Experimental study related to sunken mobile catenary for railroad power supply loading line

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Abstract. The traditional fixed catenary and the existing translational mobile catenary cannot meet the working space requirements of large machinery on the railway power supply loading line. Therefore, this article has designed a sunken mobile catenary and completed non-electrified operational test and electrified operational test. According to the test results, the sunken mobile catenary can normally switch between working and non-working positions, maintain the height of conductor, stagger value, and clearance within the prescribed range, and there are no occurrences of drilling, hitting, and scraping pantograph, or wire clip loosening. The widespread usage of this equipment can effectively save manpower, locomotive resources, and improve the efficiency of railroad freight transportation.

Keywords: Railway freight; Power supply line; Mobile catenary; Structural design; Movement mechanisms

1 Introductory

The loading line has adopted power supply-type design in recent years in order to increase the effectiveness of railroad freight loading operations and decrease the waste of time, locomotive resources, and manpower due to the mobilization of diesel locomotives. However, on the power supply loading line using a fixed catenary, large-scale loading operations such as frontal lifting cannot be accomplished due to the lack of space above the wagons. Based on the above reasons, mobile catenary should be designed for electrified railway power supply loading lines.

Domestic and international mobile catenary systems now available mostly come in rigid and flexible types [1][2]. Rigid mobile catenary is only suitable for depot use, and has high cost, high maintenance, high failure rate and less practical. The suspension mode of flexible mobile catenary is consistent with the fixed catenary, and the pantograph-catenary is smoother and easier to maintain, with a cheap cost, low failure rate and convenient maintenance[3][4][5]. Existing parallelly trave flexible mobile catenary can be in loading operations when the contact suspension pan to the side of the pillar, at this time, pan to the non-working position of the mobile catenary is much higher than

H. Bilgin et al. (eds.), *Proceedings of the 2023 5th International Conference on Civil Engineering, Environment Resources and Energy Materials (CCESEM 2023)*, Advances in Engineering Research 227,
https://doi.org/10.2991/978-94-6463-316-0_28

the height of the carriage, When the gantry crane operates, the construction process, thermal expansion and contraction, as well as other factors, may cause the catenary, the contact wire, and the catenary pillars to collide with the goods, failure to meet safety clearance requirements [6][7][8].

Based on the above factors, this article has designed a sunken mobile flexible catenary for railway power supply loading line and completed the relevant tests. The device can support electric locomotives to directly enter and exit the freight loading area. After the locomotive passes through, it will disconnect the power supply of the mobile catenary and control the catenary and the pillars to sink to the ground or pit together, so that sufficient space for loading operation is left above the train [9][10]. After the loading is finished, the pillar and contact suspension are raised and moved back to the working position above the locomotive [11][12]. The device can greatly improve the operational efficiency of railroad freight loading line, completely solve the problem of mobile catenary affecting loading efficiency and safety distance.

2 Working Principle of Sunken Mobile Catenary

2.1 Structure of sunken mobile catenary

The longitudinal dimensions of the sunken mobile catenary of different yards are not consistent, depending on the size of the yard. Mainly consists of portal frames, pillars, hinged cantilever, contact wires and driving weights on both sides. As shown in figure 1.

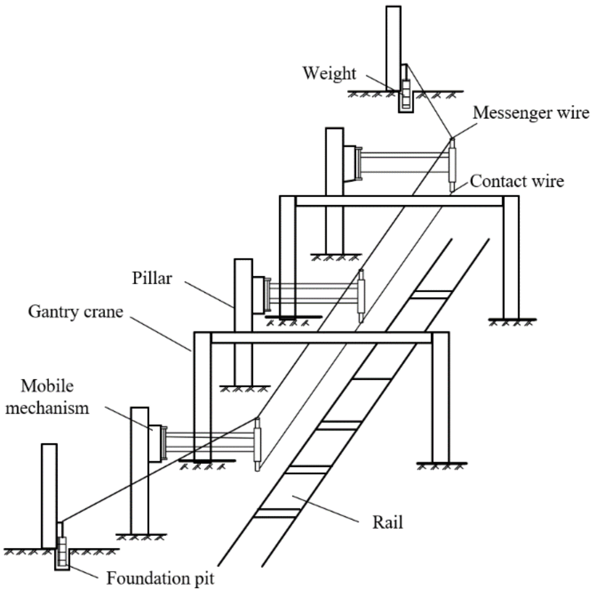

Fig. 1. Structure of mobile catenary system

The portal frame has a certain mechanical strength and provides anchor support for fixed and mobile catenary. The pillars provide height for the mobile catenary and support the mobile catenary to be retracted from the line and then lowered to the ground or foundation pit. Hinged cantilever enables the contact wire to be rotated from above the line and retracted to the pillar side. The weights on both sides of the mobile catenary are driven to rise or fall by the driving mechanism on each side, and the two sides of the weights are respectively coordinated from both ends of the mobile catenary to regulate the working state of the mobile catenary, which is used to compensate for the tension of the mobile contact wire, and can effectively prevent breakage of the line, jamming and other phenomena from occurring.

2.2 The working condition of the sunken mobile catenary

The working condition of sunken mobile catenary is related to the presence of trains in the working area and the presence of loading operations, as shown in figure 2.

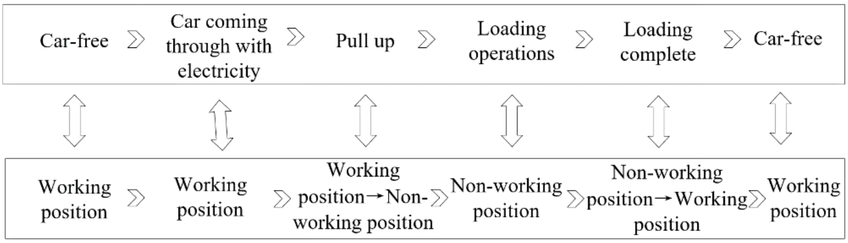

Fig. 2. State transition of mobile catenary

When there are no trains, the mobile catenary is in the working position. At this time, the catenary is energized. The locomotive comes from one side, keeps the pantograph raising, decelerates through the mobile catenary and stops under the fixed catenary on the other side, while the carriages are partially parked under the mobile catenary, ready for loading operations. The connector of the mobile catenary on the portal frame is automatically disconnected, so that the mobile catenary is not energized, and the left and right weights are synchronized through their respective mobile mechanisms to descend to regulate the drive to rotate the hinged cantilever, and then move the catenary and contact wire to the side of the pillar with the pillar as the center of the circle and in the clockwise direction, and then sink to the foundation pit together with the pillar, which is non-working position.

After the mobile catenary is moved to the non-working position, several conductor leads are connected to the grounding device in the non-working position in the form of a splice, so that the mobile catenary is free of any electrical charge. At this time, there is enough space above the trunk for large machinery loading operations.

After loading, the locomotive pantograph contacts the fixed catenary on the other side, and the train drives out of the working area. There are no trains in the mobile catenary section. At this time, after controlling the pillar to drive the contact suspension to rise, the catenary is moved above the center of the line and returned to the working position, preparing for the next loading operation.

3 Related experimental study

As a special structural equipment for freight yard, mobile catenary should have integrity, synchronization, safety and reliability. In order to verify that this sunken mobile catenary can meet the technical requirements, relevant experimental studies were carried out in Urumqi Railway Bureau power supply loading line.

This section of the mobile catenary is 52 m long, using flexible contact suspension, five pillars, both ends of the pillars are used to support the driving weight, the middle three pillars 16 m apart, the upper part of the installation of the hinged cantilever, adjacent to the two pillars are equipped with a fixed catenary clamp, totaling four clamps.

3.1 Non-electrified operational test

3.1.1 Test condition.

Non-electrified operational test is carried out when the mobile catenary is not energized, at this time, the isolation switch is in the open position, the mobile catenary can be operated normally by the driving device, the mechanical part is normal, but the contact wi0re part is not energized. When the mobile catenary is in the working position, the pantograph and catenary remain in contact, and the test train runs back and forth at low speed below it. The test was conducted 20 times. The non-electrified operational test conditions are shown in table 1.

Table 1. Non-electrified operational test conditions.

Number of tests	weather	average temperatures	Average speed
20 times	fine	24℃	14.7km/h

3.1.2 Experimental procedure.

Non-electrified operational test is performed as follows:

(1) At the beginning of a single test, place the disconnecting switch in the open position so that the mobile catenary is in the working position and measure the relevant data.

(2) The test train rises the pantograph, enters the mobile catenary section from one side of the fixed catenary at a constant speed, until the test train runs completely to the other side of the fixed catenary and then stops, and records the data.

(3) Driving the mobile catenary to a non-working position and recording data.

(4) In the next test, the train runs in the reverse direction and mobile catenary with a similar course of action.

3.1.3 Observation and recording of data content during the test.

Record the following during the non-electrified operational test.

(1) When the catenary is in the working position. Depth of contact between the movable contact of the mobile catenary and the static contact of the fixed catenary. Height of contact wire to rail surface and catenary gradient. Horizontal distance between the contact wire and the center of the line at the positioning point. Whether scraping, drilling, bowing, or jamming occurs when the test train passes.

(2) When the catenary is in the non-working position. Whether the overhead catenary sinks into the foundation pit. Horizontal distance between the mobile catenary and the center of the line.

(3) During catenary movement. Uniformity of contact wire tension in the vicinity of the wire clamps, and whether the clamps have come loose. Time-consuming transition between the working and non-working positions for mobile catenary. Whether there are bends, twisted surfaces, and mutations in the contact wires.

3.2 Electrified operational test

When the electrified operational test is carried out, the disconnector is in the closed position, and when it is in the working position, the contact wire is partially energized, and the pantograph of the test train can take power from the contact wire. During the test, the pantograph and the catenary maintain a certain pressure between the operation. The electrified operational test conditions are shown in table 2.

Table 2. Electrified operational test conditions.

Number of tests	weather	average temperatures	Average speed	voltage of overhead catenary
20 times	fine	23°C	14.5km/h	27.5kV

The execution process of the electrified operational test is similar to that of the non-electrified operational test, the difference is that the disconnecting switch is in the closed position and the mobile catenary is energized.

4 Analysis of test results

4.1 Non-electrified operational test results

During the non-electrified operational test, no scraping, drilling, bowing, jamming or loosening occurred in the mobile catenary, and no bending, twisting or mutation occurred in the catenary. The result of laser ranging measurement shows that the contact wire height of conductor and slope are within the specified range. In the non-working position, the contact wire is able to sink to the foundation pit. The average time for the mobile catenary to switch from the working to the non-working position was 150 s, and the average time for the reverse run was 240 s. The combination depth of the static contacts of the fixed catenary and the moving contacts of the mobile catenary in the working position is shown in figure 3(a), and the horizontal distance between the contact wire and the center of the line in the non-working position is shown in figure 3(b).

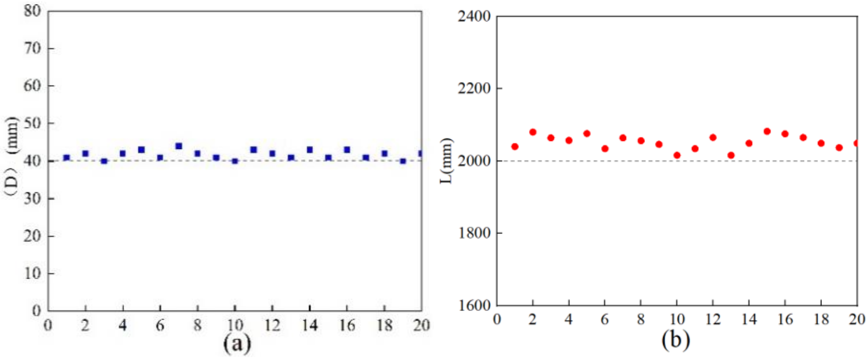

Fig. 3. Non-electrified operational test results

From figure 3, it can be seen that among the 20 non-electrified operational tests, the contact depth of fixed and moving contacts in working position is not less than 40 mm, among which, there are 3 times of combining depth of 40 mm, which is in the critical depth. In the non-working position, the contact wire is more than 2000 mm from the line center, which meets the technical requirements. There is no significant correlation between the experimental data, a single experiment is not affected by the results of other experiments.

4.2 Electrified operational test results

During the electrified operational test, the pantograph can take power from the mobile catenary, so that the test train can pass through the mobile catenary section and stop under the fixed catenary on the other side. During the test, no scraping, drilling, hitting, jamming or loosening occurred, and no bending, twisting or mutation of the contact wire occurred. Through laser rangefinder measurement, it is known that the contact wire height of conductor and slope are within the specified range. In the non-working position, the contact wires were able to sink to the foundation pit. The average time for the mobile catenary to switch from the working position to the non-working position was 150 s, and the reverse average time was 239 s. The combination depth of the static contacts of the fixed catenary and the moving contacts of the mobile catenary in the working position was recorded during the test, and the horizontal distance between the contact wire and the center of the line when it was not in the working position are shown in figure 4.

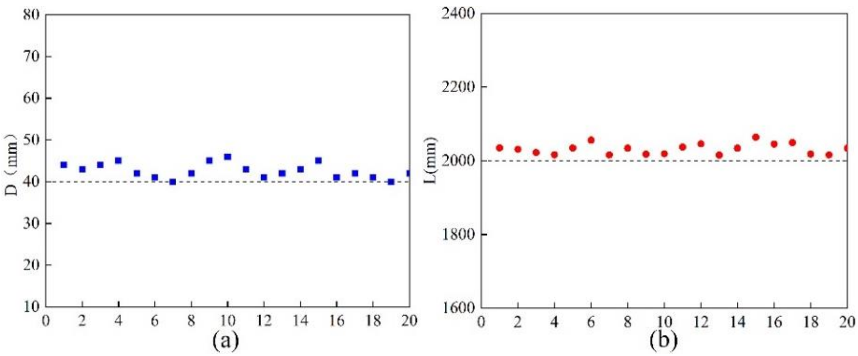

Fig. 4. Electrified operational test results

From figure 4, it can be seen that among the 20 electrified operational tests, the contact depth of moving and fixed contact is not less than 40 mm in working position, among which there are 2 times of 40 mm, which is in the critical depth, but still can ensure the electrical effective connection. When not in working position, the distance between the contact wire and the line center is more than 2000 mm, which meets the requirements of the side clearance of mobile catenary and the requirements of loading space.

5 Conclusion

Non-electrified and electrified operational test results show that the mobile catenary can work normally. In the working position, can ensure the electrical effective connection. In the non-working position， which meets the technical requirements of the side clearance of mobile catenary and the requirements of loading space. But there are still the following aspects need to be improved.

The mobile catenary is outdoor, affected by the temperature change, the tension of its hanging part and hinged cantilever part will also change, when this test is executed, the average temperature is about 20°C, the mobile catenary can work normally. However, it remains to be further observed whether the mobile catenary can work normally in extremely cold and hot environments. Since the non-electrified and electrified operational test occupy the freight loading site and affect normal loading operations, the number of tests performed is on the low side. After passing the electrified operational test, it is still necessary to observe the working condition of the equipment during the specific use process.

The sunken mobile catenary proposed in this paper can effectively solve the problem of insufficient space for large-scale machinery operation during the railroad power supply loading line operation, avoiding the problem of frequent shunting of fixed catenary and the problem of safety encroachment on the line by using other forms of mobile catenary.

Acknowledgements

This study was funded by the Science and Technology Research and Development Program of China National Railway Group Corporation Limited (N2022X009) and the Science and Technology Program of Gansu Province (23CXGA0023).

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