PORT OF OAKLAND DESIGN LOADS FOR NEW CONTAINER CRANE GIRDERS

ANALYSIS - GENERAL CONSIDERATIONS

CRITERIA

The strength of the crane rail girder shall be calculated using the strength design provisions of the *Building Code Requirements for Reinforced Concrete ACI 318-89* (Revised 1992) (ACI code). The structural strength of piles shall be calculated using the provisions of Section 4.7.6 of *PCI Design Handbook* with modifications for pile slenderness.

The applied loadings are multiplied by load factors consistent with the ACI code. Crane dead load is treated as an ACI dead load because the weight of crane is known.

LOADINGS

The loads on the crane rail girder include the container horizontal and vertical crane wheel loads, loads on crane stowage hardware, the wharf dead load tributary to the girder, and wharf live load tributary to the girder. The components of crane loads shall be applied to cause the maximum load. The load components are shown so the crane wheel loads may be calculated after the crane designer provides the actual crane load data. The design wheel load is shown in the Design Strength section, page 6.

Crane Loads

Crane Loads consist of the following components:

COLL	Collision Load	The load determined by dynamic analysis, assuming that, with the crane traveling at full speed and power off, the gantry bumpers hit the crane stops or hit another stopped crane.
DL	Dead Load	The weight of the crane's structure including all permanently attached machinery and equipment.
EQO	Operating Earthquake Load	The ***smaller*** of 0.20 (DL + TL + LS + LL) or the load corresponding to the lateral acceleration required to cause one or more legs to lift off the rail. The lifted load is raised to maximum height and earthquake accelerations are applied parallel and perpendicular to the gantry rails
EQS	Stowed Earthquake Load	The 0.20 (DL + TL +LS) applied parallel and perpendicular to the gantry rails
IMP	Impact	The loads due to vertical acceleration of the lifted load as sensed by the main hoist ropes 0.25(LS + LL).
LATT	Trolley Lateral Load	The loads imposed on the crane due to positive or negative acceleration of the trolley, gantry, or other pieces of equipment which move horizontally. The lateral inertia forces developed due to trolley travel is at least 0.10 (TL) plus 0.10 (LS + LL) parallel to the travel direction plus a simultaneous load of 0.025 (TL) plus 0.025 (LS + LL) perpendicular to the travel direction. The lateral forces due to gantry travel parallel to travel direction are 1.5 times the maximum inertia force that can be developed due to acceleration or deceleration of the gantry drive system. Minimum gantry inertia load is 0.05 times all weights present on the operating crane. A simultaneous load of one-fourth the gantry inertia force is applied perpendicular to the travel direction.
LATG	Gantry Lateral Load	

LL	Lifted Load	The weight of the container plus its contents which shall be taken as 89,600 lbs. (40 long tons), unless otherwise noted, and applied concentric to the geometric center of the container.
LLF	Fatigue Lifted Load	Fatigue design is based on an effective container which, for simplicity, is assumed to be equivalent to the actual spectrum of various weight containers including impact effects. The weight of the container plus its contents shall be taken as 67,200 lbs. (30 long tons), unless otherwise noted, and applied concentric to the geometric center of the container.
LS	Lifting System	The weight of the spreader, head block, portions of the lifting ropes, sheaves, and all other equipment which hangs from the main hoist ropes and is supported by the container when the spreader is placed upon it.
OL1 OL2 OL3 OL4	Overload Conditions 1, 2, 3 & 4	Refer to Table 1 "Load Combinations."
OP1 OP2	Operating Conditions 1 & 2	Refer to Table 1 "Load Combinations."
RL	Rated Load Container	A container 48' long, 9'-6 1/2" high and 8'-6" wide weighing, with it contents, 89,600 lbs. (40 long tons) unless otherwise noted.
S1 S2	Stowed Conditions 1 & 2	Refer to Table 1 "Load Combinations."

SN	Snag Load	The load, imposed on the crane due to the head block and empty spreader traveling at maximum hoist speed, becoming jammed in the ship's cell guides or being accidentally two-blocked against the underside of the trolley, resulting in the kinetic energy of the rotating equipment being dissipated in elastic deflection of the machinery and structure and/or in any energy-absorbing devices provided for that purpose.
STL	Stall Torque Load	The load developed by stalling any motor in the crane. The load is due to the stall and/or breakdown torque of AC drives and 200% rated motor torque of DC drives. For the main hoist, stall torque load shall be the load induced by stalling the hoist motors with one end of a container or hatch cover dogged down.
TL	Trolley Load	The weight of the trolley, including all permanently attached machinery and equipment, but excluding the weights included in LS.
OWL	Operating Wind Load	The load due to an operating wind speed of 55 mph assumed uniform over the full height of the crane applied in any direction. The corresponding dynamic wind pressure is 7.7 psf. The container used in calculating operating wind shall be the rated load container.
SWL	Stowed Wind Load	The effect of stowed wind shall be determined in accordance with *ASCE Standard 7-88* (formerly *ANSI A58.1), Minimum Design Loads for Buildings and Other Structures*. Recommended parameters: Wind Speed, V — 70 mph Importance Factor, I — 1.0 Exposure — D For ease of calculation for a typical crane structure, the height z may be taken at the midheight of the crane machinery house. The velocity pressure for this height may be then applied to the full height of the crane. The wind shall be applied in any horizontal direction.

WHARF DECK LOADS

Wharf deck loads applied to the crane rail girder are defined below.

WDL	Wharf Dead Load	The dead load of the wharf structure tributary to the crane rail girder.
WLL	Wharf Live Load	The superimposed wharf loading of 1000 psf, unless otherwise noted, tributary to the crane rail girder. See Figure 2 for loaded areas.

METHOD OF ANALYSIS

The analysis used shall include the effects of the elastic deflection of the piles when determining forces in the crane rail girder structure. The maximum effect of the factored loads shall be determined.

The beam-on-elastic-foundation method shall be used to design continuous spread footings that support crane rails supported on continuous spread footings.

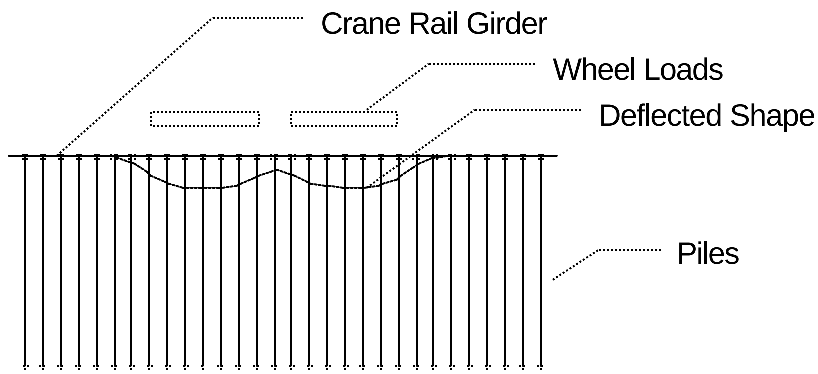
STIFFNESS

The girder may be modeled with cracked section properties. Cracked properties would be used because the girder moments with an uncracked section are high enough to crack the section.

In the analysis, the support stiffness for the girder shall be modified to include the effects of soil stiffness. The pile stiffness may be modeled with uncracked section properties since the pile is prestressed and under axial compression.

SPAN LENGTH

Moments may be calculated at the face of the piles in accordance with ACI. The effective length of the crane girder is greater than the pile spacing, since the piles are modeled as elastic supports. See Figure 1 below.



Deflected Shape of Girder
Figure 1

Ordinarily, the crane girder would be designed as a deep beam if the piles didn't deflect, since the distance between piles is relatively short. However, the girder need not be designed as a deep beam, since the elastic supports cause the girder to spread the load over several piles.

Allowance should be made in the girder span length for pile driving tolerance. The usual tolerance is 6 inches.

ARRANGEMENT OF LOAD

The crane design load shall be moved along the girder to determine the most critical load position. The crane load is shown in Figure 2. The wharf deck live load is applied as shown in Figure 3.

STRENGTH AND SERVICEABILITY REQUIREMENTS

GENERAL

All elements of the rail girder structure shall be designed to have design strengths at all sections at least equal to the required strengths calculated for the factored loads and forces in the combinations noted below.

REQUIRED STRENGTH

The load factors used are in general conformance with the ACI code. The load factors shown in Table 1 shall be used.

LOAD COMBINATIONS AND FACTORS

LOAD NAME	COMB NAME	OPERATING		OVERLOAD				*STOWED	
		OP1	OP2	OL1	OL2	OL3	OL4	S1	S2
Wharf Loads:									
Dead Load	WDL	1.4	1.4	1.0	1.0	1.0	1.0	1.05	1.05
Superimposed Live	WLL	1.7	1.7	1.0	1.0	1.0	1.0	1.28	1.28
Crane Loads:									
Dead Load	DL	1.4	1.4	1.0	1.0	1.0	1.0	1.05	1.05
Trolley Load	TL	1.4	1.4	1.0	1.0	1.0	1.0	1.05	1.05
Lifting System	LS	1.4	1.4		1.0		1.0	1.05	1.05
Lifted Load	LL	1.7	1.7		1.0		1.0		
Impact	IMP		.85						
Trolley Lateral	LATT		1.4						
Gantry Lateral	LATG	1.4							
Operating Wind	OWL		1.3	1.0	1.0				
Stall Torque	STL			1.0					
Snag	SN					1.0			
Collision	COLL				1.0				
Operating Earthquake	EQO						1.0		
Stowed Wind	SWL							1.3	
Stowed Earthquake	EQS								1.4
EXAMPLE:	OP1 is 1.4 x WDL + 1.7 x WLL + 1.4 x DL + 1.4 x TL + 1.4 x LS + 1.7 x LL + 1.4 x LATG.								
*STOWED: The boom is up, the trolley and lifting system are in the stowed position, and tiedowns, if any, are in place.									

Load Combinations
Table 1

DESIGN STRENGTH

The design strength of the girder for moment and shear shall be determined using the provisions of Chapters 10 and 11 of the ACI code.

The pile capacity shall be checked for two cases: (1) structural strength of the pile, and (2) the bearing capacity of the soil. The pile strength may be taken from interaction diagrams for the pile that are in conformance with ACI and PCI provisions. The soil strength shall be provided by a geotechnical engineer.

DESIGN LOADS

New crane rail girders, both waterside and landside shall be designed for the loads in Table 2 as modified in the accompanying text . All loads in the table are factored and are at one rail.

FACTORED LOAD		COMBINATION				COMMENTS
		A	B	C	D	
Vertical	55 k/ft	x	x		x	See Figure 2
Horizontal ⊥ Rail || Rail	 2.5 k/ft 3.0 k/ft	 x x	 x	 x		 See Figure 2
Ties Downs	300 kips			x		See Figure 3
Stowage Pins	250 kips		x	x		See Figure 3
Bumper Stops	300 kips				x	
Notes on table						
Combination	A, B C D	Operating and stowed conditions. Stowed condition on lightly loaded rail Crane collision with end stops.				
Apply other than crane loads according to ACI.						

Crane Girder Design Loads
Table 2

The recommended loads are the maximum expected for a dual hoist post-panamax 40 LT container crane with a rail gage of least 90'. The loads include reasonable contingencies.

These recommendations apply to typical conditions. The proper loads should be developed for each specific situation. If there are special conditions such as heavy lift or a wheel gage less than 90', these design recommendations should be evaluated for their suitability for the specific situation. The design loads in Table 2 should be considered a minimum.

The crane supplier should be required to supply the basic loads so that the factored loads can be calculated using Table 1 and compared to the criteria.

MISSING PILE

In the design of a new waterside crane girder, there should be an economic analysis made to determine the cost of designing for one and two missing piles. The incremental cost should be determined to:

design the wharf for the loads in Table 2 with one pile missing; and

design the wharf for the loads in Table 2 with two piles missing.

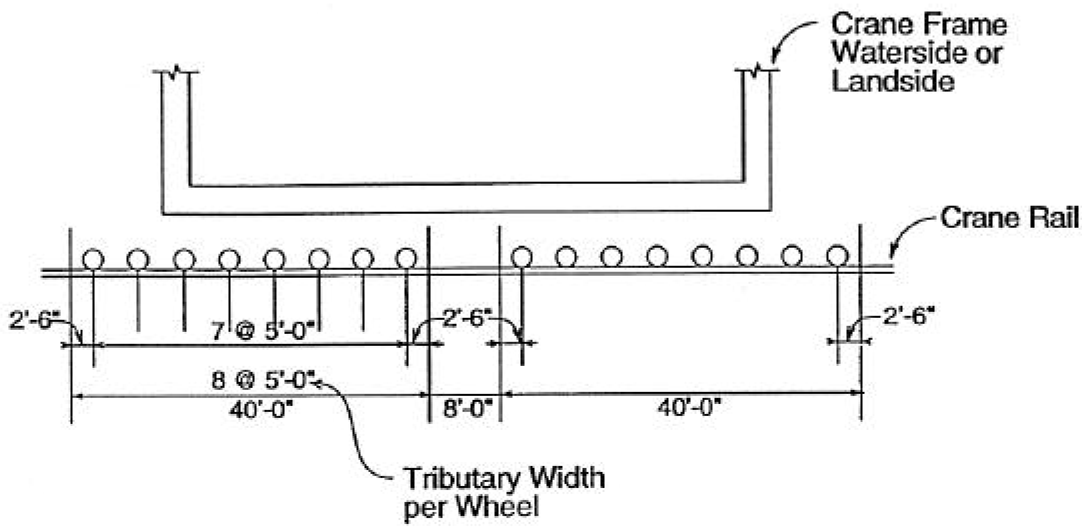
Once the cost is reported to the port, the port will decide if some provision for missing piles should be included in the design.

If no provision is made for missing piles, then the following information shall be provided to the port on the wharf design drawings:

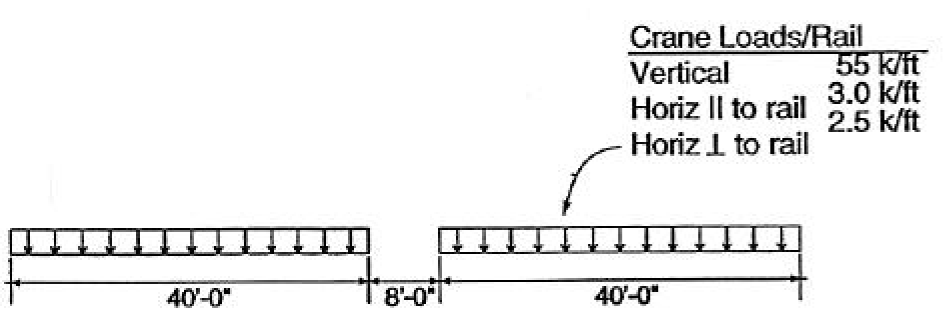
the wharf wheel load capacity with one pile missing; and

the wharf wheel load capacity with two piles missing.

Crane Wheel Spacing

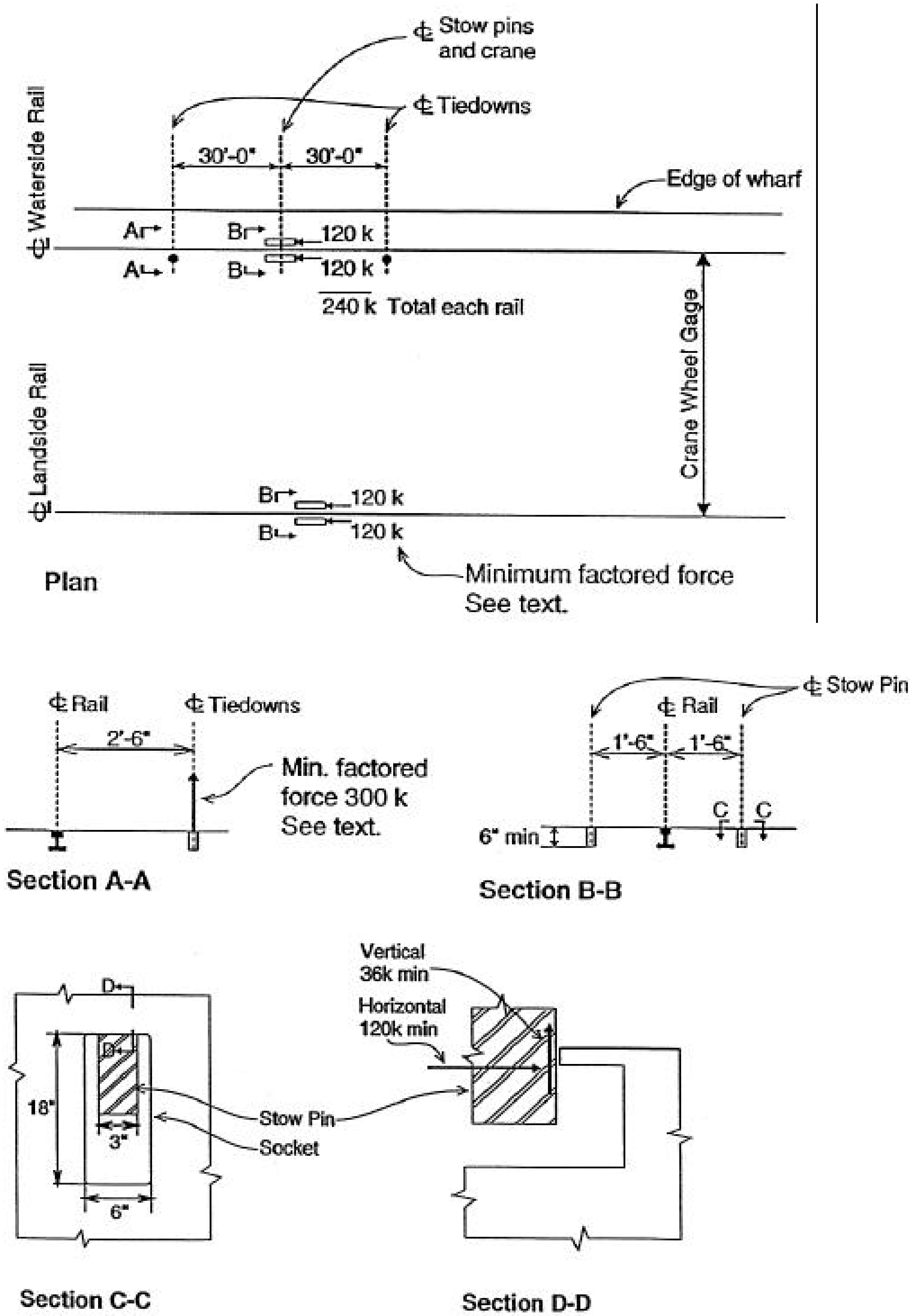


Apply horizontal and vertical loads as line loads. See text for load combinations.

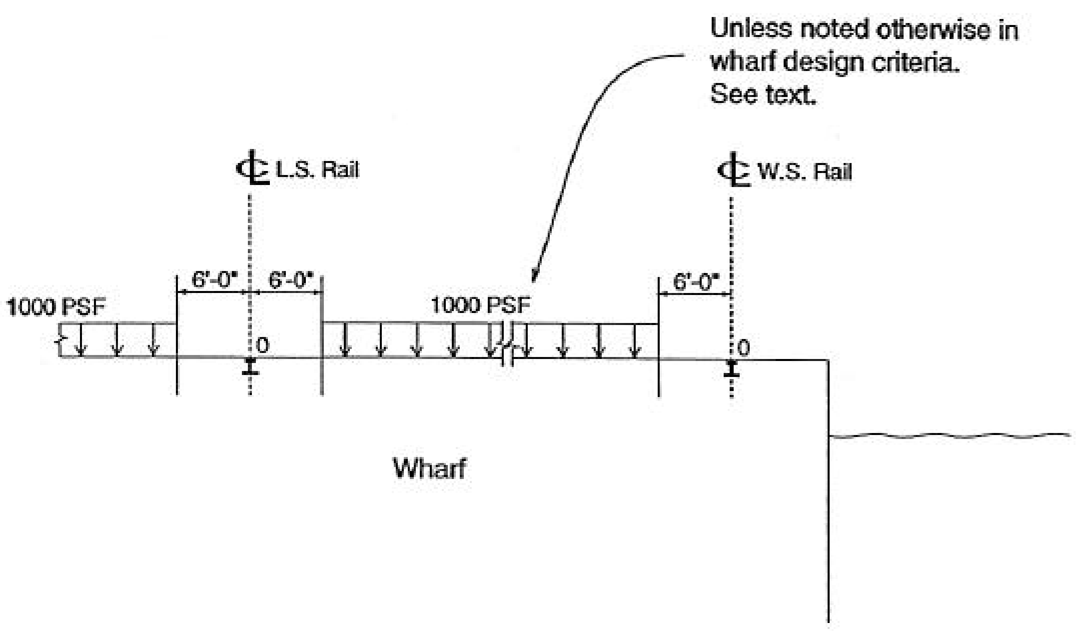


Equivalent wheel load = 5 x 55 = 275^k
Wheels @ 5'-0" o.c.

Crane Wheel Loads Factored Loads
(with ACI factors)
Figure 2



Crane Stowage Sockets and Tiedowns Factored Loads
(with ACI factors)
Figure 3



Surface Working Load WLL
Figure 4

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