In the current economic climate asset owners, asset managers, engineers and contractors are all facing budgetary challenges. Balancing cost restraints with appropriate choice of materials for infrastructure is very difficult but extremely important. If cost becomes the major focus, then stakeholders can lose sight of project life, serviceability expectations, and the overall objective of the infrastructure.

Taking a risk in the design and installation of infrastructure because of cost issues is fraught with danger. Any failure is unacceptable and can affect the health, safety and well being of the community. More often than not these failures can be avoided by choosing the right materials to be used under the correct design criteria, and installed using the appropriate methods. This is vitally important for underground structures such as drainage pipe.

To avoid these risks designers and specifiers should not lose focus on the important criteria that a pipeline should exhibit. Structural strength, robustness and long term durability provide security to the community that any pipeline is found in. Steel reinforced concrete pipe has been produced in Australia since the early 1900’s and has proven itself over and over again that it should be the pipe material of choice to ensure security. How? Let’s take a look at the reasons:

**STRENGTH**
- The inherent nature of concrete is that it is strong.
- Concrete pipe exhibits compressive strengths up to and greater than 60 MPa
- Concrete pipe can be designed for any site conditions

**ROBUSTNESS**
- Concrete pipes are tough and can survive mishandling during transportation, on site, during installation and after placement.
- The robust nature of concrete pipes means the joints can withstand shear action during placement.

**DURABILITY**
- Concrete pipes are made using raw materials in accordance to Australian and New Zealand Standards, ensuring manufacturers make quality pipes.
- Concrete pipes can be tailored for use if necessary in aggressive conditions.
- AS/NZS4058 outlines the specific requirements manufacturers must meet at achieve durable pipe.
- In accordance with AS/NZS4058 “Precast Concrete Pipes”, steel reinforced concrete pipes can be designed for 100 years in accordance with the performance based standard.

Why is this so important? A number of recent pipeline failures, locally and around the world, have occurred due to materials being chosen for conditions they were not appropriate for, or had not been designed and/or installed in accordance with their specific guidelines. Circumstances like flood and fire should not be considered unforeseen as design for infrastructure should be in accordance with the worst case scenario. Steel reinforced concrete pipe has the ability to meet the most difficult conditions.

So why risk using anything else? The objective should be to manufacture, design and install a pipeline system that will last 100 years. Reinforced concrete pipe relieves the risk on ALL stormwater drainage projects without compromise because of its **STRENGTH, ROBUSTNESS** and **DURABILITY**.
AS/NZS3725 “Design for installation of buried concrete pipe” states that “Each pipe shall be evenly and uniformly supported along the length of its barrel by suitable fill material”. When selecting for the appropriate class of pipe, the designer makes the assumption that this will be the case as the concrete pipe is designed to accept vertical loads under these conditions.

However, failure to meet these conditions can result in the concrete pipe being asked to act as a beam. The pipe relies on the internal hoop strength of the structure to accept a load, but cannot act as a simply supported beam or cantilever when the foundation and bedding conditions are not uniform. This can result in cracking, in particular circumferential cracking. Whilst the issue is not widespread, it is a problem when stakeholders are not aware of the pitfalls of unstable ground and inappropriate installation under these conditions. So what should we look out for?

• Small diameter pipes, typically 225DN – 375DN, are most vulnerable to external circumferential cracking under these conditions (also known as “broken backs”), and should be installed with great care.

• Where local soft spots exist, remove all unstable material and replace with compacted select material.

• Where general poor foundation conditions exist, over excavate unsuitable foundation material and replace with compacted select material. If necessary widen the trench to create a raft effect to spread the load to acceptable levels.

• Dewatered fine grained soils can be a problem unless specific precautions are taken. On shutdown of dewatering pumps the bottom of the trench can develop a “quicksand” condition if the hydrostatic pressure exceeds the load generated by the fill cover over the pipe. The use of geotextiles and controlled pump shutdown minimises the disturbance to foundation and bed support minimising the risk of the pipes settling onto collars and generating beam action.

• Broken backs are often observed where soft soil lenses exist in the foundation, particularly in combination with excessive or inappropriate construction loads.

• Geotextiles may be necessary to maintain the stability of constructed foundation outlined above. The geotextile is designed to stop the foundation and bedding material from migrating into the trench base or sides.

• Construction loads are often associated with pipe damage. Excessive loads will cause damage to the pipe, whilst some loads may cause damage to the foundations that provide uniform support if the foundation has a low bearing capacity.

• Foundations on peat or constructed with unstable materials may be troublesome due to the instability and may not provide long term support.

• Construction of a uniform bed zone in accordance with the Standard paying particular attention to the uniformity of the contact zone between pipe and bed zone.

• Minimise potential for foundation disturbance by specifying an installation that requires the minimum acceptable compaction levels (this may require a higher pipe class).

• Minimise the amount of compactive effort required in placing the haunch and side fill select material by ensuring grading compliance with AS/NZS 3725 (or consider using CLSM).

• Select materials for the bed, haunch and side zones that compact to the required levels with the minimum effort. The Standard AS/NZS3725 provides excellent guidance on suitable material, which ensures ease of compaction (The use of CLSM may present the best option). The use of inappropriate materials, requiring high compactive efforts, may result in foundation heave or displacement destroying the bed uniformity.

The above considerations are applicable to all concrete pipe installations, but are particularly relevant to small diameter pipeline construction, especially under roads where road construction standards require very high compaction standards. The use of other material types under these conditions will not provide long term stability due to ground movement and subsequent joint displacement. The only choice is steel reinforced concrete pipe, placed using appropriate installation techniques for the ground conditions, expected construction loads, and long term loading requirements for the job.
To “reinforce” the durability message we look at a technical paper written by Dr Norwood Harrison in 2007 on the use of concrete pipes in aggressive conditions. To read the paper in full go to www.concpipe.asn.au.

For severe salt water environments, reinforced concrete will usually be specified with a high strength grade, high cover and an additional property aimed at ensuring that the concrete will delay as far as possible the penetration of chloride to reinforcement depth. However there is no single measurable property suitable for inclusion in a specification which will accurately reflect the rate at which chloride will diffuse into the concrete. Estimating service life of a structure is made more difficult by uncertainty about conditions which will prevail at the concrete surface. While the concrete structures code AS 3600 has a classification C defined as “sea water, in tidal or splash zones”, in fact the splash zone above the high water mark is more severe than areas washed by the tide. Given the complexity of processes leading to corrosion of reinforcing steel in concrete by chloride it is not surprising that structures designed and built using an earlier state of knowledge have often failed to live up to expectations.

Experience with concrete pipe

This however has not been the case with concrete pipes. Surveys carried out by the industry in Australia found little or no deterioration in pipes subject to tidal flow, including several instances where the cover to reinforcement was less than 15 mm. According to American experience there are no reports or evidence of any chloride induced corrosion problems with buried precast concrete pipe.

Compared with other types of marine structures this raises the question, is the difference in the concrete, or in the type of exposure? The absence of problems can be attributed to “a lack of the proper mechanism to concentrate chlorides in concrete, a lack of oxygen, and the high strength, low absorption properties of precast concrete pipe.”

As part of the Australian survey of 2000 a core was taken from a concrete pipe sample which had been in service in saline conditions for 55 years. Examination of the reinforcement showed minimal corrosion. The concrete was analysed for chloride, giving a concentration at reinforcement depth 0.7% of the concrete (corresponding to about 4% of the cement) — significantly higher, by a factor of 10, than the commonly accepted threshold for initiation of corrosion. Consultants Taywood Engineering who carried out the examination concluded that:

“The apparently low incidence of corrosion initiation may be due to a combination of bound chlorides raising the corrosion activation level, the very dense cement matrix, which promotes a stable passive film, and saturated concrete, which restricts oxygen ingress required for corrosion processes.”

The Australian & New Zealand concrete pipe standard AS/NZS4058:2007 recognises “an environment in which the interior pipe surface is subject to tidal flow”, which is undoubtedly less severe than open-air environments where salt is concentrated on the surface of the concrete, and in spite of the shared reference to “tidal” is quite different from AS 3600’s exposure classification C.

Conclusion

Concrete pipes underground exposed to levels of chloride as great as the level found in sea water show no deterioration even after very long periods of service. The rate of chloride penetration, given so much emphasis in investigation of above-ground structures, is just about irrelevant — the reinforcing steel in concrete in equilibrium with environments containing moderate levels of chloride, whether from sea water or groundwater, is not subject to corrosion provided that alkalinity is maintained at reinforcement depth. Salty water is no more able than fresh water to corrode the reinforcement. This puts the onus squarely on maintaining alkalinity at reinforcement depth — i.e. the concrete at this depth is not carbonated; but in terms of required cover this is no greater than would be necessary in a normal environment. Some extra cover for marine exposure may be justified on the basis that the greater the specified cover, the less the risk of reinforcement accidentally is placed at too shallow a depth. However there is no correspondence with high levels of cover required for the most severe open-air environments.

A 225mm diameter pipe inspected in Moreton Bay (Qld) 56 years after being placed showed clear reinforcement at cover depths up to 15mm.
New CPAA member – RCPA

Following the merger of two Australian concrete pipe manufacturers, Australasian Pipeline and Precast (APP) and Reinforced Concrete Pipes (RCP), the CPAA is pleased to announce the inclusion of a new member to the Association – RCPA.

The new member joins foundation CPAA members Rocla and Humes (from Australia) and long standing members from New Zealand, Humes Pipeline Systems and Hynds Pipe Systems, adding to the knowledge base and experience already found within the Association.

The Association and the industry welcome RCPA aboard to the Concrete Pipe Association of Australasia.

66 year old pipes exhumed

In 1943 John Curtin was the Australian Prime Minister, WWII was still 2 years away from finishing, and Casablanca won best picture at the Academy Awards. In fact, if you were born in that year then you would most likely be setting up for a well earned retirement.

Well reinforced concrete pipe was being manufactured back then and 66 years later a number of elements have been exhumed in the Toowoomba region in excellent working condition.

The pipes were dug up due to a development change, and upon inspection the large diameter pipes have shown little deterioration after many years of service. In fact the pipes could easily be reused for stormwater drainage requirements if required. After 66 years of service, retirement is not an option for durable concrete pipe – they still have nearly 40 more years to wait!

Upcoming Workshops

Concrete pipeline design

The CPAA is pleased to be associated with the “Reinforced Concrete Pipes and Pipeline Design Workshops” to be conducted in 2009 by Cement Concrete Services. The workshop will look at the comprehensive design of concrete pipeline systems in accordance to the appropriate standards AS/NZS4058 and AS/NZS3725. To date the courses have been held in Sydney, Brisbane and Melbourne. Details of the remaining two seminars for 2009 are:

Perth – Wednesday 26 August 2009, Hotel Ibis, Perth WA
Sydney – Monday 12 October 2009 Stamford Grand Hotel, North Ryde, NSW

Visit the CPAA website www.concpipe.asn.au or the CCS website www.cementandconcrete.com for more details.

PipeClass Software

The PipeClass workshops are continuing throughout the regional areas of Australia and New Zealand. The software program used for selecting appropriate concrete pipe is the benchmark product offered by the CPAA to assist designers and specifiers. The 2 hour workshop focuses entirely on the software program and how designers can get the most of it to add value to their pipeline design.

Details of the remaining workshops for 2009 are:

CAIRNS – 10 November 2009, Brothers Leagues Club
TOWNSVILLE – 11 November 2009, Mercure Hotel
MACKAY – 12 November 2009, Magpies Sporting Club

Please visit the CPAA website www.concpipe.asn.au to download a registration form or contact the Association at info@concpipe.asn.au.