Practical Research on Application of New Special Sleeper for Small Radius Curve of Heavy Haul Railway

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Abstract: Based on the research on a number of small radius curves (R=200m) for the heavy-duty traffic between the I and II inter-fields in the port operation area of the Huanghua Port Station of the Huangzhou-Hongzhou Railway, this paper describes the various diseases of small radius curves under heavy loading conditions, mainly including frequent problems such as large gauge, serious damage of spare parts, deviation of sleeper, extrusion damage of sleeper shoulder and rail abrasion, etc. Through the summary of the laws and causes of various diseases, combined with a variety of measures to carry out the practice of small radius curve disease remediation, the application of the new special concrete sleepers has fundamentally effectively solved various diseases in the operation of small radius curves. The maintenance period has been extended, and the safe operation reserve of the small radius curve of the Huanghua Port Station of the Huanghuang Heavy Railway has been increased.

1. Introduction

As the second largest channel of China's West Coal East Transportation, the Shuohuang Railway has been growing at an annual rate of 10 million tons since its opening in 2000. At the end of 2018, the volume reached 305 million tons, featuring heavy-duty railways with high density, large volume and large shaft. As the terminal station of the Shuohuang Railway, Huanghua Port Station belongs to the key technical station of the Shuohuang Railway. The net weight of the station in 2018 is 200 million tons. The station site of Huanghua Port is divided into the pre-port operation area and the port operation area. The port operation area station includes I to VI field, of which I field, II field and IV field are heavy yards, and III, V and VI fields are empty parking lots. Among them, the traffic from I to II in the port operation area includes five small radius curves ($R \leq 200m$), which are located at 105-111# complex road to 216# road curve (length 72m), 216# to 234# road Inter-curve (length 110m), 115# to 218-224# complex intersection curve (length 150m), 117-123# complex intersection to 226# road inter-turn curve (length 235m), 228# to 246# turn curve (long 216m), carrying the unloading task of 6 dumpers, the annual total weight is about 70 million tons.

The original design of the small radius curve is designed and laid according to the laying pattern as the special line 9668-II "60kg/m rail prestressed concrete heavy duty sleeper". The speed of designing the heavy truck is about 20km/h and the gauge is widened by 15mm. The ultra-high setting is 25mm, the sleeper is G3 type, and the iron pad is provided with the rail bottom slope. Before 2010, when the traffic volume of the Shuohuang Railway was relatively low, the equipment damage of the small radius curve appeared less, and then with the increase of traffic volume. Since 2012, the small radius curve has various types of diseases, including the damage of the sleeper shoulder, the serious wear of the rail, the frequent changes in geometric dimensions, and the failure of the joint parts.

In view of the characteristics of the above diseases, comprehensive analysis and judgment have been carried out. Since 2014, the team has mainly adopted the encryption and maintenance cycle in management, increasing the input cost of manpower renovation and ensuring relatively sTable operation. In terms of equipment frame reinforcement, the installation of the gauge rods is carried out in a one-to-one manner, and the ground anchor piles are fixed on the outer side of the upper rails to stabilize the track frame. Bainite rails are used in the selection of rails to enhance the wear resistance of the curves and to extend the life of the rails. Through the implementation of the above

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measures, various diseases of small radius curve have been alleviated, but still cannot be cured. In addition, more and more maintenance operations are carried out on site, resulting in more and more labor costs. With the continuous increase of the annual traffic volume of Shuohuang Railway, the risk of small radius curve of train operation is high, and the safety reserve of equipment is obviously insufficient.

In a comprehensive analysis of the causes of the disease, the lack of sleeper strength is the root cause of all kinds of sudden diseases, so the design, research and application of the new special sleeper is the ineviTable choice.

2 Main design ideas and parameters of new type sleeper

2.1 Main design parameters of the line

(1) Curve gauge with small radius: S=1450mm; gauge widening is designed according to 15mm.

(2) Curve radius: R≤200m.

2.2 Calculation parameters of sleeper design

(1) Bearing capacity of concrete heavy load curve radius modified pillow. Positive moment M=23.6 kN.m, negative moment M=17.7 kN.m.

(2) The pulling force of the embedded base is greater than 60kN.

(3) Material performance and specification: 42.5 ordinary Portland cement is used for cement, and its technical requirements shall be 300kg/cm3 cubed -350kg/cm3 cubed in addition to the provisions of GB175; The aggregate shall be 5mm-25mm gravel, and the mud content shall not be more than 0.5% by weight, and the rest shall comply with the provisions of JGJ53; Prestressed steel wire with a diameter of 7.0mm for GB/T5223 phi; The hoops are q235-a phi 5.5mm smooth round steel wire[1].

(4) The initial total tensile strength of the prestressed rebar is 592kN, and the total prestress loss is 19% of the initial total tensile strength.

(5) The strength grade of concrete is C60.

(6) The static load cracking strength of the modified pillow under heavy load curve radius shall meet the following requirements: The load value of the positive bending moment test is 240kN; The fatigue strength of heavy load curve radius modified pillow of concrete by negative bending moment test should meet: The maximum test load value of positive bending moment is 255kN; The maximum test load value of negative bending moment is 200kN [2].

(7) The crack strength test of the sleeper section shall be conducted in accordance with TB1879, and the fatigue strength test shall be conducted in accordance with TB1878.

2.3 Design of spare parts for sleeper

For the design of the sleeper fastener, the fastener is applicable to the track line with the curve radius R less than 350m. The track bottom slope of 1:40 is set on the iron pad in accordance with the design standards. The track bottom slope is not designed for the sleeper itself. The rail support is in contact with the rail waist, fixed on the iron pad by t-type bolts and spring bars, and is closely fitted with the bolt base on the iron pad through the gauge block. In the process of train operation, the transverse force received by the rail is transferred to the bolt base on the iron pad through the rail support, and at the same time, the iron pad and the embedded iron seat are closely fitted by the gauge block, and the transverse force transmitted to the embedded iron seat again. Through the conduction of two transverse forces, rail lateral displacement can be effectively avoided [3].

Adjust the design block gauge is designed with reference to Academy of Raiway Science line 9591 - II design, raw materials for glass fiber reinforced polyamide 66, withhold rail surface and rely on the bottom of the rail flatness of the chamfered edge is 0.5 mm. The hardness of gauge block is greater than or equal to 110 HRR, the strength is large enough, and the toughness is better than steel or iron, which is consistent with the existing 30T axle weight rail structure fastener design. The ears on both ends of the gauge block are not damaged after the 4.5kn force shear. At room

temperature 30±5℃, the gauge block by 6 times without rupture after impact test. Insulation resistance is greater than 107Ω gauge block, insulation performance is good.

The configuration model of insulated gauge block includes no.7, no.8, no.9, no.10, no.11 and no.13. The adjustment amount of gauge is -8mm~+16mm, which can achieve accurate adjustment with the adjustment level of 1mm. Considering that the four gauge blocks are interchangeable, spare parts are reduced, site construction and operation efficiency is improved, and the probability of large area error is reduced. The structure of the four gauge blocks currently designed is the same. The elastic strip adopts the type II reinforced one, and the buckle pressure in the assembled state is no less than 13.7KN. The diameter of the design spring bar is 1mm larger than the diameter of the II type spring bar, the buckle pressure is larger, the length is longer, and the stability is better. The fastener adopts a single-sided double-elastic structure, which has better effect of damping and buffering lateral force.

The pre-embedded iron seat adopts a new design type, and both sides are positioned. Compared with the traditional small radius curve, the pre-embedded iron seat is kept vertical when the sleeper is made, and the model is in close contact with the model, so it is not easy to leak slurry. The production of the sleeper iron seat has large anti-pull capability and accurate size. (See Figure1)

The material of the iron pad is ductile iron QT450-10, which has high strength, high toughness and plasticity. Since the area of the iron pad is large, the force per unit area is small. There is an insulating cushion plate in the middle of the sleeper, which reduces the impact on the sleeper when the force is applied, thereby improving the service life of the sleeper. (See Figure 2)

Figure 1 Sleeper design pre-embedded iron seat

Figure 2 Sleeper with iron pad

3. Current sleeper and disease remediation for small radius curve

3.1 Application of small radius curve sleeper at present

At present, the small-radius curve sleepers are generally laid on the site for the new Type II sleepers, Type III sleepers, and special curved wide-angle sleepers for individual sections. The heavy-duty SH-I type sleepers and supporting SH-1 type fasteners are used in the small-radius curve of the section of the Shuohuang Railway. The new Type II sleepers are used less in the small radius curve of heavy-duty railways and cannot meet the requirements of running strength. Type III sleepers and special curved wide sleepers mainly reduce the pressure of the sleeper bearing groove and the shoulder from the concrete sleeper manufacturing process, increase the depth of the sleeper bearing groove, and reduce the slope of the sleeper shoulder. Which relatively extend the service life of sleeper [4].

3.2 The main disease of small radius curve

(1) The disease of the sleeper itself. Lots of the sleeper bolts are broken. Due to the impact of the shearing force of the heavy truck, the sleeper bolts with small radius curves are broken heavily, and the sleeper shoulders are damaged or even failed.

(2) The rail wear is severely damaged. The side of the curve is sharply ground and the lower part is crushed. The running life of the rail is too short, with an average downline period about 8 months.

(3) Parts damage is ineffective. The connecting parts of the small radius curve are easy to loose and the damage rate is high. It shows that the impact force and the lateral force of the connecting parts on the small radius curve are larger than those of the ordinary line section. When the impact force and the lateral force reach a certain value, the appearance occurs. The spring bar is broken, the joint bolt is broken, and other diseases [5].

(4) The geometric size is not easy to maintain. It is easy to exceed the limit for the geometrical dimensions of the track, which is characterized by the height of the small radius curve, the gauge distance, the super high, the positive vector is easy to change relative to other lines, and the period of the maintenance is short, especially the hidden trouble of the large gauge. The maximum gauge can reach about 1460 mm. And with the increase of rail side grinding, it gradually intensifies, which seriously endangers the driving safety of train operation [6].

3.3 Curvilinear disease remediation

(1)In terms of remediation measures for sleeper diseases, the main method is to re-anchor the broken vertical bolts and the sleepers with serious damage to the sleeper shoulders may even replace the sleepers.

(2) For the refurbishment of rail side grinding and grinding, the main measures are comprehensive rectification, including strengthening the maintenance and repair of the rail joints, changing the rail bottom slope, properly setting the curve superelevation. Besides, we should polish and lubricate the curved rail, optimize the track structure and adopt the measures of bainite rail with good abrasion resistance [7-8].

(3) For the damage caused by the damage of spare parts and the difficulty of maintaining the geometrical dimensions, the overall framework measures of the enhanced curve are mainly adopted to solve the problems, including the addition of ground anchor piles on the curved steel rails and the installation of gauge gauges.

4. Advantages and application practices of new special sleepers

4.1 Advantages of the new special sleeper

Design new type of sleeper contrast small radius curve Other types of sleeper advantages: First, the design of the sleeper shoulder is not designed, the design adds a pre-embedded iron seat, eliminating the risk of breakage of the sleeper shoulder and breakage of the vertical bolt; second, the design of the fastener part is rail Support, in the case of large lateral forces, can effectively prevent the rail from moving sideways. Third, the design of the supporting base of the iron pad increases the lateral resistance during the operation of the track frame. Fourth, the gauge adjustment block of synthetic material has complete models, large adjustment range, high precision, good wear resistance and anti-extrusion performance, and the size of various models makes the adjustment of the gauge distance more convenient. (See Figure 3)

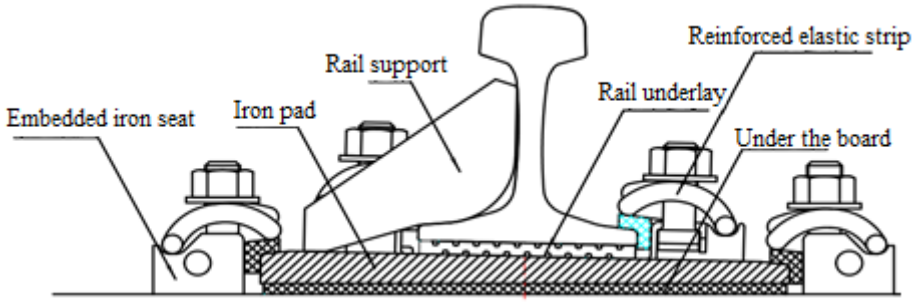

Figure 3 Schematic diagram of the sleeper fastener

4.2 Application Practice of New Special Sleeper

The new special sleepers were put into use in five small-radius curves connected at the station of Huanghua Port Station in May 2018. Through the application practice of 9-month operation and on-site tracking observation, the application advantages of the new special sleepers are obvious and

fully satisfied. Yellow line heavy-duty railway requirements.

(1) Sleeper operation

Through the one-year running application of the new special sleeper, the prefabricated iron seat of the sleeper is in good running condition, and there is no looseness, deformation of the extrusion, failure of pulling out and the like. (See Figure 4)

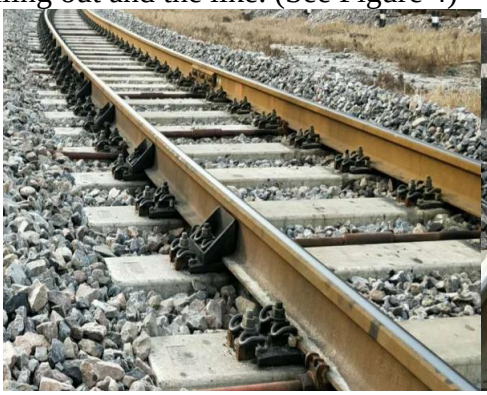

Figure 4 Special sleeper site situation

Figure 5 Special sleeper and rail operation

(2) Rail operation

Through the on-site observation after laying, the side grinding and falling block phenomenon of the rail has been greatly alleviated, and a variety of measures have been taken to carry out special rectification of the rail disease, which effectively prolongs the service life of the rail and greatly reduces the labor input cost caused by the rail changing work. Through the comparison of the operation of the new and old sleepers, the rails are in service for about 9 months in the case of heavy-duty sleepers, and the down-line conditions are basically met due to factors such as side grinding and serious blockage. In the case of new special sleepers, the rails are in service for about 9 months. On the curve, the side of the steel rail is worn faster, reaching about 7mm, and there is a slight drop in the block. The lower rail is slightly crushed, which is basically a slight injury to the rail, and the running advantage is obvious. (See Figure 5)

(3) Parts operation status

The new special sleeper has been in service for 9 months. The spare parts of the sleeper are complete and effective, and the operation is in good condition. The iron pad is not broken, the under-pad rubber has no wear and tear, the spring bar is not broken, and the nut and T-bolt are in good condition. The gauge adjustment block of the synthetic material is not damaged.

(4) Geometric size changes

In terms of the geometry of the small radius curve, the actual laying gauge is 1448mm (the theoretical calculated gauge distance should be 1435mm plus 15mm or 1450mm), and the gauge distance after 1 month of operation is 1449mm to 1450mm, with little change. Other geometrical variations including horizontal, high and low, direction, and curve positive are within the tolerance of the line maintenance.

5. Conclusion

Through the application practice of the new special sleeper with small radius curve in the Yellow Railway, it is concluded that:

(1) Based on the design of the prefabricated iron seat of the special sleeper, the fundamental problems such as breakage of the sleeper shoulder and breakage of the vertical bolt are effectively solved, and the running strength of the sleeper is fundamentally enhanced.

(2) Based on the design of the fastener part of the special sleeper, it mainly includes iron pad, rail bracing, reinforced elastic bar, under-rail iron pad, under-plate rubber pad, gauge block and T-bolt, etc. Solved the problem of failure of the parts and components of each department.

(3) After the new special sleeper is put into use, it effectively reduces the degree of rail wear and prolongs the use of the rail. The problem of the large gauge of the key radius of the small radius

curve is cured, the operating state is stable, and the operation of the heavy-duty railway can be operated. Matching, enhances the safety reserve of small radius curve operation, and has high use value.

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