We all have an interest in public safety and have created governmental agencies to act on our behalf – airline safety (FAA) --- food and drug safety (FDA) – highway safety (DOT/FHSA). Bridge safety (BTS/FHA). And yet most of us never think about bridge safety until there is a disaster such as the Florida bridge collapse in 2018 that killed six (<https://www.usatoday.com/story/news/2018/11/15/ntsb-miami-bridge-collapse-design-errors/2012020002/>) or the Silver Bridge collapse in Ohio (1967) that killed 46 (<https://en.wikipedia.org/wiki/Silver_Bridge>). The National Bridge Inventory maintained by the FHA lists 616,087 bridges. 7.63% are rated “structurally deficient.” (47052/616087) and need urgent repairs. Estimated cost to complete all needed bridge work is $171 Billion. <https://artbabridgereport.org/>

Americans cross these deficient bridges 178 million times a day. (<https://artbabridgereport.org/reports/2019-ARTBA-Bridge-Report.pdf>).

The FHA (Federal Highway Administration) National Bridge Inventory is huge:

Over 600,000 rows

Over 100 attributes

Most attributes have several codes.

As you can see, there are a lot of bridges and a lot of data. Most reports are like the one mentioned above where they tell you how many or what percentage and may give a simple prioritization to the bridges. I will survey this data and apply several statistical tests to better understand the true state of our bridges. In particular, I would like to rank the bridges that are ‘structurally deficient’ because funding will not arrive in time to fix them all at once. In other words, a more granular prioritization is needed.

So, how does a bridge get rated as “structurally deficient?”

“Structurally deficient” is based on primary **CONDITION RATINGS**: **Deck, Superstructure, Substructure –** used to evaluate every bridge.

Labeling a bridge as “structurally deficient” is the result of getting a low rating on just one of the conditions – though you may get a low rating on more than one.

The **DESIGN LOAD** is an abstract number. It is a max load based on the design, the “as-built” condition as opposed to the “live” (in-use) condition ratings. The codebook states the following about the relationship between the Design Load and Condition Ratings: “Condition ratings are used to describe the existing, in-place bridge as compared to the as-built condition … The load carrying capacity will not be used when evaluating condition items. The fact that a bridge was designed for less than current legal loads and may be posted shall have no influence upon condition ratings.”

In other words, there should be no relationship between the Design Load and the Condition Ratings. But is this true? If it is, great. If it isn’t, then it needs to be factored into the ratings and may impact the ultimate rating and change your repair rankings.

My hypothesis is that dividing up the data by Design Load will produce Condition Ratings means that are statistically different than the population Condition Rating means. In other words, the Design Load does matter and should be factored into the ratings.

Math:

I will be using the following:

stats. Describe

QQ-plots

ANOVA

Shapiro-Wilk

**CONDITION** **RATINGS**: **Deck, Superstructure, Substructure –** used to evaluate every bridge --are the same for each **Design Load.**

Bridge condition assessment is the evaluation of differences between the as-designed, as-built, and as-is states of the structures.

<https://pdfs.semanticscholar.org/0db4/26250bed10f31cc2f7ffa227e356b94350c3.pdf>

I will also create a dashboard that will allows you to ask questions about any specific bridge or locate all the bridges in your area or identify/locate the bridge closest to you.

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Let’s start by understanding what a bridge is according to the FHWA: Any structure that carries a highway load and has a total length greater than 20 ft. is a bridge.

Next let’s understand the challenge I faced: The real challenge here was not applying statistical methods to analyze the date – the real challenge was deciphering the codebook. Once you understand the codebook (data dictionary) you can begin to filter the data and find possible relevant relationships worthy of further investigation/analysis.

To show you the complexity of the data here is how to decipher the attribute known as “Design Load.” The table does not come from the codebook. Nor does it tell what each of the entries mean.

| **Code** | **Metric Description** | **English Description** |
| --- | --- | --- |
| **0** | **Unknown** | **Unknown** |
| 1 | M 9 or | H 10 |
| 2 | M 13.5 | H 15 |
| 3 | MS 13.5 | HS 15 |
| 4 | M 18 | H 20 |
| 5 | MS 18 | HS 20 |
| 6 | MS 18 + Mod | HS 20 + Mod |
| 7 | Pedestrian | Pedestrian |
| 8 | Railroad | Railroad |
| 9 | MS 22.5 **or greater** | HS 25 **or greater** |
| **A** | **HL 93** | **HL 93** |
| **B** | **Greater than HL 93** | **Greater than HL 93** |
| **C** | **Other** | **Other** |

So, as you can see, once you understand the codebook you can understand the data. Once you understand the data you are good to go.

The government classifies a bridge as “structurally deficient” if any one of the following bridge components are rated less than or equal to 4 (in poor or worse condition):

* Deck condition
* Superstructure condition
* Substructure condition

Culvert condition

According to FHWA, any structure that carries a highway load and has a total length greater than 20 ft. is a bridge.

Federal Highway Administration (FHWA) requires load ratings of all the structures of length 20 feet or greater in compliance with National Bridge Inspection Standards (NBIS)

The real challenge here was not applying statistical methods to analyze the date – the real challenge was deciphering the codebook.

Tet to see if sample means same for all design loads

Per design load check all three conditions

.  A bridge is classified as structurally deficient and in need of repair if the rating on a key structural element is four or below.