FEM Analysis of the Telescopic Tunnel in Passenger Boarding Bridges

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Abstract. With the rapid development of cruise tourism, passenger boarding bridges are becoming more important in cruise terminals. In this paper, the passenger boarding bridge was introduced. Model of the telescopic tunnel used for the passenger boarding bridge was built. And the finite element method was chosen to evaluate the static performance of the telescopic tunnel. The results shows that the design of the telescopic tunnel can meet the demand of the passenger boarding bridge.

Keywords: Passenger Boarding Bridge; Telescopic Tunnel; FEM; Static Analysis.

1. Introduction

The boarding bridge for passenger is a kind of basic equipment for cruise terminals. It can connect the ship and the waiting hall, providing a comfortable and convenient walking passage for passengers to get on and off the ship. the passenger boarding bridge is not only a tool for the port to provide services, but also a medium for communication with passengers. Therefore, the technical level of the passenger boarding bridge is also an important index to measure the service level of the port. Inland river and lake ferry terminals, strait and cargo passenger Ro-Ro passenger terminals, cruise home ports and cruise affiliation terminal, etc., all need to be equipped with professional passenger boarding bridges [1-6].

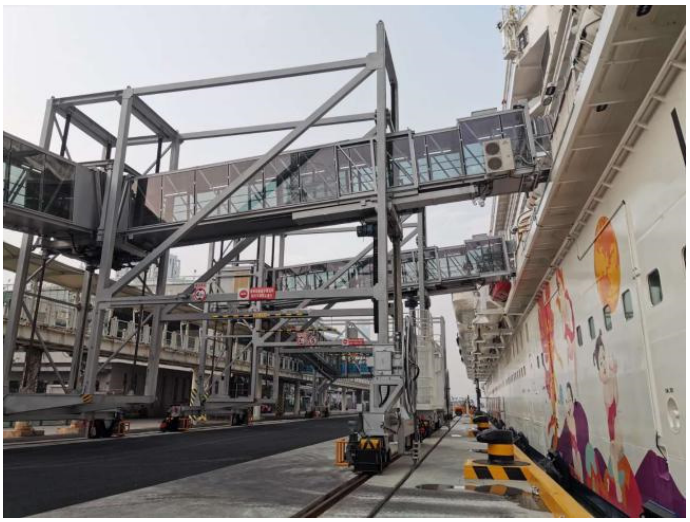


Figure 1. The passenger boarding bridge in the cruise terminal

In this paper, in this paper, the passenger boarding bridge was introduced. Model of the telescopic tunnel used for the passenger boarding bridge was built. And the finite element method was chosen to evaluate the static performance of the telescopic tunnel. The results shows that the design of the telescopic tunnel was safe. Finally, the development trend of passenger boarding bridges in the future were analyzed, and the epidemic prevention measures related to the boarding bridges was introduced .

2. The Technical Characteristics of Boarding Bridge

There are different types and forms of passenger boarding bridges at home and abroad, and there are characteristics for each type of passenger boarding bridge. At first, passenger ships in the traditional passenger transport industry only took transportation as their main function, but the rise of cruise tourism brought the service idea of luxury cruise ships, coupled with the prosperity of river and island tours, people's demands for travel comfort, satisfaction and well-being are getting stronger. Furthermore, new and higher requirements were put forward for the boarding bridge in superior performance, convenient pass, attentive service and security.

The boarding brigde is consisted of the gantry frames, telescopic tunnel, lead screw elevating mechanisms, ramps, the driving system and so on as shown in figure 2. the telescopic tunnel is an essential part for the boarding bridge. It can connect one gantry frame with the other gantry, providing walking space for passengers. Therefore, the mechanical characteristic of the telescopic tunnel plays an important part in the design of the passenger boarding bridge.

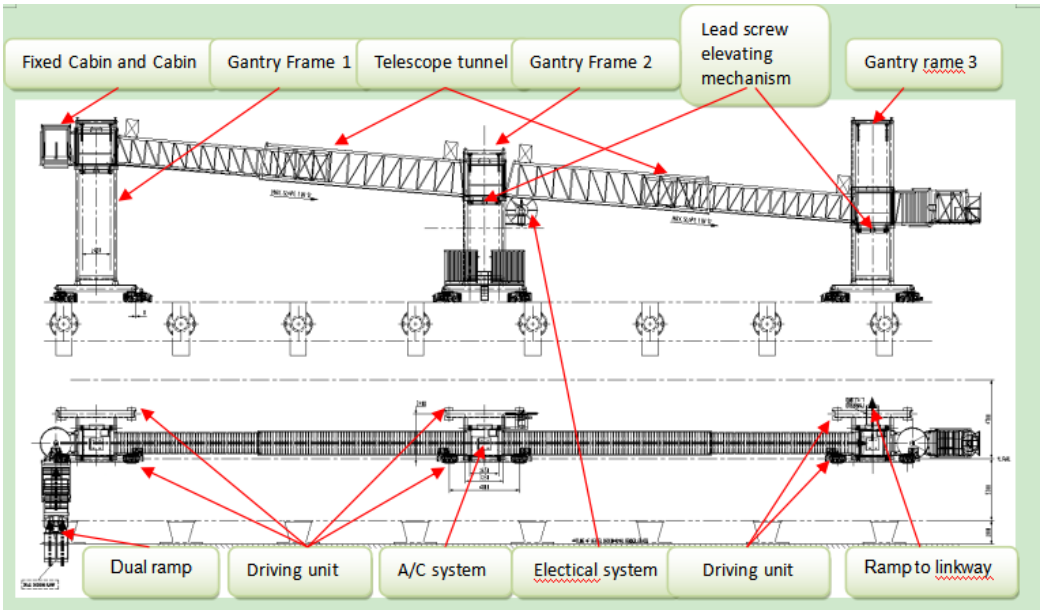


Figure 2. Schematic diagram of the boarding bridge with dual telescopic tunnels

3. Telescopic Tunnel Linear Static Analysis

The length of Telescopic Tunnel Length is 30m. The analysis was carried out based on the following standards of Federation Europeenne De La Manutention (FEM).software packages of ANSYS 14.0 was chosen to evaluate the linear static of the telescopic tunnel.

The materials used for the telescopic tunnel are structural steel ASTM A572 Gr50. The material properties are shown in Table 1. Safety factor is 1.5 against the yielding stress.

Table 1. Material properties

Material	Density	Young' modulus	Poisso'n ratio	Min. yield strength $R_{p0.2}$	Min. tensile strength R_m	Allowable stress
ASTM A572 Gr50	7850 kg/m^3	210 GPa	0.3	345 MPa	510 MPa	230 MPa

3.1 FE-Model

The tunnel model was built with linear elastic beam elements. Because of the telescopic characterizes of the tunnel, models with different length were built as shown in figure 3.

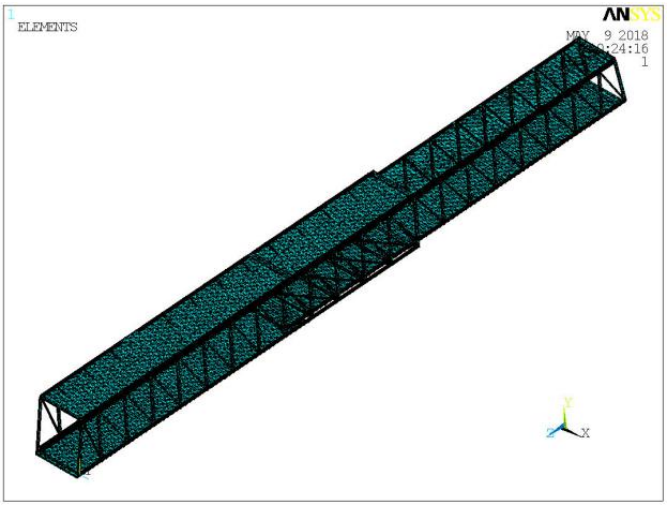


Figure 3. Finite element (FE) model of normal operating(Length=29m)

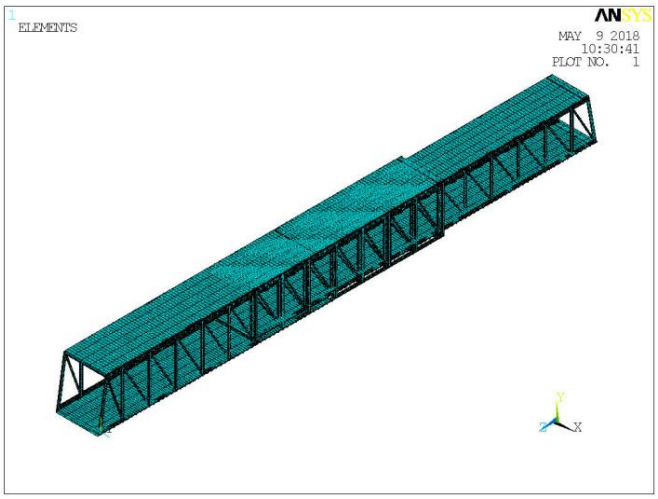


Figure 4. FE model of non-working(Length=27m)

3.2 Loads Setting

Table 2. Setting of the different loads

Name of the load	Setting of the different loads
Dead load	the Dead weight of the tunnel
Live load	-Floor load: 3000 N/m^2 -Roof load: 800 N/m^2
Wind load	-Wind speed during the normal operation: 20 m/s -Non-working wind speed: 40 m/s
Earthquake load	Peak acceleration of the earthquake: 0.15 g
Load Cases (LC)	Live load case 1 (LLC 1): Floor load and Roof load on the tunnel Wind load case 1 (WLC 1): Wind force caused by normal operating wind speed Wind load case 2 (WLC 2): Wind force caused by non-working wind speed Dead load case 1 (DLC1): Dead load of the tunnel Earthquake load case 1(ELC 1): The force caused by earthquake
Load Groups (LG)	LG1: Extended condition 1.05 * (DLC1 + LLC1) + WLC1 + ELC1 LG2: Extended condition DLC1 + LLC1 LG3: Shorten condition DLC1 + WLC2

The loads were taken into consideration to the tunnel in the analysis as shown in Table 2.

3.3 Constraints

The tunnel was pinned at both two ends as shown in Figure 5.

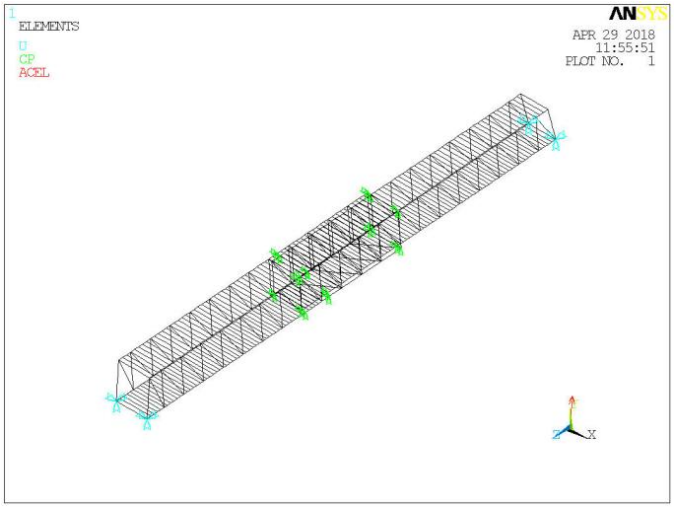


Figure 5. Constraints setting for the telescopic tunnel

4. Static Analysis Results

The stresses as shown in the following part are maximum nodal equivalent stresses (von Mises).

The stress in LG1were shown in 0 and Fig7 at the extended condition. The maximum stress was 209 MPa which was lower than the allowable stress 230 MPa. Fig.8 shows the deformation of the LG2. The maximum deformation is 64.7 mm.

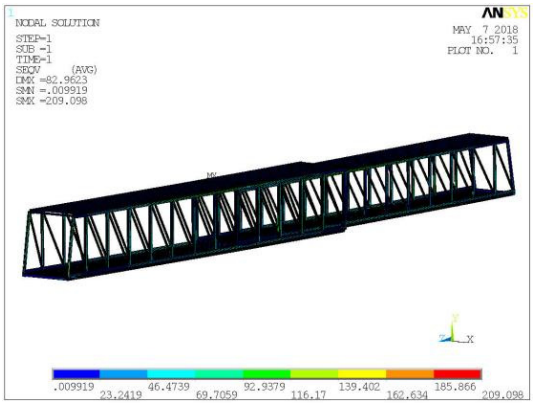


Figure 6. Stress distribution in LG1

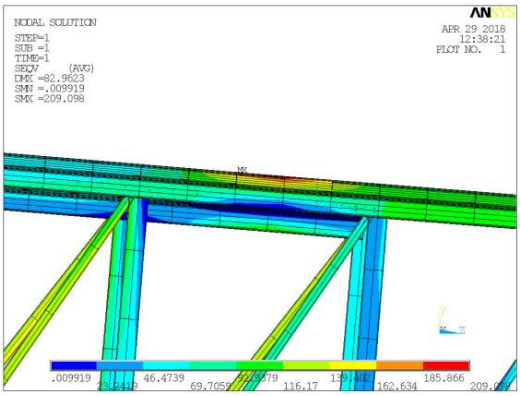


Figure 7. Local stresses distribution in LG1

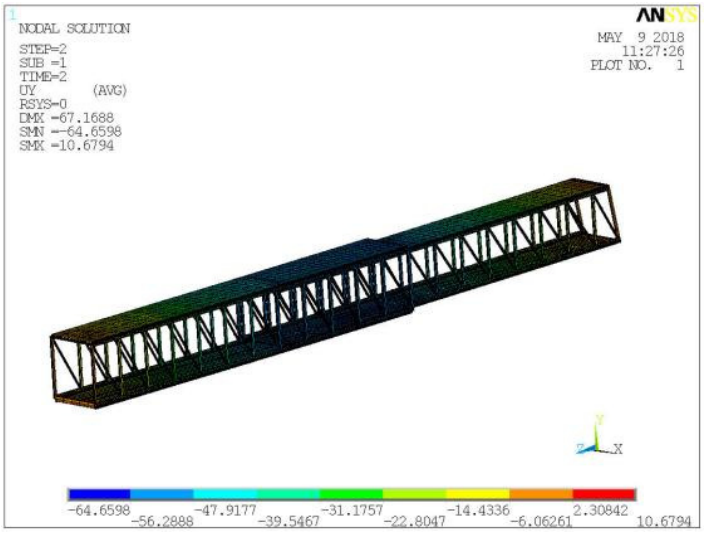


Figure 8. The deformation of tunnel in LG2

Fig.9 and Fig.10 show the stress in LG3 at the Shorten condition. The maximum stress was 189 MPa which was lower than the allowable stress 230 MPa. The maximum deformation was 30.9 mm as shown in Figure 11.

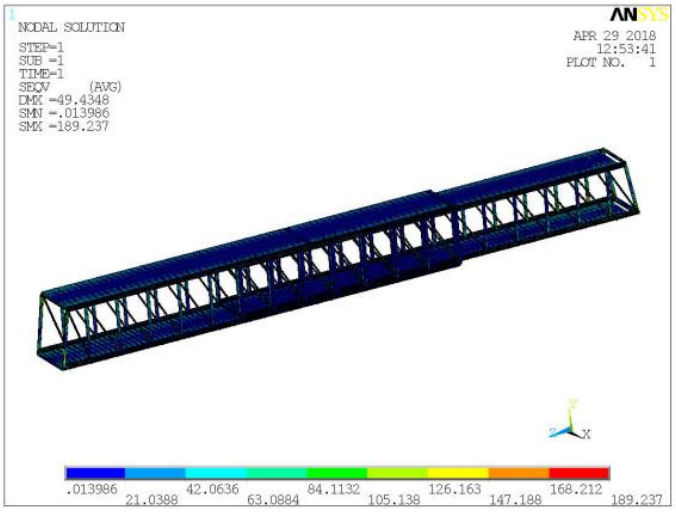


Figure 9. Stress distribution in LG 2

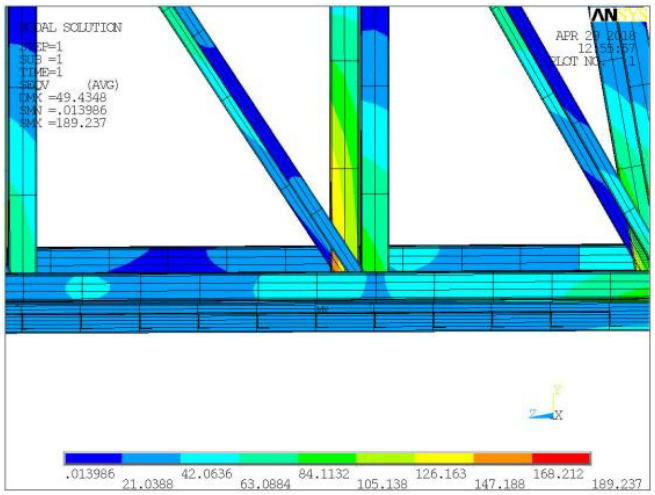


Figure 10. Stresses distribution in LG3

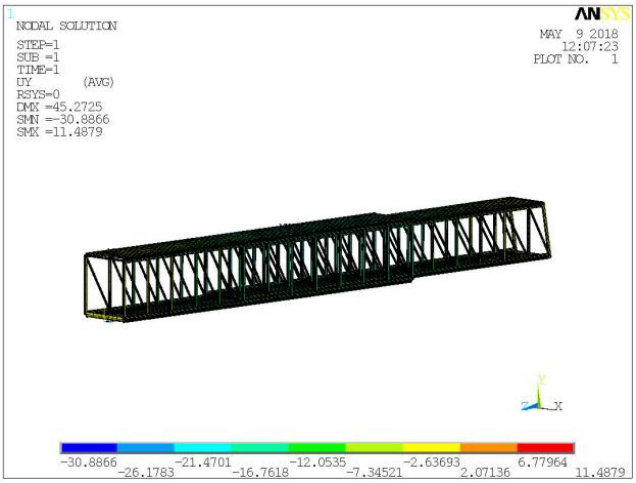


Figure 11. The deformation of tunnel in LG3

Based on the FEM analysis and the results, the mechanic strength of the tunnel was adequate with minimum allowable safety factor 1.5 against the yielding stress. The maximum deformation was 64.7 mm which was acceptable as well.

5. Conclusion

The passenger boarding bridge is an important part in cruise terminal and passenger-cargo Ro-Ro terminals. It can facilitate the process of the getting on and off the ship. In this paper, a kind of the passenger boarding bridge with dual telescopic tunnels was introduced. the telescopic tunnel used for the passenger boarding bridge was chosen to evaluate the mechanical property. And the finite element method was chosen to carry out the static performance of the telescopic tunnel. The results shows that the design of the telescopic tunnel can meet the demand of the passenger boarding bridge. With the development of science and technology in the future, automation and intelligence will become one of the development highlights of boarding bridges.

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