CITY OF HAMILTON

Efficient condition management of sewer systems using both Zoom Camera technology and "Traditional CCTV"

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Background

The effective management of municipal sewer collection pipes has been evolving significantly over the past several years. The availability of technologies and the capability of using those technologies to deliver usable and manageable data along with the visual inspections have increased significantly.

As a result of aging sewer systems, municipalities are facing significant increases in risk over the next several years. Subsequently, there is a need for effective investigative programs to efficiently control the risk to a reasonable level. There are a significant number of technologies available in the industry today to assist municipalities in the inspection of their sewer systems, but which technology (or which combination of technologies) is the most effective and efficient?

In 2004, the City implemented a Zoom Camera inspection program that would facilitate the inspection of manholes with a depth of up to 10 metres (33 feet) and located inside the City's road right-of-way (ROW). Each manhole inspection includes a zoom camera inspection for every sewer main connected to that manhole. Inspection data is uploaded to the City's maintenance management database where it becomes readily accessible and permanently linked to its asset. The program has also produced other valuable inventory data such as XYZ co-ordinates on manhole lids, uncharted manhole locations and pipe invert depths. To date, Zoom Camera inspections have produced 23,566 manhole inspections and 1,441 kilometres (895 miles) of mainline inspection representing 54.86 per cent of the entire network.

The Zoom Camera program was initiated to assist operations and maintenance with sewer cleaning and emergency repair requirements in a cost effective manner. However, with the capability to inspect and condition rate using WRc defect observation codes for a significant portion of each pipe entering and exiting manhole structures, Zoom Camera inspections became an alternate indication of structural pipe condition where historic CCTV sewer inspection data did not exist. The Zoom Camera program was, therefore, also turned to focus not only on the identification of operations and maintenance issues, but also on capital planning and infrastructure management issues.

Cost/Time Benefit

Strictly from a cost and time perspective, it is evident that Zoom Camera can produce results at a fraction of the cost and time required for traditional CCTV inspections.

CCTV inspection costs from the City's 2003 to 2006 CCTV inspection programs place the average cost to inspect a sewer at $5.74 per linear metre or $1.75 per foot (cost includes any pre-cleaning requirements). The City's maximum annual production rate observed since 2003 has been 240 kilometres (149 miles); this translates into a production rate of 700 metres (2,297 feet) per day per crew. Zoom Camera inspection costs are fixed based on a per manhole rate, which based on the City's contract is $73.28. Since Zoom Camera inspections don't record linear metres of inspected pipe, but rather the number of inspected manholes, a direct comparison is difficult to make. By translating the number of manholes to a number of linear metres, however, an indirect comparison between the two technologies can be made. In order to do this, a number of city areas were randomly selected. From these areas, 25 manholes were also randomly selected. The total length of sewers inspected can be estimated based on the average production rate of 25 manholes per day for a single zoom camera crew, the average number of 2.5 sewer segments connected to a manhole, and the previously stated average of 30 metres (98 feet) of pipe inspection. This results in an estimated 1,875 metres (25 x 2.5 x 30) of pipe inspection per Zoom Camera per day, per crew (6,152 feet per day, per crew).

In order to compare the cost value between CCTV and Zoom inspections, it is necessary to adjust the sewer main inventory to exclude trunk and interceptor mains. The City has developed a more comprehensive (specialized) inspection program that can be used to obtain an inspection and condition assessment for these types of sewer mains. Thus 60 kilometres (37 miles) of sewer main, which are classified as either being a trunk or interceptor sewer have been excluded from the inventory.

The average price per metre for Zoom Camera was derived from the simple function:

Sample Data

$$x = \frac{ab}{c}$$

Where
x= Cost per Metre
a= Average Number of Manhole Inspections
b= Cost per Manhole
c= Average Production Rate in Metres

$$x = \frac{(25)(73.28)}{1875} \qquad x = 0.977$$

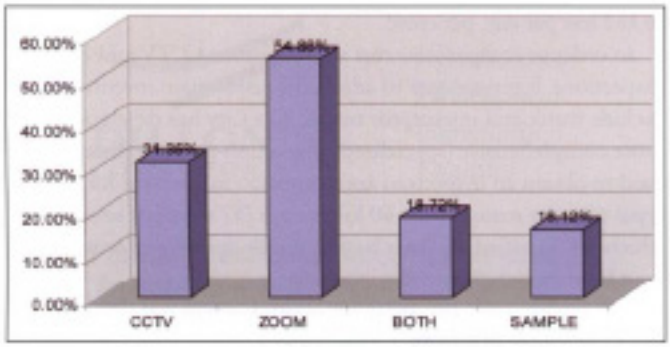
Cost/Time

Technology	Adjusted Inventory (m)	Average Price/m	Funding Requirements	Average Production Rate(Metres/day/crew)	Time Requirements in Years*
Traditional CCTV	2,566,000	5.74	$ 14,728,840.00	700m (2,297ft)	10.04
Zoom Camera	2,566,000	0.977	$ 2,506,982.00	1875m (6,152ft)	3.75

CCTV inspections to date have covered 31.35 per cent (823 kilometres / 511 miles) and Zoom Camera inspections have covered 54.86 per cent (1,441kilometres / 895 miles) of the entire system. A sample set of sewers, which have been inspected by both Zoom Camera and CCTV within the last four years was extracted from all completed inspections. This resulted in a set of inspection data which covered 460 kilometres (286 miles) or 18.72 per cent of the system. This group was then screened for sewers which had been rehabilitated or replaced in the past four years in order to eliminate inspection data collected after the rehabilitation or replacement had occurred. This results in 423 kilometres (263 miles) of inspections representing 16.12 per cent of the entire system to be used for comparison purposes. In order to understand the accuracy of Zoom Camera inspections, some statistical comparisons were made in the difference between the condition ratings derived through Zoom Camera inspections versus CCTV inspections, two distinct areas of comparison were made.

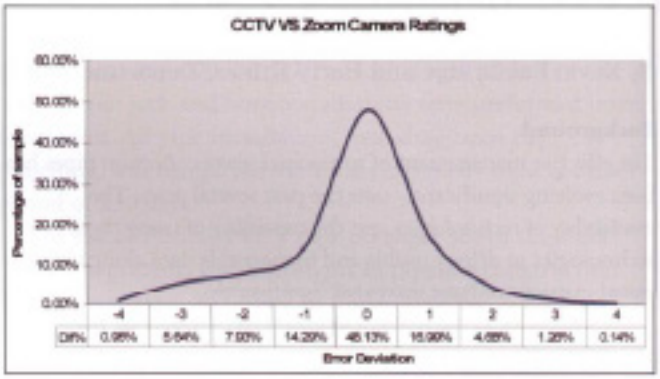
a)Error Deviation

b)Error Deviation by Segment Length



Ratings CCTV-Zoom Error Deviation

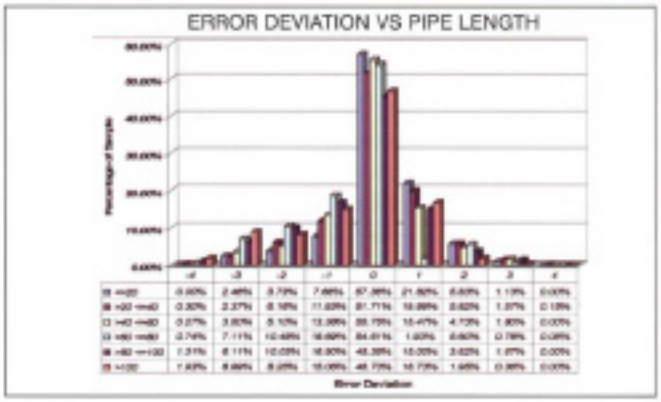
The entire sample was analyzed to produce the spread of difference in ratings between CCTV and Zoom results. Chart 2, "Spread of Rating Differences" demonstrates in percentage of sample pipe length the deviation of Zoom Camera ratings from CCTV ratings. The X-axis represents the error in Zoom rating and the Y-axis represents the percentage of sample pipe found to be inside the error deviation zone. For example, 1) Zoom Camera is equal to CCTV ratings 48.13 per cent of the time. 2) Zoom Camera shows a better condition rating by one 14.29 per cent of the time. 3) Zoom Camera shows a worst condition rating by one condition rating compared to CCTV 16.99 per cent of the time.



Zoom Camera Rating Reliability by Segment Length

Since Zoom Camera on average can only inspect the first and last 30 metres (98 feet) of pipe segments under optimal conditions, it is necessary to investigate how pipe length influences Zoom Camera rating accuracy.

The following chart (Chart 3) demonstrates the effect of pipe length in Zoom Camera rating error (x-axis +\- error). Six groups of pipe lengths in 20-metre (66-foot) intervals are used in this example. The first thing noticed here is that @ error deviation 0 (no difference in CCTV and Zoom Camera ratings) the value drops from 57.36 to 46.73 indicating that the accuracy is effected by length. Reading the chart table horizontally, one is able to observe what the pipe length impact is on Zoom Camera ratings across each error deviation.

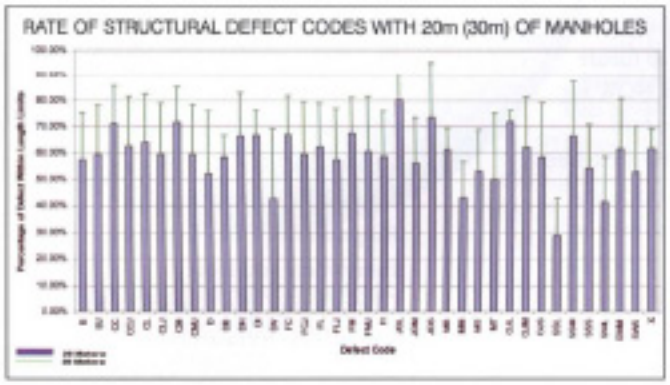


Pipe Defect Location

In order to better understand the accuracy of the Zoom Camera condition ratings, the capability of Zoom Cameras needs to be understood. Given that zoom cameras are limited in their capability of inspecting the entire length of typical sewers (80 metres / 26 feet) due to the potential presence of

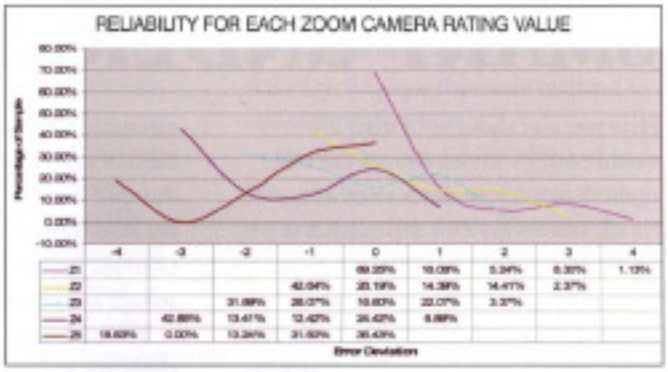
obstructions in a sewer pipe, e.g., bends, major blockage, protruding services, etc., Zoom Cameras are typically capable of viewing defects which occur in the first 20 to 30 metres (66 to 98 feet) of pipe. Therefore, if we use CCTV data to understand statistically where the majority of defects are identified as a function of distance from the manhole structures, we can obtain a better understanding of the accuracy of Zoom Camera inspection. Essentially, we are trying to understand statistically how many defects Zoom Camera inspections are missing.

On average, 59.44 per cent of defects are found within 20 metres (66 feet) of manholes and 76.12 per cent are found within 30 metres (98 feet) of manholes.



Zoom Camera Rating Reliability

Finally, the reliability of Zoom Camera ratings was individually compared to CCTV ratings to produce a reliability level presented as a percentage of pipe length in each group. Z1 to Z5 represent each Zoom Camera rating and the X-axis is the rating error deviation as compared to CCTV ratings. For example, when Zoom Camera indicates a rating of 1, the actual rating is 1 with 69.25 per cent certainty, the actual rating is 2 with 16.08 per cent certainty, the actual rating is 3 with 5.24 per cent certainty and so on ...



Conclusion

Although there are several factors which will control the effectiveness of Zoom Camera inspections, the City of Hamilton has found the structural rating results of the Zoom Camera program to be sufficient and acceptable in relation to the Capital sewer management philosophy adopted. The levels of accuracy from Zoom Camera inspections are not as unfailing as ones from traditional CCTV inspections, however, in combination with an effective management protocol based on probability and consequence of the failure of sewer pipe, the utilization of Zoom Camera technology can provide significant benefits. These benefits can be gained in economics, level of risk, social impact, resource utilization and/or any combination of these.

The City of Hamilton's Zoom Camera inspection program has resulted in the initiation of more than 5,000 work orders to date, covering everything from cleaning, CCTV, emergency repair and rehabilitation by accurately and quickly identifying problems related to these issues.

It is not suggested or implied that Zoom Camera should replace traditional CCTV inspections. Rather, it is advised that the integrated utilization of both technologies be harnessed by leveraging the "level of effort," the "level of confidence" and the "level of risk" to effectively and efficiently manage storm and wastewater collection systems. ❍