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The effect of centre of gravity height on statical stability calculations for a vessel free to trim.

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THE EFFECT OF CENTRE OF GRAVITY HEIGHT ON STATICAL STABILITY CALCULATIONS FOR A VESSEL FREE TO TRIM

INTRODUCTION

The popularity of stern trawlers, vessels which commonly experience heavy trims, has prompted the Department of Trade to modify the form taken by the statical stability data submitted to them for approval.

The conventional cross curves of stability, calculated at a constant trim, are now to be replaced by cross curves which allow the vessel to trim freely whilst the righting lever is calculated for a series of roll angles and displacements.

Discussion

When calculating cross curves, the centre of gravity of the vessel is assumed to be at the keel and when constructing a GZ curve from the cross curves a simple correction for the actual centre of gravity height gives the required result at that trim.

For a vessel free to trim however an artifical decrease of the centre of gravity height to the keel will cause an error in the calculated trim value, and a corresponding error in the KN value and freeboard values. This effect is shown by the small amount of data included in this report which were calculated for a proposed fishing vessel of conventional form. The principal dimensions of the vessel are as follows:

LENGTH BP	20.42 m
LENGTH OA	22.86 m
BEAM MLD	6.4 m
DEPTH MLD	3.2 m
DEPTH TO SHELTER DECK	5.8 m

Free trimming statical stability calculations were carried out for inital trim values of 1m by the head, 1m by the stern and level. Data are presented for light and loaded conditions in each case the calculation was carried out both with an assumed centre of gravity height of 3m (Table 2), and with the centre of gravity taken at the keel (Table 1).

All results are tabulated in metre units:
WL, VCB, LCB, GZ, KN, in metres,
VOL in cubic metres.

N.B. Values tabulated as 1.2846 @2
This is identically equal to 128.46

The values for KN in table 2 were derived from the GZ values using the formula $KN = GZ + VCG \sin\theta$ where θ is the angle of heel..

Table (2) therefore gives correct values for KN and trim and the values presented in table 1 are merely approximations. Comparison of tables 1 and 2 reveals that for this particular vessel, errors become considerable when trimmed by the stern, since the trim increases with increasing heel angle. Consider for example the case when Volume = 247.98 m^3 and intial trim = 1 m. With a heel angle of 45°, the error in KN is 1.3% and the error in trim is 0.4 m, when VCG is assumed to be at the keel.

When the vessel is trimmed by the bow, as in the case where Volume = 115.25 m^3 and trim = 1m, it first continues to trim by the bow, but as heel angle increases beyond 45° the direction of trim change is reversed. With a heel angle of 60°, the trim is back to - 0.98m and the results are correct in both tables. Discrepancies do occur however at other heel angles when the trim is somewhat different to its initial value.

Significant errors occur even in the case when the vessel is initially at level trim since this vessel experiences 2.35m of trim when heeling to 90%.

At this point the error in KN is 1% and the error in trim 0.47m.

Conclusions

When calculating cross curves of stability using the free to trim method a representative VCG height should be used and the results corrected back to KN values for presentation.

When calculating cross curves using the free to trim method with the assumed VCG on the keel the errors in KN and freeboard are proportinal to trim change and may become significant.

TABLE (1)

VCG= 0.00

VOLUME= 1.2846@ 2

LCB= -1.99

WL	TRIM	VCB	ANGLE OF HEEL	GZ
2.00	1.00	1.38	0.00	0.00
2.01	0.97	1.41	10.00	0.65
2.05	0.87	1.51	20.00	1.25
2.11	0.80	1.65	30.00	1.77
2.24	0.83	1.92	45.00	2.37
2.37	1.01	2.32	60.00	2.88
2.53	1.49	2.80	75.00	3.21
2.73	2.01	3.19	90.00	3.19

VOLUME= 2.4798@ 2

LCB= -2.10

WL	TRIM	VCB	ANGLE OF HEEL	GZ
3.00	0.99	1.97	0.00	0.00
3.05	1.17	1.99	10.00	0.55
3.14	1.47	2.04	20.00	1.07
3.25	1.77	2.12	30.00	1.57
3.41	2.22	2.34	45.00	2.27
3.60	2.68	2.59	60.00	2.78
3.83	3.07	2.82	75.00	3.04
4.07	3.41	3.05	90.00	3.05

VOLUME= 1.1525@ 2

LCB= 0.53

WL	TRIM	VCB	ANGLE OF HEEL	GZ
2.00	-1.00	1.29	0.00	0.00
2.01	-1.02	1.33	10.00	0.60
2.04	-1.07	1.42	20.00	1.18
2.08	-1.14	1.57	30.00	1.71
2.15	-1.16	1.90	45.00	2.40
2.25	-0.98	2.40	60.00	3.02
2.39	-0.69	2.99	75.00	3.44
2.57	-0.31	3.42	90.00	3.43

VOLUME= 2.2708@ 2

LCB= -0.09

WL	TRIM	VCB	ANGLE OF HEEL	GZ
3.00	-1.00	1.88	0.00	0.00
3.01	-1.00	1.90	10.00	0.60
3.03	-0.98	1.97	20.00	1.18
3.08	-0.89	2.09	30.00	1.73
3.17	-0.58	2.34	45.00	2.44
3.29	-0.19	2.64	60.00	2.96
3.50	0.17	2.92	75.00	3.20
3.78	0.55	3.22	90.00	3.22

TABLE (1) (CONTD).

VOLUME= 2.36700 2

LCB= =1.13

WL	TRIM	VCB	ANGLE OF HEEL	GZ
3.00	-0.00	1.90	0.00	0.00
3.01	0.01	1.92	10.00	0.60
3.07	0.12	1.99	20.00	1.15
3.15	0.33	2.08	30.00	1.66
3.27	0.72	2.32	45.00	2.36
3.43	1.15	2.60	60.00	2.87
3.65	1.52	2.87	75.00	3.12
3.91	1.88	3.12	90.00	3.13

TABLE (2)

VCG= 3.00
VOLUME= 1.28460 2
LCB= -1.84

WL	TRIM	VCB	ANGLE OF HEEL	GZ	KN -GZ
2.00	1.00	1.38	0.00	0.00	0.00
2.01	0.96	1.41	10.00	0.12	0.64
2.05	0.85	1.51	20.00	0.23	1.26
2.12	0.77	1.65	30.00	0.27	1.77
2.24	0.80	1.92	45.00	0.25	2.37
2.37	1.01	2.32	60.00	0.28	2.88
2.53	1.56	2.79	75.00	0.30	3.20
2.73	2.19	3.17	90.00	0.17	3.17

VOLUME= 2.47980 2
LCB= -1.96

WL	TRIM	VCB	ANGLE OF HEEL	GZ	KN -GZ
3.00	1.00	1.97	0.00	0.00	0.00
3.05	1.23	1.99	10.00	0.02	0.54
3.14	1.62	2.04	20.00	0.03	1.06
3.25	2.03	2.13	30.00	0.06	1.56
3.42	2.63	2.34	45.00	0.12	2.24
3.61	3.23	2.58	60.00	0.15	2.75
3.85	3.77	2.80	75.00	0.10	3.00
4.09	4.21	3.01	90.00	0.02	3.02

VOLUME= 1.15250 2
LCB= 0.39

WL	TRIM	VCB	ANGLE OF HEEL	GZ	KN -GZ
2.00	-1.01	1.29	0.00	0.00	0.00
2.01	-1.03	1.33	10.00	0.08	0.60
2.04	-1.09	1.42	20.00	0.15	1.18
2.08	-1.17	1.57	30.00	0.21	1.71
2.15	-1.18	1.90	45.00	0.28	2.40
2.25	-0.98	2.41	60.00	0.42	3.02
2.39	-0.66	2.99	75.00	0.54	3.44
2.57	-0.22	3.41	90.00	0.42	3.42

VOLUME= 2.27080 2
LCB= -0.23

WL	TRIM	VCB	ANGLE OF HEEL	GZ	KN -GZ
3.00	-1.01	1.88	0.00	0.00	0.00
3.01	-1.01	1.90	10.00	0.08	0.60
3.03	-0.99	1.97	20.00	0.16	1.19
3.08	-0.87	2.09	30.00	0.23	1.73
3.17	-0.50	2.34	45.00	0.32	2.44
3.30	-0.04	2.63	60.00	0.35	2.95
3.51	0.40	2.91	75.00	0.29	3.19
3.79	0.85	3.20	90.00	0.20	3.20

TABLE (2) (CONTD)

VOLUME= 2.36708 2
LCB= -1.13

WL	TRIM	VCB	ANGLE OF HEEL	GZ	KN GZ
3.00	-0.00	1.90	0.00	0.00	0.00
3.01	0.01	1.92	10.00	0.08	0.60
3.07	0.14	1.99	20.00	0.12	1.15
3.14	0.40	2.08	30.00	0.16	1.66
3.28	0.89	2.32	45.00	0.23	2.35
3.44	1.43	2.59	60.00	0.26	2.85
3.67	1.90	2.85	75.00	0.20	3.10
3.92	2.35	3.10	90.00	0.10	3.10