U.S. Department of Homeland Security

United States Coast Guard

Marine Safety Center Technical Note

MTN 05-94, CH-2
16710/46CFR72.01-15
January 11, 2016

MARINE SAFETY CENTER TECHNICAL NOTE (MTN) NO. 05-94, CH-2

Subj: SPECIAL CONSIDERATIONS REGARDING RACKING LOADS IN THE STRUCTURAL ANALYSIS OF LARGE MULTI-LEVEL SUPERSTRUCTURES ON PASSENGER VESSELS OPERATING ON PROTECTED WATERS

Ref: (a) American Bureau of Shipping (ABS), "Rules for Building and Classing Steel Vessels for Service on Rivers and Intracoastal Waterways, 2007"

1. Purpose: This Marine Technical Note provides guidance regarding the structural adequacy of large multi-level superstructures on passenger vessels, with specific regard to the analysis of racking loads. Change 2 (CH-2) incorporates minor administrative changes and restricts the applicable route to protected waters only to align with reference (a).

2. Applicability: This MTN applies to vessels designed to reference (a). It does not apply to vessels designed to other ABS Steel Vessel Rules or ABS Steel Vessels Under 90 Meters.

3. Discussion:

a. Many high capacity passenger vessels built for service on protected waters incorporate multi-level superstructures which extend nearly the entire length of the vessel. Due to the service nature of these vessels (casino, excursion, dinner, theater) and the high passenger densities, designers and owners strive to provide large, open public spaces within the superstructure. Such arrangements usually result in few, if any, interior transverse bulkheads within the superstructure. In addition, brackets are typically small so that they can remain entirely above the finished ceiling and out of sight. This is a departure from traditional ship construction, which typically uses the interior transverse bulkheads in combination with brackets to provide transverse structural stability and rigidity for the superstructure. The lack of major transverse structure raises concerns about the ability of the superstructure to resist global side or racking loads.

b. The concern over transverse structural rigidity is further amplified when the superstructure is constructed with "floating channels." In floating channel construction, the transverse deck girders are placed across the bottom face of the longitudinal deck stiffeners, rather than being welded directly to the deck plate as in more traditional construction (see Figure 1). This type of construction, which is quicker and less expensive to build, has been approved by ABS primarily for barges and tow boats, where it is used below the main deck only, and the transverse rigidity of the hull is provided by large diagonals and required watertight bulkheads (see reference (a)). When floating

channel construction is used for large, open, multi-level superstructures the resistance to racking loads is further reduced.

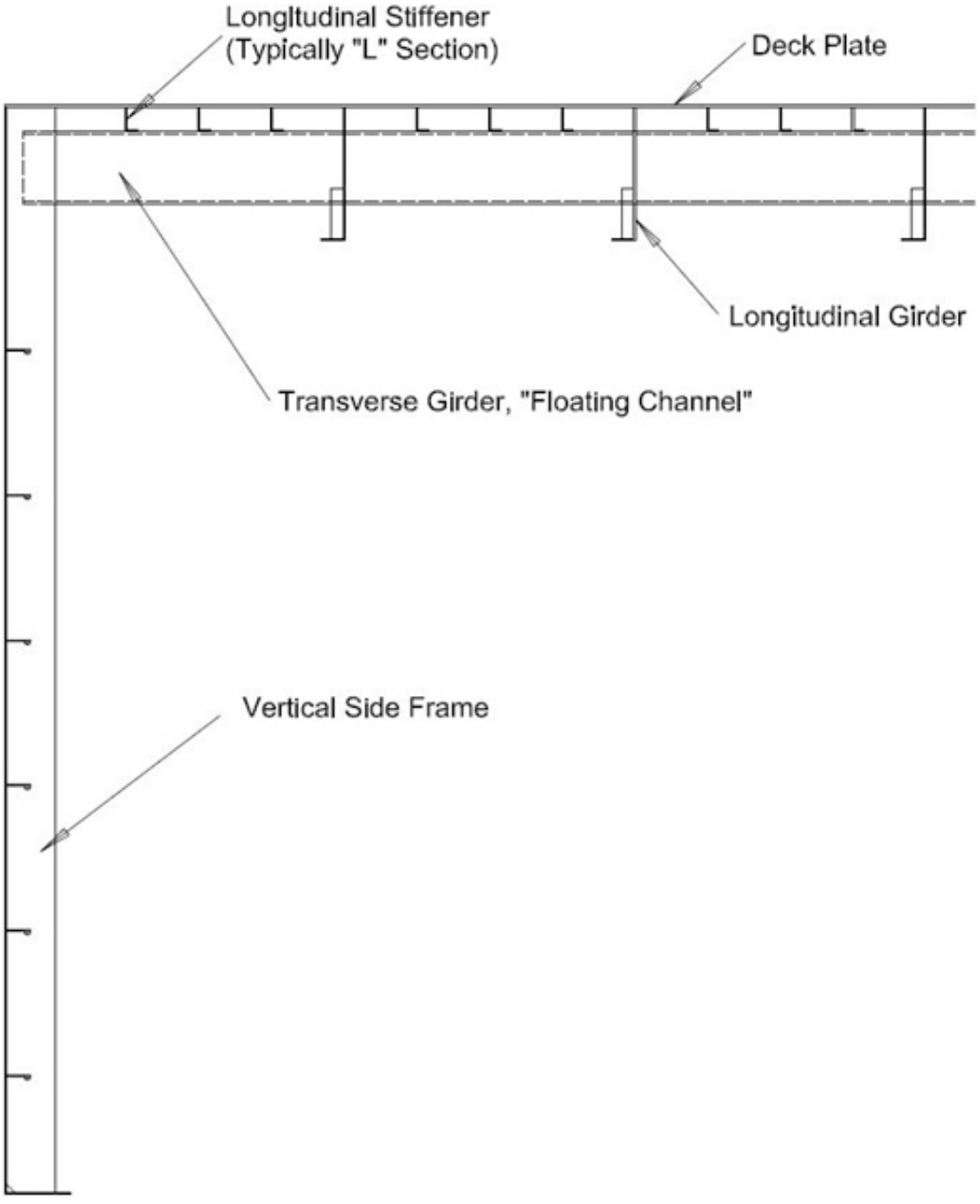


Figure 1: Typical Floating Channel Construction

Subj: SPECIAL CONSIDERATIONS REGARDING RACKING LOADS IN THE STRUCTURAL ANALYSIS OF LARGE MULTI-LEVEL SUPERSTRUCTURES ON PASSENGER VESSELS OPERATING ON PROTECTED WATERS

c. ABS rules do not specifically address the design of multi-level superstructures for global side or racking loads. In those cases where the rigidity of the superstructure is in question, ABS has required specific analysis of the racking condition, which falls outside of the scope of the published rules. Unfortunately, this type of analysis usually involves extensive use of Finite Element Methods (FEM) and is both complicated and time consuming, and does not lend itself to routine plan review.

d. The MSC undertook a limited FEM study to qualitatively determine the effect of racking loads on large, open, multi-level superstructures such as those commonly found on river casino vessels, particularly those constructed with floating channels. The goal of the study was to determine the magnitude of racking loads and to develop some simple rules which can be used in everyday design and plan review in lieu of a full FEM study. The study concluded that the primary resistance to racking loads comes from the deck plate and the transverse bulkheads, not from the web frames in the superstructure. However, the superstructure frame and connection must be designed for the shear loads transferred from the deck plate. A superstructure designed for local loads in accordance with reference (a) typically has sufficient rigidity for the global side loads anticipated on protected waters, provided that a few simple additional design calculations and structural modifications are made as outlined below. Where the guidelines below are not applied, detailed calculations and FEM studies may be required at the discretion of the Marine Safety Center plan reviewer to ensure that the structure is sufficient for all anticipated loads.

4. Action:

a. In the structural design and review of large multi-level superstructures, especially those with few transverse bulkheads, the following steps should be taken in addition to the requirements of reference (a):

i. The vertical members in the house sides which form the side of the truss (side frame) serve the dual role of supporting horizontal and vertical loads. Accordingly, they should be sized for both the lateral load (accounted for by the section modulus requirement in reference (a) and the axial or bearing loads transmitted from above. Because there are few interior bulkheads in the superstructure, the vertical loads are transmitted primarily through the vertical frames in the house sides and the stanchions. To account for the combined loading on the vertical side frames, the sectional area of a member which satisfies the section modulus requirement of reference (a) should be increased by 1 square inch for each 10 tons of axial load supported. The axial load on these vertical members should be calculated in a manner similar to the load on a stanchion which supports deck girders.

Subj: SPECIAL CONSIDERATIONS REGARDING RACKING LOADS IN THE STRUCTURAL ANALYSIS OF LARGE MULTI-LEVEL SUPERSTRUCTURES ON PASSENGER VESSELS OPERATING ON PROTECTED WATERS

ii. Both vertical frames in the superstructure sides and stanchions, which support deck girders in the superstructure, must have a ratio of length to least radius of gyration less than 150. This ensures that these members can resist the bending moments caused by the global side loads on the superstructure.

iii. An effective means of transmitting the load from the deck stiffeners to the superstructure frame at the house ends (fore and aft) must be provided. Typically, this is accomplished with vertical stiffeners in the house ends which are connected to each longitudinal stiffener on the deck where they terminate. When the house end is horizontally stiffened, vertical members must be fitted from the termination of the longitudinal deck stiffener down to the first horizontal stiffener on the house (Figure 2). The load on longitudinal deck girders in the superstructure must be effectively transmitted to the main deck through vertical frames in the house ends, as shown in Figure 2.

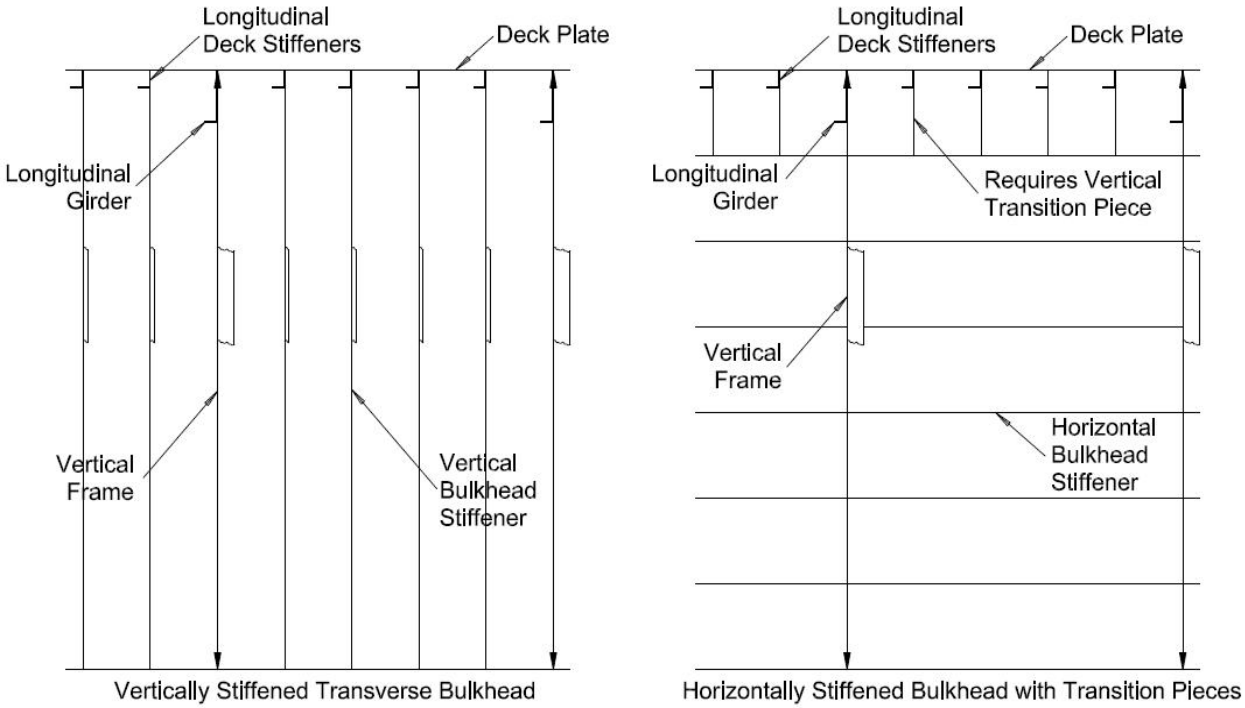


Figure 2: Sectional View of Transverse Bulkheads

iv. Where floating channel construction is used, a plate of thickness at least equal to the thickness of the transverse girder must be inserted in the gap between the deck plate, the transverse girder, the farthest outboard longitudinal stiffener, and the vertical truss member in the superstructure side, at every frame (Figure 3). This plate greatly

reduces the shear stress at these connections by increasing the area available to transmit the loads.

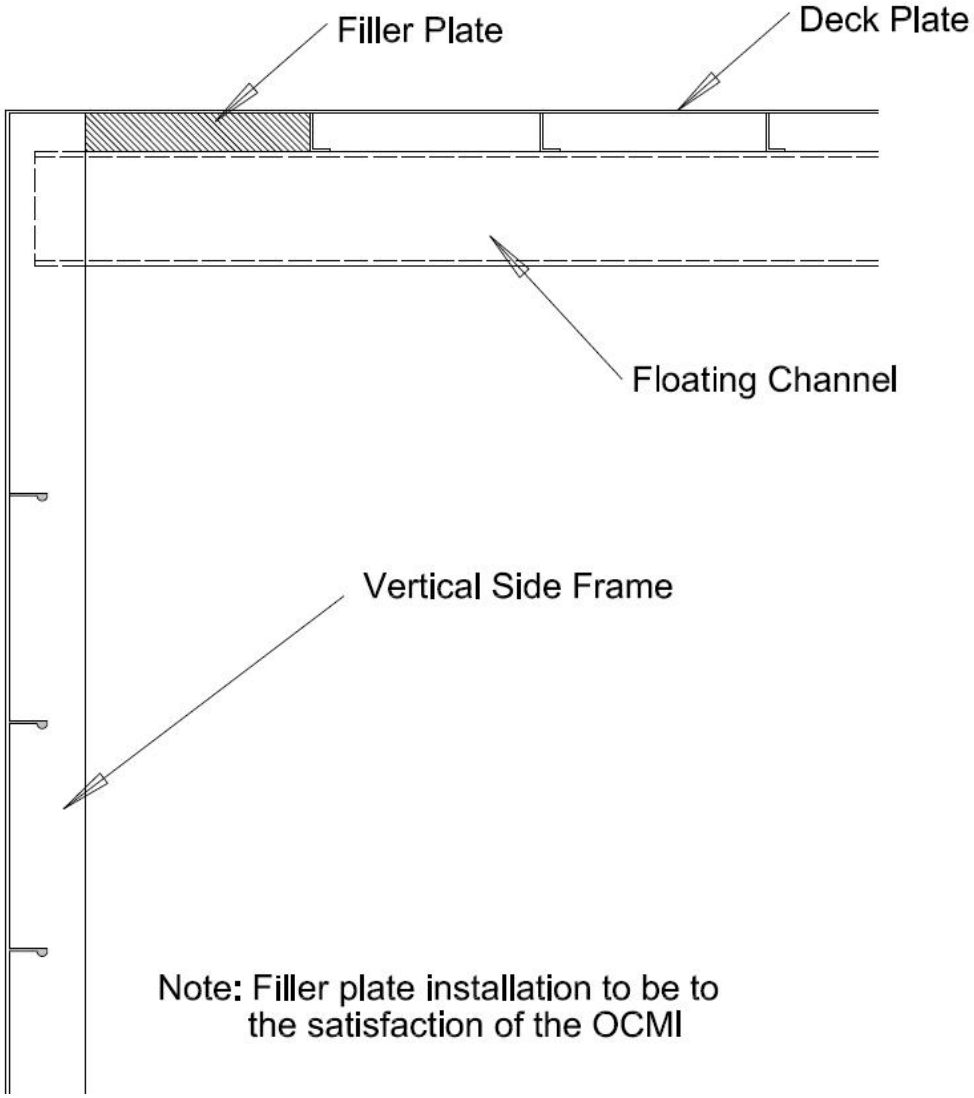


Figure 3: Floating Channel Construction with Required Filler Plate

v. Where floating channel construction is used, the transverse deck girders should be channel sections. Where "L" or other sections are used, tripping brackets must be fitted at least every 10 feet of transverse span.

Subj: SPECIAL CONSIDERATIONS REGARDING RACKING LOADS IN THE STRUCTURAL ANALYSIS OF LARGE MULTI-LEVEL SUPERSTRUCTURES ON PASSENGER VESSELS OPERATING ON PROTECTED WATERS

vi. Where the decks in the superstructure are transversely stiffened with the deck girders running longitudinally, the same general guidelines above apply. Each transverse deck stiffener must connect to a vertical stiffener in the longitudinal superstructure side shell. Floating longitudinal girders must be fitted with filler plates as described above, and vertical members which form the truss ends in the transverse superstructure bulkheads should be sized for axial and side loads.

b. Special consideration will be given to designs which do not meet the above guidelines provided that calculations are made which specifically address the following:

i. Analysis of the superstructure side frame under combined loading of both axial and lateral loads.

ii. Adequacy of the design for the resistance of racking loads, including buckling analysis of the deck plate.

iii. Detailed analysis of the stress at the connection of the deck plate to the transverse bulkheads under racking loads.

iv. Detailed analysis of the shear loads at each connection of a floating transverse girder with a vertical side frame or longitudinal deck girder.

c. Racking calculations, with a finite element or similar model, will be required to demonstrate the adequacy of the superstructure. Any such study must contain the following as a minimum:

i. A 3D model extending at least one web frame spacing longitudinally and from side shell to side shell transversely. Symmetry in structure or loading cannot be assumed.

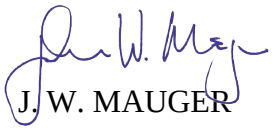
ii. A statement of boundary conditions used and how they were derived from global forces.

iii. List of maximum permissible stress for each type of element used.

iv. An explanation of the loading conditions investigated.

Subj: SPECIAL CONSIDERATIONS REGARDING RACKING LOADS IN THE STRUCTURAL ANALYSIS OF LARGE MULTI-LEVEL SUPERSTRUCTURES ON PASSENGER VESSELS OPERATING ON PROTECTED WATERS

5. Disclaimer: While the guidance contained in this document may assist the industry, the public, the Coast Guard, and other Federal and State agencies in applying statutory and regulatory requirements, this guidance is not a substitute for the applicable legal requirements, nor is it in itself a regulation. It is not intended to, nor does it impose legally binding requirements on any party, including the Coast Guard, other Federal agencies, the States, or the regulated community.



J. W. MAUGER

Copy: Commandant (CG-ENG-2) Office of Design and Engineering Standards - Naval Architecture Division
Commandant (CG-5P-TI) Traveling Inspector Staff