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ASSESSING THE HYDRAULIC CONDUCTIVITY OF OPEN DRAINAGE FOR SURFACE WATER IN ROAD SAFETY ZONES

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Abstract. The relevance of research on removing surface water from the drained areas has increased along with a rising number of drainage systems. A large part of inlets for surface water are installed in the ditches of road safety zones and / or terrain drops in safety zones where flowing surface water accumulates. The practice of constructing and rebuilding roads in Lithuania shows that each new route of the road section most frequently passes through the drained area and redistributes runoff characteristics of that sector. Each subgrade passing through the watercourse of surface water is a local dam *for* surface runoff. The surface water that has accumulated in road safety zones have to be drained to avoid damage to road structures and from the flood in the drained roadside areas. The article discusses the efficiency of hydro technical measures such as inlets for surface water in the mining area and highlights the specificities of hydraulic calculations when the complete drainage system for surface water *Inlet–Water Drainage Line* is integrally assessed. The paper also proposes a methodology for the hydraulic calculations of the system *Inlet–Water Drainage Line*. The article examines the condition of water inlets having the F-5 or PN-42 structure. The findings of the research carried out in 2017 demonstrate that only 15.3% of inlets for surface water were completely clean, 45.2% of the inlets were found fully contaminated and 39.5% of those were partially silted up. Thus, a clear upward trend towards polluting the cross-sectional areas of inlets for surface water with soil and grass root plants and a strong downward trend towards clean cross-sectional areas of inlets for surface water are observed. 22.6% of inlets for surface water were found damaged by farmers using tillage machinery.

Keywords: drainage, *Inlet–Water Drainage Line*, road safety zones, surface water.

1. Introduction

Any available or newly designed road section with the finished subgrade passing through the watercourse of surface water is a local dam to surface runoff. The surface water that has accumulated in road safety zones have to be drained to keep away from damage to road structures and the flood in the drained roadside areas. Accurately maintained and properly functioning open inlets for surface water greatly assist in the avoidance of losses and in timely drainage for surface water.

Inlets for surface water are designed for draining a larger content of surface water from lower places of the terrain to the drainage network and for regulating surface runoff thus protecting road ditches and fields from erosion. Drainage for surface water is particularly relevant within the seasons expecting more rain, particularly in spring; moreover, the problem of draining water becomes acute when the soils of more complex mechanical composition are drained. Compared to the full drained array, the areas of the average closed hollows collecting surface water are small; however, farmers suffer from considerable losses in such fields: crops soak, sowing and harvesting fail to be in time. The number of hollows on the ground is greatly increased by the subgrade passing through the drained area.

The situation in foreign countries discloses that, due to the risks of silting up the drainage and polluting surface water with various contaminants from farmland utilities, open borehole inlets are unpopular. The most common

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ways to solve the problems of surface water include the installation of shallow slope beds and digging ditches; blind inlets are also sometimes recommended (Stuyt *et al.* 2005). Environmentalists suggest replacing the currently used open inlets with underground columns made of bulk materials (stone, crushed stone, gravel), which helps with avoiding failures in silting up and reduces the pollution of open water bodies with nutrients and chemicals used in agriculture (Ginting *et al.* 2000). To increase the efficiency of drainage for surface water, the majority of scientific works focus on improving the filtration properties of drainage ditches (Petošic *et al.* 2004). These works were also intensively carried out in some areas of Lithuania having soils of severe mechanical composition (Šaulys *et al.* 2005).

Open inlets for surface water are most frequently used in Lithuania. In 1959, 350 such inlets were installed, and the density of equipment in the drained areas reached only 0.32 pcs per 100 ha^{-1}. From year to year, along with an increase in drainage volumes, the number of inlets for surface water rose, and, on 1 January 2015, more than 142 thousand such inlets were counted, whereas density grew up to 5.5 pcs per 100 ha^{-1}.

The serial production of precast-concrete inlets of different structures (Šaulys 2009), including recently manufactured equipment of the plastic structure (PN-42) easily fixed on the installation site, has determined the spread of the above introduced reclamation systems. Some of them are very common while the employment of other types is less frequent or is only found in temporary objects. Inlets impede digging land, and though their average density of installation in the drained areas reaches 5.5 pcs per 100 ha^{-1}, however, they are rare on arable land and make on average only 0.5 pcs per 100 ha^{-1}. Inlets are most frequently installed on the outlines of arable fields in road safety zones.

Field observations of inlets for surface water have revealed that their real hydraulic conductivity is significantly lower than the presented theoretical one, which is reasoned by hydraulic losses in the drainage line of the inlet. Therefore, the hydraulic conductivity of the inlet for surface water is assessed as the hydraulic conductivity of the joint system *Inlet–Water Drainage Line*.

Research on the condition of drainage systems showed that the most common failures in drainage were related to silting up drainage pipes with soil particles (21%) and to damaged inlets for surface water (13%). Failures in inlets for surface water, otherwise than those in the drainage system, are visible. Therefore, their causes and the extent of repairs are easily identified. A more difficult task is to detect the volumes of hidden failures in the drainage where the pipe silted up with soil particles is a very particular malfunction. Neglecting the maintenance of inlets for surface water is another reason for the occurrence of failures.

The carried out research is aimed at developing a hydraulic calculation methodology of inlets for surface water assessing inlet conductivity as the hydraulic conductivity of the joint system *Inlet–Water Drainage Line* thus ensuring timely drainage for surface water from road safety zones.

The research demonstrates how to examine maintenance efficiency and damage dynamics of inlets for surface water to ensure timely drainage for surface water from roadsides.

2. Investigation methods

The observations of the technical condition of surface water inlets installed in road safety zones have been carried out from 1986. The analysis of the technical condition and maintenance of inlets for surface water reveals that for expeditionary monitoring, the most commonly (more than 90%) used structures of the inlet are F-5 and PN-42 that is a recently applied plastic analogue of the F-5. Although the installation of plastic inlets having the PN-42 structure is in progress and their number is increasing, however, at the moment, the inlets of the F-5 structure (Fig. 1) are predominating in road safety zones in Lithuania. These inlets consist of a lid of 90 cm (1) and a man-hole base of 58 cm in diameter (6) where the opening (4) for connecting a drainage pipe is created. The drain starts with a perforated asbestos-cement pipe. A column of the mixed sand and gravel (3) is installed above the pipe to faster drain water from the external device for silt deposit (2). The basement of the deposition device around the inlet is laid out with concrete slabs (7). Space (5) for depositing silt is left inside equipment F-5.

The hydraulic calculations of the conductivity of inlets for surface water show that bearing in mind the physical meaning the general equation is faultless. The main dependency is applied for determining the hydraulic losses of pipes and is known as the Darcy-Weisbach equation (Lahiouel, Lahiouel 2015).

$$\lambda = \frac{2g}{v^2}\frac{d}{l}h_L, \quad (1)$$

where λ – the Darcy friction factor; v – the average flow rate in pipes, m s^{-1}; g – gravitational acceleration, m s^{-2}; d – the internal diameter of pipes, m; l – the length of the section of the tested pipe, m; h_l – difference in water pressure, or head losses at the beginning and end of the pipe section, m.

An equation for setting average flow rates v in pipes is known as the Chezy equation and is easily derived from Equation (1):

$$v = C\sqrt{RI}, \quad (2)$$

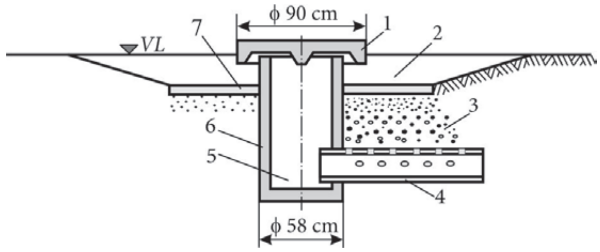

Fig. 1. Inlet F-5 for surface water (Šaulys 2009)

where C – the Chezy coefficient that depends on pipe diameter and the roughness coefficient; R – hydraulic radius, m; I – hydraulic gratient.

The Darcy friction factor or the Chezy coefficient have to be known to apply Equations (1)–(2) for practical calculations. The problem is that although the relationship among them is simple:

$$\lambda = \frac{8g}{C^2}. \tag{3}$$

However, these coefficients depend on the roughness of the pipe and are usually determined by laboratory testing.

For assessing the hydraulic conductivity of the inlet for surface water as the joint system *Inlet–Water Drainage Line*, research consider smooth and corrugated plastic pipes. The examination was carried out by the authors employing a hydraulic test stand.

Field investigations into inlets for surface water were conducted in 2017 and compared to those done in 1986, 1996 and 2007 (Šaulys 2009). In 2017, the observations of water inlets having the F-5 and PN-42 structure were made in the regions of Anykščiai, Akmenė, Joniškis, Kaunas, Kėdainiai, Panevėžys, Radviliškis, Šalčininkai, Šiauliai, Ukmergė, and Vilnius. Overall, 124 inlets, including 92 having the F-5 structure and 32 having the PN-42 structure were monitored. The observations identified the condition of the cross-sectional areas of inlets for surface water and formed three categories: cross-sectional areas of inlets for surface water are clean (1), partially silted up (50%) (2) and completely silted up (3). Besides, field investigations revealed other types of damages to inlets.

3. Investigation results and discussion

Quantitative changes in the reclaimed lands are recorded in the cadastre the data analysis of which allows assessing the trends, condition and actual situation of the reclaimed land and the installation of reclamation buildings applying field indicators. Along with an increase in the drained area, the length of the inlet network (drainage ditches) has risen. The relationship between the spread of the drained area and the length of drainage ditches is expressed by a linear regression equation (correlation coefficient r = 0.98):

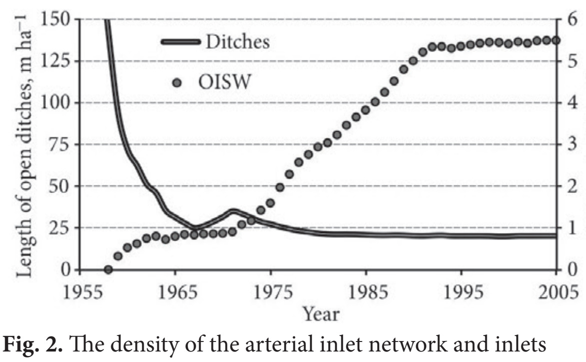

Fig. 2. The density of the arterial inlet network and inlets for surface water in the drained areas

$$L = 16.91A + 10.02, \tag{4}$$

where L – the length of arterial ditches, km; A – drained area, thousand ha.

As only from 48.1 thousand ha to 68.6 thousand ha of land was drained in Lithuania for the period 1957–1958, the length of arterial ditches per single ha of the drained area amounted to 141–196 meters. Over the next decade, the drained area increased 10 times (617.6 thousand ha of land was drained in 1967), and the length of arterial ditches decreased to 25.0 m ha^{-1}, i.e. 7.8 times. Over the following period of installing drainage systems, the length of the ditches remained stable and made 24.4 ha^{-1} in 1977, 20.6 ha^{-1} in 1987, 20.3 ha^{-1} in 1997, 20.3 ha^{-1} in 2007 and 20.2 ha^{-1} in 2015 respectively.

Meanwhile, concerning the data provided by the cadastre of reclamation and taking into account an increase in the drained area, the number of inlets for surface water has grown accordingly to exponential dependence (correlation coefficient r = 0.99):

$$N = 1.14e^{1.88A}, \tag{5}$$

where N – the number of inlets for surface water, thousand units; A – drained area, thousand ha.

The analysis of the installation dynamics of arterial ditches and inlets for surface water (OISW) has revealed three stages. At stage one (up to 1970), growth in the drained area and a reduction in the length of arterial ditches per single hectare of the drained area resulted in a slight rise in the number of inlets for surface water (Fig. 2).

Each additional drained 100 ha area counted on average 0.36 installed inlets for surface water. At stage two (1970–1990), the situation changed. First, the length of the redirection network (arterial ditches and regulated streams) in a single hectare of the drained area decreased from 31.6 m to 20.4 m, and the installation of inlets for surface water reached 5 pcs per 100 ha. These numbers show that for installing drainage systems in the 1980s, much attention was paid to increasing drainage efficiency, particularly to removing surface water from the drained areas.

As for the independence period (Stage 3) starting from 1990, the volumes of installing new and renovating the existing drainage systems have reduced and had constantly been declining due to the well-known reasons. Naturally, the length of the arterial draining network (20.3 m ha^{-1}) and the density (5.5 pcs 100 ha^{-1}) of inlets for surface water in the drained area have become stable.

The largest part of inlets for surface water is installed in roadside ditches and downward gradients of the terrain where flowing surface water accumulates, and timely drainage is one of the priorities.

Tests on inlets for surface water on the hydraulic research stand have disclosed that the discharge rate m_{PVN} of inlet F-5 becomes stable at the limit of 0.66 (Fig. 3) when the diameter of the drainage pipe of the water inlet is 150 mm in the zone of square losses. The determined discharge rate assesses all cases of the losses of the inlet system starting from those at water inlet openings when they are clean and ending in the water inlet to the drain. Nationwide more than 90% of inlets having the F-5 structure were installed. However, a lighter plastic analogue PN-42 of inlet F-5 is currently in use.

Discharge rate Q of the inlet for surface water without the drainage line is calculated according to the known equation of hydraulic residues:

$$Q = m_{PVN} A \sqrt{2gH_0}\,, \tag{6}$$

where m_{PVN} – the discharge rate of the inlet for surface water; A – the cross section of the drainage pipe, m^2; H_0 – reduced pressure height (difference in water levels beforehand and behind the inlet assessing acceleration height), m.

The performed measurements of the rates of water inflow to the inlet showed that regarding flow, they are lower than critical rate limits even under soft grounds at inlets. The figure of the rates of water inflow to inlet F-5 shows that bottom rates (measured at a distance of 8 cm, 20 cm and 35 cm from the edge of the lid under the maximum flow discharge) are lower than 10 cm s^{-1}. Therefore, due to low inflow, reduced pressure height H_0 in the rate Equation (6) is simply replaced by pressure height H.

The field observations of inlets for surface water have shown that their real hydraulic conductivity is significantly lower than the traditional theoretical one. The situation is determined by the hydraulic losses of the water drainage line of the inlet, and therefore the hydraulic conductivity of the inlet for surface water is assessed as the hydraulic conductivity of the joint system *Inlet–Water Drainage Line* (Fig. 4).

The hydraulic calculations of the system *Inlet–Water Drainage Line* are performed concerning the Bernoulli equation that undergoes simple transformations and is as follows:

$$H = \left(\Sigma\zeta_{PVN} + \lambda \frac{L}{d} + \zeta_{col} \right) \frac{v^2}{2g}\,, \tag{7}$$

where H – pressure height – difference in water levels between the hollow of the road safety zone and water collector, m; $\Sigma\zeta_{PVN}$ – the total local loss of the inlet for surface water; λ – Darcy friction factor of the drainage line; L – the length of the drainage line, m; d – the diameter of the drainage line, m ; ζ_{col} – the local loss coefficient of inflow to the water collector; v – flow rate in the water drainage line, m s^{-1} ; g – gravitational acceleration, m s^{-2}.

The flow rate of surface water in the drainage line is as follows:

$$v = \frac{1}{\sqrt{\Sigma\zeta_{PVN} + \lambda \frac{L}{d} + \zeta_{col}}} \sqrt{2gH}\,, \tag{8}$$

Since the connected pipe for determining the discharge rate of inlets for surface water was 150 mm in diameter, the assessment of the hydraulic conductivity of the system *Inlet–Water Drainage Line* showed that, under a new diameter of the pipe, the total local loss of inlet $\Sigma\zeta^n_{PVN}$ was recalculated using the Equation (9):

$$\Sigma\zeta^n_{PVN} = \left(\Sigma\zeta_{PVN} - \zeta_{in} \right) \left(\frac{d^n}{d} \right)^4 + \zeta^n_{in}\,, \tag{9}$$

where $\Sigma\zeta^n_{PVN}$ – the total local loss of the inlet for surface water considering a new diameter of the water drainage pipe; ζ_{in} and ζ^n_{in} – the local loss of inflow to the water drainage pipe corresponding the diameters of 150 mm and the new one of the pipe respectively; d^n – a new diameter of the water drainage pipe, m .

The hydraulic loss of inlet for surface water F-5 has been recalculated under the new diameters of the water drainage pipe and is presented in Fig. 5 for drawing, which corrugated plastic pipes of certain diameters and those currently applied in hydro-technical construction were used. Analogous dependencies have also been made for smooth plastic pipes because, in some cases, separate (autonomous) lines are installed for draining surface water.

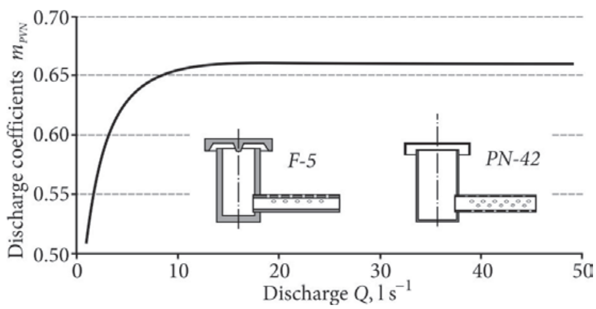

Fig. 3. Discharge rates of inlets for surface water F-5 and PN-42

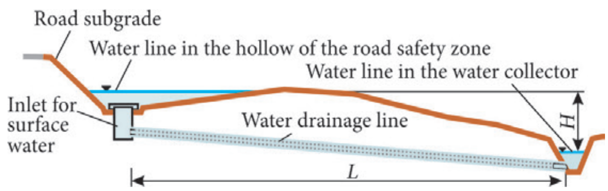

Fig. 4. Scheme for the hydraulic calculations of the system for surface water *Inlet–Water Drainage Line*

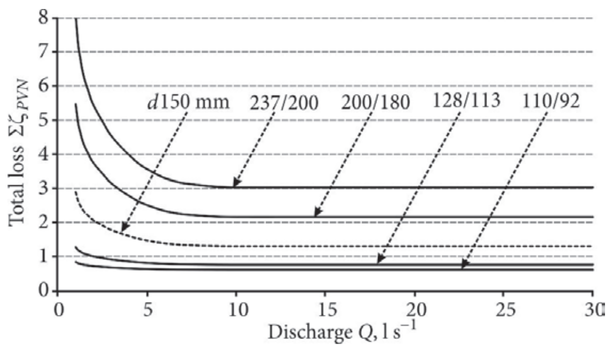

Fig. 5. The hydraulic loss of inlet for surface water F-5 under the presence of the water drainage pipe: *d* 150 mm – clay pipes and corrugated plastic pipes of certain diameters *D*/*d* in mm

A range of dependencies is suggested by Gurklys *et al.* (2008) to perform the hydraulic calculations of the water drainage line installing clay smooth or corrugated plastic pipes. Gurklys and Miseckaitė (2010) carried out detailed analysis and additional hydraulic testing on the stand with smooth and corrugated plastic pipes. Therefore, for assessing their conductivity, the following dependencies of smooth non-perforated plastic pipes (Equation (10) and corrugated plastic pipes (Equation (11) are proposed:

$$Q = 6.19 i^{0.602} d^{2.85} \quad (10)$$

$$Q = 3.87 i^{0.588} d^{2.99} d\ , \quad (11)$$

where Q – discharge flow in the line, l s^{-1}; I – pipe-line gradient, %; d – the internal diameter of the pipe-line, dm.

Based on the dependencies above, a nomogram of the hydraulic calculations of the system *Inlet–Water Drainage Line* of inlets for surface water F-5 and PN-42 has been composed (Fig. 6).

When an inlet for surface water (F-5 or PN-42) having a 200 m water drainage line from corrugated (D/d) plastic pipes of 237/200 mm in diameter is installed in the road safety zone, the discharge of surface water reaches 32.8 l s^{-1} under 3.0 m pressure height between water level at the inlet and in the collector. Under similar morphometric parameters of the environment and a water drainage line built from smooth non-perforated plastic pipes

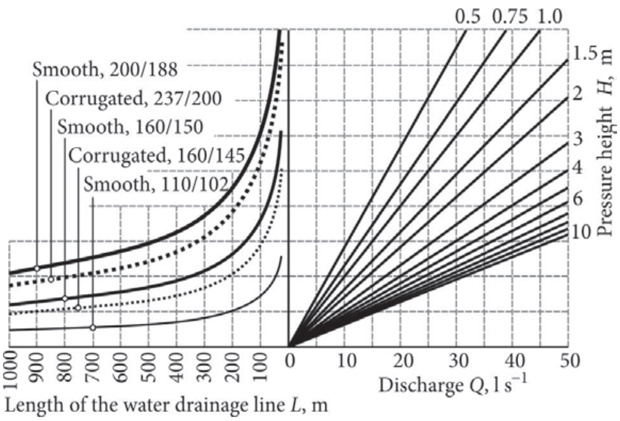

Fig. 6. Nomogram of the hydraulic calculations of the system *Inlet–Water Drainage Line* of inlets for surface water F-5 and PN-42

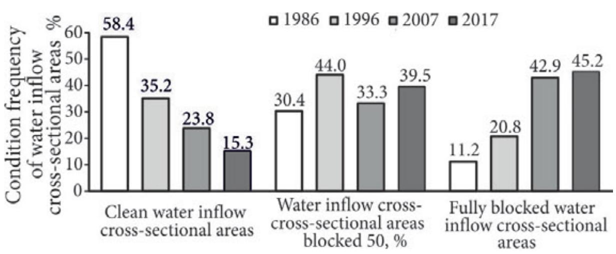

Fig. 7. The dynamics of the condition of the cross-sectional areas of surface water inlets having the F-5 and PN-42 structure for the period 1986–2017

of 200/188 mm in diameter, the received drained discharge of surface water is 38.8 l s^{-1}, i. e. 18.3% higher despite the inner diameter of redirecting line d that dropped from 200 mm to 188 mm. The hydraulic roughness coefficient of non-perforated smooth plastic pipes is less than that of the corrugated plastic ones.

In the case of a new road lane crossing a drained area and under conditions for the concentration of surface run off, an independent water drainage line (for surface water only) for installing, which smooth pipes is a better option is most frequently set up. The employment of non-corrugated smooth plastic pipes is always a better option because their Darsy friction factor is lower. Furthermore, an increase in the diameter of the water drainage line results in the rising hydraulic friction of the pipe. For instance, the drained discharge of the smooth pipe of 145 mm in the internal diameter, compared to the corrugated one, increases to 17.1%, while the discharge of the smooth pipe of 200 mm in diameter rises by 37.8%.

The length of the drainage line has a significant impact on the conductivity of the system *Inlet–Water Drainage Line*. As mentioned above, the discharge of the water drainage line made of 200 m long corrugated pipes of 200 mm in the inner diameter amounted to 32.8 l s^{-1}. Under the same conditions and an increase in the length of the water drainage line up to 800 m, the drained discharge drops to 19.9 l s^{-1}, or 48.5%. Unfortunately, the length of the water drainage line is hardly selected, as in the majority of cases it is determined by the landscape and the location of a water collector.

As for the calculated maximum hydraulic conductivity of the inlet for surface water, it is only achieved in the case if the system *Inlet–Water Drainage Line* is undamaged and water inflow openings of inlets are clean, i.e. omitting soil particles or overgrown grass. Following any bigger storm, surface runoff is formed and erosion products, including washed away soil particulate matter and various mostly organic waste such as duckweed, are shipped from the pool to the inlet (installed in the lowest place of the empty reservoir). Erosion products accumulate in the outer or inner silt deposit device of the inlet.

The conducted field investigation into the condition of water inlets having the F-5 and PN-42 structure shows that most frequently the products of erosion accumulating in the devise for silt deposition are inappropriately removed and therefore accumulate after every rain at the inlet. Soil particles are reinforced with plant roots and, as a result, reduce water permeability, or the inlet stops working completely. Thus, inlets fall into three categories: cross-sectional areas of inlets for surface water are clean (1), partially silted up (50%) (2) and completely silted up (3) (Fig. 7). The summary of field investigations carried out in 2017 provides that only 15.3% of the cross-sectional areas of inlets for surface water were clean, 45.2% of the inlets were found with completely silted up cross-sectional areas and 39.5% of those were (50 %) partially silted up.

The inlets have the F-5 structure and with completely silted up cross-sectional areas made 11.2% concerning data on research conducted in 1986, whereas in 1996 they amounted to 20.8% and in 2007 peaked up to 42.9%. The above introduced failure occurs more and more frequently (for the decade from 1996 from 2007, the cases increased more than twice) and counts 45.2% for today. Thus, a clear upward trend towards polluting the cross-sectional areas of inlets for surface water with soil and grass root plants and a strong downward trend towards clean cross-sectional areas of inlets for surface water are observed. Inlets for surface water fail to reach the designed hydraulic water permeability, which results in the formed surface water during the periods of spring thaws at roadsides or harder summer-autumn rains. In 1986, the number of inlets able to reach the designed hydraulic conductivity made more than a half (58.4%). However, recent calculations point to a decrease in up to 15.3%. The number of malfunctioning inlets increased from 11.2% in 1986 to 45.2% in 2017.

The analysis of data on the condition of the cross-sectional areas of inlets for surface water was carried out in 2017, the cross-sectional areas of plastic inlets having the PN-42 structure were cleaner. The clean cross-sectional areas of these inlets for surface water make 28.1%, whereas those having the F-5 structure count only 10.9% (Fig. 8). The introduced situation is described by the fact that plastic PN-42 inlets have been recently installed and still have the reserve of polluting the cross-sectional areas of the water inlet. This idea is based on observation data analysing whether an inlet has been lately maintained and cleaned and identifying maintenance check. Research data analysis shows that only 5.6% of the inlets were supposed to have been properly maintained, 17.7% of the inlets raise some doubts about maintenance execution and 76% of repair works failed to be done as required following the rules of protecting reclamation equipment.

For emphasizing the maintenance of inlets for surface water, 28 inlets from 124, which makes 22.6%, were found damaged by farmers using tillage machinery, which is an alarming situation. Lids and frequently the right ring were found broken, which occurs when the inlet is affected by tillage machinery. The damaged lid of the inlet or the suitable lid allows erosion products (soil particles, organic waste) transported from the basin to access the drain network and clog it easily. Local damage to the inlet turns into a grave failure in the entire drainage system. It seemed that changes in the approach to ownership assisted farmers and the members of agricultural companies with shifting serious attention to the maintenance of inlets for surface water; however, the main reason is the absence of the real owner of drainage systems today. The Reclamation Act provides that the State owns the major part of drainage equipment that requires maintenance.

Fast draining a greater amount of surface water concentrated in the lower areas of the relief and redirecting it to the drainage network is an advantage of the inlets installed in road safety zones over the other measures used for draining surface water (underground columns, dense network of drainage pipes, increase the conductivity of drainage ditches). Apart from a drawback that inlets require regular maintenance, pollution caused by water collectors is accepted as another shortcoming because the contaminated water from the drained areas directly flows to ditches, streams and lakes. From the point of environmental protection, establishing a wetland to collect surface water is more beneficial. The wetland is surrounded by the safety zone of water reservoirs and protect from the access of nutrients and other contaminants to the drainage system (Šaulys *et al.* 2011) and thus to the water collector. Foreign scientists (Ayar, Evans 2015; Fahle *et al.* 2013; Reinhardt *et al.* 2005) state that such artificial wetlands are powerful tools for reducing the spread of agricultural pollution. According to Raisin (1996), wetlands withhold up to 23% of nitrogen and 38% of phosphorus entering from the reclaimed basin.

In the majority of cases, road safety zones exclude the installation of inlets for surface water. Instead, setting up underground pillars with the increased conductivity of the surface layer and a rise in the conductivity of drainage trenches in clay soils using lime are applied (Klimašauskas, Šaulys 2014). The carried out research demonstrates this is a long-term and environmentally friendly means: the content of phosphates entering the drained waters is reduced with no increase in the conductivity of the drainage trench.

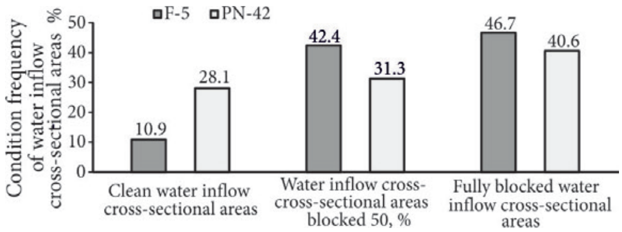

Fig. 8. The dynamics of the condition of the cross-sectional areas of surface water inlets having the F-5 and PN-42 structure in 2017

4. Conclusions

1. Each road subgrade passing through the watercourse of surface water is a local dam to surface runoff. The surface water accumulated in the road safety zone must be drained to protect from damage to road structures and to escape from floods in the drained roadside areas.

2. The hydraulic conductivity of surface water inlets installed in road safety zones is considered to be the hydraulic conductivity of the joint system *Inlet–Water Drainage Line*. Thus, the methodology for hydraulic calculations and a nomogram of the system *Inlet–Water Drainage Line* of inlets for surface water F-5 and PN-42 have been developed.

3. Within the investigated period (1986, 1996, 2007 and 2017), a clear upward trend towards polluting the cross-sectional areas of water inlets with soil and grass root plants in the inlets for surface water F-5 and PN-42 is

observed. The number of fully contaminated cross-sectional areas of inlets for surface water varied from 11.1% in 1986 to 20.8% in 1996, 42.9% in 2007 and 45.2% in 2017.

4. Through water inlets and from road safety zones and drained areas, the polluted surface water directly runs into open water sources (ditches, streams, lakes), and therefore is subject to anti-pollution measures.

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