University of Minnesota
ST. ANTHONY FALLS HYDRAULIC LABORATORY

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HYDRAULIC MODEL STUDIES OF SEWER TRANSITION

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I. INTRODUCTION

A contract was awarded to the St. Anthony Falls Hydraulic Laboratory to perform a hydraulic model study of energy losses in a combined sewer for the Minnesota Highway Department. The sewer is located in the vicinity of 38th Street South and Hiawatha Avenue in Minneapolis, Minnesota.

The sewer passes under redesigned State Highway 55. The new highway design requires a modification of the existing sewer. The proposed new sewer design includes a change in geometry from the original circular 9.25 ft pipe section to a 4.25 ft high by 16 ft wide box, a length of box section, and then a transition back to the original 9.25 ft pipe section. The crown of the pipe is depressed 5 ft to the top of the box section with the invert remaining at the present grade. The depression of the sewer crown allows the highway gradeline to be lower than it was for the old Highway 55.

The transition had to be designed so that a minimum of headloss would result from the change in geometry. The Highway Department submitted designs A and C (see Photo 1) for testing. Design B (see Photo 1) was suggested by the St. Anthony Falls Hydraulic Laboratory. In design A the perimeter of the circular 9.25 ft diameter pipe was divided into 16 equal chords. The perimeter of the 16.67 ft by 4.25 ft box was also divided into 16 segments. Strips were then run from the circular pipe to corresponding locations on the box. In design B the circular pipe was again divided into 16 chords. Each point on the pipe was then connected to a corner of the rectangular box. This produced a common transition geometry built up of flat triangular strips. In design C a short transition piece was used to change from the circular pipe to an 8.2 ft square of equal area. The remainder of the transition then used flat shapes to change from the square shape to the rectangular box shape. A center wall in the box section was included in each of designs A, B, and C for structural reasons, although the box could be constructed without this intermediate support. In designs A, B, and C equal cross-sectional flow area was maintained through the transition to the box section. In a fourth test transition (Design D) this rule was violated slightly. Design D is similar to Design C except that the short transition piece changes from a circular pipe to a rectangular opening with the same width as the original pipe section (9.25 ft) and a height of 8.2 ft.

In all three designs the slope of the bottom of the pipe remains unchanged. A different design, such as an inverted siphon, could have been used, but it would have been much more difficult to assure sediment transport through the modified portion of the sewer. For the designs proposed, the removal of the center wall in the box section and the addition of a simple vee bottom confined the low discharges to a small area and facilitated the movement of sediment through the box section. The contract was initially concerned only with head loss due to the change in geometry of the section. However, it was found that sediment transport was an important aspect of the problem, and the contract was informally extended to include qualitative tests of sediment transportation.

II. TEST APPARATUS AND PROCEDURE

The test apparatus was constructed at a scale ratio of 1:18.5. The model consisted of a water supply pipe into a head box, an approach pipe, a transition from a round to a rectangular box section, the box section, another transition, and a downstream pipe. The model was so constructed as to allow changes to be made in the transition sections and in the box section. All prototype dimensions are given in Fig. 1.

model during sediment tests. The top cover of the box section and transition has been removed to allow observation of sediment deposition patterns. With this configuration an equilibrium deposition pattern was established at the upper end of the box section. At equilibrium the amount of sediment moving into the test section is equivalent to the sediment moving out the lower end. Without the vee bottom in place, larger deltas built up at the upper end and the total accumulation of sediment was greater than for the vee bottom. Photo 3 shows the equilibrium pattern established near the entrance to the box section with the vee bottom in place. Photo 4 shows the downstream pattern for the same conditions.

IV. CONCLUSIONS

The model tests indicate that each of the alternate designs for the transition piece was hydraulically well designed and that, essentially, they performed equally well. The decision of which design to select should be based on the relative costs of construction of the alternatives. The most significant part of the loss through the entire structure is attributed to friction loss in the box section. The use of a vee bottom in the box will improve its sediment transport characteristics at low flows.

V. ACKNOWLEDGMENTS

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