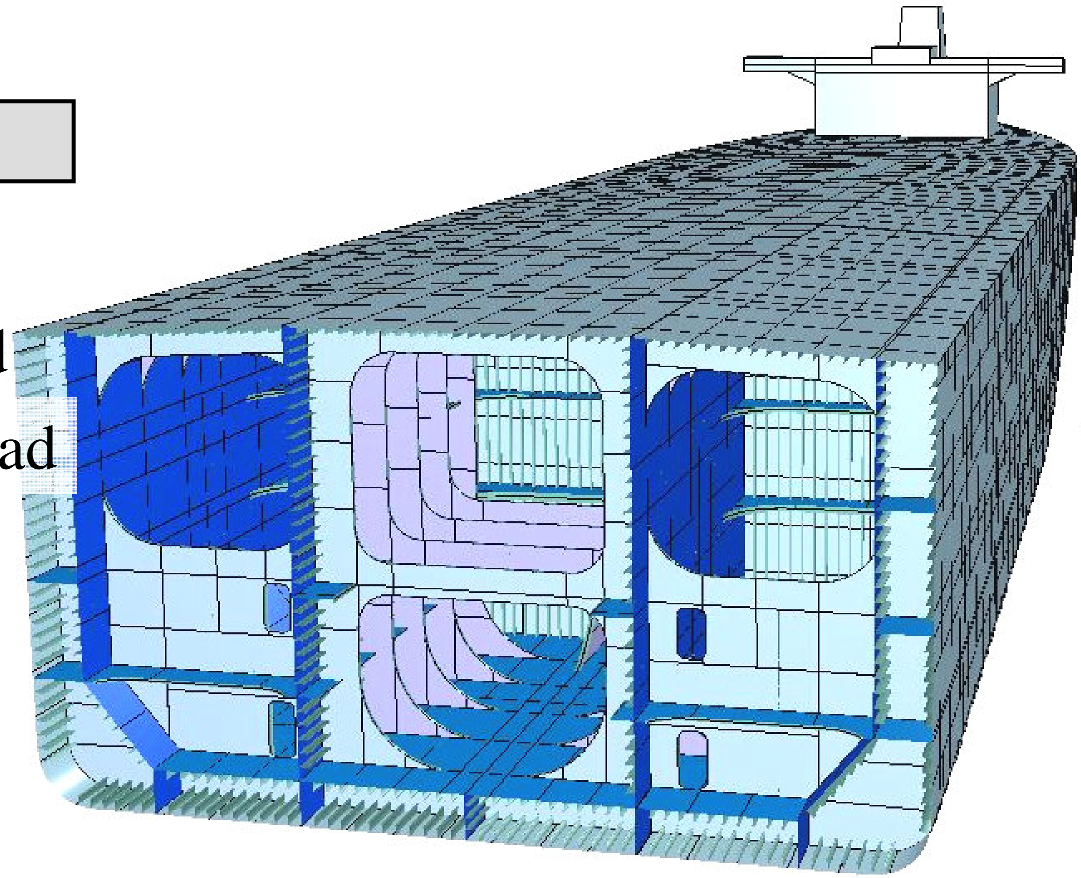
Oil
Tankers

# Hull Structural Breakdown - Bottom



1. Side
2. **Bottom**
3. Deck
4. Transverse bulkhead
5. Longitudinal bulkhead
6. Web frames



# Structural functions of bottom

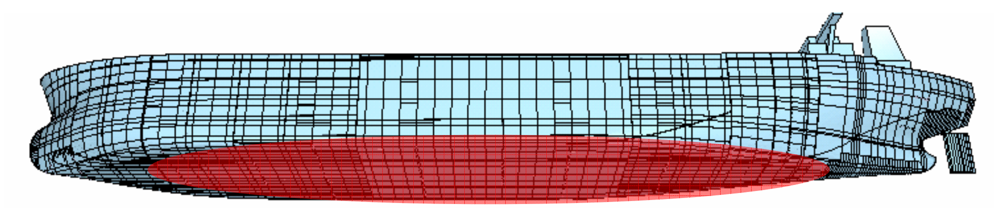


Watertight integrity

- Resist external sea pressure
- Resist internal pressure from cargo and ballast

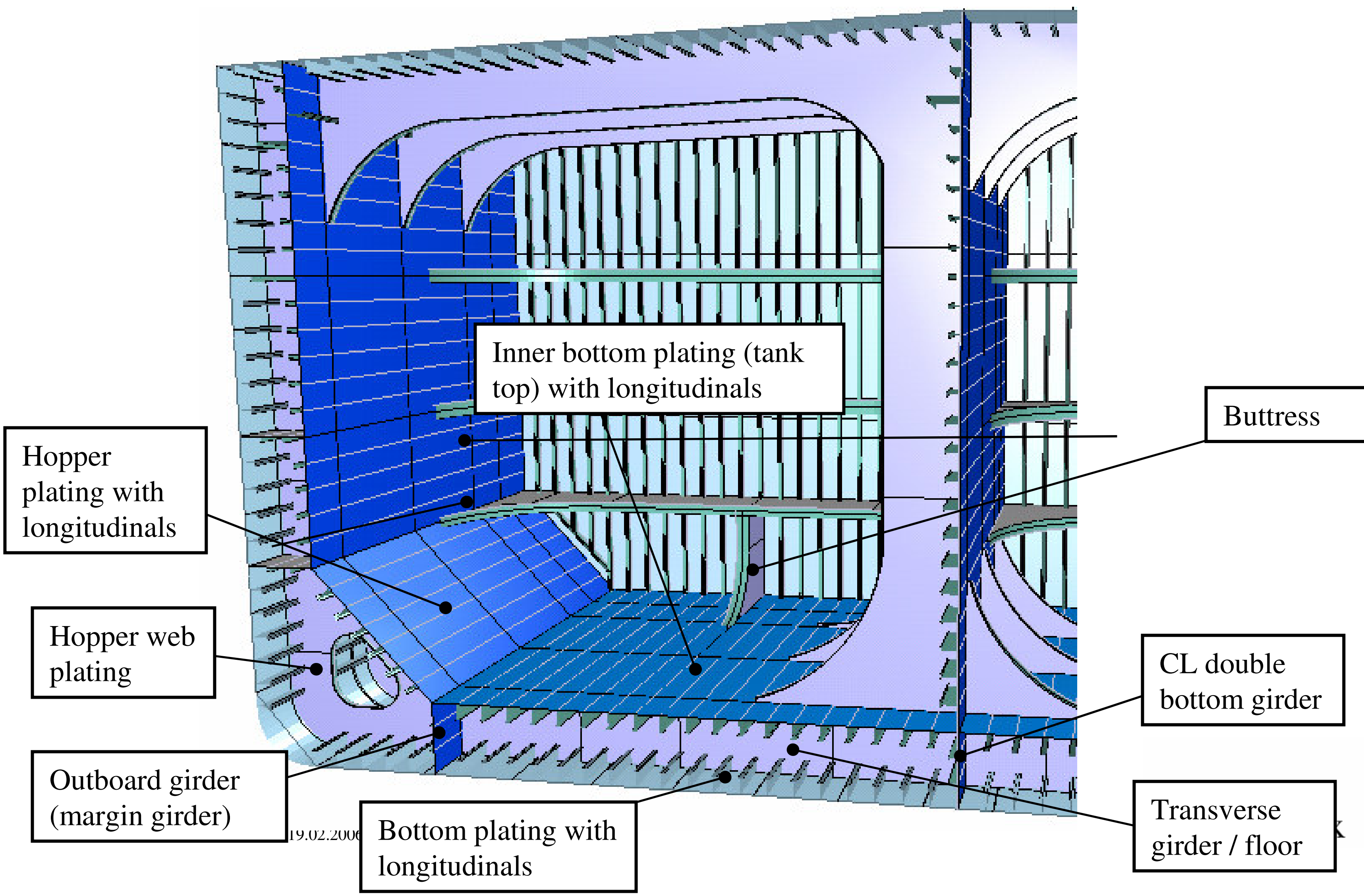
Flange in hull girder

- Bottom plating and longitudinals act together as the lower flange in the hull girder beam



# Structural build-up of a double bottom structure



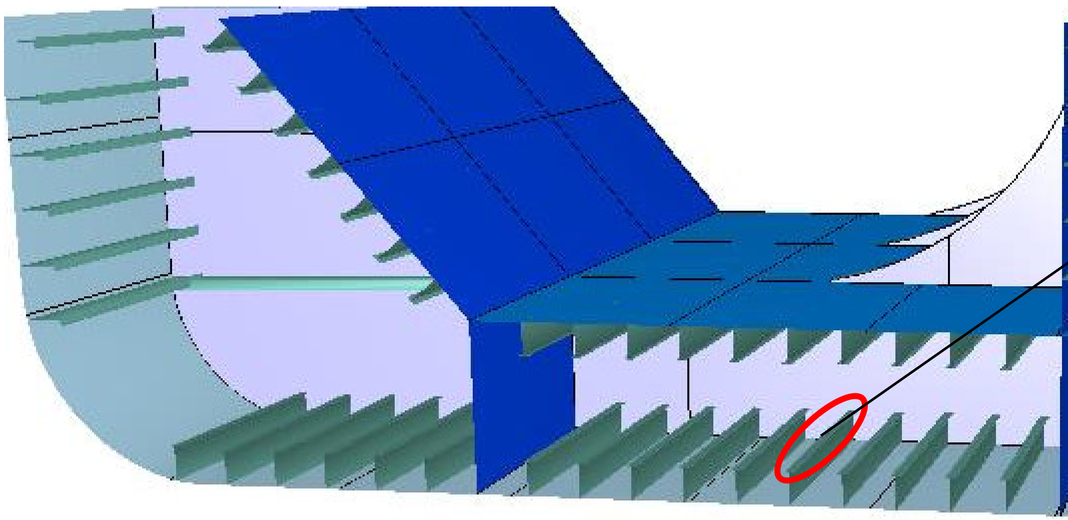


# Function: Watertight integrity

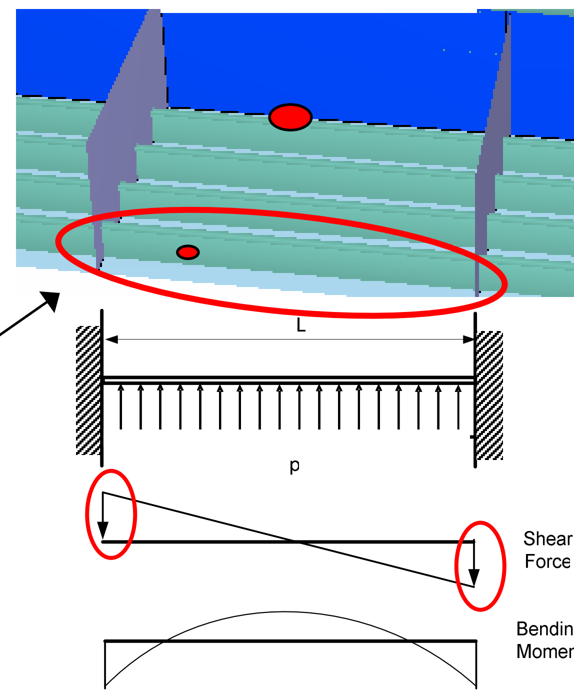


**Fixation?**

External loads induce shear forces and bending moments in the bottom longitudinals, acting as single beams (between each web frame)



Bottom longitudinal as a single beam between two web frames




BM and SF distribtion for a single beam with distributed load and fixed ends

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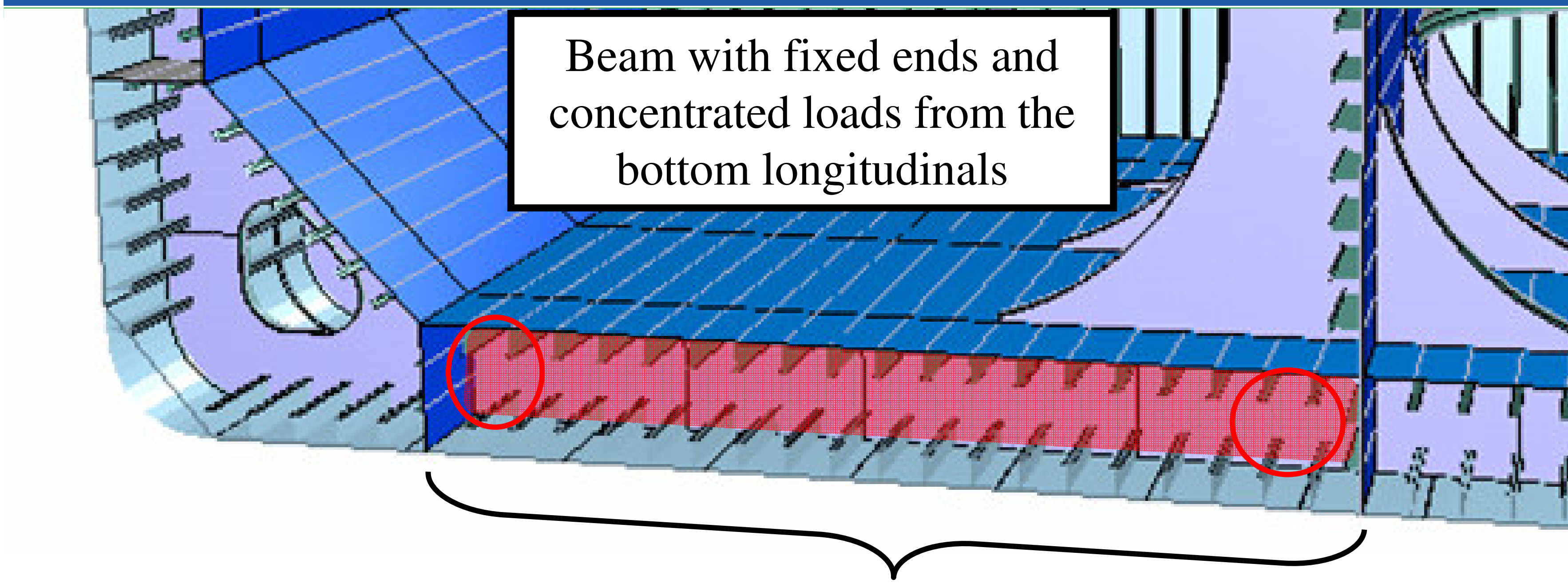
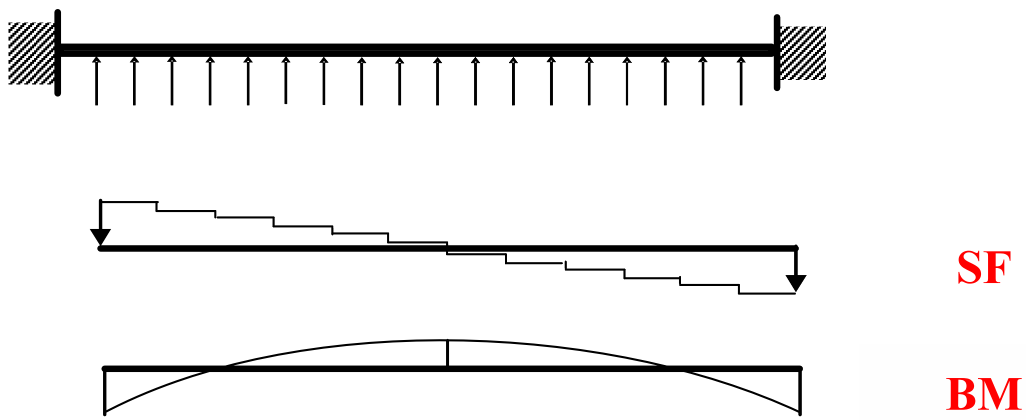
# Function: Watertight integrity

2. Bottom



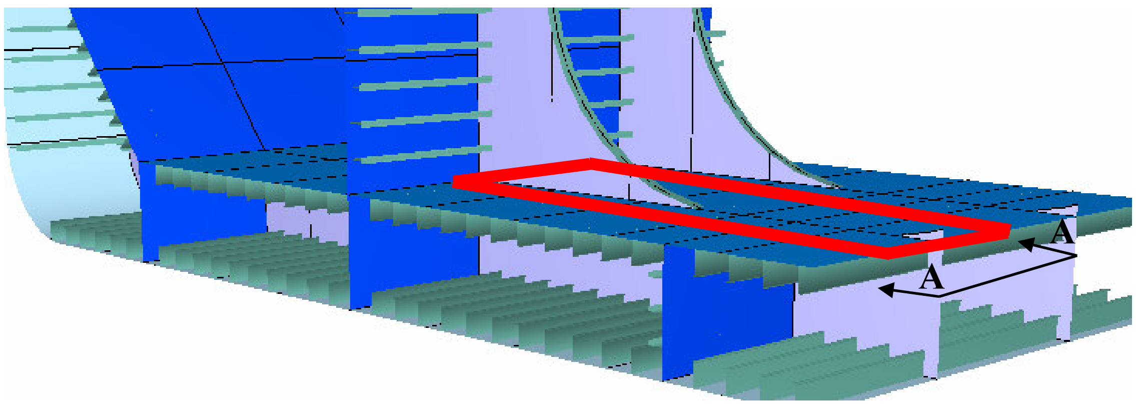




Max shear and bending moment towards ends (side & long bhd.)

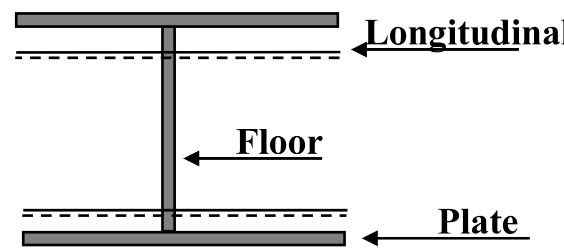
# Function: Watertight integrity



Bottom plating with longitudinals are also acting as flange for the transverse web frame

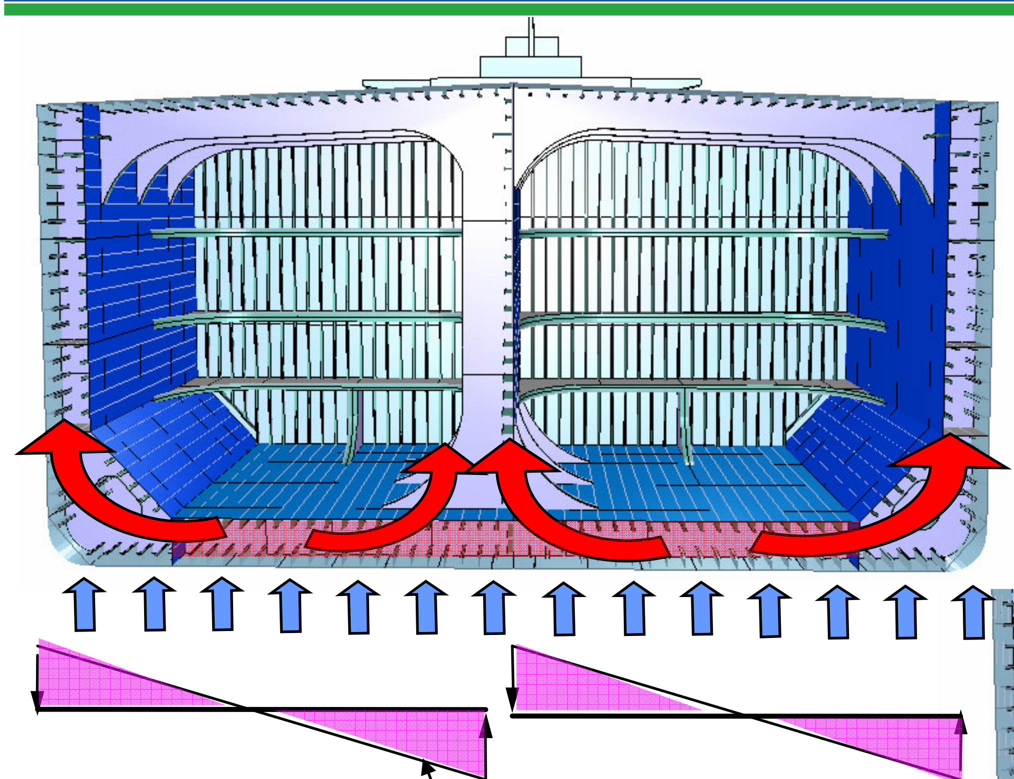



View A-A

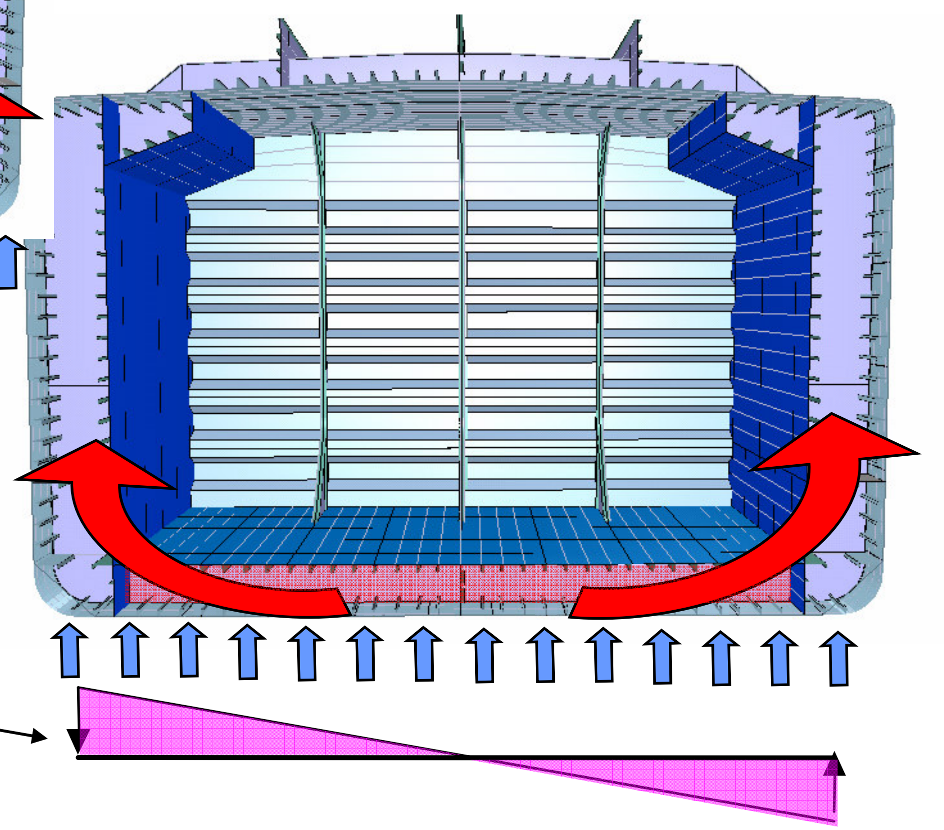


# Bottom is supported by ship side and longitudinal bulkhead





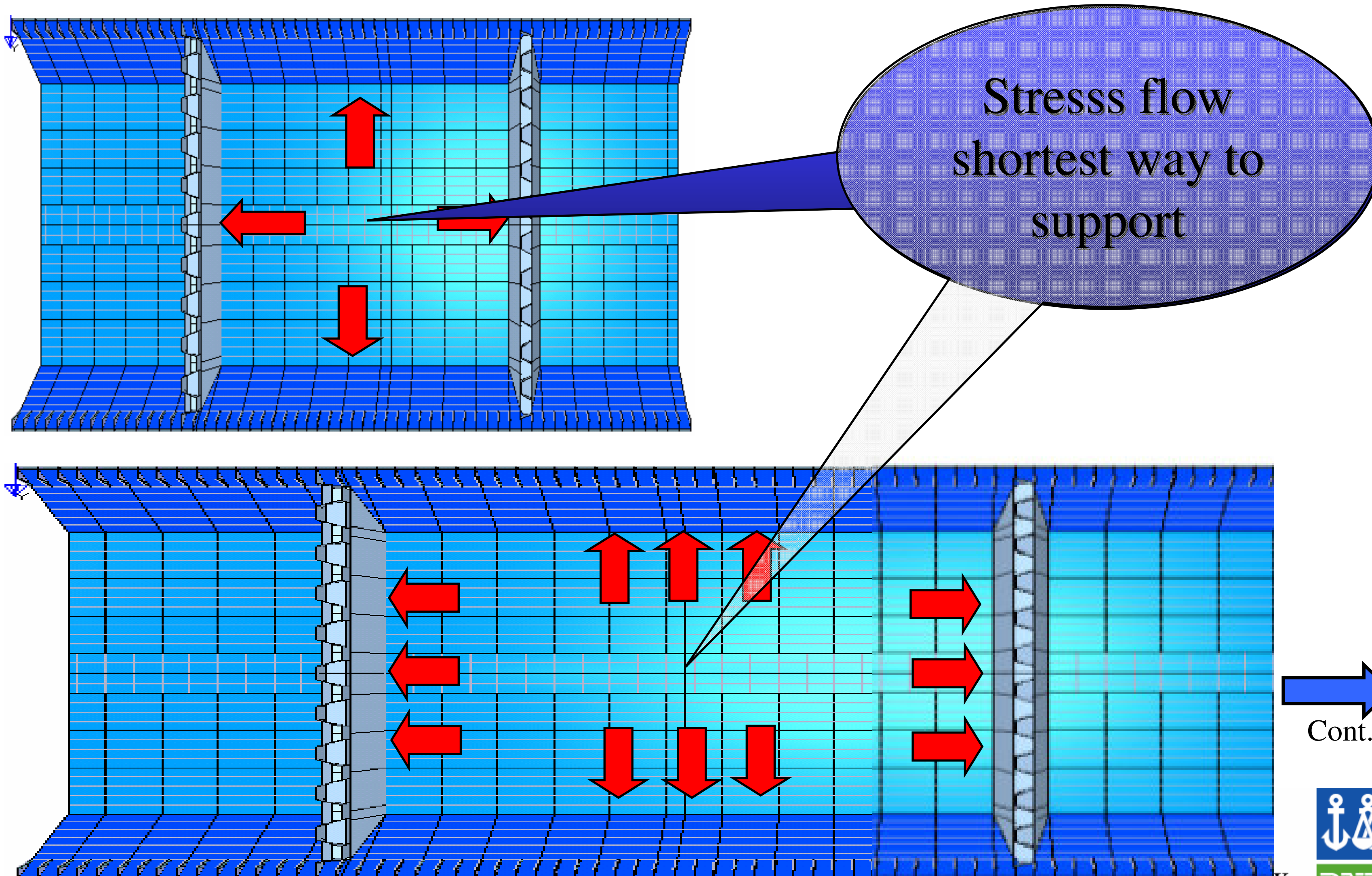
Double span for double bottom without CL longitudinal bulkhead



Shear stress in double bottom floor due to external sea pressure

# Load response double bottom “grillage”



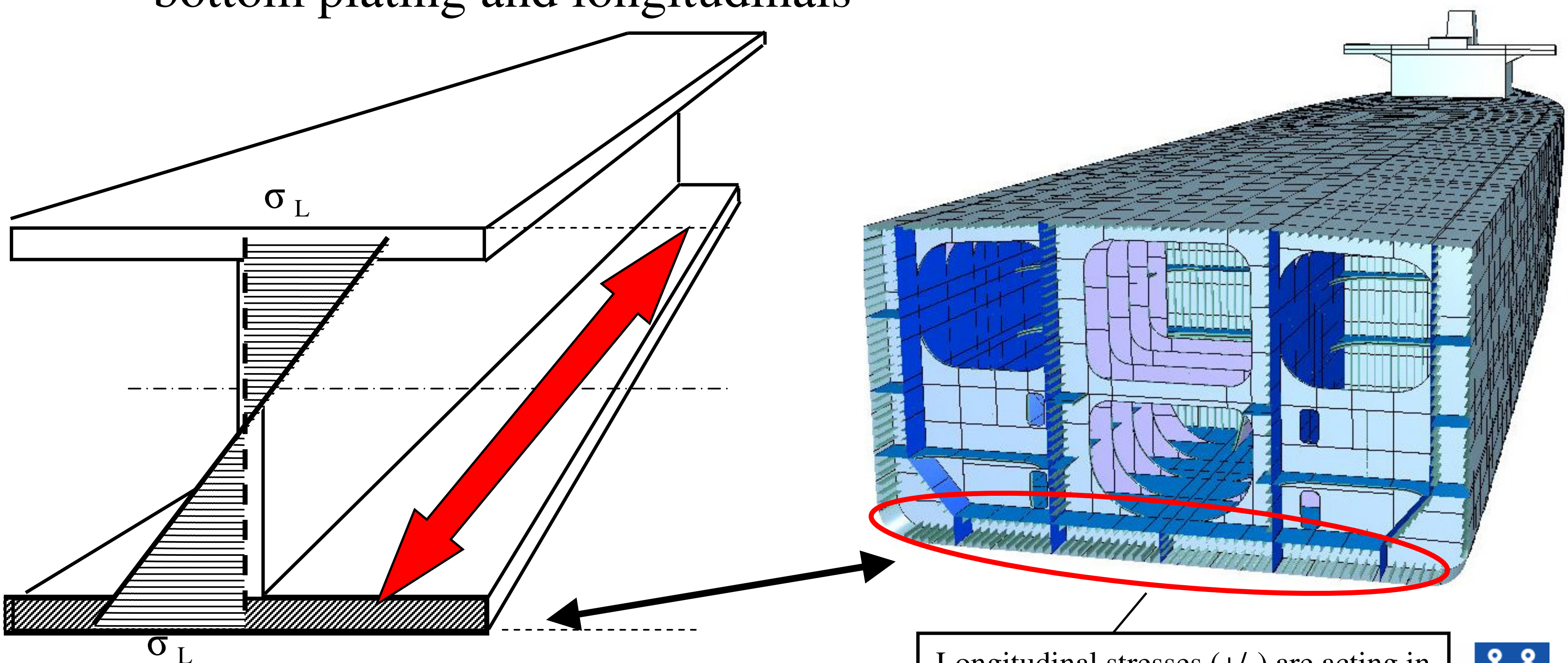



Cont.

# Function: Flange in hull girder



Global bending moment induces longitudinal stresses in the bottom plating and longitudinals




**Section A-A**

Longitudinal stresses (+/-) are acting in the bottom plating and longitudinals due to bending of hull girder

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# Characteristic damages

2. Bottom

1. Bilge keel terminations – crack in hull plating
2. Fatigue cracking in bottom longitudinal connections to web frame and transverse bulkhead
3. Corrosion of bottom structures
4. Hopper knuckle – cracks

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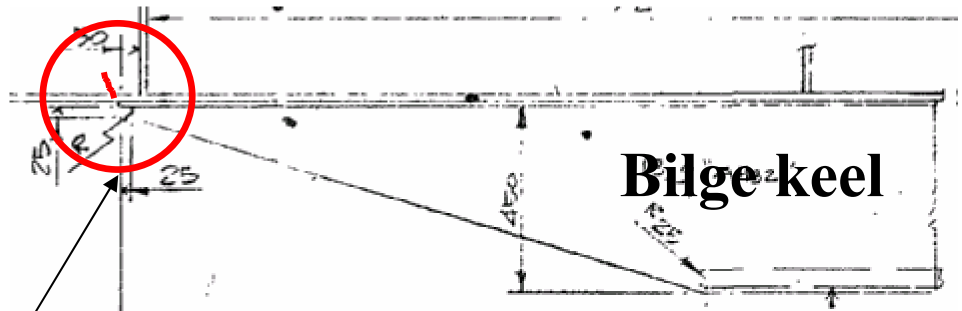
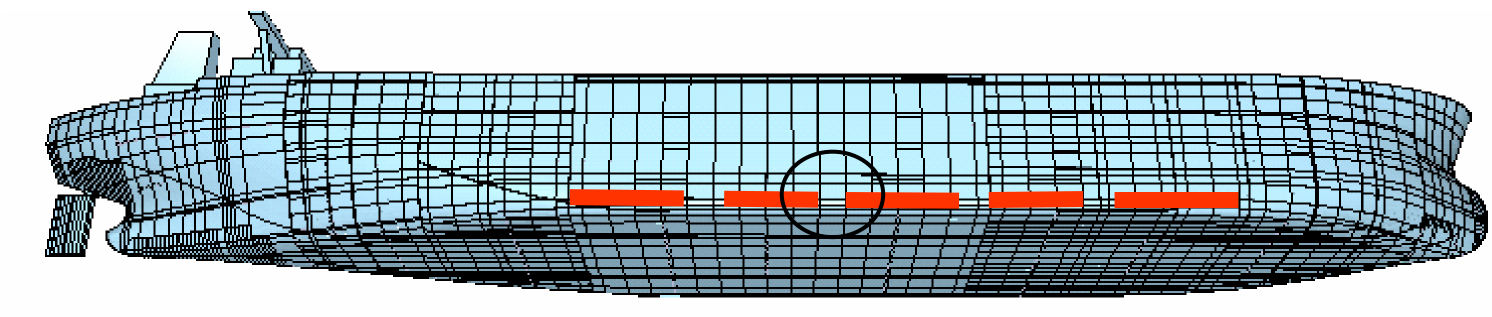
# Bilge keel cracking

2. Bottom

**Oil Tanker**
**285,690 DWT built 1990**
Crack in hull plating i.w.o. bilge keel terminations




Crack in hull plating in way of bilge keel toes





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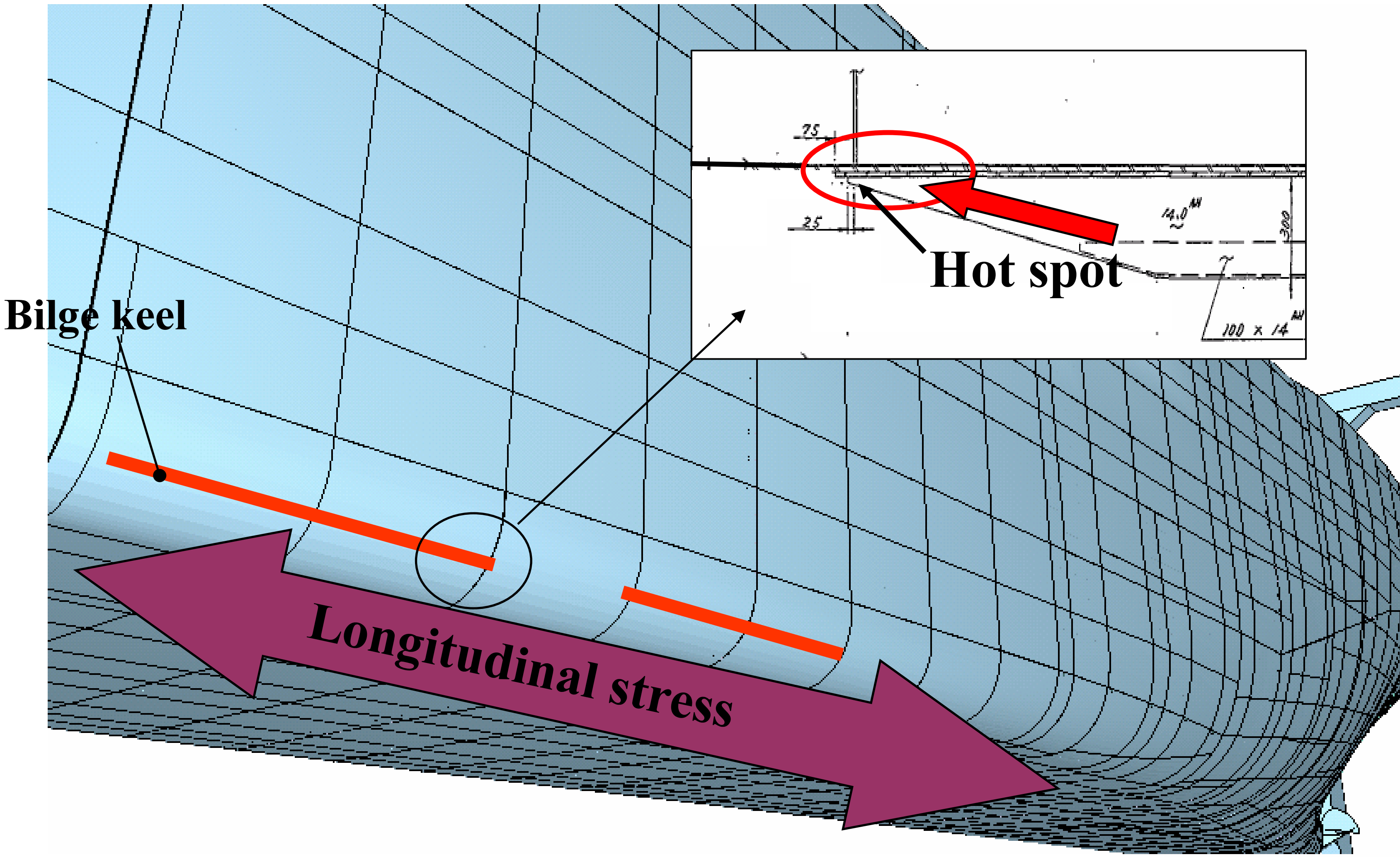
# Bilge keel cracking

2. Bottom



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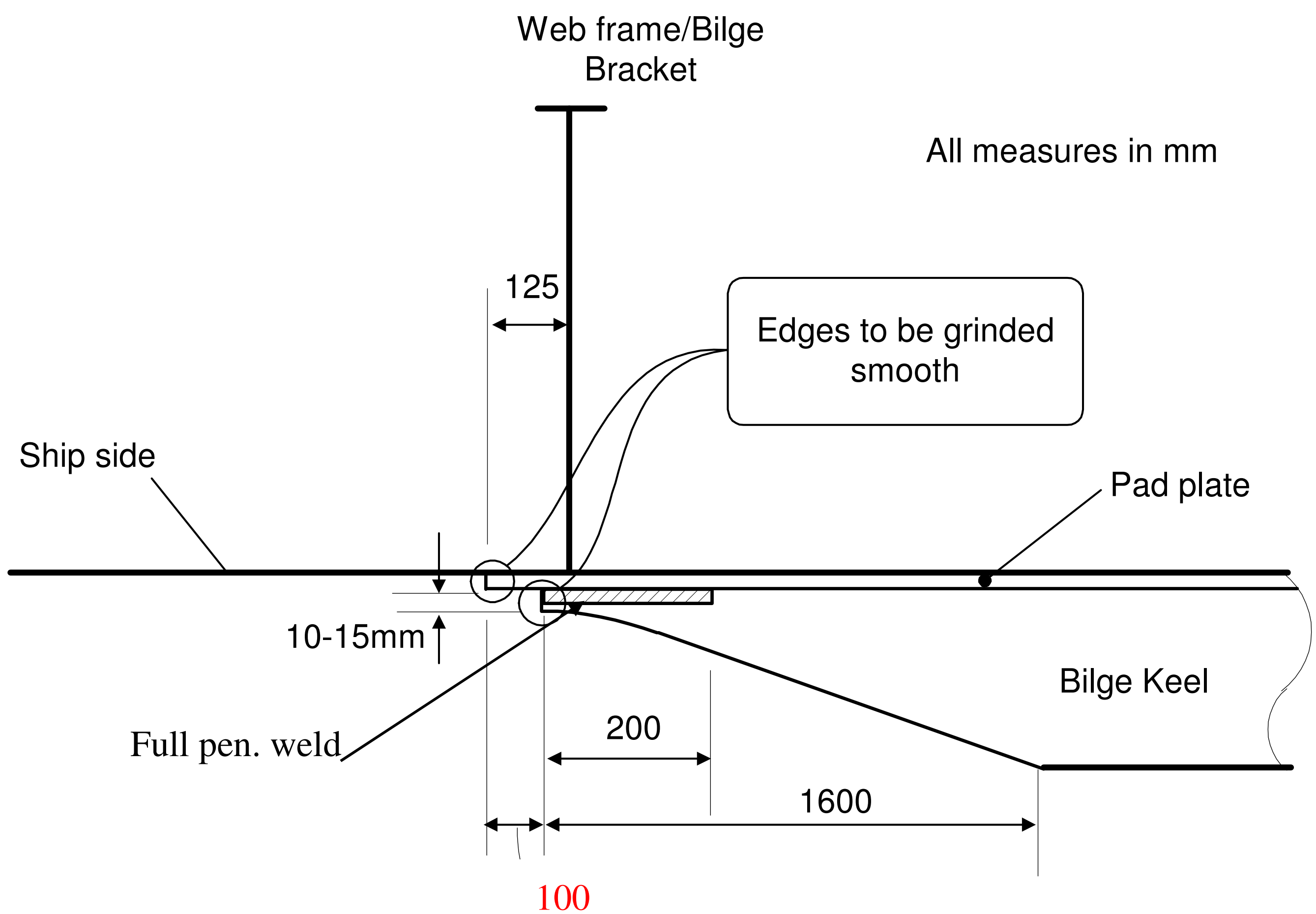
# Bilge keel cracking

2. Bottom



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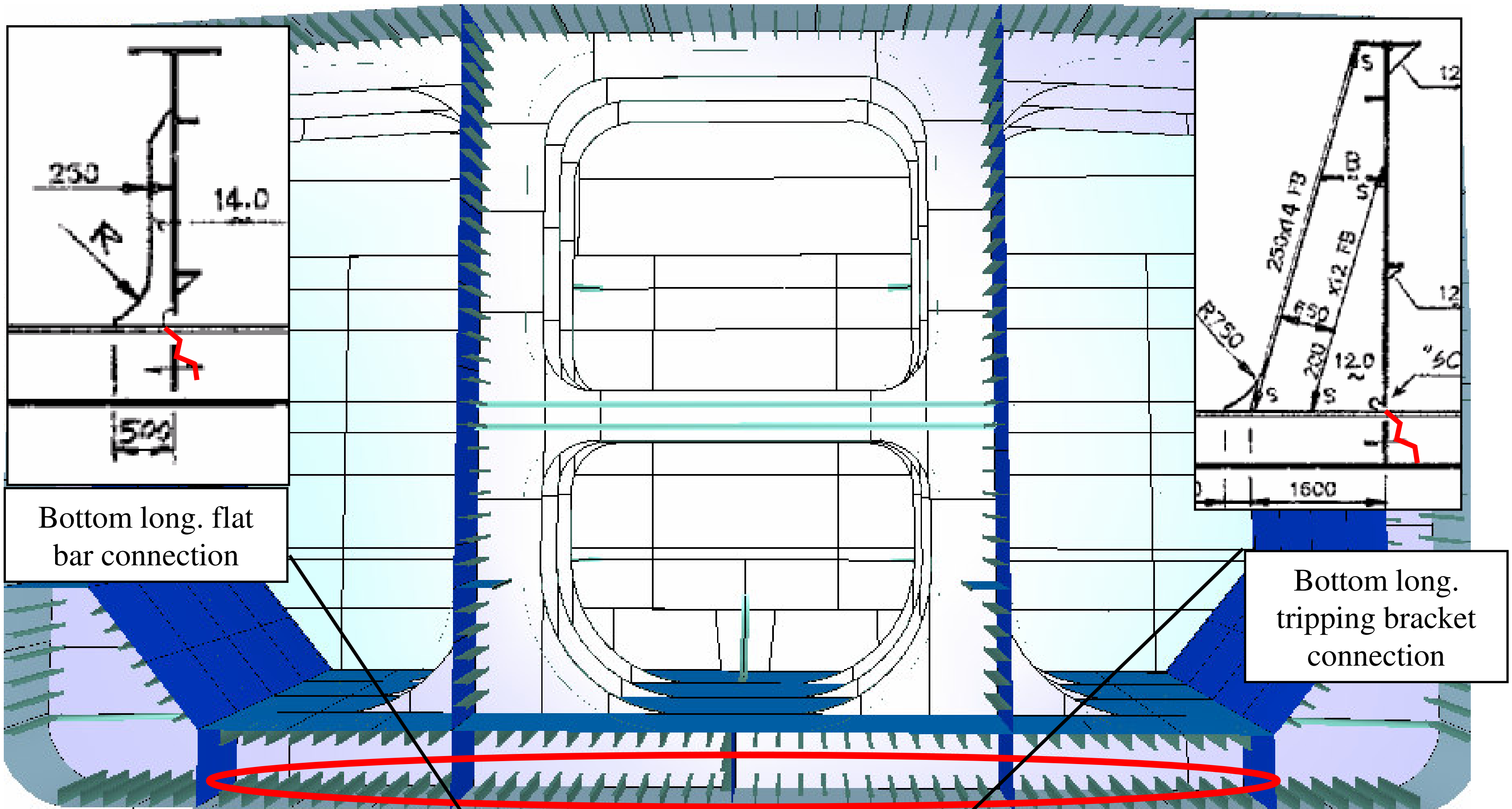
# Cracking in bottom longitudinals

2. Bottom




Similar cracking in bottom longitudinals is also valid for double hull tankers



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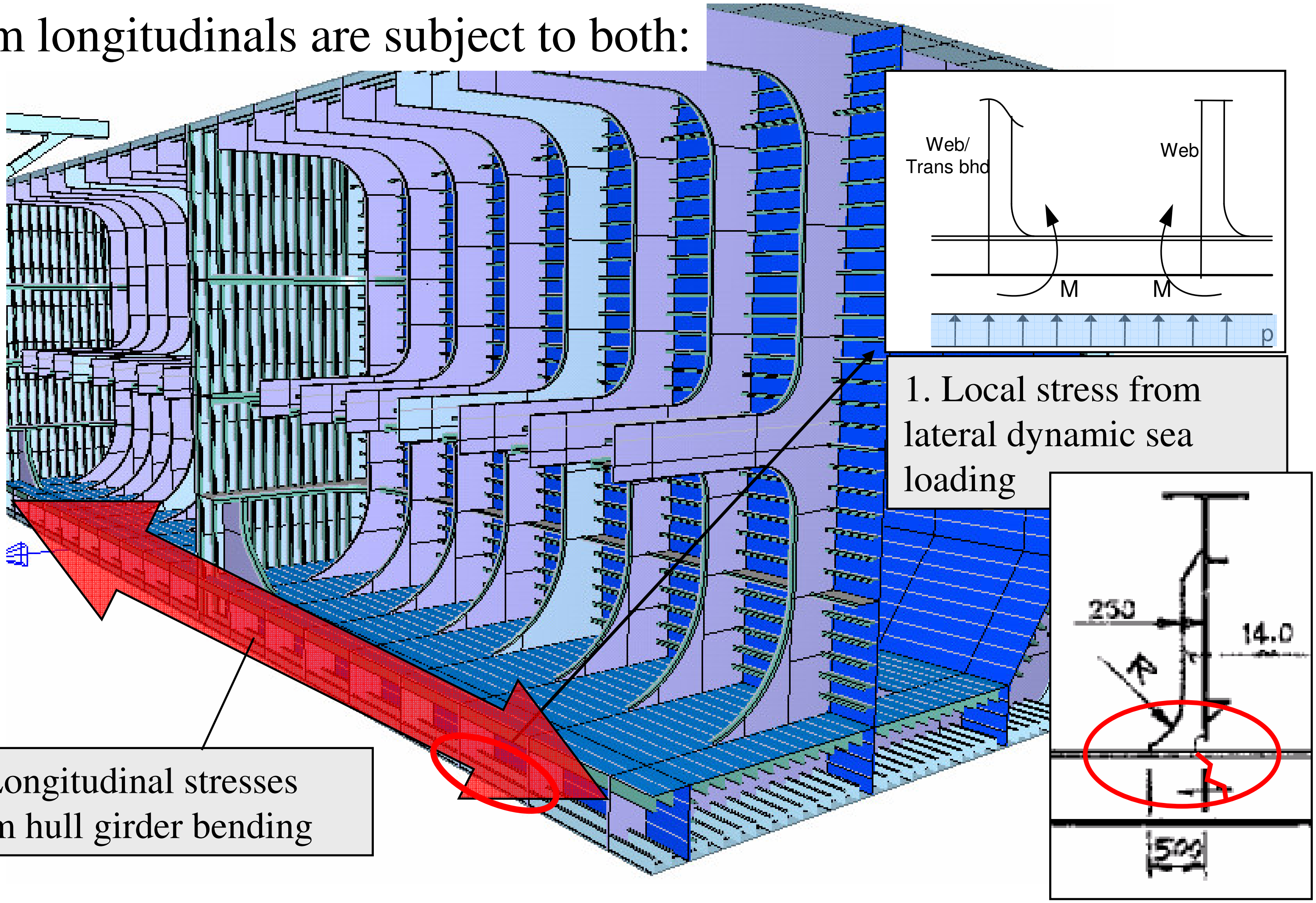
# Cause for cracking in bottom longitudinals



Bottom longitudinals are subject to both:




1. Local stress from lateral dynamic sea loading

2. Longitudinal stresses from hull girder bending

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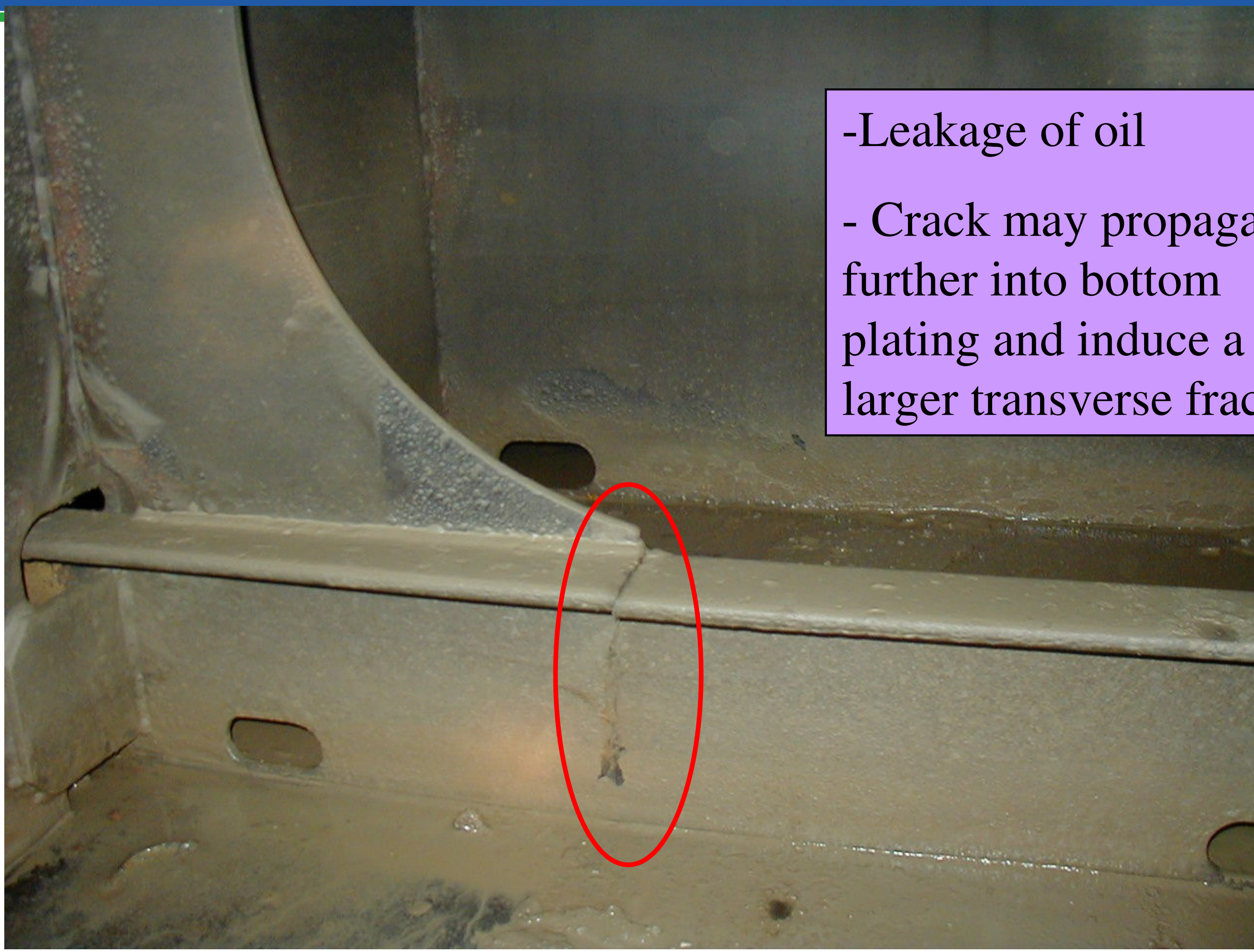
# Consequences of cracks in bottom longitudinals:

2. Bottom



-Leakage of oil

- Crack may propagate further into bottom plating and induce a larger transverse fracture

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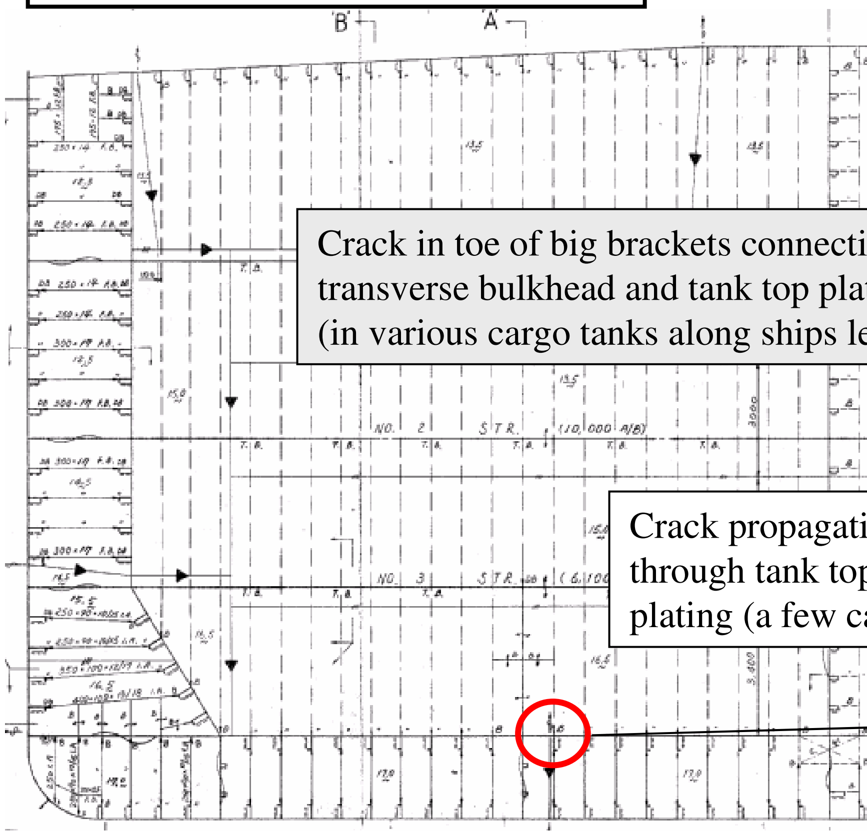
# Example: Cracks in inner bottom

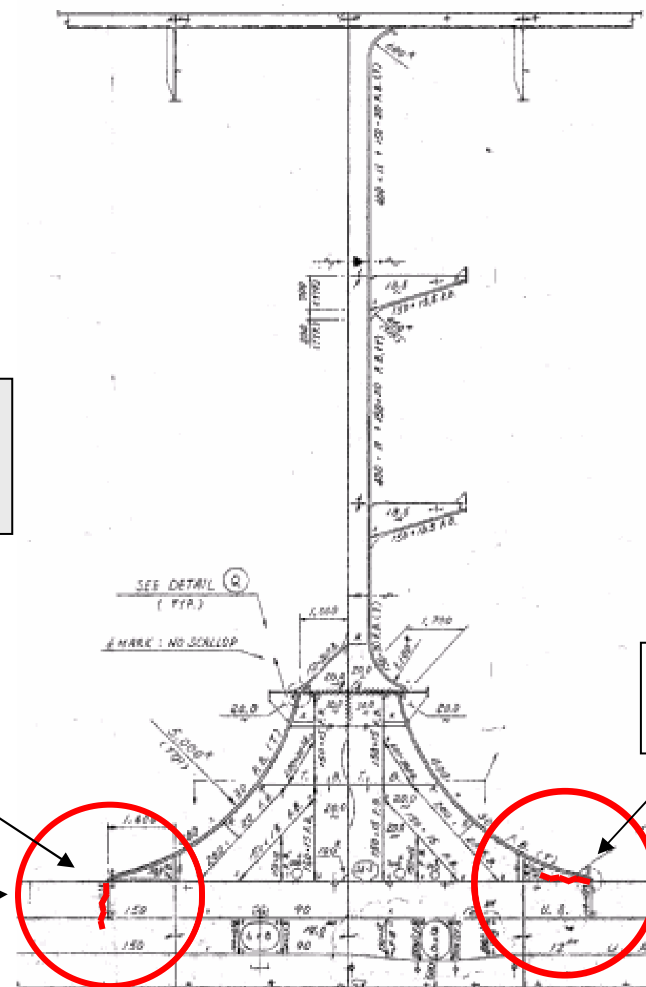
2. Bottom

**Oil Tanker**
**95,371 DWT**
Crack in tank top plating at toes of transverse bulkhead buttress P/S



Crack in toe of big brackets connecting transverse bulkhead and tank top plating (in various cargo tanks along ships length)

Crack propagating through tank top plating (a few cases)



Crack in bracket toe

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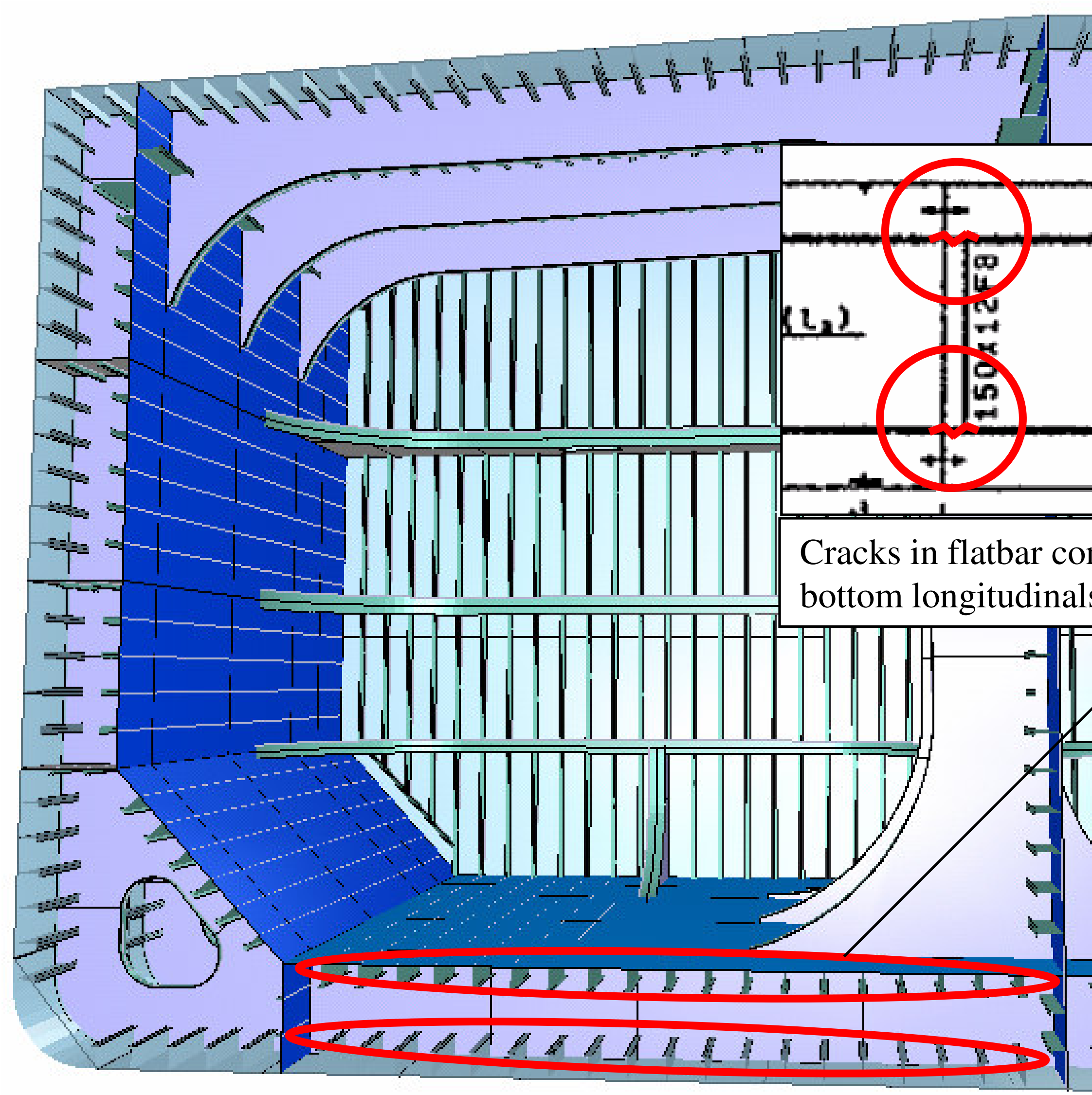
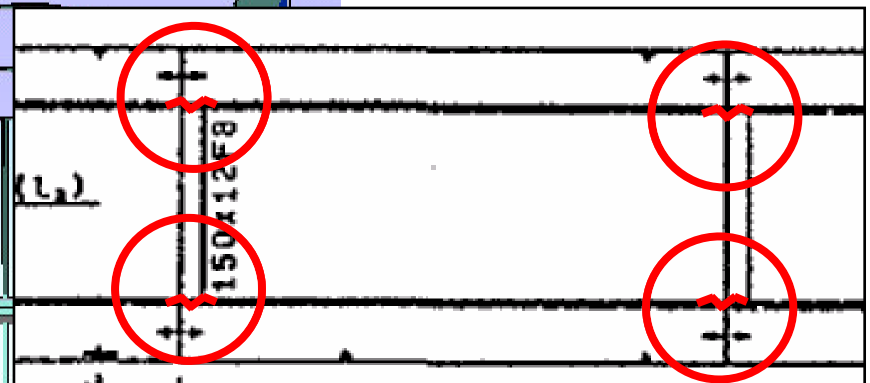
# Cracking in double bottom longitudinals

2. Bottom





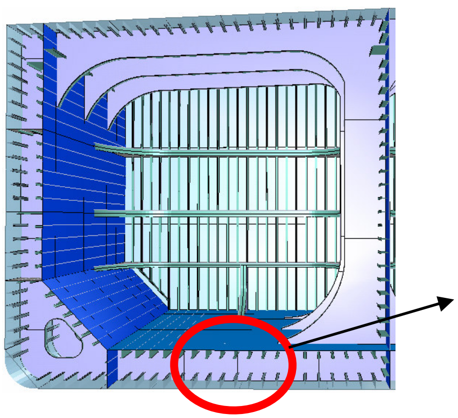
Cracks in flatbar connections for bottom and inner bottom longitudinals

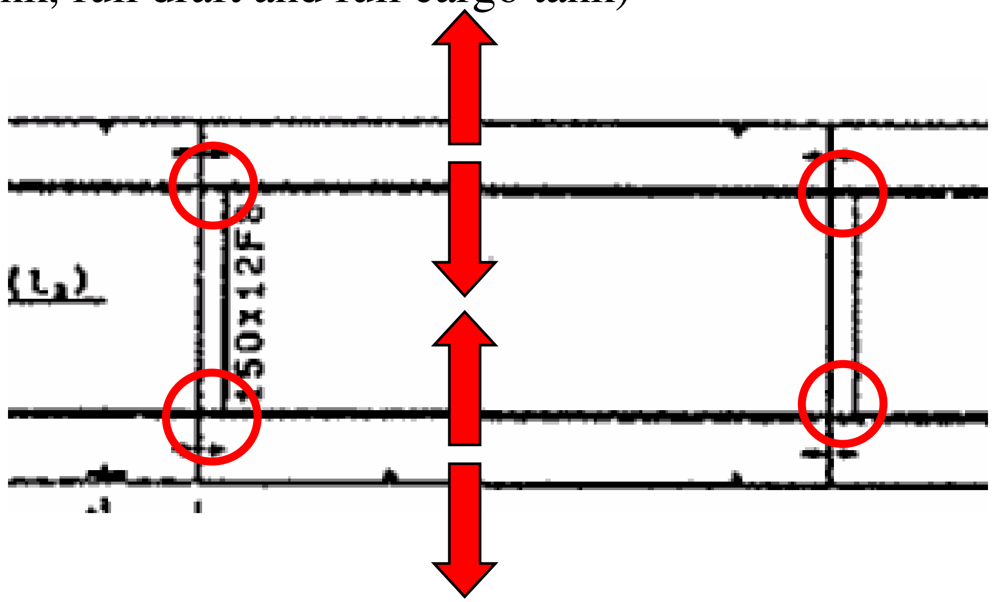
# Cause for cracking in double bottom longitudinals



In a ballast condition there is a net overpressure in the double bottom ballast tank (full ballast tank and empty cargo tank)

In a loaded condition there will be a negative net pressure on the double bottom (empty ballast tank, full draft and full cargo tank)



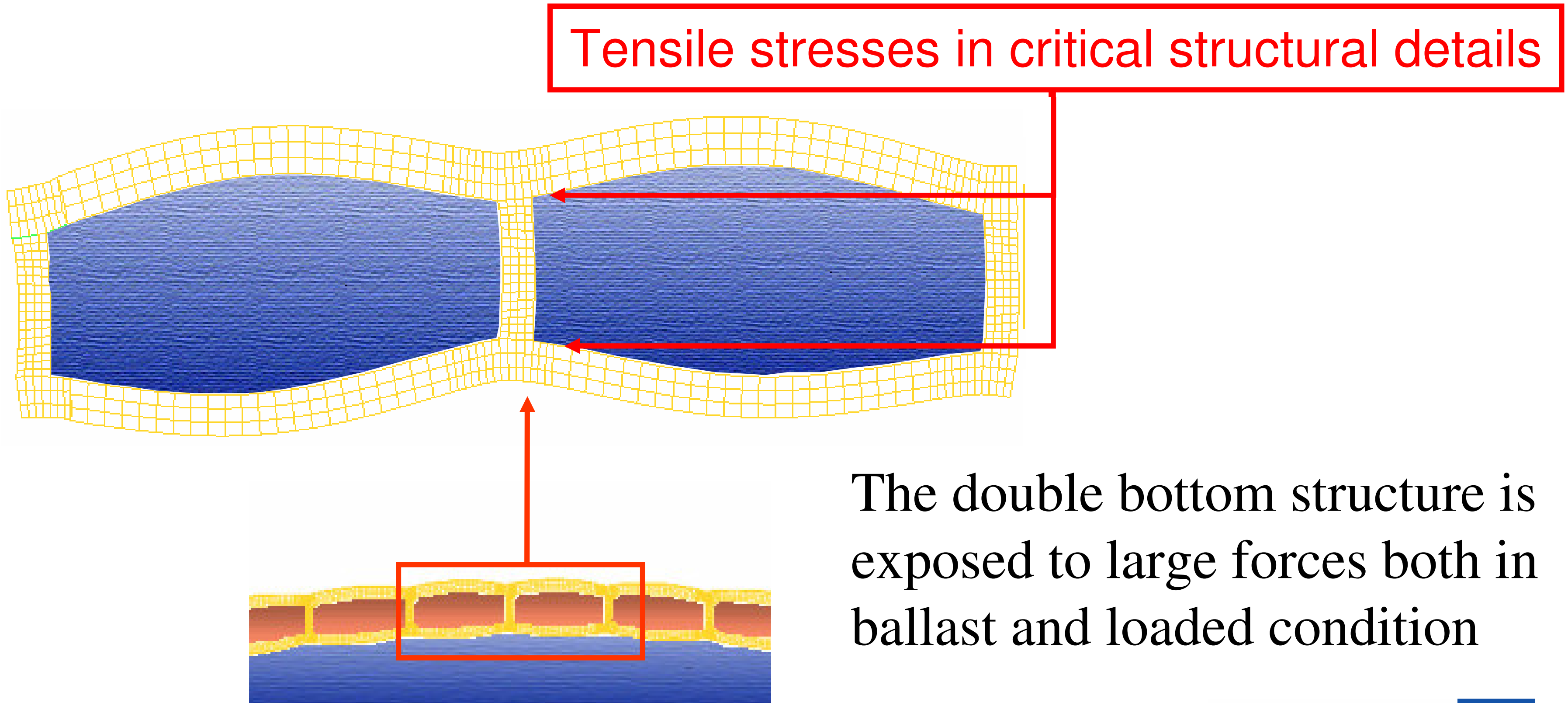


This effect may cause yield stress in hot spots at flat bar connections

Due to the dynamic +/- variation of stresses, low cycle fatigue may occur

# Illustration – double bottom flatbar connections






The double bottom structure is exposed to large forces both in ballast and loaded condition

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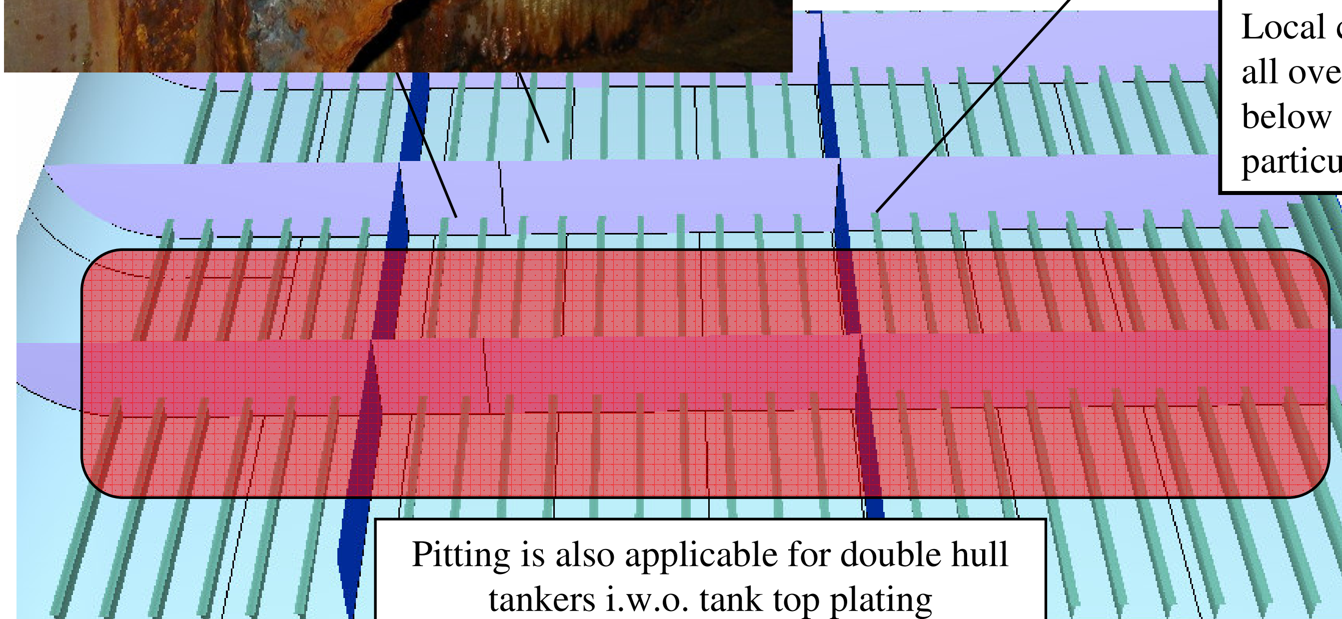
# Corrosion of bottom structures

2. Bottom



Local corrosion (pitting): may occur all over the bottom plating, but area below and around bell-mouth is particularly exposed

Pitting is also applicable for double hull tankers i.w.o. tank top plating

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# Corrosion of bottom structures



- *Pittings and local corrosion* may cause leakage, in general not any structural problem

- *General corrosion* will reduce the bottom sectional area, which can lead to an increased stress level:

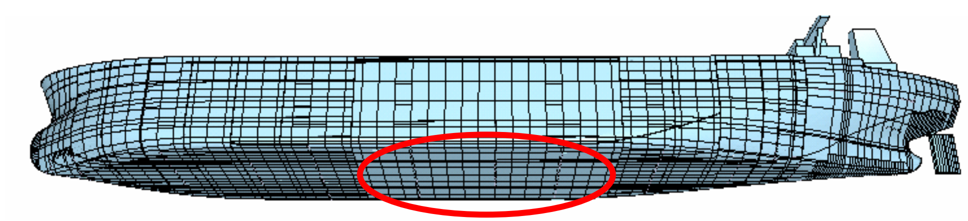
1. Higher risk for fatigue cracks in bottom longitudinals
2. Higher risk for buckling of plate fields in the bottom

Longitudinal stress

Force

$$\sigma_L = \frac{F}{A}$$

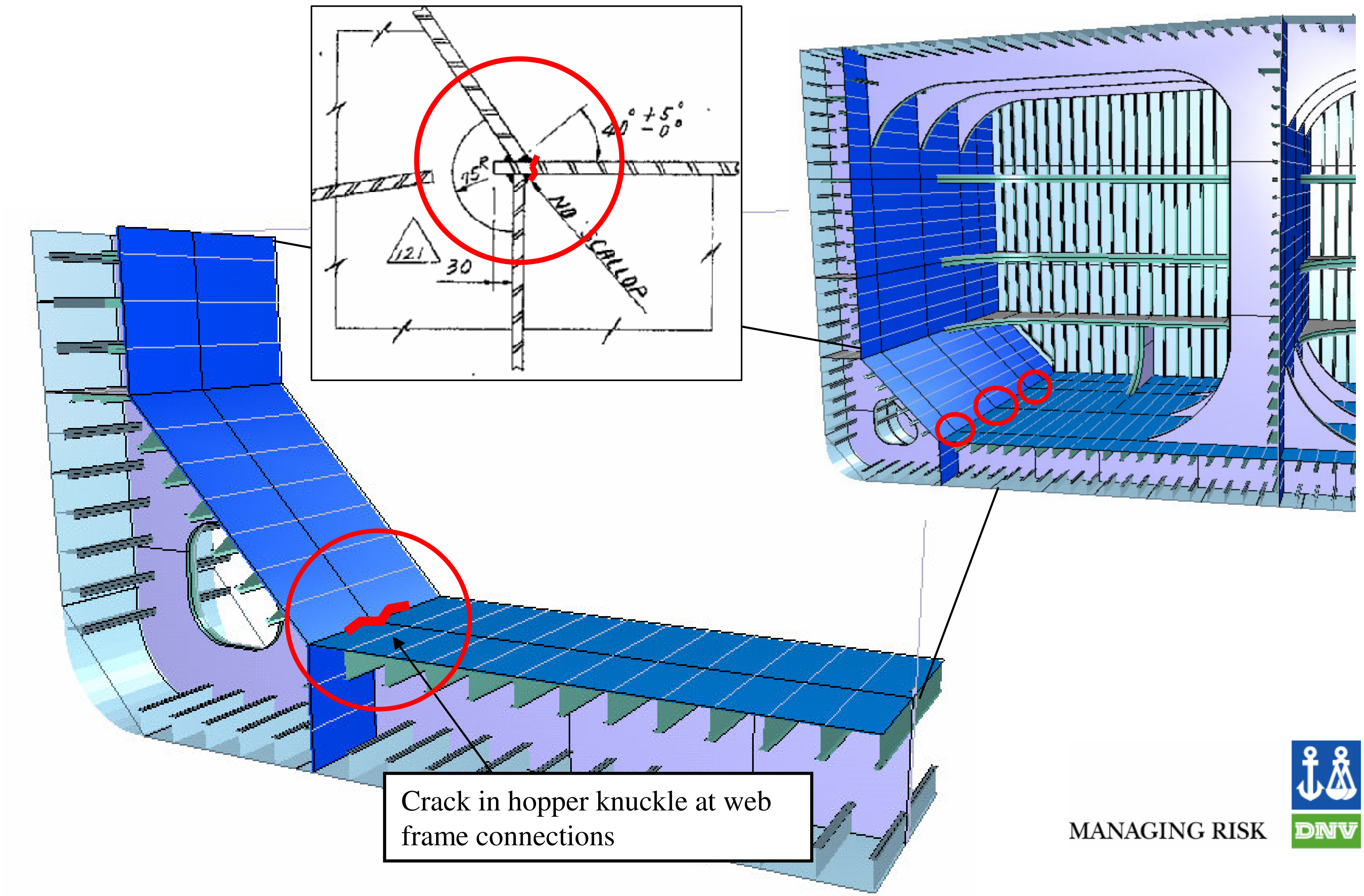
Area



Increased risk for fatigue cracking and buckling of bottom panels if general corrosion has developed over the cross section

# Cracking in hopper knuckle

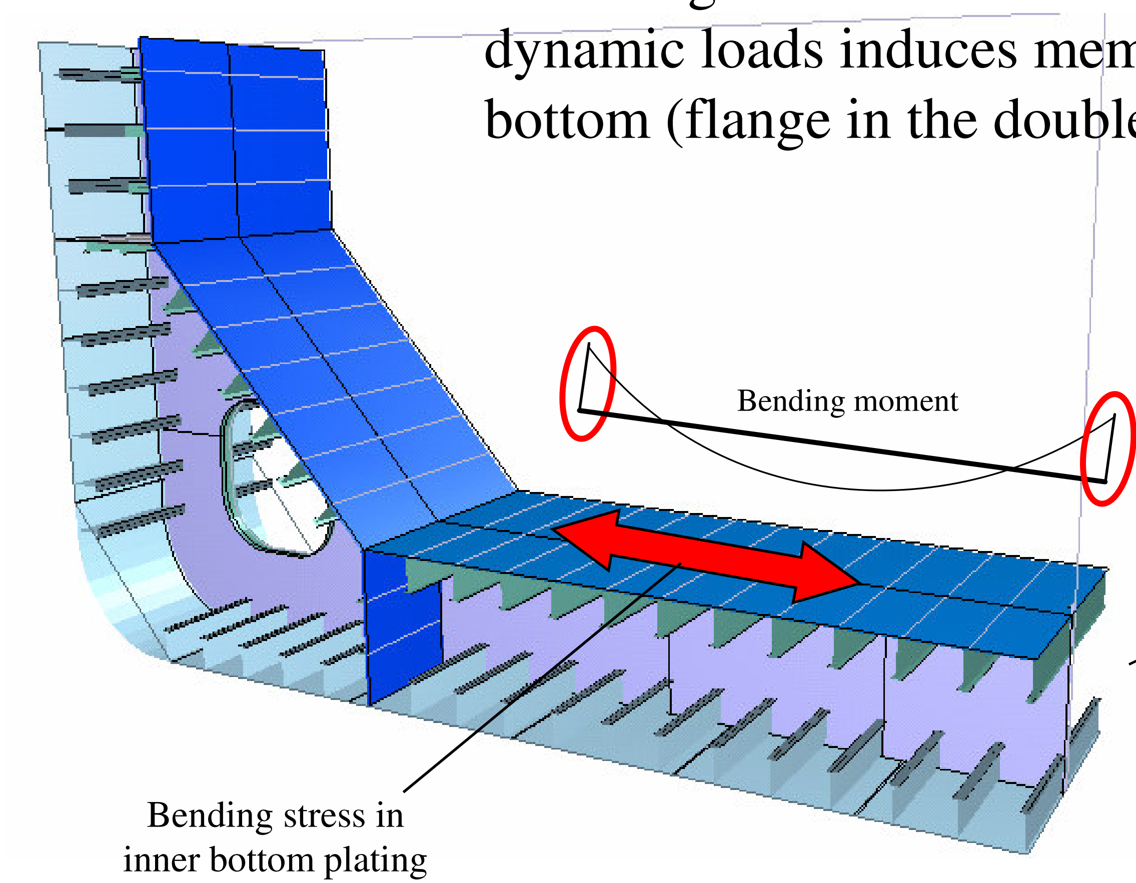


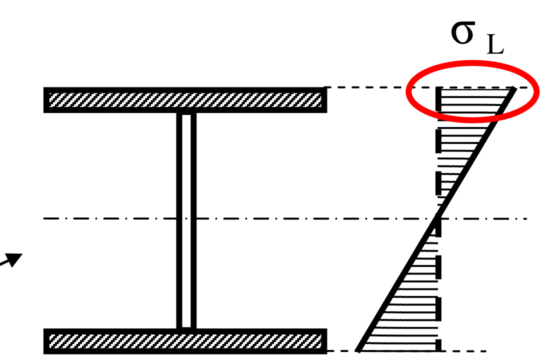


# Cause for cracking in hopper knuckle



- Bending of double bottom due to external and internal dynamic loads induces membrane stresses in the inner bottom (flange in the double bottom transverse girder)




Bending stress in double bottom girder $\sigma_L$

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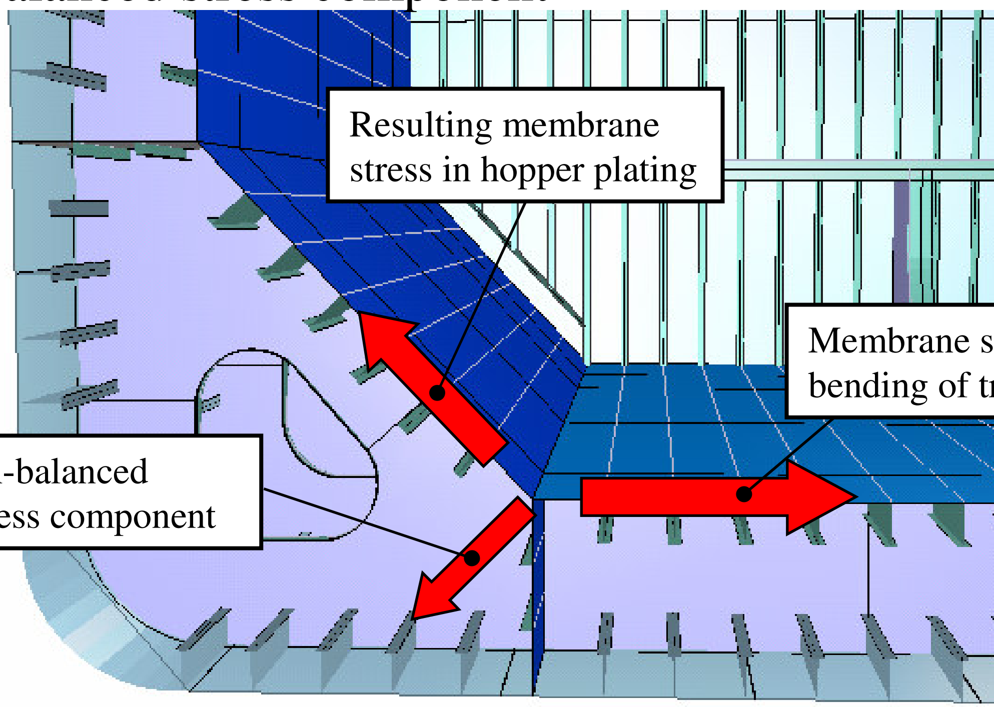
# Cause for cracking in hopper knuckle

2. Bottom

- Inner bottom membrane stresses are transferred into the hopper plating
- The turn of the stress direction (inner bottom to hopper plating) results in an unbalanced stress component




- This effect together with the knuckle being a geometric ‘hard point’ at web frame connections, induce very high stresses in the knuckle point