


SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

Chloride Penetration Resistance and Link to Service Life Design of Virginia Bridge Decks

Virginia DOT Workshop – Charlottesville, VA

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Design Section

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U.S. Department of Transportation
Federal Highway Administration

American Association of State Highway and Transportation Officials
AASHTO

Service Life Design Aid

- Design Aid (spreadsheet) for implementation of service life design
- Follows *fib* Bulletin 24, Section B2, methodology
  - Full probabilistic approach
- Utilizes FHWA SHRP2 R19a service life design tool
  - Monte-Carlo simulation for 1000s of randomized trials
  - Developed by Mike Bartholomew
  - Published on SHRP2 website
- Incorporates findings from Virginia-specific research

Presentation Outline

- User Interface (front end)
  - Basic input
  - Model output
  - User overrides
- VDOT-specific data
  - Recommended values
  - Historic sampling data
- Full-probabilistic model (back end)
  - Input parameters
  - Monte Carlo simulation
- Some unresolved issues
  - Material properties
  - Model parameters
  - Policy decisions

User Interface

DRAFT – VDOT Bridge Deck Service Life Design Aid
Follows: *fib* Bulletin 34, Section B2, Full Probabilistic Design Method
Draft Final Report, Bridge Service Design Life, SHRP2 R19a (VTRC)

Source Information: https://www.fhwa.dot.gov/goshrp2/Solutions/
.../R19A_ProbabalisticToolsChlorideIngressModel.xlsx
http://vtrc.virginiadot.org/PUBS.aspx

BASIC USER INPUT – BRIDGE DECK SERVICE LIFE DESIGN

Design Service Life	T_{SL} =	100 yrs
District		1) Bristol
Region		Southwestern Mountain
Concrete Cem. Mat'l.		PCC w/ Fly Ash
Reinf. Class		MMFX

fib SERVICE LIFE MODEL RESULTS

Total Passing	4581	
Total # of Trials	5000	
Pf, Probability of failure	8%	
β, Reliability Index (calculated)	1.38	Passes
β, Target Reliability Index	1.3	

[FORMAT KEY]
- Typical input values
- Model computation
- User override values
- Results

fib SERVICE LIFE MODEL – PRIMARY VARIABLES

Target Reliability Index	β =	1.3	
Standard Reference Temperature (*K*)	T_{ref} =	293	
Reference Time (*yrs*)	t_0 =	0.0767	[= 28 days]
Transfer Function (*mm*)	Δx =	12.7	

		Distr.	Mean	Std. Dev.
Average Annual Temperature (*K*)	T_{real} =	Normal	284.9	7.9
Regression Variable (*K*)	b_e =	Normal	4800	700
Surface Chloride Conc. (*wt. cl./wt. binder*)	$C_{s,\Delta x}$ =	LogNorm	1.57	0.73
Initial Chloride Conc. (wt. cl./wt. binder)	C_0 =	Normal	0.034	0.021
Cover Depth, (*mm*)	a =	LogNorm	58.6	6.6

		Distr.	Mean	Std. Dev.	Upper Limit	Lower Limit
Chloride Migration Coefficient, (*mm²/yr*)	$D_{RCM,0}$ =	Normal	567.3	84.5		
Aging Coefficient	α =	Beta	0.6	0.15	0	1
Critical Chloride Conc. (*wt. cl./wt. binder*)	C_{crit} =	LogNorm	1.08	0.443	-	-

OVERRIDE for PRIMARY VARIABLES

β =
T_{ref} =
t_0 =
Δx =

** Provided for common user override values

	Distr.	Mean	Std. Dev.
T_{real} =			
b_e =			
$C_{s,\Delta x}$ =			
C_0 =			
a =			

	Distr.	Mean	Std. Dev.	Upper Limit	Lower Limit
$D_{RCM,0}$ =					
α =					
C_{crit} =					

50 in

User Interface

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OVERRIDE for PRIMARY VARIABLES

** Provided for common user override values

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T_{ref} =	
t_0 =	
Δx =	

	Distr.	Mean	Std. Dev.
T_{real} =			
b_e =			
$C_{s,\Delta x}$ =			
C_0 =			
a =			

	Distr.	Mean	Std. Dev.	Upper Limit	Lower Limit
$D_{RCM,0}$ =					
α =					
C_{crit} =					

VDOT-specific data

DRAFT – VDOT Recommended Input Values

District	Climatic Region
1) Bristol	Southwestern Mountain
2) Salem	Southwestern Mountain
3) Lynchburg	Western Piedmont
4) Richmond	Eastern Piedmont
5) Hampton Roads	Tidewater
6) Fredericksburg	Northern
7) Culpeper	Northern
8) Staunton	Central Mountain
9) NOVA	Northern

Regional Data	Average Annual Temperature Statistics, T_{real} (*K*)		Surface Chloride Concentration, $C_{s,\Delta x}$ (*wt. cl./wt. binder*)				Cover Depth, a (*mm*)	
Distribution	Normal		LogNorm				LogNorm	
	Mean	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Central Mountain	285.2	8.1	1.13	0.72	0.35		62.1	6.9
Eastern Piedmont	286.7	8.0	0.78	0.18	0.40		59.6	6.6
Northern	287.3	8.2	0.99	0.43	0.80		54.6	6.5
Southwestern Mountain	284.9	7.9	1.57	0.73	0.30		58.6	6.6
Tidewater	288.21	7.92	0.42	0.27	0.25		56.9	7.4
Western Piedmont	285.82	8.41	1.33	0.54	0.25		52.2	5.8
Source	Bales (2016)		Bales (2016)		*fib* (2006)		Williamson (2007)	

Model Variable / Material Property		Distribution	Mean	Std. Dev.	Lower Limit	Upper Limit	Source
Target Reliability Index, β		-	1.3	-	-	-	*fib* (2006)
Standard Reference Temperature, T_{ref} (*K*)		-	293	-	-	-	
Reference Time, t_0 (*yrs*) [28 days]		-	0.0767				
Regression Variable, b_e (*K*)		Normal	4800	700	-	-	
Transfer Function, Δx (*mm*)		-	12.7	-	-	-	Cady & Weyers (1983)
Initial Chloride Conc. C_0 (*wt. cl./wt. binder*)		Normal	0.034	0.021	-	-	VDOT
Critical Chloride Concentration for Rebar, C_{crit} (*wt. cl./wt. binder*)	Carbon Steel	Beta	0.65	0.15	0.2	2	*fib* (2006)
	MMFX	LogNorm	1.08	0.443	-	-	Ji et al. (2005)
	Class I CRR		2.4				Mathews (2014)
	Class II CRR		6				
	Class III CRR		3.6				
Aging Coefficient, α	PCC	Beta	0.3	0.12	0	1	*fib* (2006)
	PCC w/ Fly Ash	Beta	0.6	0.15	0	1	
	PCC w/ Slag	Beta	0.45	0.2	0	1	
Chloride Migration Coefficient, $D_{RCM,0}$ (mm^2/yr)	PCC	Normal	31.6	6.3	-	-	*fib* (2006)
	PCC w/ Fly Ash	Normal	567.3	84.5	-	-	VDOT
	PCC w/ Slag	Normal	207.2	59.9	-	-	

VDOT-specific data

DRAFT – VDOT Historic Sampling Data for Bridge Decks

Bridge ID	District	Region	Cement	Additives	Chloride Migration Coefficient, $D_{RCM,0}$				Curing-based Aging Coefficient, α		Initial Chloride Concentration, C_0 (*wt. cl./ wt. binder*)		Surface Chloride Concentration, $C_{S,\Delta x}$ (*wt. cl./ wt. binder*)	
					(m^2/s)		(mm^2/yr)							
					Normal		Normal		Beta		Normal		Lognormal	
					Mean	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Bridge 1	Richmond	Eastern Piedmont	Type II	40% Slag	4.40E-12	7.95E-13	138.7	25.1	0.446				1.0272	0.4176
Bridge 2	Richmond	Eastern Piedmont	Type II	25% Fly Ash	1.96E-11	2.12E-12	619.6	67.0	0.24				1.0645	0.4327
Bridge 3	Richmond	Eastern Piedmont	Type II	24% Fly Ash	1.52E-11	1.99E-12	479.0	62.7	0.87				1.1172	0.4541
Bridge 4	Bristol	Southwestern Mountain	Type I/II	19.6% Fly Ash	2.23E-11	8.78E-13	703.4	27.7	0.51		0.033	0.009	1.2323	0.5705
Bridge 5	Bristol	Southwestern Mountain	Type I/II	20% Fly Ash	1.80E-11	6.52E-12	567.4	205.9	0.318		0.024	0.003	1.2655	0.5859
Bridge 6	Hampton Roads	Tidewater												
Bridge 7	Hampton Roads	Tidewater												
Bridge 8	Richmond	Eastern Piedmont												
Bridge 9	Staunton	Central Mountain												
Bridge 10	Salem	Southwestern Mountain												
Bridge 11	Salem	Southwestern Mountain												
Bridge 12	NOVA	Northern												
Bridge 13	Culpeper	Northern												
Bridge 14	Fredericksburg	Northern												
Bridge 15	Richmond	Eastern Piedmont	Type II	40% Slag	9.04E-12	1.53E-12	285.4	48.4	0.662		0.004	0.0006	1.1265	0.4579
Bridge 16	Richmond	Eastern Piedmont	Type II	40% Slag	6.26E-12	3.37E-12	197.5	106.3	0.766		0.054	0.006	1.0272	0.4175
Bridge 17	Lynchburg	Western Piedmont	Type I/II	15.8% Fly Ash, 4.2% Silica Fume	1.48E-11	1.88E-12	466.9	59.4					0.8372	0.3652
				fib value for 0.45 w/c PCC:	1.00E-12	2.00E-13	31.6	6.3		All samples:	0.034	0.021		
				Avg. for:		PCC w / Fly Ash	567.3	84.5						
						PCC w / Slag	207.2	59.9						

Full-probabilistic model

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Input Parameters

fib Bulletin 34, Section B2 - Full probabilistic design method for chloride induced corrosion - uncracked concrete

Fick's 2nd Law

C_{crit} Critical chloride content $C_{crit} = C(x = a, t) = C_0 + (C_{s,\Delta x} - C_0) \cdot \left[1 - \text{erf}\left(\frac{a - \Delta x}{2\sqrt{D_{app,C} \cdot t}}\right)\right]$ Equation (B2.1-1)

$D_{app,C}$ Chloride diffusion coefficient $D_{app,C} = k_e \cdot D_{RCM,0} \cdot k_t \cdot A(t)$ Equation (B2.1-2)

k_e Environmental transfer variable $k_e = \exp\left(b_e\left(\frac{1}{T_{ref}} + \frac{1}{T_{real}}\right)\right)$ Equation (B2.1-3)

$A(t)$ Aging function $A(t) = \left(\frac{t_0}{t}\right)^{\alpha}$ Equation (B2.1-4)

				Normal Distr. Coeff.			Log-Normal Distr. Coeff.		Beta Distr. Coeff.			
Parameter	Description	Units	Distribution Function	Mean, μ	Std Dev, σ	Coeff. of Variation, σ/μ	λ	ζ	Lower Bound, a	Upper Bound, b	α	β
$D_{RCM,0}$	Chloride migration coefficient	mm^2/yr	Normal	567.3	84.5							
b_e	Regression variable, (limited to 3500 K to 5500 K)	K	Normal	4800	700							
T_{real}	Temperature (from Local Weather Data)	K	Normal	284.9	7.9							
T_{ref}	Standard test temperature	K	Constant	293								
k_t	Transfer parameter	N/A	Constant	1.0								
α	Aging exponent - All types in atmospheric zone	N/A	Beta	0.6	0.15				0	1	5.80	3.87
t_0	Reference point of time (28 days = 0.0767 yrs)	yrs	Constant	0.0767								
C_0	Initial chloride content of concrete	mass% of binder	Normal	0.034	0.02							
$C_{s,\Delta x}$	Chloride concentration at substitute surface Δx	mass% of binder	LogNorm	1.57	0.73	0.46	0.35	0.44				
Δx	Transfer function	mm	Constant	12.7								
cover, a	Concrete cover	mm	LogNorm	58.60	6.60	0.11	4.06	0.11				
C_{crit}	Critical chloride content	mass% of binder	LogNorm	1.08	0.443	0.41	0.00	0.39				
t_{SL}	Design service life	yrs	N/A	100								
β	Target Reliability	N/A	N/A	1.3								

λ: $\ln\mu - \ln((\sigma/\mu)^2 + 1)/2$

ζ: $\sqrt{\ln((\sigma/\mu)^2 + 1)}$

$\alpha = \frac{\frac{(a-\mu)^2(\mu-b)}{\sigma^2} - a + \mu}{a - b}$

$\beta = \left(\frac{(b-a)}{(\mu-a)} - 1\right)\alpha$

Full-probabilistic model

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Monte Carlo Trial Results

Trial Results of Randomly Generated Values of Input Parameters to Fick's 2nd Law

Trial	$D_{RCM,0}$ (mm²/yr)		b_e (K)		T_{real} (K)		k_e	α		$A(t_{SL})$	$D_{app,C}$ (mm²/yr)	C_0 (mass% of binder)		$C_{s,\Delta x}$ (mass% of binder)		Δx (mm)		cover (mm)		C_{crit} (mass% of binder)		$C(x=cov,t_{SL})$	Pass (1)
	rand 0-1	RESULT	rand 0-1	RESULT	rand 0-1	RESULT		rand 0-1	RESULT			rand 0-1	RESULT	rand 0-1	RESULT		RESULT	rand 0-1	RESULT	rand 0-1	RESULT	RESULT	/Fail (0)
1	0.743	622.49	0.602	4981	0.017	268.2	0.2	0.511	0.611	0.0125	1.61	0.11	0.01	0.875	2.369		12.700	0.476	57.8	0.493	0.992	0.04	1
2	0.359	536.84	0.668	5105	0.147	276.6	0.4	0.740	0.706	0.0063	1.20	0.28	0.02	0.263	1.076		12.70	0.904	67.4	0.141	0.654	0.02	1
3	0.169	486.44	0.160	4103	0.366	282.2	0.6	0.925	0.811	0.0030	0.84	0.96	0.07	0.183	0.955		12.70	0.757	63.0	0.994	2.664	0.07	1
4	0.091	454.36	0.721	5211	0.757	290.3	0.8	0.767	0.719	0.0058	2.22	0.02	-0.01	0.206	0.990		12.70	0.390	56.4	0.424	0.926	0.03	1
5	0.751	624.47	0.259	4348	0.433	283.5	0.6	0.719	0.697	0.0067	2.56	0.25	0.02	0.659	1.706		12.70	0.909	67.6	0.203	0.720	0.05	1
6	0.761	627.35	0.590	4959	0.338	281.6	0.5	0.638	0.663	0.0086	2.71	0.35	0.03	0.435	1.324		12.70	0.187	52.7	0.711	1.244	0.14	1
7	0.671	604.78	0.044	3604	0.988	302.5	1.5	0.537	0.622	0.0116	10.27	0.82	0.05	0.959	3.070		12.70	0.314	55.2	0.946	1.885	1.11	1
8	0.333	530.81	0.154	4087	0.989	303.0	1.6	0.021	0.285	0.1297	108.99	0.05	0.00	0.693	1.779		12.70	0.846	65.3	0.910	1.696	1.28	1
9	0.386	542.71	0.241	4307	0.636	287.6	0.8	0.377	0.556	0.0185	7.63	0.83	0.05	0.369	1.228		12.70	0.276	54.5	0.247	0.763	0.39	1
10	0.262	513.33	0.976	5500	0.349	281.8	0.5	0.398	0.565	0.0174	4.23	0.77	0.05	0.130	0.864		12.70	0.983	73.8	0.842	1.485	0.08	1
11	0.737	620.83	0.532	4856	0.146	276.6	0.4	0.633	0.661	0.0087	2.03	0.74	0.05	0.106	0.819		12.70	0.512	58.4	0.223	0.740	0.07	1
12	0.095	456.41	0.063	3730	0.555	285.9	0.7	0.318	0.530	0.0224	7.46	0.33	0.02	0.843	2.224		12.70	0.187	52.7	0.185	0.702	0.69	1
13	0.893	672.23	0.016	3500	0.767	290.6	0.9	0.487	0.602	0.0133	8.11	0.97	0.07	0.014	0.540		12.70	0.897	67.1	0.532	1.031	0.16	1
14	0.197	495.21	0.518	4831	0.310	281.0	0.5	0.260	0.501	0.0274	6.70	0.25	0.02	0.665	1.719		12.70	0.310	55.1	0.270	0.785	0.44	1
15	0.332	530.55	0.552	4891	0.019	268.6	0.2	0.400	0.566	0.0173	2.01	0.03	-0.01	0.934	2.769		12.70	0.460	57.6	0.752	1.306	0.06	1
16	0.673	605.18	0.019	3500	0.953	298.0	1.2	0.949	0.834	0.0025	1.87	0.47	0.03	0.538	1.485		12.70	0.547	59.0	0.014	0.419	0.06	1
17	0.776	631.54	0.383	4592	0.636	287.6	0.7	0.584	0.641	0.0101	4.73	0.53	0.04	0.802	2.074		12.70	0.768	63.2	0.368	0.875	0.24	1
18	0.839	651.13	0.271	4373	0.789	291.2	0.9	0.957	0.842	0.0024	1.41	0.62	0.04	0.904	2.535		12.70	0.473	57.8	0.377	0.883	0.06	1
19	0.122	468.77	0.290	4413	0.509	285.0	0.7	0.435	0.581	0.0155	4.78	0.68	0.04	0.780	2.004		12.70	0.590	59.7	0.402	0.906	0.30	1
20	0.086	451.75	0.173	4139	0.288	280.5	0.5	0.409	0.570	0.0168	4.03	0.60	0.04	0.686	1.765		12.70	0.501	58.2	0.386	0.891	0.23	1
21	0.252	510.75	0.373	4574	0.647	287.8	0.8	0.746	0.709	0.0062	2.38	0.50	0.03	0.083	0.772		12.70	0.619	60.2	0.589	1.092	0.06	1
22	0.095	456.63	0.009	3500	0.348	281.8	0.6	0.903	0.795	0.0033	0.95	0.40	0.03	0.562	1.526		12.70	0.080	49.7	0.830	1.455	0.04	1
23	0.814	642.87	0.787	5357	0.077	273.7	0.3	0.312	0.527	0.0229	4.04	0.60	0.04	0.744	1.902		12.70	0.876	66.3	0.312	0.824	0.15	1
24	0.950	706.54	0.985	5500	0.326	281.3	0.5	0.343	0.541	0.0206	6.69	0.93	0.07	0.240	1.041		12.70	0.383	56.3	0.952	1.927	0.29	1
25	0.030	408.34	0.027	3500	0.488	284.6	0.7	0.496	0.606	0.0130	3.73	0.97	0.07	0.704	1.804		12.70	0.912	67.8	0.698	1.226	0.15	1
26	0.780	632.56	0.165	4119	0.814	291.9	0.9	0.620	0.655	0.0091	5.44	0.22	0.02	0.493	1.413		12.70	0.598	59.9	0.455	0.956	0.23	1
27	1.000	912.89	0.665	5098	0.269	280.0	0.4	0.735	0.704	0.0064	2.61	0.53	0.04	0.688	1.767		12.70	0.557	59.2	0.105	0.610	0.11	1

Full-probabilistic model

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Monte Carlo Trial Results

Trial Results of Randomly Generated Values of Input Parameters to Fick's 2nd Law

	$D_{RCM,0}$ (mm^2/yr)		b_e (K)		T_{real} (K)		k_e	α		$A(t_{SL})$	$D_{app,C}$ (mm^2/yr)	C_s (mass% of binder)		$C_{s,\Delta x}$ (mass% of binder)		Δx (mm)		cover (mm)		C_{crit} (mass% of binder)		$C(x=cov,t_{SL})$	Pass (1)
Trial	rand 0-1	RESULT	rand 0-1	RESULT	rand 0-1	RESULT		rand 0-1	RESULT			rand 0-1	RESULT	rand 0-1	RESULT		RESULT	rand 0-1	RESULT	rand 0-1	RESULT	RESULT	/Fail (0)
4986	0.819	644.38	0.444	4702	0.734	289.8	0.8	0.446	0.585	0.0150	8.10	0.15	0.01	0.442	1.334		12.70	0.374	56.2	0.035	0.489	0.38	1
4987	0.041	420.05	0.476	4758	0.147	276.6	0.4	0.255	0.499	0.0279	4.48	0.62	0.04	0.953	2.993		12.70	0.022	46.5	0.564	1.065	0.81	1
4988	0.950	705.97	0.028	3500	0.798	291.4	0.9	0.404	0.568	0.0171	11.28	0.58	0.04	0.952	2.977		12.70	0.474	57.8	0.772	1.341	1.04	1
4989	0.984	747.80	0.636	5043	0.719	289.4	0.8	0.198	0.468	0.0349	21.10	0.47	0.03	0.123	0.852		12.70	0.770	63.3	0.224	0.740	0.39	1
4990	0.138	475.39	0.960	5500	0.533	285.5	0.6	0.349	0.544	0.0202	5.87	0.52	0.04	0.786	2.021		12.70	0.169	52.3	0.782	1.358	0.53	1
4991	0.788	634.90	0.215	4247	0.372	282.3	0.6	0.485	0.601	0.0134	4.90	0.23	0.02	0.194	0.972		12.70	0.274	54.4	0.684	1.207	0.19	1
4992	0.331	530.31	0.737	5244	0.240	279.3	0.4	0.547	0.626	0.0112	2.47	0.15	0.01	0.804	2.080		12.70	0.925	68.4	0.382	0.888	0.04	1
4993	0.613	591.61	0.643	5057	0.015	267.8	0.2	0.909	0.799	0.0032	0.38	0.03	-0.01	0.293	1.118		12.70	0.479	57.9	0.287	0.800	-0.01	1
4994	0.647	599.20	0.441	4696	0.992	303.8	1.8	0.377	0.556	0.0185	19.64	0.59	0.04	0.300	1.128		12.70	0.045	48.1	0.430	0.932	0.66	1
4995	0.927	690.17	0.011	3500	0.116	275.5	0.5	0.699	0.689	0.0072	2.31	0.03	-0.01	0.687	1.766		12.70	0.481	57.9	0.696	1.223	0.06	1
4996	0.880	666.56	0.396	4615	0.749	290.1	0.9	0.978	0.872	0.0019	1.10	0.64	0.04	0.184	0.956		12.70	0.617	60.2	0.059	0.539	0.04	1
4997	0.415	549.15	0.901	5500	0.376	282.4	0.5	0.368	0.552	0.0191	5.16	0.66	0.04	0.686	1.764		12.70	0.454	57.5	0.145	0.658	0.32	1
4998	0.666	603.51	0.592	4963	0.122	275.7	0.3	0.188	0.461	0.0365	7.61	0.21	0.02	0.569	1.537		12.70	0.753	62.9	0.077	0.570	0.32	1
4999	0.144	477.57	0.124	3992	0.360	282.0	0.6	0.404	0.568	0.0170	4.79	0.80	0.05	0.115	0.837		12.70	0.299	54.9	0.266	0.781	0.19	1
5000	0.873	663.63	0.917	5500	0.415	283.2	0.5	0.964	0.851	0.0022	0.77	0.07	0.00	0.173	0.938		12.70	0.479	57.9	0.361	0.868	0.00	1

SUMMARY

	$D_{RCM,0}$	b_e	T_{real}	k_e	α	$A(t_{SL})$	$D_{app,C}$	C_s	$C_{s,\Delta x}$	Δx	cover	C_{crit}
Computed Mean	567.93	4740	284.7	0.7	0.60	0.02	9.38	0.03	1.56	12.70	58.60	1.08
Input Mean	567.30	4800	284.9		0.60			0.03	1.57	12.70	58.60	1.08
Max	855.60	5500	313.52	2.94	0.98	0.43	250.82	0.11	6.26	12.70	86.79	5.32
Min	247.18	3500	258.27	0.10	0.12	0.00	0.16	-0.04	0.28	12.70	40.46	0.23

Total Passing	4638	
Total # of Trials	5000	
Reliability	0.93	
P_f, Probability of failure	0.07	
β, Reliability Index (calculated)	1.458	Passes
β, Target Reliability Index	1.3	

User Interface

DRAFT – VDOT Bridge Deck Service Life Design Aid
Follows: *fib* Bulletin 34, Section B2, Full Probabilistic Design Method
Draft Final Report, Bridge Service Design Life, SHRP2 R19a (VTRC)

Source Information: https://www.fhwa.dot.gov/goshrp2/Solutions/
.../R19A_ProbabalisticToolsChlorideIngressModel.xlsx
http://vtrc.virginiadot.org/PUBS.aspx

BASIC USER INPUT – BRIDGE DECK SERVICE LIFE DESIGN

Design Service Life	T_{SL} = 100	yrs
District	1) Bristol	
Region	Southwestern Mountain	
Concrete Cem. Mat'l.	PCC w/ Fly Ash	
Reinf. Class	MMFX	

fib SERVICE LIFE MODEL RESULTS

Total Passing	4581	
Total # of Trials	5000	
Pf, Probability of failure	8%	
β, Reliability Index (calculated)	1.38	Passes
β, Target Reliability Index	1.3	

[FORMAT KEY]

Typical input values
Model computation
User override values
Results

Some unresolved issues

- Material and environmental characterization
  - Model sensitivity ←→ variable uncertainties
  - Capturing time-dependent material changes
- Limited historic data
- Changes in de-icing practices
- Policy decisions
  - Avoidance of deterioration vs. probabilistic design
    - Validation
    - Implementation
  - Setting reliability index and design service life values
  - Programming future data collection

   

SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

Thank you!

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U.S. Department of Transportation
Federal Highway Administration

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AASHTO