

# Analysis of Navigation Aid Effectiveness of Tianjin Port Water Depth Signal Tower and Development Protection under New Technical Conditions

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**Abstract.** The Tianjin Port Water Depth Signal Tower is a navigational aid facility that provides tidal level information. In the last century, it made great contributions to the shipping industry of Tianjin Port and played an indispensable role in local flood control work; However, with the improvement of the accuracy of marine radar sounders, the influence of background lights, the increase of surrounding buildings, and the continuous widening and deepening of navigation channels, it is becoming increasingly rare for ship drivers to obtain tidal level information through their eyes or with the help of telescopes. In addition, whether drivers can obtain tidal level information through these methods is also a topic worthy of attention and research.

**Keywords:** Signal Tower; Navigation Effectiveness; Analysis; Protection; Development.

## 1. Introduction to the Functions of Tianjin Port Water Depth Signal Tower

The Tianjin Port Water Depth Signal Tower is located at the Xingang Shiplock in Binhai New Area, Tianjin. The signal tower is approximately 350 meters away from the shiplock in a straight line. Below the signal tower is a concrete brick and stone structure, and above it is a steel structure tower. The tower is 27 meters high, with the lowest sign height of 12.63 meters. The tower is white, and there are ten black signs and ten signal lights above the tower, Used to indicate the rising and falling tides during the day or night, as well as the tide level information at the ship lock (see C in Figure 1 for the water gauge label), for the use of ships in the main channel of Tianjin Port and as a reference for flood control departments.



**Fig 1.** Tianjin Port Water Depth Signal Tower and Water Gauge

The square label on the north side of the tower's central axis represents 2 meters, the circular label represents 1 meter, the top triangular label represents rising tide, the triangle does not display represents falling tide, the circular label on the south side of the central axis represents 0.2 meters, and the lower square label represents 0.1 meters, The upper square sign represents the negative water level. Similarly, at night, the red light on the north side of the central axis of the tower represents 2 meters, the white light represents 1 meter, the green light represents high tide, the white light on the south side of the central axis represents 0.2 meters, the red light represents 0.1 meters, and the orange

light represents negative water level. During the day, the sum of the values represented by each sign represents the current tide level, while at night, the sum of the values represented by each light represents the current tide level. Personnel who need tide levels can obtain them through eye observation or telephone consultation. A in Figure 1 is a top-down view of the drone, while B in Figure 1 is a close-up view.

## **2. The History and Development of Tianjin Port Water Depth Signal Tower**

The Tianjin Port Water Depth Signal Tower is located on the North Battery Site on Banana Island. The North Battery was established by the Qing government in the 21st year of the Jiaqing reign of the Qing Dynasty (1816). In 1900, the Eight Nation Allied Forces invaded Tianjin, and the officers and soldiers of Banana Island North Battery vowed to resist to the death. Due to being attacked on three sides, the North Battery eventually fell. Later, the Japanese occupied the North Battery alone for a year and a half. When the Japanese retreated, they demolished the North Battery. In 1919, the authorities built the North Battery Water Depth Signal Tower on the demolished site of the North Battery, providing water depth information for passing ships.

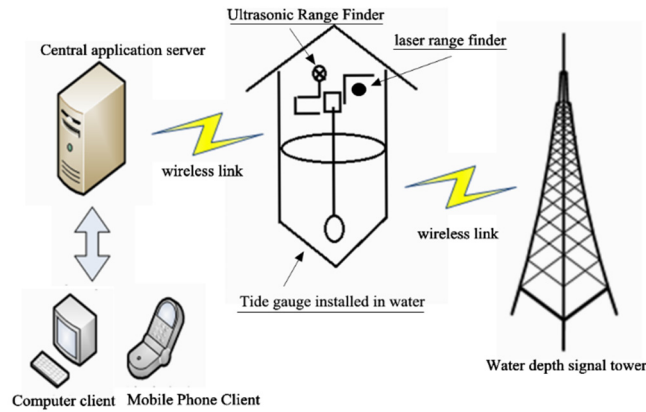
The water depth signal tower in the Tianjin area can be traced back to the sixth year of the Tongzhi reign of the Qing Dynasty (1867), when Tianjin Customs established a benchmark flag at Dagukou to display water level signals. In the fourth year of the Later Guangxu reign (1878), a tidal station was established in the Dagu area, named the Customs tidal station, and a standard tidal signal marker post was established.

The current Tianjin Port Water Depth Signal Tower was formerly known as the North Battery Water Depth Signal Tower. In August 1960, the government rebuilt the North Battery Water Depth Signal Tower and constructed buildings, lifting equipment, and other ancillary facilities, and renamed it the Tianjin Port Water Depth Signal Tower. In 1972, the Tianjin Aerial Survey Brigade rebuilt the Tianjin Port Water Depth Signal Tower on its original site and removed the original wooden structure markers, replacing them with a steel pipe triangular frame structure; In 1993, the government renovated the tide level observation station located near the ship lock into a two-story small building, and later installed the SCA6-1 acoustic water level gauge. Subsequently, several upgrades and renovations were carried out.

## **3. Latest Technology Upgrades and Service Models**

Before 2015, the duty personnel of the Tianjin Port Water Depth Signal Tower obtained tide level data by observing the tide level and water gauge with their eyes, and then manually or electrically displayed the tide level data on the tower of the water depth signal tower. This work required staff to continuously observe and record it 24 hours a day. In order to solve the problems of low efficiency and high labor intensity, in 2016, the management department used tower to platform linkage control technology, and developed an automatic tidal gauge display control system, which solves the problems of low work efficiency and high labor intensity, and improves the informatization level of hydrological observation.

The working principle of the automatic tidal gauge display control system is shown in Figure 2. The tide gauge installed in the water can generate data signals, which can be transmitted to the tower of the water depth signal tower through a wireless link to display real-time tide level data. The tower to platform linkage control technology can process data information and establish an association with the signal tower indicator, allowing the system to automatically read the current water depth information and change the content indicated by the indicator. The tide gauge can also transmit data to an application server through a wireless link. The application server can further upload the data to a computer client or a mobile client for users to check at any time. The client can not only query real-time data, but also access historical records. In addition, staff can also monitor the tide level at any time through high-definition cameras and verify the accuracy of automatically generated data.



**Fig 2.** Working principle of the automatic tidal gauge display control system

#### 4. Questionnaire Survey for Ship Drivers and Other Personnel

Although the Tianjin Port Water Depth Signal Tower has provided a large amount of tide level data for ship drivers and flood prevention personnel, in recent years, with the increasing number of buildings near the Haihe River Bridge and other objective reasons, it has become increasingly rare to obtain tide level information through eye observation. In order to better understand the usage of relevant personnel, the author conducted a survey by distributing questionnaires, telephone consultations, and WeChat consultations. The survey subjects included ship drivers, staff near the dock, and fishermen in the surrounding area. The investigation content includes the above personnel's understanding of the Tianjin Port Water Depth Signal Tower, the frequency of obtaining tidal level information through observing the signal tower, the reasons for observation or non observation, the frequency of consulting tidal level information through phone calls, the frequency of querying tidal level information through computer or mobile phones, and suggestions for improving the Tianjin Port Water Depth Signal Tower. The survey results are shown in Table 1.

Through a questionnaire survey, it was found that ship drivers and crew members have a significantly higher understanding of the Tianjin Port's water depth signal tower than the staff near the dock and surrounding fishermen. However, everyone's use of the water depth signal tower (including eye observation, telephone consultation, computer, and mobile phone) shows a very low level, and the reasons for not using it include not needing, not understanding, not having the habit of observation, not being able to see, etc. A few people know that they can consult by phone, but they do not know the phone number. Many people do not know that they can search through computers or mobile phones. Suggestions for improvement include removing and installing large digital display screens.

**Table 1.** Questionnaire survey on the usage of the water depth signal tower in Tianjin Port

Degree (A=more, B= ordinary, C= rarely)	Ship drivers and crew (53 people)			staff near the dock (26 people)			fishermen around the dock (15 people)		
	A	B	C	A	B	C	A	B	C
Understanding of Tianjin Port Water Depth Signal Tower	0	19	34	0	5	21	1	2	12
Frequency of obtaining tidal level information by observing signal towers	0	4	49	0	0	26	0	1	14
Frequency of consulting tide level information through phone	0	1	52	0	0	26	0	0	15
Frequency of querying tide level information through computer or mobile phone	1	1	51	0	0	26	0	0	15

## 5. On Site Observation of the Visual Effect of the Water Depth Signal Tower in Tianjin Port

In order to further understand whether ship drivers can obtain tidal level information by observing the Tianjin Port water depth signal tower, the author took the "Hai Xun 15020" ship and observed it at a distance of approximately 1.15 nautical miles from the Tianjin Port water depth signal tower (see point A in Figure 3 for the observation location) at sea (see point B in Figure 3 for the location of the Tianjin Port water depth signal tower). Through careful observation, the approximate location of the Tianjin Port Water Depth Signal Tower can be found. However, due to the large number of surrounding buildings, it is difficult to obtain specific hydrological information. The observation effect is shown in Figure 4, and even with the help of telescopes, the effect is still poor. Therefore, obtaining hydrological information through eye observation is indeed a difficult task.

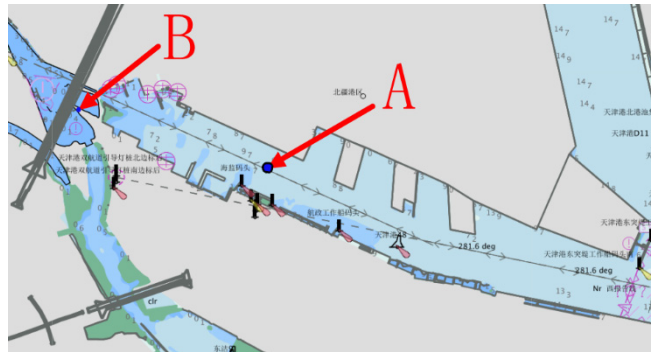


Fig 3. Tianjin Port Water Depth Signal Tower and Observation Points



Fig 4. Overall situation observed by the observer at sea

## 6. Analysis of Navigation Aid Effectiveness of Tianjin Port Water Depth Signal Tower

Through the statistical results of the questionnaire survey and the author's on-site observation, it was found that the current role of the Tianjin Port Water Depth Signal Tower in assisting navigation is indeed very weak, which can be summarized into two reasons.

Firstly, the observation distance of the Tianjin Port's water depth signal tower is only 6.5 kilometers, about 3.5 nautical miles. Large ships can only see it when they enter the visible range. Then, in the past thirty years, Tianjin Port has undergone tremendous changes, with various buildings near the port becoming taller and larger, and the tonnage of ships entering and exiting the port also increasing. In addition, the opening of the Haihe Bridge and the traffic on the bridge have resulted in too many objects in the field of view during the day, and at night, the background light is too dense, making observation difficult. In addition, the water depth signal tower sign itself is not large, and the signal light power is small and not bright enough. In the reality of strong background light and many background objects, it is indeed not eye-catching and difficult to observe.

Secondly, with the development of Tianjin Port, the main waterway has been continuously widened and excavated to a depth of over 21 meters, which can accommodate 300000 ton ships entering and exiting. Under these conditions, ship draft is no longer the main problem that troubles many drivers. On the other hand, large ships often have multiple high-precision sounders on board. Drivers can work with tide tables, electronic charts, etc. to accurately determine the real-time water depth at multiple positions such as the bow and stern of the ship, which makes many drivers lack the habit of observing old water depth signal towers, especially many young new generation ship drivers who are not even aware of the existence of water depth signal towers.

## **7. The Significance and Development Protection of the Tianjin Port Water Depth Signal Tower**

In the last century, the Tianjin Port's water depth signal tower did provide many conveniences for ships entering and leaving the port. Ship drivers can quickly obtain tide level information 24/7 through observation or telephone consultation under limited water depth conditions. Especially when the ship is fully loaded, accurate tide level information can help prevent accidents such as grounding. In addition, flood control departments also use water depth signal towers to obtain tide level information, in order to better carry out flood control work. However, in recent years, the flood control department's own tide level detection methods have also been constantly updated, and water depth signal towers are more often used for auxiliary and comparative functions.

Although the number of users using the Tianjin Port Water Depth Signal Tower is very small now, it is still necessary for this tower to exist and has protection value. In summary, there are three points.

1. The geographical location of the Tianjin Port Water Depth Signal Tower is the Battery Site. Although the battery has been demolished, it has witnessed the entire process of modern Chinese history. The Dagukou Battery Site Museum not far away displays many past batteries and cultural relics, detailing the role of Tianjin Port in modern Chinese history and the dark history of losing power and insulting the country. Although the current Water Depth Signal Tower is a building built after the founding of the People's Republic of China, However, it has been rated as an immovable cultural relic by the local cultural relic protection unit and still has high historical and educational significance.

2. The Tianjin Port Water Depth Signal Tower is currently the only water depth signal tower in the Tianjin region. It has played an important role in the local maritime security industry in history, witnessing the development of Tianjin Port after the establishment of the People's Republic of China and the rapid rise of Tianjin Port after the reform and opening up. At the same time, China is moving towards becoming a maritime power, and the Tianjin Port Water Depth Signal Tower witnessed the process of China's development from a maritime weak country to a maritime power, which has certain historical significance. At present, the Tianjin Port Water Depth Signal Tower is managed as a manned lighthouse, which demonstrates its importance.

3. Although the number of users using the Tianjin Port water depth signal tower is very small now, the small number of users does not mean that there are no users. Occasionally, there are individual ship drivers who obtain tidal level information through observation or telephone consultation. As long as someone is using it, even if there are few users, the signal tower still needs to exist. In addition, although various electronic devices are advanced and complete at present, in the event of malfunctions or in certain emergency, special, or unexpected situations, people still obtain tidal level information by observing signal towers.

## **8. Conclusion**

Although the water depth signal tower of Tianjin Port has been shut down several times due to various reasons in history, it still provides good navigation assistance services for ships entering and exiting Tianjin Port, and plays a positive role in the development of the port economy. However, at present,

the usage rate of the signal tower by ship drivers is very low, which is an undeniable fact. Even though the managers of the signal tower have updated the technical means of data display and provided more information transmission methods, it seems that it has not been widely recognized by users, leaving the signal tower in an awkward situation of about to withdraw from the historical stage. Nevertheless, as a long-standing navigational aid facility, the signal tower still needs to exist. If the navigational aid function is completely lost in the future, it is also a good choice to protect this signal tower as a historical relic for people to visit and learn.

## References

- [1] Xue Jiali, Wang Lilin. Research on real-time monitoring technology for ocean observation data transmission business flow [J]. *Ocean Information*, 2015.
- [2] Yang Di. Research on the Technical Transformation of Tianjin Port Water Depth Signal Station Based on Information Collection and Processing Technology [J]. *China Maritime*, 2014 (09): 55-56.
- [3] Chen Yidi, Xie Haidong. Research on the Application of Tower Linkage Control Technology in Tianjin Port Lock Signal Station [J]. *China Maritime*, 2018 (02): 52-54. DOI: 10.16831/j. cnki. issn1673-2278.2018.02.021.
- [4] Guo Qiang, Yang Fan, Gu Miao. Analysis of the Development of The Tianjin Port Water Depth Signal Tower from the Perspective of Historical Relics Protection, [C] 2022 Entrepreneurship and Innovation Paper Collection of Beihai Navigation Support Center, 301-304.
- [5] Wang Yingzhi. *Navigation Aids*, Dalian: Dalian Maritime University Press, 2021.