

Bridge Condition Performance Groups: Mining National Bridge Element Data by Statistical Clustering

Basak Bektas, Ph.D.

Iowa State University

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Bridge Condition Performance Measures

- NBI Condition Ratings
- Good, Fair, Poor
- BHI
 - Condition state weights
 - Element weights
- Motivation

Element Condition Data

- AASHTO CoRe Elements
- 2013 Manual, NBEs
- Multivariate, numeric continuous

Bridge Condition Assessment

Element Condition Data

#	Env	Element Name	States	Subsystem (Use)	% in 1	% in 2	% in 3	% in 4	% in 5
22	1	P Conc Deck/Rigid Ov	5	Deck	0	100	0	0	0
359	1	Botm Deck Smart Flag	5	Deck	0	100	0	0	0
109	1	P/S Conc Beam	4	Superstructure	100	0	0	0	
109	2	P/S Conc Beam	4	Superstructure	97	3	0	0	
202	1	Pntd Stl H-Pile	5	Substructure	94	0	0	6	0
234	1	R/C Pier Cap	4	Substructure	99	1	0	0	
234	2	R/C Pier Cap	4	Substructure	70	30	0	0	
271	1	R/Conc Stub Abutment	4	Substructure	97	3	0	0	
275	1	R/C Backwall w/Stub	4	Substructure	72	25	3	0	
279	1	R/Conc Column	4	Substructure	62.5	37.5	0	0	
300	1	Strip Seal Exp Joint	4	NA	70	30	0	0	
301	1	Pourable Joint Seal	3	NA	0	100	0	0	
310	1	Elastomeric Bearing	3	NA	100	0	0		
313	1	Fixed Bearing	3	NA	0	100	0		
321	1	R/Conc Approach Slab	4	NA	100	0	0	0	
331	1	Conc Bridge Railing	4	NA	90	10	0	0	

NBI Condition Ratings

→ 6

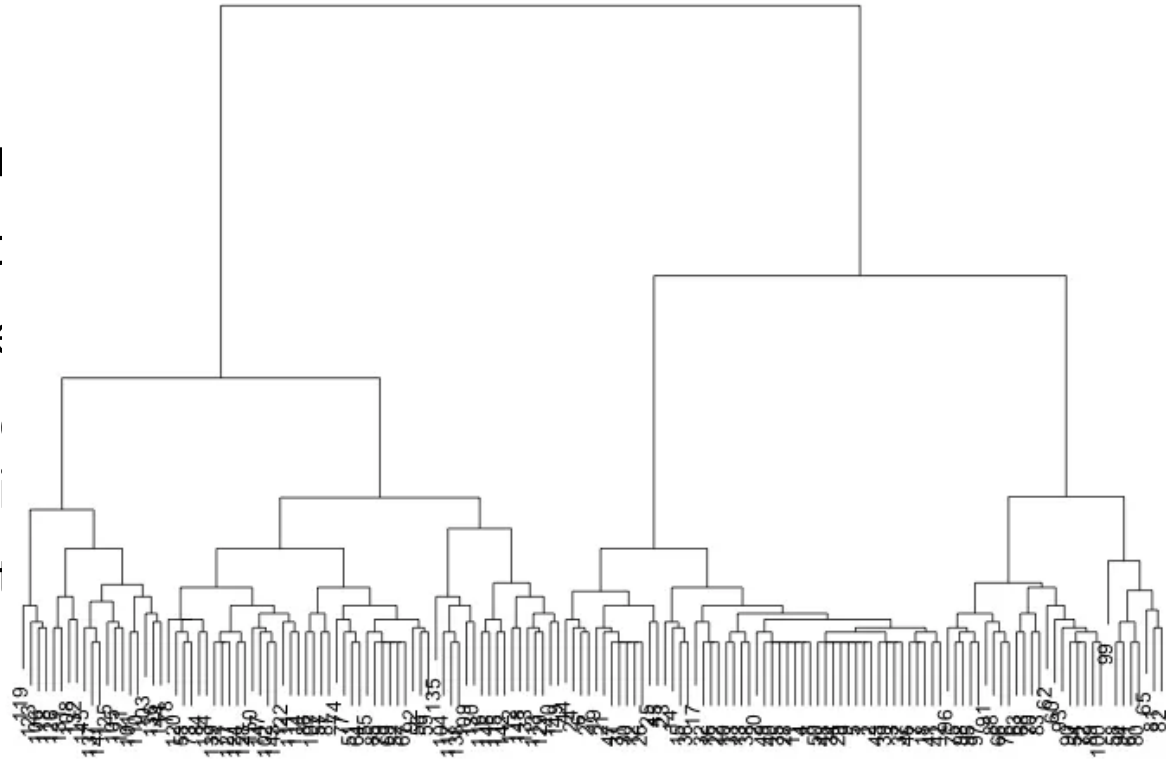
→ 5

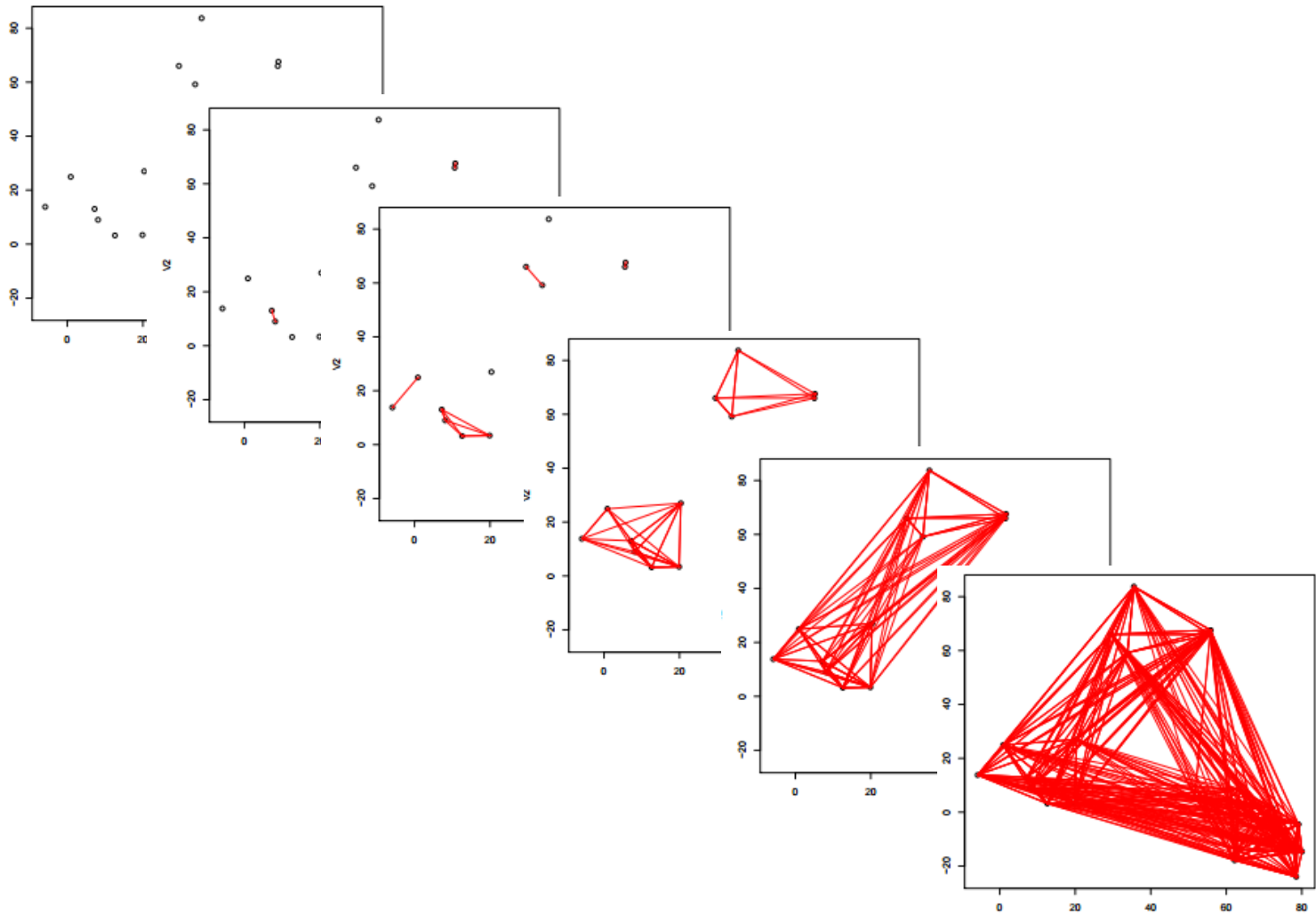
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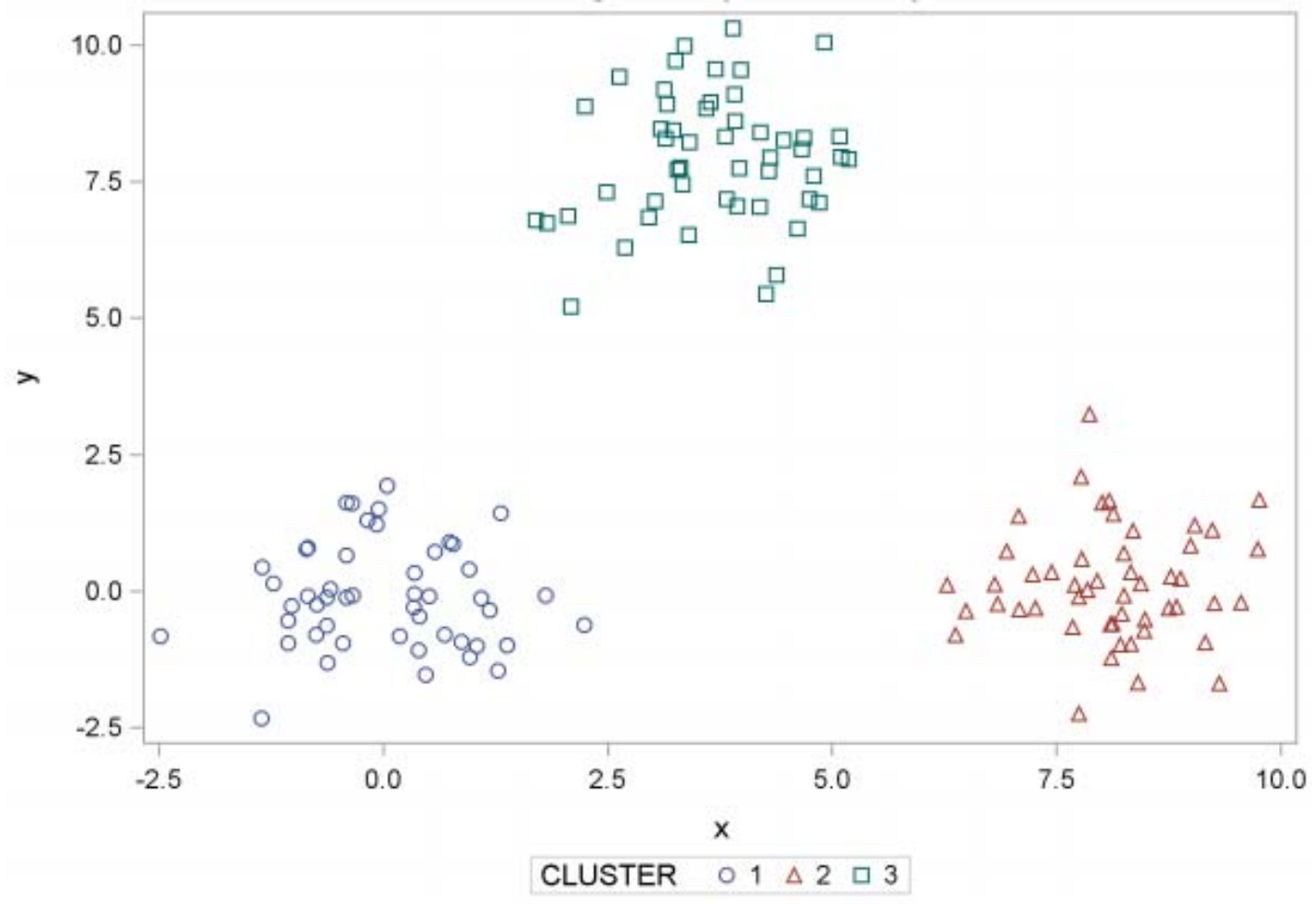


Statistical Clustering

- Start with each data point as your own group
- Iteratively merge the two most similar groups
- Repeat until all the data points are in one group
- The algorithm produces a dendrogram showing the number of points in each group
- The user chooses the number of clusters







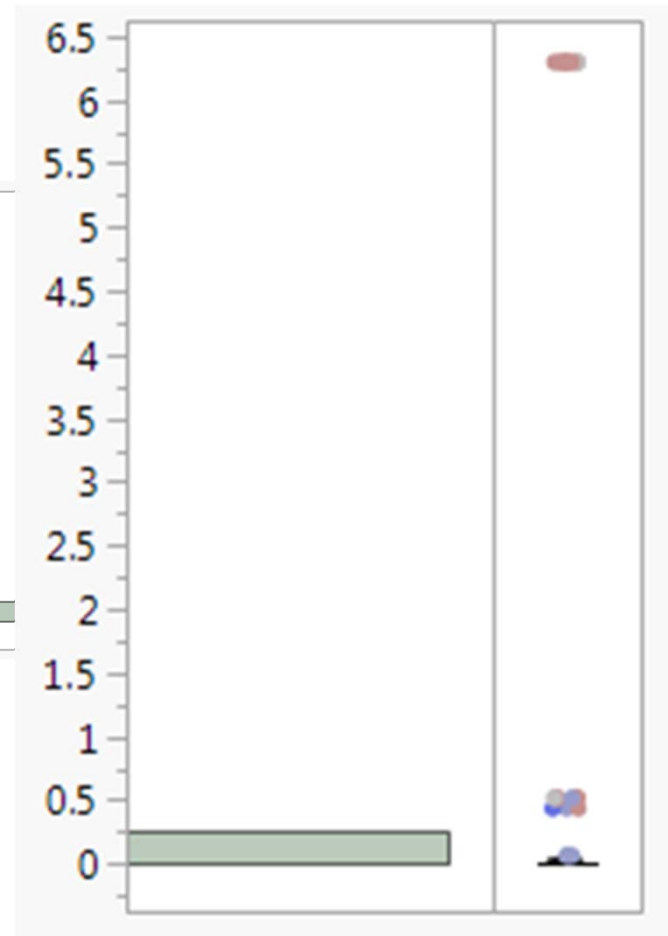
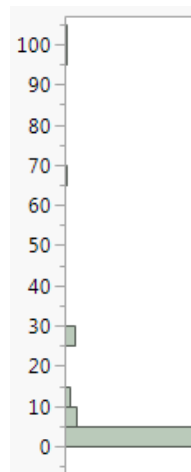
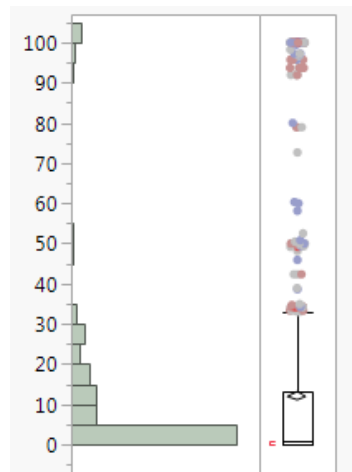
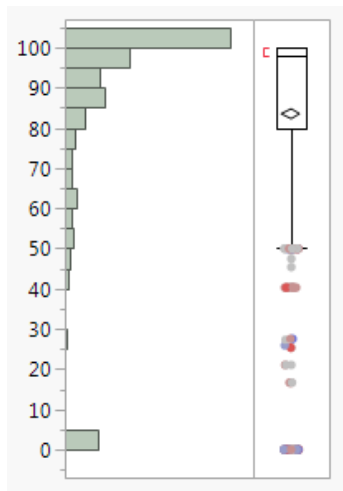
Data

- Initial Study
- National Bridge Element Data
 - 2016 submission
 - Field collected NBE and NBI
 - Data from 12 agencies

NBI State Code (NBI1)	State
14	Alabama
49	Arizona
113	District of Columbia
134	Georgia
160	Idaho
185	Indiana
231	Maine
297	Missouri
362	New York
374	North Carolina
406	Oklahoma
441	Rhode Island

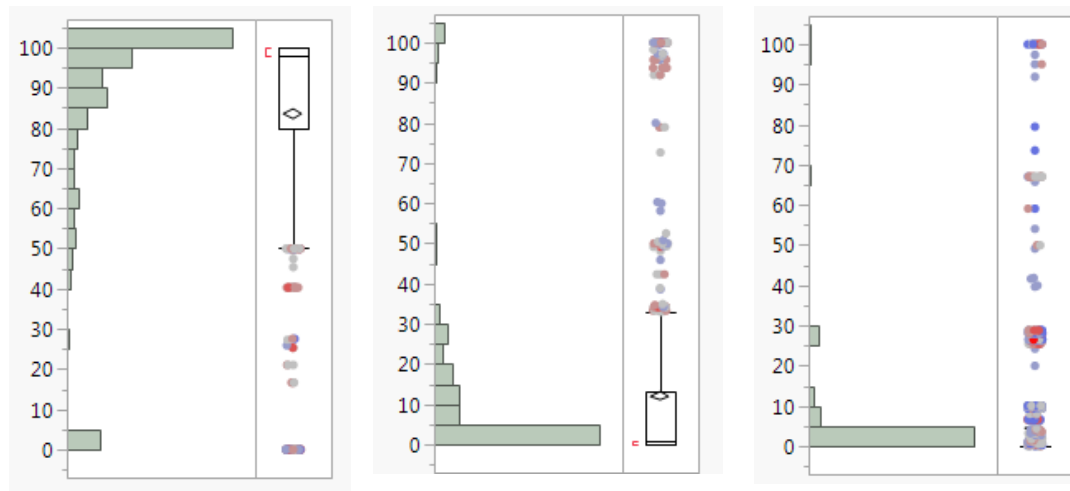
DECK CONDITION

Condition State 4

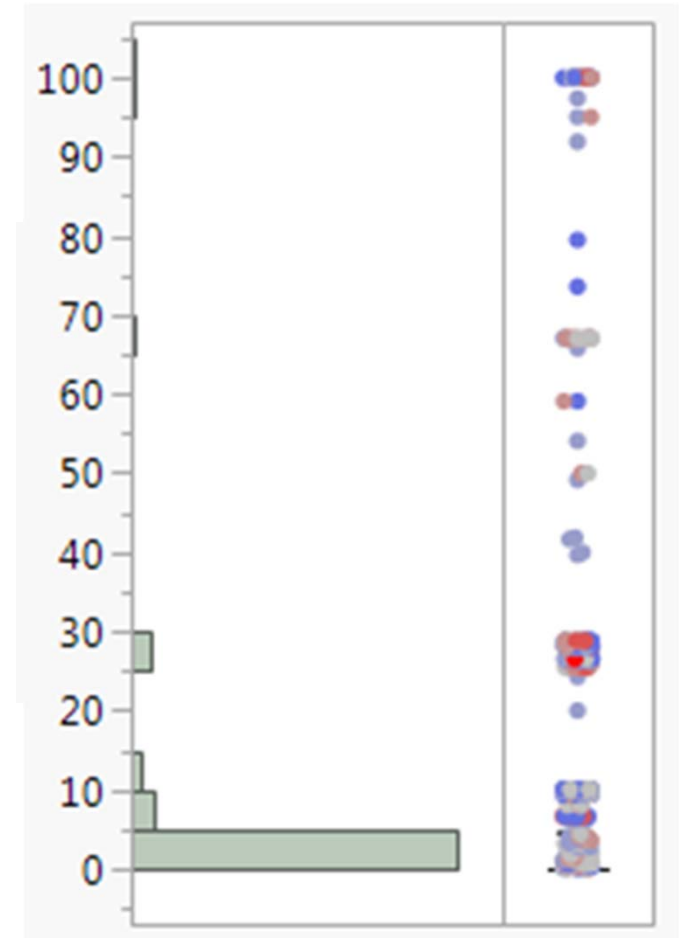


- 1877 observations
- 22 of 1877 PCT4 > 0
- PCT4 was 0.1% to 6.3% for these observations

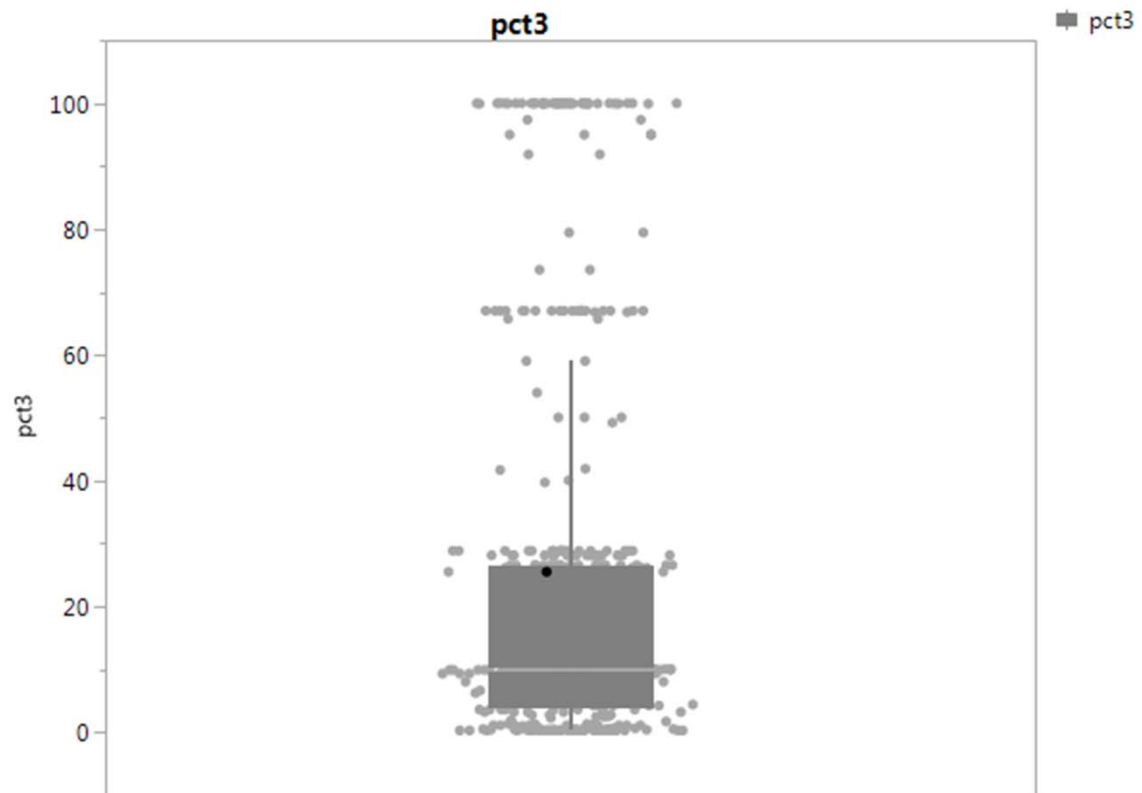
Condition State 3



- 1877 observations
- 73% PCT3 = 0

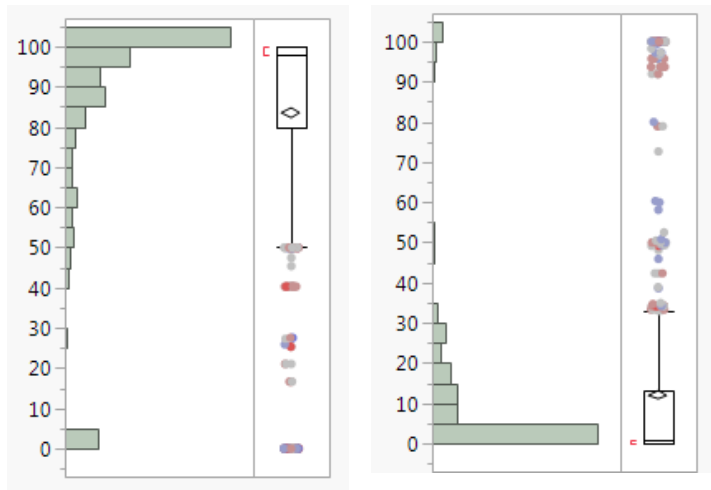


Condition State 3

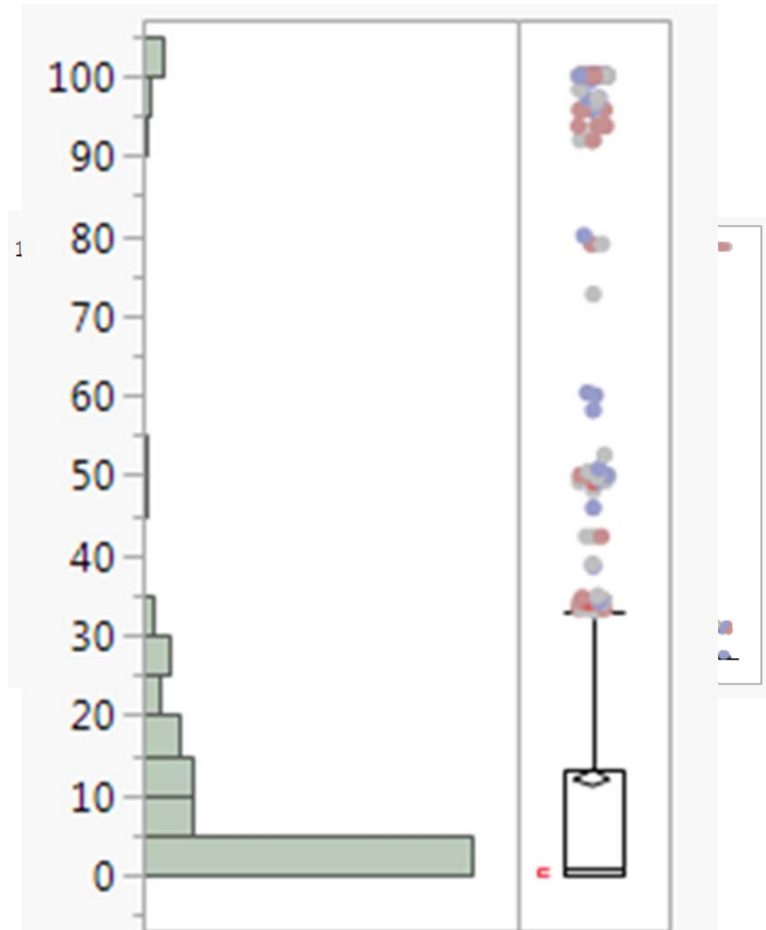


Mean: 16.7
Median: 9.3

Condition State 2



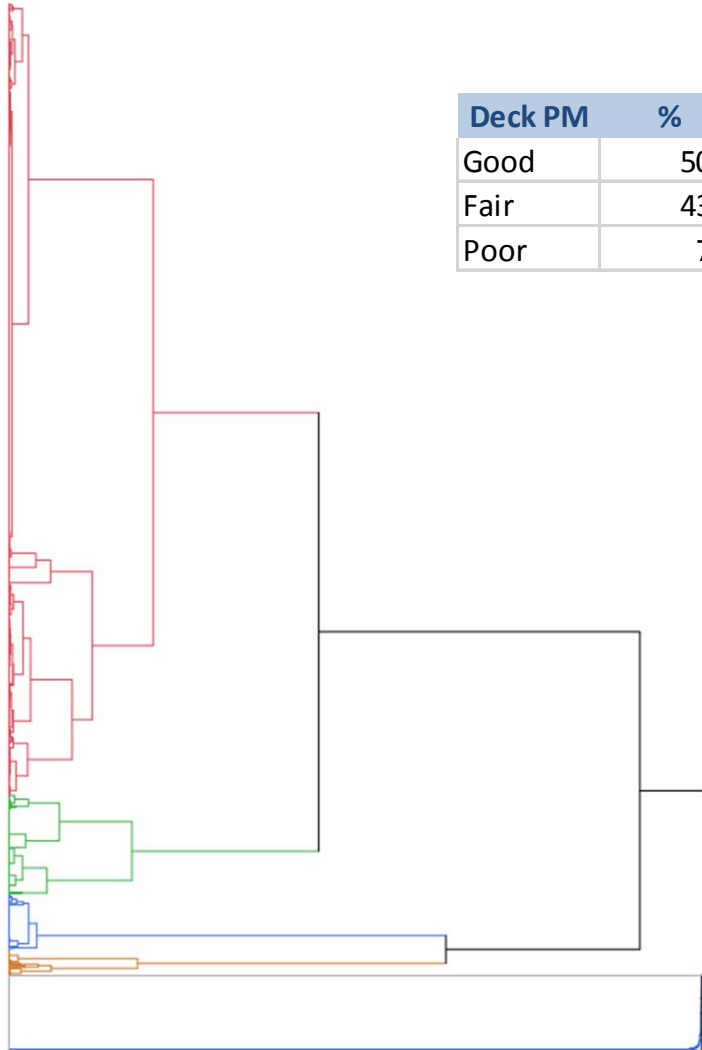
- 1877 observations
- 42% PCT2 = 0



Condition State 2

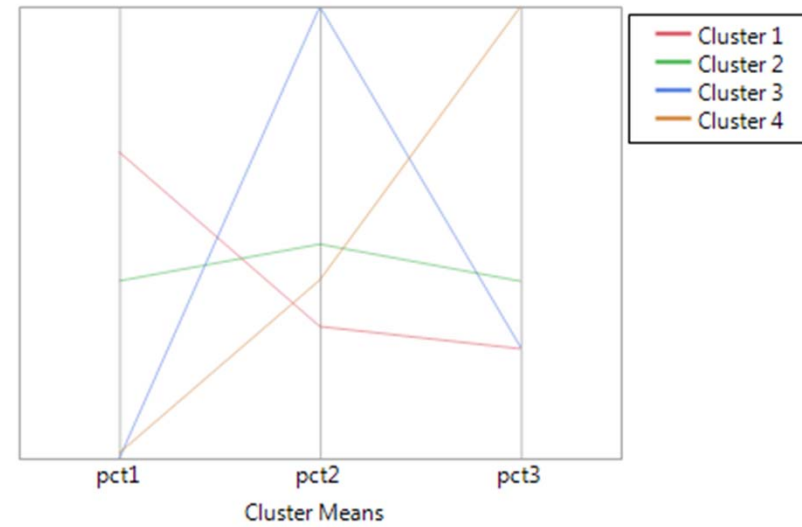


Mean: 21
Median: 10.1



Deck PM	%
Good	50%
Fair	43%
Poor	7%

Cluster	Count	pct1	pct2	pct3
1 (81%)	1529	95.3208	3.9887	0.6872
2 (10%)	191	55.6128	28.0714	16.3158
3 (6%)	106	0.8538	97.5615	1.0501
4 (3%)	51	2.5690	17.6219	79.8051



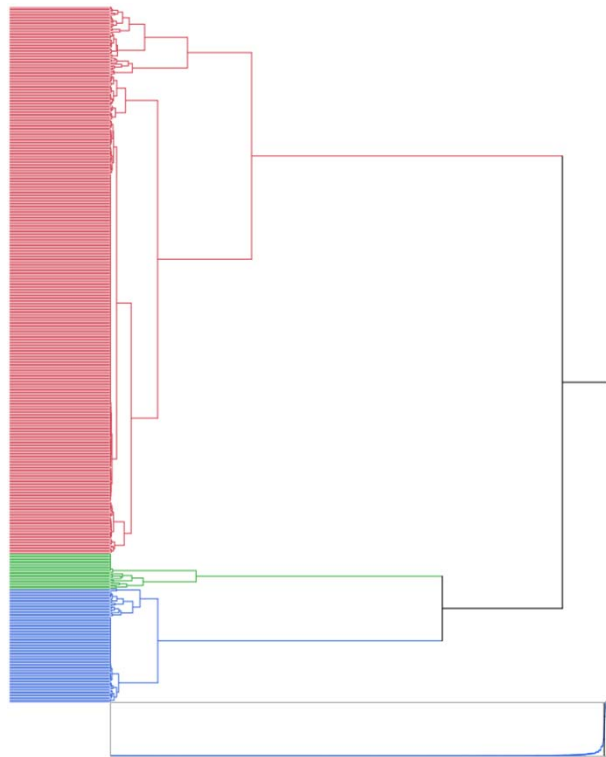
Cluster	Count	pct1	pct2	pct3
1	1720	90.9114	6.66303	2.4227
2	106	0.8538	97.56146	1.0501
3	51	2.5690	17.62193	79.8051

SUPERSTRUCTURE CONDITION

Superstructure NBEs

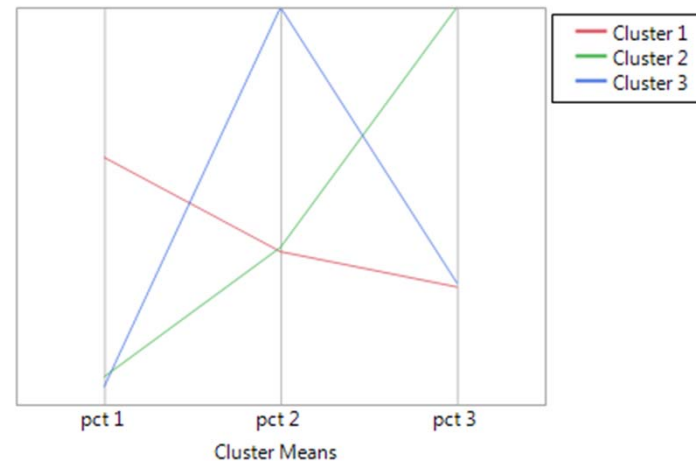
Group	# elements	# Obs.	% in sample	Elements
Sup1	1	448	23%	Girder/Stringer/Truss/Arch
Sup2	2	1078	48%	Girder-Bearings
Sup3	3	489	23%	Girder-Bearings-Bearings

Superstructure/ One-Element

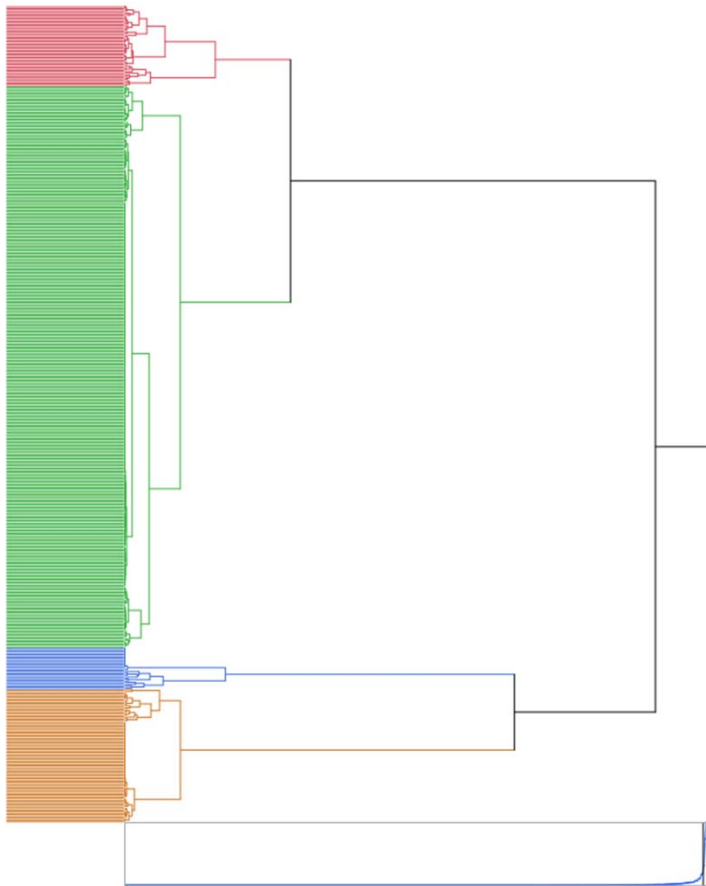


Cluster	%	pct1	pct2	pct3
1	78.6%	92.6	5.9	1.3
2	5.1%	6.7	7.5	82.2
3	16.3%	2.9	93.7	2.5

Super 1 PM	%
Good	40%
Fair	54%
Poor	6%



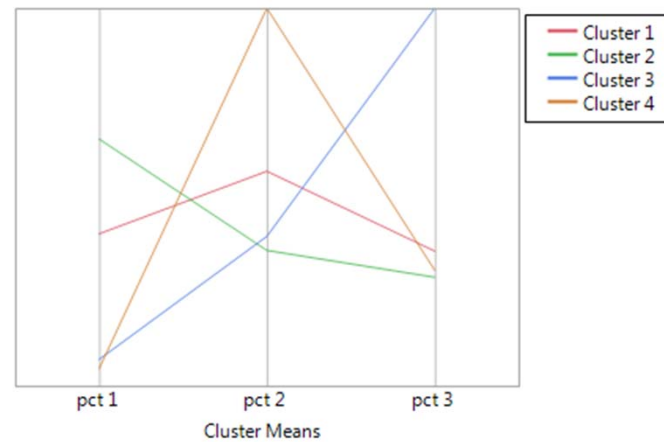
Superstructure/ One-Element



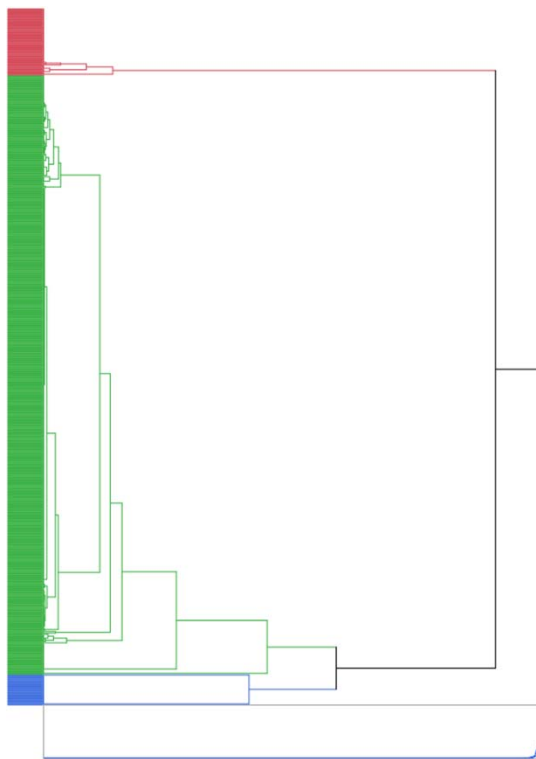
Four natural groups

Cluster	%	pct 1	pct 2	pct 3
1	9.8%	58.4	32.1	8.3
2	68.8%	97.5	2.2	0.3
3	5.1%	6.7	7.5	82.2
4	16.3%	2.9	93.7	2.5

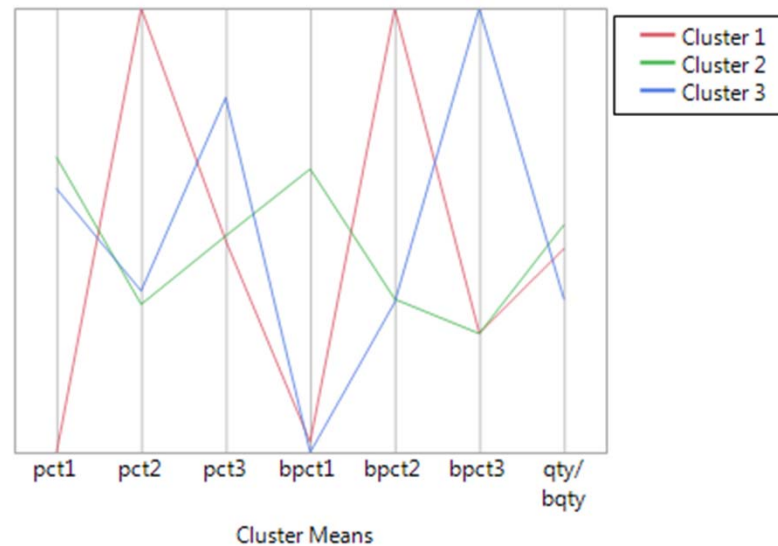
Super 1 PM	%
Good	40%
Fair	54%
Poor	6%



Superstructure/ Two-Elements

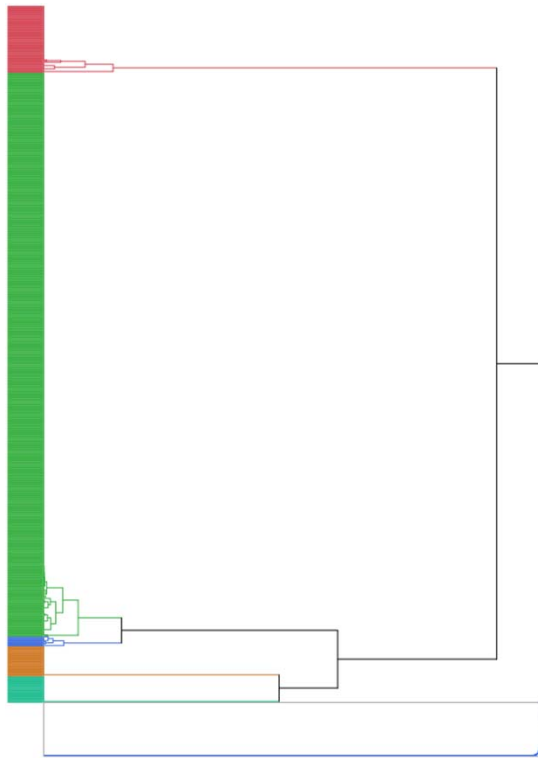


Cluster	%	Girder			Bearing			qty/bqty
		pct1	pct2	pct3	bpct1	bpct2	bpct3	
1	9.6%	23.87	75.91	0.22	4.13	95.67	0.20	37.70
2	86.1%	98.71	0.95	0.34	98.93	1.01	0.04	48.09
3	4.4%	90.76	4.36	3.65	0.47	0.00	99.41	16.05



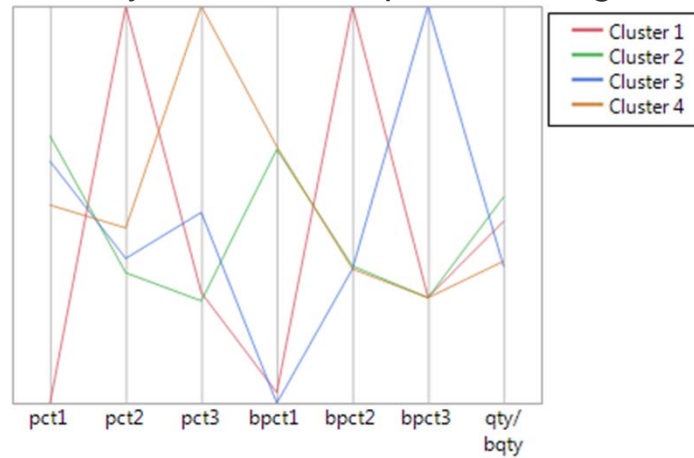
Super 2 PM	%
Good	54%
Fair	39%
Poor	6%

Superstructure/ Two-Elements



Cluster	%	Girder			Bearing			qty/bqty
		pct1	pct2	pct3	bpct1	bpct2	bpct3	
1	10%	23.9	75.9	0.2	4.1	95.7	0.2	37.7
2	82%	99.6	0.4	0.0	98.9	1.1	0.0	49.5
3	4%	92.4	4.5	2.1	0.0	0.0	100.0	15.9
4	4%	80.0	13.1	6.9	100.0	0.0	0.0	18.4

Dionysus leather top handle bag



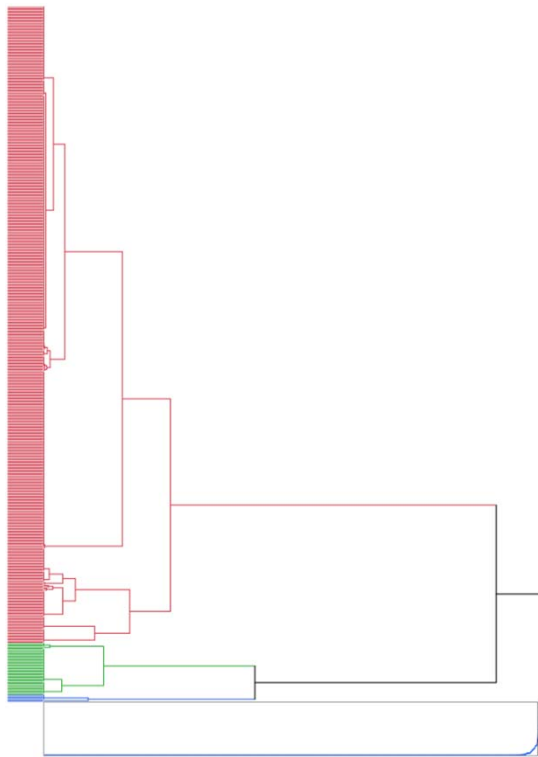
Super 2 PM	%
Good	54%
Fair	39%
Poor	6%

SUBSTRUCTURE CONDITION

Substructure NBEs

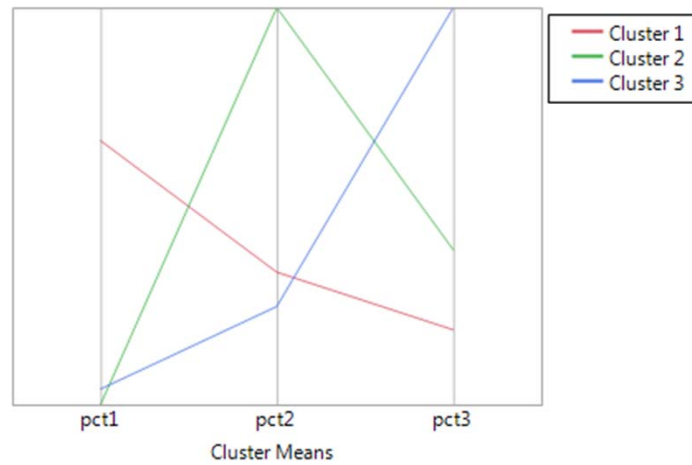
Group	# Elements	# Obs.	% in sample	Elements
Sub1	1	459	16%	Abutment
Sub2a	2	291	10%	Column/Pile -Abutment
Sub2b	2	570	19%	Pier Wall -Abutment
Sub3	3	1613	55%	Column/Pile-Abutment-Pier Cap

Substructure/ One-Element

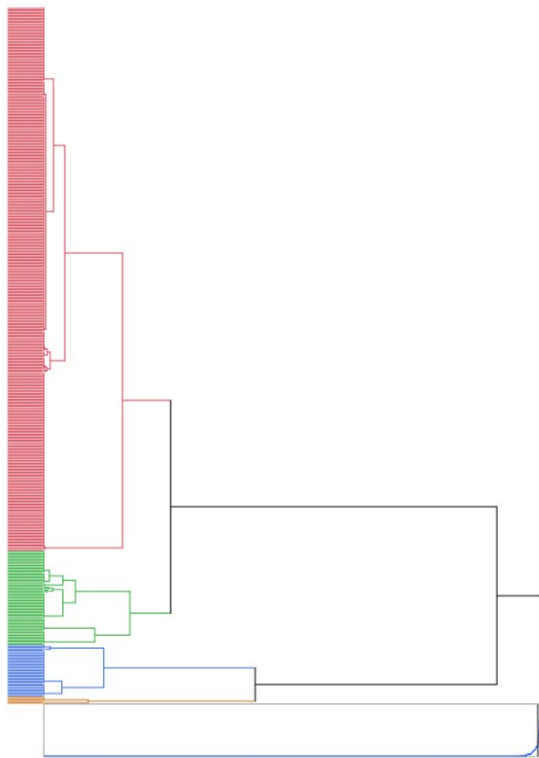


Cluster	%	pct1	pct2	pct3
1	92%	90.67	8.45	0.89
2	7%	0	73.71	23.58
3	1%	5.37	0	92.2

Sub 1 PM	%
Good	72%
Fair	25%
Poor	3%

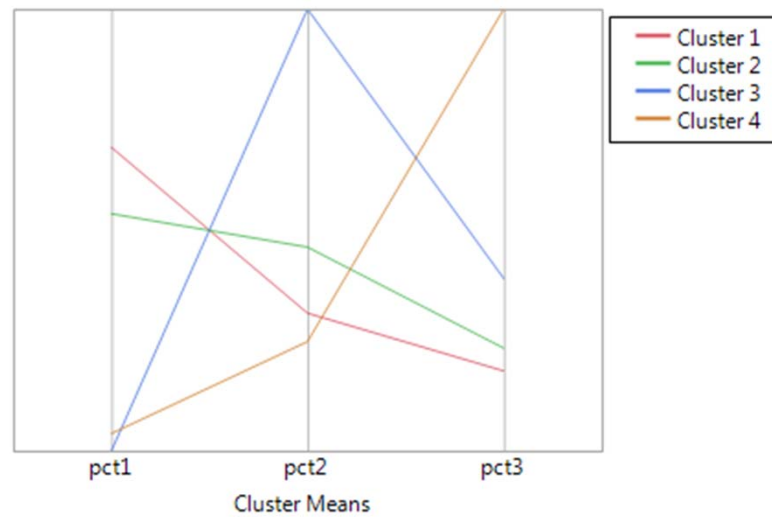


Substructure/ One-Element



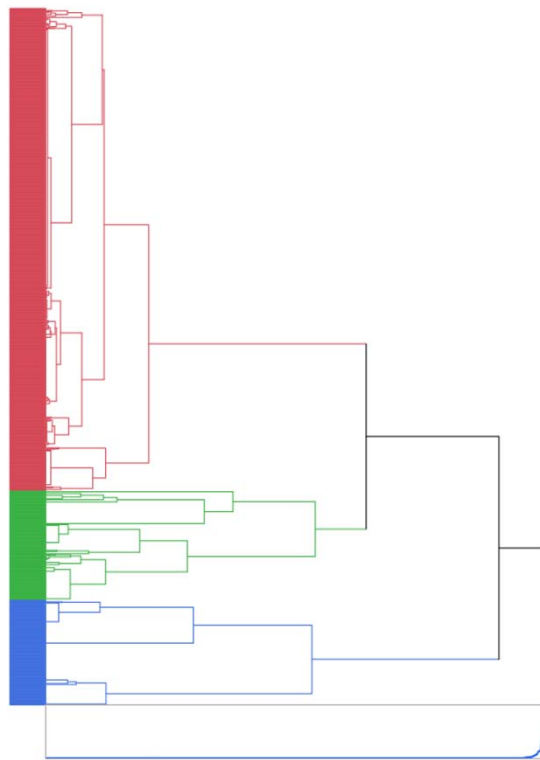
Cluster	%	pct1	pct2	pct3
1	78.0%	93.7	6.3	0.0
2	13.5%	73.2	20.9	5.8
3	7.4%	0.0	73.7	23.6
4	1.1%	5.4	0.0	92.2

Sub 1 PM	%
Good	72%
Fair	25%
Poor	3%



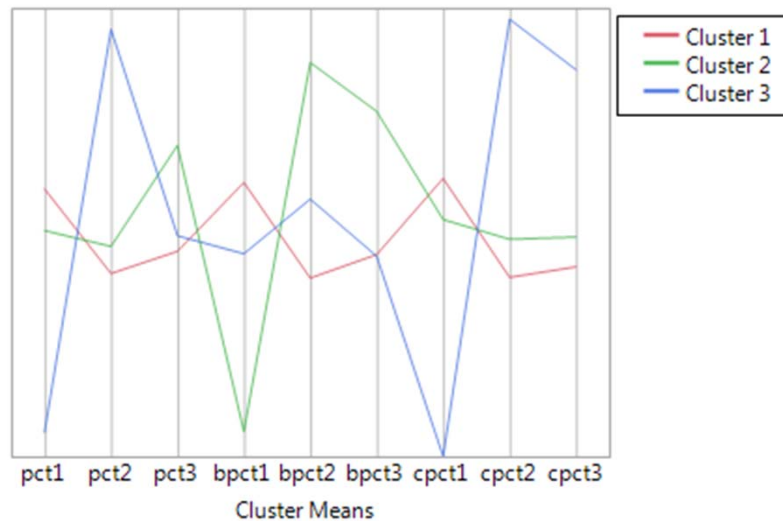
Substructure/ Three-Elements

(Column/Pile – Abutment - Pier Cap)



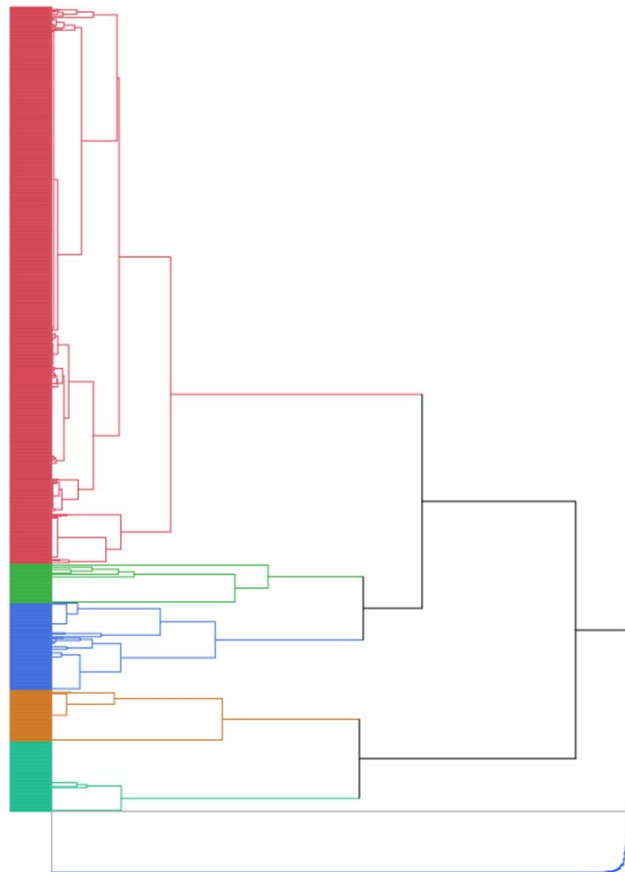
Cluster	%	Column/Pile			Abutment			Cap		
		pct1	pct2	pct3	bpct1	bpct2	bpct3	cpct1	cpct2	cpct3
1	69%	95	5	0	92	8	0	99	1	0
2	16%	82	13	5	45	45	10	87	11	2
3	15%	21	78	1	78	22	0	18	69	13

Sub 3 PM	%
Good	53%
Fair	41%
Poor	6%



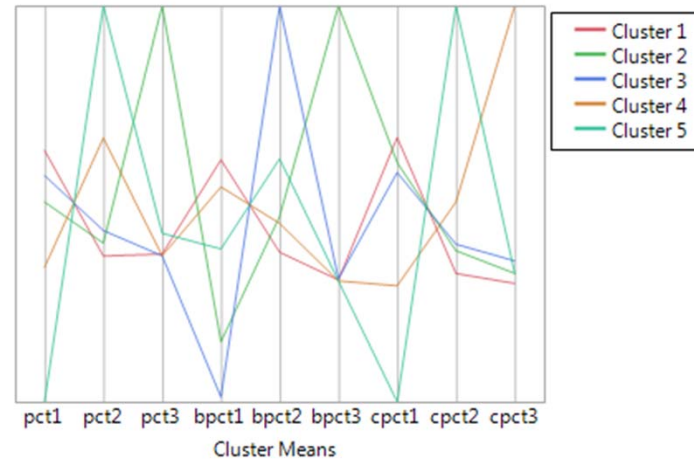
Substructure/ Three-Elements

(Column/Pile – Abutment - Pier Cap)



Cluster	%	Column/Pile			Abutment			Cap		
		pct1	pct2	pct3	bpct1	bpct2	bpct3	cpct1	cpct2	cpct3
1	69%	95	5	0	92	8	0	99	1	0
2	5%	76	10	15	53	15	32	89	10	1
3	11%	86	14	0	41	59	0	85	12	3
4	6%	51	49	0	86	14	0	43	27	29
5	9%	0	99	1	73	27	0	0	99	1

Sub 3 PM	%
Good	53%
Fair	41%
Poor	6%



Conclusions & Future Work

- Statistical clustering is a potential tool to explore natural groupings within element condition data.
- Condition groups have potential uses for network level condition assessment and long-term planning.
- Initial analysis typically indicated four condition groups.
- 2017 NBE data will be added to data set for further analysis.