated with rolling with a roller of a tamping type, shall be continued until the gravel is thoroughly compacted and has the required line, grade and cross section, except that the harrowing shall not be carried on at such times or to such an extent that the fine material will be separated from the coarse material.

(b) Maintenance During Construction. - If there appears, after the road or any portion thereof is opened to traffic and prior to final acceptance of the road, evidence of rutting or undue loosening of the surface, gravel shall be added where necessary to fill depressions and the road shall be rolled and floated until the surface is firm and even.

4. BASIS OF PAYMENT

This work will be paid for at the contract unit price per square yard (or per cubic yard if the proposal so specifies) for "One Course Gravel Surface," measured in place, which price shall be payment in full for furnishing the materials (unless otherwise specified) and constructing the surface complete as specified herein.

DETERMINATION OF COST

In determining the cost of the road, the list of the unit prices was furnished by the Michigan State Highway Department. They represent the average unit price for over a period of nine months. This average was taken from contracts awarded by the State Highway Department.

PRICE LIST

Earth Excavation	$ 0.30 per cu. yd.
Overhaul (Earth Excavation)	0.011 per yd. sta.
Muck Excavation	0.25 per cu. yd.
Borrow	0.28 per cu. yd.
Overhaul (Borrow)	0.01 per yd. sta.
Gravel Surface (1 Crs. 6")	0.35 per sq. yd.
Gravel Haul	.27 per yd. mi.
Corrugated Metal 12"	1.35 per L ft.
Guard Rail (Cable)	0.50 per L ft.
Seeding	30.00 per mile
Sodding	0.16 per sq. yd.
Miscellaneous and Engineering	10%
Concrete (Class A)	19.40 per cu. yd.
Land	100.00 per acre

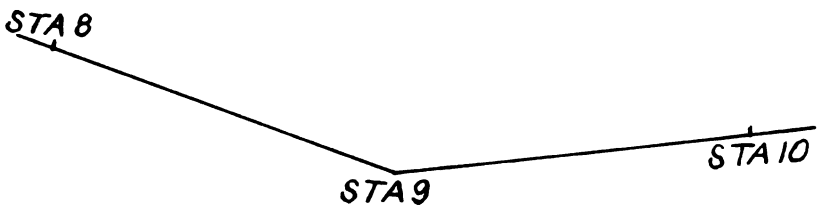
QUANTITY SHEET

Earth Excavation	11,864.69 Cu. yd.
Overhaul (Earth Excavation)	2,322.12 Yd. sta.
Muck Excavation	16,639.35 Cu. yd.
Borrow	21,966.55 Cu. yd.
Overhaul (Borrow)	167.36 Yd. sta.
Gravel Surface (1 course 6")	9,386.67 Sq. yd.
Gravel Haul	3,128.90 Yd. mi.
Corrugated Metal (12")	155.00 Ft.
Seeding	5,280.00 Ft.
Sodding	3,758.76 Sq. yd.
Concrete (Class A)	11.2 Cu. yd.
Land	12.2 Acres

ESTIMATE COST SHEET

Earth Excavation	$ 3559.41
Overhaul (Earth Excavation) @ $.011 / yd. sta.	25.54
Muck Excavation	4159.84
Borrow	6150.63
Overhaul (Borrow) @ 1¢ / yd. sta.	1.67
Gravel Surface (1 course 6") @ 35¢ / sq. yd.	3285.33
Gravel Haul @ 27¢ / yd. mi.	844.80
Corrugated Metal @ $1.35 / L ft.	209.25
Guard Rail (Cable) @ 50¢ / L ft.	452.50
Seeding @ $30 / mile	30.00
Sodding @ 16¢ / sq. yd.	601.40
Concrete (Headwalls) @ $19.50 / cu. yd.	217.28
Miscellaneous and Engineering	1953.26
Total Cost	21489.23
Land @ $100.00 / acre	1220.00
Total Cost plus Cost of Land	22709.23

VERTICAL CURVE NO. 1



$$\text{Elev. } K = \frac{873.59 + 872.51}{2} = 873.05$$

$$\text{Elev. } H = \frac{873.05 + 872.10}{2} = 872.57$$

$$VH = 872.57 - 872.10 = 0.47$$

OFFSETS AT

$$25 \text{ ft.} = \frac{47}{16} = .03$$

$$50 \text{ ft.} = \frac{47}{4} = .12$$

$$75 \text{ ft.} = \frac{9 \times .47}{16} = .26$$

ELEVATIONS AT

8 + 00	=	873.59
8 + 25	=	873.25
8 + 50	=	872.97
8 + 75	=	872.73
9 + 00	=	872.57
9 + 25	=	872.46
9 + 50	=	872.43
9 + 75	=	872.44
10 + 00	=	872.51

VERTICAL CURVE NO. 2

$$\text{Elev. K} = \frac{878.48 + 878.10}{2} = 878.29$$

$$\text{Elev. H} = \frac{878.29 + 878.89}{2} = 878.59$$

$$\text{VH} = 878.59 - 878.89 = -.30$$

OFFSETS AT

$$25 \text{ ft.} = \frac{-.30}{15} = -.02$$

$$50 \text{ ft.} = \frac{-.30}{4} = -.07$$

$$75 \text{ ft.} = \frac{-9 \times 30}{16} = -.16$$

ELEVATIONS AT

24 + 60	=	878.48
24 + 85	=	878.56
25 + 10	=	878.61
25 + 35	=	878.73
25 + 60	=	878.59
25 + 85	=	878.54
26 + 10	=	878.43
26 + 35	=	878.28
26 + 60	=	878.10

VERTICAL CURVE NO. 3

$$\text{Elev. K} = \frac{866.57 + 866.38}{2} = 866.48$$

$$\text{Elev. H} = \frac{866.48 + 865.77}{2} = 866.13$$

$$\text{VH} = 866.13 - 865.77 = .36$$

OFFSETS AT

$$25 \text{ ft.} = \frac{.36}{16} = .02$$

$$50 \text{ ft.} = \frac{.36}{4} = .9$$

$$75 \text{ ft.} = \frac{9 \times .36}{16} = .23$$

ELEVATIONS AT

41 + 50	=	866.57
41 + 75	=	866.40
42 + 00	=	866.27
42 + 25	=	866.20
42 + 50	=	866.13
42 + 75	=	866.15
43 + 00	=	866.18
43 + 25	=	866.26
43 + 50	=	866.38

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[redacted] [redacted]

NAME Cogan & Grossman

Class..... Course..... Party.....

FIELD NOTES

[redacted] [redacted]

[redacted] [redacted]

[redacted]

[redacted]

Geodetic station No 17 C

Large flat grayish white stone S.E. corn.

Stone N.W. side of Hillary Tree

Top of post end of fence from N. to S.

1/4 section mark

Stone by 2nd post N of said fence

township E. from Sec 3 & 10

Tree 4 of 4 S 74 & 15

[redacted]

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87726 8.660

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8.665 1.420

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2.7630 2.650

$\frac{50}{2.49}$ $\frac{50}{2.43}$
2.4950 2.430

[redacted]

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L.		R.
50		50
7.45		70.13
875.51		874.34
50		50
2.72		2.72
872.62		871.44
50		50
13.0		12.21
871.12		872.25
50		50
6.99		6.10
871.40		871.71
50		50
8.95		7.72
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870.66	3[illegible].55	87[illegible]
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50	40	50
5.02	3.45	5.02
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287°15'

247°15'

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41+80	[illegible]
41+00	15.70
41+70	12.00
41+80	9.00
42+00	4.00
42+35	

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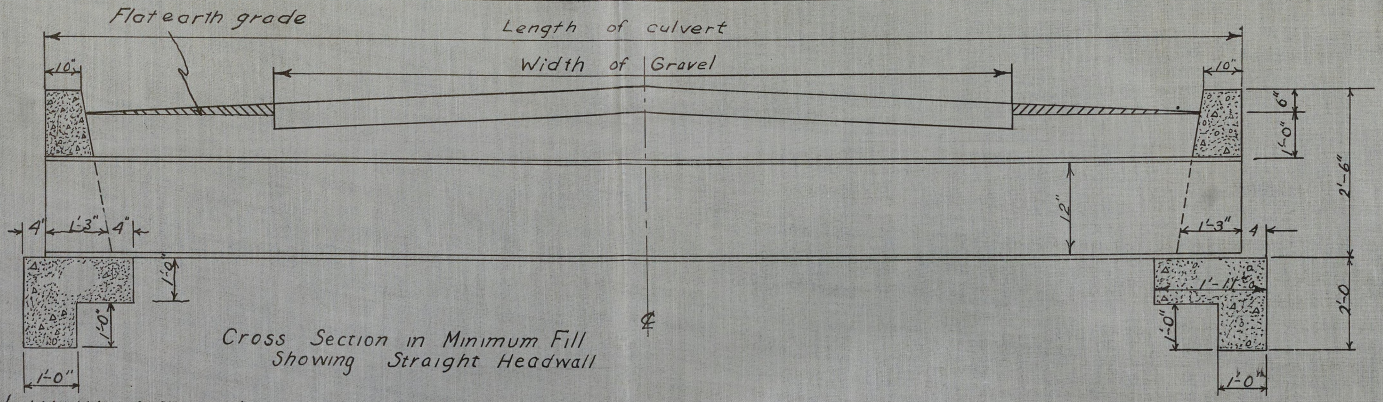
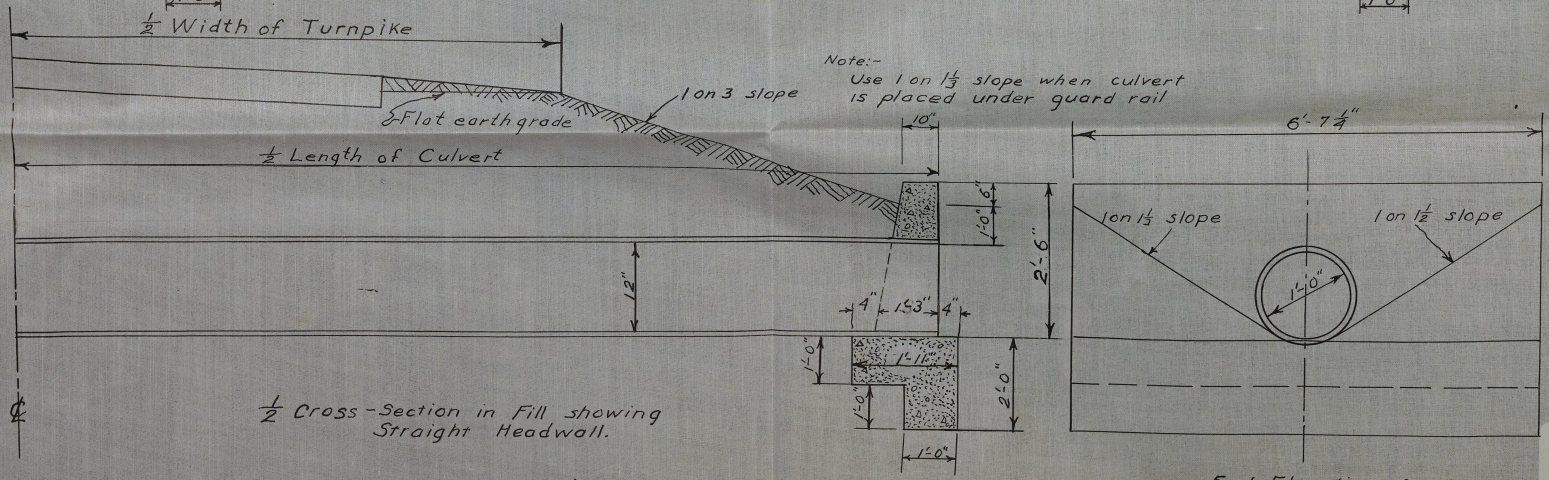


Cross Section in Minimum Fill
Showing Straight Headwall

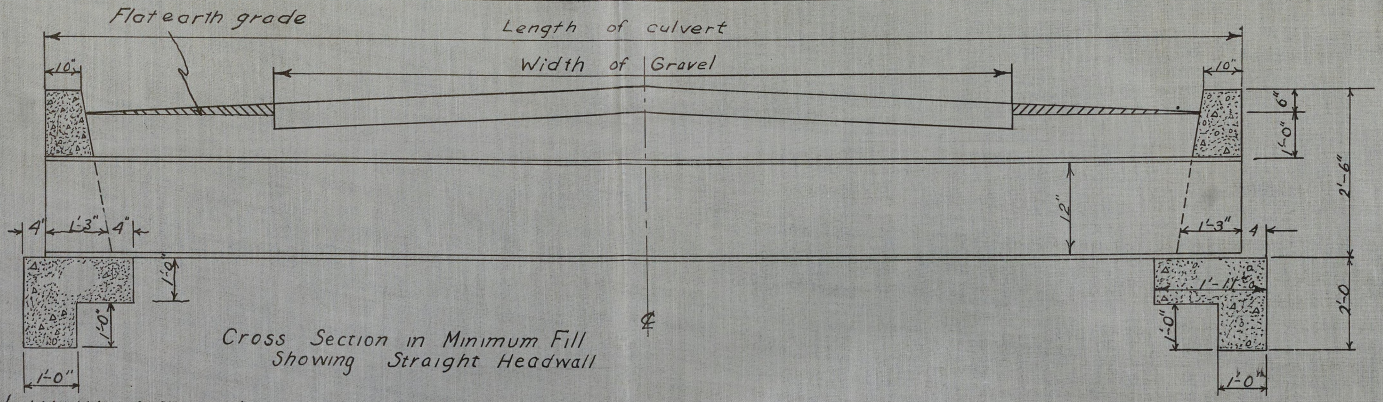


Note:-
Use 1 on 1½ slope when culvert is placed under guard rail

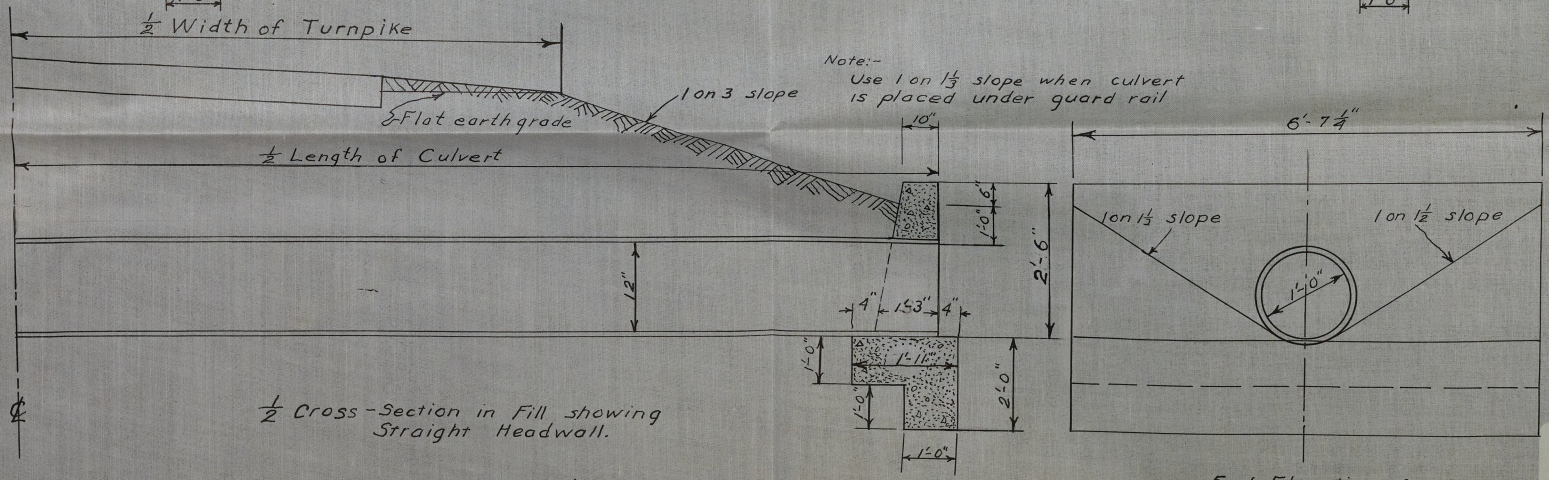
½ Cross-Section in Fill showing Straight Headwall.

End Elevation of Straight Headwall

PLANS FOR THE HEADWALL OF A STANDARD CULVERT



Cross Section in Minimum Fill
Showing Straight Headwall

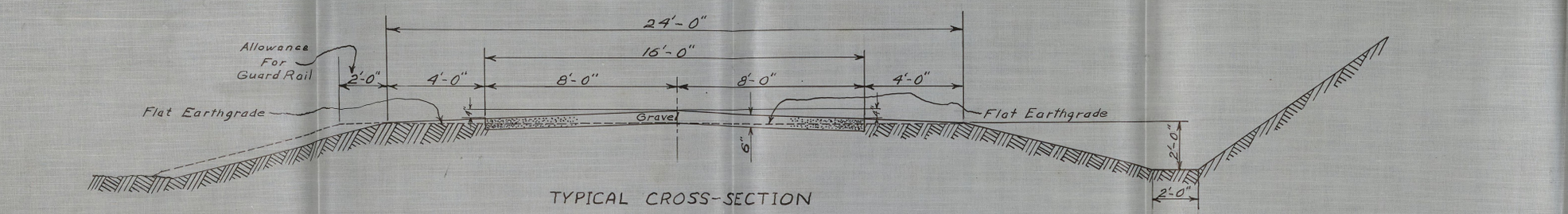


Note:-
Use 1 on 1½ slope when culvert is placed under guard rail

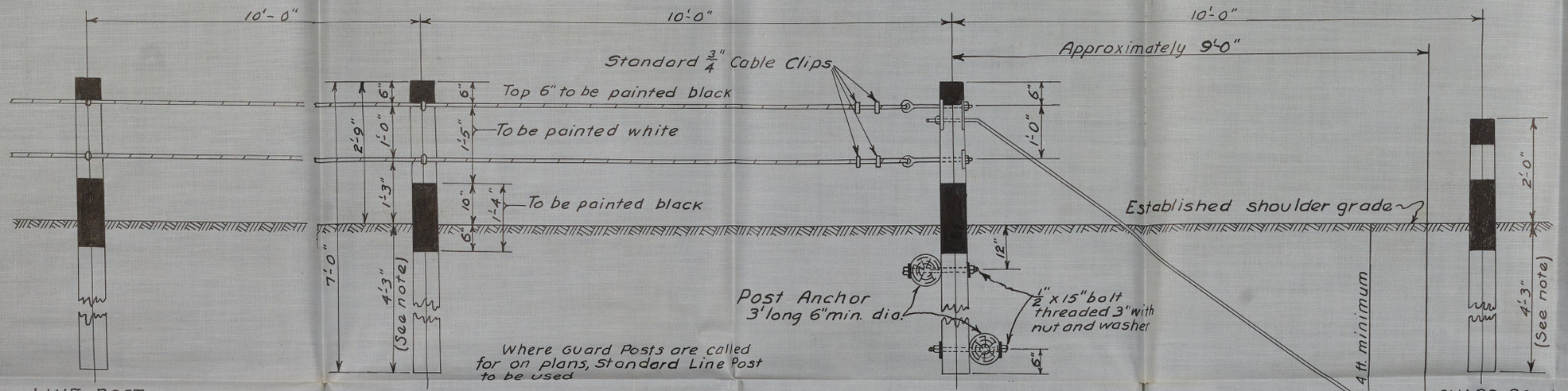
½ Cross-Section in Fill showing Straight Headwall.

End Elevation of Straight Headwall

PLANS FOR THE HEADWALL OF A STANDARD CULVERT



TYPICAL CROSS-SECTION

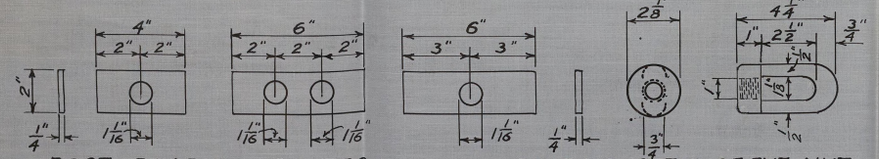


LINE POST
Standard 7"

INSIDE VIEW
Showing Normal ending and anchoring of Guard Rail

END POST
Standard 8"

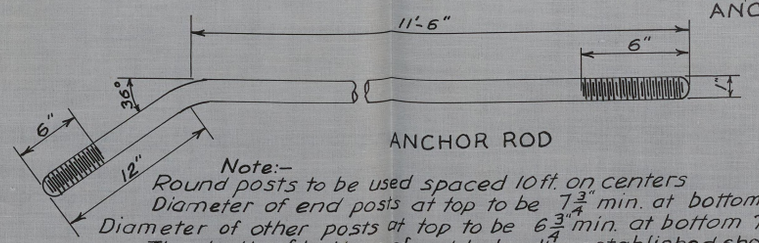
GUARD POST
Standard 7"



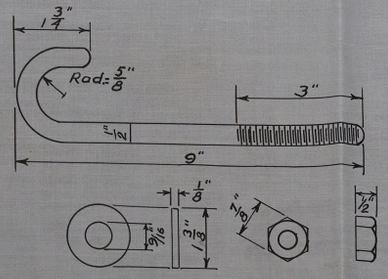
POST BEARING PLATES

ANCHOR BEARING PLATE

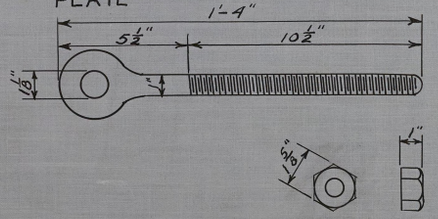
DETAIL OF EYE NUT



ANCHOR ROD



CABLE RETAINER BOLT WITH FITTINGS



EYE BOLT WITH FITTINGS

Note:-
Round posts to be used spaced 10 ft. on centers
Diameter of end posts at top to be 7 3/4" min. at bottom 8 3/4" min.
Diameter of other posts at top to be 6 3/4" min. at bottom 7 3/4" min.
The depth of bottom of post below the established shoulder grade shall not vary more than three (3) inches from the dimensions shown.
All bolts and other metal fittings to be dipped in red lead previous to installation. Cable to be double galvanized.
After erection all cable retainer bolts projecting more than one inch from nut to be cut off one-half inch from nut.
All metal fixtures to be made from twenty to thirty point carbon steel. Eye bolts, eye nuts and cable clips to be drop forged.
Materials and workmanship to be in accordance with the Michigan State Highway Department's 1926 Specifications for Road Construction.

The anchors and bottom 4'-9" of posts to be given a single brush treatment of preservative oil according to Division 12 Section 13, Item 4(b) using Anthracene Oil specified under Division 12, Section 14, Item 9(c) or Heavy Creosote Oil specified under Division 12, Section 14, Item 9(d)

DETAIL SHEET