LABORATOIRE DE CONSTRUCTIONS HYDRAULIQUES

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Physical Model Tests for the Sewer System of La Paz (Bolivia)

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Problematic

The city of La Paz is located in the western part of Bolivia, close to the Peruvian border. The city is constructed on the valley slopes. The major longitudinal conduits of the drainage system consist of rectangular channels with arched roofs, characterized by a stair-step profile. This entire system operates under pressure at lower elevations and perfuses large quantities of water over the streets. Pictures of the drainage conduits are shown in Figure and Figure 2.

Figure 1: General view of the sewer pipeline

Figure 2: View looking upstream showing the stair-step structure.

Methodology and Results

In order to improve the hydraulic performance of the existing sewer system, physical model tests have been carried out in the Laboratory of Hydraulic Constructions at the Swiss Federal Institute of technology in Lausanne (see Figure 3). Physical model tests have been achieved for several configurations to define the optimal geometry able to increase the flow capacity and in the same time to maximize the energy dissipation. With respect to the physical modelling the following issues were addressed:

- Hydraulic capacity of different profiles having the same cross-section but with different average slopes and bottom roughness.
- Energy dissipation of different profiles having the same cross-section but with different average slopes and bottom roughness.
- Qualitative behaviour of the sediment transport in the conduit.

Figure 3: Left: looking upstream view of the physical model; Right: longitudinal element of the model

The tests performed with the existing geometry of the culvert, characterized by a succession of single steps, put in evidence that different flow regimes occur in the conduit. With the increase of the discharge, nappe flow, skimming flow and pressurized flow succeed under the influence of the stepped bottom and the top surface of the culvert (see Figure 4).

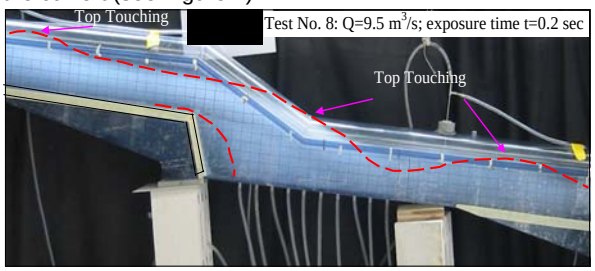

Figure 4: Scheme of the jet trajectory and flow behavior with single steps, smooth bottom and 27% average slope

Considering that the single steps are at the origin of early pressurized flows in the culvert, due to the impact of the jets on the top surface, a multi steps solution was tested in order to increase the free surface flow capacity (see Figure 5). This new bottom configuration permits to increase the hydraulic capacity at free surface flow of about 10%, when increasing the energy dissipation efficiency of 5% approximately (see Figure 6).

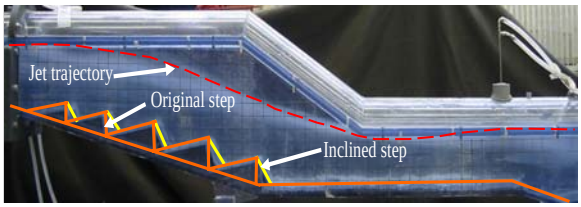

Figure 5: Scheme of the jet trajectory and flow behavior with inclined multi steps, rough bottom and 10% slope

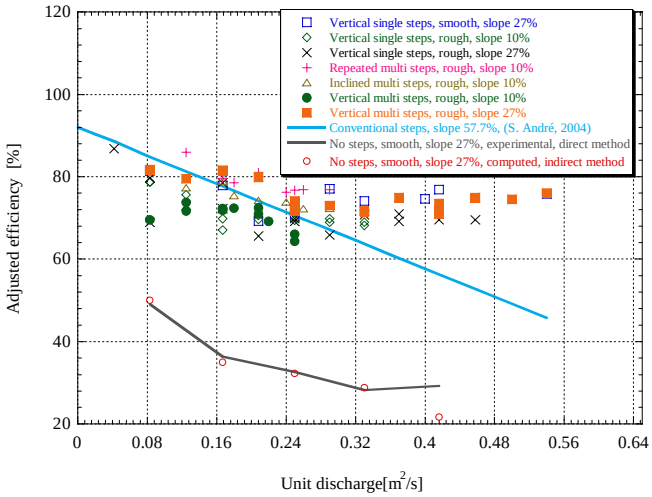

Figure 6: Comparison of the energy dissipation efficiency for all experimental tests **after** adjustment

The multi step design reveals able to improve the hydraulic performance of the culvert by comparison with the actual profile. This solution can be recommended for the rehabilitation of the existing culverts and for future similar structures.