THESIS

Presented in Application for the Degree

of

CIVIL ENGINEER

Virginia Polytechnic Institute
Session 1911-12

Study and Design of Collapsible Forms Used on Sewer System at Blacksburg, Virginia.

Submitted by P. K. Prosser
(with three sheets of original drawings
(Graduate Student in Civil Engineering 1912)

I certify on honor that the within paper and drawings have been
prepared personally by me.

Signed.................................

To

Dean of Engineering Dep't and Professor of Civil Engineering.
Manholes.

Manholes must be placed at intervals along sewers to permit of examination and repairs. They must be large enough at the bottom, and for a couple of feet above the top of the pipe sewer to permit a man to work satisfactorily. Four feet in diameter is a satisfactory size.

The cover casting may be of any manufacturer's design satisfactory to the engineer, weighing at least 375 pounds. The lid should usually be perforated with 1" holes to permit ventilation of the sewer, and immediately below it, there should be hung a heavy cast-iron dust pan to catch any dirt entering through the perforation.

The channels in the concrete bottom should be very carefully formed to give smooth, true, circular channels. They are sometimes lined with split pipe. The benches at the side of the channels should slope down towards the channel.

Opinions differ somewhat as to the distance apart to which manholes should be placed. In general, a manhole should be placed at all junctions of sewers, and at every change of grade or alignment in all sewers except those large enough to be entered readily for cleaning. This means that sewers should ordinarily be perfectly straight between manholes, to facilitate inspection and repairs, all changes in both grade and alignment being made at the manholes themselves. Also in any part of the
system—such as in the business district—where it is especially objectionable to have the street dug up for repairs, manholes should be placed at least as often as every block, that is 300 to 400 feet apart. In the other parts of the system some engineers leave out every other manhole where the grade and alignment are straight, putting manholes at every two blocks. The intermediate manholes left out are replaced by lampholes to save cost.
Materials used in Building a Manhole.

The sides of the manhole are built of either brick or concrete and in some cases stone or metal is used. Brick makes a very good manhole but is a little more expensive than concrete. It has the advantage over concrete because it does not disintegrate by the action of the chemicals in the sewage.

About the best material for building a manhole, taking everything into consideration, is concrete. It lasts well, is easily laid and is fairly cheap. In building a manhole of concrete, some kind of form is necessary to hold the concrete in place while it is being rammed and until it has set sufficiently to stay in place and support the pressure of the earth. When the earth is of a loose texture, such as sand or loose loam, it is necessary to have two forms, outside of the other, the concrete being placed between. But when the earth is clay or some other compact soil, it is only necessary to have the one form, which is on the inside of the manhole.

The form must be strong enough to hold the concrete in place while it is being tampered and it should also be so designed that it can be collapsed on the inside and taken out so that it may be used again.

The forms are usually made of either sheet metal or wood. In extensive work where there are a great number of manholes to be built, it would be cheaper in the end to make the forms of sheet
metal, they last longer and do not warp.

There there are comparatively few manholes to be built, wood is used. It is cheaper than sheet metal and is just as satisfactory and is to be used for only a short while. The location is also an important factor to be considered in the selection of the material to be used for the forms. In some localities, it is necessary to build the forms of wood on account of the cost of transportation, etc. of the metal.
Forms for Manholes on Sewer System at Blacksburg, Virginia.

In selecting the material for the forms for the manholes on the sewer system for the town of Blacksburg, Virginia, both sheet metal and wood were carefully considered and it was decided to use wood. Many varieties were considered and it was decided to use Long Leaf Yellow or Southern Pine, which is the best wood that could be obtained in this locality at reasonable cost. The wood could be obtained fairly cheap and the forms could be made at the wood shops of the Virginia Polytechnic Institute, whereas if sheet metal was used, it would cost a considerable amount more and then the wood would last as long as required for the work.

There were three forms of manholes used on the sewer system of Blacksburg. The depth ranging from three feet down to eighteen feet.

For the shallow manholes, that is those less than four feet deep, there were two sizes used. In the streets where they are subject to heavy loads they were made two feet in diameter and with vertical sides.

For manholes with a depth greater than four feet deep, the manhole was made in the shape of a bottle, with sides vertical and a diameter of four feet up to within one foot, three inches (1' 3") of the iron covering, then with a slope of 450 until the
diameter decreased to two feet and then for the remaining three inches with vertical sides and a two foot diameter.

Forms were also used for the channels, inside of the manhole. These channels were made in sizes; 6, 8 and 10 inches, according to the diameter of the sewer pipes. The channels coming into the manholes and intersecting at different angles made it necessary to have a large number of channel forms, because it was necessary to have a channel form for each angle of each size channel.

No outside form was necessary as the earth was of a clayey texture which was compact enough to hold the concrete and moisture in place until the concrete had set.
The Bottle Form of Manhole.

The manhole being made with a four foot diameter at the bottom gives a man ample room to work and by tapering at the top to two feet, does not require as large an iron top as would otherwise be necessary.

The forms for this manhole are made of wood. The boards being 7/8 of an inch tong and groove flooring and the ribs 2"x 4". This makes a form strong enough to stay in place while the concrete is being rammed.

The straight sections are made 12 and 18 inches high and with an outside diameter of 4'. The 18 inch straight sections are used except where it is necessary to make the depth such that a number of 18 inch sections will not give the required depth, and in this case, a 12 inch section is used along with the 18 inch sections. There are also extra ribs with an outside diameter of four feet which are used to build the form up to the required height. These form are 2 inches thick, therefore, the straight portion of the manhole can be built to any height of an even number of inches. The conical section has a vertical height of 15" which allows the total height of the manhole to be built up to any odd number of inches.

In designing the straight forms, it was found best to divide each section vertically into four parts. The two smaller
parts being alike and the two larger ones being alike. The ribs of the larger part are made into two parts and joined by a lap joint. This is done to save wood.

The vertical joints are made so that either of the smaller sections will pull out from the inside, thus collapsing the form. These parts, after collapsing, can easily be taken out of the two foot opening at the top.

The sections are held in place by 5/8" bolts, twelve bolts being required for bolting two sections together. The bolt holes are bored 3/4" in diameter so as to allow plenty of room for the bolt to be put in and taken out easily, and they are so bored that when the joints are broken, the holes in the top rib of the lower section, which is to be joined, will fit the bottom rib of the section above it, and any section can be used in any position. The joints are broken as shown in the drawings and by so doing, no bracing besides the bolts is necessary to hold the portions of the sections together.

The conical section is divided into four equal parts by diameters at right angles to each other. It is cut in such a manner that it cannot be collapsed from the inside except by first taking out the straight section immediately beneath it and letting the conical section drop down 18". By doing this, there is plenty of room to take the section to pieces. On account of the rounded shape of these pieces, it is necessary to take them out before
putting on the iron cap.

The joints in the conical section break joints with the top straight section and the two sections are held together by twelve bolts. On account of the slope of the conical section, these bolts are only 1" from the inside edge, therefore, the top rib of the top straight section has its bolt holes in a little different position from the rest of the ribs for the straight section. In order that the rib of the conical section can be bolted to the rib of the straight section, it was necessary to cut notches to fit the bolt head, as there is not enough room otherwise for the nut. The bolt is pushed in from the bottom of the hole. The nut put on and held in place while the head of the bolt is turned. A cast iron ring 1/2" thick is bolted on top of the conical section to hold it in place. Two bolts are used in each quarter of the section and are put in from the bottom, the wood being cut away, as shown, so as to give a bearing area for the bolt head.
Straight Forms, Shallow Manholes.

1st Manholes to be used in streets.

These manholes are less than four feet in depth and are made two feet in diameter so that the iron covering will not occupy too much space in the street.

The forms for this manhole are divided into sections one foot in height, each section being made in six parts. The parts are so made that either of the two smaller portions can be pulled from the inside, thus collapsing the section, after which they are removed from the opening. The sections break joints with each other as shown in the drawing and are joined together by 5/8" bolts, twelve bolts being required to join two sections together. The bolt holes are bored 3/4" in diameter, and in such a manner that the section may be used in any position in the form and the holes will fit one another. The top section is held in place by means of an iron ring 1/2" thick and bolted onto the top rib with twelve 5/8" bolts. The ribs are made 1 1/2 X 3" and the boards are 1/2" tong and groove flooring. Extra ribs are provided two inches thick and with an outside diameter of 2' or so that the form can be built up to any even number of inches.
2nd Manholes used inside of property lines.

As these manholes do not have to carry any great weight and as the matter of occupying space does not enter, it was thought best to make the inside diameter 4\" so as to allow ample room for a man to work. The same forms can be used for this manhole as were used in the straight portion of the bottle shaped manhole. The top section is held in place by means of an iron ring 1/2\" thick and 4\" wide which is bolted to the top rib.
Channel Forms.

The channel is the most important part of the manhole and too much care cannot be taken in making it smooth, true, circular and of an even grade. The only successful way of making a satisfactory channel is to have some manner of form to hold the concrete in place until it has hardened. A wet mixture should always be used for this part of the work and unless there is some form used to hold it in place it cannot be used.

This portion of the manhole was carefully considered and although the cost is greater if forms are used, the additional cost will pay for itself in the end. If the channels are rough and full of pockets, they will stop up and a man will have to be paid to look after them.

The forms for the channel are made of wood and are made in three sizes; 6", 8", and 10" in diameter depending on the size of the sewer pipes entering and leaving the manhole, and they are made to fit the angle of intersection of the pipes at the manhole. Only two channel forms are shown in the drawings as the others are all made after the same general rule, the only difference being the angle.

The forms are made as shown in the drawings:

A semicircle with the same outside diameter as the size of the sewer pipe, and straight sides for two inches on the top.
The forms for the opening in the walls of the manhole are made with an outside diameter of 1" diameter greater than the outside diameter of the pipe, so that there will be plenty of room to put the pipe into its proper place and then fill in the space with cement grout. This form is made wide enough to go through the 4" concrete wall and then 8" into the earth walls, so as to hold it into place. It is made in two pieces, the bottom piece being screwed to the channel form, and the top piece is nailed in place after being fitted up around the vertical form for the side of the manhole.

The channel form is made in two pieces, being bolted together at the middle with three 5/8" bolts which holds the complete form, channel form, and form for making opening in the wall, together while the concrete is being put into place and until it has set. In order to take the form out, the three bolts are taken out and the forms are pulled from the outside. This is done after the concrete for the complete manhole has set and the ditches for the sewer pipes have been dug up to the sides of the manhole. When the angle is somewhere near 90" or where three pipes intersect, the channel form is made in three sections so that it may be removed.
### Estimate Cost

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<tr>
<td>Bottle Shaped Manholes</td>
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<td>Channel Forms</td>
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**Total Cost for Forms**: $116.50
Form for shallow manholes to be used in streets where depth is not greater than 4' shallow.

Form for manholes less than 4' deep.

Used in Building Sewer System for Town of Blacksburg, Va.

Designed by

F. J. Prouser

April 1912