INCORRECT PROPOSAL OF RUNOFF DRAINAGE THROUGH INFILTRATION FACILITY - CASE STUDY

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ABSTRACT. - Incorrect proposal of runoff drainage through infiltration facility - case study. Imbalance of the natural dynamic equilibrium between the processes of percolation, evaporation and surface runoff is caused because of urbanization of the previously natural areas which are transformed by humans now. More and more rainwater flows over the surface of the catchment area. Infiltration facilities are devices designed for fluent and natural infiltration of rainwater from the roofs of buildings and paved surfaces. Facilities for infiltration as one of source control measures are permeable paved areas, unpaved areas for infiltration, vegetated swales, vegetated buffer strips, bioretention, detention ponds, dry well, infiltration basins and infiltration gallery and many more. Rainwater drainage from the bridge object in Sarisske Luky in Presov district (Slovakia), using infiltration gallery is presented in the paper. Its capacity is not efficient now, so the reconstruction or other supplement solution is needed. From the wide possibilities of solutions, one of them which full fills all criterions about the rainwater infiltration in selected building object is presented and discussed.

Keywords: rainwater management, infiltration gallery, Sarisske Luky, Slovakia.

1. INTRODUCTION

Stormwater infiltration systems capture stormwater runoff and encourage infiltration into surrounding in-situ soils and underlying groundwater. This has the benefit of reducing stormwater runoff peak flows and volumes, reducing downstream flooding, managing the hydrologic regime entering downstream aquatic ecosystems and improving groundwater recharge (Poórová et al., 2015).

The purpose of infiltration systems in a stormwater management strategy is as a conveyance measure (to capture and infiltrate flows), NOT as a stormwater treatment system. Appropriate pretreatment of stormwater entering infiltration systems is required to avoid clogging and to protect groundwater quality.

Infiltration systems generally consist of a 'detention volume' and an 'infiltration area' (or infiltration surface):

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- the ‘detention volume’ can be located above or below ground and is designed to detain a certain volume of runoff and make it available for infiltration. When the ‘detention volume’ is exceeded, the system is designed to overflow to the downstream drainage systems and the receiving environment;

- the ‘infiltration area’ is the surface or interface between the detention volume and the in-situ soils through which the collected water is infiltrated (GCCC, 2005).

A sub-surface water filtration system designing allows water to infiltrate into surrounding soils with the purpose to encourage stormwater to infiltrate into surrounding soils, to reduce runoff as well as provide pollutant retention on site and to provide some detention and retention functionality (GCCC, 2005).

In the engineering design of systems for detention storage volume associated with infiltration many measures are distinguished. Infiltration trench, permeable pavement, infiltration basin, detention basisn, detention vault, retention pond and infiltration gallery are often use (SFSDG, 2009).

An infiltration gallery is horizontal drain made from open joined of perforated pipes, or a block drain, which is laid below the water table and collects groundwater. Infiltration galleries need soils that are permeable to allow sufficient water to be collected. The gallery should be surrounded with a gravel pack to improve flow towards it and to filter any large particles that might block the perforation (Markovič et al. ,2015; WSSCC WHO, 2005). It can be built in these steps: excavation a trench to at least 1 m below the water table, supporting the sides to prevent collapes, laying graded gravel on the base of the trench then laying the pipe on drain blocks on the top of the gravel. Cover the top and sides with more graded gravel and finally cap the gravel with impermeable layer of puddled clay to prevent surface water entering the gallery (WSSCC WHO, 2005).

For the purpose of rainwater drainage from the bridge object in Sarisske Luky in Presov district (Slovakia) presented in this paper an infiltration gallery was used. Its current state do not full fill the requirements for drainage the rainwater so new calculations, design of new measures are consequent reconstruction or reparation is needed.

2. MATERIAL AND METHODS

Experimental research of infiltration efficiency is located in Šarišské Lúky near Prešov-city. Rainwater infiltration as a drainage solution is from bridge road after its reconstruction. The infiltration gallery from infiltration units was designed in the monitored area by theoretical calculation.

Bridge object (Figure 1) is located on road 1/8 between Prešov and Kapušany. Approached two-way road on the bridge contains 4 lanes. It is bridge road over the train and local road MK Sekčov and road III/06815. Roadway on the bridge has one-sided slope 1.5% (Markovič and Vranayová, 2013; Zeleňáková and Rejdovjanová, 2014).

Fig. 1. ***Studied bridge object***

Figure 2 shows the location of measuring equipment and objects for research. Rainwater from the bridge flows into filter shaft, which serves for capture and sedimentation of coarse and fine impurities. The rainwater subsequently flows into the infiltration gallery, where the water is filtered during infiltration to the soil. A flow meter is located in the filter shaft, which record incoming rainwater in l/s. The water level in the infiltration gallery can be monitored by means of the float-gauge which is located in inspection shaft. Near this infiltration gallery is located rain-guage.

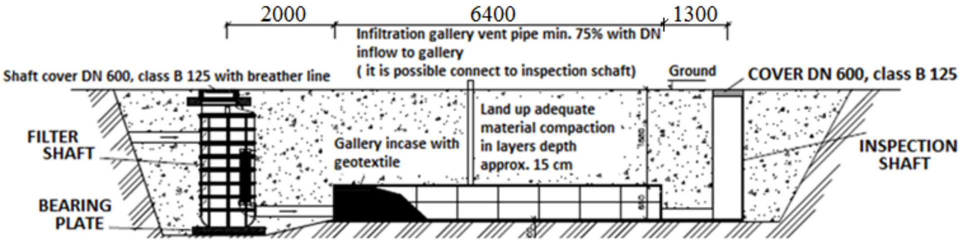

Fig. 2. ***Infiltration gallery – longitudal section***

The percolation gallery is formed by plastic units. The percolation area of the infiltration gallery is 46.08 m^2. Its surface is rectangular. They are designed according to standard ATV - DVWK - A 138 Design of infiltration modules of rainwater which is used in the most of EU states.

Used infiltration module HAURATON DRAINFIX – BLOC is made from strong polypropylene. Space structure of armed pieces allows reaching high substance and carrying capacity, pressure substance in upright course achieves 600 kN/m and in horizontally course 120 kN/m.

It is possible to use infiltration blocks under roads and trucks parking places, thanks to reached values. Each blocks may be put in more layers and so create infiltration entity with huge capacity on smaller surface. Depending up on proposed conveyor duty and friction angle of surrounded soil it is possible to put modules to the depth of 7.10 m below the ground level.

Infiltration block parameters are 0.60 x 0.80 x 0.33m (length x width x height).

These infiltration modules were used in terrain in which research will be done. Detailed characterization of infiltration process, which is object of future investigation, is included in next chapter.

3. RESULTS AND DISCUSSION

During the design phase of the infiltration gallery the infiltration coefficient was estimated by designer as 8.2E-05 m/s. All parameters of infiltration gallery were calculated with this infiltration rate which should ensure a sufficient and suitable percolation characteristics for this facility.

But results from laboratory test set infiltration coefficient in area of interest as 4.84E-07 m/s. It means about 100 times lower infiltration efficiency and also lower accumulation volume of infiltration gallery as was design for safe disposal of rainwater runoff. This results to insufficient infiltration rate of this percolation gallery. Infiltration coefficient 4.84E-07 m/s represents practically impermeable type of soil not suitable for infiltration facilities. Unfortunatelly this inaccurate design caused flooding and silting all infiltration gallery and result to failure of installed devices for research (Figure 3).

Fig. 3. ***Flooded filter shaft with measurement devices***

Figures 4-6 represent typical process of rainwater percolation in infiltration gallery respectively water level in gallery during the month of April, May, and June 2013. Data from research showed that there was continuously high water level in percolation gallery. This represents a very low infiltration rate of this infiltration gallery what is given by the coefficient of infiltration of soil at the bottom of gallery determined as k_f = 4.84E-07 m/s and also means overfill of percolation gallery.

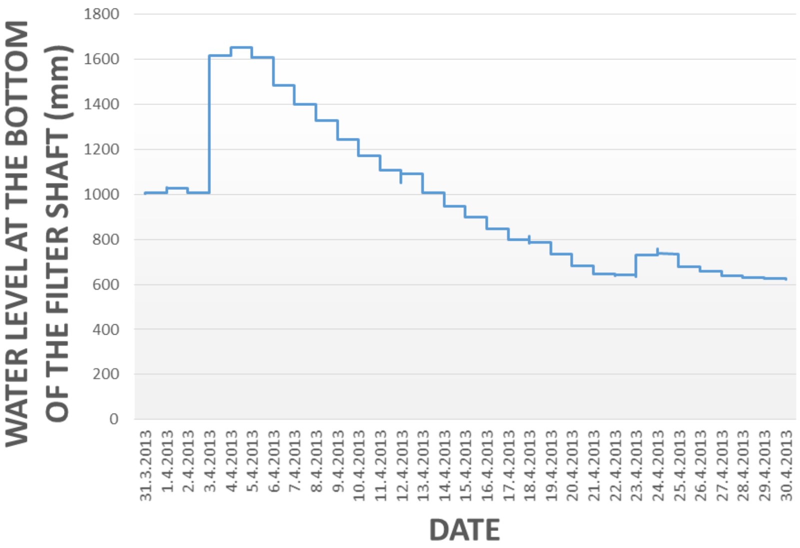

Fig. 4. ***Water level variations at the bottom of filter shaft during April 2013***

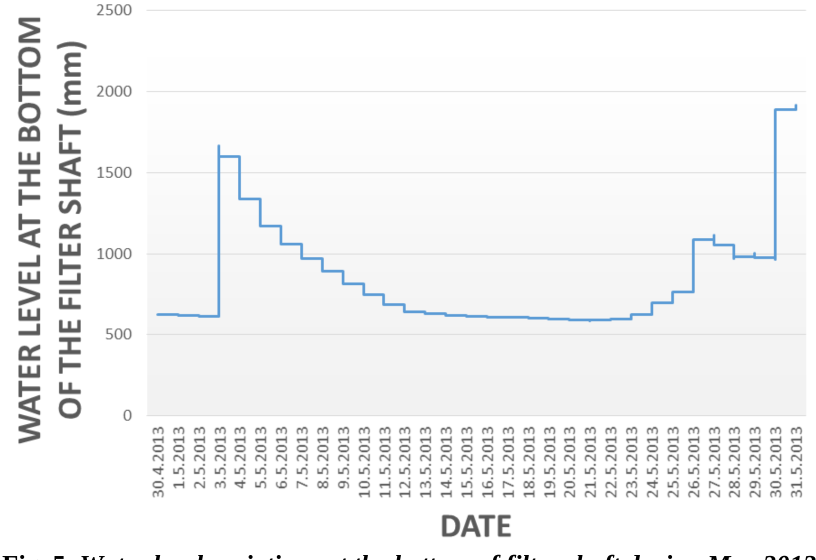

Fig. 5. ***Water level variations at the bottom of filter shaft during May 2013***

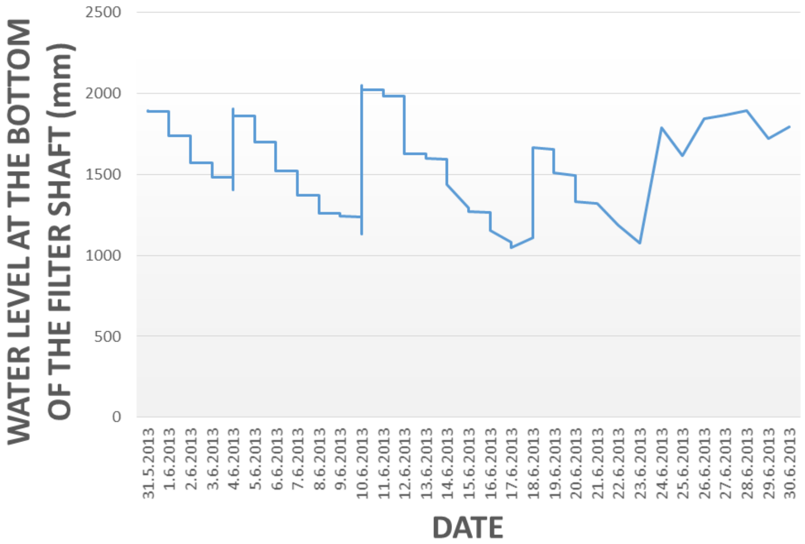

Fig. 6. ***Water level variations at the bottom of filter shaft during June 2013***

When soil has a poor percolation rating, water cannot enter the ground unimpeded during a rainfall event; it either ponds on the surface or runs off the land. Runoff can carry soil particles and other contaminants to streams and lakes, increase the chance of local flooding of streams and rivers, plus result in accelerated soil erosion.

Permeability of the infiltration zone is a main qualitative and quantitative requirement for rainwater infiltration. Permeability of loose rock depends primarily on the size and distribution of the particles and compactness, in soils is critical soil structure and water temperature and is given by the infiltration coefficient. Permeability of loose rock varies in general between 1.10E-02 and 1.10E-10 m/s. The k_f values apply to the process of infiltration water in the saturated zone. The range of values for the filtration coefficient for technical drainage ranges from 1.10E-03 and 1.10E-06 m/s.

4. CONCLUSIONS

The most often causes of incorrect proposal and incorrect operation of percolation facilities is resulting from poor or no information of geogogical or hydrogeological conditions in site - incorrect percolation area design, poor or no information of meteorological data – estimated amount of precipitation, compliance with size of the drainage area and real size of the drainage area after realization, incorrect calculating of required volume of infiltration facilities, incorrect separation distances, realization nit corresponding with drawings, poor or no maintainace of percolation facilities. Choosing of suitable type of infiltration measure depends on local condition but we have to also consider the principles of design of percolation/infiltration measure especially distance from building, hydrogeological conditions in site of design, infiltration coeficient or groundwater level.

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