Relative Material Loss:

A Methodology for Assessing Island Airport Steel Marine Bulkheads

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"Most U.S. airports are aging […] and because of budgetary restrictions, they're not aging well. The average airport in the United States is about 40 years old…

SLEP!

The youngest airport in the U.S. just had its 20th birthday.

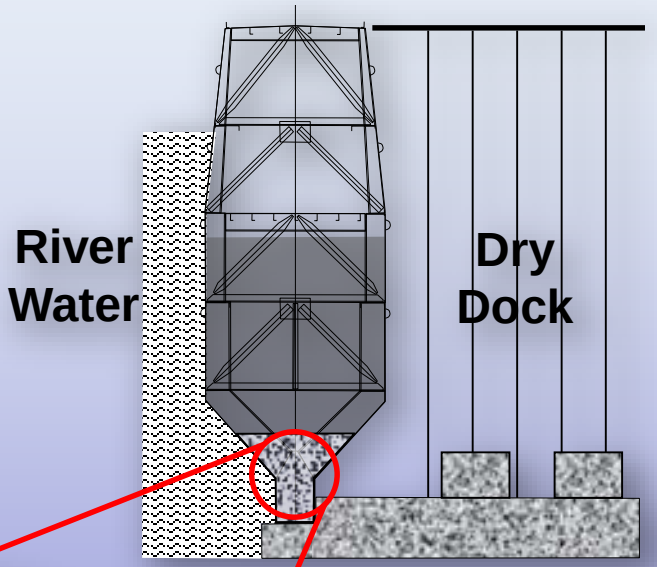
…Denver International Airport"

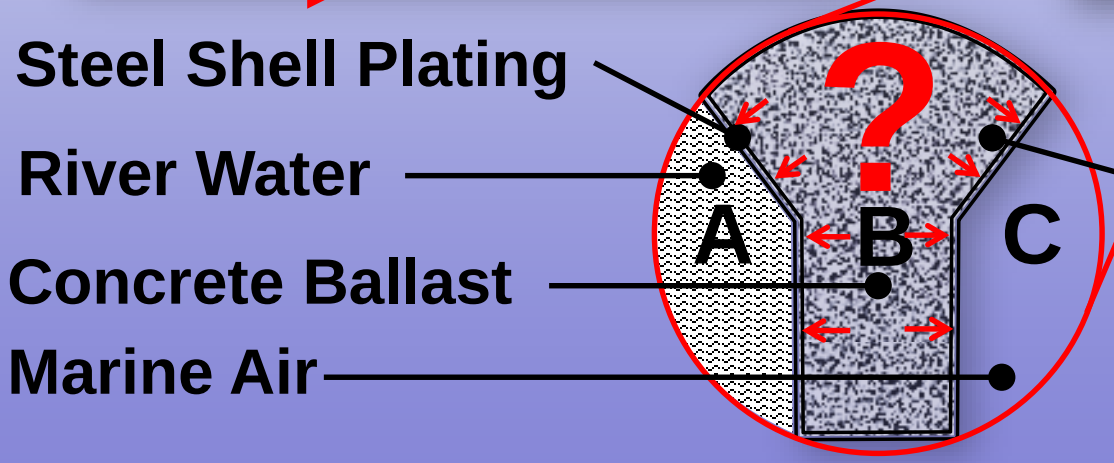
ACI-NA President and CEO, Kevin M. Burke
Source: http://skift.com/2015/07/29/

What is RML?

- **Relative Material Loss (RML)** - An inspection methodology for approximating material loss on each side of structural members subjected to dissimilar environments.
- **Homogeneous Environment** - An environment is said to be homogeneous when material loss is equivalent for all locations within the boundaries of the environment.
- **Material Loss (Contribution)** - The amount of material loss on a structural member contributed by the homogeneous environment in which the member exists.
- **Relative Loss Equations** - Mathematical relationships in the form of equations defined across various environmental boundaries (such as a steel plate) and solved simultaneously to suggest solutions.

RLM Research

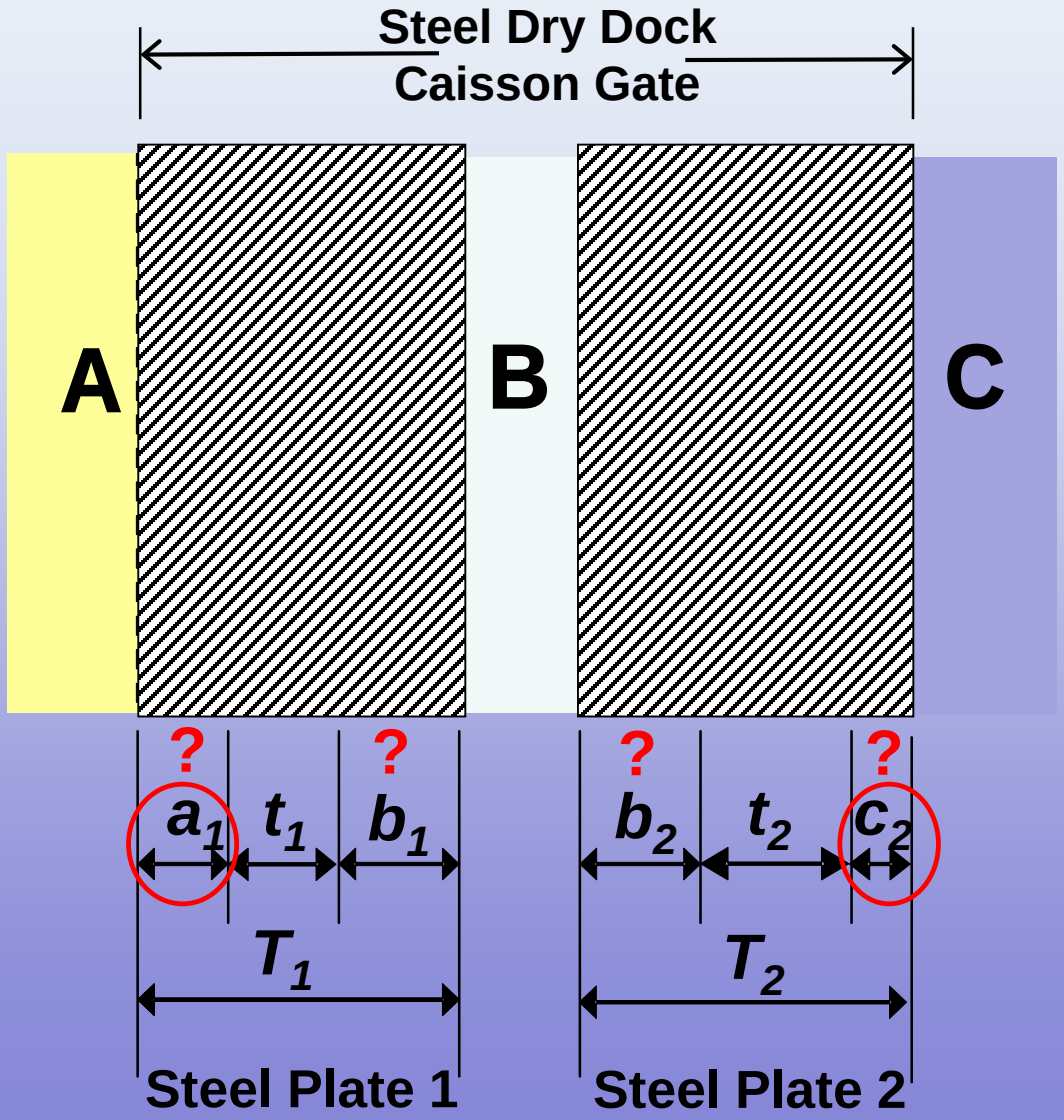




What's happening inside here?

Costa, A., and J. Appleton (1999)

RML Theory



$$T_1 = a_1 + t_1 + b_1$$
$$T_2 = b_2 + t_2 + c_2$$

But if $b_1 \approx b_2$ then…

$$b_1 \approx b_2 = T_1 - t_1 - a_1$$
$$= T_2 - t_2 - c_2$$
$$T_1 - T_2 = a_1 - c_2 + t_1 - t_2$$

Material loss relationship:

$$a_1 = f(c_2)$$

$$a_1 = c_2 + \underbrace{T_1 - T_2}_{\text{Constants}} + \underbrace{t_2 - t_1}_{\text{Random Variables}}$$

for $a_1 \geq 0$

Artificial Island Airports

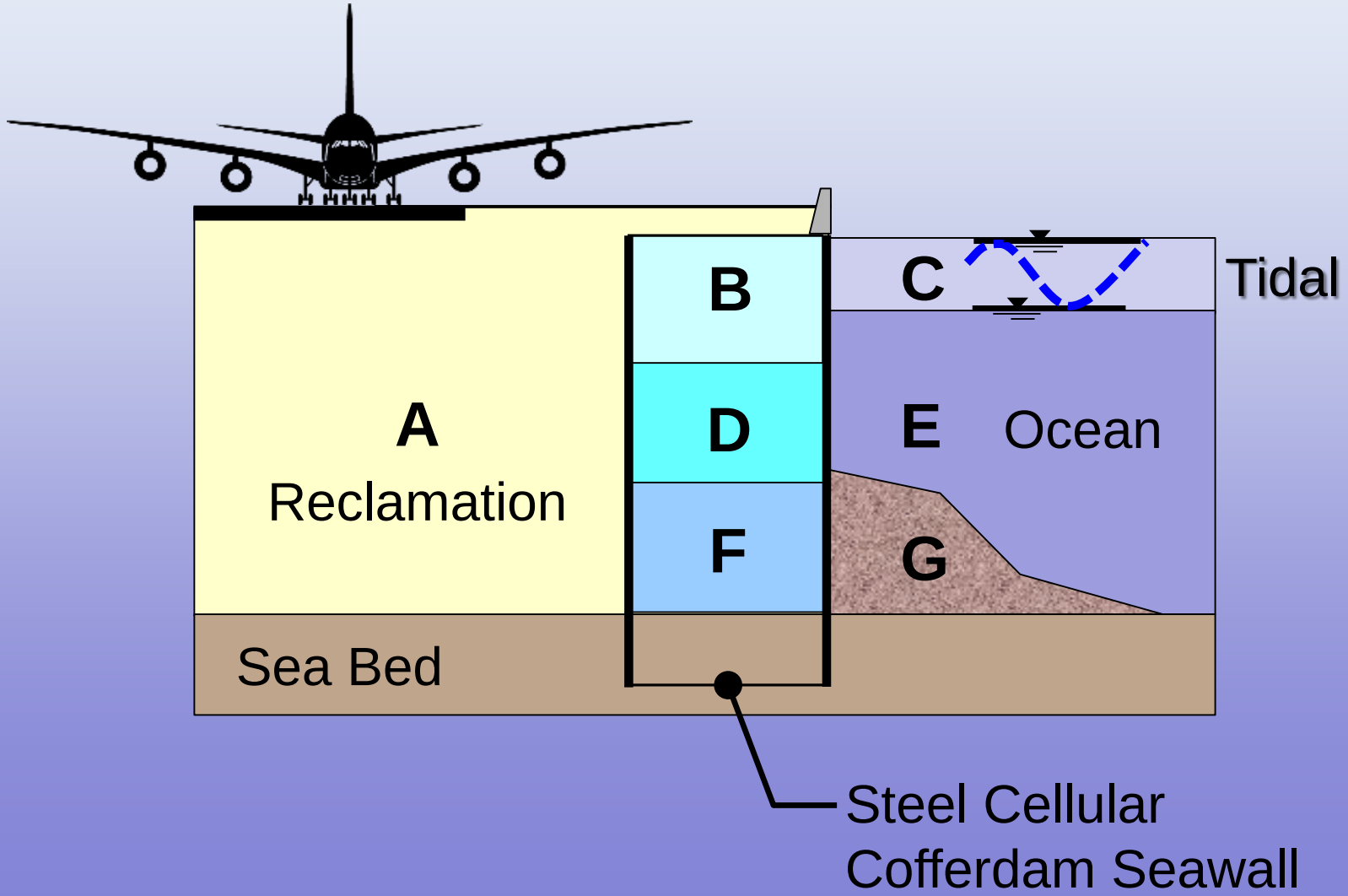
Source: http://myscienceacademy.org/2013/09/12/11-incredible-island-airports/

Hong Kong - Third Runway

Steel Cellular Cofferdam Seawall

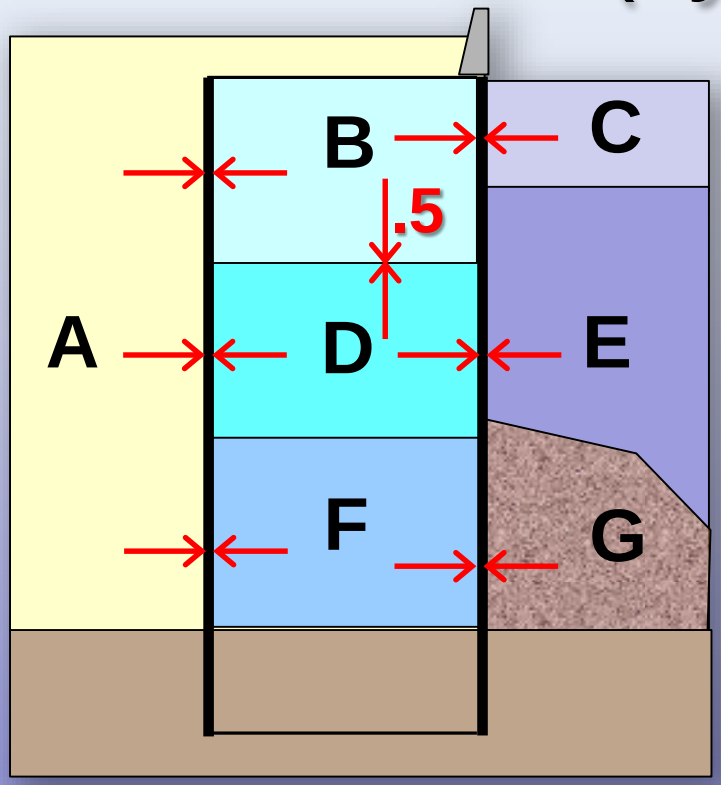
Courtesy: American Piledriving Equipment, Inc. (APE)

7 Dissimilar Environments A thru G



Field Data (hypothetical)

Assume: 0.5B = D



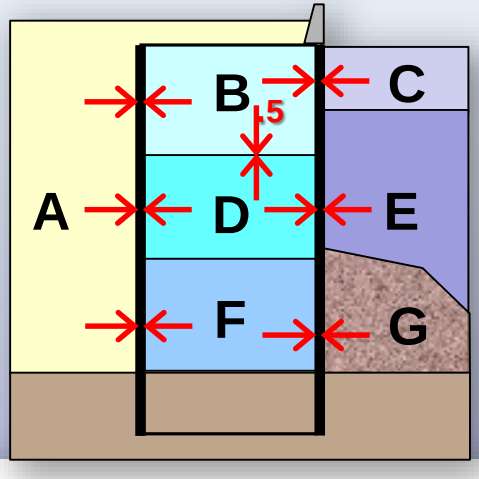
Random Variables, $N(\mu,\sigma)$				
Total Wastage	μ	σ	n	
W_{AD}	0.78	0.26	15	
W_{BC}	3.14	0.80	15	
W_{AD}	1.50	0.52	15	
W_{DE}	2.59	0.41	15	
W_{AF}	1.43	0.30	15	
W_{FG}	1.97	0.62	15	

						W_{FG}
						2.06
						2.04
						1.82
						0.96
						2.42
						3.12
						2.13
						2.03
						2.44
						2.60
						1.01
						1.49
						1.02
14	1.07	3.40	0.90	2.60	1.70	2.08
15	0.36	1.92	2.15	2.62	1.66	2.35

- 7 RL Equations
- 7 Unknown Variables

All data in millimeters (mm)

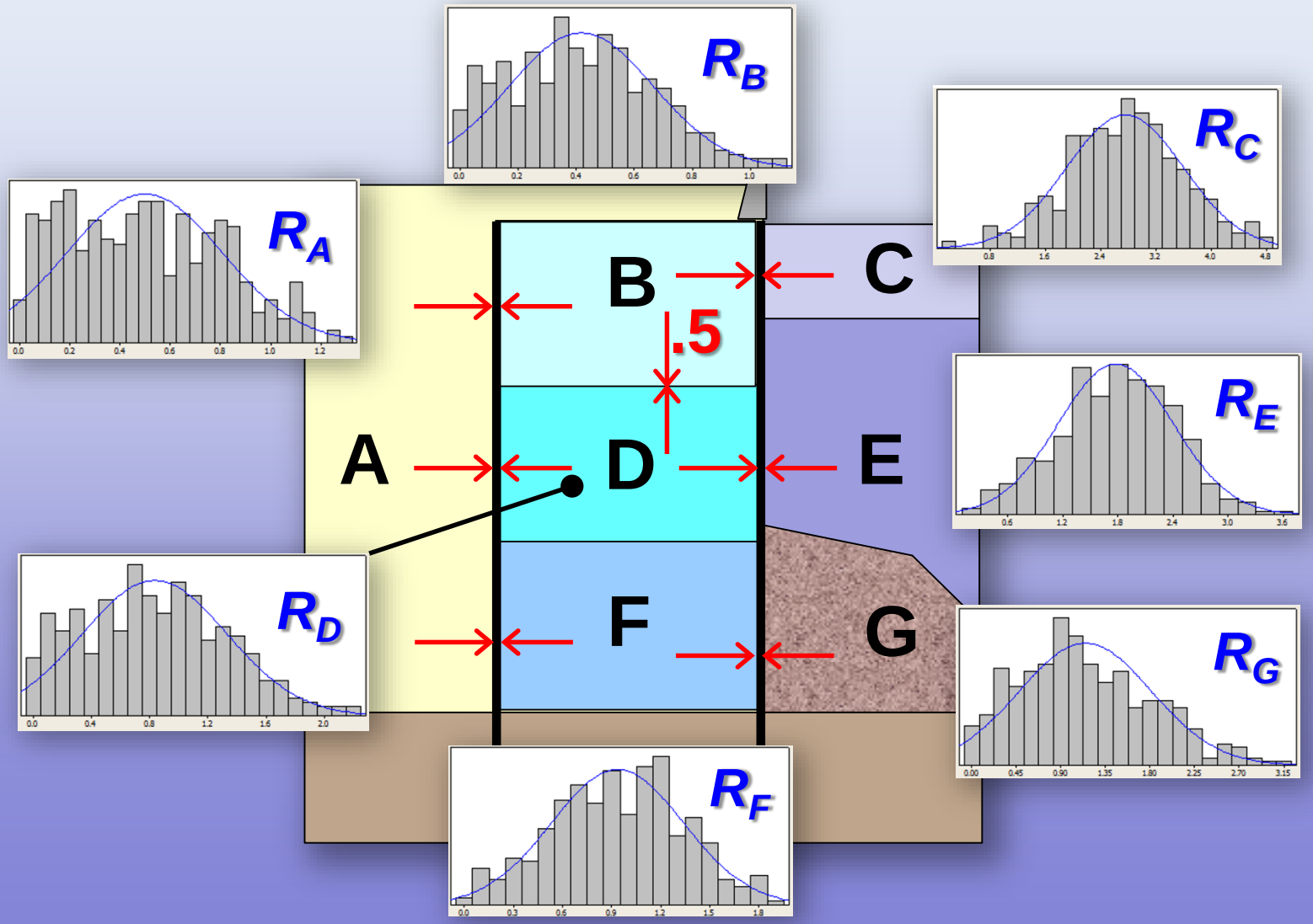
Relative Loss Equations



A	B	C	D	E	F	G	RL	Random Variables

$$\begin{bmatrix} 1 & 1 & & & & & & \\ & 1 & 1 & & & & & \\ 1 & & & 1 & & & & \\ & & & 1 & 1 & & & \\ 1 & & & & & 1 & & \\ & & & & & 1 & 1 & \\ & 1 & & -.5 & & & & \end{bmatrix} \begin{bmatrix} R_A \\ R_B \\ R_C \\ R_D \\ R_E \\ R_F \\ R_G \end{bmatrix} = \begin{bmatrix} W_{AB} \\ W_{BC} \\ W_{AD} \\ W_{DE} \\ W_{AF} \\ W_{FG} \\ 0 \end{bmatrix}$$

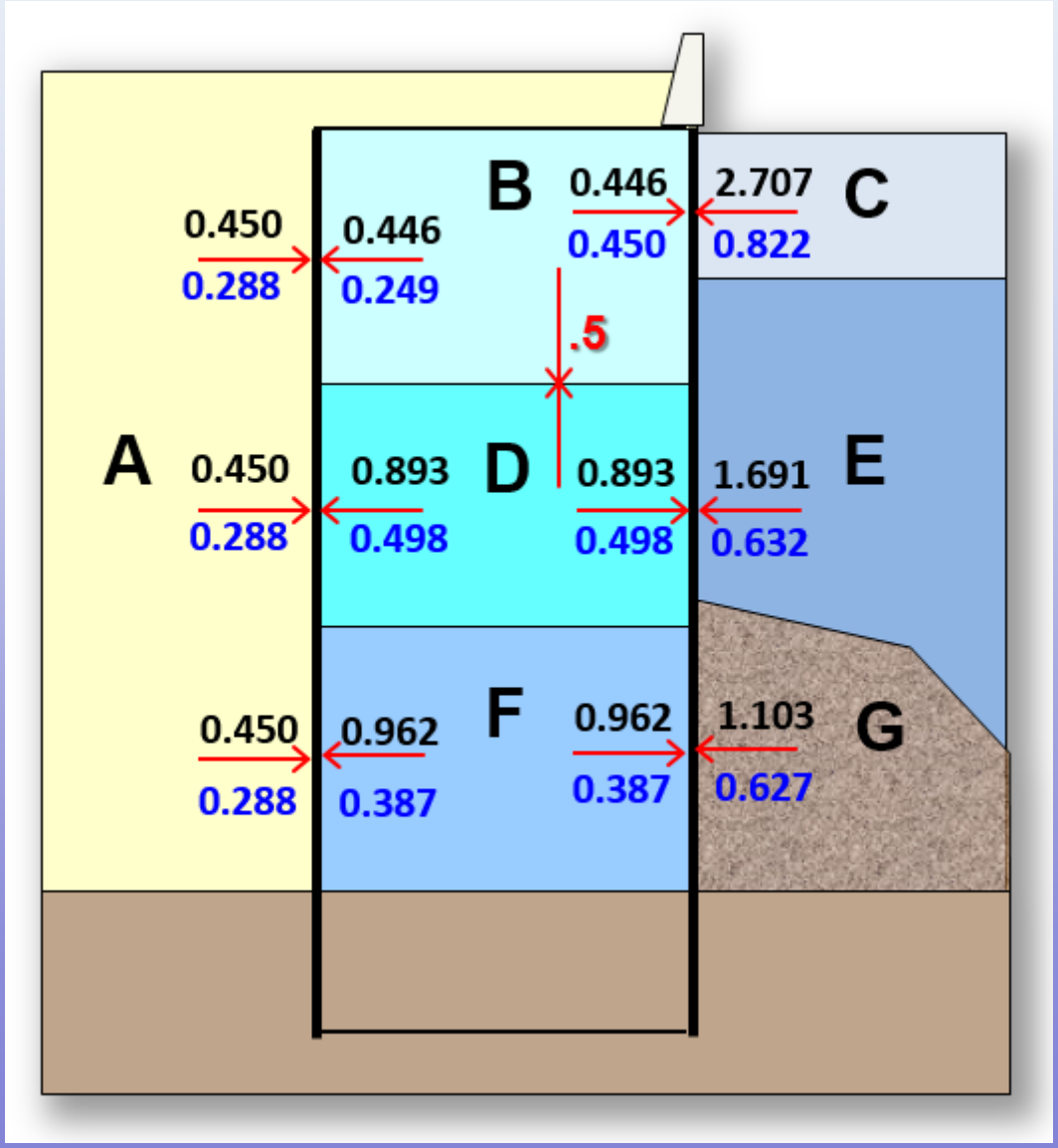
Material Losses (contributions)



Material Losses (Mean)

R_x →

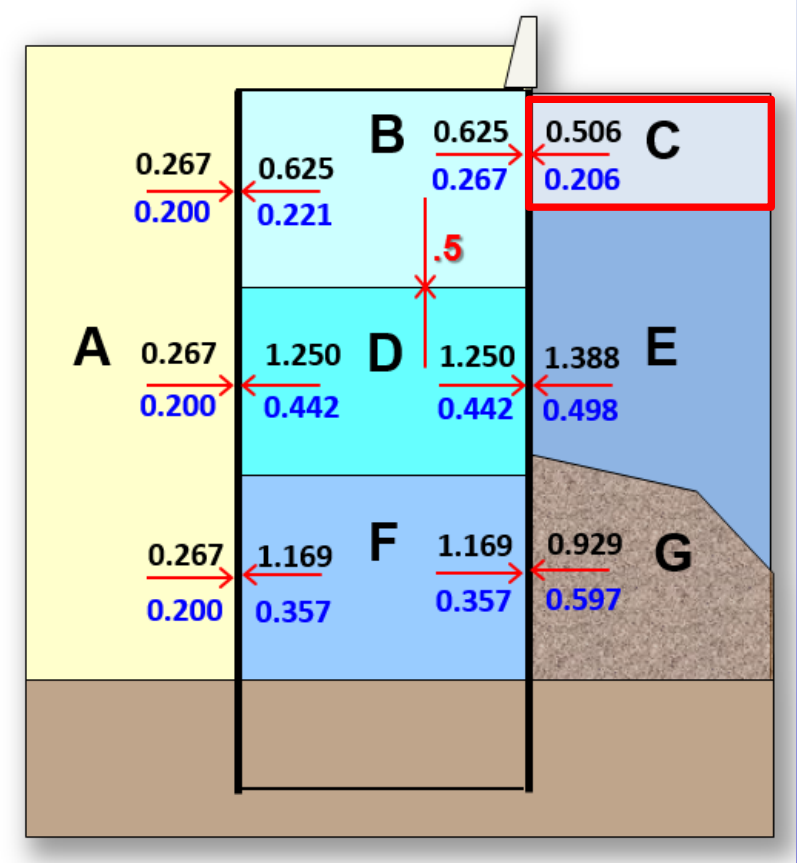
StDev, σ



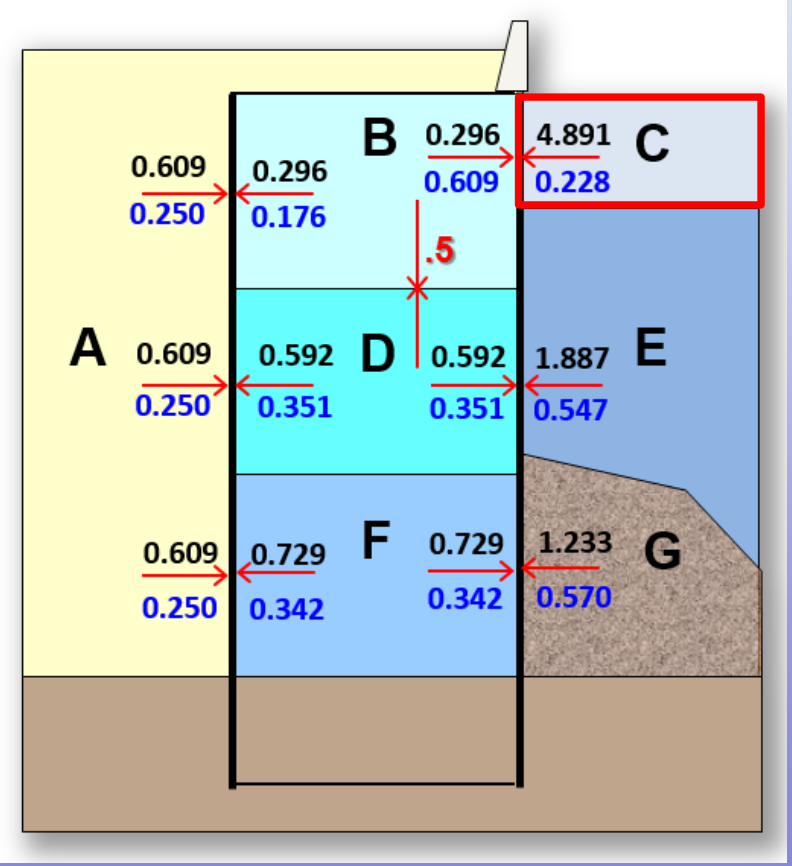
Sensitivity Analysis

R_x → StDev, σ

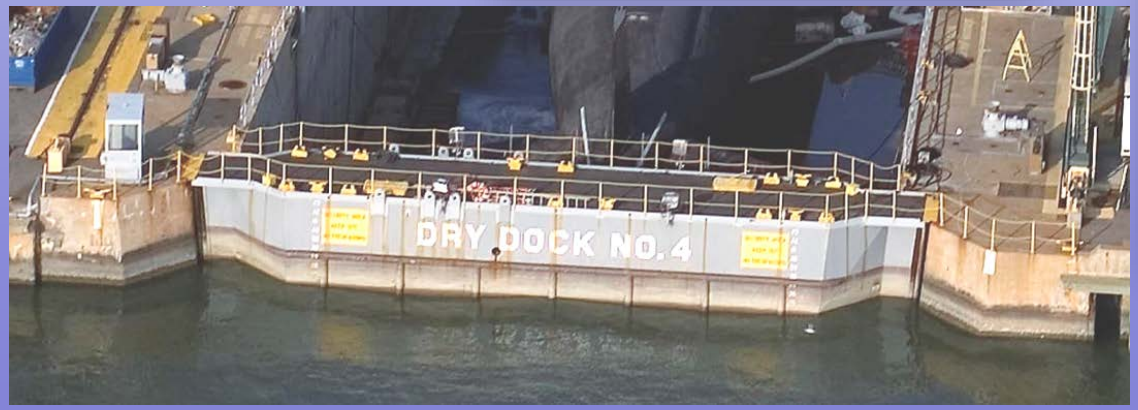
Min Condition, **C**



Max Condition, **C**



Various Applications



Conclusions

- Relative Material Loss (RML) - A new nondestructive evaluation methodology.
- Initially validated on a 65 year old dry dock caisson gate data.
- RML approach is illustrated using a hypothetical steel cellular cofferdam seawall.
- Monte Carlo and extreme values sensitivity analysis is performed to derive material loss solutions.

Questions?

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"It is better to wear out than to rust out"
Francis E. Willard

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