CONSTRUCTION OF VITRIFIED PIPE LINES

By J. F. Springer, New York City.

This article, while quite elementary in its nature, collects together some details of construction in convenient form for use and may aid both engineer and contractor. It is one of a series of articles by the same author which has appeared at intervals.

The basic material used in the manufacture of vitrified sewer pipe is either shale or clay. As it is not general practice to ship such pipe long distances, the character of the basic material will vary for pipe made and used in different parts of the country.

The preparation of the shale or the clay before molding has much importance. For example: The amount of surface pimpling on salt glazed pipe is less when clay is used that has been passed through a 16-mesh screen than clay which had been passed through an 8-mesh screen. A finer screen gives but little better results. The experimenter responsible for the foregoing discovered, or was of the opinion that he had discovered, that pimpling was due to "the incipient fusing, bubbling and swelling of small particles of shale, lying close to the surface of the pipe." Other makers of pipe found that pimplies apparently arose from the oxidation during burning of the iron contained in the clay. The pimpling may be reduced by the proper management of the temperatures during the burning process and by carrying out the glazing only at a time when the flame is good and clear.

After clay pipe has been molded to form it is allowed to season under cover to give opportunity for a reduction of the water content by natural means. A slow drying and burning in the kiln is the next procedure. During this period the defects known as fire cracks develop. These may zig-zag more or less, but usually they have a general circumferential direction. They are possibly caused by sudden local changes of temperature brought about by the direct action of hot flames or cool currents. Another type of defect is the network of water cracks, thought to be due to a too rapid heating at the beginning of the kiln operations. Blisters are probably due to improper heating at the beginning.

As vitrification proceeds heat cracks of all kinds are brought into evidence by the shrinkage attendant upon vitrification. A single fire crack is not to be regarded as a fatal defect. It being permissible to have one at the spigot ¾ inch wide, 2 inches long and penetrating the full thickness of the shell. Blisters on the interior, if unbroken, not higher than ¾ inch, and having a diameter of say 2 inches, do not warrant condemnation of the pipe section.

Since nearly all classes of defects may either be eliminated or reduced in amount by proper manufacture, considerable care ought to be given to any desired reputations of concerns within a practicable shipping distance of the point of use.

In England, a distinction is made between sewer pipe made from fire clay and that called by them stoneware pipe. This latter is rated as "stronger and better able to resist the decomposing effects of the sewage." The pipe is salt-glazed inside and out, except on the surfaces of bell and spigot where the jointing material comes into contact with the pipe. Here an unglazed surface is preferred.

The British have devised a form of spigot end which prevents carelessness in setting spigots out of center with the bells in which they are inserted. The spigot end is given a slight flare and it is only necessary to force the pipe well home. An additional advantage is a reduction in amount of jointing material required.

Vitrified sewer pipe not being well adapted to perform the service of a beam, they should be supported evenly where in place along their length and generally all over the underground surface. Hard spots in the supporting soil may easily convert the sewer into a series of short beams. Ordinarily, it is not considered good practice to place vitrified sewer pipe immediately upon rock. The latter is excavated for perhaps 6 inches below the sewer level and a filling of gravel or fine material put in. At the bells it is sometimes required that the full depth of the softer material be maintained, requiring being holes in the rock.

Sewers of vitrified material sometimes give way because of the overhead load. In such cases, following the theory of stresses, the pipe breaks into four longitudinal pieces, each of which is roughly a quadrant of the circumference of the pipe. The points of breakage are at the ends of vertical and horizontal diameters. "For this reason fire cracks and slight imperfections which do not cause the rejection of a pipe should be placed at a point about 45 degrees above the horizontal laying, and not at the top."

The pressure of the back fill on top of the pipe may be reduced in many cases by sharply narrowing the trench at a level somewhat above the top of the sewer. The lodges of berms thus produced become the resting places for the ends of an earthen arch. The natural narrowing of the trench in excavating lends itself as aching action even if the berm is not formed. The narrowing is sometimes so great that local enlargements in the excavation must be made for the bells.

The tampering iron used in filling the space around the pipe should be given a weight of not more than 7 pounds. It is recommended that the tampering face be not greater than 1½ by 5 inches. "A tamper of even smaller size made be used to advantage until the filling is brought well up above the springing line of the pipe."

With small sizes of pipe, the side thrust is probably negligible or nearly so in most cases. Such pipe will carry a fixed overhead load of, say, 8 or 10 feet of backfilling. But the nature of the backfilling will cause variations in the character of the load transmitted to the pipe. Gravel will often tend to form an arch. Its weight will accordingly be partially moved. Clay when wet forms a rather poor arch, so that the load transmitted is a large part of the overhead weight.

A thin covering of backfill transmits loads moving on the surface over the sewer, such as loaded wagons, road rollers etc., whereas with deep fills these loads will be distributed almost evenly at the sewer level so that the sewer itself will get but a small share, if the arch action does not take up the moving load entirely.

Much trench tamping is now done by machinery. The apparatus used at Wilmington, Del., was provided with a vertically moving ram having a tamping face 8 inches square. The ram is provided with a long vertical rod, to whose sides secured contact strips of wood. Two cams rotate continuously in opposite directions. When the high parts come around close together they grip the rod and lift it until the high part is through. Then the ram drops and gives the tamping blow. A gasoline engine runs the apparatus, which, operated by two men, can do the work of five or six men. Hand tamping is used for 2½ feet up from the springing line and above that the machine is employed.

The laying of vitrified sewer pipe often becomes rather difficult when the trench is in water-bearing soil. Wakefield spilling may be made water-tight and can be made from mortar.
CONSTRUCTION OF VITRIFIED PIPE LINES

close at hand. Steel sheet piling drives easier than wooden piling and thru more difficult soils. Some types are reasonably water-tight, and other types require plugging, which may be done in rather simple ways. Steel piling may be obtained in very light weights, so light, in fact, that 10 or 12-foot lengths may be handled by one man. If the soil is not too difficult, light-weight piling may be driven by hand, a maul or light hammer being used. It will often be necessary, however, to use a steam or air hammer, or some other means of striking a heavy blow. Such apparatus may be quite portable. It is set up on top of the pile to be driven. Sometimes there will be a step upon which the operator may take his stand, thus adding his own weight. Steel sheathing may be driven by a derrick pile driver, and such apparatus may be mounted on a scow for a sewer line across a body of water. Two parallel lines of piling may be put down and carried out from the shore to some convenient point in the water. A few piles will then be driven to form a transverse wall connecting the two lines. The material in between may sometimes be excavated by hand and often by orange peel buckets. The excavated material may be piled up against the steel sheathing on the outside and thus aid in making it water-tight. By pumping out the interior space excavation may be continued comparatively dry. An impervious stratum may be expected not far below the bottom of a body of still water, and if not too far down the piling can be driven down to it, thus relieving the difficulty of water coming up thru the bottom of the trench.

Vitrified pipe must sometimes be laid upon a concrete bed. H. S. Watson, a British sewer engineer, gives the following method: A number of bricks are laid flat at distances from each other of about 10 feet. The upper surfaces are set carefully below the invert levels, the thickness of the pipe wall lower than the corresponding levels of the invert. Concrete is then filled in until it reaches the top of the bricks, and is leveled off to the exact grade with a straight edge. The concrete is now allowed to set for, say, two days, if the ground is dry. Bricks to serve as reference marks will now be set on edge aside from the center line 10 feet apart and worked into the concrete to bring the upper edges exactly to the invert level.

The pipe is now laid, bells uphill, beginning at the lowest point of the section. Back of each bell a brick is set to support the pipe. This brick will be laid flat or set on edge according to the amount of projection of the bell. A line of pipe will thus be set upon a line of bricks, one brick to a pipe length. As this line of pipe grows in length the jointing is begun by three men. First, the pipe layer applies cement to the lower part of the joint. He does this in such a way as to make bell and spigot concentric. As the pipe sections are elevated above the concrete floor he has opportunity to get his fingers beneath the under surface at the joint and make sure that everything is right. The remainder of the circuit of the joint is now filled in with cement by the second man, who follows the pipe layer closely. Any cement which may have gotten inside the pipe is promptly cleared away. The third man puts on a fillet of cement covering the edge of the cement joint, extending the joint cement for 1/2 or 1 inch. It is claimed for this method of laying pipe that, when the bed has been laid with proper care, the pipe may be set in place very rapidly, little or no packing being required to secure proper grade, also that a small flow of water on the concrete slab will not interfere with the making of the joints. Where pipe is laid directly on the ground or on concrete with depressions to receive the bells so that the pipe rests for its whole length on the bed, there is difficulty in making the joints properly, whether the trench be wet or dry. A water test suggested by Mr. Watson is made next by

VITRIFIED SEWER ACROSS SALTPOLISH IN SLAME TRENCH, BORO OF BROOKLYN, NEW YORK.
filling the section with water and observing the loss. A slate disk, readily broken out afterwards, is fitted in the lower end and in inlets and a right-angled bend at the upper end, and the water filled in. About a half-hour is then allowed for the escape of air bubbles and 15 minutes additional observation will, ordinarily, now suffice to determine whether the line is tight or not. In Mr. Watson's practice a 9-inch pipe sewer 300 feet long is regarded satisfactory if the water level does not drop more than \( \frac{1}{2} \) inch in 10 minutes. This is equivalent to about 11,000 gallons per mile of sewer per 24 hours. Defective joints show moisture if the trench is perfectly dry. If there is water in the trench the dropping of water upon water may be noted by the ear or eye. "In fact, a little water in a trench aids inspection, as it acts like a mirror in reflecting the underside of the pipes." American practice omits this test, but it is becoming each year more desirable as sewage purification works are installed.

The concrete fill is begun by filling in the spaces between brick supports with fine concrete. Thus a firm support is given the pipe line from end to end. The remainder is then put in place. The side faces may often be battered in towards the sewer so as to finish at the level of the horizontal diameter. In American practice it is common in wet trenches to wrap a strand of jute or oakum which has been soaked in cement grout all around the end of the spigot. A wooden tool may be employed in caking the cement or cement mortar into place. More material is often applied than is needed in order to provide for a fillet finish. Sometimes a second gasket is employed after the jointing space has been partially filled. It is claimed that a joint with a fillet is ordinarily more nearly water-tight than one without. A rather wet mortar will probably make the better joint. To overcome the tendency of such mortar to leave the joint a strip of cheesecloth may be wrapped all round. The joint with a fillet requires much more mortar than one made flush, but is worth its cost in bad soil.

The following table by F. C. Coffin, given the amounts of mortar required for joints for vitrified clay pipe:

<table>
<thead>
<tr>
<th>Diameter of Pipe in Inches</th>
<th>Flush Joints</th>
<th>Joint with Fillet</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>0.0045</td>
<td>0.0113</td>
</tr>
<tr>
<td>5</td>
<td>0.0054</td>
<td>0.0134</td>
</tr>
<tr>
<td>6</td>
<td>0.0065</td>
<td>0.0195</td>
</tr>
<tr>
<td>8</td>
<td>0.0080</td>
<td>0.0315</td>
</tr>
<tr>
<td>10</td>
<td>0.0100</td>
<td>0.0182</td>
</tr>
<tr>
<td>12</td>
<td>0.0140</td>
<td>0.0365</td>
</tr>
<tr>
<td>15</td>
<td>0.0220</td>
<td>0.0323</td>
</tr>
<tr>
<td>18</td>
<td>0.0270</td>
<td>0.0377</td>
</tr>
<tr>
<td>20</td>
<td>0.0300</td>
<td>0.1443</td>
</tr>
<tr>
<td>24</td>
<td>0.0350</td>
<td>0.1700</td>
</tr>
</tbody>
</table>

Variations in pipe dimensions will modify these quantities. A Canadian method of jointing pipe requires first that a strip of Russian hemp or like material dipped in neat cement grout be laid in the bottom quarter of the bell at the entrance, and the lower part of the bell be given a coating of stiff cement mortar to line the bell for the lower third, the two inuring to the centering of the pipes. The new pipe length is set in place, the spigot being shoved into contact with the shoulder without jamming the hemp piece back into the bell. The joint space above is caked with a suitable gasket just dipped in neat cement grout and the remainder filled with stiff cement mortar. A fillet may be required. Rubber mittens are used in all forming of cement joints. The man caking in the gasket travels two or three joints ahead of the one putting in the cement mortar. A semi-circular wooden scraper is used for cleaning the inside of pipe not larger than 15 inches. The pipe is 16 to 22 inches in diameter, the joints should be pointed on the lower half of the inside; if larger, the points should be carried all round. When a long length of sewer tested hydraulically the pressure may cause portions of the line to rise. This may be prevented by the use of struts as the line.

Joints are sometimes made by using a mixture of sand and sulphur, a modification of the Stamford joint materia. Omitting the tar, at one time much used in England. Flo-white sulphur and sand in equal parts are mixed and heated to 2
degrees, F. The sand should be very fine and contain no grit. It serves two purposes: To prevent shrinkage during the cooling process, and to increase the tensile strength of sulphur from 100 pounds to from 400 to 700 pounds per square inch. If rather coarse sand is employed it will be apt to sink to the bottom of the container. The temperature should not go much beyond 220 degrees, since the mixture then loses fluidity and becomes difficult to pour, regaining it, however, when cooled down. The substance when cold has a high degree of impermeability. The sand is an important factor in its success. A satisfactory sand has an effective size of 0.005 inch, but fine Long Island beach sand was found unsuitable. So experiments with sand proposed for use are recommended to determine whether it is of the right size and quantity to produce a proper cement. The joint is not penetrated by tree roots and is waterproof within one minute after the joints are made. The joint is quite rigid and may give trouble because the material hardens so quickly. Therefore the joint must be poured quickly. A form to fit the pipe and the joint is required and a funnel of clay, says 3 inches high, is advised to give a small head to facilitate the filling process. In cold weather and with large pipe a piece of jute thrown over the pipe close to the joint and lighted will usually provide sufficient heat to prevent cooling too quickly. The cost is somewhat higher than that of ordinary Portland cement joints, but about equal to the cost of the latter if a reasonable effort is made to see that they are really tight.

The use of asphalt for making joints is common in Germany. From Elberfeld come certain points of technique in using this material. The engineer giving the information used an asphalt with specific gravity of 1.32, softening at 131 deg. F. and liquid at 355 deg. At 378 deg. it was sufficiently liquid to pour and reach its place. The light oils in the asphalt are to be retained, consequently the melting container should be kept closed. The surfaces of the pipe within the joint should be made dry and clean before pouring begins. The spigot is set in place in the bell. Then a gasket made of tarred jute, for example, of two strands is caulked into the innermost part of the joint space. A rope well smeared with clay is then wrapped round the spigot of the new pipe length and brought up against the bell edge of the old length. Thru a hole made at the top the liquid asphalt is poured. Instead of the rope India rubber may be employed.

A Brooklyn, N. Y., specification for joints demands a material which shall preferably have a bituminous base and shall be quite liquid at 250 deg. F. This temperature is very much lower than that used at Elberfeld. However, the Brooklyn pouring temperature was set at about 400 deg. In pouring a ½-inch space is left to be filled with a guard band of 1:1 cement mortar extending at least 3 inches from the face and outside of the bell. Another jointing material consists of a mixture of tar and Portland cement. It was extensively used in certain New Jersey sewers where the trenches were quite wet, in preference to cement because cement joints could not be thereby relied upon to prevent the infiltration of ground water. The mixture was made about as follows: North Carolina tar was poured into a bucket of Portland cement, the mixture being kneaded by hand until a rather stiff dough-like substance was formed. This was rolled on a board into a long rope, which was then caulked into the jointing space. A space ½ deep, horizontally, was left, and a cement mortar guard or casing added.

TESTING CRUSHING STRENGTH OF VITRIFIED SEWER PIPE. LABORATORY OF DORO OF BROOKLYN, NEW YORK.
Sometimes the practice is followed, when laying vitrified pipe, of uniting two or even three lengths on the bank. When this can be done without entailing new difficulties, it seems advisable. It is more convenient to make joints on the surface and with pipe lengths vertical. The first length is set up with the spigot end on the ground. The spigot of the next length may then be readily centered in the bell of the bottom length. However, if the bed or floor of the trench is such that the long length formed by the two or three ordinary lengths will not rest properly until considerable settlements and adjustments have taken place, it may be wiser to make all joints in the trench.

One of our illustrations exhibits a 36-inch vitrified, salt glazed, pipe being lowered into a sewer trench in the Boro of Brooklyn. Vitrified pipe of this size is but little used, apparently, in the East, unless the conditions make it especially desirable, as other types of sewer can ordinarily be constructed for less money. The 24-inch size may be regarded as the Brooklyn limit for vitrified pipe where conditions are of an ordinary character. The special object in view in the present case is to get a sewer that will be impervious to leakage in from the outside to keep down the pumping and treatment requirements at sewage disposal points.

The best approved practice with vitrified clay pipe in soft ground provides a concrete cradle. Brooklyn, N. Y., has been using such a cradle and has acquired considerable experience. A wooden platform, upon which the pipe line is blocked up, is used if the bottom of the trench is sand thru which water is moving, otherwise the moving water would destroy the green concrete. Being perpetually submerged the planking will not rot. Where the sand is dry and firm no planking is required, the concrete being placed in immediate contact with the sand. The planks when used may be the ultimate foundation or they may really be part of the capping for a single or double row of wooden plies.

Two of the photographs show sewers in such concrete cradles located in a valley near the Hudson River, half a mile north of the extreme northern end of Manhattan. The land was practically a salt marsh, being only about one foot above mean high water. Wooden plies were put down to considerable depths and cut off at mean high water. The concrete base is supported by them, reaching down one foot below the plie tops and extending up to the level of the sewer grade. The vertical height of the concrete is, accordingly, determined by the two levels.

One photograph shows the sewer in a wide shallow trench and the other where a fill must be made to cover the line. They show the differences in design of the concrete foundation and the manhole supports.

The boro of Brooklyn, New York City, builds a considerable percentage of sewer of vitrified, salt glazed, stoneware pipe. The sizes used run up to 36 inches. Naturally the sewer department needs to determine the degrees in which such pipe possesses certain qualities. The crushing test seeks to determine, for example, the resistance which the pipe when laid may be expected to exert against the load of the back fill. One of the illustrations shows a pipe length in position in the hydraulic press, ready to undergo the crushing test. This press exerts its pressure from above downwards. What is desired is that the pressure and reaction shall be concentrated along a narrow longitudinal path on the crest of the arch and along a similar path beneath the bottom of the invert. Wooden strips are, accordingly, laid lengthwise above and below. However, it is necessary to take special precautions in order to provide for an even bearing. This is done by spreading a thin coat of plaster of paris on the contact surface of the strip. In this way provision is made to develop an evenness of pressure all along the length, in spite of slight irregularities in the pipe surface.