

Outcome 2

LESSON 10

Producing a Curve of Statical Stability



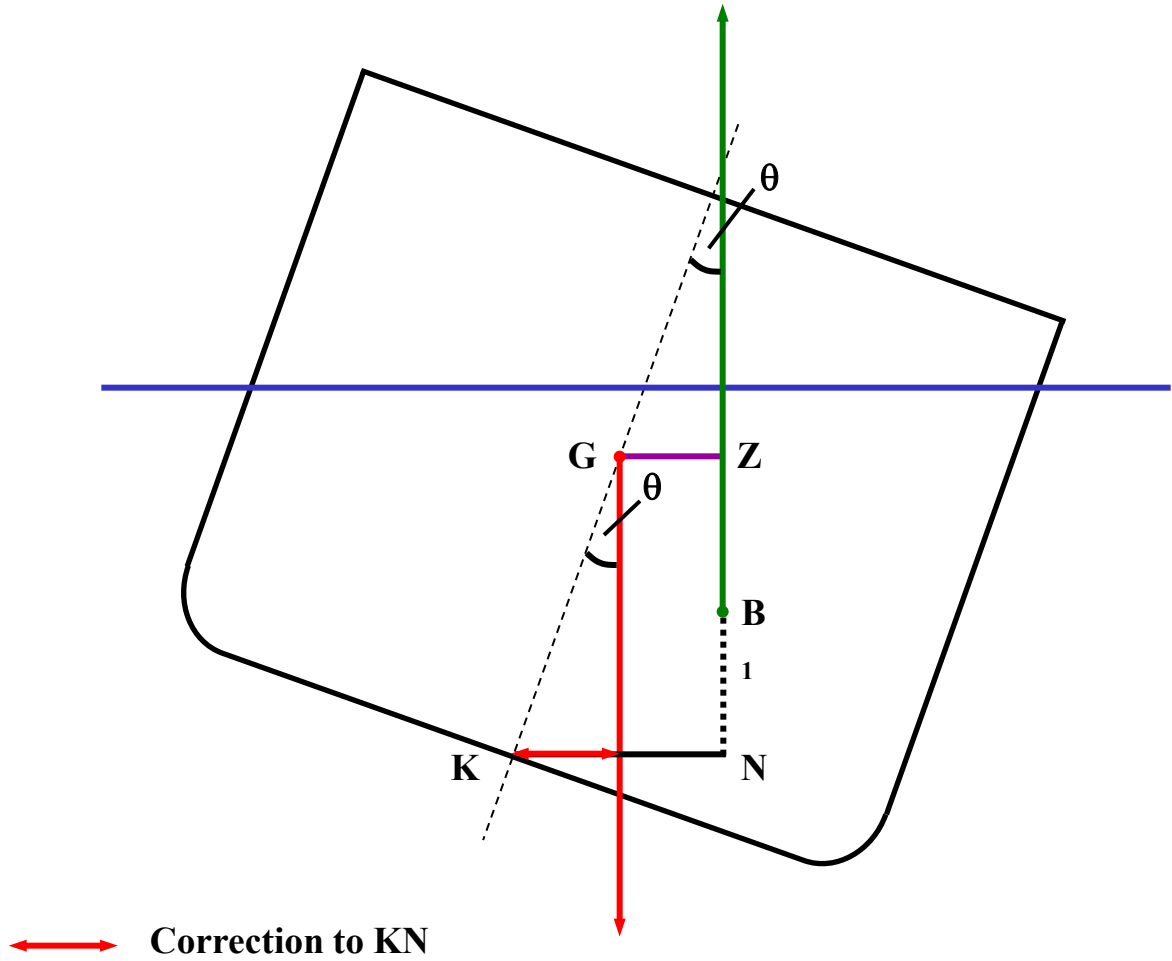
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PRODUCING A CURVE OF STATICAL STABILITY

As a ship heels B constantly moves, it's position is dependent on:

- * the displacement (draught) of the ship;
- * the angle of heel at any instant.

The righting lever GZ depends on the ship's KG , but because of the many possible positions of G it is convenient to consider the GZ that would exist if G was at the keel, termed KN , and to make a correction for the actual height of G above the keel.



If the figure is considered:

$$\text{Sine } \theta = \frac{\text{OPP}}{\text{HYP}}$$

$$\text{Sine } \theta = \frac{\text{Correction to KN}}{\text{KG}}$$

Therefore: $\text{Correction to KN} = \text{KG} \times \text{Sine } \theta$

and:

$$\text{GZ} = \text{KN} - (\text{KG Sine } \theta)$$

Cross curves of stability (KN curves) are provided by the builder to allow GZ values to be determined for any value of displacement and KG. Sometimes the values may be tabulated.

It is usual that KN values are given for angles of heel at 10° or 15° intervals.

An example of such values is given;

	ANGLE OF HEEL - DEGREES						
DISPLACEMENT (t)	12	20	30	40	50	60	75
15000	1.72	2.98	4.48	5.72	6.48	6.91	7.05
14500	1.73	2.98	4.51	5.79	6.58	6.95	7.08
14000	1.74	2.98	4.55	5.85	6.68	7.00	7.10
13500	1.75	2.99	4.58	5.90	6.73	7.08	7.13
13000	1.77	3.00	4.62	5.93	6.78	7.14	7.16
12500	1.78	3.03	4.63	5.98	6.83	7.18	7.18
12000	1.78	3.05	4.65	6.04	6.88	7.20	7.20
11500	1.80	3.12	4.70	6.10	6.93	7.25	7.22
11000	1.82	3.15	4.75	6.15	6.98	7.30	7.24
10500	1.83	3.19	4.79	6.18	7.02	7.35	7.27
10000	1.86	3.23	4.83	6.22	7.07	7.40	7.30
9500	1.93	3.28	4.91	6.25	7.11	7.45	7.35
9000	2.00	3.36	5.00	6.28	7.18	7.50	7.40
8500	2.05	3.43	5.04	6.32	7.20	7.55	7.41
8000	2.10	3.52	5.10	6.36	7.22	7.60	7.42
7500	2.17	3.62	5.18	6.38	7.24	7.65	7.46
7000	2.22	3.70	5.25	6.40	7.26	7.70	7.50
6500	2.32	3.85	5.35	6.43	7.27	7.70	7.51
6000	2.42	4.00	5.45	6.48	7.28	7.70	7.52
5500	2.57	4.15	5.55	6.53	7.29	7.68	7.51
5000	2.72	4.32	5.65	6.58	7.30	7.66	7.50
KN VALUES ARE FOR HULL AND FORECASTLE ONLY.							
KN VALUES ARE CALCULATED FOR VESSEL ON AN EVEN KEEL							
AND FIXED TRIM							

Note

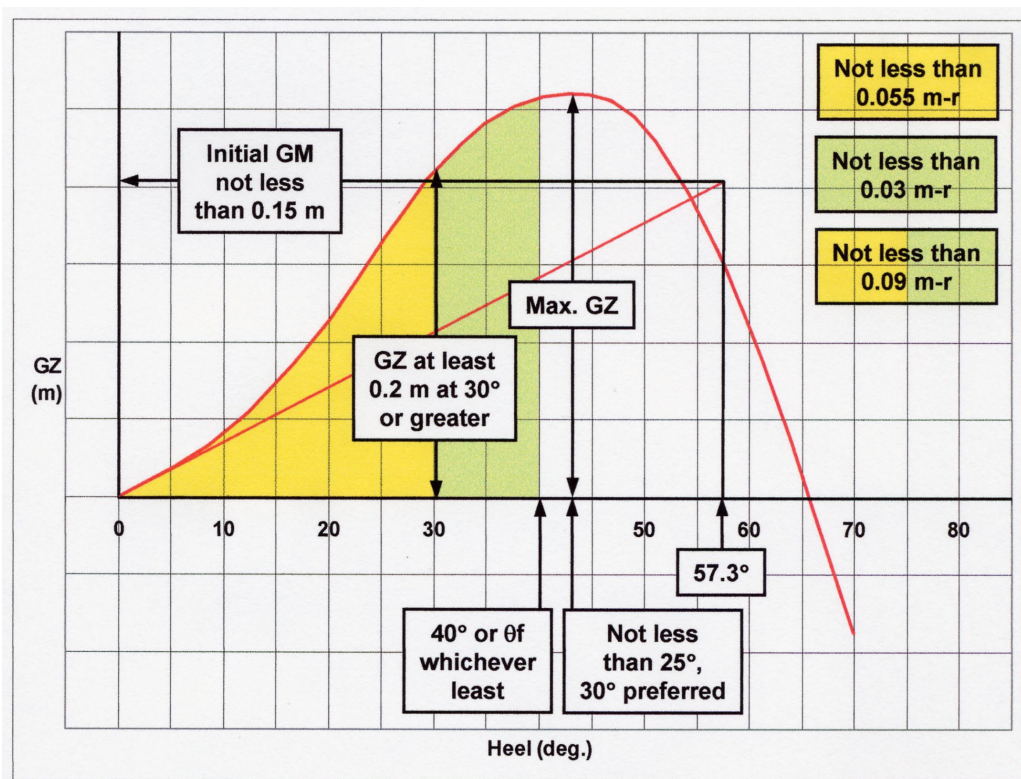
When KN values are tabulated as shown interpolation for displacements other than those stated may be done, but it should be borne in mind that the rate of change of KN will not be linear.

Procedure for constructing a curve of statical stability

1. Determine the ship's displacement and effective KG for the condition being considered (effective KG being that taking into account free surfaces in tanks).
2. From hydrostatic data find value of KM for ship's displacement.
3. Find GM_{FLUID} using: **$GM = KM - KG$**
4. Enter KN tables (or curves) and obtain KN value in metres for each angle of heel given.
5. Using: **$GZ = KN - (KG \text{ Sine } \theta)$** determine GZ values for angles of heel given.
6. Plot the GZ values.
7. Before joining all the points on the curve construct a vertical at 57.3° and from the base upwards mark off the value of the effective GM (using the GZ scale). From this point draw a straight line to the origin of the curve to be drawn. This will indicate the initial trend of the curve at small angles of heel and will assist in sketching the actual curve between the origin and the first plotted GZ value.

(GZ and GM are closely related at small angles of heel.)

Intact stability requirements - M.S. (Load Line) Regulations 1998



- * *Area 0° to 30° to be not less than 0.055 m-r;*
- * *Area 0° to X° to be not less than 0.09 m-r;*
- * *Area 30° to X° to be not less than 0.03 m-r;*
- * *X° is equal to 40° or any lesser angle at which progressive down-flooding would take place;*
- * *Maximum GZ to be not less than 0.20 m and to occur at an angle of heel of 30° or greater;*
- * *Initial GM to be not less than 0.15 m.*

Procedure to verify that a ship's loaded condition complies with legislation requirements

Consider the following example:

A ship has a displacement of 12000 t, KG 8.22 m and a KM of 8.54 m. Using the KN values provided determine whether the ship's loaded condition complies with the requirements of the *M.S. (Load Line) Regulations 1998*.

1. Determine the GZ values.

KG	8.22	KM	8.54	GM	0.32			
HEEL	0	12	20	30	40	50	60	75
KN (m)	0.00	1.78	3.05	4.65	6.04	6.88	7.20	7.20
(KG Sin Heel)	0.00	1.71	2.81	4.11	5.28	6.30	7.12	7.94
GZ (m)	0.00	0.07	0.24	0.54	0.76	0.58	0.08	-0.74

2. Plot the GZ curve.

Obtain a value for 10° heel so that GZ values are available at 10° intervals up to 40° heel.

3. Using Simpson's rules calculate the areas under the curve (0°- 30° and 0°- 40° and 30°- 40°)

Area 0° - 30°

Heel	GZ (ord)	SM	Area Fn.
0	0	1	0
10	0.07	3	0.21
20	0.24	3	0.72
30	0.54	1	0.54
			1.47

$$\text{Area} = 3/8 \times 10/57.3 \times 1.47 = 0.096 \text{ m-r } (0.055)$$

Area 0° - 40°

Heel	GZ (ord)	SM	Area Fn.
0	0	1	0
10	0.07	4	0.28
20	0.24	2	0.48
30	0.54	4	2.16
40	0.76	1	0.76
			3.68

$$\text{Area} = 1/3 \times 10/57.3 \times 3.68 = 0.214 \text{ m-r } (0.090)$$

Area 30° - 40°

$$\text{Area} = 0.214 - 0.096 = 0.118 \text{ m-r } (0.03)$$

Max GZ and angle at which it occurs
Satisfies the requirements.

Effective GM

$$\text{KM} - \text{KG} = \text{GM};$$

$$8.54 - 8.22 = 0.32 \text{ m } (0.15)$$

SHIP COMPLIES