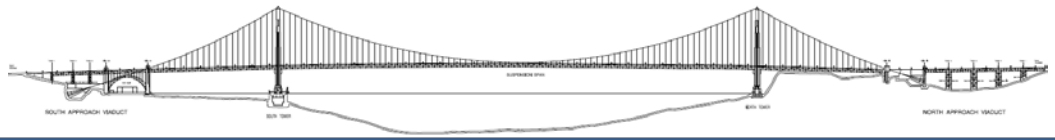
Golden Gate Bridge Inspection Program

Bridge Engineering 101

- Bridge Components (Ref: NHI 130055):
  - Deck: The component of a bridge to which the live load is directly applied
  - Superstructure: The component of a bridge, which supports the deck or riding surface of the bridge, as well as the loads applied to the deck
  - Substructure: The component of a bridge, which includes all the elements supporting the superstructure
- Bridge Elements
  - Girder: Large size steel beam, which is typically built-up or welded, along the longitudinal direction
  - Floor beam: Steel beam along the transverse direction, which is typically placed between steel stringers and other main load carrying members such as trusses or steel girders
  - Pedestal: The element supports deck and transfer live loads to other superstructure elements such as floor beam
  - Deck Joint: The element accommodates any movements of the superstructure.
  - Bearing: This element is an interface between the superstructure and substructure, transferring loads from super- to sub-structure.



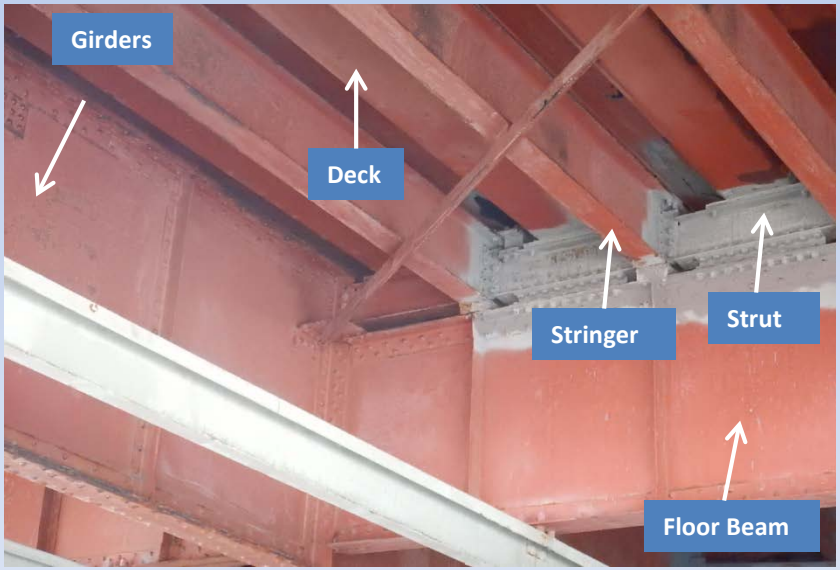
Bridge Engineering 101

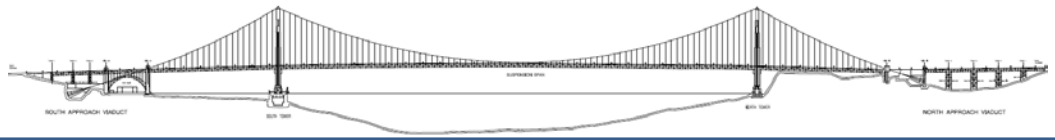
Deck (Orthotropic Deck and Concrete Deck) ➡ Strut & Stringers (act as a bearing) ➡

Floor Beams (4 per each span, total 12) ➡ Girders (3 per each span, total 9) ➡

Seismic Isolation Bearings (link between superstructure and substructure) (total 12) ➡

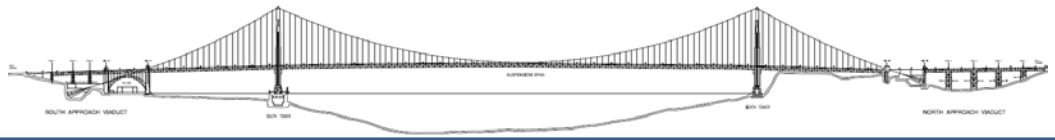
Columns (3 per each bent, total 6) ➡ Reinforced Concrete Pile Cap ➡ Footing





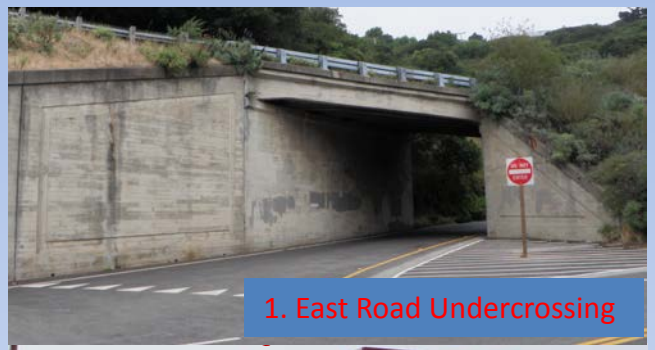
National Bridge Inspection Standards 23 Code of Federal Regulations 650

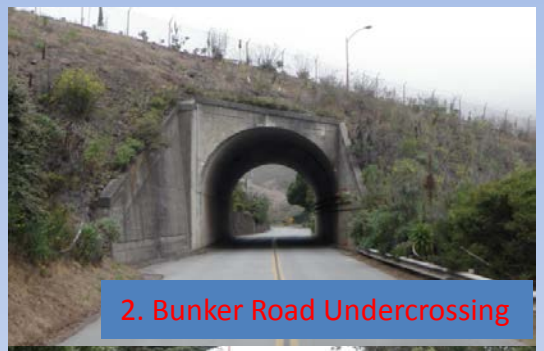
- Established in 1971 after 1967 Silver Bridge Collapse
- Apply to all publicly owned highway bridges longer than twenty feet located on public road
  - Golden Gate Bridge and four small bridges
- Regulate inspection frequency and elements
  - Fracture critical Inspection: every 24 months
  - Routine bridge inspection: every 24 months
  - Complex bridge inspection: every 24 months
  - Underwater inspection: every 60 months
- Define the minimum qualifications required for a Program Manager and a Team Leader
  - Several engineers and steel inspectors qualify for a Team Leader in the Engineering Dept.



National Bridge Inspection Standards

- Bridges over 20ft on all public loads

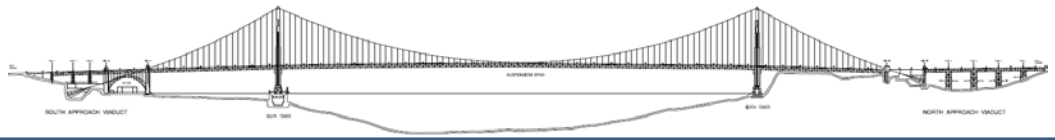

1. East Road Undercrossing


2. Bunker Road Undercrossing

3. Toll Plaza Undercrossing

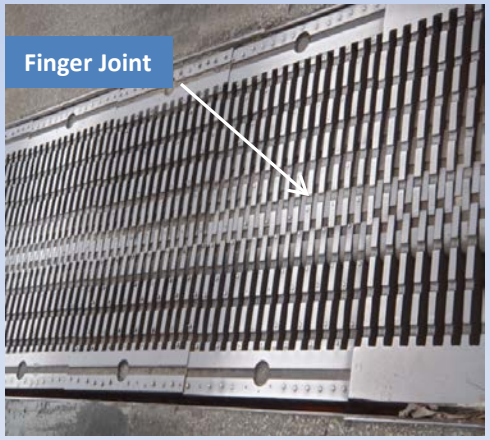
4. Lincoln Blvd Undercrossing

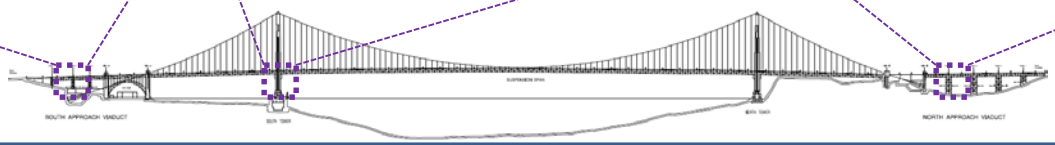

Golden Gate Bridge



Routine Bridge Inspection

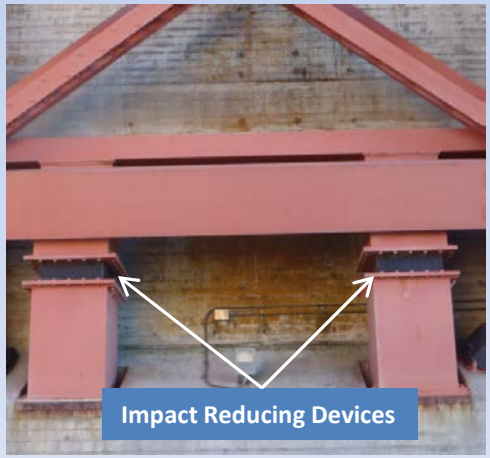
- Routine Bridge Elements (RBEs) cover most areas and elements of the bridge
- Perform visual inspection and utilize the best available access for this inspection, e.g. fall protection, catwalk, ground, ladder and etc.
- Routine inspection frequency: every 24 months

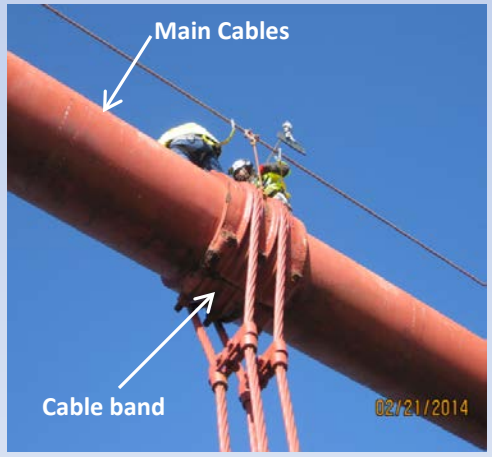


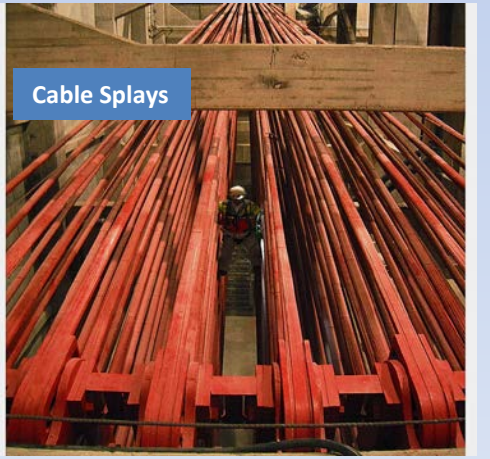


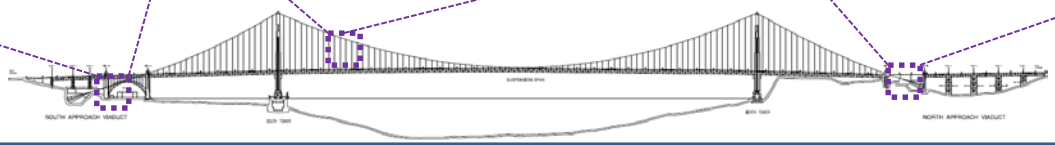
Complex Bridge Inspection

- Complex Bridge Elements (CBEs) are related to suspension features and seismic devices of the bridge.
- Perform visual inspection and utilize the best available access for this inspection, e.g. fall protection, catwalk, ground, ladder and etc.
- Complex bridge inspection frequency: every 24 months





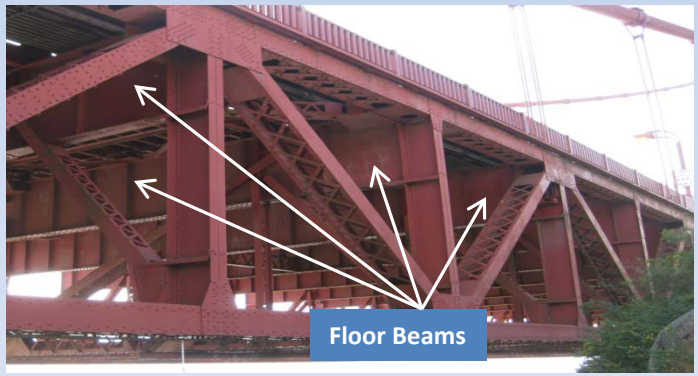




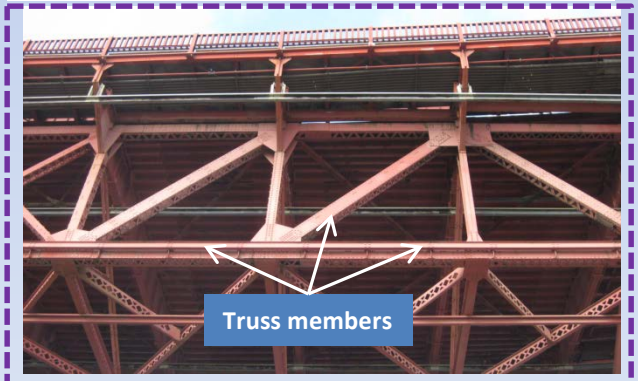
Fracture Critical Member Inspection

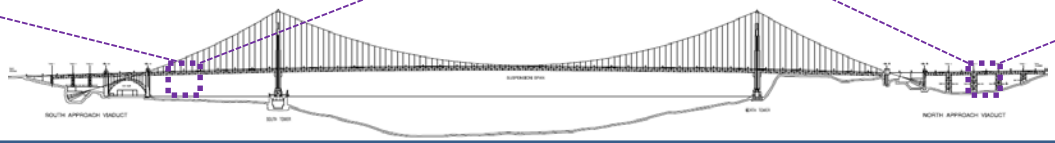
- Fracture Critical Member (FCM) is a steel member in tension, whose failure would probably cause a portion of or the entire bridge to collapse
- It requires hands-on inspection, i.e. within arms' length
- Engineering Bridge Inspection team performs inspections for accessible fracture critical members and Consultants carry out rope inspections for inaccessible FCMs
- Fracture critical member inspection frequency: every 24 months

Floor Beams (Suspension Span)



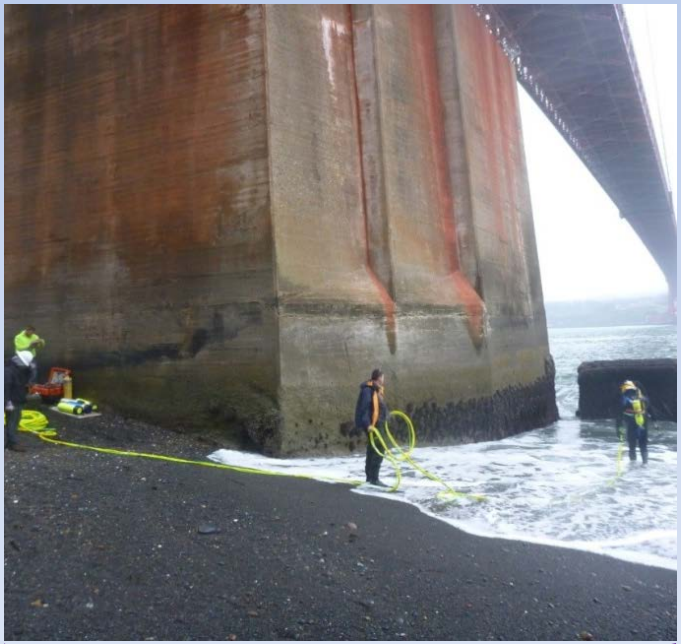
Trusses (North Approach Viaduct)

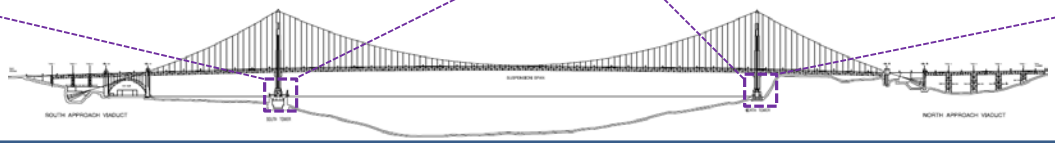




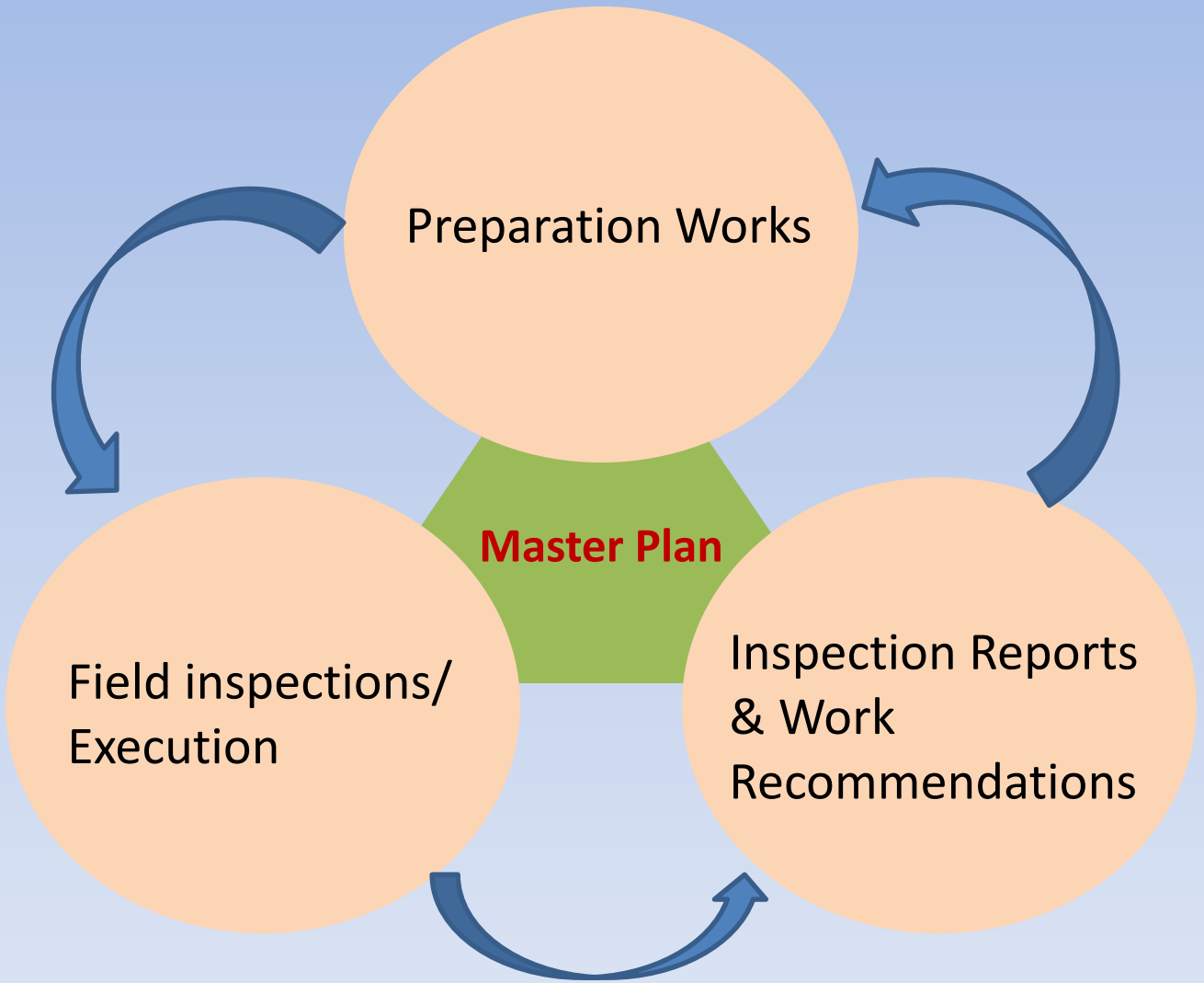
Underwater Bridge Inspection

- Underwater Bridge Inspection
  - Level 1 – Visual, tactile inspection
  - Level 2 – Detailed inspection with partial cleaning
  - Level 3 – Highly detailed inspection with Non Destructive Testing (NDT) based on Levels 1 and 2 results





District's Bridge Inspection Program



Engineering Bridge Inspection Team

District Engineer
Ewa Bauer

Deputy District Engineer
John Eberle

Program Manager
Wilson Lau*, PE

Load Rating Engineer
Steve Song*, Ph.D., PE

Lead Engineer & Primary Team Leader
Steve Song*, Ph.D., PE

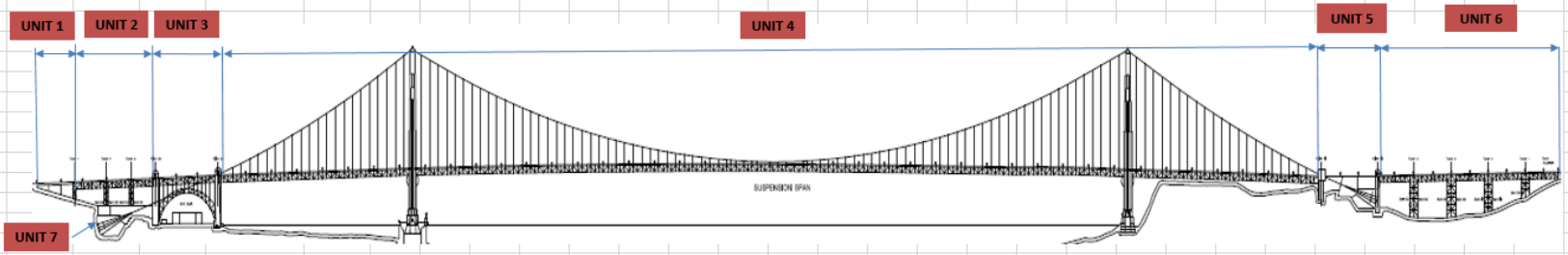
Primary Inspectors
Rameses Johnson*, PE
Jeff Lee*, PE
Mark Baker
Robert Oleksy

Backup Inspectors
Carolina Wallin*, SE, PE
Rodolfo Galang*, PE
Mike Yim, PE
Tony Cheung, PE
Jorge Lee
Ken Woo

* Team Leader

GGB – Biennial Inspection Schedule

Golden Gate Bridge Inspection Plan (2017-2018)

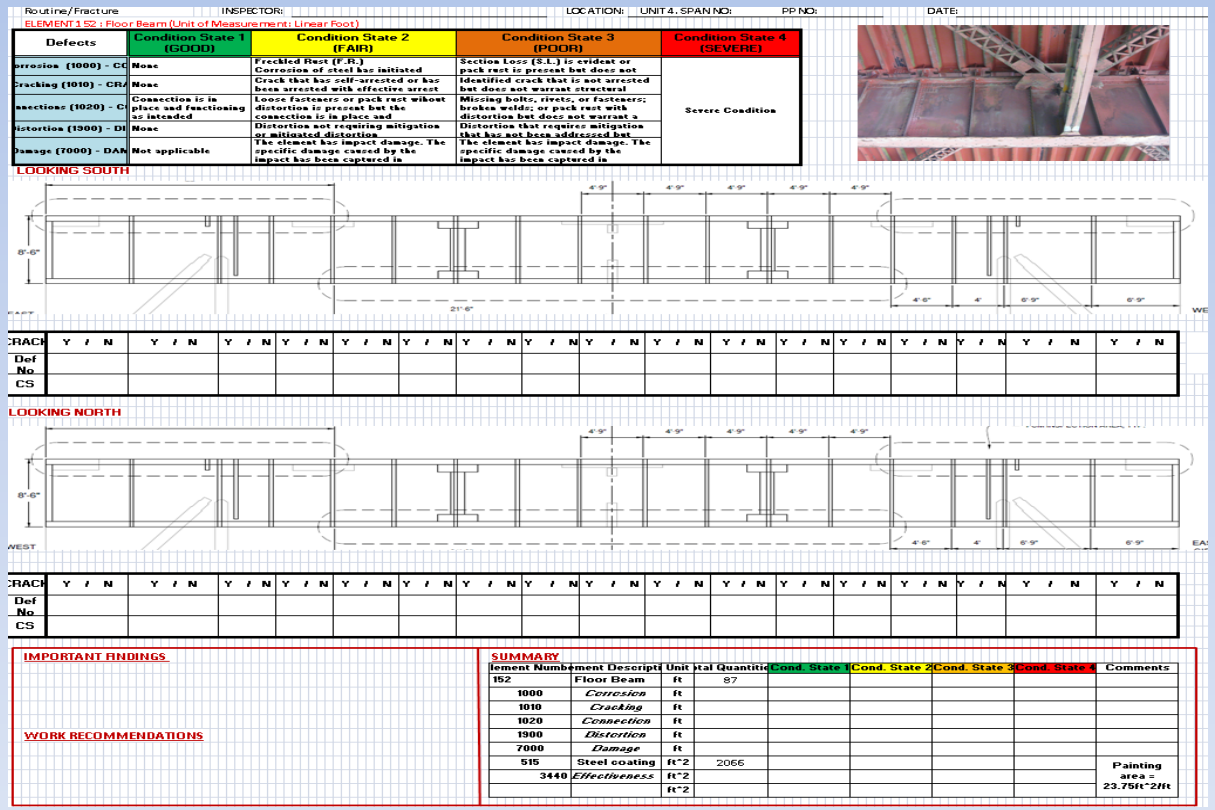


Structure		2017												2018											
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
UNIT 1 - Girder Spans	PLAN											■	■												
UNIT 2 - Truss Spans	PLAN													■	■										
UNIT 3 - Fort Point Arch	PLAN																	■	■						
UNIT 4 - Suspension Spans	PLAN	■	■	■	■	■	■	■	■	■	■														
UNIT 5 - North Anchorage Housing	PLAN															■	■								
UNIT 6 - North Approach Viaduct	PLAN																			■	■				
UNIT 7 - South Anchorage Housing	PLAN															■	■								
GGB Bridge Inspection Report	PLAN																					■	■	■	■
Rope Inspections for FCMs	PLAN						■	■	■																
Inspection Report	PLAN										■	■													
Auxiliary Bridges	PLAN														■										
Auxiliary Bridge Inspection Report	PLAN																	■							

- The GGB is broken into 7 different units for accurate and efficient inspections.
- The master plan was developed to ensure that field inspections and their reports are completed in 24 months.

District's Bridge Inspection Program

- Preparation works before any inspections
  - Implement a newly adopted guideline of element level inspections
  - Develop inspection forms tailored for specific locations/elements


Routine/Fracture INSPECTOR: LOCATION: UNIT 4, SPAN NO: PP NO: DATE:

ELEMENT 152 : Floor Beam (Unit of Measurement: Linear Foot)

Defects	Condition State 1 (GOOD)	Condition State 2 (FAIR)	Condition State 3 (POOR)	Condition State 4 (SEVERE)
Corrosion (1000) - CO	None	Freckled Rust (F.R.) Corrosion of steel has initiated	Section Loss (S.L.) is evident or pack rust is present but does not	
Cracking (1010) - CRA	None	Crack that has self-arrested or has been arrested with effective arrest	Identified crack that is not arrested but does not warrant structural	
Connections (1020) - C	Connection is in place and functioning as intended	Loose fasteners or pack rust without distortion is present but the connection is in place and	Missing bolts, rivets, or fasteners; broken welds; or pack rust with distortion but does not warrant a	Severe Condition
Distortion (1300) - DI	None	Distortion not requiring mitigation or mitigated distortion	Distortion that requires mitigation that has not been addressed but	
Damage (7000) - DAM	Not applicable	The element has impact damage. The specific damage caused by the impact has been captured in	The element has impact damage. The specific damage caused by the impact has been captured in	

LOOKING SOUTH

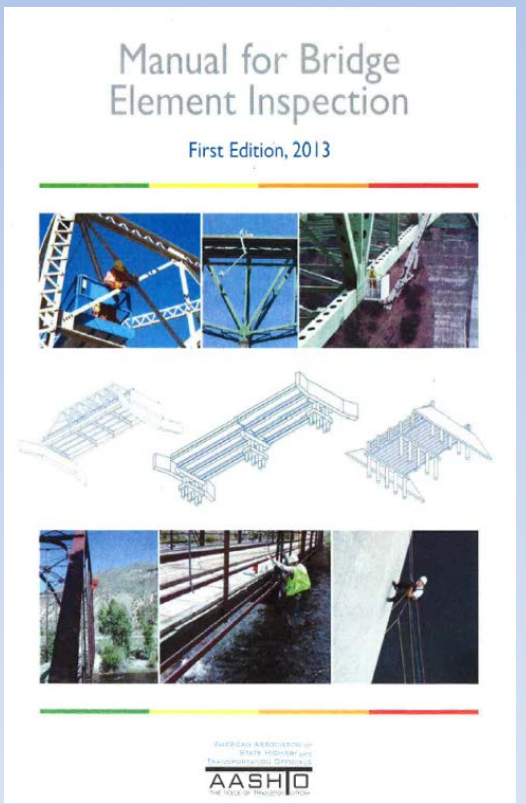
LOOKING NORTH

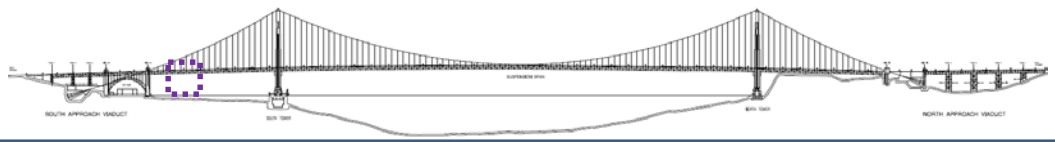
IMPORTANT FINDINGS

WORK RECOMMENDATIONS

SUMMARY

Element Number	Element Description	Unit	Total Quantity	Cond. State 1	Cond. State 2	Cond. State 3	Cond. State 4	Comments
152	Floor Beam	ft	87					
1000	*Corrosion*	ft						
1010	*Cracking*	ft						
1020	*Connection*	ft						
1900	*Distortion*	ft						
7000	*Damage*	ft						
515	Steel coating	ft^2	2066					Painting area = 23.75ft^2/ft
3440	*Effectiveness*	ft^2						
		ft^2						



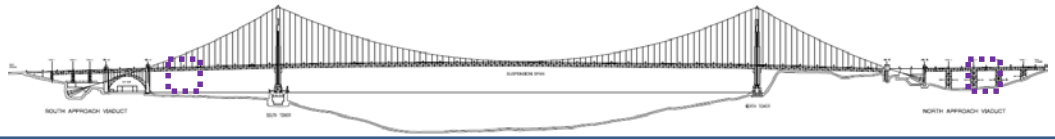


District's Bridge Inspection Program

- Perform bridge inspections
  - Microclimate weather, e.g. foggy and windy
  - Mentally and physically challenging
  - Team efforts

Main suspension cable and cable band inspections

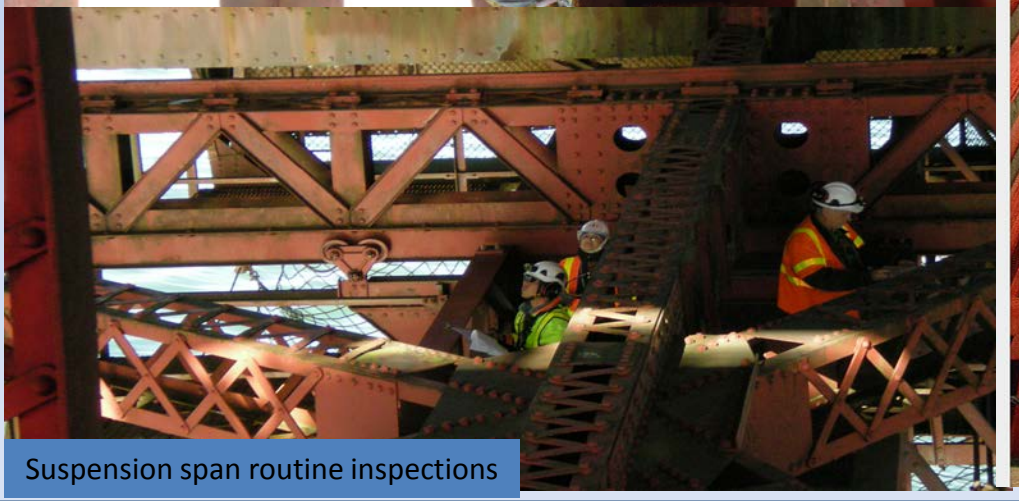
Suspension span fracture critical inspections



District's Bridge Inspection Program

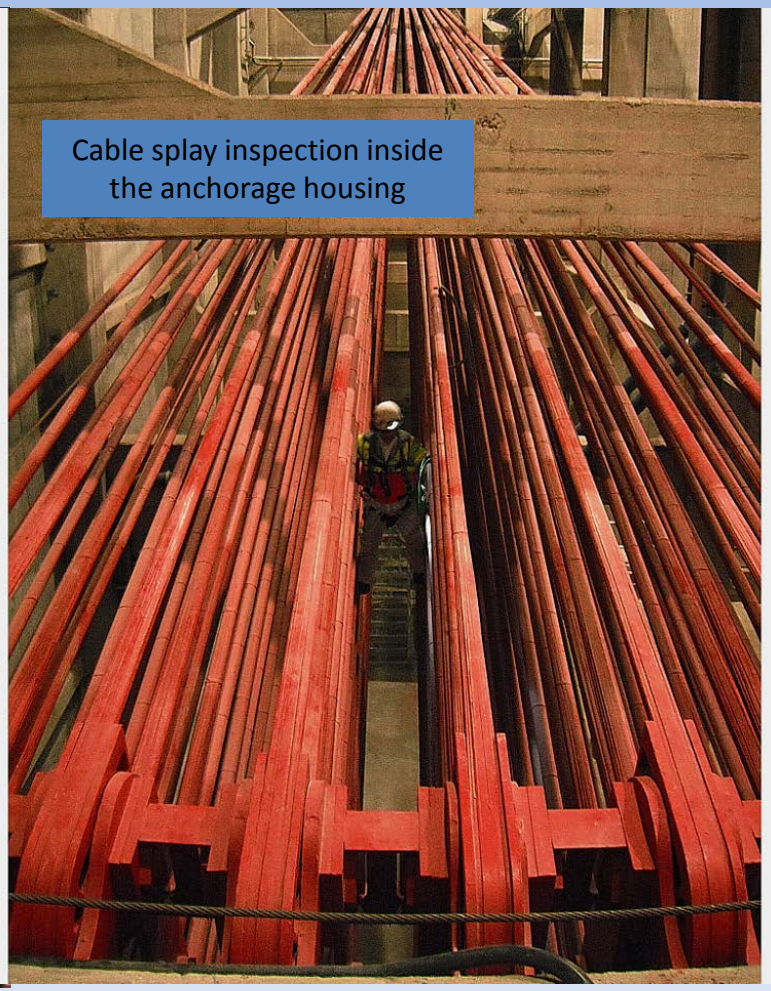
- Perform bridge inspections

Inspections for rocker arms located at the suspension span towers



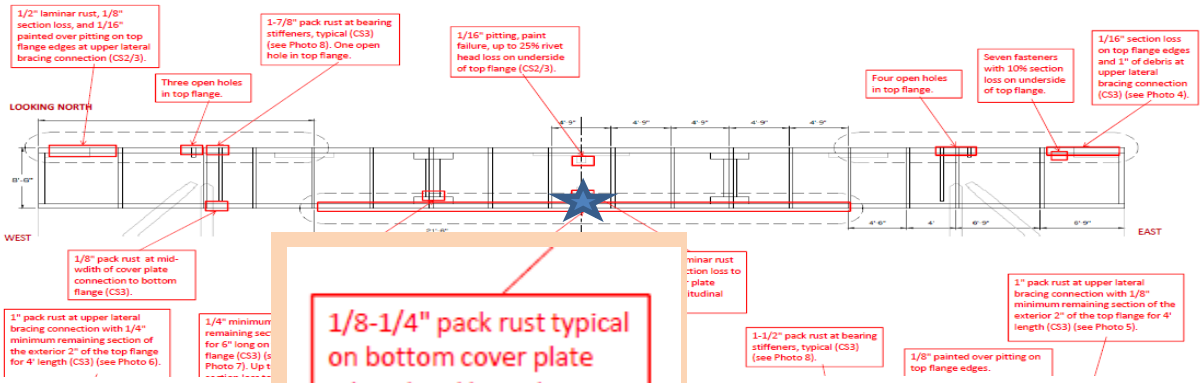
Suspension span routine inspections

Cable splay inspection inside the anchorage housing



District's Bridge Inspection Program

- Inspection reports and work recommendations
  - Determine defect quantities per the Manual
  - Prepare and submit bridge inspection reports to Caltrans and FHWA
  - Develop a list of bridge maintenance and repairs



IMPORTANT FINDI

NONE

WORK RECOMMENDATIONS

1. Clean and paint corroded areas and replace fasteners as n
2. Remove dirt/debris from stiffener pockets at sway bracing connection and install drain holes in the stiffeners to help rec up/corrosion.

SUMMARY

Element Number	Element Description	Unit	total Quantities	Cond. State 1	Cond. State 2	Cond. State 3	Cond. State 4	Comments
152	Floor Beam	ft	87	0	6	81	0	
1000	*Corrosion*	ft		0	6	77	0	
1010	*Cracking*	ft		0	0	0	0	N/A
1020	*Connection*	ft		0	0	4	0	
1900	*Distortion*	ft		0	0	0	0	N/A
7000	*Damage*	ft		0	0	0	0	N/A
515	Steel Coating	ft^2	2066	930	723	207	207	Painting area = 23.75ft^2/ft
3440	*Effectiveness*	ft^2		930	723	207	207	

District's Bridge Inspection Program

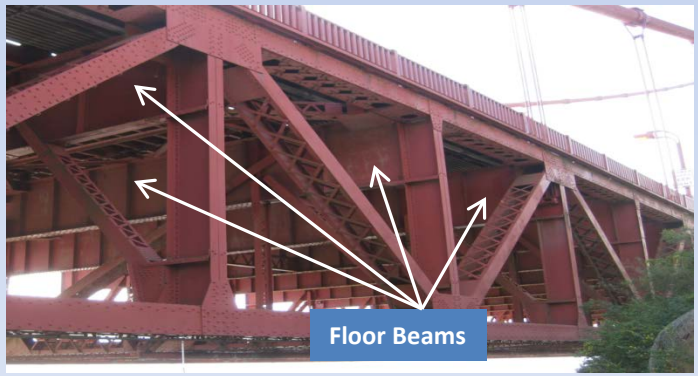
- Inspection reports and work recommendations

Stru Unit	Bridge Portion	Features Inspected	Type of Inspection	TYPE (NBE, BME, ADE)	ELI			Condition State Rating				Date Last Inspected
					No.	Quant.	Unit	1	2	3	4	
South Approach Viaduct (SAV) - Girder Span (Structure Unit 1)												
	Steel Girders		Fracture Critical & Routine Inspection Plan	645		ELEM (ft)	42	423	180	0		11/18/2015
				12,090		PAINT (Area)	1681	4394	4476	1539		
SAV - Girder	Steel Girders		Inspection Plan	NBE	107							11/18/2015
SAV - Girder	Steel Girders (widened)		Routine Inspection Plan	NBE	107	216	ELEM (Area)	0	216	0	0	1/12/2016
						767	PAINT (Area)	0	102	486	179	
SAV-Girder	Floor Beams		Fracture Critical & Routine Inspection Plan	NBE	152	802	ELEM (ft)	52	285	465	0	12/7/2015
						11,720	PAINT (Area)	5903	3759	1272	786	
SAV-Girder	Steel Column		Routine Inspection Plan	NBE	202	6	Each	6	0	0	0	12/23/2015
						936	PAINT (Area)	0	785	90	61	
	Seismic Isolation Bearings		Complex Bridge Inspection Plan	12		ELEM (Each)	12	0	0	0		1/11/2016
						PAINT (Area)	NA					
	seal						PAINT (Area)	NA				
SAV-Girder	Seismic Isolation Bearings		Complex Bridge Inspection Plan	NBE	314	12	ELEM (Each)	12	0	0	0	1/11/2016
							PAINT (Area)	NA				
SAV-Girder	Metal Bridge Railing		Routine Inspection Plan	NBE	330	414	ELEM (ft)	303	18	93	0	1/10/2015
						4,140	PAINT (Area)	1242	1449	207	1242	
SAV-Girder	Moveable Median Barrier		Routine Inspection Plan	NBE	333	207	ELEM (ft)	112	95	0	0	1/25/2016

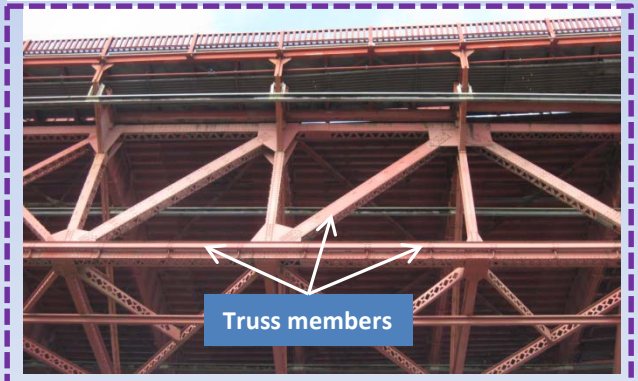
Fracture Critical Member Inspection

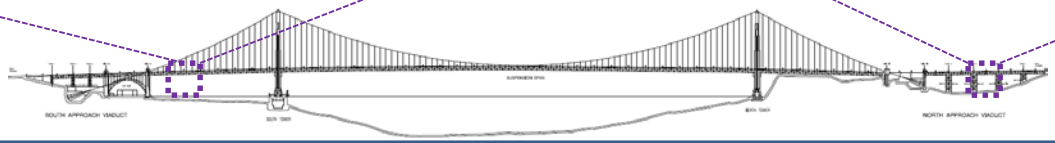
- Fracture Critical Member (FCM) is a steel member in tension, whose failure would probably cause a portion of or the entire bridge to collapse
- It requires hands-on inspection, i.e. within arms' length
- Engineering Bridge Inspection team performs inspections for accessible fracture critical members and Consultants carry out rope inspections for inaccessible FCMs

Floor Beams (Suspension Span)



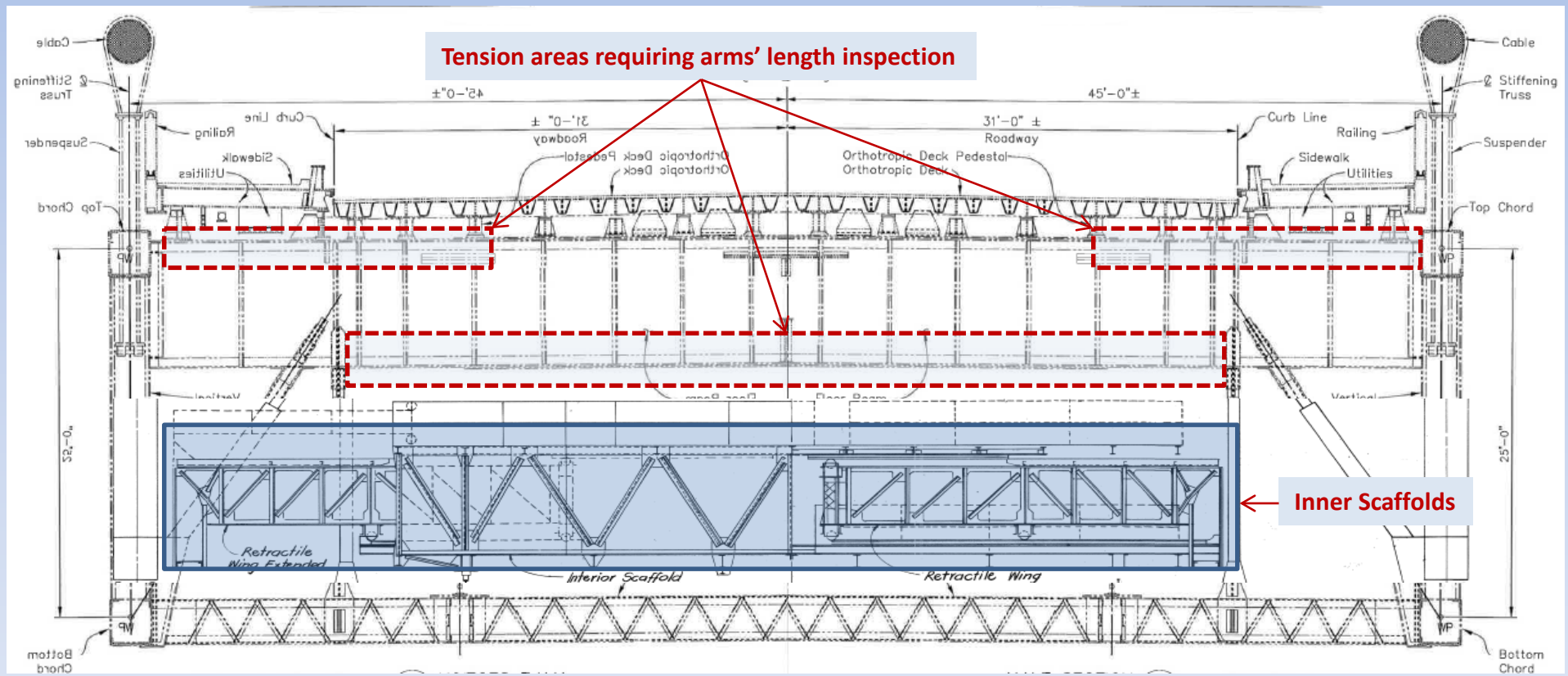
Trusses (North Approach Viaduct)



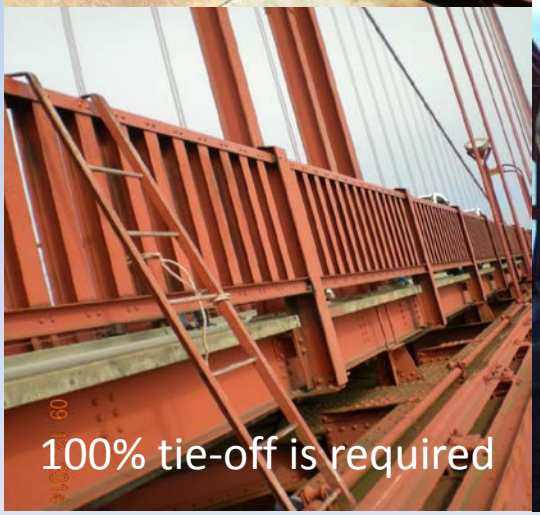


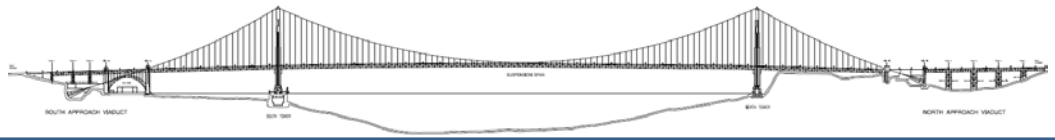
Accessible FCM Inspection (Floor Beams @ Suspension Spans)

- The Suspension Spans have outer and inner scaffolds. The Bridge Inspection team utilizes the inner scaffolds with retractile wings.



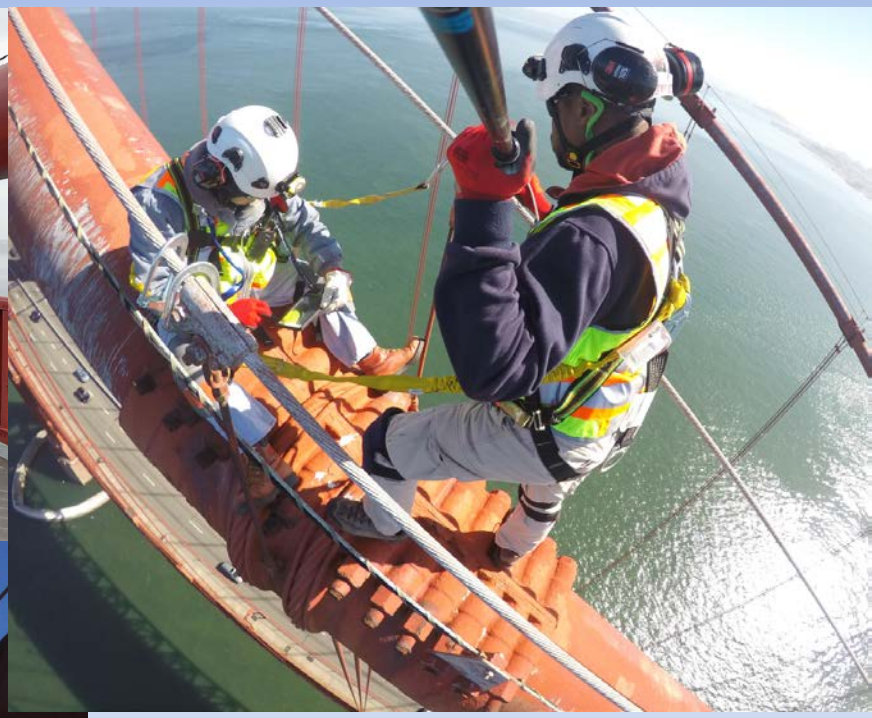
Accessible FCM Inspection (Floor Beams @ Suspension Spans)





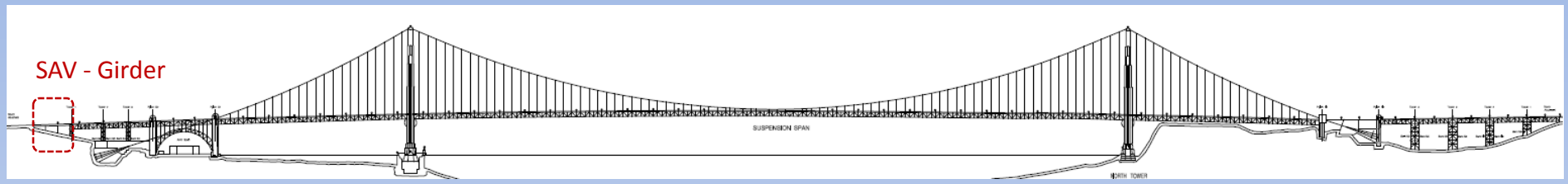
Accessible FCM Inspection (Main Suspension Cables)

▪Checking harness and lanyards before climbing up the main cables



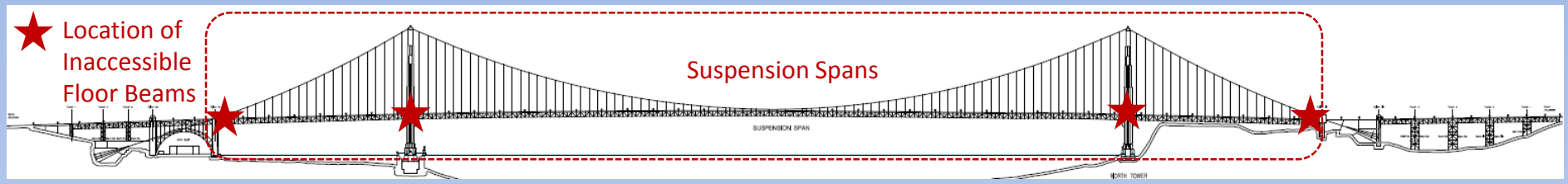
- Improve public safety with cones and a bridge inspector on the sidewalk during inspections
- 100% tie-off
- Utilize the best available tools such as mirrors or go-pro camera for inspections

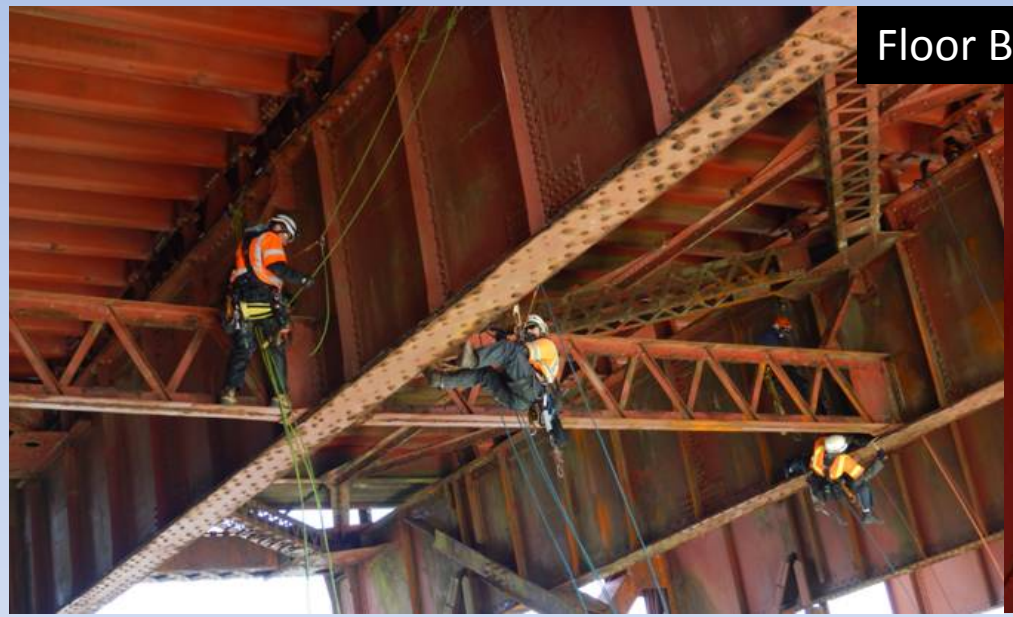
Rope Inspection for Inaccessible FCMs



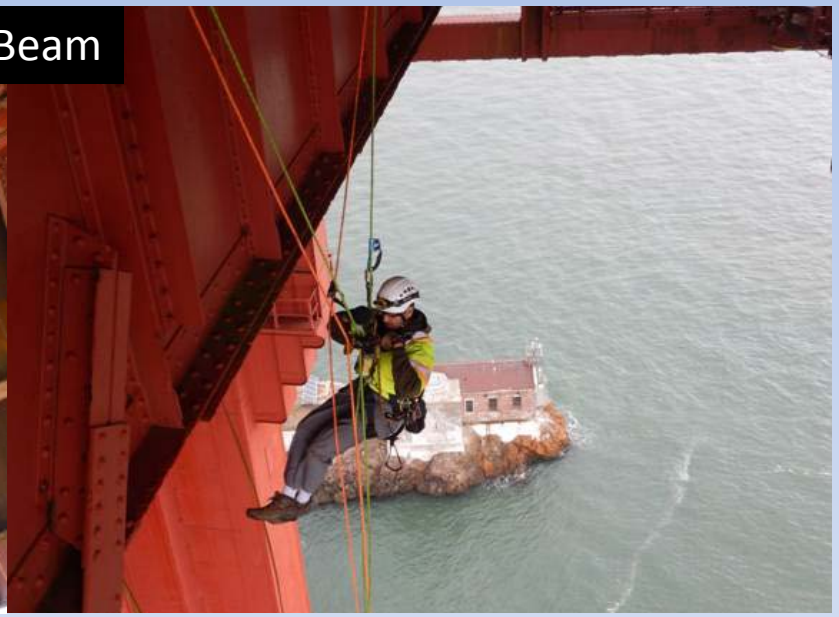
Structure	No. of Girders Inspected	No. of Floor Beams Inspected	Inspection Dates	Status
SAV Girder Spans	9 (out of 9)	12 (out of 12)	July 23, 24	Completed

Rope Inspection for Inaccessible FCMs



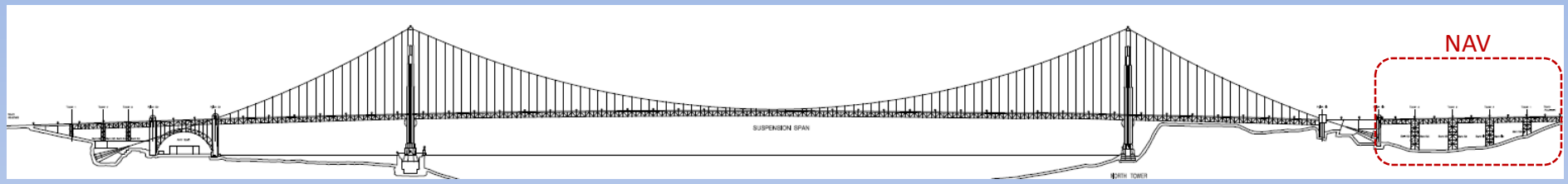


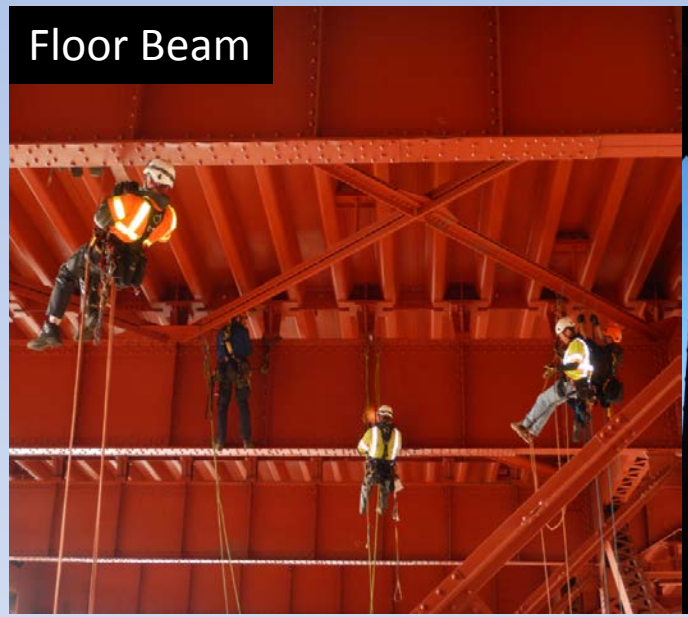
Floor Beam

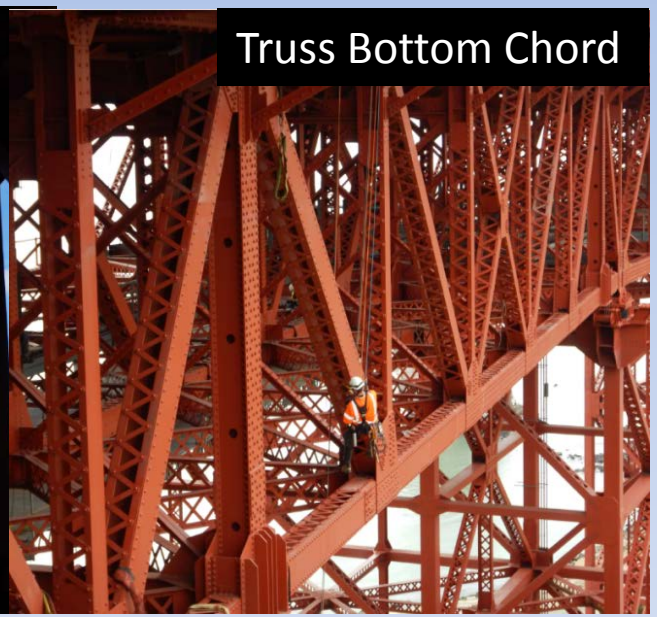


Structure	No. of Truss Members Inspected	No. of Floor Beams Inspected	Inspection Dates	Status
Suspension Spans	Not Applicable	22 (out of 22)	July 10, 13, 14, 16	Completed

Rope Inspection for Inaccessible FCMs



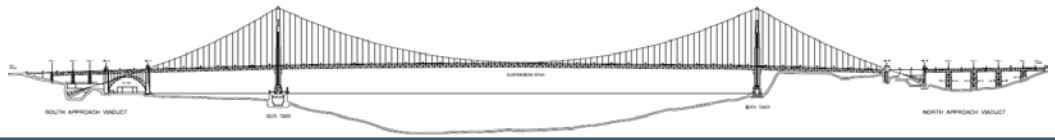




Structure	No. of Truss Members Inspected	No. of Floor Beams Inspected	Inspection Dates	Status
North Approach Viaduct	117 (out of 117)	27 (out of 27)	July 17, 20, 21, 22	Completed

Inspection Form and Report

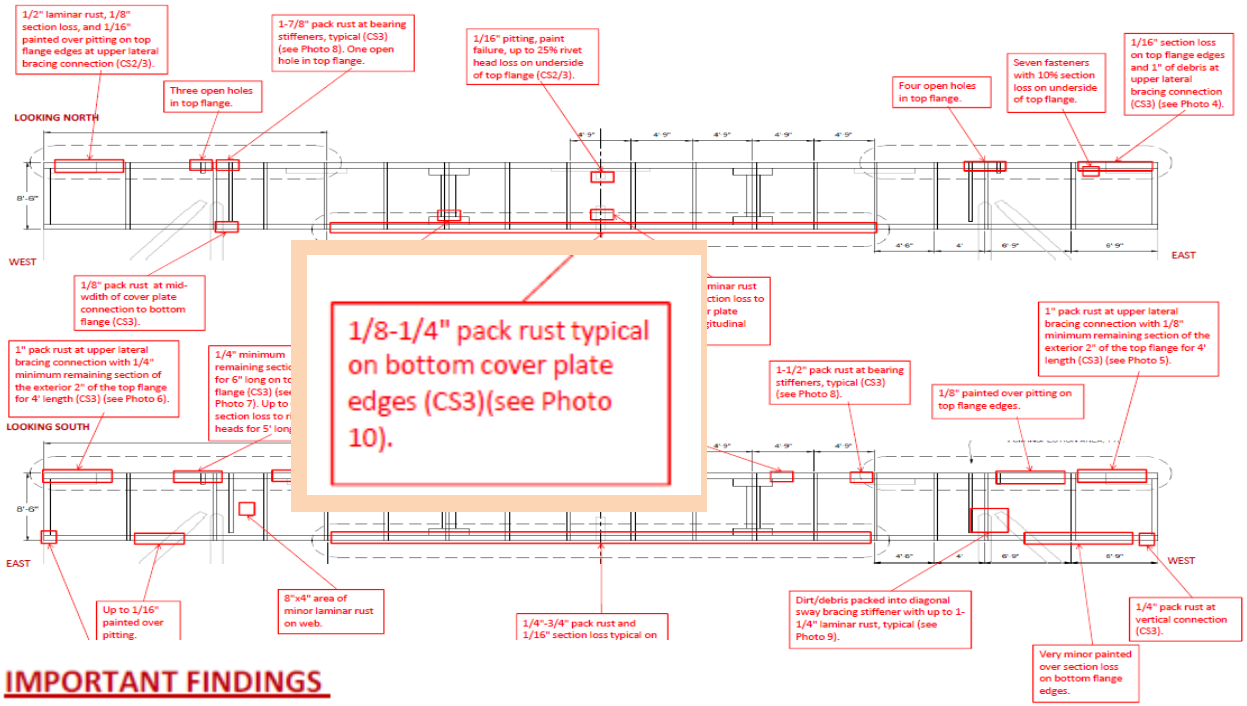
- Basic information: Who, When, What and Where
- Defects
  - Identify element defects such as corrosion, crack and connection
  - Provide condition statements and states for each defect
  - Determine coating/paint condition
- Quantity Table
  - Generate element defect quantities per the Manual
- Important Finding
- Work Recommendation
- Photos for general overview and for CS 3 or 4 defects



Inspection Form and Report

FC/Routine Inspection INSPECTOR(S): Nick Clark/Tom Howell LOCATION: Suspension Span SPAN NO: 1 PP NO: 42 DATE: 7/13/2015

If you find anything that you think needs repair in a timely manner, please draw a star symbol in the box to the right and next to defect(s) noted in figure(s) below.



Typical Floorbeam Condition (S Face)

IMPORTANT FINDINGS

NONE

WORK RECOMMENDATIONS

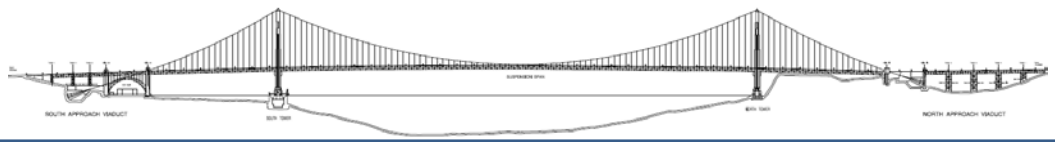
1. Clean and paint corroded areas and replace fasteners as nece
2. Remove dirt/debris from stiffener pockets at sway bracing to connection and install drain holes in the stiffeners to help reduc up/corrosion.

SUMMARY

Element Number	Element Description	Unit	total Quantities	Cond. State 1	Cond. State 2	Cond. State 3	Cond. State 4	Comments
152	Floor Beam	ft	87	0	6	81	0	
1000	*Corrosion*	ft		0	6	77	0	
1010	*Cracking*	ft		0	0	0	0	N/A
1020	*Connection*	ft		0	0	4	0	
1900	*Distortion*	ft		0	0	0	0	N/A
7000	*Damage*	ft		0	0	0	0	N/A
515	Steel Coating	ft^2	2066	930	723	207	207	Painting area = 23.75ft^2/ft
3440	*Effectiveness*	ft^2		930	723	207	207	

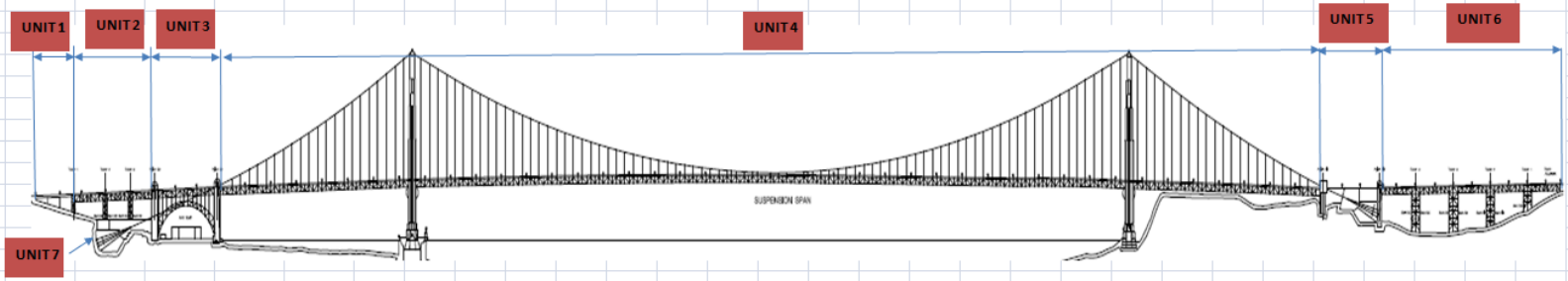
Inspection Outcomes (Unit 1)

Stru Unit	Bridge Portion	Features Inspected	Type of Inspection	TYPE (NBE, BME, ADE)	ELI			Condition State Rating				Date Last Inspected
					No.	Quant.	Unit	1	2	3	4	
South Approach Viaduct (SAV) - Girder Span (Structure Unit 1)												
1	SAV - Girder	Reinforced concrete Deck	Routine Inspection Plan	NBE	12	2,918	ELEM (Area)	2742	176	0	0	1/12/2016
							PAINT (Area)	NA				
	SAV - Girder	Orthotropic Deck	Routine Inspection Plan	NBE	30	12,834	ELEM (Area)	9851	2878	105	0	11/16/2015
						20,700	PAINT (Area)	10580	4830	3105	2185	
	SAV - Girder	Steel Girders	Fracture Critical & Routine Inspection Plan	NBE	107	645	ELEM (ft)	42	423	180	0	11/18/2015
						12,090	PAINT (Area)	1681	4394	4476	1539	
	SAV - Girder	Steel Girders (widened)	Routine Inspection Plan	NBE	107	216	ELEM (Area)	0	216	0	0	1/12/2016
						767	PAINT (Area)	0	102	486	179	
	SAV-Girder	Floor Beams	Fracture Critical & Routine Inspection Plan	NBE	152	802	ELEM (ft)	52	285	465	0	12/7/2015
						11,720	PAINT (Area)	5903	3759	1272	786	
	SAV-Girder	Steel Column	Routine Inspection Plan	NBE	202	6	Each	6	0	0	0	12/23/2015
						936	PAINT (Area)	0	785	90	61	
	SAV-Girder	Concrete abutment	Routine Inspection Plan	NBE	215	129	ELEM (Each)	0	19	110	0	1/14/2016
							PAINT (Area)	NA				
	SAV-Girder	Reinforced concrete pile cap	Routine Inspection Plan	NBE	220	57	ELEM (ft)	49	8	0	0	1/14/2016
							PAINT (Area)	NA				
	SAV-Girder	Joint - Assembly without seal	Routine Inspection Plan	BME	305	0	Elem (each)	49	29	0	0	1/10/2015
							PAINT (Area)	NA				
	SAV-Girder	Seismic Isolation Bearings	Complex Bridge Inspection Plan	NBE	314	12	ELEM (Each)	12	0	0	0	1/11/2016
							PAINT (Area)	NA				
	SAV-Girder	Metal Bridge Railing	Routine Inspection Plan	NBE	330	414	ELEM (ft)	303	18	93	0	1/10/2015
						4,140	PAINT (Area)	1242	1449	207	1242	
	SAV-Girder	Moveable Median Barrier	Routine Inspection Plan	NBE	333	207	ELEM (ft)	112	95	0	0	1/25/2016
						1,946	PAINT (Area)	1946	0	0	0	
	SAV-Truss	Roadway Deck Wearing Surface	Routine Inspection Plan	BME	510	14,214	ELEM (Area)	6724	7423	67	0	1/10/2015
							PAINT (Area)	NA				



Inspection Status

Golden Gate Bridge Inspection Plan (2015-2016)



Structure		2015												2016											
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
UNIT 1 - Girder Spans	PLAN																								
	ACTUAL																								
UNIT 2 - Truss Spans	PLAN																								
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GGB Bridge Inspection Report	PLAN																								
	ACTUAL																								
Auxiliary Bridges	PLAN																								
	ACTUAL																								
Auxiliary Bridge Inspection Reports	PLAN																								
	ACTUAL																								

List to Do after Inspections

- Engineering Department develops a list of repairs/work recommendations based on bridge inspections and load rating.

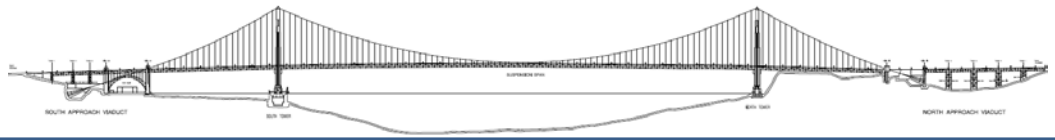
- Engineering Department prioritizes the list and determines whether repairs can be made by Bridge Division crew or contractors.

Bridge Division

Contractors

- Engineering Department is informed of any repairs made.

- Engineering Department updates the list.

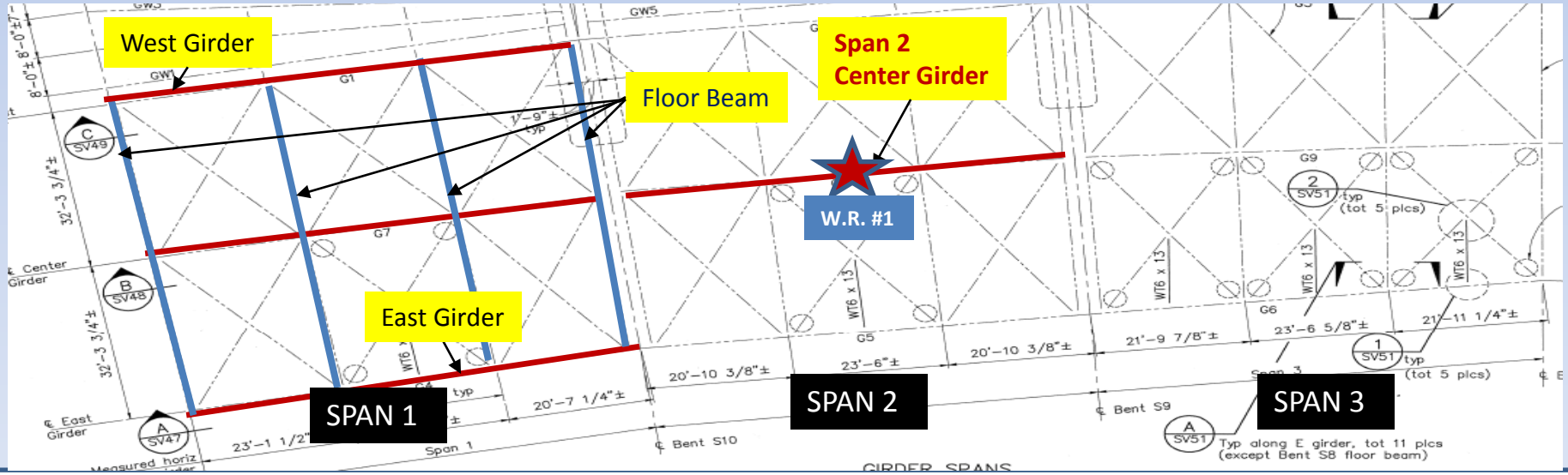


Work Recommendation #1

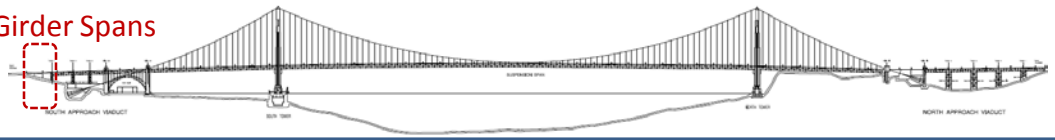
- Rating Factor (R.F.)

Live Load	Rating Factor	Location
Legal Vehicle – Type 3S2	1.06	Span 2 – Center Girder

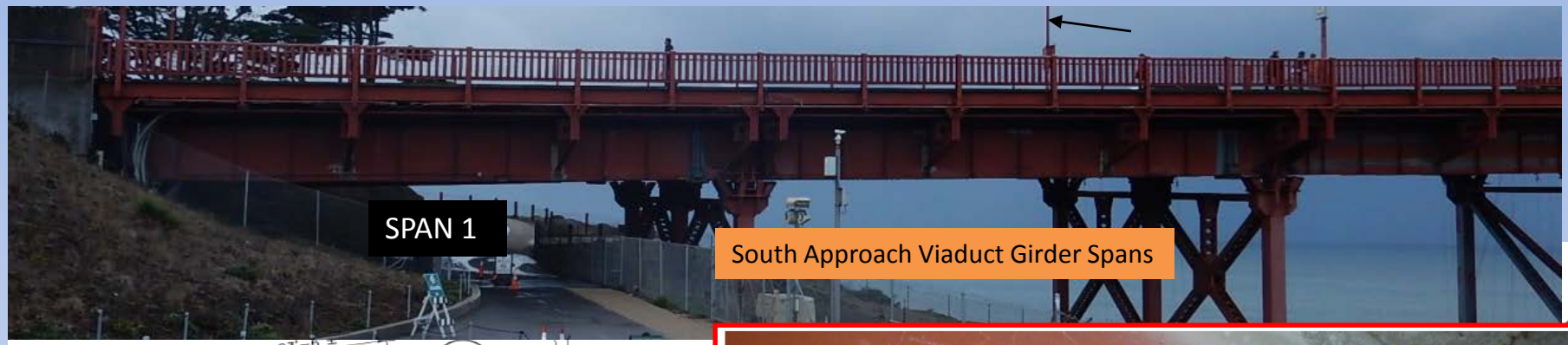
- The Span 2 center girder is the controlling member for the entire GGB. So, any additional weight which makes the R.F. less than 1.0 could lead to post weight limits on the bridge

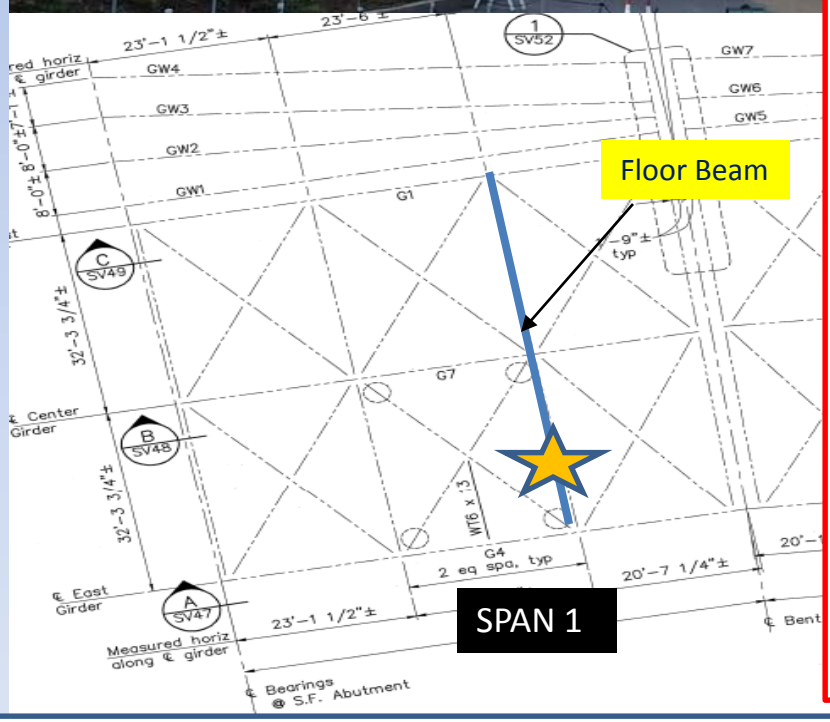


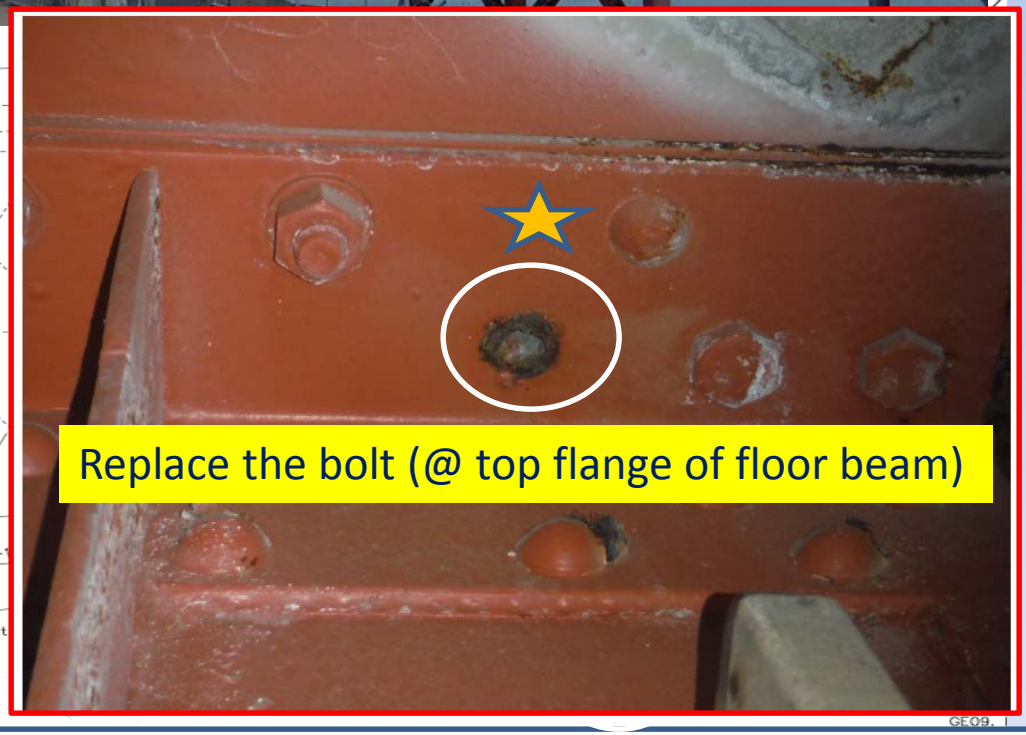
SAV-Girder Spans



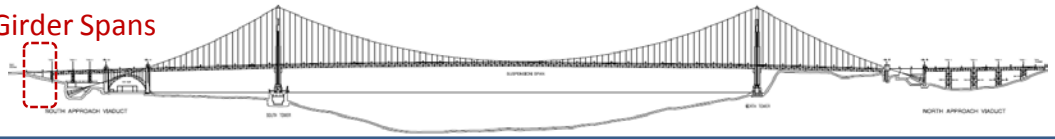
Work Recommendation #2



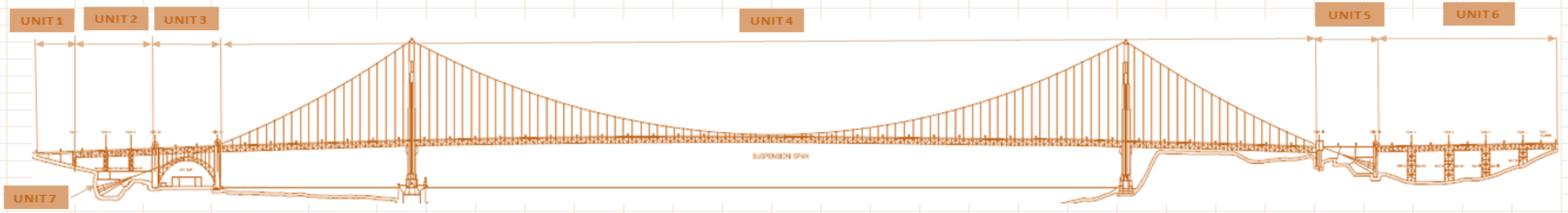




SAV-Girder Spans



Golden Gate Bridge Inspection Plan (2017-2018)



Structure		2017												2018											
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
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