APPLICATION OF MODELLING TECHNOLOGY AND KNOW-HOW FOR MASTER PLANNING OF SEWER SYSTEMS IN LARGE CITIES OF CENTRAL AND SOUTH-EASTERN EUROPE

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ABSTRACT

Numerical modelling of large combined urban storm drainage and sewerage networks has become a standard and inevitable practice in any serious attempt of evaluating hydraulic and environmental performance of these extremely complex systems. Capacity of well-suited models, featuring advanced urban hydrology approach, accurate sewer flow calculations based on fully dynamic flow description, as well as pollution transport based on advection-dispersion dynamic calculations, is incomparable with any alternative approach for these purposes.

Key words: sewer systems, drainage networks, numerical modelling

Through the past 15-20 years, software systems for modelling of urban drainage networks have passed through several development phases[2]. From initially moderate PC-based programmes, centred around the computational core, comprehensive, modular modelling systems have been developed, covering all aspects related to engineering analysis of urban drainage networks and including strong hydroinformatics features[3]. A typical software package[1], features e.g. several types of surface runoff calculations, continuous urban hydrology (RDII), efficient and stable fully dynamic flow computation in dendritic and looped network, Real-time control (RTC), long-term simulations with performance statistics, pollution transport, sediment transport, etc.

Along with the development of the simulation software, appropriate methodologies have been developed for its efficient usage in various applications. Among these, one of the most challenging applications is the performance analysis and master planning of large combined sewer networks. The methodology relies on the following main elements:

- Extensive and reliable flow monitoring tailored for the model calibration needs and flow analysis. In the context of a modelling study, the flow monitoring is viewed as an essential complementary, rather than competitive technology. The flow monitoring and modelling, only when applied in optimal proportions, ensure the overall economy and quality of the study[5]. For the success of this notoriously difficult and unpopular undertaking, a proven technology and know-how, supported with long reference list, must be applied. Efficient technical support for the instrumentation must be insured throughout the period of survey. Often, the flow survey is accompanied with a water quality sampling campaign.

- Processing, control and presentation of the historical and actual measured data.
- Consolidation of structural system data and its transfer from different digital (e.g. GIS) or hard copy sources into the model-compatible, comprehensive data management environment.
- Development of a global hydrological model for the urban catchment, including frequently forgotten continuous rainfall dependent inflow & infiltration component. This model is crucial for the establishment of a correct water balance in the catchment.
- Construction and calibration of the hydrodynamic model for the primary collector network. This model includes all vital elements of the network, like significant storage volumes, automated flow control devices, etc.
- Definition and verification of a pollutant transport model for selected pollution components. Optionally, for the completeness, this model can be extended by a dynamic wastewater treatment process simulator.
- Diagnosis of the present system performance, relying on long-term simulations over multiple years and extensive statistical analysis of the key variables: flows and pollution loads at the system outlet (i.e. at the entrance to wastewater treatment plant), combined sewer overflow (CSO) volumes and pollution emissions, critical water levels, etc. The extent of the long-term simulations depends primarily on the availability of reliable rainfall records of high time resolution for the area of concern.
- Optionally, where appropriate, construction and verification of the hydrodynamic and water quality model of the recipient(s), to be used for the environmental impact analysis for the present and future systems.
- Definition and modelling of alternative problem alleviation and/or development schemes. The alternatives usually include considerations for changed loads in future and rely heavily on extensive simulations of real-time control (RTC) schemes, which contributes to the solution economy. Performance of any alternative is simulated for exactly the same period and the loading conditions as the present system. Resulting statistics are then compared, so that a cost-benefit relation can be established, and the best solution selected.
- Close co-operation with a client's local consultant and the client's own key technical personnel, including extensive training for the post-project use of the developed planning tools (models). This is focussed on securing the continuity and keeping the results of the project up-to-date long after the project's termination.

Along with the modelling-related activities, the project team must provide advice in relation to the application of GIS and database tools for the management of urban drainage assets, as well as advice on optimisation of institutional set-up of the client's sewerage management organisation.

The entire concept is driven by the ever-increasing performance requirements for urban drainage systems, imposed by the relevant national and EU pollution emission control and environmental legislation. What concerns EU member states, the newest approach, embodied in the so-called "EU Water Framework Directive", focuses on the environmental status of the recipient, along with the traditional, emission-based approach. Taken the complexity of the systems under consideration, importance of efficient and qualified application of advanced numerical models will continue to grow in the future.

On the other hand, countries of central and south-eastern Europe have long and respectable tradition in handling of wastewater in major cities, comparable by all means to that of western Europe. It was only in the second half of the 20^{th} century, due to the overall economic and political setbacks and due to generally low priority level of environmental issues, that important gap has developed there in the related legislative and technological areas. Under pressure of burning environmental problems and the prospects of EU membership in future, this situation requires introduction of tools and know-how for a quick and efficient connection to the European wastewater "philosophy".

Sometimes, this process must be initiated even before the national legislation has been fully adapted[8]. Accordingly, several important projects in the cities of central and south-eastern Europe have been conducted using the technological and methodological approach as outlined above. Notable examples are the Master Plan of the Sewerage System in Ljubljana[7] (Slovenia, 1994-96), Optimisation Plan of the Sewer Network in Zagreb[4] (Croatia 1996-1998) and Prague Wastewater System Master Plan[6] (Czech Republic, 1998-2001).

Each of the three projects has carried some distinct features, which required addition of new elements or the modification of the "standard" set of activities. However, a strong common point in all three cases was initially relatively low technological level of the sewer assets management: weak or non-existing digital databases, only sporadic use of contemporary software tools (GIS, numerical models), non-existent or very sparse reliable historical performance records for the network. This, however, did not prevent that the projects were generally successfully completed, for the satisfaction of the clients.

Another common point was that the relevant legislative foundation in respective countries was not fully up-to-date, concerning the key issues of CSOs and environmental impact on the recipient. The problem was solved by a sensible application of appropriate practices from environmental forerunners - Scandinavian EU member states.

The paper will provide an extensive information on the technical contents and the results of the three discussed projects. Considering the technical and traditional circumstances that are similar to those found in Yugoslavia, these projects may serve as good examples to be followed in the rehabilitation process of urban drainage infrastructure in major cities of Yugoslavia.

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