CIVIL AND ENVIRONMENTAL ENGINEERING REPORTS

No. 8 2012

PEAKING FACTORS OF DRY WEATHER FLOWS IN GŁOGÓW COMBINED SEWAGE SYSTEM

Ireneusz NOWOGOŃSKI*, Ewa OGIOŁDA
University of Zielona Góra, Faculty of Civil and Environmental Engineering,
Institute of Environmental Engineering
Szafrana st 15, 65-516 Zielona Góra, Poland

This paper presents the results of dry weather flowrate studies in inflow and outflow channels of overflow structure PB-1. The facility is located in P.Skargi Street in Głogów. Based on the results the average daily peaking factor of dry weather sewage outflow was estimated. Low efficiency of the algorithm allows the estimation of the flow when depth of the channel is less then 20 cm and when it is not possible to perform measurements with the ultrasound probe. Pointed to inadequate reconstruction of cross-sectional shape of the channel during device configuration as the cause of getting inconsistent results. The results of corrective calculations based on Manning's formula and typical cross-sections of channels were presented. Obtained results confirm the possibility of significant differences obtained when the channel parameters are configured incorrectly. Confirmed the low quality of the built-in algorithm supporting measurements at low depths, mistakenly called by the device manufacturer "Manning's formula method".

Keywords: combined sewage system, dry weather flowrate, peaking factor

1. INTRODUCTION

In designing of sewer systems, good estimation of design maximum flowrates are very important. Sewer system needs to have capacity large enough to accommodate increased domestic flows associated with increases of population and system expansion (Moulton 1999). Good estimation of minimum flowrates are valuable when designing combined sewer system. If the flowrate is too small, solid deposits can become substantial and adequate self-cleaning isn't achieved. Analising of existed systems is connected with choosing adequate measurement equipment. The use of profiling flowmeters to measure flowrate in

* Corresponding author. E-mail: i.nowogonski@iis.uz.zgora.pl

the channels seems to be a very good solution. Advanced algorithms for auto-calibration, measurement using more than one ultrasonic probe, suggests the possibility to obtain reliable results. In practice, it turns out that despite the higher cost repeatedly obtained results are far from ideal. The least reliable results are obtained when the small depth is observed. In theory, the method of calculating the flow rate using the Manning's formula is used here. Practically, algorithms that generate the flow curves, based on measurements of large fillings are used. As a result, incorrect results are obtained and their use is not possible.

2. RESULTS

The study was conducted in city Głogów with population of about 67 thousands people located in Dolnośląskie Province 60 km away from Zielona Góra. The combined sewer system serves an area of 3511 ha. Analyzed sewer system in Głogów is equipped with three combined sewer overflows with single side weir and one flow divider connected with storage facility.

Rainfall was measured by six tipping-bucket rain gauges (Fig. 1). Measurements were taken in all seasons of the year.

Fig. 1. Locations of rain gauges and overflow structures in the city

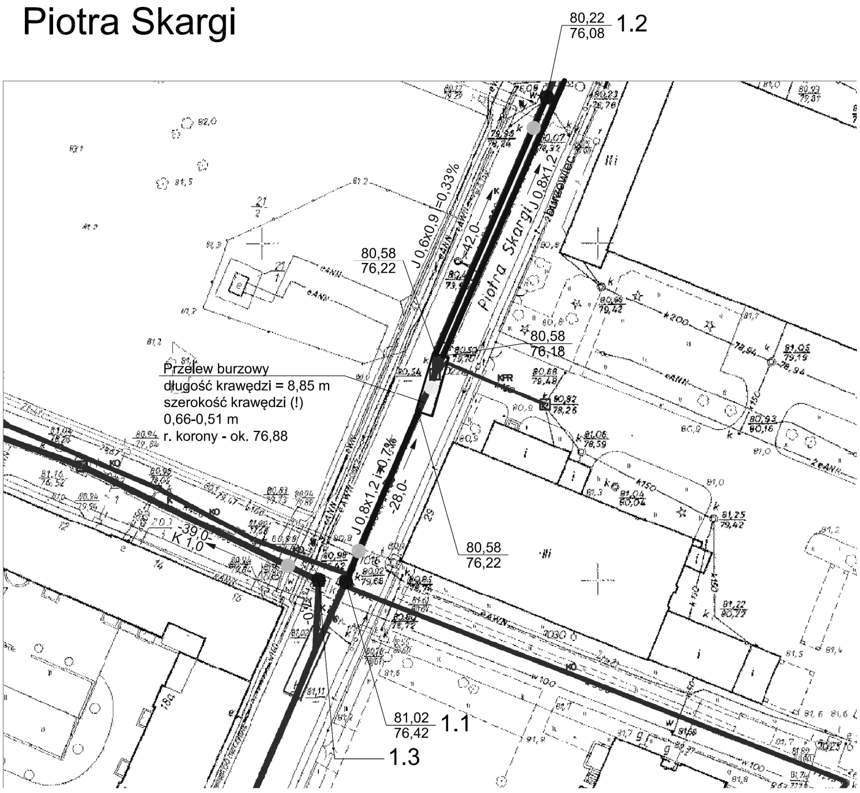

Fig. 2. Locations of flowmeters near overflow structure PB-1

Tab 1. Specification of dry weather minimum and maximum flow rates [lps]

Month	Skargi 1.1		Skargi 1.2	
	min	max	min	max
10.2011	5	64	12	56
11.2011	5	29	12	56
12.2011	6	52	12	47
01.2012	13	54	12	46
02.2012	14	60	12	51
03.2012	-	-	12	52
04.2012	13	55	12	45
05.2012	-	-	10	55
06.2012	11	51	12	44
07.2012	8	64	5	51

Tab 2. Specification of dry weather minimum and maximum depth [mm]

Month	Skargi 1.1		Skargi 1.2	
	min	max	min	max
10.2011	77	176	134	262
11.2011	77	160	132	252
12.2011	80	145	132	242
01.2012	86	151	135	224
02.2012	83	153	139	238
03.2012	-	-	143	244
04.2012	85	150	135	229
05.2012	-	-	132	233
06.2012	82	148	135	231
07.2012	98	164	137	248

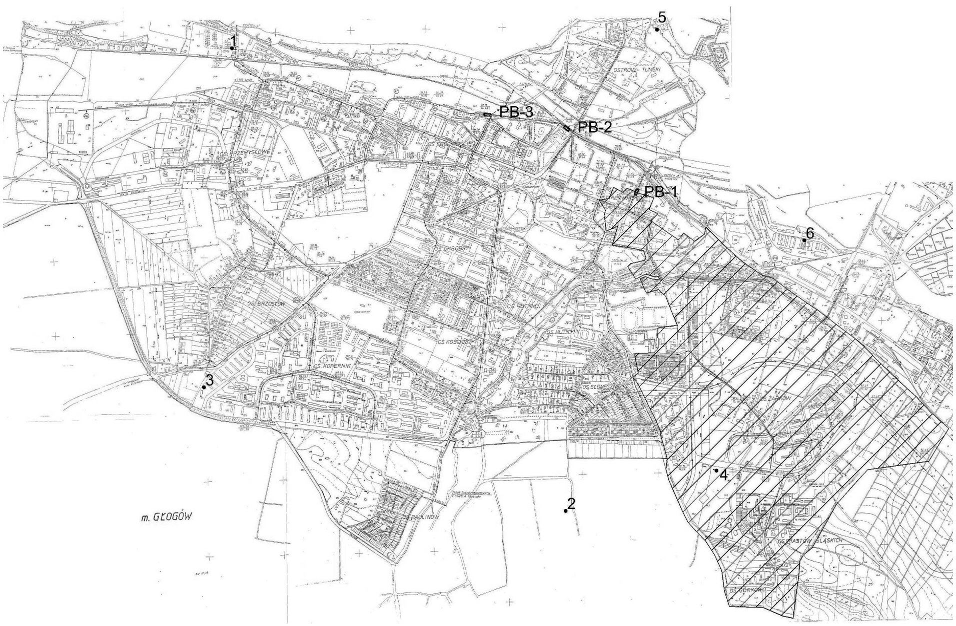

Fig. 3. Subcatchment connected with overflow structure PB-1

Flow rates were measured by ISCO ultrasonic profiling flow meters located at sewer manholes upstream and downstream of the CSO chambers. Special attention was taken to avoid improper installation of the ultrasonic probes (e.g., in sections with backwater effects or places with large amounts of sediments). All instruments were equipped with data loggers, which were fully synchronised and set for 5 min recording intervals. Locations of analysed flowmeters were shown on Figure 2.

Tab 3. Dry weather peaking factors estimation

Date	Flow rates – Skargi 1.1			Flow rates – Skargi 1.2		
	maximum	average	peaking factor	maximum	average	peaking factor
14.10.2011	56,0	40,2	1,39	43,0	24,1	1,79
16.10.2011	49,0	34,4	1,42	48,0	24,7	1,94
29.10.2011	22,0	15,9	1,39	39,0	25,2	1,54
31.10.2011	22,0	15,0	1,47	36,0	24,8	1,45
05.11.2011	22,0	16,2	1,36	40,0	14,0	1,51
15.11.2011	22,0	14,5	1,52	36,0	22,6	1,60
27.11.2011	21,0	14,5	1,45	39,0	24,3	1,61
29.11.2011	25,0	14,2	1,76	42,0	23,2	1,81
26.12.2011	52,0	34,6	1,50	43,0	24,0	1,79
31.01.2012	54,0	35,8	1,51	42,0	25,1	1,67
04.02.2012	50,0	35,6	1,41	51,0	26,4	1,93
07.02.2012	51,0	34,3	1,49	37,0	23,4	1,58
20.02.2012	-	-	-	41,0	25,5	1,61
02.03.2012	-	-	-	35,0	23,4	1,50
03.03.2012	-	-	-	52,0	25,8	2,02
04.03.2012	-	-	-	45,0	23,2	1,94
05.03.2012	-	-	-	35,0	22,0	1,59
07.03.2012	-	-	-	43,0	22,4	1,92
15.03.2012	-	-	-	43,0	24,3	1,77
20.03.2012	-	-	-	43,0	24,3	1,77
01.04.2012	47,0	32,4	1,45	37,0	22,4	1,65
11.04.2012	55,0	36,7	1,50	45,0	22,0	1,50
02.06.2012	47,0	32,4	1,45	44,0	24,5	1,80
24.07.2012	53,0	38,5	1,38	41,0	23,2	1,77
25.07.2012	54,0	37,6	1,43	44,0	24,8	1,90
26.07.2012	52,0	36,6	1,42	40,0	20,5	1,95
27.07.2012	56,0	37,5	1,49	51,0	27,3	1,87
Average	42,6	29,3	1,46	42,03	23,6	1,73

During dry weather periods minimum and maximum flows and depths of channels were specified from October 2011 to July 2012. The results are shown in Tables 1 and 2. For a detailed analysis 19 days when there was no rainfall were selected for position Skargi 1.1 and 27 for position Skargi 1.2. For each day minimum, maximum and average flow rate were specified. Based on the maximum and average values, peaking factors were estimated. The values of flow rates and peaking factors were shown in Table 3.

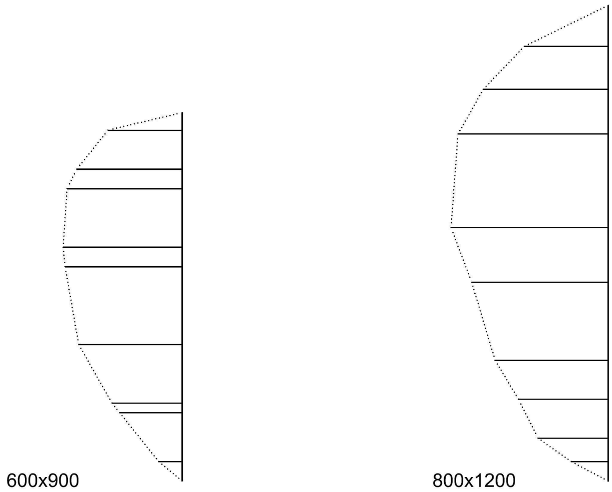

Fig. 4. Cross sections of channels reconstructed during the inventory

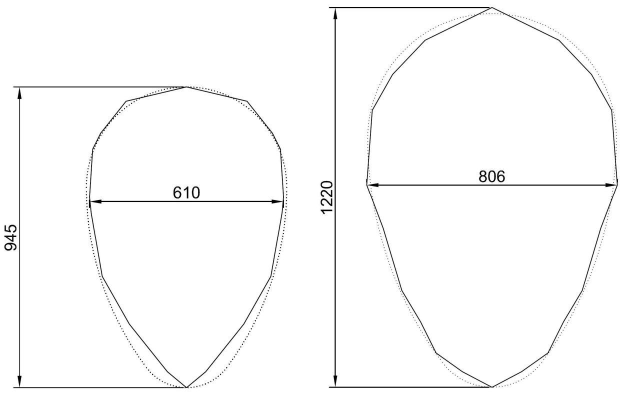

Fig. 5. Cross sections of channels reconstructed and typical

Flow rates in channels were estimated when depth is less then 20 cm and when it is not possible to perform measurements with the ultrasound probe. Obtained results are inadequate to real flow conditions. Flowmeter are located at a distance of less than 80 m. Therefore, the values obtained should be almost identical. As a reason, inadequate reconstruction of cross-sectional shape of the channel during device configuration was pointed (Fig. 4 and 5). This effect connected with low efficiency of the algorithm allows the estimation of the flow when depth is less then 20 cm (mistakenly called by the device manufacturer “Manning’s formula method”) is the cause of getting inconsistent results.

Tab 4. Dry weather peaking factors estimation – corrected values

Date	Flow rates – Skargi 1.1			Flow rates – Skargi 1.2		
	maximum	average	peaking factor	maximum	average	peaking factor
14.10.2011	50,5	37,8	1,34	53,0	41,6	1,28
16.10.2011	44,8	33,1	1,35	61,7	40,1	1,54
29.10.2011	44,2	33,8	1,31	54,0	41,0	1,32
31.10.2011	44,8	32,1	1,39	53,0	39,4	1,35
05.11.2011	45,4	34,4	1,32	54,0	41,5	1,30
15.11.2011	44,2	31,6	1,40	52,6	37,2	1,41
27.11.2011	42,4	31,4	1,35	54,0	39,0	1,38
29.11.2011	50,5	31,0	1,63	69,8	37,3	1,87
26.12.2011	46,0	32,8	1,40	55,5	38,2	1,45
31.01.2012	46,7	33,2	1,41	59,6	42,3	1,41
04.02.2012	44,2	33,0	1,34	69,2	44,0	1,57
07.02.2012	44,8	32,0	1,40	55,5	41,8	1,74
20.02.2012	-	-	-	53,5	37,9	1,41
02.03.2012	-	-	-	61,1	46,8	1,31
03.03.2012	-	-	-	72,6	49,5	1,47
04.03.2012	-	-	-	64,3	47,6	1,35
05.03.2012	-	-	-	60,6	46,4	1,31
07.03.2012	-	-	-	65,4	46,0	1,42
15.03.2012	-	-	-	64,3	44,2	1,45
20.03.2012	-	-	-	62,2	43,4	1,43
01.04.2012	48,8	35,9	1,39	56,5	40,8	1,39
11.04.2012	48,6	34,2	1,42	64,3	39,5	1,63
02.06.2012	47,9	34,9	1,37	65,4	42,5	1,54
24.07.2012	55,1	42,0	1,31	64,8	50,5	1,28
25.07.2012	56,4	41,1	1,37	64,3	49,2	1,31
26.07.2012	54,4	40,2	1,35	62,7	48,1	1,30
27.07.2012	64,8	41,1	1,58	80,8	49,4	1,63
Average	48,6	35,0	1,39	61,3	43,2	1,43

The results of corrective calculations based on Manning's formula and typical cross-sections of channels were presented in Table 4.

3. RESULTS ANALYSIS

Used measuring system was designed for storm water flows and combined overflows monitoring. ISCO ultrasonic profiling flowmeters measuring range starts at 110 mm, but in real technical conditions profiling starts at 200 mm. Dry weather flows connected with small depths are estimated with algorithms automatically adapting to changing hydraulic conditions within the pipe.

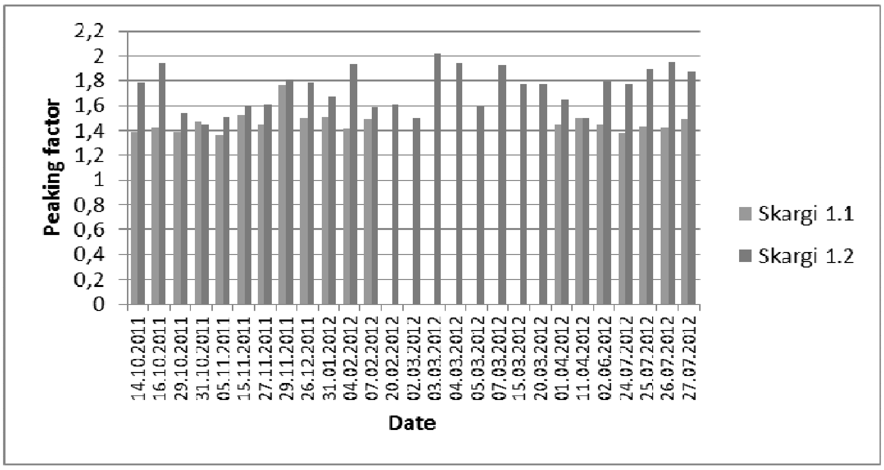

Fig. 6. Dry weather peaking factors – original values

Obtained results are inadequate to real conditions. Peaking factors estimated using logged data are characterized by significant differences between the two positions. In most cases the error exceeds 10% and in seven cases exceeds even 25%. Average peaking factor on Skargi 1.1 position is equal to 1,46. Average peaking factor on Skargi 1.2 position is equal to 1,73.

Peaking factors values calculated using corrected data are estimated with less error between the two positions. In most cases the error is less then 10%, only two cases exceeds 15%. Average peaking factor on Skargi 1.1 position is equal to 1,39. Average peaking factor on Skargi 1.2 position is equal to 1,44.

In cities the size of Głogów daily peaking factor is assumed of 1.4 (Gruszecki, Wartalski 1986).

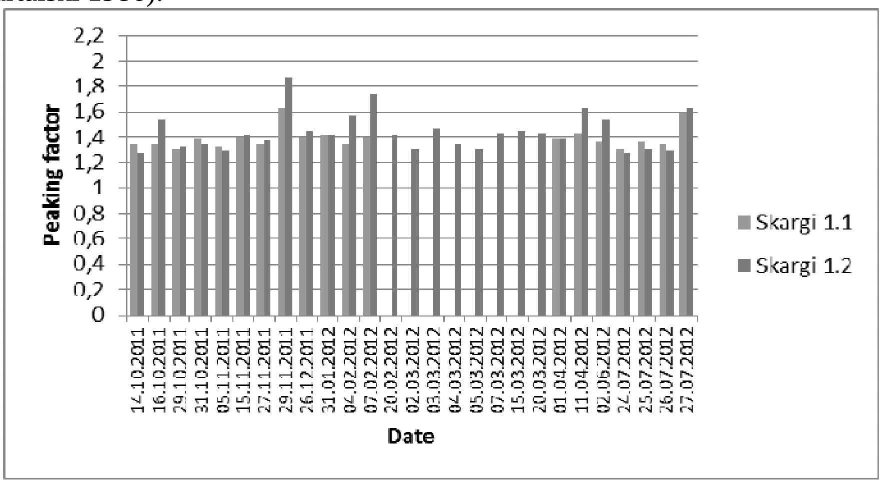

Fig. 6. Dry weather peaking factors – corrected values

4. CONCLUSIONS

Obtained results of corrected dry weather peaking factor are almost identical to typical designing factor. Original values are useless because of low efficiency of the implemented algorithms. An additional problem is limited experience of workers who build and implement measurement systems. Using profiling flowmeters to estimate dry weather values is not possible without manual calibration or correction values with Manning's formula. Optimal, though expensive solution is to apply additional ultrasonic flowmeter for small depths.

The calculations will be continued using the data obtained from measurements of the following years.

REFERENCES

1. Gruszecki T., Wartalski J.: *Kanalizacja*, Koszalin, Wydawnictwo Uczelniane WSI w Koszalinie, 1986.
2. Moulton R.B.: *Peaking factors in sanitary sewer design*, Brigham Young University, Provo, Utah 1999.

WSPÓŁCZYNNIK NIERÓWNOMIERNOŚCI PRZEPŁYWU POGODY BEZDESZCZOWEJ W KANALIZACJI OGÓLNOSPŁAWNEJ GŁOGOWA

S t r e s z c z e n i e

W pracy przedstawiono wyniki badań natężenia przepływu ścieków pogody suchej w kanałach dopływowym i odpływowym z przelewu burzowego PB-1. Obiekt zlokalizowany jest przy ulicy P. Skargi w Głogowie. W oparciu o uzyskane wyniki oszacowano średni współczynnik dobowej nierównomierności odpływu ścieków pogody bezdeszczowej. Stwierdzono niską efektywność algorytmu umożliwiającego szacowanie natężenia przepływu w zakresie 0-20 cm napełnienia kanału, gdy nie jest możliwe wykonywanie pomiarów przy użyciu sondy ultradźwiekowej. Wskazano na mało dokładne odtworzenie przekroju kanału w czasie konfiguracji urządzeń jako przyczyny uzyskiwania sprzecznych wyników pomiarów. Zaprezentowano wyniki obliczeń korygujących wykonane w oparciu o wzór Manninga i typowe przekroje kanałów. Uzyskane rezultaty potwierdzają możliwość wystąpienia znaczących różnic uzyskiwanych przy nieprawidłowo skonfigurowanych parametrach kanału. Potwierdzono niską jakość wbudowanego algorytmu wspomagającego pomiary przy małych napełnieniach, błędnie nazywanego przez producenta urządzenia metodą Manninga.