

Corrosion protection on steel bridges: Coating thickness measurements on delicate positions with an innovative instrument

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Introduction

After the first steel bridges were built 200 years ago, steel has instituted itself worldwide in the 19th and 20th Centuries and in a multiplicity of bridge constructions as best building material. This is due to the fact that opposing to concrete it has a better strength to weight relationship. With steel, the construction of bridges is easier - shorter construction time and reduced construction costs. However, the disadvantage is the additional work or rather expense, since unprotected structural steel in the atmosphere, in water and in the soil corrodes. A reliable maintenance of the steel bridges is therefore crucial because these bridges ensure smooth traffic for cars, trucks as well as rails and as such, represent the most important medium for the transportation of goods and services in our society. In the year 2000, there were 35675 bridges with a surface of 25.54 million square meters in Germany, from which 6.67 million square meters consisted of steel [1].

Standard monitoring and measurements on Steel bridges

In order to ensure traffic security on and under the bridges, the steel constructions should be examined in regular intervals. In the Federal Republic of Germany, the examination and monitoring of engineering structures is fixed in the DIN 1076. According to this standard, simple examinations of these structures should be carried out every three year and main examinations every six year and should be supervised by a certified engineer [2]. If a bridge has to be examined, as in the case with the south bridge in Duesseldorf (Josef cardinal Frings bridge, figure 1), and renovated, the repair works and required coatings must be controlled. In Germany, the norms for the controls are described in the regulation "additional technical Contract conditions and guidelines for the corrosion protection of steel structures" [3], which relates to the international standard EN ISO 12944 [4].

In the case of the redevelopment of the south bridge of Duesseldorf, the external walls of the bridge were supported with T-profiles (figure 2). After a surface preparation, two coatings consisting of an epoxy resin coating with approximately 300µm layer thickness were applied. For the execution and monitoring of the coating work a systematic proceeding and documentation of the work are necessary with such large objects. Therefore, dependent on the size of the object, check areas are defined at which verification measurements are made. Besides dry thickness measurement, each processing step also includes measuring thickness in the wet condition, associated site conditions regarding air humidity, dew point and surface temperature, as recommended in EN ISO 12944.

Measuring of coating thickness procedures underlie the international standard EN ISO 2808 [5], as can be seen for wet film combs to determine wet coating thickness and also magnetic measuring methods and/or for dry coating thickness measurement - illustrated in figure 3 and 4.

Frequently changing and rough environmental conditions during controls and coating works require durable, reliable and measuring devices, which can easily be operated and handled. Altering temperatures combined with a possible prevailing magnetization of the substrate are conditions that demand special instrument receivables. Despite these different influences on the measuring device, the user would like to obtain reliable measurements without complex adjustments. Any accessories, for example calibration foils often obstruct the progress of the work - they can be blown by wind or misplaced. Moreover, one cannot exclude the fact that these foils can be contaminated by solvents or two-component lacquers, rendering them useless. In fact, the user would prefer a measuring device, which can be used immediately without time-consuming calibration and/or adjustment on different ferromagnetic steel.

Even without considering the rough environmental conditions, verifying coating thickness on certain safety points can be very cumbersome. Due to the position of the applicator or the geometry of the construction, particularly difficult to access places are poorly coated. Furthermore, these difficult to reach places exhibit increased corrosion danger due to the dominant humidity. For this reason especially these places are considered with the examinations. At the south bridge in Duesseldorf the interiors of the welded T-profiles are relevant inspection points - as in the illustration 5. In particular for these points, a coating thickness device instrument with small overall height is needed, so that the vertical inner wall can be measured. For these types of application, flat hand-held devices or small measuring probes are imperative. Often for these critical places, cables connecting the hand-held gauge with the measuring probe are used. This connection is however, not practicable in many cases and can be a source for an accident if the user has to reach measuring points via ladder or the cable gets tangled to the ladder. For critical measuring points in heights or difficult to access places, a small measuring device and/or measuring probe is desired, which can be operated exclusively with one hand. Although a connecting cable could be a suitable solution, it can also be disturbing and even dangerous in applications where climbing is a necessity. An innovative solution for such application problems should be a small, tiny and completely independent thickness measuring probe that transfers its measurements via radio control to a data-indication and acquisition system. With a small, completely independent radio probe the user can measure easily at critical positions, without a distressing cable connection as illustrated in figure 6 and 7.

This freedom of measurements increases the security of the user on the one hand and on the other hand, the handling of the device. Moreover, the readings can be conveyed over longer distances to the indicator system. For the examination of check points in large heights or in other places which can be reached with difficulty, a consultant from a further distance can control the readings directly without being at the same measuring point. For instance, the consultant and/or expert can observe the readings at the foot of the ladder without having to do the climbing himself. Besides measuring the dry film thickness of the individual layers, the adhesive strength between the layers or layer to the substrate is characterized. For layer thicknesses greater than 250µm the pull-off method is generally applied. Here a stamp with defined size is stuck on the surface of the coating [6][7]. Subsequently the force is measured, with which a pull-off of the stamp takes place. Since an

appropriate coating system generally breaks in a lacquer layer, the steel substrate is still covered with the remainder-coating after the pull-off. The determination of the torn-off layer is afterwards investigated by a coating thickness measuring instrument, so that the torn-off layer in the multi-coating-system can be located.

Systematic data-acquisition and standardized documentation

For each checked control-area a list of individual readings with the associated statistic evaluation is to be provided and documented according to certain standards. By means of the statistical function the average, the maximum or the minimum roughness of the substrate and/or the unevenness of the coating can be computed. Due to the large surface of the object, several thousand measured values have to be stored in the hand-held gauge. In order to ensure a systematic acquisition and storage of measured data, measuring blocks are created in the hand-held gauge and assigned to the respective check areas -see figure 8.

the setting-up of the measuring blocks is possible at the hand device or with a commercial computer, which communicates via a radio link with the hand device. The possibility to configure the gauge from a computer is innovative, particularly when prescribed or uniform block names for a project are used. The measured values can be transferred from the stored blocks into a personal computer, so that the documentation can be printed out or sent in an electronic form to individual project partners. For statistical evaluation the measured data can be transferred to Microsoft Excel, which permits flexible evaluation possibilities. Besides simple statistic functions, a histogram provides a distribution of the measured data. The figure 9 shows the control procedure from the measuring procedure to data evaluation on a personal computer.

Conclusion:

The high costs for the bridge redevelopment combined with the long life span of the bridge demand for extensive control works. In almost all cases, the costs of the used coating thickness device are really small compared with the total costs of the redevelopment. Regardless of the cost proportion, the reliability and accuracy of the device determines how efficient the inspection is carried out. In terms of security, small and autonomous measuring probes will perform a better job as it reaches difficult to access places and provides the greatest freedom of movement. In addition, a small radio control measuring probe that embeds simple data acquisition and evaluation offers enormous work efficiency to the user. The QN 8500 with its independent and small radio control measuring probe is unique. The combination of this radio control autonomous measuring probe with the QN 8500 is an innovative step towards solving problems for delicate applications in corrosion inspection on steel bridges.

Further information and photos at www.q-nix.de

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Figures:

Figure 1: South bridge in Duesseldorf (Josef cardinal Frings bridge)

Figure 2: Redevelopment of the in-cabin room of the South bridge in Duesseldorf

Figure 3: Wet film comb to determine wet coating thicknesses according to EN ISO 2808

Figure 4: Coating thickness gauge for dry coating measurements according to EN ISO 2808

Figure 5: Coating thickness measurement with device QNix® 8500 and a radio-based measurement-probe in a steel T-girder

Figure 6: Comfortable coating thickness measurement with QNix® sat- radio-based probe on a ladder

Figure 7: Unlimited freedom of movement with QNix sat- coating-thickness-probe

Figure 8: Systematic storage of measurement-data with allocation of control-areas to memory-blocks

Figure 9: Radio- transmission of data from the probe to the gauge as well as from the gauge to a PC, where the data-evaluation can be done with Microsoft-Excel

E1 / 0607