umbrella is lowered into position in the inside and sheet steel moulds outside, the space between the core and the mould being then run with mortar consisting of two parts of clean, sharp river sand to one part of Portland cement, mixed on an elevated travelling platform to the consistency of thin mortar, so that it will flow readily and completely surround every portion of the inclosed steel. During the process of running the cement, the outer steel mould is sharply struck with wooden mallets to facilitate the escape of air bubbles and assist in consolidation.

This portion of the work may appear simple, yet great care has to be exercised in its execution; before the cement is run into the moulds they should be well rubbed with a mixture of soap and oil, so that when they are withdrawn they will leave the finished concrete clean.

A somewhat difficult point is to determine exactly when the concrete has set sufficiently to enable the core and external moulds to be removed, the time of setting, of course, varying with the temperature, mixture, quality of cement and various other conditions. The writer has known cement set sufficiently in forty-five minutes to enable moulds to be removed, whereas in other cases six hours have elapsed.

When the moulds are taken off, the pipes are allowed to stand vertically for four or five days to harden, after which they are lowered and left in a drying yard until required. They should be allowed to dry for about a month before being laid and when ready for laying will stand quite as much rough usage as a cast iron pipe.

The next operation is laying and jointing the pipe. At the ends of the pipes a rebate of about two inches long and 1½ inches deep is left, the ends of pipes are laid hard up against each other, the rebate filled with bitumen on the outside of the pipes thus joined together, a reinforced concrete collar, made similar to the body of the pipe, is constructed and thus forms the main joint.

Bends and specials are made on much the same principle as the straight pipe, except that the cement concrete moulding is done by hand moulding and not by steel shields. This system has considerable advantage over either cast iron or steel pipes, as the angle of splay or radius of the bend can be executed by the workmen to suit the actual conditions and is not dependent on a stock pattern.

As regards testing, the writer was engineer on several works where this system was used and made many experiments during the process of making and laying the mains as to strength and water tightness.

The first testing was made on the welded steel tube before any of the reinforcing rods were fixed, in order to detect any pin holes in the welding and, if necessary, repair before the pipe was concreted. Every tube was placed in a specially designed proving frame and subjected to a test of 50 feet static head.

The finished pipe was placed in the same testing frame, about one month after being moulded, and subjected, as a rule, to a test of 1½ times the working pressure, which varied from 350 to 900 feet static head; or in other words, from 152 to 391 lbs. per square inch. One special tube was tested to a static head of 1,500 feet or 651 pounds per square inch, and showed no sign of fracture.

These pipes can be made for all diameters above eighteen inches and are essentially for trunk mains.

Where junctions have to be made for stop valves, air valves, scour valves or branch services, a specially made steel casting is usually welded on to the internal steel tube, then heavily reinforced and surrounded with concrete.

Having generally described the use of these pipes for water mains, the question of their use for main sewers need only very briefly be touched upon, as it is only a question of designing the reinforcing to suit the pressure. In one sewer made for the Corporation of Belfast, Ireland, the steel tube was entirely omitted, the only reinforcing being the spiral rods. This pipe stood a pressure of 50 pounds per square inch.

These pipes are usually made in about ten or fourteen foot lengths, where the diameter does not exceed two feet, the total thickness of the shell being from two and one-half to three inches.

As regards cost, the writer found in Great Britain on the works he was engaged on, that these pipes were manufactured, laid and jointed at about three-quarters of the price of steel and slightly more than one-half the cost of cast iron.

In the city of Grenoble, in the south of France, the city authorities arrived at the following conclusions on a line of reinforced concrete pipes which had been laid for fifteen years:—

(1) The irreproachable state of preservation of the pipes, in which there was found a slight calcareous deposit about 1/16 inch thick. They did not show the least fissure, either internally or externally.

(2) There existed no trace of oxidation from the metal. The binding-in wire which connected the longitudinal rods was absolutely free from oxidation.

(3) The adherence between the metal and the cement concrete constituting the body of the pipe was such that, despite the thinness of the concrete (1-3/8 inches), they could only be separated by heavy blows from a sledge hammer.

(4) When struck with a hammer, these pipes evinced remarkable sonority, such as might be obtained from a sound cast iron pipe.

(5) The detached fragments of the cement concrete showed very sharp angles.

(6) No repairs had been executed on these pipes from the time they were laid until the time of examination, a period of fifteen years.

A great advantage in reinforced concrete pipes is that with the aid of a few experienced men local and other authorities can carry on the manufacture themselves. This appealed to the writer very much where city councils in other countries had to deal with the great unemployed problem and provide relief work. In Johannesburg, South Africa, after the Boer War, the municipal council provided considerable relief work to the unemployed by undertaking the manufacture of reinforced concrete for the main outfall sewer.

In Scotland, about two years ago, the writer engaged a number of unemployed men on manufacturing, laying and jointing the pipes already described, which to some extent aided the corporation in alleviating the relief problem, a problem which, it is hoped, will never require solving in this country.

CONCRETE AND STEEL TIES.*

As has been said many times, it may be in the near future it will be impossible to procure wood for ties and something will have to be substituted in place of wood. Quite a number of roads are commencing to use, to some extent steel or concrete ties, and a great many roads have been and are experimenting with both concrete and steel ties of every conceivable shape and make.

Owing to the fact that some of these ties now being tried are comparatively heavy and hard to handle, this necessarily makes them quite expensive not only as far as the first cost is concerned, but in regard to their maintenance cost also.

*Presented at convention of the Roadmasters' and Maintenance of Way Association, held at St. Louis, Mo., September 12 to 15, 1911.