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RAINWATER CONSERVATION IN THE CZECH REPUBLIC

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Abstract. In the Czech Republic valid legislation (268/2009), (501/2006) demands a reduction of rainwater outflow from real estates. At present in the Czech Republic regulations for rainwater harvesting and infiltration are finalizing. The Czech standard CSN 75 9010 for rainwater soakaways is in completing process and there is also ready the Technical Tool of Czech chamber of chartered engineers and technicians (TP 1.20) about rainwater conservation management. This paper shows principles of design of rainwater harvesting systems and rainwater soakaways based on above regulations. The paper is also coupled with an example of overground soakaway dimensioning.

Keywords:.Rainwater conservation, reduction of rainwater outflow, rainwater infiltration, soakaway.

1. Introduction

In the Czech Republic valid legislation (268/2009), (501/2006) demands a reduction of rainwater outflow from real estates. Till this time sufficient technical basis for designing of rainwater conservation facilities have been missing. To restrict potential damages which can arise out of unprofessional design of these facilities (e.g. low retention volume designed just for 15 minutes rainfall etc.), there was published a technical tool of Czech chamber of chartered engineers and technicians (TP 1.20) and at the same time the Czech standard dealing with rain water soakaways (CSN 75 9010) has been completed.

2. Rainwater conservation in real estates

The conception of rainwater conservation implies:

- reduction of rainwater outflow into a sewer system or a river;
- rain water infiltration in soakaways;
- rain water utilization for a garden watering, flushing of WCs etc.

2.1. Reduction of rainwater outflow into a sewer system or a river

Reduce of rainwater outflow from real estates is possible to solve by means of vegetative roofs or detention tanks. Reduce of vegetative roof rainwater outflow depends on pervious layer thickness. The more the thickness of pervious layer over a waterproofing is, the less the outflow from a vegetative roof is.

The detention tank is a reservoir with throttling outfall situated below terrain level outside of a building, both covered and uncovered. Exceptionally the detention tank can be situated inside of a building. The detention tank outflow must be designed in order not to overrange permitted throttling outfall at the maximum working level. In front of the flow control device there should be stuffed a safety device to capture foreign matters (i.e. screens, strainer).

If the crest or detention tank waste pipe is situated under the backwater level in a sewer where the detention tank is drained, there must be a check valve stuffed both on a drain pipe and a overflow pipe.

The outfall is strangled by following devices:

- low pipe diameter;
- flow control device;
- whirl valve;
- pump (usually at least two pumps, one of them as a one-hundred-percent backup).

The detention tank outflow can be solved gravitationally when the gradient to a sewer or to a river is adequate. If gravitation drainage isn´t realizable, there is possible to solve the drainage by the help of pumping.

2.1.1. Storage volume of detention tank sizing

Storage volume of a detention tank V_{ret} (l) is given by the equation:

$$V_{ret} = \left(i \cdot A_{red} - Q_o\right) \cdot t_c \cdot 60 \qquad (1)$$

where: i is rainfall intensity (l/s.m^2) of return period and its duration, A_{red} is the reduced area receiving rainfall (measured horizontally) (m^2) according to (2), Q_o is allowed rainwater reduced flow from detention tank (l/s) ,t_c is rain-fall duration (min).

For a storage volume assessment of surface (uncovered) detention tanks it is necessary to add the surface area of a detention tank to the reduced area receiving rainfall (measured horizontally). The calculation is accomplished for all the rainfall intensities with the maximum return period of 0.2 year $^{-1}$ and duration from 5 min to 72 hrs and then the biggest storage volume of detention tank is designed.

The reduced area receiving rainfall (measured horizontally) Ared (m2) is given by the equation:

$$A_{red} = \sum_{i=1}^{n} A_i \cdot C_i \qquad (2)$$

where :A is the area receiving rainfall (measured horizontally) (m^2), C is the runoff coefficient according to the type and gradient of area receiving rainfall (see e.g. table E.3 in EN 752), n is the number of areas receiving rainfall.

2.2. Rainwater infiltration

Rainwater infiltration is realized in overground or underground soakaways and they can be used only in places where any static risks of buildings, roads, slopes etc. aren´t possible. Soakaways must be situated in sufficient distance from buildings. During decision making within a proper solution of infiltration there is the most important criterion the rainwater quality and usability of rock backround couched in a soil infiltration rate. Geological infiltration survey must precede every decision-making about rainwater infiltration in specific areas. Its outputs are necessary to respect. Rainwater from green areas, unleaded roof surfaces and terraces, roads for pedestrians and cyclists and low frequency roads are possible to infiltrate without pretreatment. Within the rainwater from the rest of areas pretreatment is needed, e.g. in upper soil level (by the surface soakaways), in settling chambers or separator for light liquids.

2.2.1. Types of soakaways

Soakaways are classified into the overground or underground devices.

Among the overground soakaways it is ranked:

- shallow terraine depression devices (Fig 1);
- surface grassed soakaways and ditches.
- Among the underground soakaways it is ranked:
- underground space filled in coarse sand with drainage pipes;
- underground space filled in plastics cells;
- tunnel systems (underground drainage tunnels);
- drainage well (Fig 2).

From every soakaway there must enabled water outfall during an overfill, e.g. on terrain surface not to building flood out. Every soakaway must be equipped with ventilation.

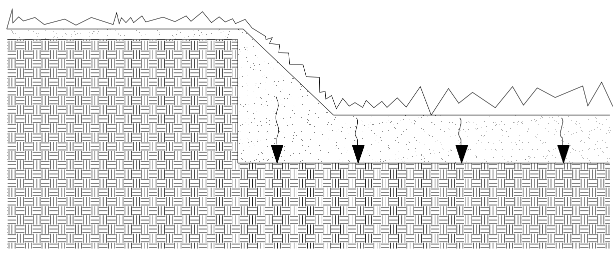

Fig 1. Shallow terraine depression device

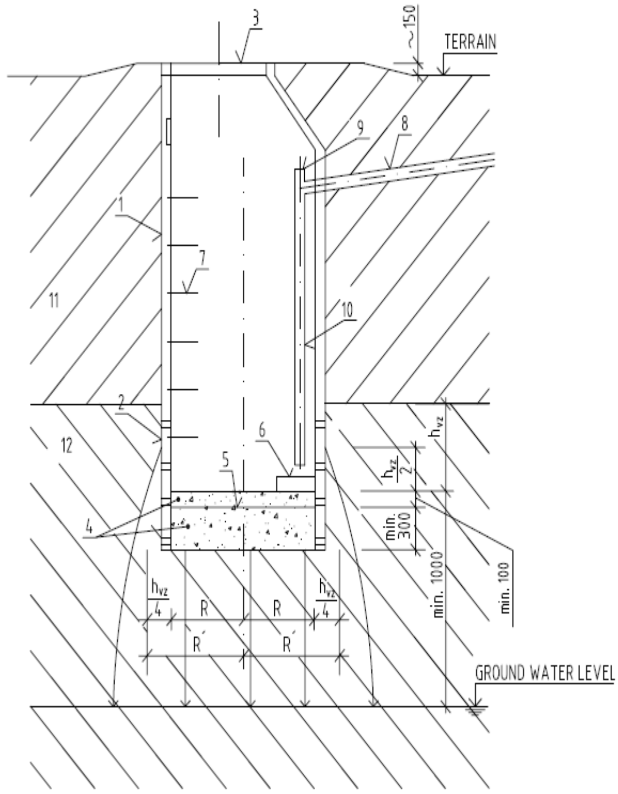

Fig 2. Drainage well: 1, 2 – shaft rings, 3 – grating, 4 – gravel, 5 – geotextile, 6 – paving brick, 7 – climbing-iron, 8 - inflow pipe, 9 – open socket, 10 – vertical pipe, 11 – impermeable rocks, 12 – pervious soil

2.2.2. Sizing of soakaways

Storage volume of soakaway and time of soakaway emptying are necessary to specify to soakaway size. Storage volume of soakaway V_{vz} (m^3) is given by the equation:

$$V_{vz} = \frac{h_d}{1000} \cdot \left(A_{red} + A_{vz}\right) - \frac{1}{f} \cdot k_v \cdot A_{vsak} \cdot t_c \cdot 60 \qquad (3)$$

where: h_d is total rainfall (mm) of given return period and duration (Table 1), A_{red} is the area receiving rainfall (measured horizontally) (m^2), given by the equation (2),

A_{vsak} is the area of porous bottom of the soakaway (m^2) (simplified), A_{vz} is the area of water level of the soakaway (m^2) (only for overground soakaway) f is assurance coefficient ($f \geq 2$), k_v is soil infiltration rate (m/s) listed in geological survey outputs, t_c is rain-fall duration (min) (Table 1).

The calculation needs to be done for every rainfalls sum with the maximum return period of 0.2 year $^{-1}$ and duration from 5 min to 72 hrs and then the biggest storage volume of detention tank is designed.

Table 1. Maximum of total rainfalls in the Czech Republic with duration time 5 min up to 4320 min (72 h)

Altitude of locality (m a.s.l.)	Return period p (year $^{-1}$)	Rainfall duration $t_{c,}$ (min)					
		5	10	15	20	30	40
		Maximum total rainfalls $h_{d,}$ (mm)					
> 650	0,1	12	18	21	23	25	27
	0,2	14	21	24	27	30	32
≤ 650	0,1	11	15	17	20	23	26
	0,2	12	17	20	22	26	30

Table 1 cont.

Altitude of locality (m a.s.l.)	Return period p (year $^{-1}$)	Rainfall duration $t_{c,}$ (min)					
		60	120	240	360	480	600
		Maximum total rainfalls $h_{d,}$ (mm)					
> 650	0,1	29	35	39	44	49	50
	0,2	35	42	46	54	56	58
≤ 650	0,1	30	40	49	58	67	76
	0,2	35	46	56	67	77	87

Table 1 cont.

Altitude of locality (m a.s.l.)	Return period p (year $^{-1}$)	Rainfall duration $t_{c,}$ (min)				
		720	1080	1440	2880	4320
		Maximum total rainfalls h_d (mm)				
> 650	0,1	51	54	55	73	85
	0,2	59	63	66	88	100
≤ 650	0,1	85	99	104	156	179
	0,2	98	122	130	200	235

Time of soakaway emptying T_{pr} (s) doesn´t have to get over 72 hrs and is given by the equation:

$$T_{pr} = \frac{f \cdot V_{vz}}{k_v \cdot A_{vsak}} \qquad (4)$$

where Vvz is the storage volume of the soakaway (m3) given by the equation (3), f is assurance coefficient (f ≥ 2), kv is soil infiltration rate (m/s) listed in geological survey outputs, Avsak is the area of porous bottom of the soakaway (m2) (simplified).

2.2.3. Example of overground soakaway designing

The aim is to determine a storage volume and time of soakaway emptying from the area receiving rainfall (measured horizontally) A_{red} = 527 m^2. There is given soil infiltration rate k_v = 10^{-5} m/s, assurance coefficient f = 2 and return period p = 0,2 year^{-1}.

Fig 3. Underground space filled in plastics cells

Estimation of area of porous bottom of the soakaway is given by the equation:

$$A_{vsak} = 0{,}1.\ A_{red} = 0{,}1\ .\ 527 = 52{,}7\ \text{m}^2.$$

The area of water level of the soakaway is simplified took up (A_{vz} = 52,7 m^2) the same as the area of porous bottom of the soakaway.

Sizing of storage volume of soakaway according to (3) is given in the Table 2 in view of maximum total rainfalls from Table 1. The result is designing storage volume of soakaway V_{vz} = 20,82 m^3, which is the biggest from the calculated volumes. Time of soakaway emptying is according to (4) a does T_{pr} = 22 h, therefore less than 72 h.

Table 2. Storage volume of soakaway

Rainfall duration t_c, (min)	Total rainfalls h_d, (mm)	Storage volume of soakaway V_{vz}, (m^3)
5	12	6,88
10	18	10,28
15	21	11,94
20	23	13,02
30	25	14,02
40	27	15,02
60	29	15,86
120	35	18,39
240	39	18,81
360	44	19,81
480	49	20,82
600	50	19,50
720	51	18,18
1080	54	14,23
1440	55	9,12
2880	73	- 3,21
4320	85	- 19,02

2.3. Rainwater harvesting

Rainwater drained from roofing is usually possible to purify mechanically, collect and use in a building as non-potable water both for urinals and WCs flushing and for garden watering outside a building. Rainwater storage tanks can be placed outside and inside of a building. Rainwater using in a building demands creation of separate water supply and piping of rainwater (non-potable water) distribution can´t be connect with piping of drinking water distribution. Supply of rainwater (non-potable water) distribution by the drinking water in dry period must be done through the air gap in accordance with EN 1717.

2.3.1. Rainwater storage tank sizing

Capacity of rainwater storage tank assessment V_a (l) is given by the equation:

$$V_a = Q_d \cdot d_1 + q_z \cdot A_z \cdot d_2 \qquad (5)$$

where: Q_d is daily non-potable water demand for using in a building (l/day), d_1 is number of days in a matter of 14 to 21 days with dry weather, when using the water in a building, q_z is non-potable water demand for watering or sprinkling (l/m^2), A_z is the area of a garden, a sport-ground or a greenth (m^2), d_2 is number of days in a matter of 14 to 21 days with dry weather, when using the water in a building for watering or sprinkling.

3. Conclusion

Because it is necessary to restrict rainwater outflow to sewerage and also conserve drinking water, rainwater management grows on importance. To avoid of inefficient mistakes in design, construction and operation of facilities for rainwater conservation technical regulations are advisable.

Acknowledgments

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References

*Czech Regulation no. 268/2009 Sb.; about technical requirements on buildings.*2009.

Czech Regulation no. 501/2006 Sb.; about general requirements on territory use as amended by Czech regulation no. 269/2009 Sb. 2009.

ČSN 75 9010 Design, construction and operation of rainwater soakaways (draft). Czech Office for Standards, Metrology and Testing. Prague, 2011. 41 p.

EN 752 Drain and sewer systems outside buildings. European committee for standardization. Brussels, 2008. 94 p.

EN 1717 Protection against pollution of potable water in water installations and general requirements of devices to prevent pollution by backflow. European committee for standardization. Brussels, 2000. 49 p.

Technical Tool TP 1.20. 2010. Rainwater conservation in real estates. *Czech chamber of chartered engineers and technicians.* Prague. 2010.