Container Stowage on Bulk Carriers

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ABSTRACT

Interest for stowing containers on bulk carriers has significantly increased since the container port bottlenecks on the US West Coast and elsewhere in the second half of 2021. The higher operational GMs of bulk carriers compared to dedicated containerships lead to considerable container accelerations that have to be addressed. The two separate methods of carrying containers on bulk carriers are: (1) according to the provisions of the IMO Code of Safe Practice for Cargo Stowage and Securing (CSS), or (2) according to Classification Societies Common Structural Rules (CSR) for Holds/Decks/Hatch Cover structure and secured to their container securing guidelines. The first option involves a much less rigorous CSS analysis and usually results in traditional wood dunnage and multiple chain or wire rope lashing arrangement, treating the containers as a solid block of general cargo. Fewer or lighter weight containers can be carried with this option. The alternate option for design and approval by Class structural and container securing rules will adequately address the ship structural and container securing issues. This second option, similar to that used for dedicated containerships, involves a comprehensive analysis of ship motions, stresses, and container lashing and securing, including evaluation of the loads on ship structure and the containers. The typically high accelerations for bulk carriers can lead to different failure modes of the container stowage, the containers themselves, or their contents.

Keywords: *Bulk Carriers, Container Stowage, Container Securing, CSS Code*

1. BACKGROUND

Interest for stowing containers on bulk carriers has significantly increased since the container port bottlenecks on the US West Coast and elsewhere in the second half of 2021. Container freight rates soared to levels supporting investigations into the alternate stowage of containers on bulk carriers, and potential voyages to the second-tier non-dedicated container terminals to avoid container port congestion. Bulk carriers are designed for bulk cargoes, typically much higher density than containers. Even with including containers stowed on deck, bulkers are typically loaded to a relatively light draft. This corresponds to a high GM and respectively high accelerations and stresses on container lashing, the containers themselves and their contents. The ship Classification Societies often require approval of the stowage plans of more than 2-high stowage and generally require their review of the container securing arrangement and structural analysis of deck and hatch cover structures.

The Classifications Societies are fairly consistent in the applicability of two options for stowage of containers on bulk carriers (see [3], [4], [5], and [8] for ABS, BV, DNV, & LR recommendations, respectively):

- Option 1 – according to the provisions of the IMO Code of Safe Practice for Cargo Stowage and Securing (CSS Code) which is usually included as procedures in the ship's Cargo Securing Manual (CSM), see [2].
- Option 2 – according to Classification Societies Common Structural Rules for Bulk Carriers governing the Holds/Decks/Hatch Cover structure, and secured to their container securing guidelines, similar to dedicated containerships. Option 2 is not generally applied to bulk carriers, but Herbert Engineering was generally familiar with the methodologies from its design work for containerships.

2. DETAILS FOR THE TWO OPTIONS

Option 1 is what is traditionally done for carriage of break bulk or special heavy lift items on bulk carriers. The ship's Cargo Securing Manual will usually include procedures for carrying and securing these individual items in addition to pure bulk cargo stowage. Often this involves a much less rigorous CSS analysis for lashing and securing and usually results in a traditional wood dunnage and multiple wire rope or chain lashing arrangements, treating the containers as a solid block of cargo. Realistic container capacities for Ultramax bulkers with 2-tiers on deck and 3-tiers in the holds are about 500 TEU total depending on mix of desired container lengths and the specifics of the lashing and dunnage arrangement. An example is shown in Figure 1.

The Option 2, similar stowage to a conventional containership, would require design and approval by Class and will adequately address the ship structural and container securing issues. This option will require an analysis of ship motions, stresses, and container lashing and securing, including evaluation of the loads on the ship structure, the containers, and the container securing components. This option generally requires extensive installation of supporting structure on or under the ship's deck to support the weight of the container stacks and lashing equipment. Typical capacities for bulkers can be 1100 TEU or more for the Ultramax-size ships, depending on the extent of structural reinforcements. An example is shown in Figure 2.

General Particulars of a typical Ultramax size bulk carrier are:

LOA	200m
Beam	32.26m (original Panamax)
Depth	18.5m
Max Draft	13.3m
Max DWT	about 60-65,000 m. tons

A preliminary investigation began regarding the possible container stowage aboard a typical Ultramax-sized carrier with a review of the ship drawings and capabilities. Target container loads of over 1000 TEU per ship necessitated typically two and three tiers high stowage on deck, within bridge visibility limits, and typically five and six tiers high stowage in the cargo holds. As this was not considered possible with the Option 1 conventional dunnage & chain securing systems, which typically resulted in significantly lower capacities.

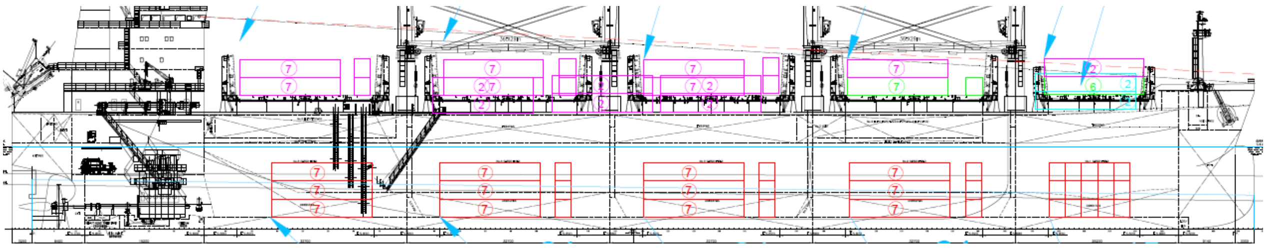

Figure 1: Typical Option 1 stowage on an Ultramax Bulk Carrier.

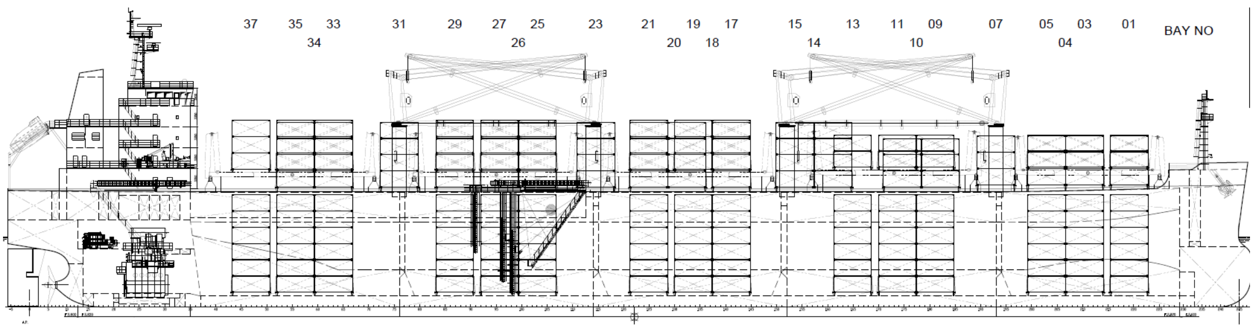

Figure 2: Typical Option 2 stowage on and Ultramax Bulk Carrier.

3. THE PILOT PROJECT

In the initial instance, in order to maximize container stowage and ship utilization, a decision was made to proceed with the conceptual and detailed design for the Option 2 modifications for maximum container stowage. The initial design concept was to design for traditional mix of 15 metric ton 20-foot containers and 20-25 metric ton 40-foot containers, with no 45's or 53's. Structural modification were targeted for main deck, hatch cover and inner bottom. In order to simplify and shorten the on-board installation of the structural reinforcements, preference was given to designs involving only structural reinforcement above the deck, hatch cover, or inner bottom plate, without reinforcement installation underdeck or from inside the inner bottoms or the underside of the hatch covers or main deck. Conventional containership deck load type stowage with twist locks and lashing rods were proposed for hatch covers and on deck, as well as within the cargo holds.

There were several significant unknowns impacting the initial evaluations and ability to provide solid budget estimates for the pilot project:

- Structural Analysis General – The prototype project involved three major ship classes and multiple sub-classes of ships and involved independent submissions and approvals by each of the three involved Classification Societies, DNV, ABS, and LR. There were initially unknown specific requirements from the three Classification Societies for the application of container securing fittings and structural reinforcements to Bulk Carriers based on CSR (the Common Structural Rules for Bulk Carriers) and different requirements for analysis of the structure for the container reinforcements.
- Ship Hull Structure (Inner bottom and Weather Deck) – Because these ships are based on the CSR rules, the concentrated loads from the container loading should properly be integrated into the CSR load cases for the ship design. This can be done if access to the original CSR ship model is available. For cases where this is not practical an alternate method based on equivalent stresses to the current approved uniform loading was proposed. Both the inner bottom and the main deck outboard of the hatch covers a typically rated for a specific uniform load rating, typically 20 to 25 mt/m^2 for the cargo holds and 3.5 to 4.5 mt/m^2 for the decks. The ship's maximum deck and inner bottom stresses result from a complex combination of global and local stresses from hydrodynamic and inertial loads, which are considered in the CSR global analysis. The equivalent stress method only considers the local loads from the cargo loading. It uses the resulting stresses from the existing approved uniform cargo load rating as a practical equivalent limit for evaluating the concentrated loads from the container loading. All of the Classification societies were agreeable to accept this equivalent stresses method for the analysis of the inner bottom and decks for the Type 2 analysis.
- Hatch Cover Structure – the covers were typically not designed to accommodate any significant cargo on deck and had a very limited strength and were usually designed to withstand water pressure (typically 1.0 to 2.2 t/m^2) loading based on the Loadline Requirements, with minimal strength uniform load to support cargo. The Class rules all require a full Finite Element Analysis to analyze the possible structural reinforcements. It was unknown if the existing structure of the hatch coaming could support the additional weight of the containers without significant structural reinforcement.
- Novel Design and Requirements – in general, these structural reinforcements based on dynamic container loads had not been previously accomplished for bulk carriers. Agreement needed to be reached with each Classification Society on the criteria for ship motions and accelerations and the methodology for analysis of the lashed container stacks. In most cases this involved a combined application of both the methodology from the CSR ships motions and accelerations and the corresponding values from the container securing guidelines developed for containerships.

4. FINDINGS – GENERAL

It is obvious that bulk carriers are not containerships. They can successfully be adapted to carry container loads, but it is not the intended function of these ships, and many compromises must be made in the adaption of these ships to carry significant container loads using either Option 1 or Option 2 methods.

The container load conditions (see Table 1) for both Option 1 & 2 are substantially similar to a heavy ballast condition with similar characteristics of high GM typically 6m-8m, partial propeller immersion, and significant aft trim limiting deck stowage for meeting bridge visibility requirements. Seakeeping and ship motions resulting from the high GM's result in large accelerations which drive the lashing and structural strength requirements. These are substantially different operational condition compared to mid-sized containership, typically with GM's close to, or less than, 1.5 meter.

	Displacement	Draft	GM
	m. tons	m	m
Ultramax Bulk Carrier			
Full Load Bulk	75000	13.3	7.7
Heavy Ballast	43000	8.0	5.6
Normal Ballast	20000	6.2	8.9
Container Option 1	37000	7.0	7.0
Container Option 2	39000	7.4	5.3
20k TEU Conatinership	180,000	16.0	1.5

Table 1 – Bulker & Containership characteristics

5. FINDINGS SPECIFIC TO OPTION 1

Option 1 for container stowage can generally be categorized in two ways, based on the initial configuration of the ship: as initially capable of carrying deck loads, or initially capable of underdeck cargos only.

For ships initially capable of carrying deck loads the adaption of the ship to carry containers is relatively straightforward. The cargo plan consists of developing a proposed stowage arrangement and evaluating this plan based on the existing CSS Code based Cargo Securing Manual. This will usually involve developing a block stow container lashing and dunnage plan based on existing information in the Cargo Securing Manual, based on the loading plan. Lashing and bridge visibility need to be evaluated based on the specific container loading and resulting Trim & Stability calculations. Resulting stows are typically block stow containers, locked to each other by twist-locks between tiers and bridge fitting between adjacent stack, with wire or chain diagonal lashings connected to welded D-rings, and stowed on wood dunnage and welded shear clips on the deck. Review of this specific loading plan by the ship's Classification Society is optional, and generally not required, since the stowage is based on methods in the current approved Cargo Securing Manual.

For ships that are initially capable of underdeck cargos only, an initial step is to qualify the ships to be capable of carrying deck loads. This will typically involve developing an addendum to the ship's Trim & Stability Booklet or Loading Manual and often requiring updates to the Damage Stability Calculations (SOLAS Probabilistic vs Loadline based), update to the bridge visibility, the Cargo Securing Manual, and often implement these addendums into a revised onboard Loading Program. Each of these items need to be completed and approved by the ship's Classification Society prior to proceeding with container loading according to the CSM.

6. FINDINGS SPECIFIC TO OPTION 2

Adapting bulk carriers to carry container with Option 2, in ways similar to conventional container carriers, is not straightforward. Adapting the analysis in consideration of the combined Classification Societies Common Structural Rules, the Container Securing Guidelines, as well as some of the methodologies for analyzing concentrated loads for Classing Containerships is novel and somewhat complicated.

Using the equivalent stress comparison method using the existing approved uniform loading is quite conservative, and results in the design and installation of substantial steel reinforcements for the decks, hatch covers, and inner bottom. With care, this design can be somewhat simplified and accomplished without using any underdeck reinforcement, but the costs are not trivial (often over 1M USD per ship) and requiring significant time out of service for installation. Also, these reinforcements in the cargo hold must be designed for easy removal when the ship returns to traditional bulk service, since their presence will interfere with bulk cargo carriage on deck or typical bulk grab bucket discharge and easy cleaning of the holds between cargos.

	Displacement	Draft	GM	Roll Angle	Transverse Acceleraton g	
	m. tons	m	m	degrees	Hold	Hatches
Ultramax Bulk Carrier						
Container Option 1	37000	7.0	7.0	30	0.45	0.80
Container Option 2	39000	7.4	5.3	26	0.40	0.60
20k TEU Conatinership	180,000	16.0	1.5	16	0.25	0.30

Table 2 – Bulker & Containership Accelerations

7. LESSONS LEARNED AND WARNINGS

For **Option 1** stowage, the main lesson learned is to stay with the conservative and standardized approach in the CSS and the existing ship's Cargo Securing Manual. Two and three-high block stows have been safely carried even through difficult winter storm North Pacific crossings. However, while generally conservative, we do not believe that the CSS methodology is suitable to be extended beyond 2- and 3-high block container stowage arrangements. Pressing this methodology to analyze 4, 5, or 6-high stacks is not recommended and through our accident investigation work we have observed significant container casualties from such stowages.

Note that the P&I Clubs also have detailed recommendations for implementing the CSS Option 1 methodology, see [1], [6], and [7]. Also, the P&I clubs also note the necessary focus required for the internal stowage within the containers. Factories and others in the business of loading containers are well aware of the typical acceleration on container from road and marine transportation. Transporting container on bulk carriers potentially expose the containers and securing components to significantly higher accelerations than on typical containerships, see Table 2. Therefore, not only the external container lashing, but the internal shoring, blocking, and reinforcement of the cargo inside the container must be adequate. Recent casualties of internally shifted cargo inside container carried on bulkers show that this is a vulnerability and there have been several casualties reported with damage caused by heavy cargo inadequately supported and blocked inside the containers

We also note that the analysis and evaluation of load spreading by wood dunnage is inconsistent and often given cursory treatment. While we have not seen any casualties or deck plate damage from insufficient dunnage implementation, probably due to conservative Class Requirements, the analysis and evaluation of what constitutes the proper use of wood dunnage is often closer to art than science.

For **Option 2** stowage the main lesson learned is that the conversions are not simple or cheap. For intended service in the container market for only a few voyages or even an extended season, the conversion to Option 2 designs and maximizing the container stowage is generally not financially feasible, and Option 1 is recommended. Bulk carrier hatch covers, typically with only an existing uniform load rating of 1-2 mt/m^2, are generally not suitable for significant container stowage and require substantial structural reinforcement. Consideration for complete hatch cover replacement should be considered for longer term container conversions.

8. CONCLUDING REMARKS

This was a unique and very challenging project for Herbert Engineering to consider container carriage on a fleet of bulk carriers. Being a novel and unique project, it was difficult to initially estimate, and technically difficult to carry out. There were many unknowns and significant difficulties in executing the project. The preliminary design of the Option 2 reinforcements were deemed to be too expensive for the temporary carriage of containers, and we are not aware of any Option 2 conversions being carried out. However, as a result of this work numerous single-voyage Option 1 plans were developed, evaluated, and successfully carried out, and facilitated carrying high revenue container cargo directly on charters for major North American retailers and logistics companies. In some cases, loading containers on bulk carriers permitted cargo to bypass the major congested ports and discharge as 2nd tier North America ports, and hopefully contributing to ease the transportation bottleneck and supply chain issues arising since the winter of 2021.

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