1881

Location, construction, and drainage of common roads

Edward B. Summers

THESIS

—

COMMON ROADS

—

SUMMERS

—

1881

THESIS

COMMON ROADS

SUMMERS

1881

A

THESIS

FOR THE DEGREE

OF

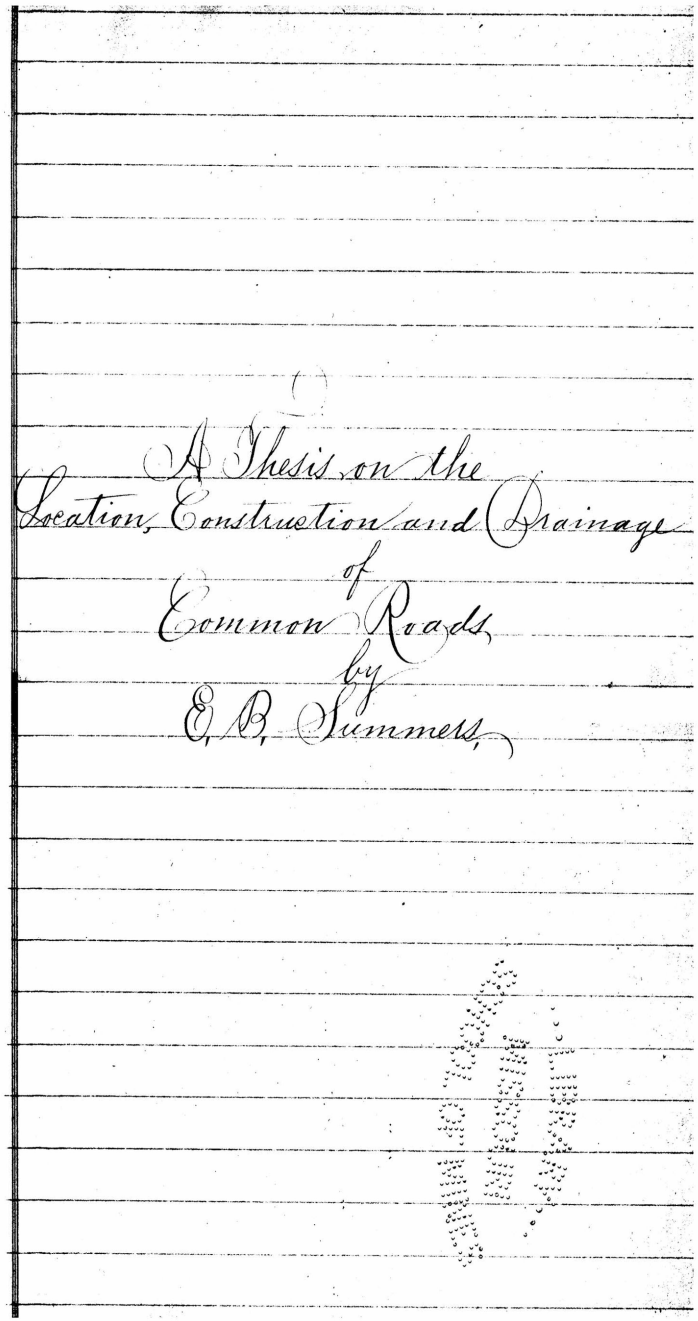
C. E.,

BY

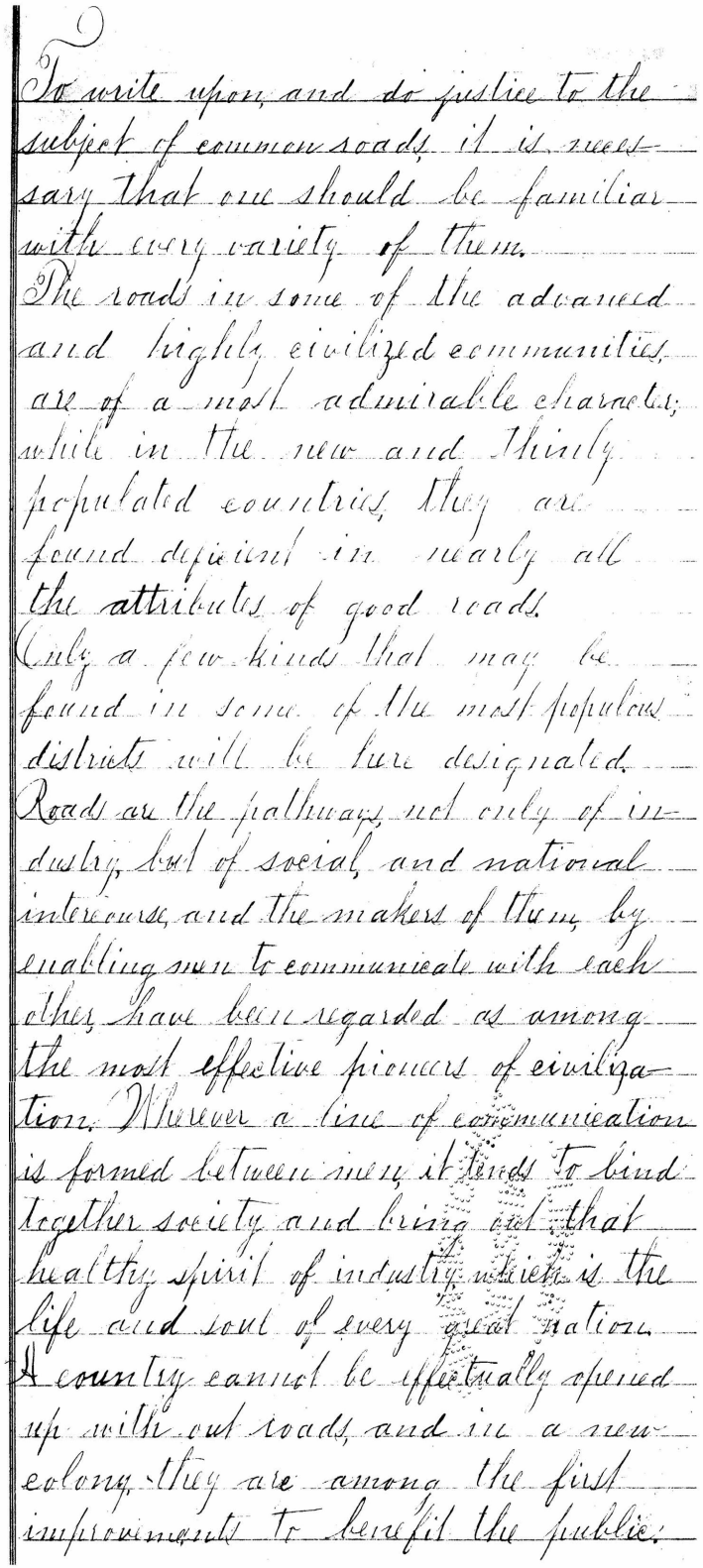
E. B. SUMMERS,

'81.

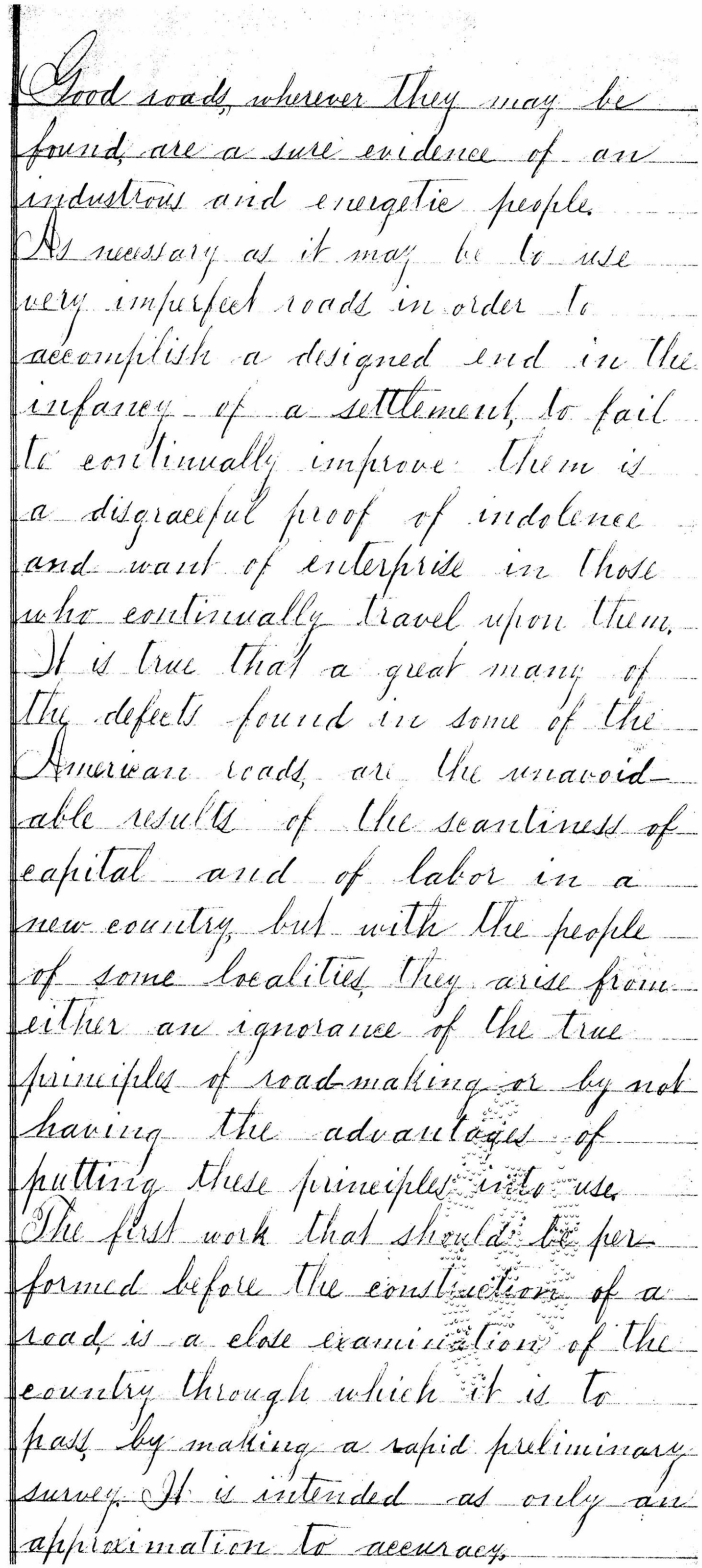
A THESIS FOR THE DEGREE OF C. E. BY E. B. SUMMERS 1881



A Thesis on the
Location, Construction and
Drainage
of
Common Roads
by
E. B. Summers



To write upon, and do justice to the
subject of common roads, it is necessary
that one should be familiar
with every variety of them.
The roads in some of the advanced
and highly civilized communities
are of a most admirable character;
while in the new and thinly
populated countries, they are
found deficient in nearly all
the attributes of good roads.
Only a few kinds that may be
in some of the most populous
districts will be here designated.
Roads are the pathways, not only of
industry, but of social, and national
intercourse, and the makers of them, by
enabling men to communicate with each
other, have been regarded as among
the most effective pioneers of civilization.
Wherever a line of communication
is formed between men, it tends to bind
together society and bring out that
healthy spirit of industry, which is the
life and soul of every great nation.
A country cannot be effectually opened
up with out roads, and in a new
colony, they are among the first
improvements to benefit the public.



Good roads, wherever they may be found, are a sure evidence of an industrous and energetic people. As necessary as it may be to use very imperfect roads in order to accomplish a designed end in the infancy of a settlement, to fail to continually improve them is a disgraceful proof of indolence and want of enterprise in those who continually travel upon them. It is true that a great many of the defects found in some of the American roads, are the unavoidable results of the scantiness of capital and of labor in a new country, but with the people of some localities, they arise from either an ignorance of the true principles of road-making or by not having the advantages of putting these principles into use. The first work that should be performed before the construction of a road, is a close examination of the country through which it is to pass by making a rapid preliminary survey. It is intended as only an approximation to accuracy.

and to serve to determine through what points routes should be instrumentally surveyed.

The road-maker in determining the most desirable route, will be greatly assisted by an examination of the map of the country.

He should visit and identify the various points selected on the map, and see whether his decisions have been correct. He must pass over the country in opposite directions, for it will often appear quite different, and convey very dissimilar appearances according to the point from which it is viewed. Thus, a hill may appear to have a very easy slope in descending, while the ascent might present a very tiresome contrast.

These first explorations, if properly carried out, will doubtless save much expense in the subsequent surveys, which in their turn should be thoroughly executed, to secure the most economical route in construction.

A road intended to connect two points, should be as straight as practicable, so that its length,

and, therefore, the time and labor expended in travelling upon it, should be the least possible, that is, its direction, departing from one extremity of it, should constantly tend towards the other.
However, it may be the principal object in view to connect two distant points, and yet there may be instances in which it would be expedient to greatly deviate from a straight line.-

In the accompanying Figure. Suppose for instance, that it is desired to connect the two points A and B. Now at first sight, it would appear that a perfectly straight line drawn from one point to the other would be the best that could be chosen. On a careful examination, however, of the locality, it is found that there is a third place C, situated somewhat on one side of the straight line drawn from A to B, and although the primary object in view is to connect only the two latter points, it may nevertheless be of considerable service if the whole of

the three places were connected.
Now this connection may be made
in three different ways, any one
of which might, under certain
circumstances, be the best.
In the first place, it may be done
by a straight road from A to B,
together with two other straight
roads; one from A to C, and the
other from B to C, and this
would be the most perfect way to
effect the object in view, and the
distance between any two of the
points would be reduced to the
least possible.
However, this mode of connection
would be considerable expense, and
would naturally require a greater
length of road than according
to a second plan, which would
be to form, as before, a straight
road from A to B, and another
one from C to AB, making
right angles with it at a point D.
The traffic between A and B, in this
case would proceed to the point D,
and if desired turn off to C.
With this arrangement, the length
of the road would be greatly

decreased, and only a slight increase would be occasioned in the distance between C and the other two points. The third and most usual method would be to construct only the two roads AC and CB, in which case the distance between A and B would be somewhat increased, while that between A and C, or B, and C, would be diminished, and the total length of the road to be constructed would be lessened.

In choosing the best direction for a roadway, the proper gradient should not be over looked, since it is of far greater importance than the mere maintaining of a direct line. If a road be not level a large potion of the power will be expended in raising the load up the ascent. It is a principle fully demonstrated in Mechanics, that when a weight is drawn up an inclined plane, the resistance of the force of gravity, or the weight to be overcome, is such a part of the whole weight, as the height of the plane is of

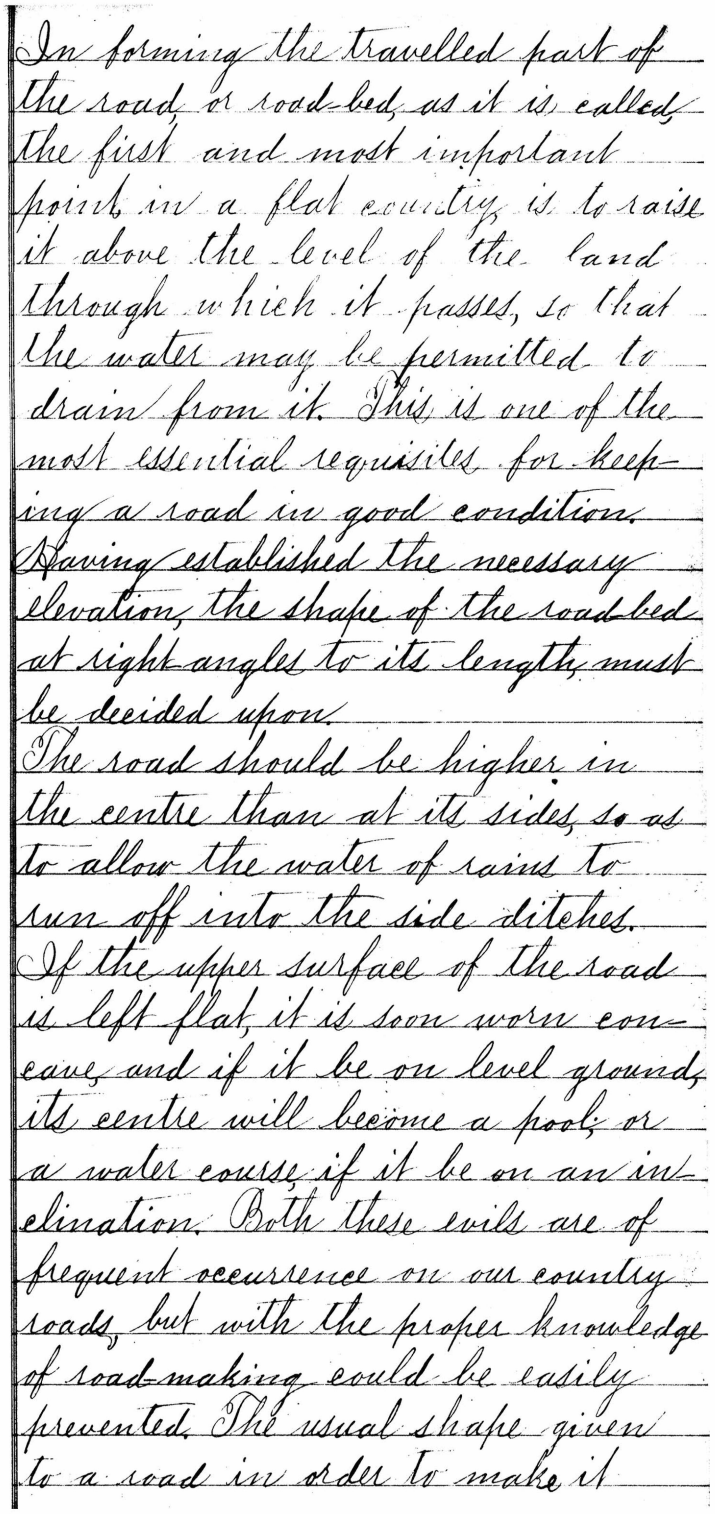
its length. If then a road
rises one foot in every twenty
of its length, a horse drawing
up it a load of one ton is com-
pelled to actually lift up one-
twentieth of the whole weight,
that is, one hundred pounds,
through the whole height of
the ascent, besides overcoming
the friction of the entire
load. Now a horse will exert
for a short time twice the average
tractive pull which he can
exert continuously throughout
a days work, Therefore, so long
as the resistance on the gradi-
ent is not more than double
the resistance on the level,
the horse will be able to take
up the full load which he
is capable of drawing.
If the resistance to traction is
taken at one-thirtieth of the
load on the wheels, then the
maximum gradient should not
exceed one in thirty; because on
that slope the gradient resis-
tance is equal to the resistance
on the level, and the total

resistance exactly doubled.
Again, in regard to descending, it may be assumed that the slope should not be so great that the gravity acting down the slope should exceed the resistance to the traction.
In that case, the vehicles would tend to accelerate in velocity under the action of gravity, and brakes would become necessary to control the descent, thus, causing a waste of work in friction. This consideration again fixes the maximum gradient at one in thirty.
For a short distance steeper gradients may be adopted with economy, but their number should be as few as possible.
When inclinations are reduced to the limit of one in thirty, there is little loss of power, compared with a perfect level, in either direction of the travel; for the increased labor of ascending is compensated in a great degree by the increased ease of descending, while on

a steeper slope this advantage
is nullified by the necessity
of the horses holding back to
resist the excess of the force of
gravity. It requires great
engineering skill to construct a road
through some sections of country,
and at the same time avoid
too great inclinations.
It is said that the road between
London and Barnet, the total
number of perpendicular feet that
a horse must now ascend, is
upwards of 1300, although Barnet
is only 500 ft. higher than London,
and in going from Barnet to London,
a horse must ascend 800 ft., although
London is 500 ft. lower than Barnet.
It is also said, that another
instance of this defect in road
engineering is observable in
the line of the old road across
the Island of Anglesea, on
which a horse was obliged to
ascend and descend 1283 perpendicular
feet more than was found
necessary by Telford when he
laid out the present new line, as
shown by the Table on following page.

	Height of Summit above High Water	Total rise and Fall	Length	
			miles	yards
Old road	339	3540	24	428
New road	193	2247	21	1596
Difference	146	1283	2	592

Breadth and Cross-section of Roads.
The proper width for a road depends, of course upon its importance, and the amount of travel upon it.
Its minimum is about one rod, or 16 ½ feet, sufficient to enable two vehicles to pass each other with ease.
For ordinary town roads a good width is from 20 to 25 feet.
For the widths of roadways in populous towns and their neighborhood, no general rule can be given.
In some of those cases in which the traffic is greatest, the width of carriageway is about 50 feet with foot-paths on each side, from 10 to 15 feet in width.
The widths prescribed for those parts of public roads in Britain which are interfered with by railways are as follows:
Turnpike roads.....35 feet
Public carriage roads (not turnpike)...25 ..



In forming the traveled part of
the road, or road-bed, as it is called,
the first and most important
point in a flat country is to raise
it above the level of the land
through which it passes, so that
the water may be permitted to
drain from it. This is one of the
most essential requisites for
keeping a road in good condition.
Having established the necessary
elevation, the slope of the road-bed
at right angles to its length must
be decided upon.
The road should be higher in
the centre than at its sides, so as
to allow the water of rains to
run off into the side ditches.
If the upper surface of the road
is left flat, it is soon worn concave,
and if it be on level ground,
its center will become a pool, or
a water course, if it be on an
inclination. Both these evils are of
frequent occurrence on our country
roads, but with the proper knowledge
of road-making could be easily
prevented. The usual shape given
to a road in order to make it

crown has been a convex curve, approaching a segment of a circle, or a flat semi-ellipse. This form was recommended by Mr. Telford; but Mr. Walker prefers two straight lines, connected by a short curve at the crown.

Since the curved profile is subject to many evils; Mr. Walker's plan is thought by road-makers, to be the one most preferable.

The degree of inclination of the sides will depend on the surface of the road; being greatest where the road is rough, and lessening with its improvement in smoothness. A narrow road will permit its being less, as the water will have less distance to pass over. Its greatest slope is limited by the inconvenience which an excessive transverse slope would cause to carriages. It is thought that the proper inclination for a road with a broken stone surface, is 1 in 24. The Holyhead road, 1 in 30 was adopted by Telford. On a rough road the inclination may be increased to 1 in 20; and

diminished on a road paved
with square blocks, to 1 in 40, or 1 in 50.
The transverse slope should exceed
that of the longitudinal, in order
to prevent the water running too
far down the length of the road.
The direction of water running
from the centre of the road, is the
diagonal of a rectangle, the sides
of which are proportional to the
steepness of the longitudinal and
transverse slopes.

Ditches for the Drainage of Roads.
It is useless to attempt the improve-
ment of a road unless suitable
provisions are made to dispense of
the water that is liable to accu-
mulate upon it. The proper construc-
tion of ditches to convey the water
from a road, is one of the most
important elements in road-making.
A bad road can often be transformed
into a good one, by side ditches, suf-
ficiently inclined to carry off all
the water which falls upon it.
Even if the water does not stand on
the surface so as to form mud,
and is permitted to enter by fil-

diminished on a road paved
with square blocks, to 1 in 40, or 1 in 50.
The transverse slope should exceed
that of the longitudinal in order
to prevent the water running too
far down the length of the road.
The direction of water running
from the centre of the road, is the
diagonal of a rectangle, the sides
of which are proportional to the
steepness of the longitudinal and
transverse slopes.

Ditches for the Drainage of Roads.
It is useless to attempt the
improvement of a road unless suitable
provisions are made to dispense of
the water that is liable to accumulate
upon it. The proper construction
of ditches to convey the water
from a road, is one of the most
important elements in road-making.
A bad road can often be transformed
into a good one by side ditches,
sufficiently inclined to carry off all
the water which falls upon it.
Even if the water does not stand on
the surface so as to form mud,
and is permitted to enter by filtration

tration from the higher land, it will render the road incapable of bearing heavy loads, and by capillary attraction, will be absorbed into the upper stratum.

If the soil over which the road is to be built is, naturally of a marshy character, it should be thoroughly drained before an attempt is made to construct the roadway.

To do this, there should be on each side of the road, a wide and deep open main-drain, to convey the water to the natural water courses.

Covered cross drains, or culverts, should be made at frequent intervals. Their bottom should slope each way from the centre of the road, so as to permit the water to flow into the main drains.

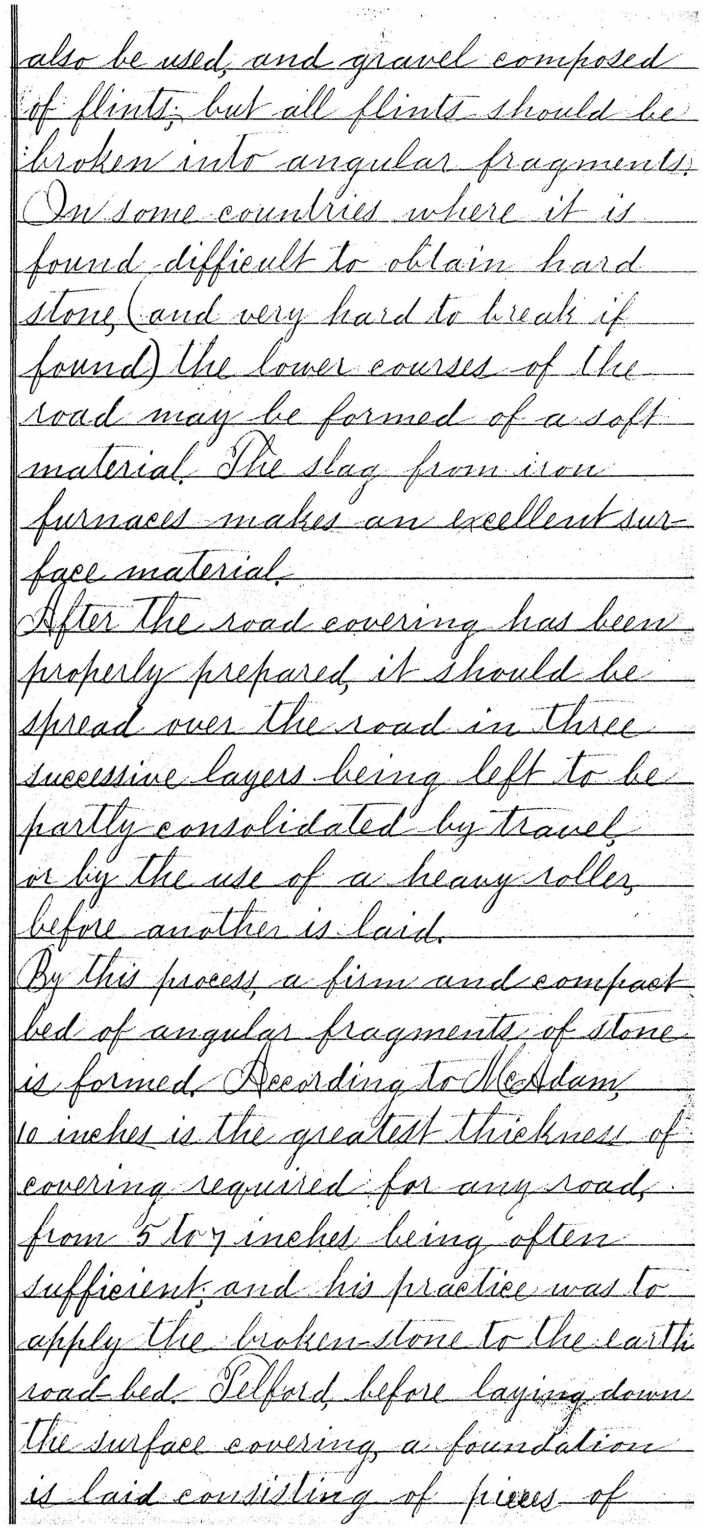
When the subsoil is of a spongy, elastic nature, an artificial bed for the road covering may be required. This bed may sometimes be formed by removing the upper stratum to a depth of several feet, and supplying its place with gravel, or any soil of a firm character.

It has been found necessary in

some cases, to form a bed of brushwood, from 7 to 18 inches in thickness, to receive the soil on which the road-covering is to rest.
For structures on a weak, wet soil, this method has been long practised, and experience has fully tested its excellence.

Broken Stone Roads.

John Loudon McAdam is said to have been the first to discover the true principles of the construction of roads covered with broken stone. Of broken stone roads, the McAdam; and Telford roads are the most important.
The difference in the two is that Telford advocates the necessity of a paved foundation beneath the broken stone covering, and constructs his roads accordingly; while McAdam denies that as being any advantage whatever.
The materials employed for a broken stone road should be hard, tough, and durable. The best materials are granite and greenstone.
Hard compact limestone may



also be used, and gravel composed of flints; but all flints should be broken into angular fragments. In some countries where it is found difficult to obtain hard stone, (and very hard to break if found) the lower courses of the road may be formed of a soft material. The slag from iron furnaces makes an excellent surface material.

After the road covering has been properly prepared, it should be spread over the road in three successive layers being left to be partly consolidated by travel, or by the use of a heavy roller, before another is laid.

By this process, a firm and compact bed of angular fragments of stone is formed. According to McAdam, 10 inches is the greatest thickness of covering required for any road, from 5 to 7 inches being often sufficient; and his practice was to apply the broken stone to the earth road-bed. Telford, before laying down the surface covering, a foundation is laid consisting of pieces of

any ordinary stone, measuring
from 6 to 8 inches in each dimen-
sion. These stones are arranged so
as to form a compact layer about
8 inches deep in the centre of
the road, and from 4 to 5 inches
deep at the sides, thus forming
a part of the required convexity.
On this foundation, the small
stone is spread as already described.
To repair a broken stone road,
the surface must be loosened
so that the new materials
may the more readily unite
to the old ones.
After thus loosening and levelling
the surface, the necessary material
is applied in uniform thickness.
The late spring or early summer
is the best season for repairing
broken stone roads; for if the weather
is very wet or very dry the material
is prevented from becoming com-
pact, and therefore causing either
a heavy or a dusty road.
A road repaired at this season
is left in a good condition
to resist the work of the
ensuing winter.

any ordinary stone, measuring
from 6 to 8 inches in each dimension.
These stones are arranged so
as to form a compact layer about
8 inches deep in the centre of
the road, and from 4 to 5 inches
deep at the sides, thus forming
a part of the required convexity.
On this foundation, the small
stone is spread as already described.
To repair a broken stone road,
the surface must be loosened
so that the new materials
may the more readily unite
to the old ones.
After thus loosening and levelling
the surface, the necessary material
is applied in uniform thickness.
The late spring or early summer
is the best season for repairing
broken stone roads; for if the weather
is very wet or very dry the material
is prevented from becoming compact,
and therefore causing either
a heavy or a dusty road.
A road repaired at this season
is left in a good condition
to resist the work of the
ensuing winter.

Paved Roads.

The use of paved roads is, principally confined to large towns and cities, where there is a constant and heavy traffic.
A good paved road should offer little resistance to wheels.
The stone should be of such a quality as to give a firm foothold to horses. Street pavements in cities should be easy to remove and replace, inorder to give access to gas and water pipes.
The first preparation towards the making of a paved road, is the construction of a foundation upon which the stones are to be placed. The principal foundations are those of sand, of broken stone, and of pebbles. Foundations of any of the named materials are constructed by excavating the bed of the road to a depth of about 8 inches, leaving the earth bottom sloping each way from the centre, then filling the excavation by applying 3 equal layers of the material to be used, seeing that each layer is

Paved Roads

The use of paved roads is, principally confined to large towns and cities, where there is a constant and heavy traffic.
A good paved road should offer little resistance to wheels.
The stone should be of such a quality as to give a firm foothold to horses. Street pavements in cities should be easy to remove and replace, in order to give access to gas and water pipes.
The first preparation towards the making of a paved road, is the construction of a foundation upon which the stones are to be placed. The principal foundations are those of sand, of broken stone, and of pebbles. Foundations of any of the named materials are constructed by excavating the bed of the road to a depth of about 8 inches, leaving the earth bottom sloping each way from the centre, then filling the excavation by applying 3 equal layers of the material to be used, seeing that each layer is

well consolidated before the next is applied.

Perhaps the most efficient of all the foundations for paved roads are those made of Concrete or Beton, the construction of which consists in making an excavation about 12 inches lower than the bottom of the proposed pavement, and filled with that depth of the concrete or beton which soon becomes a hard and solid mass, on which a pavement may then be laid.

The best materials for stone pavements are syenite and granite, the hardest that can be found.

The size of the stones to be used in paving, will be governed by the intended purpose of the road.

Any single stone should be large enough to sustain the entire weight of any load that may pass over the road; for it is not unfrequently the case that the whole load (or nearly) is thrown on one wheel. Stones of different dimensions should not be used on the same part of the road;

for if mixed, the small ones will sink lower than the large ones, thus forming depressions that will be increased by every passing wheel. Cubes of eight inches are sufficiently large for nearly all paved roads.

W. M. Gillespie C. E. recommends that the blocks of stone taper towards their lower ends, while Rankine opposes that by saying that special care be taken that they do not taper downward. There is an advantage in having the stones taper slightly towards their top; for if the wedge-shaped spaces thus formed are properly filled with gravel, chips of stone, cement &c. the road gives a more secure footing for horses than a close-jointed pavement.

Plank Roads

The formation of a plank road in the most general approved system is effected by digging two parallel ditches about 16 feet part, and throwing the earth taken out between them so as to make an earthen surface of one half

of the space between, and sloping towards the nearest ditch with a fall of 6 inches. On the other half, the plank covering is made, by imbedding in the ground two parallel lines of longitudinal wooden sleepers, 4 ½ feet apart from centre to centre.

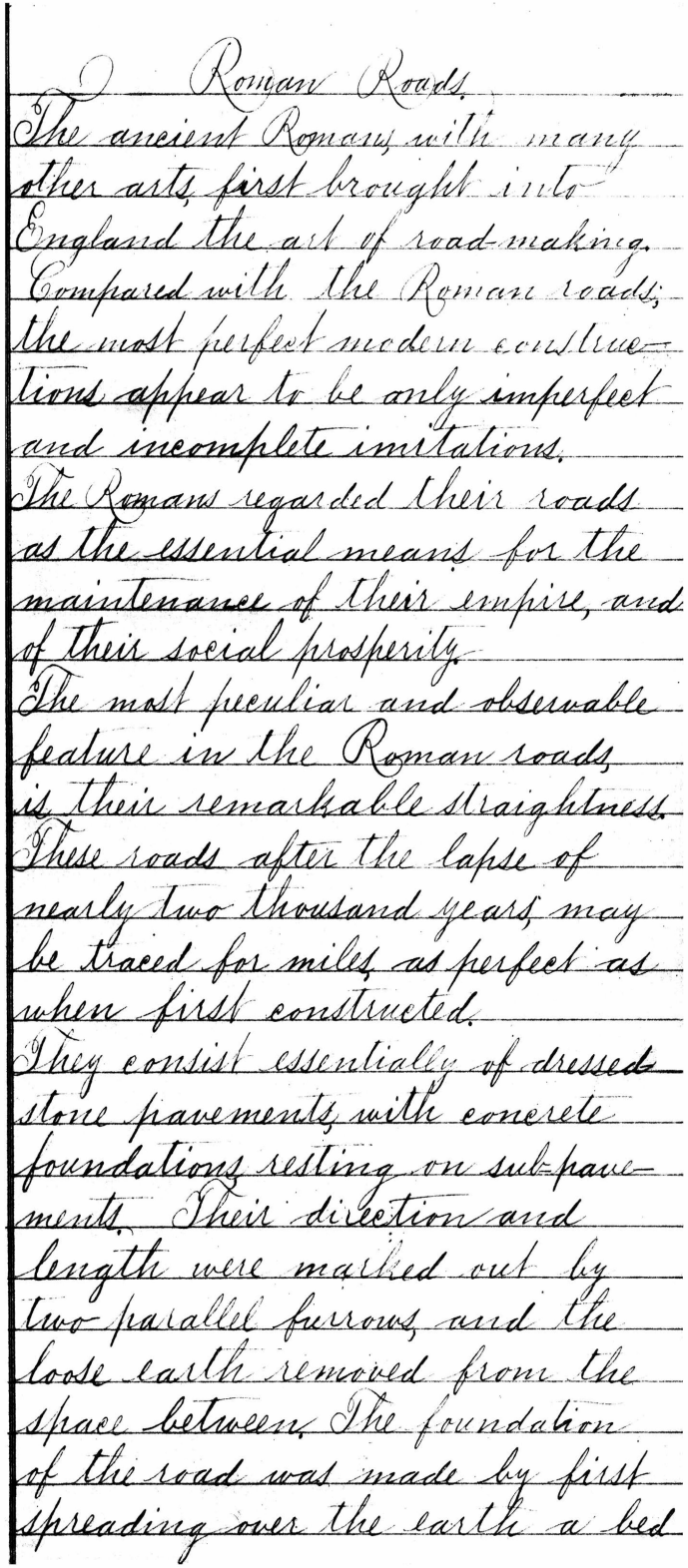
These sleepers should be from 14 to 20 feet long, 12 inches broad, and 4 inches thick; they should be laid with flat side down with short connecting sleepers of the same scantling under their joints.

After the earth is well consolidated between and beside the sleepers, and is level with their upper sides, the planks, which are 8 feet long and 3 inches thick, are laid across.

The ends of the planks next to the earthen division of the roadway should not be laid evenly, but should have alternate projections, in order that carriages may be easily drawn on to the planking from the soft part of the road, by giving a hold for the wheels.

If this provision is not made

the wheels will scrape along the ends of the planks, causing much difficulty to enter upon the plank road with a loaded wagon.
Since the planked part of the road is broad enough for one wagon only, it is intended that when two wagons meet and pass, the lighter will make way for the heavier by moving to the earthen part of the road.
On a new and well constructed plank road, a horse can draw about three times as much as he can on an ordinary McAdam or good common road.
As admirable as plank roads are when new, their short duration and the expense in keeping them in repair, has caused them to be abandoned, except in certain localities where an abundance of timber is found, or on account of some peculiar circumstance.
A Telford or McAdam road, or even a good gravel road, is more profitable, and in the long run makes a much better road.



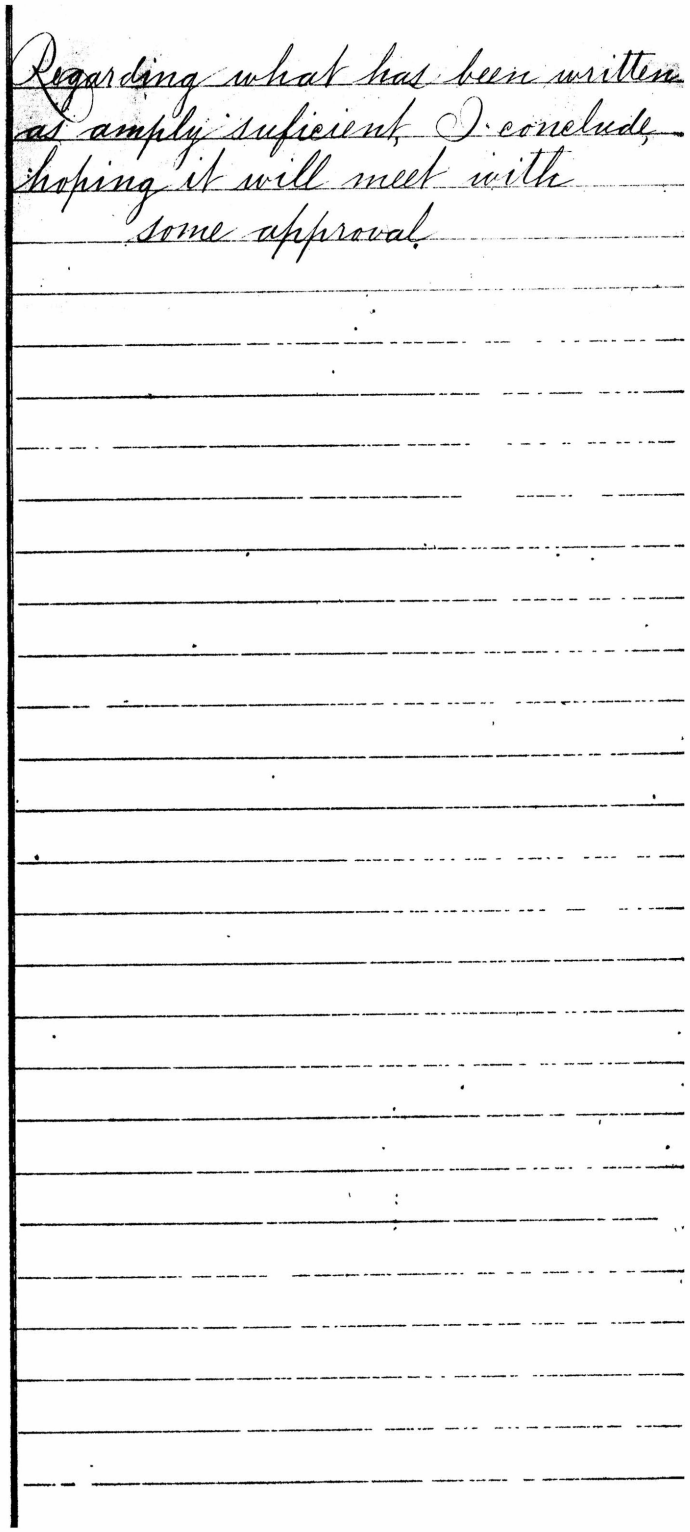
Roman Roads.

The ancient Romans, with many other arts, first brought into England the art of road-making. Compared with the Roman roads, the most perfect modern constructions appear to be only imperfect and incomplete imitations. The Romans regarded their roads as the essential means for the maintenance of their empire, and of their social prosperity. The most peculiar and observable feature in the Roman roads, is their remarkable straightness. These roads after the laps of nearly two thousand years, may be traced for miles, as perfect as when first constructed. They consist essentially of dressed-stone pavements, with concrete foundations resting on sub-pavements. Their direction and length were marked out by two parallel furrows, and the loose earth removed from the space between. The foundation of the road was made by first spreading over the earth a bed

Roman Roads
The ancient Romans, with many other arts, first brought into England the art of road-making. Compared with the Roman roads, the most perfect modern constructions appear to be only imperfect and incomplete imitations. The Romans regarded their roads as the essential means for the maintenance of their empire, and of their social prosperity. The most peculiar and observable feature in the Roman roads, is their remarkable straightness. These roads after the laps of nearly two thousand years, may be traced for miles, as perfect as when first constructed. They consist essentially of dressed-stone pavements, with concrete foundations resting on sub-pavements. Their direction and length were marked out by two parallel furrows, and the loose earth removed from the space between. The foundation of the road was made by first spreading over the earth a bed

of mortar, upon which was laid a course of large flat stones, and upon this came a course of concrete formed of three parts of freshly broken stones to one part of quicklime.
Another course which formed one-fourth of the whole thickness was composed of broken bricks, tiles and pottery, mixed with lime. This last mixture was spread in a thin layer, and in it were imbedded the large blocks of stone which formed the pavement. These stones were so perfectly fitted together that the joints were scarcely perceptible. The entire thickness of the road when completed was about three feet.

There are many other forms of common roads not here mentioned; to go into account and give a detailed description of them, and the mode of their construction, would require more time and labor than is generally given to any subject that may be intended for a Thesis.


Regarding what has been written
as amply sufficient, I conclude,
hoping it will meet with
some approval