Mile Long Boardwalk Enhances Estuary Restoration

Paul C. Gilham, P.E., S.E.
Chief Engineer
Western Wood Structures, Inc.
Tualatin, Oregon USA
paulg@westernwoodstructures.com

Paul Gilham has worked at Western Wood Structures, Inc. for the past 31 years. His responsibilities include design of engineered timber structural systems including bridges, trusses arches and domes. He inspects and designs repairs and upgrades for existing timber structures.

Summary

Timber boardwalks have seen an increase in use over the last 10 years as regulations regarding the disturbance of the ground in wetlands and sensitive environments have tightened. Such was the case in an estuary restoration project in south Puget Sound, Washington. This project included the removal a earthen dike allowing the area to revert back to a saltwater marsh. A timber boardwalk over 1.6 km (1 mile) long was constructed in the tidal zone to provide hiking, viewing and photography opportunities. The boardwalk included an observation tower, two viewing platforms and a bird viewing blind. Diamond Pier foundations, which are installed with minimal soil disturbance, were used to support the boardwalk. Tidal channels, formed after the removal of the dike, were spanned using timber pony truss bridges.

Keywords: Timber Boardwalk, Diamond Pier Foundations, Glulam, Timber Frame, Pony Truss.

1. Introduction

The US Fish and Wildlife Service (FWS) partnering with Ducks Unlimited (DU) and the Nisqually Indian Tribe removed a 100 year old dike as part of an estuary restoration project. The removal of the dike returned 762 acres of land to a tidal marsh, vital to the environmental health of the estuary. The estuary provides nesting areas for waterfowl and important resting areas for migratory birds. More than 200 species of birds have been tallied in the area.

Figure 1. Boardwalk at high tide

As part of the restoration effort, a timber board walk was installed to provide access for birdwatchers and hikers. Where most boardwalks are built to allow passage over a wetland or sensitive area from

one end to the other the Nisqually boardwalk invites visitors to linger and gaze at the surroundings, waterfowl and other wildlife. The boardwalk is located in the tidal flats allowing hikers to walk above the water at high tide and above the mudflats and the waterfowl feeding areas when the tide is out.

DU developed the layout for the boardwalk and the concept for the several ancillary structures. Western Wood Structures of Tualatin, Oregon took these concepts and provided the structural design for the boardwalks and ancillary structures.

2. Boardwalk Framing

The boardwalk is designed to carry a live load of 4.07 kPa (85 psf.). The wind speed at the site is 38 m/s (85 mph), Exposure D due to the unobstructed areas and water surfaces. The seismic base shear was 42%g using a seismic response modification factor of 1.5 for timber frames. The boardwalk is constructed using timber bents which are designed to carry the dead and live loads as well as resist the lateral loads due to wind and seismic forces. The glulam deck panels and sawn lumber handrails are made from Port Orford cedar (POC), a naturally decay resistant species and the balance of the timber is preservatively treated Douglas fir (DF).

2.1 Diamond Pier Foundations

figure 2. Installation of Diamond Piers.

The boardwalks are supported by Diamond Piers. These are precast concrete pier blocks with galvanized pipe pins that are driven into the soils. Bearing resistance of the piers is based on the horizontal projected area of the pins. The length of the pins is determined by the bearing characteristics of the soil and the load to be resisted. These piers are especially suited for sensitive areas such as wetlands and the tidal marsh. They require only a few shovels of soil to be disturbed to set the piers and they can be installed without heavy equipment. A 60 lb. electric jack hammer drives the pins into the soil. The spacing of the timber bents was set at 3.048m (10 foot) on center based on the 30.11 kN (6.72 kips.) capacity of the piers using 2 in. schedule 40 pipes, 2.1336m (7'-0") long. Each pier had a lateral capacity of 8.2kN (1.83 kips.) The maximum lateral load was 1.93kN (432 lbs.) due to seismic loading. A total of 940 Diamond Piers were used on this project.

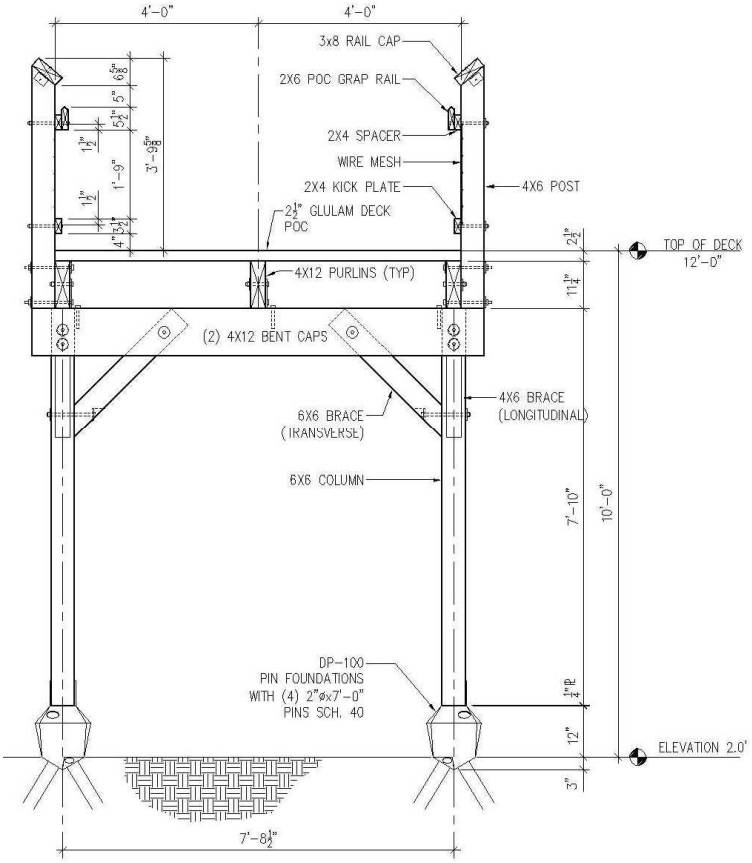

Figure 3. Typical Boardwalk Section

2.2 Timber Bents

The timber bents consisted of 6x6 DF#1 posts ranging in length from 2.44m (8'-0") to 4.88m (16'-0"). 4x12" DF#1 bent caps sandwiched the posts. 4x6 and 6x6 diagonal braces were used in the longitudinal and transverse directions respectively. These diagonal braces provide the lateral restraint necessary to resist lateral loads due to wind and seismic loading. The bents elevate the walkway to 3.66m (12'-0") above sea level.

All of the bent material was preservatively treated with ACZA meeting the AWPA use category UC5A. This treatment is used for lumber located in brackish or salt water environments and subject to marine borer attack. All of the preservative treatments were in accordance with the "Best Management Practices for the Use of Treated Wood in Aquatic Environments". This specification ensures that the minimum amount of treatment required to protect the wood is used, that the treatment is fully fixated in the wood and that the surfaces are clean before delivery to the jobsite.

2.3 Walkway framing

Three 4x12 DF Select Structural purlins support 6.35cm x 38.1cm (2½"x15") glulam deck panels. These panels are manufactured by ripping a 13.0175cm x 38.1cm (5 1/8"x15") beam lengthwise with a bandsaw. The rough sawn face is placed up and provides a skid resistant surface. The glulam deck panels are made with POC to reduce the amount of preservative in the project available to leach into the environment.

Originally DU specified Reinforced Plastic Lumber (RPL) for the deck and for the top rails. Preliminary bids for RPL came in almost twice as expensive as the glulam deck panels. Since the bending strength of the RPL is significantly lower than the glulam panels, three additional purlins would also be required adding to the expense of this system. RPL also continues to creep with time and over the years will sag between the purlins. Clearly the POC glulam deck panels were the best choice for this application.

The posts, kick plate and cap rail are made with DF sawn lumber. All of the DF lumber in the walkway was preservatively treated with ACQ meeting the AWPA use category UC4B which is appropriate for lumber subject to saltwater splash. The rail system features a 10.1cm x 10.1cm (4"x4") wire mesh to meet the required 10.1cm maximum opening size and to allow a greater degree of visibility for children and those in wheelchairs. A grab rail made with Port Orford cedar was chosen to provide a rail free of preservative chemicals.

2.4 Ancillary Structures.

The project included one observation tower, two viewing platforms, two walkway pushouts and a bird viewing blind. Each of these features invites visitors to stop and take in the views using observation scopes or rest on the benches provided by FWS. All of these structures are supported by Diamond Pier foundations and are made with pressure treated DF framing members and POC deck and grab rails. Roofs at the observation tower and viewing platforms provide a place to get out of the rain. DU specified a four sided hip roof for the Observation Tower, a gable roof for the first observation tower and an eight sided roof at the octagonal platform at the end of the boardwalk. Each of these roof structures were design to provide column free space. At the observation tower and octagonal platform, the hip beams acted as arches with a tension ring designed and detailed at the eave and a steel compression assembly at the peak.

2.4.1 Observation Tower

Figure 4. Observation Tower

The 3.6576m (12'-0") square observation tower, located at the beginning of the boardwalk has a floor height of 6.096m (20'-0") above sea level. From this height, visitors have a commanding view of the entire estuary. Full height columns at the corners support a gable roof. These columns are wrapped with cedar boards. Ramps slope up to the tower at 8.33% slope to allow handicap access to the platform. The ramp is 20.87m long (68'-6") with two switchbacks and two flat landings at the turns as required by the American with Disabilities Act.

2.4.3 Octagonal Platform.

Figure 5. Octagonal Shelter at end of boardwalk

The highlight of the boardwalk is an octagonal shelter at the end that provides a 360 degree view of McAllister Creek, the Olympic Mountains to the west, Mount Rainier to the east and several islands in Puget Sound. Measuring 7.3152m (24'-0") corner to corner, this structure provides 36.4m^2 (391.9 ft^2) of open space. The 6x6 columns in the corners extend to the tension ring at the eave level and support the eight hip beams that meet at a compression ring at the apex.

3. Tidal Channel Bridges

Figure 6. 15.24m (50'-0") Pony Truss Bridge

The construction of the boardwalk began shortly after the dike was removed. It soon became apparent that tidal channels were forming in several locations. These had not been accounted for in the layout of the boardwalk and it was not possible to predict where they would be located before the dike was removed. In four locations these channels were too wide to span with the standard 3.048m (10'-0") bent spacing. Timber Pony Truss Bridges were designed and installed to span these channels. These bridges ranged in length from 9.144m to 15.24m (30'-0" to 50'-0"). Each bridge consisted of timber pony trusses using 6x12 chords and 6x6 webs. These bridges were supported on timber bents with two Diamond Piers at each support. The trusses were shop assembled after preservative treating and shipped to the site where they were lifted into place with a helicopter.

4. Summary

The Nisqually National Wildlife Refuge boardwalk provides visitors with a unique opportunity to view a restored tidal estuary up close and personal. The project includes over a 1.6km (1 mile) of elevated boardwalk, viewing platforms, a bird viewing blind and an observation tower. Pressure treated Douglas fir and naturally decay resistant Port Orford cedar was used to provide durability for the boardwalks and other structures. Pony truss bridges provide clear spans over the tidal channels formed when a century old dike was removed. The light weight of the timber structure resulted in very small vertical reactions and base shears, allowing for the use of Diamond Pier foundation blocks.

The timber boardwalk fits beautifully into this setting. Its light footprint minimizes site disturbance while providing public access to the newly restored estuary.

Figure 7. Boardwalk at high tide with bird viewing blind and viewing platform