Capacity of the Four-Lane Highway

There is very little available information indicating the capacity of the four-lane highway. We know that it is much more than twice the capacity of the two-lanes. Reports from Connecticut indicate a flow of 40,000 vehicles per day on the Boston Post Road on certain peak days. Where two lanes are available in the same direction, the traffic can separate by speeds, allowing two lanes to flow at approximately their maximum capacity.

The information at hand indicates that a four-lane highway has a larger capacity than two two-lane roads separated by a parking space or parkway. To get the added capacity, one of the third lanes must be used to overtake vehicles moving in the direction of the preponderance of travel. Mr. Johannassen, in discussing the capacity of the four-lane road, says: “A four-lane roadway is capable of carrying a volume of traffic of such magnitude as may be met with except in locations where the traffic is exceptionally great, providing the four traffic lanes are free to carry the traffic and are not blocked by parked vehicles or otherwise.

“More than four traffic lanes on a roadway is generally inadvisable, because when the number is greater than four and they are all occupied, the smoothness of operation is interfered with. Drivers become nervous and anxious and accidents are likely to occur. When more than four traffic lanes are needed to take care of the traffic, it may be better to build another highway at another location to serve the additional traffic. Of course, if it is desired to make room for parking vehicles, it is proper to build the roadway with additional width.”

It is probable that four lanes will carry the maximum traffic demanded on highways except in the urban areas. When the capacity of four lanes is reached, a new location will prove to be a more economical design than the addition of lanes over and above a maximum of four.

SETTLING FILLS ON MUCK LANDS

By J. T. Hallett, Assistant Chief Engineer in Charge of Roads, Indiana State Highway Commission

Muck pockets or peat marshes are important topographic features to be considered in the location and construction of highways. They are encountered quite frequently in the northern part of this state. To one who is not familiar with them, they may not seem objectionable or at all serious in road location and construction; but experience will teach one
differently. Some of them, apparently quite harmless, may be from 20 feet to perhaps 70 feet in depth and filled mostly with a partly decayed vegetation mixed with water to form a mixture of a soupy consistency and with a fibrous mat of vegetation on top to support only light loads of growing vegetation. In some of these marshes the muck is more fibrous than in others and has, of course, more supporting value.

The construction of a road across muck marshes is not an impossibility, but, when the location of the road is determined, due consideration should be given to the cost and difficulties which are liable to be encountered in building across them. Because of the variable conditions encountered, the difficulty and the cost are not easily determined in advance with any degree of accuracy. Therefore, if reasonable, the location should miss these marshes.

Muck marshes were formed in this state by the glaciers, in prehistoric days, digging out deep holes in the ground and forming small lakes. Water vegetation started growing in these lakes, died, partly decayed, and more vegetation grew, and still more, until in some instances the fibrous mat of decayed vegetation is many feet in thickness. This material has little load-supporting value and, therefore, is not a suitable base on which to build roads or any other permanent structure.

The only way of building a stable road across a muck marsh is to displace the muck with other firm and suitable material. There are three different methods in use for displacing this muck:

(1) Where the muck is shallow and not in a liquid state, it can be excavated. (Fig. 1). (2) By building a high fill of firm earth across a muck marsh, an earthen wedge can be forced down through the muck. This method is most applicable where the muck is deep and the consistency and nature of the muck are such that the fill will displace it. (3) Where the muck is too deep to be excavated and where it is too

Fig. 1. Shallow muck excavated and replaced by suitable fill material.
fibrous to be displaced by the loading method, it can be displaced by blasting. (Figs. 2 and 3).

For the first few years the highway commission was in existence, we did not give much consideration to muck marshes although we realized they were bothersome and expensive sections over which to construct and maintain roads. Where it appeared necessary, we located and built roads across them. If they settled, we built them up again until stabilized.

Fig. 2. State Road 53 north of Rensselaer. Fill 2000 feet long across muck land. Drill sinking blast holes on fill.

Fig. 3. Blasting through muck land.
The maintenance division is still building up fills on some of these sinks as they gradually subside. With the idea of trying to build across them more substantially and thereby reducing the expensive, periodic rebuilding and making it possible to construct a continuous pavement, about two years ago we started the practice of sounding the depth of these marshes when the location surveys were made. Then we plan the construction so that the muck will be displaced by more stable material and, if possible, get the stable fill entirely to penetrate the depth of the muck and rest on solid bottom.

Our practice, somewhat standardized, consists of excavating all muck which is less than 8 feet in depth. A trench about 4 feet wider than the pavement is excavated and the muck cast to the side to form the sides and slopes of the embankment. The fill is then started at the bottom and built up in the usual way. Practically all muck pockets are low and the grade is built up 2 feet or more above the level of the surrounding muck. Where the muck is deeper than 8 feet for any great distance, the top mat is broken by preliminary blasting before any fill is started.

**Specifications**

The following are extracts from our specifications on blasting and loading:

**Preliminary Blasting.** Before any filling is done the surface of the peat shall be blasted by the propagation method in two rows, 10 feet or 15 feet each side of the road center-line, or in the case of an existing road, along the toe of slope of the road fill, using one stick of 50% straight nitroglycerine dynamite in each hole, 18 inches deep, and spaced 18 inches apart in rows. Preliminary blasting may be omitted where the peat is soft and there is no dense surface mat. If power or telephone lines may be endangered by blasting, a narrow trench shall be cut through the surface mat on each side in the position specified for blasting.

**First Loading.** In the case of peat marshes, 20 feet or more in depth, the peat marsh shall first be filled along the road center-line to a height 5 feet above plan grade and to a top width of 20 or 40 feet with 1-to-1 slopes. In case of peat marshes from 8 feet to 20 feet in depth, the peat marsh shall be loaded in two runways centered 15 feet from center-line to an elevation 5 feet above plan grade and to a top width of 10 feet, with 1-to-1 slopes. Where rapid settlement is not attained by this loading, the height of loading shall be increased with a uniformly narrowing section on 1-to-1 slopes to a maximum height above the surface of the peat equal to one-half the depth of peat until rapid settlement takes place, after which the loading shall be kept to an elevation of 5 feet.
above plan grade by additional filling until the rate of settle-
m ent is not more than 0.1 of an inch per day for 5 days. After
this stage of settlement has been attained, the marsh shall
be blasted according to the requirements for "Final Blasting";
provided, however, that this blasting may be omitted if the
fill has settled to the bottom of the peat, as determined from
borings. The contractor shall furnish the labor and equip-
ment for such borings.

Final Blasting. Two-inch pipes plugged on the bottom end
shall be driven 10 feet apart, in rows spaced 10 feet, in case
of a proposed 18-20 foot pavement or 20 feet in case of pro-
posed 40-foot pavement, from the road center-line, to a depth
approximately halfway between the bottom of the first load-
ing and the bottom of the peat. The pipes may be driven in
a vertical position or on an angle at the base of the fill. After
the pipes are placed, the plugs shall be removed and one stick
of 50% straight nitroglycerine or gelatine dynamite shall be
shot in each hole to form a chamber, after which 20 to 30
sticks of 50% straight nitroglycerine or gelatine dynamite
shall be placed in each hole. The number of sticks per charge
shall be varied in proportion to the depth of the peat. A mini-
mum of 20 charges shall be shot at one time by means of
blasting machines and both rows shall be shot together. After
this blasting the final loading shall be made. The pipe used
in blasting shall be salvaged when feasible; otherwise it is to
be driven and cut off or bent over to an elevation one foot
below plan grade.

Final Loading. The loading shall be brought to an elevation
5 feet above plan grade and to a top width of 20 or 40 feet
and with 1-to-1 slopes, and shall be maintained to this eleva-
tion by additional filling until the fill has reached the stage
where the rate of settlement is not more than 0.05 of an inch
in 30 days, after which the load is to be spread and thoroughly
compacted to form the cross-section and grade shown on plans;
provided, however, that excess earth shall be used uniformly
to widen the grade and flatten the slopes on each side.

Observation Stakes. Stakes for the observation of settle-
ment shall be placed by the engineer at 25-foot intervals along
each shoulder of the first and final loading. These shall be
2-by-4-inch stakes, long enough to allow for considerable set-
tlement, placed with the bottom at the bottom of the fill. Level
readings shall be taken and recorded daily while the loadings
are in progress and weekly after the final loading is made.
Extensions to these stakes shall be made as the fill settles by
spiking new lengths to the old ones. As soon as the final cross-
section is completed, new stakes shall be set to shoulder grade
and readings taken monthly until the job is accepted. These
shoulder stakes shall be left in the ground for future readings
after the job is accepted.
Newer Developments

We have found that the two-lane loading, even for muck 8 to 20 feet deep, is not as satisfactory as the one-lane loading. We have discontinued it altogether, although our specifications have not been so revised.

We have found what seems to be a better way of blasting and loading than we have specified. It consists of blasting the muck for the width of the fill at the top of the muck and at various depths from top to bottom until within that area the muck is thoroughly churned with all mats or crusts broken. The fill is then applied with the super-load. In two instances, the fill material has pushed the muck aside and satisfactory results have been obtained. However, that does not mean that the method would be entirely satisfactory in all cases. In fact, there are many different conditions and there are many problems encountered in settling fills over muck lands.

Better results can always be obtained in settling fills on a relocation where there is no old road. Many of these old roads have been started by throwing down brush, poles, logs, straw, or anything that would float, and, as it became water-soaked and sank, adding more material. In fact, many earth and gravel roads are actually floating across these muck marshes. If it sinks, this type of road can be added to and built up more readily than a high-type road. When you attempt to displace all of the various kinds of material which have been used to build up a road, either by excavating, loading, or blasting, you are likely to run into as many difficulties as there are kinds of material which have been used. Muck itself varies but is usually much more uniform and easily handled than an existing floating road.

Very often a bridge is to be constructed where muck is encountered. If the structure is very large, it should be built on piling or relocated where solid foundations can be secured. Sometimes small culverts can be built in the fill after it has been settled to the bottom by one of the previously mentioned methods.

Very often farm drain tile is encountered, and as soon as you start displacing the muck, the drainage is destroyed. This should be replaced by relocating around the muck or replacing after the fill and muck have become stabilized.

Costs

By the excavation method of removal, the cost of excavating and back-filling can be accurately determined for any given location. The cost of producing a stable fill by either loading or blasting, or a combination of both, is quite variable for ordinary depths up to 30 feet. Where there are no old logs, bridges, trestle work, etc., to encounter, the actual cost of blasting, both preliminary and final, according to bids we have
received may be from $1.40 to $3.00 per linear foot of roadway. The amount of filling material needed below the top of the muck line will vary from 25% to 100% of the amount required if all muck were entirely removed and the fill allowed to take a 1 1/2-to-1 slope. If extreme depths or unusual conditions are encountered, full allowance should be made for them in estimating the costs and determining the economics of location and construction. The consistency, nature, and depth of muck seem to cause the percentage required to vary. Indications are that the slope of the underlying foundation material has considerable to do with the amount required, and the kind of filling material also probably has its effect. The cost of the construction, maintenance of detours, etc., which lie above the ground, can be determined without difficulty and in the usual way as for any other construction work.

BLACK TOP ROADS

By A. O. Hastings, District Engineer,
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Black top roads, as ordinarily considered by the public, include many types, such as oil mats, light and heavy mulch, retread, bituminous macadam, rock asphalt wearing surface, bituminous concrete, or sheet asphalt. Ordinarily the public does not differentiate between the cheaper mats and the higher types. In most of the criticisms of failures in these types of roads the public fails to take into account the cost. Ordinarily, if the proper selection of materials and bitumen is made, we get what we pay for. We cannot expect a very light surface mat to stand up under heavy truck traffic.

In selecting types to economize properly, the one in charge should consider several items, namely: the stability of the surface he proposes to mat, the amount and kind of traffic, the probable traffic demands for the next few years, the availability of materials, and any other agencies contributing to the lasting quality or destruction of the road. Light traffic can be economically carried over the lighter mats, but where heavy truck traffic prevails, such light mats are soon disintegrated; and, for this reason, it would pay to construct the heavier wearing course where such improvement is considered. I will describe briefly some of the methods we have used in the past few years on the various so-called black top roads.

Road Oil Mat

When traffic on a road is not heavy enough to justify a high-type pavement yet warrants the construction of some