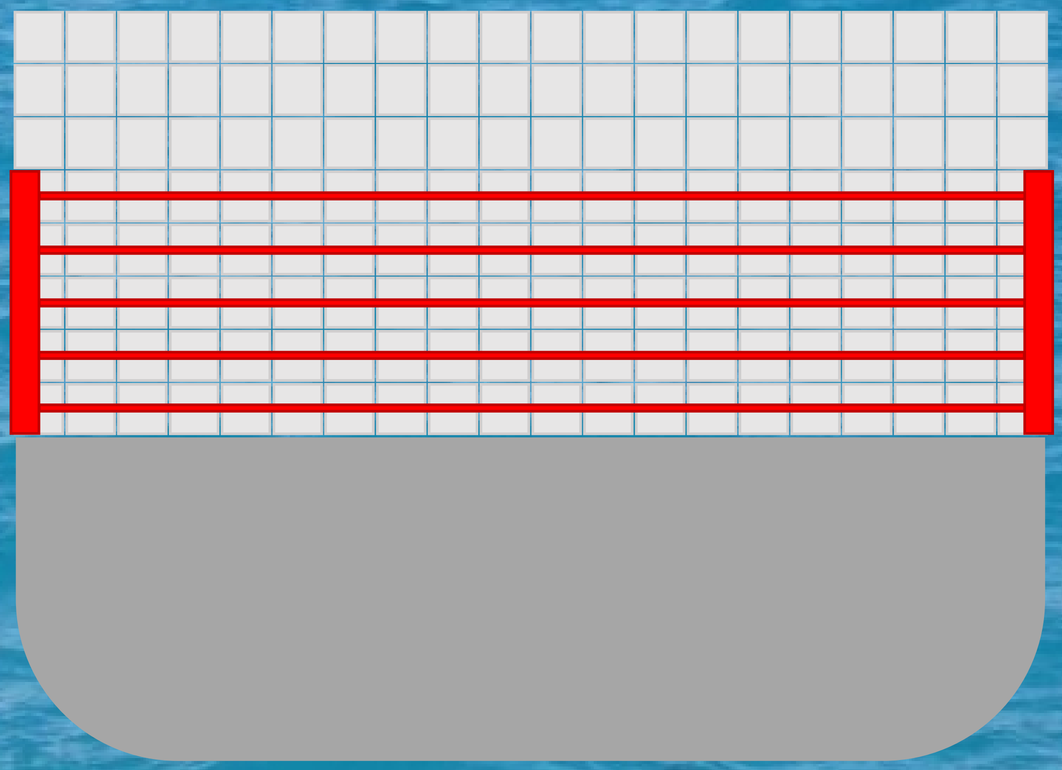
SUPERBLOCKING



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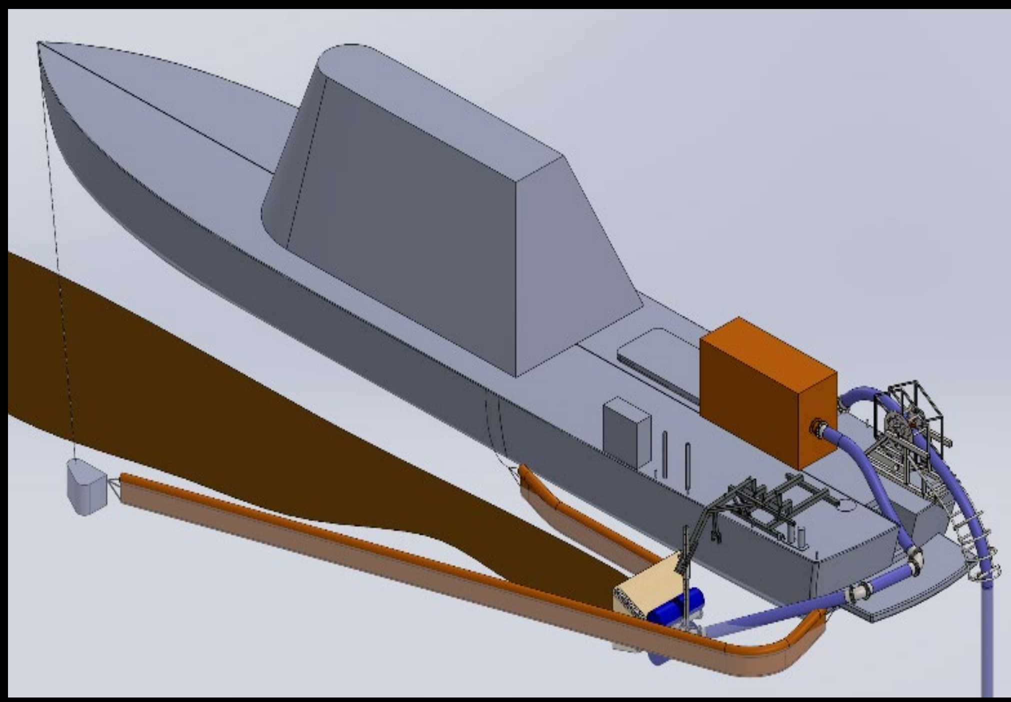
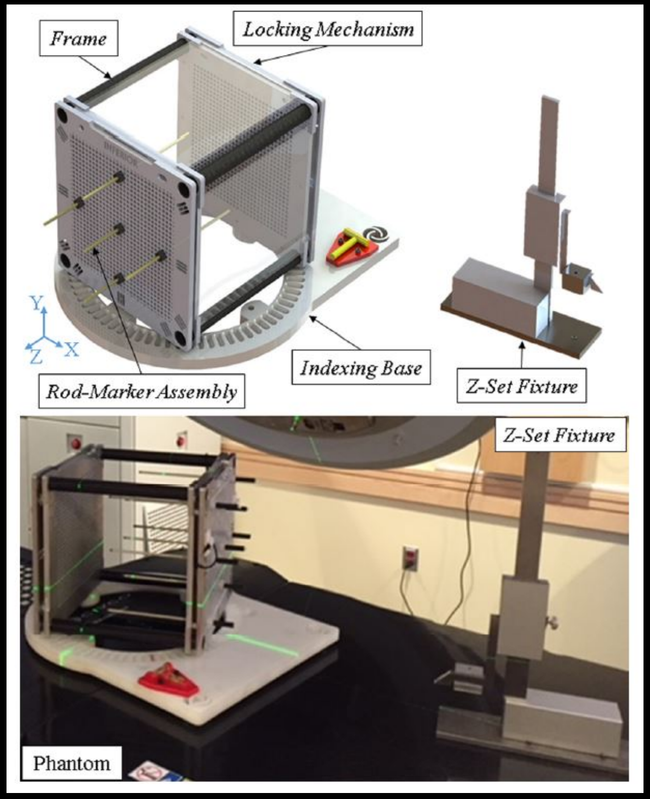
Developing World

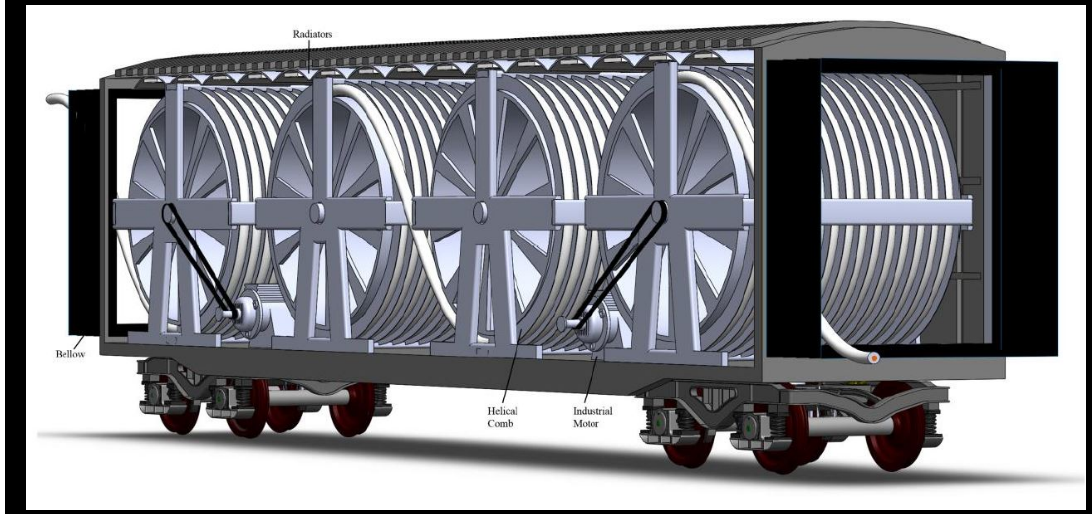
Climate Adaptation



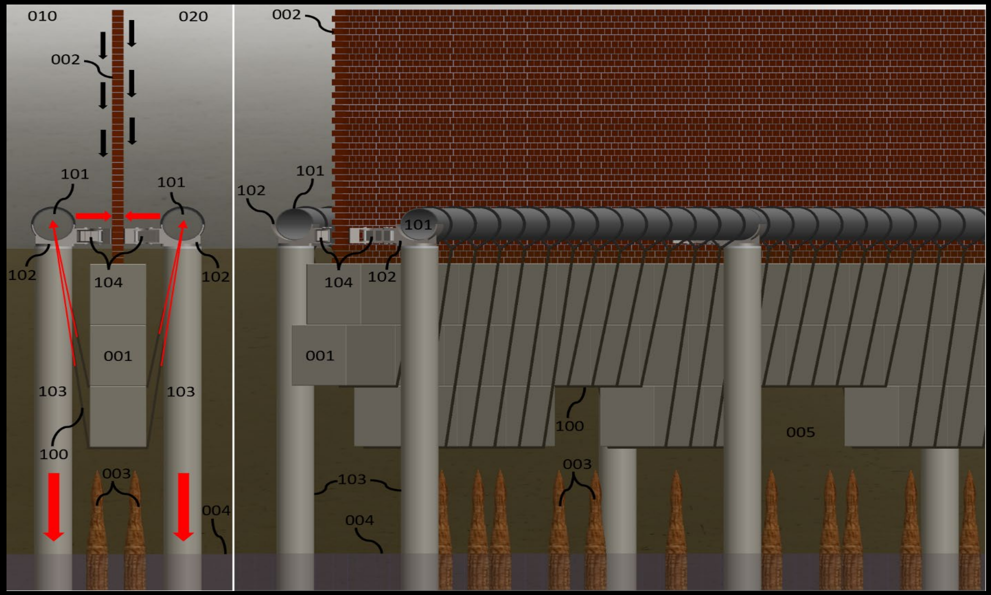
Medical Devices

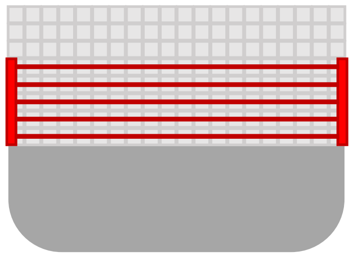


Renewable Energy Infrastructure



Foundation Repair





Superblocking Overview

Entire bay of containers is squeezed together by rigid spreaders 101, tensioned together by transverse wire ropes 102 and hydraulic cylinders.

Sufficient friction between container stacks 002 causes the entire bay to act as one "superblock" 001.

Gravity therefore acts as a RESTORING force rather than as an OVERTURNING force.

Superblock 001 can maintain equilibrium with extreme angles and accelerations with gravity, friction, and twistlocks alone.

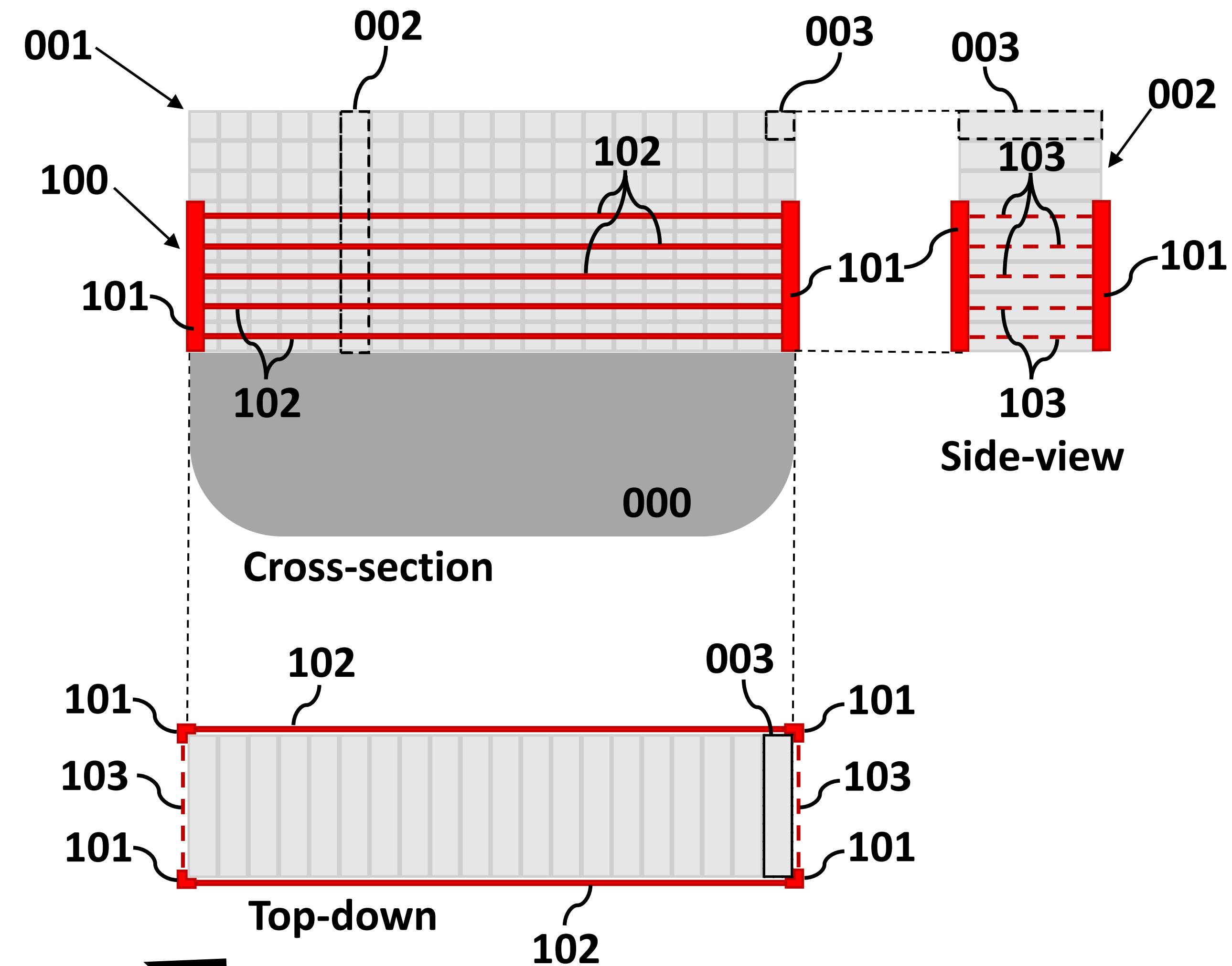
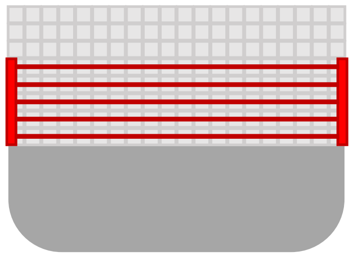


FIG 1

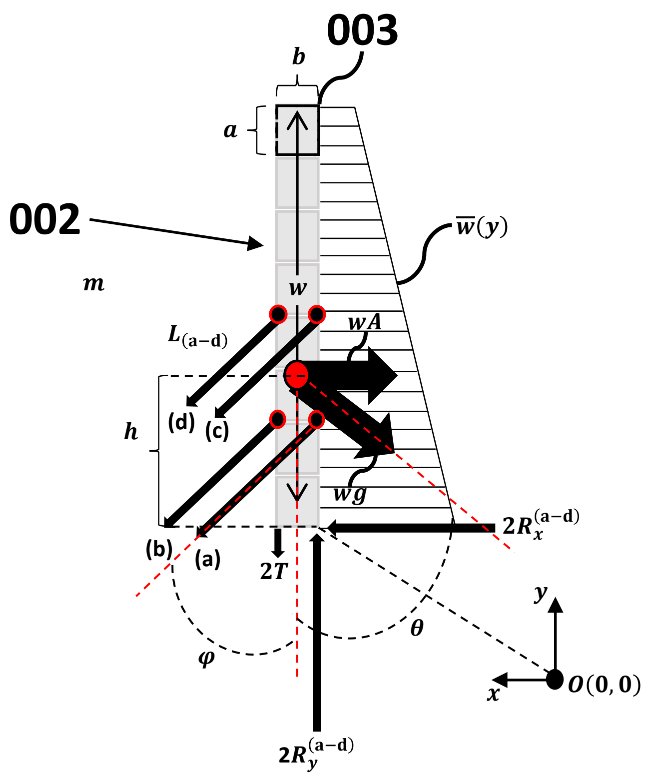
Superblock: 10 wire ropes automatically tensioned
Vs.
Lashing Rods: Up to 240 lashing rods manually applied

Longitudinal wire ropes 103 are optional.



Cornerpost Compression and Container Racking

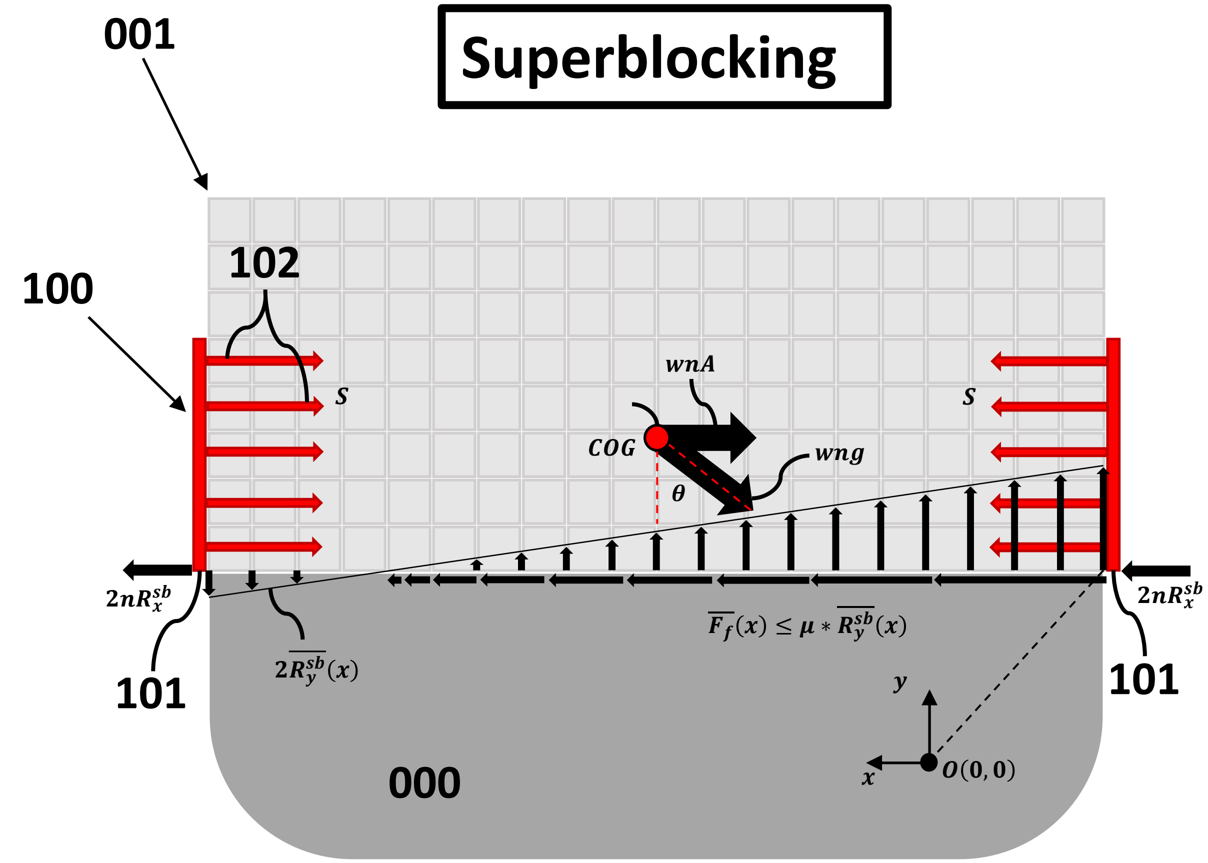
Lashing Rods



Parasitic vertical component of lashing rod tension actually increases cornerpost compression, thereby limiting stack heights.

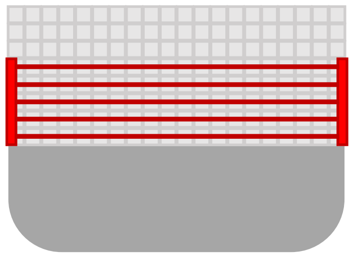
vs.

Superblocking

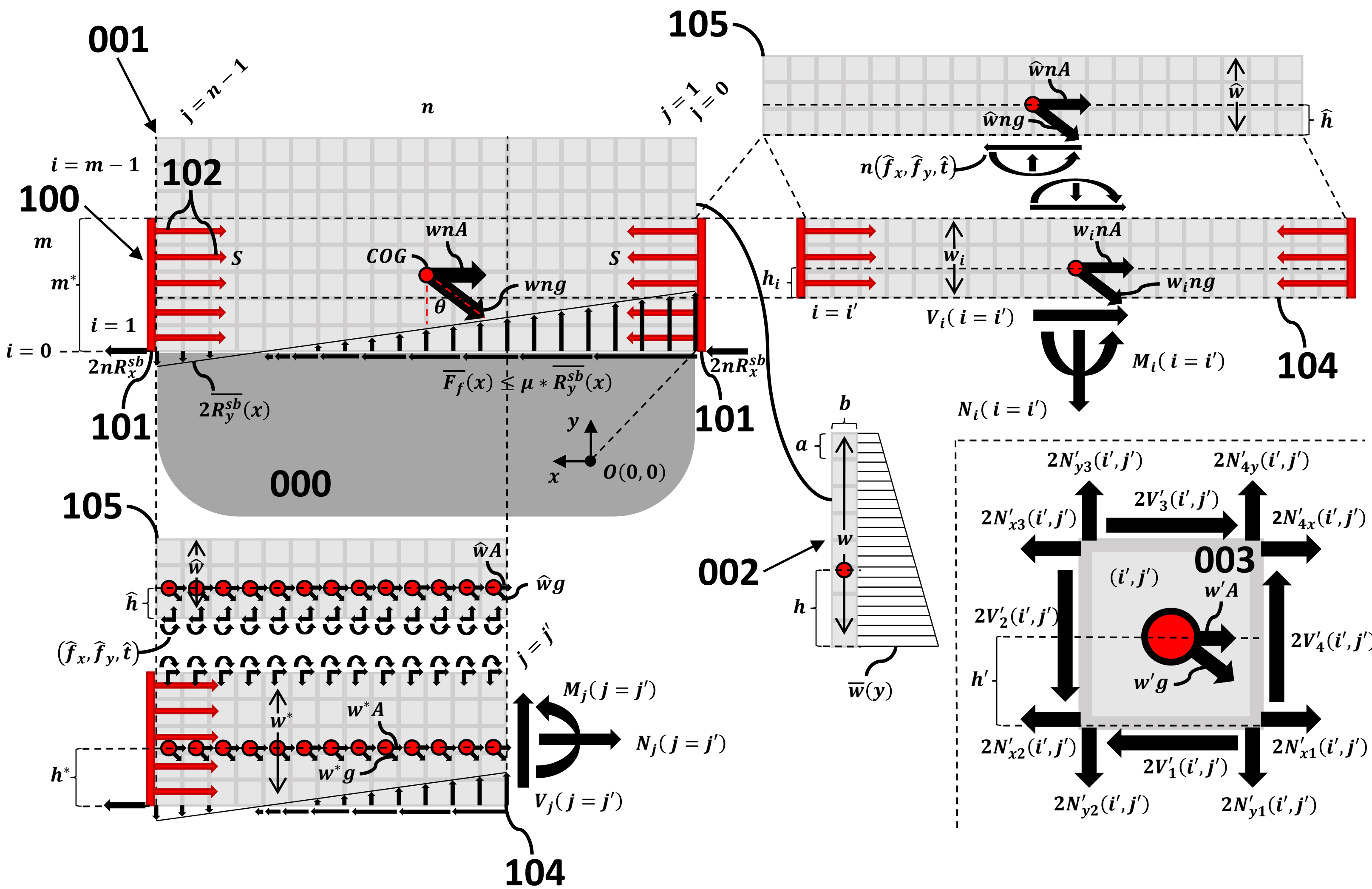


Max cornerpost compression is actually less compared to lashing rods (even external lashing configuration), which may enable greater stack heights. Max cornerpost compression can be further reduced by changing compliance of foundation and/or preloading spreaders into deck.

Spreaders are rigid and compression via wire ropes yields rigid connection with container stacks such that all containers between spreaders share the same shear strain – this prevents racking load in bottom tier from exceeding SWL.



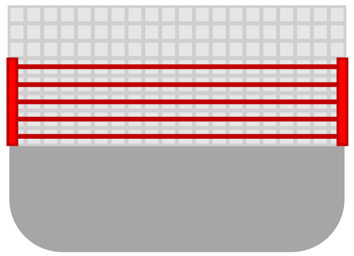
Internal Forces and Wire Rope Tension



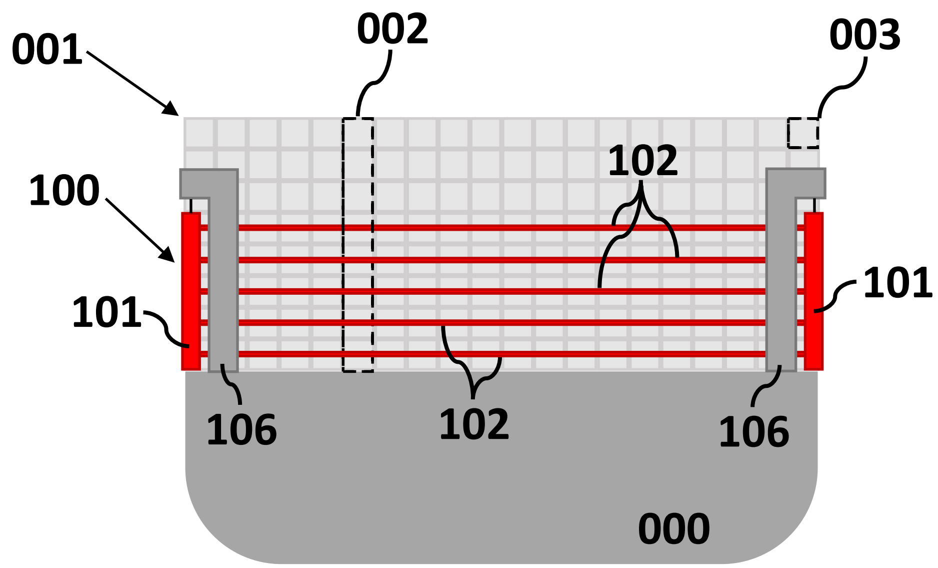
Internal superblock forces are found by dissections between stacks and tiers. Racking, cornerpost, and shoring forces can be solved for each container component. Note current model indicates horizontal compression of bottom-tier containers may exceed SWL, HOWEVER, stiffnesses of wire ropes, foundation twistlocks, and container floors are not modeled currently and loading scenarios used may be exaggerated.

$S = 2,500$ [kN] could be applied, in this example, through ten transverse wire ropes 102 comprising ~2” steel wire ropes, each providing 250 [kN], which ensures that there is no slip between container stacks and the “superblock” assumption holds:

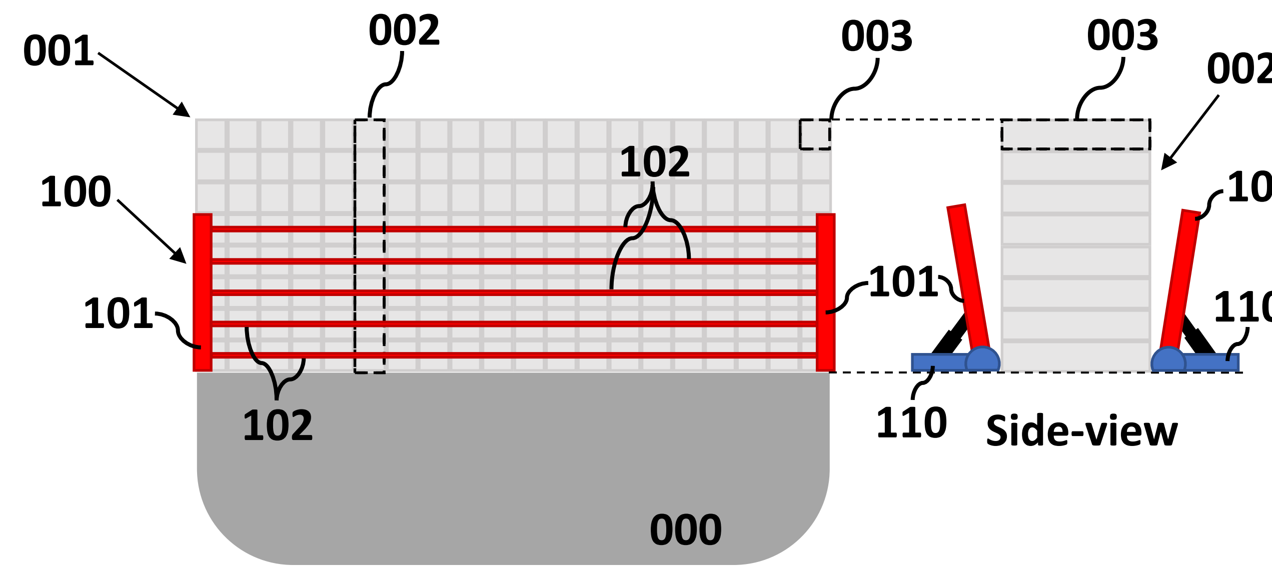
$$\mu N_j(j = j') \geq (Factor\ of\ Safety) * V_j(j = j') \quad \text{for} \quad 1 \leq j' \leq n - 1 \quad \rightarrow \quad \text{“no-slip”}$$



Ship Integration



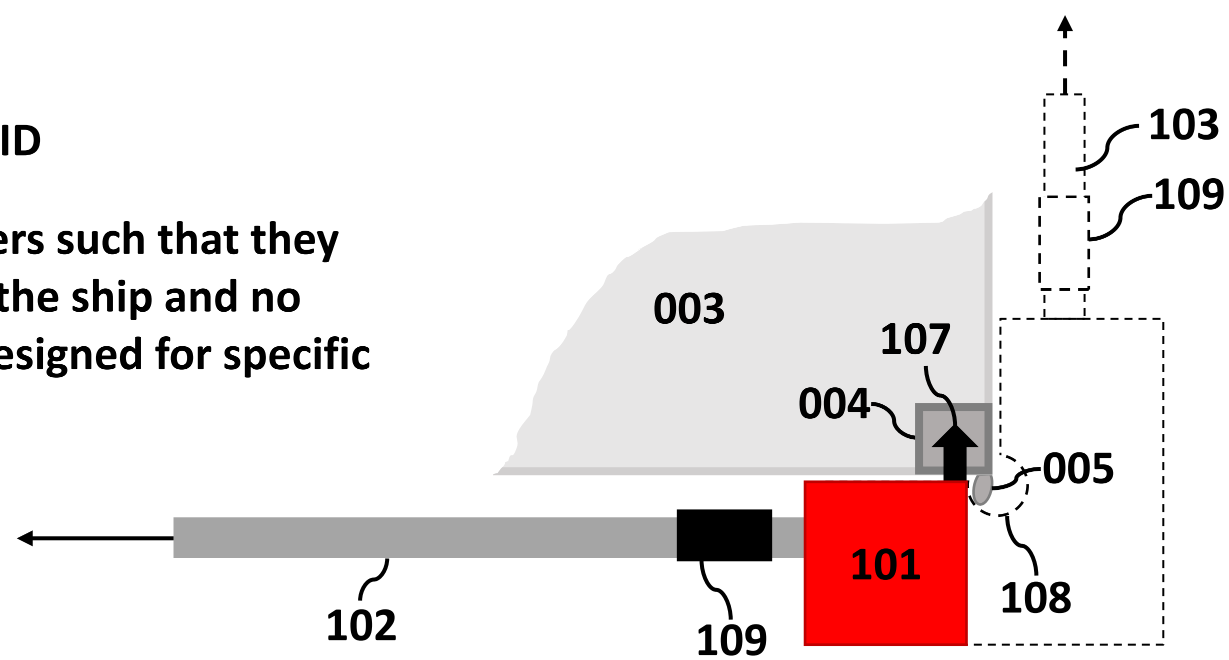
Cross-section



Cross-section

NON-RIGID

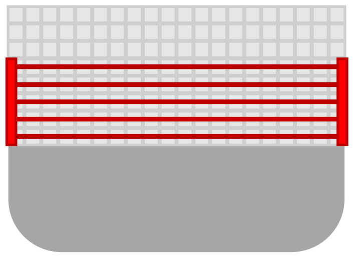
Spreaders hang from towers such that they are not coupled rigidly to the ship and no mechanisms need to be designed for specific loads.



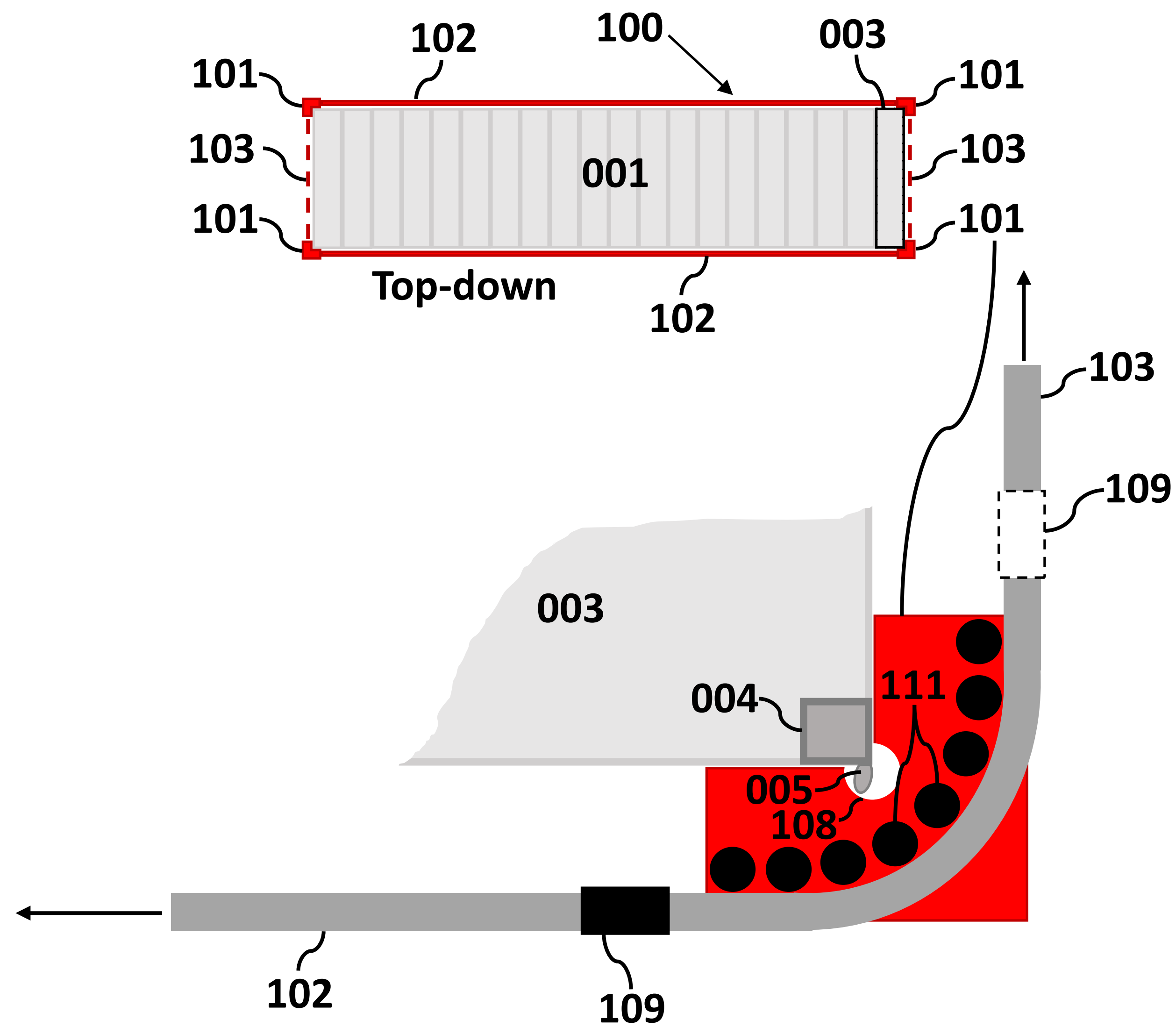
RIGID

Spreaders are manipulated by rigid, powered linkages.

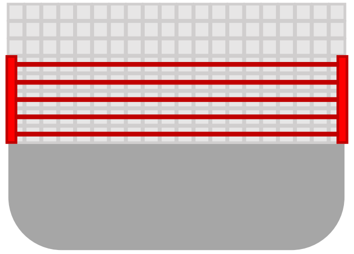
In the case that longitudinal wire ropes 103 are not used, retractable twistlocks 107 can provide rigid connection to protect containers from longitudinal racking.



Ship Integration (continued)

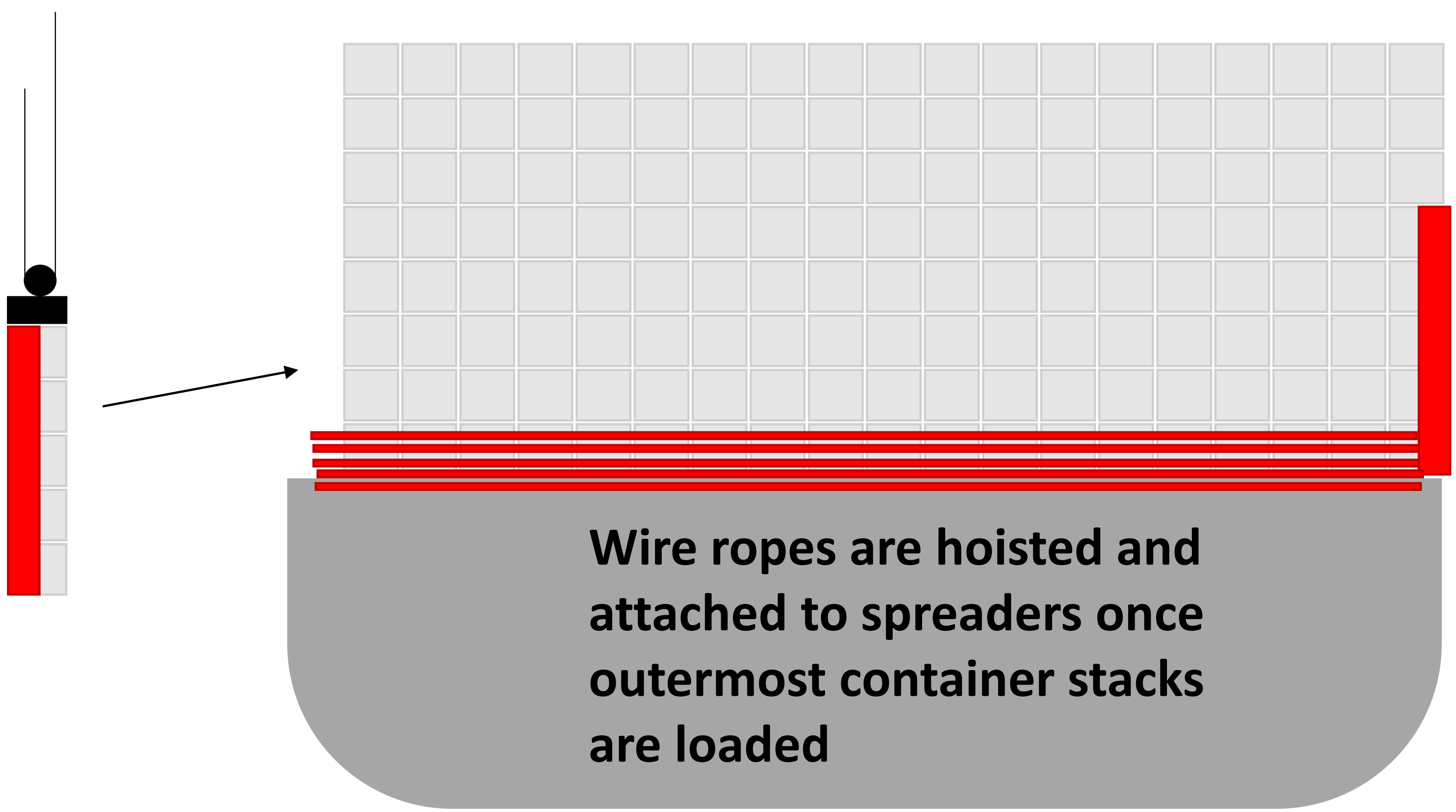


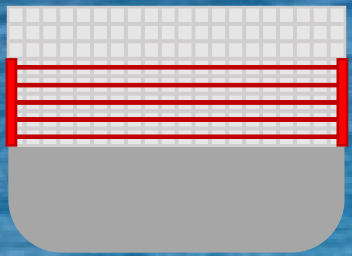
Transverse and longitudinal wire ropes can be continuous, passing through all four spreaders via fairleads. This enables equal tensioning of all wire ropes simultaneously and from one position/set of tensioning elements (similar to a picture-frame clamp).



No Ship Modifications Required for Initial Testing

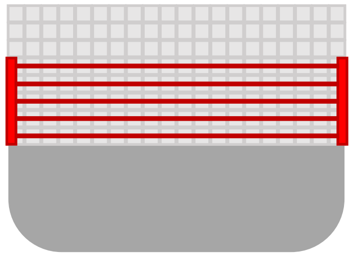
- Spreaders can be attached to coupled portion of outermost container stacks in terminal and lifted onto ship altogether.
- This eliminates the need for ship modification / barrier-to-entry.
- During testing, lashing rods can still be used as a back-up measure.





Risks + Countermeasures

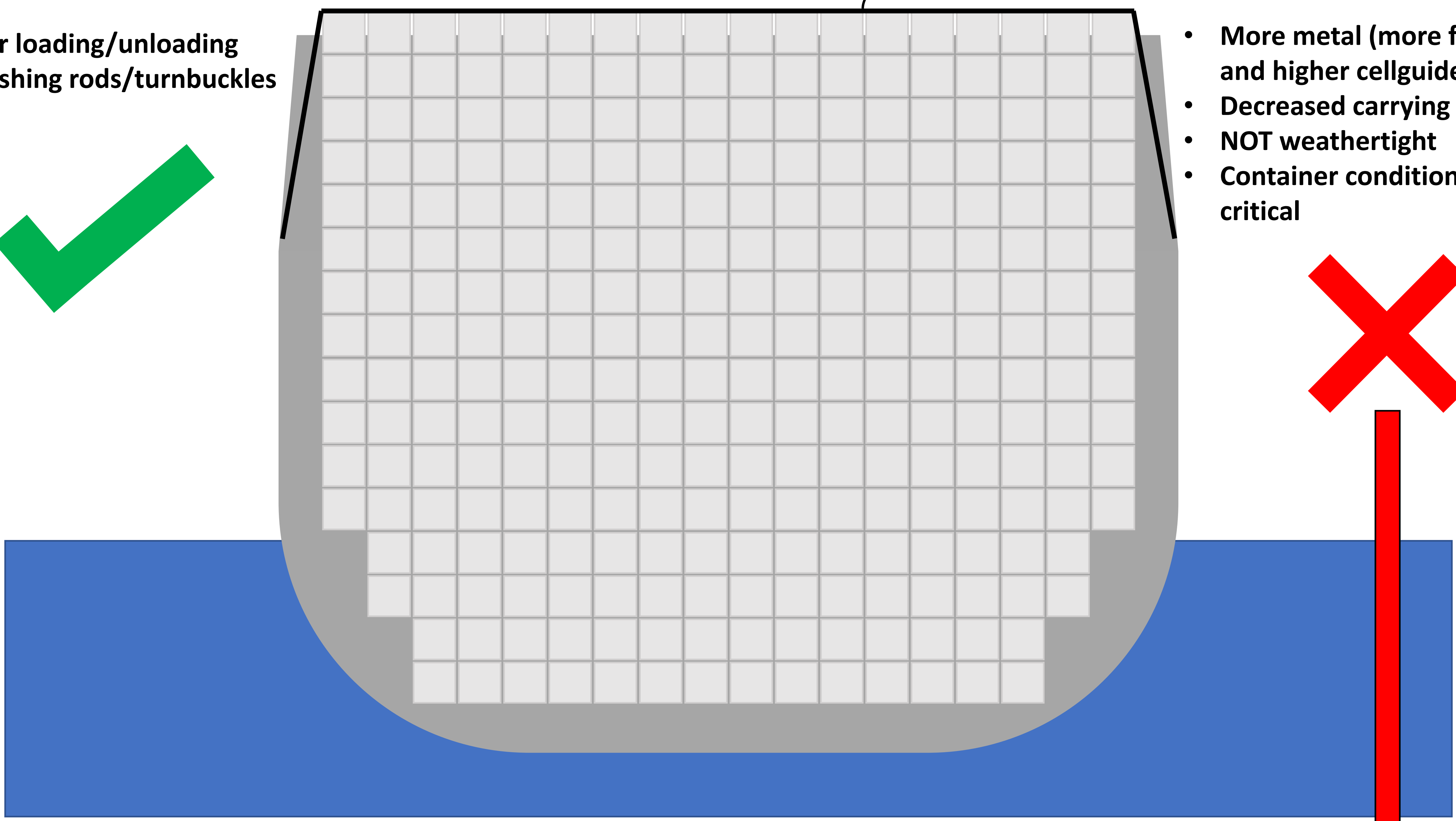
Risk	Countermeasure(s)
Coaming/hatch deformations cannot be restricted.	Hatchless ship (must solve weathertightness and over-compression problems – see next slides). Superblock sits on below-deck containers (which do not deform with the ship).
Difficult to pick/place containers without spaces between stacks.	Eccentric twistlocks to below-deck containers that “spring-return” so spaces reappear when superblock tension released.
Coupled portion of superblock must be full at all times.	Logistics (empty containers if necessary).



Hatchless Ships are the Future?

+

- Faster loading/unloading
- No lashing rods/turnbuckles



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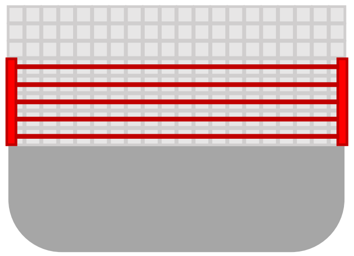
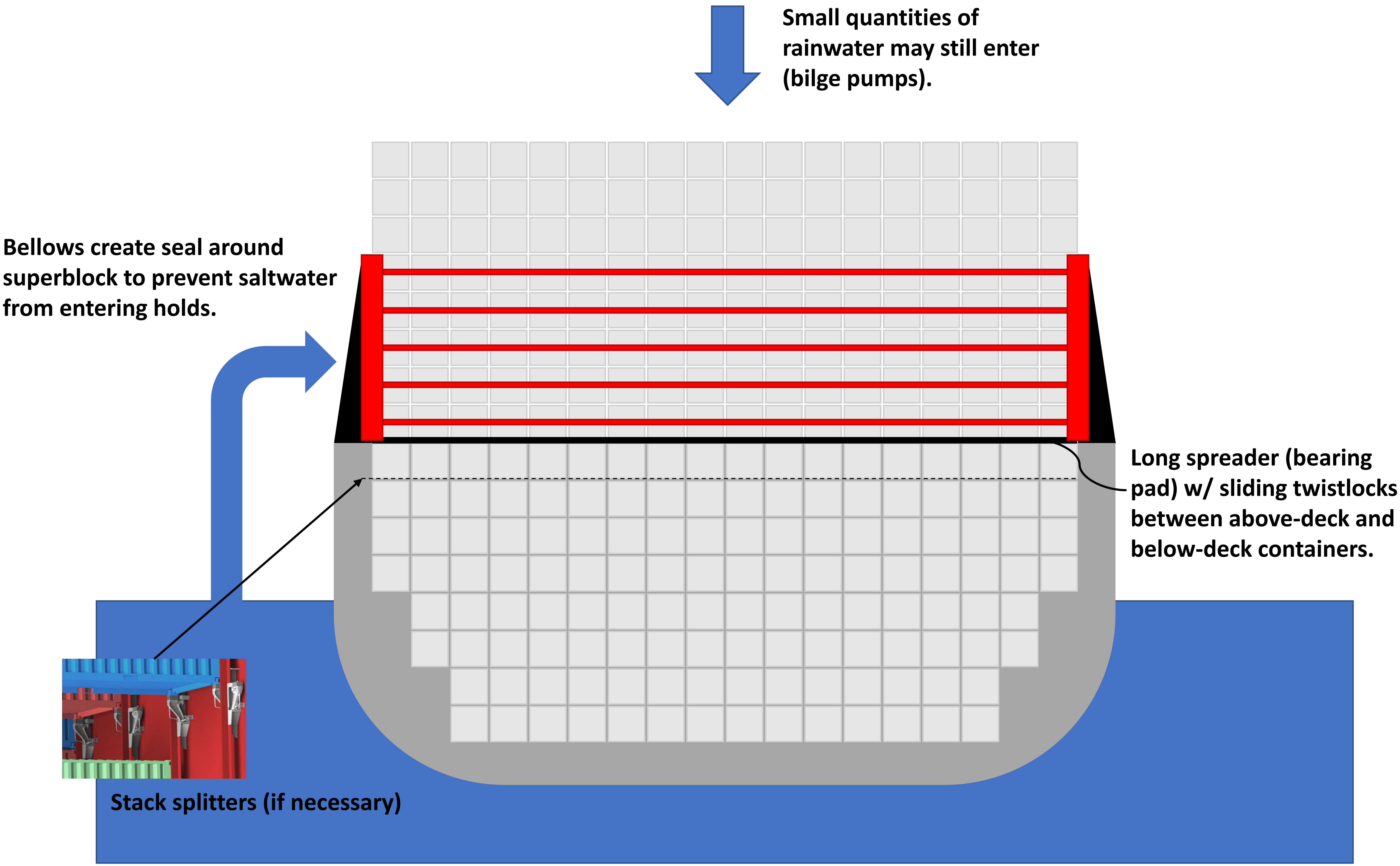
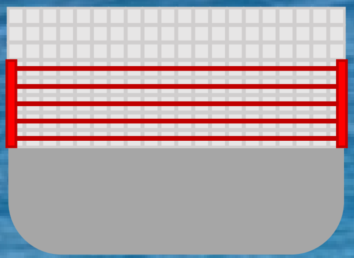
- More metal (more freeboard and higher cellguides)
- Decreased carrying capacity
- NOT weathertight
- Container condition/strength critical

...NOT if these issues aren't solved.



A Solution for Hatchless Ships?





Advantages of Superblocking

- Remove personnel from most dangerous terminal job.
- Reduce cost.
- Reduce container loss.
- Increase container stack heights and/or bay width (larger ships).

Next Steps

- Refine model to better incorporate stiffnesses of various components.
- Verify major risks and develop countermeasures.
- Find partner to test on low-risk routes.