MILITARY TECHNICAL COLLEGE

CAIRO - EGYPT

STABILITY ANALYSIS FOR NILE'S VESSELS

BY

A.A.M. AMIN*

ABSTRACT

The final stability assesment for Nile Cruises vessels,Launches and Ferries taken into account the effect of shapes and the actual location of the C.G. are important for the safety considerations for such vessels. Analysis for gathered data for various existing vessels are introduced with curves and tables to give an aid for owners and builders in selecting principle dimensions for preliminary design stages. Practical application is given to illustrate the benifit of the presested analysis and to show the effect of proposed alteration to improve the stability characteristics for a given vessel.

INTRODUCTION

Among the other safety requirements for vessels in River Nile, the stability and the ability to survive in various weather conditions have to be carefully examined and also to avoid grounding and capasizing.

Having considered the loss of human lives and property one reaches to a conclusion that it is essential to develop some reliable guid lines to be followed in the design and operation of vessels of different functions.

Accomulated data concerned the nature of the River Nile indicate that a successful design should consider the environmental constraints, which include maximum permissible values of 1.5 m draft, 12 m for breadth, 72 m for length, 10 m height of clearance, 10 knots for running speed, and 100 km/hr for wind speed. It goes on to compare between the existing criteria and presents a method for stability assesment. The results found from the application of such method are plotted in curves shown in Fig. 2,3, and 4 for three groups of vessels defined below to demonstrate its potential. However, whatever methods are used to make these calculations, the methods must reflect established characteristics for the type of vessel which is being investigated. One of the aims of this paper is to restate these principles and to introduce the variables affecting the capability of these vessels to cope its functions.

* LECTURER,SHIP ENGINEERING DEPT.
FACULITY OF ENGINEERING& TECHNOLOGY
SUEZ CANAL UNIVERSITY
PORT-SAID, EGYPT.

Analysis based on the available data which are gathered from vessels built by the local shipyards in the past decade enable to achieve comparison of similar vessels as indicated in tables 2 and 3,Figs 8,10,11,12,and13. These vessels are classified as follows :-

a- FIRST GROUP

Residential Nile Cruises (NCV),its route are from Cairo to Aswan and Vice-Versa . These vessels are well docorated and should have many facilities for tourists comfort, such as swimming pool, dining room, bed rooms,...etc. as shown in Fig 14 .

b- SECOND GROUP

Ferries intended to carry a restricted number of passengers, cars, lorries, and animals between the two banks of the River Nile.

c-THIRD GROUP

Vessels intended for carrying number of passengers for short voyages along the River Nile (Launches) .

A practical example is given to indicate the neccessity of such investigation and corrections which should be considered to find the final GZ curve .

2 - REVIEW OF EXISTING WORK

The stability critiria for measuring the capability of different shapes of vessels was the main point of theargument for many authors. This section is devoted to present briefly some of the researches which have been done in last decade.

George C. Nickum (1), indicated that two standards for intact stability put in regulatory form in the design of new vessels. They are the wind heel and passengers heel criteria. Also the GZ curve calculated based on the vessel on an even keel condition and did not take into account the 61 cm (24") trim by the stern which might existed at the time of the casualty of some vessels. Beside that the deck edge could be reached to the water level and the freeboard were only a few inches. Stability calculation made for a vessel has this trim condition and the GZ curve plotted and the results were 7.6 cm(0.25 ft), the angle of the GZ occured at 10 degs, the total range of positive maximum stability was only 22 degs. Of course this vessel was satisfying the IMCO stability criteria in the even keel condition.

The author believed that the above is a clear-cut case where the IMCO criterion was directly responsible for permitting a vessel to operate in a clearly unsafe condition. Ozkan(2), reached to a conclusion that there is a need of producing some reliable guide lines to be used in the design and operation of ships. The aim of the study was for the applications of the theory for forced rolling motion. A proposed GM criterion may be given as follows:-

$$\overline{GM} = \frac{1.89}{\Delta} \sqrt[3]{(E + WM) \cdot e}$$

where

WM = wind gust moment in t.m.

. . .

E = /e, (t)/ t.m
(e,t) = time dependent wave exicitation

Burcher (3), suggested avoiding lowering of the metacentre due to roll motion, change of trim and the sea profile relative to the ship.

The ballast may lowering the centre of gravity, and also may lowering the metacentric height due to the increase of displacement. This results poorer speed and endurance performance. He used a pressure vector approach to find the effect of the section shape on the stability of the vessel. Curves are presented for GZ for different angles of flare varying from 0° to 24°, and indicated that as the angle of flare increases the GZ curve also increases. The slope of the side can be computed by the following formula,

$$\frac{dB}{dT} = \frac{\overline{KM} - T}{B}$$

where T and B are the draft and breadth of the vessel respectively. The approach was carried out assuming the ship motions in quasi-static condition.

Vassales, kuo, Martin and Alexander(4), presented a quasi-static approach based on the Froude-Kriloff hypothesis. The roll and pitch angles were taken into consideration to find the influence of the static and dynamic pressure on the wetted surface of the ship. The result was the pitch angle effect on the both GZ and GM is negligible.

Check was carried out on the incident wave profile caused by the presence of the ship, and the consequant change in the GZ(θ,t) computation. Assumption was made that sinusoidal waves of arbitrary length and height meet the ship in an arbitrary direction.

Kobylinski(5), collected stability data for ships capsized and for ships known to have satisfactery stability and found that the basis of analysis stability curves with the range below 60° and within the maximum below 30° insufficient. IMCO intreduced in 1968 modified criteria for static and dynamic conditions for passengers and cargo vessels under 100 m. in length. The weather criterion refers to situation inwhich ship is positiond on beam waves and wind heeling moment and balanced with righting moment, taken into account rolling angle. For the safety of the vessel one should consider, the human error, faulty construction in the stability assesment. Krappinger (6), pointed out that the advanced mathematical models are not sufficient in order to design safe ship. The suggested approach is by determining of the multi dimensional joint probability distribution, and taken into account of possible wave formulations, wind and gust data, icing, loading condition etc. Examples to illustrate the proposed theoretical approach not given.

Bird and odabasi (8) presented brief review of the past developments of the static and dynamic stability criteria until 1975. They found that IMCO criteria deal with all types of ships and there are very little difference for judging the stability of ships from Rohola's results.

They devided the stability assesment into three categories as follows:-
1- Formulae for GM& Freeboard values for small vessels.
2- Minimum requirements for GM and statical and dynamical righ-ting levers for all types of ships (IMCO).

3- Estimation of heeling arm for comparison of righting levers, with over simplifications are involved (USSR, Eastern Eurepean contries and japan).

The final conclusion is that the stability of ship can be judged by means of the righting arm curve which is determined from the geometry of the ship and the vertical location of the C.G., and by hypothetical wind and waves forces which are assumed to be potential.

They recommended that if any similar study is carried out in future it should be based on a weight statical analysis, and some altermative form of stability information should be provided which can be easily and quickly used by ship masters. Cleary (9), introduced ranges of the forms coefficients for the so-called "normal" ship for carge or passengers ships such as, C_b from 0.55, to 0.80; C_{wp} from 0.7 to 0.9, and C_m from 0.85 to 0.88. A formulae to estimate GM is as follows :-

$$GM = \frac{N\ b}{24 \Delta \tan \phi}$$

N is the number of passengers on multi deck steamers, b distance in ft from center line to geometrical center of passengers deck area on one side of center line, Δ is the displacement in long tons and ϕ is the angle of heel to deck edge of 14 degrees which ever is less. He found that a small coastal cargo was nearly capasized but fortunately because its course was so close to the sea shore, the ship grounded and kept from turning over.

Kobyliski (10), presented useful results based on data colected from casualty records and statistics including cargo, passengers, and fishing vessels. The result of the study caused capsizing of vessel in head seas is very small and can be ignored, and this agreed with IMCO statistics. For passengers vessels have poor stability, sudden capsizing in wind gust may be occured even in comparatively calm water. It was found that the number of casualities caused by gust wind is so large in proportional to the additional effects of water trapping on deck, free surface effect and action of helm.

3- EXISTING STABILITY CRITERIA FOR PASSENGERS VESSELS

Some authors have introduceed one or more the well known stability criterion for sea going vessels. we are concerned with the vessels intended to serve in the River Nile which can be considered as calm water. They are varying in forms and design parameters. for example, NCV, lauches and Ferries, i.e mostly passengers vessels. However, the required criteria should be combined with static and dynamic equilibrium conditions. Comparison was made between three well known existing criteria given breifly in table 1. These criteria are applied by the U.S Coast Gaurd, Itergovernemental Maritime consultative Organization(IMCO) and Rahola.

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TABLE 1

U.S. Coast Gaurd	IMCO	Rahola
$GZ < 0.6\ GZ_{max}$ (See Fig 1) $A_1 > 1.4\ A_2$ (represents the ship's rolling energy for 25° roll to windward) (See Fig 1) (Ref 13)	——— Area under righting arm curve ≥ 0.09 m.rad. Initial GM at least 0.15 m Passengers heeling moment not exceed 10° (Ref 13)	GZ not less than 0.2 m ANG not less than 30° (0.25 rad) E_{max} not less than 0.08 m.rad. E_{max} is the area under the righting arm curve up to the least of the following angles 40° (0.7 rad). ANG angle at which opening immerse (down floading) (Ref 13)

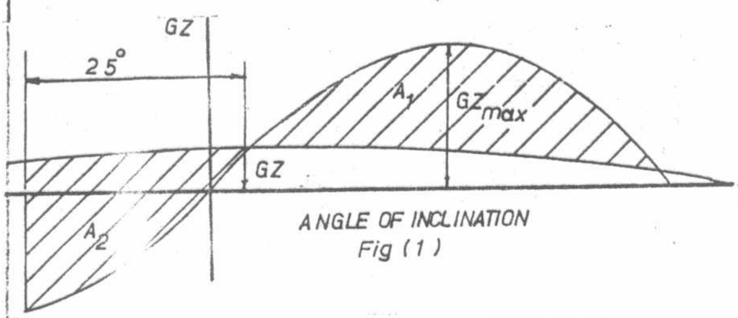


Fig (1)

STABILITY ASSESMENT

The vessel is assumed in even keel condition. Two methods may be applied as given in Ref(7), they are based on drawing equivolume waterlines at equal angular intervals by determining auxiliary waterline (Krylov methods).

Hydrostatic data were calculated, and by Tchebycheff's chart the fore and aft stations were taken, and scale 1:10 was selected for accurate measurments. The stability assesment were carried out in three stages as follows:-

Stage 1: The statical stability calculations by means of Krylov's second method.

Stage 2: Dynamic stability calculation caused by wind speed of 100 km/hr and crowding passengers in one side.

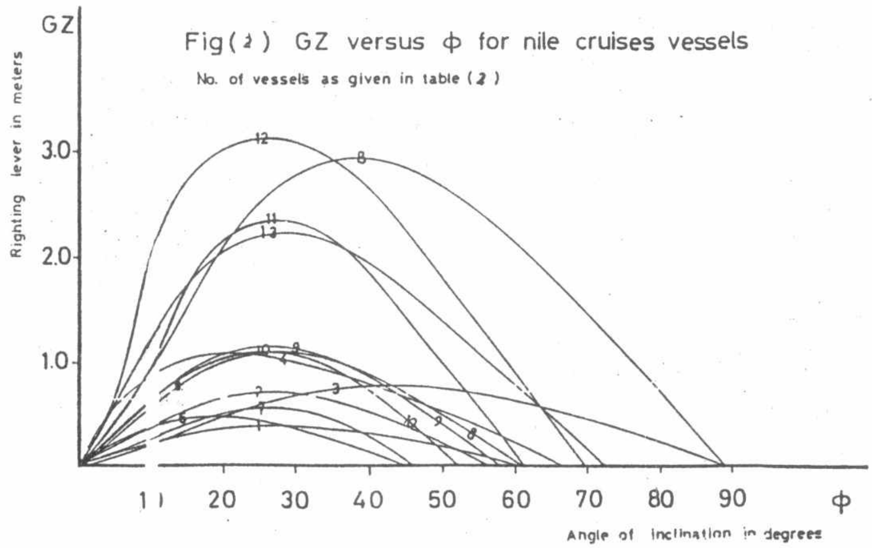
Stage 3: Conducting inclining experiments for load condition.

The results are introduced in Fig 2,3 and 4 and tables 2 and 3 for Nile cruises vessels, Ferries, and launches respectively.

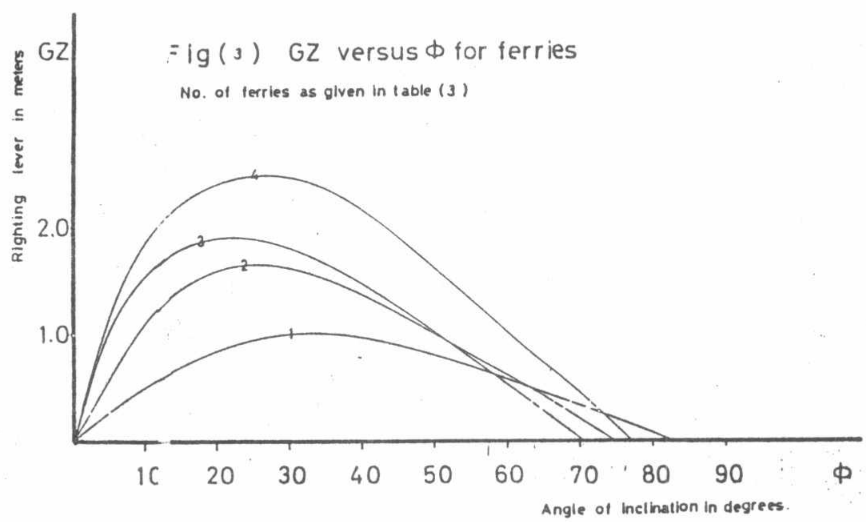
4- VARIABLES AFFECTING STABILITY CHARACTERISTICS

Whatever means used to make the previous stability calculations, the methods must reflect accurate results applicable for the existing condition of the type of vessels.

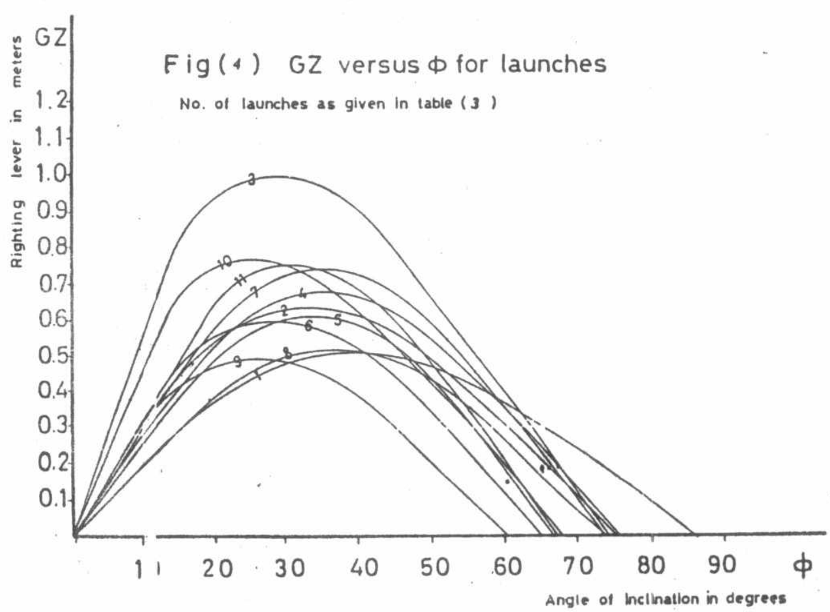
Safety of the ship is dependent mainly on the maximum righting arm and the angle at which this maximum arms occurs. One of the aims of this research is to restate the factors influence the existing stability condition.



Fig(2) GZ versus Φ for nile cruises vessels
No. of vessels as given in table (2)



Fig(3) GZ versus Φ for ferries
No. of ferries as given in table (3)



Fig(4) GZ versus Φ for launches
No. of launches as given in table (3)

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TABLE 2

Main Particulars For Some Existing River Nile's Cruises Vessels

Ship's No.	Displacement Tons	L m	L/B	L/D	B/T	GM/B	CB	No. of Pass.	Heel angle Wind	Heel angle Pass.
1	210	42	7.5	21.54	4.48	0.16	0.725	72	7º 30'	3º 30'
2	210	34.5	4.6	11.13	6.52	0.39	0.7	90	5º	2º 30'
3	227	31.6	5.6	9.58	3.73	0.22	0.76	35	3º	2º
4	318	42.2	5.28	23.44	6.67	0.43	0.79	360	2º	2º 30'
5	410	40.0	4.93	12.31	5.23	0.14	0.88	100	3º	4º
6	421	40	4.93	22.22	5.79	0.33	0.884	82	2º	1º
7	492	45.6	5.3	14.48	5.21	0.1	0.76	86	6º	5º
8	552	49.5	4.95	15.23	6.67	0.36	0.81	160	3º	2º
9	582	55.5	5.63	17.08	7.04	0.3	0.84	155	4º	2º 30'
10	662	58.5	5.85	16.71	7.14	0.25	0.87	180	3º	2º
11	950	68.8	5.98	20.54	7.67	0.38	0.84	215	1º	1º
12	1033	68.0	5.91	19.43	7.67	0.43	0.87	225	1º 30'	2º
13	1105	70.0	5.83	28.57	8.57	0.54	0.94	250	2º	1º

TABLE 3

Main Particulars For Some Existing River Nile's Ferries and Launches

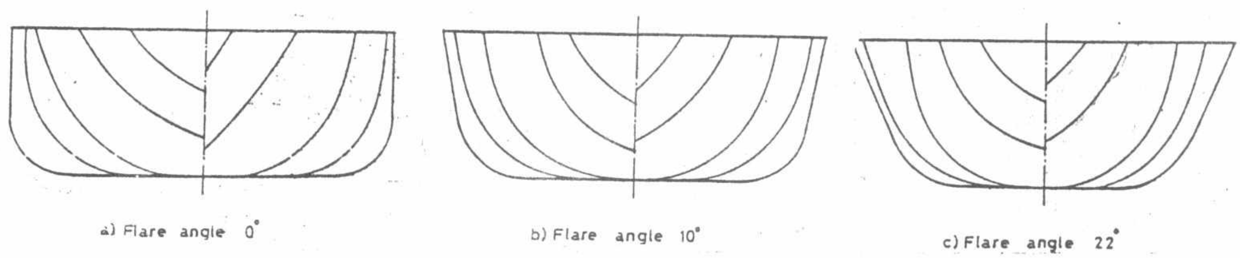
Ship's Type	No. of Vessel	Disp. Tons	L m	L/B	L/D	B/T	GM/B	C_B	No. of Pass.	Heel angle Wind	Heel angle Pass.
Motor Ferries	1	26	11	2.2	6.67	5.56	0.56	0.608	30	1º 30'	7º
	2	172	13	1.18	5.31	7.33	0.65	0.802	40	1º 30'	3º
	3	500	25	1.67	10.2	9.38	0.84	0.85	120	30'	1º
	4	152.2	16	1.23	6.4	8.13	1.32	0.743	160	1º 30'	1º 30'
Motor- Launches	1	32.6	18	4.24	9.5	4.25	0.28	0.407	112	2º 30'	6º 30'
	2	39	14	3.11	8.75	5.63	0.38	0.68	80	2º	6º
	3	53	18	3	12.4	8.0	0.5	0.62	160	1º 30'	6º
	4	60	20	3.13	7.84	5.33	0.27	0.45	160	3º	5º
	5	65.4	15	2.5	7.69	6.0	0.25	0.727	160	3º	6º
	6	70.5	18	2.7	10.28	6.2	0.32	0.632	160	3º	6º
	7	96.0	20.6	3.07	8.58	6.1	0.25	0.67	160	2º 30'	6º 30'
	8	108.3	24	4.7	10.67	4.64	0.19	0.803	120	4º	5º
	9	106.9	27.4	4.93	16.6	5.55	0.51	0.7	200	3º	6º
	10	112.1	26	4.03	15.75	6.45	0.41	0.67	240	2º	5º 30'
	11	113.2	20	3.03	9.1	6.0	0.28	0.78	160	2º 30'	5º 30'

4-1- FLARED HULL

The flare is the slant upward and outward from the vertical of a transverse section of a hull above the design waterline. Detail investigation given in (Ref 3) for the changing angles of flare from 0º up to 24º with 6º ervals, the main effect is rising of C.G. within the hull and increase the rolling motion.

The flaredhull is not likely for the Nile's cruises vessels,because the inside rooms are prefered to be vertical sides for better view and arrangements of the furnatures and decoration.

However, for launches and Ferries the flared gives wider beam at the upper deck which provides much more deck area at a lower level and meanwhile reduces the superstructure. Therefore, for equal payload and volume designs the flare hull ship can have a lower overall V.C.G. at the same time the higher centroid of hull volume will increase the range of positive stability. Fig 5 shows three selected existing body plan for launches have 0,10°, and 22° and the corresponding GZ curves is given in Fig 4, for ships no. 5,4, and 3 respectively. It is found that GZ and the range of stability increase with increasing the angle of flare for a given vessel and this agreed with the results given in Ref 3.



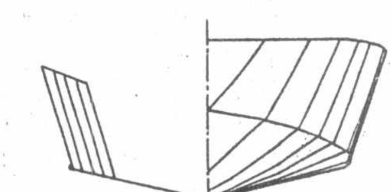
Fig(5) body plan for existing launches

4-2- DEADRISE AND ITS EFFECTS

The deadrise is known as the rise of floor and it is suggested to be minimum for the NCV to be utilized with the buoyancy of the under water part to keep the draft less than the permissible height (1.5 m), and to reduce the possibility of grounding of such vessels.

Kenneth andBarrnaby (15) introduced measurements for different speed/ length ratio concerning the behaviour of vessels in sea way. The obtained results show that for $V/\sqrt{L}$ less than 1.34, the vessel tend to settle bodily in the water where the bow has a little increase of settlement than the stern; while for $V/\sqrt{L}$ more than 1.34, the bow tends to rise and the stern to fall "Squat". Also for the hard chine hull form such as the vessel shown in Fig 6, the behaviour will be similar to that for $V/\sqrt{L}$ less that 2.0, but with more sinkage and squat.

The study is made for the data available given in tables 2 and 3, and Fig 7 which shows that $V/\sqrt{L}$ for NCV less than 0.9 assuming running speed 10 knots and its draft are closed to 1.5 m height. Therefore, these vessels will tend to settle bodily as mentioned above which is not



Fig(6)-HARD CHINE HULL.

Likely for ship's masters, but for launches $V/\sqrt{L}$ less than 1.4, and because of its drafts are less than 1.5 m and also the main function are service between the nile's banks in which the water depth is more than 1.5 m, so deadrise or the chine hull form may be used.

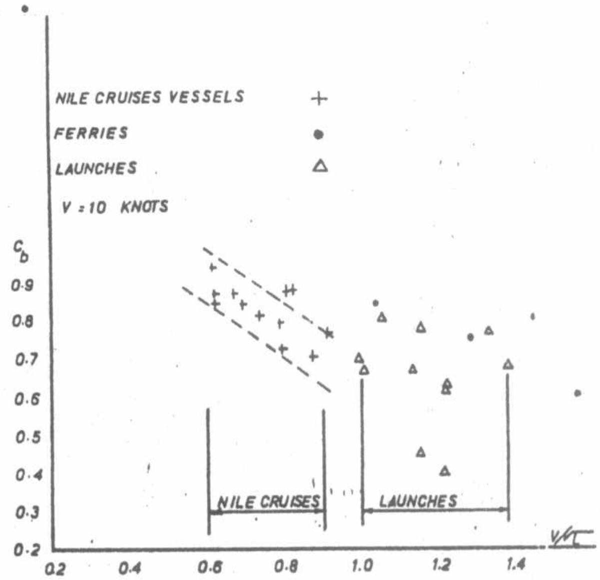


Fig (7)_ SPEED/LENGTH RATIO VERSUS C_b FOR NILE VESSELS.

4-3- EFFECT OF ALTERATION OF C.G.

To abtain the final stability curve for any vessel, correction should be applied if there is differece between the actual KG from that used in the GZ calculation procedure or adding, removing and shifting weight. Correction in vertical and transverse planes may be handled separately (see Ref 15). By simple geometry the formulae can be drived for the required corrections as follow :-

a- CORRECTION FOR VERTICAL HEIGHT

$$\overline{GG} = \overline{KG_o} - \overline{KG_a} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$\overline{GZ_a} = \overline{GZ_o} \pm \overline{GG} \sin \phi \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Plus sign is used when KG_a is below KG_o, and minus is when KG_a is above KG_o

$\overline{GG}$ = The vertical defference between the origin and actual vertical centre of gravity KG_o and KG_a respectively.

b- CORRECTION FOR OFF-CENTER SHIFT(TRANSVERSE SHIFT)

This is to consider the angle of list which may be occured for the equilibrium of the vessel.

$$\overline{GZ_{act}} = \overline{GZ_o} - \overline{GG_T} \cos \quad \ldots\ldots\ldots\ldots (3)$$

Where

$\overline{GG_T}$ = The horizantal shift between the ℄ to the actual centre ofgravity.

ϕ = The angle of list.

The calculation procedure given in the example of application.

c- TOTAL CORRECTION FOR C.G.

The total effect due to the actual location of CG on the static stability curve can be estimated by summation over Equations (2) and (3) to find

Equation (4).

$$\overline{GZ}(\phi) = \overline{GZ}_o(\phi) \mp \overline{G\bar{G}} \sin\phi - \overline{G\bar{G}} \cos\phi \quad .....(4)$$

d- MEASURING OF GM

GM_T must be determined by the slope of the origin GZ curve and then correction can be followed for the actual vertical location of G to find the final GM by Equation (5). Comparison was made in Ref (12) between the final GM estimated by Equatim (5) and by defferentiating Equation (2) with respect to ϕ which approximately equal 10°. A small error was found between the two apprpahes which can be overlocked.

$$\overline{GM}_a = \overline{KM} - \overline{KG}_a \quad ....(5)$$

4-4- FREE SURFACE EFFECT

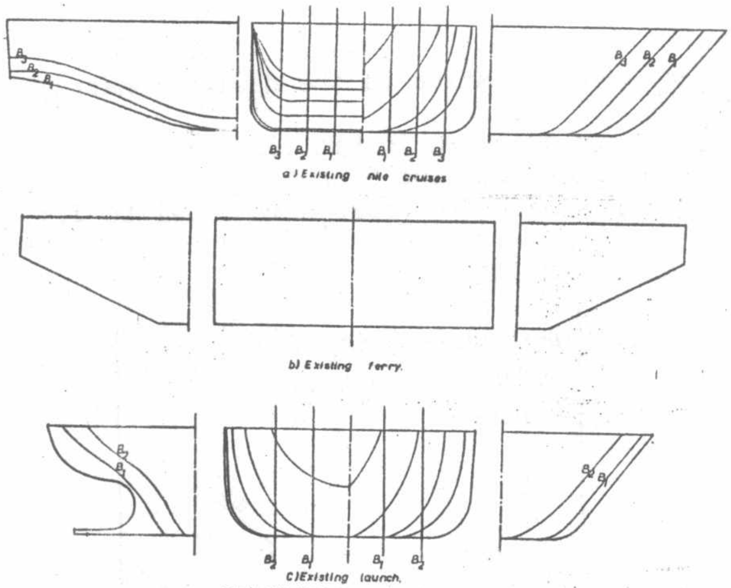
For initial stability calculation the effect of the centre of gravity due to movement of liquid can be neglected.
The free surface correction (FSC) should be applied to the $\overline{GM}$ assuming that a fixed position of the metacentric height M and pocketing will not occur, Ref (12).

4-5- THE RANGE OF STABILITY (ϕ)

It is required the amount of residual stability to afferd the vessel a reasonable chance of survival or to permit safe working condition. Derret (18), found for a particular vessel with load draft and KG remain unchanged increasing in breadth or the freeboard results increasing in the righting arm $\overline{GZ}$ and ϕ . This explains why ϕ varies as shown in fig 2,3 and 4, which are resulted from the stability assesment for vessels with particulars given in tables 2 and 3. For instance for vessel number 6, its freeboard and breadth 0.4, and 8.1 respectively, was found to be equal to 46°.

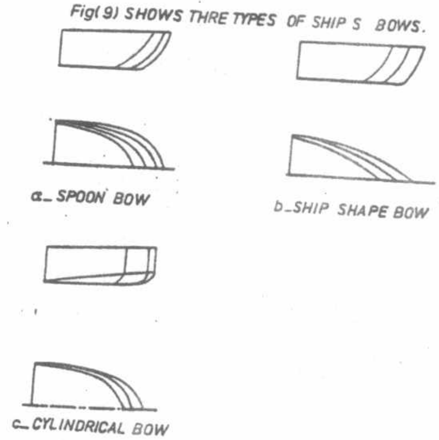
4-6- VARIABLES CAUSING TRIM

Fig (8) represents ship lines for NCV, ferry and launches respectively. The main vairables cause the trim for such vessels are the position of L.C.B. and L.C.G. These are function of the weight distribution and buoyancy all over the vessel. For instance for N.C.V. positioning the engine room, kitchen including cook's equipment, main fridge and semetimes the swimming pool are situated abaft the midship section. These are responsible of shifting the C.G. aft for a distance depending upon the defference between the total weight with its position for the fore and aft parts of the vessel. Consequently the trimming moment will be existed and ship now trims until the L.C.G. and L.C.B. will be in the same vertical line. So the selected shape of the water plane would be decided by the designer aiming to eliminate/reduce the trim.
Unfortunately little can be don for the parallel middle body which may be extended from foreward to aft collision bulkheads as explained in section 5 and Fig (8-C). Also the flat bettom stern of such vessels is common for construction simplicity from the point of view, of the shipbuilders beside it proved satisfactory flow to the propeller relative to the limited water depth for such vessel.



Fig(8)_ SHIP LINES FOR NILE'S VESSELS

Fig(9) SHOWS THRE TYPES OF SHIP S BOWS.



However, three types of bows are introduced in fig (9), which suggest that the ship shaped bow is likely for less buoyancy and bigger volume relative to other for the part above the water level in order to give a chance to reduce the trim and also the required permanent ballast.

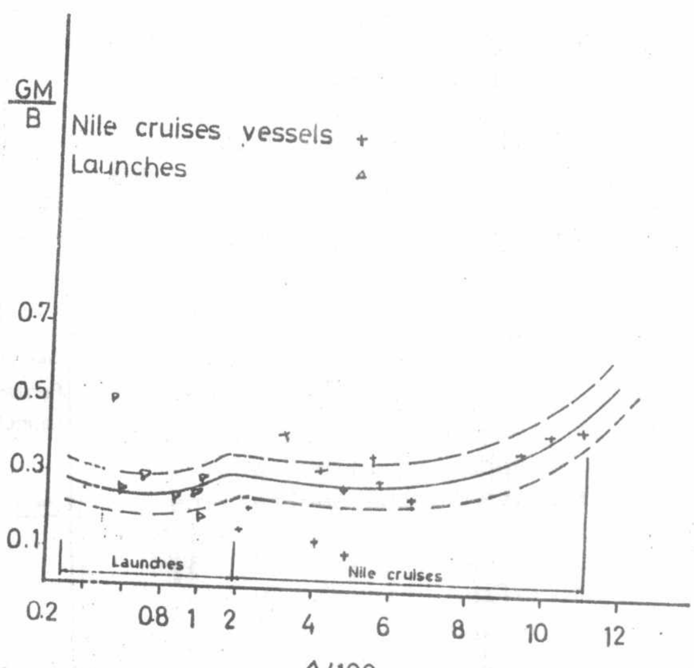
5- PRINCIPLE DIMENSIONS FOR NILE'S VESSELS

5-1- ANALYSIS OF EXISTING DATA

Investigation based on the available data are gathered from existing vessels which satisfy the stability criteria and working efficiently given in tables 2 and 3, such as, Residintial Nile's Cruises vessesl, Launches, and Ferries.

Fig 10 presents full-load displacement (Δ /100) plotted against GM/B ratio-with a few exceptions, all the values were found to be within a band of $\pm$ 0.05 from the GM/B line whilist a majority of the points lie within much closer limits. Fig (11) provides the relation between breadth and depth which governs the stability characteristics for these vessels. It was noticed that most of the plotted points are within B/D ratio from 2 to 4. This is because of limited depth and stability requirements due to relative functions of these vessels.

An indication of the drafts for most of NCV were closed to 1.5 m.

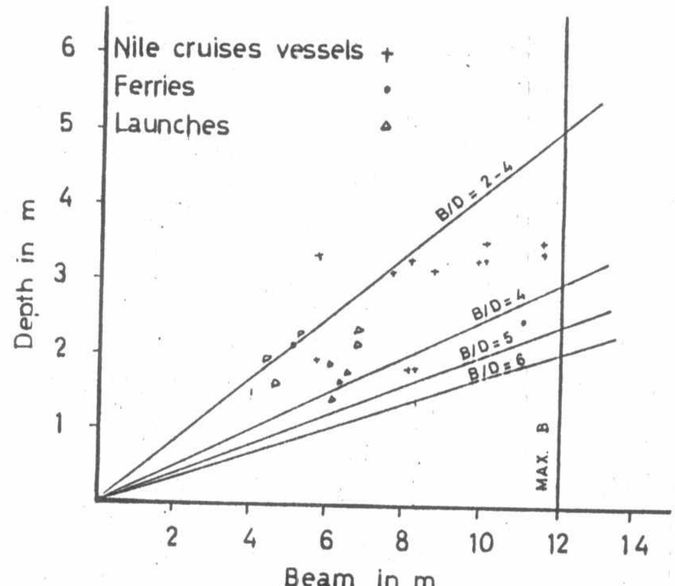


Fig(10) DISPLACEMENT VERSUS GM/B RATIO FOR NILE'S VESSELS.

because of the required large displacements relative to the design constraints mentioned previonsty, see Fig (12).
The breadth was plotted against the length as shown in Fig (13), where the ratio of length/Breadth for launches are within 2.5 and 5, but for NCV the ratio increased to be between 5 and 6 except one of these vessels is equal to 7.5.

5-2- RESIDINTIAL NILE'S CRUISES VESSELS

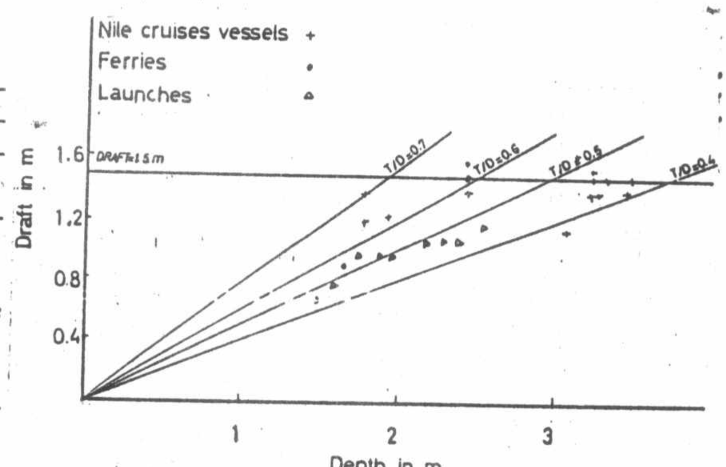
Length and breadth can be estimated based on the required mumber and sizes of bed rooms, restaurant, salon, kitchen, swimming pool, and the accommodation of the crew. Second step is to fix the height of the main deck based on the permissible height of D.B. and the lower room. Other floors can be followed taken into account that the clearance height is not more than 10 m. The lengths of entrance and run should be added to find the overall length, and then the presented figures may be used for accuracy of measurements in relation to the stability characteristics of the vessel.



Fig(11) BREADTH VERSUS DEPTH FOR NILE'S VESSELS

5-3- LAUNCHES

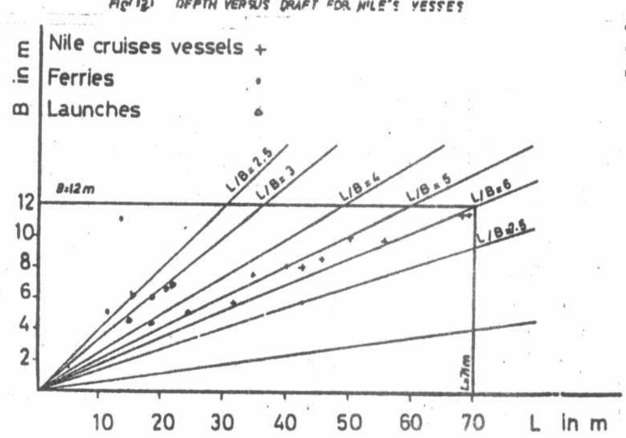
Two dominant variables may be considered in preliminary design stages for Launches. They are the maximum number of passengers with the required area accupied per person and the allowable heeling moment for crowding passengers in one side to the centre line of the vessel. However, figs 10, 11, 12, and 13 are presented to give an aid for selecting prenciple demensions for such units.



Fig(12) DEPTH VERSUS DRAFT FOR NILE'S VESSES

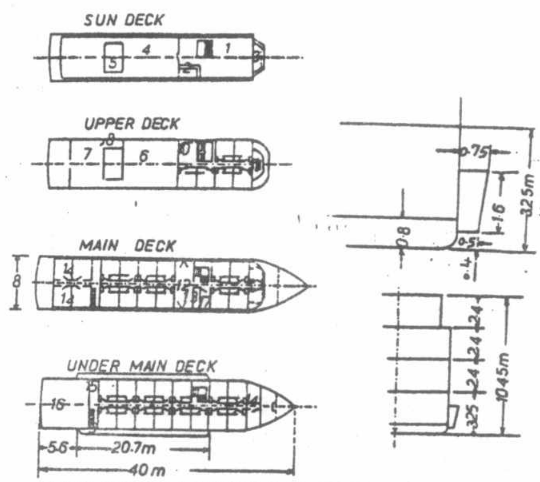
5-4- FERRIES

The required area accupied by passengers, lorries, cars and animals with its corrosponding weight and position relative to the centre line of the vessel should be considered. Two variables given in section (5-3) should be satisfied. Figs 3, 10, 11, 12, and 13 show the GZ curves for typical ferries and the selecting dimensions may be checked.



6- PRACTICAL APPLICATION

Determining the stability characteristices for a Nile Cruises vessel and showing the inftuence of the alteration have been proposed by fitting two side tanks. The general arrangement with the required principle dimensions and detailed contents are given in Fig (14). There are 30 tons solid ballast distributed in the double bottom in arbitrary poisitions.



Fig(14)_GENERAL ARRANGMENT AND PROPOSED ALTERATION.

NO. OF PASSENGERS = 66 PERSONS

NO. OF CREW AND SERVICE = 24 PERSONS

DRAFT = 1.5 m DISPLACEMENT = 409 TONS

1_LOUNGE 2_BAR 3_PROMONADE
4_SUN DECK, 5_SWIMMING POOL 6_DINING ROOM
7_KITCHEN 8_COLD ROOM 9_STORAGE
10_BOUTIQUE 11_WHEEL HOUSE 12_ENTRANCE
13_RECEPTION 14_STAFF 15_LAUNDRY
16_ENGINE ROOM 17_OFFICE.

SOLUTION

The following steps are suggested:-

1- From Figs 11, 12, and 13 agreement was found for the relations given below :-

$$\frac{B}{D} = 2.46 \; , \; \frac{T}{D} = 0.46 \; , \text{ and } \frac{L}{B} = 5$$

2- Hydrostatic calculation was carried out and the required results are as given in the following table :-

Item	Existing Principle dimensions	
	Without side tanks	with two side tanks
T in m	1.5	1.45
KM in m.	4.48	6.09
V.C.B. in m.	0.78	0.75
Δ in tons	409.67	425.0

$\Delta \approx 409.67 + 15$ tons (Steel weight of two side Tanks).

3- The Krylov second method was applied assuming the following :-

a- V.C.G. (KG_V) = 3.25 m.

b- The vessel is in even keel condition.

The results are presented in Fig (15), Curve number 1.

4- Eight inclining experiments were carefully conducted and the average of the total measurements by considering the free surface effects are given below :-

V.C.G. (KG_{act}) = 3.8 m
List angle = 5°
GM_T = 0.68 m

5- Usign equation (4) to find the correction due to vertical and off-centre shift of $\overline{KG}$ for various angles of inclinations to obtain the final GZ curve, the results are plotted in Fig(15) curve number 2.

6- The available solid ballast were re-located again to eliminate the list angle. So the correction can be made for the actual height of C.G. by equation (2) and the results are shown in Fig 15, curve number 3.

7- Having considered the actual location of C.G. which is equal to 3.75 m. the stability calculation was carried out including the two side tanks and the results can be seen in Fig 15, Curve number 4.

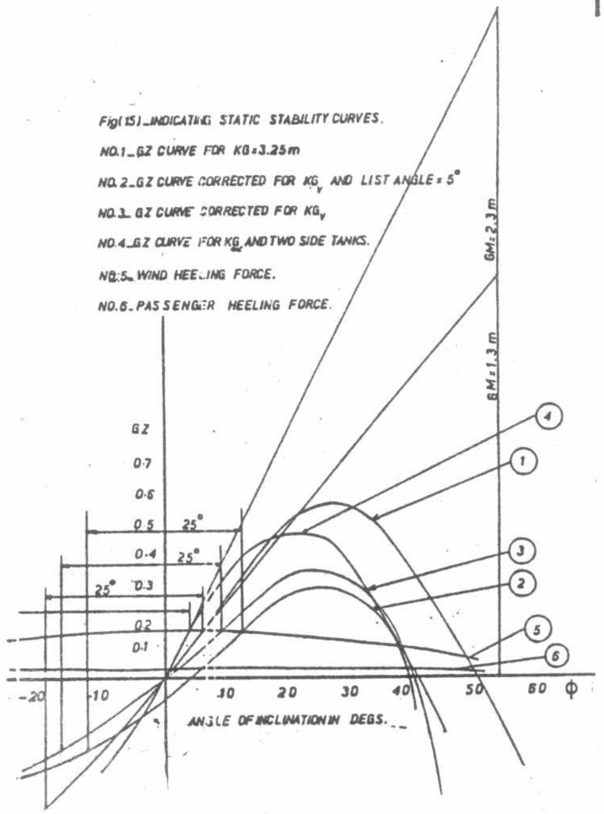


TABLE 3 Common Stability Characteristics Taken From Fig (15)

	IMCO MINIMUM	Original GZ curve No. 1, KG_V= 3.25 M.	Correct KG_V and list angle No, 2	Correct KG_V, NO, 3	KG_{act} with two side tanks No. 4
Area 0-30° (m.Radian)	0.055	0.187	0.088	0.109	0.179
Area 0-40°(m.Radian)	0.09	0.269	0.117	0.152	0.218
Area 30-40°(m.Radian)	0.03	0.082	(0.029)	0.043	0.039
GZ at 30° (m)	0.2	0.56	0.27	0.32	0.37
Max GZ (m)	Not stated	0.572	0.27	0.33	0.47
GM (m)	"	1.3	0.75	0.75	2.24
Range of stability (Degrees)	"	50°	39°	40°	43°
Heeling Angle due to 100 km/hr wind velocity (degrees)	"	6°	12° 30°	9°	4°
Heeling angle due to crowded pass in one side (degrees)	"	1°	6°	2°	1°

COMMENTS AND OBSERVATIONS

The common stability characteristics for the given vessel was compared with the IMCO criteria to indicate the imfluence of the actual location of the C.G. and the suggested alteration by fitted two side tanks is given in

Fig 14, the results are briefly given in table 3. It was found that the proposed two side tanks to be fitted improve the stability characteristics and would have much effect on the range of stability by increasing the height of tanks or by fitting them in a higher position than that selected in the general arrangment, see Fig 15.

7- CONCLUSIONS

Statistical data are now available for recent forms of River Nile's vessels to insure that the selected dimensions have adequate reserve of stability compared with the minimum criteria. However, some clear general points may be stated as follows :-

1- Taking into account the corrections concerning the actual location of CG and the data resulting from the inclining experiments, the calculated and measured the righting arm indicated that the presented procedure of stability calculation gives reasonalde guidance.

2- The analysis of variables affecting the stability characteristecs has been suggested that there is a value exists which affects the relative contribution of the ship form into reserve stability for vessels with various functions.

3- The outcome of the research seems to match with openions of the vaval architects, builders, and owners. These openions are, the flare hull is benificial for Launches, and Ferries, because of the resulted wider beam at the upper deck; this is simply provides much more deck area at the lower level besides improving the stability characteristics for such vessels. However, for Nile Cruises vessels wallsideness shape is preferred.

4- Aiming to have less buoyancy and bigger volume above the water level, the ship shape bow can be used in order to reduce/eliminate the trim condition for Nile's vessels.

5- The effect of turning manoeuvres was found to be small and did not contribute to a significant loss of stability due to low running speed of the vessel.

6- It is essintial to establish the resistive ccapacity of the Nile's vessels as function of the operation required at a level of excess of overturning forces and thus be confident that the vessel would not capasize.

8- REFERENCES

1- GEORGE C. NICKUM "An Evaluation of Intact Stability Criteria" SNAME, Vol. 15, No. 3, July 1978.

2- OZKAN I. "Applications of the Ship Practical Stability Criteria" International Maritime Association of East Mediterranean, Helenic Institute of Marine Technology, 1984, (I.M.A.E.A. 1984).

3- BURCHER, R.K. "The Influence of Hull hape on Transverse Stability" RINA, May, 1980.

4- VASSALES D., KUO C., MARTIN, J., and ALEXANDER, J. "Intact Ship Stability Criteria in Following and Quartering Seas" I.M.A.E.A., 1984.

5- KOBYLINSKI, L. "Safety of Ships Against Capsizing", I.M.A.E.A., 1984.

6- KRAPPINGER, O. "Stability of Ships and Modern Safety Concept" International Conference on Stability of Ships and Ocean Vehicles, University of Strathclyde, Clasgow, 1975.

7- SEMYONOV, TYAN AND SHANSKY "Statics and Dynamics of the Ship" Translated From the Russion by Maria Konyaeva, Peace Publishers, Moscow.

8- BIRD H., and ODABASI A.Y. " State of Art Past, Present and Future", International Conference on Stability of Ships and Ocean Vehicles" University of Strathclyde Glasgow, 1975.

9- CLEARY W.A. "Marine Stability Criteria" International Conference on Stability of Ships and Ocean Vehicles, University of Strathchyde, Glasgow, 1975.

10-KOBYLISKI L. "Rational Stability Criteria and Probability of Capasizing", International Conference of Ships and Ocean Vehicles, University of strathclyde, Glasgow, 1975.

11-WATSON D.G. "Some Ship Design Methods" RINA, Nov. 1976.

12-GILMER, T. and JAHNSON B."Introduction tp Naval Architecture", Published by E. & F.N. Spon Ltd, Britian, 1982.

13-HENRICKSON W.A. "Assessing Intact Stability" SNAME, April, 1980.

14-RAWSON K. and TUPPER E. "Basic Ship Theory" Longmans Green and co Ltd, London, 1968.

15-PURSEY H. "Merchant Ship Stability" Published by Brown, Son & Ferguson, Ltd, Glasgow,Britian, 1977.

16-KENNETH C. and BARNABY C. "Basic Naval Architecture" Published by Hutchinson &Co. Ltd, London 1967.

17-PISKORZ J.W. "Effect of Ship Stern Asymmetry on Propulsion Efficiency" SNAME; June, 1980.

18-DERRETT, D.R."Ship Stability for Master and Mates" Published by Stanfor Martime Ltd, London, 1980.