



Substructure - Inspection and Rating

## Substructure Inspection and Rating




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## Introduction

- That portion of the bridge located below the bearings
  - Abutments
  - Piers
  - Rated separately
- Purpose is to:
  - Receive the loads from the superstructure
  - Transfer forces to the ground
  - Contain the approach fills
  - Withstand other forces on it
    - Ice
    - Debris/drift
    - earth pressure




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## Introduction

- Components
  - bearing seats, caps
  - piles
  - backwalls
  - wingwalls
  - bracing and struts
- Component materials
  - timber
  - concrete
  - steel

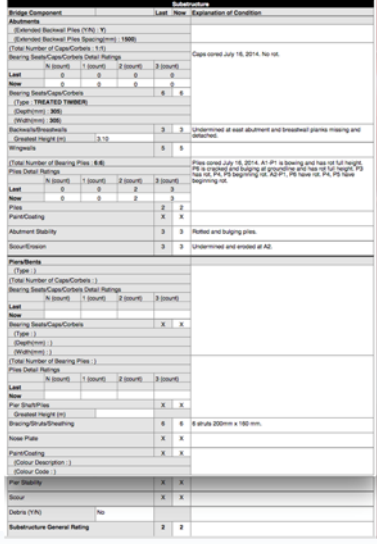



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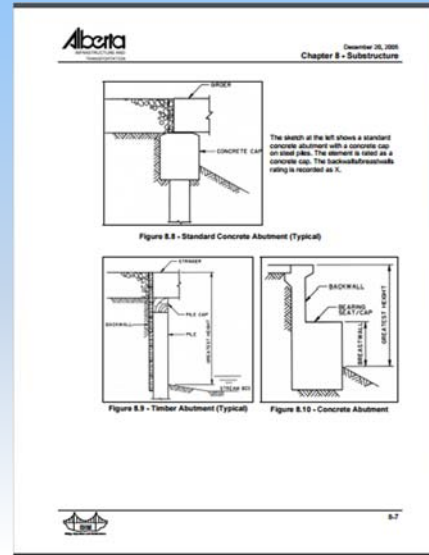
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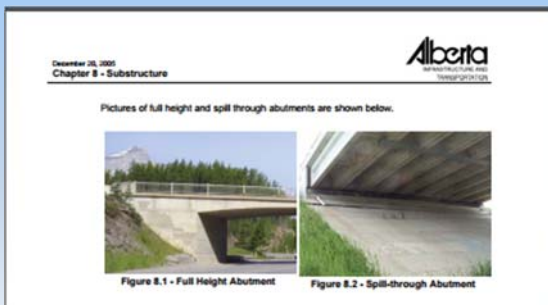
## Abutments

- Purpose
  - Support the ends of the girders or stringers
  - Contain the approach fills
- Two types in standard bridges - classified according to their height

## Abutments



## Full Height & Spill Through Abutments



## Abutments

- Full Height Type
  - Solid retaining walls
  - Extend the full height of the bridge
  - Has wingwalls
  - No headslopes
  - Susceptible to lateral displacement from earth pressure
  - Vulnerable to undermining if not protected

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## Abutments

Full Height Type



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## Full Height Abutment



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## Full Height Abutment



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## Abutments

- Spill Through Type
  - Intersect the headslopes at the cap height
  - No retaining wall (backwalls) below caps
  - Short wings
  - Vulnerable to undermining if headslopes not protected with scour protection
  - Susceptible to slumping if headslopes too steep or scour at toe

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## Spill Through Abutment



## Abutments

- Indicate Extended Backwall Piles “Yes” or “No”
- Record Extended Backwall Pile maximum spacing in mm
- Provide Backwall/Breastwall rating—refer to 8.6
- Measure and record greatest height – lowest point to top of deck
- Rate struts on single span bridge in Pier section of form

## Extended Backwall Pile



## Backwalls/Breastwalls

Backwalls/Breastwalls	3	3	Undermined at east abutment and breastwall planks missing and detached.
Greatest Height (m)	3.10		

- Applies to abutments only
- That part of the abutment sheeting between the wingwalls
- Function is to retain the approach fill
- On standard bridges, backwalls are:
  - horizontal timber planks nailed to the piles
  - vertical driven tongue and groove timber planks nailed to walers attached to piles
  - Includes extended backwall piles
- Measure and record greatest height – lowest point to top of deck

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## Backwalls/Breastwalls

- On Standard bridges Breastwalls refer to planks attached to streamside of abutment piles
- Look for:
  - Defects common to timber and steel
  - Sheathing not installed low enough
    - sheathing to be set 300 mm below ground level or scour protection
  - Loss of fill material below the backwall or breastwall
  - Loose, missing, or bowing planks



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## Backwalls/Breastwalls Ratings

- Rate according to condition and ability to perform as designed (retaining wall)
- Sheeting bowing out from earth pressure rate 5 providing it is functioning (retaining fill).
- Loss of material under sheathing - rate 4 or less
- Excessive gaps between the planks allowing infiltration rate 4 or less
- Decay, broken or missing planks - rate 4 or less



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## Backwalls/Breastwalls Loss of Fill Rated 4



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## Repair with Breastwall



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## Vertical Driven Backwall Sheathing



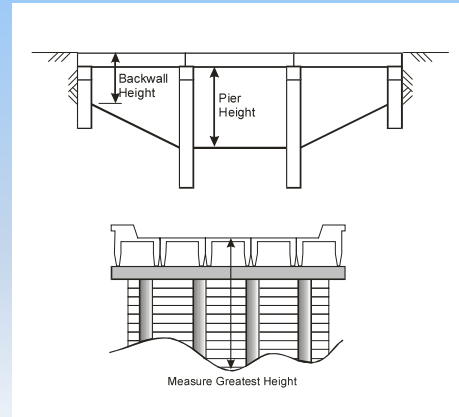
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## Backwall & Pier Height



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## Wingwalls

- Applies to abutments only
- Primary function is to retain fill
- Consist of horizontal or vertical driven sheathing attached to piles
- Wing piles are included in inspection and rating
- Stability and Scour/Erosion are rated separately
- Look for:
  - Material defects
  - Sheeting not installed low enough - sheeting to be set below the ground level or scour protection installed at the bottom
  - Loss of fill material below the wingwall
  - Excessive gaps between the planks allowing infiltration
  - Sheeting or piles bowing out from earth pressure
  - Missing or broken planks or piles
  - Missing or damaged tin tops on timber wing piles
    - installed to prevent water from entering cut end and rotting interior of pile
  - Proper attachment to backwall - loose or missing wing cleat
  - Broken or loose anchor tie to pile

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## Wingwall Ratings

- Requires repairs for aesthetics but is still functional - rate 5 or more
- Requires repairs to be functional - rate 4 or less
  - Loss of fill material – rate 4 or less (also rate under Scour)
  - Sheathing or piles bowing out from earth pressure rate 5 or less depending on functionality
  - Missing or broken planks rate 5 or less depending on functionality
  - Broken or rotted piles rate 4 or less
  - Missing or damaged tin tops on wing piles rate 4

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## Wingwall – Separation from Backwall



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## Wingwall – Broken Pile



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## Piers

- Intermediate supports between the abutments on multi-span bridges
- Record pier type
  - On Standard bridges piers are usually “Pile Bents”
  - Pile bent is a single row of piles
  - Pile Bent is recorded as “Pier Column”
- Measure and record greatest height – lowest point to top of pier cap
- Material Type:
  - Timber
  - Steel
  - Concrete (major bridges)

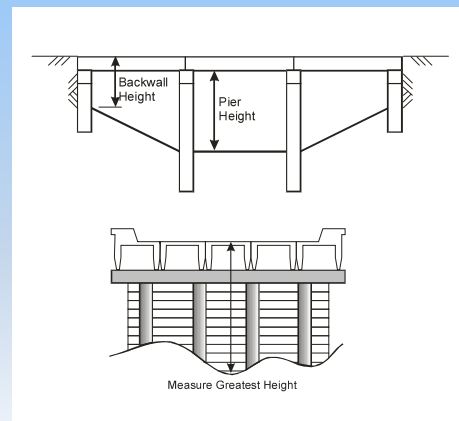
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## Backwall & Pier Height



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### Timber Pier Bent (Column) with Sway Bracing



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### Timber Pier Bent (Column) with Sheathing



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### Teepee Pier Bent (Column) with Sheathing, Capitals, Steel Caps



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### Galvanized Steel Pier Bent (Column) with Bracing



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## Bearing Seats/Caps/Corbels

8.5. ABUTMENT AND PIER BEARING SEATS / CAPS / CORBELS

Bridge Component	Last	Now	Explanation of Condition		
Abutments or Piers/Bent					
(Total Number of Caps or Corbels)					
Bearing Seats/Caps/Corbels Detail Rating					
	N (count)	1 (count)		2 (count)	3 (count)
Last					
Now					
Bearing Seats/Caps/Corbels					
(Type: )					
(Depth (mm) : )					
(Width (mm) : )					

- Applies to abutments and piers
- Corbels used on major bridges only
- Purpose
  - Receive the loads from the superstructure
  - Transfer loads to the piles
- High stress concentrations in bearing areas
  - Under girders or timber stringers
  - Above piles



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## Abutment or Pier Caps

- Types
  - Timber - found on timber pile bents
  - Concrete - found on concrete or steel
  - Steel - found on steel or timber pile bents
- Confirm and/or record:
  - ✓ Total number of individual caps at each abut and pier (west: east or south: north) (e.g. 3:3)
  - ✓ Record Detailed rating boxes for caps
    - record number of caps not visible in "N" box
    - record "0" if timber caps are rated 4 or more or if caps are not timber
  - ✓ Provide cap rating - refer to Section 8.5
  - ✓ Record Type and size of caps – if different sizes provide comment
    - Use nominal dimensions-(250, 305, 356mm)



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## Abutment or Pier Caps

- Look for:
  - Concrete caps with wide cracks, delamination, spalls, corrosion of rebar, other deterioration
  - Material defects
    - Especially decay in timber
    - Check shape of timber caps (bulging/crushing)
  - Good contact between girders and caps , and between caps and piles
  - Fire damage-reduced section and strength
  - Evidence of defective connections
    - Corrosion of dowels or drift pins
    - Broken, cracked or poor welds
  - Capitals
    - proper size for pile
  - Location and installation of steel cap stiffeners
    - over pile locations
    - on both sides of web
  - Rotation or displacement
    - Usually indicates substructure movement



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## Timber Caps – Abutments or Piers

- Decay in timber
  - check moist areas - contact between girders, piles, sheathing planks
  - check cut ends, dowel, drift, and bolt holes
  - most often occurs in the cap interior while the treated surface remains sound
  - look for discoloration at bottom of caps where moisture leaches out decay by-products
  - look for crushing or bulging especially in high stress areas at piles or under girders
  - sound caps with hammer to detect hollow areas
  - Recommend Level 2 coring if any decay present or suspected based on visual clues



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## Rating Abutment/Pier Caps

- Refer to Section 8.5.3 in Manual
- Rate according to condition and functionality
- Record number of caps rated N, 1, 2 & 3 in Detail Rating Field. Record "0" if caps rated >3
- Any deficiencies reducing ability to transmit loads rate 4 or less
- Spalling and rebar exposed - rate 4 or less
- Girder bearing less than 100mm rate 4 or less
- Girder bearing less than 75 mm rate 3 or less
- Timber caps with:
  - Vertical or horizontal splits extending through full dimension rate 4 or less
  - Early signs of rot rate 4 or less
  - Signs of bulging rate 3 or less
  - Signs of crushing rate 2 or less



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## Bulging Timber Cap—Rated 3



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## Crushing/Bulging Timber Pier Cap—Rated 2



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## Crushing/Bulging Timber Abutment Cap—Rated 2




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### Crushing/Cracked Timber Pier Cap – Rated 2



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### Crushing/Cracked Timber Abutment Cap – Rated 2



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### Crushing Timber Cap – Rated 2



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### Timber Corbels Major Bridges



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### Level 2 Timber Coring



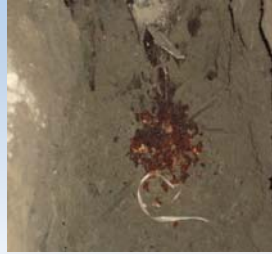
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### Level 2 Core Samples

Core shavings with rot      Good texture and color – no rot



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### Fire Damaged Timber Cap with Section Loss



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### Concrete Pier Cap with Spalling



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## Abutment and Pier Piles

### 8.8. ABUTMENT BEARING PILES AND PIER SHAFT / PILES

Bridge Component	Last	Now	Explanation of Condition
(Total Number of Bearing Piles : )			
Piles Detail Rating			
N (count)	1 (count)	2 (count)	3 (count)
Last			
Now			
Abutment Piles or Pier Shaft/Piles			
Greatest Height (m)			

- Applies to piles at abutments and piers
- Piles receive the loads from the caps and transmit them to the ground
- Piles also accommodate lateral loads
  - ice and drift
  - earth pressure
- Record Detail Ratings as “0” if timber piles rated 4 or more - or if not timber piles

## Abutment and Pier Piles

- Pile types
  - Timber
  - Steel H-pile
  - Steel pipe pile filled with concrete
  - Concrete
- Record the maximum pier height
  - Measure from lowest point to top of pier cap

## Abutment and Pier Piles

- Look for:
  - Material defects
    - Cracks, decay of timber piles (especially in wet/dry zone)
    - Cracks, corrosion/loss of section of steel piles
  - Collision damage from ice, drift or vehicles (Lead pile especially)
  - Abrasion from ice or drift
  - Bowing due to excessive earth pressure or vertical loads
  - Misalignment (out of plumb – not sharing loads) due to lateral forces
  - Uneven spacing due to poor construction
  - Signs of heaving or settlement. Note in vertical misalignment


## Abutment and Pier Piles

- Confirm and/or record:
  - ✓ Total number of bearing piles at each abutment and pier (west: east or south: north)
  - ✓ Example 8:7 (numbers may be different)
  - ✓ Record Detailed Rating boxes for piles
    - record total number of abut/pier piles not visible (“N”)
    - record “0” if timber piles caps are rated 4 or more or if piles are not timber
  - ✓ Provide rating for abut and pier piles - refer to Section 8.8

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## Abutment and Pier Piles

- Rate according to condition and functionality
- Do not consider
  - Stability - rate under abutment or pier stability
  - Bracing - rate under bracing
  - Struts - rate under struts
- Piles that are not sharing the loads from the superstructure - rate 4 or less
- Wide splits or cracks (>15mm) rate 4 or less
- If repaired (banded, clamps, struts) rate 5.
- Horizontal bending cracks rate 3 or less
- Crushing from horizontal load of struts rate 3 or less
- Piles showing duress (bowing) under loads - rate 2 or less
- Piles with bulging outer fibers - rate 2
- Record number of timber piles rated N, 1, 2 or 3 in pier and abutment Detail Ratings (0 if piles rated >3 or if not timber piles)



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## Timber Abutment Piles Bulging – Rated 2





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## Timber Abutment Piles Bulging – Rated 2





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## Timber Abutment Piles Bulging/ Bowing– Rated 2





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### Timber Abutment Piles Wide Split—Rated 3



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### Timber Abutment Piles Horizontal Bending Crack—Rated 3



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### Timber Pier Piles with Rot — Rated 3



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### Timber Piles Repaired with Steel Splice




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## Timber Pile Not Sharing Load – Rated 3





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## Paint / Coating

Nose Plate	4	4	Stream has degraded below bottom of nose plates.
Paint/Coating (Colour Description :)	X	X	No paint on nose plate.
(Colour Code :)			

- Applies to abutments and pier elements
- Steel
  - Paint
  - Galvanizing
- Concrete
  - Cosmetic coatings
  - Pigmented Sealers
  - Waterproofing coatings
- Does not refer to the creosote on timber components
- Refers to nose plate coating only on timber piers



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## Paint / Coating

- No coating on treated timber substructures therefore rate X.
  - unless there is a nose plate then rate plate coating
- Check areas exposed to moisture and or salt
  - under leaking joints
  - water line
  - ground line
- Check areas that are difficult to coat
  - edges and corners
  - bolts and connections
  - areas with poor access



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## Paint / Coating

- Rate according to condition and ability to protect the underlying element
- Top coat deteriorating but prime coat intact - rate 5
- Pitting or loss of section of underlying element - rate 4 or less
- Coatings for aesthetics only (cosmetic coatings on concrete) - rate 3 or more
- If no coating on steel elements and there is corrosion, rate 4 or less.



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## Abut/Pier Stability


		Substructure		
Bridge Component	Last	Now	Explanation of Condition	
<b>Abutments</b>				
Abutment Stability)				
<b>Pier Stability</b>				

- Applies to abutments and piers but rated separately
- Can cause failure of the structure or problems with superstructure
- Small movement can be tolerated
- Excessive movements are those which affect load carrying capacity, level of service or cause distress to bridge elements



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## Abut/Pier Stability

- Types
  - Rotational or dipping
    - excessive earth pressure
    - Scour/erosion
    - Superstructure movement
  - Vertical
    - heaving due to frost
    - settlement due to inadequate bearing capacity
  - Horizontal
    - movement of soil mass or slope failure



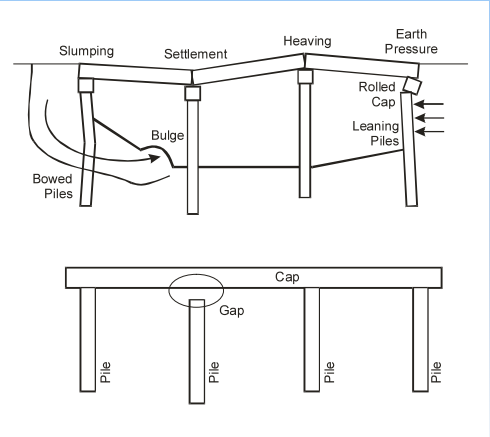
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## Abut/Pier Stability





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## Abut/Pier Stability

- Span alignment problems detected in superstructure inspection may indicate substructure instability
- Rotational Movement - look for:
  - mis-alignment of caps with backwalls or piles (rotating or rolling)
  - damage to connections at bearing areas
  - damage to anchoring system
  - signs of embankment movement



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## Abut/Pier Stability

- Lateral Movement - look for:
  - uneven bearing areas
  - horizontal misalignment between spans
  - separation between backwall and wingwalls
  - signs of embankment movement
  - out of plumb piles
  - bowed struts
  - broken backwall scab/anchor pile connections



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## Abut/Pier Stability

- Vertical Movement - look for:
  - unevenness in superstructure
  - gaps between piles and caps
  - misalignment of structural elements
- Can have serious scour without affecting stability
- Movement that requires monitoring - rate 4 or less
- Movement causing damage to any bridge element - rate 4 or less



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## Abut/Pier Stability Bowed Struts



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## Stability – Heaved Pier



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## Scour / Erosion

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Bridge Component	Last	Now	Explanation of Condition
Abutments			
Scour/Erosion			
Piers/Bents			
Scour			

- Abutments and piers rated separately
- Refers to removal of material by flowing water stream or approach drainage
- Most bridge failures associated with scour / erosion during floods
- Only scour which affects or has the potential to affect the abutments or piers



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## Scour / Erosion

Definition – refer to 16.2

- Scour – Removal of streambed material due to increased velocities caused by obstruction or constrictions
- Erosion – general removal of material on stream banks, drainage ditches etc. by flowing water
- Factors
  - stream geometry
  - type of material in stream banks and bed
  - obstructions
    - ice, drift, piers, abutments, river training works
  - alignment of piers and abutments
  - degree or constriction at bridge
  - severity of flood




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## Scour / Erosion

- Look for:
  - A variation from the natural stream banks or bed
  - General stream degradation and associated slumping of banks
  - Loss of material
    - toe of headslopes
    - in front of abutment backwalls
    - around piers
  - scour if any debris is present




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## Scour / Erosion

- Determine the extent of the scour / erosion and probable cause
- Approach road drainage that is also causing abutment erosion rated in Abut Scour/Erosion
- Scour or erosion causing loss of fill material from below or behind backwall rate 4 or less
- If stability of structure threatened rate 3 or less
- If vertical bank at the abutment rate 3 or less
- If loss of fill is safety concern resulting in a hazard, rate 2 or less



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## Bracing / Struts / Sheathing

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Bridge Component	Last	Now	Explanation of Condition
Bracing/Struts/Sheathing			

- Applies to piers only
  - Bracing or sheathing on piers
  - Struts which extend between abutment or pier piles
- Bracing and sheeting
  - For load distribution between piles
  - To give the pier rigidity
  - Bracing are single planks or steel members connecting the piles
  - Sheathing is a solid wall of planks on both sides of the pier
    - usually combined with a nose plate

## Bracing / Struts / Sheathing

- Struts
  - Normally timber
  - To prevent the earth pressure from pushing the abutment piles out
  - if no struts, check that other pile anchor systems in place for backwall type abutment

## Bracing / Struts / Sheathing

- Look for:
  - Material defects
  - Adequate connections
    - struts include retainer planks (horizontal planks on piles supporting struts)
  - Whether struts interfere with passage of drift or ice
  - Struts bear on piles and not caps
  - Missing or bowing struts


## Bracing / Struts / Sheathing

- Rate according to condition and functionality
- All elements a single rating - use the "Explanation of Condition" to identify details
- If struts are bowed, missing, or bear on caps instead of piles
  - significant abutment movement has not occurred rate 4
  - Significant movement, rate 3 or less.
- If sheathing on pier does not extend to waterline or above high water level rate 4
- Loose/missing sheathing rate 4 or less
- Cracked/broken bracing rate 4 or less

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## Bracing / Struts / Sheathing

<b>Piers/Bents</b>				
(Type : <b>PIER-COLUMN</b> )				
(Total Number of Caps/Corbels : <b>8:5</b> )				
Cape corod Aug. 25/15 Pier 2 has 1 100x305 T.T. on top of caps Pier 1 has 2 - 100x305 T.T. on top of caps Beginning rot in all 100x305 T.T. top planks at both piers.				
<b>Bearing Seats/Caps/Corbels Detail Ratings</b>				
	N (count)	1 (count)	2 (count)	3 (count)
<b>Last</b>	0	0	0	0
<b>Now</b>	0	0	0	0
<b>Bearing Seats/Caps/Corbels</b>				
(Type : <b>TREATED TIMBER</b> )				
(Depth(mm) : <b>305</b> )				
(Width(mm) : <b>396</b> )				
(Total Number of Bearing Piles : <b>10:9</b> )				
Piles corod Aug. 25/15 P1-P4, P6 and P2-P5, P6, P8 and P9 all with beginning rot at base of pile Wide checking to Pier 2, Pile 9 - Ok.				
<b>Piles Detail Ratings</b>				
	N (count)	1 (count)	2 (count)	3 (count)
<b>Last</b>	0	0	0	0
<b>Now</b>	0	0	0	0
<b>Pier Shafts/Piles</b>				
	Created Height (m)			
	5.30			5.4
<b>Bracing/Struts/Sheathing</b>				
	4	4		
	Pier 2 - 1 cracked bracing plank. Struts in Sp. 1 and 2 (150 x 200 TT Rated ?			



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Substructure - Inspection and Rating

## Nose Plate


Nose Plate	4	4	Stream has degraded below bottom of nose plates.
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- Applies to piers only
- Located on the upstream side
- Protects pier from impact or abrasion from ice or drift
- Made from steel and bolted or welded to pier
- Found on H-pile and sheeted timber piers



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Substructure - Inspection and Rating


## Nose Plate

- Look for:
  - Material defects
  - Adequate connections to pier shaft/piles
  - Impact damage
- Rate according to condition and functionality
- Do not rate damage to pier - rate under piles or bracing/sheathing
- Missing nose plate on timber pier prone to damage from ice or drift rate 3 or less
- Timber pier with no plate and damaged rate X and recommend installation in comments and recommendations




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Substructure - Inspection and Rating


## Nose Plate





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Substructure - Inspection and Rating


## Debris

Debris (Y/N)	Yes		Old piles.
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- Applies to substructure as a whole –abuts and piers
- Material deposited in the bridge opening
  - trees and vegetation
  - logs
  - boulders
  - beaver dams
  - Refuse (tires, washing machines, etc)
  - old piling under bridge




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Substructure - Inspection and Rating

## Debris

- Problems caused by debris
  - reduction in flow carrying capacity of bridge
  - scour
  - impedes fish passage
  - upstream siltation




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Substructure - Inspection and Rating

## Debris

- Look at the entire bridge opening for any debris accumulation
- If debris is located away from the bridge, record under the “Channel” section
  - If has an effect on the bridge or has the potential to
- Indicate whether any significant debris is present by **Yes** or **No**
  - If Yes, explain
- No rating is required but the presence of debris may affect the Substructure General Rating
- Old piling is considered debris, note in Explanation




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Substructure - Inspection and Rating

## Abutments

Substructure			
Bridge Component	Last	Now	Explanation of Condition
<b>Abutments</b>			
[Extended Backwall Piles (Y/N) : Y]			
[Extended Backwall Piles Spacing(m) : 1500]			
[Total Number of Caps/Corbels : 1:1]			
Bearing Seats/Caps/Corbels Detail Ratings			
	N (count)	1 (count)	2 (count)
<b>Last</b>	0	0	0
<b>Now</b>	0	0	1
Bearing Seats/Caps/Corbels : 6 : 2			
[Type : TREATED TIMBER]			
[Depth(mm) : 305]			
[Width(mm) : 305]			
Backwall/Breastwalls			
		3	3
Greatest Height (m) : 3.10			
Wingwalls			
		5	5
[Total Number of Bearing Piles : 6:6]			
Piles Detail Ratings			
	N (count)	1 (count)	2 (count)
<b>Last</b>	0	0	2
<b>Now</b>	0	0	2
Piles			
		X	X
Paint/Coating			
Abutment Stability			
	3	3	Rotted and bulging piles.
Scour/Erosion			
	3	3	Undetermined and eroded at A2.




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Substructure - Inspection and Rating

## Piers

<b>Piers/Bents</b>				Caps changed in 1988.	
(Type : PIER-COLUMN)					
(Total Number of Caps/Corbels : 3-3)					
<b>Bearing Seats/Caps/Corbels Detail Ratings</b>					
	N (count)	1 (count)	2 (count)	3 (count)	
Last	0	0	0	0	
Now	0	0	0	0	
<b>Bearing Seats/Caps/Corbels</b>				6	6
(Type : TREATED TIMBER)					
(Depth(mm) : 300)					
(Width(mm) : 350)					
(Total Number of Bearing Piles : 5-5)				Wide cracks and outer fibers are bulging at west pier P5 and east pier - P2, P5. Remaining piles have wide cracks and suspect rot.	
<b>Piles Detail Ratings</b>					
	N (count)	1 (count)	2 (count)	3 (count)	
Last	0	0	2	8	
Now	0	0	3	7	
<b>Pier Shaft/Piles</b>				2	2
Greatest Height (m)				4.50	
Bracing/Struts/Sheathing				5	4
				Missing 1 bottom plank at P2 but allows for pile inspection.	
Nose Plate				4	4
				Stream has degraded below bottom of nose plates.	
Paint/Coating (Colour Description : )				X	X
(Colour Code : )				No paint on nose plate.	
<b>Pier Stability</b>				4	4
				Rot in pier piles.	
Scour				5	5
				Minor scour behind both piers.	
Debris (Y/N)				Yes	
				Old piles.	
<b>Substructure General Rating</b>				2	2




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Substructure - Inspection and Rating

## General Rating

- Governed by; refer to 1.10.3 and 8.15
  - Structural load carrying members
  - Caps/Seats ratings
  - Pile ratings
  - Backwall rating of 2 or less
  - Abutment and/or pier stability ratings
- The structural element ratings for both the abutments and piers must be taken into account when determining Substructure General Rating



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## Questions??



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