4 Corrosion protection of steel bridges – heritage of the past and trends of the present

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Optimum corrosion protection of the steel structure ensures the required function and service life under conditions of appropriate production, assembly and, above all, use.

The current state of the art in corrosion protection in most steel construction applications is focused on the use of combined corrosion protection systems, so-called duplex systems. For less aggressive environments, however, it is also appropriate to use coatings made from organic coatings or hot-dip galvanizing alone.

Historically, corrosion protection of steel bridge structures was only provided by organic coatings, which provided mainly passive barrier protection. Active protection using electrochemical protection (cathodic protection) has only been applied to selected welded bridge structures.

Corrosion protection with organic coatings

In general, it can be stated that the organic coatings used were suitably pigmented with corrosion inhibitors, thus increasing the effectiveness of the corrosion protection. In the case of the application of organic coatings, mainly linseed oils (fermets; practically the only option in the mid-19th century) pigmented with red lead (Pb_3O_4) were used.

Red lead was a very effective corrosion inhibitor, used in significant proportions in primers until the 1970s. Most bridge structures in our country also used organic coatings pigmented predominantly with red lead (Pb_3O_4) or other lead compounds, such as lead divalent, lead cyanamide or lead benzoate, for corrosion protection.

Primers pigmented by red lead were preferably used on riveted bridge structures. The most commonly used was a suspension of red lead in linseed oil, less often a mixture of red lead and alkyd (usually alkyds modified with fatty acids of vegetable oils).

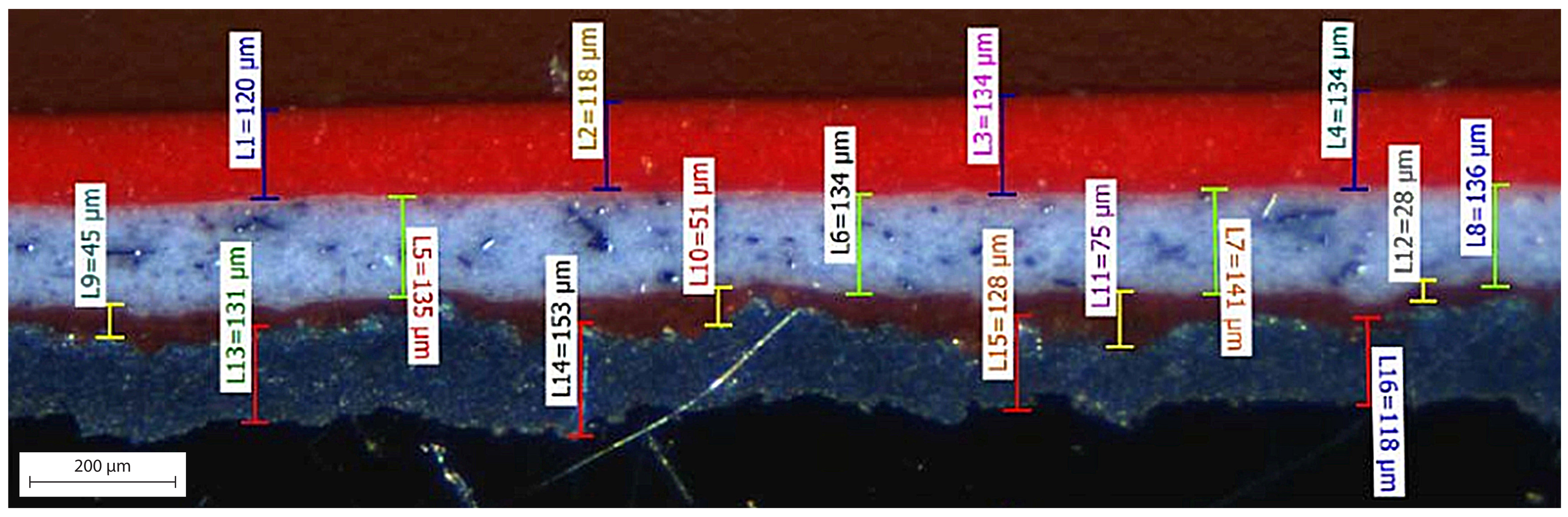
Corrosion protection of riveted bridge structures built in the territory of the present-day Czech Republic in the 19th century was carried out exclusively with oil-based paints. These paints were based on drying oils that were purely natural and subsequently partially technologically modified (heat treated) and were widely used as the usual anti-corrosion protection of steel elements against atmospheric corrosion.

At the end of the 19th century, alkyd resin paints were spreading rapidly. These were usually esters of functional alcohols (glycerol or pentaerythritol) with organic acids or their anhydrides (especially phthalic anhydride).

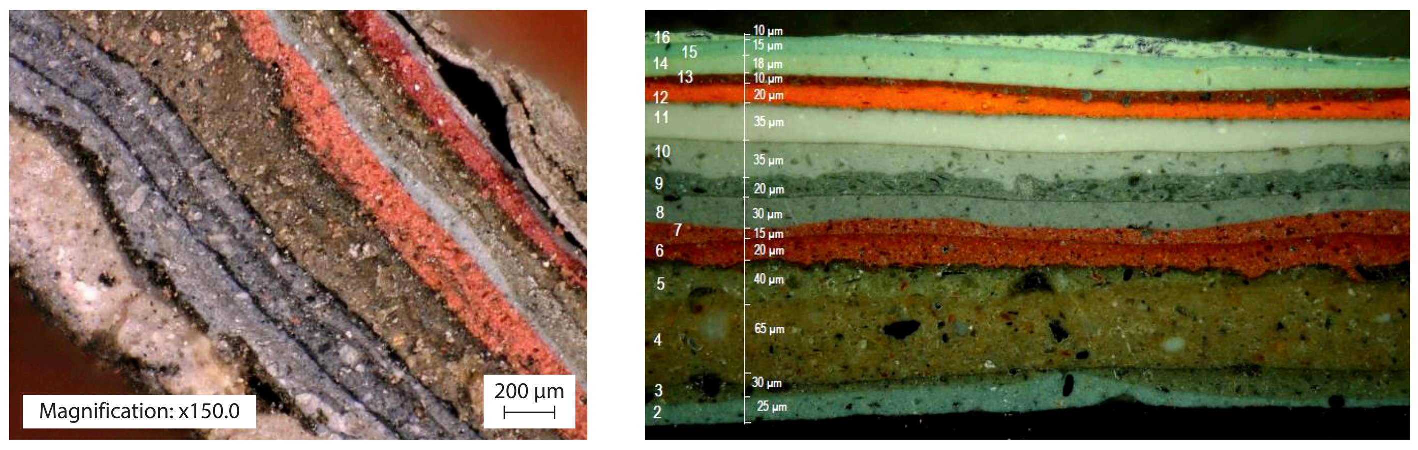
In the 1950s came the development of epoxy resins, polyacrylates and other synthetic paints. Epoxy paints contain an epoxy resin and a hardener that gives these coatings elastic and at the same time very hard surface properties. The epoxy paints resists abrasion, moisture and non-aggressive chemicals.

At present, corrosion protection using coatings for steel bridge structures is based mainly on a combination of multilayer epoxy paints and a polyurethane topcoat. For more corrosive environments, epoxy primers with high zinc content or zinc-silicate primers with medium zinc content are used. There are many types and manufacturers of paints for steel structures today, and selecting a suitable coating is not easy, given the many factors that affect the corrosion protection of a steel structure in a direct exposure environment.

Protection of the Komenský Bridge in Jaroměř by hot-dip galvanizing, 2015



Duplex system – measurement of thicknesses of individual layers



Layers of the coating on the historical Čech bridge

Protection of the Railway bridge over the River Dyje on the Hohenau–Přerov line by duplex coating system, 2016, photo by David Rose

Corrosion protection of steel structures with zinc coating

The zinc coating itself, created for example by hot-dip galvanizing technology, provides quite satisfactory corrosion protection. The ability of zinc to protect steel against corrosion was discovered as early as 1741, and since 1837, when the first patent for hot-dip galvanizing was obtained, the method of protecting steel by zinc plating has been used industrially.

Nowadays, hot dip galvanizing of steel bridge structures is used more for secondary (non-load bearing) parts of the structure, such as railings, bridge caps, etc. However, the use of hot-dip zinc coating itself for the load-bearing parts of the bridge steel structure is not an exception. However, the greater use of zinc coatings for corrosion protection of steel structures is in combination with the subsequent application of coatings, when we speak of the so-called Duplex system.

Duplex systems are combined corrosion protection systems consisting of zinc coating and coatings. The zinc coating is applied to the surface either by hot spraying (metallization) or by hot dipping. These corrosion protection systems are usually used for corrosion protection of main load-bearing steel structures. The main reason for this is their ability to provide cathodic protection to the base metal surface in the event of minor damage, thus extending the life of the corrosion protection. A duplex system generally has a much longer life than either coating alone. A prerequisite is good and permanent adhesion of the organic coating to the zinc surface, which means that the zinc surface must be carefully cleaned and the right type of coating system chosen.

In recent years, investors have begun to realise that the investment money coatings should be so efficient that we do not have to spend additional funds on repairs and maintenance. In practice, experience shows that long-term protection of OK is only possible with a combination of hot-sprayed zinc or aluminium coating or a combination of these and a coating system, even at a higher cost It should be remembered that the cost of corrosion protection represents a considerable sum. In many cases, it is 10 to 15% of the price for heavy structures, or up to 40% of the price for light and rugged structures. It is therefore essential to always consider the suitability of the coating technology depending on the type of bridge, its purpose and the required service life.