CLASSIFICATION SYSTEM TO ESTIMATE THE LEAKAGE OF SEWERS

Mandy Rutsch, Holger Uibrig, Institute for urban water management, Dresden University of Technology

ABSTRACT

Within the European project APUSS (Assessing infiltration and exfiltration on the performance of urban sewer systems) a model describing the ex- and infiltration process will be developed. Therefore sewer classification by leakage is required. A main input to this classification is the structural deterioration of sewer pipes observed by closed-circuit-television (CCTV). This paper proposes a new classification system, which evaluates the leakage of sewers based on existing CCTV records. The classification is focused on the assessment of defects that cause a potential leakage. The condition classes obtained can be compared with the pipe characteristics from sewer databases and with ex- and infiltration rates. The comparison is a subsequent step in the modelling process.

Keywords
Sewer leakage, Sewer classification, CCTV records, Ex-/Infiltration

1. INTRODUCTION

Leaking sewers, the main reasons for exfiltration and infiltration of urban sewer systems, are major cost factors. Sewer operators can reduce the inspection and maintenance costs by applying models to predict the leakage of sewers. In setting up such models the first step was the development of a classification system, which is focused on the aspect of leaking sewers.

Classification systems are used for describing and evaluating the condition of sewers. The data are classified by the urgency for rehabilitation or just by describing the sewers actual value, leaving the interpretation/evaluation for further requirements to the sewer operators. The different classification systems are based on different inspection coding systems [ATV, 1999, DIN, 1999]. Most of the existing classification systems provide condition classes with the time scale of a required rehabilitation [Sawatzki, 1991, ATV, 1994]. In existing classification systems leakage in particular is only accounted if penetrating water is observed through the CCTV inspection. Impacts due to exfiltration cannot be accounted for even if the defect shows a high exfiltration potential.

The German ATV standard A 149 [ATV, 1994] is considered being more an orientation for the set up of own systems. It leaves a wide scope to adapt the classification to ones own circumstances. The classification system proposed in this paper is loosely based on this standard. It is supposed to evaluate the leakage of sewers due to their structural state. Thus, only defects contributing to possible leakage are accounted.

2. CLASSIFICATION

To apply our classification system data files are required including general information on the sewer and the visual inspection codes. The general information (listed in Table 1) is material, length, diameter, and an unequivocal name. A later analysis of the characteristics requires information such as construction date, subcatchment, soil, and groundwater table. Data on ground and groundwater are important to differentiate between in- and exfiltration or at least to give an idea about the potential of the interaction between groundwater and sewer flow. The respective information is hopefully stored in the sewer database.

Table 1: General information on the pipe (example)

Unequivocal name	05L905L10
Material	Concrete
Diameter	400/600
Construction date	1901
Length	28.50 m
Soil	Sand
Groundwater level	Above invert
Subcatchment	Description

Having obtained the general information the inspection codes are evaluated. Every code expresses a certain defect described by extent, length, and location within the cross-section. The inspection codes are evaluated by type and size emphasising a potential leakage of the defect (Table 2). The evaluation is demonstrated with the example reach mentioned in Table 1. At 1.20 m a leakage at a connecting pipe was detected (code *UCE-*). *U* indicates a leakage, *C* a further specification (connection), *E* the extent of leakage, and *(-)* provides information about the location of the defect. The numerical annex describes the size of the leakage *(0).* The beginning and the end of the defect were not recorded, so the defect length could not be calculated. The result is a leakage with the severity 4 (heavily damaged).

Table 2: Evaluation of inspection codes one reach

length [m]	inspection code	size	defect length	defect	leakage	crack	break	defor-matio n	cor-rosion	de-viation	ob-stacle	con-nection	others
1.20	**UCE-**	**0**	**0**	**leakage**	**4**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
1.80	AN-L	0	0	leakage	2	0	0	0	0	0	0	0	0
2.30	SNBL	0	0	leaky HC	4	0	0	0	0	0	0	0	0
2.30	UC-R	0	0	leakage	2	0	0	0	0	0	0	0	0
3.30	UC-R	0	0	leakage	2	0	0	0	0	0	0	0	0
15.90	A--L	0	0	connection	0	0	0	0	0	0	0	0	0
27.00	AN-L	0	0	leakage	2	0	0	0	0	0	0	0	0
27.40	RC-O	0.1 mm	0	crack	0	1	0	0	0	0	0	0	0
28.50	C--U	0	0	corrosion	0	0	0	0	0	0	0	0	0

The evaluated defects are summarized by the name of the reach differentiated by its severity. Severity and number of defects per reach are put into one figure, consisting of 10 digits (Table 3). In this example the reach has 2 defects with severity S4 (heavy), 4 with severity S2 (slight), and 1 defect with the severity S1 (just detected). The position of the number defines the severity and the number the amount of defects. As the amount can easily exceed 9 the leakage figure consists of 10 digits.

Table 3: Classification and leakage figure

S5	S4	S3	S2	S1	Leakage figure
00	02	00	04	01	0002000401

There are different possibilities to sort the leakage figure. In sorting the 10-digits figure (see left hand side of table 4) the reach is rather ranked by the severity of the defects (the higher the number of severe defects is the higher the 10-digits figure). Still, the operator has to decide, whether a reach with a lot of small defects or a reach with a few heavier defects is worthwhile to rehabilitate. This information is to be obtained by sorting the single figures (right side of table 4). The order has changed, as the table was sorted by the highest number of small defects.

Table 4: An example of classified reaches with different sorting of the leakage figure

Name	S1	S2	S3	S4	S5	Leakage figure
A	00	**04**	00	00	00	0004000000
B	00	01	01	00	00	0001010000
C	00	01	00	06	03	0001000603
D	00	01	00	01	05	0001000105
E	00	01	00	00	12	0001000012
F	00	01	00	00	01	0001000001
G	00	01	00	00	00	0001000000
H	00	00	03	00	00	0000030000
I	00	00	01	00	04	0000010004
J	00	00	01	00	02	0000010002
K	00	00	01	00	00	0000010000
L	00	00	00	01	00	0000000100
M	00	00	00	01	00	0000000100
N	00	00	00	00	02	0000000002
O	00	00	00	00	01	0000000001
P	00	00	00	00	01	0000000001

Name	S1	S2	S3	S4	S5	Leakage figure
E	00	01	00	00	**12**	0001000012
D	00	01	00	01	05	0001000105
K	00	00	01	00	04	0000010004
C	00	01	00	06	03	0001000603
J	00	00	01	00	02	0000010002
N	00	00	00	00	02	0000000002
F	00	01	00	00	01	0001000001
O	00	00	00	00	01	0000000001
P	00	00	00	00	01	0000000001
L	00	00	00	01	00	0000000100
M	00	00	00	01	00	0000000100
H	00	00	03	00	00	0000030000
B	00	01	01	00	00	0001010000
I	00	00	01	00	00	0000010000
A	00	04	00	00	00	0004000000
G	00	01	00	00	00	0001000000

As mentioned above the grading of the different defects is based on ATV standard ~~A~~ M 149. To give an idea of the procedure two examples are explained.

Table 5: Example for the differentiation of the defect size after ATV [1994]

Defect	**S 5**	**S 4**	**S 3**	**S 2**	**S 1**
Break (e.g. BWBL)	25 cm²	< 25 cm²			
Root intrusion (in percent of the cross section)	30 %	20% - 30%	10% - 20%	5% - 10%	X <5%

It can be seen that a break is only differentiated into two severities 4 and 5, indicating that a break as such has a high leakage potential. The percentage of root intrusion is differentiated into 5 groups. This way of grading the single defects depends very much on the accuracy of the CCTV records. The observer needs good equipment to estimate the right size of the defect. Still, it is quite subjective to decide whether the root intrusion covers 20 or 30 % of the cross section. Similar problems do also occur in grading the other defects.

Another controversial issue is how to include the length of the defect. If the CCTV record does not provide any defect length, it will not be considered in the classification. In case the defect length exceeds the limit of 2 meters it was decided to raise the originally evaluated severity by 1. This means a 2.5 m long crack of severity S4 changes to S5.

3. APPLICATION IN THE DRESDEN SEWER SYSTEM

The distribution of the defects with regard to the sewer characteristics was investigated for the Dresden sewer system. For a better overview condition classes based on the leakage figure were defined. A reach with only small defects obtained class 1. With increasing damage the condition class number also increases. The highest class is number 5 expressing extremely heavy damage on the reach.

The CCTV records of approximately 7.2 % of the Dresden sewer system can be attributed to their structural data/pipe characteristics. Returning to the initial idea of the project (comparison of structural data and condition classes in order to obtain information on the leakage of sewers) the classification system was applied to the dataset.

Figure 1 shows the distribution of the condition classes obtained from our classification system with respect to the sewer material. An overall trend is detectable. The percentage of reaches increases with decreasing number and severity of defects. The distinct increase of condition class 0 is due to reaches constructed in the last 10 years. Figure 2 underlines this assumption with 80 % of completely intact reaches.

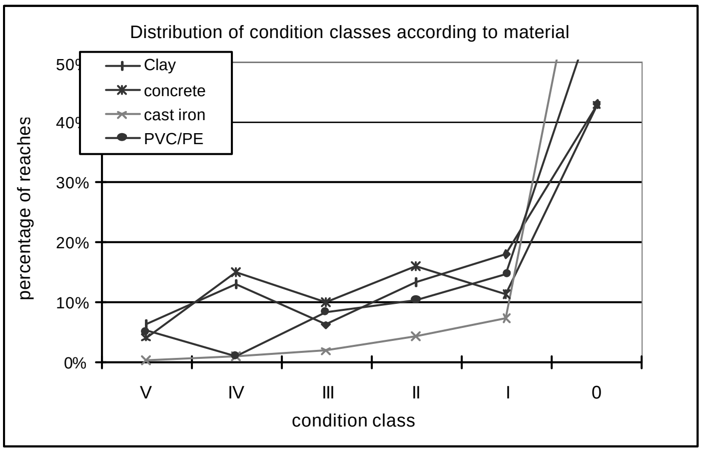

Figure 1: Distribution of condition classes with respect to material

Figure 2 shows the distribution of condition classes with respect to the construction date. The single construction dates were grouped to construction periods according to the historical and technological development. The distribution looks very much the same as in Figure 1. A slightly higher percentage of reaches in class IV and II, and a distinct increase in class 0.

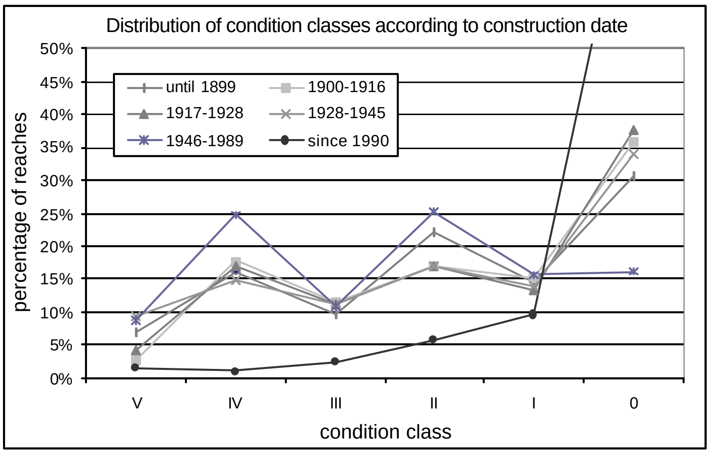

Figure 2: Distribution of condition classes with respect to construction date

4. CONCLUSION

The proposed classification system results in a ranking of reaches with regard to their potential leakage. A leakage figure provides sufficient information on the extent and the type of the defects, and can be sorted after different aspects. The figure does not express a condition class but shows size and number of actual defects. The existing classification systems provide a condition class but no information on the defects as such and on the specific problem of ex- and infiltration. Due to this fact a comparison of classification systems seems to be difficult. To compare our classification system with others, the leakage figure can be summarized to condition classes as well. To apply the classification system existing CCTV records can be used. The leakage figure is automatically evaluated assumed all required data are available in the CCTV data file. A connection with other data such as groundwater level, structural data (soil, date of construction,…), and ex- and infiltration rates will lead to reasonable results identifying leakage in sewer systems.

This classification is based on a German coding system. If the European standard [DIN, 1999] will be accepted as coding system the classification can easily be adapted. But seeing that every city has different inspection printouts the classification systems always need to be adapted.

Furthermore, the rating of the single defect by type and extent needs to be improved. The estimation of the defect size is subjective, although digital devices for an accurate determination of the defect size are already available. The assessment of defects depends highly on the quality of CCTV records. Missing specification such as size and length will result in an incorrect classification.

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