

Application Research of Quality Control Technology of Asphalt Pavement based on GPS Intelligent

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Abstract. Due to the difficulty of steel deck pavement asphalt layer compaction caused by the effect of the flexible supporting system (orthotropic steel deck plate), it is usually hard and difficult to control for the site compactness to reach the design goal. The intelligent compaction technology is based on GPS control technology and real-time acquisition of actual compaction tracks, and then forms a cloud maps of compaction times, which guide the roller operator to do the compaction in accordance with the design requirement to ensure the deck compaction technology and compaction quality. From the actual construction situation of actual bridge and checked data, the intelligent compaction technology is significant in guaranteeing the steel deck asphalt pavement compactness and quality stability.

1.Introduction

At present, gussasphalt is usually adopted on steel deck pavement with thickness of 6cm~8cm, which is constructed in two layers. Due to thin thickness of pavement and high construction requirement, it belongs to very delicate project, in which every application detail is very sensitive, and minor construction defects can bring serious subsequent damage.

Compaction is one of key procedures of steel deck pavement construction, and the under-compaction and uneven compaction caused by traditional roller and control procedure can be one of the main factors triggering early damage of steel deck pavement. The under-compaction and poor stability of steel deck pavement can cause cracks or potholes etc., which generates additional repairing and maintenance charges. Therefore, not only compactness but also the evenness of compactness must be guaranteed. Considering that the complicated compaction procedure of steel deck pavement requires more flexible and economic application technique, the intelligent compaction technology has better feasibility and prospect, and the real-time control of construction procedures such as compaction times can effectively improve the steel deck pavement quality and reliability. This paper has done the analysis and research on the application of intelligent compaction technology in the steel deck pavement.

2.The Intelligent Compaction Technology Principles and Composition

2.1 Working Principle

The intelligent compaction technology is a kind of new compaction quality control technology which integrates the sensor technology, embedded system and computer technology together. It could guide the roller to automatically judge and adjust the compaction performance parameters in accordance with



the rolled material and mechanical operation status in the compaction process, so as to achieve the best compaction effect.

The intelligent compaction equipment can measure and record the compaction quality and automatically judge and adjust the compaction performance parameters in accordance with the rolled material and mechanical operation status with the going of compaction process, so as to achieve the best compaction effect. This system can automatically check the stiffness and surface temperature of compacted asphalt surface layer and integrate the checked road compaction quality with automatic vibration adjustment. Besides, it uses the map based on the GPS to indicate the parameter situation and compaction quality in the compaction process and realizes the automatic storage of documents with specialized software. This technique solves the problems such as miss-compaction, under-compaction and over-compaction fundamentally so as to ensure the evenness of compactness. The working principle of controlling rolling times, automatic frequency conversion and amplitude variation control is showed in Figure 1.

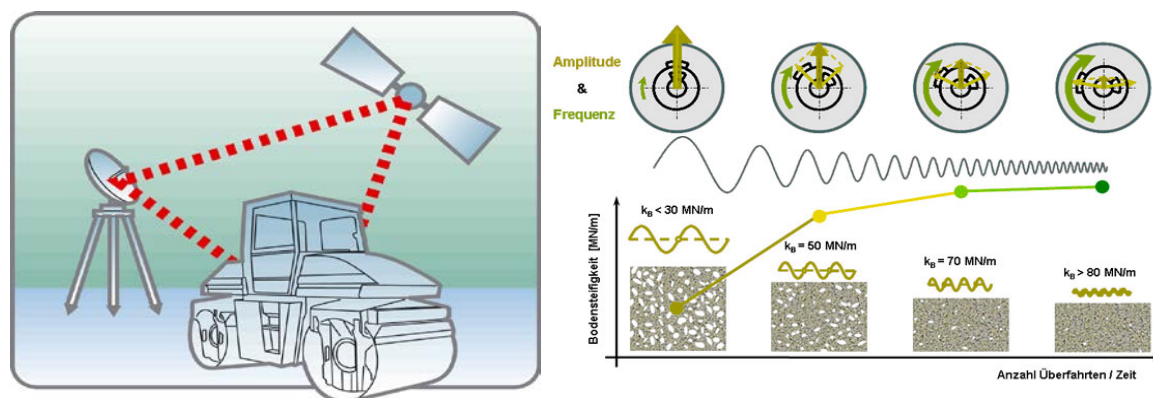


Figure 1. The Working Principle of Controlling Rolling Times, Automatic Frequency Conversion and Amplitude Variation Control

The intelligent compaction technology was used in subgrade construction. Because the compaction effect of subgrade is obvious and identification of the compaction degree is relatively easy. However, when it comes to asphalt pavement, the application becomes more difficult. The application of intelligent compaction technology in this research for the asphalt pavement is a technological breakthrough.

2.2 System Composition

CCSFlex asphalt compaction control system with GPS real-time dynamic location control technology and compaction sensor monitoring technology will be adopted in the test, and CCS900 application software is used to real-time deal with acquired correct location and posture information of roller steel wheel, and rolling times, road surface temperature, heading direction and speed are shown in forms of figures, values and sound signal etc. to lead the operator to do work.

From Figure 2, it is shown that CCSFlex asphalt compaction control

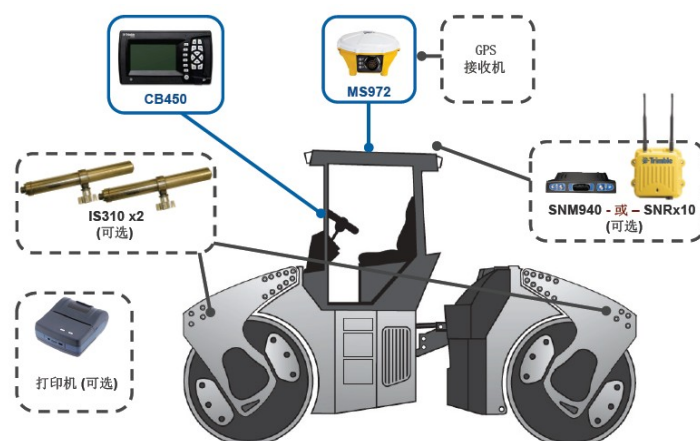


Figure 2. CCSFlex Asphalt Compaction Control System Composition

system is composed of the following parts: MS990 receiver, CB450 control box, SNR410 data transfer radio, IS310 temperature sensor (optional), printer (optional), GNSS base station.

3.Site Implementation and Data Analysis

3.1 Implementation Scheme

It is shown in Figure 3 and Figure 4 that, in September 2013, intelligent compaction system was tested in Guangxi Liuzhou Guangya Bridge construction, and three sets of intelligent compaction systems (one for the first rolling and two for the second rolling) were installed on three rollers to check rolling times of each roller and finally, the data of three rollers was combined to confirm the accumulated rolling times.

Guangxi Liuzhou Guangya Bridge steel deck pavement project adopts the pavement scheme: TOPEVER® waterproof binding layer + gussasphalt + high-elastic modified SMA, as shown in Figure 3. Gussasphalt is formed by fluidity and doesn't need rolling and the test focuses on the high-elastic modified SMA mixture (thickness 35mm) compaction process. The pavement structure is shown in Table 1.

Table 1. Guangxi Liuzhou Guangya Bridge Steel Deck Pavement Structure

Layer	Detailed parameters
Pavement upper layer	High-elastic asphalt SMA, thickness: 35mm Scatter modified emulsified asphalt, dosage: 300~500g/m ²
Pavement lower layer	Gussasphalt concrete GA10, thickness: 35mm: scatter 5~10mm pre-mixed debris
Waterproof binding layer	Responsive binder, dosage: 100~200 g/m ² TOPEVER (two layers) Polymer waterproof coating, total dosage: 2500~3500g/m ² Anti-corrosive primer, dosage: 100~200 g/m ²
Steel plate	Sand blasting and de-rusting, cleanliness: Sa 2.5, roughness: 50~100μm

At the same time, two comparison tests are done to verify the control effect of intelligent compaction system. In two tests, intelligent compaction systems are installed to check the rolling times and temperature. For the first construction (left deck), the operator does rolling according to the previous experiences and just records rolling tracks and times; for the second construction (right deck), the operator is guided by real-time shown tracks and times to set up rolling times control goal to do rolling.



Figure 3. Install the Intelligent Compaction System



Figure 4. Collect Data in Construction Process

After the recorded data was input into the computer, rolling result was showed in Figure 5 and Figure 6. By putting the rolling times of three rollers together we get the accumulated rolling times of each position. (From red to green represents the rolling times from more to less, and the green stands for once, and the red stands for over 20 times).

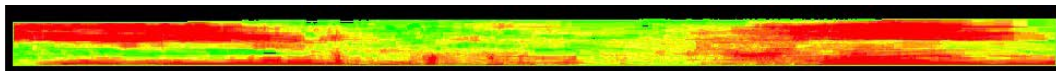


Figure 5. Rolling Result of Using the Traditional Method (Left Deck)

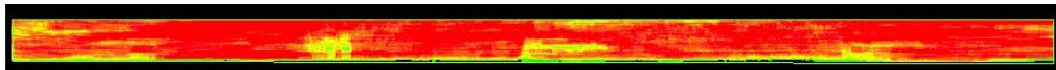


Figure 6. Rolling Result of Using the Intelligent Compaction Equipment (Right Deck)

Figure 5 and Figure 6 show that, after applying intelligent compaction system to control rolling times, the rolling evenness is better.

Through the site compaction engineering we found that the intelligent compaction technology had obvious advantages. Compared with traditional rolling procedure, the intelligent compaction is more convenient in field management and more efficient. Because in the traditional compaction, roller operator is relatively blind. More controllers are needed on site and over-compaction often happened.

3.2 Data Analysis

After the completion of SMA on the whole bridge, pave track TM Plus is used to inspect the compactness of SMA which is shown in Figure 7. Test data is obtained from every 3m on both left and right width of the deck.



Figure 7. Using Pave Track TM Plus to Collect the Data of Compactness

Table 2. The Test Results of Guangya Bridge Compactness

Chainage No.	Left Deck Compactness/% (Traditional Rolling Procedure)			Right Deck Compactness/% (Controlling Rolling Times)		
k0+20	98.9	100.0	100.6	99.2	98.7	97.9
k0+40	99.4	96.9	101.0	99.3	97.8	99.1
k0+60	99.8	97.1	103.0	99.4	99.0	98.2
k0+80	99.4	99.2	99.6	100.2	99.1	99.0
k0+100	99.7	99.9	97.0	97.8	97.5	99.7
k0+120	95.9	98.3	99.6	100.3	99.5	98.4
k0+140	97.8	96.1	97.8	96.2	98.6	97.8
k0+160	97.9	97.3	96.1	100.0	99.1	98.4
k0+180	97.3	97.8	98.3	98.1	97.6	99.3
k0+200	97.9	99.6	98.1	98.6	98.6	98.0
k0+220	98.9	101.8	97.4	97.7	98.6	98.1
k0+240	98.4	98.6	98.5	99.2	97.7	97.5
k0+260	99.4	99.3	99.7	98.6	98.4	99.9
k0+280	96.8	98.5	99.5	99.6	98.9	96.7
k0+300	99.4	96.8	97.1	98.8	98.1	97.9
k0+320	96.8	97.5	98.4	99.5	99.5	98.2
k0+340	97.2	99.0	96.5	98.3	96.5	99.5
k0+360	98.3	97.8	97.5	99.3	100.9	98.7
k0+380	97.6	99.1	98.0	98.8	98.4	98.6
k0+400	99.0	96.1	98.0	98.2	101.2	98.5
k0+420	95.9	100.8	97.8	97.5	97.8	99.5
k0+440	98.2	92.7	98.0	97.7	98.4	99.0
k0+460	95.6	98.1	97.0	97.9	97.8	99.6
k0+480	97.0	97.6	97.3	99.5	101.1	98.3
k0+500	97.6	99.4	97.9	98.9	98.8	99.4

Test results of Guangya Bridge compactness is shown in Table 2. In asphalt pavement project, the compactness variation coefficient and standard discrepancy are usually used to reflect the discretion degree of gussasphalt compactness and larger variation coefficient and standard discrepancy indicates higher data discretion degree. In accordance with the compactness analysis method stipulated in *Technical Specifications for Construction of Highway Asphalt Pavement*, the variation coefficient and standard discrepancy of compactness of two decks are analyzed.

The average compactness, standard discrepancy and variation coefficient of tested road section can be calculated by equation (1), equation (2) and equation (3).

$$K_0 = \frac{K_1 + K_2 + \dots + K_n}{N} \quad (1)$$

$$S = \sqrt{\frac{(K_1 - K_0)^2 + (K_2 - K_0)^2 + \dots + (K_n - K_0)^2}{N - 1}} \quad (2)$$

$$C_v = \frac{S}{K_0} \quad (3)$$

Where K_0 is the average compactness of that tested road section, %; S is the standard discrepancy of that tested road section, %; C_v is the variation coefficient of that tested road section, %; K_1, K_2, \dots, K_N is the compactness of every tested point in that tested road section, %; N is the total number of tested points in that tested road section, and DOF is $N-1$.

The analysis results are shown in Table 3.

Table 3. The Calculation Results of Standard Discrepancy and Variation Coefficient

Parameters	Average Compactness/%	Standard Discrepancy/%	Variation Coefficient/%
Left Deck (Traditional Rolling Procedure)	98.2	1.53	1.56
Right Deck (Control Rolling Times)	98.7	0.96	0.96

The data in Table 3 shows that the compactness standard discrepancy and variation coefficient after applying the intelligent compaction system to control rolling times are obviously lower than that of the layer which doesn't control rolling times and the compactness after applying the intelligent compaction system to control rolling times indicates that the intelligent compaction system can better control rolling times and achieve better construction quality control result.

4. Conclusions

By the application of intelligent compaction equipment in the steel deck pavement, the following conclusions can be obtained:

(1) The intelligent compaction system can real-time record the walking tracks of pavement roller and feedback the rolling times and temperature to the operator so as to effectively control the steel deck pavement layer compaction quality.

(2) For steel deck pavement with the intelligent compaction system, the rolling times of asphalt mixture can be better controlled than that without the intelligent compaction system.

(3) The compactness standard discrepancy and variation coefficient used the intelligent compaction system to control rolling times were obviously lower than those didn't use intelligent compaction system to control. Moreover, the compactness using the intelligent compaction system to control rolling times is higher. The intelligent compaction system plays an important role in the quality control.

5. References

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