ASSESSMENT AND ACCEPTANCE OF NEW STORMWATER PIPELINES

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ABSTRACT

Most NZ Territorial Authorities specify that newly installed Stormwater pipelines shall be free from defects before accepting their ownership. However, most specifications do not have a clear definition of defects or provide an acceptable limit of tolerance to assess them. The methods for testing and evaluation of new pipelines, in many cases, are either at odds with the design standards, do not assess the appropriate criteria, or do not provide adequate information to properly determine the adequacy of newly constructed pipes. The high rate of urban development required to deliver the housing demand means that there is a large quantity of new pipelines under construction. An efficient process for evaluating the adequacy of new Stormwater pipes is necessary to ensure that the cost and effort in delivering quality, functional infrastructure is minimized while ensuring expected quality and resilience is delivered.

Proper Quality Assurance of new pipeline installation should confirm that the new pipeline would achieve the asset owner's objectives by complying with the functional requirements set during the investigation and design stages of the project. The asset owner's objectives typically include, but are not limited to the following:

1. Not adversely affect the environment by:
   - Causing flooding
   - Contaminating or damaging receiving water courses
   - Contaminating groundwater
   - Causing odors or producing corrosive gases.
2. Structural integrity under design loads
3. Durability to achieve design life
4. Water tightness to specified level
5. Ability to be maintained as planned
6. Does not adversely affect adjacent soil, structures and utility services
7. Maintaining design flow.

Any defect, which does not affect any of the above objectives, would generally be classified by asset owners as acceptable, while defects that affect one of more would be classified as not acceptable.

In recent years, CCTV inspection has gradually been accepted as the best available tool to assure the quality of the new stormwater pipeline installation. Most new specifications

nominate CCTV inspection as per the New Zealand Pipe Inspection Manual as the acceptable method to assure quality of the newly installed Stormwater pipelines, however, almost all of them stop short of specifying how the footage of the CCTV inspection shall be assessed. While CCTV inspection provides an excellent visual inspection for the inside of the pipeline, the condition grading methodology is designed to evaluate existing assets for maintenance and upgrading planning, and not determining repair or acceptability.

A comprehensive assessment of quality of the new pipeline installation should also necessary include the following:

1. Collection of information regarding layout, grade, location and design hydraulic capacity of the pipeline.

2. Natural soil and bedding materials properties, including any slop stability issues.

3. Water table location and sessional movement.

4. Type and Class of pipes and any observed pre-installation defects.

This paper presents a method for the evaluation of new pipes based on the assessment of defects identified, whether they are within the acceptable serviceability limit of the pipe and/or how the defects might affect the function of the new pipeline. The paper will also present the new pipe assessment guidelines in the upcoming version of the Pipe Inspection Manual.

KEYWORDS

CCTV Inspection, New Pipelines, Installation quality, Assessment, Pipe defects

PRESENTER PROFILE

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1 INTRODUCTION

Most NZ Territorial Authorities specify that newly installed Stormwater pipelines shall be free from defects before accepting their ownership. However, most specifications either have no clear definition of defects, and no acceptable limit of tolerance to assess them, or mix their assessment with condition coding hat designed for management of existing assets (Auckland Council 2015, Tauranga City Council 2017, and Hamilton City Council 2010). The methods for testing and evaluation of new pipelines, in many cases, are either at odds with the design standards, do not assess the appropriate criteria, or do not provide adequate information to properly determine the adequacy of newly constructed pipes. The high rate of urban development required to deliver the housing demand means that there is a large quantity of new pipelines under construction. An efficient process for evaluating the adequacy of new Stormwater pipes is necessary to ensure that the cost and effort in delivering quality, functional infrastructure is minimized while ensuring expected quality and resilience is delivered.

Proper Quality Assurance of a new pipeline installation should confirm that the new pipeline would achieve the asset owner's objectives by complying with the functional requirements set during the investigation and design stages of the project. Any defect, which does not affect the specified objectives, (refer to section 2 of this paper) would generally be classified by asset owners as acceptable, while defects that fail to comply with one of more would be classified as not acceptable.

In recent years, CCTV inspection has gradually been accepted as the best available tool to assure the quality of the new stormwater pipeline installation. Most new specifications nominate CCTV inspection as per the New Zealand Pipe Inspection Manual (NZPIM) as the acceptable method to assure quality of the newly installed Stormwater pipelines, however, almost all specifications stop short of specifying how the CCTV inspection shall be assessed. While CCTV inspection provides an excellent visual inspection for the inside of the pipeline, the NZPIM (New Zealand Water and Wastes Associations Inc. 2006) condition grading methodology has been designed to evaluate existing assets for maintenance and renewal planning, and not determining which individual pipes require repair or the acceptance of new pipe.

It was noted by the industry that the use of CCTV inspection scoring and coding as an acceptance criterion for newly installed pipeline assets has generate a lot of controversy about assessment methodology and guidelines. This controversy was mainly noticed in case of concrete pipes, while it was much less, for flexible pipes (plastics) since CCTV inspection cannot easily detect the pipe deflection and ovality, which the main serviceability limit state for acceptance of flexible pipes.

The draft of the new fourth Edition of the NZPIM, which will be more specifically renamed as New Zealand Gravity Pipe Inspection Manual (NZGPIM) (Water New Zealand 2019), will try to resolve some of the controversy by including a new section specifically for inspection and assessment of defects in newly constructed assets.

NZGPIM assessment criteria and guidelines are expected to be a step forward in resolving some the assessment and acceptance of new asset issues, this paper will try to go further in discussing this issue, by presenting a proposed procedure for the industry to follow though the inspection and acceptance process. The Authors of this paper believe that acceptance is a pure engineering process, and it is up to the Engineer, not the "Inspecting Technician" to analyze the CCTV inspection footages and recommend future steps.

2 ASSET OWNER'S OBJECTIVES

Asset owner's codes of practice and specifications typically include their general objectives and requirements of construction quality of the new assets. Quality objectives are not static, they are changing from location to location in the country, region, town and even neighborhood, therefore, it is important to clarify any objectives that are different from the standard ones stated below, and the tolerance limit of each of them. Unless the asset owner or the engineer has set out specific functional requirements during the investigation and design stages of the project, it is assumed that any new or lined pipeline shall achieve the general asset owner's objectives that typically include but are not limited to the objectives listed below.

Asset owners or quality assessors would generally classified any defect that does not affect any of the targeted objectives as acceptable, while defects that affect one or more would be classified as not acceptable unless cleared by further investigation.

2.1 NOT ADVERSELY AFFECT THE ENVIRONMENT

Stormwater lines are specified, designed and constructed to protect urban environment or transport facilities from the effect of rainwater by safely diverting the water to natural watercourses or the sea. It is always the intension of the specifier/designer that the construction quality level of new stormwater lines does not cause them to have any adverse effect on the environment in the present and in the future. The adverse effect of defective stormwater lines on the environment may include, but not limited to the following:

- Cause flooding
- Contaminating or damaging receiving water courses
- Contaminating groundwater
- Cause odors or producing corrosive gases.

2.2 STRUCTURAL INTEGRITY UNDER DESIGN LOADS

Buried pipelines structures are designed to achieve both the serviceability limit state and ultimate limit state performance stated in the relevant national and local codes. The asset owner's specifies design loads and they emphasized that buried pipes are strictly achieving structural integrity for the life of the pipeline. Buried pipelines are not similar to exposed structures where structural defects could be visually observed and easy to measure, they are hidden under ground and defects are almost impossible to detect until structural failures, such as sinkholes happen. Inspection of the newly constructed pipelines might be the only opportunity to the owners and engineers to assure structural integrity, therefore; any possible existing or future structural defects shall be thoroughly investigated and assessed.

2.3 DURABILITY TO ACHIEVE DESIGN LIFE

Replacement of existing buried pipelines in establish urban or transport facilities area is one of the most complicated and costly construction exercises. To avoid this, asset owners require new pipelines to be designed and constructed to a quality level that will be durable to serve without invasive maintenance for their design life that is now generally set as 100 years. Many stormwater lines in old cities in Europe are still in a good shape after as many as 500 years, therefore the New Zealand target of 100 years should not be considered as excessive and should be treated by the engineering community as achievable.

Asset owners generally select for their new pipelines, materials that been proven as durable to achieve the design life. Designers also consider conditions that might affect durability in their designs, therefore, the onous will be on the constructor to achieve the targeted objectives, and on the assessors to assure that construction quality achieve this goal.

2.4 WATER TIGHTNESS TO SPECIFIED LEVEL

Absolute water tightness is generally required for Wastewater Pipelines where both infiltration and exfiltration have an adverse effect on the environment and the capacity of the system. On the other hand, for Stormwater pipelines, limited infiltration or exfiltration typically does not have the consequences as Wastewater pipes. For Stormwater pipelines and culverts, watertightness is often a secondary requirement as lines are often designed with lateral connections to various subsoil drains, making the pipe system open in both directions to the ground water system. For this reason, non-watertight pipes such as flush joint pipes are acceptable in such installations. An example of an asset owner's water tightness objectives, Auckland Council's Stormwater Code of Practice (AC 2017) specify that the *potential for infiltration and exfiltration shall be minimized*. However, in some critical installations, when absolute watertightness is essential to achieve other objectives such as structural integrity, effect on the environment, and effect on adjacent soils and structures, engineers shall specify a site-specific limit and assessment method to assure that the new pipeline is complying. An example of many cases where a tighter limit may be specified are, pipelines in acidic soils to avoid discharging acidic effluents to sensitive streams, pipelines in unstable slopes, pipelines alongside slopes and exposed pipes.

2.5 ABILITY TO BE MAINTAINED AS PLANNED

Asset owner's maintenance departments and contractors typically base their maintenance plan for the new assets on the assumption that assets are free from defects that might affect maintenance frequencies, methods and required resources until many years in to the future. Any pipeline with defects that might affect any of above generally considered as non-compliant and need repair. However, most of codes of practice and specifications stop short of specifying a tolerance limit for pipeline construction from a maintenance point of view. A possible solution is that the asset owner specifies their maintenance objectives and plan so that the quality assessors are able verify if any existing defect might adversely affect the operation maintenance plan.

2.6 DOES NOT ADVERSELY AFFECT SOIL, STRUCTURES AND UTILITY SERVICES

Stormwater pipelines are part of the urban or transport infrastructure and not a standalone structure. Defective stormwater pipelines may cause landslides, sinkholes, damage to buildings and other structures and possible damage to utility services that typically run along or near them. A typical example of such adverse effect is an exfiltration from a stormwater pipe that is laid higher than an adjacent communication or power junction pit. The asset owner's objective in this case is always to keep the pit dry. Any pipeline defect shall then need to be assessed to this level of water tightness, rather than to the standard minimum exfiltration approach.

Migration of fines from outside backfill to the inside of the pipeline through defective joints and cracks represent one of the major adverse effects of pipeline defects on safety and stability of the surrounding soils and structures. To achieve this objective, pipelines shall be constructed to achieve full silt tightness of all joints and walls, or otherwise installation of the pipes shall be designed to assure fines will not migrate inside the pipe with excessive infiltration by using filter media, selected graded bedding materials, or install pipes higher than water table level if possible.

2.7 MAINTAINING DESIGN FLOW

Pipelines are designed to divert certain quantities of water that been calculated using precise hydrological design processes. Any pipeline with defects that reduce hydraulic capacity below design levels shall be considered as non-compliant. As design information is seldom included in the project drawings and specifications, assessors may need to refer to hydraulic designers to verify if a defective pipeline is still capable of meeting asset owner's objectives regarding hydraulic capacity.

3 AVAILABLE TESTING AND ASSESSMENT METHODS

3.1 CCTV INSPECTION

The information available from CCTV inspections is limited to an internal visual inspection of the pipe and associated structures and the physical limitations of the equipment. In particular, CCTV has significant limitations with quantifying dimensions inside the pipe, confirming water tightness and understanding the conditions outside the pipe that might affect its durability and future performance.

Man entry inspection of large diameter pipes can facilitate taking measurements, and undertaking some non-destructive testing, or sampling etc. However, this type of information cannot be obtained from standard CCTV inspections.

3.2 HYDROSTATIC TEST

The most reliable proof test of the workmanship in a laid concrete pipeline is by the application of a hydrostatic test, but it is not always convenient to carry this out. There can be problems or excessive cost in obtaining water at some locations and then in disposing of it afterwards.

The purpose of this test is to check that the jointing has been performed correctly and the rubber ring properly located. It is intended to pick up any fault that has occurred during the laying process. If the ground water is equal or greater than the test pressure (2.4 m above invert level of the pipe) (24 kPa) and the pipe wall or joints are not leaking when viewed by CCTV for pipes less than 1200mm or when visually inspected for larger pipes, the pipeline is considered acceptable and no additional testing is required. Moisture or beads of water appearing on the surface of the joint will not be considered as visible leakage.

3.3 AIR PRESSURE TEST

Where a hydrostatic test cannot be carried out, or it is not convenient, it may be possible to apply a low-pressure air test. However, concrete pipelines will tend to show greater and more variable permeability to air than to water, so care is needed in applying the air test and in interpreting the results. Although results of air tests and water tests do not always correlate, a satisfactory air test can serve as a useful indication that a line will pass a water test.

Points to note in the application of air tests are as follows:

- Low-pressure test recommended by New Zealand Building Code (Department of Building and Housing 2011) is highly sensitive to air and pipe temperature, small variation in temperature may produce false results.

- Concrete pipes are more permeable to air than they are to water. For this reason, a failed air test shall not deem the pipeline as unsatisfactory. If the pipeline fails the air test, again a hydrostatic test should be carried out after a further 24 hours soakage.

- The basic air leakage is affected by the degree of dampness in the pipe walls. This is seen as one reason for the poor correlation of air test results with hydrostatic water test results. Therefore, the section of line to be tested should be rigorously flushed out and cleaned. This serves to remove any debris and thoroughly wet the pipe surface. It is recommended that pipelines be water soaked for a period of 24 hours prior to the air testing.

- Care is needed in making airtight seals at the plugs, joints and the air test equipment of the pipework. It is recommended that pneumatic plugs be used instead of screw rubber plugs, as these provide a better seal at the pipe walls. Loss of air at plug points are often difficult to detect and can be wrongly interpreted as being due to faults in the pipeline.

- As pipe diameters increase the air test becomes more hazardous because of the danger of end seals (which can have imposed loads of several tones) blowing out.

- Defects may not be easy to locate with air tests.

- Experience with air tests in New Zealand indicates that concrete pipelines take a long time for pressure to stabilize as compared to pipelines of some other pipe materials. The omission of pressure stabilization at commencement may yield incorrect results.

In summary, this test, which use low-pressure air, is only applicable where it is more convenient than using the hydrostatic test. It can provide the criteria for acceptance of a pipeline but not for its rejection. When unacceptable leakage rates occur during the air test, the contractor has the option to revert to the hydrostatic (water) test. This test is not recommended for pipes >600 mm diameter because of the large forces to be resisted by the pneumatic plugs.

3.4 LASER PROFILING OR PROVING PIGS

Flexible pipes can tolerate a certain limit of deflection (ovality) during their installation without affecting their serviceability under design loads throughout their service lifetime. CCTV inspection can only detect ovality that is way beyond this acceptable limit.

Ovality testing of flexible pipes <750mm using proving pigs is specified within ASNZS1566.2 as part of the verification process. Laser profiling is also able to determine the ovality of flexible pipes and can be a quicker and more reliable testing method.

The Laser Profiler gives pipeline quality assessors the ability to analyse the ovality, alignment, diameter and capacity of a pipe using projected laser light. The profiler projects a ring of light on the pipe wall, and then software extracts the profile from the camera video and builds a 3D geometric profile of the pipe. The captured profile data is readily analysed to verify the pipe ovality.

The use of Laser Profiling and Proving Pigs is still limited in New Zealand as a quality control criterion for new pipe installations. Asset owners overseas like State departments of transportation such as The Florida DOT and Arizona DOT, on the other hand, mandate contractors to use laser profiling to inspect the installation of new culverts under highways before they complete the project. (V. S. Bhatia 2015), AC Stormwater Code of Practice specified that Laser Profiling testing for ovality, vertical and horizontal deflection, pipe measurements, cracking and pipe distortion may be required by the council. (AC 2015), Laser profiling applications also include measuring pipes scheduled for rehabilitation, as these measurements can show contractors where pipes are undersized or oversized. With typical CCTV inspection, old pipes are visually inspected, and engineers often estimate pipe distortion. Laser profile provides detailed information about the pipe's circumferential profile, allowing for a more accurate pipe liner design.

3.5 INVASIVE AND DESTRUCTIVE TESTING

This include digging the trench and inspecting the pipe from outside, taking cores or cutting parts from the pipe to inspect. The cost and implications of this type of testing are very high, especially when the trenches are backfilled, and other infrastructures are already constructed. It is always of doubt also that the pipe and the infrastructure could be reinstated to the original standard when inspection is finished.

Any invasive testing and inspection shall be avoided whenever possible and not to be used unless the suspected defects are highly critical to the safety and overall performance of the installation.

4 CCTV INSPECTION AND ASSESSMENTS

4.1 PRELIMENERY CCTV OPERATOR'S OBSERVATIONS AND LOGS

Inspection of newly installed pipelines is a first step in a process to provide indication of the quality of the asset before being vested to the utility owner and it is different from the standard practice of scoring analysis for the condition assessment of existing assets. CCTV operators, contractors and assessors shall always consider in their process that there will be a financial and possibly legal implications based on the results of their inspection and assessment.

To allow assessors to best evaluate the real and potential effects of any defect it is important that the CCTV inspection capture a sufficient view and examination of the extent of all visible defects. CCTV Operators need to look for the following features and clearly show them in the CCTV footage and log sheets records:

- All manufacturing marks, stamps, writing, scratches or stains appearing on the pipe surface
- The location, position and full longitudinal or circumferential extent of the pipe
- Chipping or spalling of crack edges and whether it is a single or branching crack
- Signs of autogenous healing
- Evidence of infiltration
- Any signs of exposed reinforcement or corrosion
- Joint gap opening or angular deflection
- Joint displacements
- Exposed joint seals and seal locations
- Ovality/deflection of the pipe
- Dimples, bulges and other reflective shapes in close fit liners

Where possible the CCTV inspection equipment used for the inspection of new pipe should have the capability to measure the width of joints gaps, e.g. Laser measuring tools. As a minimum, the equipment should have the capability to pan and tilt to observe the joints.

4.2 PRELIMENERY ASSESSMENT

The draft of the new version V4:2019 of "The New Zealand Gravity Pipe Inspection Manual (NZGPIM)" (WNZ 2019) includes for the first-time dedicated sections for the assessment of the newly installed pipelines as part of the construction QA process, and not a condition assessment process.

The new sections include an "Evaluation and Acceptance Criteria" for both concrete, flexible pipes and rehabilitated pipes. The acceptance criteria include a matrix that describes in detail all possible defects and show if they can be accepted, need repair or replacement, or require further Engineering Assessment in order to make the acceptability decision.

NZGPIM acceptance criteria is based on accepting all manufacturing tolerances stated in the pipe production and installation standards as an acceptable defect. Furthermore, it accepts all defects that research in New Zealand, Australia and overseas indicates that they are self-healing and or have no adverse effect on general asset owner's objectives.

An example part of this matrix for Reinforced Concrete Pipes is shown below:

Defect	Description	More Conditions	Acceptable	Engineering Assessment	Repair or Replace
Longitudinal Crack	Less than 300mm long		✓		
	Autogenously healed		✓		
	Less than 0.15mm width	Full pipe section (joint to joint)	✓		
	0.15mm-0.5mm	Full pipe section (joint to joint)[1]		✓	
		Full pipe section & observed in more than one quadrant[1]		✓	
Longitudinal Crack	0.5mm-1.0mm	Full pipe section (joint to joint)[1]		✓	
		Full pipe section & observed in more than one quadrant			✓
		In an aggressive environment			✓
	More than 1.0mm				✓

Defect	Description	More Conditions	Acceptable	Engineering Assessment	Repair or Replace
Circumferential Cracks[2]	Autogenously healed		✓		
	Less than 0.15mm width	Extended full pipe circumference	✓		
	0.15mm-0.5mm	Extended full pipe circumference	✓		
		Multiple circumferential cracks extended full pipe circumference and space less than D/2		✓	
	0.5mm-1.0mm	Extended full pipe circumference	✓		
		Multiple circumferential cracks extended full pipe circumference and spaced less than D/2			✓
		In an aggressive environment		✓	
	More than 1.0mm			✓	
Multi-Directional Cracks[2]	Autogenously healed		✓		
Multi-Directional Cracks[2]	Less than 0.15mm width	Covers area < 25% of circumference of the pipe	✓		
	Less than 0.15mm width	Covers area > 25% of circumference of the pipe		✓	
	0.15mm-0.5mm	Cover area < 25% of circumference of the pipe		✓	
		Cover area > 25% of circumference of the pipe			✓
	More than 1.0mm				✓
All Crack Types[2]	Allow Infiltration	Damp surface only	✓		

Defect	Description	More Conditions	Acceptable	Engineering Assessment	Repair or Replace
		Water Beads on wall		✓	
		Flowing water		✓	
	Allow entry of backfill materials				✓
	Scaling and surface damage			✓	
	Spalling	No exposed reinforcement	✓		
		Exposed reinforcement		✓	
	Slabbing				✓
	Vertical or side offset	Impedes flow		✓	

An experienced person may review the CCTV video, Logsheet and operator observations and hence, accept all defects that meet the proposed criteria and request repair of any defect that fail to meet the quality criteria.

If the preliminary assessment indicates that, some defects need further Engineering Assessment, all available information should be referred to an Experienced Engineer to evaluate and certify that the work are complying with the Asset Owner's objectives and project specifications, or recommend replacement, or repair if otherwise not complying.

4.3 COLLECTION OF RELEVANT INFORMATION FOR ENGINEERING ASSESSMENT (Minimum Requirements)

Full evaluation of defects may require further investigations or additional information to be gathered and reviewed. This may include:

- Pressure tests (hydrostatic, low pressure air or vacuum) if available
- Ovality/Deflection inspections (laser profiling or proving pigs)
- Destructive material testing
- Hydraulic and structural design data, parameters or assumptions
- Plans and long sections of the installation to verify location and effect on other structures.
- Geotechnical and chemical tests of surrounding soil
- Test results on bedding materials and compaction results
- Understanding of the embedment material compaction methods and equipment

- Any notes in drain layer logs or pipes delivery sheets regarding factory repairs or pre-installation defects.
- Any notes or information on post-installation repairs if any.
- Dates and conditions of installation
- Review of pre-rehabilitation CCTV inspections
- Measurement of pipe gradient and any variation of gradient
- Existence of dips where self-flushing gradients might not occur

4.4 ENGINEERING ASSESSMENT

An experienced Engineer may review the CCTV video, inspection log-sheets, preliminary assessment notes and all extra information collected for the project.

As a minimum requirement of the Engineering Assessment, the Engineer shall evaluate the effect of each defect on the following properties of the pipeline that covers both its stability and function:

1. Structural Stability: Evaluate the effect of each defect on the structural stability of the pipeline based on previous knowledge both in New Zealand and overseas, and the site-specific conditions of pipe location and installation methods.

2. Durability: Predict compliance of the installation with this requirement from CCTV observations, site-specific conditions, and other background information to evaluate the effects on achieving the design life.

3. Water and Silt tightness: Evaluate pipe water and silt tightness based on direct observation, CCTV date of investigation, site-specific conditions, and other background information as mentioned above.

4. Hydraulic Capacity: Evaluate defects that might affect the required hydraulic capacity of the pipeline.

Based on the above methodology, each defect may be evaluated against each of the above requirement as either complying, not complying, or not clear, in case of absence of enough information for contractor and engineer to clarify.

The recommendations of the Engineer typically based on the following requirements wherever applicable, in the following order of precedence:

1. Project Specifications and drawings

2. Asset Owner’s Codes of Practice

3. New Zealand Gravity Pipe Inspection Manual

4. Pipe manufacturer’s recommendations, manuals, and trade associations literature

5. International Specifications, research work and case studies.

6. Engineering Experience.

Below an example of an assessment matrix for a project in Auckland.

#	Asset ID	Defect Location m	Diameter	Inspector's Assessment	Rate	Engineering Assessment	Rate
STORMWATER							
1	SWMH13.6 - SWMH13.5	1.9	225	Crack circumferencial, small, visible but not open, from 12 to 12 o'clock, self healing	S	Typical CC crack less than 0.15mm wide, no clear carbonate and fines build up inside pipe wall to heal the crack tat this stage, this is normal as here is no water infiltration from outside observed and inside water flow is still limited, continues exposure to water will further fill the small crack opening with time. View footages show what is like a longitudinal cracks or multi cracks at same location however, zooming and slow speed viewing indicates that they are discolouring marks from washing water or happened during curing, storage, or installation. No signs of infiltration or structural damage observed.	S

#	Asset ID	Defect Location m	Diameter	Defect	Structural Stability			Durability 100 years			Water and silt tightness			Hydraulic Capacity			Recommended Actions	Compliance
					Not Clear	Comply	Not Comply	Not Clear	Comply	Not Comply	Not Clear	Comply	Not Comply	Not Clear	Comply	Not Comply		
1	SWMH13.6 - SWMH13.5	1.9	225	CC													Accept work with defect	Structural & Durability: 100 years AS/NZS 4058, CC <0.15, Watertightness: Minimum infiltration ACCP Cluse 4.3.9.1. c)

If the Engineering assessment includes items where compliance is not a clear, final decision on what action required might be based on the following:

1. Review of design assumptions such as loading and hydraulic capacity
2. Cost value decision of the contractor if the cost of repair or replacement justify more spending on further investigation.
3. Asset Owner's acceptance or compensation arrangement for future risk.

5 CASE STUDY

The CCTV inspection of a Reinforced Concrete Stormwater Network for one of the major transportation projects in Auckland indicated that there were many defects in the installed pipelines.

The contractor started repairing, lining the defective pipes in attempt to get the Asset owner's approval. Selection of which defect to repair was based mainly on the inspection logsheets and the NZPIM condition scoring. However, the asset owner still disputed the contractor's decisions and highlighted a further 55 lines of various lengths as defective and needing to be repaired.

At this stage, the contractor decided to request an independent engineering assessment of the pipelines in dispute before taking further repair or replacement action.

The CCTV Logsheets highlighted the following defects:

a) 79 Joint Failure including chipping or longitudinal cracks in the joint zone

b) 73 Circumferential Cracking of various severity

c) 35 Open Joints

d) 19 Longitudinal Cracks

e) 7 Permanent Obstructions

f) 5 Displaced Joints

g) 4 Surface Damage

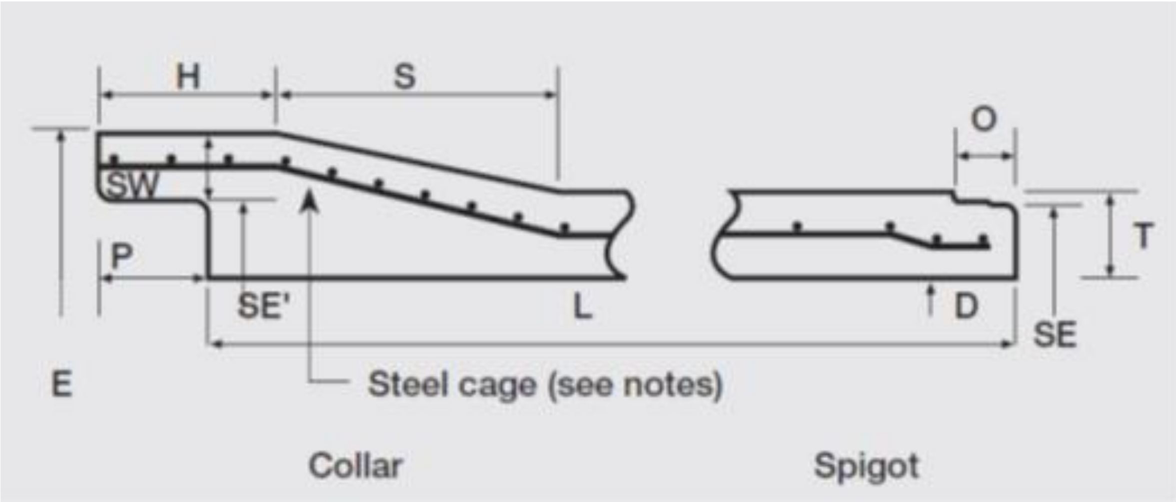
h) 4 Multiple Cracks.

Engineering assessment of the defects determined and recommended the following:

a) All defects assessed by CCTV inspector as "joint Failure" are:

- Small chips in joint area that either happened during manufacturing and handling or during installations. All chips are estimated to be within AS/NZS 4058:2007 (Australian Standards Australia/ Standards New Zealand AS/NZS 2007) tolerance limits and hence considered acceptable.
- Alternatively, short shrinkage cracks in pipe collars that frequently happened during manufacturing of concrete pipes due to reinforcement placement in the pipe as per Figure (1) which increase the thickness of cover, and hence, make concrete prone to shrinkage cracking.

Figure 1: Long Section in Typical Reinforced Concrete Pipe



b) All Circumferential Cracks were less than 0.25mm width, free from any signs of excessive infiltration and had clear signs of Autogenous healing. Therefore, all of them were assessed, as having no threat to structural stability of the pipes because the pipes are designed as continuous ring structures and CC cracks of any width has no structural significance.

   Crack width, and installation information indicated that there was no chance of soil migration through any of them. All cracks were also assessed as having no or minimum water infiltration, in agreement with AC Stormwater Code of Practice – Clause 4.3.9.1 (b) requirements.

c) Joint gaps in defects assessed as open joints were found to be more than the joint gap recommended by the pipe manufacturer. Review of pipe joint design with the pipe manufacturer indicated that with existing joint gap, the rubber seal was still safely engaged to assure silt and water tightness. As pipes were installed in a flat ground, and the period between installation and inspection is more than one year, it is fair to consider that pipe joints as being stable in their existing condition and would not present a threat to the stability of the pipeline in the future.

d) Most of the other defects were found to be minor, such as scratches inside the pipe, small surface chips in pipe wall, short longitudinal hair cracks, and small dips in joints that have minor effect on flow.

e) The only serious defects that need repair were cracks in one Earthenware connector of one of the Catchpits that need replacement and an open joint between another Earthenware and Concrete pipes that need either replacement or watertight Patch repair.

6 CONCLUSIONS

1. The assessment of CCTV inspections of new stormwater pipe installation is a completely different process from that of the condition assessment of existing pipelines using the scoring analysis process in the NZPIM. The new pipeline assessment is a QA process that is intended to assure asset owners that the new assets meets their design, specifications and quality objectives.

2. Since assessment using CCTV inspections results are only a qualitative measure of condition, verification of compliance shall be based on evaluation of possible effect of each defect on current and future performance of the pipeline. Assessors undertaking a Preliminary Assessment might use the CCTV contractor's observation, carful viewing of the video and industrial guidelines to classify defects as compliant, not compliant or needing further Engineering Assessment.

3. Engineering assessment might require a review of various design and installation processes, design and properties of the installed pipes, verification of the pipeline service conditions, geotechnical information, quantitative pipeline testing and other relevant data to verify compliance.

4. The new draft version of the NZ Gravity Pipe Inspection Manual includes for the first time a special section on assessment of new pipelines. The Draft of the manual includes verification procedure and guidelines which are designed to facilitate preliminary assessment of the CCTV inspection and verification of which defect might need Engineering assessment.

5. A case study of a stormwater network inspection in Auckland indicates that most of the defects could be verified as compliant using available industrial standards and guidelines, therefore the asset owner is not expected to achieve any improvement in pipeline performance by requesting contractor to do complicated, high cost repairs before vesting of the assets.

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