CONCRETE PIPE INFRASTRUCTURE – BEYOND 2000

Concrete Pipe Association of Australasia

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ABOUT THE AUTHOR

Patrick McGuire is the Executive Director of the Concrete Pipe Association of Australasia, an organisation representing the industry in areas of:

- Research and Development
- Technical Support
- Education and Training
- Standardisation

With a career in civil engineering spaning over 30 years, Mr McGuire has been involved in all aspects of the industry: planning, design and construction in Government and in the private sector in Australasia, Europe and South East Asia.

Mr McGuire is a member of several joint Australian/New Zealand Standards Committees.

He has a particular interest in Training, both at the grass roots level training installers of pipeline systems and in ensuring that designers gain maximum benefit for their clients by optimising the standard installations available in the joint Australian/New Zealand Standards in their designs.

SUMMARY

The recent advent of high impact compaction techniques and their effect on buried underground structures has been little understood by the construction industry. Specifiers have generally left consideration of live construction loads to the installer who has not possessed the appropriate design tools to enable a full assessment. Site Supervisors similarly have been unaware of both the significance of these loads and the need to provide adequate support. This has resulted in damage to pipes in some cases.

The Concrete Pipe Association of Australasia has undertaken a co-operative study with Brisbane City Council. The progress of the study has highlighted the need for action by all stakeholders in the industry – specifiers, manufacturers, installers and asset managers.

A range of tools to assist all stakeholders is now well advanced. This will enable a full assessment of all appropriate loads to be conducted and assist in the improvement of quality in our infrastructure.

1 INTRODUCTION

The Brisbane City Council is one of the largest Local Government organisations in the Southern Hemisphere, managing in excess of 2500 km of stormwater drainage pipeline assets.

To meet Australian Accounting Standards relating to accrual accounting in Local Government, Council's Works Department conducted audits of a number of subdivisions in 1994/95 and 1997 (Lee, Hansen & Demartini, 1999). The aim of these audits was to investigate the quality of assets donated to Council following subdivision of land and establish both the value and remaining life of the asset for depreciation purposes.

Cracking both longitudinal and circumferential was found in all pipelines inspected with a diameter of 600 mm or less. A summary of results of both audits is contained in **Table 1**.

Council concluded that the cracking was most likely related to trench backfilling and compaction methods, and carried out a detailed study into the problem.

The results of this study were presented to the development, construction and pipe manufacturing industries at a series of industry forums.

Pipe Diameter (mm)	**Length Surveyed** (m)	**Length Cracked** (m)	**Cracked Length** (%)
300	185	101	55%
375	392	182	46%
450	230	163	71%
525	31	2	6%
600	162	36	22%
675	387	18	5%

Table 1 *Results of Council audits for pipe sizes 675 and below.* (Lee, Hansen & Demartini, 1999)

2 THE ASSET MANAGER'S RESPONSE

Council, in addition to initiating the industry consultation process, undertook several initiatives, including:

- Revision of its design charts to allow for construction loads
- Amendment of its standard drawings and specifications
- Revision of acceptance criteria in Council's pipe supply contract
- Amendment to the scope and technical requirements of Council's pipe supply contract
- Introduction of CCTV monitoring during the maintenance period
- Involvement in the development of Australian Standards

Council staff have also given presentations throughout Australia and New Zealand to highlight the need for consideration of construction loads by designers.

3 AUSTRALIAN PIPE STANDARDS

Concrete pipes have been manufactured to an Australian Standard since 1932. The current manufacturing standard for steel reinforced concrete pipes, AS 4058–1992 *Precast concrete pipes (pressure and non-pressure)* is performance based.

Performance requirements fall into three categories:

- Visual
- Serviceability and strength
- Durability

The design requirements for these are assured during manufacture by performance tests carried out on randomly selected sample pipes from a nominated batch of pipes. The effectiveness of the tests has been proven by the millions of metres of steel reinforced concrete pipe currently in service and forming an important part of Australia's infrastructure.

Testing for serviceability and strength of steel-reinforced concrete pipes is undertaken by applying a load uniformly distributed over the top length of the pipe with the pipe supported underneath by two parallel hardwood bearers. The working strength of a steel reinforced concrete pipe referred to as the "crack load" refers to the test load that will cause a crack in the tension zone of the pipe of a specified width. This crack load is well below the ultimate load of the pipe.

Figure 1 *Load Test on Pipe*

The pipe load class is determined by this physical testing procedure and is the point of interface between the manufacturing process and the calculated load on a pipe for a specified bedding installation.

It follows that if a pipe is subjected to a load equivalent to the pipe load class (with due allowance made for the installation) the pipe will exhibit a crack of the width specified in the standard.

Such crack development is fundamental to the service performance of steel reinforced concrete pipe (CPAA, 1995).

4 THE CONSULTATIVE PROCESS

Brisbane City Council in its presentation at one of the industry forums noted that there was no correlation between the incidence of cracked pipes and either the pipe laying contractor or the pipe manufacturer.

Council was also concerned about long term performance, particularly since a minimum design life of 100 years is required. These issues, together with the implications of a “no crack” policy, led to the Concrete Pipe Association of Australasia offering to undertake an investigation into the cause of the cracks and their impact on asset management.

This offer was accepted by Council and a joint research project was undertaken between Council and CPAA.

The Scope & Objectives of the study were to:

1 Identify the cause of cracking;

2 Define the significance of cracking;

3 Make recommendations to avoid compromising asset life;

4 Develop measurement techniques, and

5 Set acceptance criteria.

The first stage of the project (items 1 to 3 above) was undertaken by Brisbane based consultant Cardno and Davies (now Cardno MBK) and an initial report prepared in September 1998.

The study methodology covered:

- Field Investigation to identify possible causes in the areas of manufacture, delivery, installation and backfilling
- CCTV Survey to review whether changes had occurred in the 4 years since the initial survey
- Literature Review to attempt to define the significance and effect on service life of cracks in concrete pipe.

The findings confirmed those of the Brisbane City Council subdivision audits. They indicated, however, that the solution required input from all stakeholders in the industry (McGuire & Cottman, 1998) including:

- Designers/Specifiers,
- Manufacturers,
- Installers/Contractors, and
- Owners/Asset Managers,

if concrete pipe assets which will perform to the design criteria in a more cost effective manner are to be delivered.

5 DETAILED RECOMMENDATIONS

For each of the stakeholder groups identified above the Consultants made specific recommendations.

5.1 SPECIFIERS, CONSULTANTS/DESIGNERS AND SUPERINTENDENTS

- Standardise plans and specifications rather than adopt an individualistic approach.
- Ensure fitness for purpose of the pipe selected.
- Ensure that plans clearly show:
  1 Pipe load class
  2 Design loads both during construction and in-service
  3 Trench dimensions
  4 All bedding and backfill detail and
  5 Maximum allowable load versus depth of pipe cover
- Ensure that specifications detail:
  1 Critical inspection procedures;
  2 Testing requirements and
  3 Acceptance criteria.
- Ensure that:
  1 Pre-start meetings are held;
  2 Pipelayers are aware of design and construction limitations and
  3 The proposed work methods do not compromise the design assumptions
- Ensure that respective legal liabilities of construction contractors and certifiers are clearly defined in service agreements.
- Ensure that certifiers are fully aware of their personal legal liability in certifying “as constructed” work for acceptance.

5.2 CPAA AND ITS MEMBER COMPANIES

- Review and promote “user friendly” design aids.
- Liaise with professional engineering organisations to ensure uniformity of specifications and drawings and compliance with Australian Standards.
- Promote the CPAA Concrete Pipe laying Training Program to better utilise the options available in the standards.
- Continue to improve technical competency of sales representatives so that they can better advise the industry on pipe laying.
- Review and continually improve input into other training programs such as conducted by TAFEcolleges and the various industry groups.
- Liaise with Regulatory Authorities to provide pipe laying contractors with an incentive to adopt the satisfactory completion of the CPAA Concrete Pipe Laying Training program as a minimum competency standard.

5.3 PIPELINE CONSTRUCTORS

- Insist on detailed plans and specifications.
- Employ only appropriately trained and experienced personnel.
- Implement an appropriate QA system
- Ensure that the selected work method and compaction equipment are appropriate for the pipe class being used.

5.4 REGULATORY AUTHORITIES (ASSET OWNERS)

- Document all requirements including design life.
- Select on performance and quality of work as well as price.
- Insist on certification by an appropriately formally qualified person, such as a Registered Professional Engineer, and pursue any non-conformance until resolved.
- Ensure that respective legal liabilities of construction contractors and certifiers are clearly defined in service agreements.
- Develop clear guidelines for inspection, evaluation, acceptance and management including:
  - certification;
  - condition evaluation before hand-over;
  - after-installation management.

6 CPAA ACTIONS

On completion of Stage I of this project an industry working group, including members of CPAA and Council, was formed. This group was to promote the implementation of the recommendations of the study, examine new issues, which may arise and act as a steering group for technical review of design aids and standards.

The actions taken by Brisbane City Council were discussed earlier and have been presented in other forums. (Lee, Hansen & Demartini, 1999).

The initiatives undertaken to date by CPAA have included the following.

6.1 STANDARDS

Although the current harmonised Australian and New Zealand Standard (AS/NZS 3725-1989) requires that consideration be given to applied live loads, it gives little guidance to designers to enable them to quantify these loads.

CPAA has provided a complete revision of the Live Load provisions in the current standard for consideration by Standards Committee WS/6 in preparation of the next revision.

In addition to road vehicle loads, railway loads and aircraft loads a complete section on construction loads has been added together with guidance material on minimum depths of fill required for Load Class 2 pipes for a range of construction equipment from vibratory plates to compaction wheels.

6.2 COMPUTER SOFTWARE

The Association's Pipe Selection Software package to assist designers in the design and selection of the load class of concrete pipe, has been updated and will be released as version 4.0 at the end of February 2000

The features of version 3 have been retained and expanded to include both pressure pipe and design of jacking pipe installations.

Apart from having a new look and being fully windows compatible, a library containing a full range of standard construction vehicles and equipment has been added to allow the designer to consider and include the live loads imposed. User defined vehicles, surcharge loads and point loads have also been included.

A Help system has been added to guide users through the pipe selection process and expand the versatility of the program.

The software will be available for free download from the Association's website from July 2000.

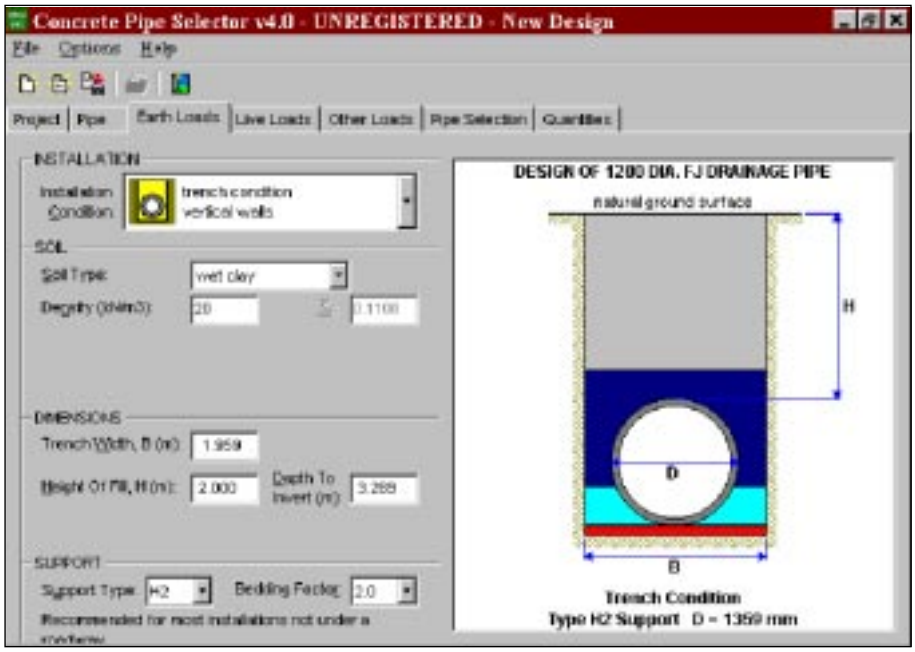

Figure 2 *Pipe Selection Software, Version 4.0*

6.3 BEST PRACTICE DRAWINGS

A standard format for drainage plans has been developed. In addition to addressing the provision of the information recommended in 5.1 above it includes, minimum cover requirements before the application of a range of construction and compaction equipment.

It is anticipated that this currently available standard drawing format will become accepted practice by its adoption as part of Infrastructure Guidelines by Brisbane City and other key asset managers.

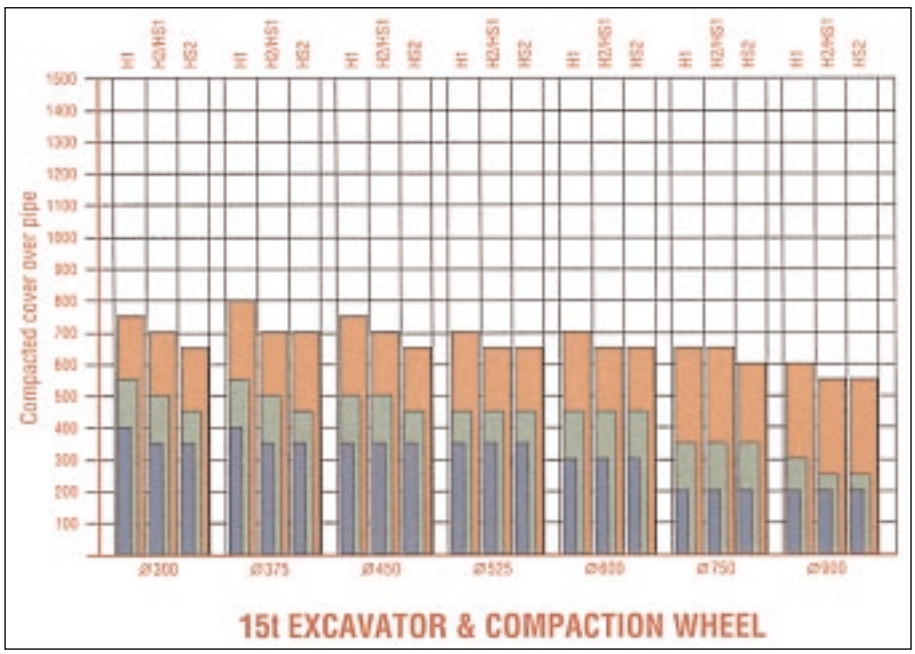

Figure 3 *Typical Load/Cover Chart*

6.4 SPECIFICATION

A Guideline specification to support AS 3725 and the Best Practice Drawing is under preparation and due for release late 2000. This will be supported by Specifier Seminars (refer 6.6 below).

6.5 RECOMMENDED PRACTICE

A new Technical Bulletin, *Recommended Practice – Installation of Steel-Reinforced Concrete Drainage Pipelines* has been produced and will be available to industry in late 2000.

This guideline document has been prepared to assist Engineers and other technical personnel to inspect, evaluate and accept “as-constructed” stormwater infrastructure.

It is not the intention of the document to instruct contractors and pipe layers in undertaking these construction activities but to explain the key areas in pipe installation which should be carefully inspected and evaluated

In addition to reviewing design issues, which may affect subsequent installation, the Recommended Practice explains and examines the important site activities and provides a checklist of items which should be considered in evaluating the progress of work.

The effect of construction loading and bedding support on pipe installation activities are included, together with useful information on inspection and testing practices commonly adopted in the construction of a pipeline. Condition assessment is also presented.

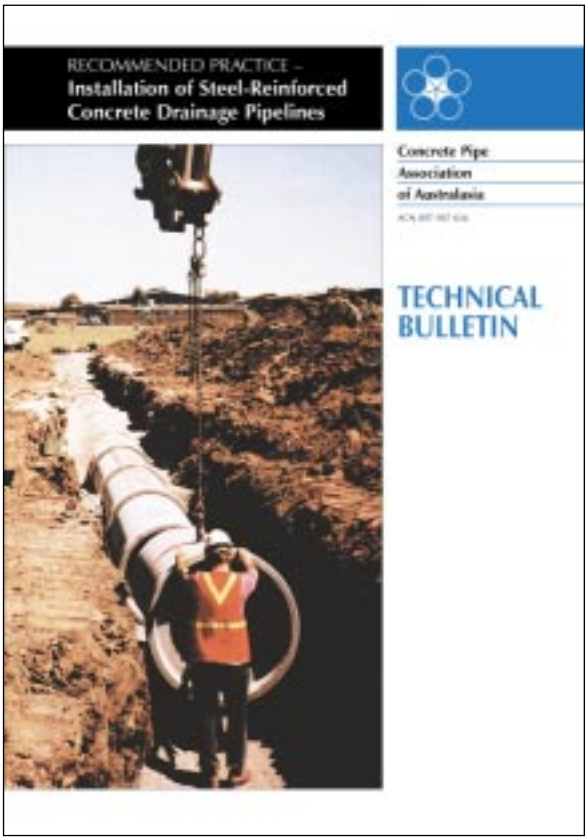

Figure 4 *Recommended Installation Practice*

6.6 EDUCATION & TRAINING

Specifiers

In-house seminars are now being offered to specifiers and designers throughout Australia to educate and promote full use of the Standard and associated design aids. Industry awareness of the effect of construction loads remains a largely unresolved issue.

Pipelayers

The Concrete Pipelaying Training Program is targeted at pipelayers (both those new to the industry and experienced), inspectors, quality checkers, leading hands and to a lesser extent designers and consultants.

The program (the only generic, competency-based course of this nature currently listed on the National Register of approved courses) is delivered as a one day workshop to those working in the industry and contains four modules:

- Introduction;
- Site Preparation and Work Organisation;
- Foundation and Bedding;
- Laying and Jointing Pipes.

Workshops are practically oriented and competency based. Practical tasks are emphasised and include case studies, a plan reading exercise, a load/ bedding/trench width demonstration/ experiment and laying and jointing pipes.

The workshops are delivered in partnership with the Civil Contractors Federation and can be linked to Industry-based traineeships and apprenticeships.

The opportunity now exists for formal recognition of this program in specifications. This represents a challenge to designers and specifiers.

Figure 5 *A Practical Session from the Concrete Pipelaying Training Program*

7 CONCLUSIONS

The work undertaken by Brisbane City Council has demonstrated the need to consider construction loads during the design process.

The cooperative study by Brisbane City Council and the Concrete Pipe Association of Australasia has highlighted actions required by the various stakeholders.

The training and design aids now available will assist other industry stakeholders in the design and construction of stormwater infrastructure that will perform its intended function through its design life.

8 ACKNOWLEDGEMENTS

The commitment of the Brisbane City Council and the cooperation and assistance provided by its officers during the study is acknowledged with thanks.

9 REFERENCES

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