



## Design Tools

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TRANSPORTATION RESEARCH BOARD  
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# Design Tools

- SHRP2 Website:
- <http://shrp2.transportation.org/Pages/ServiceLifeDesignforBridges.aspx>

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**Need More Information?**

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**Service Life Design for Bridges**

AASHTO > Strategic Highway Research Program 2 > Service Life Design for Bridges

**SERVICE LIFE DESIGN FOR BRIDGES (R19A)**

**Product Overview**

Comprehensive guidance to select and design durable bridge systems and components that are both easier to inspect and better-suited to their environments.

- SHRP2 Service Life Design Guide For Bridges Document

**Presentations and Webinars**

- Concept Overview presentation: Durability Design Structure Birth Certificate
- Product Detail presentation: Integrating Durability and Structural Design
- Service Life Design for Bridges Progress Update Webinar

**Tools and Technologies**

**Reports**

- Durability Assessment of a Bridge Substructure (R19A)

**Design Tools**

# Design Tools

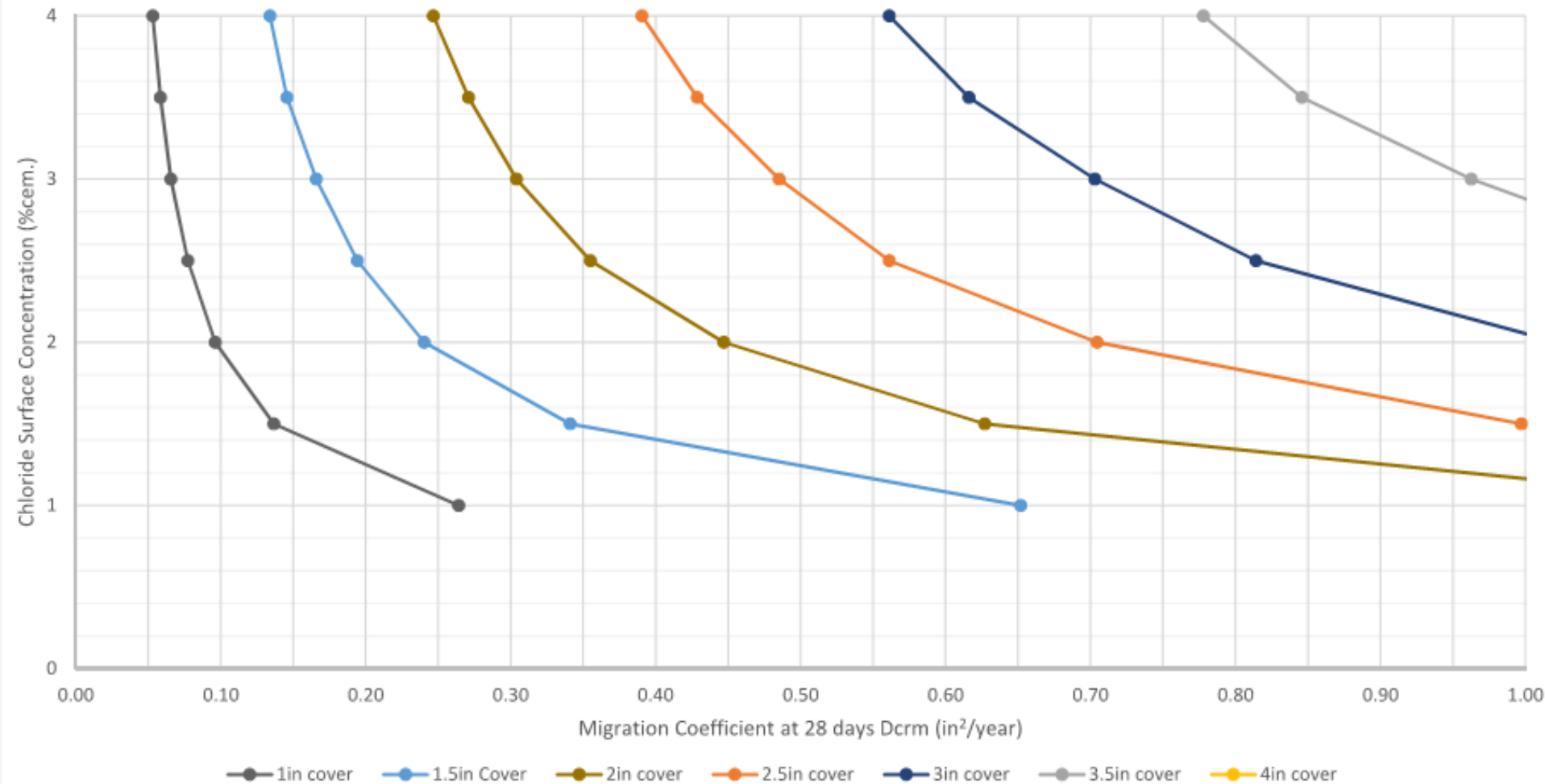


- SHRP2 R19A: Design tools for fully probabilistic model for chloride-induced corrosion
  - Excel spreadsheet
  - Design charts

# SERVICE LIFE DESIGN - GRAPHICAL SOLUTION

Calculations as per fib Bulletin 34 - fully probabilistic design  
 Service Life = 100 years  
 Beta = 1.3, Probability of failure = 10%  
 Critical chloride concentration: black bars - 0.6%cem.  
 Initial chloride concentration : 0.1%cem.

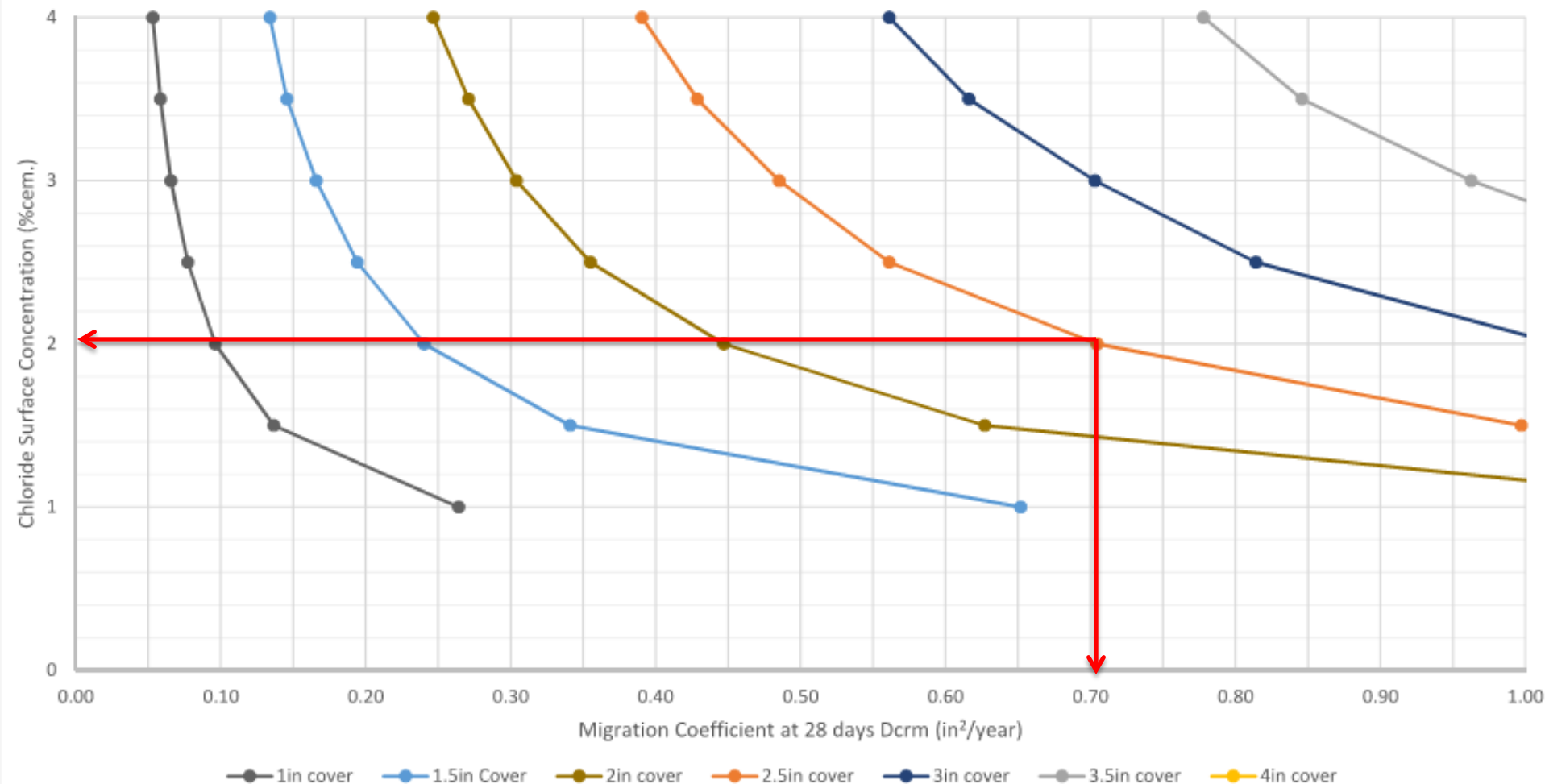
Temperature: mean = 49.1F, std = 12.1F  
 Exposure Zones: Buried/Submerged  
 Concrete Type: OPC + >20%FA



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# Full Probabilistic Tool - Input

Parameter	Description	Units	Distribution Function	Normal Distr Coefficients		
				Mean, $\mu$	Std Dev, $\sigma$	Coeff of Variation, $\sigma/\mu$
$D_{RCM,0}$	Chloride Migration Coefficient (from Nordtest NT Build 492 - results are given in $m^2/sec$ )	$in^2/yr$	Normal	0.420	0.084	0.20
		$mm^2/yr$		271.0	54.2	
		$m^2/sec$		8.59E-12	1.72E-12	
$b_e$	Regression variable, (limited to 3500 °K to 5500 °K)	°K	Normal	4800	700	
$T_{real}$	Temperature (from Local Weather Data)	°F	Normal	49.1	12.06	
		°C		9.5	6.70	
		°K		282.65	6.70	
$T_{ref}$	Standard test temperature	°F	Constant	67.6		
		°C		19.8		
		°K		292.9		
$k_e$	Environmental transfer variable	n/a	n/a			
$k_t$	Transfer parameter	n/a	Constant	1.0		
$\alpha$	Aging exponent - All types in atmospheric zone	n/a	Beta	0.65	0.15	
$t_o$	Reference point of time (28 days = 0.0767 yrs)	yrs	Constant	0.0767		
$A(t)$	Aging function	n/a	n/a			
$C_o$	Initial Chloride Content of Concrete	mass% of binder	Normal	0.10	0.00	0.001
$C_s$ or $C_{s,\Delta x}$	Chloride Concentration at surface, or at substitute surface $\Delta x$	mass% of binder	Log-Normal	3.00	1.50	0.50

# Monte Carlo Trial Results

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

Trial	$D_{RCM,0}$ (mm <sup>2</sup> /yr)		$b_e$ (°K)		$T_{real}$ (°K)		$k_e$	$\alpha$		$A(t_{SL})$ (h)
	rand 0-1	RESULT	rand 0-1	RESULT	rand 0-1	RESULT		rand 0-1	RESULT	
1	0.392	256.08	0.117	3967	0.918	292.0	1.0	0.921	0.853	0.0022
2	0.924	348.42	0.607	4990	0.690	286.0	0.7	0.236	0.541	0.0207
3	0.547	277.42	0.325	4482	0.682	285.8	0.7	0.473	0.650	0.0094
4	0.510	272.31	0.118	3970	0.025	269.5	0.3	0.094	0.439	0.0430
5	0.422	260.27	0.379	4585	0.203	277.1	0.4	0.757	0.766	0.0041
6	0.995	412.47	0.158	4099	0.160	276.0	0.4	0.935	0.864	0.0020
7	0.965	369.00	0.104	3920	0.320	279.5	0.5	0.398	0.619	0.0118
8	0.654	292.43	0.844	5500	0.626	284.8	0.6	0.102	0.447	0.0406
9	0.899	340.12	0.979		0.223	277.5	0.4	0.135	0.475	0.0330

cover (mm)	$C_{crit}$ (mass% of binder)		$C(x=cov, t_{SL})$	Pass (1) / Fail (0)
	rand 0-1	RESULT		
0.528	50.9	0.788	0.716	0.10 1
0.411	49.0	0.372	0.538	0.46 1
0.005	36.5	0.666	0.654	0.55 1
0.432	49.3	0.240	0.486	0.27 1
0.172	44.8	0.517	0.592	0.10 1
0.520	50.7	0.623	0.635	0.10 1
0.336	47.8	0.511	0.590	0.15 1
0.782	55.5	0.296	0.509	0.71 0
0.266	46.6	0.112	0.424	0.43 0

4999	0.892	338.07	0.897	5500	0.238	277.9	0.4	0.610	0.705	0.0022
5000	0.911	344.10	0.347	4524	0.702	286.2	0.7	0.865	0.819	0.0022

0.116	43.4	0.279	0.502	0.10 1
0.805	56.1	0.669	0.655	0.10 1

SUMMARY										
Computed Mean	270.47		4740		282.6		0.6	0.65		0.0022
Input Mean	270.97		4800		282.7			0.65		
Max	469.64		5500		309.08		2.41	1.00		0.0022
Min	92.56		3500		259.46		0.10	0.09		0.0022

50.76	0.60		
50.80	0.60		
76.30	1.21		
32.65	0.24		
Total Passing	4526		
Total # of Trials	5000		
Reliability	0.91		
$P_f$ , Probability of failure	0.09		
$\beta$ , Reliability Index (calculate)	1.312	Passes	
Target Reliability Index	1.3		

# More Than Design Tools...

- There are more information than just design tools!
- Design Guide produced by prior project
- Past webinars presentations
- Full example report for a bridge substructure
  - example for service life design of concrete structures
- Materials testing recommendations
- Chloride diffusion coefficient calculation spreadsheet
  - based on a chloride profile, calculate the diffusion coefficient



# Academic Toolbox



- Document with practical information divided in 3 chapters:
  - Probabilities and Reliability
  - Service Life Design of Concrete Structures
  - Service Life Design of Steel Materials
- Intent is to provide basic information and direct the reader to useful references if he needs to learn more
- To come in 2018!

# Questions?

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<http://shrp2.transportation.org/Pages/ServiceLifeDesignforBridges.aspx>

## **FHWA GoSHRP2 Website:**

[www.fhwa.dot.gov/GoSHRP2/](http://www.fhwa.dot.gov/GoSHRP2/)