Evaluation of the hot dip galvanized coating on the access walkway for bungi jumping on the Bloukrantz Bridge along the N2, Eastern Cape

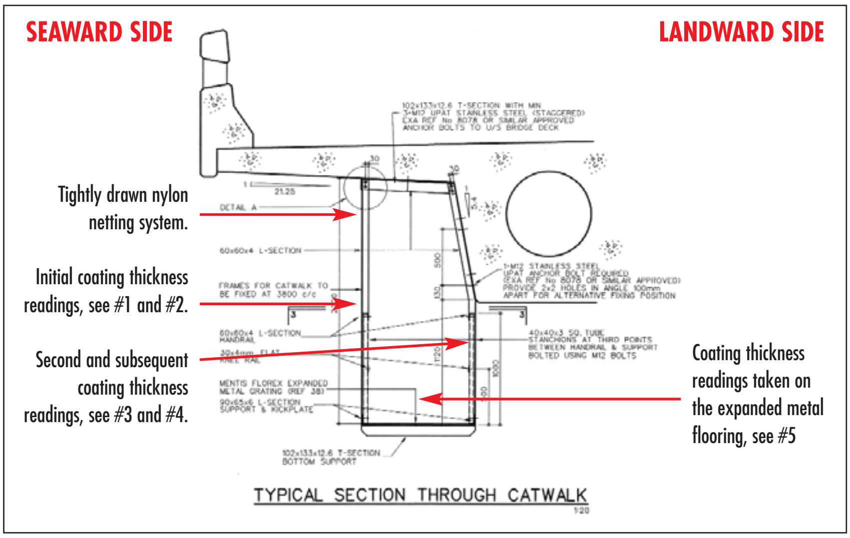
The application

The hot dip galvanized walkway is about 200m long (running from East to West) fixed to the underside on the seaward side of the concrete bridge. The steel walkway is approximately one kilometre from the sea and is about 10 years old. All the components other than some of the fasteners, some tubular hand railings and the steel wire rope supporting the nylon netting on the sides of the walkway, have been hot dip galvanized by the general process.

In my initial assessment of the performance of the coating at hand after examining some photos, taken by a Consulting Engineer in Cape Town, the hot dip galvanized coating in certain areas on the mesh floor was being attacked by chlorides. The remainder of the walkway structure did not seem to be in the same state but this could only be proved by removing the tenacious zinc chloride layer and taking residual coating thickness readings and comparing to known coating thicknesses of similarly aged components that are not quite exposed to the same conditions.

In order to evaluate the integrity of the hot dip galvanized coating, it was suggested that several coating thickness readings be taken on steel sections on the east and west side and also on fasteners and expanded mesh that looked suspect. Although coating thickness readings were taken on a variety of the steel sections, because the 40 x 40 x 3mm thick tubular stanchions looked most suspect and comprised the thinnest steel and therefore likely to have the thinnest original hot dip galvanized coating thickness due to the chemical composition of such steels, most of the recorded readings and photos were taken on these members.

Left – A general view of the bridge from the landward side (the bungi jumping ropes can be seen in the centre of the bridge) and right - a view of the access walkway looking from the east end, fixed to the underside the bridge on the seaward side.



Cross sectional sketch of the walkway indicating where coating thickness readings were taken.

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Photo 3.

Photo 4.

Photo 5.

The cross sectional sketch of the walkway on the previous page indicates where coating thickness readings were taken.

As the walkway was covered on the seaward side with a tightly drawn nylon netting system and other than one lot of readings, see #1 it was difficult to take all the coating thickness readings in this area. However, it was established that at several parts of the walkway the hot dip galvanized coating on the outside of the walkway was no worse than the areas that coating thickness readings were taken.

It was therefore decided to take readings on components that were on the inside of the walkway still facing the seaward side that looked as though they were showing signs of rusting.

1	2	3	4	5	6	7
				MAINTENANCE FREE LIFE OF THE COATING		
Corrosion category	Description of environment	Corrosion rate (av. loss of steel in µm/yr.)	Corrosion rate (ave. loss of zinc in µm/yr.)	Continuously hot dip galvanized sheeting Coating class – Z275 (±20µm)	Hot dip galvanized coating (85µm) Steel thickness ≥ 6mm	DUPLEX COATING SYSTEM Hot dip galvanizing + an appropriate paint system
C1	Interior: dry	≤1.3	≤0.1	>50	>50 #A	Not required for corrosion protection #B
C2	Interior: occasional condensation Exterior: exposed rural inland	>1.3 to 25	0.1 to 0.7	>40	>50 #A	Not required for corrosion protection #B
C3	Interior: high humidity, some air pollution Exterior: urban inland or mild coastal	>25 to 50	0.7 to 2.1	10 to 40	>40	Not required for corrosion protection #B
C4	Interior: swimming pools, chemical plant, etc. Exterior: industrial inland or urban coastal	>50 to 80	2.1 to 4.2	5 to 10	20 to 40	Coating life in columns 5 & 6, plus the paint life multiplied by a factor of at least 50%
C5-I or C5-M	Exterior: industrial with high humidity or high salinity coastal	>80 to 200	4.2 to 8.4	2 to 5	10 to 20	Coating life in columns 5 & 6, plus the paint life multiplied by a factor of at least 50%

#A - Although mathematically incorrect (coating thickness divided by the corrosion rate), the maintenance free life indicated in column 6 has for practical purposes been curtailed to a maximum of 50 years.

#B - A duplex coating system may also be specified in order to provide a colour for aesthetic reasons.

Atmospheric corrosivity categories and examples of typical environments, taken from ISO 9223, Table 1.

Environmental conditions

The bridge is situated about 300m above sea level and about a kilometre from the sea. Damp sea air is driven by the prevailing wind through the gorge adjacent to the bridge and settles on the surfaces of the hot dip galvanized steel components.

A hot dip galvanized coating will generally provide a service life of between 8 and 70 years depending on the coating thickness and local conditions at hand. Hot dip galvanizing when new has a shiny silver appearance and this when exposed to the elements; carbon dioxide and moisture will change into

Location of reading	Mean	Min	Max	No of readings
Taken on the zinc chloride layer on the outside of the hand railing. (60 x 60 x 4mm L)	281	250	336	12
Taken on the coating where the zinc chloride was removed – #1.	169	161	178	9
Taken on the coating including the zinc chloride layer on the inside of the hand railing – #2.	170	158	181	12
Taken on the coating where the zinc chloride was removed – #2.	147	144	150	13

Table 2: Coating thickness readings #1 and #2 (µm).

Photo 6.

Photo 7.

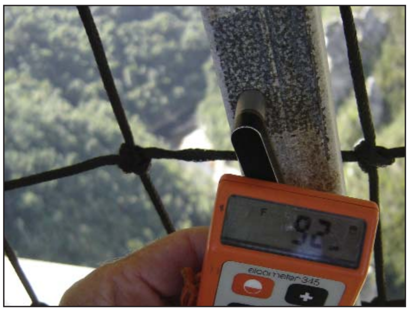

Photo 8.

Photo 9.

Photo 10.

Photo 11.

Pictorial view of the hot dip galvanized bolts on the inside of the walkway, the two on the left are facing the seaward side, with the one on the right having been over coated with paint.

a matt grey colour (zinc carbonate film – stable layer).

Prevailing off shore winds containing moisture and chlorides from the sea can ultimately convert or partly convert this stable film into a zinc chloride layer (often seen only on the exposed side of a hot dip galvanized component near the sea).

The zinc chloride layer on top of the hot dip galvanized coating will when measured with an electromagnetic thickness gauge, indicate a thicker coating when compared to the surface on the opposite face. Chlorides are therefore attacking the metallic coating and when the metal coating has eventually been depleted, only a zinc chloride film will remain, providing very little corrosion protection, this layer can easily be removed and will tend to flake off resulting in discoloration and surface rust.

Whilst hot dip galvanizing is an excellent barrier, which by its nature corrodes slowly over its service life, acceleration of the corrosion rate can be affected by the conditions at hand. The atmosphere at hand is most probably an aggressive C4 or normal C5M environment. *See table* 1.

In spite of the atmospheric conditions the hot dip galvanized coating has provided a reasonable maintenance free life over the last 10 years of exposure.

The assessment

Photo 3 indicates a typical coating thickness reading (166µm) taken on the east end on the seaward side of the walkway hand railing (where the nylon netting was pulled away) on an area that was scrapped clean of the zinc chloride salt layer (see further readings #1 - table 2), *photo* 4 - the coating thickness including the zinc chloride layer (163µm) and *photo* 5 where the zinc chloride layer was removed (154µm) – on the inside of the hand railing – #2 table 2.

Photo 6 shows the appearance of the coating on the first 40 x 40 x 3mm thick tubular stanchion (east end), *photo* 7 – the coating thickness

Photo 15.

Photo 16.

Photo 17.

including the zinc chloride layer (214µm) #3 table 3 and *photo* 8 – the coating thickness reading where the coating was cleaned (92µm) #3 table 3.

Photo 9 shows the appearance of the coating on the stanchion on the west end, *photo* 10 – the coating thickness including the zinc chloride layer (291µm) #4 table 3 and *photo* 11 – the coating thickness reading where the coating was cleaned (77µm) #4 table 3.

Expanded metal flooring

Photo 15 shows the expanded metal flooring where due to discoloration of the hot dip galvanized coating, the expanded metal was painted. The photo shows the delaminating of the paint coating. *Photos* 16 and 17 show the residual hot dip galvanized coating thickness (14.7 and 16.3µm respectively). See #5 table 3.

Originally over cleaned and damaged hot dip galvanized coating.

Photos 18 - 23 show where the coating was originally over cleaned and not repaired or damaged and repaired inappropriately, which has subsequently failed. *Photo* 19 shows a damaged area with the zinc rich paint repair coating that has now failed and *photo* 20 shows the residual coating thickness (15.6µm) at the damaged area. In *photo* 22 the adjacent coating alongside the damaged area was measured to be 162µm thick and in *photo* 23 residual coating thickness was measured at the damaged area (18.7µm).

Photo 24 shows under creep film and a zinc rich paint coating failure. The zinc rich paint was most probably originally applied over a damaged hot dip galvanized coating. Unfortunately, the position of this damaged and repaired coating was out of reach so that the paint coating could not be scraped off and the surrounding hot dip galvanizing, assessed. It is felt, however, that when the paint is removed an uncoated area will be revealed surrounded by a metallic zinc coating and this should be repaired in accordance with the coating repair procedure. Corrosion at this point will be localised and concentrated at the

Photo 18.

Photo 19.

Photo 20.

Photo 21.

Photo 22.

Photo 23.


Photo 24.


Photo 25.

Photo 26.

area of damage. Corrosion creep with hot dip galvanized coatings is impossible.

Abrasion resistance of a hot dip galvanized coating

The vastrap stair treads have been in place for 10 years and first impressions indicated that the coating had been worn off at the edge of the stair tread. Taking coating thickness readings proved to the contrary that a residual coating existed (*see photos* 25 *and* 26 (49µm)). Walking on the vastrap plate stair treads, the hot dip galvanized coating on the edges seemed to have been worn off by the passing traffic. A residual coating thickness, however, in excess of 40µm, was found in most instances.

Conclusion and recommendations:

- The only successful method of removing the tenacious zinc chloride film that is adherent to many of the seaward face components, is to mechanically sweep blast the surface and due to the degree of difficulty in achieving consistent substrate cleanliness and the inevitable environmental restrictions of doing this, this cleaning technique will not be acceptable.
- The residual coating has been assessed for its integrity and other than several local areas, which require an appropriate coating repair; the hot dip galvanized coating is performing adequately and at the indicated corrosion rate, the coating is expected to last at least another 10 years.
- Areas that require coating repair using an approved coating repair material in accordance with the attached procedure are: All fasteners; all areas that were previously damaged and originally repaired by means of a zinc rich paint and all local areas that have subsequently been damaged and are showing discoloration or rust.
- The expanded metal flooring can also be repaired but due to the constant abrasion provided by the feet of passing traffic, may be better off being replaced using newly hot dip galvanized panel/s.
- All subsequent welding of the newly hot dip galvanized expanded metal flooring must be repaired in accordance with the Association coating repair procedure.
- The areas that were identified and where the coating was evaluated and thickness measured, should be suitability marked and identified for subsequent evaluation in two years time, say March 2010. Following this future coating evaluation and assessment, a more accurate assumption can be made as to the coatings durability and future maintenance free life.
- Should it be indicated that the hot dip galvanized coating in years to come has failed (defined as when the red rusted surface is greater than 5% of the total surface area), the individual walkway sections can be removed, abrasive blasted and regalvanized at the cost of only the hot dip galvanizing.

Location of reading	Mean	Min	Max	No of readings
Taken including the zinc chloride layer on the inside of the walkway on the seaward face of the tubular stanchion. East end – #3.	214	72	329	19
Taken where the zinc chloride was removed on the inside of the walkway on the seaward face of the tubular stanchion. East end – #3.	79	70	92	11
Taken including the coating including the zinc chloride layer on the inside of the walkway on the seaward face of the tubular stanchion. West end – #4.	229	165	342	11
Taken where the zinc chloride was removed on the inside of the walkway on the seaward face of the tubular stanchion. West end – #4.	90	70	104	14
Typical hot dip galvanized bolt, scrapped clean of zinc chloride salts	85	72	99	7
Expanded metal flooring where the zinc chloride and failed paint coating was removed. West end – #5.	22	15.9	30	9

Table 3: Coating thickness readings #3, #4 and other areas (µm).