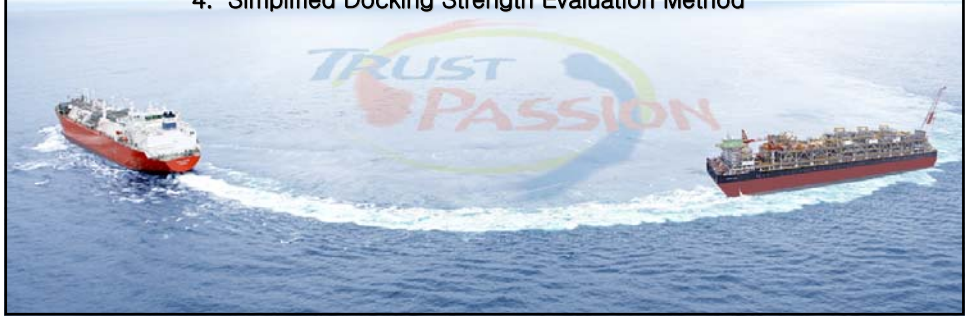
DSME 대우조선해양주식회사

Contents



1. Simplified Fatigue Guideline for Deck Attachments and Openings

A. Background(1)

Increasing the Importance of Fatigue Strength Evaluation;

• **Hull Structure**

; Welding & Structure discontinuity verification at the design stage.

- Connection point of longi. stiffener/web plate (especially, around draft line)

- Connection point of T.Bhd/L.Bhd and stringer/longi. stiffener

- Hopper knuckle area, etc.

Main consideration items at the Design Stage for Owner/Class & Design Engineer

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1. Simplified Fatigue Guideline for Deck Attachments and Openings

A. Background(2)

*** Outfitting (installed on deck & inside of cargo & ballast tank)**

- Support & piping holes installed on upper deck

- Various access holes i.w.o cargo/ballast tank, and so on.

Installed & Constructed according to the Yard experience and practice without reasonable verification procedure.

Reported casualties due to the crack, occurred on outfitting and around holes on Upper Deck & inside Tanks.

A request of Fatigue Strength evaluation/verification to the relative structures.

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1. Simplified Fatigue Guideline for Deck Attachments and Openings

B. Verification Object(1)

*** Selection :**

- Piping/Access Hole & Coaming, Pipe & Ladder Support, etc.

*** Grouping :**

1) Grouping by ship type :

Tanker(VLCC basis), Container & LNGC

2) Grouping by compartment :

Upper Deck, Ballast Tank, Cargo Hold/Tank, etc.

3) Grouping by Installed location :

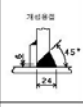
Stress concentration degree, Weight degree and consideration for Inspection/Easier Maintenance, etc.

1. Simplified Fatigue Guideline for Deck Attachments and Openings

B. Verification Object

Grouping Ex.) Simplified Fatigue Strength Evaluation iwo Hole & Outfittings on Strucutral Strength Members

Vessel

No.	Group Name	Details							Dep.	SCF
		형상	Size	방향	위치	Loading	Welding	선종		
1	Machinery (Closed Check)		1) 1000*500 2) 830*470		Shear Strake			COT		To be evaluated by FEM.
2	Machinery (Ballast)		1) 2510*820 (t=22) 2) 2040*690 (t=18)		Deck OutSide			COT		
3	Machinery (Cross Tie)		ø 300		Deck OutSide			COT		Max. 3.3
4	Machinery (Pipe Heavy Support)				Deck Center		Fillet	COT		Max. 2.2

1. Simplified Fatigue Guideline for Deck Attachments and Openings

B. Verification Object

Grouping Ex.) Simplified Fatigue Strength Evaluation iwo Hole & Outfittings on Strucutral Strength Members

Vessel :

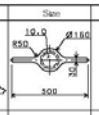
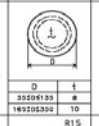
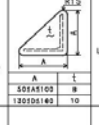
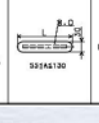
No.	Group Name	Details							Dep.	SCF
		형상	Size	방향	위치	Loading	Welding	선종		
5	Machinery (Hose Handling Crane)		Ø 2035		Deck Outside			LNG COT		Max. 3.3
6	Machinery (Water Brake)			Longitudinal	Deck Outside		Fillet	COT		Max. 2.2

1. Simplified Fatigue Guideline for Deck Attachments and Openings

B. Verification Object

Grouping Ex.) Simplified Fatigue Strength Evaluation iwo Hole & Outfittings on Strucutral Strength Members

Vessel :

No.	Group Name	Details							Dep.	SCF
		형상	Size	방향	위치	Loading	Welding	선종		
	SUPPORT				I.W.O O.L	HEAVY LOAD"G	FILLET	TANKER	선장 배관	Max. 2.2
	SUPPORT				ALL	HEAVY LOAD"G (IF PIPE SUP"T) LIGHT LOAD"G (OTHERS)	FILLET	ALL	선장 철의 선장 배관	Max. 2.2
	SUPPORT			LONGI & TRANS	ALL	LIGHT LOAD"G	FILLET	ALL	선장 철의	Max. 2.2
	SUPPORT			LONGI & TRANS	ALL	LIGHT LOAD"G	FILLET	ALL	선장 철의	Max. 2.2

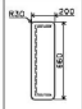
1. Simplified Fatigue Guideline for Deck Attachments and Openings

B. Verification Object

Grouping Ex.)

Simplified Fatigue Strength Evaluation iwo Hole & Outfittings on Strucutral Strength Members

Vessel :

No.	Group Name	Details							Dep.	SCF
		형상	Size	방향	위치	Loading	Welding	선종		
	SUPPORT (ACC.LAD.)			LONGI & TRANS	SHIP SIDE (1-W.O SHEER STRAKE)	LIGHT LOAD*G	FILLET	ALL	선장 협의	Max. 2.2
	SUPPORT (STANCHION)				ALL	NO LOAD*G	FILLET	ALL	선장 협의	Max. 2.4
	SUPPORT (STANCHION)			LONGI & TRANS	ALL	NO LOAD*G	FILLET	ALL	선장 협의	Max. 1.8
	MAST				I-W.O C-L	NO LOAD*G	FILLET	ALL	선장 협의	Max. 2.2

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1. Simplified Fatigue Guideline for Deck Attachments and Openings

B. Verification Object

Grouping Ex.)

Simplified Fatigue Strength Evaluation iwo Hole & Outfittings on Strucutral Strength Members

Vessel :

No.	Group Name	Details							Dep.	SCF
		형상	Size	방향	위치	Loading	Welding	선종		
1	CUTOUT (Pipe Hole)		~ 100 101 ~ 300 301 ~ 500 501 ~ 1000 1001 ~		All Position		Open Type 	All	선장 협의 가능해역	Max. 3.0
							Ring Type 			Max. 3.3
							Double Pl. 			Max. 3.45 (doubler)
							Coaming 			Max. 3.0 (cut_out)
			365*365*883		T-BDH					
			230*430*860		T-BDH					Max. 3.3 (Welding) Max. 2.8 (cut_out)

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1. Simplified Fatigue Guideline for Deck Attachments and Openings

B. Verification Object

Grouping Ex.) Simplified Fatigue Strength Evaluation two Hole & Outfittings on Strucutral Strength Members

Vessel

No.	Group Name	Details							Dep.	SCF
		형상	Size	방향	위치	Loading	Welding	선종		
2	CUTOUT (Tank Access Hatch)	255 1070	1070*700	PORT FWD	SHEAR STRAKE		Coaming 11t	COT	선장철회	Welded : Max. 3.3 Cut out : Max. 3.0 (2.38)
	CUTOUT (Access Hatch)		800*600*R120 800*650*R135	PORT FWD	SHEAR STRAKE		Coaming 11t	ALL	선장철회	
			650*600*R130 650*600*R100	PORT FWD	SHEAR STRAKE		Double PL 20t	ALL	선장철회	Doublers : Max. 3.45 Cut out : Max. 3.0 (2.38)
	CUTOUT (Rescue & Maint. Hatch)		900*900*R180 1000*800*R160	PORT FWD	Deck Mid.		Coaming 11t	COT	선장철회	
	CUTOUT (Gas Freeing Pass Seat)		D320 D650		Deck Mid.		Double PL 22t	LNG	선장철회	

Notes:

The value in ( ) means SCF of base metal.

Reason : The fatigue life of base metal is about 2 times of welded joints. Therefore SCF of 3.0 can be reduced to 2.38 for base metal.

1. Simplified Fatigue Guideline for Deck Attachments and Openings

C. Fatigue Strength Evaluation

- **Base :** **DnV, Classification Note 30.7**

  (Fatigue Assessment of Ship Structures)

- **Evaluation :** **Group Detail S.C.F / Max. Allowable Stress Range**

- **Application :**

  - On Upper Deck.

  . Object : Outfitting and Hole Details

  . Governing Factor : Hull Girder Dynamic Effect

  . Evaluation : S.C.F & Max. Allowable Stress Range

  → Max. Allowable S.C.F.

1. Simplified Fatigue Guideline for Deck Attachments and Openings

C. Fatigue Strength Evaluation

• Flow Chart

-for the concerned position/details;
. SCF and S.M
. B.Mt(Vert. & Hori.) for full &ballast condition
. Principal Dim. Etc.

→ **Max. Dyn. Stress Calculation by wave.**

To be considered the operation route (f_e = 1.0 for N.A, 0.8 for W/W)

$\Delta\sigma_0 = f_m \Delta\sigma$

$\Delta\sigma = f_e \Delta\sigma_g$

$\Delta\sigma_g = \sqrt{\Delta\sigma_v^2 + \Delta\sigma_{hg}^2 + 2\rho_{vh}\Delta\sigma_v\Delta\sigma_{hg}}$

Calculation of the Dyn. Stress Range
(for Full Load/Ballast Condition)

Alt. I

Calculation of Max. Allowable Stress Range
- Table 2.7&2.8 of CN 30.7
- Using Weibull Shape Parameter, $h = 2.21 - 0.54\log_{10}(L)$

Evaluate the Fatigue Strength
- Comparison with Max. allowable stress and calculated dyn. stress range of full load or (full + ballast)/2 or (0.45*full + 0.4 ballast for Tanker)

Alt. II

Evaluate the fatigue damages to full and ballast condition.
Using the below equation :

$$D = \frac{\nu_0 T_d}{a}\sum_{n=1}^{N_{load}} P_n Q_n^m \Gamma(1+\frac{m}{h_n}) \le \eta$$

Evaluate the fatigue life.

Modify/Confirm the structural end detail for the required fatigue strength

1. Simplified Fatigue Guideline for Deck Attachments and Openings

C. Fatigue Strength Evaluation

• Calculation Sheet.(Ex.)

Simplified Fatigue Evaluation Sheet iwo Hole & Outfitting on Deck (for Aframax Tanker)

2004-09-30

Ship characteristics

Length:	234.78	[m]
Breadth:	43.00	[m]
T-loaded:	14.30	[m]
T-ballast:	7.00	[m]
Depth:	21.00	[m]
Block:	0.831	[-] Full
	0.771	[-] Ballast
Weibull(h_0):	0.930	[-]

Wave bending moments(at 10^{-4} P.L.)

Hogging:	1.82E+06	[kNm]	Full
Sagging:	-1.94E+06	[kNm]	Full
Hogging:	1.68E+06	[kNm]	Ballast
Sagging:	-1.86E+06	[kNm]	Ballast
Horizont:	1.66E+04	[kNm]	Full
Horizont:	1.13E+04	[kNm]	Ballast

$W_{D(ACT.)}$: 32.38 [m^3]
$I_{y(ACT.)}$: 1185.34 [m^3]

Reduction factor.

f_e :	0.8	[-]
f_m :	1.0	Ballast
	0.7	Full
a		
b		

Parameters

C_w :	10.22	[-]	
k_{wm} :	1.00	[-]	at m/s
f_f :	0.475	[-]	
x :	119	m	(at m/s)
K :	2.65	[-]	
y :	21.5	m	

Max.A.Stress Range :

(for W.J. Air/Ca.)	232.2	Mpa	(Level 1)	$\triangle\sigma_v$:	306.48	Mpa	Full
(for W.J. Cor.)	176.6	Mpa	(Level 2)		289.57	Mpa	Ballast
(for B.M. Air/Ca.)	278.7	Mpa	(Level 3)	$\triangle\sigma_{hg}$:	1.60	Mpa	Full
(for B.M. Cor.)	212.3	Mpa	(Level 4)		1.08	Mpa	Ballast
				$\triangle\sigma_g$:	306.65	Mpa	Full
					289.69	Mpa	Ballast
				$\triangle\sigma$:	254.52	Mpa	Full
					240.44	Mpa	Ballast
				$\triangle\sigma_{0L}$:	178.16	Mpa	Full
					240.44	Mpa	Ballast
				$\triangle\sigma_0$:	176.35	Mpa	

Results : O.K for all details

For all details iwo hole & outfitting on deck structure,

the environment to the corrosion protection can be applied only for air/cathodic, so in this calculaiton sheet do not need to consider Level 2 & 4 details.

Max. SCF to the details iwo Hole & Outfitting on deck (refer to the attached sheets for the hole and outfitting details);
- 3.3 for welded joints except 2 cases which are needed to evaluate using more comprehensive tool.
- 3.3 (2.8 for row material) for cut out with coaming.
  3.45 for doubler iwo cut-out.

Conclusion :
Considering the above actual SCF's, the calcuated Max. allowable SCF of 3.61 is higher than those of the actual. Therefore it can be considered that this vessel has a sufficient fatigue strength for design fatigue life of 20 years.

D. Application(1)

D.1 Applied Vessels

- 300K VLCC
- 105K Aframax Tanker
- 140K LNG Carrier.

D.2 Applied sea area and fatigue life

- Sea area : World-Wide & North Atlantic
- Standard fatigue life : 20, 30 & 40 Yrs.

D.3 Application Standard

- Acc. to Environment : 4 Levels
  ; Weld Joint(Corrosive/Non-Corrosive),
  Base Material(Corrosive/Non-Corrosive).
- Standard of fatigue life estimation : Max. Allowable S.C.F.

D. Calculation Example

Vessel Type	Env.		World-Wide			North Atlantic			Remarks
			20 yrs	30 yrs	40 yrs	20 yrs	30 yrs	40 yrs	
LNGC (140K)	Weld Joint, Non-Corr.	Level 1	5.42	4.73	4.30	4.33	3.78	3.44	
	Weld Joint, Corr.	Level 2	4.13	3.61	3.28	3.34	2.92	2.65	
	Base Metal, Non-Corr.	Level 3	6.50	5.68	5.16	5.20	4.54	4.13	
	Base Metal, Corr.	Level 4	4.97	4.34	3.94	3.97	3.47	3.15	
Aframax Tanker	Weld Joint, Non-Corr.	Level 1	3.61	3.15	2.87	2.89	2.52	2.29	
	Weld Joint, Corr.	Level 2	2.65	2.31	2.10	2.20	1.92	1.75	
	Base Metal, Non-Corr.	Level 3	4.33	3.78	3.44	3.46	3.02	2.75	
	Base Metal, Corr.	Level 4	3.30	2.88	2.62	2.64	2.31	2.10	
VLCC (320K)	Weld Joint, Non-Corr.	Level 1	3.31	2.89	2.63	2.65	2.31	2.10	
	Weld Joint, Corr.	Level 2	2.53	2.21	2.01	2.03	1.77	1.61	
	Base Metal, Non-Corr.	Level 3	3.97	3.47	3.15	3.18	2.78	2.52	
	Base Metal, Corr.	Level 4	3.05	2.66	2.42	2.44	2.13	1.94	

2. Ladder End Connection

A. Background :

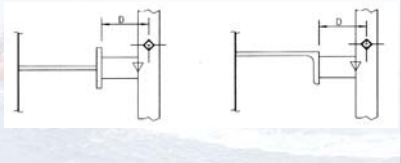
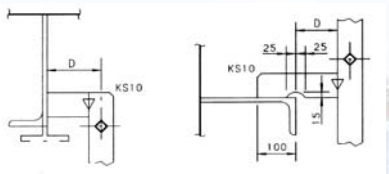
. Raised many arguments between surveyors and designers in the construction stages.

. Considered ladder support as the fatigue sensitive area

B. Object : End Connections of Ladder

C. Location : Ballast Tank

D. Detail of V/L End Connection;

To face plate	To web plate
	

2. Ladder End Connection

E. Evaluation :

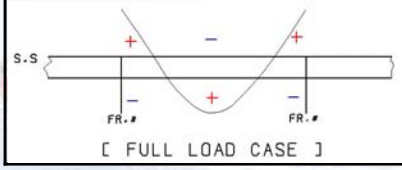
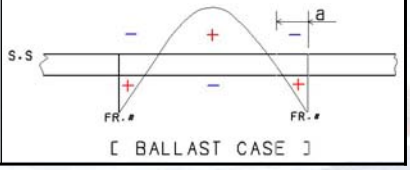
. Assumption : Longi. Top Stiffener is satisfied with the Design Fatigue Life.

. Based on Fatigue Life/S.C.F. of Top Stiffener.

- Considering the size / direction of Longi. Stiffener Span,Bending Stress.

- Selection of applicable area(range) Instead of Allowable Value.

. Evaluation Standard : Bending Stress at the span of Longi. Stiffener

Full Load	Ballast
	
[FULL LOAD CASE]	[BALLAST CASE]

2. Ladder End Connection in Ballast Tank

F. Conclusion for Application :

Location	End Connection Type	
	To Face Plate	To Web Plate
Full Load governing area (S.S., draft line 2*Z_{wl} area)	a > 0.1/	0 < a < /
Other Space (Ballast Load, governing factor)	a > 0.2/	0 < a < /

3. Pad of the Outfitting Supports

A. Background:

. To set up the yard's practice for the application of outfitting support in case of with/without Pad.

. Need to provide the application standard (yard's practice) of the doubling pad considered the installed location and position and the scantling of the deck, stringer & web plate (i.e, plate thickness)

. Comparing with the other company's practice as shown in the table below, yard's scantling is very conservative

Company	C/H, Main Member	E/R & A/B Etc.	Remark
A 社	16.0	10.0	C/H Main Member ; . Main Tight Bhd . Hull Tank Bhd . Upp. Deck (Weather Part)
B 社	16.0	11.0	
C 社	16.0	16.0	
DSME	No standard for the application considering the plate thickness		

3. Pad of the Outfitting Supports

B. Evaluation Procedure:

. Considering the force and role of the outfitting support,

1. Yield Strength Evaluation (Based on Rule Scantling)
   - Assume: the concentrated force on the support to apply for the deck plate scantling
   - Rule : DnV Pt.6 Ch.1 Sec.2

$$t = k \times (1+s) \times (P_w)^{0.5} / (f_1)^{0.5} + 2.0 \ (\text{mm})$$

2. Fatigue Strength Evaluation (Based on Simplified Method)
   - Need to evaluate the fatigue strength at the hot points of the support attached on the deck
   - Base : DnV Classification Notes 30.7

3. Pad of the Outfitting Supports

C. Classification Societies' Opinion:

1. Class. Rule Requirement :
   - No rule requirements for the concerned area confirmed by ABS, BV, DnV, GL & LR
   - Also, confirmed DSME's Proposal to evaluate the structural strength is reasonable.
   - But, only GL Class informed that for double plate two requirements to be considered as follows:
     1. Not applicable with double plate in case of raising tension force at the supports.
     2. for fatigue strength, need to satisfy the requirement of GL Rule Sec. 20. Table 20.3.I(refer to the next slide).
        → which is similar concept with DnV method.

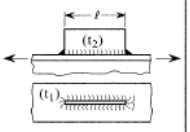
→ It can be concluded that DSME's proposal to evaluate the structural strength is reasonable considering the above mentioned.

3. Pad of the Outfitting Supports

2. Reference : GL Recommendation for Fatigue Strength Evaluation

Table 20.3 Catalogue of details *(continued)*

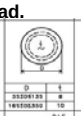
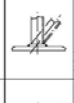
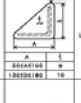
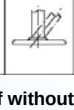
C. Non-load-carrying attachments

Type No.	Joint configuration showing mode of fatigue cracking and stress σ considered	Description of joint	Detail category $\Delta\sigma_R$ Steel	Al
C1		Longitudinal gusset welded on beam flange, bulb or plate:		
		$\ell \leq 50$ mm	80	28
		50 mm $< \ell \leq$ 150 mm	71	25
		150 mm $< \ell \leq$ 300 mm	63	20
		$\ell >$ 300 mm	56	18
		For $t_2 \leq 0{,}5\ t_1$, $\Delta\sigma_R$ may be increased by one category, but not over 80 (steel) or 28 (Al); not valid for bulb profiles.		
		When welding close to edges of plates or profiles (distance less than 10 mm) and/or the structural element is subjected to bending, $\Delta\sigma_R$ is to be decreased by one category.		

3. Pad of the Outfitting Supports

D. SCF with/without Outfitting Support Pad:

- in Case of with Pad.

SUPPORT				ALL	HEAVY LOAD*G (IF PIPE SUP'T) LIGHT LOAD*G (OTHERS)	FILLET	ALL	선장 참의 선장 방급	Max. 2.2
SUPPORT			LONGI & TRANS	ALL	LIGHT LOAD*G	FILLET	ALL	선장 참의	Max. 2.2
SUPPORT			LONGI & TRANS	ALL	LIGHT LOAD*G	FILLET	ALL	선장 참의	Max. 2.2

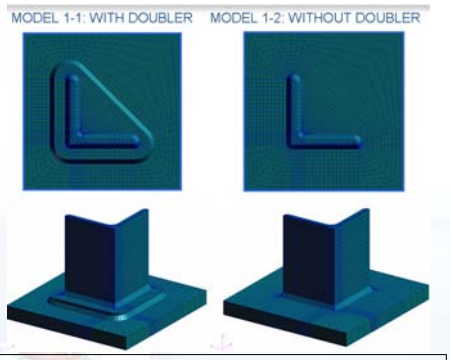
- in case of without Pad.

SUPPORT (STANCHION)		25A PIPE		ALL	NO LOAD*G	FILLET	ALL	선장 참의	Max. 2.4
SUPPORT (STANCHION)		65X16F.B	LONGI & TRANS	ALL	NO LOAD*G	FILLET	ALL	선장 참의	Max. 1.8

3. Pad of the Outfitting Supports

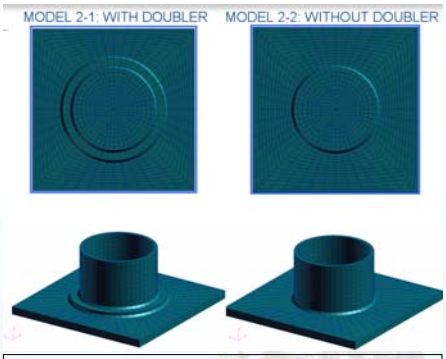
E. Evaluated SCFs through FE Analysis

- For Angle Support



- SCF : 1.35 1.37

- For Pipe Support



- SCF : 1.29 1.08

* Pad (double plate) could not give a positive effect in view point of fatigue strength

3. Pad of the Outfitting Supports

F. Evaluation: (for VLCC)

1. For Yielding Strength (Based on Rule Scantling)

- Support가 설치되는 Deck 상에서 집중하중 작용하는 것으로 고려하여 평가
- 적용 Rule : DnV Pt.6 Ch.1 Sec.2

*** Evaluation Results :**

(Strength Check at the Supports on the Upper Deck in C/H Area)

(for VLCC)

for Yielding Strenght Cal. of Plate

$t = k * (1+s) * (Pw)^{0.5} / (f_1)^{0.5} + 2$ (mm) [Pt. 6, Ch.1, Sec.2, C200]

k = 0.7 in longitudinal framed strength deck and in weather deck hatch cover

s = beam spacing (m)

Pw = fraction of total landing force P acting on the wheel(s) considered (kN)

= 여기서는 support에 걸리는 최대하중(KN)

f_1 = material factor, =1.0 for NV-NS steel, =1.28 for NV-32 steel, =1.39 for NV-36 steel

a). Plate thick requirement

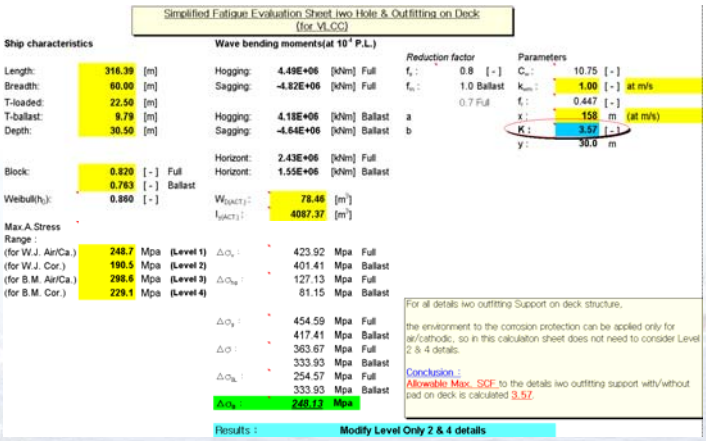
Location	k	s(m)	Pw (kN/)	f_1 (AH32)	t_{req}	t_{act}	Remarks
Upper Deck	0.7	0.95	40.0	1.28	9.63 AH	18.0 "AH" 20.0 "AH"	OK

3. Pad of the Outfitting Supports

2. Fatigue Strength Evaluation (Based on Simplified Method)

- Need to evaluate the fatigue strength at the hot points of the support attached on the deck.
- Based on DnV Classification Notes 30.7

*** Evaluation Result ;**



3. Pad of the Outfitting Supports

G. Evaluation Results ;

According to the strength evaluation results,

. For yield strength evaluation

- **With the concentrated force to the outfitting supports, the considered deck plate scanting (Req. 9.5 mm AH vs. Act. 18.0 mm AH) is sufficient comparing with the requirement**

. For the fatigue strength evaluation,

1. **Due to the double pad, SCF of the detail can be increased**

   → It can lead a disadvantage to the fatigue strength

2. **As a calculated result with simplified method, to avoid fatigue problem max. allowable SCF is 3.57. but the actual SCF (Max. 2.2 ~ 2.4) of the concerned details is much less than the allowable.**

   → Much fatigue strength margin, about 4 times (80 years) of the design fatigue life of 20 years.

H. Conclusion :

. In view point of structural strength for yielding and fatigue, the double plate is not necessary to be attached on the deck plate.

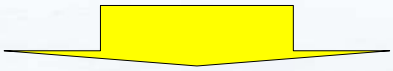
. If necessary, determine the minimum plate thickness for outfitting support installed without pad as a yard's practice.

→ As Min., 16.0 mm or 15.0 mm (based on the evaluation results, it's reasonable)

4. Simplified Docking Strength Evaluation Method

A. Needs & Background

- To avoid the docking block arrangement based on the experiences according to vessel types.
- To avoid difficulties to make whole ship FE model, whenever required the docking analysis.
- To provide flexibility of the docking block arrangement due to the change of the construction method & the bigger assembly block
- To correspond the increasing Owner's requests to verify the structural strength for the dry docking and the re-docking in case of the repairing.
- To reduce the engineering time for the docking strength evaluation with sufficient accuracy



- Developed the Simplified Docking Strength Evaluation Tool to utilize at the basic/detail design stage.

4. Simplified Docking Strength Evaluation Method

- **Purpose :**
  To develop the program for the simplified docking strength analysis / evaluation system based on the beam theory

- **Reduce the time for the docking strength evaluation:**
  . using the fixed format of Input data
  . the automatic data generation for the report.
- **to verify the adequacy of the method through comparison with 3D F.E. Analyses Results and 2D Beam Evaluation**

4. Simplified Docking Strength Evaluation Method

B. Assumption for Docking Strength Evaluation

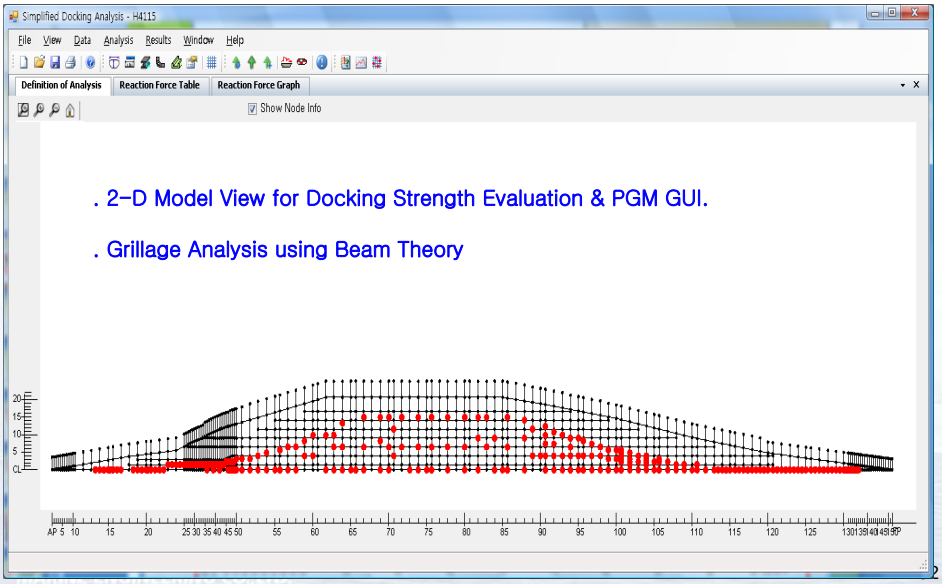
- Light Weight & Partial Loading Condition
- Dry Docking Condition
- Docking Block : Assume as Spring Element
  - . Spring Constant : 14218.8 Ton/m (Acc. To LR Rule)
  - . Wooden Block, Section Area : 0.455 m^2

C. Considered Vessel Type: (Total : 7 Vessels)

- Container Ship : 4400 TEU, 8400 TEU
- LNG Carrier : 140K, 160K & 210K
- Tanker : Aframax
- PCTC : 8000 Unit.

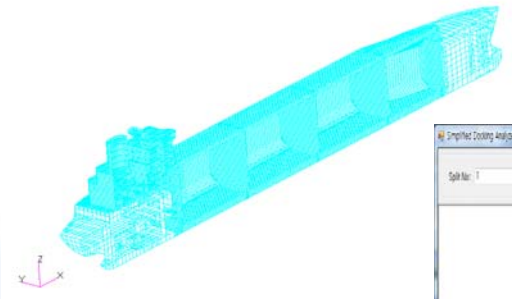
4. Simplified Docking Strength Evaluation Method

D. Program:

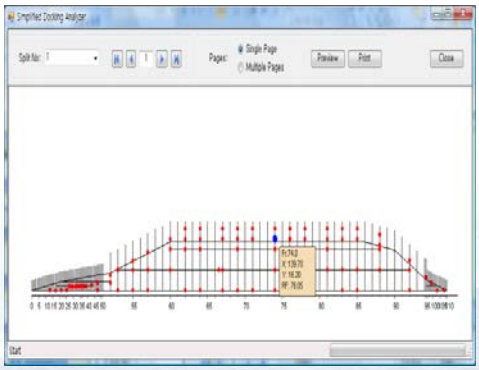


4. Simplified Docking Strength Evaluation Method

E. Verification through 3D & 2D Analysis



3D Whole Ship FE Model



2D Simplified Grillage Model

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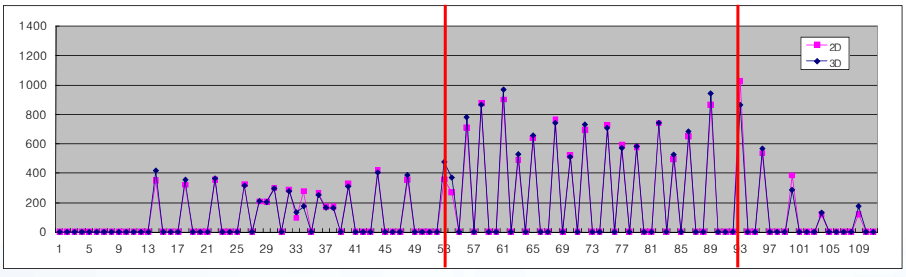
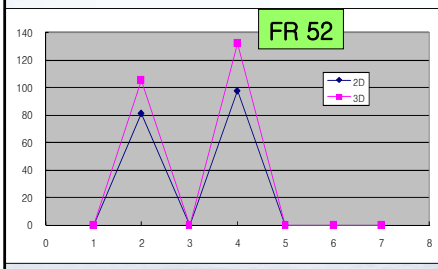
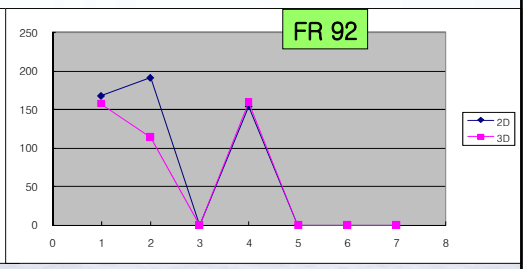
4. Simplified Docking Strength Evaluation Method

F. Comparison

For AFRAMAX Tanker

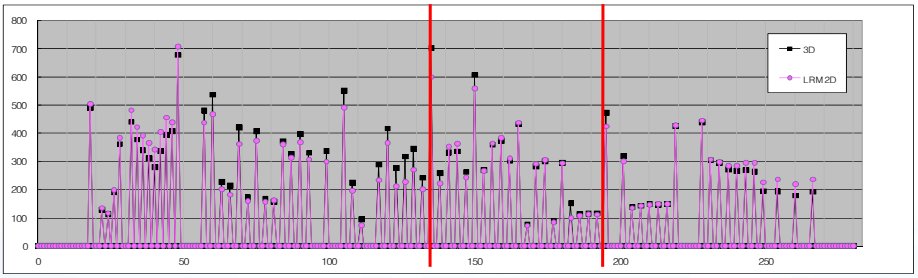


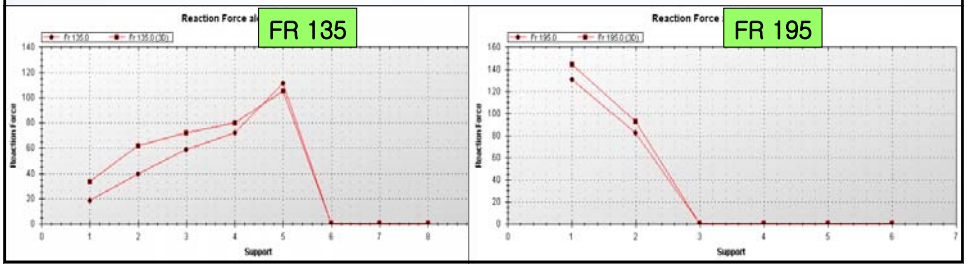




4. Simplified Docking Strength Evaluation Method

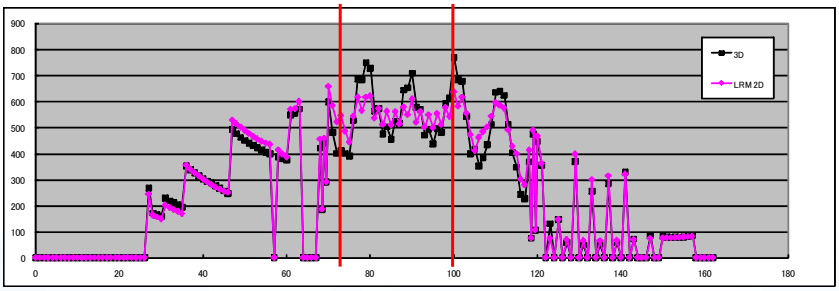
For PCTC

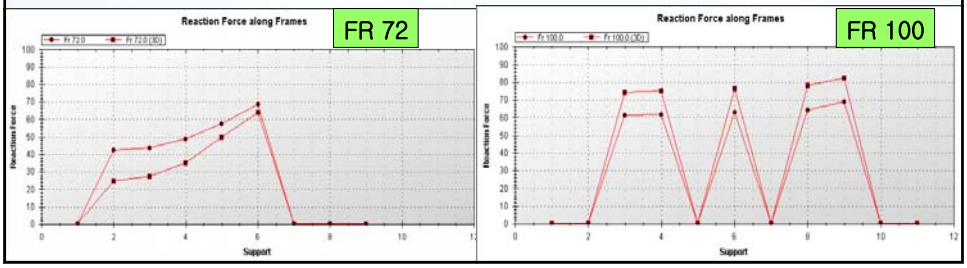




4. Simplified Docking Strength Evaluation Method

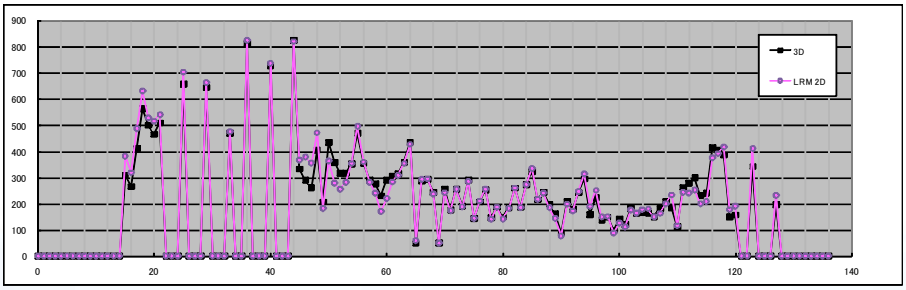
For LNG Carrier

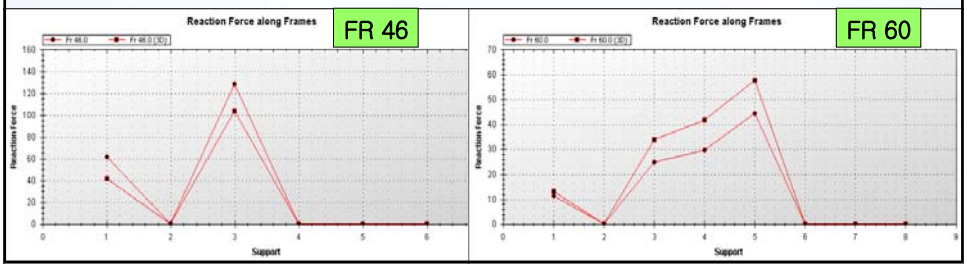




4. Simplified Docking Strength Evaluation Method

For Containership





5. Conclusion

Through this presentation, 4 technical items developed for practical detail structural design have been introduced based on the simplified methods as follows.

1. **Simplified Fatigue Guideline for Deck Attachments and Openings**
2. **Ladder End Connection in Ballast Tank**
3. **Pad of the Outfitting Supports on Deck**
4. **Simplified Docking Strength Evaluation Method**

Using the above useful design tools, many advantages can be gained;

1. **Reduce engineering/design time lose**
2. **Easy finding of the strength weak points**

→ **Provide sufficient strength margin for yielding, buckling and fatigue and so on.**

3. **Accomplished the sound structural arrangement using the developed tools**

→ **for easy maintenance.**

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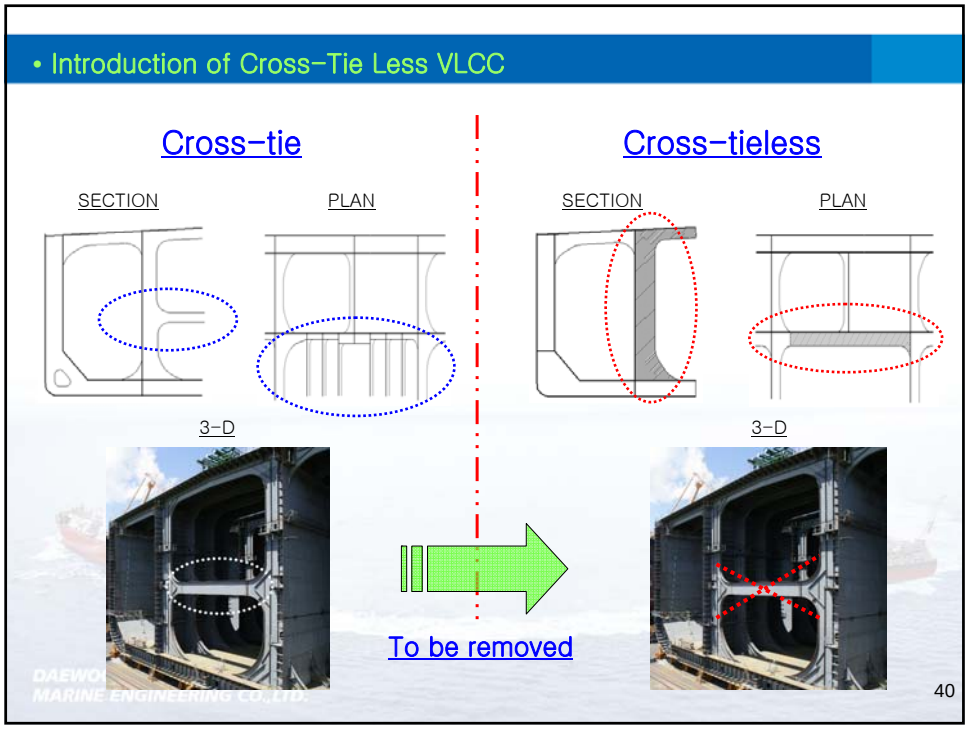
Thank you…


• Introduction of Cross-Tie Less VLCC
Cross-tie
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3-D
To be removed
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