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Agenda item [[2]](#footnote-1) n.n

Technical Domain / Task Number 2 …………………………………

Author(s) / Submitter(s) CHINA MSA

Best practice for G1165

*Resilient and Sustainable AtoN Structure Design*

# Summary

China MSA provides a case study of linear low-density polyethylene light beacon construction on Changxing Island, Dalian, China as a best practice for the guideline.

## Purpose of the document

In active response to the requirements of G1165 ***Resilient and Sustainable AtoN Structure Design***, this proposal takes a linear low-density polyethylene light beacon construction on Changxing Island, Dalian, China as a best practice case study, demonstrating how project design and construction processes have resulted in resilient and sustainable Marine Aids to Navigation.

## Related documents

1. IALA Guideline G1165 ***Resilient and Sustainable AtoN Structure Design***

# Background

In IALA ENG19, the task group encouraged IALA members to share examples of resilient and sustainable design and construction prior to ENG20. In this context, China MSA actively respond to the task group’s call by providing a case study of a linear low-density polyethylene light beacon on Changxing Island, Dalian, China as a best practice in accordance with the requirements of the guideline.

# Discussion

The case study covers multiple aspects including "Location, Purpose/navigational requirements, Environmental design conditions, Design life, Standards and codes applied to design, Special/sustainable considerations, Additional information", demonstrating and verifying how project design and construction processes have resulted in resilient and sustainable Marine Aids to Navigation. Linear low-density polyethylene light beacons can be widely used on islands, capes, and breakwaters due to the modular design, environmentally friendly materials and efficient construction techniques. These features collectively advance the goal of resilience and sustainability, making this case a best practice example for the guideline.

# References

None.

# Action requested of the Committee

The Committee is requested to:

Consider the information in this proposal.

1. Best practice example of light beacon construction
2. **Location**

Changxing Island, Dalian, China.

1. **Purpose/navigational requirements**

The light beacon was built on the mooring dolphin of a certain dock on Changxing Island. It meets the positioning and navigational requirements of large vessels and special ships entering and leaving the port, as well as berthing and berthing operations. It fully utilizes navigation assistance efficiency and ensures the safety of both vessels and port facilities.

1. **Environmental design conditions**
   1. Location

The light beacon is located at a certain dock on Changxing Island. All materials, supports, components, and construction machinery and equipment required for the project can be transported by vehicles. The entire construction process was carried out on land, with access to fresh water and electricity supply, ensuring good construction conditions.

* 1. Geomorphology

According to ***Seismic Ground Motion Parameters Zonation Map of China*** (GB18306-2015) and its Explanation, the basic seismic intensity of Class II site on Changxing Island is 7 degrees, the seismic peak ground acceleration is 0.1g, and the characteristic period of the acceleration response spectrum is 0.45s.

The light beacon is built on the upper platform of the mooring dolphin. The platform, made of reinforced concrete, has good load-bearing capacity. The preliminary construction of the light beacon includes concrete placement and foundation maintenance, etc. The bottom of the light beacon is connected and fastened with the pre-embedded parts in the concrete foundation through bolts, ensuring that the foundation of the light beacon is safe, reliable, and in line with the seismic requirements.

* 1. Air

The average relative humidity (RH) of Changxing Island is 67.5% over the years. The RH is relatively high from May to September, with a maximum monthly average RH of 86% occurring in July. The RH is relatively low from October to the April of the following year, with a minimum monthly average RH of 59% occurring in January and December.

Environmental conditions at coastal sites generally feature high humidity and salt laden moisture in the air, resulting in severe salt spray corrosion. The main threat is rusting of the metal, especially when exposed to harsh saline conditions. To address this, the internal frame of the light beacon is made of Q355B low-alloy steel, treated with hot-dip galvanized process for strong corrosion resistance. The external ladder and connecting bolts are also made of stainless steel. The external shell is made of linear low-density polyethylene (LLDPE), which is primarily made from ethylene as raw material, with a small amount of α-olefin co-monomers, polymerized under the action of catalyst through high-pressure or low-pressure process. It has good resistance to most non-oxidizing acids (such as hydrochloric acid, phosphoric acid), alkalis (such as sodium hydroxide), and salt solutions (such as seawater) at room temperature, and exhibits long-term stability in high humidity and harsh saline conditions.

* 1. Wind

Changxing Island is located in the East Asian monsoon region. In winter, it is influenced by cold air from Siberia and Mongolia, resulting in prevailing north wind. In summer, it is affected by warm and moist airflow from the Pacific Ocean, leading to predominantly south wind. In December 2004, a temporary observation station was established in the northern part of Changxing Island for meteorological, wave, and tide observation, obtaining observational data over a three-year period. According to the observation data from December 2004 to November 2007, the average annual wind speed on Changxing Island is 6.2 m/s, with the prevailing wind direction NE at a frequency of 17.2%, and the secondary prevailing wind direction SW at a frequency of 13.3%; throughout the year, the dominant wind directions are mainly NNE ~ ENE and S ~ WSW, accounting for 33% ~ 34% and 26% ~ 38% of the annual frequency, respectively. The strong wind directions are NE and NNE, with maximum wind speeds of 32 m/s and 31 m/s, respectively. The maximum wind speed in WSW direction can reach 24 m/s. The maximum recorded wind speed was 32 m/s in 2005, with the wind direction NE. Typhoons have little impact on Changxing Island. For example, Typhoon No. 8509 crossed western of Liaodong Peninsula in September 1985, and Typhoon No. 7303 crossed Liaodong Bay in July 1973, but no strong wind records were found.

The internal frame of the light beacon is composed of segmented steel structures, connected and fastened by bolts, covered with external LLDPE shell. The bottom of the light beacon is connected and fastened with the pre-embedded parts in the concrete foundation through bolts. LLDPE has good elasticity and Environmental Stress Cracking Resistance (ESCR, passing ASTM D1693 1,000-hour test) due to the distribution of short chain branches in its molecular architecture, absorbing the wind loads energy through elastic deformation to ensure the stability of the light beacon. The external LLDPE shell adopts rotational molding technology, and each section is a seamless shell. It has a Tensile Strength at Yield > 15 MPa (ISO 527), and an Impact Strength > 25 J/mm (ARM). Combined with bell and spigot frame, the entire light beacon is stable, with a wind resistance of wind scale 13 (wind speed 37.0 ~ 41.4 m/s), exceeding the historical maximum wind speed of 32 m/s on Changxing Island, which ensures long-term reliability.

* 1. Temperature

The Changxing Island region has a maritime climate and is significantly influenced by monsoons. According to the observation data from December 2004 to November 2007, the average annual temperature of Changxing Island is 10.9℃, with the extreme maximum and minimum temperature 30℃ (on July 18 and August 13, 2005) and -15.6℃ (on February 3, 2006), respectively. The highest average monthly temperature is 23.7℃ (August) and the lowest is -3℃ (January).

Extremely low or high temperatures can affect the performance of the external equipment; it can shorten the expected useful life of the equipment and make certain materials fragile. According to historical data, extremely high or low temperatures are rare on Changxing Island. The external LLDPE shell exhibits excellent temperature resistance: the Deflection Temperature is 60℃ (0.45MPa, ISO 75), and the Brittleness Temperature is -40℃ (ISO 974). Within the range of -40 ~ +60℃, the mechanical properties remain stable, and its operating temperature range far exceeds the extreme climate conditions of Changxing Island, ensuring long-term reliability. In addition, extremely low or high temperatures can also affect the performance of the light. The light beacon is equipped with an integrated solar power light, which operates within a temperature range of -35 ~ +60℃.

* 1. Ultraviolet (UV) light

High ultraviolet (UV) light levels in prolonged periods of strong sunlight can cause degradation of material properties, and environmental conditions at coastal sites require high UV resistance of materials. In order to prevent or mitigate the effect of photo-oxidative aging, antioxidant and light stabilizer are added in LLDPE to improve its stability, and address the issue of external LLDPE shell colour fading after prolonged use.

The external shell is made of UV-20 rating (passing ASTM 2565 20,000-hour UV test) LLDPE, offering excellent UV resistance, capable of withstanding long-term direct sunlight exposure, and preventing the external LLDPE shell from embrittlement, fading, or cracking due to UV exposure.

1. **Design life**

10 years.

The external LLDPE shell has features such as high UV resistance rating, good ESCR performance, high tensile and impact strength, etc. Even after 10 years of use,  the surface colour of the light beacon can still comply with IALA R0108 ***The Surface Colours used as Visual Signals on Marine Aids to Navigation*** (December 2017), and the light beacon can still withstand the impact of strong waves.

1. **Standards and codes applied to design**

The light beacon was designed by a professional unit, complied with relevant national AtoN standards and codes, such as ***Maritime buoyage system, China*** (GB 4696-2016), etc., and the design considered the suggestions and opinions of AtoN users and maritime administration departments, etc.

1. **Special/sustainable considerations**

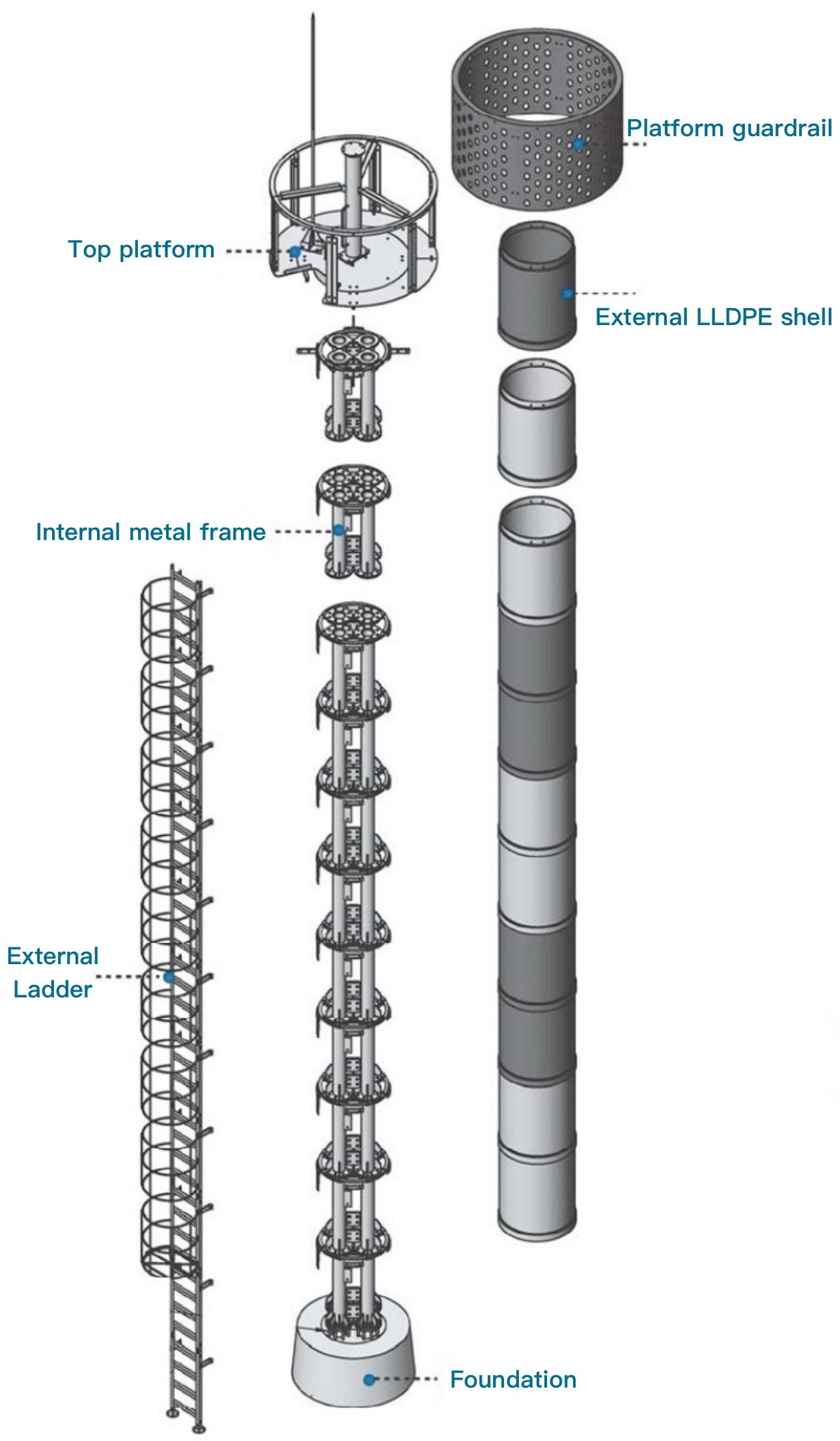
The external LLDPE shell adopts rotational molding technology, ensuring a consistent color throughout the shell, thereby eliminating the need for secondary painting process. The color is less likely to peel off even when scratched, making it relatively stable. Maintenance personnel can directly use high-pressure water to clean the surface of the external LLDPE shell. Compared to traditional light beacons made of stone, concrete, or metal, the repair process is simpler, as it reduces maintenance work such as rust removal and painting, which is labor-saving and cost-saving. Furthermore, the production process of the light beacon is eco-friendly and pollution-free. Both the internal metal frame and external LLDPE shell can be recycled, making the entire light beacon environmentally friendly.

The light beacon adopts a modular design, and the external LLDPE shell (with a density generally around 0.937 g/cm³) is connected and fastened with the inter metal frame through bolts. Each individual component is lightweight, supporting manual transportation and rapid installation, resulting in a short construction period, minimizing the use of concrete and the emission of construction waste, reducing energy consumption and carbon footprint. The construction of the light beacon has minimal impact on the environment, achieving green and environmentally friendly construction.

The light beacon is equipped with an integrated solar power light, featuring a modular structure and a remote monitoring and control system. It can withstand harsh environmental conditions at coastal sites, offering high reliability and stability with low maintenance costs, which is in line with the concept of sustainable development.

1. **Additional information (Technical parameters of the light beacon)**
2. *Technical parameters of the light beacon*

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| --- | --- | --- | --- |
| **Main material** | Linear low-density polyethylene | **Colour of the light beacon** | Red and white |
| **Material of the internal frame** | Q355B | **Surface treatment of the internal frame** | Hot-dip galvanized |
| **Material of the external ladder** | 316L | **Height of the light beacon** | 8.0m |
| **Main body diameter** | 0.8m | **Lightning protection** | Lightning rod |
| **Wind resistance** | Wind scale 13 | **UV Rating** | UV-20 |
| **Design life** | 10 years |  |  |



1. *Structure of the light beacon*



1. *Construction site of the light beacon*



1. *The light beacon construction completed*

1. Input document number, to be assigned by the Committee Secretary [↑](#footnote-ref-0)
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