and semi-circular sections, and there is undoubtedly a prejudice in favor of the latter.

The great advantage of the reinforced arch for use in sewer construction lies in the economy in material. In large sizes, 8 feet or over, the reinforced concrete sewer requires only from 60 to 80 per cent. as much masonry as the "gravity" type. Also, where the amount of concrete per foot is sufficient to warrant an efficient plant, the unit cost of the concrete should be somewhat less than that of good brick masonry. In addition to the saving in masonry, there is usually an accompanying difference in excavation, and in deep work this may be a material consideration. Finally, there may reasonably be a difference in required size of sewer due to the greater smoothness of good concrete work, which amounts to between 5 and 10 per cent. reduction in mean diameter.

There can be no question that reinforced concrete is the natural engineering solution for the problem of large sewers. If reasonably designed and carefully constructed, it gives the best and cheapest sewer. In the hands of a designer not thoroughly familiar with the conditions surrounding sewer construction and maintenance, or of a contractor not experienced in reinforced concrete work, it is likely to be a dangerous material and it is a much too common occurrence that work is handled under just these conditions. The fact that many of these sewers are built by contractors whose whole experience has been with massive masonry, has not tended to add to the safety of the finished work.

When the excavation is complete, the invert is concreted. In rock or in dry ground, this can be done efficiently, but if water or mud is present, a portion of the concrete is sure to be unsatisfactory. With very bad bottoms, it is often necessary to place a raft of extra concrete and allow it to set before attempting to place reinforcement. If such conditions appear possible, good practice will provide for this work in both specifications and estimate and many reasonably provide for underdrains to relieve the new concrete of damage from water flowing from the trench ahead. Unless the specifications are to provide that the work is to be expensively delayed, it should be noted that there will be quite an amount of working over and across the new invert while the concrete is setting and exposed bars left for splicing are likely to be bent and jarred and their bond value in the invert concrete decreased. Also, because of these stub bars, it is usually impracticable to protect that portion of the invert from dirt and rubbish. While it is generally the custom to leave the sides of the invert rough to furnish a bond with the arch, it is an open question whether the finishing of this concrete smooth is not the lesser evil, as it can then be thoroughly and efficiently cleaned before additional concrete is laid.

Before the arch forms are set, it is necessary to remove cross bracing up to the crown level, and it must be replaced with verticals bedded in the new invert and cross-braced above the crown. Even with the most careful work, this will produce some disturbance with the sides of the trench and may even allow a bulging of the side plank enough to protrude within the neat measurements of the sewer. To widen and rebrace the section from the surface down may be expensive and hazardous as well as disorganizing, and the engineer often faces the problem of modifying the section instead. Instances can be recalled where the contractors have even asked permission to fill the whole trench to the top of the sewer with concrete at their own expense, rather than to attempt the re-excavation, and the construction engineer must be able to decide whether the deficiency in thickness at the sides can be compensated in this manner.

Collapsible steel forms are usually favored for the arch, and if kept well cleaned and oiled, produce the best interior surface, but well-made wooden centres carefully planned will result in more satisfactory work. The choice will usually depend on the contractor's organization and schedule, as greater progress with one outfit can be secured if the collapsible forms are used.

Under the conditions prevalent in this work, the setting and holding of the arch reinforcement in accurate position is especially difficult and the importance of accuracy is rarely appreciated by foreman and laborer. When properly set, the rods are difficult to hold during concreting, as it is often necessary for the men to stand on the reinforcing while spading the concrete. The cost of special chairs or holders for the reinforcement is usually well warranted.

The placing of the concrete is made especially difficult because of the double mat of reinforcing bars, which tend to break up the stream of concrete and to cause a separating out of the aggregate. The concrete is also likely to be lowered in quality by an almost unavoidable leakage of water. The concrete is also contaminated to some extent by earth and rubbish knocked from the surface into the forms. There occurs, also, even in the best regulated work, certain small slips of earth from between the side planking, and it is possible that portions of the clay or loam may be churned into the concrete before it can be cleaned out from the tangle of reinforcement.

In view of the unavoidable construction contingencies inherent in this class of work, the writer would recommend to the designer the following prescription:

1. Use the best grade of concrete and considerable excess of mortar.

2. Do not work concrete at more than 450 pounds, unless the construction conditions are to be exceptionally favorable.

3. The concrete cover outside of the steel should be at least 2 inches.

4. Use a minimum thickness of concrete of about 9 inches unless the work is close to the surface, or is to be built under very favorable conditions, and increase this minimum and also the cover over the steel if the conditions are likely to be very unfavorable.

5. Specify the setting of the reinforcement with especially designed holders. These might be made of cast iron and left in the concrete.

6. If there is any possibility that the trench will be very wet or mucky, provide for a sub-base of concrete and provide means of keeping the trench work away from the work if possible.

7. To secure a concrete that will flow into place with the least assistance, a specification for a 2½ or a 3-minute mix should be seriously considered, as might also the use of hydrated lime. This would naturally result also in a denser and more waterproof concrete and might be a very considerable factor in prolonging the life of the reinforcement.

8. Provide for a lining of vitrified brick for the invert, or at least provide an excess internal area to allow for such a lining at some later date. This is of more importance in maintenance than in construction, as under average conditions it is easier to obtain a reasonably smooth invert with the brick than to attempt to finish the concrete itself.

9. Specify cold weather methods. Concrete can be placed satisfactorily and economically at even a zero tem-