"Structural Design of the Marine Terminal"

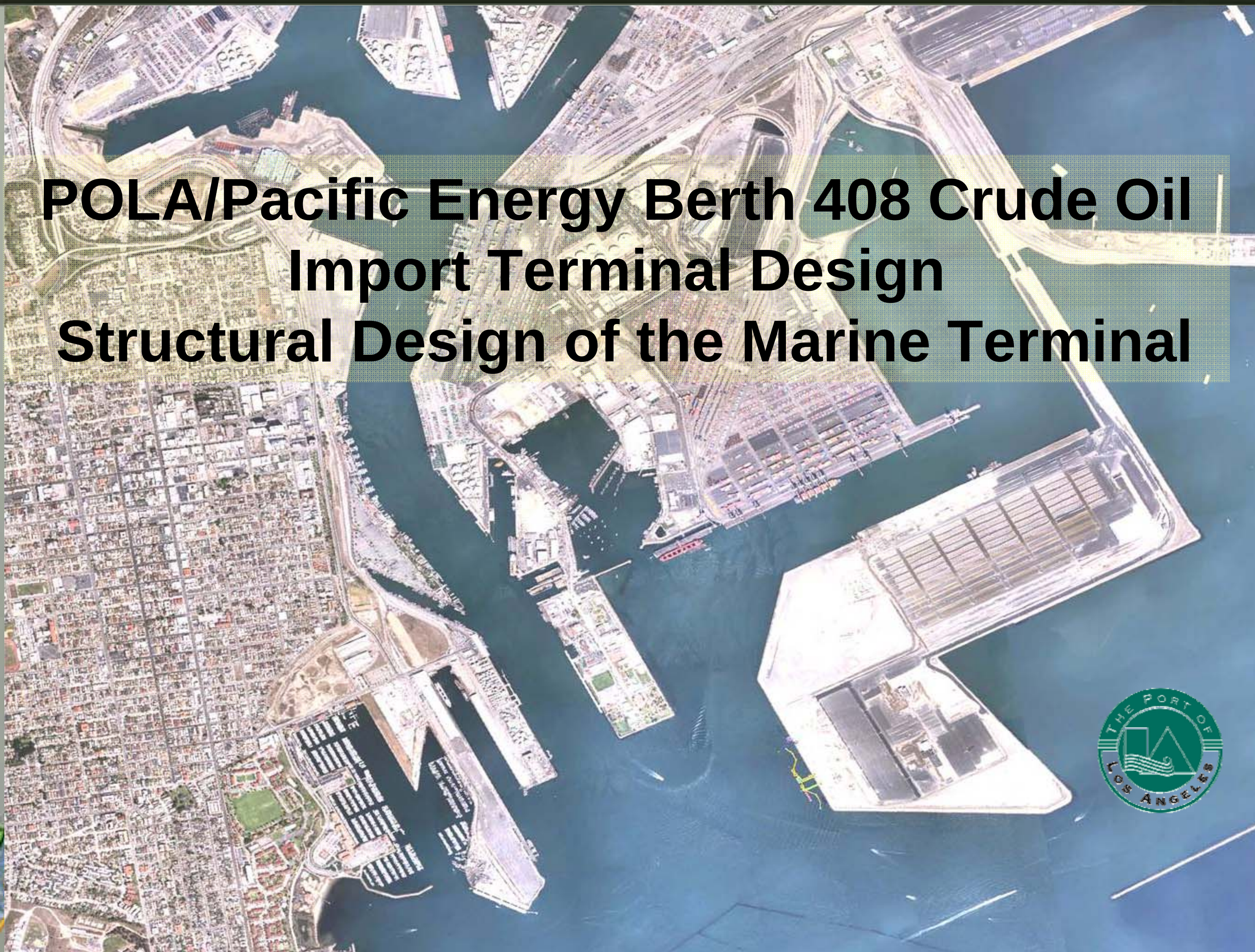
Prevention First 2006

September, 2006

Long Beach, CA

Angel Lim, S.E. & John Posadas, P.E.

Berth 408 Crude Oil Import Terminal



POLA/Pacific Energy Berth 408 Crude Oil Import Terminal Design
Structural Design of the Marine Terminal

OUTLINE

- ❑ Unique Features
- ❑ Facility Description
- ❑ Structural Design per MOTEMS
- ❑ Mooring & Berthing per MOTEMS
- ❑ Structural Details
- ❑ Design Innovation

Unique Features

- 1st New Oil Terminal Designed to MOTEMS
- Designed to meet new MOTEMS and POLA Seismic Code
- 81 ft of water depth
- Designed to accommodate VLCC's
- 3-D analysis between structure and pipes

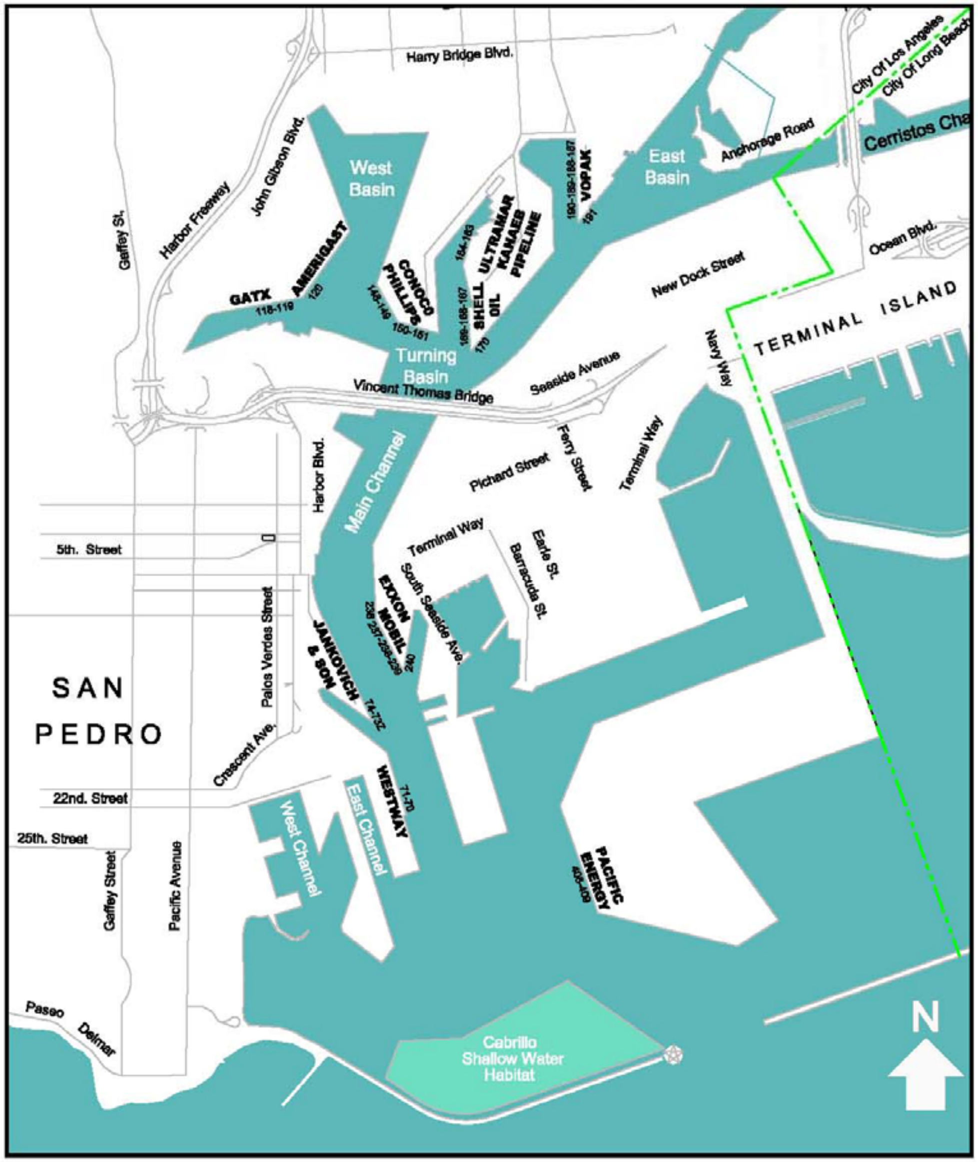
Facility Description

- POLA Map
- Faults
- Structural Components

POLA Map

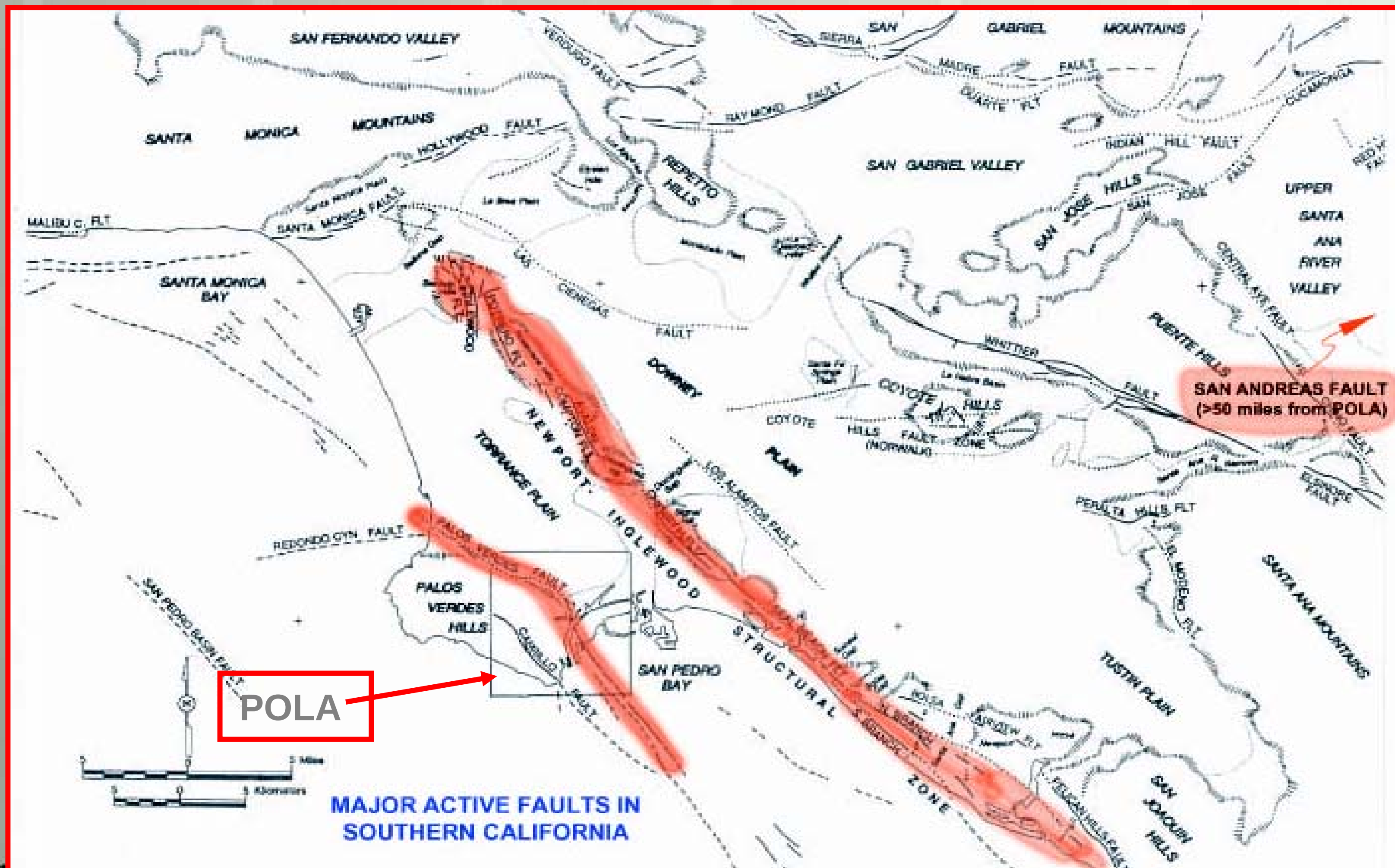
STRUCTURAL DESIGN OF THE MARINE TERMINAL

POLA Map

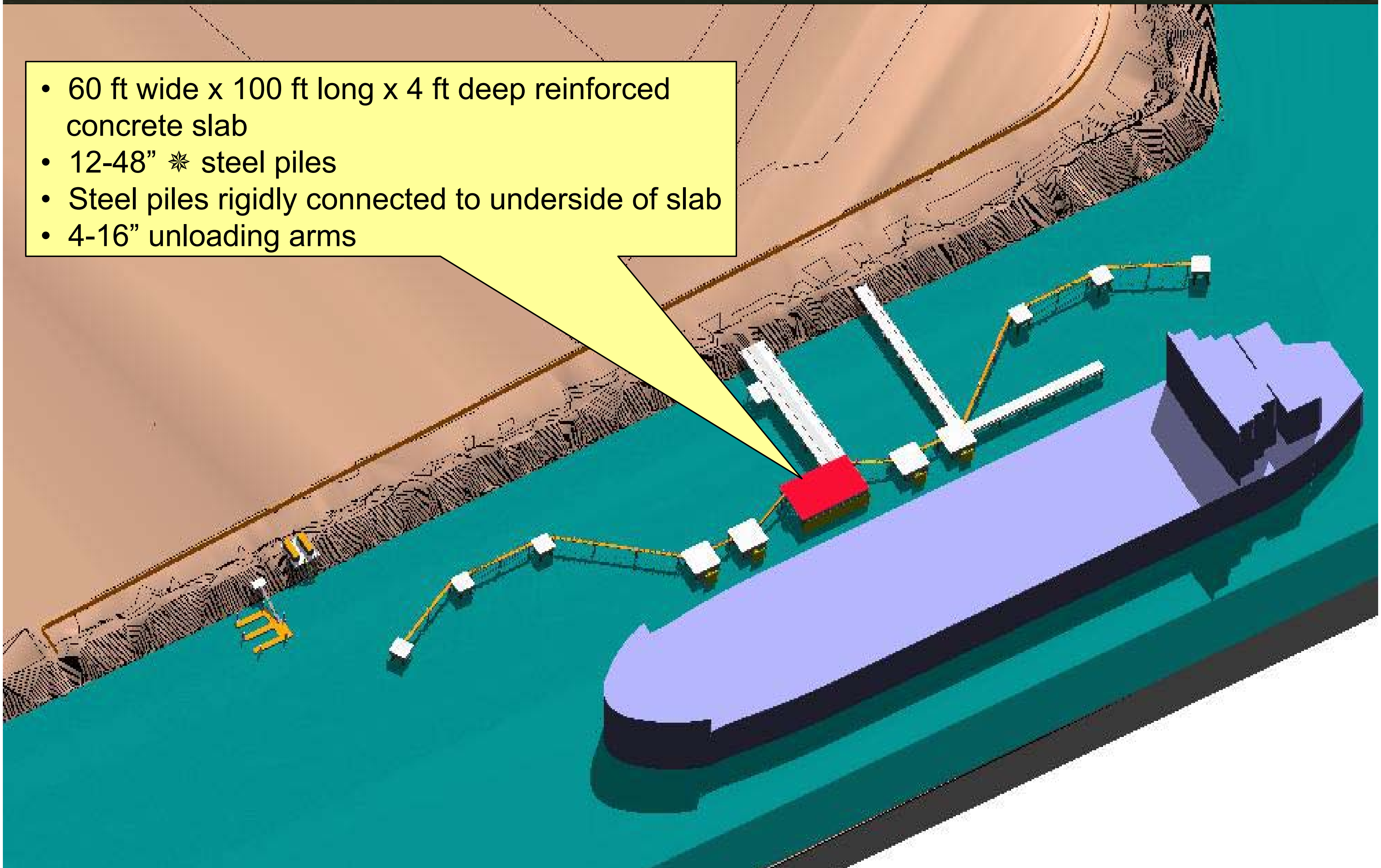


Harry Bridge Blvd.
West Basin
East Basin
Anchorage Road
City Of Los Angeles
City Of Long Beach
Cerritos Cha
Gaffey St.
Harbor Freeway
John Gibson Blvd.
GATX
118-119
AMERIGAST
120
CONOCO PHILLIPS
145-149
150-151
SHELL OIL
165-166-167
ULTRAMAR KANAES PIPELINE
164-163
VOPAK
187
Ocean Blvd.
New Dock Street
TERMINAL ISLAND
Navy Way
Turning Basin
Vincent Thomas Bridge
Seaside Avenue
Ferry Street
Terminal Way
Pichard Street
Main Channel
Harbor Blvd.
5th. Street
Terminal Way
Earle St.
Barracuda St.
South Seaside Ave.
EXXON MOBIL
Palos Verdes Street
JANKOVICH & SON
SAN PEDRO
Crescent Ave.
22nd. Street
25th. Street
WESTWAY
West Channel
East Channel
PACIFIC ENERGY
Gaffey Street
Pacific Avenue
Paseo Delmar
Cabrillo Shallow Water Habitat
N

Faults in Southern California

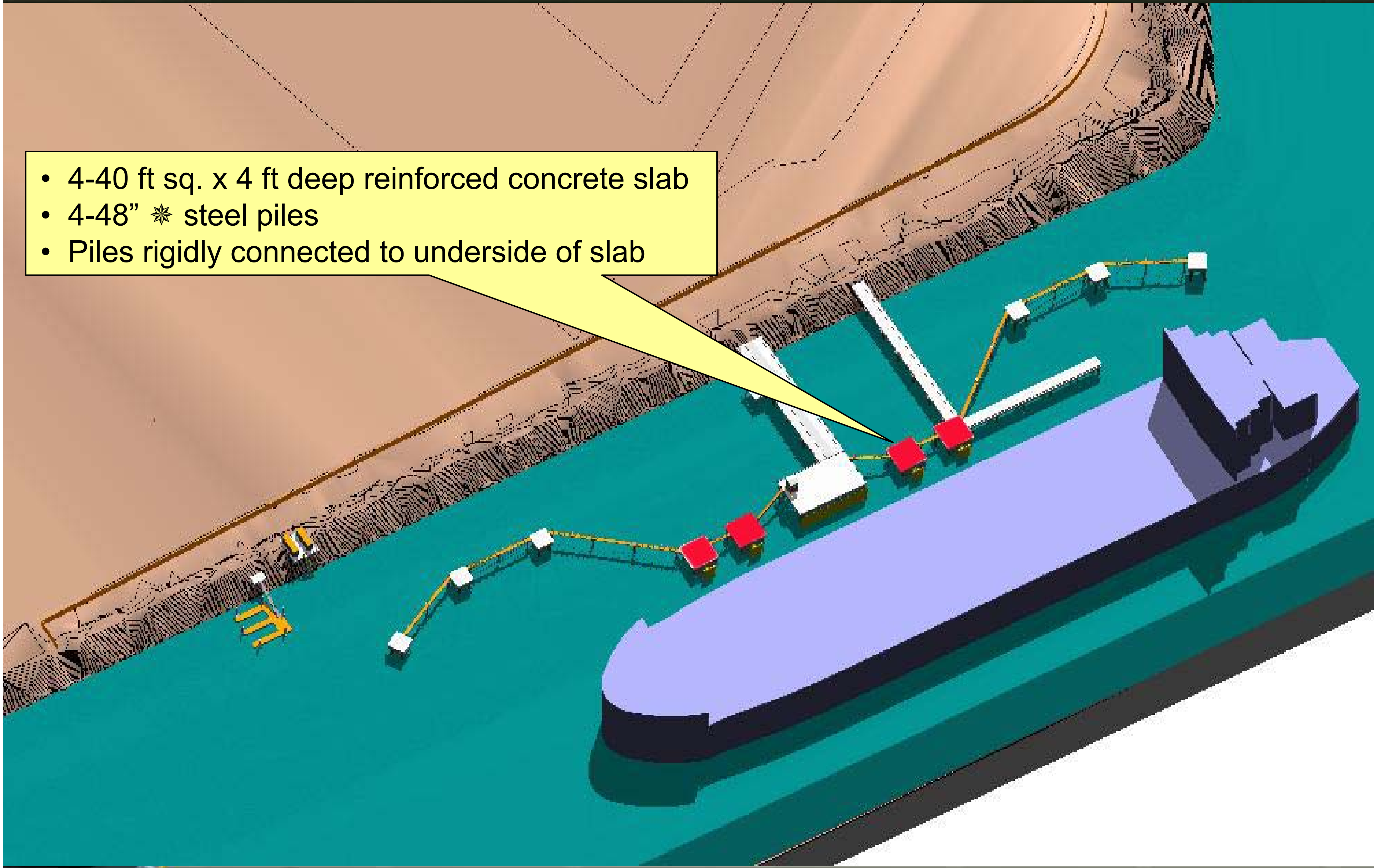


Structural Component - Unloading Platform



- 60 ft wide x 100 ft long x 4 ft deep reinforced concrete slab
- 12-48” ✵ steel piles
- Steel piles rigidly connected to underside of slab
- 4-16” unloading arms

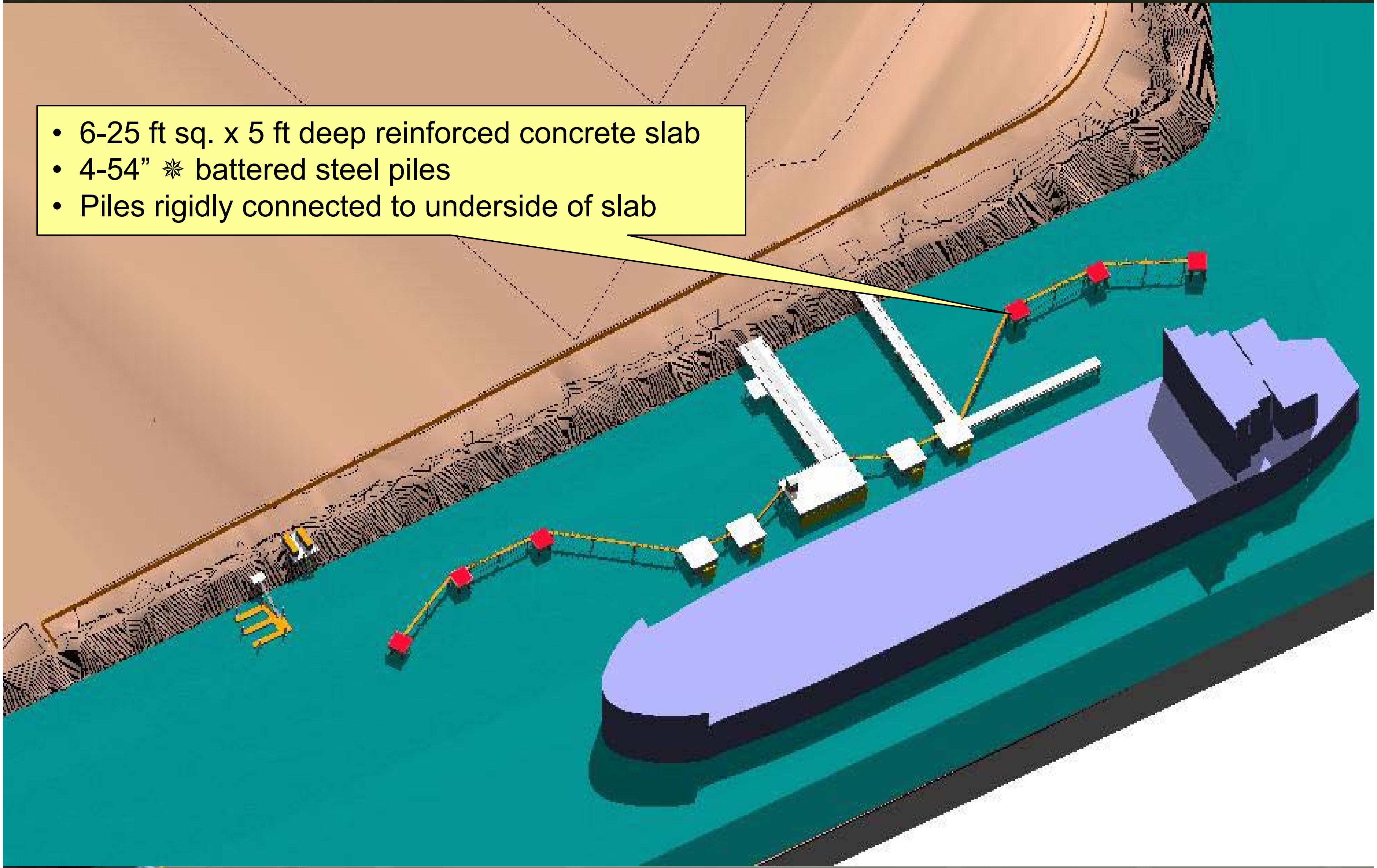
Structural Component - Breasting Dolphin



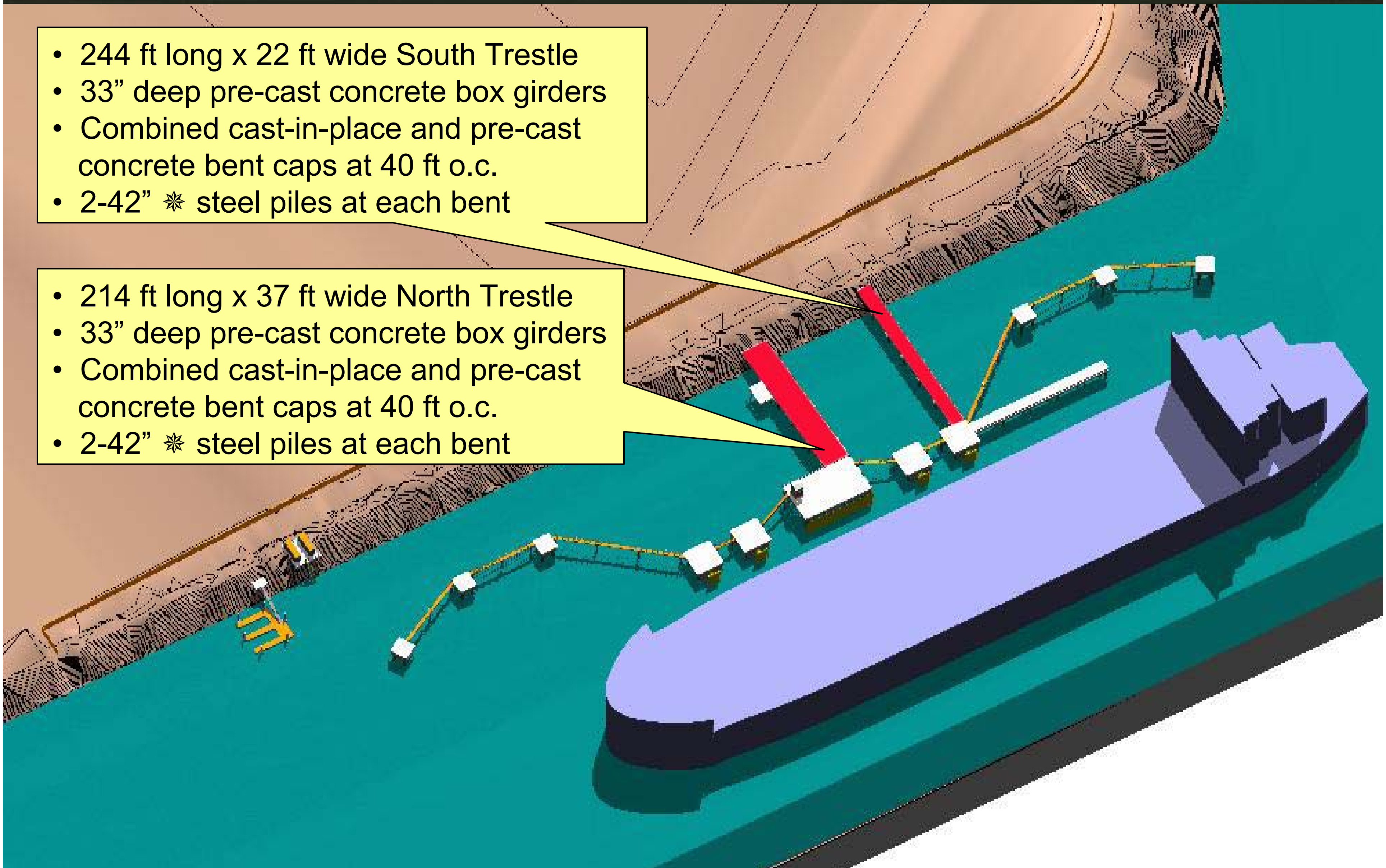
- 4-40 ft sq. x 4 ft deep reinforced concrete slab
- 4-48" ❈ steel piles
- Piles rigidly connected to underside of slab

Structural Component - Mooring Dolphin

- 6-25 ft sq. x 5 ft deep reinforced concrete slab
- 4-54" ⌀ battered steel piles
- Piles rigidly connected to underside of slab



Structural Component - North & South Trestles



Structural Design per MOTEMS

- MOTEMS Risk Classification
- Seismic Performance Criteria
- Minimum Required Analytical Procedure

MOT Risk Classification

TABLE 31F-4-1 MOT RISK CLASSIFICATION			
Risk Classification	**Exposed Oil (bbls)**	**Transfers per Year per Berthing System**	**Maximum Vessel Size (DWTx1000)**
High	≥1200	N.A.	N.A.
Moderate	<1200	≥90	≥30
Low	<1200	<90	<30

Purpose is to establish minimum seismic analysis and structural performance.

Structural performance is evaluated at a two level criteria:

Level 1 and Level 2

MOTEMS risk classification (Table 31-F-4-1)

All new MOTS are classified as high risk.

1. Exposed oil ≥ 1200 bbls

MOTEMS Seismic Performance Criteria

TABLE 31F-4-2
SEISMIC PERFORMANCE CRITERIA

Risk Classification	Seismic Performance Level	Probability of Exceedance	Return Period
High	Level 1	50% in 50 years	72 years
	Level 2	10% in 50 years	475 years
Moderate	Level 1	65% in 50 years	48 years
	Level 2	15% in 50 years	308 years
Low	Level 1	75% in 50 years	36 years
	Level 2	20% in 50 years	224 years

<u>Design Earthquake Motions:</u>

Level 1

- Minor or no structural damage
- Temporary or no interruption in operations

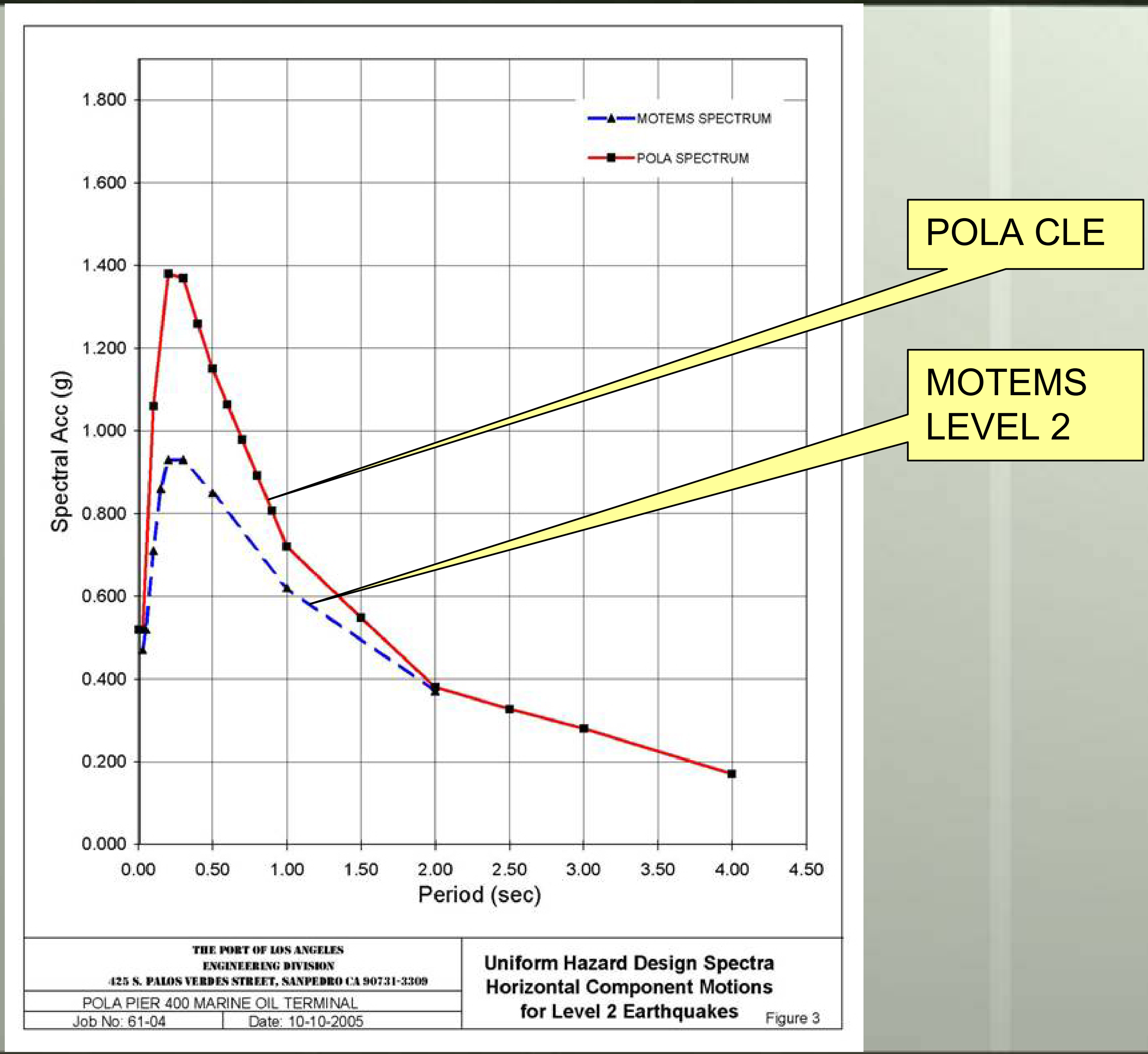
Level 2

- Controlled inelastic structural behavior with repairable damage
- Prevention of structural collapse
- Temporary loss of operations, restorable within months
- Prevention of major spill (≥ 1200 bbls)

<u>Seismic Performance Criteria:</u>

Select:	High risk classification:	
Seismic Performance Level:	Level 1	Level 2
Probability of Exceedance:	50% in 50 years	10% in 50 years
Return Period:	72 years	475 years

Response Spectra



MOTEMS Minimum Required Analytical Procedures

TABLE 31F-4-3 MINIMUM REQUIRED ANALYTICAL PROCEDURES				
Risk Classification	**Configuration**	**Substructure Material**	**Displacement Demand Procedure**	**Displacement Capacity Procedure**
High/Moderate	*Irregular*	*Concrete/Steel*	*Linear Modal*	*Nonlinear Static*
High/Moderate	*Regular*	*Concrete/Steel*	*Nonlinear Static*	*Nonlinear Static*
Low	*Regular/Irregular*	*Concrete/Steel*	*Nonlinear Static*	*Nonlinear Static*
High/Moderate/Low	*Regular/Irregular*	*Timber*	*Nonlinear Static*	*Nonlinear Static*

- Minimum Required Analytical Procedures:
- Select: High / Moderate:
- Configuration: Irregular
- Substructure Material: Concrete/Steel
- Displacement Demand Procedure: Linear Model
- Displacement Capacity Procedure: Non Linear Static

Minimum Analytical Procedure

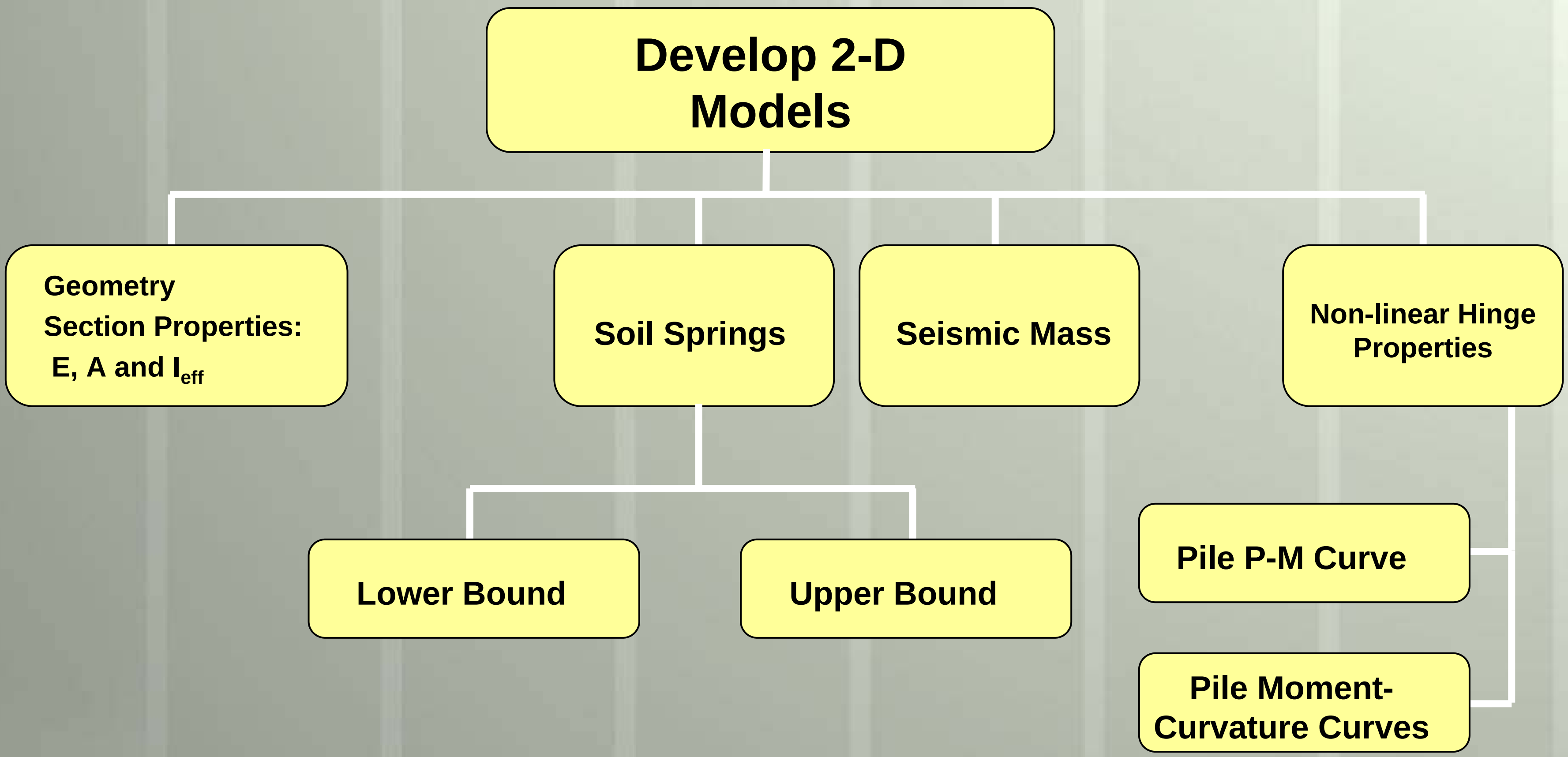
- **Minimum Analytical Procedure Design Approach**
  - **Basic Classification**
    - **Seismic Performance Level**
  - **Displacement Based Design**
    - **Develop Computer Model**
      - **Calculate Displacement Demand**
      - **Calculate Displacement Capacity**

Check Pile Shear

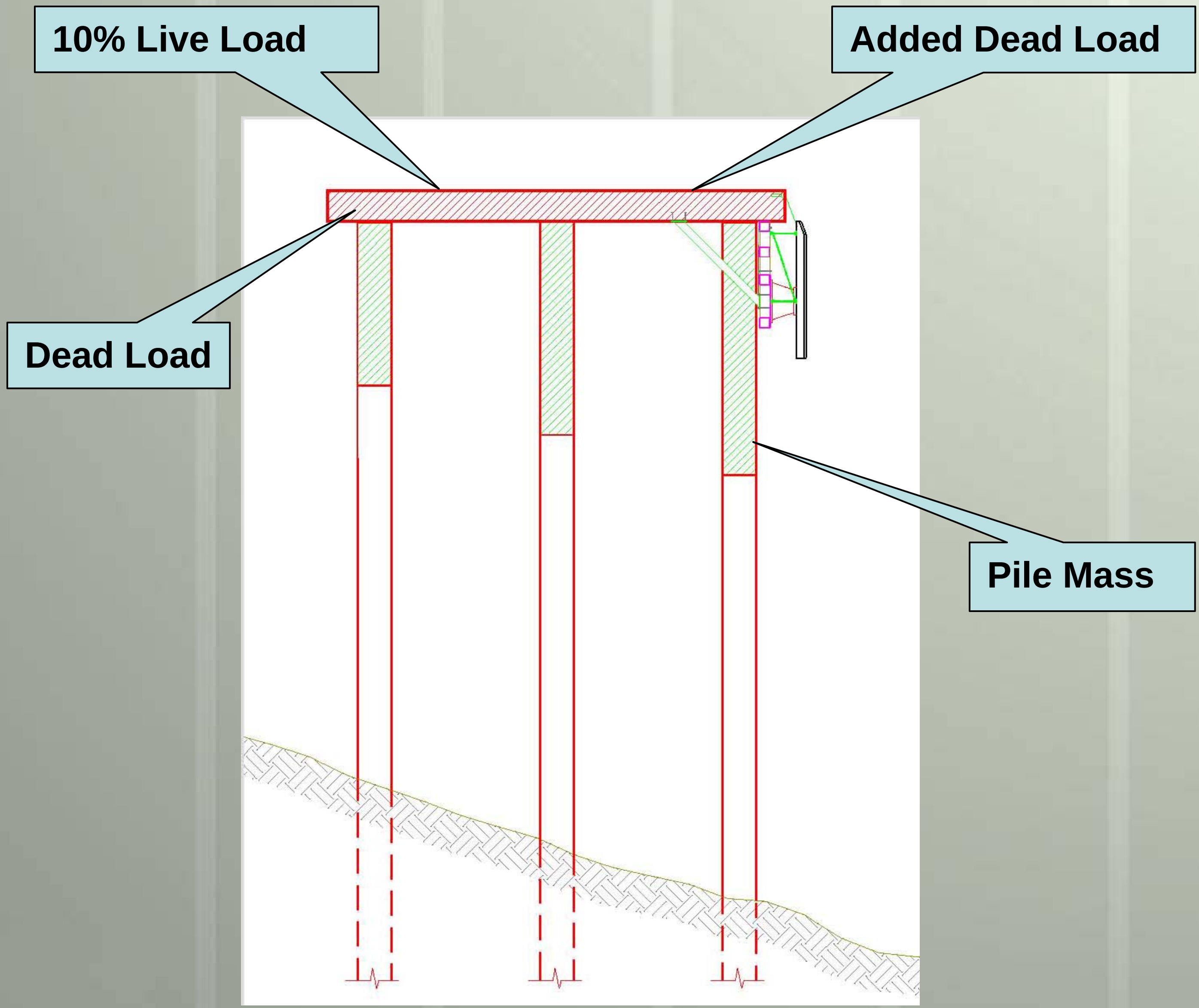
Check P-Δ

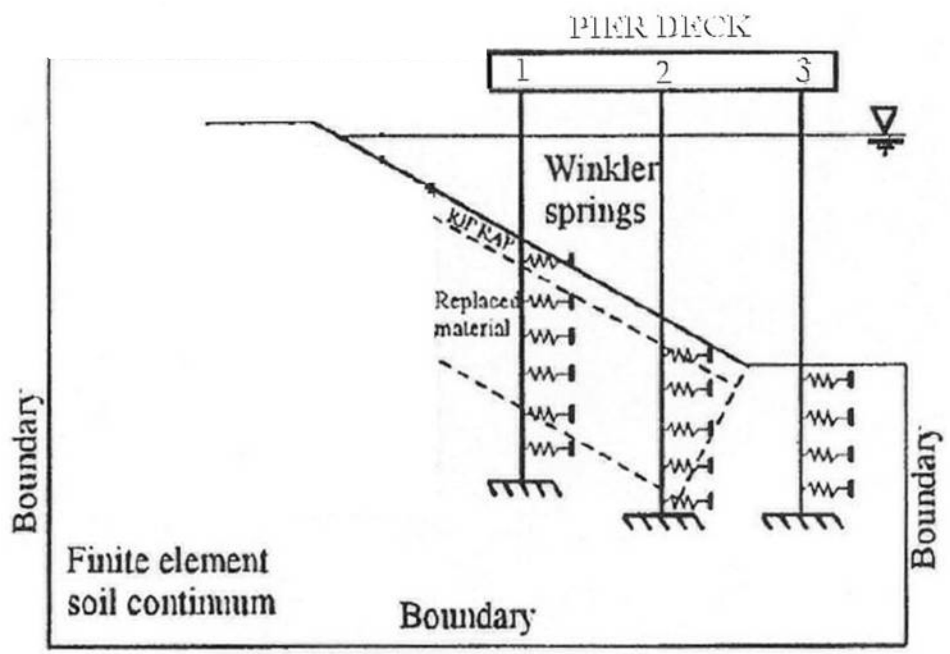
Design for Shear Key Forces

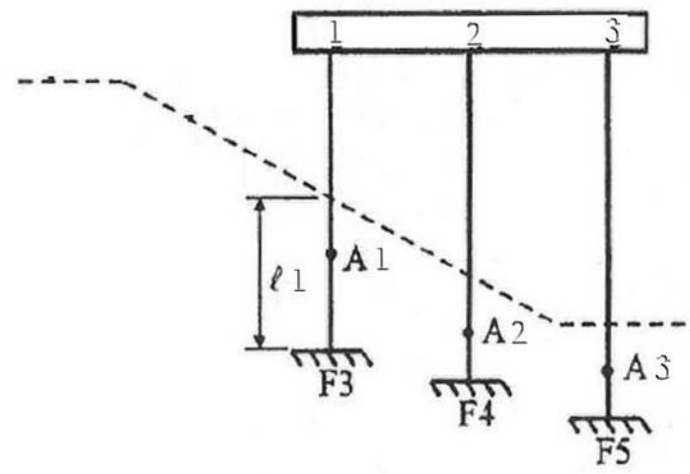
Displacement Capacity Flow Chart



Seismic Mass







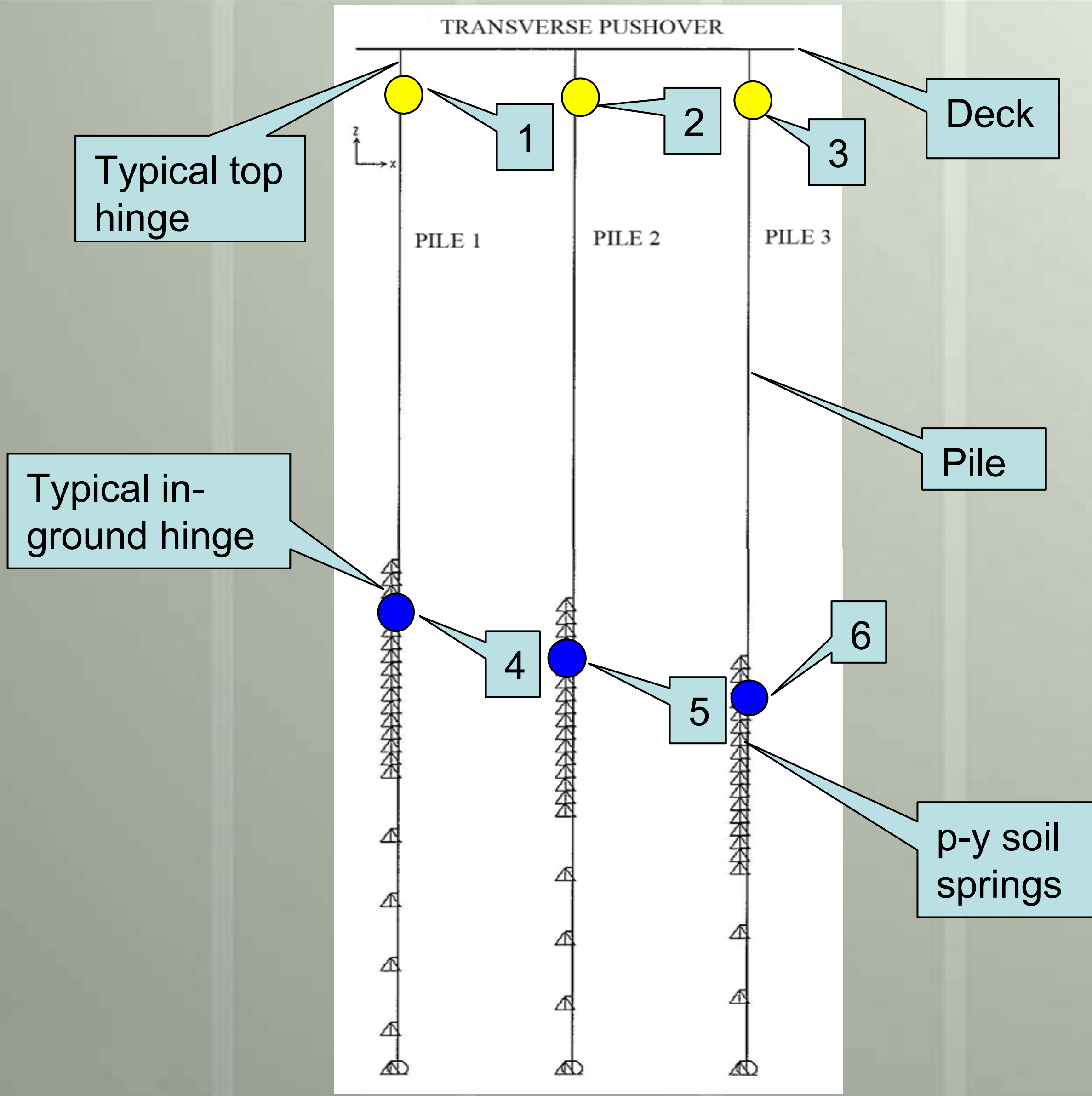
INELASTIC FE (SOIL + PILE) MODEL

EQUIVALENT DEPTH TO FIXITY MODEL

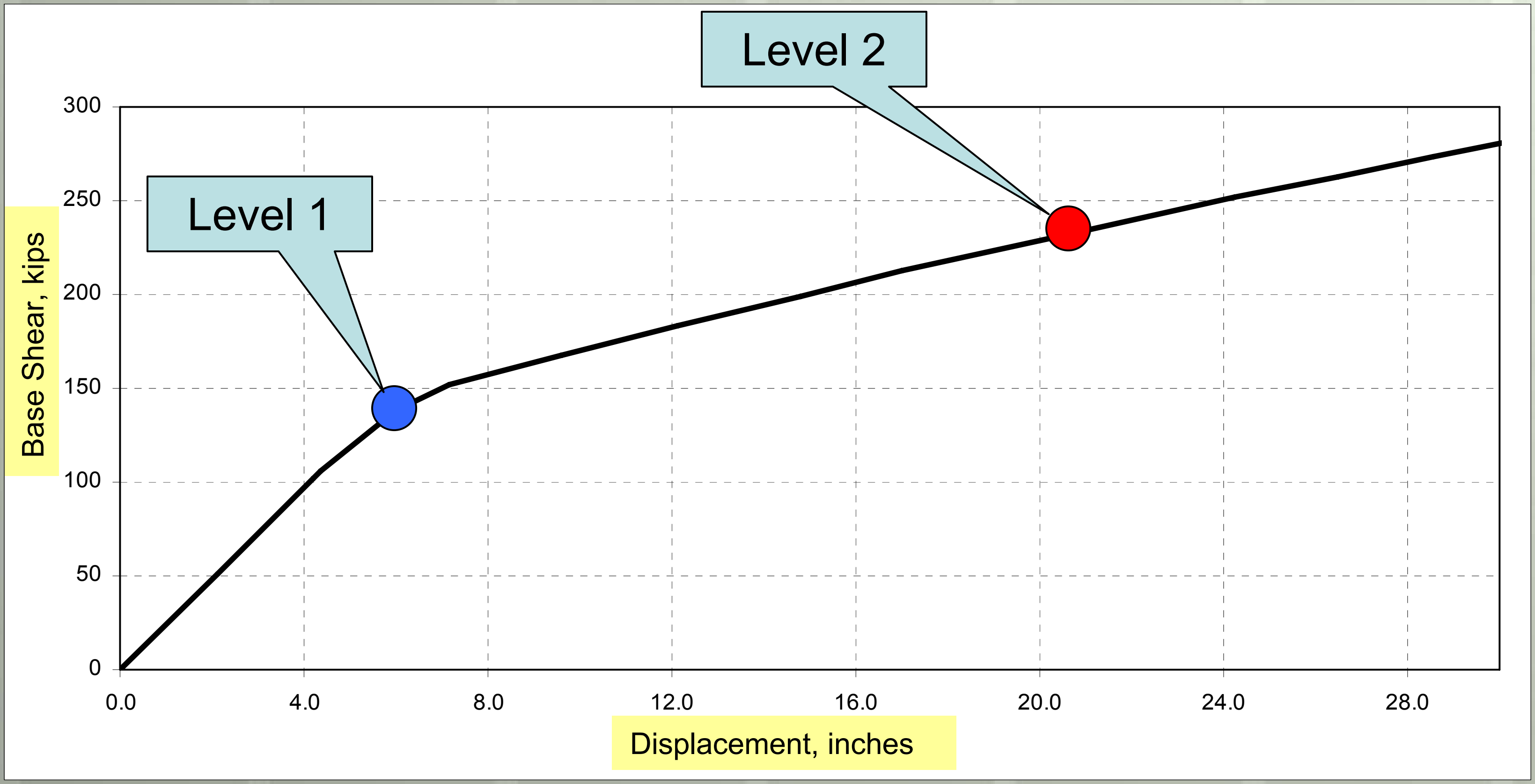
Too complex!

Too simplistic!

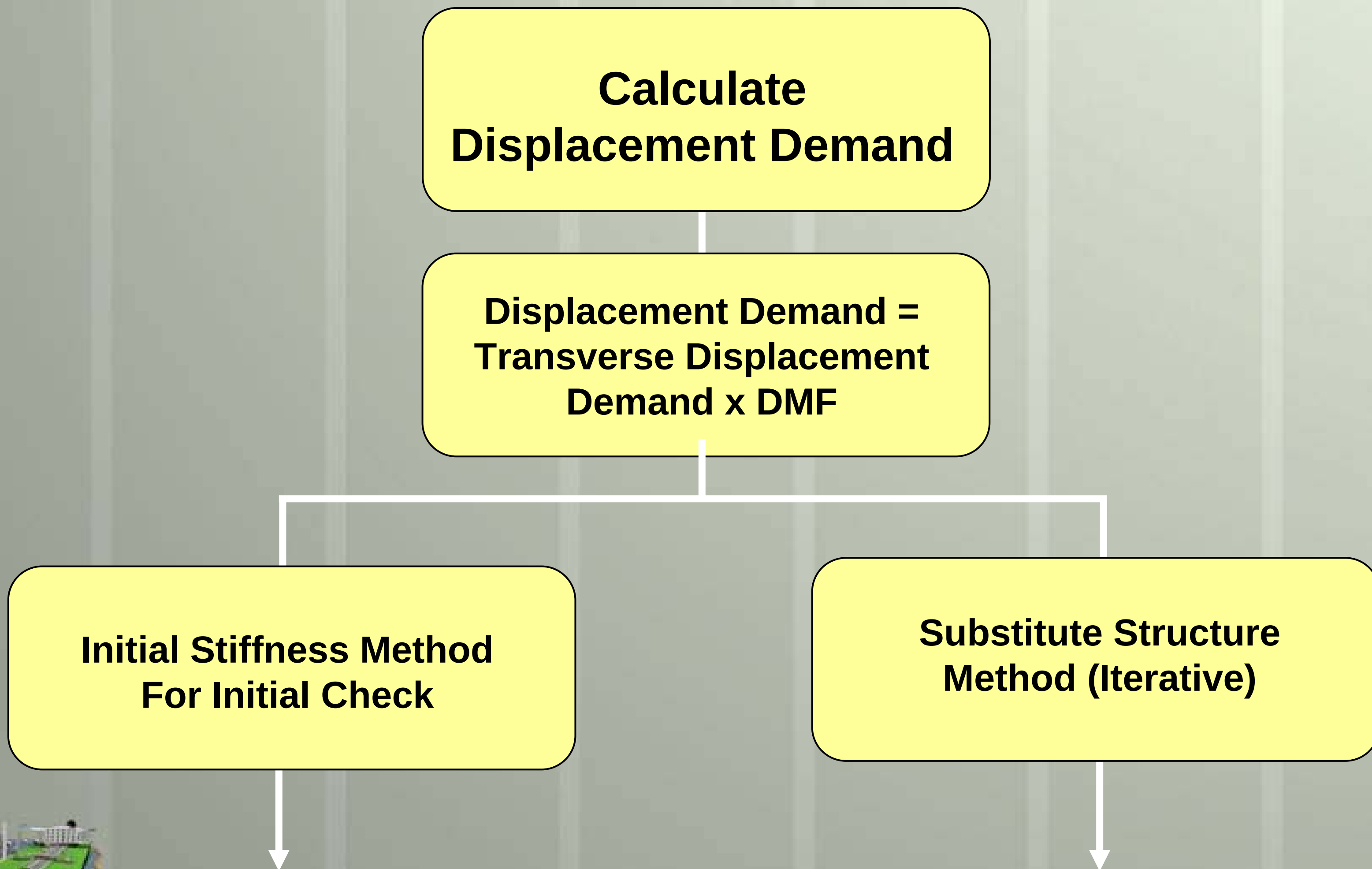
SAP2000 2-D Model Layout



Pushover Curves



Displacement Demand Flow Chart



Displacement Demand Flow Chart

Calculate Displacement Demand

Initial Stiffness Method for initial check

- **Initial stiffness from pushover curve**
- **Damping = 5%**
- $$T = 2\pi\sqrt{\frac{W}{gK}}$$
- **Read displacement demand form displacement spectra for 5% damping**

Demand-to-Capacity Ratio (DCR)

- **Demand x DMF / Capacity < 1.0**

- **DCR < 1.0**

Mooring & Berthing per MOTEMS

- Mooring/Berthing Risk Classification
- Mooring Analysis
- Berthing Analysis

MOTEMS Mooring/Berthing Risk Classification

TABLE 31F-5-1

MOORING/BERTHING RISK CLASSIFICATION

Risk Classification	Wind, (V_W) (knots)	Current, (V_c) (knots)	Passing Vessel Effects	Change in Draft (ft.)
High	>50	>1.5	Yes	>8
Moderate	30 to 50	1.0 to 1.5	No	6 to 8
Low	<30	<1.0	No	<6

Based on site specific parameters:

1. Wind
2. Current
3. Hydrodynamic effects of passing vessels
4. Change in vessel draft

Mooring Analysis

Load Generated By

- Wind
- Wave
- Passing Vessel
- Seiche
- Tsunami

MOTEMS Ref.

- 3105F.3.1
- 3105F.3.1
- 3105F.3.2
- 3105F.3.3
- 3105F.3.4

MOTEMS Windspeed Conversion Factor

The available wind duration shall be adjusted to a 30-second value, using the following formula:

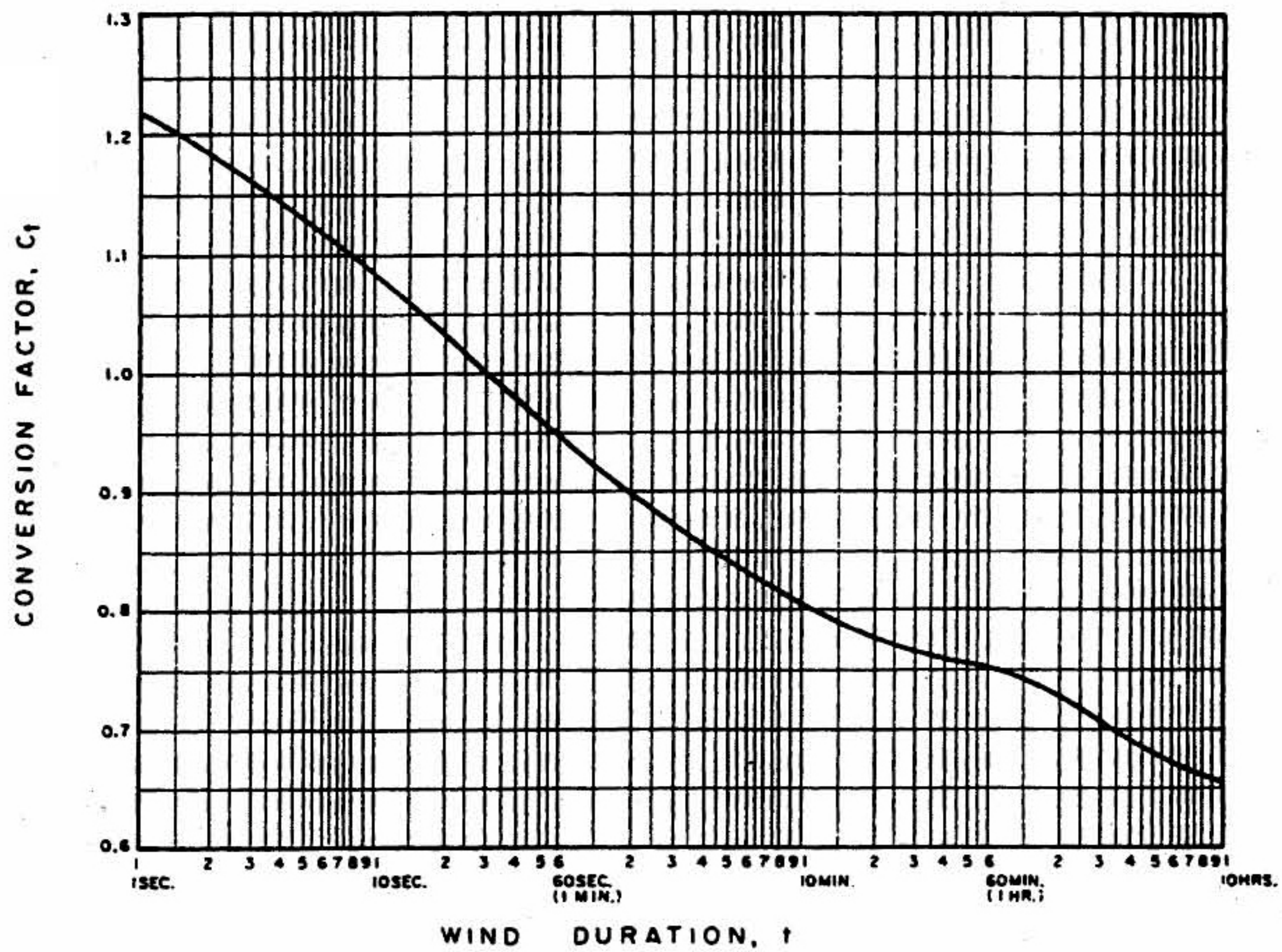


Figure 31F-3-3 Windspeed Conversion Factor [3.10]

MOTEMS Current Velocity Correction Factor

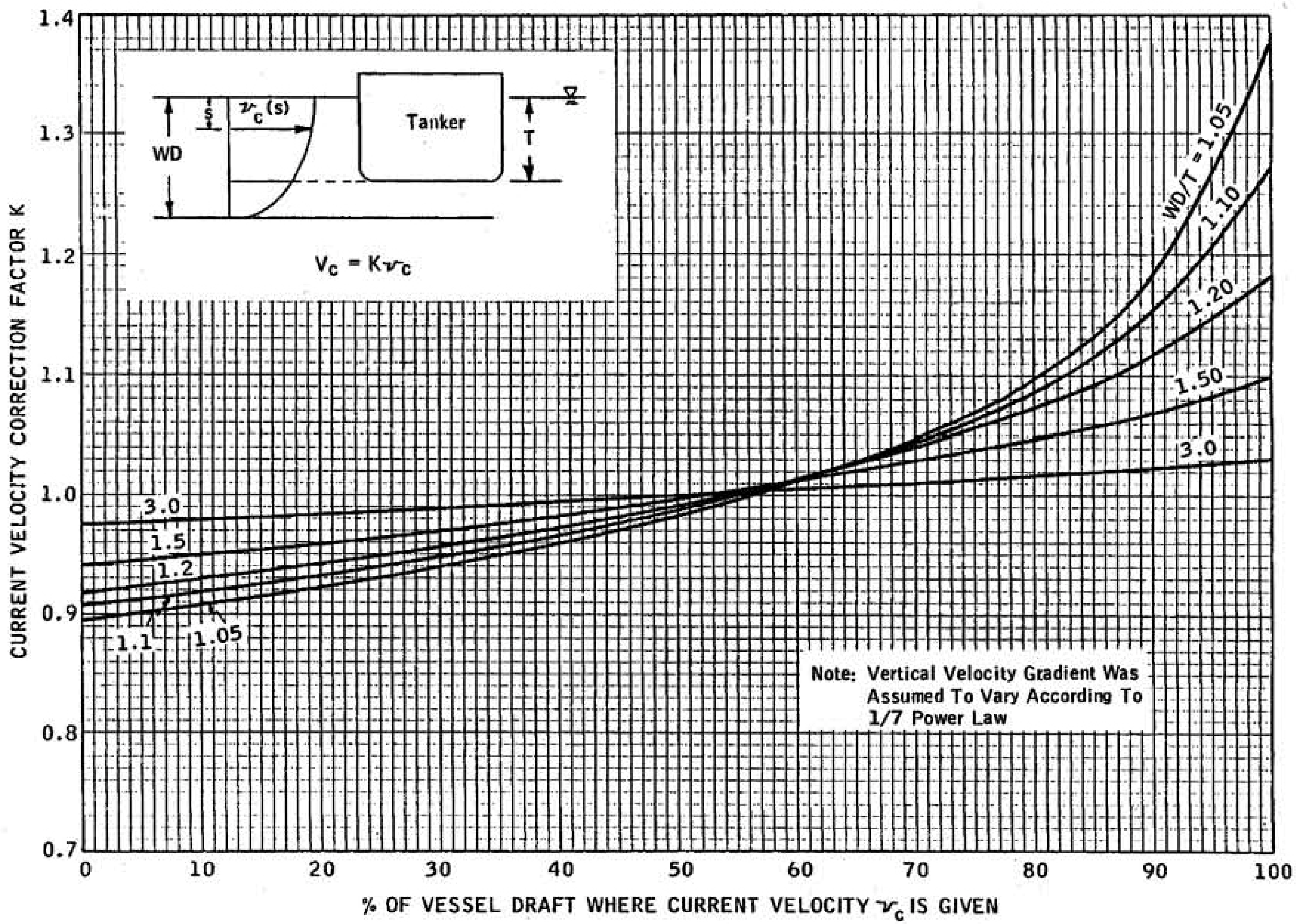


Figure 31F-3-4 Current Velocity Correction Factor (p. 41, OCIMF, 1997 [3.11])

Berthing Analysis

- Fender Design

  Berthing Energy Demand

  $E_{vessel} = ½(W*V_n^2/g)$

  Berthing Energy Capacity

  $E_{fender} = C_b*C_m*E_{vessel}$

- Tanker Contact Length

  $Lc = 2r \sin \alpha$

- Longitudinal or Vertical Berthing Forces

  $F = \mu N$

MOTEMS Berthing Velocity, Site Conditions & Max. Berthing Angle Tables

TABLE 31F-3-9

BERTHING VELOCITY V_n (NORMAL TO BERTH)

Vessel Size (dwt)	Tug Boat Assistance	Site Conditions		
		Unfavorable	Moderate	Favorable
<10,000[1]	No	1.31 ft/sec	0.98 ft/sec	0.53 ft/sec
10,000 – 50,000	Yes	0.78 ft/sec	0.66 ft/sec	0.33 ft/sec
50,000 – 100,000	Yes	0.53 ft/sec	0.39 ft/sec	0.26 ft/sec
>100,000	Yes	0.39 ft/sec	0.33 ft/sec	0.26 ft/sec

1. If tug boat is used for vessel size smaller than 10,000 DWT the berthing velocity may be reduced by 20%

TABLE 31F- 3-10

SITE CONDITIONS

Site Conditions	Description	Wind Speed[1]	Significant Wave Height	Current Speed[2]
Unfavorable	Strong Wind Strong Currents High Waves	>38 knots	>6.5 ft	>2 knots
Moderate	Strong Wind Moderate Current Moderate Waves	>38 knots	<6.5 ft	<2 knots
Favorable	Moderate Wind Moderate Current Moderate Waves	<38 knots	<6.5 ft	<2 knots

1. A 30-second duration measured at a height of 33 ft.
2. Taken at 0.5 x water depth

TABLE 31F-3-11

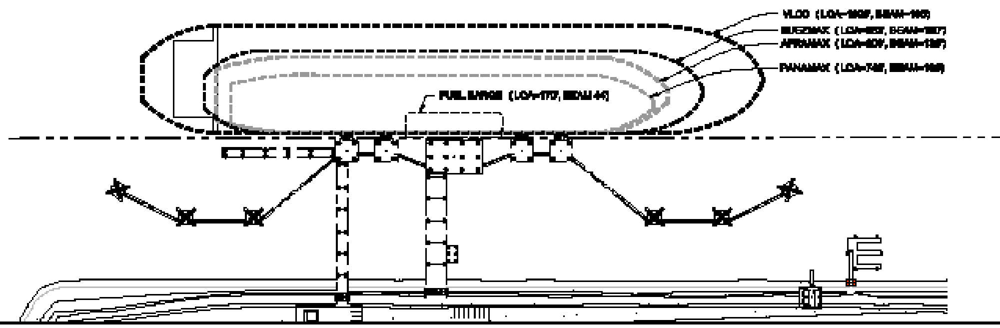
MAXIMUM BERTHING ANGLE

Vessel Size (DWT)	Angle [degrees]
Barge	15
<10,000	10
10,00-50,000	8
> 50,000	6

Structural Details

- Ship Design Parameters
- General Layout & Elevation
- Mooring Layout for VLCC
- Section at Unloading Platform
- ULP Rigid Frame Joint Detail
- ULP Reinforcing
- MD Deck & Pile Reinforcing
- MD Deck Reinforcing Plans
- N & S Trestle Box Girder Layout
- N & S Pier Layout & Cap Bm Details

Ship Design Parameters



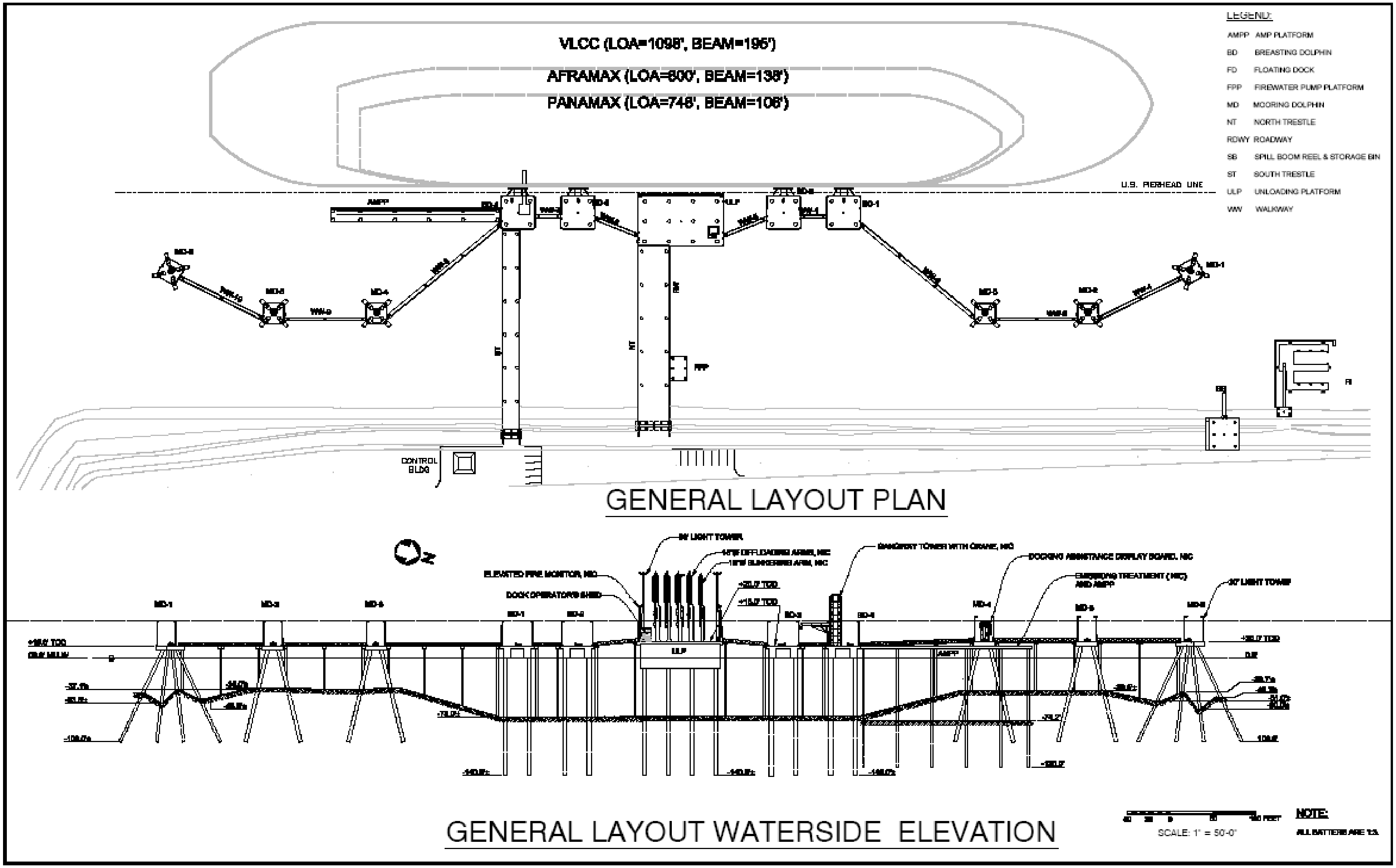
SHIP DESIGN PARAMETERS							
ITEM	UNIT	PARAMETER					
VESSEL CLASS	-	VLCC	VLCC	SUEZMAX	AFRAMAX	PANAMAX	BUNKER BARGE
VESSEL NAME		"GENERIC" DESIGN VESSEL	FRONT CENTURY	ASIAN SPIRIT	AEGEAN LEGEND	CHEMTRANS STAR	LBM #3
DWT	METRIC TON	325,000	311,000	152,000	105,000	68,000	1,400
DISPLACEMENT	METRIC TON	370,000	353,000	174,000	125,254	77,000	ABOUT 1,800
LOA	FT	1,098	1,098	883	800	750	170
LBP	FT	1,051	1,050	848	771	718.5	-
BEAM	FT	195	190	150	138	105.8	44
MOULDED DEPTH TO MAIN DECK	FT	105	102	80	70	60.7	11.8
LOADED DRAFT	FT	74	74	57	48.5	42	ABOUT 7
BALLAST DRAFT	FT	33	31	27	23	23	ABOUT 4
LENGTH OF PARALLEL BODY AT BALLAST WATER LINE	FT 2	430	478	384	400	385	150
TRANSVERSE WINDAGE AREA AT BALLASTED DRAFT	FT 2	85,000	80,000	50,600	39,600	32,500	850
LONGITUDINAI WINDAGE AREA AT BALLASTED DRAFT	FT	22,000	20,000	12,000	10,800	7,500	220
TYPE OF MOORING LINES	-	WIRE	WIRE	WIRE	WIRE	WIRE	c
DIAMETER OF MOORING LINES	IN	1 5/8	1 5/8	1 1/2	1 1/2	1 1/4	c
MINIMUM BREAKING LOAD	TON	114	114	94	81	73	c
TAIL LENGTH	FT	38	38	38	38	38	NA
DIAMETER SYNTHETIC TAIL	IN	3 1/2 [a]	3 1/2 [a]	3	3	3 1/8	NA
BREAKING STRENGTH OF TAIL	TON	187 [a]	187 [a]	134	120 [a]	110	NA
PRE-TENSION MOORING LINES	TON	17	17	9	12	7	c
WINCH BRAKE HOLDING CAPACITY	TON	68 [b]	92	75	72 [b]	48	c
DISTRIBUTION HEAD/BREAST FORE/SPRING FORE / SPRING AFT/BREAST AFT/STERN	-	10 FWD 10 AFT	10 FWD 10 AFT	8 FWD 8 AFT	8 FWD 8 AFT	6 FWD 6 AFT	c

SHIP DESIGN PARAMETERS

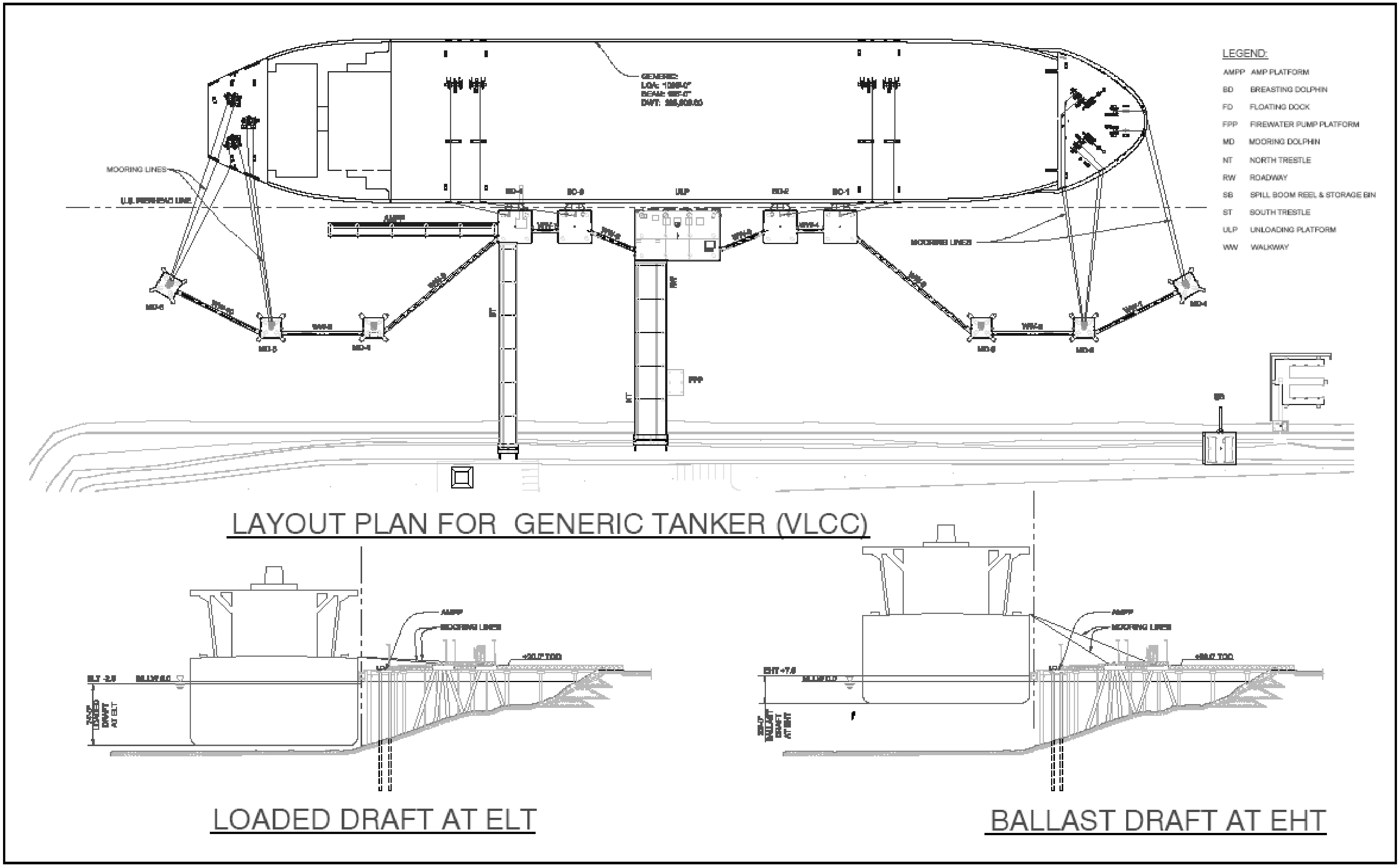
NOTES:

1. SPECIFIC VESSEL NAMES ARE NOTED TO PRESENT "TYPICAL" VESSELS IN EACH CLASS; HOWEVER, INDIVIDUAL TANKERS WILL VARY.
2. a: BASED ON 25% INCREASE ON WIRE MBL PER OCIMF MOORING EQUIPMENT GUIDELINES.
   b: BASED ON 80% OF LINE MBL PER OCIMF MOORING EQUIPMENT GUIDELINES.
   c: THESE VALUES STILL NEED TO BE OBTAINED FROM THE BARGE OPERATOR.

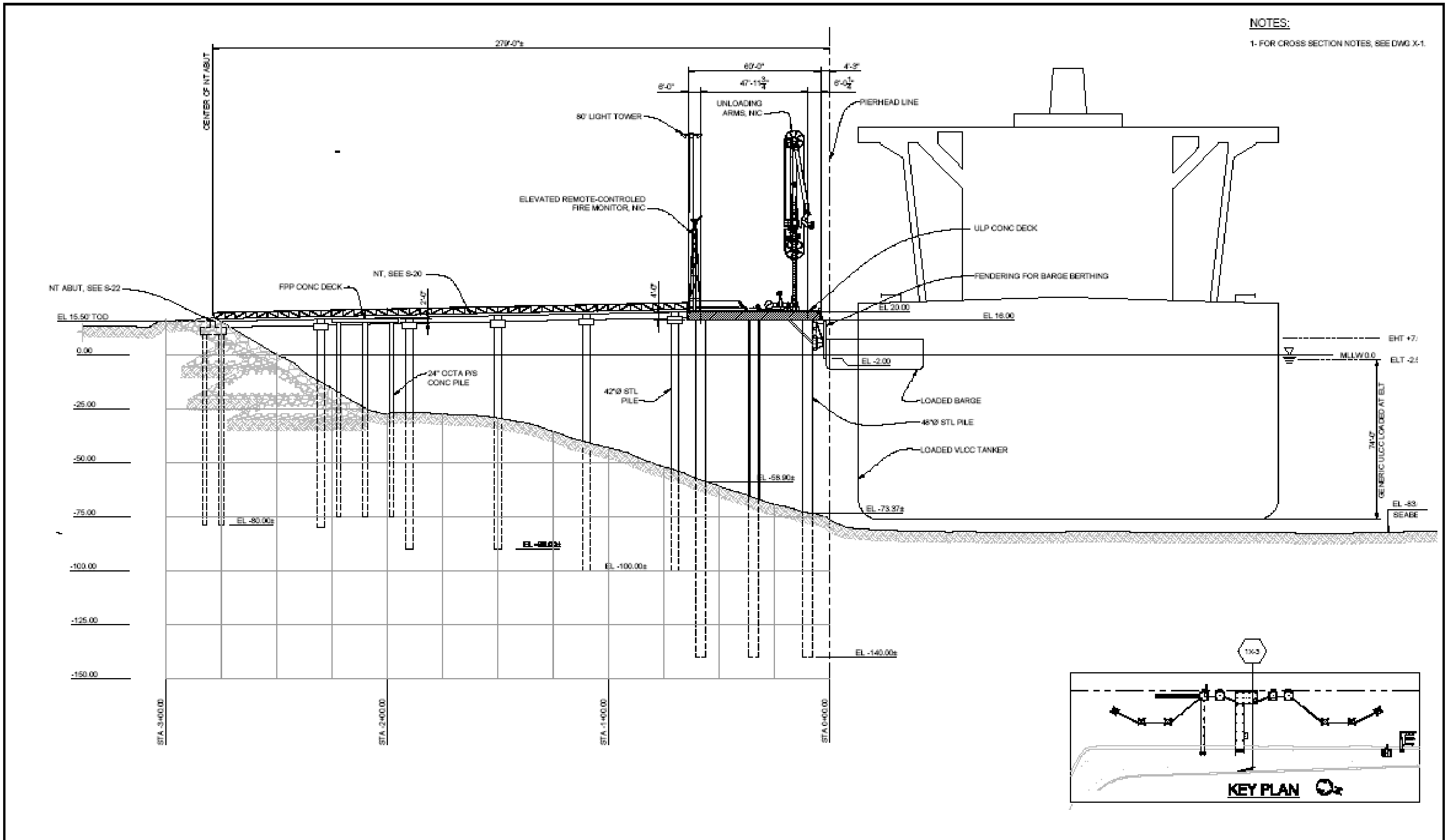
General Layout Plan & Waterside Elevation



Mooring Layout for VLCC

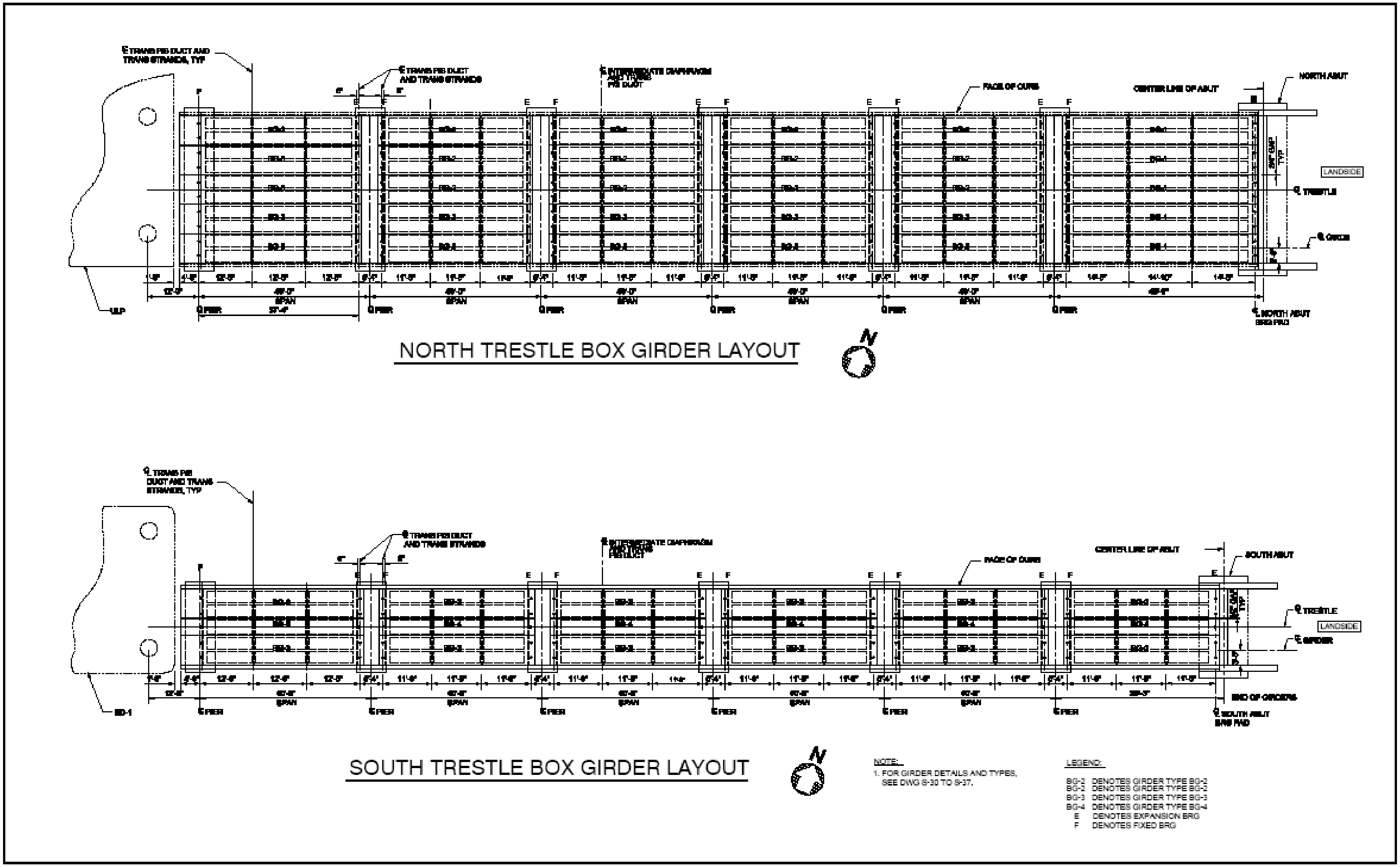


Section at Unloading Platform



SECTION AT UNLOADING PLATFORM

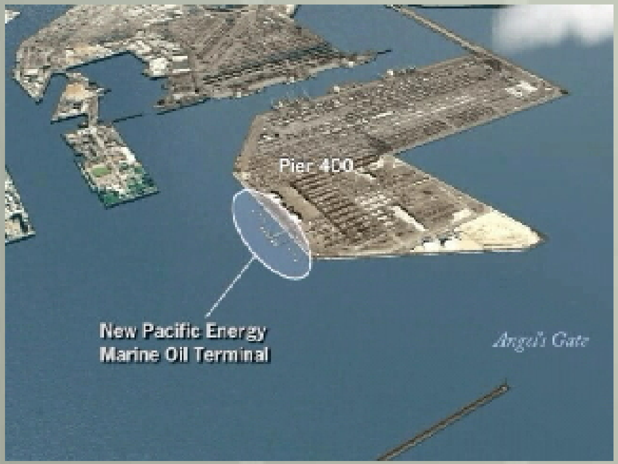
North & South Trestle Box Girder Layout



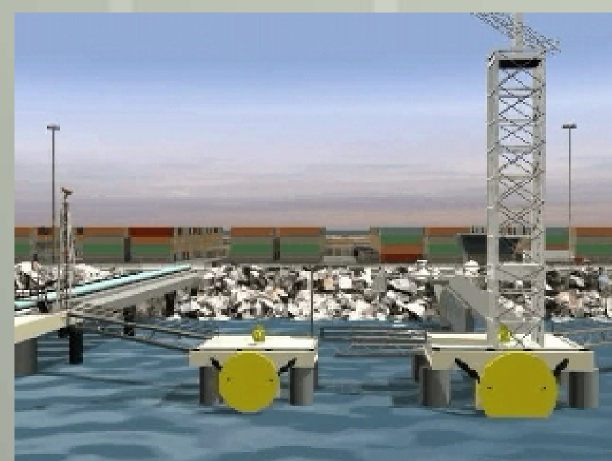
Design Innovations

- 1st New Oil Terminal Designed to MOTEMS
- Optimized Seismic Design Analysis
- Modularization of Structural Components
- Advance Design-Build Process
- Environmental Technologies

Project Photos



Project Photos



STRUCTURAL DESIGN OF THE MARINE TERMINAL

"Structural Design of the Marine Terminal"

Question?

Thank You!

lima@portla.org

jposadas@portla.org