"MHI DILAM", the most sophisticated Fatigue Design methodology developed by MHI

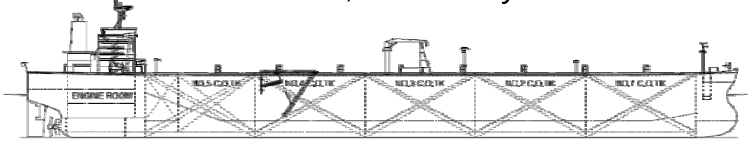
— Application of MHI DILAM to the latest design of a Malaccamax VLCC —

Mitsubishi Heavy Industries, Ltd.
Ship & Ocean Engineering Department
Shipbuilding & Ocean Development HQ

1. Introduction

- ✓ MHI has developed State-of-the-art structural analysis with Direct Loading Analysis Method (DILAM) on purpose to assess fatigue strength of the ships with novel design or offshore structure.

- ✓ This presentation shows the result of fatigue study by DILAM for the latest Mallaccamax VLCC, which conforms to the CSRs, is currently under construction.



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1. Introduction
2. Overview of MHI DILAM: Latest fatigue analysis method by direct wave load
3. Application of DILAM to primary member of Mallaccamax VLCC
4. Conclusion

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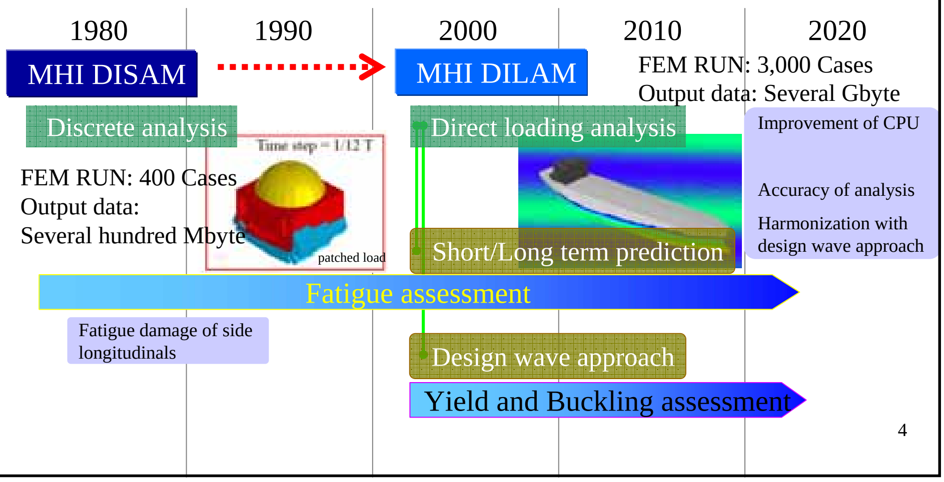
2. MHI-DILAM: Latest fatigue analysis method by direct wave load

2.1 History of MHI's development of fatigue analysis method



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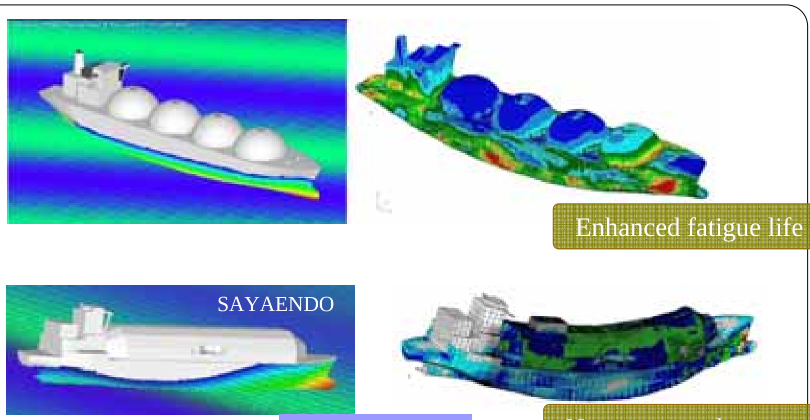
2. MHI-DILAM: Latest fatigue analysis method by direct wave load

2.1 History / Application



LNG Carrier

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2. MHI-DILAM: Latest fatigue analysis method by direct wave load

2.1 History / Application

Independent tank

Non-linier: Contact, Friction

LPG Carrier

Exceeds conventional size

Mega Container Ship

Comparison with full scale measurement

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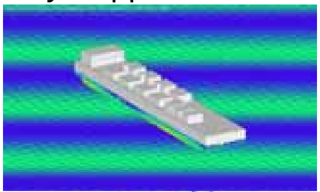
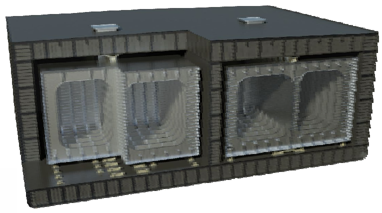
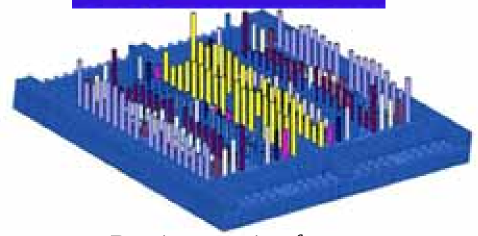
2. MHI-DILAM: Latest fatigue analysis method by direct wave load

2.1 History / Application







Bearing reaction force

FPSO (FLNG)

Independent tank type B

Non-linier: Contact, Friction

Exceeds the scope of conventional service condition

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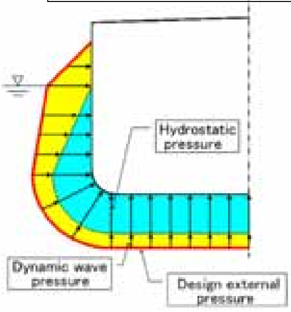
2. MHI-DILAM: Latest fatigue analysis method by direct wave load

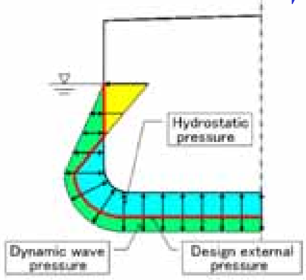
2.2 Concept of MHI-DILAM

Simplified "design wave loads"
(Conventional structural analysis method)

Relative comparison with existing structures



Wave crest



Wave trough

Development of a new type of structure

Analysis which can faithfully simulate the complexity of the loads

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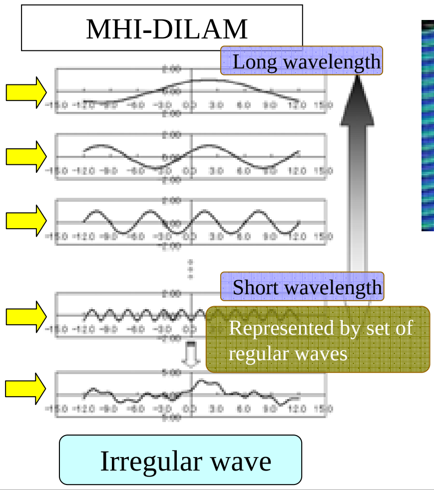
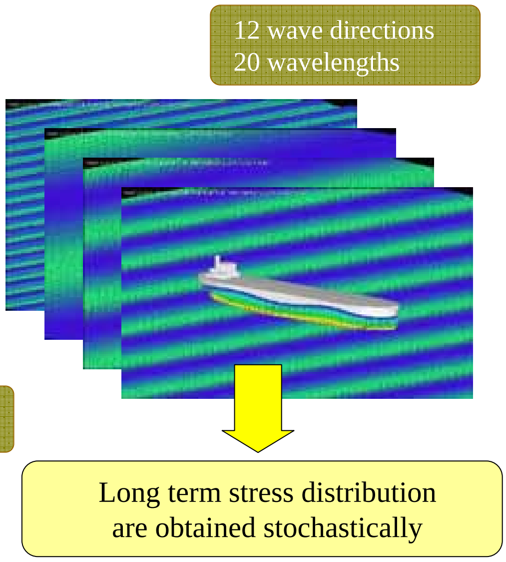
2. MHI-DILAM: Latest fatigue analysis method by direct wave load

2.2 Concept of MHI-DILAM





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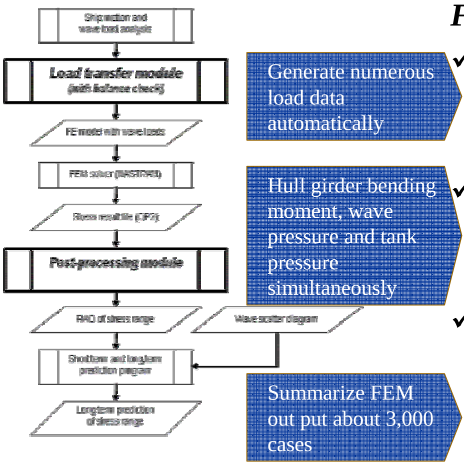
2. MHI-DILAM: Latest fatigue analysis method by direct wave load

2.3 System configuration



Feature of MHI-DILAM

✓ ***Automatic load-generation module***
Automatically generates load data for NASTRAN

✓ ***Global load-check module***
Automatically sums up local loads and checks load and moment balance

✓ ***Post-processing module***
Automatically generate the stress Response Amplitude Operator (RAO)

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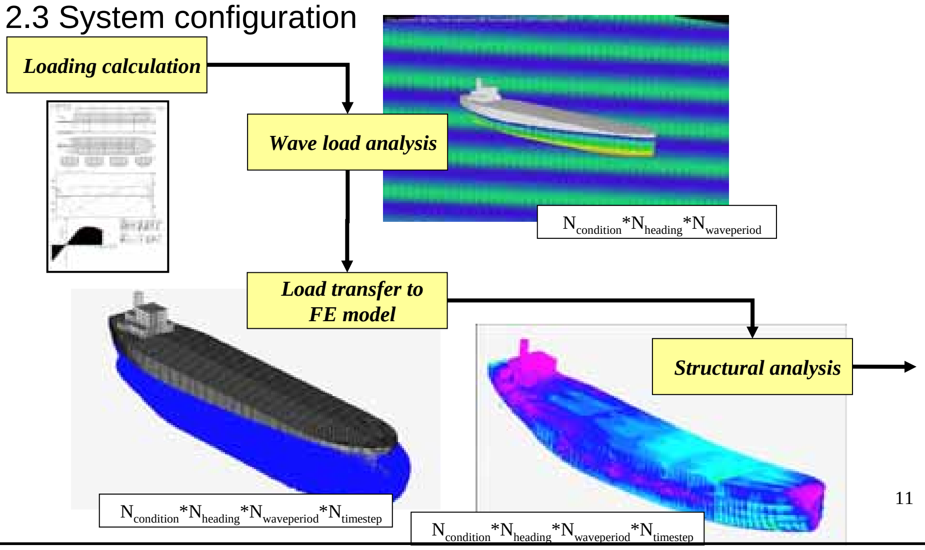
2. MHI-DILAM: Latest fatigue analysis method by direct wave load

2.3 System configuration



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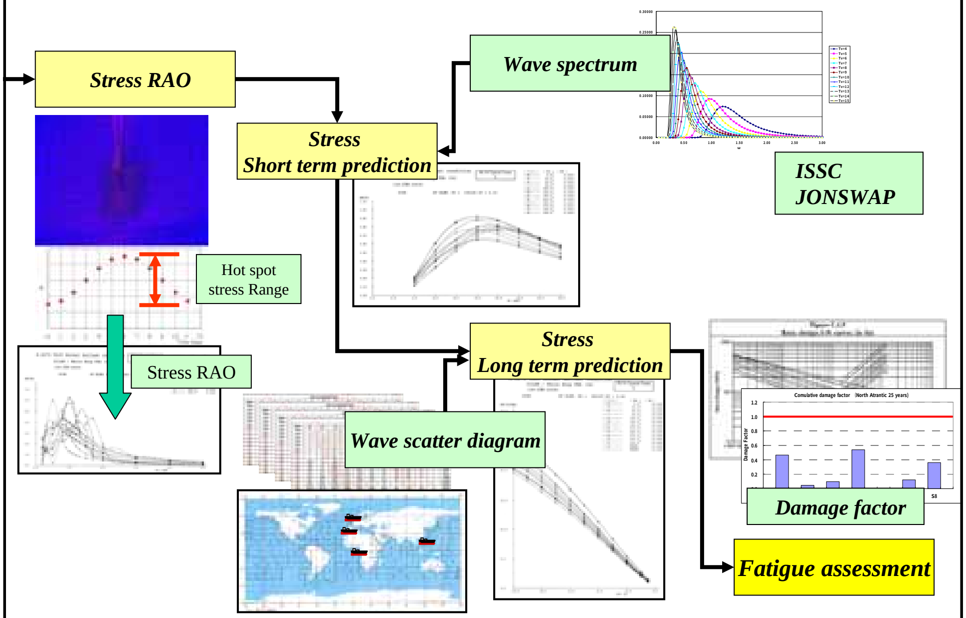

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2. MHI-DILAM: Latest fatigue analysis method by direct wave load

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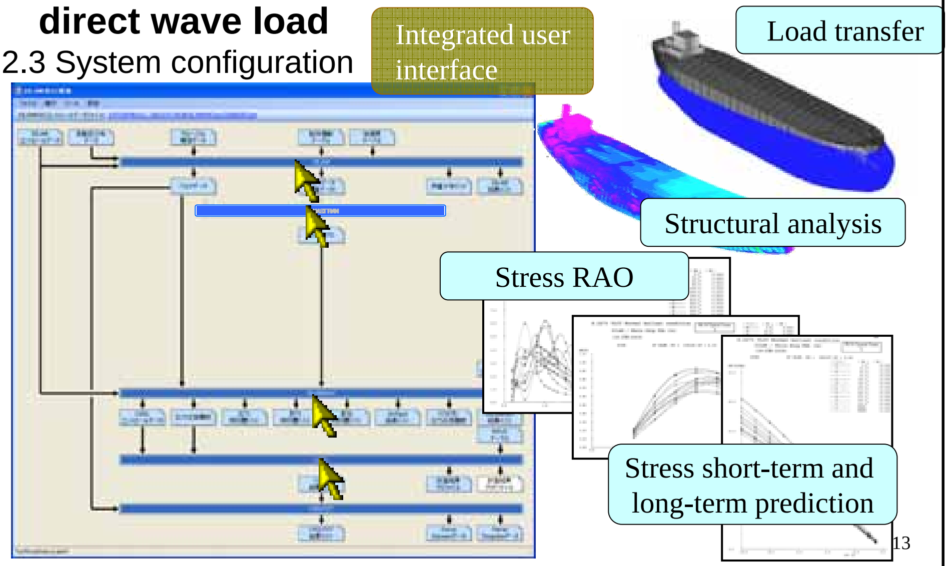

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1. Introduction
2. MHI DILAM: Latest fatigue analysis method by direct wave load
3. Application of DILAM to primary member of Mallaccamax VLCC
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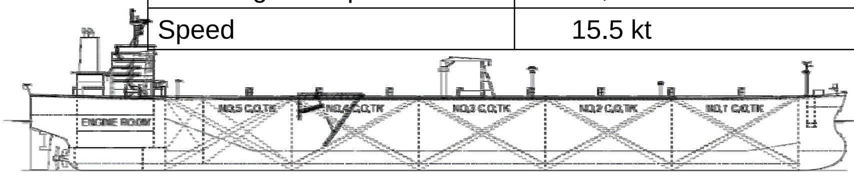
3. Application of DILAM to primary member of Mallaccamax VLCC

The main particulars of the VLCC

LxBxD: 324.0 x 60.0 x 29.1

ddes./dscant. 20.5 / 20.8

Deadweight tonnage	298,500 t (ddes.) 304,000 t (dscant.)
Cargo tank capacity	355,000 m³
Gross tonnage	160,300 t
Main engine	Mitsubishi UE 7UEC85LS II
Main engine output	27,020 kW
Speed	15.5 kt



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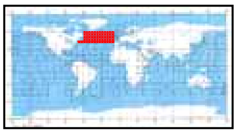
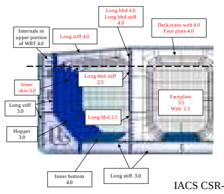
3. Application of DILAM to primary member of Mallaccamax VLCC



Requirement of Fatigue Design Methodology by CSR

Basic conditions

- ✓North Atlantic wave
- ✓25 years design life
- ✓Net thickness approach



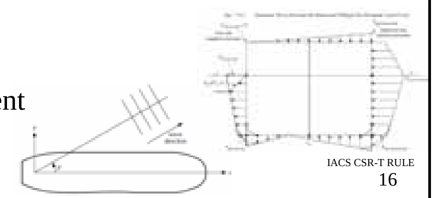
IACS CSR-T RULE

Provability of dynamic load

- ✓Q=10^{-4} probability level

Load for fatigue assessment

- ✓vertical wave bending moment
- ✓horizontal wave bending moment
- ✓dynamic wave pressure
- ✓dynamic tank pressure



IACS CSR-T RULE

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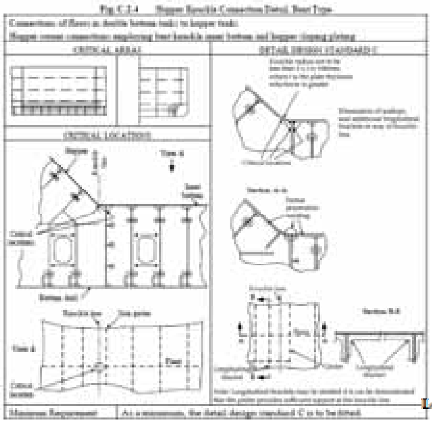
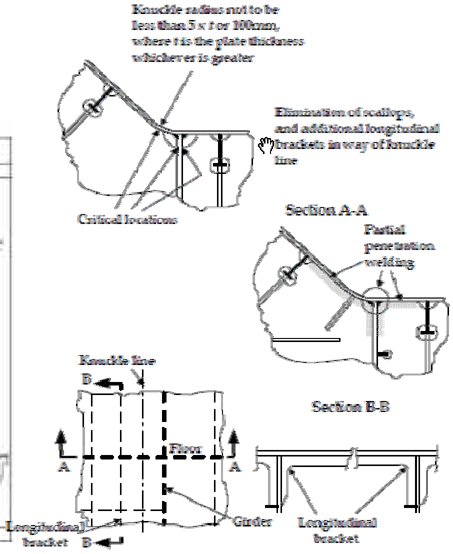
3. Application of DILAM to primary member of Mallaccamax VLCC

Example of standard design of primary member by CSR

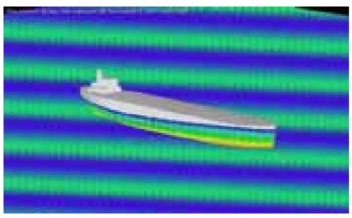


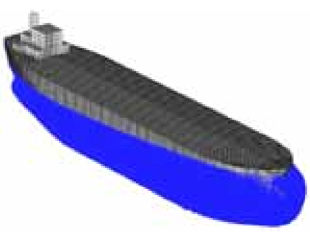


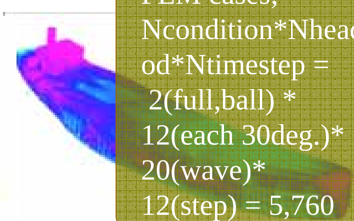
IACS CSR-T RULE

3. Application of DILAM to primary member of Mallaccamax VLCC

Number of Element: 400,000



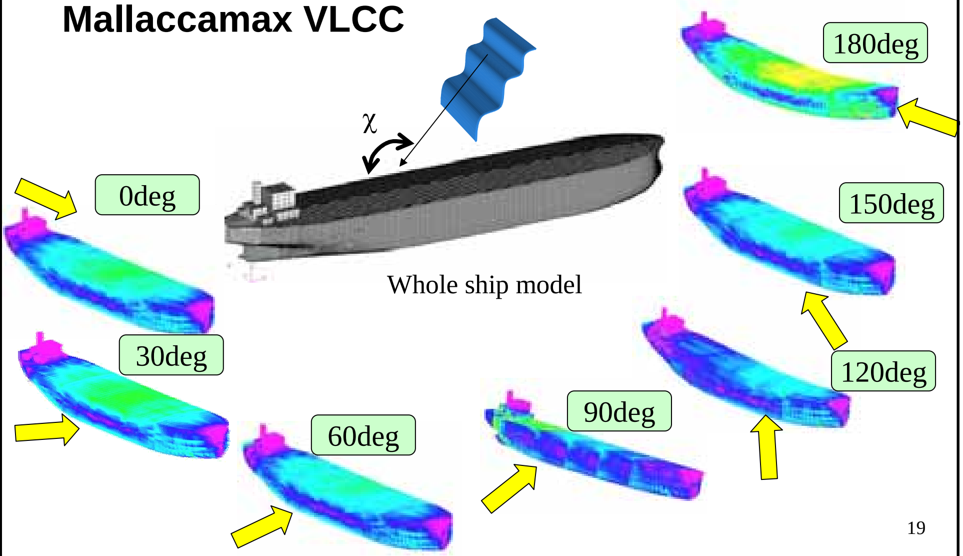




FEM cases;
Ncondition*Nheading*Nwaveperiod*Ntimestep =
2(full,ball) *
12(each 30deg.)*
20(wave)*
12(step) = 5,760

Whole ship model

3. Application of DILAM to primary member of Mallaccamax VLCC



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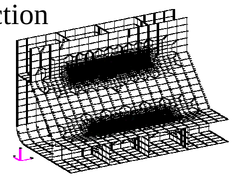
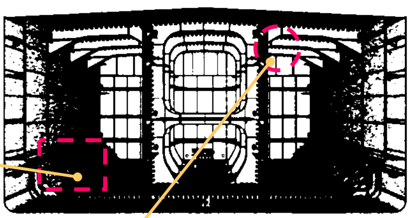
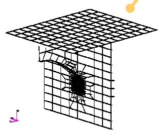
3. Application of DILAM to primary member of Mallaccamax VLCC

1. Bilge hopper knuckle connection



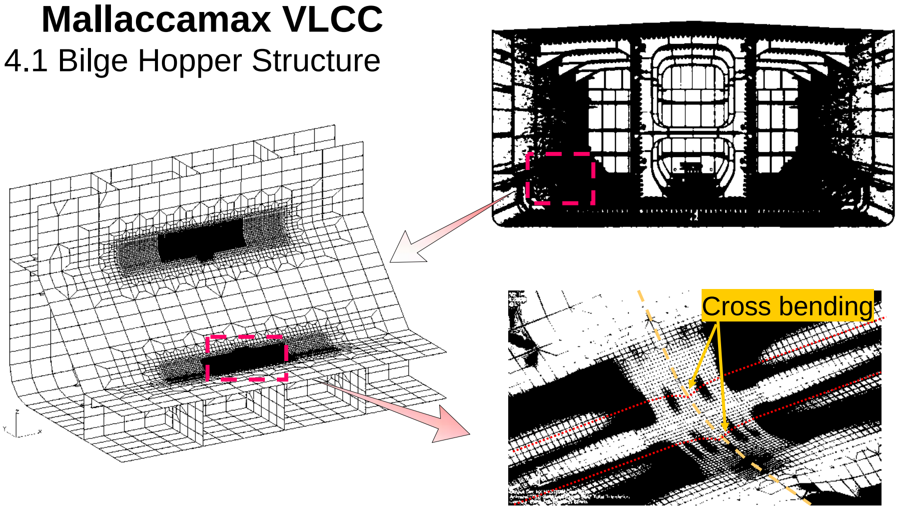


2. End of deck trans.



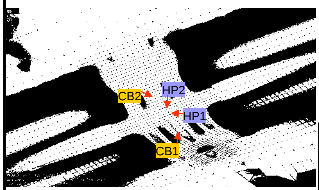
3. Application of DILAM to primary member of Mallaccamax VLCC

4.1 Bilge Hopper Structure

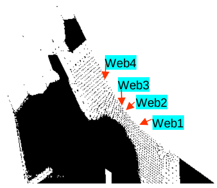


4. Application of DILAM to primary member of Mallaccamax VLCC

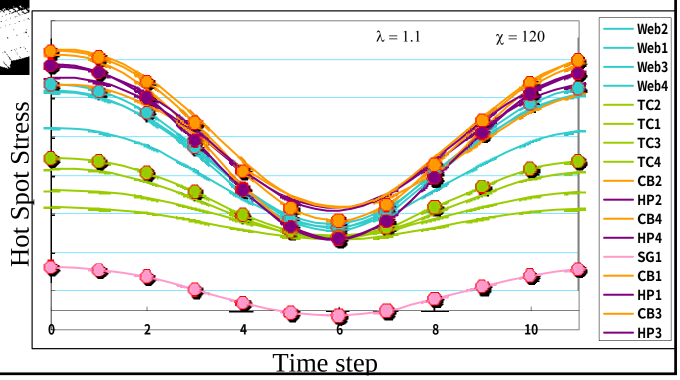
4.1 Bilge Hopper Structure



Mises Stress
(Hopper plate)



Mises Stress
(Trans. web plate)



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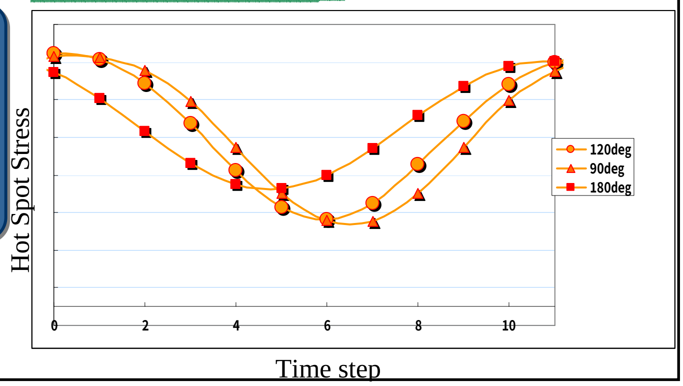
3. Application of DILAM to primary member of Mallaccamax VLCC

3.1 Bilge Hopper Structure

Dominant phenomena can be confirmed with stress history and structural deformation.

+ Heading sea (180 degree)



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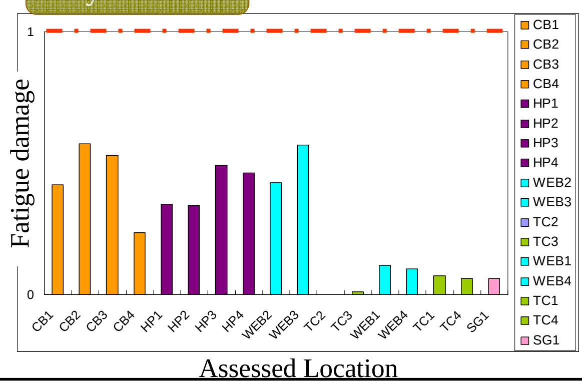
3. Application of DILAM to primary member of Mallaccamax VLCC

3.1 Bilge Hopper Structure

Assessed hot spot:
17 points

North Atlantic
25 years



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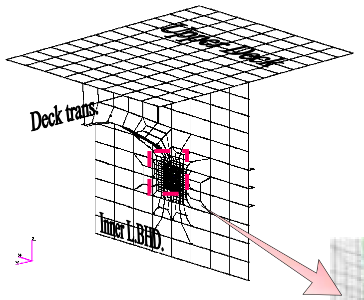
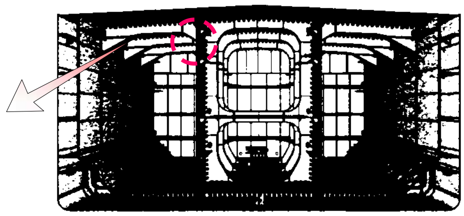
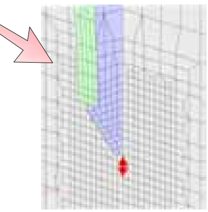
3. Application of DILAM to primary member of Mallaccamax VLCC

3.2 End connection of Deck Trans.







Toe of Snake head BKT

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3. Application of DILAM to primary member of Mallaccamax VLCC

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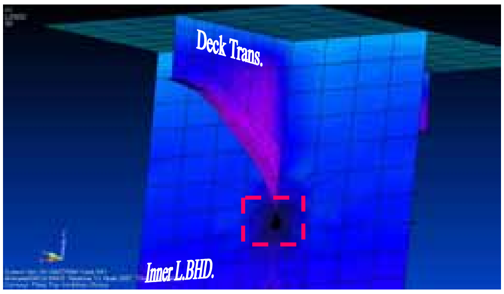


Mises Stress

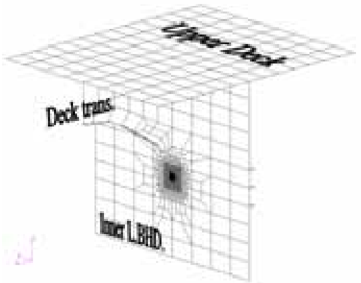
Mises Stress
(Trans. web)

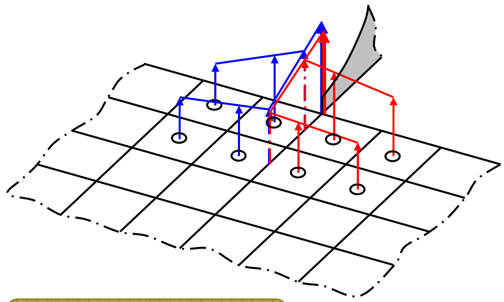
Mises Stress
(Inner L.BHD. plate)

Stress contour and deformation

3. Application of DILAM to primary member of Mallaccamax VLCC

3.2 End connection of Deck Trans.

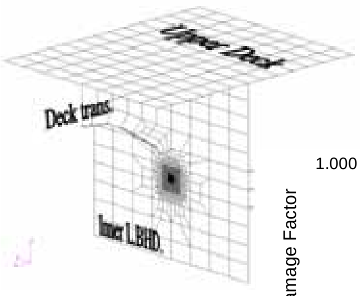


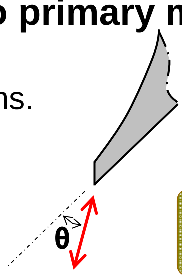


Extrapolation of Hot Spot stress

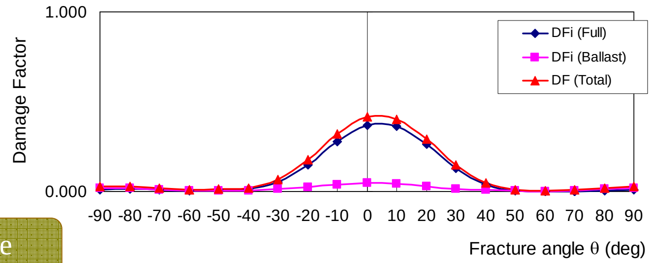
3. Application of DILAM to primary member of Mallaccamax VLCC

3.2 End connection of Deck Trans.





North Atlantic
25 years



Results of fatigue assessment (DF)

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4. Conclusion

1. The technical overview of state-of-the-art direct loading analysis, DILAM is presented.

2. Fatigue assessment with DILAM is applied to primary member of the latest Malaccamax VLCC which is designed with CSR.

   It is confirmed that fatigue damage is enough less than the criteria of CSR. (North Atlantic, 25 years fatigue life)

Another feature of MHI-DILAM is...
・Technical maturity through down-to-earth efforts
・Continuous comparative study with actual service experience
From a historical angle in shipbuilding industries, we believe that simultaneous blending among experience, rules and new technology is the very nature of an advancement of the reliability and safety of ship structure.

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Thank you for your attention!