

# Determining the Capacity of Aged Assets

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# Focus of Presentation

- Develop assessment methodology
- Discuss how to determine structural demand on an aged facility
- Discuss how to determine structural capacity of an aged facility
- Repair/rehabilitation can be a next step
- Goal – Check Capacity  $\geq$  Demand

# Similar Assessments

- Civil – grading, paving, drainage, sanitary sewer
- Mechanical – fire protection (wet & dry), water
- Electrical – lighting, power
- Operations – facility layout

# Presentation Outline

- Develop Assessment Methodology
  - Assess Current Conditions
  - Determine Demand
  - Determine Capacity
  - Obtain Owner Agreement
  - Perform Analyses
- Apply Assessment Methodology

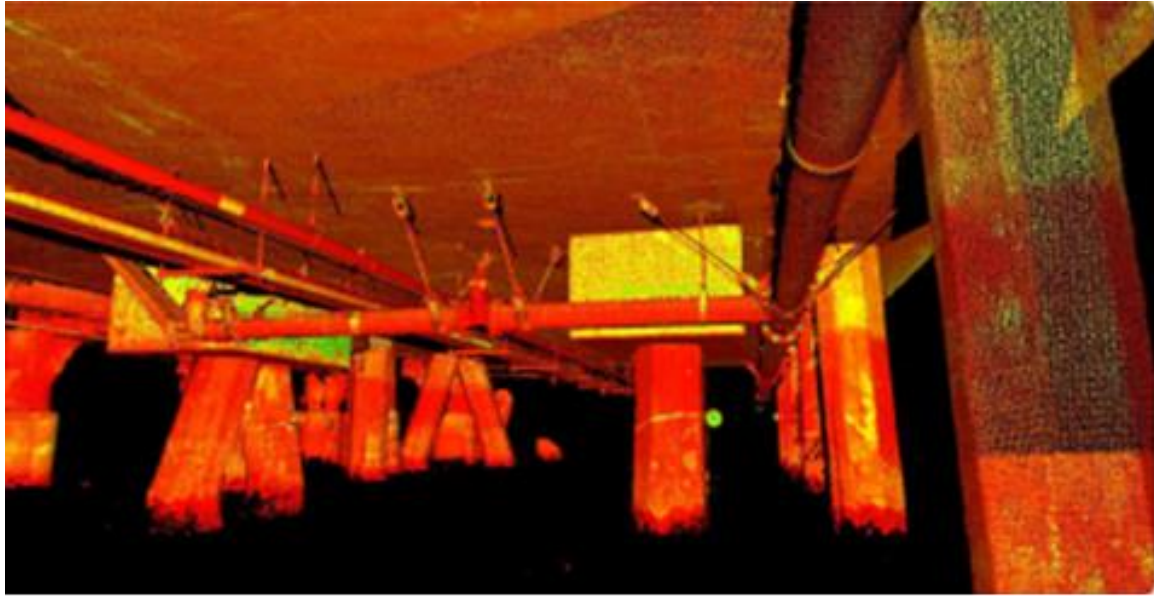
# Determine Current Conditions

- Perform record search
- Review document development
- Verify as-built conditions shown
  - Modifications made after facility built
  - Repairs made after facility built
  - Update plans for current conditions
- Construction tolerances not reflected
- Select guidelines for assessment

# Assess Current Conditions

- ASCE Waterfront Facilities Inspection & Assessment – Manual No. 130 (2015)
- Multiple levels of inspection/assessment
- Baseline inspection level –  
    Verify dimensions/details
- Structural repair inspection level –  
    Record defect attributes
- Underdeck and top of deck –  
    Consider a laser scan survey

# Assess Current Conditions





# Establish Demand

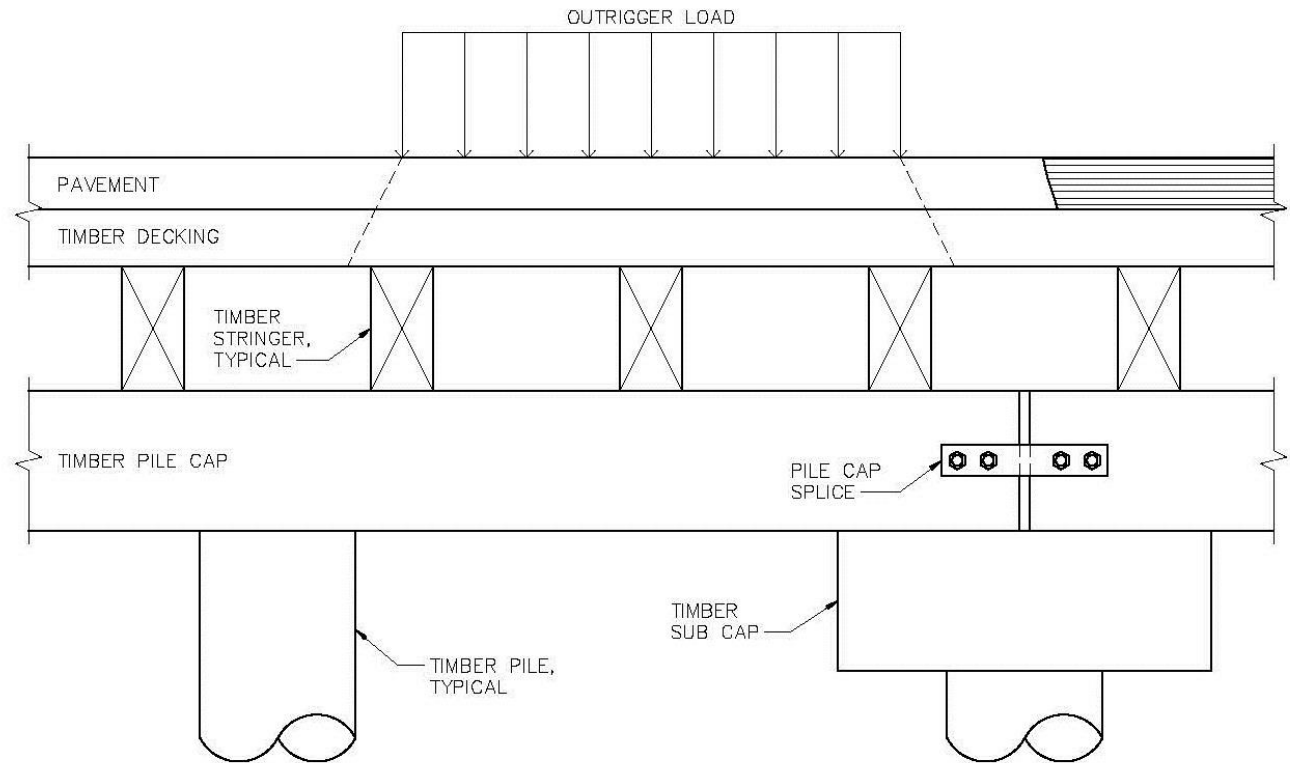
- Jointly – Engineer, Owner, Tenant(s)
- Establish present and future use(s)
- Why is the assessment being performed?
- Minor changes – methods, equipment
- Major changes – new container cranes  
cargo to amphitheater  
cargo to cruise ship facility
- How long will the facility be in use?
- Do operation methods vary with tenants?



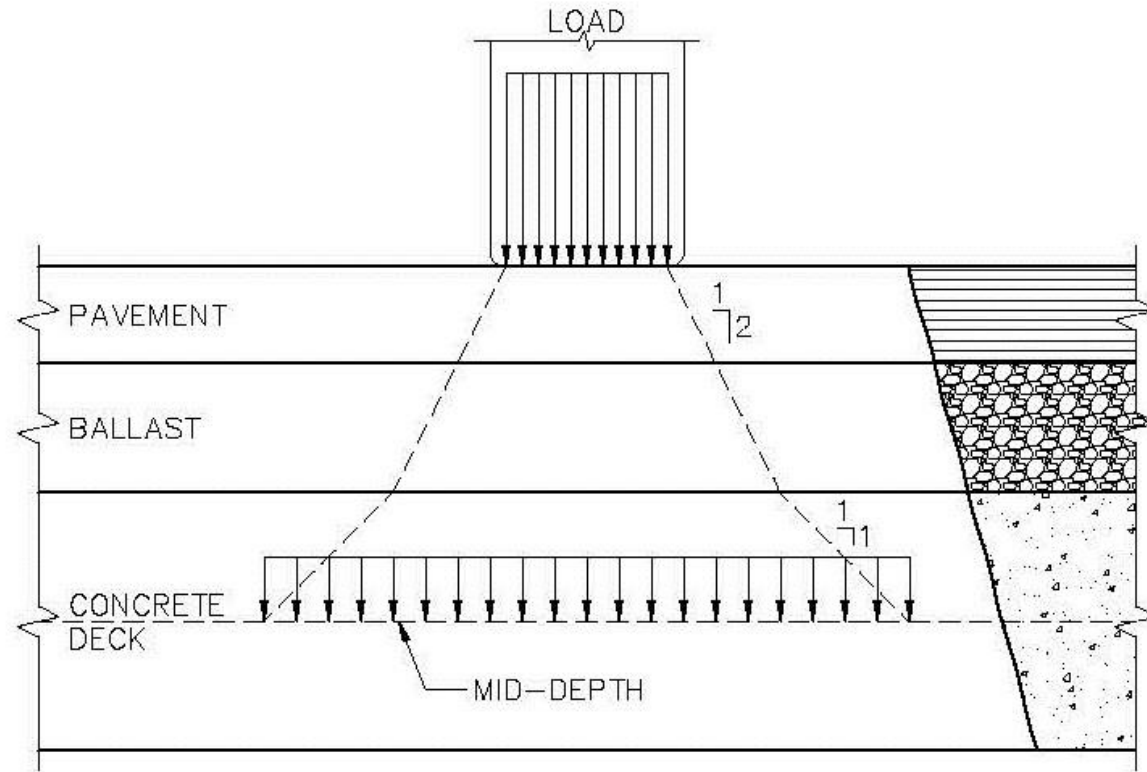
# Determine Demand

- Dead loads
- Concentrated live loads - equipment
- Uniform live loads – piles
- Berthing loads – ships, barges, other
- Mooring loads – wind, sail area, draft
- Seismic loads – a separate presentation
- ASCE 7-10 – Minimum Design Loads for Buildings and Other Structures
- AASHTO LRFD Bridge Design Specification, 7<sup>th</sup> Edition

# Determine Demand

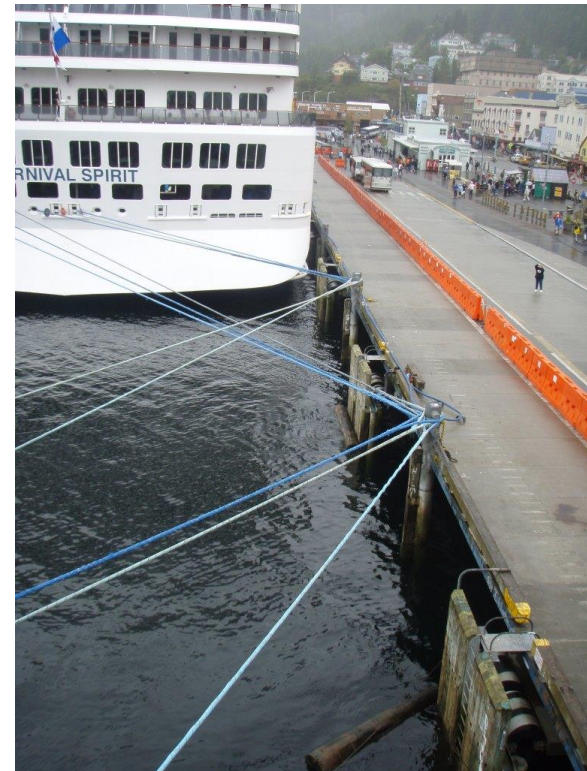


# Determine Demand



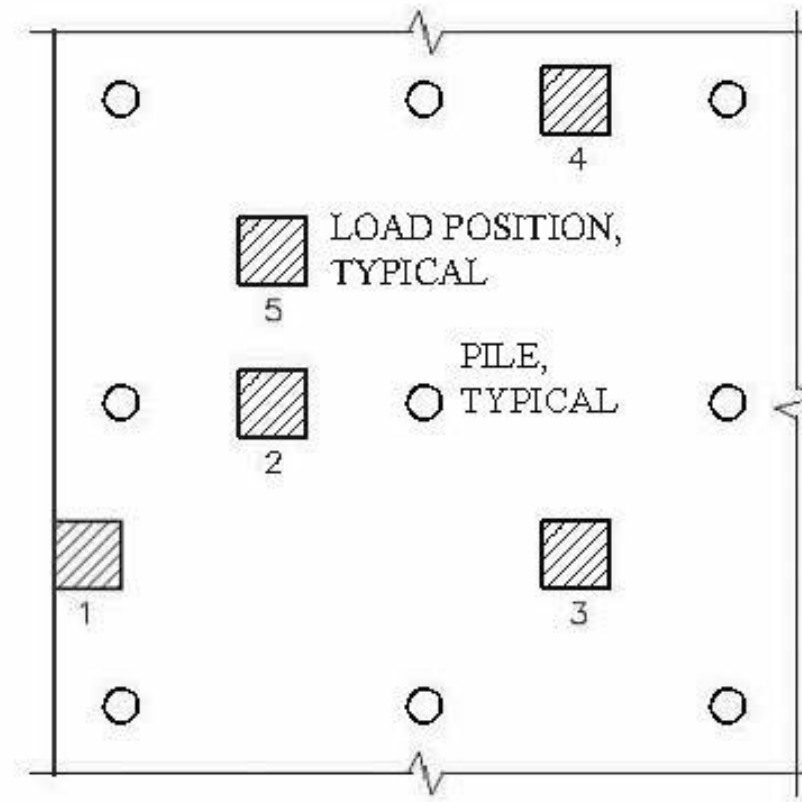
# Determine Demand

- Moving – vary location to maximize load
- Wind – direction/speed, draft, sail area
- Mooring – plan direction, elevation/angle
  - Multiple lines? Tended? Limit devices?



# Determine Demand

Position – maximum moment (shear similar)



# Determine Demand

- Goal – assess for operating conditions
- Goal – check for extreme conditions
- Try to avoid assessment controlled by extreme conditions
- Give structural elements all available “credits”

# Determine Capacity

- Combine codes & standards –  
    Use provisions from different sources?  
    Load factors and phi factors?
- Note – building codes have shortcomings if used to evaluate marine structures
- Need engineering judgement when outside of recognized codes & standards
- Codes & standards – AASHTO, ACI, AREMA, ASCE, Calif. Building Code 31f, PIANC, UFC

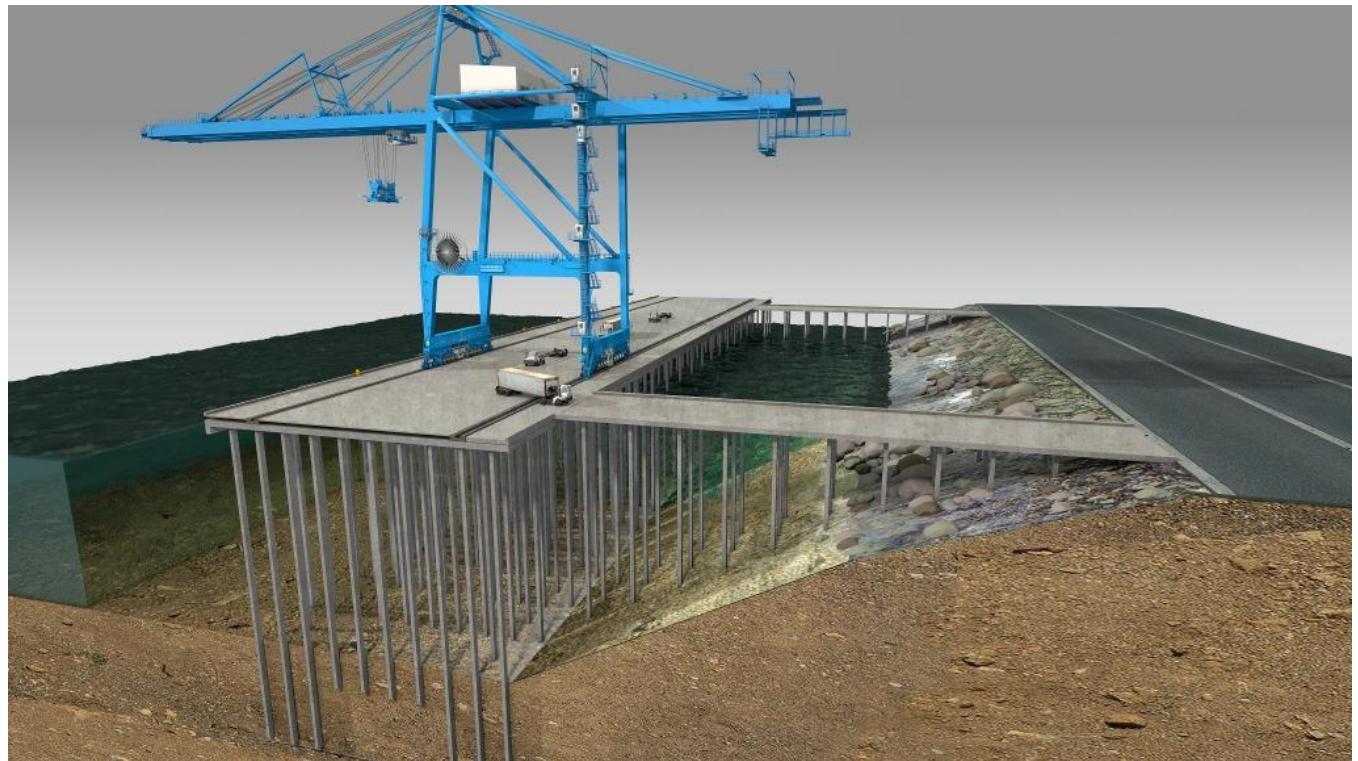


# Determine Capacity

- International Building Code – 2012 IBC – Section 3405
- Building and non-building structures
- Jurisdiction having authority?
- Does jurisdiction have expertise?
- Corrosion/deterioration prevention in aggressive environment often secondary
- Example - pan joist system, many edges

# Determine Capacity

- Wharf does not behave like a building – judgement needed if using building code



# Determine Capacity

- International Existing Building Code – 2012 IEBC
- Building-related, but some guidance
- Many existing structures do not comply with current codes
- Rehabilitation often cost-prohibitive
- “Controlled departure” option from code?

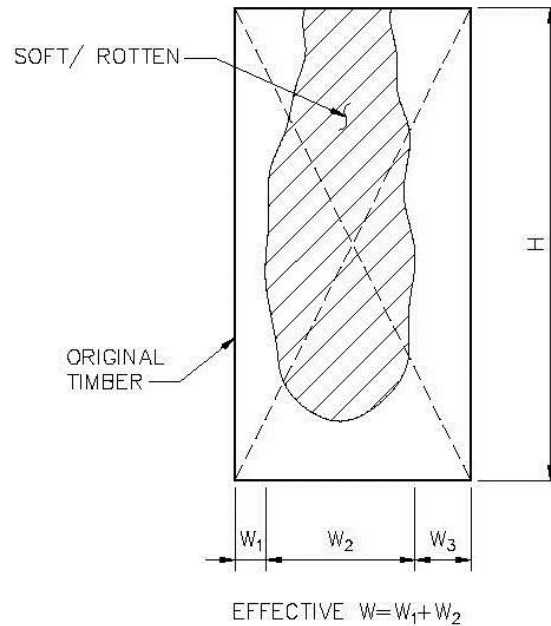
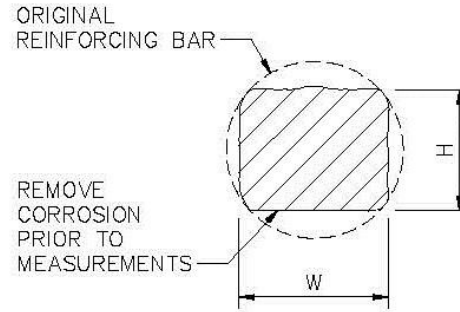
# Determine Capacity

- Use accepted material properties for operating loads – “realistic”
- Consider higher values in earlier codes
- Consider higher material properties for extreme loads – “controlled departure”
- Timber properties – conservatively established, often have reserve capacity
- Concrete properties – probabilistic basis
- Steel properties – expected properties

# Determine Capacity

- Assess timber deterioration
  - Visual, sounding, thermal imaging
  - Drilling – select locations
- Assess reinforced concrete deterioration
  - Concrete section
  - Corroded reinforcement, P/S strand
- Assess steel deterioration
  - Visual – calipers, scales
  - Ultrasonic – various technologies

# Determine Capacity



# Determine Capacity

- Account for deterioration processes  
Example - volumetric expansion
- Establish rate of deterioration
- Reactions can take time to lower capacity
- Example – decision to install jackets on 30-year old piles due to “traces of DEF”



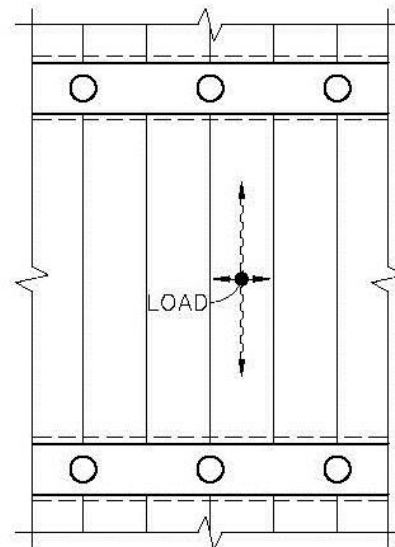
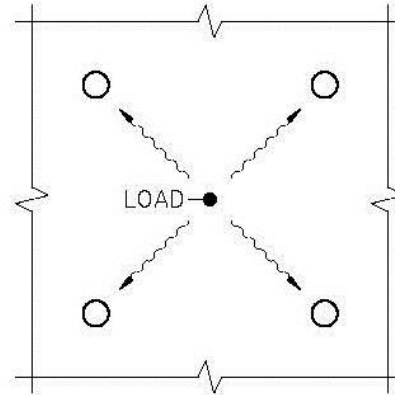
# Determine Capacity

- Selection of load factors (LF) - uncertainty
- Want to select appropriate LF
- Consider normal loads versus extreme loads
- Example – crane outrigger, tipping based
- Port –  $LF=1.3$  on outrigger load
- UFC – currently  $LF=1.6$  on outrigger load, proposed change to  $LF=1.3$

# Determine Capacity

- Account for sequence of construction  
Shows how load introduced when built  
Locked-in stresses decrease over time?
- Account for phased construction over time
- Structural system difference(s) affects how load was distributed within structure
- Example – cast-in-place concrete deck versus precast concrete deck panels

# Determine Capacity



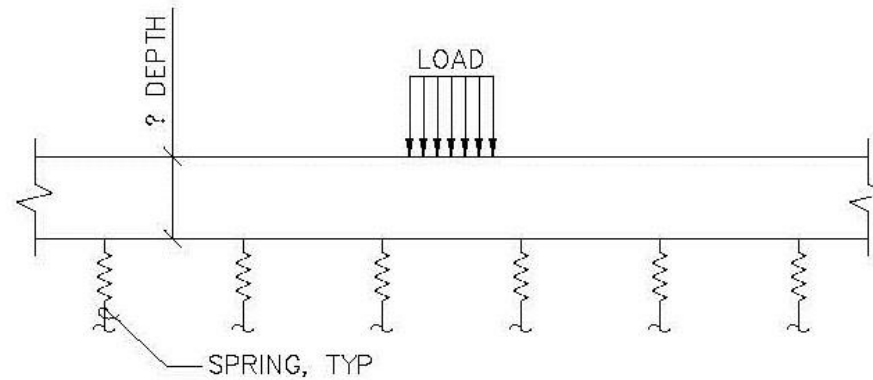
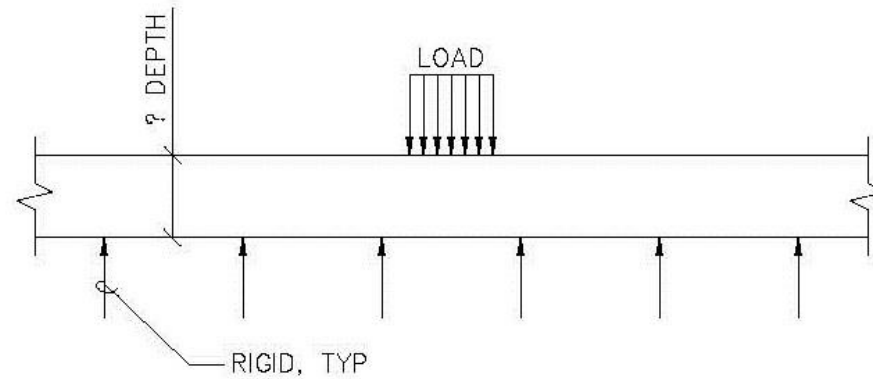
# Obtain Owner Agreement

- Develop basis of design – larger projects
- Meet with Owner and Tenant(s)
- Explain assessment approach
  - Loads discussed earlier
- Identify risks
- Consider limitations
- Reach agreement with Owner & Tenant(s)
- Create memorandum of understanding

# Perform Analyses

- Select applicable technique(s)
- Consider materials and construction
- Methods can vary – simple to complex
- Staged or phased construction – account for history of changes in load path
- Historical – analyses less sophisticated
- Current – analyses more sophisticated, more capacity used (less “reserve”?)

# Perform Analyses



# Perform Analyses

- Serviceability generally governs design of marine facilities except for seismic
- Exceptions sometimes based on life expectancy
- Example – berthing/mooring, 5-year life
  - No coating on steel elements
  - Lower wind speed based on direction
  - Controlled departure from allowables



# Perform Analyses

- Pile capacity versus time
- Timber – maintenance program slows decrease
- Steel – decrease unlikely if coated (above water) and CP system present and active (below water) in salt water
- Concrete – often little or no decrease, adequate cover and lack of damage or lack of deterioration process

# Apply Assessment Methodology

- Presentation of capacity most important  
Figures, tables, factors of safety
- Use of methodology best demonstrated  
by application to existing facilities
- 1 – Timber pier, varying live loads
- 2 – Concrete wharf, slope modifications
- 3 – Concrete pier, proposed large crane

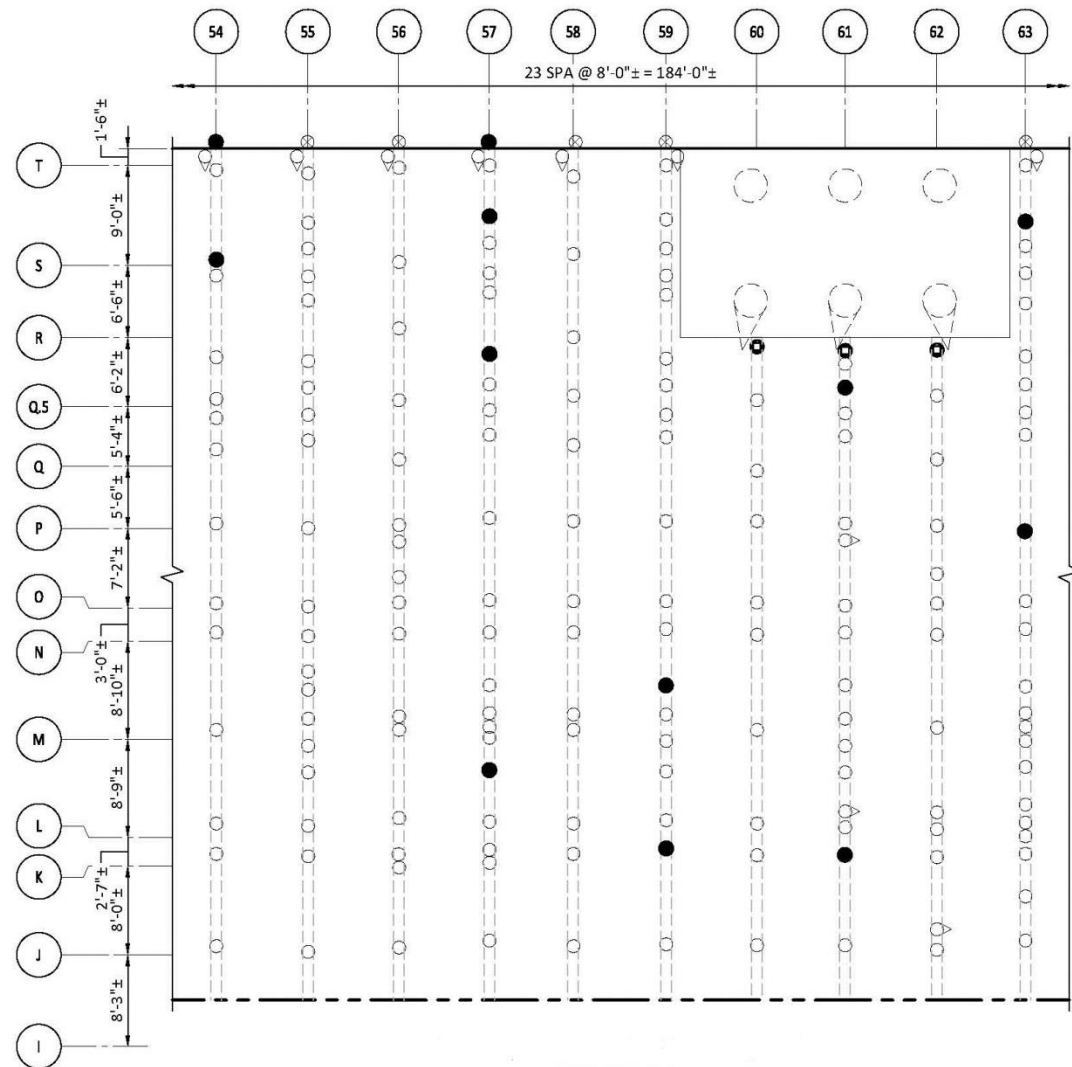
# Apply Assessment Methodology

- Example 1 – Timber Pier
- Existing timber piles and system deck
- Concern - existing load rating charts not usable by equipment operators
- Loads determined with owner & tenant(s)
- Facility inspected, repairs performed
- Provide single composite plan of ratings/locations to equipment operators

# Apply Assessment Methodology

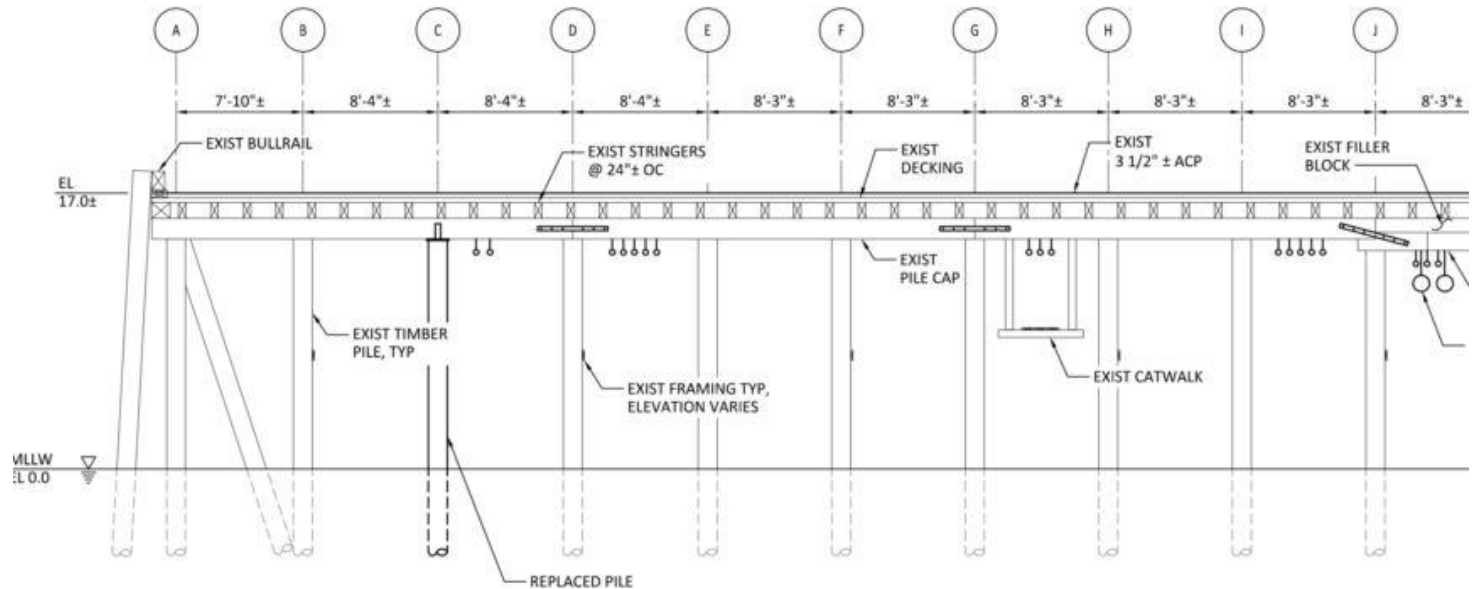


# Apply Assessment Methodology

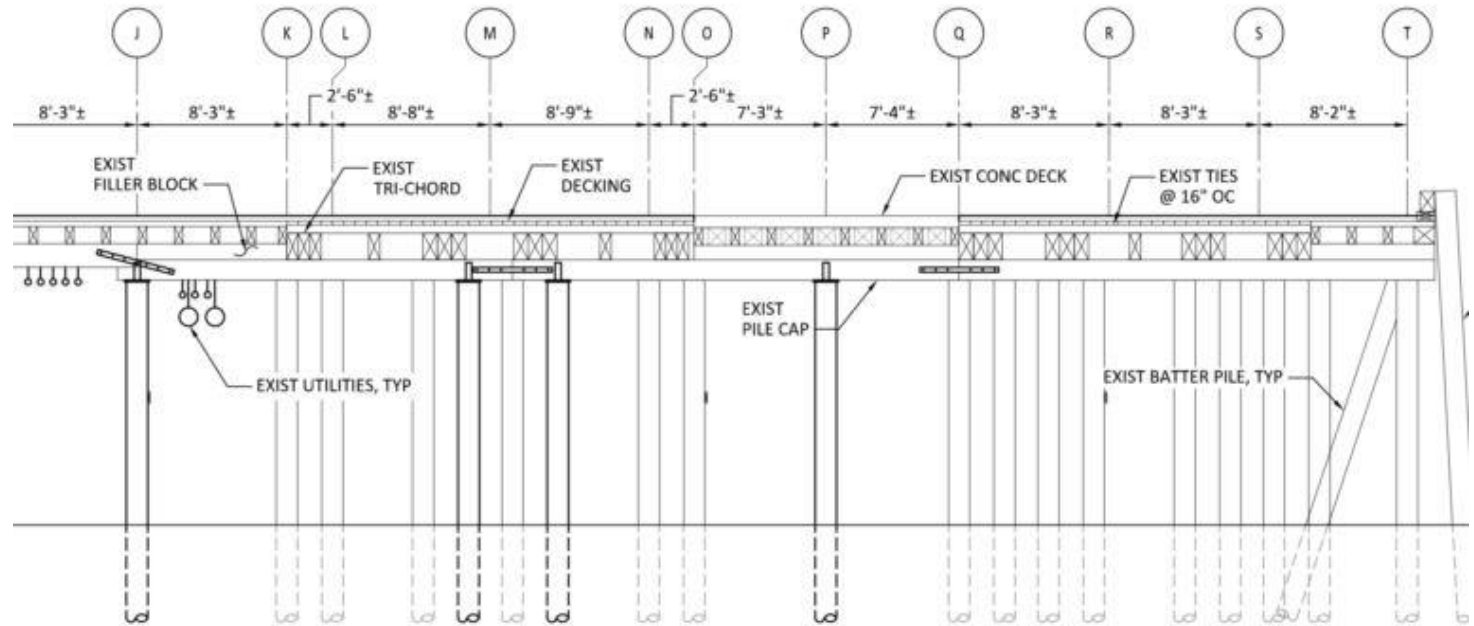




# Apply Assessment Methodology



# Apply Assessment Methodology





# Apply Assessment Methodology

## ALLOWABLE LOADS

1. TERMINAL 1 ALLOWABLE LOADS REPRESENT THE CAPACITY OF THE STRUCTURE AFTER PROJECT REPAIRS ARE COMPLETE.

2. DEAD LOADS: ACTUAL WEIGHT OF ALL MATERIALS

3. UNIFORM LIVE LOADS, SEE TABLE 1, AND  $\frac{1}{-}$

**TABLE 1**

ZONE	ALLOWABLE UNIFORM LOADS (PSF)	4-TON FORKLIFT	HS-25 TRUCK
1	500	YES	YES
2	500	YES	YES
3	600	YES	YES
4	600	YES	YES
5	200	NO	NO
6	200	YES	YES
7	250	YES	YES

4. CONCENTRATED LIVE LOADS, SEE TABLE 2, AND  $\frac{1}{-}$

**TABLE 2**

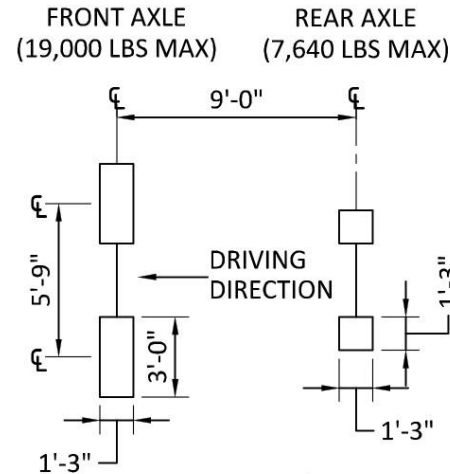
ALLOWABLE POINT LOADS (LBS)					
ZONE	POINT LOAD SIZES				
	18"x18"	24"x24"	36"x36"	48"x48"	6'x12' (d)
1	18,700	28,800	35,500	40,000	52,000
2	18,900	66,400	66,400	66,400	152,300
3	17,800	21,700	30,100	39,100	99,200
4	26,600	35,000	55,000	83,700	99,200
5	SEE (a)	SEE (a)	SEE (a)	SEE (a)	SEE (a)
6	17,100	19,700	27,200	35,000	SEE (b)
7	SEE (c)	SEE (c)	SEE (c)	SEE (c)	SEE (c)

### NOTE

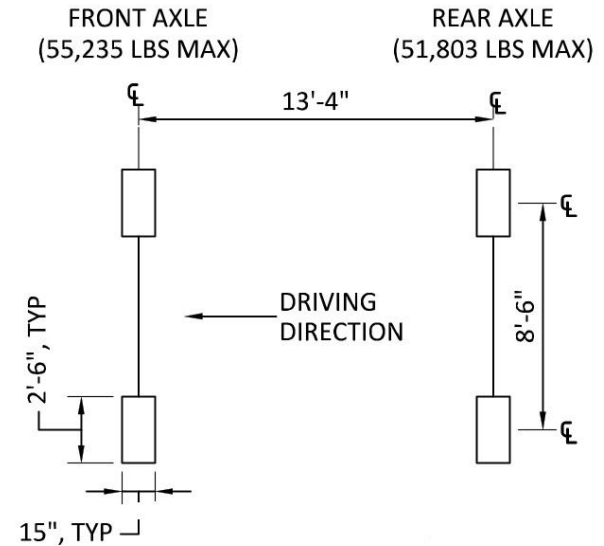
- NO POINT LOADS ALLOWED.
- ALLOWABLE POINT LOADS FOR 6'x12' TIMBER MATS HAVE NOT BEEN DETERMINED FOR ZONE 6.
- ALLOWABLE POINT LOADS WERE NOT DETERMINED FOR THIS ZONE.
- FOR 6'x12' POINT LOADS, SEE  $\frac{2}{-}$

# Apply Assessment Methodology

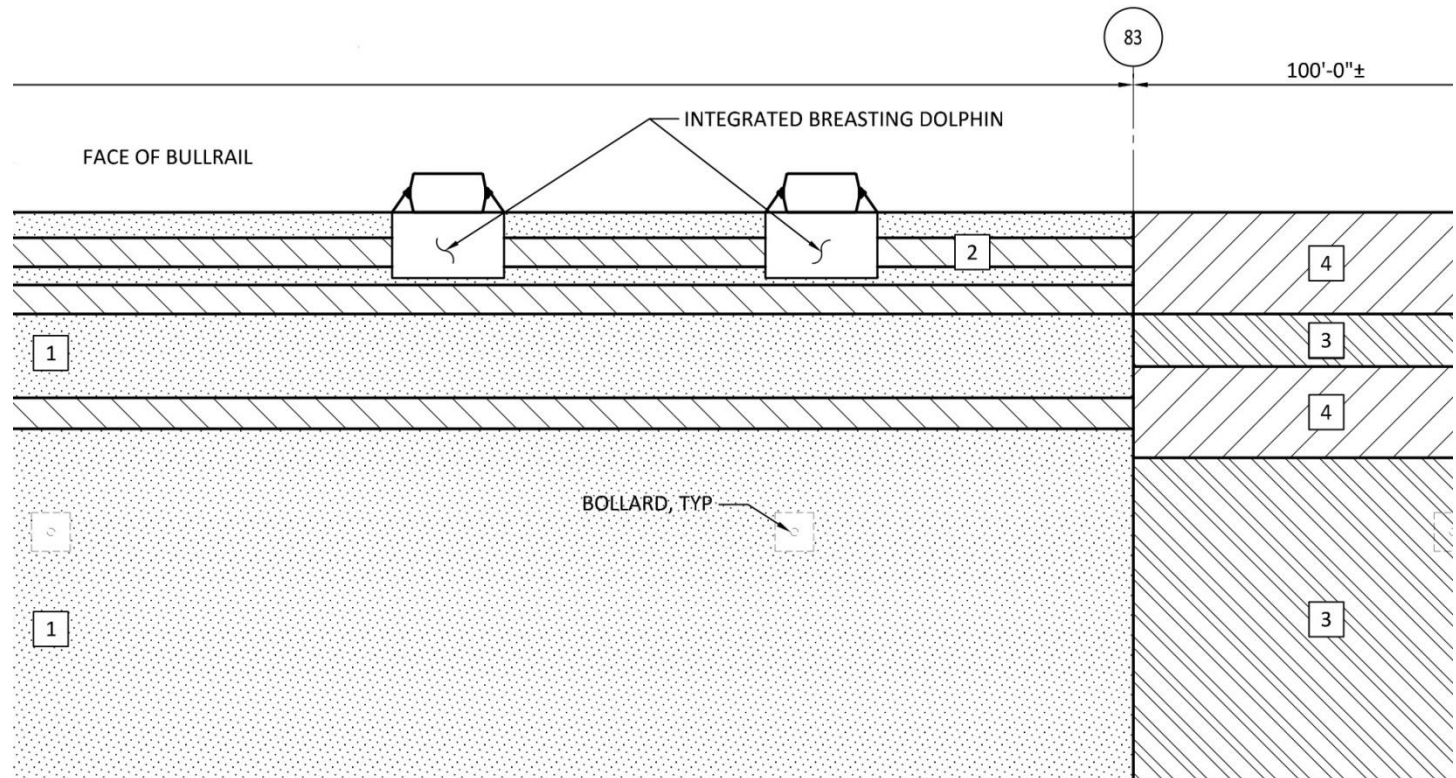
4-TON FORKLIFT



CRANE



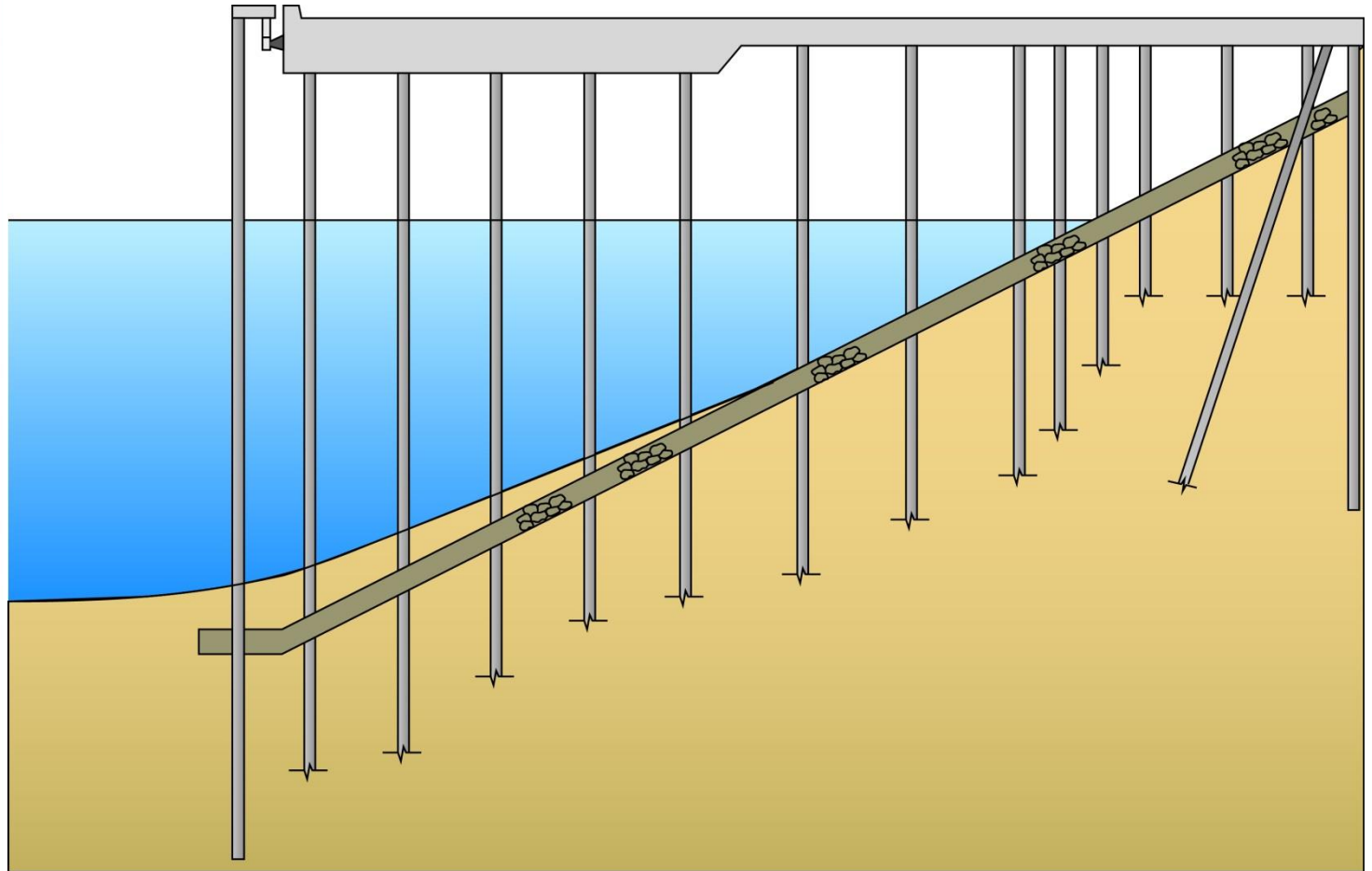
# Apply Assessment Methodology



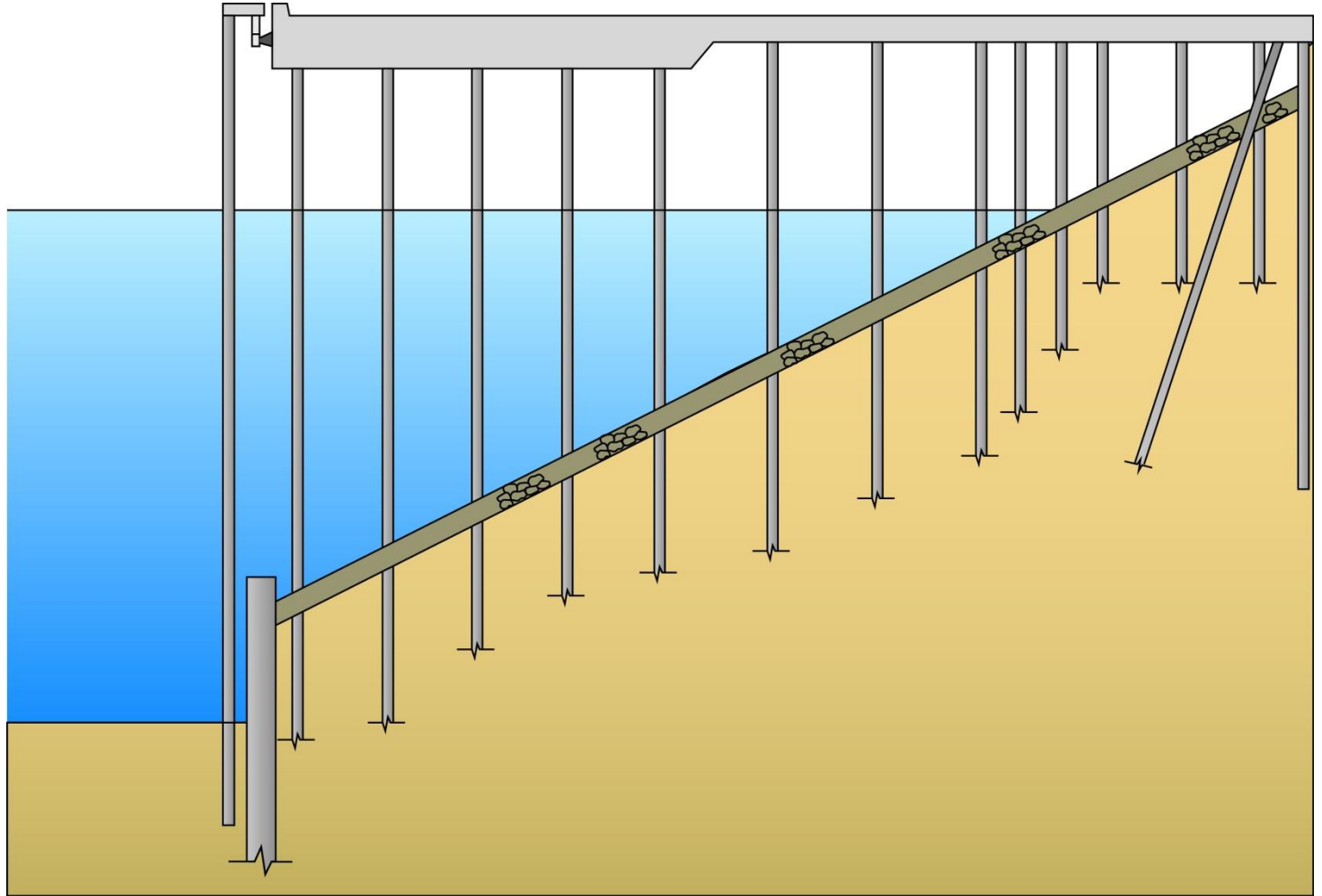
# Apply Assessment Methodology

- Example 2 – Slope at Concrete Wharf
- Dredging for deeper draft vessels
- Proposed construction – dredge, install underwater wall, densify soil as needed
- Concern – slope stability
- Establish factor of safety (FOS) for slope
- Goal – work does not decrease FOS
- Note – sometimes  $FOS < 1$  (seismic)

# Apply Assessment Methodology



# Apply Assessment Methodology





# Apply Assessment Methodology

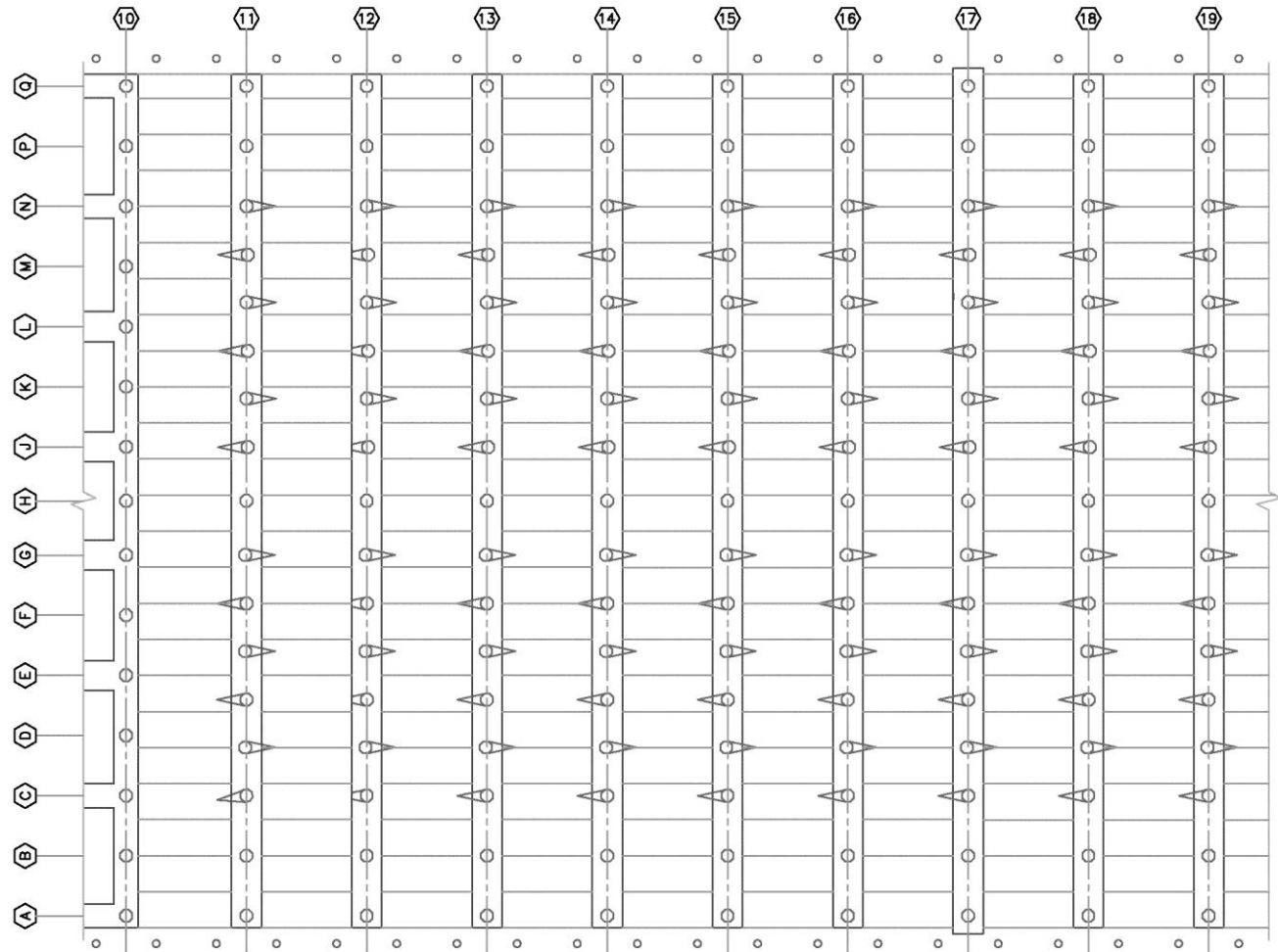
- Example 3 – Concrete Pier
- Existing structure consisting of precast deck panels on cast-in-place concrete pile caps and piles
- Issue - owner needed larger mobile crane on pier for heavy load handling
- Chart of load versus radius showing load handling limits to operators



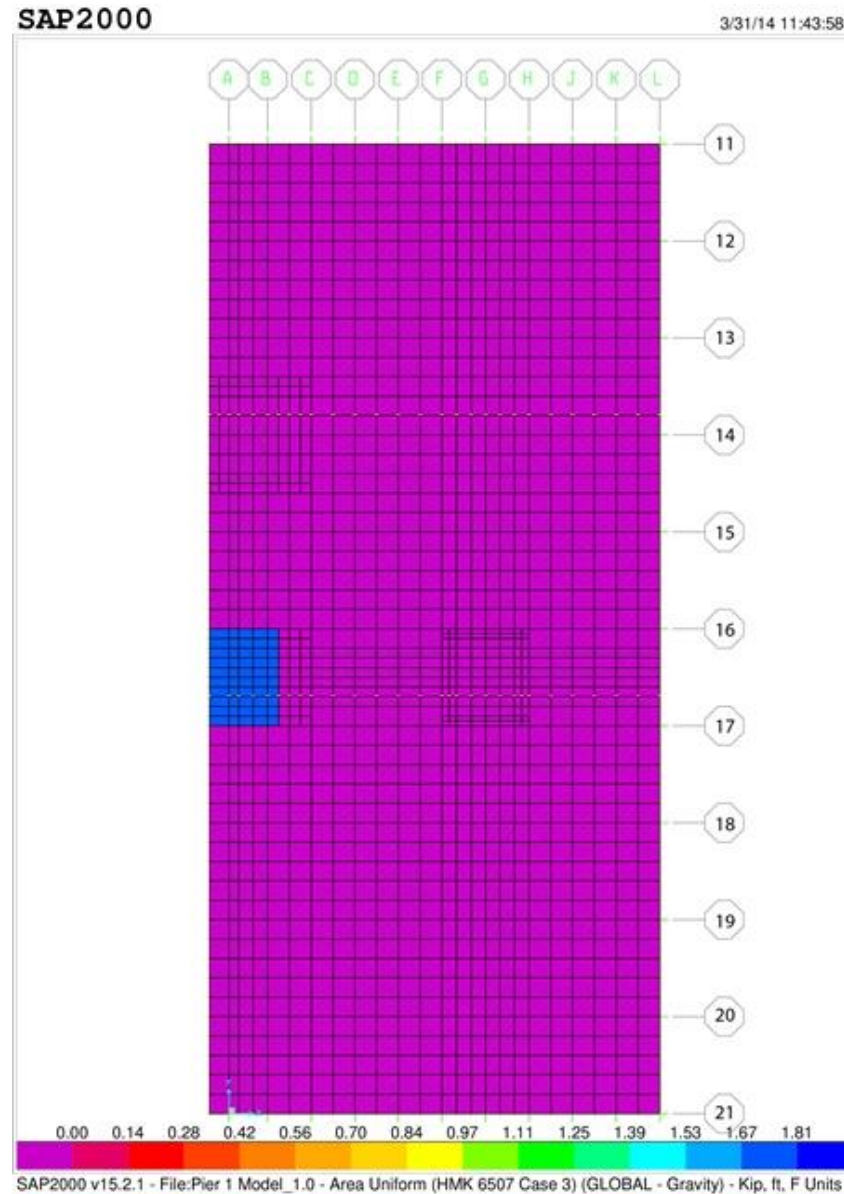
# Apply Assessment Methodology



# Apply Assessment Methodology



# Apply Assessment Methodology



# Apply Assessment Methodology

SAP2000

4/1/14 13:50:51

22.1 k-ft/ft  
4.5k-ft/ft  
-4.8k-ft/ft

BENT 16  
BENT 17

-54. -36. -18. 0. 18. 36. 54. 72. 90. 108. 126. 144. 162. 180.

SAP2000 v15.2.1 - File:Pier 1 Model\_1.0 - Resultant M22 Diagram (HMK 6507 Case 3) - Kip, ft, F Units



# Apply Assessment Methodology

HMK 290E Maximum Gross Pick Capacity			
Pick Radius (meters)	Pick Radius (ft)	Capacity (metric tons)	Capacity (short tons)
20	65.6	44	48
21	68.9	44	48
22	72.2	44	48

48	157.5	9	9
49	160.8	8	8
50	164	7	7

\* Gross = Weight of box plus contents.

Maximum Spreader Weight = 9.4 metric tons (22,700 lbs.)

## Operational Requirements

- Single outriggers only will be used
- Single outriggers will be 2 meters by 4.5 meters (6.56 feet by 14.76 feet)
- All outriggers are fully extended
- The adjustable spreader weighs 9.4 metric tons (10.4 short tons)
- Allowable loads, including spreader weight, will not exceed the Gottwald published radius/load rating for general cargo operation with a 1.5 tipping safety factor (66 percent)

# Conclusions

- Multiple approaches available to determine capacity of aged assets
- Accurately describe asset conditions
- Determine demands
- Determine capacities
- Obtain owner and tenant(s) agreement
- Perform analyses – Capacity  $\geq$  Demand?
- Provide results in a usable format

Single plan if possible

# Thanks

- Kim Crow
- Mike Dodson
- Daryl English
- Joe Galloway
- TJ Schilling
- Elmer Ozolin