JAPANESE CRUISER DESIGN
A CRITIQUE

BY

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Introduction

Between the wars, Japanese cruisers seemed very fast compared with ships of most other navies and incredibly well armed for their declared displacement. Some writers still say this even though it is now known[1] that they completed grossly over-weight with poor stability and inadequate strength. Attempts to remedy these faults led to further major increases in displacement. However, they were different in many ways from similar ships elsewhere and it is worth exploring these differences and trying to see what went wrong.

'Yubari'

Yubari was a small, experimental cruiser designed in 1920–21 by CONSTRUCTOR LIEUTENANT COMMANDER FUJIMOTO under the direction of CONSTRUCTOR CAPTAIN HIRAGA to test the latter's ideas. (Both trained at

Greenwich). He aimed at high speed and heavy armament saving weight by the structural use of armour. The funnels were trunked together and swept aft to keep the smoke away from the bridge and the uptakes had some protection.

She was designed[2] for 3,141 tons and completed at 3,560 tons, 419 tons (14%) overweight. Earlier cruisers had completed about 5% over the design figure. The reasons for this are not clear but some suggestions will be made in the last section. This excess weight brought the lower deck scuttles very close to the waterline and the deeper immersion of the stern caused a loss of speed. There was no treaty limit in force and there was no advantage to the Japanese in releasing false figures.

Her side protection consisted of a 60lb internal, rivetted belt, forming an upwards extension of the inner bottom, behind a 30lb outer bottom. British cruisers had for many years used the belt as structure but over separate shell plating. *Yubari* was not dissimilar in principle but later classes would have external belts worked structurally without shell plating. Despite the weight growth her stability was seen as adequate until the *Tomozuru* incident (Appendix 1) when 124 tons of ballast was added. She was strengthened after the incident described in Appendix 2.

The FURUTAKA and AOBA Classes

The same design team produced these four ships and the final design was approved in August 1921, six months before the Washington Treaty was signed and two years before it was ratified. They were well inside the 10,000 ton limit imposed on cruisers but their declared displacement of 7,100 tons, standard,[3] was much less than the true figure of 7,950 tons. This was a serious breach of the Treaty which called for accurate disclosure of the main particulars. No one seems to have noticed.

This design introduced the continuous wavy deckline which was such a prominent feature of Japanese cruisers. This came straight from the contemporary Greenwich design notes which called for high freeboard forward for seakeeping and amidships for a good range of stability and low freeboard in way of the turrets and aft to keep the centre of gravity low. The continuous upper deck was favourable to a strong, light hull but the results were not outstanding in these ships. Hull weight[4] divided by the product of length, beam and depth is a good measure of weight efficiency—*Furutaka* came out at 3.3×10^{-3}, later Japanese cruisers at about 3.0 compared with 2.99 for the contemporary British KENT class.

The side armour was 3in thick and rivetted. This did not prove very successful and by 1932 some 3,000 rivets had to be replaced.[5] *Furutaka* introduced some other less obvious features which were repeated in later classes and were to sink many of them. The class carried a heavy torpedo armament in 12 fixed tubes (plus reloads) between decks. HIRAGA protested strongly about the risks of this arrangement but was overruled by the staff. Also against HIRAGA's advice, the staff insisted on a centre line bulkhead in the engine rooms and all but the forward boiler room. A superficial examination of the intact stability characteristics of these ships would show them to be only slightly deficient but the heeling moment if two or more of these sides spaces were flooded would need much greater initial stability if capsize were to be avoided. (It wasn't).

The second pair of these ships had three twin 8 inch in place of the six single 7.9 inch of the first two. The hole needed in the deck for these big turrets caused local weakness which had to be stiffened.

Over-weight

Rather than repeat the sad story of weight growth during building, the figures will be given as a table for other classes.

Class	Design	Actual Trial Displacement, *Tons*
FURUTAKA	8,586	9,502
AOBA	8,910	9,820
MYOKO	11,850	13,,300
TAKAO	11,850	14,129
MOGAMI	11,169	14,112
TONE	13,370	14,070
AGANO	7,710	7,895

The bigger ships, from *Myoko* onwards were well over the Washington limit of 10,000 tons.

Class	Declared	True Standard	Displacement increase
MYOKO	10,000	10,980	0 .8%
TAKAO	9,850	11,350	15.2%
MOGAMI	8,500	11,200	31.8%

Quite a lot of the difference was deliberate deceit; *Mogami* was intended to be 8,500 tons but it was soon realised that 9,500 was more realistic but other treaty signatories were given the original figure. An extra 10–30% displacement should increase fighting capability by a higher percentage—more guns do not usually need additional control equipment and its crew etc. Because of stability and strength problems, the Japanese were unable to benefit from the extra weight available and, instead of the heavy armament for their declared displacement, they may be seen as under-armed for their true size.

Rectification and more weight growth

Almost all classes required remedial action after first trials and much more drastic changes after the incidents described in the appendices. Rather than repeat the story for each class, only the history of the *Mogami* will be given in detail with a table of final displacements.

The original design for *Mogami* was by FUJIMOTO (Now Captain), replaced by FUKUDA after the *Tomozuru* incident for which FUJIMOTO was blamed. An attempt was made to keep the displacement down by the extensive use of welding. After the accident, the superstructure was greatly reduced and the deck heights were reduced in the last two ships. *Mogami* ran trials in March 1935 during which severe cracking and distortion occurred in the welded hull. More severe damage to *Mogami* and her sister *Mikuma* occurred in the storm of September 1935.

It was decided to replace the welded Ducol outer bottom plating by rivetted plates over 80% of the length and with welded mild steel at the ends. Additional 25lb plates were rivetted to the bottom outboard of the keel and the long superstructure deck was strengthened in way of the barbettes. Additional bulges were fitted outboard of the original ones increasing the displacement by 1,000 tons. *Mogami* re-entered service in February 1938, *Mikuma* in October 1937. During 1939–40 the triple 6 inch turrets were replaced by twin 8 inch (as had always been intended).

Date	Design	1935	1938
Trials dspt	11,169	12,962	14,112 Tons

Somewhat similar changes took place in other classes though they did not need re-skinning. Stanley GOODALL noted in his diary for 19 May 1937 on the occasion of the Coronation Review:

> 'Visited *Asigara*, an interesting ship, workmanship not up to our standards, welding crinkles on deck bad. Midship section puzzling; looks as though the sheer strakes were added*, bulge another puzzle. Propellers below keel line.'

*They were!

Class	Date	Final Displacement
FURUTAKA	1939	10,507
AOBA	1940	10,822
MYOKO	1941	14,949
TAKAO	1939	14,838

Sinking[6]

HIRAGA had objected, unsuccessfully, to centre line bulkheads and to torpedo stowage in the most highly stressed area of the ship. The war was to prove him right. One may identify[7] some 40 incidents in which Japanese cruisers were sunk or seriously damaged.

	Damaged	Sunk
Unrelated to longitudinal bulkheads	24	4
Possibly related to longitudinal bulkheads	2	10

Notes follow on the incidents in which longitudinal bulkheads played a part:

Aoba 23 October 1944. Hit by a Mk 14 torpedo (300 Kg warhead) in the forward engine room. 13° list but survived.

Myoko 24 October 1944. Hit by air dropped Mk 13 (272 Kg warhead) in the aft engine room. Survived and could steam at 15 knots.

Kako 10 August 1942. Hit by 3 Mk 10 torpedoes (226 Kg) and **capsized** in 5 minutes.

Furutaka 11 October 1942. Hit by many shells; all four engine rooms flooded (symmetric flooding) and sank after 2 hours.

Kinugasa	14 November 1942. A 1000 lb bomb hit at the fore end of the bridge and exploded low in the ship, There was an immediate 10° list and she **capsized** later.
Aoba	5 November 1943. A bomb hit detonated on the torpedo warheads which flooded the starboard engine room. There was a heavy list and she was beached to prevent a **capsize**. Became a total loss.
Atago	23 October 1944. Hit by 4 torpedoes (330 Kg warhead) and, despite counter flooding, she **capsized.**
Maya	23 October 1944. Hit by 4 torpedoes (330 Kg warhead) **30° list** when magazines exploded.
Nachi	5 November 1944. Hit by about 10 torpedoes, 20 bombs and 16 rockets—broke into 3 sections and sank.
Hagura	15 May 1945. Hit by 3 British Mk 9 torpedoes and **capsized** quickly.
Ashigara	8 June 1945. Hit by 4 British Mk 8 torpedoes, **capsized** and sank
Aoba	24–28 July 1945. Hit by several bombs and sank despite counter flooding.
Kumano	6 November 1944. Hit by 2 torpedoes. All 4 engine rooms flooded by one hit but temporary repairs got one engine going, giving her 6 knots.
Kumano	25 November 1945. Hit by 4 bombs and 5 torpedoes, all to port. Capsized despite counter flooding.

The damage to *Aoba* on 23 October 1944 may have been limited by the longitudinal bulkhead but this is the only such instance. In most cases there was rapid capsize. The hit on *Kumano* which flooded 4 engine rooms shows the increasing power of torpedoes. It should also be noted that that the first reaction of the crew was to flood the space on the opposite side, nullifying the advantage of the bulkhead!

Tentative conclusions

It is likely that the main cause of the design problems was lack of experience at all levels and in every aspect of design and building. Japan began designing and building major warships before World War I though there was still a considerable amount of equipment, material and expertise imported. In particular, Japanese constructors were trained at Greenwich until 1923 when Fukuda, mentioned earlier, was the last to graduate.

However, Japan completed very few cruisers until 1919. In those days feedback from completed ships was an important part of the design process. One ship of each class would be 'weighed'—every item put on board during construction would be weighed and its position noted. These weighed weights would be compared with the design estimates and with the position of the centre of gravity derived from the inclining experiment. In an evolutionary design process, estimates based on known data from earlier ships could be very accurate. The wartime cruisers completing in 1919, based on British data, had no problems.

The design process depended on experience at all levels. Hiraga had considerable personal experience; after leaving Greenwich in 1908 he had worked on the design of several classes of battleship and had supervised building work as well. However, he was a first generation designer, he had no experienced predecessors to pass on experience.[8] Experience was also in the custody of senior and chief draughtsmen who had worked on a particular ship type for much of their career; such men are bound to have been rare in the Japanese design office. It is probable that lack of experience was even greater in the shipyards where the innumerable detail drawings were prepared. If the designers intention was mis-interpreted, problems of weight growth would be almost certain. Finally, the sub-contractors supplying equipment would be unfamiliar with warships work.

This overall lack of experience weakened the hand of the designers in the inevitable arguments with the staff. They lacked examples of the penalty of ignoring technical requirements. (The British learned this lesson with *Captain*). There is a revealing passage in the GOODALL diaries:[9]

> 5 July 1934 'HIRAGA called. He said *Tomozuru* that capsized had a range (of stability) of 60°. Her stability was 'like that of the old French torpedo boats'. I gathered that the Japanese organisation does not allow designers to keep a grasp of the job so that they can watch stability.'

HIRAGA's novel ideas to save weight could only be implemented if he had authority to impose his ideas. The naval staff were also inexperienced in understanding technology. HIRAGA argued against the centreline bulkheads but accurate stability calculations involving massive asymmetric flooding were almost impossible without a computer and he would not have had strong evidence to support his views. (The approximate calculations which were all that was possible tended to understate the effects of flooding.)

Experience in the Royal Corps of Naval Constructors showed a very close correlation between Greenwich exam results and rank on retirement. It is likely that the highly marked student would get the best jobs and work for the best superiors but a survey over 60 years did show that exam results mattered. HIRAGA and FUJIMOTO just scraped second class and FUKUDA got a poor third. (No Japanese student did very well at Greenwich; there may have been a language problem). Combined with lack of experienced guidance from above, the outlook was not promising.

The cruisers discussed here seem to have many of the characteristics of student exercises, e.g. the wavy deck line. HIRAGA was probably on the right lines in his ideas for weight saving but it is likely that the purity of his approach was compromised by lack of understanding from the draughtsmen and builders compounded by his lack of authority.

The main problem was the way in which the staff over-rode technical arguments. As Sir Rowland BAKER RCNC put the constructors viewpoint in his usual forceful manner,

> "..... our business is not to agree with the staff, or argue with them, but control them. They can only have what 'we' can offer."

Japanese cruisers certainly were different.

Appendix 1—The 'Tomozuru' incident

In March 1934, the torpedo boat *Tomozuru* was exercising with sister ships and the light cruiser *Tatsuta* west of Nagasaki. The weather worsened and by 0300 on 12 March the waves were of 'triangular form' with a height of 3–4m. *Tatsuta* was rolling[10] to 15° and the torpedo boats to 30°. By 0325 these rolls had increased to 30° and 39° respectively and a little later to 40–45° for the torpedo boats. At 0428 contact was lost with the *Tomozuru* and at 1405 her remains were found floating upside down. She reached Sasebo at 0725 on 13 March where 3 survivors were extracted. She was docked, upside down, at 0300 on 14 March when 10 more survivors and 100 bodies were removed.

The enquiry found that ships of this class completed 92 tons over the design displacement of 615 tons and the centre of gravity was higher. Turning trials had to be abandoned because of excessive heel angles. Ships of the class (including *Tomozuru*) were bulged to improve stability but the centre of gravity was still very high. (1.3m above the waterline).

New stability standards were laid down; for a 15,000 ton cruiser in the trials condition, the centre of gravity was to be at or below the waterline, the Metacentric height was to be more than 1.3m with a range of stability in excess of 85°. In addition, the profile area above water was to be less than 1.5 times that below water. These standards were adequate for ships with no longitudinal subdivision but not for Japanese cruisers with centreline bulkheads.

Appendix 2—The Fourth incident, 26 September 1935.

For the 1935 manoeuvres a force of carriers, cruisers, destroyers and other ships was organised as the Fourth fleet. On the morning of 26 September they were about 100 miles east of northern Honshu when a typhoon warning was received. By 1300 10m waves were reported with wind speeds over 39 knots. The central group entered the eye of the typhoon at about 1430 and though the wind had dropped there were 'triangular' waves at 10–15m height.

The forward end of *Hosho's* flight-deck was distorted and her bridge crushed as was that of *Ryujo*. Plate joints failed amidships on *Myoko, Mogami, Taigei* and to a lesser extent on other ships of the *Myoko* class and *Mikuma*. Also, the fore end of *Mogami's* hull was distorted. When the destroyers reached the eye, they were rolling 75° for the *Mutsukis* and 70° for the *Fubukis*. At 1602 the bow of *Yugiri* broke off in front of the bridge whilst that of Hatsuyuki came off in the same way at 1729. Both are said to have been on the crest of a 'triangular' wave at the time. Most other destroyers had suffered slightly lesser damage with opened seams, broken bridge windows etc. 54 men were killed or missing.

The enquiry found that the main body had encountered abnormally, short steep waves with a length of 100–150m and a height of 10–15m. The destroyer force encountered waves with a length of 200m and a height of 15m. They found that the longitudinal strength of the *Fubuki* class destroyers was inadequate, particularly sagging with a crest bow and stern. Strengthening plates were rivetted to most modern cruisers and destroyers.

Permitted stresses were laid down as:—

Hogging, Deck 10 tons/in^2 tension, bottom 8 tons/in^2, compression,

Sagging, Deck 8 tons/in^2 compression, bottom 9 tons/in^2, tension.

Note that a lower value of compressive stress was permitted due to the risk of buckling.

1. The factual material in this article is derived almost entirely from:
   Eric Lacroix; Linton Wells II.: 'Japanese Cruisers of the Pacific War'. *Annapolis, 1997*. (Reviewed in the previous issue of the *Journal*).
2. Japanese practise was to design for a trial displacement with $^2/_3$ liquids on board. Unless otherwise noted, this figure will be used throughout the article.
3. Standard displacement was roughly that of the ship empty of all liquids.
4. Including fittings. Different design offices use different definitions of weight groups making comparisons unreliable but these Japanese were British trained and it is likely that differences were small..
5. British practise was to limit rivet size to $1^1/_8$ in as bigger ones could not be hammered home properly. This limited plate thickness to 1½–2in.

6. This section is based on a note prepared by the author, together with J.D. Brown, Naval Historical Branch and circulated privately.
7. This section is based on Dr Lacroix' earlier articles in *Warship International* but I do not think there is any difference.
8. It was only partly in jest that British constructors said that design was taught by the 'laying on of hands'.
9. Goodall was the year ahead of Hiraga as a student at Greenwich and would have known him quite well.
10. It is not entirely clear if these angles are 'out to out' or upright to out but the latter seems more likely.