"THESIS"

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" COST AND CONSTRUCTION OF MACADAM ROADS"

UNDER:

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THESIS

Cost and Construction of Macadam Roads.

Experience has put in evidence that macadam roads are durable and suitable for renewal sections of main roads, providing that the construction is carried out properly. We find now that macadam roads are being built between principal towns or where a road is very much used, it is too expensive for a little traveled road.

The word "macadam" as herein used, relates to a surfacing composed of stone broken into small fragments, the largest not exceeding two and one half inches in diameter, suitably bound together into a compact mass so as to be substantially a sort of concrete, but with no binder other than stone dust or screenings. A road so surfaced might be more properly called a "broken stone" road.

This thesis with intention of making the construction and cost more comprehensable to the public at large will be divided into three parts: first, principal knowledge and facts required to undertake the work: second, correct method of construction: third, plans, computations and drawings , also total cost of building twenty one hundred feet of macadam road.

First:- the macadam should be hard, smooth, and impervious to water. Much attention must be given to the foundation. It should be composed of porous material free from clay or loam, firm, and sufficiently strong to sustain any load likely to come upon the road at any time of the year.

The principal qualities which are necessary in road building stones are hardness and toughness. The cementing values of the stone dust should nor be forgotten, but these are not so important as the qualities first mentioned. Often the choice of stone is very limited, it may be that only field stones may be had, or perhaps nothing but inferior rock or ledge stone can be found, except at a prohibitive cost.

Trap rock- meaning by the term the diabases, the diorite, and certain other igneous rocks- has long been considered the best material for macadam purposes. Unfortunately, except in certain localities these stones are not common. Some of the horneblendic granites

give good results, as do the felsites and some of the harder limestones. The slates, schists, most of the sandstones, the micaceous granites, and the quartzites have but little value as road-surfacing material. Often these stones may be used economically in the lower course of the macadam, providing the upper stratum is composed of better grade of stone. Stone from a ledge, because of its uniformity in desirable quanities, is usually better than field stone and makes a smoother and more desirable road; but if the ledge is of an inferior grade of rock, it should not be used, merely because it is a ledge, in preference to field stones of a better quality of rock.

When broken stone is bought from a manufacturing company and shipped by rail, or otherwise, it is frequently sold by weight. Before estimating the cost of a road when the stone is to be paid for by weight, the road officials must know how much the stone will weigh per cubic yard. All stone does not weigh the same per cubic yard, it depends on the specific gravity of the rock under ivestigation. In contracting for stone the place of measurement should be stated in the contract, for on hauling the volume will decrese.

Tools and Machinery. IN addition to the shovels, picks, and other implements, a considerable outlay for machinery is necessary. In these days of high-paid labor and short working hours one rarely hears of in this country of macadam stone being broken by hand. It has been found that it is very much cheaper to have a stone crusher to do this work, that was done before by hand. These plants are made in several styles, for country use I would suggest a portable plant. There are several kinds of portable plants which may be bought at prices ranging from $1600 to $2500, which are admirably adapted for country use. These plants include the stone crusher, engine, and boiler, portable bins, revolving screen, and an elevator to lift the stone after it is broken and to discharge it into the screen. The moving of these plants from place to place is very easy as they are mounted on wheels and the cost is very little in comparsion to the saving in the hauling of the broken stone and loss of stone by handeling.

Experience has showen that two miles of road is about the

economical limit for operating the plant in one place. If a greater length of road is to be built it is usually cheaper to move the plant than to haul the product a longer distance. The plant should be setpp as nearly as practicable in the center of the section to be built, but the crusher position is often goverened by the water supply for the boiler and the watering carts.

Rollers:- macadam roads may be built with rollers drawen by horses, they may also be built without any rolling at all, except by the wheels of moving vehicles. But experience has demonstrated that quicker and better work can be done with the steam roller, and usually at a less cost. A so called "10-ton roller" is sufficiently heavy for country roads. Most of the culverts and many of the bridges are to weak to sustain, with safety, the heavier rollers,

Watering Carts:- since water is always needed in dolling the macadam, a watering cart or sprinkler should be provided. The road official can not often wait for rain. A cart with a capacity of 450 to 600 gallons will be sufficient. Most of these carts are provided with extremely broad tires, so that the cart assists in consolidating the stone, instead of rutting it.

Road Machines:- this is a most servicable instrument when used properly. Often it is misused in repairing eartg roads. The practice of scraping back upon the road worn-out material which has been washed into the gutters can not be too heartily condemed. The road machine can be used to an advantage in prepairing the road for the broken stone. Drag and wheel scrapers are useful in grading and shaping the roadbed. Automatic spreading carts of several different kinds are often used in spreading the broken ston. They are useful and save considerable time and labor, but are not essential.

Labor and Teams:- in macadam work, as in all other construction work, there should be a competent foreman or superintendant in charge. Since no two pieces of road are ever alike, no definate statement can be made as to the number of men required for the grading and other details, except with regards to the broken stone portion of the work, and the same is true with regards to the teams. Not many laborers are required to take care of the output of a single crushing plant. The crusher engineer and the roller operator should

be skilled mechanics. Both of these men act as firemen, and, in fact usually take care of the machinery under their charge, Two ordinary laborers are usually enough to feed the crusher, with a third man to assist them occasionally and to maul stones which are too large for the receiving orifice. Two spreaders are needed to take care of the broken stone as it is delivered to the road, and a driver and a pair of horses are required for the watering cart. It is impossible to give the number of teams needed for the broken stone, since the number is dependent almost wholly on the length of the haul. IN quarrying ledge stone, the number of laborers required depends largely on the character of the stone, and each case must be considered by itself.

Earthwork:- a civil engineer should lay out the work, establish the grades, and set the grade stakes. Often in rebuilding an existing road it is advisable to change the grades to a considerable extent, and then the services of a civil engineer are also required. Theoretically, the grades should be as nearly level as possible, but in most localities this ideal condition can not be realizwd, nor will the available appropiations usually permit even an approach to the maximum grades adoped by the railroddes. Practically, in road construction little is ordinairly done beyond reducing the hills to the maximum grade which has been adoped and in removing the irregularities between the hills. If suitable, the materials excavated from the hills are used in filling the depressions. IN American practtice the maximum grade for important roads has been generally fixed at five percent where such a grade can be had without too great expense for grading and for damage to abutting property. In fixing the grades care must be taken to adjust the cuts and fills so that there will be little or no waste of material. This requires some judgement and experience, since most materials shrink to a greater or less extent when taken from cuts and placed in fills. It is estimated that this shrinkage, together with certain unavoidable waste, averages about fifteen percent.

A line of grade stakes should be set on each side of the road way. These stakes should be not more than fifty feet apart and the established grade should be plainly marked on them. They should be set sufficiently

far from the roadway not to be disturbed by the grading and other operations. These atakes will serve later for the macadam work. The road should be graded to the approximate subgrade elevation, with a sufficient surplus of material to form the shoulders. It should also be rembered that the materisl will settle when the steam roller is brought on it.

The surface water should always have opportunity to drain from the roadway as quickly as possible, and the gutter grades should be so fixed that there will be at least six inches fall in one hundred feet. With a less fall, if there be snow in the winter, the water will be held back and cause trouble.

No impervious materials, such as clay and loam, should be permitted within at leas eighteen inches of the top of the compleated road, particularly if it is a locality where the ground freezes in the winter. All stumps and roots should be grubbed out and removed. The clay and loam may be placed on the sides of the road, but such materials should not be permitted under the broken stone. Sand, gravel, or other material which does not hold water should replace them.

Drainage:- water should never be permitted to remain under a macadam road. It softens the foundation so that the broken stone is forced down into it by the wheels of vehicles, thus causing ruts to develop in the macadam. In freezing it expands and "heaves" the broken stone, destroying the bond and causing the larger fragments of stone to rise to the surface.There are several ways of removing the subsurface water, at least in part. Sometimes if the grade is raised in wet places the trouble will be lessened, particularly if porus materials are used.

Side Drains:- may be constructed in the cuts on each side of the road, just outside of the limits of the macadam. These drains consist of narrow trenches, filled with broken stone or small gravel stones, with a pipe five or six inches in diameter near the bottom. The pipe is laid with open joints, true to grade, and is carried to a proper outlet. Sometimes the pipe is omitted and the entire trench is filled with stones, in which case it is called a blind drain. Such drains serve to cut off the subserface water before it can get under the macadam.

Another way of nullifying in part the effect of the subserface water is to sonstruct a foundation of telford. Formerly nearly all macadam roads were built with telford base, regardless of any consideration of the requirements of traffic. It is now generally recognized that, except in unusual cases where the subsoil is full of water which can not be drained out, the telford base is unnecessary except for purposes of subdrainage. Several other devices are sometimes employed to take care of the subserface water, such as the center box drain, built of slabs of stone, these are either too expensive or of too unstable a nature to be recommended.

Surface Drainage:- this has been discussed to some extent under "earthwork". It is obvious that the water which falls on the road and which flows upon it from adjacent lands should be got rid of as soon as possible. Culverts should be built at loww places where outlets are available, and existing streams should always be used for outlets. The water should never be carried in the gutters or in side drains any farther than is necessairy. When the volume of water is small it may be carried across the road in tile pipes burried deep enough not to be broken by the passing traffic, For large volumes of waterculverts of rubble masonery or Portland-cement concrete may be built. Very often it will be found to be more economical to use the concrete, particularly if it is reinforced with steel.

Shaping the Subgrade:- it is not enought that the roadway shall be graded with reasonable care. The surface upon which the broken stone is to be placed must be hard, smooth, and carefully crowned. I f the foundation is not hard and firm the stones will be pressed into it by the roller and wasted. If not crowned,an unnecessary quanity of stone will be used. When the macadam is to be uniform thickness throughout its cross section, the crown of the subgrade should be the same as that of the finished road. IN shaping the subgade a road machine may be used to an advantage, but is not necessairy. Usually sufficient material is left on the sides to form the shoulders for the macadam. If the natural soil is not suitable, material should be brought on at this time.
After the roadbed is shaped to the approximate cross section it should be rolled thoroughly until it is hard, firm and smooth.

This is essential, since if the subgrade is soft much of the broken stone will become embedded in it later. If soft places are found or depressions develop during the rolling, more good material should be put on, so that when the subgrade is ready for the broken stone it shall conform to the proposed cross section as nearly as practicable.

The Courses if Macadam:

SIzes of Stone: a stone two and one half inches in diameter is as large as should be used in macadam work. Usually fragments of this size are used in the lower or first course. Those of the one and one fourth inch size are used in the upper course. If the stone is hard, this size is about as large as can be used to give a smooth surface. Soft stone will often crush under the roller, and, where such stone is used, a size large than the one and one quarte inch may sometimes be used with good results.

Crown:- every macadam road should be crowned, in order that the water falling on it may run quickly to the gutters. It is also necessary that the shoulders should have the same slope as the macadam or perhaps a little greater.For a road fifteen feet or less in width it will be found satisfactory to have the center five and one half inches higher than the sides, forming a crown of three-quarters of an inch to the foot, On roads of greater width it will be necessairy to reduce the crown to one-half inch to the foot, or perhaps even less. The apex should be slightly rounded.

Thickness of Courses:- since the wear at the center of the roadway is always greater than at the sides, some saving of stone may be made by reducing the thickness at the outer edges. A layer of loose stone more than six inches deep can not be compacted with a roller easily, if at all, and modern roads are built in two or more layers or courses. To secure smoothness and even wearing, the smaller sizes of stone should be placed in the upper course and the larger in the lower. When a road is built with the sizes mixed, unless the stone is unusually soft, a rough surface inevitably results, in a compartively short time after the road is opened to travel.To secure a finished roadway six inches thick, about eight and one half inches of loose stone, not reckoning

the binder, is necessary. This is in part due to the unavoidable forcing of the stones, to a slight extent, into the foundation. The binder or "matrix" as it is sometimes called, consisting of the stone dust and small fragments of stone which pass through the one half inch holes in the screen, is not counted a course. No more of the binder should be used than is necessairy to fill the voids and just cover the upper course of the stone.

Placing the Broken Stone:- as soon as the drainage work is completed and the roadway has been graded, shaped, and rolled for a few hundred feet, the spreading of the broken stone should be commenced.

Lower Course:- the larger size of stone should be spred first. The stone should never be dumped from the carts directly upon the road. When broken stone or gravel is dumped from the ordinary cart it fall in a pile with the smaller fragments consolidated to a greater or less extent in the center of the heap. An uneaven road usually results and often the individual loads may be counted after the road is finished and in use for some time. Unless automatic spreading wagons are used tha stone should be shoveled from the carts or dumped on a movable platform of planks about six feet long and three feet wide, sometimes called a "dumping board". The spreaders should then shovel the stone from this platform upon the prepared sub grade to the required depth for the lower course, rembering, as before stated, that the course will shrink in depth under the roller. The depth of course should be ~~tetes~~ tested frequently by strings streched across between the grade stakes. Sometimes blocks of wood of the required height are used, these are set on the sub grade and the stone is spread until the top of the course is flush with the tops of the blocks, The stone is frequently leveled with rakes. When a hundred feet or so of the first course has been spread, the rolling should begin. It will be found best to begin the rolling at the oter edge of the macadam, running upon the shoulder a few inches. When this portion of the stone ceases to wave and seems firm under the foot, the roller should be moved to the other side of the roadway and the operation repeated there. After both sides of the roadway are moderately firm, the roller should be

moved gradually toward the center until the entire lower course is thoroughly compact. Sometimes it is found that the wavy motion continues and that the stones will not compact. This may be due to a wet subgrade, which, if allowed to dry for a day or two, will give no further trouble or it may be due to the use of an extremly hard stone, in which case the application of a little sand or fine gravel may remady the difficulty. With somw soft, corse, gravel stones, a "crawling" motion may be noticed. In this event, instead of compacting, the sharp corners of the stones become rounded.A slight sprinkeling of sand or the sprinkeling with water will often remove this difficulty. It must not be expected that the lower course will be absolutely rigid. If it is rolled enough to prevent the stones from shaking when one walks over them it is sufficient. If depressions develop as a result of the rolling, additional stone of the same size as used in the course should be added and rolled, and before the second course is put on the lower course should be smooth and true to the cross section.

Upper Course:- after about one hundred feet of the first course of stone is rolled, the second course, consistingof the fragments varying in diameter between one half inch and one and one fourth inches should be spread from the dumping board the same as in the first course and rolled in the same manner. After this course is thoroughly compact, the binder should be spread. Usually but little more than one inch in depth of the screenings is required in six inch work. The watering cart should then be put in advance of the roller ans as much as possible of the dust should be flushed into the crevices between the stones. The roadway should be wet and rolled until it "puddles" on the surface, showing that the voids are substantially filled.No more of the screenings should be used than are necessairy to fill the voids and to leave a very thin coverihg over the larger stones. Depressions in the upper course should not be filled with screenings, but rather with stones of the size used in the course. There is of necessity more or less teaming over the road during its construction, and while the courses are in a uncompact condition the horses hoofs and the wheels

of vehicles are detrimental to the work; but when the macadam is compleated the sooner it is used the better.

The Roadsides:- no matter how smooth and well constructed the traveled road may be, if the roadsides are not cared for, the highwyy as a whole will not give a good impression. All rubbish should be removed; the excavations should be filled and embankments smoothed and plantdd with grass wherever it will grow.The trees should be trimmed up to make a good impression, and they also serve an other purpose, for in exposed places where the sweep of the wind would be otherwise unbroken they serve to prevent in a measure the blowing away of the binder from the road surface.

The Cost of Macadam Surfaces:- comparison of average costs of roads in one locality with those on an other is of little value, for the reason, that the conditions in two localitie are different. BUt I find on investigation of the goverment reports on this subject that a verage cost of from$2,000 to $6,900 per milo, it often happens that the cost is less and again more. This is for a roadway of fifteen feet and stone from four to six inches deep. This does not includ the expense of grading, drainage, or any other incidental items.

Maintenance:- someone has said that the maintenance of a macadam road should begin on the day that it is compleated. In a sense this statement is not far from the truth. It is usually not neceaaary to do much to the macadam surface for a year or two; but the gutters catch basins, and culverts must be kept clean, the weeds along the roadside must be cut,or, preferbly, pulled out by the roots, and the small gullies in the shoulders and on the slopes filled before they become too large. But the above facts are equally true concerning dirt roads or most any other form of roads. Of course the macadam will become worn in time and need repair. No one can state accurately how much of the macadam surface will wear off in a given time. The dictum, heard so often, that the macadam will wear down one half inch in a years use is a fallicy. The length of life of a properly built macadam road depends especially upon the volume and kind of traffic over it, the quality of stone of which it is composed, and its

peculiar fitness to resist the wear to which it is subjected; also upon the climate in the locality where it is situated.It was formerlly held that the macadam surface should be restored annualy to its origional thickness. Doubtless this practice was excellent, so far as the condition of the roads were conserned, but such annual restoration was very costly. The present practice is to always keep the surface smooth, to fill any small holes or ruts which may appear, but to do now resurfacing until the stones have worn down at least to the lower course of macadam. At the present time the worst foe of the macadam road is the motor vehicle. The steel wheels of the ordinary vehicle grind off enough powder from the stones to serve as a binder, replacing the binding material blowen away by the winds or washed off by the rains. It is usually possible when the binder becomes deficient and the stones in the upper course begin to appear, to spread a little coarse sand in the middle of the macadam road. The sand soon spreads by the traffic over the greater portion of the surface of the road. It relives the roughness and keeps the stones from raveling,BUt the swiftly moving motor car has introduced an other factor in road building and maintenance. THE large rubber tires on the wheels of small diameter appear to exert a suction on the binder of the road. The vehicle moving rapidly over the road lifts the dust in clouds, and it is blowen away into the fields. various substances are now being applied to the surfaces of roads to lessen or obviate this evil. Coal tar and oils with an asphaltic base seem to give the best results. There may be a time when we can treat a macadam road with some kind of a coating that will lessen the cost of repairing and also avoid the dust.

SECOND.

Correct Method of Construction.

SPECIFICATIONS FOR BUILDING 2,100 ft. OF MACADAM ROAD.

ROADBED.

MATERIAL:- The roadbed for the macadam construction is to consist of the natural earth roadbed, prepared and rolled until firm and hard in the following manner: If sandy or other soil be encountered which will not compact readily under a ten to fifteen ton roller, a small amount of clay, or other means satisfactory to the engineer, shall be used until a firm,hard surface is obtained after rolling.

CUTS and FILLS:- In cuts and fills, unless otherwise specially directed the road bed is to be graded to a width of twenty five feet(25), and is to be free from all spongy and vegatable matter, roots, and stumps. The portion of the road bed prepared for the broken stone surface is to be twenty feet(20) wide and brought to the grades and cross section as showen on the plans and rolled with a steam roller until firm and hard. All depressions that may appear during the rolling are to be filled with earth and rolled until an even surface is obtained with a proper grade and cross section.

TRENCH FOR BROKEN STONE:- The portion of the roadbed prepared for the broken stone is to be below the sides by an amount equal to the thickness of the first course of stone so as to prevent the broken stone spreading at the sides.

SHAPE:- The shape of the roadbed is to be as showen on the accompanying plans, and is to have a cross slope of 0.2 inch to 1foot.

FIRST COURSE.

MATERIAL:- The first course of the macadam construction is to consist of sound stone, knowen as trap rock, it is to be broken to varying sizes from 3inches to 2 inches; no piece to have a dimension greater than 3 inches. This to be knowen as #1 size.

SPREADING:- No broken stone is to be spread before the roadbed has been made as specified.

The broken stone is to be spread upon the roadbed, prepaired as herein described, with shovels from piles alongside the road or from a dumping board, or it may be spread directly from wagons especially constructed for this purpose and approved by the engineer; but in no case shall the broken stone be dumped directly upon the roadbed.

ROLLING:- After the broken stone for the first course has been spread to an uniform thickness, and has a proper cross section, it is to be rolled with a steam roller, weighing not less than ten tons, until it is compacted to form, and a firm, smooth surface. Should any difficulty be experienced while rolling in having the stone readily compact, water shall be sprinkled or sand or other material be spread, as the engineer may direct. The rolling must begin at the sides and work towards the center, thoroughly covering this space with the rear wheel of the roller.

UNEVENESS or DEPRESSIONS: Should any uneveness or depressions appear, during or after rolling of the first course, they are to be remedied immediately with broken stone and rerolled until a firm, even surface is obtained.

THICKNESS:- The thickness of the first course is to be 4 inches at the center and 2 1/2 inches on the sides after being thoroughly rolled. If for any reason, a greater thickness than specified is made by the contractor no extra allowance for such additional thickness will be made.

SHOULDERS:- After the first course has been made as before described earth shoulders are to be constructed along each side of the road for a width of at least five feet as shown on the accompanying plans.

No material which is considered unfit for thr work by the engineer is to be used and where any such is put on the work it shall be immediately removed, upon notice by the engineer, at the contractors expense.

SECOND COURSE.

The second course of the mecadam construction is to be the same width as the first course.

MATERIAL:- The second course is to consist of stone broken to sizes varying from 1 inch to 2 inches; no piece to have a greater dimension than 2 inches. This will be knowen as number 2 size.

The stone for this work shall be trap rock as specified before.

SPREADING:- The spreading shall be performed in the same manner as in the preceding course.

ROLLING :- Rolling shall be done as in the preceding course.

UNEVENESS and DEPRESSIONS:- Uneveness and depressions shall be remedied as in the preceding course.

THICKNESS:- The thickness of this course shall be 2 inches thick at the middle and 1 1/2 inches thick at the sides.

The specifications for the first course shall apply also to the second course with the exceptions above noted.

THIRD COURSE.

MATERIAL:- The third course of the macadam construction is to consist of trap rock screenings varying in size from dust to 1 inch pieces.

Other material than trap rock screenings may be used if approved by the engineer in charge.

SPREADING:- After the second course of #2 stone has been rolled and compleated as above described the screenings are to be spread, but in no case are screenings to be used until the second course has been thoroughly rolled and compacted. The screenings are to be spread dry with shovels from piles along the ro ad, or from dumping boards, but in no case are the screenings to be dumped directly on the second course. The quanity of screenings to be used shall be just enough to cover the second course.

WATERING and ROLLING :- After the screenings are spread they are to be sprinkeled with water from a properly comstructed watering cart, and then rolled with a steam roller weighing not less than ten tons. The amount of water necessairy is to be determined by the engineer in charge. The rolling is to begin at the sides and to continue until the surface is hard and smooth and shows no perceptible tracks from vehicles passing over it.

If after rolling the screenings, the #2 stone appears on the surface additional screenings shall be used in such places.

The rolling and watering shall continue until the water flushes to the surface. The rolling is to extend over the whole width of the road, including the shoulders.

UNEVENESS and DEPRESSIONS:- If any uneveness or depressions occur in the roads surface after the rolling of the screenings, #2 broken stone and screenings shall be used until they are removed and the finished surface conforms to the proper cross section, as showen on the accompanying plans, and presents a smooth, even appearance.

CULVERTS.

A culvert shall be put in at station 14.6. Concrete culverts shall be constructed where ordered by the engineer to the lines and grades given by him.

Culvert ends shall be laid parallel to the center line of the roadway.

All culvert masonery shall be measured in accordance with the dimensions showen on the accompanying plans.

For dimensions and specifications see the accompanying plans.

PORTLAND CEMENT CONCRETE:- The concrete shall be composed of broken stone or screened gravel , and sand- all of which shall be clean, hard durable, and free from clay, dirt, and other objectionable material,- Portland cement and frsh, clean water.

To each part of Portland cement there shall be by volume two parts of sand and five parts of broken stone or screened gravel, and such a portion of water as the engineer may from time tot time determine.

The broken stone or screened gravel shall be of the following sizes: For all work less than six inches in thickness the stones may vary in their longest dimensions from one quarte on an inch to three quarters of an inch;between six inches and twelve inches, from one quarter of an inch to an inch and one quarter inches; more than twelve inches in thickness, from one quarter of an inch to two and one half inches.

The cement and sand shall be first thoroughly mixed dry, in the proper proportions specified, in proper boxes. Clean water shall then be added and the materials thoroughly mixed. The broken stone previously drenched with water, shall then be deposited in this mixture and the ingredients thoroughly mingled and turned over until each stone is covered with mortor. The batch shall then be carefully deposited without delay and thoroughly rammed in layers not more than six inches in depth until the water flushes to the surface and all the voids are filled.

The concrete shall not be allowed to fall from any considerable height. Before the concrete is placed in the molds, a sheet iron plate, six or eight inches in width and about six feet long, or of such other dimensions as the contractor may find suitable, shall be held in position one and one-half inches from the surface of the mold or form. The space between the form and this seperator shall be filled with mortar, composed of one part Portland cement and one part os sand, mixed to such a consisyency as the engineer may direct, and, if he shall so direct, the mortor shall be mixed at a time, and then only as needed. Immediately after the space between the seperator and the form is filled with mortar the ordinary concrete shall be placed behind the seperator, the seperator removed and the backing

and facing thoroughly rammed together to a close bond. NO delay shall be permitted in placing the concrete backing, and both the facing and the backing shall be done as nearly simultaneously as is possible. Should voids be discovered when the forms are taken down, the defective work is to be removed and the space refilled with one to one cement mortar. The exposed surfaces shall be smoothed over with a neat Portland cement grout, laid on with a brush , until a smooth surface is secured.

Centres and forms, satisfactory to the engineer, shall be provided by the contractor. They shall be made of planed lumber and shall fit the curves and shapes of the work. The sheathing shall be laid tight and shall be made clean before using.

The centers shall be true to the lines, satisfactorily supported and firemely secured, and shall remain in place as long as the engineer may direct, and shall be replaced by new ones when they losse their proper shape or dimensions.

In connecting concrete already set with new concrete, the surface shall be cleaned and roughened and mopped with a mortar composed of one Part Portland cement and one part sand.

When work is done under such conditions that the mortar may freeze, the contractor shall provide the necessary means for, and shall thoroughly protect and heat all material, and also the water, and shall thoroughly protect the masonery from damage by rain and frost during and after laying.

During warm and dry weather, and whenever the enginner may direct, all newly built concrete shall be kept well shaded from the sun and well sprinkled with water until set.

In laying concrete under water the concrete shall not fall from any considerable height, but deposited in the alloted place in a compact mass . The concrete must not be rammed, but leveled with a rake or other suitable tool immediately after being deposited. No concrete shall be laid in running water.

No back filling or loading whatever shall be placed on or against the concrete masonery until ordered by the engineer.

The price to be paid per cubic yard for concrete masonery shall include the back-filling and all necessary centers and forms, and all the work

on the same, and no allowance shall be made for cofferdams, pumping, or bailing, or for any materials or labor necessary on account of water.

All concrete shall be measured in accordance with the dimensions showen on the accompanying plans.

SIDE DRAINS

SIDE DRAINS:- Shall be constructed an d laid as showen on the accompanying plans and placed under the direction of the engineer in charge.

GUARD RAILS

GUARD RAILS:- Fencing shall be placed on edges of embankments and at such other places along the road as the engineer may deem necessairy.

NOTES FOR TRANSIT LINE.

STATION		BEARING	DEFLECTION	
21				End of line, on hub.
20				
19				
		S41-30E	2-30 R	
56.5	⊖	S44-00E		
18				
17				
16				
15				
14				
.60				STREAM six feet wide.
13				
12				
11				
10				
9				
59.5	⊖	S44-00E		
		S 44-00E		
8				
7				
6				
		S44-00E	4-10 L	
03	⊖	S40-00E		
5				
4				
3				
2				
1				
0	⊖	S40-00E		Hub on Main street Lexington, Va, at intersection of roadin concrete on brass plate.

LEVEL NOTES

STATION	PLUS SIGHT	H.I.	MINUS SIGHT	ELEVATION	
B.M	8.91	108.91		100.00	B.M on corner main stn and Houston st.
0			10.4	98.5	
1			7.9	101.00	Brass plate on walk.
2			6.00	102.90	
3			5.0	103.90	
4			6.5	102.49	
5			8.3	100.60	
03 0			8.3	100.60	
T.P.	0.95	102.11	7.75	101.16	
6			3.5	98.6	
7			6.5	95.6	
8			7.6	94.5	
59.5 0			8.1	94.0	
T.P.	5.86	100.46	7.5	94.6	
9			6.2	94.2	
10			5.1	95.3	
11			4.0	96.4	
12			2.0	98.4	
13			1.1	99.3	
T.P. 0	8.6	107.16	1.9	98.56	
14			6.8	100.3	
15			5.3	101.8	
16			3.5	103.6	
T.P. 0	13.1	117.56	2.7	104.46	
17			8.3	108.2	
18			2.3	115.2	
T.P. 0	7.91	124.97	0.5	117.06	
56.5			6.5	118.4	
19			4.7	120.2	
20			3.0	121.9	
21			1.8	123.1	

CROSS SECTION

STATION	SURFACE ELEVATION	GRADE ELEVATION	SURFACE ELEV.R.	SURFACE ELEV. L.	CUT	FILL
B.M.	100.00					
0	98.5	98.5	98.5	98.5		
1	101.00	98.6	100.8	100.6	2.37	
2	102.9	98.8	103.1	102.8	4.1	
3	103.9	98.9	103.9	104.1	5.0	
4	102.4	99.0	102.4	102.6	3.4	
5	100.6	99.2	100.8	101.3	1.4	
03	100.6	99.2	100.8	101.3	1.4	
T.P.						
6	98.6	99.3	98.3	98.5		0.7
7	95.6	99.4	94.7	95.7		3.8
8	94.5	99.5	94.0	94.5		5.0
59.5	94.0	98.6				4.6
T.P.						
9	94.2	99.7	94.1	94.8		5.5
10	95.3	99.8	95.6	94.3		4.5
11	96.4	99.9	95.4	95.3		3.5
12	98.4	100.00	97.8	97.3		1.6
13	99.3	100.10	98.1	99.1		0.8
T.P.						
14	100.3	100.3	100.2	99.3		0.0
15	101.8	103.5	101.8	100.5		1.7
16	103.6	106.7	104.0	103.6		3.1
T.P.						
17	108.2	109.9	108.5	108.5		1.7
18	115.2	113.1	116.0	114.7	2.1	
T.P.						
56.5	118.4	114.7			3.7	
19	120.2	116.2	120.7	119.2	4.0	
20	121.9	119.5	122.0	121.2	2.4	
21	123.1	123.1	123.1	122.3	0.0	

CROSS SECTIOnCONTINUED

STATION	CUT R.	FILL R.	CUT L.	FILL R.
0	0.0	0.0	.0	0.0
1	2.2		2.0	
2	4.3		4.0	
3	5.0		5.2	
4	3.4		3.8	
5	1.6		2.1	
03 T.P.				
6		1.0		0.8
7		4.7		3.7
8		5.5		5.0
59.5 T.P.				
9		5.6		4.9
10		4.2		5.5
11		4.5		4.6
12		2.2		2.7
13 T.P.		2.0		1.0
14		0.1		1.0
15		1.7		3.0
16 T.P.		2.7		3.1
17		1.4		1.4
18 T.P. 56.5	2.9		1.6	
19	4.9		3.0	
20	3.5		2.7	
21	0.0		0.8	

AmOunt Of Material.

EXCAVATION----------95.5 cu.yd.

BORROW----------62.8 "

SURFACE TO BE SHAPED----------3366.6 "

AMOUNT OF STONE

VOLUME FIRST COURSE----------11582 cu. ft.

VOLUME SECOND COURSE---------- 6258 "

VOLUME THIRD COURSE---------- 4011 "

TOTAL VOLUME----------21651 cu.ft.

AMOUNT OF CONCRETE FOR CULVERT

VOLUME OF CONCRETE----------45.75 cu.fd.

COST

The cost of macadam road cannot be definately set, it all depends upon the locality, the following table is about the average cost.

EXCAVATION	$0.43 cu.yd
BORROW	0.56 "
SHAPING	0.02 sq.yd.
STONE	1.96 ton
CEMENT	1.97 bbl.
FORMS	0.09 cu.yd.
LABOR	3.35 "
HAULING STONE TO ROAD	.25 ton
SPREADING STONE	.05 "
WATERING STONE	.06 "
ROLLING STONE	.12 "