INFLUENCE OF FLAT AREA TYPE ON SEWAGE DESIGN CONDITIONS

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Abstract: *The paper discuss about advantages and disadvantages in sewer system design in dependence on designed area composition focusing on flat areas and offer the solution, how to solve these problems, respecting the proper design conditions.*
The Slovakia area consists from various type of surface. The choice of sewer building type depends on this type too. The West and East Slovakia cover flat areas. The flat areas, without natural slope require the special approach concerning the sewer system built. This area type offers various solutions. Slovak legislative recommend to keep the design principles, which are under pressure of investor – the build price decreasing. The dispute between investment cost and on the other side operational costs and operational conditions must consider the design principles. The alternative sewer system design is allowed, such as gravity and vacuum system, but it is strictly recommends to prove the validation of designed system. The very important influence on the sewer system design has the EU promises, which make a press for the fast sewer system built in Slovakia, which could be decrease the quality process of designing.

Keywords: *sewer design, pressure and underpressure system*

Introduction

The preparation process for sewer system building in Slovakia depends on various factors, which have influence on quality and effective build up. The landscape of the country has important influence for the system of build up. East-Slovakian Lowland and west part – Danube Lowland, allows realize the sewage networks by various principles. The investment process needs to revalue the approaches, needs to take the consideration, that the building sewage will be operated under the municipalities, which will be want to operate it without non wanted operational costs involved by the improper design, or no adequate cheap investment.

The sewer designing could be in alternatives - mean gravitational, pressure or vacuum sewage system very often decides the financial conception solution. Especially the flat areas allow using these alternative solutions, which very often saving the money, but the relevancy mirror could be not clear.

Minimal slope

The present Slovakia sewage state, when the greatest problem of the build is non design documentation, but the investment gaining and the fastest building process, shunts the technical, especially operational conditions on the minor side. The sewage alleviation is no discussed, only quantitative aspects are important. It concerns to the gravitational solution. The problem will be significant in the future when no only operational costs will increase, but rehabilitation and reconstruction will be necessary, too, together with the increasing financing.

The present minimal slope recommended in Slovakia sewage design is defined by the empirical equation (1)

$$i_{min} = {}^{1500}/_{D} \qquad (1)$$

Where D is the sewer diameter in millimeters and the minimal slope define the build-technical slope, which is possible to observe in building process and this slope have no eligible value concerning sewage alleviation, where the sewer slope we need to define regarding the amount and quality of waste water. The minimal slope were defined till few years ago and through more than 50 years by the equation (2)

$$i_{min-historical} = {}^{1000}/_{D} \qquad (2)$$

It was more advantage in the design process, especially when the minimal allowed sewer diameter were DN 300 mm against present recommended DN250. The historical design saved the excavation and together the investment costs and allowed more sewer capacity reservation and in the flat areas saved the number of pumping stations.

The present value of minimal slope (1) is insufficient - despite of slope increasing This opinion is supported by the authors Stránsky D. et al. [2], which are interested about the question of alleviation and related problems of the odor. They recommend the minimal slopes, which are mentioned in the table 1. The columns (3) and (5) are the multiplication of the columns (1)x(2) and (1)x(4). These aspects clear the situation and we can say that there is no empirical influence between the recommended slope and sewer diameter. Mentioned values of minimal slope were determined by the influence of minimal recommended transportation waste water velocity v_t, at which the dry weather sewage recommended for the Q_{hmax}=0,6 m.s^{-1}. In the case of combined sewer system, the 0,75 m.s^{-1} is recommended and in the case of storm water sewage this value is represented 0,75 m.s^{-1} where the flow is Q_p - average flow.

Self-cleaning slope

The EN752 recommendations for the design of dewatering and sewer systems are explicitness and want to prevent the sewers against the permanent drift deposition, which increasing the risk of the flooding involving by the sewer system and follow environmental pollution.

The sewers bedded in the minimal slope are drifted and we need to clean it. The Čížek [1] in the 1953 advised to compute the sewer slope of the combined sewage with the exploitation of the equation for critical tangential tension near the wall of the sewer pipe by the eq. (3)

$$\tau = \rho . g . R . i_o \ (N.m^{-2}) \qquad (3)$$

Where

τ – Tangential tension - [Pa]

g – Gravitational acceleration – [m.s^{-2}]

R – Hydraulic radius – [m],

i_o – Slope

When we put $\tau_{critical}$ =4,0 Pa for combined sewer system, then self-cleaning velocity is defined by eq. (4).

$$v_s = 0{,}02 . R . 0{,}167 . n^{-1} \ (m.s^{-1}) \qquad (4)$$

Where

n – Manning's roughness coefficient.

In the case of dry-weather sewage we choose the $\tau_{critical}$=2,0 Pa [3]. The sewer bottom slope is equal i_s=0,00204/R, and the R is relative to the average dry-weather flow Q_{b24}.

Table 1. Recommended values of minimal slopes in dependency on sewage type

Indicators	Recommended value				
Minimal recommended slope	(1) DN [mm]	(2) Sanitary sewage [‰]	(3) x/D x	(4) Combined sewage [‰]	(5) x/D x
	250	18	4500	12	3000
	300	14	4200	9	2700
	400	9	3600	6	2400
	500	7	3500	5	2500
	600	6	3600	4	2400
	800	5	4000	3	2400

Computer application

The design software exploitation in the flat areas is the effective tool for the alternative sewer system design. The hand calculation of sewer system take too much time, this is maybe inaccurate and very difficult. The software using offer the chance in a short time to investigate more alternatives of design, the using of more diameters of sewers and solve the conception of sewer pumping station.

The Department of Sanitary and Environmental Engineering use offer the solution, through the computational system SeWaCAD, which offer to design alternative solutions with the possibility of alternatives comparing. The using minimal diameter DN250 against DN300 in older period bring the saving the profile diameter, but not excavation and number of pumping stations. To elaborate of alternatives could clear us the effective solution, and answer the question, what is effective. For example the historical approach uses the minimal slope 3,33‰ with the profile DN300 against present minimal slope 6 ‰ together with the DN250 diameter using. It caused the lost of elevation 60 cm – 33 cm = 27 cm for every 100 meters, which represent total lost of elevation 2,7 meters per 1 km of sewer length. So we can very easy assert that we need to build twice more pumping stations against older principles. If is it effective or no, we find this answer through the alternative design evaluation, from technical and economical view, with the respecting the operational conditions and operational costs. We can say that influence of terrain composition play the important role in sewer system design. Evaluation of many sewer system design in various conditions offer for us declaration, that saving profile diameters DN250 is not in every case the clever solution, but in many cases legitimate. And we can declare, that only complex alternative solution could give answer this question.

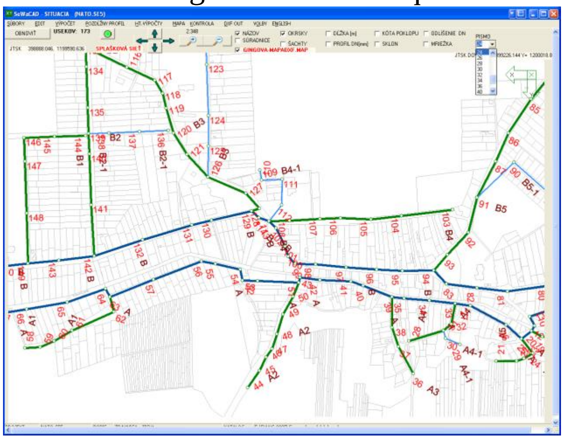

Fig. 1. Computational example of sewer system design in the flat area (SeWaCAD)

Under-pressure or vacuum sewage

Is the alternative way of sewage concerning only for sanitary waste waters in the locations, where the problem to build the gravitational sewer system from the technical is or investment view.

This system we can use in location, where the storm water dewatering system is done and where we want to save the environment against the excavation together with the saving of building works, and where we want to save a relative financial costs. The word relative is for discussing, because investment costs saving with the excavation and profiles, which are from DN50 do DN200, against gravitational sewer system which start from DN250 are become evident, when we need to build the vacuum station with the relatively high operational costs concerning energy, which is needed for making the vacuum in the pipes. The under-pressure range is usually from 400 to 500 mm of quicksilver column, minimum 175 mm from the maximum 760 mm, which represent theoretically max. 7,5 m of water column. Under-pressure 400-500 mm allows overrunning the elevation differences approximately from 4 to 5 m.

The main part of this sewage becomes the vacuum station, which produces the under-pressure. This part is very demanding for the energy, which could cause the operational of this system economically intolerable.

Sewage waters are collected through the system of pipes in the collection container, from this there are transported to the WWTP. The advantage of such sewage is a minimum depth of the bedding, the ease exploitation by user and groundwater protection.

Its use is appropriate when we have a problem to build a gravity sewer system in places where there are no suitable geological conditions such as high groundwater level, soil inconsistency - sands (Slovakia - Záhorie).

The application vacuum sewer system requires the build management base on the assumption of construction quality.

The insufficiency of this type of sewage is noted by the residents in the village Vajnory in Slovak republic, when was implemented [6] this type of sewage, and there was published the instruction article in the local newspaper, how to exploit this sewage, and after the state is unsatisfied [5].

Pressure sewage

The idea of pressure sewer system started up as alternative dewatering of small residential areas, small municipalities in flat areas, resp. on the terrain with the low elevation differences with the aim to save an investment costs. The greatest influence has investors. The operational quality depends on equipment, mainly on end pressure stations, on tide gate. Results from the operational experiences of pressure sewage say that this sewage alternative can be favorable. The build of pressure sewer system is suitable in spread areas, in recreational zones. From the financial demand, this type of sewage is the most competitive, considering the argument, that the pumping stations are situated on the residential owners, which are financing and operating the pressure pumping stations. From the operational company this is an advantage, but on the other side it could generate the complex problems concerning the faults cause by this pressure pumping stations.

How to make a decision

In EU countries every designer must consider, which type of sewer system will be designed, base on investment costs, operational costs and from the technical opportunities. In the places, where is the slope of terrain enough, the gravitational is more effective than in flat areas. We reflect the vacuum system designing in the next cases:

- Inadequate nature slope
- Isolated or rare build-up area
- No quality underbed
- Zone of hygienic water supply protection

- Barriers in the way of build – other engineering networks, water streams
- Seasonal operation - touristic zones
- In the places where we need to eliminate excavation works

The vacuum sewage design consists from the network design, longitudinal profiles designing, the separate branches designing and the location of collection manholes. The main criteria of design is the appraisal of total pressure loses on separate branches of the system, where are the losses involved by friction - mixture of water-air in the velocity 6 $m.s^{-1}$ and local losses which are involved by the flow direction – refractivity. The determining item is the energy demand needed for vacuum station air-pump engine and pumping stations. The specific demand of energy for air-pump power drive increases with increased length of main sewer branches. [9]

Conclusion

The built-up of sewage in flat areas is the intersection of investor interest and operator. The decision which type of sewage we will build up and how we will solve this problem absolutely belong under expert decision, and this is very incorrect, if this decision is accepted by the investor, without expert and operator discussing.

The experiences show, that investment interests have the highest priority for decision and it mean the saving investment costs without interest on the operational experiences. The final problem is transferred on operational company, on users of the sewage. The start decision, which sewer type we will build up, have a longtime impact and this could be very negative in the horizon of more years, could have an impacts on lifetime of sewage, to transfer the problems into the future. Eighty percent of a municipality's problems are caused by twenty percent of its sanitary sewers and storm water drainage systems. The best way to avoid the majority of future problems is to pay greater attention to them during the design phase.

Only clever and expert approach of main decision, supported by expert could have an effective, optimal impact on dewatering the area from waste waters.

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