RETROWRAP
ANODE ENGINEERING

Arklow Bank, Southern Ireland
Retrofit of Monopile in Splash zone and Subsea to Seabed

Contents

Company Information

Anode Engineering is an Australian industrial supplier of cathodic protection products and services. Catering to the needs of the energy and resources sectors in Australia, New Zealand and the South Pacific, Anode Engineering leads the field in CP design and material supply. Anode Engineering is the exclusive distributor of Retrowrap® products in the region and provide world class support, knowledge and solutions for industries looking for asset corrosion management.

Corrosion Control International

CCI is recognised as the industry leader in the design, production and installation of inshore and offshore, subsea and splash zone corrosion control systems. CCI developed its patented, cold applied Retrowrap® systems for retrofit protection of pilings, risers and piplines as an alternative to factory coatings for new and existing underwater construction for quick and easy installation.

What is Retrowrap®?

Retrowrap is a gel-infused, tension induced wrap system designed to mitigate corrosion in the splash zone and underwater sections of piles, pipelines and risers. The development of fabric and gel technology over the past 10 years has enabled one-piece wraps to be produced to cover pipe diameters from 3.8 to 305cm. Corrosion inhibitors and biocidal formulations contained within a range of gels provide "active" protection of steel, concrete and timber substrates in the range of -40 to 130 ° C.

How does it work?

Sandwiched between layers of polyurethane are memory enhanced textile-reinforcing scrims that lock the system in place over the substrate. A unique in-line manufacturing process produces a dedicated monocoque fabric that is cut to shape during factory-assembly and thermal-welded into any size required. Full-length Geon closure flanges are attached to provide a long-term re-enterable closure. These flanges are factory-drilled to accept a variety of fasteners supplied in materials ranging from SS-316L to Inconnel 625. During installation, the thixotropic gel is forced into the surface interstices without any requirement for separately applied fillers, primers and tapes. The result is a one-piece, easily installed jacket that provides a long-term service life in a marine environment. Since production began in 1985, Retrowrap has reached the fourth generation of perfection.

Induced tension wrap systems afford both active and passive protection to marine and freshwater structural members. The wrap acts as a physical barrier to the environment, depriving the pile surface from oxygenated seawater while active corrosion inhibiting agents within the wrap arrest the corrosion process.

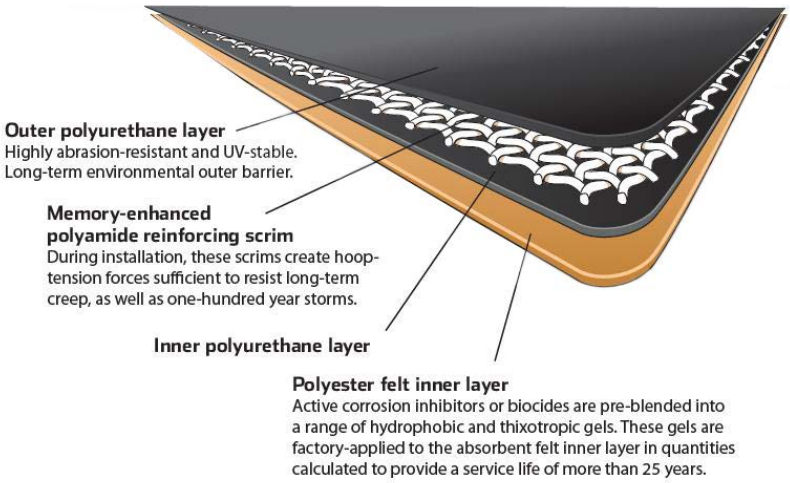
To maintain its position once installed, and provide a good association between the substrate and active components of the wrap, the membrane is stretched around the pile like an elastic band, generating hoop tension. The required hoop tension is a function of the strength of wave suction forces the wrap has to overcome to maintain position, and hydrostatic pressure differential to prevent water ingress due to tidal fluctuations.

What is it made from?

The primary membrane of the wrap is polyamide woven textile scrim which supports, during manufacture, a multi-layer of coatings selected for their long term record of excellent marine resistance throughout the system's life.

The multi layer construction method provided fabric of dedicated thickness selected to suit the operational environment. Conditions can vary from inland waterways, harbours and offshore deep water structures as well as northern regions, necessitating ice abrasion resistance. Simultaneous in-line bonding of the scrim to the inner face of a polyester absorbent felt enhances the physical properties of the fabric and provided an absorbent carrier for a range of corrosion inhibitors or biocides suspended in the thixotropic hydrophobic gel.

The finished fabric provides essential elastomeric memory and stretch retention characteristics together with the ability to be in-line welded into position.



How was it designed?

The wrap design is based on a combination of materials with excellent performance records in some of the toughest environments. The components are in-line bonded to form the monocoque fabric, resistant to immersion in both seawater and freshwater and to biological and chemical attack. The system also withstands the degradative influences of environmental UV, ozone and temperature variations.

The materials in the system are stressed below their operational elastic limits, ensuring a high safety factor in all parameters while in service. If accidentally punctured, the hoop tension causes the gel impregnated within the inner carrier layer to be exuded from the damaged area and then self seal. The inhibitor within the gel serves to protect the base metal underneath the damaged area. The design of the multi-layer monocoque membrane and the hoop tension combine to ensure that in the extremely unlikely event of a tear in the wrap, it will not propagate.

The system is designed to be a one-piece factory ready jacket for quick and easy installation. No labour intensive ancillary materials such as tapes, sealants or adhesives are used to reduce the possibility of human error and/or incompatibility of components in the installation system.

Is it safe?

The Retrowrap system has a number of proven environmental benefits, including:

• Environmentally friendly surface preparation that does not require abrasive blasting of piles prior to installation

• More environmentally friendly than tape based systems due to quicker installation providing shorter periods where the surrounding environment is impacted.

• The systems effective life span (25 years) also results in fewer environmental disturbances. The Retrowrap system requires no ongoing maintenance other than visual inspections and monitoring of probes if inserted. The physical parts of the wraps (fabric, flanges and gel) require no maintenance once installed.

• The system is capable of surviving direct hits from tropical cyclones and major floods while maintaining complete containment and integrity (See cases below).

• The thixotropic gel enclosed within the Retrowrap system presents no harm to the surrounding marine environment.

Technical Specifications

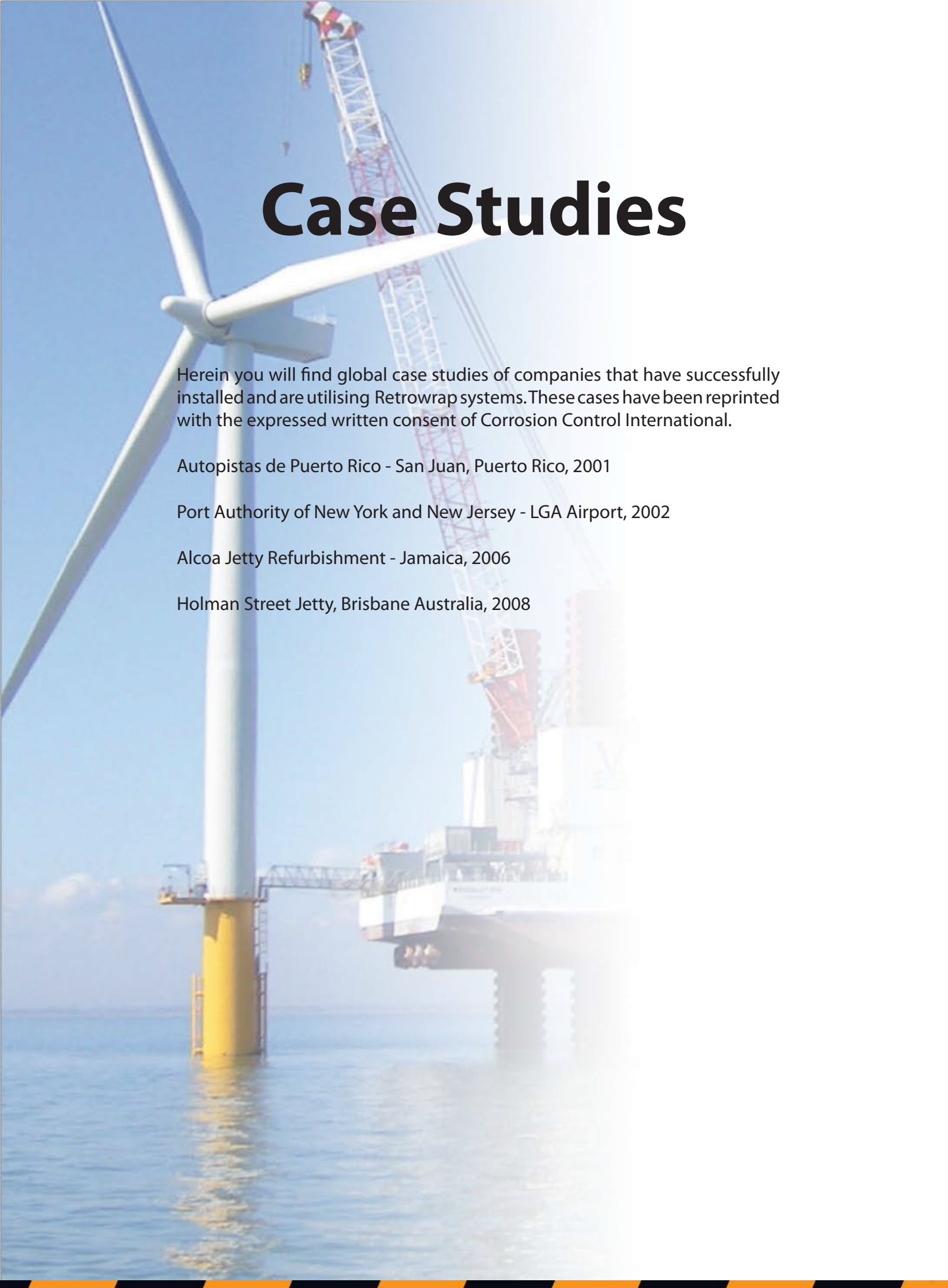
Gel Components

Refined petroleum wax	50%
Thixotropic Media	40%
Oxyalkylates and alcohol in heavy aromatic naphtha	10%
Colour	Tan
Appearance	Soft paste
Odour	Oily hydrocarbon
Specific gravity	1.2

STD19 Retrowrap Physical Data

Fabric	Type BX 4OUF
Coating material	100% PTMEG Polyurethane
Colour	Black
Surface finish	280 R.M.S (max)
Total thickness	Finished +/- 0.254mm 4.75mm
Weight	ASTM D-751 50 oz/sq yd
Base fabric	ASTM D-751 Nylon
Strip tensile	MD/XMD ASTM D-751 500/500lbs
Tongue tear	MD/XMD ASTM D-751 200/200lbs +/- 20lbs
Taber abrasion	ASTM 3389 >70,000 cycles 1000g weight Nylon reinforcing H18 wheel fabric exposure
Coating adhesion	ASTM D-751 35 (+/- 5) lbs/inch
Accelerated weathering	ASTM D4396 1000 hrs - Excellent
Low temperature bend	ASTM D-746 70 ° F
Felt	Type polyester
Weight	ASTM D-751 19 oz/sq yd
Wrap operating temperature	
Retrogel P	-20 ° C to 90 ° C
Retrogel S	-40 ° C to 120 ° C


RAP



Case Studies

Herein you will find global case studies of companies that have successfully installed and are utilising Retrowrap systems. These cases have been reprinted with the expressed written consent of Corrosion Control International.

Autopistas de Puerto Rico - San Juan, Puerto Rico, 2001

Port Authority of New York and New Jersey - LGA Airport, 2002

Alcoa Jetty Refurbishment - Jamaica, 2006

Holman Street Jetty, Brisbane Australia, 2008

Autopistas de Puerto Rico - San Juan, Puerto Rico, 2001

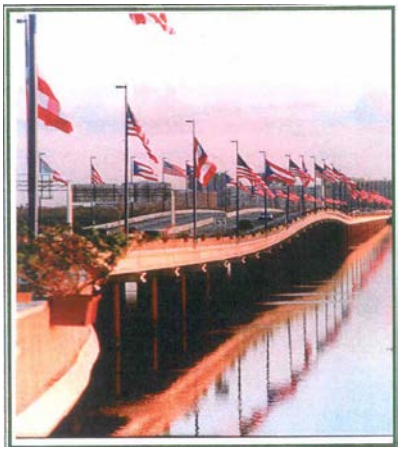
Rafael B. Acosta - General Manager

The Teodoro Moscoso Bridge began operation on February 23rd, 1994. The Bridge is 2.4 kilometers long and is a reinforced concrete structure spanning over the San Jose Lagoon connecting the International Airport with the San Juan banking and business district. The bridge is supported by 521 steel piles, 42" in diameter and is 1/2" thick. The piles were

protected by a coal tar epoxy coating and a cathodic protection system individually for each pile.

Of the 521 piles, 409 are in water. Corrosion has been a challenge especially in the splash zone of these 409 piles. The expense of cleaning, scraping, protecting and repainting every year was high and the problem was not going away. After 4 years of service, it became apparent that the coating in the splash zone was failing and the piles were corroding.

After thorough research, we selected the Retrowrap system for installation on the 409 piles using their flexible, polyurethane saturated, fiber reinforced fabric jackets. These would be installed to cover above and below the water line.



We initiated a new corrosion inspection monitoring program that started one year after the installation of the Retrowrap on our 409 piles. The inspection would include verification of CP, visual inspection of the coating above the jackets and periodic removal and inspection of a sample of jackets in the splash zone. We also installed 9 corrosion coupons to verify corrosion control in the sample. These coupons have an their exact weight recorded at 1/10,000 of a gram at regular intervals.

Results after one year were as follows. Corrosion monitoring coupons were removed at three different elevations on pile No. 1, row 34. Coupon No.1 had a metal loss equivalent to 0.2428 mil per year. Coupon No. 2 and No. 3 showed even less with 0.0648 and 0.0321 mil per year respectively.

The corrosion rates in the second year show even smaller loss than the first.

Based on this loss, the calculated time to corrosion penetration exceeds the life expectancy of the bridge.

Port Authority of New York and New Jersey - LGA Airport, October 2002

Prepared by Anthony E. J. Strange (CCI)

In September 1988, the Port Authority of New York/New Jersey, under the direction of the then staff corrosion engineer, Victor Chaker, embarked upon an extended evaluation of splash zone corrosion protection systems for the protection of 3,200, 16" and 18" pipe piles originally installed in 1964 to support the runway extensions at LGA Airport.

CCI, then known as NICC Inc. along with others, was invited to participate in the trials and provided the Retrowrap Mark 1 design for long term testing which after 18 months of evaluation was subsequently approved for the protection of 1,800 deepwater piles. The test results were published by the PA of NY/NJ in a paper presented at Corrosion 90 which quoted corrosion rates of 0.19 mils per year when measured by weight loss coupon method at 9 separate locations on each of the test piles.

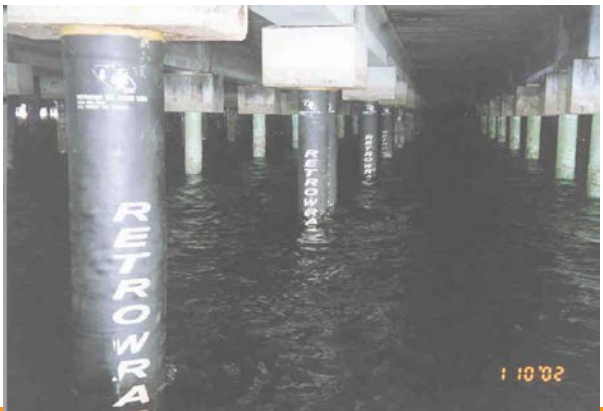
Contract 495. Commencing in the summer of 1991 and completed in 1992 when approximately 1,800 18" and 16" diameter Retrowrap Mark 1 wraps were installed by J. Picone along with 1,400 multi component wraps of the Denso SeaShield design. During the ensuing years, under deck inspection of the piles revealed that certain wraps and anode assemblies were suffering from impact and abrasion damage primarily caused by contractor's work barges in areas under the runway where extra piles were being driven during strengthening modifications which commenced in 1999.

In 2000, CCI was invited by the PA NYNJ to participate in discussions regarding the feasibility of providing both impact and abrasion resistant wraps to replace those that have failed and repair those wraps exhibiting localized impact damage. CCI proposed that our Retrowrap HD (.246") developed for offshore oil and gas riser protection be modified to accept the new anode bracket attachment design and also designed a shorter localized repair wrap for installation over both the original Retrowrap Mark 1 and Denso SeaShield systems. All replacement wraps were fitted with special Grade B8 Class 2 SS316L as specified by the client.

Contract LGA 669. In September 2002, CCI was specified on a **no substitution basis** to supply Retrowrap HD with impact resistance of 175 ft lbs and abrasion resistance of 90,000 cycles when tested to tabor A H-18.

PQT trials commenced in March followed by a presentation of production drawings and approval to commence production in late April. Installation and on site training of divers commenced in June together with a number of technical audit visits to site during the installation period primarily to insure that all CCI approved installation procedures were being followed.

Completion on schedule in October proved that by utilizing offshore methods to control all aspects of design, supply and installation produced results that in spite of a higher than normally paid wrap supplied price, **the overall project was completed ahead of schedule, under budget and provided a 25 year design life.**




After damaged wrap removed, close up of blisters in existing epoxy visible.


Top seal installed on 16" pile, top seal installed on 16" batter pile.


16" Retrowrap HD being secured into position.


Temporary bolts replaced with Class 2 SS316L bolts, fully installed.


16" diameter batter pile showing outline of top seal in contact with underside of dock. Note top seal is forced against underside of pile due to hoop tension induced into fabric during installation.


Water jet removal of marine growth from damaged Denso wrap prior to fitting 18"x28" repair Retrowrap. Double repair over damaged Denso SeaShield.

Impact and abrasion resistant Retrowrap HD retrofitted over piles where earlier installed wraps have been damaged.

UAL757 landing on runway extension 4. 22 retrofitted piles with Retrowrap HD in foreground.

Alcoa Jetty Refurbishment - Jamaica 2006

Prepared by Anthony E. J. Strange (CCI)

Retrowrap H Pile jackets to suit:

12" x 64 lbs

14" x 89 lbs

14" x 102 lbs

Retrowrap H Pile outer jacket with associated pre felted pre gelled filler blocks being loaded on work barge

Full length one piece outer jacket with lag fasteners pre installed. Note Indent tag attached to jacket to ensure correct installation

Temporary work platform attached to pile to permit upper pile cleaning and attachment of upper seal collar against pile cap

Full length outer jacket installed. Note Radius contour visible across pile flat face

Jacket and filler blocks installed on 14" vertical and raker piles

After hurricane Dean ripped through Jamaica in 2007, the concrete jetty was completely ripped from its H-beam piles. The Retrowrap system that was installed escaped untouched by the force of the hurricane with all wraps intact.

Raker pile cap termination

Vertical pile cap termination

Vertical pile jacket showing outline (under fabric) of pile cap top seal seated at pile/ pile cap high stress interface

Holman Street, Brisbane AU

Prepared by Gordon Graham

Holman Street jetty is situated in the heart of Brisbane's CBD riverways. Brisbane City Council contracted Anode Engineering to implement a corrosion protection system for the jetty in 2008. The system consisted of a Cathodic Protection Unit supplying DC protection current via two immersed anodes, supported by the corrosion control piling jacket system, Retrowrap.

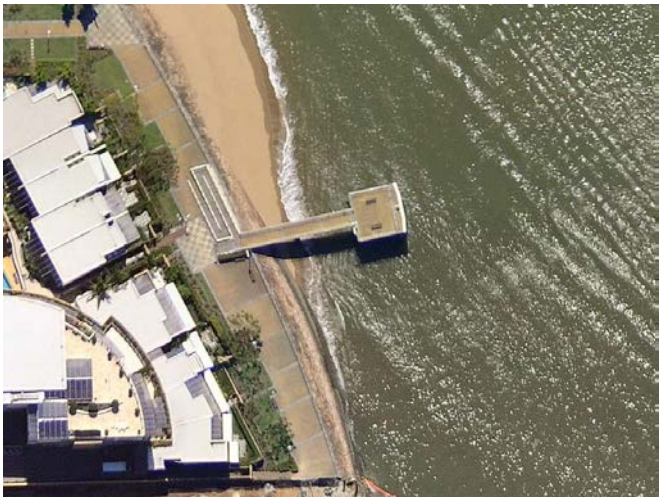
The Holman street structure, an original Kangaroo Point Dockside shipyard mooring dolphin, now an observation deck, has 13 hexagonal HP2 steel piles, approximately 433mm in diameter.

Each of the 13 piles are wrapped in Retrowrap ST19. In addition to Retrowrap, a petrolatum based tape system was used as a custom 'top seal'.

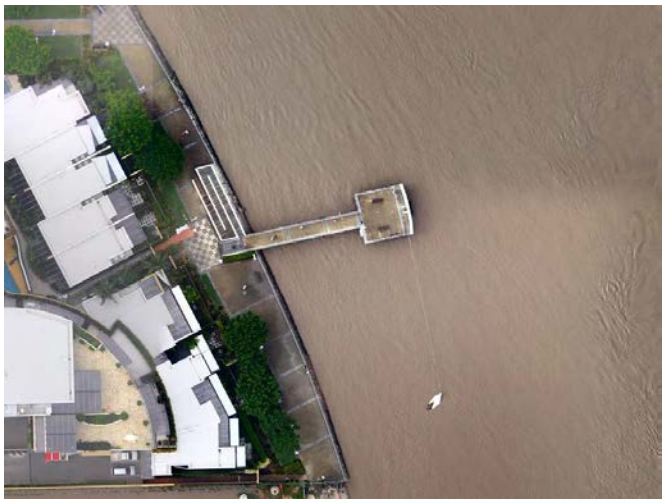
In January 2011, Brisbane experienced a more than 1-in-100 year flood event where the river burst its banks in several locations including the CBD. Wharfs, walkway structures and water infrastructure were subjected to extensive damage including complete breakaways of pontoons and vessels. The current over the duration of the flood was measured at an average of 22 knots.

Fast moving debris including logs, drifting vessels, pontoons, marine structures, sand and silt subjected the 13 piles to stress well beyond the design requirements of inshore/ river conditions.

After post-flood inspections by Anode Engineering, it was evident that all wraps were still intact, with nil damage present on all piles. It was also clear that the petrolatum based tape systems installed as a top seal had, in most cases, been swept away or required complete replacement.



Aerial view of Holman St, normal river conditions



Aerial view of Holman St during the January 2011 floods.
Notice capsized boat tied to jetty

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