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Technical Domain / Task Number 2 Task 2.3.3/2.3.4

Author(s) / Submitter(s) CHINA MSA

Application of Combined Mooring with Special Construction

# Summary

This paper describes the application of a combined mooring with special construction in China. Compared with the traditional concrete mooring, the new mooring have better effect in preventing unexpected movement of buoys, and the mooring is lighter in weight and simpler in construction. This paper shares the experience of the China MSA in applying this new type of mooring, which aims to provide information for the revision of Guideline G1066 or other relevant documents.

## Related documents

1. Recommendation R0107 Moorings for Floating AtoN
2. Guideline G1066 Design of Floating AtoN Moorings

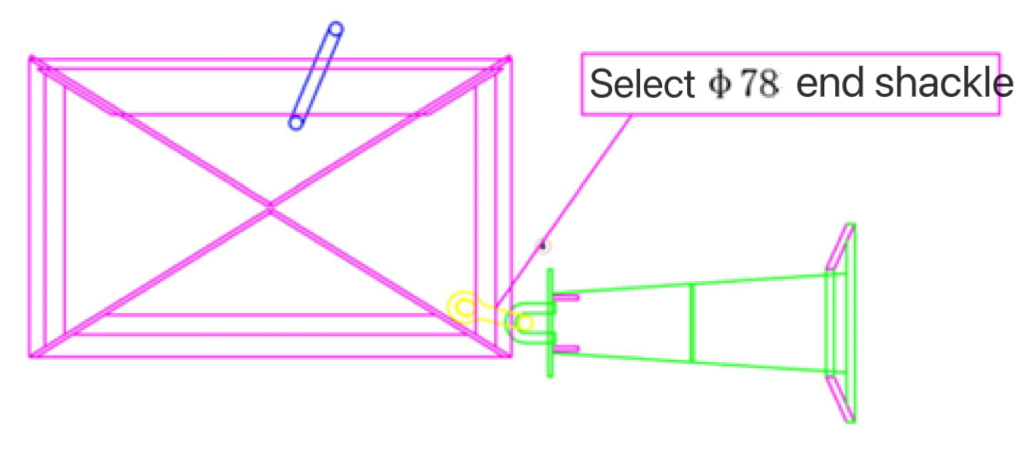
# Background

In some turbulent waters, or when extreme weather occurs, buoys are prone to shift and threaten the safety of navigation. How to prevent the unexpected movement of buoys has always been one of the key tasks of China MSA, especially of the department responsible for Aids to Navigation (AtoN) management. In the past, the main ways to prevent the buoys from unexpected movement is to increase the weight of concrete sinker and to use cast iron sinker. However, the effect of these measures is sometimes not obvious, or bring new problems, such as increasing the difficulty of buoy tender operation while weighting concrete sinker, and difficult to recover the sinkers after adopting cast iron sinker. In recent years, China MSA has adopted a special construction of combined mooring, which has been tested and achieved obvious positive results.

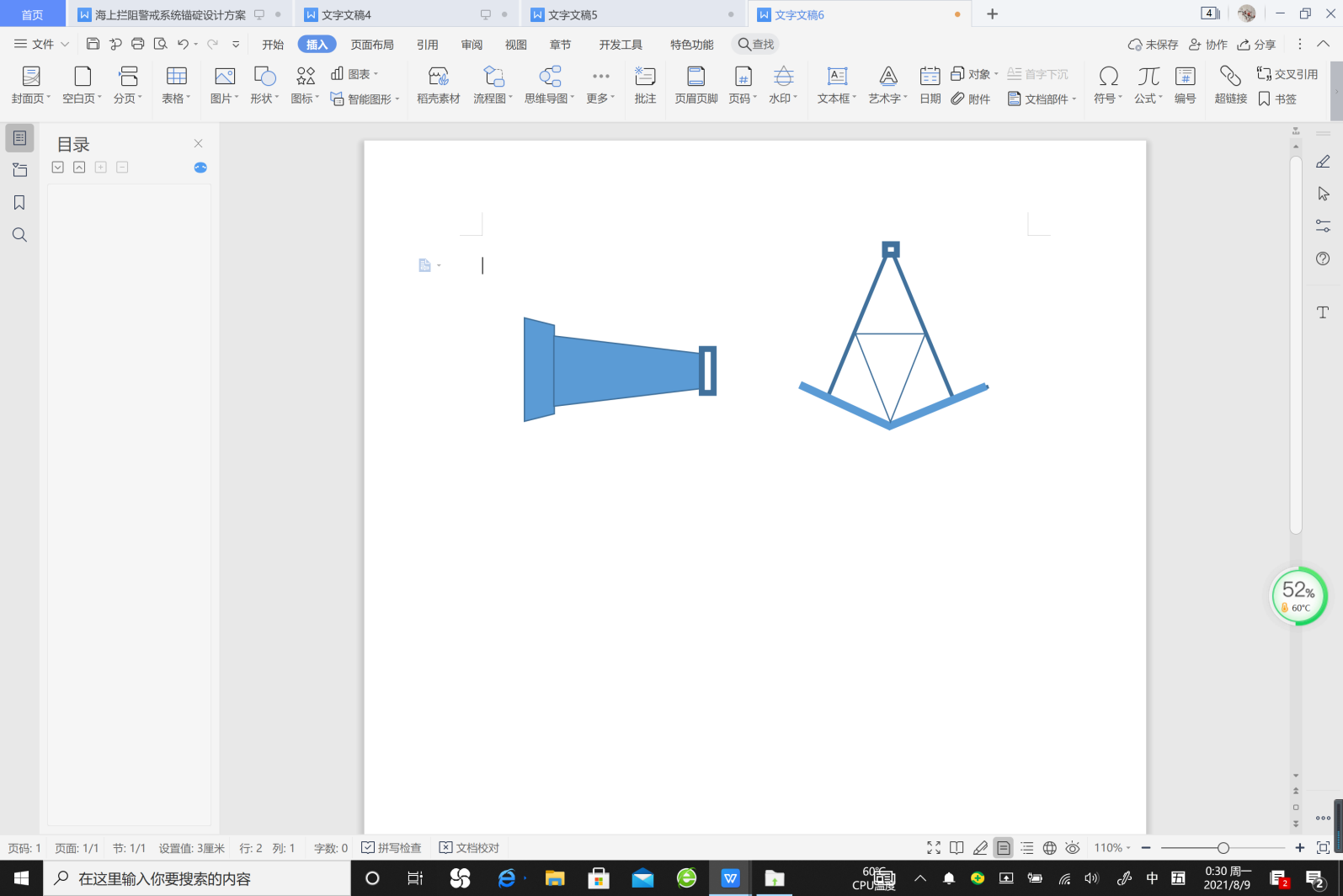
# Discussion

## The construction of mooring

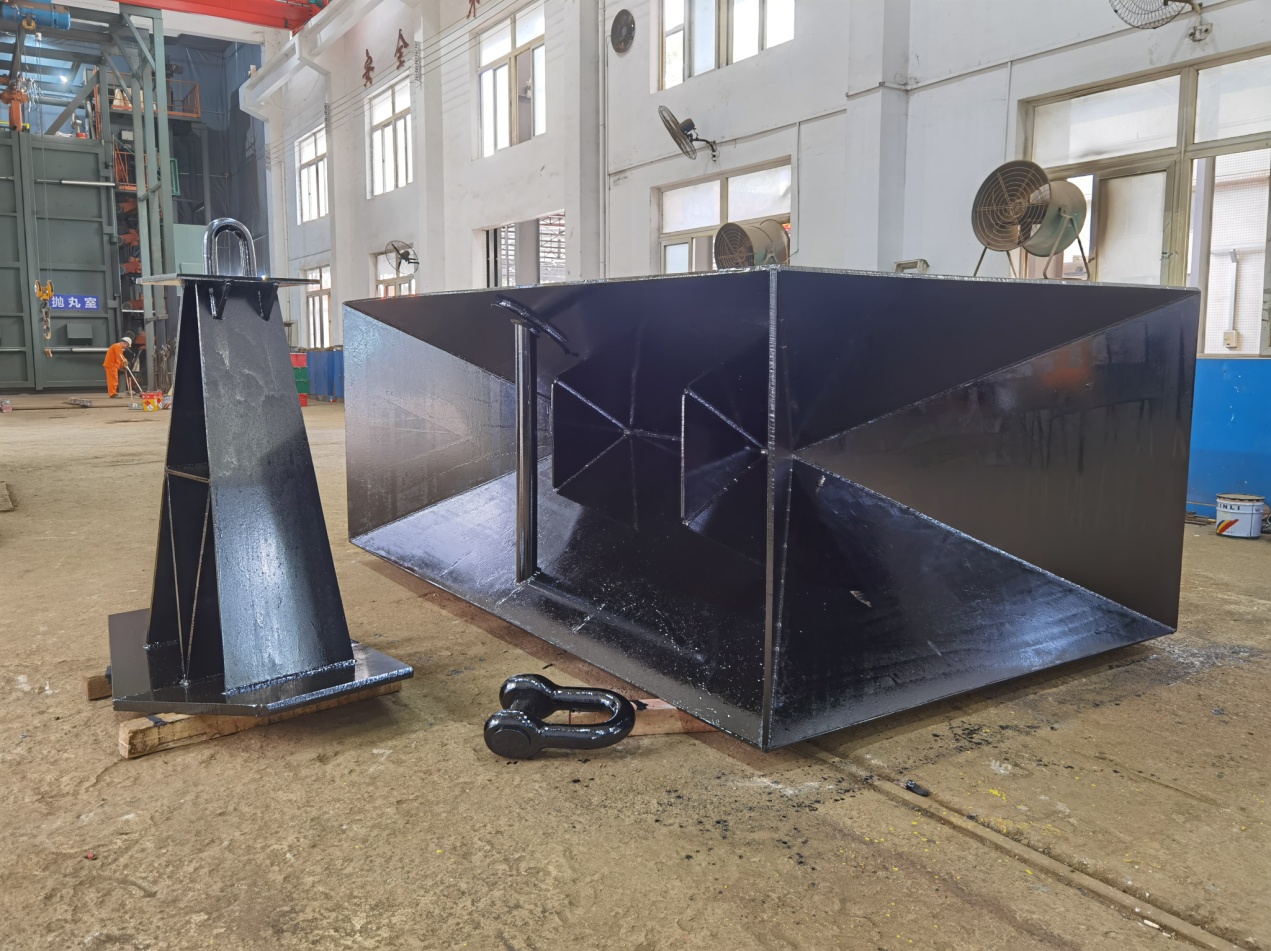
The mooring in special construction is composed of a steel cuboid and a steel triangular claw, both of them are linked by shackle and mooring chain. The ratio between the length, width and height of the steel cuboid is a golden ratio, and the six outer surfaces of the steel cuboid are inwardly spliced by steel plates to form grooves. The four surfaces of the cuboid are welded with reinforced connecting rods, which can be connected to the shackles and mooring chains.



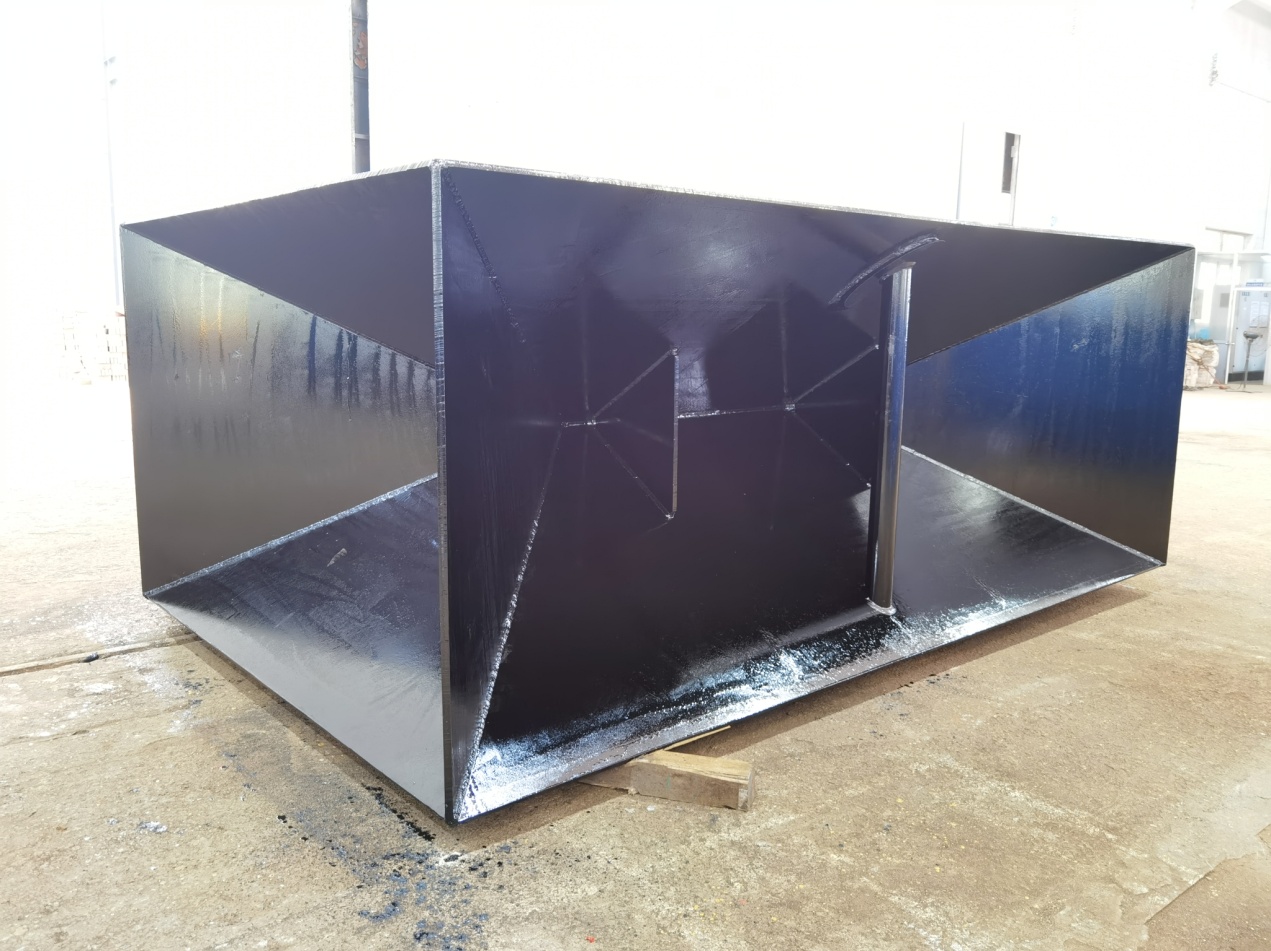
1. Schematic diagram of the combined mooring with special construction



1. Schematic diagram of the combined mooring with special construction



1. REAL PICTURE of the combined mooring with special construction



1. REAL PICTURE of the steel cuboid



1. REAL PICTURE of the steel claw



1. REAL PICTURE of clenching shackle

When the combined mooring with a special construction is launched, the triangular claw touches the bottom first, followed by the side of the steel cuboid. Whichever side of the cuboid touches the seabed, the side of the cuboid is pulled by the mooring chain and embedded in the sedimentary seabed. The greater the external force, the deeper and denser the mooring sink into the sediment layer, and the more sediment accumulates at the front end, thus preventing the mooring from moving. When the mooring are fully submerged or half submerged and in the case of soft substrates, the groove on the bottom of the mooring contacting the seafloor eventually removes the water and mud from the mooring to create a vacuum. The mud and sand mixture on the bottom produces a non-Newtonian fluid effect at the moment of external force, and the mooring produce a large pulling force to prevent the buoy from shifting.



1. Launching operation - single steel triangular claw construction

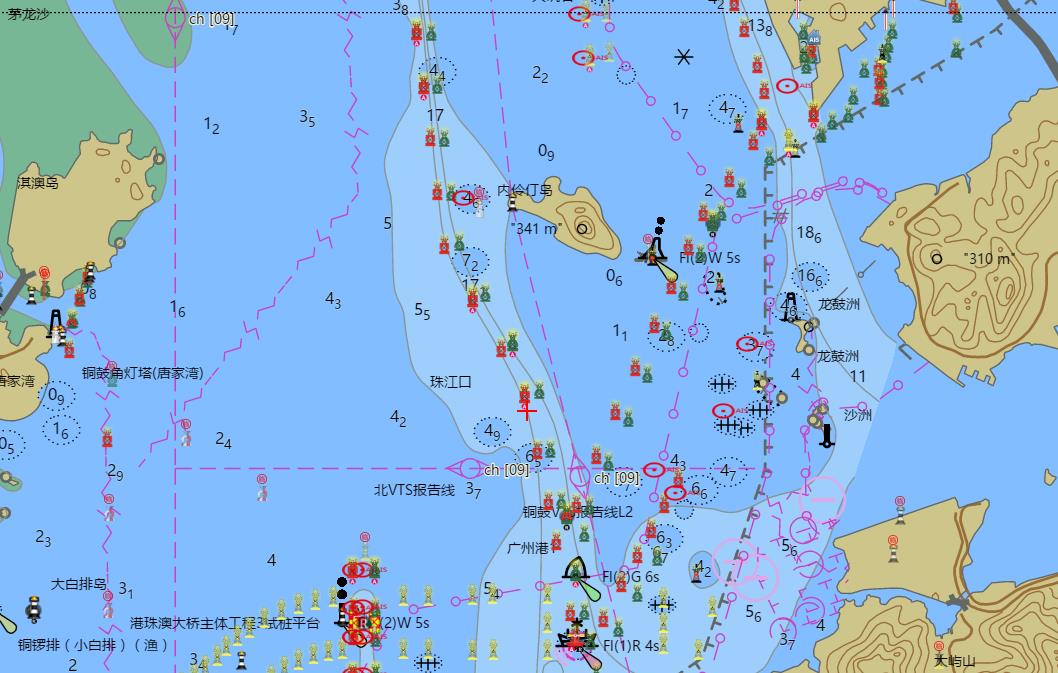
In the case of strong currents or poor substrate quality, the grip effect and stability of the mooring can be improved by adding a steel claw on the other side of the steel cuboid.



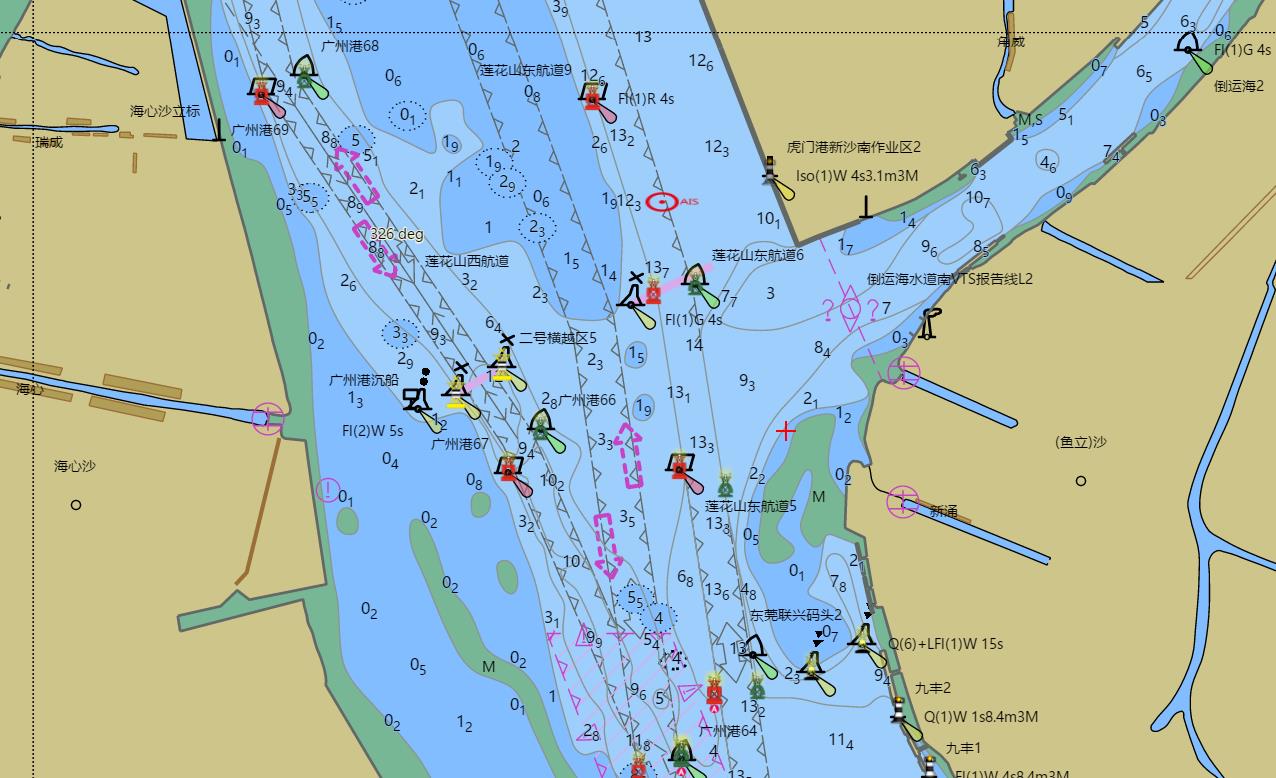
1. Inspection operation - Double steel triangular claw construction

## Test report

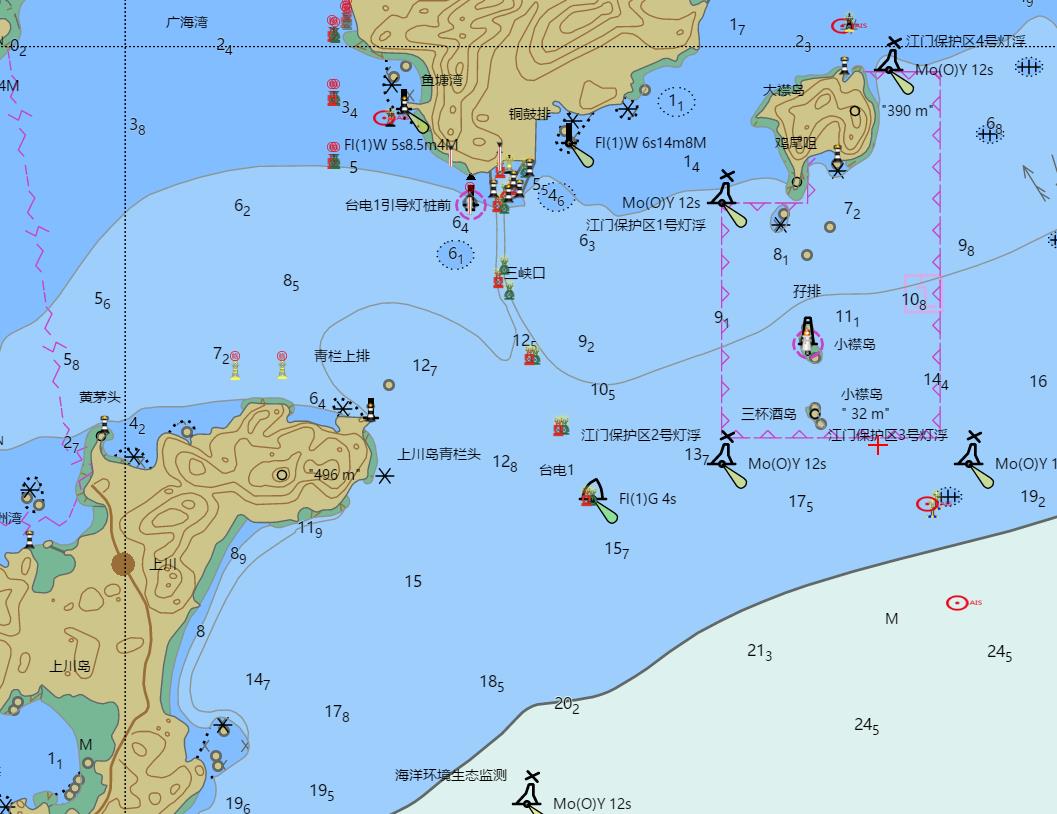
The tests were carried out in the waters of southern China, where the Pearl River, the third largest river in China, enters the sea. The Pearl River has many tributaries with complex water systems, and enters the sea with turbulent currents. What’s more, there are also large-scale offshore wind farms in the coastal area. Every year, during the typhoon, rainy season and other extreme weather periods, some buoys are very easy to shift away from the designed position.



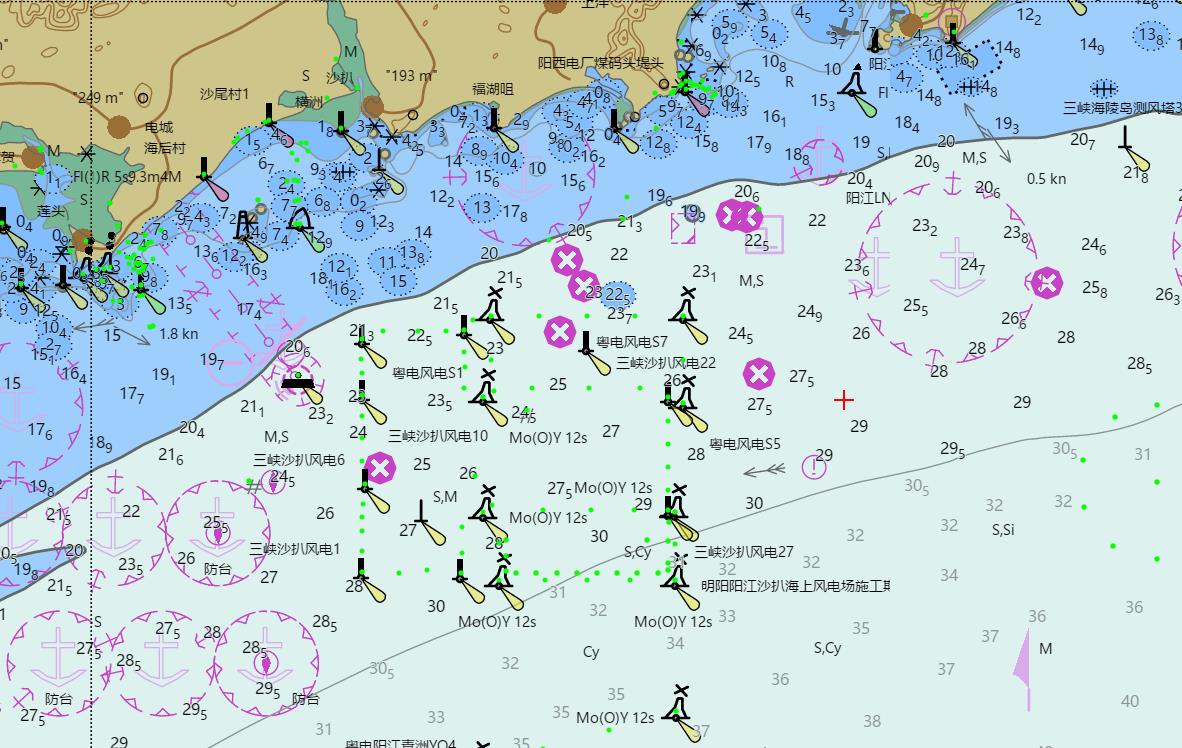
1. Test site – Pearl River estuary



1. Test site – Confluence of Pearl River tributaries



1. Test Site - Open Water Artificial Waterway



1. Test site - Wind farms far offshore

The size of the combined mooring is 2m\*1.24m\*0.76m for the steel cuboid and 1.6m for the steel triangular claw. The total weight of the new combined construction is 0.98 tons. By January 2024, a total of 23 buoys have been tested, mainly sited in the Pearl River estuary, Pearl River tributaries at the confluence, artificial navigation channel, as well as the offshore wind farm waters where the unexpected movement of buoys easily happen. The test report is as follows.

1. Test report

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Number | Water Area | Substrate Substance | Water Depth (m) | Characteristics | Test Quantity | Test Results |
|  | Pearl River estuary | Mud ,sand | 15-20 | The water flow is rapid all year round, and during the rainy season when there is a high tide, the flow rate can reach 3-4 knots, and the substrate sludge is easy to be loosened. | 13 | Reduction in buoy off-position after trial with partial adoption of double steel triangular claws |
|  | Confluence of Pearl River tributaries | Mud ,sand | 10-15 | At the confluence of rivers, the water flow is rapid, the direction of flow changes quickly, and the substrate sludge is easy to loose | 2 | The buoy position has been maintained stable and no further deviation after trial with partial adoption of double steel triangular claws |
|  | Open Water Artificial Waterway | mud | 15-20 | Open water artificial navigation channel has a big difference in water depth, and the surging waves are big all year round. Buoys are easily shifted in winter and typhoon season | 5 | No deviation occurred during the following typhoon season after the trial, and other buoys in the same waters had deviations during the typhoon season |
|  | Wind farms far offshore | Mud ,sand | 20-50 | The water depth here is deep, with large swells all year round, and the buoys are prone to shifting during winter and typhoon seasons | 3 | Slight or no deviation compared to other buoys in the same waters during the following typhoon season after trial. |

## Test conclusion

After testing, this combined mooring with special construction has obvious advantages over traditional concrete mooring or cast iron mooring in preventing the buoy from deviating from its designed position. The main advantages include:

1. Great hoiding power. Traditional concrete or cast iron mooring mainly rely on their own gravity to grip. The combined mooring with special construction is composed of a steel cuboid and a steel claw. The concave construction of the steel cuboid plays a similar role as the mooring' grip, and the steel claw plays the role of stabilizing the posture of steel cuboid when it is landed to ensure that the mooring effectively grip the ground. After the mooring is stabilized on the ground, the mooring is more and more embedded in the mud and sand under the action of external force, which can provide a larger and more stable gripping force for the buoy.
2. Light weight and simple construction. Take the size of the new type of mooring tested by China MSA as an example, the total volume is comparable to that of traditional concrete mooring, while the weight is only one-fifth of that of the latter.
3. Simple operation and strong compatibility. The mooring is relatively easy to launch and recover without special equipment, and can be connected with conventional mooring chains and shackles.
4. Flexible configuration and wide range of application scenarios. The mooring is formed by the combination of steel cuboid and steel claw with shackles and mooring chain. The size and quantity of steel rectangular body, steel triangular claw, mooring chain and shackles can be configured differently according to the needs, which is suitable for a variety of application scenarios.

This combined mooring with special construction is designed by a senior engineer of AtoN department, China MSA, who has obtained the invention certificate for the special mooring construction, also known as Cao's Mooring. Tests on the special combined mooring are still going on. In addition to buoys, China MSA is also actively conducting applied research in scenarios such as offshore construction protection and physical collision prevention for bridges.

# Action requested of the Committee

The Committee is requested to note the information in this document.

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2. Leave open if uncertain [↑](#footnote-ref-2)