Design and Analysis of Offshore Access Gangways

Qibin Zhang[1,a], Shihong Gan[1,b]

[1]School of Shanghai Maritime University, Shanghai 201306, China.

[a]18862961736@163.com, [b]1533139609@qq.com

Abstract

With the rapid development of offshore wind power and oil mining industry, as an important large-scale auxiliary equipment of offshore oil platform, the retractable boarding trestle can ensure the safe transportation of personnel in adverse sea conditions. In 2016, abs-guide for certification of offshore access gangways (abs-oag) was proposed by American Bureau of shipping. The code mainly introduces the overall design, hydraulic system design and electrical system design of telescopic boarding trestle. This paper mainly introduces the structural design of trestle and relevant formulas according to the specifications.

Keywords

Offshore access gangways, ABS-OAG, Personnel transportation, Structural design.

1. Introduction

With the rapid development of offshore wind power and oil mining industry, it is very important for the personnel rotation and maintenance personnel getting on and off the ship for offshore projects such as drilling platform, FPSO, wind power installation, etc. Such a kind of telescopic boarding trestle system with motion compensation will become quite necessary. This product can not only solve the safety transportation of personnel under the harsh sea conditions, but also provide power supply, water, oil and mud transportation [1].

With the development of design and manufacturing capacity of large-scale marine equipment in China, many domestic manufacturing of large-scale marine equipment has been realized, such as various pile driving vessels, floating cranes, drilling platforms, etc. However, the current mainstream design of semi submersible support platform still relies on foreign design, and some core supporting equipment, such as the retractable boarding trestle, as one of the key supporting parts, plays an important role in maritime transmission personnel. However, due to the lack of corresponding independent intellectual property products in China, the procurement negotiation is often subject to control. As one of the key offshore components in urgent need of localization, it is also urgent to have a prototype to realize the application in the semi submersible support platform. At present, ABS classification society and DNV are the main codes for the design of telescopic boarding trestle_ Two GL classification societies published [2].

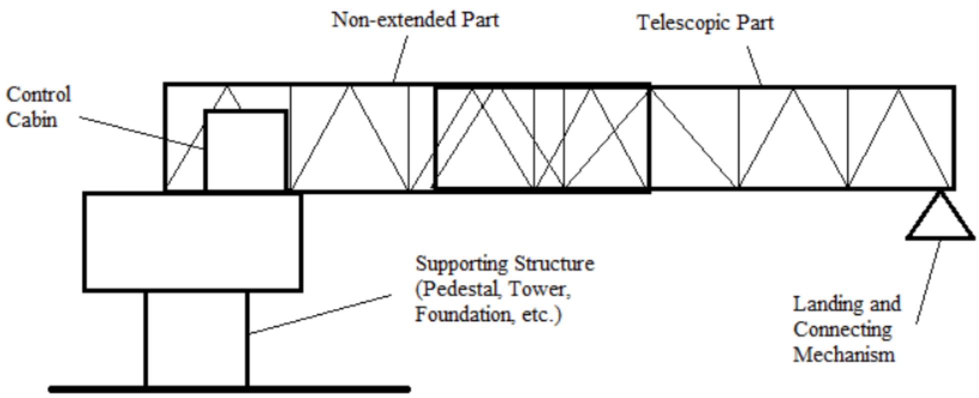


Fig. 1 Example configuration of an offshore access gangway

2. Overall design

From the appearance of the trestle, the trestle is similar to the tower crane used in land construction. Both of them have a long truss structure and can be rotated. Therefore, the abs-oag specification is based on the specifications of large-scale truss machinery on land. It can only be said that they look the same, and the difference between the working environment and the nature of the work makes the two extremely different in terms of design. Generally speaking, a boarding trestle consists of many parts, mainly motion compensation system, fixed truss channel, telescopic truss channel and mechanical device, [4].

2.1 Structural design

2.1.1 Category of Gangways

According to the specifications, the Gangways is divided into two categories

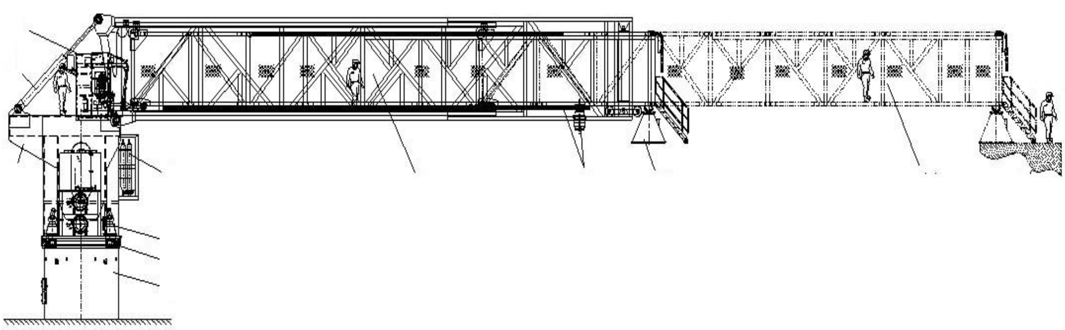
(1) Type I: unlimited personnel flow (Fig. 3)

This kind of trestle is used for personnel transportation between large ships and offshore platforms, and there is not much requirement for the number of personnel passing through at one time.

(2) Type II: Limited personnel transportation (Fig. 4)

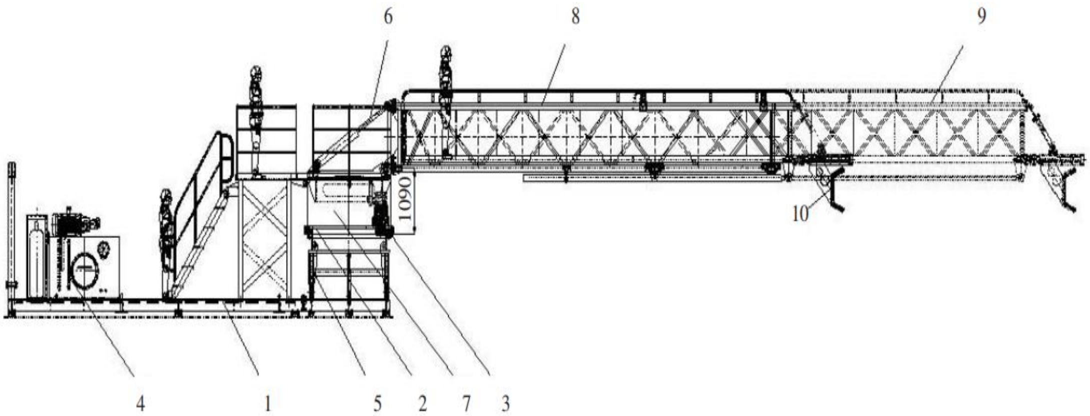
This kind of trestle is used for personnel transportation between large ships and offshore platforms. Due to the different design of trestle, there are requirements for personnel passing through, and the number of people passing through at one time cannot be too much, [1].

Fig. 2 Physical picture of boarding gangway



Base 2. Slewing bearing 3. Slewing reducer 4. Accumulator station 5. Cab 6. Luffing cylinder 7. Slewing platform 8. Fixed channel 9. Telescopic mechanism 10. Landing cone 11. Telescopic channel

Fig. 3 Structural diagram of type I boarding gangway



Base 2. Slewing bearing 3. Slewing reducer 4. Pumping station 5. Rolling platform
6. Luffing cylinder 7. Slewing platform 8. Fixed channel 9. Telescopic channel 10. Landing cone
Fig. 4 Structural diagram of type II boarding gangway

2.1.2 Structural design

After determining the type of trestle, the structure of trestle is designed according to abs-oag specification.The overall structure and layout of the trestle generally includes the motion mechanism of amplitude variation, rotation and trestle expansion and contraction. The luffing capacity of the trestle is mainly powered by the luffing cylinder (see Fig. 2 and Fig. 3), so that the fixed truss channel of the trestle can rotate clockwise to 25° and anticlockwise to 16.5° around a point. The rotation of the trestle is mainly driven by the hydraulic motor inside the slewing mechanism (see the figure above) to control the trestle to rotate. The telescopic truss can extend and shorten to a certain extent through telescopic mechanism, roller and track. One end of the trestle is fixed on the rotary platform, the upper end is connected with the hydraulic cylinder, and the lower end is hinged with the rotary platform.

2.2 Functional analysis

The use process of gangway is as follows:

2.2.1 Before lapping

This situation belongs to the working condition of the trestle. Through the command issued in the trestle control room, the trestle is luffed, rotated and truss telescoped to approach the target platform. The trestle itself has a set of motion compensation system, that is, the system will feed back the status of the trestle to the control room, and the operator will adjust the trestle. During the personnel operation, the motion compensation system will also carry out amplitude variation, rotation processing and truss expansion and contraction to get closer to the target platform.

2.2.2 After lapping

This situation is that the trestle has been successfully connected to the target platform. At this time, the hydraulic power station of the trestle will enter a floating pressure state. In this state, the traffic control system will release the blockade. Once the pressure of the telescopic, rotary and luffing mechanisms is lower than the floating pressure, each mechanism will passively move between the target platform and its own base in a passive manner, [1].

2.3 Design load

2.3.1 Dead Loads

This load is mainly the dead weight of the trestle, which is represented by landing fixture, control room, hydraulic, electrical and mechanical.

2.3.2 Live Loads

In the overall design of the trestle, the minimum live load of the trestle is 4.51 kn/m^2 (460 kgf/m^2, 94.2 LBF/ft^2); in the local design, the minimum live load is 5 kn/m^2 (510 kg/m^2, 104.5 lbf/

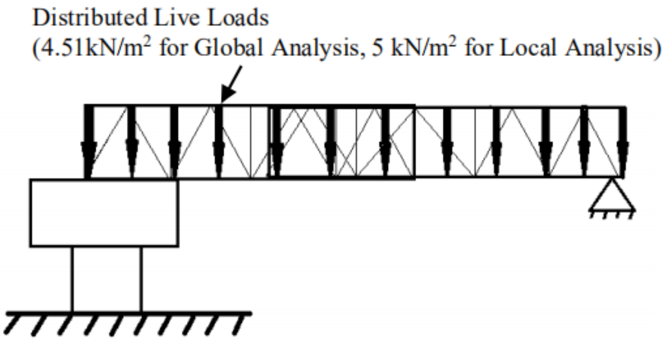


Fig. 5 Type I gangway – distributed live loads

For the emergency lifting or lowering of the trestle, the local load of 5 kn / m^2 (510 kg / m^2,104.5 lbf / ft^2) acts on the expansion part of the trestle, and the minimum live load of 15 kn (1.53 tf , 3.37 ltf) acts on the tip of the trestle,see Fig. 6.

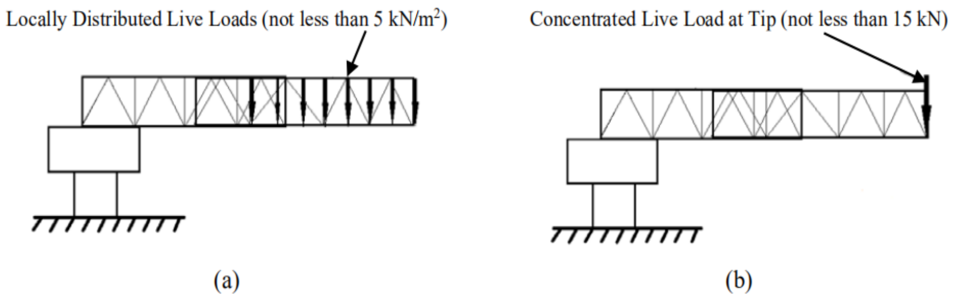


Fig. 6 Type I gangway – live loads for emergency lift-off condition

For type II trestle, the two ends of the trestle will be supported after lapping with the target platform. At this time, the live load is mainly the passing personnel and equipment, see Fig. 7.

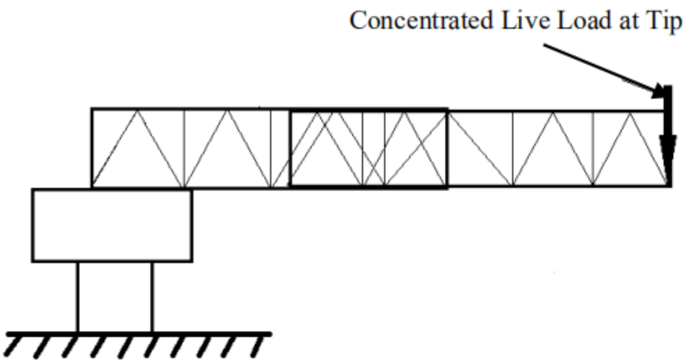


Fig. 7 Type II gangway –live load for gangway supported at two ends

3. Calculation standard of allowable stress

Computed tensile, bending and shear stress components and, as applicable, combinations of such stresses, for primary structural members, stresses are not to exceed the allowable stress, *F*, as obtained from the following equation:

$$F = Fy \cdot Sc.$$

where

Fy = specified minimum yield strength of material. For design purposes, for steels with yield strength not exceeding 355 N/mm^2 (36 kgf/mm^2, 51 ksi) *Fy* is to be limited to no more than 72% of the minimum ultimate strength of the steel.

Sc = allowable stress coefficient as specified in the following table. For accidental conditions, an increase of up to 33% in the allowable stresses may be used, see Table 1.

Table 1 Allowable Stress coefficients, Sc

Type of Stress	Allowable Stress Coefficients, Sc
Tension:	
Non-Pin Connected Members (gross area)	0.60
Pin Connected Members (net area)(4)	0.45
Shear:	
On the Cross Sectional Area effective in Resisting Shear	0.40
Bending (Tension and Compression on Extreme Fibers):	
Solid Round and Square Bars	0.75
Members with Compact Sections(3)	0.66
Members with Non-Compact Sections(3)	0.60
Bearing Stress:	
On Contact Area of Surfaces and Projected Area of Pins in Holes	0.90
Combined Stress:	
Von Mises Stress (Static Loads)	0.67
Von Mises Stress (Combined Loads)	0.75

For plated structures, von Mises stress using finite element analysis for all load conditions is not to exceed $Fy \cdot Sc$, where *Sc* is the allowable stress coefficient.

S_c = 0.67 for Operating Condition – Static Loads
= 0.75 for Operating Condition – Combined Loads
= 0.75 for Transit Condition and Severe Storm Condition
= 0.90 for Accident/ Damaged Condition

4. Serviceability Limit State (SLS)

The relative deflection of the gangway, max, in the operating condition, is not to exceed the following criteria:

δmax ≤ $\ell/100$ Gangway designed with a cantilever free end
≤ $\ell/200$ Gangway designed with both supported ends

Where

δmax = maximum relative vertical or lateral deflection
= max($|\delta B1|$, $|\delta B2|$)
= $\delta B1$ and $\delta B2$ are shown in Fig. 8

ℓ = design length of the gangway

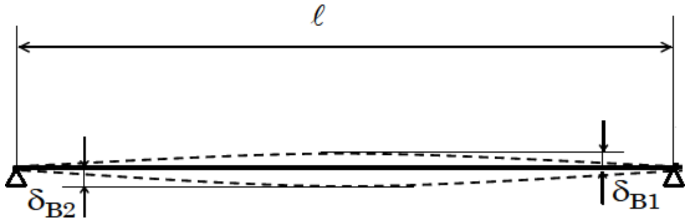


Fig. 8 Relative deflection

5. Conclusion

In this paper, the structure design and related formulas of boarding trestle based on abs-oag specification are described. But after all, abs-oag specification is a code that has just been in operation for several years. At present, few products have been designed and delivered to users according to this specification. Compared with the crane specifications that have been used for many years, many places need further practice and discussion.

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