

RADBUG Meeting 2023

Enhancing Bridge Load Rating Analysis: Key Considerations—Part 1



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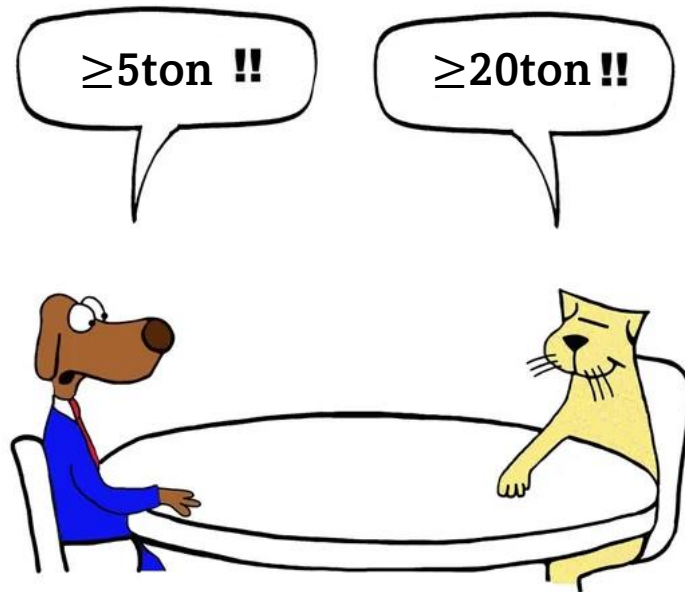
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Topics

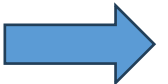
- 1000+ Structures of varied complexity
 - Codification research to refine bridge safety evaluation
 - STEAM Education & Bridge Aesthetics
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- Problems & Visions
 - How to Enhance Load Rating Analysis

➤ 1 Which Result Shall I Use?



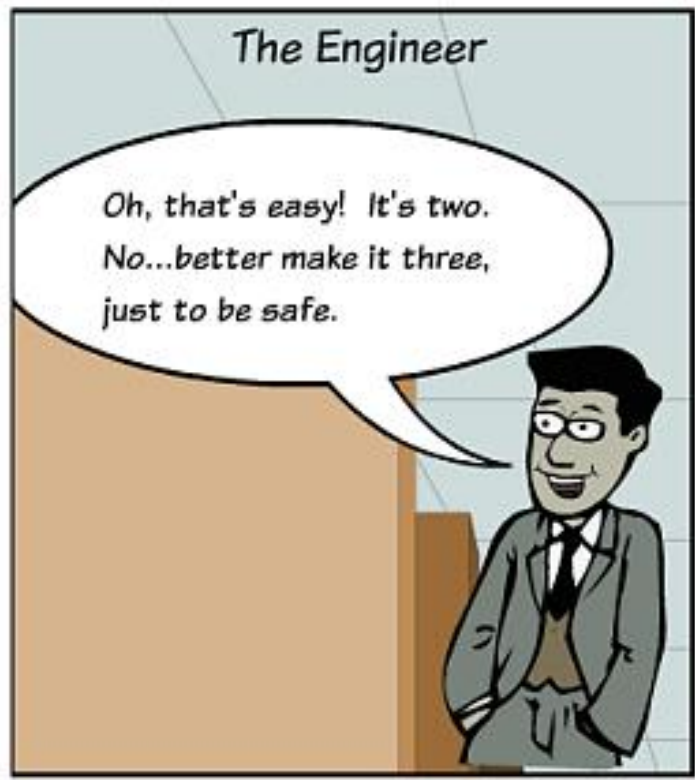
Different **load rating methods** & **analytical methods** may lead to different rated capacities.

What's the live load capacity of that bridge?



➤ 2 Is It Always Good to Be Conservative?

What's 1 + 1?



"Why post the bridge? It has been in use and is in good shape."

We should evaluate the postability of bridges and look for alternative solutions, not just settle on the more conservative result.

If the public perceives bridge engineers as overly conservative, they may not respect posted limits.



➤3 Rating V.S. Design

Evaluation Level		Reliability Index β
Design		3.5
Design Load Rating	Inventory Level	3.5
	Operating Level	2.5
Legal Load Rating		2.5

This reduction in reliability target is a consequence of economic considerations.



How much would it cost to increase the load capacity of a bridge by 25%?

Bridges on computer

1-2% of total cost

Existing bridges

very costly or even impossible

Evaluation codes allow more flexibility and less conservatism.



➤ 4 Large Complex Bridge V.S. Small Simple Bridge



Heavy traffic, complex large bridge



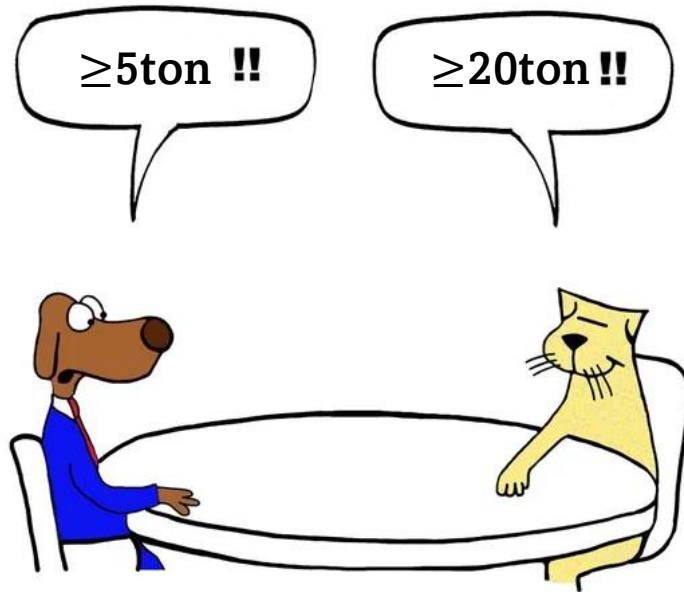
Low traffic, simple small bridge

Target Reliability levels depend on the location of a structure, costs associated with safety measures, and the availability of resources.



➤ 5 Would Increasing the Weight Limit Jeopardize the Safety of the Bridge?

The aim is to produce rating results that are **closer to reality**, without compromising the safety of network.



Estimate

Safety Factor

$\geq 5\text{ton}$

8

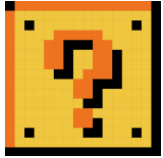
$\geq 20\text{ton}$

2

Squeeze the sponge to release the water.
But won't squeeze it completely dry.



The Inherent Safety Margin in Bridge Design/Rating



A 60-ft span designed for HS20 (80kips) was not damaged by a vehicle weighed 550kips. Why?

(This example is quoted from NCHRP Report 454: Calibration of Load Factors for LRFR Bridge Evaluation)

$$R \geq 1.3DL + 2.17LL$$

$DL \approx LL$ for a 60ft span

$$R \geq 1.0DL + 0.3LL + 2.17LL = 1.0DL + 2.47LL$$

One lane actually loaded (distribution factor)

$$R \geq 1.0DL + 2.47(\times 2)LL = 1.0DL + 4.92LL$$

(IM = 0.3)

$$R \geq 1.0DL + 4.92(\times 1.3)LL = 1.0DL + 6.42LL$$

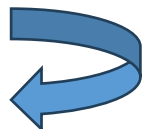
(1.13 strength bias in R)

$$R \geq 1.0DL + 6.42(\times 1.13)LL = 1.0DL + 7.25LL$$

$$7.25 \times 80kips = 580kips > 550kips$$

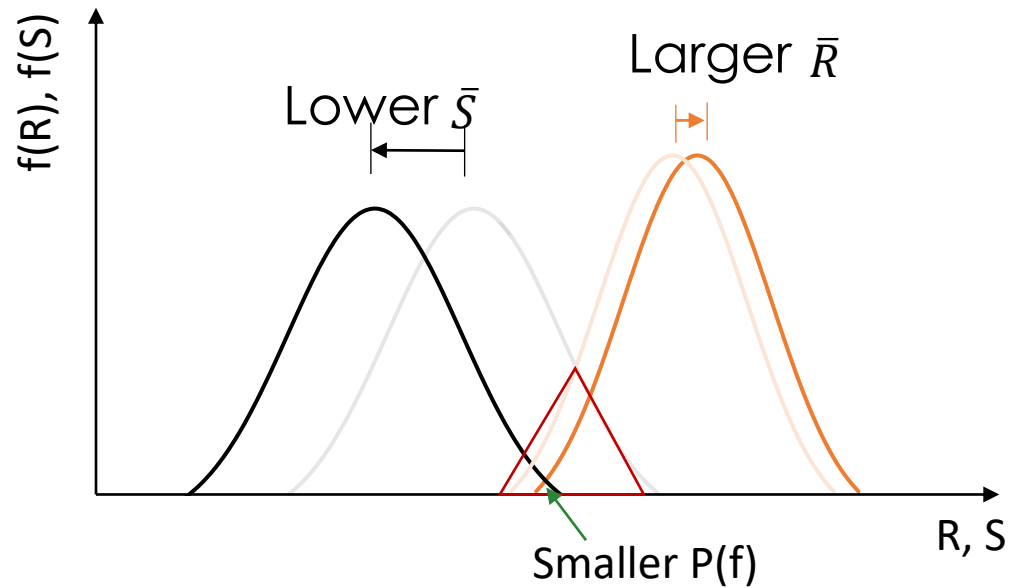


Failure to follow weight limits may cause the structure to deteriorate quickly and shorten the service life.



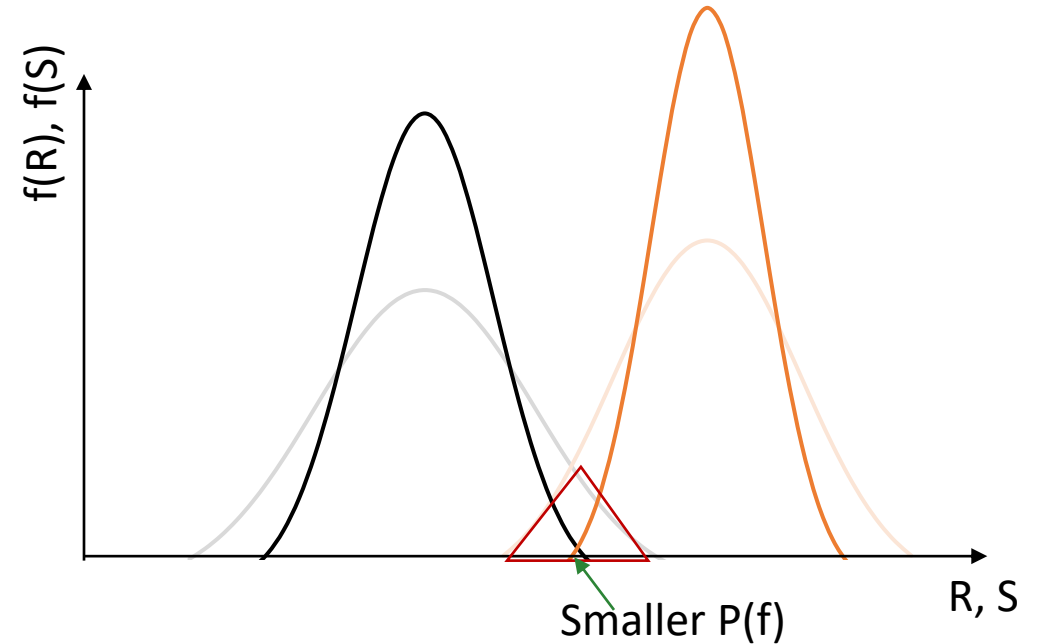
➤6 How to Enhance Load Rating Analysis? – “Trace to It’s Source”

More accurate prediction of S, R



“Push apart” the curves

Reduce uncertainties



“Squeeze” the curves

