VYSOKÁ ŠKOLA BÁŇSKÁ – TECHNICKÁ UNIVERZITA OSTRAVA

FAKULTA STAVEBNÍ

KOROZEENECK 1.0

UŽIVATELSKÁ PŘÍRUČKA

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1. Úvod

Spolehlivosti železobetonových konstrukcí je v mnoha případech ovlivněna časově závislými degradačními procesy díky kterým mnoho konstrukcí vyžaduje předčasnou rekonstrukci, či výměnu. Snížení životnosti vede obvykle k nárůstu celkových nákladů čímž dochází v případě mostních konstrukcí ke zvýšenému zatížení veřejných rozpočtů. Harmonie mezi náklady na pořízení a celkovými náklady stavby hraje důležitou roli. Je proto důležité budovat konstrukce mající dlouhou životnost, čehož lze dosáhnout vhodnou předpovědí degradačních mechanizmů. Kvalitní odhad degradačních procesů umožní odborníkům lépe navrhovat železobetonové konstrukční systémy, tak aby byly dlouhodobě odolné vůči působení prostředí a zatížení.

Zakomponování trvanlivosti do veřejné infrastuktury nebo průmyslových oběktů vyžaduje pokročilé znalosti degradačních mechanismů, stavebních materiálů, posudku spolehlivosti, kontroly kvality a konstrukčních postupů. Přesto, že je zřejmá nutnost navrhovat konstrukce s dlouhou životností, nástroje a pomůcky k dosažení tohoto cíle jsou stále ve vývoji.

Dnes implementované a doporučené normy v Evropě a Spojených státech jsou bohužel obvykle ve své podstatě preskriptivní ([23], [21], [27] a [13]), a to navzdory snaze formulovat normy orientované na užitnost ([12], [2] či [1]). Tyto normy obvykle formulují spíše vhodné materiálové a konstrukční řešení, ale neuvádějí úroveň spolehlivosti či trvanlivost [27].

V inženýrské komunitě roste poptávka po funkčně orientovaném přístupu k návrhu stavebních konstrukcí, který by zohledňoval požadovanou úroveň spolehlivosti, životnost, optimalizaci celkových nákladů stavby a vlivů na životní prostředí. Pozornost je tedy upřena k relativně novému přístupu zvanému Performance-Based Design (volně přeloženo dle [28] jako posudek spolehlivosti s ohledem na užitné vlastnosti, viz. např. [27], [15]). Performance-Based Design je spolu s rizikovým inženýrstvím, monitoringem částí tzv. integrovaného návrhu (viz. např. [7]).

1.1 Železobetonové konstrukce

Trvanlivost železobetonových konstrukcí může být ovlivněna mnoha faktory, a to zásadami, kyselinami, opakovaným změnami vlhkosti, cyklickými změnami teplot, karbonatací, působením chloridů, UV zářením, sulfidy, únavou a jinými vlivy včetně trhlin. Působení slaného prostředí. Chloridy pronikají skrz krytí k ocelové výztuži, vyvolávají korozi výztuže. Typickými představiteli jsou konstrukce vystavené mořskému prostředí a silniční konstrukce vystavené účinkům posypových solí. Rozmrazovací prostředky jsou jedním z nejvýznamnějších faktorů snižujících životnost silniční železobetonové infrastruktury jak ve střední Evropě tak na severovýchodě USA. Chloridy vyvolaná koroze může způsobit pokles užitnosti konstrukce nejen s ohledem na použitelnost, ale i na únosnost, a ve svém důsledku může vézt ke zvýšeným nákladům životního cyklu mostu. Modely umožňující odhad průběhů degradačních procesů mohou dát stavebním inženýrům nástroje pro vhodnější návrh a realizaci stavebních konstrukcí.

2. Účel programu

Program Korozeeneck umožňuje provádět deterministické a stochastické modelování degradace železobetonové konstrukce s ohledem na působení chloridů. Umožňuje tedy získání lepší představy o chování konstrukce vystavené agresivnímu prostředí.

Korozeeneck modeluje jak iniciační, tak propagační fázi koroze. Umožňuje odhadnout dobu do vzniku koroze ocelové výztuže v železobetonové konstrukci, a také dobu do vzniku rovnoměrnou korozí vyvolaných trhlin. Ke stochastické aplikaci je nutné použít spolehlivostní nástavbu Monte [5].

Následující části obsahují popis transformačních vztahů aplikovaných v programu Korozeeneck a příklad deterministické a pravděpodobnostní aplikace programu.

3. Modelování koroze vyvolané působením chloridů

Úroveň spolehlivosti železobetonové konstrukce se mění s postupem degradačního procesu a dobou života železobetonové konstrukce. Je-li koroze vyvolaná vniknutím chloridů k ocelové výztuži uvažována jako dominantní parametr ovlivňující degradaci, lze tento proces s ohledem na korozi rozdělit do dvou období [31]:

$$t_{\text{service}} = t_{\text{initiation}} + t_{\text{propagation}} \qquad /1/$$

kde je $t_{initiation}$ čas do vzniku koroze a $t_{propagation}$ odpovídá času do dosažení neúnosného stupně koroze železobetonové výztuže.

3.1 Iniciace koroze

Období iniciace koroze končí depasivací výztuže. Výztuž začíná korodovat a nastává tvorba korozních produktů. Úroveň spolehlivosti - užitnosti může být konzervativně vztažena k době do započetí koroze $t_{\text{initiation}}$ ([18], [29], [27] a [10]).

Konec iniciační fáze je vyjádřen za pomocí porovnání koncentrací chloridových iontů na úrovni výztuže $C_{xy,t}$ a chloridového prahu C_{th}. (koncentrace postačujících k započetí koroze, viz. např. [14]). Koncentrace chloridů na úrovni výztuže $C_{xy,t}$ je popsána v následující části.

3.1.1 Degradační model

Koroze ocelové výztuže je primárně řízena difuzí chloridů. Vliv hydraulického tlaku a kapilární sorpce není v aplikovaném modelu zohledněn, neboť je mnoho případů kdy je jeich vliv možno zanedbat (např. ŽB mostovka [16]). Postup pronikání chloridů betonem jako funkce hloubky a času lze modelovat za pomocí 2. Fickova zákona difuze ([33], [29], [10], [24] a [25]). Řešení příslušné diferenciální rovnice, obvykle popisované jako Crankovo, je uvedeno v následujícím vztahu [8]:

$$C_{x,t} = C_0\left[1 - erf\left(\frac{x}{\sqrt{4D_c t}}\right)\right] \qquad /2/$$

kde je $C_{x,t}$ koncentrace rozpustitelných chloridových iontů (jako procento hmotnosti materiálů s cementačními schopnostmi) v čase t (roky) a hloubce x (metry). C_0 je koncentrace chloridů (% hmotnosti cementu atd.) v povrchové vrstvě betonu a D_c je tzv. „zjevný“ koeficient difuze (m^2/rok). Vztah /2/ je široce užívaným pro 1-D modelování pronikání chloridů, i když nepostihuje

kombinovaný transport vody a chloridových iontů [9], a neumožňuje rovněž popisovat specifické okrajové podmínky nutné pro zohlednění vlivu trhliny.

Numerické řešení vztahu /2/ představuje následující polynom:

$$C_{x,t} = C_0 \left\{ 1 - \frac{2}{\sqrt{\pi}} \sum_{n=0}^{14} \frac{(-1)^n \left(\frac{x}{\sqrt{4\mathrm{D}_c t}} \right)^{2n+1}}{n!(2n+1)} \right\} \qquad /3/,$$

Tikalsky v [29] uvádí při užití 14 členů polynomu akceptovatelnou chybu 0.001 pro hloubku výztuže 0 – 1 metr, difuzní součinitel betonu mezi 1×10^{-8} a 1×10^{-14} m^2/s a zkoumanou životností do 100 let.

Chování ŽB konstrukce je popsatelné s ohledem na iniciaci koroze funkcí spolehlivosti RF_t. Funkce spolehlivosti je vyjádřená jako časově závislé překročení korozního prahu C_{th} koncentrací chloridů $C_{xy,t}$ v hloubce výztuže:

$$RF_\mathrm{t} = C_\mathrm{th} - C_\mathrm{xy,t} \qquad /4/$$

Hodnota limitní koncentrace chloridů C_{th} závisí zejména na druhu a přípravě výztužných vložek a na složkách betonu. Typické hodnoty mostovky jsou 0.2 % hmotnosti chloridů v poměru k hmotnosti cementu dle ACI 222R-01 [2] a 0.4 % dle CEB [6]. Data pro ocel se specilání ochranou uvádí [11]. Širší diskuzi nad velikostí chloridového prahu uvádí [14].

Je-li koncentrace chloridů v místě výztuže $C_{\mathrm{xy,t}}$ větší než chloridový práh C_{th} končí období iniciace a začíná období koroze. Doba ve které dojde k iniciaci koroze je označena $t_{\mathrm{initiation}}$.

3.2 Propagace koroze

Během procesu koroze vznikají korozní produkty, které mají větší rozdílné fyzikálně chemické vlastnosti než původní materiál. Dochází k nárůstu objemu výztuže a zároveň poklesu efektivní průřezové plochy. Díky čemuž dochází i k poklesu únosnosti.

Program se zabývá odhadem času do vzniku trhlin v krytí betonu v důsledku objemových změn výztuže pro rovnoměrnou korozi vyvolanou působením chloridových iontů. Postup umožňuje zohlednit působení důlkové koroze.

Výpočet doby do vzniku trhlin je založen na vztazích odvozených v [Liu and Weyers [20] and Vidal et. all [32].

Hustota korozního proudu [$\mu A/cm^2$] je funkcí odporu betonu ρ (resistivity [Ohm-cm]) (Fig. 12, Morris et. all [26]):

$$i_{corr} = 55000\times\rho^{-1.3} \qquad /5/$$

Korozní rychlost V_{corr} [μm/rok] je závislá na hustotě korozního proudu

$$V_{corr} = 11.6\times \mathrm{i_{corr}} \qquad /6/$$

Korozní produkt k_p) [$mg^2/mm^2\times$rok] je dle [20]

$$k_p = 0.098/\alpha \times \pi \times D(i_{corr}/1.07), \qquad /7/$$

kde α záleží na druhu koroze (zvoleno $\alpha = 0.57$), D je průměr výztuže [mm].

Pro odvození kritického množství korozních produktů W_{crit} [20] jsou užity parametry a a b:

$$a = (D+2\times d_0\times 1000)/2 \qquad /8/$$

$$b = C+(D+2\times d_0\times 1000)/2, \qquad /9/$$

přičemž C [mm] je velikost krytí, a parametr tloušťky interfaciální zóny mezi výztuží a betonem d_0 je zvolen 1.25×10^{-2} [mm].

$$\Delta A_{s0} = \frac{\pi\times D^2}{4}\left[1-\left[1-\frac{\alpha_{\text{corr_type}}}{D}\times\left(7.53+9.32\times\frac{C}{D}\right)\times 0.001\right]^2\right], \qquad /10/$$

ΔA_{s0} *je* změna plochy v důsledku koroze dle [32], a $\alpha_{\text{corr_type}}$ zohledňuje druh koroze. V programu je užito $\alpha_{\text{corr_type}} = 2$ pro rovnoměrnou korozi. Vyšší hodnoty popisují korozi důlkovou.

Čas do vzniku koroze popisuje dle [32] kvadratická funkce

$$Ax^2 + Bx + C = 0, \qquad /11/$$

kde x představuje $t_{\text{propagation}}$ a kde jsou konstanty A, B a C definovány následovně:

$$\begin{aligned} A &= \sqrt{0.0001V_{corr}}\,\frac{\pi}{4}\alpha^2_{corr_type} \\ B &= 0.0001V_{corr}\,\frac{\pi}{4}2D\alpha_{corr_type} \\ C &= \Delta A_{s0} + \frac{w_{cr,\lim}}{0.0575} \end{aligned} \qquad /12/$$

Limitní velikost trhliny je uvažována jako $w_{cr,lim}$=0.1 mm. Druhý kořen kvadratické rovnice je pak doba propagační fáze $t_{\text{propagation}}$, tedy doba od započetí koroze do vzniku nepřípustných trhlin. Celková doba do vzniku nepřípustných trhlin je v programu označena jako t_{service} a je součtem doby iniciace s dobou propagace koroze /1/.

3.3 Stochastické modelování - Simulation-Based Reliability Assessment

Vzhledem k velkému rozptylu vstupních parametrů je vhodné pravděpodobnostní řešení dané problematiky. K řešení je zvolena metoda SBRA [22]. Ta je vhodná k aplikaci v oblasti stochastické analýzy degradačních procesů.

SBRA se rozvíjela od jednoduchý příkladů spolehlivosti konstrukčních prvků z hlediska bezpečnosti a použitelnosti, přes problematiku únavy ocelových konstrukcí, k problematice trvanlivosti. Návrh a posudek konstrukcí s ohledem na náhodně proměnné vstupní veličiny, který by umožňoval navrhovat objekty na vyrovnanou úroveň spolehlivosti je rovněž klíčovou součásti vývoje metody Simulation-Based Reliability Assessment (SBRA, viz. Marek, et. al. [22], [23], [21]), a to od prvopočátku.

Náhodně proměnné jsou v metodě SBRA charakterizovány pravděpodobnostní funkcí (obvykle useknutými histogramy), pravděpodobnost překročení vybraných referenčních hodnot je počítána s využitím simulačních nástrojů typu Monte Carlo a úroveň spolehlivosti je vyjádřena za pomocí porovnání pravděpodobnosti poruchy P_f s návrhovou pravděpodobností P_d. Požadovaná referenční kriteria a návrhové hodnoty mohou být ušity na míru konkrétnímu inženýrskému problému, tak aby odpovídaly účelu objektu, jeho umístění, očekávání klienta apod.

BRADÁČ [3] uvedl metodu SBRA na pole posudků trvanlivosti železobetonových konstrukcí. TIKALSKY a kol. následně obohatili využití metody SBRA o oblast Performance-Based Design železobetonových konstrukcí ([29], [21], [30] a [19]). Obohacení spočívá v analogii, jak mezi zatížením a působení agresivních chemikálií, tak mezi odolností a schopností vzdorovat

agresivním látkám. Posypové soli představují zatížení chloridy, které pronikají do betonu v čase a koroze započne je-li dostatečné množství chloridových iontů, vlhkosti a kyslíku dostupné na úrovni výztuže.

4. Použití programu Korozeenck

Programy jsou připraveny pro 32bitovou konzoli Windows a je ověřen na MS Windows XP.

Aktuální verze programu je dostupná na adrese: <http://fast10.vsb.cz/konecny/korozeeneck.php>.

4.1 Deterministický model

Součástí programu:

- zdrojový kód programu: korozeeneck.c,
- spustitelný soubor: korozeeneck.exe
- dávkový soubor: korozeeneck.bat
- vstupní hodnoty: ./inputs/ korozeeneck.inp

Dávkovým souborem korozeeneck.bat dojde ke spuštění programu se vstupními hodnotami načtenými ze souboru korozeeneck.inp. Výsledek výpočtu se uloží do souboru korozeeneck.out v adresáři results.

Program je možno spustit rovněž přímo v příkazové řádce při zadávání hodnot z obrazovky.

4.1.1 Příklad aplikace

Vstupní parametry jsou uvedeny na jednom řádku a jsou odděleny mezerami. První hodnota je difuzní součinitel DC [$m^2s^{-1}\times10^{-12}$], následují hloubka výztuže REB_D [m], koncentrace chloridů na povrchu betonu [% materiálu s cementačními vlastnostmi], odpor betonu vůči průchodu el. proudu RESISTIVITY [KOhm-cm], průměr výztuže DIAMETER [mm], chloridový práh THRESH_0 [% materiálu s cementačními vlastnostmi] pro výztuž označenou 0. Další tři parametry jsou chloridové prahy pro jiné druhy ochrany výztuže.

Následuje obsah vstupního souboru korozeeneck.inp. Výstupní soubor korozeeneck.out obsahuje na počátku souhrn vstupních hodnot. Výsledky výpočtu jsou v části Results.

Prvním výstupem programu je koncentrace chloridů na úrovni výztuže c_xt [%] v čase T[i] [roky] (např. po 4,8 letech je koncentrace c_xt = 0.06 [%]).

4.1.2 Odhad trvání iniciační fáze a propagační fáze

Program počítá dobu do zahájení koroze t_i [roky] a dobu do vzniku trhlin t_cr [roky] pro čtyři druhy výztuže označené 0 až 3. Výztuž označená jako 0 má dobu do vzniku koroze t_i[0] = 31.9 roků a dobu do vzniku trhlin t_cr = 42.6 roků. Rozdíl mezi těmito časy je délka propagační fáze t_corr_crack_vi zde 10,7 roků.

4.1.3 Obsah vstupního souboru **korozeeneck.inp**

```
4.91 0.075 0.61 6.6 19 0.27445 0.27445 0.4283 1.0592
```

4.1.4 Obsah výstupního souboru **korozeeneck.out**

```
*******************************************************
*                Corrozeeneck                         *
*******************************************************
 Input parameters:
```

```
************************************************************
 Diffusion coefficient [m2/s*10^-12]:
 Depth of reinforcement [m]:
 Chloride surface concentration [%]:
 Concrete resistivity (geometric adjusted)[KOhm-cm]:
 Diameter [mm]:
 Threshold for reinforcement type No: 0 [%]:
 Threshold for reinforcement type No: 1 [%]:
 Threshold for reinforcement type No: 2 [%]:
 Threshold for reinforcement type No: 3 [%]:
************************************************************
 Input summary:
 dc = 4.910000e+000
 reb_d = 0.075000
 c_0 = 0.610000
 resistivity = 6.600000
 diameter = 19.000000
 time = 100.000000
 Threshold for reinforcement type No: 0 [%] = 0.274450
 Threshold for reinforcement type No: 1 [%] = 0.138900
 Threshold for reinforcement type No: 2 [%] = 0.428300
 Threshold for reinforcement type No: 3 [%] = 1.059200
************************************************************
************************************************************
*                 Results                                  *
************************************************************
* Chloride concentration at the level of reinforcement
************************************************************
 T[0] = 0.0  c_xt[0] = 0.00
 T[1] = 4.8  c_xt[1] = 0.03
 T[2] = 9.5  c_xt[2] = 0.10
 T[3] = 14.3  c_xt[3] = 0.16
 T[4] = 19.0  c_xt[4] = 0.20
 T[5] = 23.8  c_xt[5] = 0.23
 T[6] = 28.6  c_xt[6] = 0.26
 T[7] = 33.3  c_xt[7] = 0.28
 T[8] = 38.1  c_xt[8] = 0.30
 T[9] = 42.9  c_xt[9] = 0.31
 T[10] = 47.6  c_xt[10] = 0.33
 T[11] = 52.4  c_xt[11] = 0.34
 T[12] = 57.1  c_xt[12] = 0.35
 T[13] = 61.9  c_xt[13] = 0.36
 T[14] = 66.7  c_xt[14] = 0.37
 T[15] = 71.4  c_xt[15] = 0.37
 T[16] = 76.2  c_xt[16] = 0.38
 T[17] = 81.0  c_xt[17] = 0.39
 T[18] = 85.7  c_xt[18] = 0.39
 T[19] = 90.5  c_xt[19] = 0.40
 T[20] = 95.2  c_xt[20] = 0.40
************************************************************
 Corrosion propagation time [years]
 t_corr_crack_vi = 10.660381
************************************************************
 Corrosion initiation & cracking time [years]
 No: 0 - t_i[0] = 31.931310 t_cr[0] = 42.591691
 No: 1 - t_i[1] = 12.654350 t_cr[1] = 23.314731
 No: 2 - t_i[2] = 100.000000 t_cr[2] = 100.000000
 No: 3 - t_i[3] = 100.000000 t_cr[3] = 100.000000
************************************************************
 NOTE: Corrosion initiation time t_i = 100.000000 means that
 corrosion has not started.
```

```
 Corrosion initiation times t_i[0-3] are interpolated
 between respective timesteps.
*********************************************************
```

4.2 Pravděpodobnostní aplikace v programu Monte

4.2.1 Součásti programu

- spustitelný soubor: `monte.exe`,
- knihovna – výpočetní model: `korozeeneck.dll`
- dávkový soubor: `korozeeneck-mc.bat`
- vstupní hodnoty: ./`inputs`/ `koroze.mon`

4.2.2 Postup užití programu

Dávkovým souborem `korozeeneck-mc.bat` dojde ke spuštění programu `monte` se vstupními hodnotami načtenými ze souboru `koroze.mon`. Výsledek výpočtu se uloží do adresáře `results`. Výsledkem jsou simulace realizací náhodně proměnných `TEST.res`, statistiky náhodně proměnných `stats.txt` a histogramy náhodně proměnných `TESThist.dis` uložené v podadresáři Results.

4.2.3 Příklad aplikace

Vstupní soubor obsahuje popis vstupních a výstupních veličin.
Každý blok s veličinami je uveden počtem veličin (zde po devíti).
V prvním řádku je difuzní součinitel `DC` [$m^2s^{-1}\times10^{-12}$], následují hloubka výztuže `REB_D` [m], koncentrace chloridů na povrchu betonu [% materiálu s cementačními vlastnostmi], odpor betonu vůči průchodu el. proudu `RESISTIVITY` [KOhm-cm], průměr výztuže `DIAMETER` [mm], chloridový práh `THRESH_0` [% materiálu s cementačními vlastnostmi] pro výztuž označenou 0. Další druhy výztuže jsou označeny 1-4. Je možno analyzovat 4 druhy výztuže naráz.

Specifikace vstupní veličin sestává z:

- názvu proměnné (např. DC),
- násobitele histogramu (zde `4.91`),
- typu veličiny (v této úloze vždy 1, podrobnosti viz [5]),
- názvu souboru s histogramem (zde `normal-1-02.dis` uloženém v adresáři `distribution`).

Výstupní data je třeba ponechat v níže uvedené formě. Výstupy popisují chování 4 různých druhů výztuže očíslovaných 0 – 3. `T_CORR_CRACK_VI` představuje délku propagační fáze společnou pro všechny druhy výztuže. `T_I_0` je délka iniciační fáze koroze a `T_CR_0` je doba do vzniku korozí vyvolaných trhlin. Obé pro výztuž označenou číslem `0`.

4.2.4 Obsah vstupního souboru `koroze.mon`

```
9
DC 4.91 1 normal-1-02.dis
REB_D 0.075 1 normal-1-02.dis
C_0 1.000000 1 normal-1-02.dis
RESISTIVITY 1.11 1 normal-1-02.dis
DIAMETER 6.6 1 normal-1-02.dis
THRESH_0 0.27445 1 normal-1-01.dis
```

```
THRESH_1 0.27445 1 normal-1-01.dis
THRESH_2 0.4283 1 normal-1-01.dis
THRESH_3 1.0592 1 normal-1-01.dis
9
T_CORR_CRACK_VI 2
T_I_0 2
T_CR_0 2
T_I_1 2
T_CR_1 2
T_I_2 2
T_CR_2 2
T_I_3 2
T_CR_3 2
0
```

4.2.5 Příklad

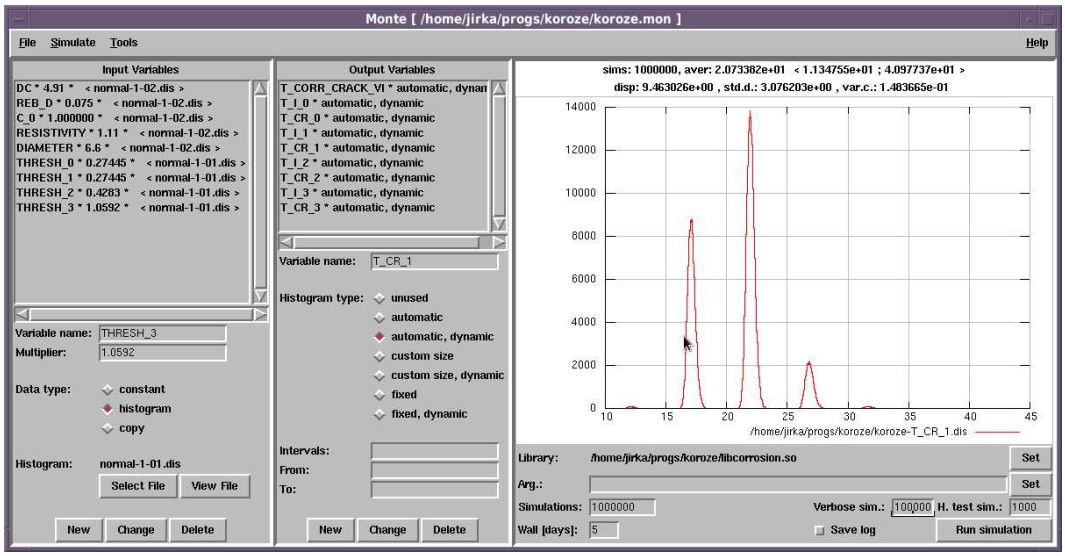
S výše uvedenými vstupními daty jsou výsledkem pravděpodobnostního řešení histogramy doby do počátku koroze a do vzniku trhlin uložené v adresáři `results`. Analýzu histogramů je možné provést programem HistAn (není součástí distribuce programu KOROZEENECK, viz [17]).

Statistické parametry jsou uloženy v souboru `stats.txt`. Pořadí výstupních hodnot odpovídá pořadí uvedeném ve vstupním souboru `koroze.mon`. První parametr obsahuje počet výstupních veličin (zde vždy 9) a druhý parametr obsahuje počet simulačních kroků (zde 10000). Na dalším řádku jsou statistické parametry pro veličinu `T_CORR_CRACK_VI`. Statistiky pro délka propagační fáze koroze je ve zvoleném případě obsahují minimální hodnotu (zde `1.91` roku), maximální hodnotu (zde `4.33` roku), průměrnou hodnotu (zde `2.89` roku), rozptyl (zde `1.09` roku), směrodatnou odchylku (zde `0.33` roku) a variační koeficient (zde `0.11`).

4.2.6 Obsah výstupního souboru `stats.txt`

```
9 10000
1.904715e+000 4.332405e+000 2.891656e+000 1.096090e-001 3.310725e-
001 1.144923e-001
9.523810e+000 1.000000e+002 6.289381e+001 1.372399e+003
3.704591e+001 5.890231e-001
1.154462e+001 1.000000e+002 6.449595e+001 1.279184e+003
3.576568e+001 5.545415e-001
9.523810e+000 1.000000e+002 6.287000e+001 1.372006e+003
3.704060e+001 5.891617e-001
1.154462e+001 1.000000e+002 6.447403e+001 1.278876e+003
3.576138e+001 5.546633e-001
1.428571e+001 1.000000e+002 7.965429e+001 1.070880e+003
3.272430e+001 4.108292e-001
1.630653e+001 1.000000e+002 8.053645e+001 9.908337e+002
3.147751e+001 3.908480e-001
5.714286e+001 1.000000e+002 9.973524e+001 5.517754e+000
2.348990e+000 2.355226e-002
5.992376e+001 1.000000e+002 9.977628e+001 4.176626e+000
2.043680e+000 2.048262e-002
```

Grafický výstup z volitelné nádstavby programu Monte (není součástí distribuce programu KOROZEENECK) je na následujícím obrázku.



Obr. 1: Grafický výstup z nástavby programu Monte (není součástí distribuce programu, viz [5]) .

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END OF TERMS AND CONDITIONS

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