CORROSION OF HISTORIC GREY CAST IRONS: INDICATIVE RATES, SIGNIFICANCE, AND PROTECTION

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ABSTRACT
In Europe many buildings and machinery in industrial sites are recognised as cultural heritage. These structures, often made from various types of irons or historic steels, have been for decades or centuries exposed to aggressive atmospheric environments and suffered from corrosion attack. The contribution discusses corrosion rates, the effects of corrosion on structural reliability, and the efficiency of surface treatments. The model for corrosion rates of historic metals cannot be based on the degradation model for mild steels even though specific features of historic alloys such as increased content of carbon and different chemical composition would be taken into account. Realistic estimates of corrosion rates need additionally account for different micro-structure with inputs and different surface properties of historic alloys. This is why the presented model is based on a limited experimental data, considering the corrosivity of environment. The model assumes no corrosion during first seven years of service life and the same type of regression function for the progress period as is provided in ISO 9224 for mild steels and other metals. The effects of repeated applications of paintings are discussed. Four principal strategies to the corrosion protection of industrial heritage structures include 'leave as it is', apply temporary protection to reduce degradation progress, apply long term protection, or undertake a complex restoration with replacement of damaged elements. Numerical example indicates that corrosion is normally insignificant for load-bearing iron structures, but may lead to severe problems for thin secondary structural and non-structural members such as railing or decorative elements. The proposed model estimates degradation progress in a mid-term perspective and supports decisions on maintenance of industrial heritage structures.
Keywords: atmospheric environment, corrosion, cultural heritage, degradation model, historic steel, industrial heritage structure, iron.

1 INTRODUCTION

1.1 Motivation

In Europe many buildings and machinery in industrial sites are recognised as cultural heritage. These structures were often made from various types of irons or historic steels. In this study a specific focus is on grey cast iron that is a construction material of many cultural heritage structures, mostly dated back to the second half of the 19th century. Grey cast iron has been used for load bearing structures (frames, columns, beams) as well for non-structural elements (hand rails, decorations).

Cast irons are resistant to uniform corrosion due to their microstructure, component compounds (graphite and phosphate eutectic), and due to the resistant compact surface formed by cooling after casting. However, historic structures have been for decades or centuries exposed to aggressive atmospheric environments and some of them suffered from corrosion attack [1]. This is why the contribution discusses corrosion rates, the effects of corrosion on structural reliability, and the efficiency of surface treatments.

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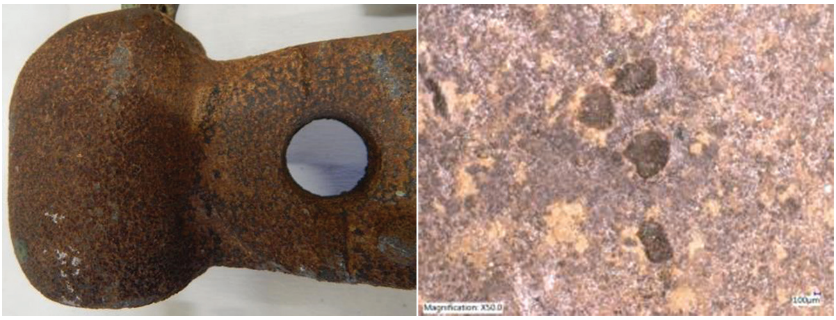

Figure 1: Surface of cast iron after 50 years of exposure – graphite particles.

1.2 Corrosion of cast irons

Though the graphite shape and the amount of massive carbides are critical to mechanical properties, they insignificantly affect corrosion resistance of cast irons. Rarely, graphite can act cathodically with regard to the metal matrix and may accelerate the corrosion attack. Cast irons show the same common forms of corrosion as other metals and alloys. Examples of the forms of cast iron corrosion include uniform or general attack, galvanic or two-metal corrosion, crevice corrosion, pitting corrosion, inter-granular corrosion, selective leaching, erosion-corrosion, stress corrosion, corrosion fatigue or fretting corrosion [2].

Cast irons typically exhibit very low corrosion rates in industrial atmospheres, say less than 130 µm/y. Cast irons are generally found to corrode at lower rates than steels in the same environment. The long-term atmospheric corrosion of cast iron is consistent (in terms of the shape of the regression function) with the models observed for mild and low alloyed steels [3], but long-term corrosion losses of cast iron are about 25% of those for mild and low alloyed steels. This is attributed to the graphitized layer holding protective corrosion products more effectively than the rust formed on mild steel.

The graphite corrosion (Fig. 1) is a form of corrosion unique to cast iron. It is a selective leaching attack seen in grey cast iron in relatively mild atmospheres in which selective leaching of iron leaves a graphite network. Selective leaching of the iron takes place since the graphite is cathodic to iron and the grey iron structure establishes an excellent galvanic cell. This form of corrosion usually occurs only when corrosion rates are low. If the metal corrodes more rapidly, the entire surface, including the graphite, is removed, and more or less uniform corrosion occurs. Though no dimensional changes take place, graphitic corrosion can cause significant problems as the cast iron loses its strength and metallic properties. During graphitic corrosion the porous graphite network, which makes up 4%–5% of the total mass of the alloy, is impregnated with insoluble corrosion products. As a result, the cast iron retains its appearance and shape but it is structurally weaker.

2 PERIOD OF FULL PROTECTION BY COATING

It is judged that no corrosion is initiated during the first seven years of service life of the structure exposed in aggressive environment (e.g. corrosivity category C4 or higher according to ISO 9223:2012), t_{ini} = 7 y. This estimate is based on:

- The experience with historic protective coatings and qualitative comparison with modern coatings considering their composition and way of application;

- An additional barrier mechanism due to the presence of scales specific for cast irons – as they were processed only by casting, their surface was strongly affected by high temperatures and the outer layer provided additional protection against atmospheric corrosion.

For milder exposures t_{ini} may be longer.

A period of seven years is slightly shorter in comparison with modern coatings, the lifetime of which is commonly around 10–15 years. The lifetime of duplex systems of coatings along with galvanised steel might well exceed 20–30 years.

3 CORROSION RATES BASED ON THE MODELS FOR MILD STEELS

It might be deemed that models for corrosion rates of historic metals could be based on the degradation model for mild steels while accounting for specific features of historic alloys such as increased content of carbon, different chemical composition, different microstructure with inputs, and different surface properties. The corrosivity of environment and effects of environmental changes over long lifetimes of historic structures should be reflected by the model.

ISO 9224:2012 for guiding values for the corrosivity categories indicates that the corrosion rate of metals and alloys subjected to atmospheric exposure is time variant. The rate commonly decreases with exposure time, t_{exp}, due to the accumulation of corrosion products on the surface that inhibit the corrosion progress. The total corrosion loss, D, is assumed to be given as:

$$D = r_{corr} \times t_{exp}{}^{b} \tag{1}$$

where t_{exp} is in years; r_{corr} denotes the corrosion rate experienced in the first year of exposure; and b is the metal-environment-specific time exponent, usually less than 1. For long-term exposures excessing 20 years, eqn (1) is slightly modified; see Section 4.

The first-year rate r_{corr} can be estimated in accordance with ISO 9223 for different alloys and corrosivity of environment. Further to r_{corr}, ISO 9224 provides indications on:

- Yearly corrosion rate calculated as an average value for the first ten years of atmospheric exposure of the metal
- Yearly corrosion rate derived from a long-term atmospheric exposure of the metal, excluding the initial exposure period of 10 years

The regression coefficient b in eqn (1) accounts for chemical composition of the alloy:

$$b = 0{,}569 + \sum b_i w_i \tag{2}$$

where b_i is regression weight and w_i is the composition mass fraction of an element i in the alloy. The weights b_i are provided in ISO 9224.

Table 1 provides the weights b_i of elements according to ISO 9224, the representative compositions of mild steels and grey cast irons and respective regression coefficients b in eqn (2). The negative values of b-coefficient for the two representative compositions of grey cast irons [4, 5] clearly demonstrate that eqn (2) along with the weights b_i recommended in ISO 9224 cannot be used to predict corrosion losses of grey cast irons. Negative b-values lead to the unrealistic predictions when corrosion loss decreases with time. Specific features of historic alloys such as increased content of carbon and different chemical composition seem to be inadequately reflected – very likely inhibiting influence of some elements (C, P, Si, and Cr) is

Table 1: Weights b_i of elements according to ISO 9224, representative composition of mild steel and grey cast irons and respective regression coefficients b in eqn (2).

Element	**Weight b_i (ISO 9224)**	**w_i in % ($b_i w_i$ in brackets) – mild steel***	**w_i in % ($b_i w_i$) – grey cast iron [4]**	**w_i in % ($b_i w_i$) – grey cast iron [5]**
C	–0.084	0.056 (–0,005)	3.24 (–0,27)	3.31 (–0,28)
P	–0.490	0.013 (–0,006)	0.43 (–0,21)	0.086 (–0,04)
S	+1.440	0.012 (0,017)	0.13 (0,19)	0.099 (0,14)
Si	–0.163	0.060 (–0,010)	2.11 (–0,34)	2.19 (–0,36)
Ni	–0.066	0.04 (–0,003)	0.065** (0)	0.065 (0)
Cr	–0.124	0.02 (–0,002)	0.296** (–0,04)	0.296 (–0,04)
Cu	–0.069	0.03 (–0,002)	0.208** (–0,01)	0.208 (–0,01)
b according to eqn (2)		0.56	–0.126	–0.021

* Reference composition in ISO 9224. **Not provided – taken from [5].

overestimated. Furthermore, realistic estimates of corrosion rates need additionally account for different micro-structure with inputs and different surface properties of historic alloys.

4 CORROSION RATES BASED ON LIMITED EXPERIMENTAL DATA

In the light of the previous findings, the presented model is based on a limited experimental data, considering the corrosivity of environment. The model adopts the same type of regression function for the progress period as is provided for mild steels and other metals in ISO 9224. The regression coefficient b is assumed to be independent of time and of corrosivity category.

Atmospheric corrosion mass losses of cast iron and mild steel are provided in Table 2 for different periods of exposure; corrosion mass losses for cast iron are based on the mean values provided in [6]. It appears that the corrosion loss of cast iron is lower than that of mild steel, particularly in the environments with higher corrosivity.

In the absence of statistical data and advanced models for prediction of corrosion losses, the corrosion losses indicated in Table 2 for one-year exposure might be adopted as r_{corr}-values for cast irons as a first approximation. The values of the b-exponent can be obtained from eqn (1) considering corrosion loss D, r_{corr}, and time of exposure t_{exp} according to Table 2.

Table 2: Atmospheric corrosion mass loss of cast iron and mild steel for different periods of exposure [in μm].

Corrosivity of environment	**Cast iron***			**Mild steel****		
according to ISO 9223	1 y.	5 y.	10 y.	1 y.	5 y.	10 y.
C2	28	50	60	25	61	90
C3	51	71	75	50	123	181
C4	61	82	98	80	196	289

* Average corrosion mass loss [6]. **Using eqn (1) and (2), considering the reference composition of mild steel in ISO 9224, the values for one year represent the maximum values indicated in ISO 9224.

Table 3: Corrosion rate and exponent b for cast iron.

Corrosivity of environment according to ISO 9223	r_{corr} **in µm/y.**	b^*
C2	28	0.36; 0.33
C3	51	0.21; 0.17
C4	61	0.18; 0.21

* Values obtained from 5-year and 10-year corrosion loss respectively; mean $\mu_b = 0.24$, standard deviation $\sigma_b = 0.074$ and coefficient of variation $V_b = 31\%$.

The b-values given in Table 3 suggest that distinctly lower b-values are obtained for categories C3 and C4. This preliminary observation needs to be investigated within further research, preferably supported by more experimental data.

Historic cast iron structures can be exposed for long periods exceeding 50–100 years, depending on re-applications of coatings. For $t_{exp} \leq 20$ y. the corrosion losses are derived using eqn (1) while for longer exposures the following linear relationship is applied in accordance with ISO 9224 to predict material losses for a steady-state stabilised corrosion progress:

$$D\left(t_{\mathrm{exp}} > 20\,\mathrm{y.}\right) = r_{\mathrm{corr}}\left[20^{b} + b \times 20^{b-1} \times \left(t_{\mathrm{exp}} - 20\right)\right] \tag{3}$$

Figure 2 displays the variation of uniform corrosion loss with time of exposure for mild steel (model according to ISO 9224) and for cast iron (proposed model with the parameters from Table 3). The figure again demonstrates that corrosion loss is much lower for cast iron; for long-term exposures, say $t_{exp} > 50$ y., the ratio D_{iron} / D_{steel} varies in the range from 15% to 30% with larger values for C2 and lower values for more aggressive environments.

Melchers *et al*. [2] observed that corrosion of cast iron was negligible in the atmospheric zone in comparison with the immersion zone and the extremely aggressive environments – the

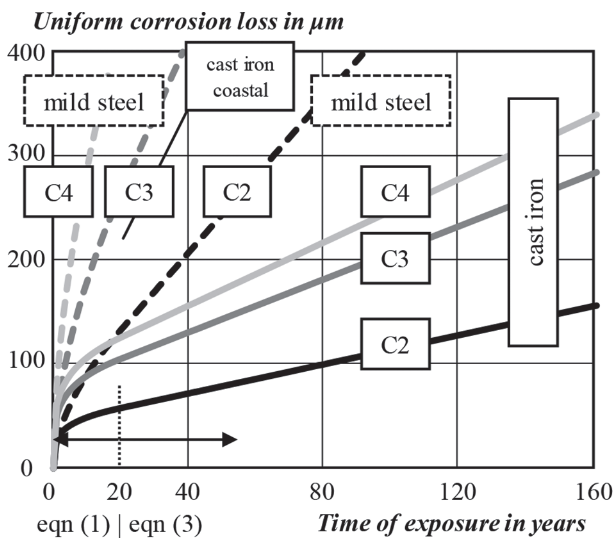

Figure 2: Variation of uniform corrosion loss with time of exposure for mild steel (model according to ISO 9224) and for cast iron (proposed model with the parameters from Table 3).

splash and lower tidal zones – in seawater. Figure 2 indicates the trend of long-term atmospheric corrosion loss for grey cast iron in accordance with the model proposed by Melchers [3] for coastal areas. It appears that more severe corrosion is expected and corrosion losses become comparable to mild steel in the C3 environment. The significant differences between corrosion losses in coastal and other (C2–C4) environments are confirmed by the typical average corrosion losses indicated by Melchers and Emslie [7] where further insights into corrosion of cast irons in aggressive environments are provided.

5 UNCERTAINTY IN CORROSION LOSS PREDICTIONS

5.1 Mild steel

To provide a first insight into uncertainties related to predictions for cast iron, uncertainties in corrosion losses are initially analysed for mild steel. The model uncertainty is described as a random variable, θ, following the recommendations provided in [8, 9]. Considering eqn (1), the uncertainty can be expressed as a ratio of the probabilistic model of D to its nominal value – best estimate based on r_{corr} and b:

$$\theta = \frac{\theta_{r\text{corr}} r_{\text{corr}} \times t_{\text{exp}}^{\theta_b b}}{r_{\text{corr}} \times t_{\text{exp}}^{b}} = \theta_{r\text{corr}} \times t_{\text{exp}}^{(\theta_b - 1)b} \tag{4}$$

where θ_{rcorr} denotes uncertainty in the estimate of r_{corr}, and θ_b is uncertainty in b. The application for eqn (3) is analogous.

ISO 9223 and related background material [10] indicate that the r_{corr}-values provided by the standard for a specific composition of mild steel reasonably correspond to the measurements (sample size of 128), the coefficient of determination being $R^2 = 0.85$. Assuming unbiased predictions and linear relationship between measurements and model predictions, it can be shown that this scatter might be approximated by θ_{rcorr}-variable with a unity mean, $\mu_{\theta r\text{corr}} = 1$, and coefficient of variation (hereafter 'CoV') $V_{\theta r\text{corr}} = 8.5\%$. In the absence of data, a lognormal distribution is assumed for θ_{rcorr} in accordance with [8, 9].

ISO 9224 indicates that the estimate of a b-value for mild steel has a normal distribution with standard deviation $\sigma_b = 0.0260$. In this study it is assumed that the estimate of a b-value according to ISO 9224 is unbiased, $\mu_{\theta b} = 1$, and $V_{\theta b} = s_b / m_b = 0.026 / 0.523 = 5.0\%$.

Figure 3 shows the probability density function of θ for $t_{\text{exp}} = 1$, 10, and 100 y. It appears that the significance of θ_b increases with time of exposure as is demonstrated by increasing CoV of θ.

5.2 Cast iron

For cast iron, the statistical characteristics of the uncertainties θ_{rcorr} and θ_b need to be modified. For the former no statistical data are available. It is thus assumed that eqn (1) and (3) along with the input parameters given in Table 3 ($\mu_b = 0.24$ and a mean value of r_{corr} for a relevant corrosivity category) lead to unbiased estimates, $\mu_{\theta rcorr} = 1$. As chemical composition, microstructure, and properties of the surface layer of cast iron are more variable than in the case of mild steel, CoV of θ_{rcorr} is expected to be larger for cast iron. In the following analysis, $V_{\theta rcorr} = 0.15$ is assumed. This estimate should be updated whenever experimental data become available. Regarding uncertainty θ_b, standard deviation of 0.074 might be considered for b-value (Table 3) and thus $V_{\theta b} = s_b / m_b = 0.074 / 0.24 = 31\%$. As this estimate is based on limited data, it should also be updated whenever possible.

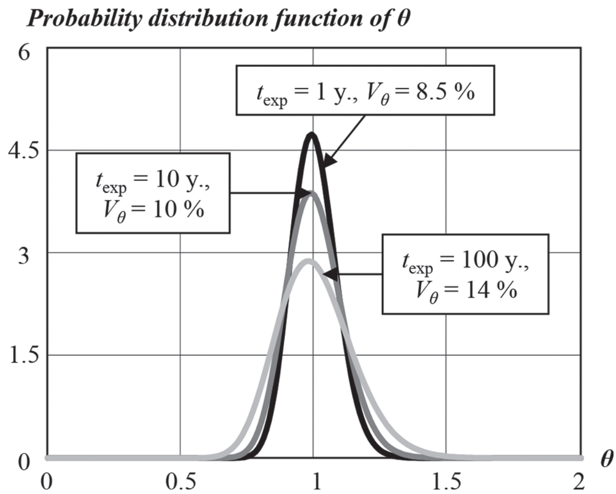

Figure 3: Probability density function of θ for t_{exp} = 1, 10, and 100 y.

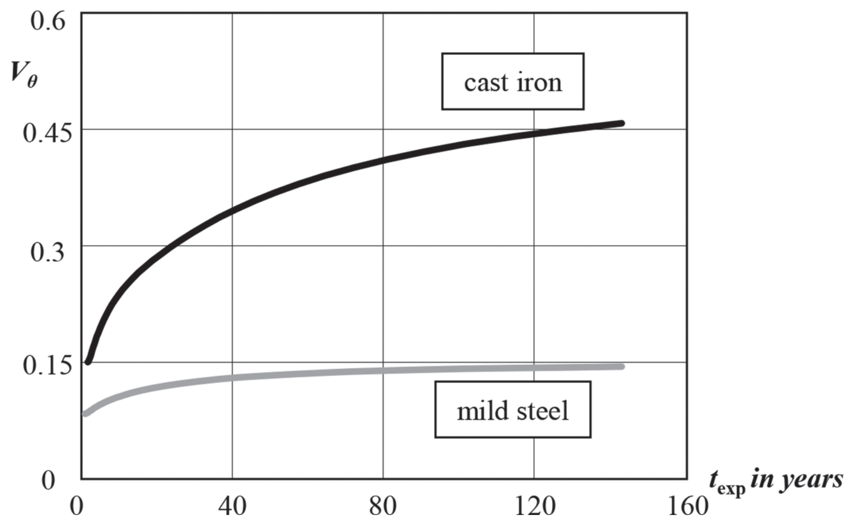

Figure 4: CoV of corrosion loss as a function of time of exposure for mild steel and cast iron.

Figure 4 displays the CoV of corrosion loss as a function of time of exposure for mild steel and cast iron. While V_θ for mild steel can be approximately considered as time independent ($V_\theta \approx 13\%$ as a representative value for exposure of 50 years), the uncertainty in b becomes dominating in the case of cast iron and V_θ changes significantly with t_{exp}.

Figure 5 shows the variation of corrosion loss with time of exposure for mild steel and cast iron in various environments – the expected trends (also plotted in Fig. 2) and 75% confidence intervals. A lower bound is obtained by multiplying the expected value by a 12.5% fractile of the uncertainty θ; an upper bound by multiplying by an 87.5% θ-fractile. In the case of cast iron, the uncertainty in a corrosion loss estimate is large and it is recommended to update the regression model.

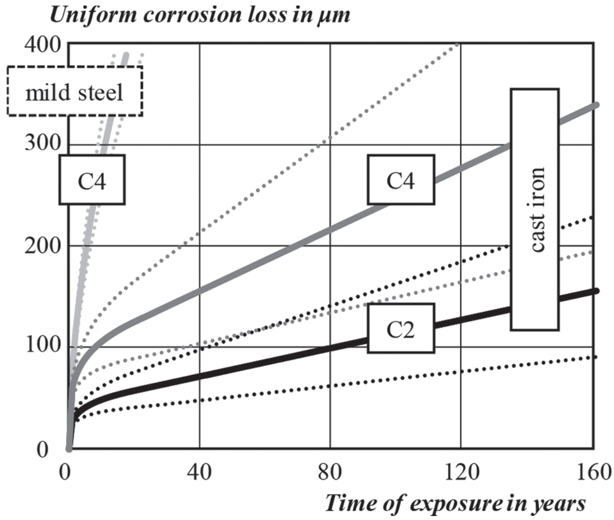

Figure 5: Variation of corrosion loss with time of exposure for mild steel and cast iron – expected trends and 75% confidence intervals.

For assessment of a particular historic structure, it may be useful to estimate the corrosion rate after a long-term exposure of the structure, t_{exp} >> 20 y. It follows from eqn (3) that:

$$\frac{dD}{dt_{\text{exp}}} = b \times 20^{b-1} \times r_{\text{corr}} \tag{5}$$

Using the input parameters in Table 3, the expected corrosion rates are time-independent while the confidence interval expands:

- C2: dD / dt_{exp} = 0.7 μm/y. ± 0.25 for t_{exp} = 50 y. (±0.30 for 150 y.)
- C3: dD / dt_{exp} = 1.3 μm/y. ± 0.45 for 50 y. (±0.55 for 150 y.)
- C4: dD / dt_{exp} = 1.55 μm/y. ± 0.55 for 50 y. (±0.65 for 150 y.)

6 EFFECTS OF REPEATED APPLICATIONS OF PAINTINGS

Four general types of coatings are used on cast iron to enhance corrosion resistance – metallic, organic, conversion, and enamel coatings. The principal strategies to the corrosion protection of industrial heritage structures include 'leave as it is', apply temporary protection to reduce degradation progress, apply long-term protection, or undertake a complex restoration with replacement of damaged elements.

Many cast iron structures were repainted without removal of previous layers and the thickness of coatings may reach 1000 μm. Figure 6 shows at least ten paint layers after more than 100 years of exposure of a cast bridge. Thicknesses of layers are scattered. Lower layers are discontinuous with a lot of vertical and horizontal cracks. The top layer is then significantly degraded – the paint is chalking. The lowest paint layer is mixed with corrosion products.

The internal stress that has been developing in the paint system since its application depends on the number of coats, the total dry film thickness (DFT), the generic type of the coating system, and the type of exposure. It is not recommended to overcoat existing paint

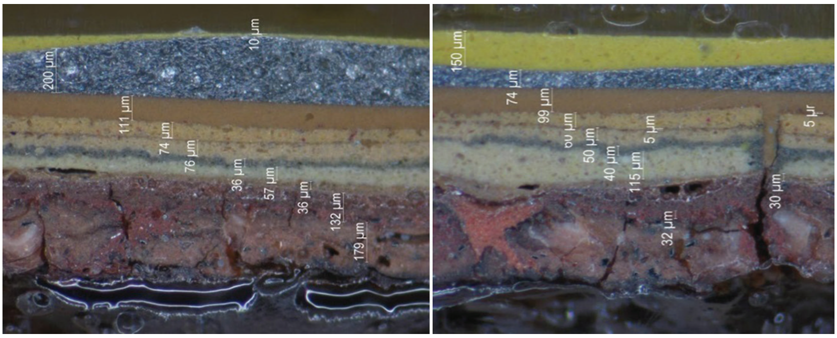

Figure 6: Example of stratigraphy of the paint system on a cast iron structure.

systems with a total DFT ≥ 800 μm as the internal stress in the existing paint may cause the overcoat to flake off.

In contrast to present technologies of painting applications, the surfaces of historic structures were not blasted. Due to very high anticorrosive efficiency of the primer layer pigmented by minimum, some areas of the structures are typically exposed to corrosion to a limited extent and structural resistance is insignificantly reduced.

In the case of minor corrosion effects, the property owner can effectively repair the structure in cooperation with a contractor experienced with surface protection of metals. In the case of extensive damage, it is recommended to consult with a specialist in the conservation of industrial structures as no generally optimum approach to such conservation exists.

7 NUMERICAL EXAMPLE – EFFECTS OF CORROSION LOSS ON STRUCTURAL RELIABILITY

7.1 Simplified reliability verification

The effect of corrosion losses on structural reliability should be analysed by probabilistic reliability analysis [11, 12], considering the randomness in load effects and resistance. Due to a limited scope of this contribution, a simplified analysis based on the commonly adopted semi-probabilistic approach – see EN 1990:2002 and ISO 2394:2015 for the basis of design and reliability analysis, respectively – is presented here. The design value of resistance, R_d, takes into account resistance model uncertainty and variability of material strength and geometry [13, 14]:

$$R_\mathrm{d} = \mu_R \exp(-\alpha_R \beta V_R)] \tag{6}$$

where μ_R and V_R denote the mean and CoV of resistance, respectively; $\alpha_R = 0.8$ is the sensitivity factor for resistance; and $\beta = 3.8$ is the target reliability index according to EN 1990 and ISO 13822:2010 for assessment of existing structures. According to the Czech standard on assessment of existing structures, CSN 73 0038:2014, a representative value of V_R is around 15% for non-corroded cast iron structures.

It is further assumed in the simplified reliability verification that the design resistance was in original design equal to the design load effect, E_d, which has not changed over time. For a corroded structure, eqn (6) may thus be extended as follows:

$$R_d = \mu_R \exp(-\alpha_R \beta V_R)] = E_d = R_d'(t_{exp}) = \mu_R \delta(t_{exp}) \exp(-\alpha_R \beta' V_R')] \quad (7)$$

where $\delta(t_{exp})$ is the degradation function and the symbol ' denotes a value updated for the corroded structure.

The degradation function needs to be specified for a failure mode under consideration. The following relationship provides an example for pure compression of a hollow circular column, based on a sectional area:

$$\delta(t_{exp}) = \frac{\left[Ø - 2D(t_{exp})\right]^2 - \left[Ø_{in} + 2D_{in}(t_{exp})\right]^2}{Ø^2 - Ø_{in}^2} \quad (8)$$

where Ø denotes a diameter; D is the corrosion loss; and the subscript 'in' indicates inner dimensions (external dimensions are without a subscript). In a similar way the degradation function can be provided for bending considering elastic sectional modulus.

It is further assumed that in the case of one-sided corrosion, only external surface is subjected to unfavourable environment and $D_{in} = 0$. An alternative with both-sided corrosion assumes that external and internal corrosion losses are identically distributed, fully correlated variables. The assumption of full correlation is rather conservative; detailed investigation is beyond the scope of this contribution.

Reliability index for a corroded structure can now be obtained from eqn (7):

$$\beta' = [\ln \delta(t_{exp}) + \alpha_R \beta V_R] / (\alpha_R V_R') \quad (9)$$

7.2 Massive column

Initially, a typical 'massive' cast iron column is considered. The dimensions are taken from the column that supports a roof structure at a railway station in the Czech Republic. Without corrosion losses, the external diameter is Ø = 219 mm, thickness of the wall is 32 mm, and the inner diameter is thus $Ø_{in}$ = 155 mm.

The CoV of resistance of the corroded structure in eqns (7) and (9) should account for uncertainty in the corrosion loss. Considering the results provided in Section 4 and 5.2 (expected trends and uncertainties in corrosion losses), an additional analysis shows that the contribution of uncertainty in corrosion loss θ to the uncertainty in resistance (estimated by $V_R \approx 15\%$) is negligible. This is an expected outcome as corrosion losses in the order of hundreds of μm are very small compared to the thickness of the wall.

Figure 7 portrays the variation of the degradation function – eqn (8) – and of reliability index – eqn (9) – with uniform corrosion loss for compression and bending. Corrosion losses at one surface are varied up to 0.6 mm, which is already high for C2–C4; cf. Fig. 5. The comparison of one-sided corrosion for compression and bending indicates that the latter is slightly more sensitive to degradation, as evidenced by both the degradation function as well as reliability index. Even if D reaches high values above 0.5 mm, reliability index drops insignificantly and the effect of corrosion on reliability of the massive column seems to be small.

7.3 Thin-walled column

In the second example, a thin-walled short cast iron column supporting a roof of a historic arbour [4, 14] is analysed (Ø = 114 mm, thickness of 12.5 mm, $Ø_{in}$ = 89 mm). In this case,

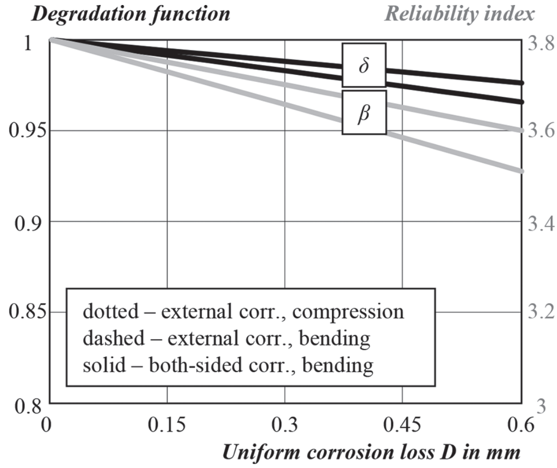

Figure 7: Variation of the degradation function (black curves) and of reliability index (light grey curves) with uniform corrosion loss for one- or both-sided corrosion of the massive column in compression or in bending.

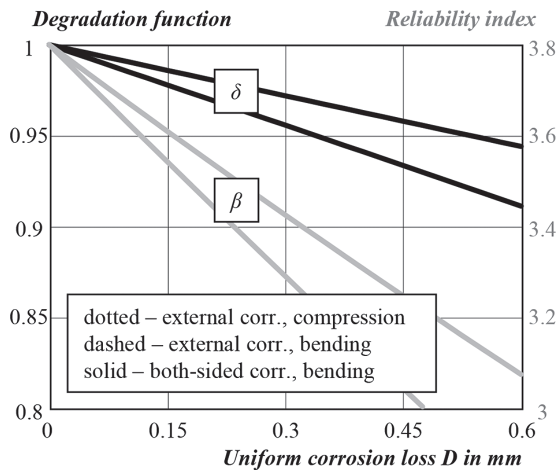

Figure 8: Variation of the degradation function (black) and of reliability index (light grey) with corrosion loss for the thin-walled column in compression or in bending.

the uncertainty in resistance slightly increases due to uncertainty in corrosion losses that is taken into account in reliability analysis. For instance, V_R for bending increases to 17% when the mean corrosion loss at each of the surfaces is 1 mm.

Figure 8 shows the degradation function and reliability index as functions of corrosion loss for the thin-walled column. It appears that corrosion losses around 0.5 mm leads to significant decrease of reliability index that drops from β = 3.8 to about 3.0.

8 DISCUSSION

The presented model for long-term corrosion losses of cast irons is based on limited empirical evidence and should be considered as approximate only. In case more data become available, a more refined approach should be taken, considering the effect of environmental changes over decades and centuries of lifetime of historic cast iron structures, often placed in industrial areas. For instance the SO_2 concentration varied considerably with time, reaching its maxima in 1950s to 1980s [15].

In the environments with low concentrations of chlorides, the risk of pitting (localised) corrosion is normally low. In aggressive environments such as immersion or the tidal zones in sea or polluted waters, the corrosion of cast iron is often not 'uniform' but exhibits considerable localised corrosion [2]. The pitting corrosion is dangerous in particular for structures with retaining functions or exposed to fatigue effects when stresses concentrate around pits and fatigue resistance may be considerably reduced.

9 CONCLUSIONS

- The model for corrosion rates of historic metals cannot be based on the degradation model for mild steels even though specific features of historic alloys such as increased content of carbon and different chemical composition would be taken into account. Realistic estimates of corrosion rates need additionally account for different micro-structure with inputs and different surface properties of historic alloys.
- The presented model is thus based on experimental data and the same type of regression function for the progress period as for modern metals is adopted. A period of full protection provided by historic coatings should normally be slightly shorter than for modern coatings.
- Corrosion is normally insignificant for load-bearing cast iron structures unless they are located in extremely aggressive environments. Corrosion may affect reliability of thin secondary members, railings or decorative elements.
- In the case of minor corrosion effects, the property owner can effectively repair the structure in cooperation with a contractor experienced with surface protection of metals. In the case of extensive damage, it is recommended to consult with a specialist in the conservation of industrial structures as no generally optimum approach to such conservation exists.
- Further investigations are planned to indicate corrosion rates for wrought iron and historic mild steels exposed to changing environmental effects over decades and centuries.

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