

## Development of a small-wheel-diameter and low-floor piggyback transport wagon



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### Abstract

As an important part of multimodal transportation, piggyback transportation has the characteristics of safety, environmental protection and speed. This article introduces the main purpose, technical parameters, structure and analysis calculation of a small-diameter low-floor piggyback transportation wagon.

**keywords:** piggyback transport wagon technical parameters structure calculation

Logistics costs in developed countries only account for about 5% of GDP, while the proportion of logistics costs in my country is more than 3.5 times that of developed countries. The main reason is the single mode of transportation. In recent years, multimodal transport has been elevated to the strategic level of the country. Railway piggyback transportation, as a road-rail combined transportation method, effectively combines the flexibility and convenience of roads with the large and low cost of railway transportation, safe and reliable transportation, and green and environmental protection in the transportation process to achieve door-to-door transportation Organizational form. However, the effective load-bearing length of the existing domestic piggyback transport vehicles accounts for about 0.55-0.75 of the vehicle length, which cannot make full use of the entire vehicle transportation space, which affects the transportation efficiency. The small-wheel-diameter and low-floor piggyback transporter is a new type of carry-back transporter developed by CRRC Shandong in response to this problem and the development of the domestic market.

### 1. The main purpose

Small-wheel-diameter and low-floor piggyback transport vehicles are suitable for running on China's 1435mm standard gauge line, mainly used for transporting highways that meet the requirements of GB1589-2016 "Outer Dimensions, Axle Loads and Quality Limits of Automobiles, Trailers and Automobiles and Trains" Trucks (total weight  $\leq$  49t, wagon length not greater than 17.1m). In addition,

the vehicle is suitable for use as a shuttle bus in harsh environment areas such as the Sichuan-Tibet railway, cross-sea bridges and subsea tunnels.



**Fig 1 – Small-wheel-diameter and low-floor piggyback transport wagon**

## 2. The main technical parameters

**Table 1 The main technical parameters**

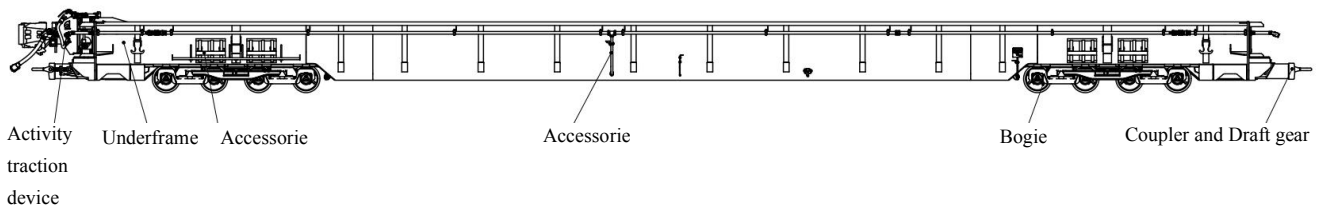
**of the small wheel diameter low-floor carry-back transport vehicle**

Load/t	49
	20.7 (Contains movable traction device)
Tare weight/t	19.2 (without movable traction device)
Axle load /t	8.75
Gauge/mm	1435
Wagon length /mm	19070
The bearing surface of the concave bottom semi-trailer is from the rail surface /mm	316
Coupler centerline height /mm	336
Center line height of coupler of movable traction device /mm	880
Wheel diameter /mm	380

Minimum curve radius /m	145
Maximum operating speed / (km·h <sup>-1</sup> )	90
Limits: Comply with the limits of locomotives and rolling stock for passenger and freight railroads in the TG/01-2014 "Railway Technical Management Regulations"	

### 3. The main structure

The small-wheel-diameter and low-floor piggyback transport wagon is a concave-bottom wagon body bearing structure, which is mainly composed of an underframe, a brake device, a coupler buffer device, a 4-axle small-diameter bogie, and wagon accessories, as shown in Figure 2. The chain hook and side buffer device are used for the connection in the train group. When it is connected to the locomotive, it needs to be equipped with a movable traction device.

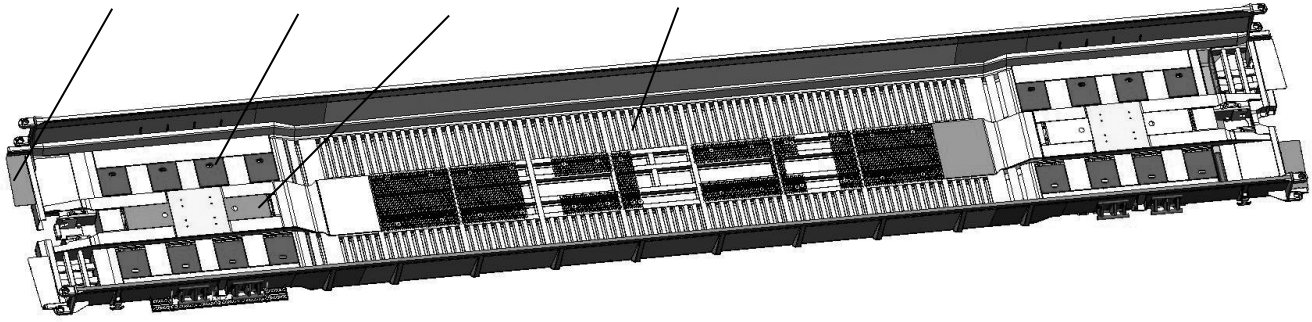


**Fig 2 – Small-wheel-diameter and low-floor piggyback transport wagon**

#### 3.1 Underframe

The underframe is an all-steel welded overall load-bearing structure, which is composed of traction beams, end beams, side beams, corbel beams, side beams, middle beams and other components, as shown in Figure 3. The traction beam is assembled by cold-formed channel steel webs, steel-welded box-shaped reinforcement beams, and couplers from the plate seat, I-steel beams and floor. The end beam is composed of an end beam plate, a connecting plate, a buffer top plate and a fixed cross plate. The side beams are welded by cold-formed side beam plates, external reinforcement beams and internal reinforcement plates, and are connected to the end beams through end connecting plates. The bolster is a load-bearing structure welded by plates, and 8 bogie wheelset inspection ports and 2 brake device inspection ports are reserved. The middle beam is welded by I-beam into a grid structure. An interface for installing a movable traction device is reserved on the underframe.

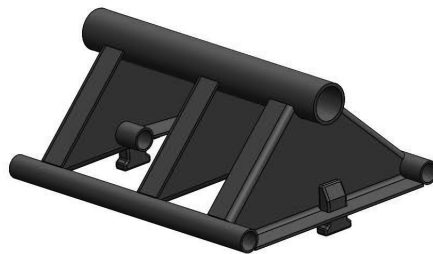
Fixed ferry      Wheelset viewport      Braking device inspection port      Middle beam



**Fig 3 – Underframe**

### **3.2 Accessories**

The wagon accessories are mainly composed of towing hook, side walking board, top car board, middle walking board, and tire stopper. The middle board is mainly composed of galvanized steel mesh. The tire stop is composed of plate and tube welding, as shown in Figure 4. When the car is loaded, the tire stop is matched with the grid structure of the middle beam on both sides to fix the car tire. When the car is unloaded, the tire stop is removed from the middle beam and hung on the hanging seat of the side beam plate.



**Fig 4 – Tire stop**

### **3.3 Coupler and Draft gear**

The coupler buffer device is composed of a discontinuous coupler, a coupler elastic system, and a side buffer device.

### **3.4 Air brake equipment**

The air brake device meets the requirements of the main pipe pressure of 500kPa or 600kPa. It is mainly composed of 120-type air control valve, A-type stainless steel ball core right-angle plug door, combined dust collector, brake relief indicator, manual empty and load adjustment device, safety valve, etc. Adopt

brake hose connector, brake pipe hanger with anti-theft function, nylon tube clamp pad, high friction coefficient synthetic brake shoe; adopt stainless steel embedded air cylinder, stainless steel brake pipe system and flange. Compression-type quick-fit pipe joints are used.

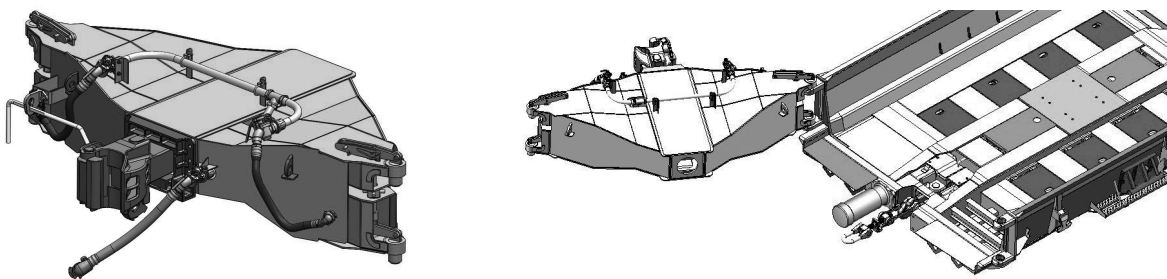
### 3.5 Bogie

It adopts a special 4-axle small-diameter bogie newly developed for small-wheel-diameter and low-floor piggyback wagon.

### 3.6 Activity traction device

The movable traction device consists of a movable pillow, a control device, a braking device and a coupler, as shown in Figure 5. The movable pillow is a box-shaped structure of tailor-welded plates, and the two ends are connected with the car body through connecting pins. The control device is composed of connecting pins, levers, handles, etc. The brake device is composed of stainless steel brake pipe system, A-type stainless steel ball core angle plug door, angle plug door crane, braided brake hose and so on. The movable traction device is equipped with E-grade steel 13B type lower acting coupler and 13B type forged hook tail frame, alloy steel hook tail pin, MT-3 type buffer, and oil-bearing nylon hook tail frame support plate wear plate and coupler joist wear plate.

The movable traction device can be assembled at the end of the vehicle body by a forklift or a crane. After the assembly is completed, the one-side control device is unlocked, and the movable traction device can be rotated along the connecting pin on the other side only by manpower, which is convenient for loading and unloading the car.



**Fig 5 – Activity traction device**

## 4. Main technical features

(1) The bearing surface is low and the center of gravity of the vehicle is low. The car uses a dedicated 4-axle small-diameter bogie with a wheel diameter of only 380mm, and its central load-bearing surface

is only 316mm from the rail surface. Speed reduction, speed limit, etc. caused by cargo exceeding the limit, increase the speed of cargo transportation and improve transportation efficiency.

(2) The effective load-bearing length accounts for a high proportion, and the total length of the car body is short. The effective carrying length accounts for more than 0.85 of the total length of the vehicle, which is 0.1-0.3 higher than other types of packback transport vehicles. At the same time, the total length of the vehicle body can park more vehicles within a limited station line length and improve transportation efficiency.

(3) Strong applicability and versatility. The wagon adopts a standard vehicle interface and can be connected to locomotives, passenger cars and trucks. The vehicle has strong applicability and versatility.

(4) High loading and unloading efficiency. When the vehicle is used in marshalling, the end of the vehicle has a continuous loading surface, which is suitable for continuous roll-on and roll-off of the entire line of road vehicles, and the loading and unloading method is simple and efficient.

(5) Simple reinforcement. The wheel block technology adopted by the car is mature and reliable, and the car reinforcement operation is convenient and quick.

## **5. Analysis calculate**

### **5.1 Static strength calculation**

ANSYS 14.5 finite element analysis and calculation software, in accordance with TB/T 3550.2-2019 "Locomotive and Rolling Stock Strength Design and Test Appraisal Specifications, Car Body Part 2: Freight Car Body", calculates the static strength and rigidity of the vehicle body structure. Among them, the first working condition stretches 1125KN, the first working condition compresses 840KN, and the second working condition compresses 1350KN. Under various combined working conditions of the car body, the calculated stress of the static strength of the car body is less than the yield strength of the material; the calculation results show that the maximum vertical deflection in the middle of the car body under the worst conditions is 21.15mm, and the deflection-span ratio is 1/ 700, which meets the requirement of flex-span ratio  $\leq 1/450$  in the technical conditions.

## **6. Concluding remarks**

The small-wheel-diameter low-floor piggyback wagon draws on the mature European technology and adopts the roll-on roll-off model. It has the advantages of safety, maturity and reliability, and has a good market prospect. This car enriches the product types of my country's railway piggyback transportation and is conducive to the development of domestic piggyback transportation.

## 7. References

- Yan Junqi. Vehicle Engineering (Second Edition) [M]. Beijing; China Railway Publishing House, 2005.
- Cheng Jianmin, Yao Jinshan, Yuwenya. Reference Manual for Vehicle Design [M]. Beijing; China Railway Publishing House, 1988.
- Zhang Baoshan. Development of a special concave bottom flat car with a load of 70t[J]. Railway Vehicles, 2016 China Railway Publishing House, 1988. 54 (11), 29-32.