TECH TIPS FROM NASSCO

PACP™ AND REMAINING USEFUL LIFE (RUL) PART 2:

UNDERSTANDING THE GROUND AROUND THE PIPE

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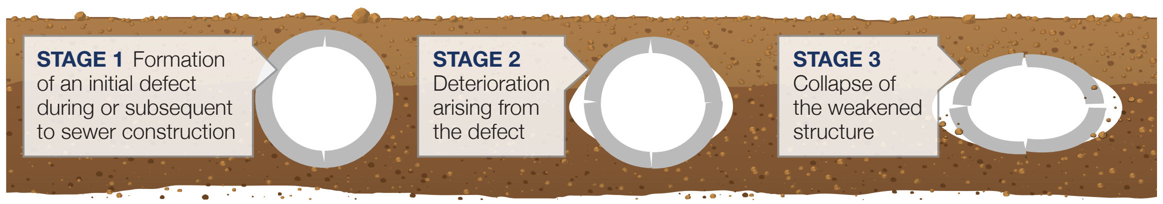
A primary objective of Condition Assessment (CA) is to gain a better understanding of the remaining useful life (RUL) of the asset, some sense of what the deterioration process will look like and when would be the best time to intervene to rehabilitate before failure occurs. As noted in our first article in this series, PACP provides valuable insight into the answers to these questions, but you need to dig a little further to get a clearer picture of how the severity of those defects can impact the deterioration process. For the purposes of this and subsequent articles in this series we'll focus on structural deterioration of sewers which will eventually lead to collapse of the pipe structure as opposed to operation and maintenance defects, which tend to reduce the service function of the sewer more than having a direct impact on sewer collapse.

One of the most comprehensive reviews of the sewer deterioration process dates to the 1980s in supporting the development of WRc's Sewerage Rehabilitation Manual (SRM) . These studies were a significant contributing factor in what became the core root structural codes in PACP. Based on these studies, the process of sewer collapse can be divided into three stages:



PACP classifies the nature of defects and their severity. To put these observations into the context of deterioration we must classify the nature of the deterioration. While some deterioration processes involve a breakdown of the sewer fabric itself, such as the breakdown of concrete by hydrogen sulfide (H_2S) corrosion; most of the processes are governed simply by the loss of ground around the sewer. For the latter, the deterioration process is caused by the flow of water in and out of the pipe which leads to ground loss in the adjacent soil. The ground loss contributes to the eventual development of unbalanced loading on the pipe. A common example of this is the classic "4 point" cracking we see in a rigid pipe.

In a pipe with longitudinal fractures it is important to understand that the sewer can sustain a vertical load far in excess of the load required to cause the initial cracks and fractures. As a crack progresses to a fracture (a fracture, in theory, is a crack that extends through the entire pipe wall), two important things change in the pipe. Firstly, the fractures allow the pipe to deform slightly which greatly reduces stress in the pipe walls as the soil pressure around the pipe is converted to passive from active support pressures. As long as there is adequate side support the pipe now functions in much the same manner as a flexible pipe. The second change that can offset that benefit over time is that soil transfer can occur through a fracture which wouldn't be able to occur through a crack.

In PACP coding a grade 5 severity is assigned to rigid pipes with 5% deformation. The severity rating is based on the ability for soil migration to occur moving forward and not a concern for the overall structural stability. Based on field-testing by Trott et al, it was found that circular concrete and clay tile sewers are routinely structurally stable with 5-10% deformation. Beyond 10% deformation, however, the sewer becomes increasingly more susceptible to failure from a random event (e.g. a rain event, a 3rd party excavation, etc.). The concern over future deterioration relates to the rate of soil migration around the pipe.

The rate of soil migration is impacted by the size of the defect; hydraulic conditions including the location of the water table, and the frequency and magnitude of surcharge; and the type of soil, including its gradation for cohesionless soils and plasticity index for cohesive soils. Based on collapse studies the SRM provides guidance on the risk or relative rate of ground loss by considering each of these supplemental factors as noted in the chart to the right.

The significance of this is that the same severity of defect in many sewers has subtly different ramifications based on the nature of the conditions in and around the pipe. The severity of the defect is well captured in standard PACP observations. The supplementary information can often be obtained by a review of regional soils records and hydraulic studies on the sewer system. With the accompanying illustrations they can be used to put into better context what the rate of deterioration is likely to be.

Sewer Defect Size (HIGH → LOW RISK OF GROUND LOSS)

- Severe defects (>1/2")
- Large defects (1/4"-1/2")
- Medium defects (1/16"-1/4")
- Small defects (<1/16")

Hydraulic Conditions (HIGH → LOW RISK OF GROUND LOSS)

(Groundwater level)

- Above sewer
- Close to sewer
- Below sewer

Exposure to Surcharged Conditions (HIGH → LOW RISK OF GROUND LOSS)

- Frequent, high magnitude
- Frequent, low magnitude
- Occasional, high magnitude
- Occasional, low magnitude
- Never

Soil Type (HIGH → LOW RISK OF GROUND LOSS)

- Non-plastic silts, silty fine sands, or fine sands
- Medium to coarse sands
- Low plasticity clays
- Fine to medium gravels
- Well graded sandy gravels
- Medium to high plasticity clays
- All clays, where sewer constructed by tunneling

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