Practical Application and Effect Analysis of GMS Monitoring System in Track Beam Adjustment

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Abstract

Due to increasing service duration and geological decline, the precise requirements for adjusting the line of Shanghai Maglev are more urgent and frequent. In this paper, the application results of GMS are applied in the adjustment of track beam shape, and the overall effect of the line maintenance of the Maglev Shanghai demonstration line is analyzed, which including the distribution and the maximum value of the long-wave deviation of the position of the buttocks in the current situation, and compared the results before and after the route maintenance. The track line could be adjusted while deviation exceeded 5mm on suspended surface and 8mm on guide surface, specially subtle changes(>2mm) also could be modified. It shows that the GMS measurement method is accurate use and high efficiency application in the maintenance.

Key words: Shanghai Maglev Line, alignment, GMS system，practice and application

Introduction

There are increasing service duration and soft-soil characteristic geology in Shanghai Maglev Rails. Which deform the shape of orbital line, so it’s emergency to adjust the line shape accurately. Zheng[1,2] presented a portable system for inspecting long wave irregularity of high-speed maglev track and used GPS technology to decide the track position. Willi[3,4] studied the guideway monitoring and detected it with long wave. From July to September 2015, Shanghai Maglev Transportation Development Co., Ltd. organized the maintenance of the line in the Maglev Shanghai Demonstration Line, combined with Shanghai Mechanized Construction Group Co., Ltd., Shanghai Yufeng Building Component Installation Co., Ltd., Beijing Construction Engineering Quality First Testing Institute Co., Ltd. and Tongji University. The GMS (Guideway Monitor System) monitoring system is used to determine the line shape of the modulating beam, and the dynamic adjustment of the adjacent adjustment points is carried out during the construction process. Finally, perform a shaking test to verify the application effect of the GMS system.

In this paper, the measurement results of GMS are applied to the adjustment of track beam shape, the overall effect of the line maintenance of the Maglev Shanghai demonstration line in 2015 is analyzed. The distribution and the maximum value of the long-wave deviation of the current position of the buttress are statistically analyzed[5], and compared the pre-maintenance values of these buttress' positions. Finally, according to the measurement results of the GMS system in the track beam shape adjustment, the linear adjustment effect is explained from the aspects of typicality and independence, and the points where the adjustment effect is not obvious are also analyzed. The results of the comprehensive adjustment and the current status of the line can be used to initially formulate the next batch of adjustment points.

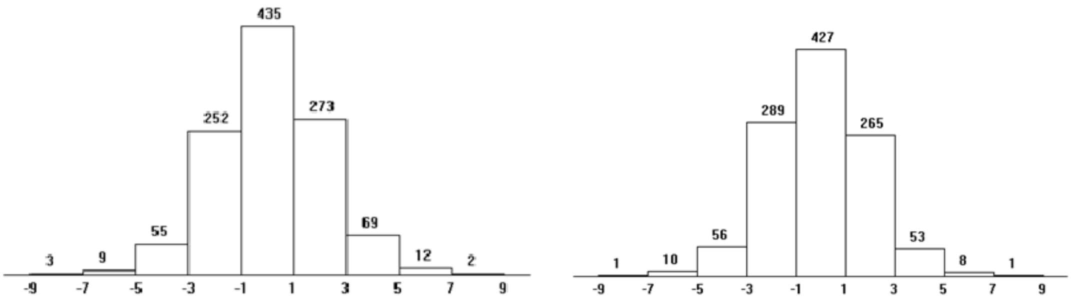
The status of track line

The GMS monitoring data from Shanghai Maglev Demonstration Line monthly in 2015, the long wave deviation distribution and the maximum value of the per-buttress-position can best indicate the current situation of the line[2].

Buttress guide surface

Long wave deviation value distribution

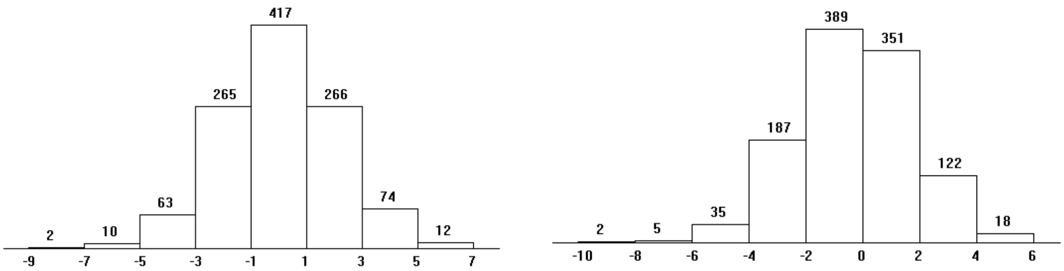
Figure 1 shows that the track A, the distribution value of left and right buttress guide surface concentrated within 5mm, and exceeding 5mm are 26 and 20 respectively. The exceeding parts account for 2.3% and 1.8% of the total line statistics (1110 piers).



a. the left of buttress guide surface(track A) b. the right of buttress guide surface (track A)

Figure1. Long-wave deviation distribution of track A guiding surface

Figure 2 shows that the track B, the distribution value of left and right buttress guide surface concentrated within 5mm-6mm, and exceeding 5mm-6mm are 24 and 20 respectively. The exceeding parts account for 2.2% and 0.6% of the total line statistics (1109piers).



a. the left of buttress guide surface(track B) b. the right of buttress guide surface (track B)

Figure2. Long-wave deviation distribution of track B guiding surface

long wave deviation maximum value

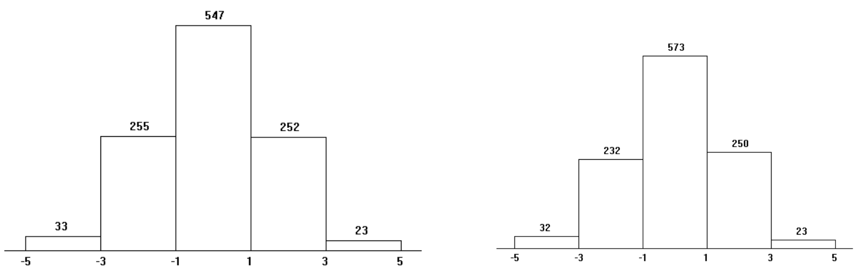
According to the A-track data 2014-09-24_10-14_LA_gui, the maximum and minimum values of the guide surface on the left side of the line are 7.605mm and -8.353mm, respectively, which are located at the piers P0109 and P0946; and the values on the right side are 7.828mm and -8.69mm, respectively located at the piers P0109 and P0104.

According to the B-track data 2014-09-13_10-14_LB_gui, the maximum and minimum values of the guide surface on the left side of the line are 5.96mm and -8.69mm, respectively, which are located at the piers P0119 and P0103; and the values on the right side are 5.86mm and -9.76mm, respectively located at the piers P0415 and P1127.

Suspended surface

Long wave deviation value distribution

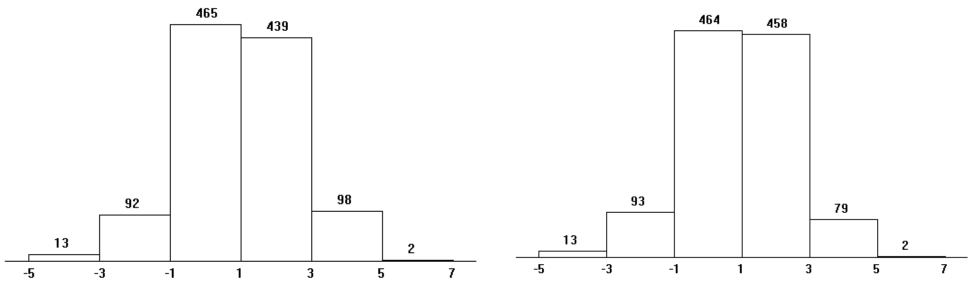
Figure 3 shows that the track A, the distribution value of left and right suspended surface[6,7] concentrated within 5mm.



a. the left of suspended surface(track A) b. the right of suspended surface (track A)

Figure3. Long-wave deviation distribution of track A suspended surface

Figure 4 shows that the track B, the distribution value of left and rights suspended surface have two positions beyond 5mm, the left side is p0101and p1031, meanwhile, the other side is p1031 and p1138.



a. the left of suspended surface(track B) b. the right of suspended surface (track B)

Figure4. Long-wave deviation distribution of track B suspended surface

The line shape is relatively stable, and the deviation of some points from the design line shape exceeds 5mm, which will cause the train to shake. These spike waveform areas are the key monitoring locations, and the curve is smoothed by adjusting the support.

long wave deviation maximum value

According to the A-track data 2014-09-24_10-14_LA_lev, the maximum and minimum values of the suspended surface on the left side of the line are 3.913mm and -4.662mm, respectively, which are located at the piers P0784 and P0336; and the values on the right side are 4.302mm and -4.646mm, respectively located at the piers P0784 and P0724.

According to the B-track data 2014-09-24_09-15_LB_lev, the maximum and minimum values of the suspended surface on the left side of the line are5.3mm and -4.5mm, respectively, which are located at the piers P1031 and P0049; and the values on the right side are 6.4mm and -4.3mm, respectively located at the piers P1.31 and P0378.

Track line adjustment scheme

Combining adjustment principle with the GMS data deviation value distribution map, to carry out the beam adjustment[8]. Select “the peak value of suspended surface long wave deviation >5mm, the peak value of guide surface long wave deviation, the difference value of adjacent long wave deviation >8mm”, and referenced the long wave deviation curve to determine 41 adjustment points in track A and track B. Among them, there are 19 points in track A and 22 points in track B. The 19 adjustment points of the track A are: P0100, P0105, P0108, P0128, P0129, P0210, P0272, P0294, P0420, P0446, P0451, P0624, P0625, P0937, P0947, P0952, P0954, P0955, P0961. The 22 adjustment points of the track B are: P0104, P0105, P0210, P0213, P0238, P0279, P0287, P0420, P0428, P0513, P0625, P0627, P0695, P0705, P0721, P0724, P0822, P0947, P0952, P0954 , P0961, P0963.

The actual maintenance adjustment scheme is shown in Figure 5 and Figure 6. (Note: 1.Put the direction of facing airport as forward direction to divide left and right; 2. In the plane adjustment , “+”is to the left, “-” is to the right; 3. In the elevation adjustment, “+ "is upward adjustment, "-" is downward adjustment.)

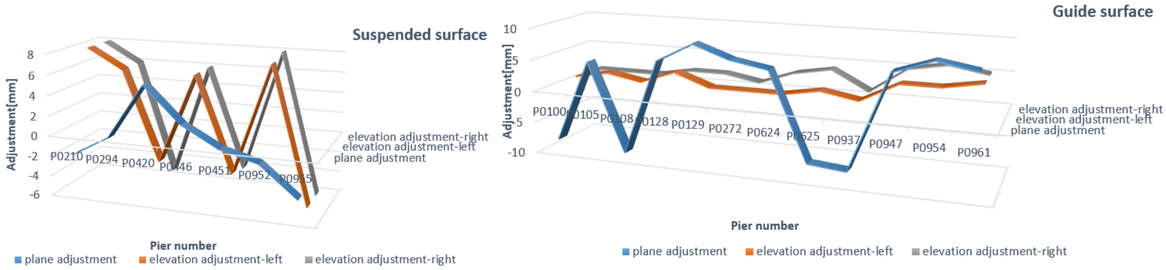


Figure5. A-track line adjustment scheme

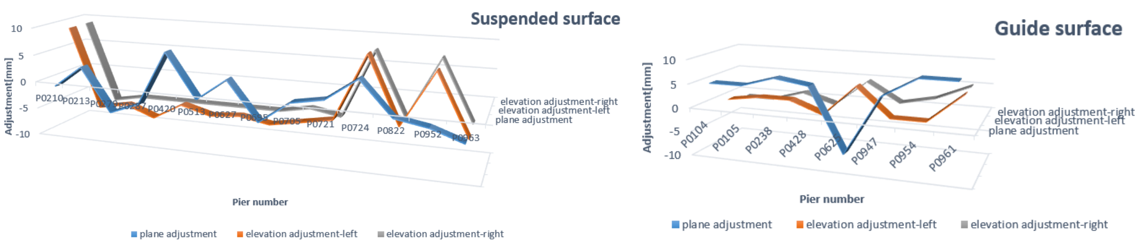


Figure6. B-track line adjustment scheme

Analyze the results after adjusted

Analyze track A

According to the long-wave deviation data measured by GMS in the A-track line, obtain the long-wave deviation values between adjustment after and before in different surface(buttress guide surface and suspended surface), which including their distributed amount, maximum and minimum value. The detail information is shown in Table 1.

Table 1. Compare long-wave deviation before and after adjustment in track A

Surface	Direction	Distribution(number)	Maximum	Minimum

		>5mm (suspended surface)		>8mm (guide surface)		Before	After	Before	After
		Before	After	Before	After				
Suspended surface	Left	4	0	--	--	5.2 P0451	3.9 P0784	-7.6 P0210	-4.7 P0336
	Right	6	0	--	--	6.0 P0451	4.3 P0784	-7.5 P0210	-4.6 P0724
Guide surface	Left	--	--	4	2	9.5 P0100	7.6 P0109	-11.8 P0954	-8.4 P0946
	Right	--	--	5	1	10.1 P0100	7.8 P0109	-10.0 P0954	-8.7 P0104

Table 1 shows that the deviation value(>8mm) of buttress position on guide surface reduced from 9 to 3(both directions), while reduced from 10 to 0 on suspended surface(both directions).

The A-track line has been improved by adjusted. They can divide into independent points and continuous points (the pier number is less than 5) among all points. Independent points include P0100、P0210、P0272、P0294、P0420、P0446、P0451、P0937、P0947、P0961, these points were improved except for P0937 and P0947. And continuous points are P0105 and P0108, P0128 and P0129, P0624 and P0625, P0952,P0954 and P0955,these points were improved except for P0105 and P0108.

This maintenance made the line of track A tend to standard shape. The maximum and minimum values of the guide surface on the left side are 7.605mm and -8.353mm, respectively, which are located at the piers P0109 and P0946. And the right side are 7.828mm and-8.69mm, located at the piers P0109 and P0104. The guide surface on the left side are 3.913mm and -4.662mm, respectively, which are located at the piers P0784 and P0336. And the right side are 4.302mm and -4.646mm, located at the piers P0784 and P0724.

Analyze track B

According to the long-wave deviation data measured by GMS in the A-track line, obtain the long-wave deviation values between adjustment after and before in different surface(buttress guide surface and suspended surface), which including their distributed amount, maximum and minimum value. The detail information is shown in Table 2.

Table 2. Compare long-wave deviation before and after adjustment in track B

Surface	Direction	Distribution(number)				Maximum		Minimum	
		>5mm (suspended surface)		>8mm (guide surface)		Before	After	Before	After
		Before	After	Before	After				
Suspended surface	Left	17	2	--	--	6.2 P0695	5.3 P1031	-7.1 P0210	-4.5 P0049
	Right	17	2	--	--	6.4 P0721	6.4 P1031	-6.4 P0210	-4.3 P0378
Guide surface	Left	--	--	2	2	6.5 P0625	5.96 P0119	-11.2 P0954	-8.69 P0103
	Right	--	--	3	1	6.1 P1125	5.86 P0415	-10.7 P0954	-9.76 P1127

Table 2 shows that the deviation value(>8mm) of buttress position on guide surface reduced from 5 to 3(both directions), while reduced from 34 to 4 on suspended surface(both directions).

The B-track line has been improved by adjusted. They can divide into independent points and continuous points (the pier number is less than 5) among all points. Independent points include P0238、P0287、P0420、P0428、P0513、P0695、P0705、P0822、P0947, these points were improved except for P0695 and P0947. And continuous points are P0104 and P0105, P0210 and P0213, P0625 and P0627, P0721 and P0724, P0952 and P0954, P0961 and P0963, these points were improved except for P0104, P0625 and P0961.

This maintenance made the line of track B tend to standard shape. The maximum and minimum values of the guide surface on the left side are 5.96mm and -8.69mm, respectively, which are located at the piers P0119 and P0103. And the right side are 5.86mm and-9.76mm, located at the piers P0415 and P1127. The guide surface on the left side are 5.3mm and -4.5mm, respectively, which are located at the piers P1031 and P0049. And the right side are 6.4mm and -4.3mm, located at the piers P1031 and P0378.

Subtle changes

In track A line, there were not obvious effect for piers P0105, P0108,P0937 and P0947 after applicating the GMS measurement. This situation result from adjustment of guide surface at P0105, P0108, P0937, and the long wave have obvious changes on guide surface due to the value of long-wave-deviation increased 2mm between adjacent points. Hence, there were not clearly modified effect near the adjustment points.

In track B line, there were not obvious effect for piers P0104, P0625, P0695 and P0947 after applicating the GMS measurement. Above all, P0695 and P0947 are independent points, the others are continuous points. This situation result from adjustment of guide surface at P0104, P0625, P0695 and P0947, and the long wave have obvious changes on guide surface except P0947, due to the value of long-wave-deviation increased 2mm between adjacent points. Hence, there were not clearly modified effect near the adjustment points, while there were almost no effect at P0947.

Conclusion

This paper applies the GMS system to monitor the Shanghai Maglev line dynamically. Distinguished the not-standard line by comparing the long wave deviation of GMS data. This methodology can obtain the range of deviation, maximum and the position of maximum, it very convenient for monitors to determine the offset positions.

The numbers both guide surface(>8mm) and suspended surface(>5mm) in track-A and track-B were reduced after this maintenance, the maximum and minimum also decreased largely. For track A line, the maximum (maximum and minimum) value appear at P0109(7.605mm), P0946(-8.353mm) on guide surface left side; while right side are P0109(7.828mm), P0104(-8.69mm). The maximum (maximum and minimum) value appear at P0784(3.913mm), P0336(-4.646mm) on suspended surface left side; while right side are P0784(4.302mm), P0724(-4.646mm).

For track B line, the maximum (maximum and minimum) value appear at P0119(5.96mm), P0103(-8.69mm) on guide surface left side; while right side are P0415(5.86mm), P1127(-9.76mm). The maximum (maximum and minimum) value appear at P1031(5.3mm), P0049(-4.5mm) on suspended surface left side; while right side are P1031(6.4mm), P0378(-4.3mm).

All points (subtle changes) in A-track and B-track are just increasing 2mm of long-wave deviation among adjacent points.

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