A comparison of sewer reticulation system design standards gravity, vacuum and small bore sewers

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Abstract

The introduction of waterborne sewerage in the villages and towns of Botswana has highlighted a number of problems in the design of the reticulation systems. The first of these is that not many people connect to the system once it is installed. The second problem is that there are not always the skills required to maintain the systems in the rural areas. Thirdly Botswana being a dry country does not always have the water supply available and only some households have a house connection which provides enough water to flush a gravity sewer.

Coupled to this is the low housing density and generally flat landscape in rural Botswana that means the conventional gravity sewer soon requires deep excavations and the consequent need for pumping stations. It became apparent that gravity sewer systems were not always the best means of providing waterborne facilities.

It was found that in certain circumstances the alternative options of vacuum and small-bore sewers were more appropriate and so design standards were developed for gravity, vacuum and small-bore sewer systems. This allows for a uniform approach to design in order to achieve a functioning system.

Introduction

Current developments in the sanitation and wastewater field in Botswana necessitated the development of a uniform approach to its development in order to avoid fragmentation, environmental pollution and a waste of resources. The Government of Botswana commissioned an overall Master Plan for the sector so that all the planning, legal, institutional and technical matters could be addressed.

As part of the technical investigation it was required of the Study Team to provide planning and design standards for all infrastructure associated with sanitation and wastewater. Part of this Design Manual set out the requirements with regard to sewer reticulation with the focus on gravity, vacuum and small bore systems. Pumping stations and force mains were also addressed in the Botswana context.

A brief description of the sanitation and wastewater environment, as it relates to sewer reticulation, is provided in order to give the reader some insight into the status quo in Botswana. In general, the landscape in Botswana is relatively flat and large areas are covered by Kalahari sand. Potable water is provided to virtually every household throughout Botswana whether it is via public standpipes, yard taps or house connections. The country is politically stable and the income from the mining sector has been used to raise the living standards of the general population. This has been done in a number of ways including the construction of infrastructure such as roads, dams, pipelines etc. and by investing in education and business development. One of the current focuses is to replace the standpipes with either yard taps or house connections. It has been found that this leads to an increase in water consumption and hence the possibility of environmental pollution. In order to counter this aspect, a programme of sewering major villages has commenced.

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For the most part conventional gravity sewers have been used but a vacuum system is also currently being installed. The possibility of using small-bore sewers has been examined but not yet used in Botswana although they are in use in neighbouring countries. This paper looks at the advantages and disadvantages of these three systems and provides design guidance for Botswana.

Gravity sewer reticulation

Gravity sewer design is very well documented and it is not the intention here to reiterate the commonly accepted. Rather, the focus will be placed on the aspects that are particular to Botswana and any other developing country.

It was found in numerous places in Botswana that the provision of a sewer pipe did not mean the household would connect to it. In fact the connection rate is extremely low. This could be for a number of reasons not least of which are household priorities. With time the connections will be made and water usage will increase but in the interim the design flows will not be attained and so scouring velocities will not occur. In common with other countries, experience dictates that as living standards are raised so water use increases and this will also impact on flows and velocities.

As only one sewer is laid in a street it is necessary to design it to overcome both the initial and final situation. The parameters used are given in Table 1 below:

TABLE 1
Gravity sewer parameters

Parameter	Initial situation	Final situation
Water use per person (house connection)	100 ℓ/d	165 ℓ/d
Return flow per person	80 ℓd	132 ℓ/d
Percentage of population connected	20%	100%
Minimum scour velocity	0.6 m/s	0.7m/s
Manning n factor	0.011	0.013