Design of 20 ft Multifunctional Platform Container

Yang Yunze1,a, Yuan Xia2,b, Chen Junhua3,c
1 School of Traffic and Transportation, BJTU, Beijing, China
2 School of Traffic and Transportation, LZJTU, Lanzhou, China
3 School of Traffic and Transportation, BJTU, Beijing, China
a 19125783@bjtu.edu.cn, c Corresponding author: cjh@bjtu.edu.cn

Abstract—In view of the problems of high transportation cost, low loading and unloading efficiency, poor reinforcement in the transportation of glass and coiled steel, combined with the transportation of tubular goods such as aluminum rods and logs, a safe, stable and recyclable 20ft multifunctional platform container is designed, which is based on the “Code for Steel Structure Design”. The overall structure of the 20ft multifunctional platform container consists of two parts: the bottom “platform” and the upper “A-frame”, which has three functions of loading coiled steel, tubular goods and bare glass. In addition, the feasibility of loading cargo on platform container was checked in accordance with the requirements of the “Rules for Loading and Reinforcement of Railway Cargo”. The platform container is constructed and carried on the finite element analysis by using the software named SolidWorks, its stress analysis and displacement analysis results are in line with relevant regulations. The designed multifunctional platform container can improve the loading and unloading efficiency of glass and coiled steel transportation, save loading reinforcement materials and transportation costs, having a promising market prospect.

1. INTRODUCTION
Glass, coiled steel, aluminum rods and logs and other tube column goods are the key materials of railway transportation, the main form of railway transport flat glass is wooden box packaging flat glass into containers or open vehicles for transport, this mode of transport wastes a lot of wood, and high transport costs, low efficiency, high rate of glass breakage; coiled steel has the characteristics of heavy weight and poor reinforcement, and it is prone to roll and move during transportation. At present, the research on solving these problems mainly focuses on the improvement and innovation of the assembly frame, or the improvement of the loading and reinforcement scheme. Rarely from the perspective of multi-purpose, platform container to design and develop transportation equipment to solve the problems of glass and coiled steel in the process of railway transportation. Platform container is a kind of topless structure, only has the bottom structure of the container, with small weight, convenient return, low transport cost, can achieve door-to-door transport characteristics. At the 8th General Meeting of the Technical Committee, held in Tokyo in October 1974, the definition of platform container was formally considered and adopted, breaking with the notion that containers must have a certain volume and were epoch-making. In order to improve the efficiency of flat glass and coiled steel transportation, ensure transport safety, and implement the concept of protecting the environment and sustainable transportation, this paper designs a multi-functional 20ft platform container with small weight, multifunctional, removable, easy to return, and reusable.
2. MULTIFUNCTIONAL 20FT PLATFORM CONTAINER STRUCTURE DESIGN

2.1 Introduction to the structure of multifunctional 20ft platform container

The overall structure of the platform container consists of the bottom “platform” and the upper “A frame” two parts, with the loading of steel, tube column cargo and bare glass three functions. The length and width of the bottom platform is the same as the bottom dimensions of the international standard 20ft container. The bottom platform consists of a side beam, an end beam, an intermediate bottom beam, an intermediate side beam, a fork groove, a bottom side pull ring, a tarpaulin reinforcement ring, a glass reinforcement ring, etc. The platform is equipped with a bottom angle and top angle piece, the bottom angle piece can be connected with the railway flat car tapered positioning pin link to make the platform container and flat car joint, the top angle piece is equipped with a rotatable tapered positioning pin, the top angle piece conical positioning pin is decentralized, the front crane can lift the platform-type container, the tapered positioning pin upside down, for the platform-type container multi-layer stacking ingenuity, can make the upper and lower platform container through the angle joint. The platform has 4 pairs of coiled steel brackets for carrying roll steel, each pair of coiled steel brackets is 60 degrees “V-type”, a platform container can be placed in a total of 2 coiled steel. The platform container side and end beams are provided with strut slots, which can be blocked from all sides when the platform-type container shipping of logs and aluminum rods is inserted into the strut slots. The platform is equipped with the bottom beam of the glass 4, the bottom beam on both sides and the horizontal surface is 3 degrees angle, the platform is equipped with a vertical movement of the glass horizontal shift of the horizontal bezel and gear bar, the bezel is bolted to the platform, the position can be adjusted to adapt to the different widths of the glass to block it, the glass bar inserted in the platform container bottom frame in the middle slot. The base of the A-cross is articulated with the bottom platform, can be pulled away, the A-cross is placed on the side of the bottom beam, the A cross and the bottom cross is angled at 90 degrees, each box 4 A-crosses, each 2 A-crosses are linked together, the glass is mounted on both sides of the A cross After the glass is loaded, the glass is rigidly reinforced with a glass reinforcement rod to prevent the glass from falling over, the glass reinforced rod is retractable to accommodate the glass of different heights, and the upper part of the glass reinforced rod on both sides of the glass is connected by a connecting rod, and the lower welds are with ratchets. The ratchet is inserted into the ratchet holder fixed at the end of the bottom beam, and the lateral position of the glass reinforcement rod is adjusted by the bar telescopic adjustment to fit the glass of different thicknesses. Platform containers are rated at 30.48t, platform containers weigh 2.83t, loading glass 27.65t, and loading coils 26t. Platform container exterior size: 6058mm × 2438mm × 400mm. As shown in Fig. 1.

![Multi-functional 20ft platform container 3D three-dimensional simulation.](image)

Platform container bottom piece using the common box standard corner structure, the top corner piece has a unique design, it has a rotatable cone-type positioning pin, top angle piece cone-type
positioning pin down, the front lifting can lift the platform-type container, cone-type positioning pin turn-up when turned up, for the platform container multi-layer stack code back, can make the upper and lower platform container angle piece joint. The angle column between the top bottom angle pieces is 160mm high. As shown in Fig. 2.

![Figure 2. Platform container corner structure.](image)

### 2.2 The main features of multifunctional 20ft platform containers

- Removable for easy return. When transporting the glass, the roll-steel bracket can be removed and the roll-steel bracket can be sunk to the bottom of the platform container, and the A frame, glass bezel and glass stop lever can be removed when transporting the coiled steel.
- Multifunctional. Can be loaded with flat glass, coiled steel, aluminum rods (tube column cargo) and other goods, under certain conditions can achieve the platform container re-return.
- The top angle piece has a rotatable cone-type positioning pin. When the top angle piece cone-type positioning pin is lowered, the front crane can lift the platform-type container, the cone-type positioning pin flips, for the platform-type container multi-layer stack code return, can make the upper and lower platform container through the angle piece joint as one.
- Transport safety is good. When transporting rolled steel, the roll-steel bracket has a fixed effect on the coiled steel to avoid the movement of the coiled steel in the transport process, when transporting aluminum rods (column cargo), the goods are tied and reinforced, inserted in the pillar slots around the platform container, and inserted into the bezels at both ends to prevent the movement of the goods in the direction.
- Repeatable recycling. In line with the concept of green and sustainable transportation development, with high economic benefits.
- Door-to-door transport of goods can be achieved. Platform containers can be placed on semi-trailers by road transport, to meet the requirements of public rail transport, so that door-to-door transport can be achieved.

### 3. MULTIFUNCTIONAL 20FT PLATFORM CONTAINER LOADING

#### 3.1 Flat glass placement method

Multifunctional 20ft platform container can be loaded with a plate length of 2440mm, 2200mm, plate height 1650mm, 1830mm, 2000mm flat glass, a total of two stacks of four sets of glass, each set contains three bags of glass, each package of glass between the thickness of 40 to 50mm partition, each group of glass vertical with two steel belt strapped, close to the A side of the a.

The glass bezels on both sides of the platform container can be disassembled and adjustable to accommodate different sizes of glass to block both sides of the glass and prevent vertical movement of the glass. As shown in Fig. 3.
Figure 3. Schematic diagram of platform container loading flat glass.

3.2 Coiled steel placement method
The coiled steel adopts the horizontal loading method. Each platform container can load two coils with a coil diameter of 1500mm and a plate width of 1250~1500mm. From the perspective of transportation, the horizontal loading method speeds up the progress of the loading operation and improves the loading efficiency. From the perspective of cost, the cost of loading reinforcement materials saved by horizontal transportation is lower than the increased cost due to delay, outbound transportation, and internal transportation. As shown in Fig. 4.

Figure 4. Schematic diagram of platform container loading coiled steel.

3.3 Pipe column cargo placement method
The side beams and end beams of the platform type container are provided with pillar slots. When the platform type container is used to transport logs and aluminum rods, the pillar bars are inserted into the pillar slots to block the goods from all around. As shown in Fig. 5.

Figure 5. Schematic diagram of platform container loading aluminum bars.
3.4 Cargo transportation

The platform container is used to load coiled steel and tubular goods, which can realize door-to-door transportation of the goods. At the place of delivery, a reach stacker with a long plunger arm is used to hoist the packed goods together with the platform-type container. On the semi-trailer truck, it reaches the railway loading station through road transportation. At the railway loading station, the cargo and flat-type containers are directly lifted from the semi-trailer to the railway flat car by using the long-swing arm reach stacker. After the railway transportation, it reaches the railway unloading station. At the railway unloading station, the cargo and the platform container are hoisted from the flatcar by the long-swing arm reach stacker, placed on the semi-trailer truck, and then transported by road to the receiving place, thus realizing the door-to-door transportation of the cargo. Compared with the use of containers for transportation, the transportation process saves the process of loading and unpacking, greatly saves loading and unloading costs, improves loading and unloading efficiency, reduces the damage rate of goods caused by loading and unloading, and ensures transportation safety.

3.5 Platform container return

Empty platform containers are returned by flat cars. The disassembled A-frame is sent back by empty container or gondola. After the glass stopper, baffle and other components are removed, they can be sunk into the platform container and sent back together with the platform container. Two groups of 14 empty platform containers are placed on a flat car to ensure that the center of gravity of the heavy car does not exceed 2000mm and the platform container does not exceed the limit when returning, as shown in Fig. 6. The bottom platform container is fixed by connecting the bottom corner pieces with the cone-shaped positioning pins on the flat car. The platform containers are also connected to form a whole through the corner pieces and fixed. The platform container and the platform container are fixed. The fixing method between the lower platform container is as follows: the cone-shaped positioning pin of the top corner piece of the lower platform container is turned up, and the bottom corner piece of the upper platform container is docked with it for fixing. As shown in Fig. 7.

![Figure 6. Schematic diagram of platform container return.](image)

![Figure 7. Diagram of connection between platform containers.](image)
4. Calculation of Loading Strengthening Strength of Multifunctional 20FT Platform Container

This calculation is a dynamic test calculation, and all the formulas used are the formulas obtained under the dynamic test in the “Loading Regulation Rules”. When designing the detachable steel coil support part of the platform container for loading coiled steel, in addition to considering the weight of the coiled steel that the platform container has to bear, the force acting on the platform container during the coiled steel transportation should also be considered.

In the calculation, the platform container is subject to greater stress. During the coil transportation, the total weight of the truck is 83.76t (30.48×2+22.8t), and two coils of about 15t are placed on the platform container. To calculate the strength of the platform container, in order to avoid the wear of the coiled steel, increase the friction between the platform container and the coiled steel, and buffer the transverse inertia force of the coiled steel, rubber pads should be placed on the coiled steel support. When the vehicle is running When impacted, the coiled steel will be cushioned, and its acceleration will be lower than that of the vehicle. The calculation of inertia force adopts flexible reinforcement.

The various force values acting on the coil steel are summarized in Tab. 1 after calculation.

| Force                  | Longitudinal inertial force(T) | Lateral inertial force(N) | Vertical inertial force(Qv) |
|------------------------|--------------------------------|---------------------------|-----------------------------|
| Force value            | 172                            | 43                        | 54                          |
| Force                  | Longitudinal friction(Fz)      | Lateral friction(Fh)      | Wind force(W)               |
| Force value            | 3                              | 74                        | 66                          |

Unit of force value : kN

Cargo stability analysis based on the calculation results of the above force values:

\[ \eta = 9.8Q \cdot a / T(D/2 - h). \]  \hspace{1cm} (1)

\[ \Delta N = 1.25(N+W) - Fh. \]  \hspace{1cm} (2)

(1): “\( \eta \)” is the longitudinal overturning coefficient. When its value is greater than 1.25, the cargo is relatively stable in the longitudinal direction and will not overturn; otherwise, it will overturn if it is unstable. “\( Q \)” is the weight of the cargo (15 tons). “\( a \)” is the distance (650mm) between the horizontal vertical plane where the cargo center of gravity is located and the cargo tipping point. “\( D \)” is the diameter of the coiled steel (1500mm). “\( h \)” is the height of the coiled steel bracket (340mm).

(2): “\( \Delta N \)” represents the horizontal resultant force (kN) generated by the cargo in the transverse direction. When its value is less than 0, it means that the cargo is relatively stable in the longitudinal direction without reinforcement, otherwise it needs to be reinforced.

Through calculation, “\( \eta \)” is equal to 1.35 and greater than 1.25, so the coiled steel will not roll in the longitudinal direction. “\( \Delta N \)” is equal to -8.5 and less than 0, so the coiled steel will not move in the lateral direction.
5. **FINITE ELEMENT ANALYSIS BASED ON SOLIDWORKS**

5.1 **Stress Analysis**

As shown in Fig. 8, different color segments represent different force values, and the stress increases from blue to red. The color display of each part of the platform container represents the force value it receives, and the maximum stress that its weakest link bears is 280.694MPa, which is less than the allowable stress of Q345 (345MPa), so the strength of the weak link meets the requirements.

As shown in Fig. 9, different color segments represent different force values. The stress increases from blue to red. The color display of each part of the platform container represents the force value it receives. The weakest link bears the maximum stress as 255.039MPa, which is less than the allowable stress of Q345 (345MPa), so the strength of the weak link meets the requirements.

5.2 **Displacement Analysis**

As shown in Fig. 10, different color segments represent different displacements and deformations. The displacements increase from blue to red. The color display of each part of the platform container
represents the displacement and deformation of the part when it is loaded. The maximum deformation of the weak link is 0.604mm, which is more reasonable.

As shown in Fig. 11, different color segments represent different displacement and deformation, and the displacement and deformation increase from blue to red. The maximum deformation of the weak link is 2.037mm, which is more reasonable.

Figure 11. Analysis of vertical load displacement when loading coiled steel.

The finite element analysis shows that the strength of the multifunctional platform container meets the requirements.

6. CONCLUSION
The multifunctional 20ft platform container designed in this paper is safe and stable in structural design, simple in structure, recyclable, detachable and easy to return, it can realize door-to-door transportation of goods. It not only saves manufacturing cost, packaging cost, transportation cost, but also is convenient to return and quick to revolve. It can also save wood for the country and implement the concept of "green environmental protection and sustainable transportation". Its good economic and social benefits will promote the development of containerized transportation, increase the degree of mechanization of loading and unloading, and improve the transportation capacity of railways. The application prospects are considerable.

ACKNOWLEDGMENT
The National Natural Science Foundation of China (NSFC) under Grant No. U1734204, and the National High Technology Research and Development Program of China under Grant No. 2016YFE0201700.

REFERENCES
[1] Xu Yong. “The design of the bare container glass transport rack,” Journal of Science & Technology Economics, 2019, pp. 34-36.
[2] Sun Yanli, Ma Jiajie, and Yuan Xia, “Research on the loading and reinforcement scheme of bare glass in railway gondola transportation,” Journal of Science & Technology Economics, 2018, pp.22-24.
[3] Zhang Hui, Xu Yong, “Research on a Coiled Steel Bracket,” Journal of Science & Technology Economics, 2020, pp.71-72.
[4] Xin Hailin, Xu Haitao, and Zhu Li, “Development of three-coil steel loading and strengthening seat frame,” Mechanical Engineer, 2016, pp.185-186.
[5] Gai Yuxian, “Railway Freight Organization,” Beijing: China Railway Publishing House, 2016.
[6] Ministry of Railways, “Railway cargo loading and reinforcement rules,” Beijing: China Railway Press, 2015.
[7] China Engineering Construction Standardization Association, “Steel structure design code,” Beijing: China Construction Industry Press, 2006.