PIPE MANIFOLD DESIGN APP

SCOPE

This App relates to water flow in submerged pipes with single-size orifices uniformly distributed over the pipe length. Two operational modes are analysed (a) flow distribution manifold pipes (outflow from pipe), and (b) flow collection manifold pipes (inflow to pipe).

BASIS OF ANALYSIS

The hydraulic analysis on which the App coding is outlined in the Appendix to this note. Multi-port manifold pipes are widely used in water engineering practice, where the design goal is usually the achievement of a minimum variation in flow through the ports. This variation increases as the ratio of the sum of the combined port cross-sectional areas to the cross-sectional area of the manifold increases.

OUTPUT

The App computes the variation in port discharge over the manifold length and reports the result as the ratio of the 'dead' end port discharge to the other end port discharge. The output parameters also include the manifold head loss and the manifold outflow/inflow velocity. The user interface includes a Copy command that copies the input data and the calculated parameter values to the clipboard to enable pasting to a written record file.

T J Casey
Aquavarra Research Limited

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Appendix

Manifold Hydraulics

FLOW DISTRIBUTION MANIFOLD

Fig 1 illustrates a submerged multi-port flow distribution pipe manifold from which the inflowing water is discharged through a number of ports.

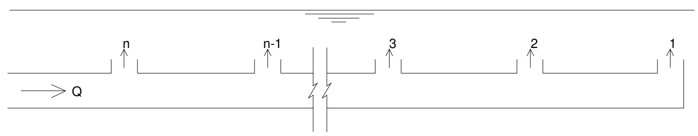

Fig 1 **Flow distribution manifold schematic**

The outflow through individual ports q_p is a function of the differential pressure across the port and the velocity of flow in the manifold pipe and can be expressed as follows (Casey, 1992):

$$q_p = C_d A_p \sqrt{2g\Delta E} \tag{1}$$

Where C_d is the coefficient of discharge for the port, A_p is the port cross-sectional area, ΔE is the total differential head which is the sum of the differential static head and the manifold velocity head ($v_m^2/2g$) at the port location. In this analysis the following empirical expression was used for C_d:

$$C_d = 0.66 - \frac{v_m^2/2g}{\Delta E} \tag{2}$$

Using equation (1) and the C_d value given by equation (2), the port discharges may be calculated in turn, starting from the 'dead' end, that is port 1 in Fig 1. The computation may be started by assuming the discharge through port 1 is Q/n, where Q is the manifold inflow and n is the number of ports. The value of the total differential head ΔE is incremented between ports by the magnitude of the calculated friction head loss. The calculated total outflow is the sum of the calculated port discharges, which in the first computational run would be unlikely to equal Q due to the variation in port discharge over the length of the manifold. A second computation is therefore carried with a revised estimate of the discharge through port 1, based on the result of the initial computation.

FLOW COLLECTION MANIFOLD

Fig 2 illustrates a submerged multi-port flow collection pipe manifold into which the outflowing water is collected through a number of ports.

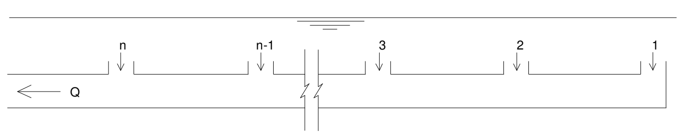

Fig 2 **Flow collection manifold schematic**

The inflow through individual ports q_p is a function of the differential pressure across the port and the velocity of flow in the manifold pipe and can be expressed as follows (Miller, 1990):

$$q_p = C_e A_p \sqrt{2g\Delta h} \qquad (3)$$

Where C_e is the inflow coefficient for the port, and Δh is the static differential head. The coefficient C_e is a function of the ratio of the static differential head and the velocity head in the manifold. In this analysis the following empirical expression was used for C_e:

$$C_e = 0.8 - 0.085 \log\left(\frac{\Delta h}{v_m^2/2g}\right) \qquad (4)$$

subject to the condition that $C_e \geq 0.6$.

Using equation (3) and the C_e value given by equation (4), the port discharges may be calculated in turn, starting from the 'dead' end, that is port 1 in Fig 2. The computation may be started by assuming the discharge through port 1 is Q/n, where Q is the manifold design outflow and n is the number of ports. The value of the differential static head Δh is calculated for each port in sequence, taking into account the calculated friction head loss and the increasing manifold velocity. The calculated total inflow to the manifold is the sum of the calculated port inflows, which in the first computational run would be unlikely to equal Q due to the variation in port inflow over the length of the manifold. A second computation is therefore carried out starting with a revised estimate of the inflow through port 1, based on the result of the initial computation.

References

Casey, T J (1992) Water and Wastewater Engineering Hydraulics, www.aquavarra.ie/Publications

Miller, D S (1990): Internal Flow Systems, 2nd Ed., BHRA, Cranfield, UK.