Ship Stability

Ch. 11 Static Equilibrium State after Flooding Due to Damage

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2. Lost Buoyancy Method
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Introduction

In general, the document which contains the following list is submitted to ship owner and classification society, and get approval from them 9 months before steel cutting.

- Principle particulars
- General arrangement
- Midship section plan
- Lines plan
- Hydrostatic table
- Bonjean table
- Tank capacity table
- Light weight summary
- Allowable Minimum GM Curve
- Trim & stability calculation (Intact stability)
- Damage stability calculation
- Freeboard Calculation
- Visibility Check
- Equipment number calculation

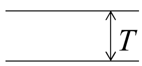
……………………

Today's main subject!

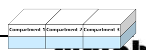
1. Change in Position Due to Flooding

Damage of a Box-Shaped Ship

✓ A ship is composed of three compartments.

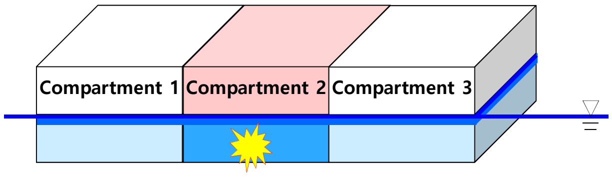


When a compartment of the ship is damaged, what is the new position of this ship?



Damage of a Box-Shaped Ship (Immersion)

When the compartment in the midship part is damaged, what is the new position of this ship?

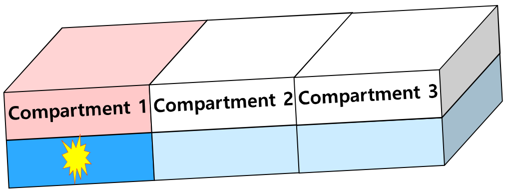


The position of the ship will be changed.

* The new position of the ship can be calculated by **the lost buoyancy and added weight methods**.

Damage of a Box-Shaped Ship (Immersion, Trim)

When the compartment at the after part of the ship is damaged, what is the new position of this ship?



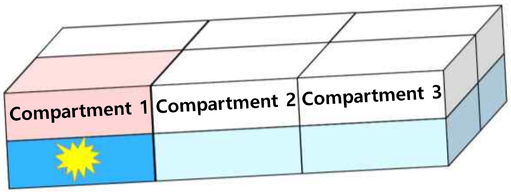
The position of the ship will be changed.

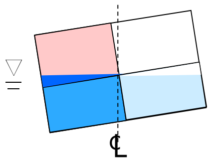
Immersion +

Damage of a Box-Shaped Ship (Immersion, Trim, Heel)

ən the ship is composed of "six" compartments.

Vhen the compartment at the after and right part of the ship is damaged,
vhat is the new position of the ship?

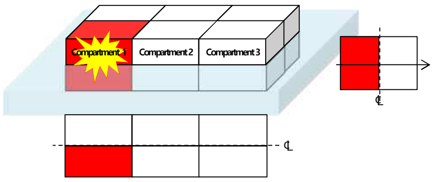


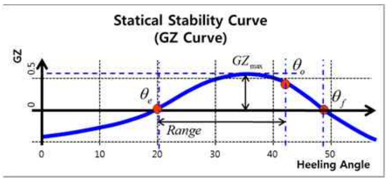


The position of the ship will be changed.

Immersion + Trim

Two Methods to Measure the Ship's Damage Stability





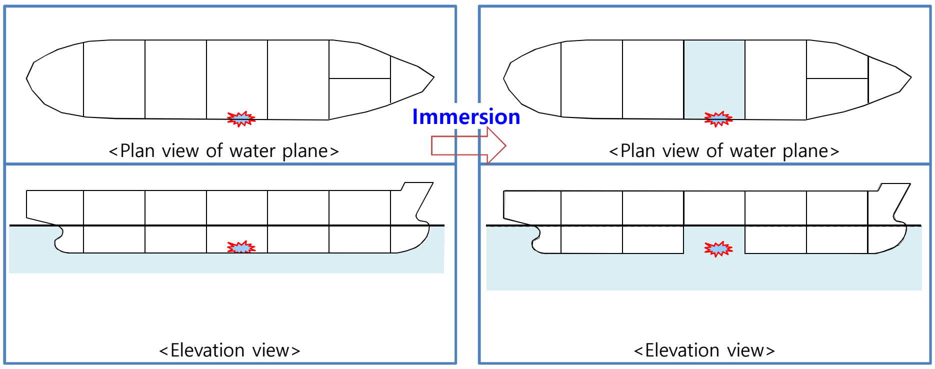
How to measure the ship's stability in a damaged condition?

Method : Calculation of survivability of a ship based on the position, stability, and inclination in damaged conditions

Method : Calculation of survivability of a ship based on the probability of damage

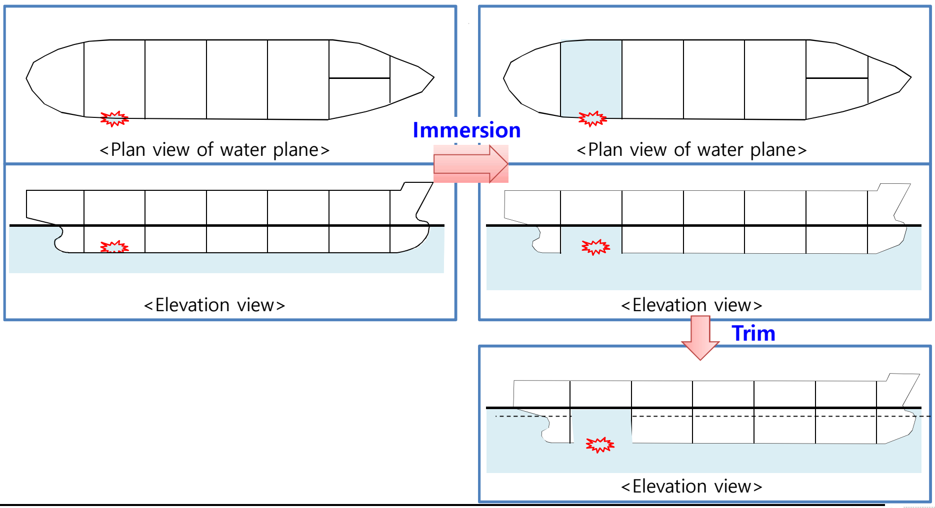
Change in Position Due to Flooding (Immersion)

What happens if the compartment located in the midship part of a ship is damaged?



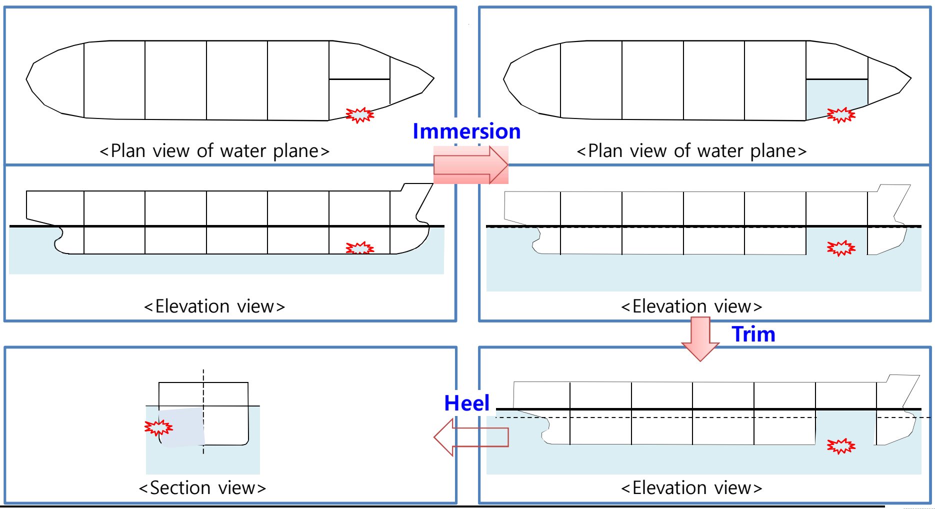
Change in Position Due to Flooding (Immersion, Trim)

What happens if the compartment located in the after part of a ship is damaged?



Change in Position Due to Flooding (Immersion, Trim, Heel)

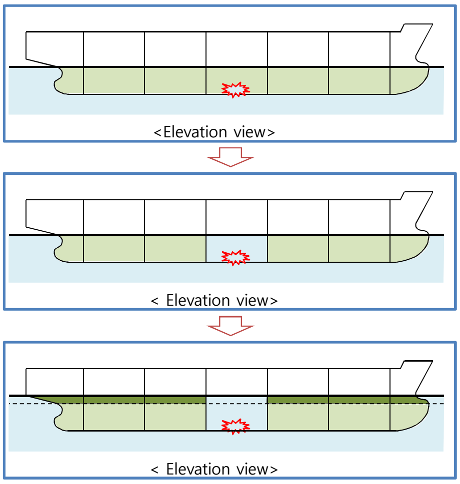
What happens if the compartment located in the fore and right part of a ship is damaged?



2. Lost Buoyancy Method

Concept of Lost Buoyancy Method (1/2)

* Hydrostatic Equilibrium
Displacement(Δ) = Buoyant Force = Weight(W)



A damage occurs.

: Volume which contributes to buoyancy

The lost buoyancy must be regained by .

: Additional volume which contributes to buoyancy (regained buoyancy)

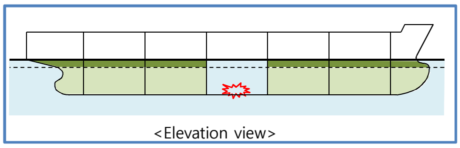
Lost buoyancy method

"The water that enters the ship is considered still part of the sea, and the buoyancy of the flooded space is lost."

Concept of Lost Buoyancy Method (2/2)

* Hydrostatic Equilibrium
Displacement(Δ) = Buoyant Force = Weight(W)

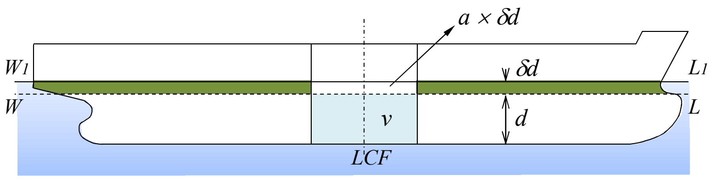
Lost buoyancy method



<Elevation view>

- In this method, it is assumed that the flooded compartment has free communication with the sea.
- The flooded compartment can be considered as a sieve (or filter), and that offers no buoyancy to the ship. Only the intact portions of the ship on either side of the flooded compartment contribute to the buoyancy.
- Since buoyancy has been lost, it must be regained via an increase in the draft.
- The ship will sink until the volume (or displacement) of the newly immersed portions equals the volume (or displacement) of the flooded compartment.

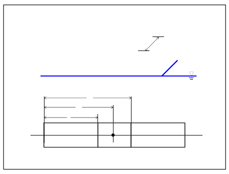
The water that enters the damaged compartment is considered as an , and the buoyancy of the flooded space is .
And the loss of buoyancy is regained by an increase of draft.

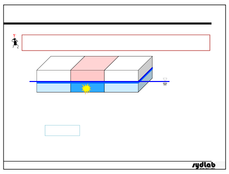


Loss of buoyancy: Sea water flooded into the damaged compartment is considered as part of the sea

$$\rho \cdot g \cdot v = \rho \cdot g \cdot (A_{WP} - a) \cdot \delta d$$

A_{WP}: water plane area of the ship
(Including water plane area of the damaged compartment)
a: water plane area of the damaged compartment
d: Draft before the compartment is not damaged
δd: Draft change due to damaged compartment
v: Volume of damaged compartment below initial water plane

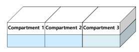




[Example] Damage of a Box-Shaped Ship (Immersion) (1/6)

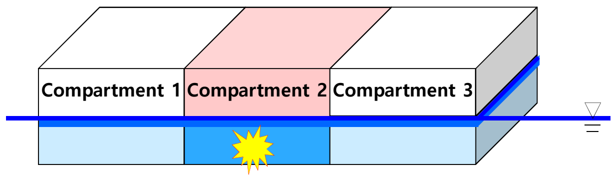
✓ **A ship is composed of three compartments.**

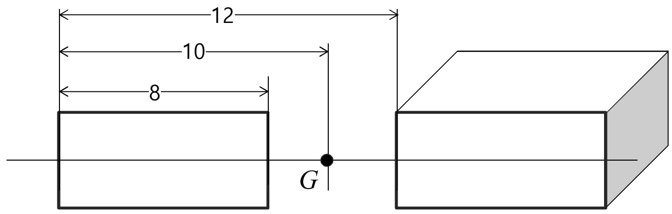
$T = 1.5$



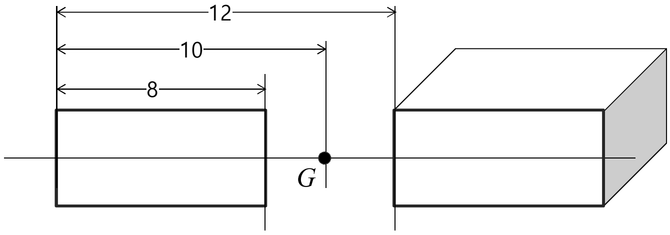
When a compartment of the ship is damaged, what is the new position of this ship?

[Example] Damage of a Box-Shaped Ship (Immersion) (3/6)





[Example] Damage of a Box-Shaped Ship (Immersion) (5/6)



Loss of buoyancy

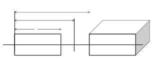
Another method

Water plane area:

Draft after immersion:

, where

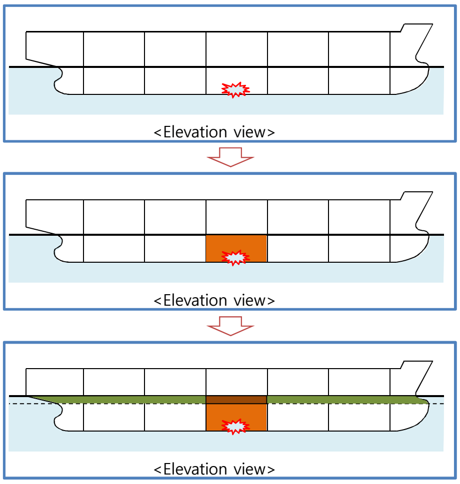
Loss of buoyancy



3. Added Weight Method

Concept of Added Weight Method (1/2)

* Hydrostatic Equilibrium
Displacement(Δ) = Buoyant Force = Weight(W)



A damage occurs.

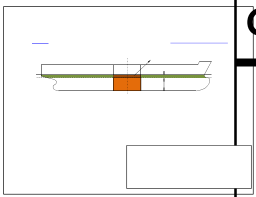
: Added weight

Added weight will be equilibrium with the buoyancy regained by

: Additional added weight
: Additional volume which contributes to buoyancy

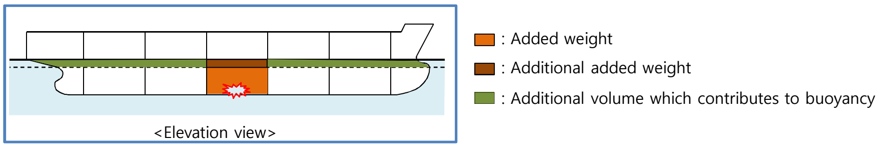
Added weight method

"The water that enters the damaged compartment is considered as an **added weight** with no loss of buoyancy."



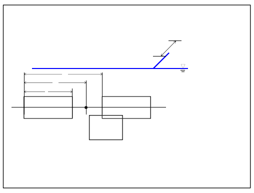
Concept of Added Weight Method (2/2)

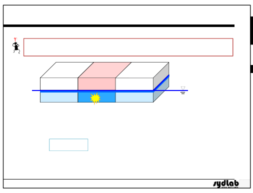
Added weight method



- The water that enters the damaged compartment is considered as an **added weight** with no loss of buoyancy.
- This is a **misnomer**, since water in space open to the sea and free to run in or out does not actually add to a ship's weight.
- For calculation purposes, it is **convenient** to regard such flooding water as adding to the displacement.
- However, it must be remembered that the resulting (virtual) displacement not only differ from the initial displacement, but varies with change in trim or heel.
- Since the added weight method involves a direct integration of volumes up to water plane at the damaged condition, it is just as well adapted to dealing with complex flooding conditions as with simple ones.

$$\delta d = \frac{v}{A_{WP} - a}$$

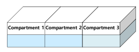




[Example] Damage of a Box-Shaped Ship (Immersion) (1/9)

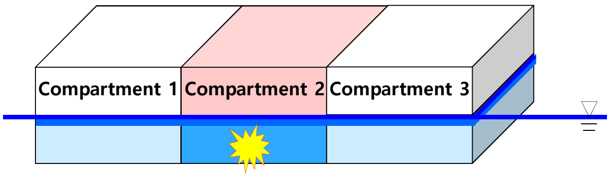
✓ A ship is composed of three compartments.

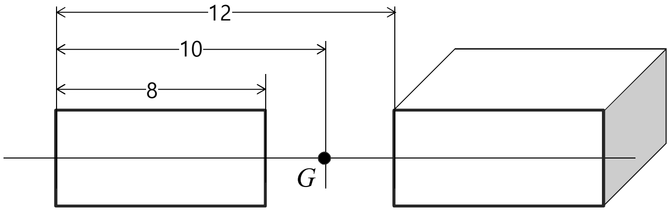
$T = 1.5$



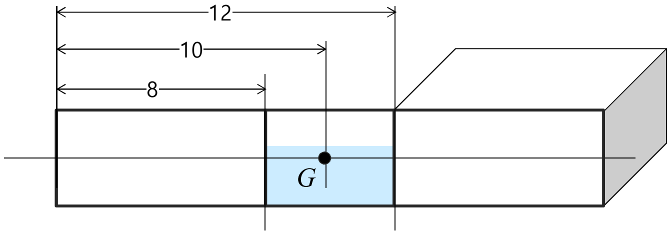
When a compartment of the ship is damaged, what is the new position of this ship?

[Example] Damage of a Box-Shaped Ship (Immersion) (3/9)



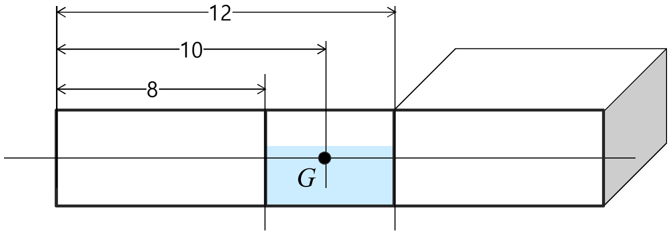


[Example] Damage of a Box-Shaped Ship (Immersion) (5/9)



The volume of flooding water:
The additional buoyant volume:
Because

[Example] Damage of a Box-Shaped Ship (Immersion) (7/9)

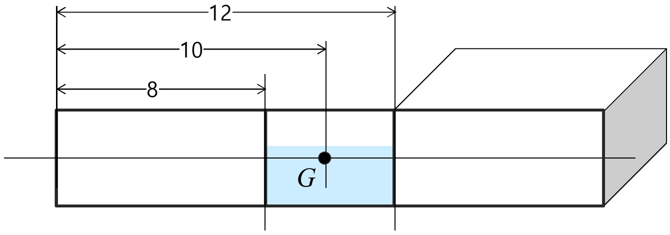


KG by the added weight method:

Free surface effect caused by the flooding water:

The moment of inertia of the free surface in the flooded compartment:

[Example] Damage of a Box-Shaped Ship (Immersion) (9/9)



Metacentric height:

The changed displacement:

The righting moment for small angle of heel by added weight method: