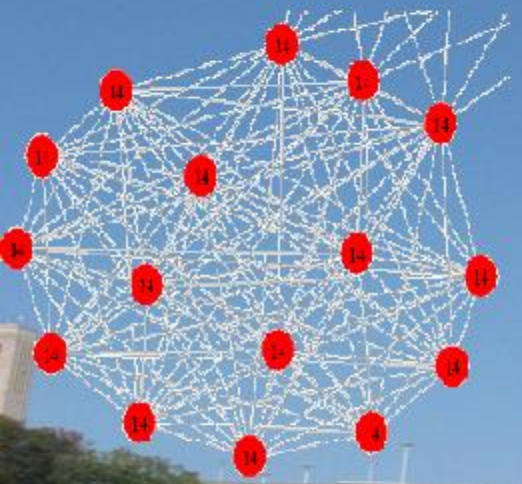
A Population Analysis Approach to Identify Significant Parameters of Highway Bridges



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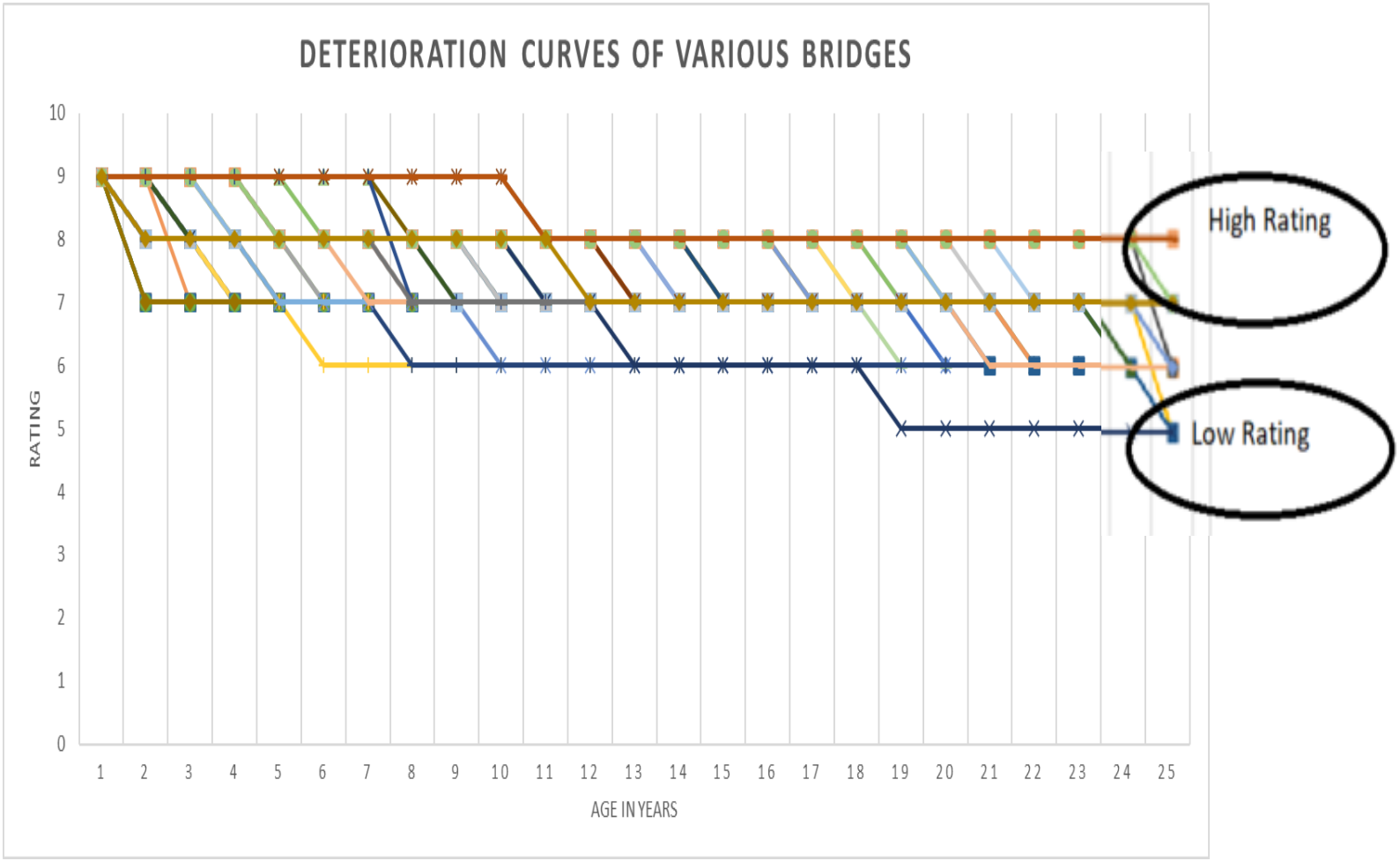
Motivation

- Why some bridges' condition ratings deteriorate faster than others?
- Are there any significantly enriched input parameters that effect the bridges' output parameters (condition ratings)?

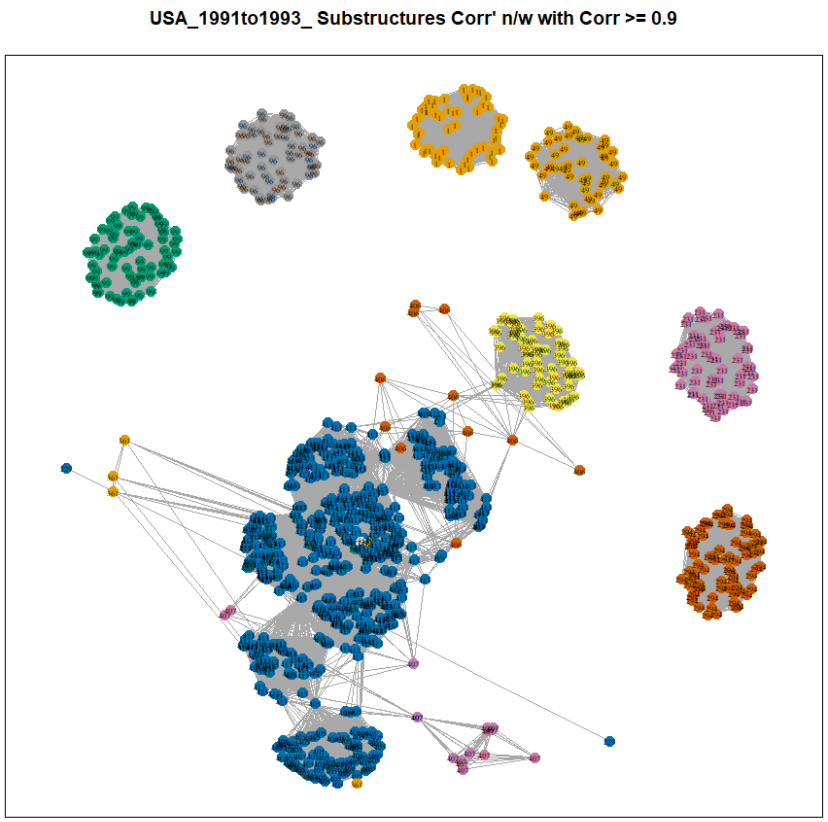


Research Question

- What input parameters are significantly enriched on the outcome condition ratings, such as substructure ratings?

What is population analysis?

- It is to conduct assessment of an individual element as it compares to a groups of peers
- Individual elements could be individual bridges/group of bridges with similar behavior in a civil infrastructures network
- In a similarity network, bridges with similar behavior are grouped into a common community
- Compare the clusters/communities with their peers to provide new insights of understanding the bigdata associated with the NBI dataset
- Identify the significantly enriched input parameters while the network is created based on outcome parameter



NBI dataset's parameters

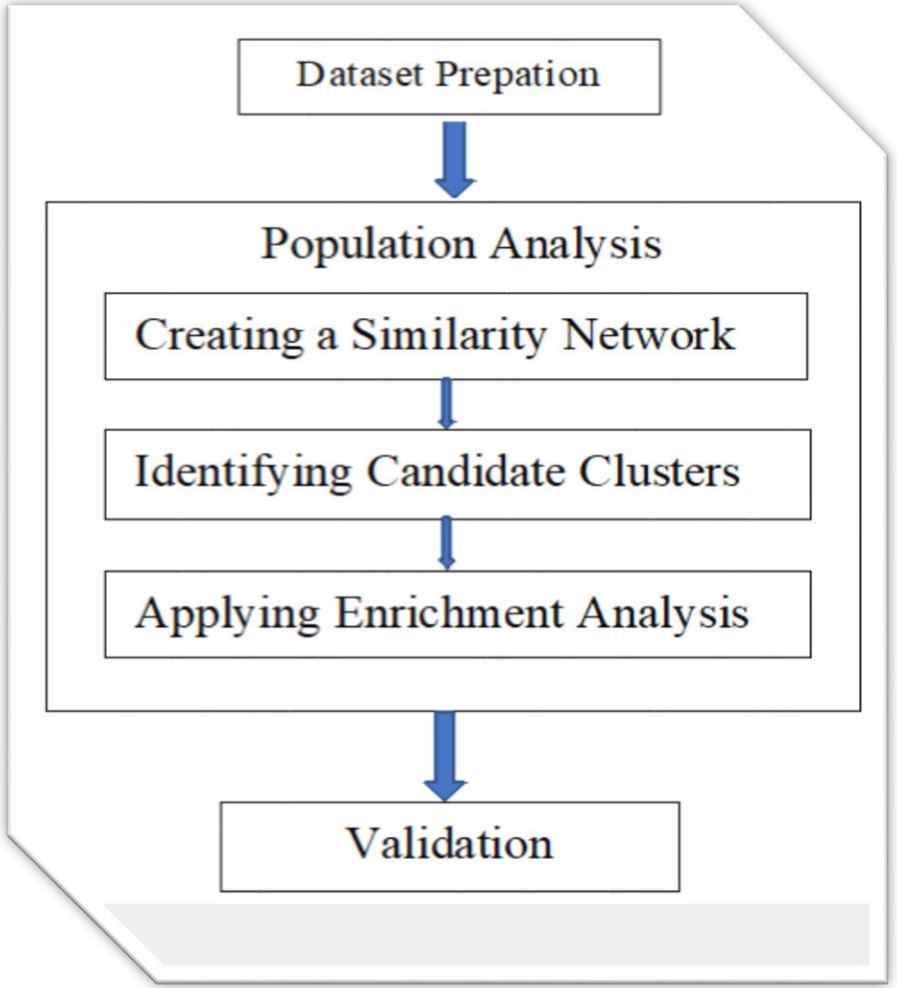
- National Bridge Inventory(NBI) dataset has more than 100 parameters
- The parameters are categorized into input and output as shown in the table
- Interactions between parameters are indicated by '*'

Input Parameters	• MaterialType • DesignType • Region • OwnerType • ADTcategory (ADT) • CoastLine • Material * Design (Mat.Design) • Material * Region (Mat.Region) • Material * Region * ADT (Mat.Region.ADT) • Material * Design *ADT (Mat.Design.ADT) • Material * Design * Region (Mat.Desgn.Region) • Material * Design *Region * ADT (Mat.Desgn.Region.ADT)
Output Parameters	• Deck Rating (DR) • Superstructure Rating (SpSR) • Substructure Rating (SbSR)

Population analysis pipeline

- Three methodological steps, such as dataset preparation, population analysis, and validation

- Three major steps in population analysis, such as creating a similarity/correlation network, identifying candidate clusters, and applying enrichment analysis using hyper-geometric distribution



Input Matrix and Correlation Matrix

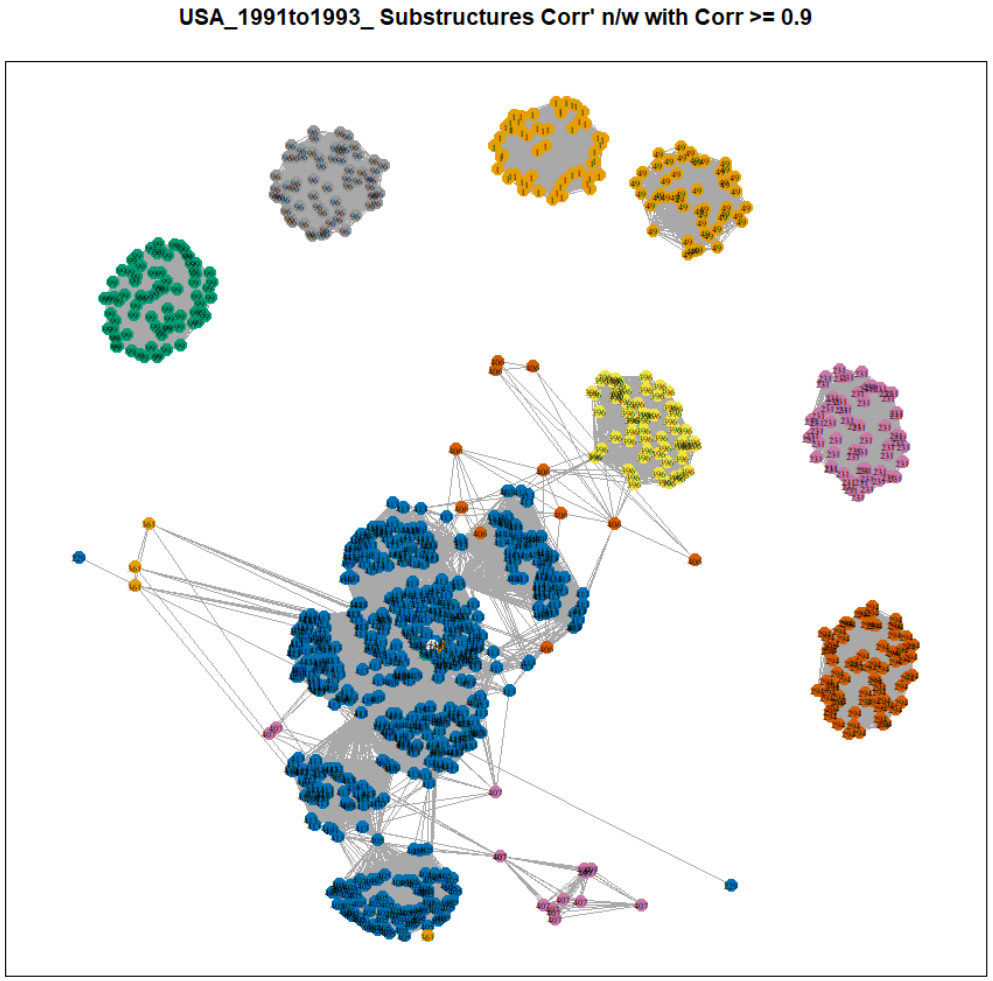
- Data of bridges that built between the years 1991 and 1993
- Age of each bridge is 26 years
- No re-built bridges
- Each condition rating starts with a rating of 9
- A temporal data of condition ratings for the next 26 years is considered for creating the input matrix (only last 15 years data is used for this case study)
- 1,136 bridges

B.Number	y1	y2	y3	y4	y5	y6	y7	y8	y9	y10	y11	y12	y13	y14	y15	y16	y17	y18	y19	y20	y21	y22	y23	y24	y25	y26
b28_1100	9	9	9	9	9	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	6	6	6
b54_0000	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	7	7
b12_5540	9	9	9	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	6	6	6
b6_12C00	9	9	9	9	7	7	7	7	7	7	7	7	6	6	6	6	6	6	6	6	6	6	6	6	5	5
b6_12C01	9	9	9	9	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
b34_1000	9	9	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
b47_860A	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	7	7	7	7	7	7	7	7	7
b31_S275	9	9	9	9	9	9	9	9	9	9	9	9	9	9	8	8	8	8	8	8	6	6	6	6	6	6
b6_57 098	9	9	9	9	9	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
b18_7700	9	9	9	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7

	b28_110(	b54_000(	b12_554(	b6_12C0(	b6_12C0(	b34_100(	b47_860/	b31_S27!	b6_57 09	b18_770(
b28_110(	1	0.526167	0.777156	0.793971	0.675826	0.457537	0.557391	0.640674	0.773378	0.572418
b54_000(	0.526167	1	0.54412	0.495261	0.123091	0.083333	0.396746	0.424918	0.140859	0.104257
b12_554(	0.777156	0.54412	1	0.71045	0.639321	0.568852	0.574903	0.638324	0.593644	0.711684
b6_12C0(	0.793971	0.495261	0.71045	1	0.670586	0.453989	0.681945	0.812643	0.683667	0.567979
b6_12C0(	0.675826	0.123091	0.639321	0.670586	1	0.677003	0.310253	0.376588	0.873863	0.84699
b34_100(	0.457537	0.083333	0.568852	0.453989	0.677003	1	0.210042	0.254951	0.591608	0.799305
b47_860/	0.557391	0.396746	0.574903	0.681945	0.310253	0.210042	1	0.856807	0.355036	0.262781
b31_S27!	0.640674	0.424918	0.638324	0.812643	0.376588	0.254951	0.856807	1	0.430946	0.318966
b6_57 09	0.773378	0.140859	0.593644	0.683667	0.873863	0.591608	0.355036	0.430946	1	0.740153
b18_770(	0.572418	0.104257	0.711684	0.567979	0.84699	0.799305	0.262781	0.318966	0.740153	1

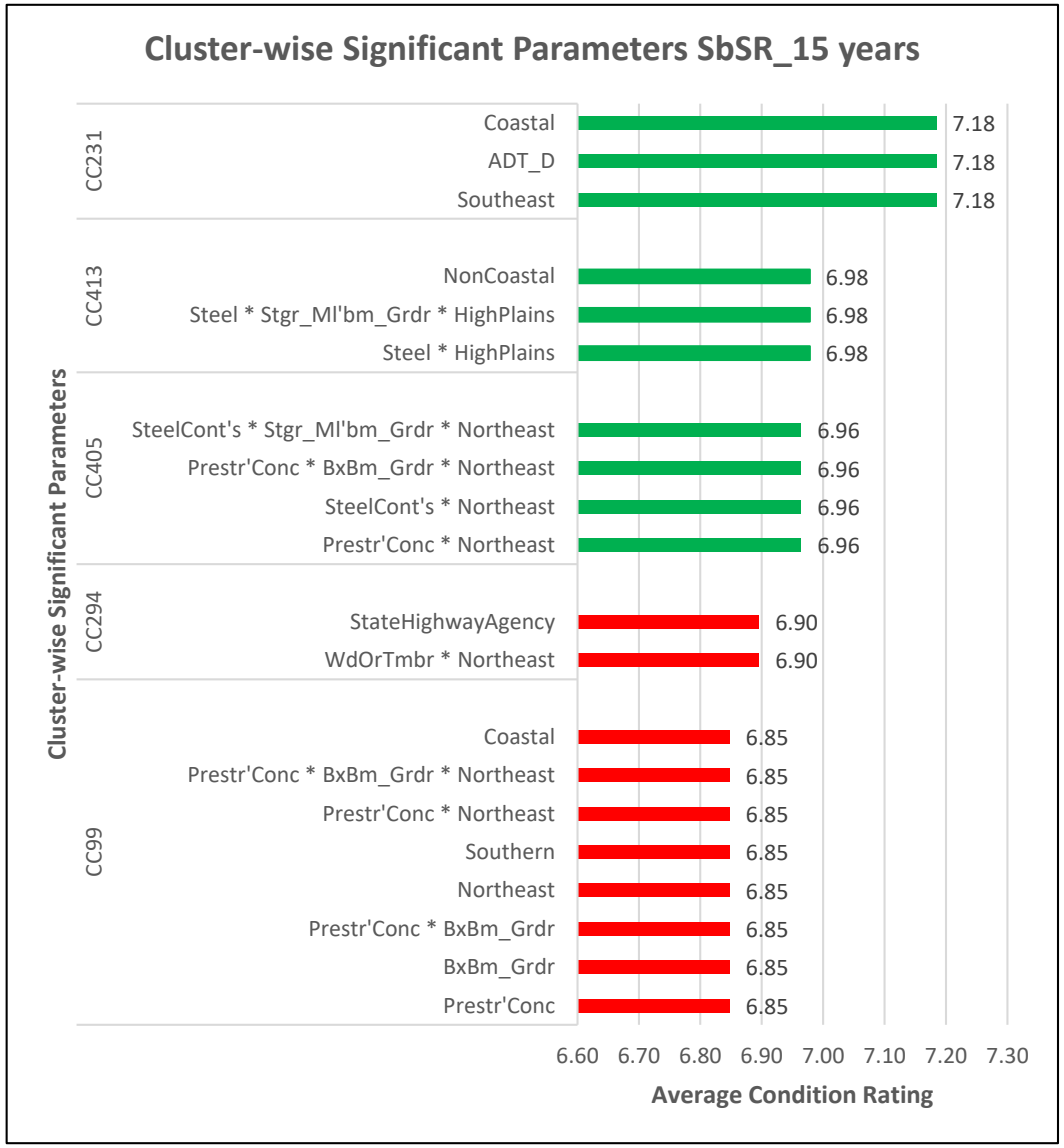
Correlation Network

- Correlation network is created with the substructure ratings' time-series data (15 years)
- Applied Markov clustering (MCL)
- 1,136 bridges and 8 candidate communities/clusters
- The median size of each community is 55

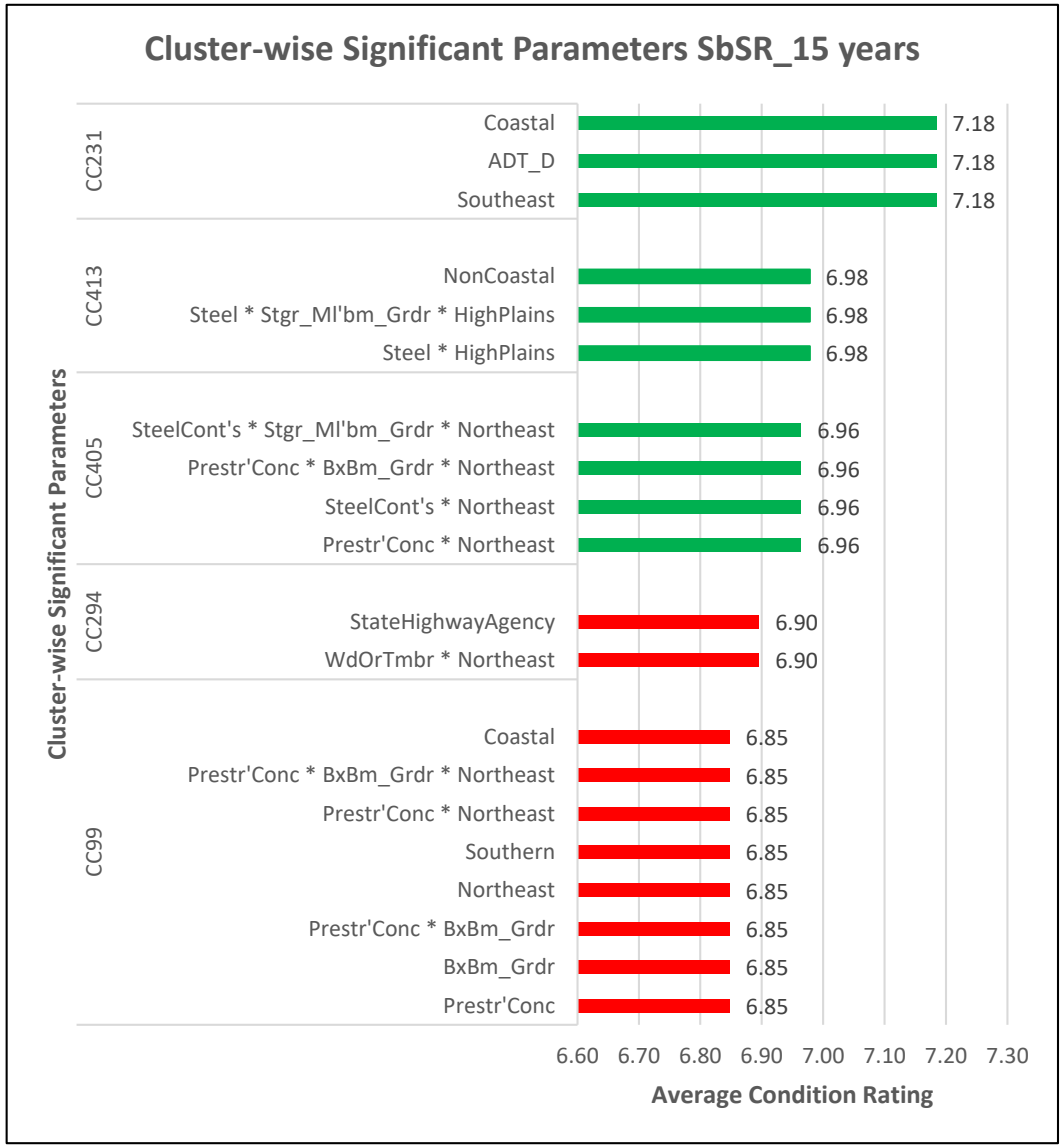


Current results

- Five communities have at least one significant parameter
- Average condition rating (end average rating) after 26 years is 6.96
- Communities are divided into two groups based on end average rating
- There are two clusters that perform below the average
- Bridges in Southeast region are performing better compared to northeast bridges
- Northeast bridges that are constructed with wood or timber or prestressed concrete are performing lower



Region Number	Climate Region Name	States Included	Notes
1	Northeast	DE, MD, WV, NJ, PA, CT, RI, ME, MA, NH, NY, and VT.	The climate of this region has four distinct seasons with warm summer and cold winter including heavy snow and ice. This region has also witnessed powerful storms and several notable tornado events.
2	Midwest	IL, IN, IA, KY, MI, MN, MO, OH, and WI.	This region has a similar climate to the Northeast region with four distinct seasons, warm summer and cold winter, but there is the difference of having a drier climate overall.
3	Southeast	VA, NC, SC, GA, FL, and AL.	This region has a hot and dry climate in summers, and mild in winter seasons with some snow.
4	High Plains	CO, KS, NE, ND, SD, and WY.	This region consists of areas with both wet and dry conditions. The high plains region has a wet winter and dry summer.
5	Southern	TN, MS, AR, LA, OK, and TX.	This region consists of hot desert climate areas. This region has thunderstorms and heavy rainfall in summer seasons.
6	Western	MT, ID, WA, OR, UT, NM, AZ, CA, NV, AL, and HI.	This region has different types of weather. Some parts of the west get high amount of rain and some are deserts with less than 5 inches of rain per year. The low elevation parts have warm summers and little or no snow. The desert parts of the west have very hot summers and pleasant winters.



What next..?

- Extrapolating the condition ratings to see when a cluster of bridges goes to a structurally deficient status (condition rating <=4)

- Generalize the results (since this case study is done only on 1,136 bridges)

Queries..?

Thank You !