ANALISA PERBANDINGAN *FATIGUE* ANTARA *HULL-V* DAN *HULL-U* AKIBAT BEBAN *SLAMMING* DENGAN METODE ELEMEN HINGGA

MUHAMMAD LUQMAN HAKIM

4111100078

Dosen pembimbing :

TOTOK YULIANTO, S.T., M.T.

JURUSAN TEKNIK PERKAPALAN

FAKULTAS TEKNOLOGI KELAUTAN

INSTITUT TEKNOLOGI SEPULUH NOPEMBER

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Latar Belakang

Variasi bentuk lambung → mempengaruhi →

- Perancangan
- Hidrodinamika
- Struktur
- Produksi.

Lambung → olah gerak kapal di laut → slamming → beban *impact* dinamis

Bentuk lambung → bentuk konstruksi → kekuatan → tegangan

Beban dinamis → tegangan → fatigue

Variasi bentuk lambung → perbedaan slamming → perbedaan tegangan → perbedaan fatigue

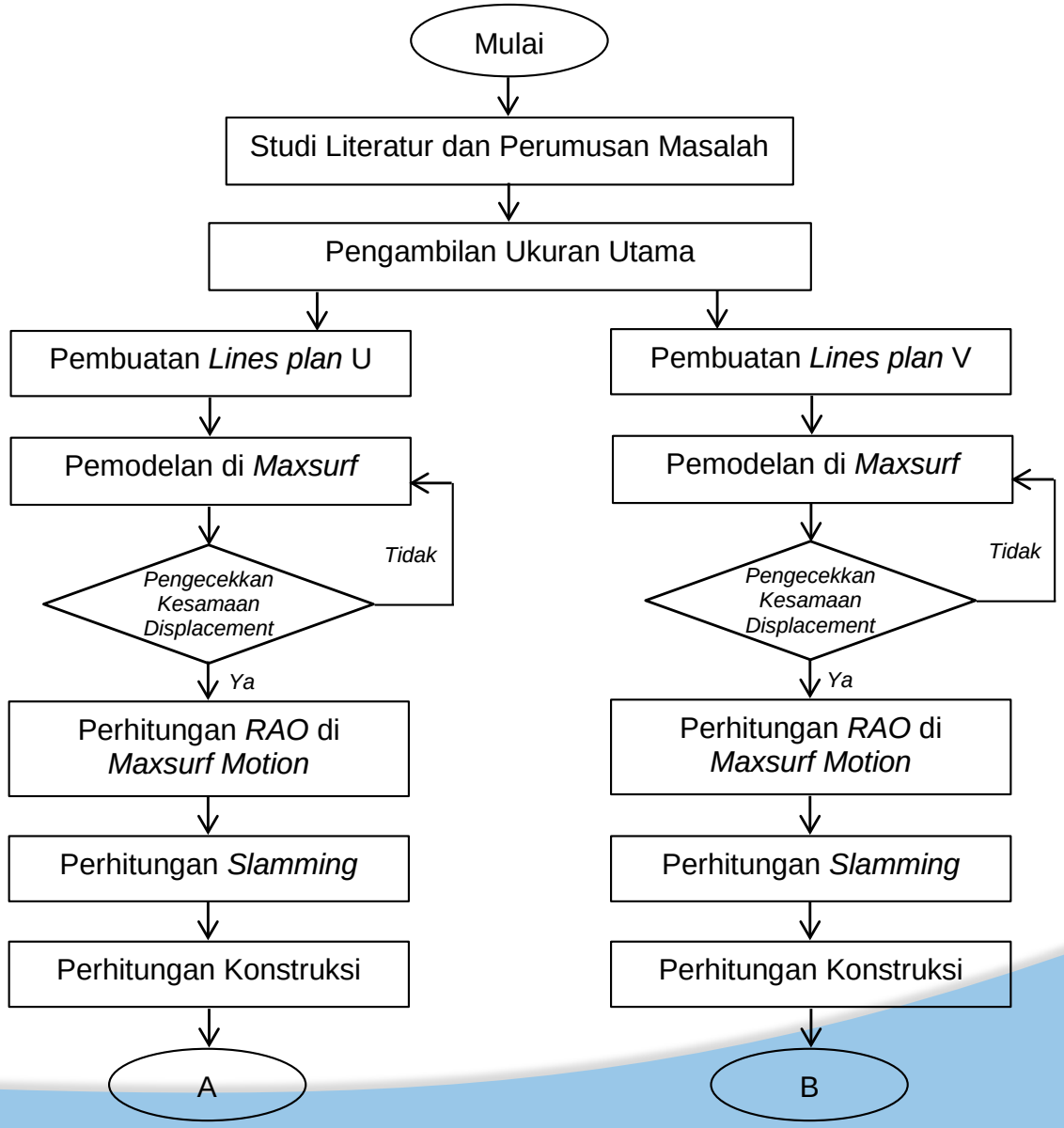
Tujuan

1. Untuk mengetahui perbedaan peluang, jumlah dan tekanan *slamming* antara lambung kapal berbentuk V dan lambung kapal berbentuk U.

2. Untuk mengetahui perbedaan tegangan struktur akibat beban *slamming* antara lambung kapal berbentuk V dan lambung kapal berbentuk U.

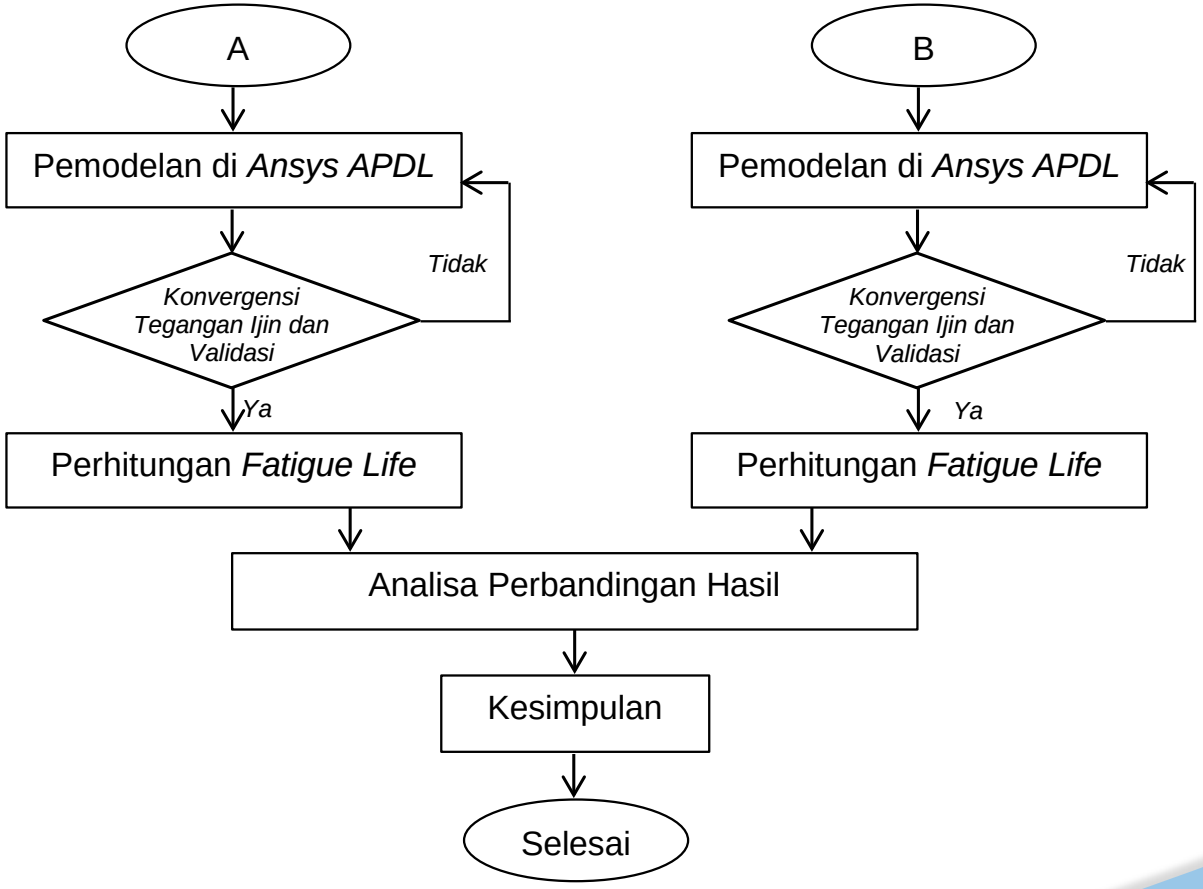
3. Untuk mengetahui perbedaan *fatigue life* akibat beban *slamming* antara lambung kapal berbentuk V dan lambung kapal berbentuk U.

METODOLOGI PENELITIAN



METODOLOGI PENELITIAN

lanjutan...

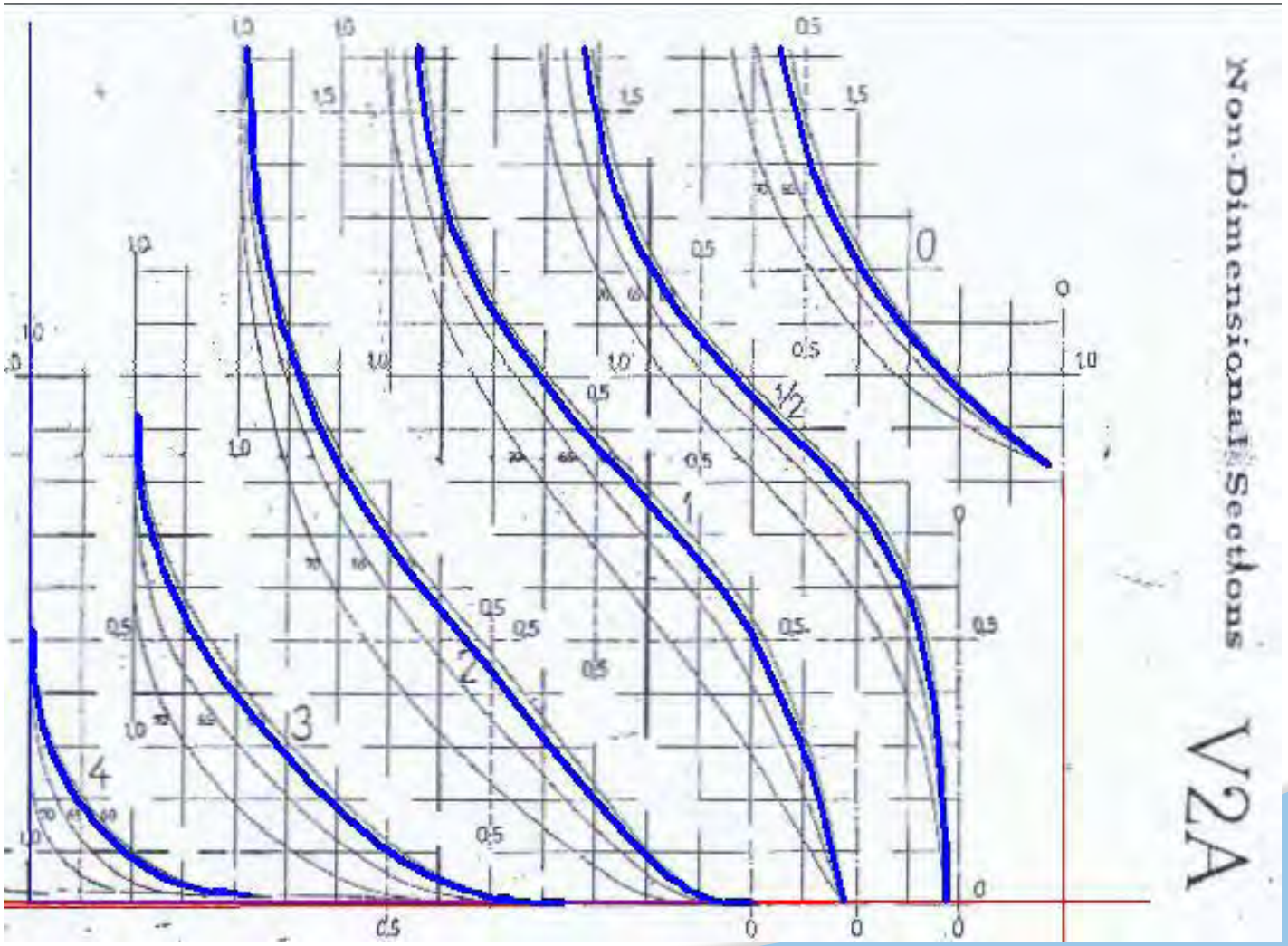


Pengambilan Ukuran Utama Kapal

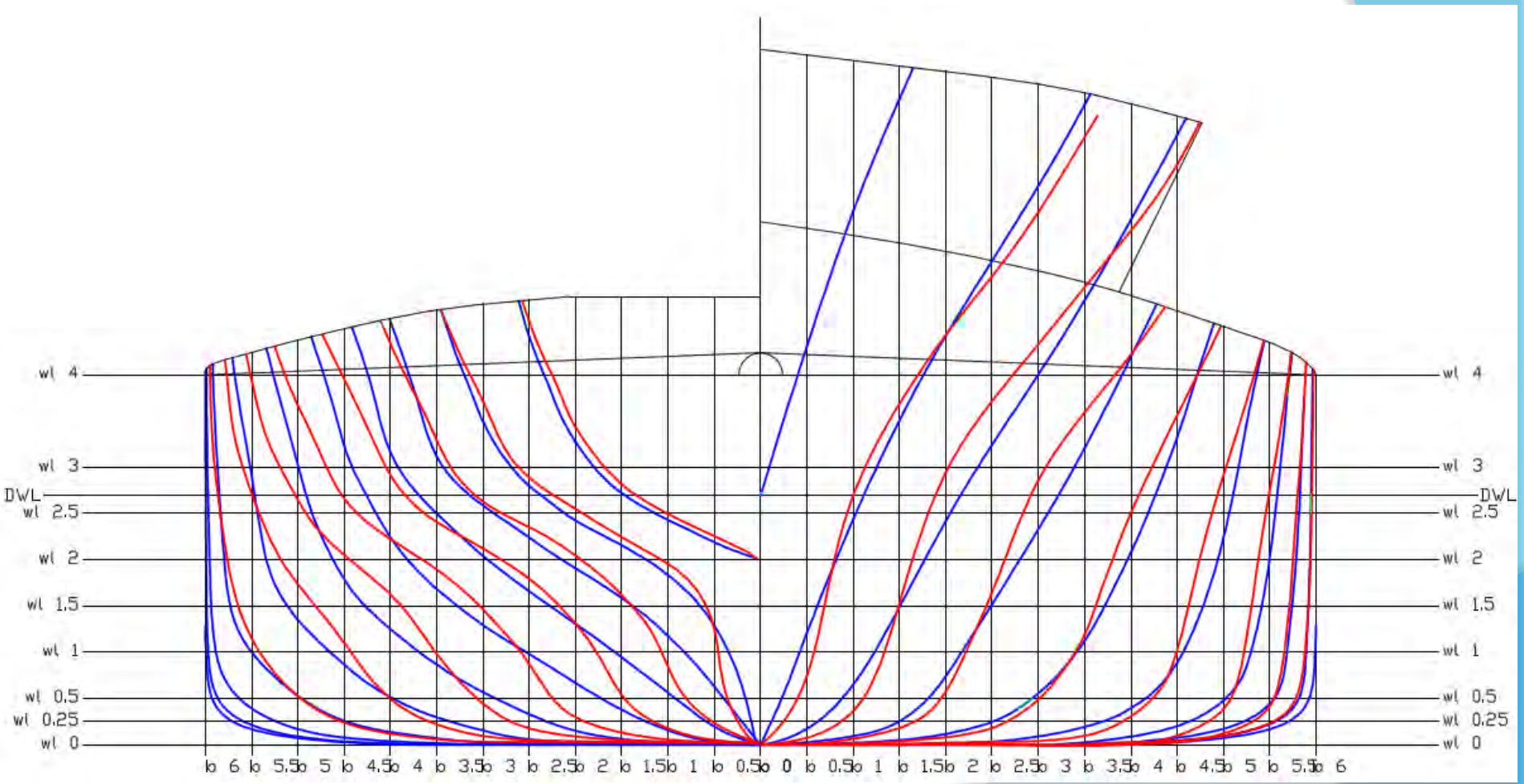
KM. Sabuk Nusantara 41

LPP	59	meter
B	12	meter
H	4	meter
T	2.7	meter
Kecepatan	12	*knots*
CB	0.6	

Pembuatan Body Plan Lambung U dan V

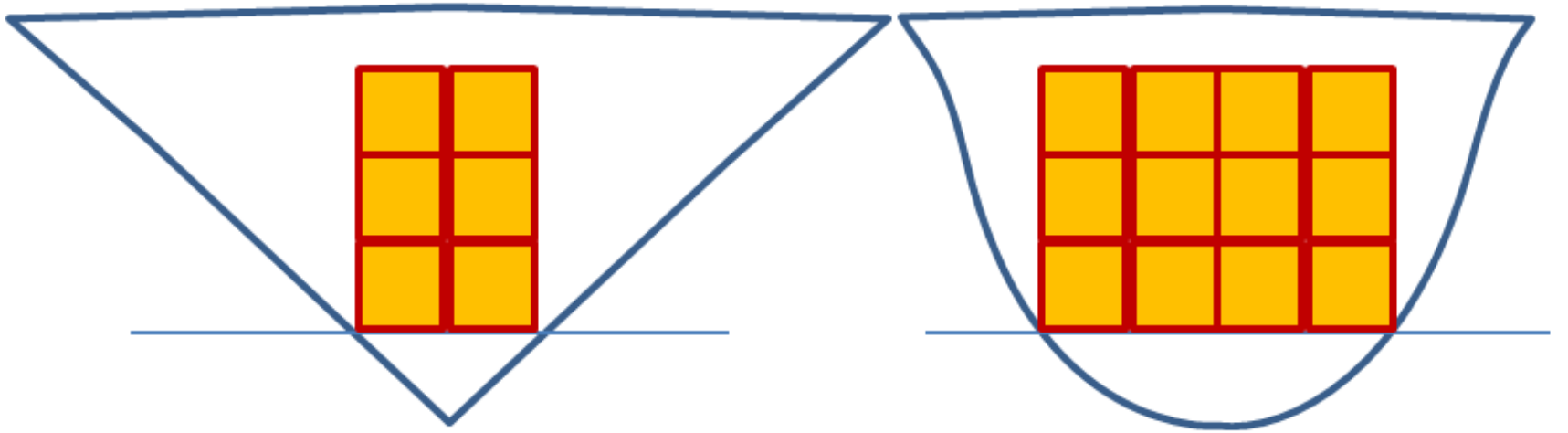


Perbandingan Lines Plan U dan V

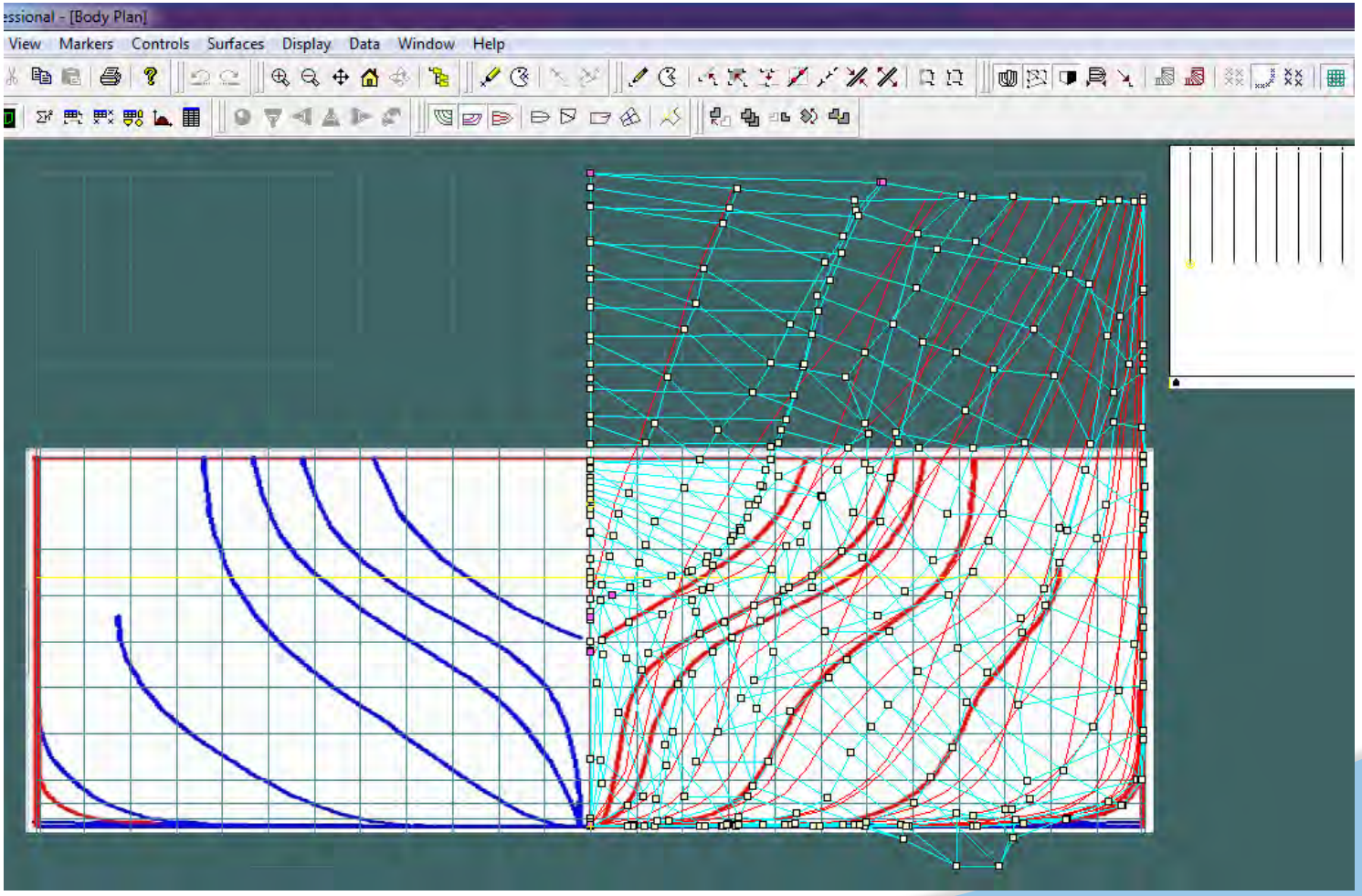


Perbandingan Lines Plan U dan V

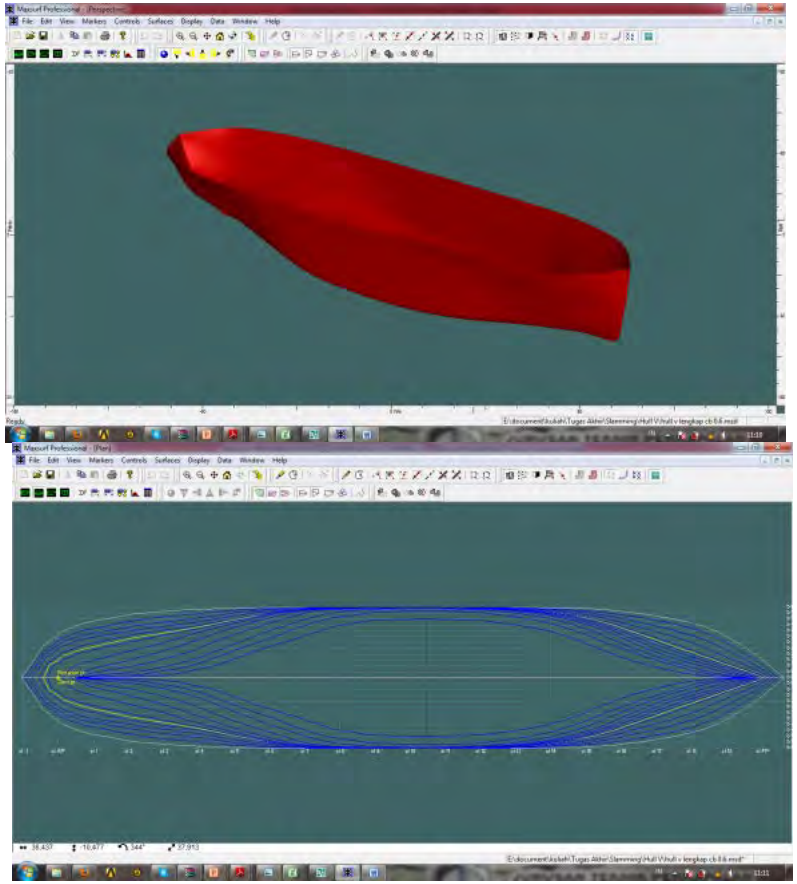
lanjutan...



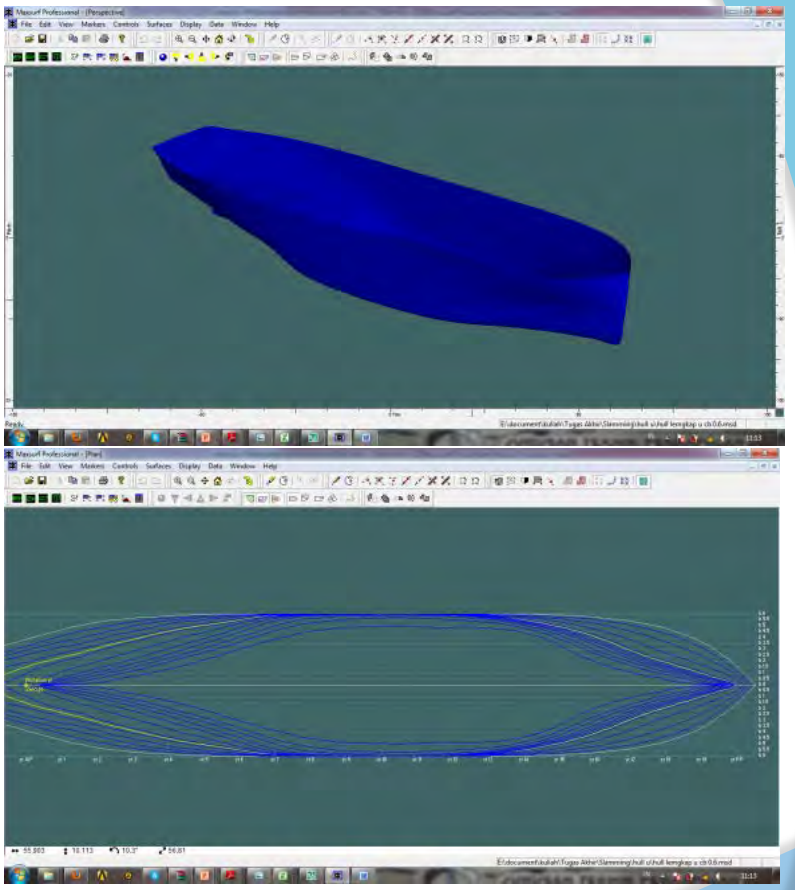
Pembuatan *Lines Plan* dan Model di *Maxsurf*



Perbandingan Hidrostatik Lambung U dan V



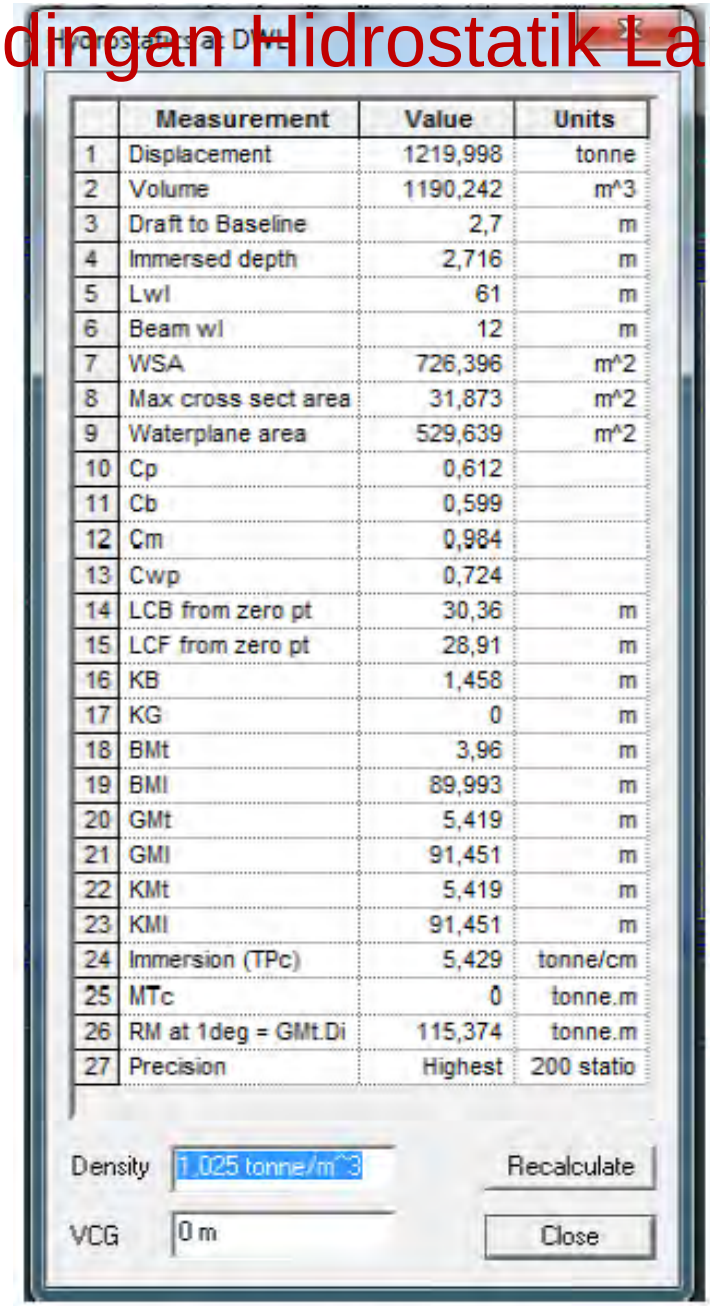
Hull-V



Hull-U

Perbandingan Hidrostatik Lambung U dan V

lanjutan...

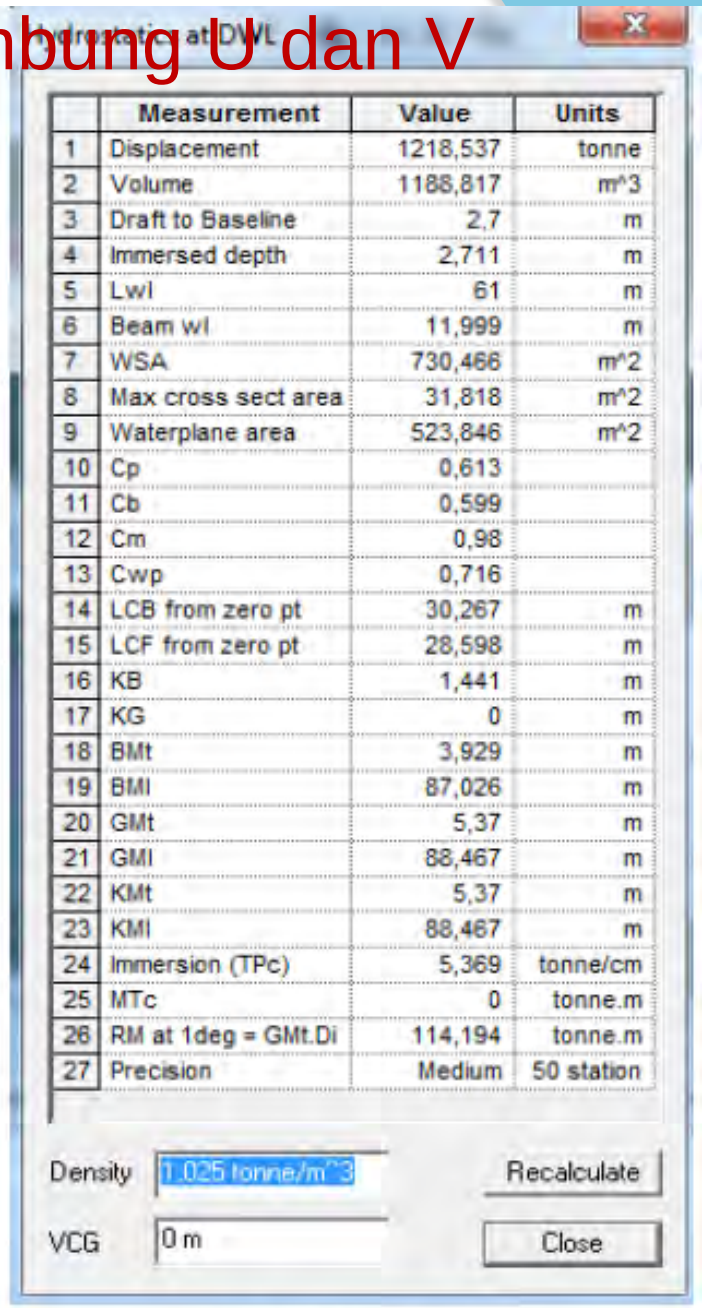


	Measurement	Value	Units
1	Displacement	1219,998	tonne
2	Volume	1190,242	m^3
3	Draft to Baseline	2,7	m
4	Immersed depth	2,716	m
5	Lwl	61	m
6	Beam wl	12	m
7	WSA	726,396	m^2
8	Max cross sect area	31,873	m^2
9	Waterplane area	529,639	m^2
10	Cp	0,612	
11	Cb	0,599	
12	Cm	0,984	
13	Cwp	0,724	
14	LCB from zero pt	30,36	m
15	LCF from zero pt	28,91	m
16	KB	1,458	m
17	KG	0	m
18	BMt	3,96	m
19	BMl	89,993	m
20	GMt	5,419	m
21	GMl	91,451	m
22	KMt	5,419	m
23	KMl	91,451	m
24	Immersion (TPc)	5,429	tonne/cm
25	MTc	0	tonne.m
26	RM at 1deg = GMt.Di	115,374	tonne.m
27	Precision	Highest	200 statio

Density 1,025 tonne/m^3 Recalculate

VCG 0 m Close

Hidrostatik V



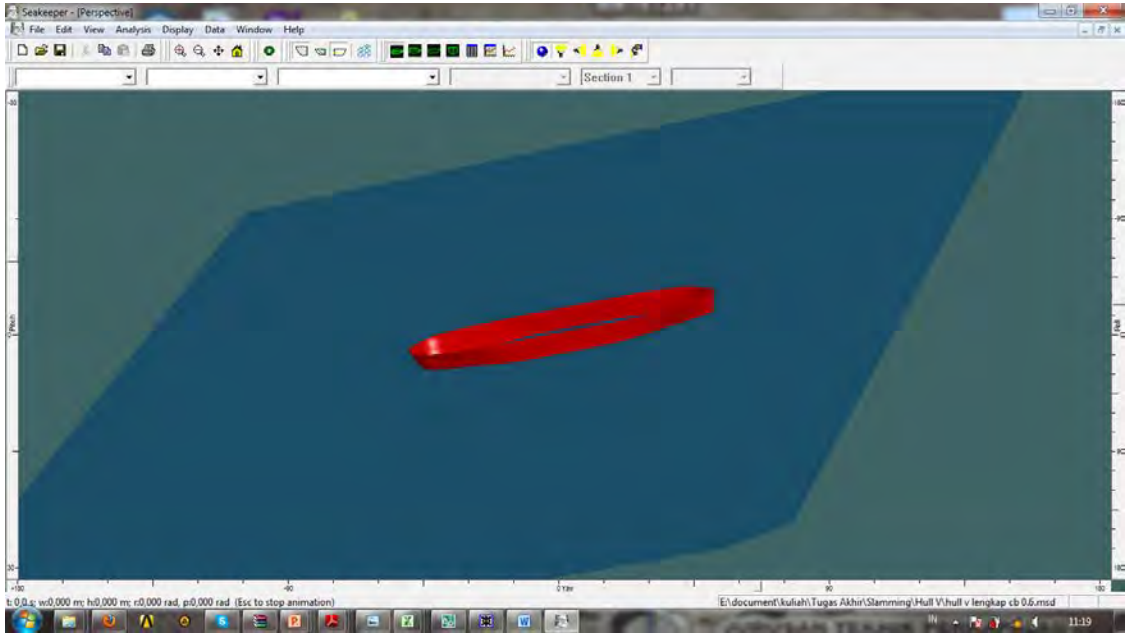
	Measurement	Value	Units
1	Displacement	1218,537	tonne
2	Volume	1188,817	m^3
3	Draft to Baseline	2,7	m
4	Immersed depth	2,711	m
5	Lwl	61	m
6	Beam wl	11,999	m
7	WSA	730,466	m^2
8	Max cross sect area	31,818	m^2
9	Waterplane area	523,846	m^2
10	Cp	0,613	
11	Cb	0,599	
12	Cm	0,98	
13	Cwp	0,716	
14	LCB from zero pt	30,267	m
15	LCF from zero pt	28,598	m
16	KB	1,441	m
17	KG	0	m
18	BMt	3,929	m
19	BMl	87,026	m
20	GMt	5,37	m
21	GMl	88,467	m
22	KMt	5,37	m
23	KMl	88,467	m
24	Immersion (TPc)	5,369	tonne/cm
25	MTc	0	tonne.m
26	RM at 1deg = GMt.Di	114,194	tonne.m
27	Precision	Medium	50 station

Density 1,025 tonne/m^3 Recalculate

VCG 0 m Close

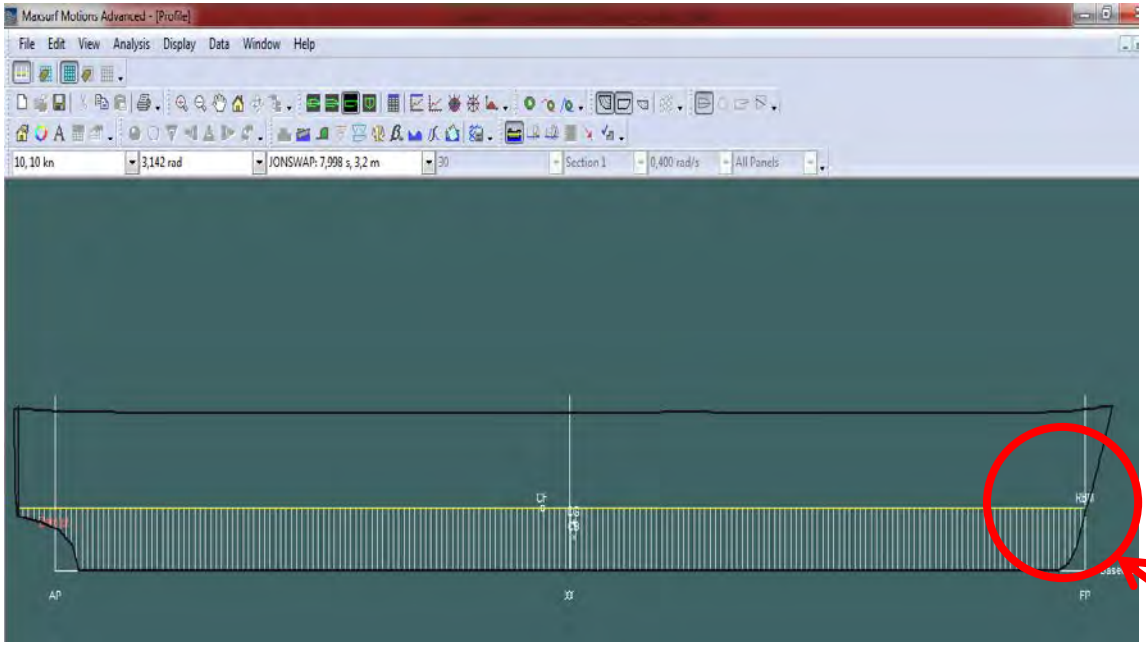
Hidrostatik U

Perhitungan *RAO* dengan *Maxsurf Motions*



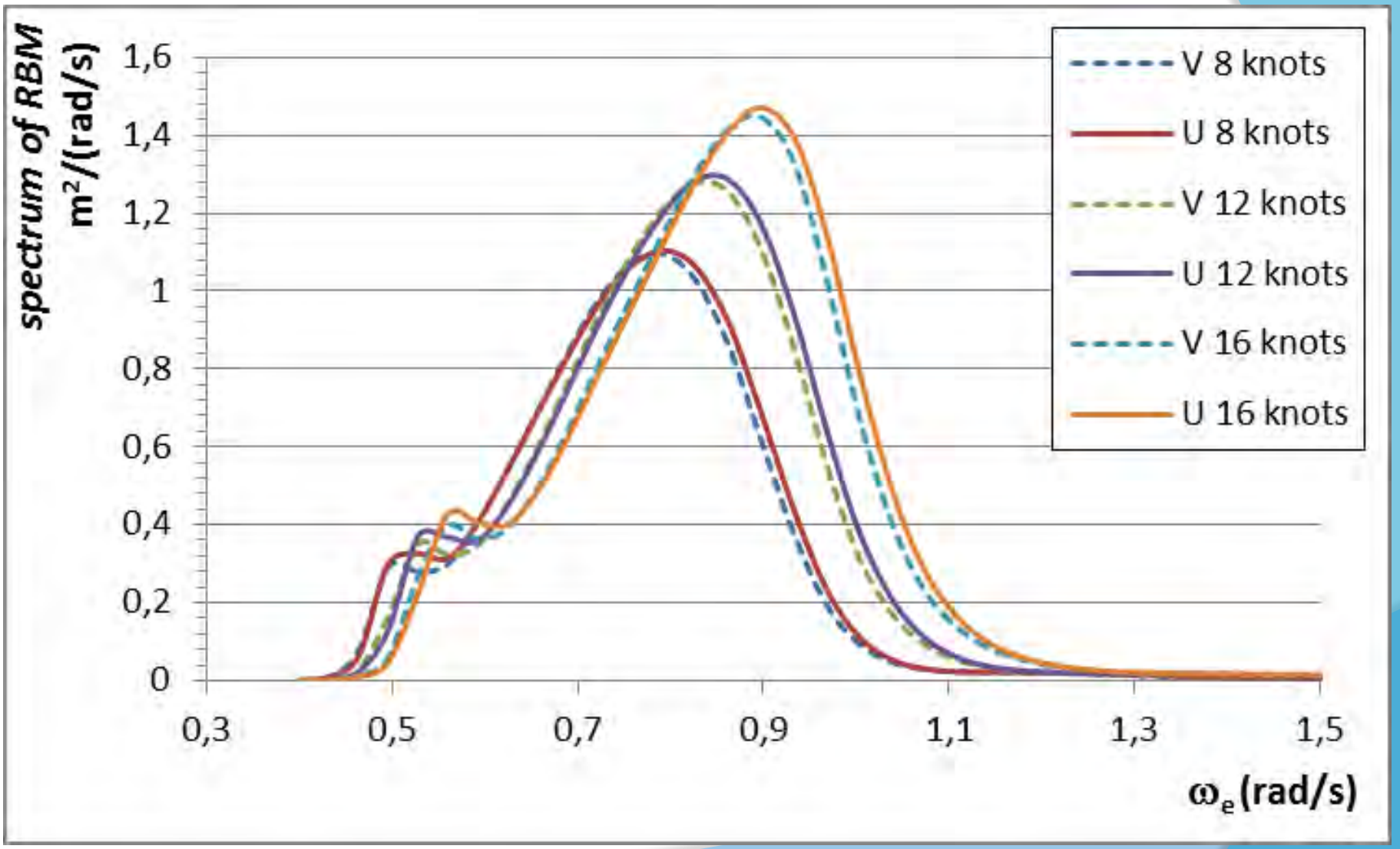
Input :
remote locations,
Speeds (8 knots, 12 knots dan 16 knots)
Headings (180°)
spectra gelombang (Jonswap, H = 3 meter)

Perhitungan *Slamming*



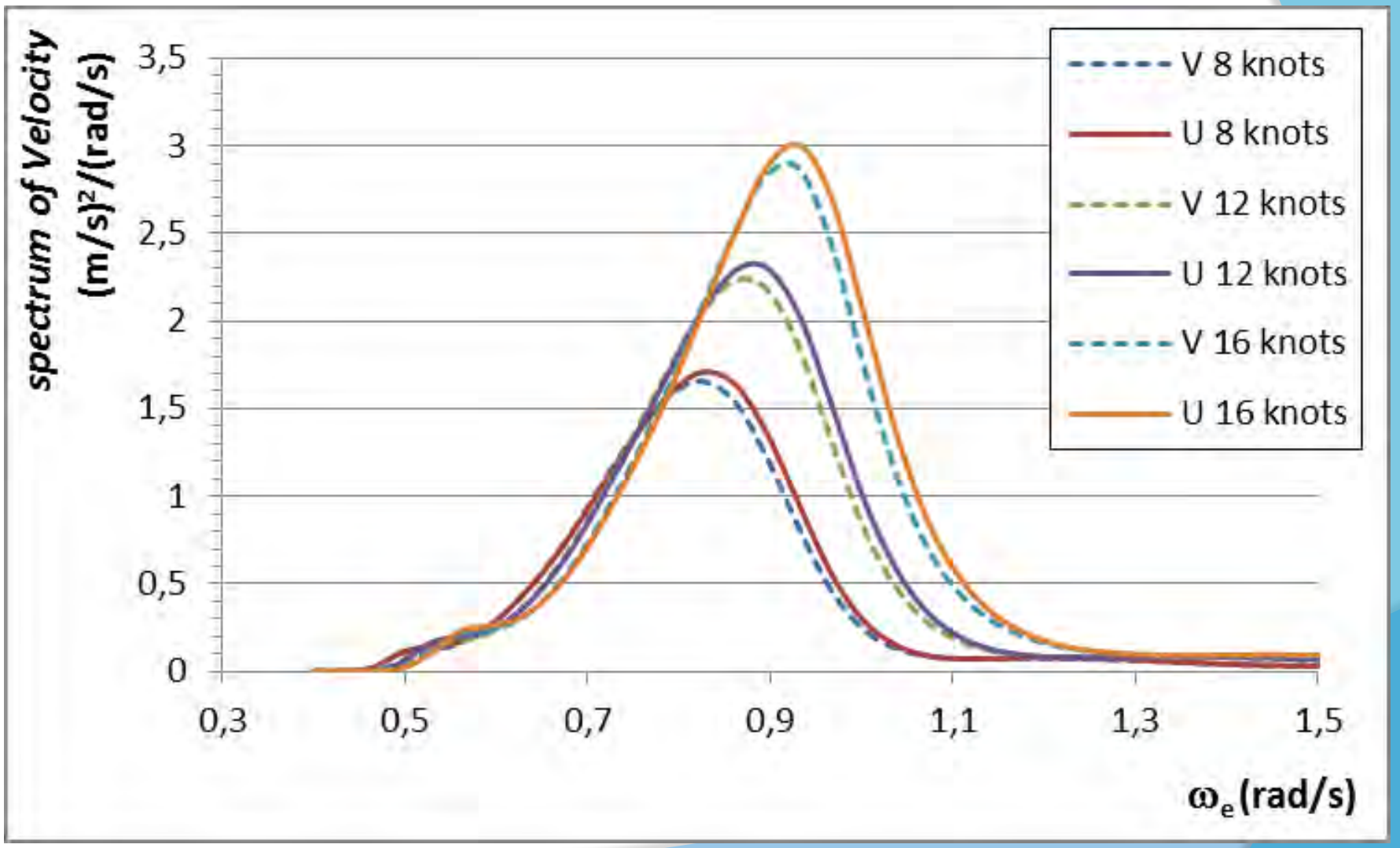
remote locations,

Perbandingan Spectrum *RBM* Lambung U dan V



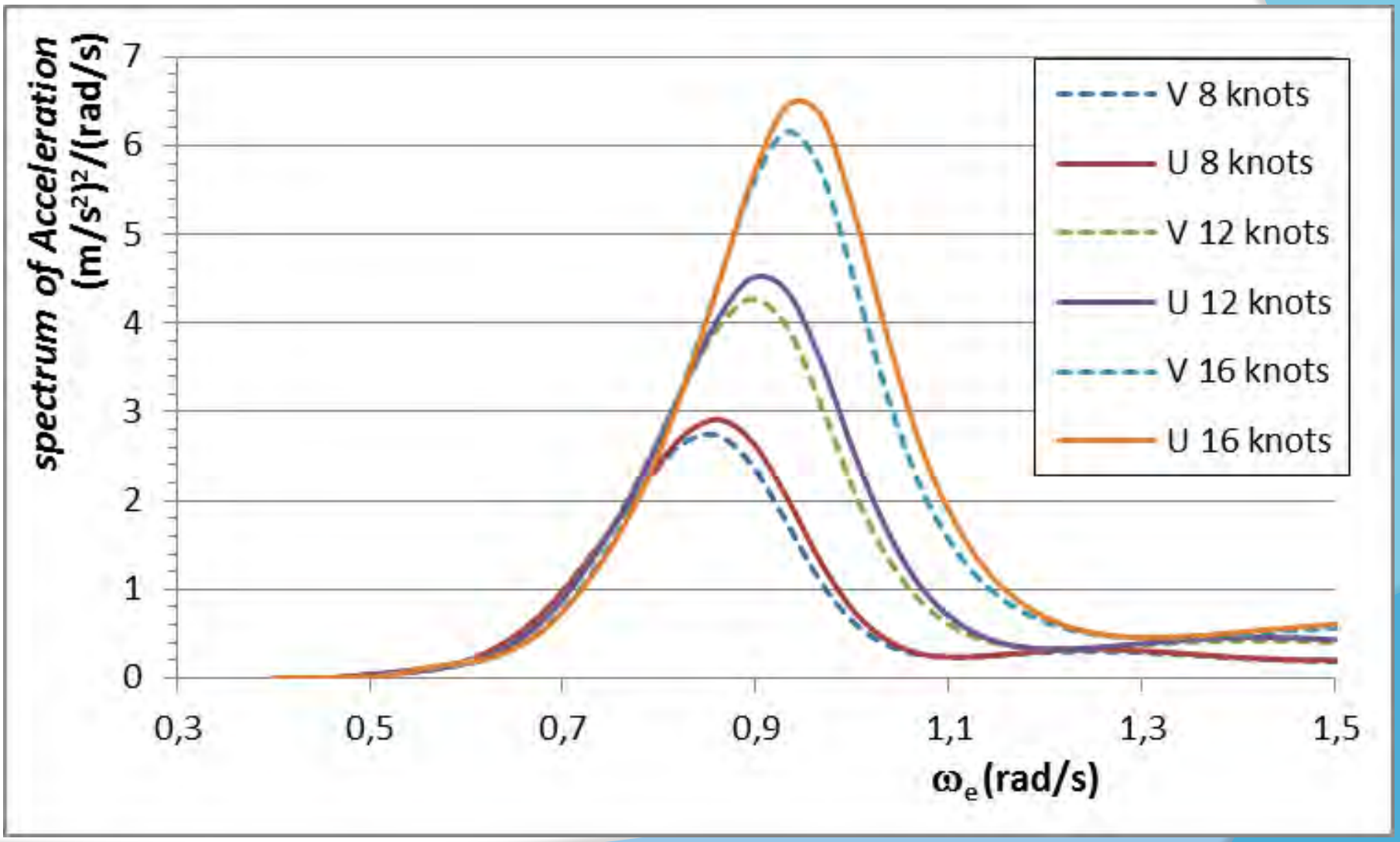
Perbandingan *RAO* Lambung U dan V

lanjutan...



Perbandingan *RAO* Lambung U dan V

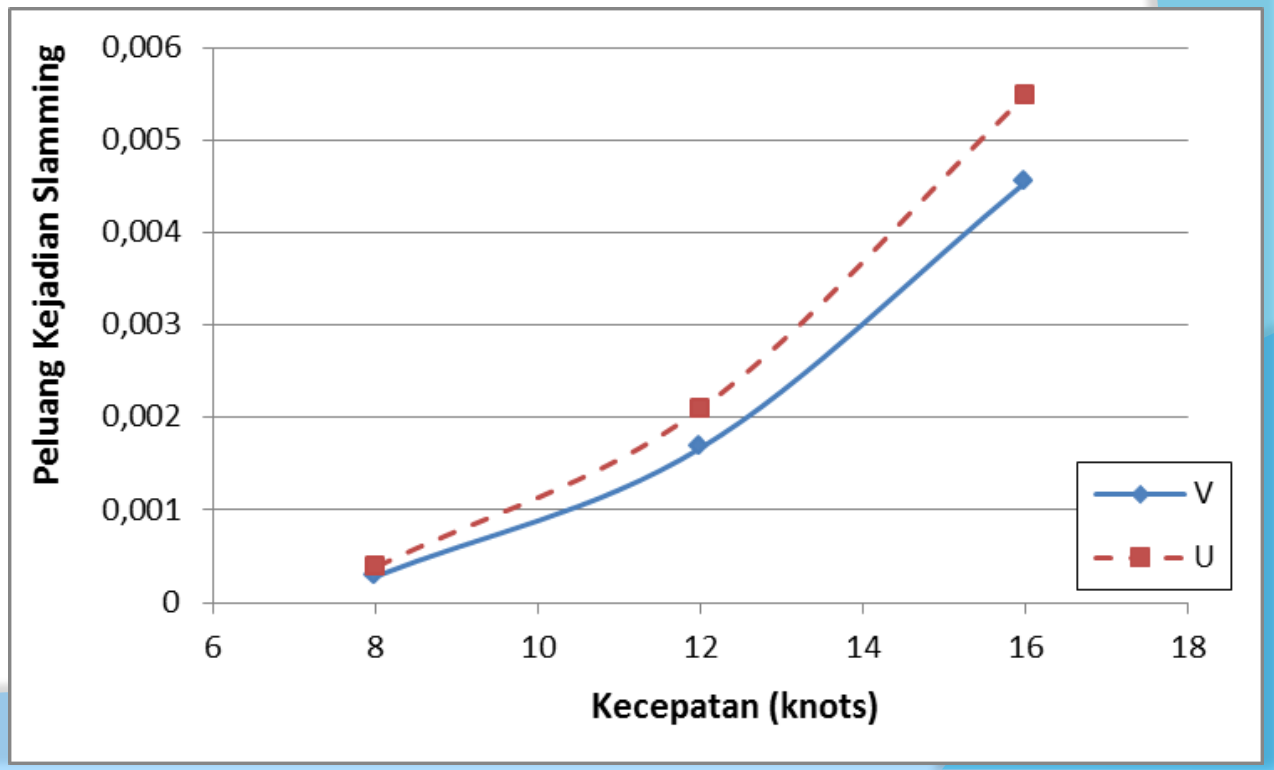
lanjutan...



Perbandingan Probabilitas *Slamming*

$$\Pr(slam) = \Pr(Z_{br} \rangle T_b \; dan V_{br} > V_{th}) = \exp\left(-\frac{T_b^2}{2m_{0Zbr}} - \frac{V_{th}^2}{2m_{0Vbr}} \right)$$

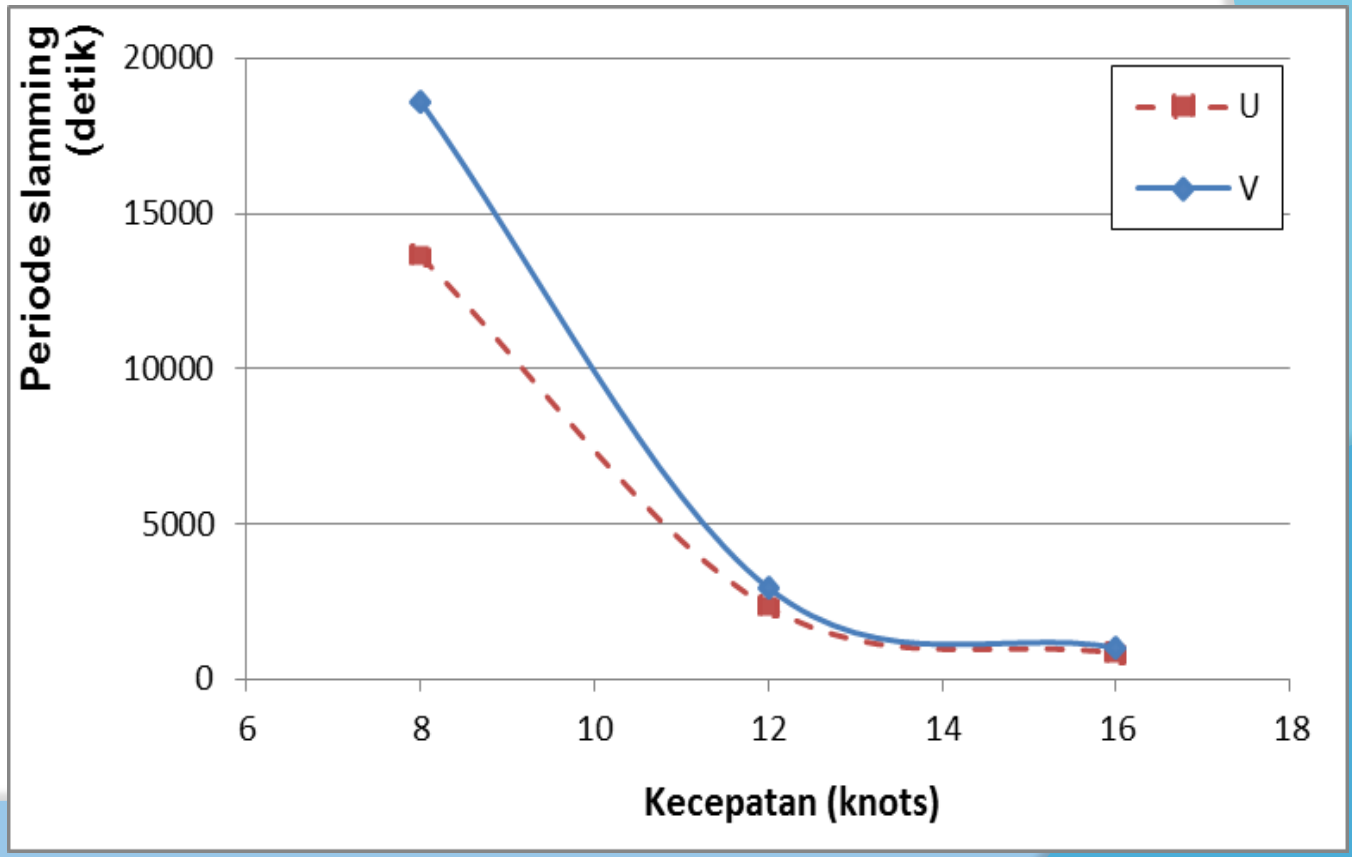
Kecepatan	m_{0zbr} (m^2)		m_{0Vbr} ($(m/s)^2$)		Pr (*slamming*)	
(knots)	hull-V	hull-U	hull-V	hull-U	hull-V	hull-U
8	0,668	0,690	0,936	0,983	0,00029	0,00039
12	0,813	0,838	1,326	1,393	0,00167	0,00210
16	0,930	0,958	1,718	1,808	0,00455	0,00549



Perbandingan Intensitas Terjadinya *Slamming*

Kecepatan	Periode (detik)		Periode (jam)		*Slamming* / tahun	
(knots)	*hull V*	*hull U*	*hull V*	*hull U*	*hull V*	*hull U*
8	18611,373	13628,325	5,16983	3,78565	1694	2314
12	2941,633	2325,326	0,81712	0,64592	10721	13562
16	1017,072	833,857	0,28252	0,23163	31007	37819

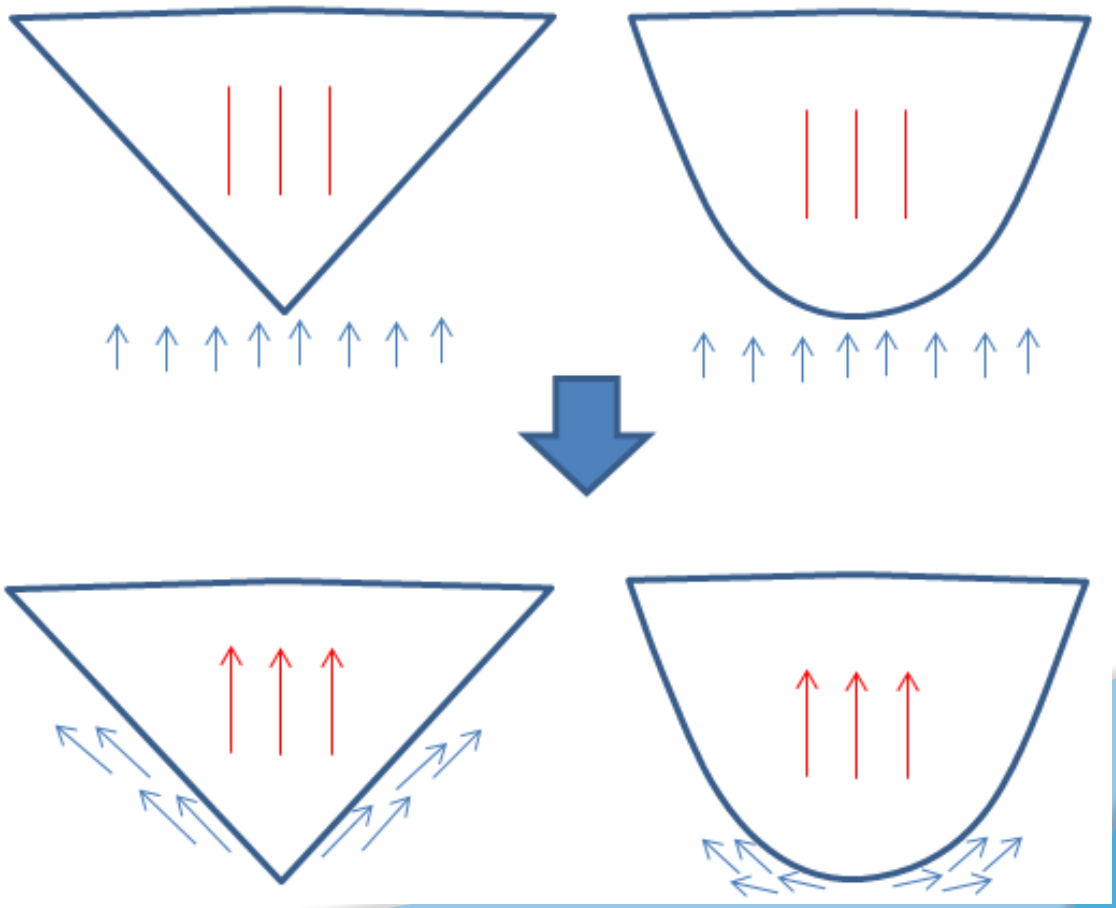
$$N_{slam} = \frac{1}{2\pi}\sqrt{\frac{m_{2Zbr}}{m_{0Zbr}}} \times \Pr(slam)$$



Perbandingan Intensitas Terjadinya *Slamming*

lanjutan...

lambung berbentuk U lebih sering mengalami *slamming* dari pada lambung berbentuk V

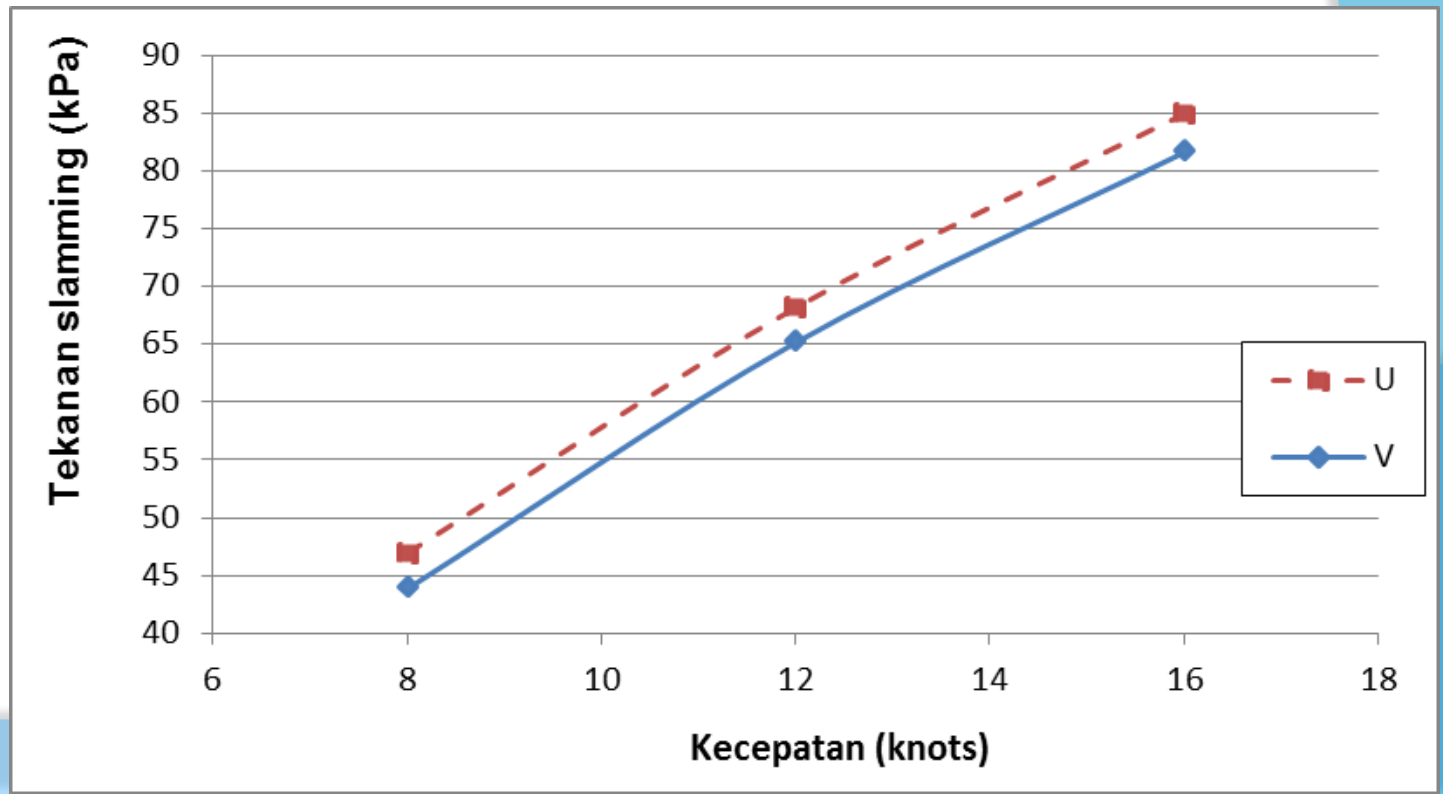


Perbandingan Besarnya Beban *Slamming*

$$P_s = \frac{1}{2}\rho k {V_{br}}^2 \text{ (kPa)}$$

$$V_{br} = \sqrt{2xln\left\{\frac{3600xT_0}{2\pi}exp\left(-\frac{{T_b}^2}{2m_{0Zbr}}-\frac{{V_{th}}^2}{2m_{2Zbr}}\right)\right\}}\sqrt{\frac{m_{2Vbr}}{m_{0Vbr}}}x\sqrt{m_{0Vbr}}$$

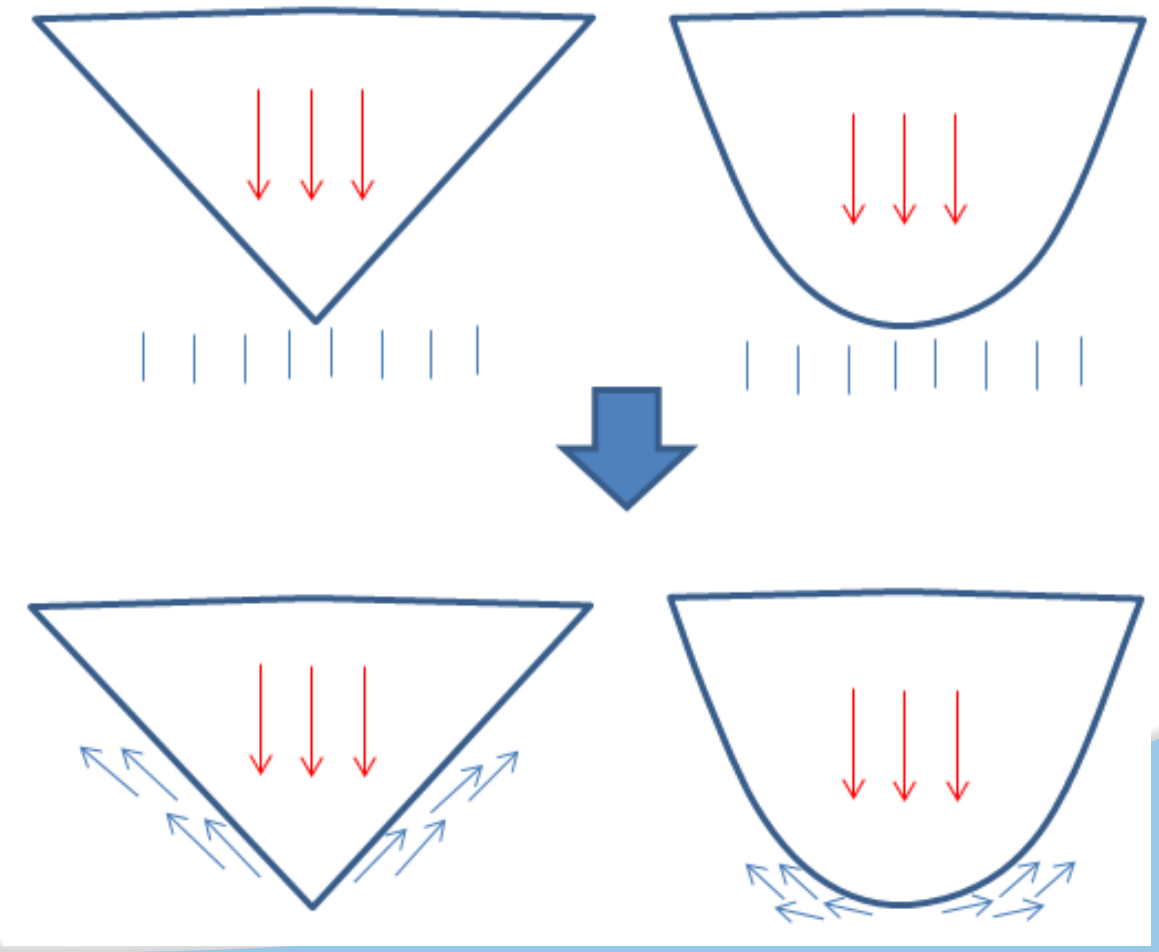
Kecepatan	ρ	k	m_{0zbr} (m^2)		m_{0Vbr} ($(m/s)^2$)		m_{2Vbr} ($(m/s^2)^2$)		Slamming Pressure (kPa)	
(knots)	(ton/m3)		hull-V	hull-U	hull-V	hull-U	hull-V	hull-U	hull-V	hull-U
8	1,025	9	0,668	0,690	0,936	0,983	2,233	2,429	43,829	46,916
12	1,025	9	0,813	0,838	1,326	1,393	3,892	4,169	65,147	68,167
16	1,025	9	0,930	0,958	1,718	1,808	5,696	6,115	81,612	84,964



Perbandingan Besarnya Beban *Slamming*

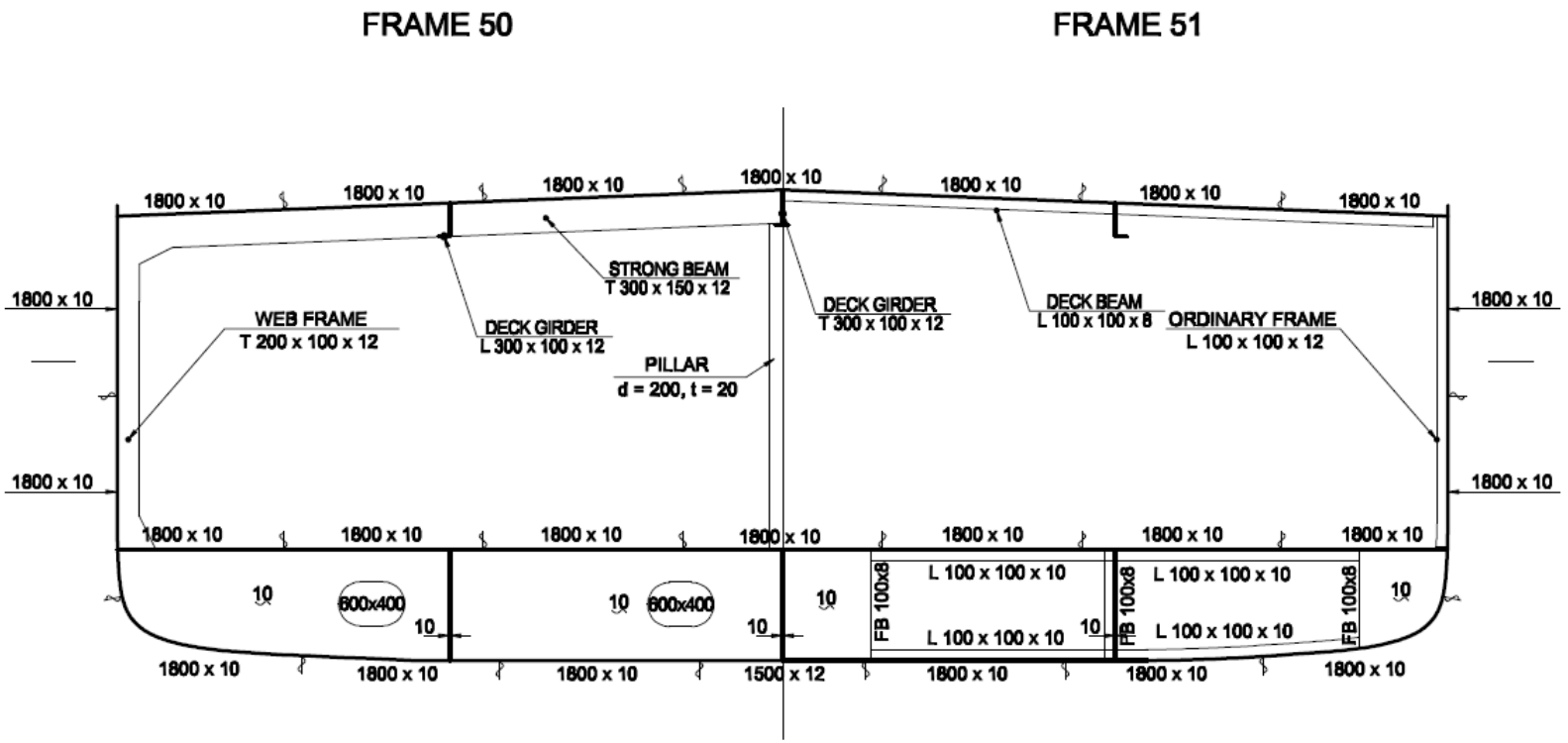
lanjutan...

lambung berbentuk U mempunyai beban *slamming* lebih besar dari pada lambung berbentuk V



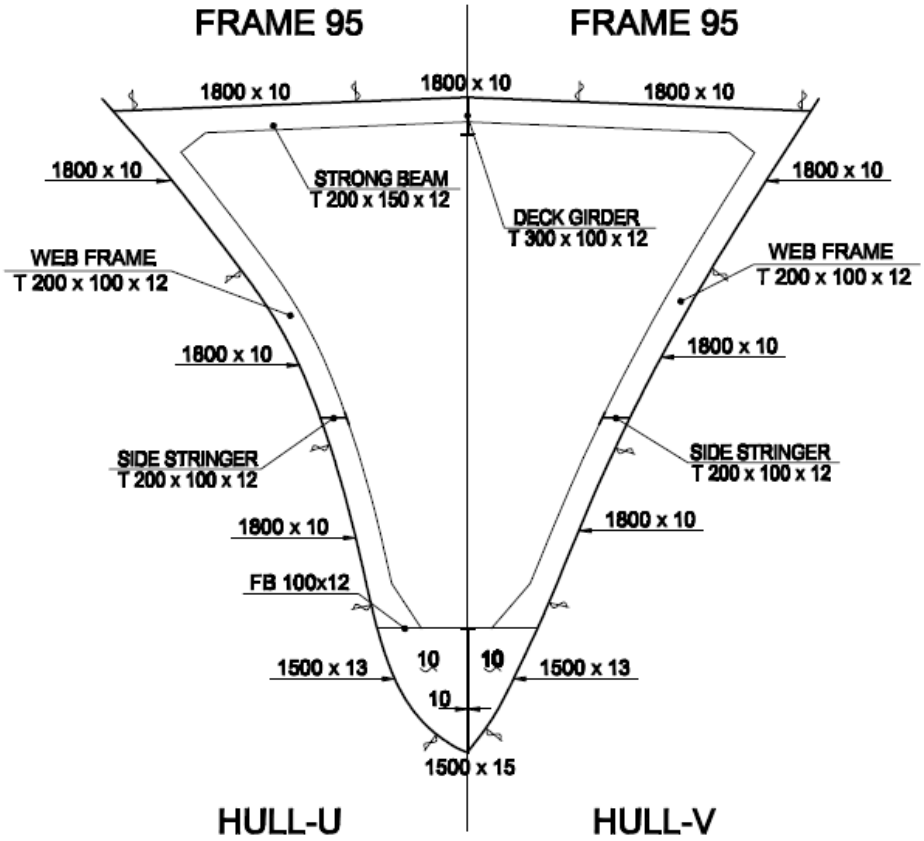
Perhitungan Konstruksi

Biro Klasifikasi Indonesia Volume II *Rules for Hull* (2014)



lanjutan...

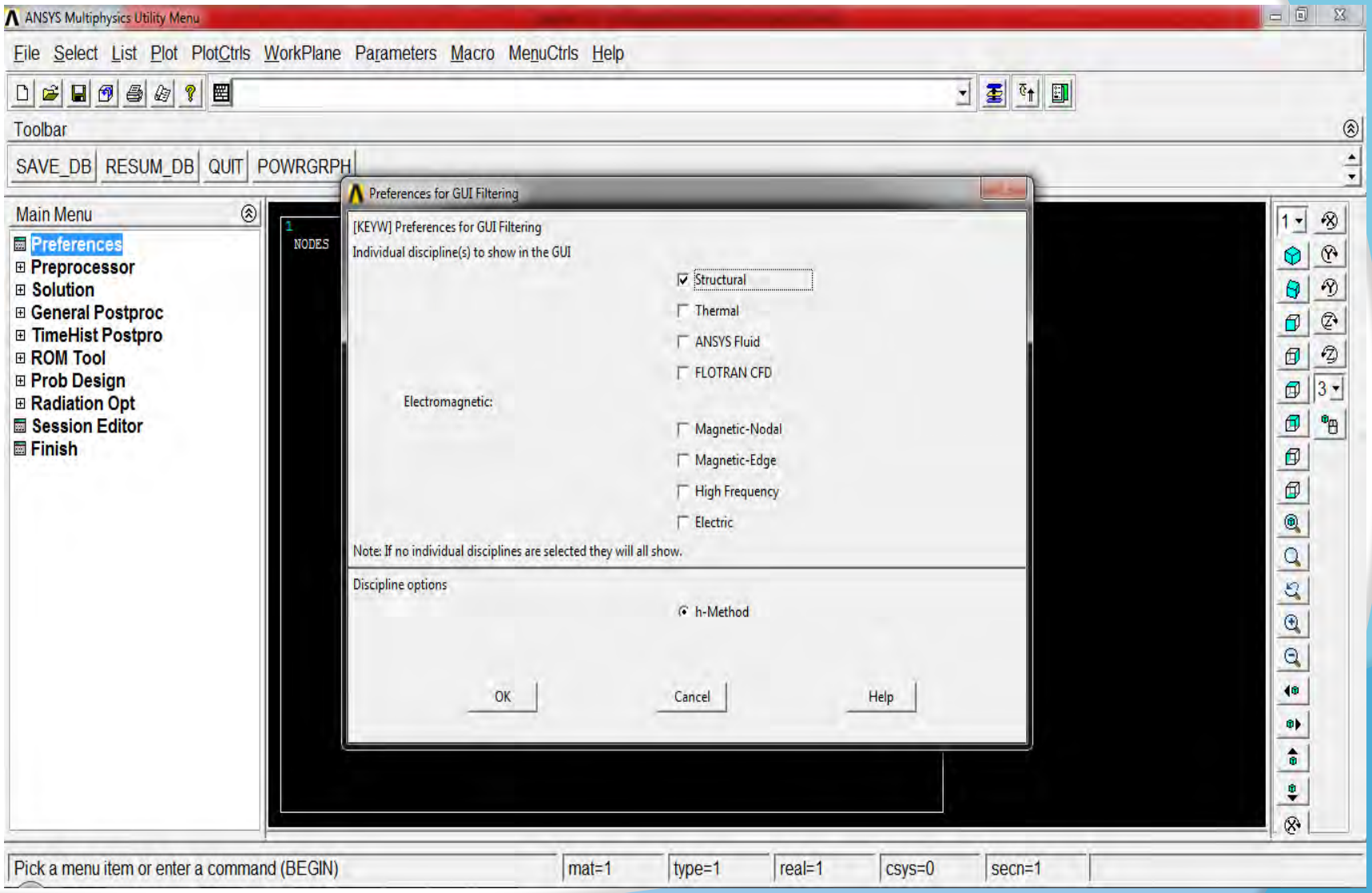
Perhitungan Konstruksi



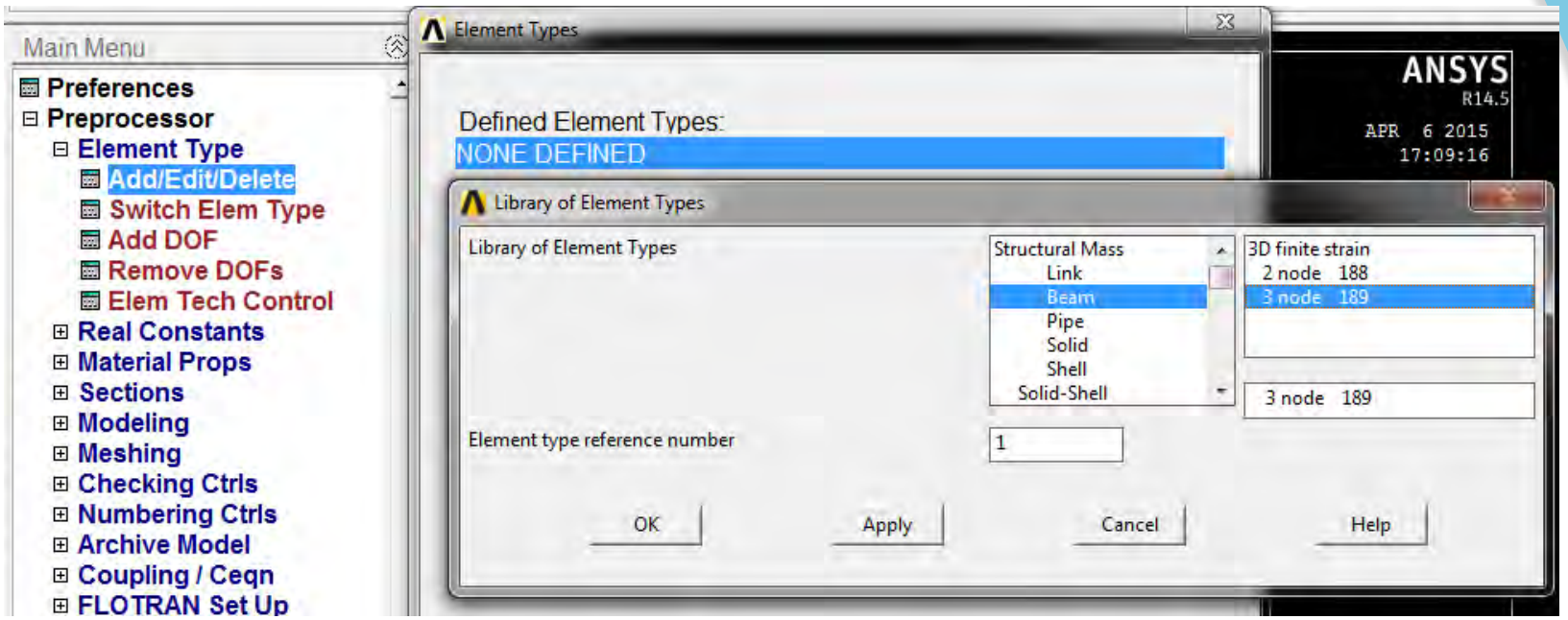
penguatan untuk daerah 0,7 L kedepan, kapal dibawah 100 meter

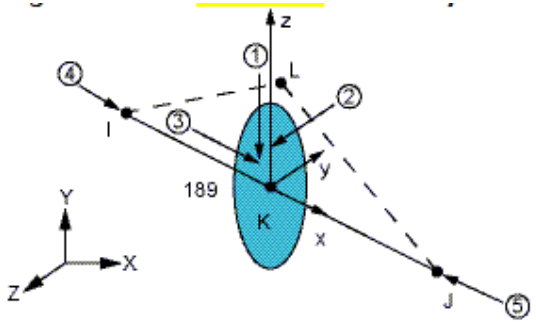
1. wrang plat dipasang setiap satu kali jarak gading.
2. Jarak antar *girder* tidak boleh lebih dari **L/250 + 0,9** meter.

Pemilihan Tipe Analisa

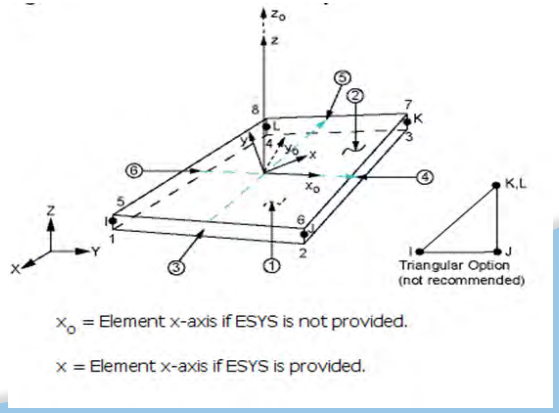


Pemilihan Tipe Elemen



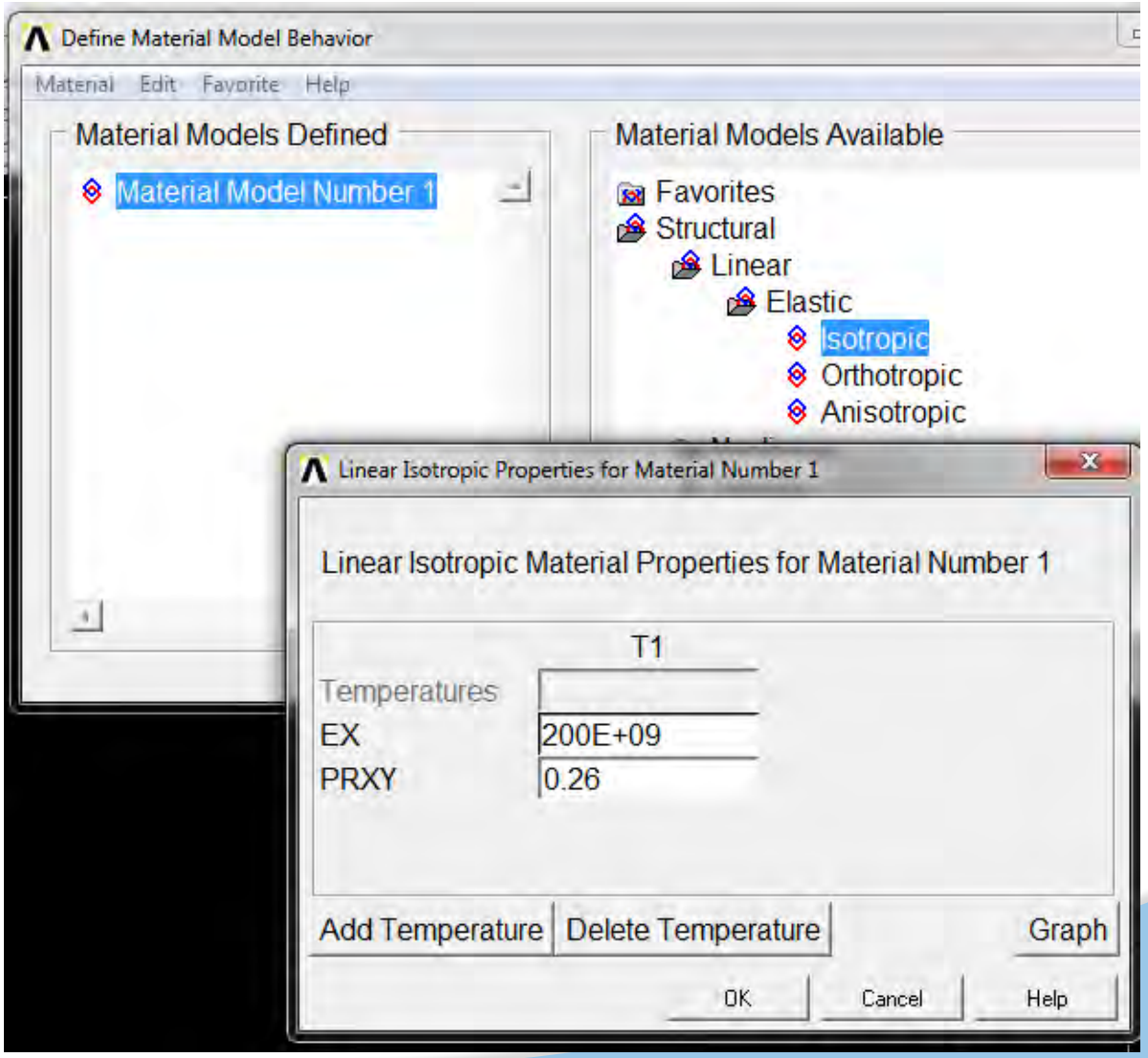


Element Beam189

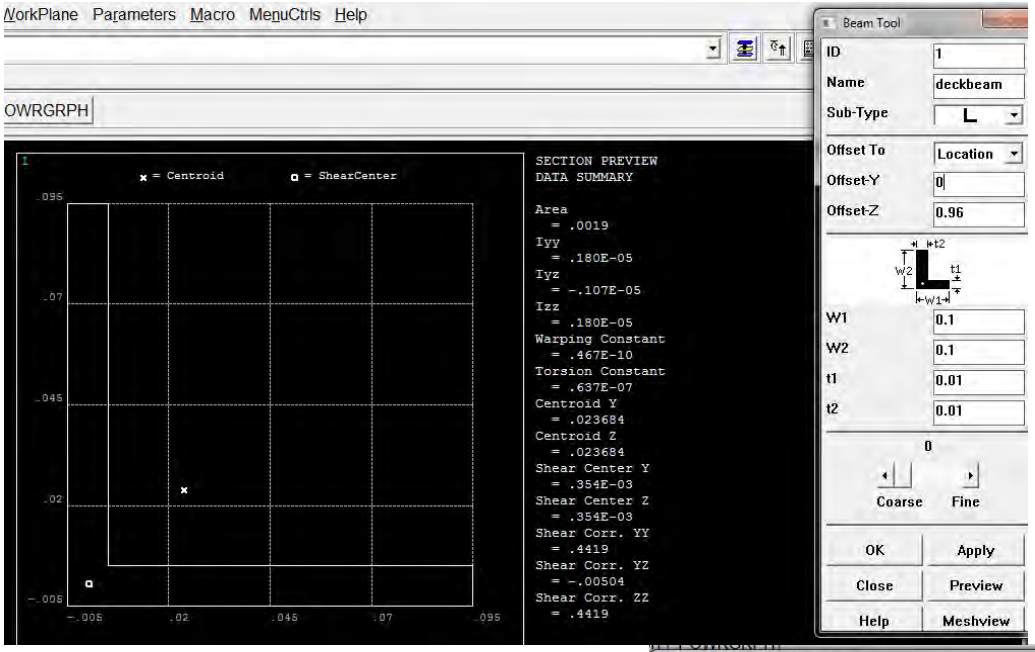


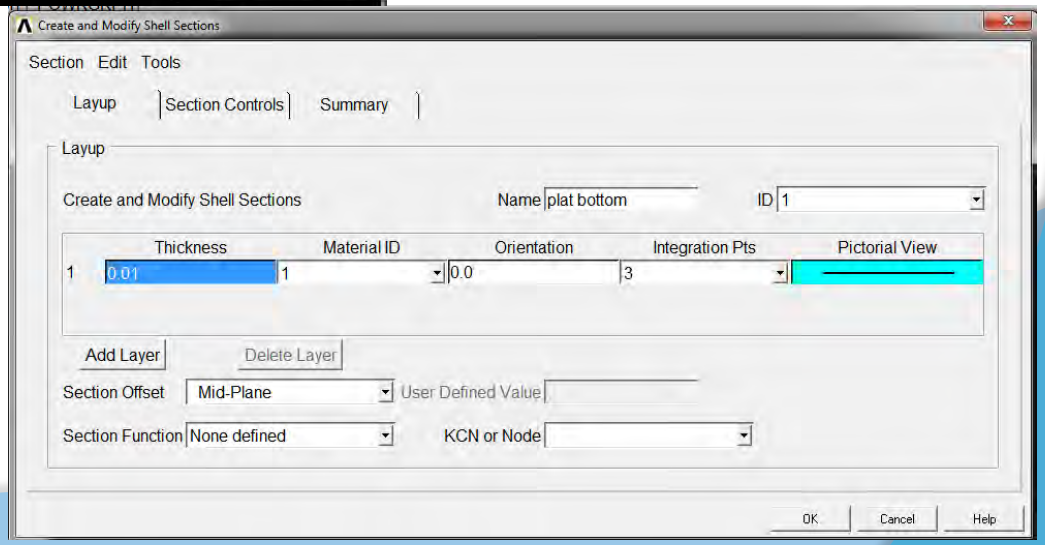
Element Shell181

Penentuan *Material Properties*



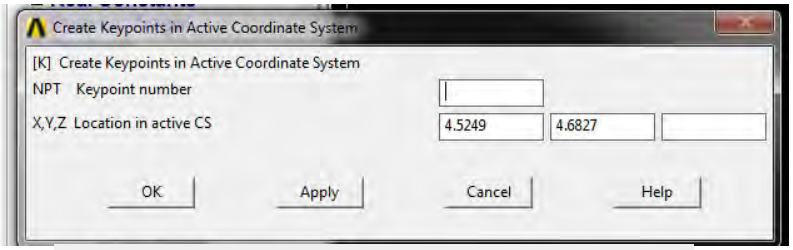
Penentuan Ukuran *Section* (profil dan plat)

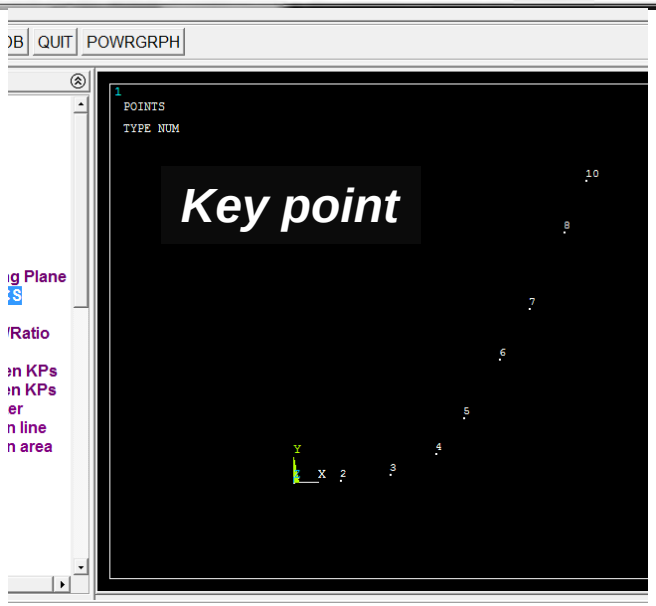


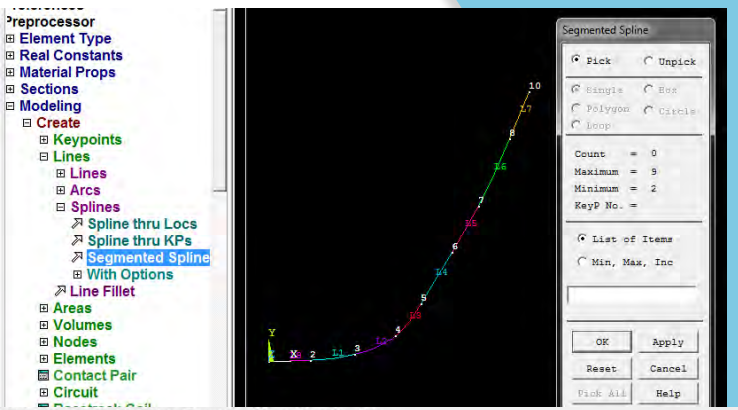


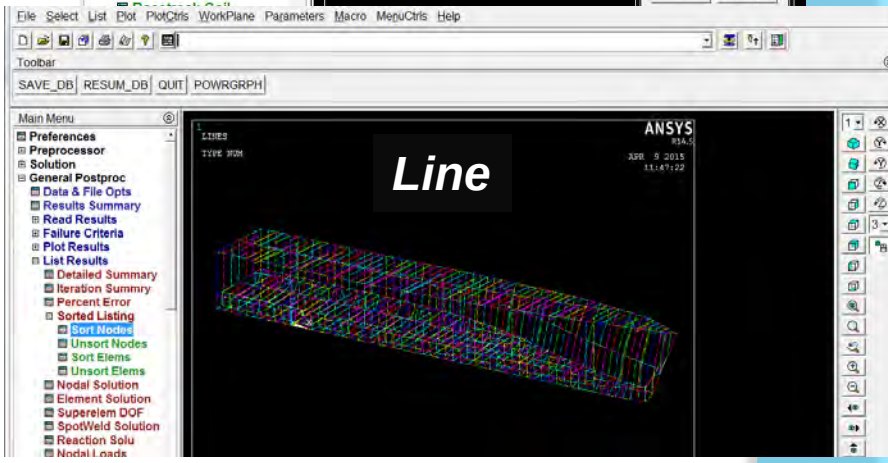
Pemodelan di *Ansys Mechanical APDL*

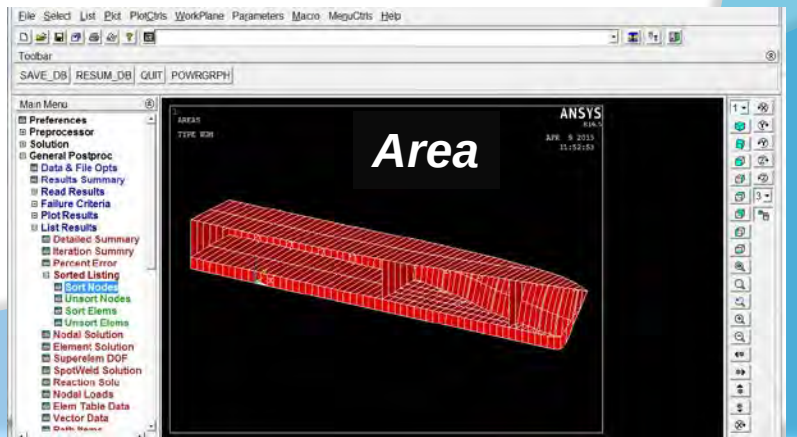
Modeling





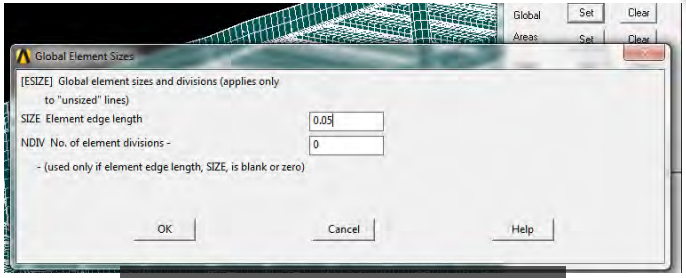




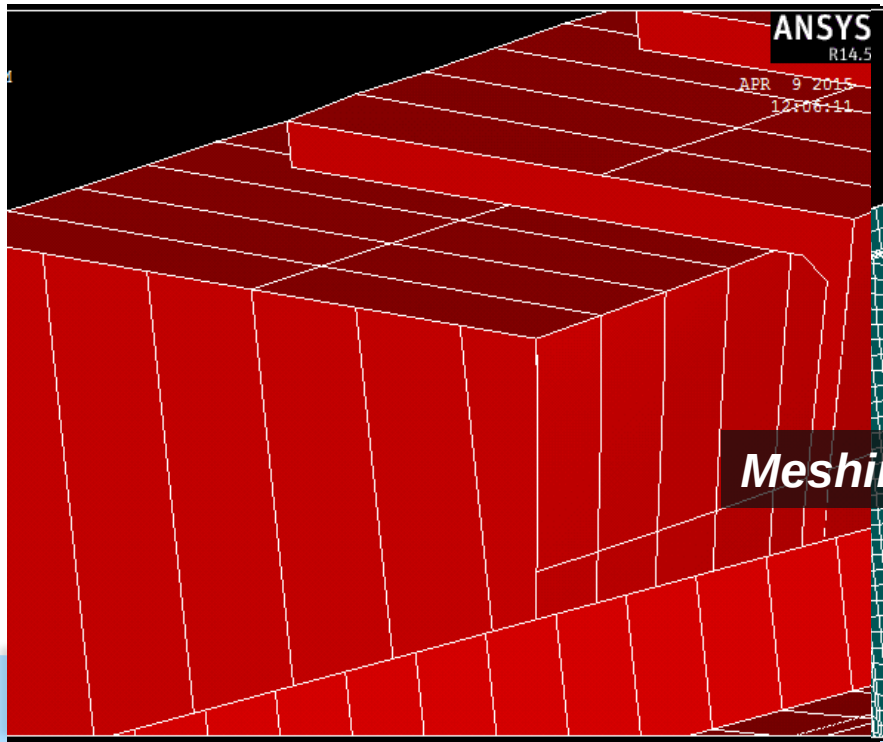


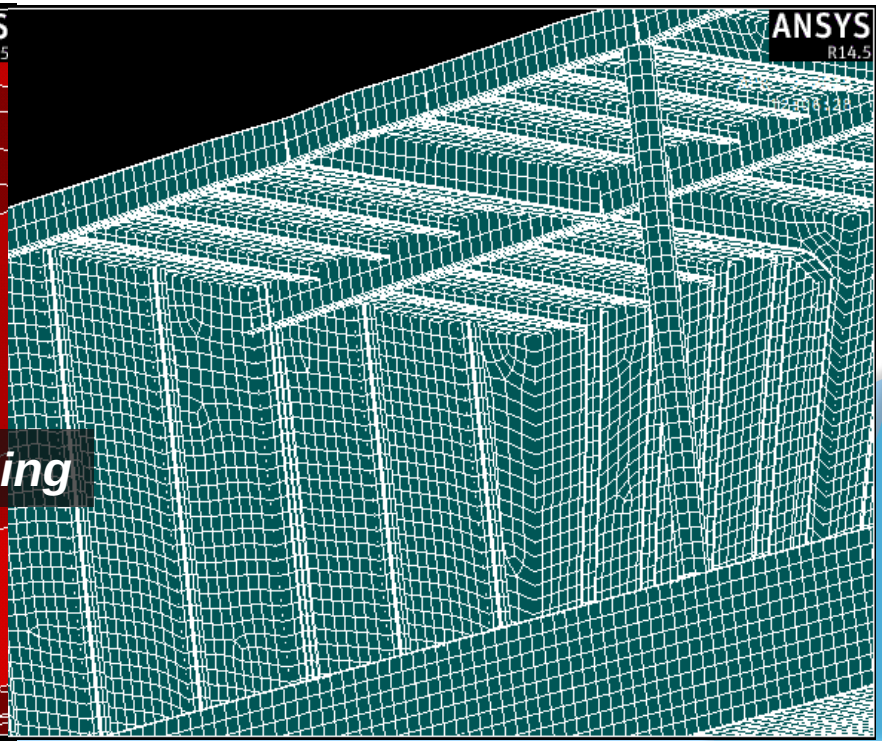
Meshing

Mesh atribute



Mesh size control

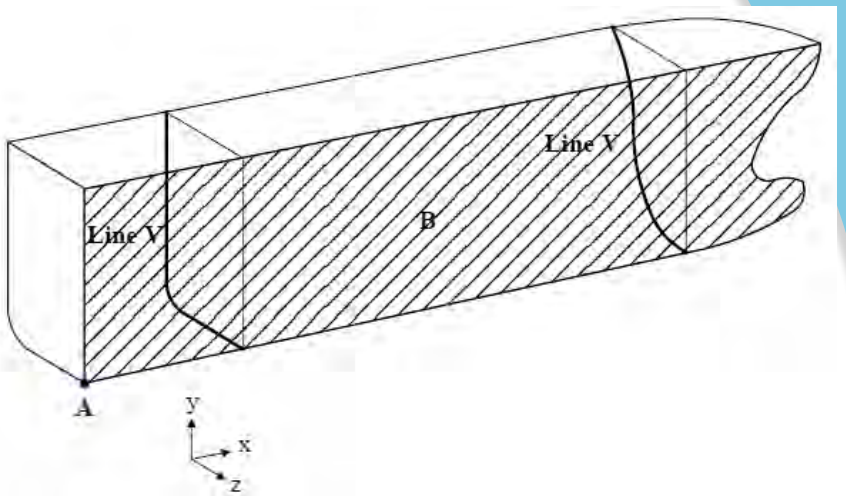




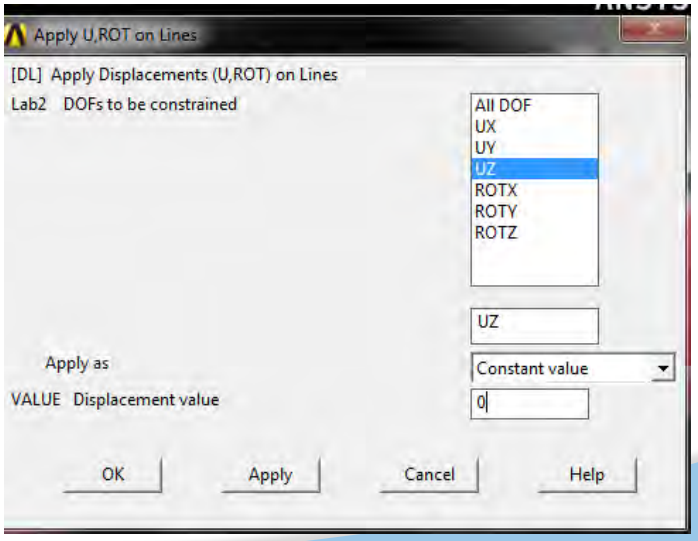
Meshing

Penentuan Kondisi Batas

Point A	UX = 0, UY = 0
Line V	Attach spring rod elements
Section B	UZ = 0, RX =0 , RY = 0



Guide for Slamming Loads And Strength Assessment For Vessels (2013) - ABS



Input Beban

Class Lloyd's Register - Rules and Regulations for the Classification of Special Service Craft, July 2014

$$P_{dh} = \Phi_{dh}\left(19 - 2720\left(\frac{T_x}{L_{WL}}\right)^2\right)\sqrt{L_{WL}\,V} \quad \text{kN/m}^2$$

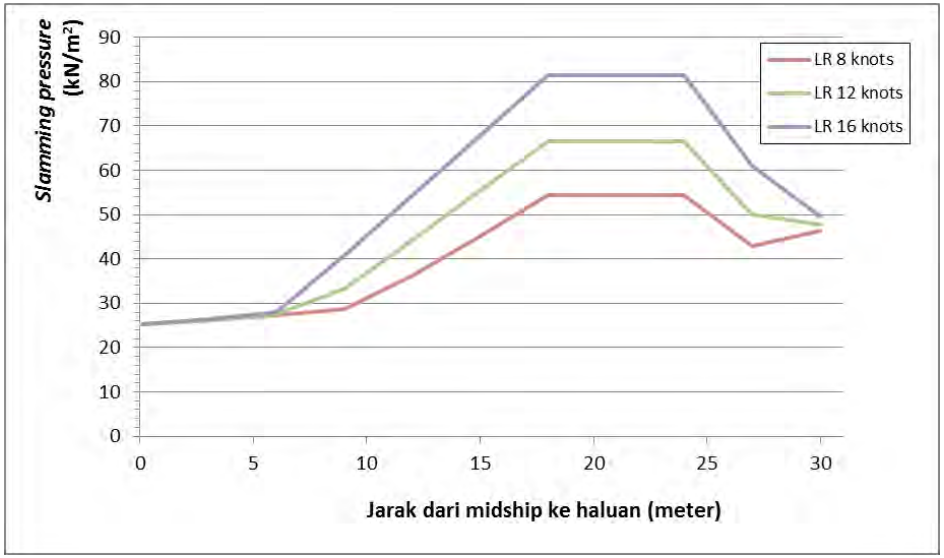
Φ_{dh} = 0,09 at L_{WL} from aft end of L_{WL}
= 0,18 at $0{,}9L_{WL}$ from aft end of L_{WL}
= 0,18 at $0{,}8L_{WL}$ from aft end of L_{WL}
= 0,0 between aft end of L_{WL} and $0{,}5L_{WL}$ from aft end of L_{WL}

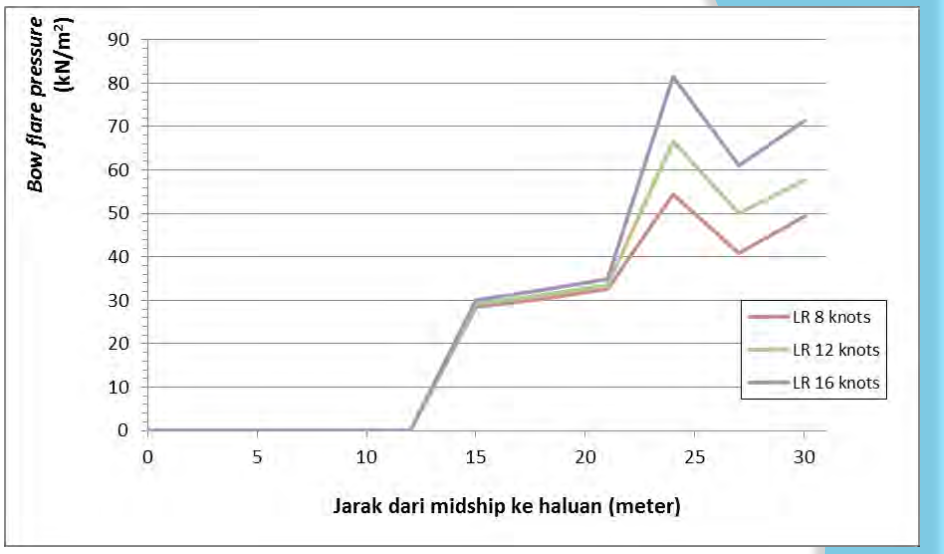
Beban muatan berdasarkan *Class* Biro Klasifikasi Indonesia – *Rules for The Classification* and *Contruction of Seagoing Steel Ships*, *Volume II* (2014).

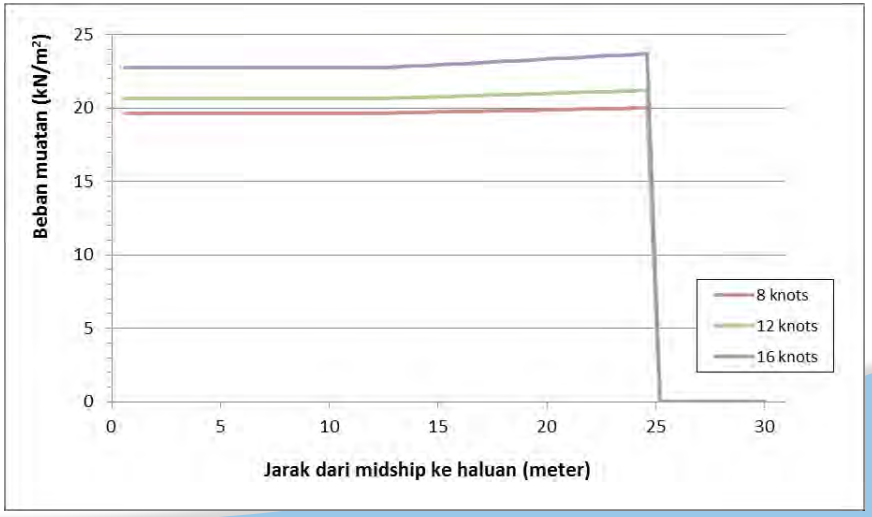
$P_i = 9.81*(G/V)*h*(1+a_v)$

Input Beban

lanjutan...

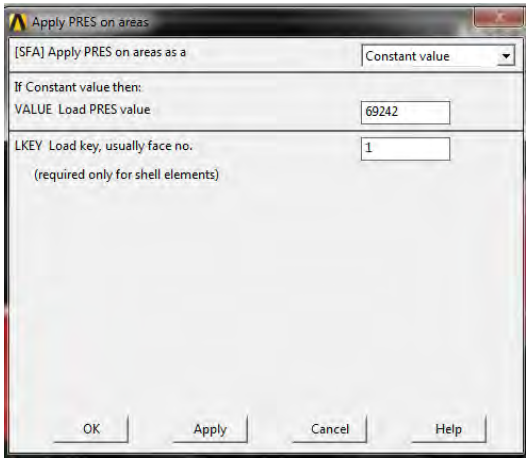


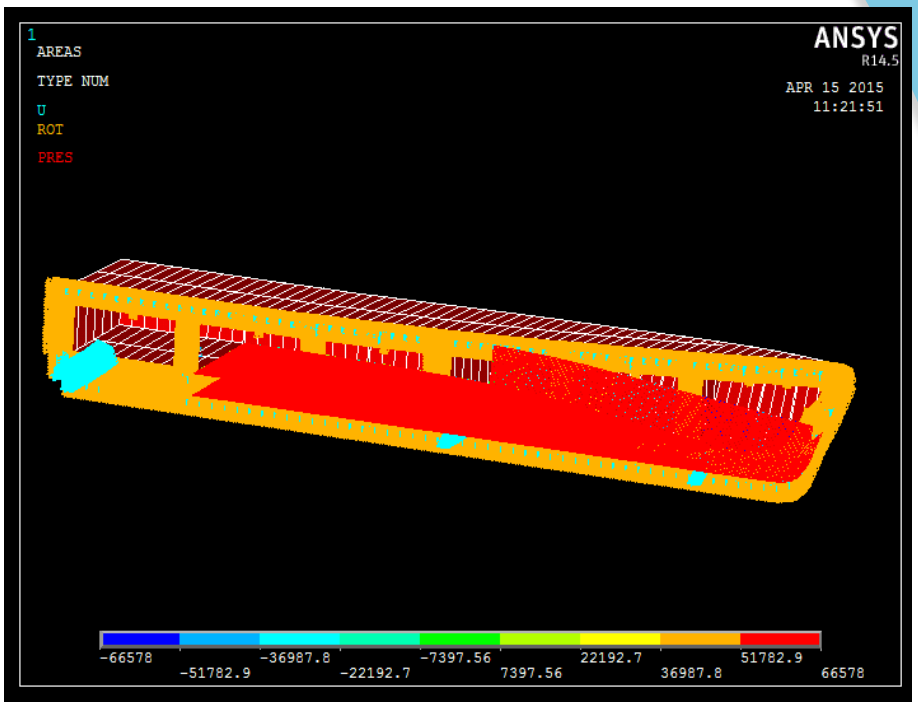


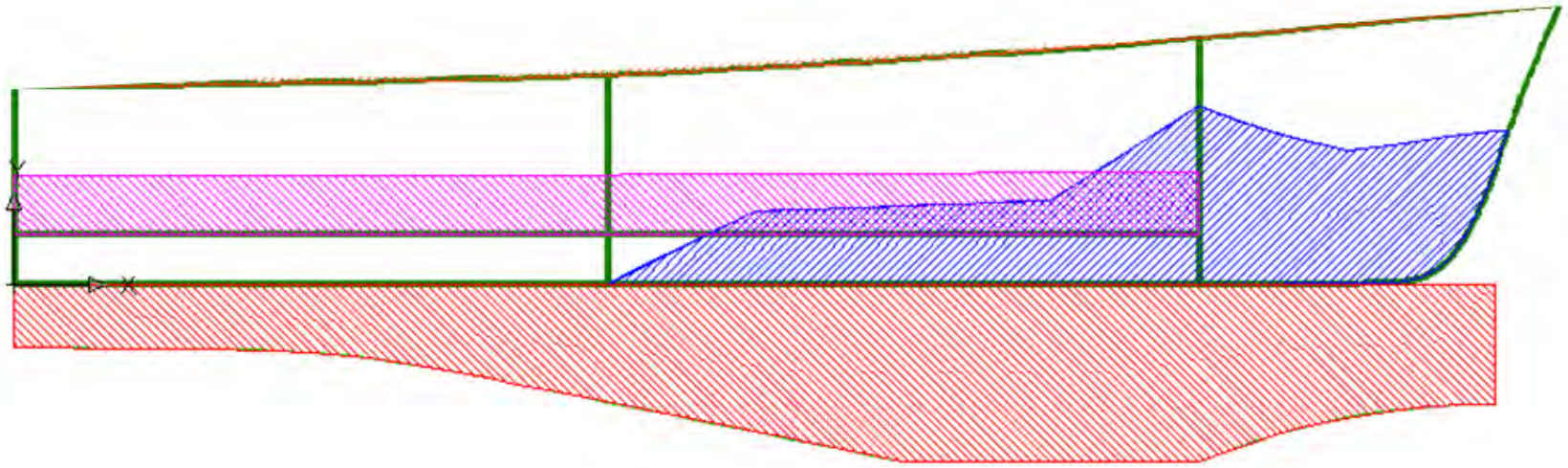


Input Beban

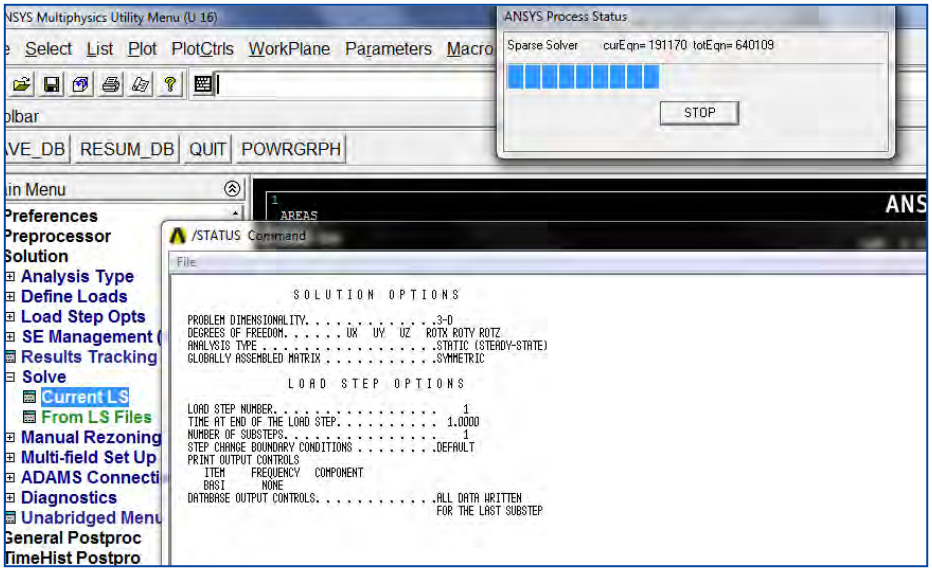
lanjutan...

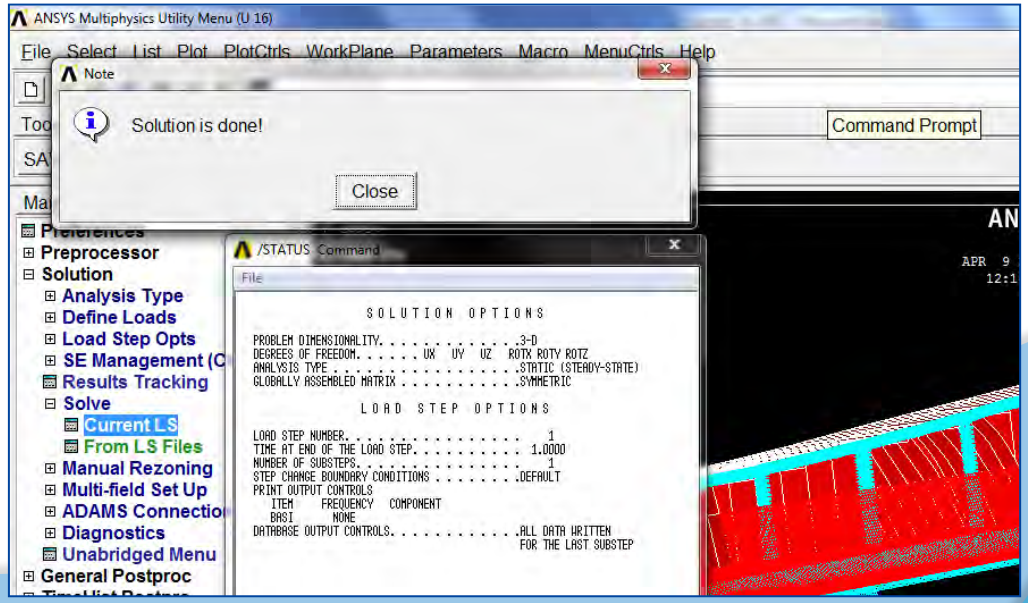






Running


ANSYS Multiphysics Utility Menu (U 16)
Select List Plot PlotCtrls WorkPlane Parameters Macro
VE_DB RESUM_DB QUIT POWRGRPH
ANSYS Process Status
Sparse Solver curEqn= 191170 totEqn= 640109
STOP
Preferences
Preprocessor
Solution
Analysis Type
Define Loads
Load Step Opts
SE Management
Results Tracking
Solve
Current LS
From LS Files
Manual Rezoning
Multi-field Set Up
ADAMS Connecti
Diagnostics
Unabridged Menu
General Postproc
TimeHist Postpro
/STATUS Command
File
SOLUTION OPTIONS
PROBLEM DIMENSIONALITY. 3-D
DEGREES OF FREEDOM. . . . . UX UY UZ ROTX ROTY ROTZ
ANALYSIS TYPE . . . . . .STATIC (STEADY-STATE)
GLOBALLY ASSEMBLED MATRIX . . . . . .SYMMETRIC
LOAD STEP OPTIONS
LOAD STEP NUMBER. 1
TIME AT END OF THE LOAD STEP. 1.0000
NUMBER OF SUBSTEPS. 1
STEP CHANGE BOUNDARY CONDITIONS . . . . . .DEFAULT
PRINT OUTPUT CONTROLS
ITEM FREQUENCY COMPONENT
BASI NONE
DATABASE OUTPUT CONTROLS. . . . . .ALL DATA WRITTEN
FOR THE LAST SUBSTEP


ANSYS Multiphysics Utility Menu (U 16)
File Select List Plot PlotCtrls WorkPlane Parameters Macro MenuCtrls Help
Note
Solution is done!
Close
Command Prompt
Preferences
Preprocessor
Solution
Analysis Type
Define Loads
Load Step Opts
SE Management
Results Tracking
Solve
Current LS
From LS Files
Manual Rezoning
Multi-field Set Up
ADAMS Connectio
Diagnostics
Unabridged Menu
General Postproc
/STATUS Command
File
SOLUTION OPTIONS
PROBLEM DIMENSIONALITY. 3-D
DEGREES OF FREEDOM. . . . . UX UY UZ ROTX ROTY ROTZ
ANALYSIS TYPE . . . . . .STATIC (STEADY-STATE)
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LOAD STEP OPTIONS
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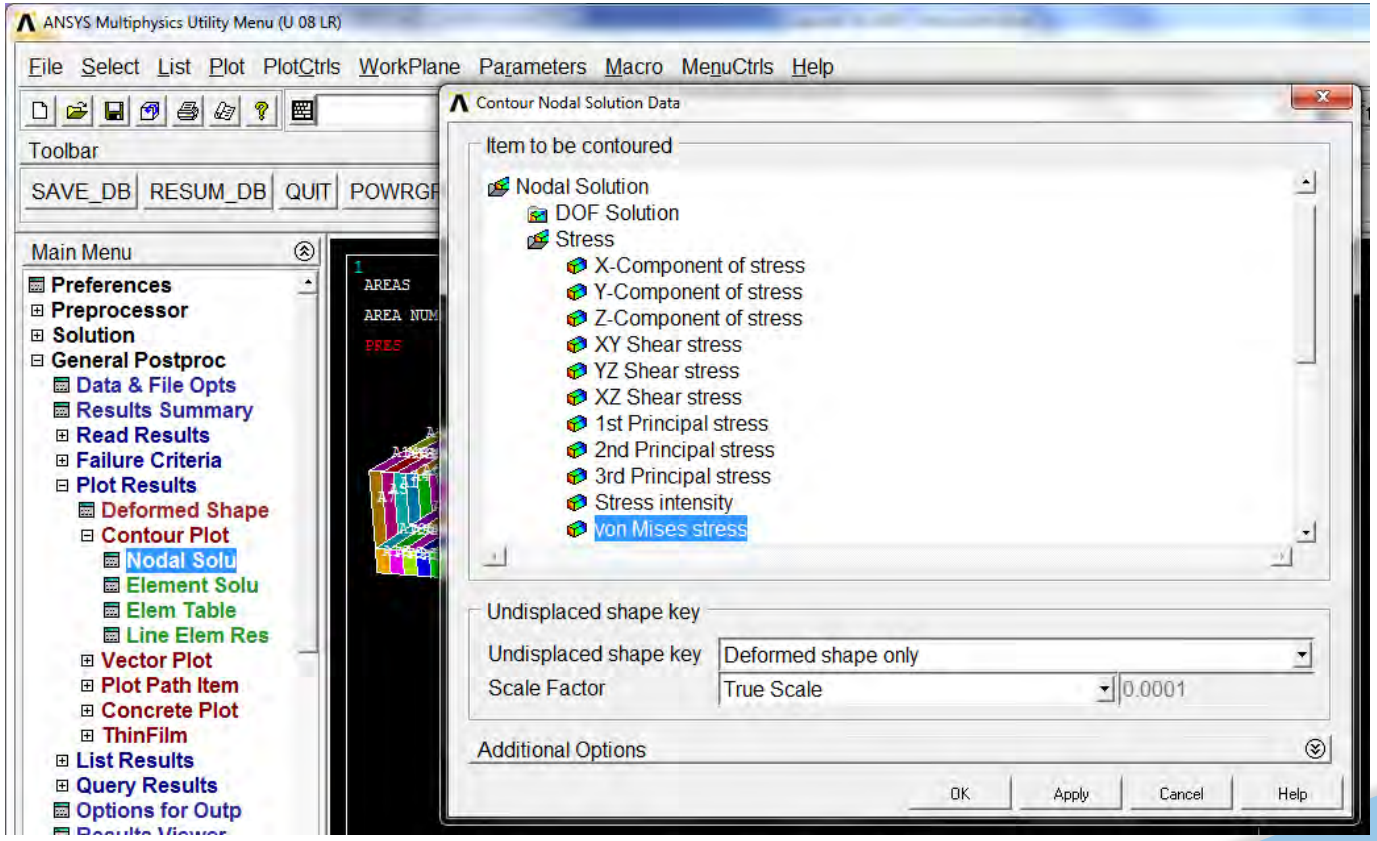
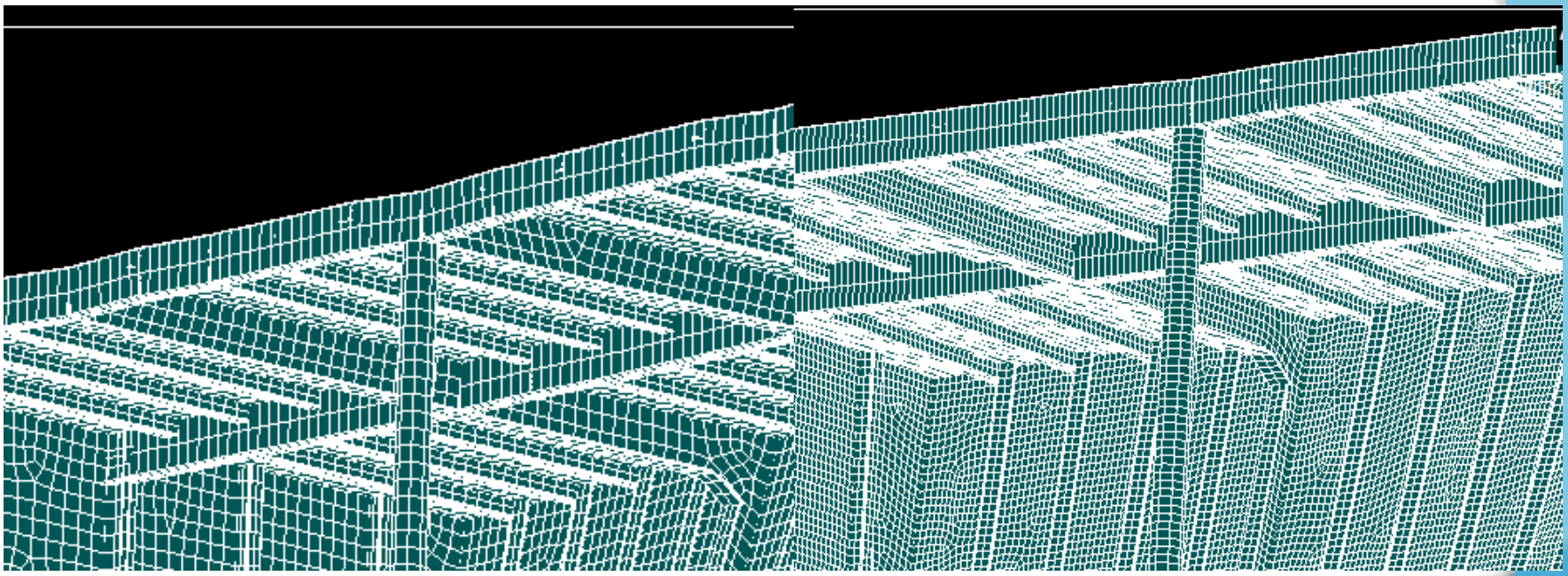
NUMBER OF SUBSTEPS. 1
STEP CHANGE BOUNDARY CONDITIONS . . . . . .DEFAULT
PRINT OUTPUT CONTROLS
ITEM FREQUENCY COMPONENT
BASI NONE
DATABASE OUTPUT CONTROLS. . . . . .ALL DATA WRITTEN
FOR THE LAST SUBSTEP
APR 9
12:1

Pembacaan Hasil



KONVERGENSI

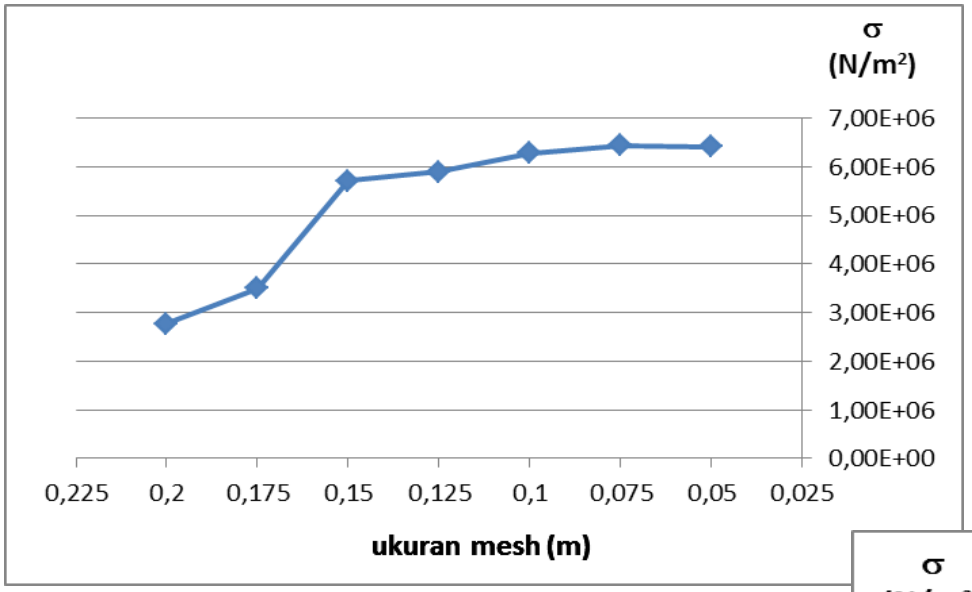


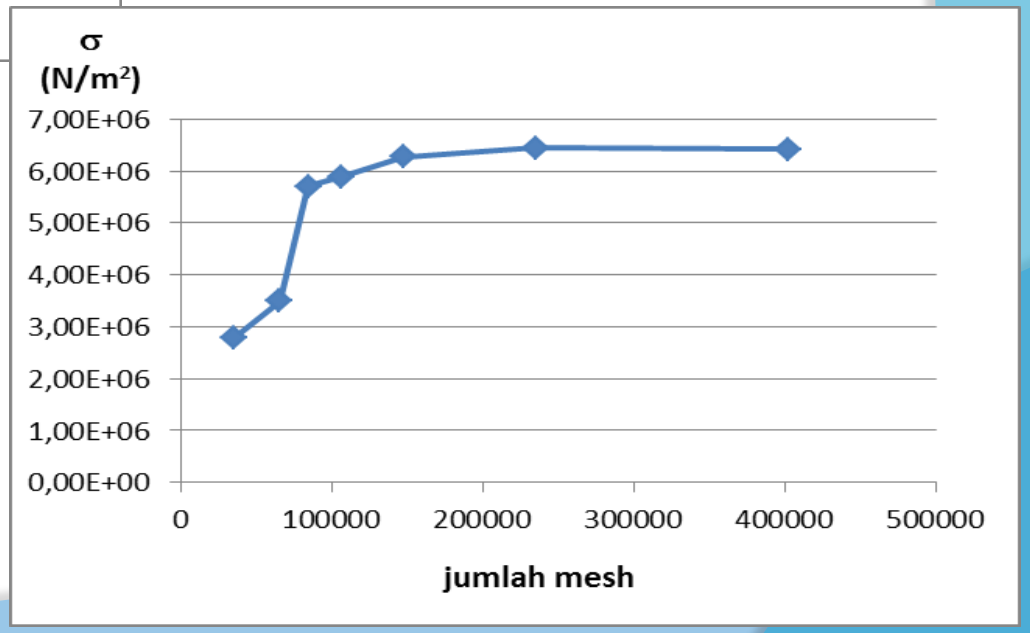
0,1 meter

0,05 meter

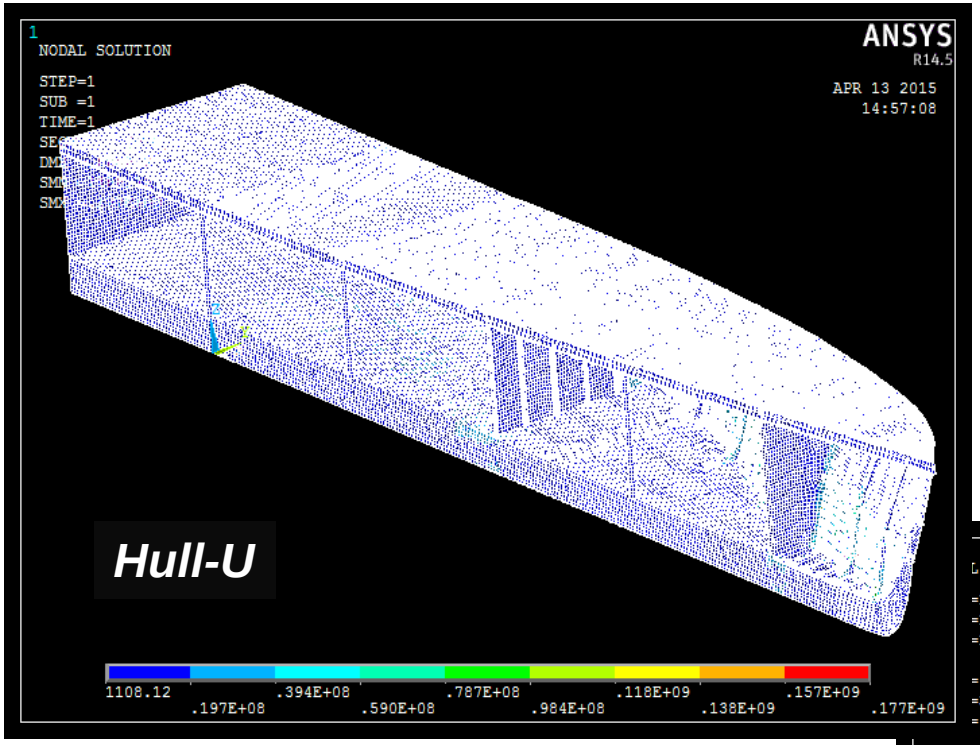
KONVERGENSI

lanjutan...

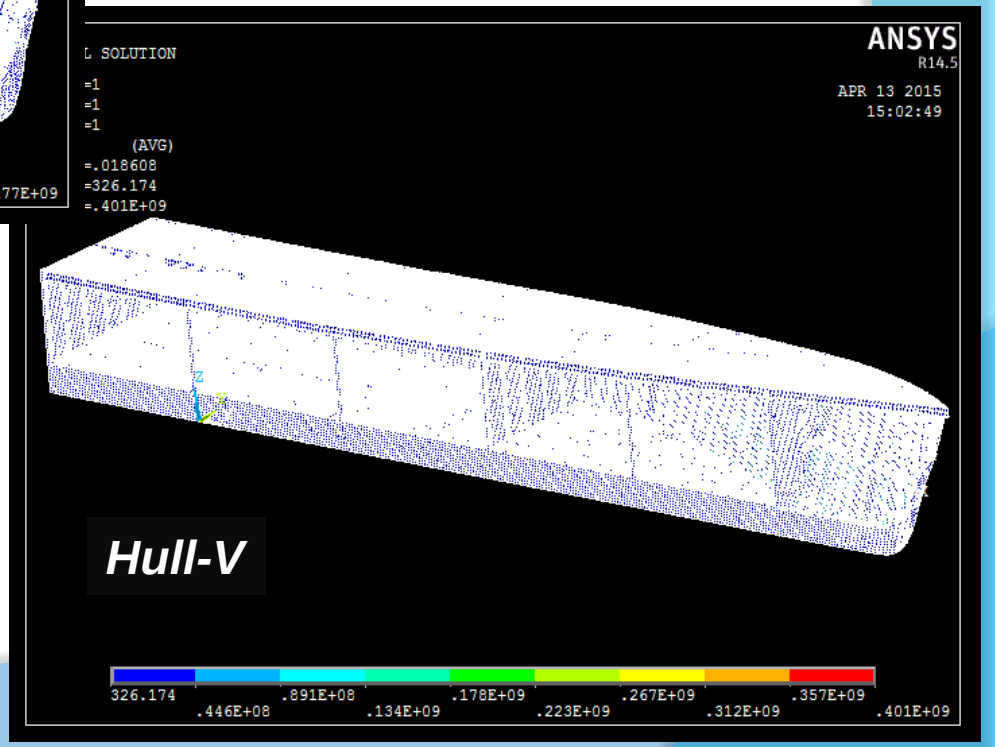




Perbandingan Hasil Tegangan



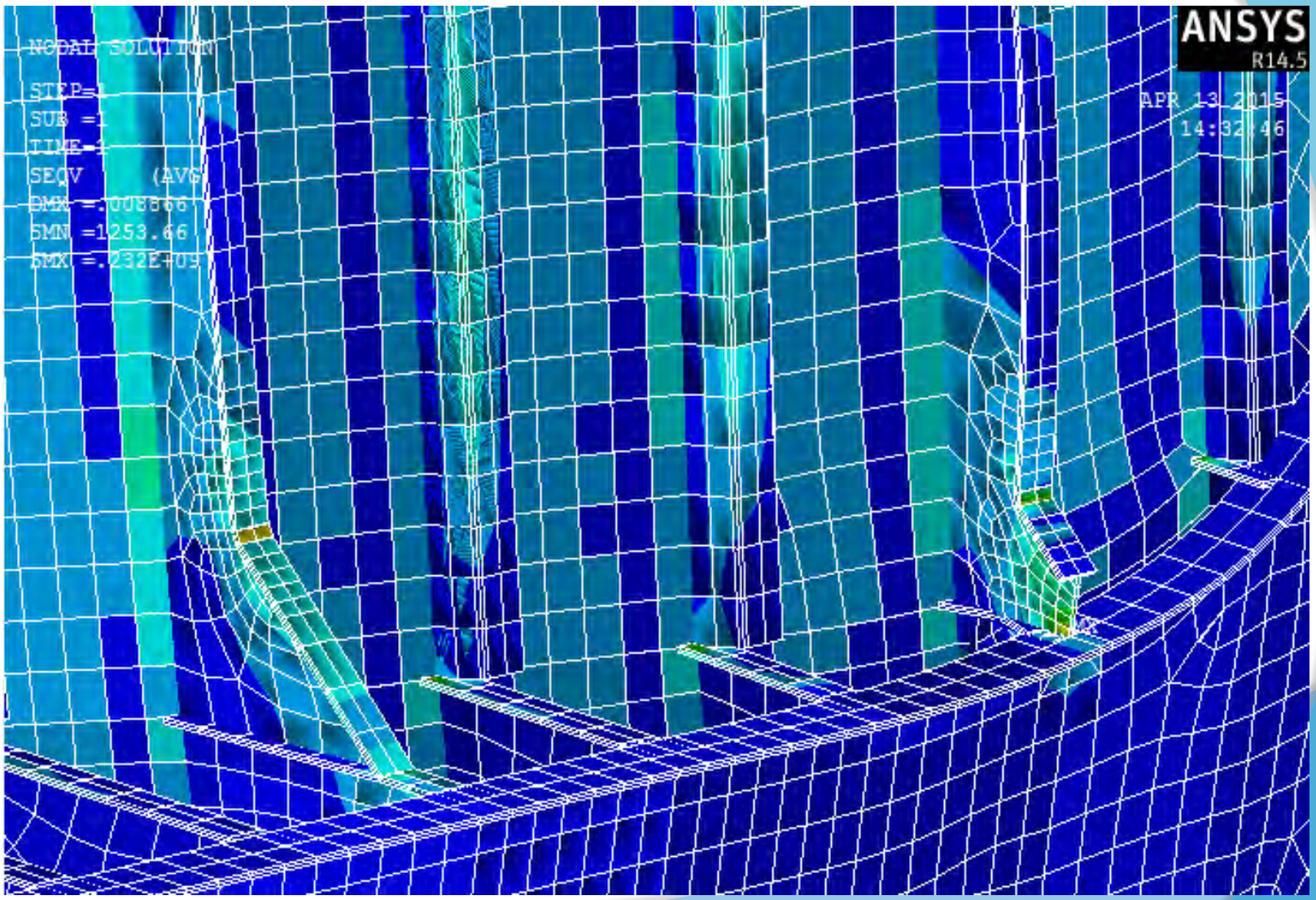
Hull-U



Hull-V

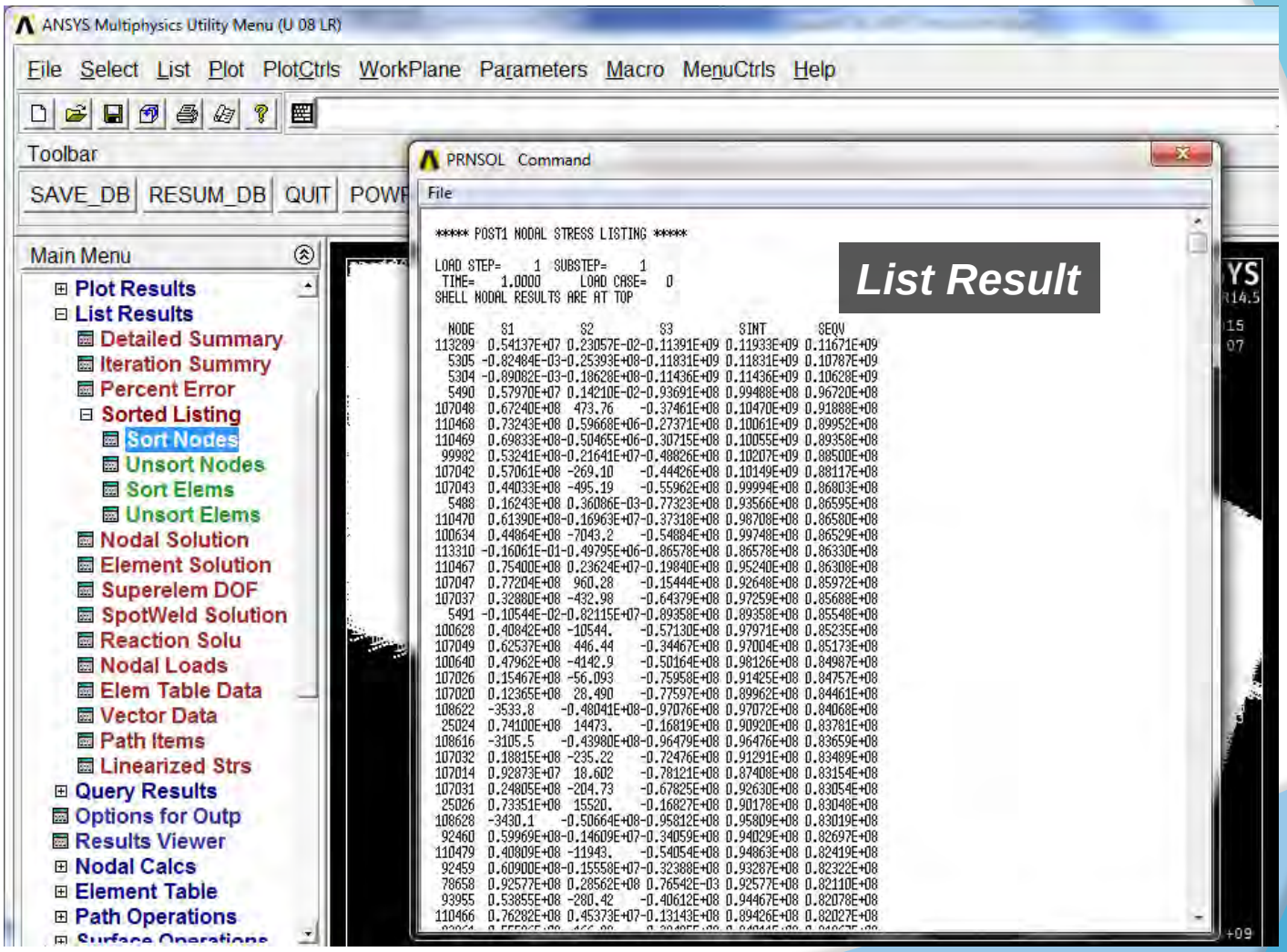
Perbandingan Hasil Tegangan

lanjutan...



Pembacaan Hasil

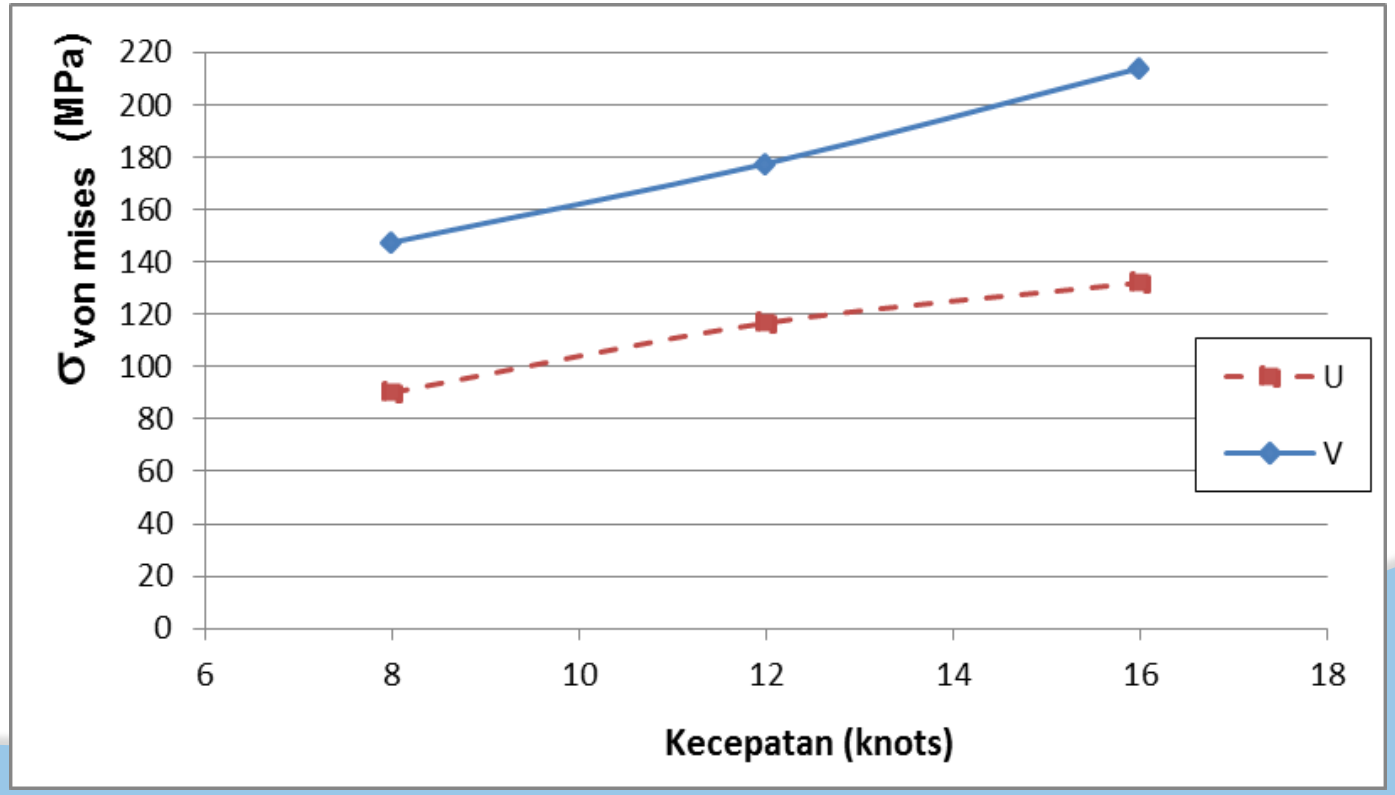
lanjutan...



Perbandingan Hasil Tegangan

lanjutan...

Hull	U			V		
Speed (knots)	8	12	16	8	12	16
Tegangan max (Mpa)	90,112	116,7	132,11	147,5	177,6	214,05
Node number	113289			114183		
Posisi	Sambungan Webframe dengan wrang pada 0,97 L					



Perbandingan Hasil Tegangan

lanjutan...

Rule – BKI Vol II *Rules for Hull* (2014) memberikan batas tegangan ijin untuk kapal L < 90 m

σ_{ijin} = $18{,}5\ \frac{\sqrt{L}}{k}$

L = 60 meter

K = 1

σ_{ijin} = 18,5*(60)^(1/2)/1

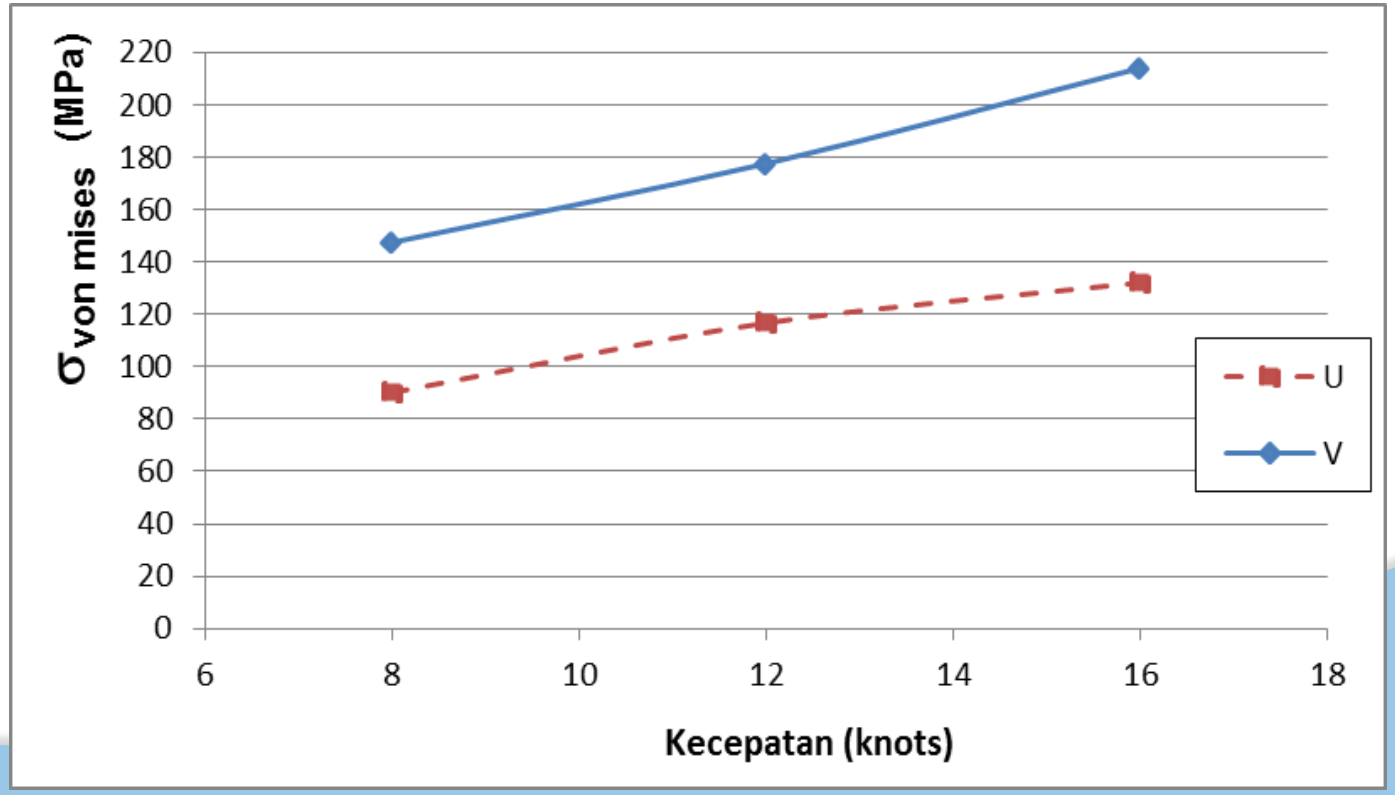
= 143,3 Mpa

lambung **U memenuhi** kriteria tegangan ijin untuk semua kondisi kecepatan dinas. Untuk lambung **V**, nilai tegangan ijinnya **tidak memenuhi** untuk semua kondisi kecepatan

Perbandingan Hasil Tegangan

lanjutan...

Hull	U			V		
Speed (knots)	8	12	16	8	12	16
Tegangan max (Mpa)	90,112	116,7	132,11	147,5	177,6	214,05
Node number	113289			114183		
Posisi	Sambungan Webframe dengan wrang pada 0,97 L					



Perbandingan Hasil Tegangan

lanjutan...

Lambung **V** adalah lambung yang mempunyai bentuk **lebih mematah**. Hal tersebut yang menyebabkan **tegangannya** lebih **tinggi** dari pada lambung berbentuk **U**. Seperti halnya mendesain sebuah **terowongan**, kebanyakan lebih memilih bentuk **tumpul** atau **circular** dari pada bentuk yang memiliki **sudut**.

Perbandingan *Fatigue*

Hull	U			V		
Speed (knots)	8	12	16	8	12	16
S_0 (Mpa)	90,112	116,7	132,11	147,5	177,6	214,05
Node number	113289			114183		
Posisi	Sambungan Webframe dengan wrang pada 0,97 L					
SCF	1,1	1,1	1,1	1,1	1,1	1,1
$S_1 = S_0$ x SCF (Mpa)	99,1232	128,37	145,321	162,25	195,36	235,455
K	1,57E+11	1,57E+11	1,57E+11	1,57E+11	1,57E+11	1,57E+11
m	3	3	3	3	3	3
Log K	11,197	11,197	11,197	11,197	11,197	11,197
m Log S	5,988526	6,325391	6,486985	6,630554	6,872507	7,115724
Log N	5,208479	4,871614	4,71002	4,566451	4,324498	4,081281
N_0	161613,9	74407,05	51288,45	36851,11	21110,46	12058,16
Tebal Plat	10	10	10	10	10	10
N	291941,5	134409,9	92648,12	66568,32	38134,21	21782,01
Jumlah Slamming / tahun	2314	13562	37819	1694	10721	31007
Umur (tahun)	126,1631	9,910769	2,449777	39,29653	3,556964	0,702487

Perbandingan *Fatigue*

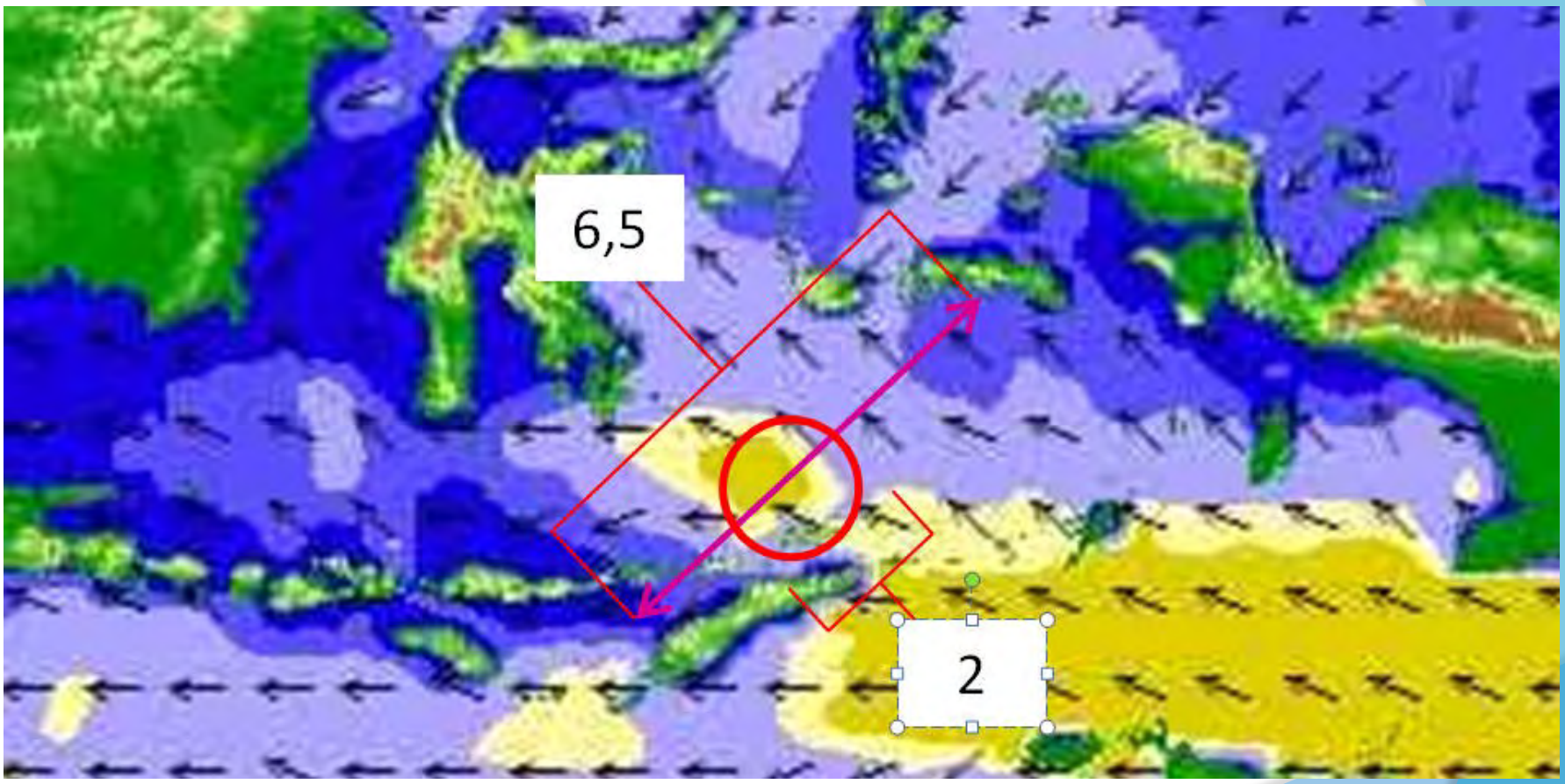
lanjutan...

Jika kapal diperhitungkan waktu pelayarannya dengan asumsi sebagai berikut :

1. Rute : Kupang – Ambon – Kupang
2. Jarak : 2 x 487 nm
3. Jadwal pelayaran : seminggu satu kali rute pulang pergi
4. Waktu docking : 1 bulan = 4 minggu
5. Areal bergelombang : 2/6,5 rute
6. 1 tahun : 52 minggu

Perbandingan *Fatigue*

lanjutan...



Perbandingan *Fatigue*

lanjutan...

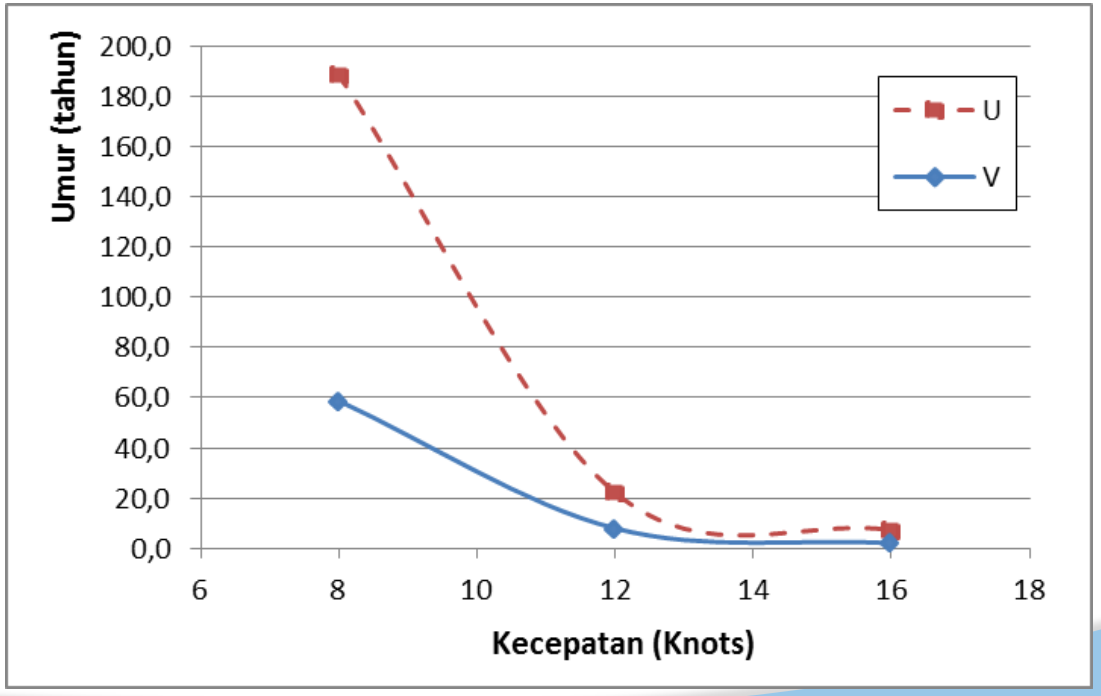
jumlah *slamming* per tahun =

jumlah *slamming* pertahun awal x [{52 minggu – 4 minggu} x {2 x 487 nm / (kecepatan kapal x 24 jam x 7 hari)}] / 52 minggu

Perbandingan *Fatigue*

lanjutan...

Lambung	U			V		
Kecepatan (knots)	8	12	16	8	12	16
Jumlah *slamming* / tahun awal	2314	13562	37819	1694	10721	31007
Jumlah *slamming* / tahun setelah diasumsi	1548	6048	12650	1134	4781	10371
N	291941,5	134409,9	92648,12	66568,32	38134,21	21782,01
Umur (tahun)	188,6	22,2	7,3	58,7	8,0	2,1



Lambung **V** harus diberi **penguat tambahan** agar tegangannya tidak terlalu besar

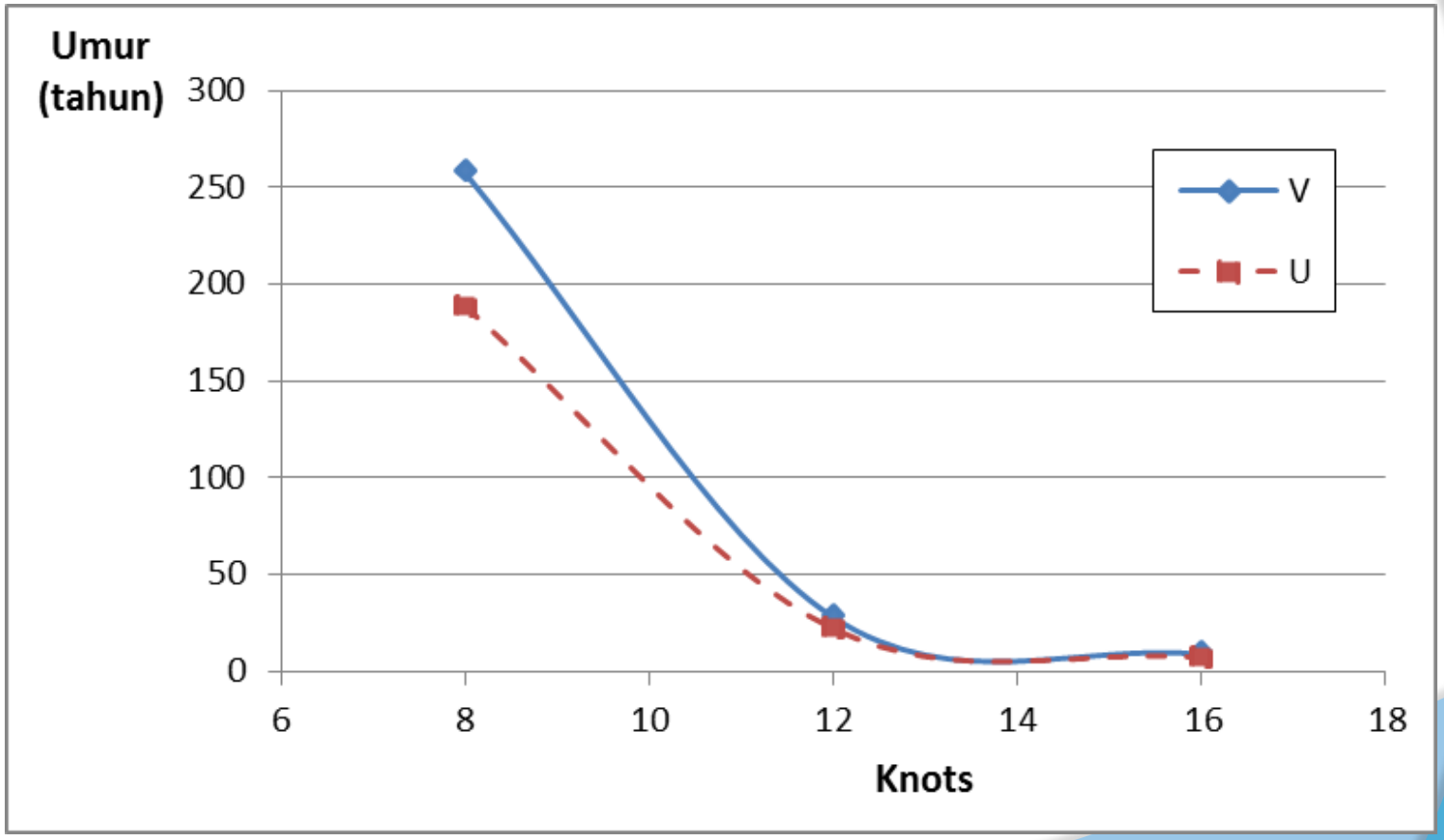
Perbandingan *Fatigue*

lanjutan...

Hull	U			V		
Speed (knots)	8	12	16	8	12	16
S_0 (Mpa)	90,112	116,7	132,11	90,112	116,7	132,11
Node number	113289			114183		
Posisi	Sambungan Webframe dengan wrang pada 0,97 L					
SCF	1,1	1,1	1,1	1,1	1,1	1,1
$S_1 = S_0$ x SCF (Mpa)	99,1232	128,37	145,321	99,1232	128,37	145,321
K	1,57E+11	1,57E+11	1,57E+11	1,57E+11	1,57E+11	1,57E+11
m	3	3	3	3	3	3
Log K	11,197	11,197	11,197	11,197	11,197	11,197
m Log S	5,988526	6,325391	6,486985	5,988526	6,325391	6,486985
Log N	5,208479	4,871614	4,71002	5,208479	4,871614	4,71002
N_0	161613,9	74407,05	51288,45	161613,9	74407,05	51288,45
Tebal Plat	10	10	10	10	10	10
N	291941,5	134409,9	92648,12	291941,5	134409,9	92648,12
Jumlah Slamming / tahun	1548	6048	12650	1134	4781	10371
Umur (tahun)	188,5927	22,22385	7,323962	257,444	28,11334	8,933383

Perbandingan *Fatigue*

lanjutan...



KESIMPULAN

1. Lambung kapal berbentuk **U** mempunya **peluang**, **jumlah** dan **tekanan** *slamming* **lebih besar** dari pada lambung kapal berbentuk **V**.

2. Untuk beban yang sama, lambung kapal berbentuk **V** memiliki **tegangan lebih besar** dari pada lambung kapal berbentuk **U**.

3. Untuk beban yang sama namun intensitas berbeda, lambung kapal berbentuk **U** mempunyai harga ***fatigue*** *life* **lebih lama** dari pada lambung kapal berbentuk **V**.

Terima Kasih