Capsize of torpedo boat Tomozuru

March 12nd, 1934, Seas near Sasebo port, Nagasaki prefecture

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(Summary)

On March 12nd, 1934, a Japanese torpedo boat capsized. The torpedo boat, named Tomozuru, was heading north to Sasebo port. However, during the navigation the weather turned to be rough, and Tomozuru was suddenly inclined by a strong wind and wave. Unfortunately she did not have enough stability against the inclination so finally she capsized, and one hundred officers, including the captain of Tomozuru, died.

Tomozuru was one of the Chidori Class torpedo boats. The center of gravity of Tomozuru was too high due to heavy armaments. As a result, her stability against inclination was insufficient; she was so-called a top-heavy vessel. At the time that the Tomozuru capsized, waves flooded from oblique behind and she shook violently because the frequencies of the waves and her own body's natural vibration frequency were almost the same.

The responsibility of the over top-heavy structure was on the crewmembers who demanded that the vessel be armed heavily and shipbuilders who accepted the demand. Since then, the Japanese Navy fundamentally rethought the ability of its vessels to maintain stability against waves.

1. Component

Tomozuru was the third vessel of the Chidori Class torpedo boats, and she was not yield to the London Naval Treaty. She had three 12.7cm main guns and four torpedo tubes while her total displacement was less than 600 tons and her maximum speed was approximately 30 knots. Her performance was no less than that of a Second Class Destroyer (Fig. 1). Tomozuru was completed on February 24th, 1934 at Maizuru, towed to Sasebo at the end of the month, and joined the 21st torpedo fleet that was organized with her and two other boats of the same type, Chidori and Manazuru. The fleet belonged to the Sasebo Guard squadron whose flagship was light cruiser Tatsuta.

2. Event

At 1:00 a.m. on March 12nd, 1934, Tomozuru following Chidori left the Terashima Channel, Sasebo port and headed for the seas south of Otateshima Island for an approach and attack training against flagship Tatsuta. The three boats kept training despite the rough weather, but as the winds and waves got rougher and rougher the training was suspended at 3:25 a.m. On the way back to Sasebo port, the sway of Tomozuru intensified and her radio fell down from the desk and died. She contacted the other boats with a light signal, but at 4:12 a.m. Tomozuru's light signal suddenly ceased.

The two other boats immediately conducted a search for Tomozuru with their searchlights but they could not find her at that time. Airplanes and vessels from the units of Sasebo Naval Station looked for her,

and finally 21st destroyer fleet found drifting Tomozuru capsized at 1:00 p.m. on March 12nd. The flagship Tatsuta managed to tow Tomozuru to Sasebo, and she reached the port at 7:00 a.m. on March 13rd.

Some sailors in Tomozuru were still alive, so air and some liquid food was sent inside the boat. However, because a capsized ship leaks easily, buoyancy was added to Tomozuru by means of binding her to other ships and cutting off some projections, then she entered the dock at 8:00 p.m. on March 13rd, and then the seawater was drained out. Finally thirteen sailors were saved and three sailors escaped by themselves before her entering the dock, but the other one hundred sailors, including the captain Lieutenant Okuichi Iwase, died.

Naval officers had assumed that vessels would never capsize, even if the winds or waves were enormously rough. This was why they conducted many hard maneuvers before the denunciation of disarmament treaty so-called 1936's crisis. Thus, this incident completely shocked them. They also had believed that the Japanese newly constructed naval vessels, like Tomozuru, had the highest performance in the world. They had believed themselves to be successful in overcoming many difficulties in constructing a vessel with a total displacement under 600-tons (disarmament treaties restricted the weight) with the same performance as a destroyer.

An inquiry commission was organized under the control of Admiral Kichisaburo Nomura. After some investigations, they discovered the cause of the capsize, and the chairman submitted a report to the Naval Minister on April 2. The Ministry of the Navy announced that the main cause was the lack of Tomozuru's stability and that improvements were needed to prevent the lack of the stability like Tomozuru.

3. Course

It was obvious that the lack of Tomozuru's stability caused the capsize, that is to say that bad design led to her capsize. In 1931, a supply plan of auxiliary ships under the restriction of the London Naval Treaty was formed, and the Headquarters presented some requirements for the new ships. But they demanded too heavy armaments for two types of destroyers (1,000-tons and 1,400-tons) in spite of the limited budget and under restriction of the number of destroyers. Although 1,400-tons class destroyers was constructed as Hatsuharu Class, the construction of the 1,000-ton class destroyers was cancelled due to the restriction of the total vessel tonnage possessed, and they decided instead to construct Chidori Class torpedo boats, which were smaller than the 1,000-ton class destroyers and therefore not under the restriction of the treaty. The Chidori Class was intended to be used in place of the Second Class Destroyers in the seas near the Japanese coast. The required performance for the Chidori Class was far greater than that of a torpedo boat in the age of the Russo-Japanese War (1904~05). Requirements included 600 tons basic displacement, 30 knots maximum speed, 3,000 miles range at 14 knots, three 12.7cm main guns and four 53cm torpedo tubes. To reduce the weight, light alloys and welding were widely used, and they cut down the weight of the engines and armaments as much as possible. However, the main gun was the same turret type gun as was used by a destroyer, and some additional equipment was added so that the weight became heavier than they had expected. The freeboards were enlarged in order to improve the vessel's seaworthiness, and livability was better than that of conventional destroyers. In addition to all of this, armament planners of each department

in the Headquarters demanded armament having complex and elaborate mechanics. As a result, the center of gravity of the Chidori Class torpedo boats rose, and her basic displacement was held down to only 527 tons.

The first vessel of Chidori Class, named Chidori, was laid keel in October 1931 at Maizuru and launched in April 1933. Originally, shipbuilders of military vessels needed to measure the vessel's weight on the way to construction. They have to know the weight of all the steel material, equipment, armaments and engines before they could equip them from beginning to completion of the construction. However, after the launch, a weight test was carried out, and they found that her weight had become 30 tons heavier and that the center of gravity was 30 cm higher than they expected. They already knew that her center of gravity was relatively high at the planning phase, and so the success of the construction depended on how far they were able to hold down her center of gravity. The department of shipbuilding at Maizuru immediately reported to the Headquarters that Chidori had an unusually high center of gravity and low GM (Magnetic Height) and that her stability was not sufficient. They decided to take measures after her trial run. In 1933 Autumn, Chidori's first operation was held in the seas near Maizuru bay, but when she turned 15 degrees at 28 knots, she rolled more than 30 degrees immediately. They suspended the 35 degrees turning maneuver because it was too dangerous, and the test itself was also cancelled at that time. They worked urgently to develop countermeasures, but many of the countermeasures they did were not effective. In the end, they put bulges on the sides of the vessel, and she succeeded in making the 35 degree turn with a rolling of 20 degree in the reexamination, and the construction of the vessel was completed with hoisting naval ensign on November 1933. As a result of the fast navigation examination during two successive day-and-nights, and the performance examination at the heavy weather such as wind speed of 15 m/s in the Sea of Japan,, they decided that Chidori had sufficient performance for her mission.

Tomozuru was completed in February 1934, took the same measurements as Chidori, and was brought to Sasebo. She capsized soon after that. When she capsized, she was not carrying many consumables like fuel or water that would have made her center of gravity lower. On the other hand, munitions such as torpedoes were fully equipped, so the situation was much worse than the trial run. As a result, the distance from the surface of the sea to the center of gravity (COG) was over 1.3 m Her stability at the time that she capsized was thought to be less than 50 degrees.

4. Cause

The cause of the capsize of Tomozuru was the lack of stability that resulted from the so called "Top Heavy Structure". The crewmembers who demanded excessively heavy armaments and the shipbuilders who accepted these demands were responsible for this incident.

5. Immediate Action

On April 5th, 1934, a special investigative committee of the vessels' performance was formed under the control of Admiral Kanji Kato. Its members consisted of crewmembers and shipbuilders, and Dr. Hiraga, Professor of the University of Tokyo, was added to the committee as a temporary employee of the Japanese Navy.

The committee investigated the cause of Tomozuru's capsize exhaustively. They looked through literature and other materials related to stability of all the previous vessels inside and outside and investigated the current situation of all the vessels of the Japanese Navy. Figure 2 illustrates the principles that govern a vessel's stability using the analogy of a self-righting "daruma" doll. A high Center of Gravity (COG) means a large distance from the surface of the sea to the COG, and a decrease of GM, resulting in a narrow range of stability. Furthermore, winds affect a vessel more severely if the displacement is small (although the small displacement was inevitable in the case of Tomozuru because of the limitations of the London Naval Treaty). In addition, she had far too many armaments for her displacement. The total weight of all guns, torpedoes and other electronic weapons amounted to 167 tons, which was almost 24 percent of her total displacement. This percentage was much larger than that of the former destroyer Mutsuki, whose weight of armaments was 178 tons and contributed to only 10 percent of the total displacement. Therefore, Tomozuru had as much armament as a First Class Destroyer whose total displacement was 2.5 times larger. Even the Special Hubuki Class Destroyer, which was known as a revolutionary heavy armed destroyer, had an armament weight of 302 tons, which was only 13.7 percent of the total displacement. .

It is clear that Chidori Class had an extraordinarily large weight of heavy armaments. Thus her center of gravity was unusually high and her stability was too low. The capsize was triggered by the situation that the frequencies of the waves were similar to the vessel's natural vibration frequency, which causes the vessel to roll terribly.

Of course, the capsize could have been avoided if the crew's navigation skill was better, but military ships have to carry out their missions under the not so extraordinary rough weather.

In May 1895, the Japanese Navy's No.16 torpedo boat (54 tons) capsized due to the rough weather in the seas near Penghu Island, Taiwan. The cause of this capsize was also lack of her stability.

In December 1932, the Second Class Destroyer Sawarabi (820 tons) capsized and went down due to the rough weather during her cruise in the seas near Taiwan. Sawarabi's incident occurred only a year before Tomozuru's capsize so investigations should have been more discreet. All the more than twenty destroyers of the same class as Sawarabi had not been pointed out that they were bad at stability for fifteen years, so they thought that the cause of the capsize was overloading on her deck, instead of her stability.

Crewmembers also demanded unreasonable amounts of armament for many other vessels, and the shipbuilders who designed Tomozuru also accepted all of those demands. As a result, many vessels designed by the shipbuilders, namely the Air Career Ryujo, Soryu, the Submarine Depot Ship Taigei, the Mogami Class Cruisers and some other minesweepers, cable repairing ships, destroyers and submarine chasers, also had high COG's. Moreover, the tendency towards high COG's increased for later vessels. The Committee urgently had to alter every vessel including existing or under construction recognized that its stability was not sufficient. For vessels that had not began construction, the committee had to determine expected standard of the vessel's stability and change the construction plan accordingly. However, since the adversary for the vessel's stability is nature, and the vessel's situation varies depending on the environment, theoretical marine engineering at that time could not determine the standard. After extensive research, they concluded that it was impossible to determine the standard at last, but that in order to avoid another incident

like Tomozuru, they should determine a rough standard. Therefore, a list was made based on the vessels that were thought to have good stability. In particular, the list treated GM as the most important quantitative value, and it gave strict standards for the ratio between the submerged area of a vessel and the non-submerged area. It also designated a lightest weight limit for each type of vessel and stipulated that if the weight did not meet the limit, ballasts must be added. A mechanical device that fills the vessel with seawater automatically as the vessel's fuel is consumed was equipped on some vessels.

Furthermore, the committee established the following rules for the vessel's stability:

(1) The weight of a vessel must be calculated and measured as accurately as possible, and any weight difference between the calculated and measured values must be clarified as quickly as possible.
(2) If a new device is added to an existing vessel, the new COG and weight gain must be calculated. If the new COG is too high, existing devices of the vessel should be either removed or shifted in order to in return the COG to a value that satisfies the vessel's stability.
(3) When the construction or refit of the vessel is completed, devices must be loaded at the expected place, and performance examinations have to be made with the vessel's weight and COG agreeing with the completed condition. Appointed member of the performance consideration committee, discusses strictly whether the vessel has enough performance to her missions.

In addition to these rules, some other measures were given for existing vessels:

(1) Unnecessary armaments and equipment were removed. The main armaments in some vessels were removed or downsized.
(2) Ballast or a ballast keel was put at the bottom of some vesses.
(3) The width of some vessels was changed, and some vessels were equipped with bulges.
(4) A seawater ballast tank was equipped on some vessels.

Moreover, bridges or funnels were shortened or downsized.

The Chidori Class Torpedo Boats and the Hatsuharu Class Destroyers were investigated especially carefully, and some of the main armaments were removed or changed. The Tone Class Cruisers, Air Career Souryu and Shiratsuyu Class Destroyers were fundamentally rethought in terms of their stability, and four Chidori Class torpedo boats were thoroughly remodeled. From the fifth, the vessels were redesigned from the start, and the newly constructed torpedo boat was categorized as Kou Class (Fig.3).

With Tomozuru's capsize as a trigger, the Japanese Navy fundamentally rethought the stability of its vessels. In 1934 and 1935, all the reconstructions of vessels were conducted at every naval (or some private) shipyard. As a result of this remodeling, while some vessels had to decrease their velocity or armament, the stability of all vessels was dramatically improved. The fundamental question is why the vessels were equipped with so many armaments at the sacrifice of the vessel stability, which is one of the most important issues for a vessel's safety. Although the principal cause of the accident is the demands of the crewmembers, the responsibility of the accident is on the shipbuilders who accepted those demands. In the middle of the 1920s, Vice Admiral Jouzo Hiraga designed the Yuubari, Furutaka and Myoko Classes of vessels. Each vessel had good stability characteristics. However, the stability of vessels in the Japanese Navy got lower and lower after Vice Admiral Hiraga retired from designing vessels. Specifically, the

stability of the Aoba Class was barely acceptable, and those of all vessels after the Takao Class, which was a revision of the Myoko Class, were obviously insufficient. This shows that although Vice Admiral Hiraga had designed some good vessels, the other persons involved in vessel design did not always agree with his designs, and theconviction that shipbuilders should have could not compatible with the compromise.

The chief shipbuilding engineer at the time was Rear Admiral Kikuo Fujimoto, and he was famous for his remarkable designing talent. However, he resigned from the post to take the responsibility for the capsize of Tomozuru, and he was transferred to a technological laboratory. We can just imagine how this well-known shipbuilding authority, who designed the Mogami and Takao Class Heavy Cruisers and Special Class Destroyers that attracted worldwide attention felt. He tried to rethink his design after the change of post, but because of his heavy anxiety he met with an untimely death. Finally Captain Keiji Fukuda (later Vice Admiral and professor of the University of Tokyo) took over as chief shipbuilding engineer.

The Tomozuru capsize incident was the turning point for the shipbuilding technology of the Japanese Navy in that the importance of the stability performance was recognized. One year after the incident, the accident concerning the shipbuilding technology occuredso called 4th Fleet Incident. Like those incidents, the Japanese Navy at the time had experienced many difficulties just before the 1936's crisis.

6. Countermeasure

Tomozuru's capsize forced the Japanese Navy to fundamentally rethink the stability of their vessels. A remodeling plan was made individually for every vessel, and shipbuilders carried out all of the remodeling plans during 1934~35 (Fig. 4). The designs of all of the vessels under construction at that time were reconsidered from scratch.

7. Knowledge

- ○ The torpedo boat Tomozuru capsized due to her top-heavy structure. Current shipbuilders have valuable experience and confidence in their knowledge of stability. However, we must remember the difficulties of shipbuilders in the past and make the best use of the knowledge that our predecessors gave us.
- ○ The problem of "top-heavy" can destroy structures and organizations. Top-heavy structures are prone to capsize and collapse. Top-heavy organizations are prone to bad management. Individual top-heavy (armchair theorist) may also cause failure.
- ○ The belief of designers in their expertise cannot coexist with an attitude of compromise.

8. Background

One background issue of Tomozuru's case was a severe demand for increasing the fighting power of each vessel under the restrictions of the disarmament treaty. In November 1921, the U.S.A, the British Empire, France, Italy and Japan formed a disarmament committee in Washington D.C. In this committee, they decided that each nation should restrict the total weight of her vessels. The U.S.A, the British Empire, France, Italy and Japan agreed to restrict the total weight of each country's vessels according to the ratios 5,

5, 1.75, 1.75, and 3.

In addition to this disarmament treaty, the London Naval Treaty was concluded in 1930. The treaty established several restrictions concerning submarines and auxiliary ship after many twists and turns. In this treaty, Japan appeared to have partly fulfilled her demands from the U.S.A and the British Empire; however, in fact the U.S.A gained an advantage over Japan in constructing support vessels under the restriction. Thus, the Japanese naval vessels had to mount large numbers of guns at the cost of their structural strength, which led to the exposure of serious defects. Tomozuru's capsize and the 4th fleet incident forced us to recognize that inconsistencies between policy and technology lead to unexpected tragedies.

9. Sequel

From October 23rd to 26th in 1944, the Japanese Navy was soundly defeated by the U.S in the battle of the Philippine Sea. After the battle, the U.S. 3rd fleet under the control of Admiral Halsey was assigned to attack Leyte Island. The 3rd fleet appeared east of the Philippines and attacked Luzon Airfield after two weeks resting in Ulithi on December 13rd. Task Group 38 carried out the attack under the control of Vice Admiral McCain.

On December 17th, Task Group 38 withdrew to the east to refuel. However, the weather worsened, and they had to suspend the refueling operations soon after the noon. On the morning of December 18th, a small but strong typhoon, which weather watcher could not find struck Task Group 38. Radars were blown off, and the commanders were unable to control the vessels or contact with each other with their radios. The wind velocity exceeded 55 m/s. The captains of Destroyers Hull, Monaghan and Spence needed to keep their fuel tanks empty in order to fill them with fuel, and so they did not lower the COG of their vessels by pumping seawater into the tanks. The three unstable destroyers repeated inclined about 70 degrees when the storm was the strongest, and finally all three vessels sank. Some other vessels, including five light air careers, three escort air careers, two heavy cruisers, and eight destroyers, were seriously damaged, and nine vessels were slightly damaged. The number of aircraft that were thrown into the sea or that crashed into each other and burned amounted to no less than 183. About 800 sailors died. Task Group 38 was heavily damaged not by the Japanese Navy, but by a natural disaster.

Perhaps this incident might be caused by lack of their stability even the situation of typhoon and empty fuel tanks was so unfortunate. Of course, the cause of Tomozuru's capsize is the top secret of the Japanese Navy at the time, and the U.S. Navy could not have known it. In contrast, almost no Japanese vessels capsized since Tomozuru did. In military field, knowledge of failure cases cannot be shared between nations.

10. On the Side

A historical museum in Sweden, named VASA Museum, exhibits Battleship Vasa and her history. Vasa capsized during her first navigation. Shipbuilders tried to make Vasa the largest and most beautiful vessel ever, but such a new and adventurous vessel is not always successful. Vasa capsized due to her top-heavy structure, in the same way as Tomozuru. However, Sweden has advanced diving and salvage technology, so

recently it succeeded in salvaging Vasa. Vasa Museum is not just a historical museum but also a museum that exhibits both the pride and the shame of Sweden. It is also a museum of failure.

Vasa was a dig sailing ship with a displacement of 1,210 tons, a body length of 47.5 m, a maximum width of 11.7 m, and ten sails. She was equipped with 64 cannons, and she carried a crew of 145 and 300 soldiers.

Here is the chronological record of Vasa;

1625 King Gustav II Adolf decided to construct Vasa
1626 Construction began at Stockholm Naval Shipyard
1627 Launching of Vasa
1628 Jan. 16th Inspected by the King
Aug. 10th Capsized in port on her maiden voyage
1664 Most of the 64 cannons were salvaged using diving bell
1953 Investigation of the sea bottom began
1957 Digging under the body of Vasa began
1961 Salvage was completed (333 years after the capsize)
1988 Last navigation from the temporary museum to the new museum
1990 Current Vasa Museum was completed

Why did Vasa capsize? Who should take responsibility? The court tried the following four persons:

○Captain at the time Ballast, Training, Operation
○Admiral at the time Rolling Test, Suspension of Her Navigation
○King Gustav II Adolf Severe Demands, Urge to Early Construction
○Designer at the time Concealment of Chart, Patrimonial Handing Down

Capsize of vessels caused by top-heavy structures has occurred often since ancient times. Because people have not been able to effectively reuse those experiences and knowledge gained, the same kind of failure has happened again and again.

11. Primary Scenario

01.Organization Problems
02. Inflexible Management Structure
03. Acceptance of Unreasonable Demands
04. Insufficient Analysis or Research
05. Insufficient Prior Research
06. Lack of Examinations and Rethinking
07. Planning and Design
08. Poor Planning
09. Poor Design
10. Torpedo Boat
11. Top-Heavy

12. Usage
13. Operation/Use
14. Navigation
15. Possible Damage
16. Potential Hazard
17. Winds/Waves in Rough Weather
18. Secondary Damage
19. External Damage
20. Capsize
21. Loss to Organization
22. Social Loss
23. Defense Deterioration

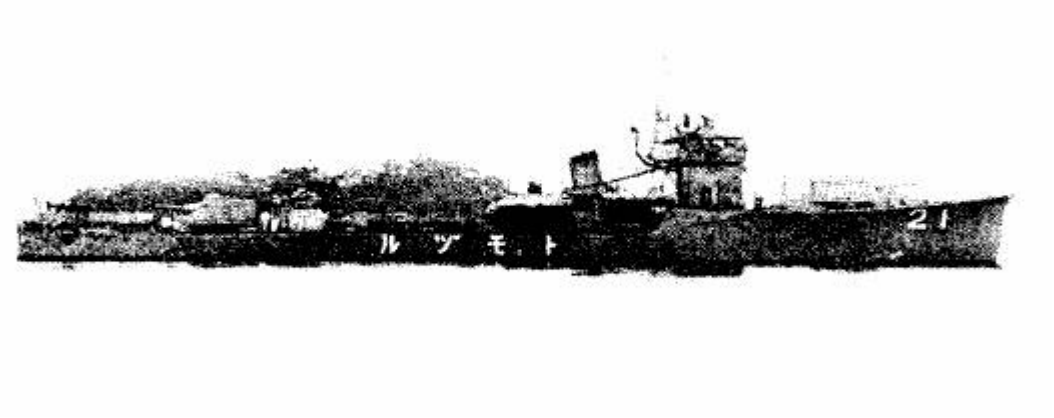

Fig.1 Torpedo Boat Tomozuru.

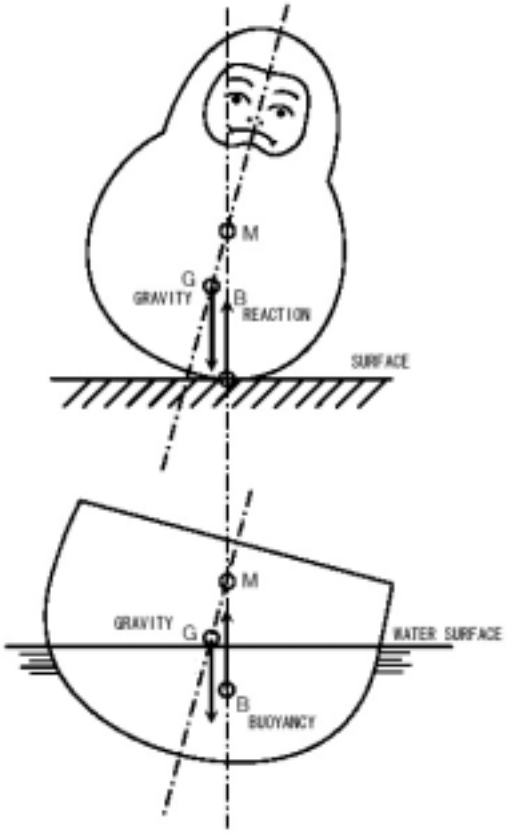

Fig.2 Vessel's Stability.

(Initial Stability is similar to a self-righting "daruma" doll)

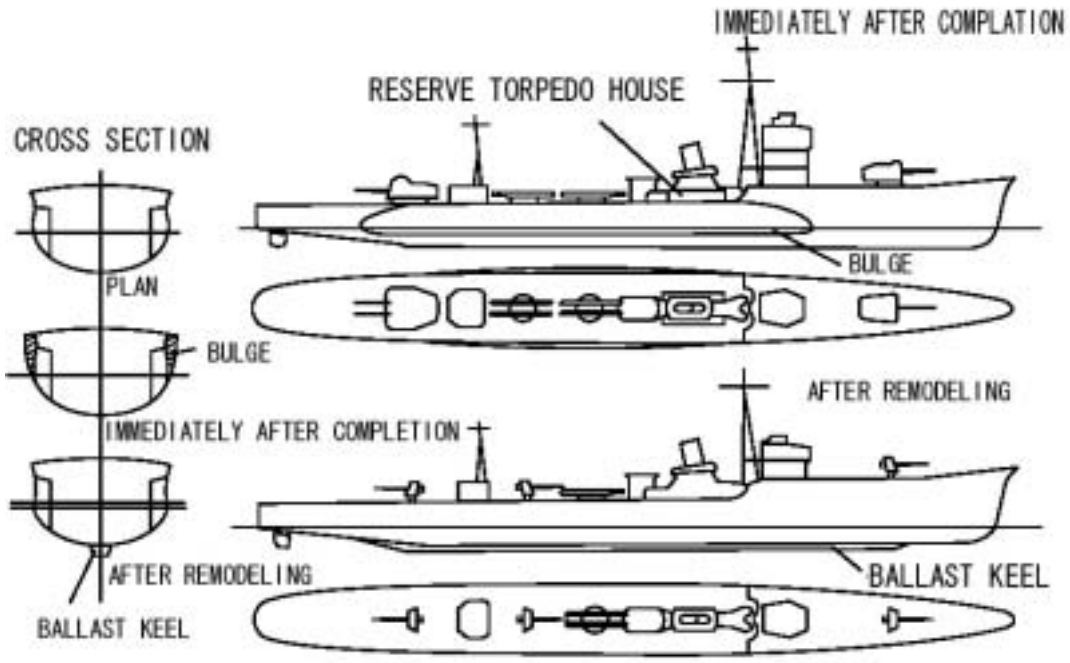

Fig.3 The main point of Chidori Class's Remodeling.

Fig.4 Change of the Destroyers and Torpedo Boats' shape.
(Before and After Remodeling)