STORM SEWER SYSTEM OF LA PAZ: A NEW DESIGN

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The City of La Paz, Bolivia, occupies a steep valley at elevations between approximately 3300 and 4000 meters. Urbanized slopes can exceed 50 %, and no part of the city is flat. Urban expansion upward above the valley floor has overloaded the lower part of the system resulting in flood flows along major streets in the lower part of the city. A rain plus hail event in February 2002 resulted in approximately 70 deaths as people in the city center were washed away and drowned. To address the flooding problem a diagnostic and design study of the stormwater drainage system in the lower portions of the City of La Paz was contracted by the Municipal Potable Water and Sewage Service (SAMAPA).

A comprehensive stormwater drainage analysis and design study was undertaken for the City of La Paz, Bolivia, incorporating both numerical and physical modeling. Behavior of major culvert sections within the system having non-standard stair-step geometry were simulated by a 1:10 scale physical modeling. Physical modeling methodology, results and recommended design modifications are reported.

The prototype system contains a series of large longitudinal single steps (Fig. 1c) and contains significant discharge of gravel and cobble size sediment. Physical modeling analyzed slopes of 10 % and 27 % using a Plexiglas model which allowed visual observation of flow patterns. Equivalent Manning roughness coefficient values of 0.025-0.030 for slopes around 10 % and 0.015-0.020 for slopes of 20-30 % were derived from head loss measurements. These values were subsequently used in numerical modeling of the whole system. It was found that system capacity was limited by air entrainment, flow pressurization, and water jets hitting the roof at steps. A smaller than real cross section was recommended for numerical modeling to account for these complex flow phenomena. An alternative design using multiple smaller steps was proposed (Fig. 1d), which doubles flow capacity without significantly impacting the roof or causing pressurization, while maintaining the current rate of energy dissipation. Design steps for the proposed culvert configuration are presented.

The flow regimes that were measured along the steps of the sewer system partially corresponded to the regimes typically encountered on stepped spillways: nappe flow at low discharges and skimming flow at high discharges. The main differences were generated by partial or total pressurization of the flow in the conduits at high discharges, generating pulsating and reverse flow conditions.

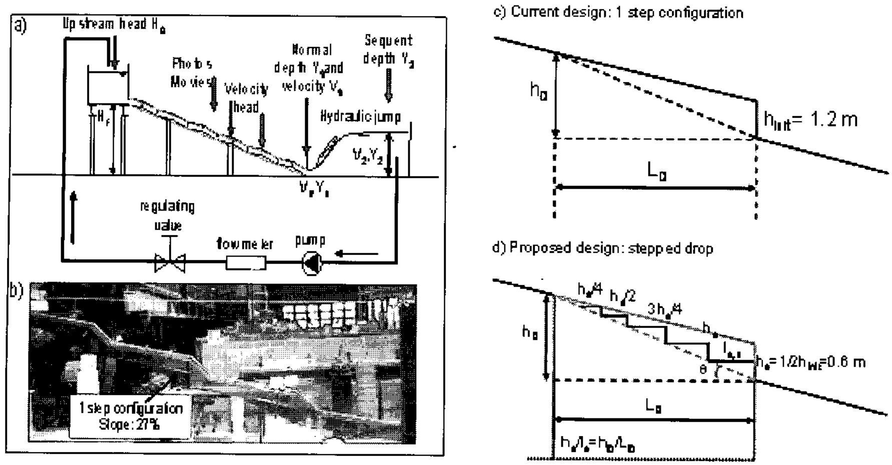

Fig. 1 a) Definition sketch of stair-step culvert, constant head reservoir upstream and hydraulic jump downstream; b) Photo showing the geometry of the invert and the roof; c) current design of sudden step; d) new proposed design with stepped drop.

REFERENCES

André, S. (2004). High velocity aerated flows on stepped chutes equipped with macro-roughness elements. PhD Thesis, EPF-Lausanne, Switzerland.