Sewer-system analysis with the aid of a geographical information system

SA Sinske* and HL Zietsman

Department of Geography and Environmental Studies, University of Stellenbosch, Private Bag X1, Matieland 7602, South Africa

Abstract

Geographical information system (GIS)-supported sewer-system analysis has major advantages over the use of traditional stand-alone sewer programs, especially with regard to establishing network topology, input of sewage contribution data, querying, displaying and mapping of results. This paper reports on the development of a GIS-supported sewer analysis software package using ArcView GIS. It supports all the stages of sewer-system analysis, viz. defining the topology of a sewer network, the specification of sewage flow contribution parameters, the allocation of sewage-contributing areas to sewer manholes, hydraulic analysis and displaying the analysis results. A sewer program has been developed for hydraulic analysis and written in Avenue, the internal programming language of ArcView. The sewer program is therefore fully integrated with ArcView, and all the functionality of ArcView is available during the sewer-system analysis. Such an integrated software package where the input data, sewer program, GIS and program results are all dynamically linked is the perfect environment for scenario management. The software package has already been successfully applied to the main sewer system of the Inner Cape Metropolitan Region (Inner CMR), as part of an M.Sc. thesis in Geography and Environmental Studies.

Introduction

The use of geographical information systems (GIS) in combination with stand-alone sewer programs to support sewer-system analysis has been known for quite some time. The integration of these systems, viz. the specially designed interfaces to transfer data from the GIS to the external program and to transfer the results back to the GIS was, however, not always perfect. The further development of such a system can also be cumbersome because of the complex link between the GIS and the external program, which must be updated all the time. Poorly integrated GIS sewer packages usually have no significant advantage over normal stand-alone sewer programs, since the data input, sewer program and program results are still separate and isolated elements. These products usually have included an optional export functionality to GIS/AutoCAD – the focus is thus mainly on the sewer program and the GIS side is totally neglected. Off-the-shelf GIS systems usually have no significant built-in sewer-system analysis functionality – they have to be tailored for the specific use. It is therefore important to have a powerful internal programming language to further customise the GIS environment and to supplement existing functionality to support sewer-system analysis.

Sewer-system analysis using ArcView

ArcView, a sophisticated desktop mapping application by means of which spatial data can be visualised, explored, queried and analysed geographically (Hutchinson and Daniel, 1995; ESRI, 1996a) is a perfect platform for sewer-system analysis, because the package is well-known for its user-friendly graphical user interface (GUI) and it has a powerful object-oriented internal programming language, called Avenue (Razavi, 1995; ESRI, 1996b). With Avenue programming code (also referred to as scripts) the ArcView environment can further be customised and standard built-in functionality can be enhanced to support all phases in sewer-system analysis. By writing the sewer program (hydraulic engine) in Avenue, the sewer-system analysis can take place completely within the GIS and interfaces (such as DLL, DDE or common data exchange files) will therefore no longer be necessary. A better, more direct and dynamic link is therefore established between the GIS and the sewer program. All of the functionality and components of ArcView (together with the enhanced functionality) can then be utilised during the sewer-system analysis.

For the purpose of discussion, sewer-system analysis has been divided into six stages (Fig. 1), viz.:

- definition of sewer networks
- selection of sewer network
- specification of sewage flow contribution parameters
- allocation of sewage-contributing areas to sewer manholes
- hydraulic analysis
- display of the analysis results.

The newly developed sewer package has already been successfully applied to the main sewer system of the Inner Cape Metropolitan Region (Inner CMR) as part of an M.Sc. thesis in Geography and Environmental Studies (Sinske, 1998) and supports each stage of the analysis. These six stages are described in the sections that follow.

Definition of sewer networks and drawing-up of attribute tables

The location of the manholes in the sewer networks, the pipe-manhole topology and attributes such as pipe slope, diameter, type of material and absolute roughness are all defined at this first stage of the analysis (Fig. 1). X, Y co-ordinates of each manhole in the sewer networks, as well as pipe invert levels, and attributes such as

* To whom all correspondence should be addressed.
☎ 021 8865140; fax 021 8865140; e-mail: stefan@sinske.com
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