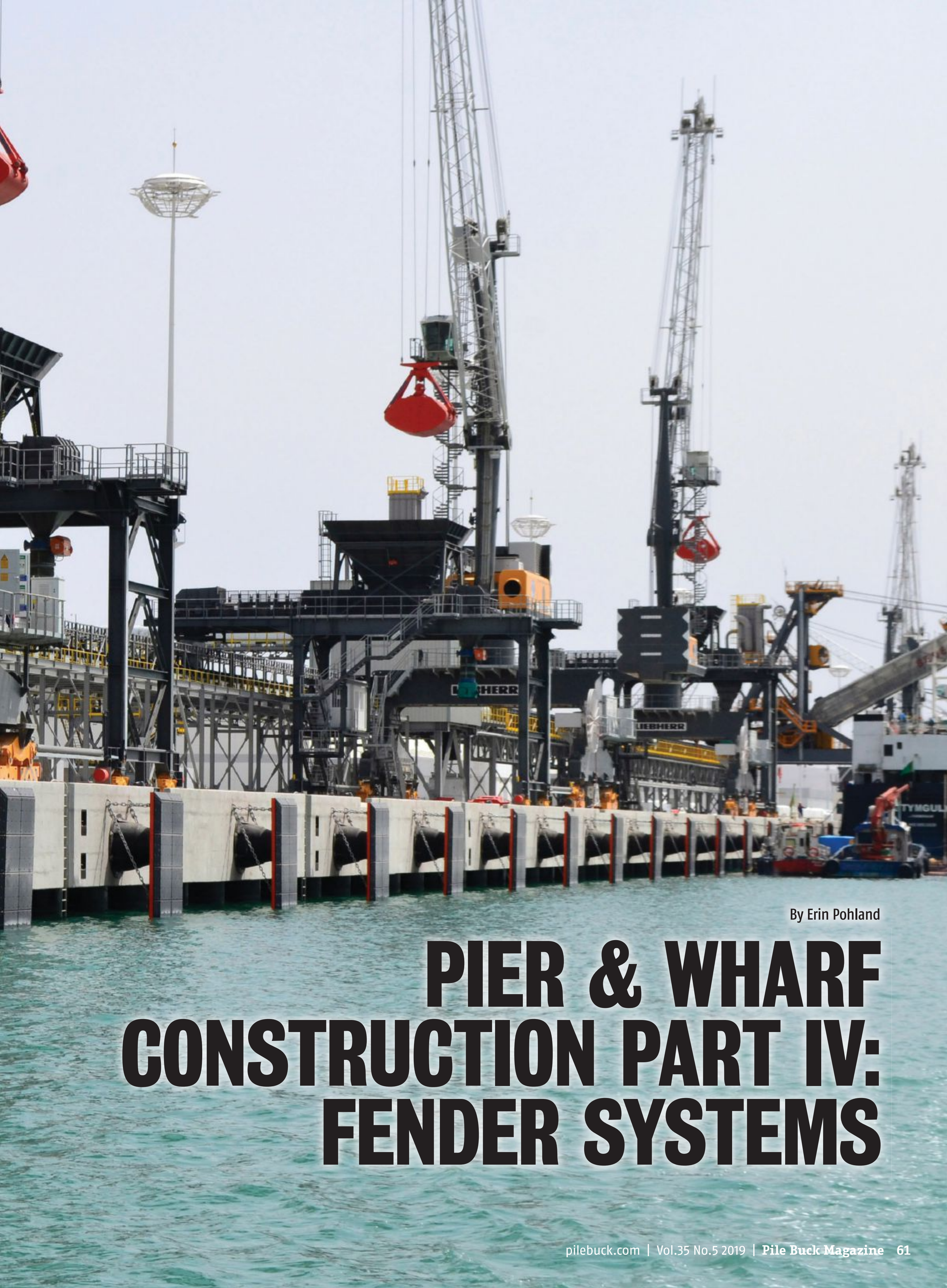
ShibataFenderTeam supplied more than 300 Fender Systems to Turkmenbashi, Turkmenistan.



By Erin Pohland

PIER & WHARF CONSTRUCTION PART IV: FENDER SYSTEMS

ShibataFenderTeam's SPC Corner Fender System for the Ferry Terminal in Zadar, Croatia.

When constructing a pier and wharf facility, one of the critical factors that must be taken into consideration is the fender system. This is the interface between the ship and shore facility that acts as a buffer during the berthing of a ship. The fender system absorbs or dissipates the impact energy of the ship, ideally without causing permanent damage to either the vessel or the facility. For this reason, a well-designed fender system is crucial to the overall function of a pier and wharf project.

This article explores the various aspects of fender systems as it relates to constructing pier and wharf facilities, from understanding berthing practicing to selecting and designing fender systems. If you are tasked with the construction of a pier and wharf facility, read on to learn more about this essential component and get in touch with your experienced fender manufacturer to make sure, your design performs as desired.

GENERAL CONSIDERATIONS

The first step in the process of designing a fender system is analyzing the greater concern: protection of the structure or of the vessel. For solid piers and wharves, which are relatively inflexible, protection of the ship is more important. With comparatively flexible pile-supported piers, wharves and dolphins, protection of the structure is the greater concern.

After the ship has been berthed and is moored to the facility, the fender system will continue to transmit environmental loads, such as wind, waves and current, on the ship to the structure. For low-profile ship berthing, the fender system will also provide a physical barrier to prevent the vessel from going under the pier.

The berthing practice of a given pier and wharf facility will impact the selection and design of a fender system. For example, large ships are often brought into berth by two or more tug boats, while smaller ships typically come in on their own power. A ship that is assisted by tugs will arrive parallel to the berth, with the tugs push and pull the ship so that it makes contact with as much of the fender system as possible. In contrast, ships that are unassisted by tugs will generally be eased into its berth at a slight angle (the angle of approach). Initial contact with the fender system in both scenarios should be fairly limited.

As a functional matter, fender systems should be designed to absorbed the ship's berthing energy in any structural type of pier or wharf, within the working stress or acceptable deformation range as defined by the contract. Note that fender systems are comparatively less expensive than either the ships that will berth against it or the facility itself. As such, some damage to this system is both permissible and acceptable. If there is a berthing accident, the fender should be sacrificed rather than the berth, any part of the structure, or the ship. Similarly, because it is more expensive to repair a ship's hull than a damaged fender system, all fender systems should be able to prevent deforming ships' hulls.

BERTHING ENERGY DETERMINATION

Berthing energy is a key factor that determines the type of fender system that should be utilized in a pier and wharf construction project. There are a number of methods that can be used to determine berthing energy: kinetic, statistical, and scale.

The kinetic model is the most-commonly used method, and is also the oldest. The calculation is based on the ships displacement tonnage and berthing speed, modified by variables to account for geometry and hydraulics. The statistical model is dependent on fender layout as well as construction of the site, including the distance between piles. It is based on actual measurements of the energy of the impact at existing berths. The scale model utilizes a small scale

model to test the berth in a hydraulic laboratory. This type of test requires experienced interpretation, and may suffer from scale and viscosity effects.

TYPES OF FENDER SYSTEMS

Fender systems work by either absorbing or dissipating the energy of the berthing ships, converting it from kinetic energy into potential energy. This may happen in a number of ways, from deflection of a fender pile, compression of a column of rubber, deformation of a foam-filled cylinder, pressuring of a pneumatic fender or torsion of a steel shaft. Some fender systems — namely, hydraulic fenders — also absorb energy in the form of heat. Most systems that can be practically applied use potential energy conversion.

There are seven potential types of fender systems. First, fender piles, which may be made of timber, steel, composites, or prestressed concrete. These piles may be connected to a chock and waler system at the deck level, then supported by rubber fender units at the bullrail.

Second, end-loaded rubber fenders work through the elastic compression of hollow rubber cylinder elements that have small length-to-diameter ratios. To minimize wear, steel fender panels with special rubbing material facing is generally used. These components are usually attached directly to the structure as a cell fender.

Third, side-loaded rubber fenders are hollow rubber units that will deform by attempting to flatten when loaded at their side. These fenders are available in four shapes: trapezoidal, square, circular, or D-shapes. The potential energy of side-loaded rubber fenders is stored

Schuyler Companies has been a leader in the business of designing and manufacturing marine fenders, having served the vessel operations industry for over 60 years.

AS A FUNCTIONAL MATTER, FENDER SYSTEMS SHOULD BE DESIGNED TO ABSORBED THE SHIP'S BERTHING ENERGY IN ANY STRUCTURAL TYPE OF PIER OR WHARF, WITHIN THE WORKING STRESS OR ACCEPTABLE DEFORMATION RANGE AS DEFINED BY THE CONTRACT. NOTE THAT FENDER SYSTEMS ARE COMPARATIVELY LESS EXPENSIVE THAN EITHER THE SHIPS THAT WILL BERTH AGAINST IT OR THE FACILITY ITSELF. AS SUCH, SOME DAMAGE TO THIS SYSTEM IS BOTH PERMISSIBLE AND ACCEPTABLE.

ShibataFenderTeam's Cell Fenders are successfully operational at the Container Terminal in Houston (TX), USA.


PORT OF HOUSTON AUTHORITY
PORT OF HOUSTON
AUTHORITY

by compressing the rubber elements. These fenders do not absorb large amounts of energy, and as a result, are typically used in combination with other components, like fender piles. Fourth, rubber shear fenders store potential energy as elastic shear deformation of the rubber. Rubber shear fenders are generally manufactured as a solid block of rubber vulcanized between two metal plates. This type of fender is sensitive to proper manufacturing, as it depends on the bond between steel plates and rubber. Shear fenders however, are rarely used nowadays and if, only for some very special application.

Fifth, buckling fenders will accept an axial load until it buckles laterally. Buckling fenders are used with an abrasion or protector panel, as they are not designed for direct contact with a moving ship. Because they can absorb high berthing energies, buckling fenders are popular for berthing large ships and the most common type of rubber fenders used on today's ports.

Sixth, pneumatic fenders store potential energy through the elastic compression of a confined volume of air. The energy absorption characteristics can then be changed by varying the internal pressure of the air, with a relief vale or deflection limiter to prevent a blowout. These fenders provide a uniform hull pressure, as they have a uniform surface pressure. A floating pneumatic fender is usually cylindrical with hemispherical ends. It is then attached to the facility with chains, floating on the water. Seventh, foam-filled fenders are made of closed-cell foam encased by an elastomeric polyurethane skin. This

FENDER SYSTEMS WORK BY EITHER ABSORBING OR DISSIPATING THE ENERGY OF THE BERTHING SHIPS, CONVERTING IT FROM KINETIC ENERGY INTO POTENTIAL ENERGY. THIS MAY HAPPEN IN A NUMBER OF WAYS, FROM DEFLECTION OF A FENDER PILE, COMPRESSION OF A COLUMN OF RUBBER, DEFORMATION OF A FOAM-FILLED CYLINDER, PRESSURING OF A PNEUMATIC FENDER OR TORSION OF A STEEL SHAFT.

Offering All-lines Insurance through ONE Carrier

Coverage includes: Property, General Liability, Contractors Equipment, Auto, Hull, Protection & Indemnity, Excess, Workers' Compensation, USL&H & Jones Act

prosightspecialty.com/marinecontractors

Policies described above are underwritten by the insurers of ProSight Specialty Insurance Group, which include NY Marine and Gen. Ins. Co., Gotham Ins. Co. and SW Marine and Gen. Ins. Co. Coverage may not be available in all jurisdictions. Actual coverage is specified in the policies issued. ProSight Specialty, 412 Mt. Kemble Ave., Morristown, NJ.

PSI-005-19

ProSight

ISR INTERNATIONAL SPECIAL RISKS

Schuyler Companies has been a leader in the business of designing and manufacturing marine fenders, having served the vessel operations industry for over 60 years.

type of fender is resilient, but additional protection may be provided by thicker coatings or an external tire net. A backing system is required to handle the load and to allow for uniform deflection of the fender. Foam-filled fenders float on the water with the tide, attached to the structure with chains. The cells of the foam deform and thereby absorb the berthing energy.

These types may be used separately (except buckling fenders liken cone, cell, leg) or in combination to form a fender system, along with the structure itself. With a proper fender system in place, ship deformation should be rare. There are a number of systems that can be used to prevent damage to both vessels and the pier and wharf facility. The five most common are discussed in detail below.

A combination of fender piles with side-loaded rubber units is frequently used in commercial and naval facilities. It involves a series of fender piles that are closely spaced, connected by chocks and walers, with rubber fender units mounted between the waler and facility. Diagonal chains from the structure to the waler finishes the fender system. The joints between the chocks, walers and pile heads should be tight. The ships can either be berthed directly or through a log camel in this system. This type of system offers flexibility in berthing, as ships of different sizes and types can be accommodated. However, this fender system is not recommended for solid and other types of piers and wharves where full deflection of the piles will be prevented. In addition, the use of floating camels may result in concentrating the energy on just one or two piles. For this reason, the rubber fender units should be sized so that the ships can be directly berthed without camels.

For direct berthing of surface ships, directly mounted fender units may be a good choice. Here, individual fender units are attached to the pier or wharf face. This is a cost-effective choice for solid piers and wharves with narrow tidal ranges and narrow vessel size ranges. But there are also multiple customized designs available addressing large tidal ranges and vessel sizes, e.g. double conical fender systems which 30ft long panels and more.

Floating fender units might be a better option when surface ships of many sizes must be berthed. This fender system involves foam-filled or pneumatic fender units along with a backing system. These units can be positioned to float with the tide, and designed so that they can be moved as berthing plans change.

A combination system may be made of any of the above systems to make up for what another system lacks. For example, dedicated berths may have floating fender units, directly mounted fenders at specific points, and then a pile-rubber system in-between. Working closely with engineers and experience marine fender manufacturers can allow you to choose a fender system that best meets the needs of the pier and wharf facility.

Finally, a monopile system involves the use of a floating ring-shaped fender unit (AKA donut fenders) that rides up

FLOATING FENDER UNITS MIGHT BE A BETTER OPTION WHEN SURFACE SHIPS OF MANY SIZES MUST BE BERTHED. THIS FENDER SYSTEM INVOLVES FOAM-FILLED OR PNEUMATIC FENDER UNITS ALONG WITH A BACKING SYSTEM. THESE UNITS CAN BE POSITIONED TO FLOAT WITH THE TIDE, AND DESIGNED SO THAT THEY CAN BE MOVED AS BERTHING PLANS CHANGE.

Seaboard Steel Corporation offers:

- Steel sheet piling for rent or purchase
- WF 14 x 120 walers for rent along with end boxes that pin together eliminating welding
- Standard vibratory hammer/extractors as well as side clamp hammers
- Hydraulic impact hammers for stubborn sheets
- Diesel hammers
- Vertical earth augers

STEEL SHEET PILING

VIBRATORY DRIVER/EXTRACTORS

PILE HAMMERS:
DIESEL & HYDRAULIC

VERTICAL EARTH AUGERS

SSC Seaboard Steel Corporation
Since 1956

Info@SeaboardSteel.com
www.SeaboardSteel.com
+941-355-9773

Trelleborg Marine and Infrastructure supplied its SCK Cell Fenders as part of a project undertaken by the Singapore Cruise Centre to upgrade its infrastructure to accommodate the latest generation of cruise vessels at its international cruise terminal.

and down on a large steel pile that has been driven to the seabed. Low friction bearing pads are installed on the inner surface of the hull, which allows the fender unit to rotate and slide on the pile. A monopile fender system is best used for corner protection, as well as for entrances to narrow slips or locks.

SELECTION AND DESIGN OF FENDER SYSTEMS

When selecting and designing a fender system, engineers must take a number of factors into consideration. Beyond cost, these issues go into the suitability of the system for the facility itself — and whether the fender system will be able to perform as desired over time.

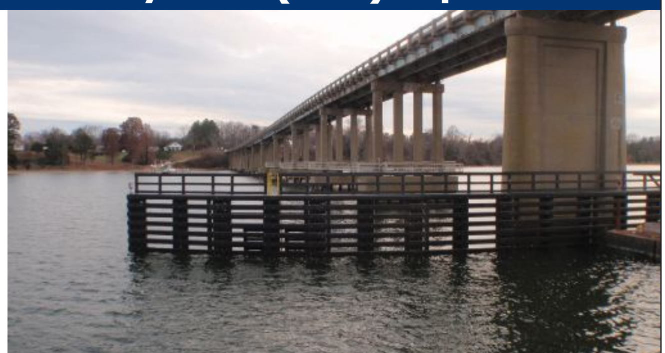
As an initial matter, the system must be able to absorb the kinetic energy of the berthing vessel. It also must have a minimal reaction force, which is the force that is exerted on the ship's hull and the structure doing impact. Hull pressure must also be limited so as to avoid causing permanent damage to the berthing ship.

Engineers must consider the amount of deflection (the distance that the face of the fender system moves when absorbing the ship's energy) when selecting and designing a fender system. The relationship between reaction and deflection will determine the stiffness of the fender system chosen.

The system must be able to withstand long-term contact without degrading over time. This includes contact involving wind, current, waves and tides during loading and unloading. Friction between the face of the fender system

AS AN INITIAL MATTER, THE SYSTEM MUST BE ABLE TO ABSORB THE KINETIC ENERGY OF THE BERTHING VESSEL. IT ALSO MUST HAVE A MINIMAL REACTION FORCE, WHICH IS THE FORCE THAT IS EXERTED ON THE SHIP'S HULL AND THE STRUCTURE DOING IMPACT. HULL PRESSURE MUST ALSO BE LIMITED SO AS TO AVOID CAUSING PERMANENT DAMAGE TO THE BERTHING SHIP.

CREATIVE PULTRUSIONS
SUPERPILE®
Fiberglass Reinforced Polymer (FRP) Pipe Piles



High Strength • Rot/Rust/Corrosion Proof

FASTEST DRIVEN -
Drives twice as fast as traditional materials

LONGEST LASTING -
Durabilty projections predict 75+ year service life

EASE OF FABRICATION -
Can be field drilled and cut in minutes

ENGINEERED SOLUTION -
Designed specifically for the pile market

Contact our Waterfront Sales Rep for more information
888-CPI-PULL (Option 2) | crpul@pultrude.com
CreativePultrusions.com

Made in the USA

and the ship's hull is also a factor to be analyzed, as it may have an impact on the performance of the fender system.

The degree of the berth's exposure to severe environmental conditions may govern the design's mooring conditions and fender system. In addition, the ability of the crew to appropriately berth the ship will impact the fender's energy absorption ability, and should be analyzed.

Both the initial cost of the fender system should be considered, as well as its operation, maintenance, and repair. If maintenance is to be frequent or expensive, a simpler system may be preferred. If there are a great number of berthings expected, a higher expenditure for the system may be justified.

If a particular type of fender is more frequently used in a given location, it may be considered, as its performance in similar conditions can be evaluated.

Finally, the type, size and shape of ships that are anticipated to use the facility should also be determined. The fender system should be able to accommodate the full range of ships that are expected to use the facility. If ships with unusual hulls may berth at the structure, special attention should be paid to the fender system. Similarly, the fender system must be useable during all water levels.

Keep in mind that in most cases, a ship will only make contact with a small length of a fender system at a time while berthing. For this reason, a discrete fender component should be designed to be able to provide the full energy, with two components installed per berth.

Fender piles, backing members and other non-rubber components are not affected by temperature fluctuations, and should perform normally. However, rubber fender units will become stiff in colder temperatures, and their performance may be significantly impacted. The ability of rubber units to absorb energy should be evaluated based on the lowest expected temperature and other correction factors for berthing angle and manufacturing tolerance. The general approach to correct factor has to make sense for the project, e.g. a conservative berthing analysis and allowance for higher berthing speeds in the berthing energy calculation, will compensate for some or all of the typical correction factors.

Fender systems place a crucial role in pier and wharf structures. By absorbing and dissipating the energy of berthing ships, these systems protect both the facility and the vessels. As a result, properly selecting and designing fender systems is an important part to the overall function of a pier and wharf facility. Therefore, the cooperation with well experienced fender manufactures in the early stage of the project is crucial for the success of the project as there are many possible oversights that can heavily impact the performance and durability of the fender system. ■

CASHMAN

Miscellaneous Steel Beams for Sale; Best Offer

Located in Chesapeake, Virginia

Points of Contact - please call:

Jason Podd: (757) 630-9022 • Brett Arnheiter: (732) 232-0786

www.4barges.com