Current Journal of Applied Science and Technology

39(1): 29-42, 2020; Article no.CJAST.54255
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

An Automatic Generation System for Traffic Organization Scheme

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Authors' contributions

This work was carried out in collaboration among all authors. Author LR designed the study, performed the statistical analysis, wrote the protocol, managed the literature searches and wrote the first draft of the manuscript. Author KL managed the experiment part. Author ZZ puts forward some suggestions for revising the article. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2020/v39i130478
Editor(s):
(1) Dr. Jakub Kostecki, Assistant Professor, Faculty of Civil Engineering, Architecture and Environmental Engineering, University of Zielona Góra, Poland.
Reviewers:
(1) Elżbieta Macioszek, Silesian University of Technology, Poland.
(2) Nain Tara, Aga Khan University Hospital, Pakistan.
Complete Peer review History: http://www.sdiarticle4.com/review-history/54255

Original Research Article

Received 01 December 2019
Accepted 03 February 2020
Published 10 February 2020

ABSTRACT

This paper presents a novel system of generating traffic organization scheme of the work area. In recent years, with the continuous improvement of China's economic level, the transportation industry is also in rapid development. Due to the characteristics of fast speed, large capacity, safe and comfortable driving, and obvious economic benefits, the highway has become an important part of the transportation system. The highway brings conveniences to people's travel. However, it is suffering road surface damage and traffic facilities breakage which results from long-term use. The cost of highway maintenance and repair work has been increasing. Previously proposed systems for generating the scheme has problems such as the difficulty of operation and complexity of the formation process for the traffic organization. We have developed an automatic generation system for traffic organization schemes in the operation area which improve the level of maintenance management of highway operation areas. This system can quickly form traffic organization solutions and drawings of traffic organization plan, thus effectively improving the efficiency of highway maintenance management.

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Keywords: Traffic organization plan; highway maintenance construction; automatic generation scheme.

1. INTRODUCTION

There are 700,000 administrative villages in China, which spread over 9.6 million square kilometres. 99.98% of them have road connectivity even in the plateau, desert and grassland. In 1978, at least half of the administrative villages in China did not have access to roads. In the 40 years since then, the total length of rural has increased nearly 6 times in China. On average 700 meters of new highways are built every hour. China is also the country with the most tunnels and bridges in the world. For example, The Wenma Highway in Sichuan Province has 121 bridges and 32 tunnels, more than 86% of which is bridges and tunnels. At present, more than 80% of China's highways have been opened to traffic, and more than 50% of highways have been in operation for many years [1]. After a period of operation of the expressway, the influence of the natural environment and the load of the vehicle will result in various important structures such as subgrade and pavement diseases. This will affect the quality of highway traffic and raises security issues. At present, China has transitioned from the rapid construction phase of the highway to the comprehensive maintenance management phase. In the process of highway maintenance construction, the work area is usually closed. While construction, there are many staff members. The construction time is tight, and the road area is large. The construction safety has hidden dangers. In the process of highway maintenance construction, it is very important and necessary to formulate scientific and reasonable traffic organization plans and management measures.

2. RESEARCH STATUS OF TRAFFIC ORGANIZATION PLANS IN CHINA AND ABROAD

Due to the impact of construction and maintenance on traffic capacity, this situation is highly valued in developed countries such as the United Kingdom, the United States and Sweden. These countries have issued corresponding regulatory management manuals according to different situations. Road maintenance and repairs need to be carried out by the transportation organization plan provided by the relevant department. China's experience in this area is still immature, and it is still carried out by traditional road traffic control measures. Traffic congestion often occurs in highway construction, which reduces the efficiency of vehicle traffic and on the other hand affects the social image of the highway sector.

The research on the maintenance and repair of highway operation areas has also increased, but most of the research work now focuses on the determination of maintenance forms and speed limits in the operation areas. There are few studies on traffic organization schemes in the work area. MUTCDDUI developed by the United States elaborates and explains the traffic control and management of the highway construction area [2]. 1996-1998, European Standard ARROWS (Advanced Research on Road Work Zone Safety Standard in Europe) project study hosted by the University of Athens. In this study, the traffic characteristics and safety maintenance measures of the road operation area were systematically analyzed [3]. The British Department of Transportation issued the Traffic Handbook in 2002. This handbook describes traffic safety measures and signs for road works and temporary maintenance. Although it has no legal effect. However, it has been recognized as the operating standard for maintenance work areas. In 1991, Garber and Tzong-Shiau studied the impact of traffic control facilities on multi-lane roads and two-lane road operating areas. They suggested that the increase in the accident rate in the work area is related to the traffic control method. In 2001, Kim, et al. in their research summarized several independent factors affecting the capacity of highway maintenance and repair areas. These factors are the number of closed and open lanes, the location of closed lanes, the length of the construction area, the longitudinal slope of the road, the strength of the work area, the type of driver, the duration of construction, and weather conditions. In 2003, Chun-Hung Chen and Paul Schonfeld analyzed the data and presented the proposed length layout for each of the four-lane work areas. Nemeth and Rathi used Freesim to simulate a highway network for simulation studies. The results of this study found that the speed limit can make the speed of vehicles passing through the work area tend to be consistent, which is conducive to traffic safety in the work area [4].

Compared with other countries, China started late in highway construction, but it has introduced a lot of specifications for highway construction. At

present, the specifications that can be utilized during highway construction are the “Safety Operation Procedures for Highway Maintenance” (JTG H30-2015) [5], “Technical Specifications for Highway Maintenance” (JTG H10-2009) and "Technical Specifications for Highway Asphalt Pavement Maintenance” (JTJ 073.2-2001) [6] issued by the Ministry of Communications. At the same time, some local management departments have formulated some management methods for construction section management. Also, the "Road Traffic Marking Line" (GB 5768-2009) has made a series of regulations on the setting of safety signs for construction sections. However, there are few studies on the length of various construction sections during highway construction, and most of them are empirical values.

In 2009, Kurita K, Oyado M, Tanaka H studied the traffic characteristics of the elevated road construction operation area and proposed the calculation method of the warning zone, transition zone, buffer zone, working zone, and termination zone length [7]. In 2009, Yan L and others used VISSIM to study various factors affecting the capacity of the operation area and provided scientific and reasonable solutions for the smooth flow of traffic in the operation area [8]. In 2014, Li Y, Huang Z, Xie B conducted research and organization design from the length of the construction work area, speed limit, and traffic safety and management. It ensures the safety of traffic organization in the highway construction area [9]. In 2011, to ensure the safety of vehicles in the construction area, Zhang QQ, Yang JM, Tang F used VISSIM to study the traffic conditions of the upstream transition section of the construction area and analyzed the length of the transition section, traffic volume and the impact of vehicle speed on traffic safety [10].

3. DETERMINATION OF THE LENGTH OF EACH SECTION OF THE HIGHWAY WORK AREA

3.1 Work Area Warning Section

The traffic organization scheme of the operation section is established on a case-by-case basis, but the method of determining the length of each section in the traffic organization must be determined before establishment. As, the work area includes the following six sections: (1) a warning section, (2) an upstream transition section, (3) a buffer section, (4) a working section, (5) a downstream transition section, and (6) a termination section. Taking the organization scheme of using the one-way and two-lane closed inner lane which uses the shoulder to pass as an example, the drawing is shown in Fig. 1.

The warning section (S) is the most important segment of the six partitions. S indicates that the road ahead is under construction so that the driver pays attention to the traffic changes and takes adjustment measures to prevent traffic accidents. In general, the length of the S is determined by two reasons, one of which is the time required for the vehicle to change the driving state within the warning section; the other is the maximum queue length when the vehicle is crowded near the operation control zone. "The HighwayMaintenance Safety Operation Procedure" (JTG-H30-2004) divides the length of S into three parts. The minimum length of the S can be calculated by the following formula:

$$S = S_1 + S_2 + S_3 \quad (1)$$

In the formula:

S- Warning section distance,m.
S_1- The distance required to reduce the speed from the normal driving speed to the working section,m.
S_2- Minimum safe distance for vehicles to arrive near the working section,m.
S_3- The length of the queue in the vicinity of the work section due to factors such as changes in driving conditions,m.

S_1 can be estimated by the following formula:

$$S_1 = \frac{v_1}{3.6}t + \frac{v_1^2 - v_2^2}{2g(\varphi \pm i)\times 3.6^2} \quad (2)$$

In the formula:

v_1- The speed of the vehicle before deceleration, $\mathrm{m/s}$.
v_2- The speed of the vehicle after deceleration, $\mathrm{m/s}$.
t- Driver response time usually takes 2.5 s.
the φ-The longitudinal friction coefficient of the road, ranging from 0.29 to 0.44.
i- Road longitudinal slope, use "+" for uphill, use"-" for downhill.
g- Gravity acceleration, 9.8 $\mathrm{m/s^2}$.

The calculated values of S_1 are shown in Table 1.

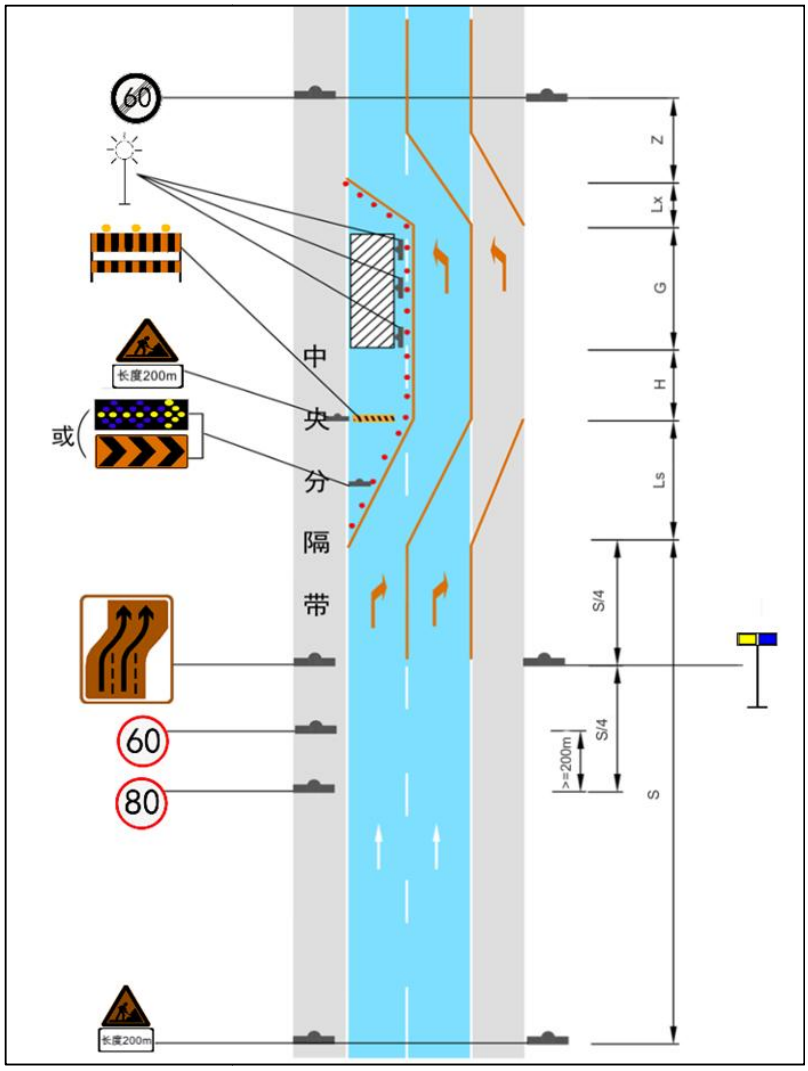

Fig. 1. One-way two-lane closed inner lane using road shoulder working area layout

S—a warning section; Ls—an upstream transition section; H—a buffer section; G—a working area construction section; Lx—a downstream transition section; Z—a termination section

Table 1. S_1 Calculation table

Normal driving speed (km/h)	Limit speed (km/h)	S_1safe distance (km/h)
120	60	225
100	60	150
80	40	120
60	30	70
40	30	45
30	30	30

S_2can be estimated by the following formula:

$$S_2 = \frac{v_2}{3.6}t + \frac{v_2^2}{2g(\varphi \pm i)\times 3.6^2} \quad (3)$$

The meaning of the symbol in the formula is as shown in the formula (2).

The calculated values of S_2 are shown in Table 2.

S_3can be estimated by the following formula:

$$S_3 = \frac{Ql}{n} \quad (4)$$

In the formula:

Q- The minimum flow of traffic jams caused by traffic events in the driveway, vehicle/ hours.
l- The average length of each car, Calculated according to 7 m.
n- Number of lanes.

The calculated values of S_3 are shown in Table 3.

Table 2. S_2 Calculation table

Vehicle speed (km/h)	S_2 (m)
80	139
70	11
60	90
40	50
20	20

3.2 Upstream Transition Section of the Working Area

The purpose of setting the upstream transition zone is to ensure that the vehicle can safely bypass the work area, and on the other hand to ensure that the vehicle smoothly transitions from the closed lane to the normal lane. The length of the upstream transition zone is calculated according to the method in Road Traffic Signs and Markings (GB5768):

$$L_s = \begin{cases} \frac{v^2 w}{155} & v \le 60\,km/h \\ 0.625vw & v > 60\,km/h \end{cases} \quad (5)$$

In the formula:

L_s- The length of the upstream transition, m.
v- Working section driving speed, km/h.
w- The width of the enclosed lane, m.

The theoretical value of the transition zone length is shown in Table 4.

3.3 Work Area Buffer Section

To avoid some driver's mistakes during the driving process, the vehicle collided with the workers or mechanical equipment in the construction area. So set up a buffer. Under normal circumstances, the buffer should be vacant to provide fault-tolerant space for passing vehicles to avoid the occurrence of malicious traffic accidents. Assume that the vehicle is travelling at a speed of v (km/h)in the warning section. The formula for calculating H is as follows:

$$H = \frac{v}{3.6}t + \frac{v^2}{2g(\varphi \pm i)\times 3.6^2} \quad (6)$$

In the formula:

t- Driver response time, value is 2.5 s.
φ- The longitudinal friction coefficient of the road, ranging from 0.29 to 0.44.
i- Road longitudinal slope, use "+" for uphill, use"-" for downhill.
g- Gravity acceleration, 9.8 m/s^2.

The length of the Longitudinal buffer is shown in Table 5.

3.4 Work Area Construction Section

The construction section of the highway work area is the operation area of the road maintenance. At the same time, it is also the area where road maintenance workers work, place road construction materials, and park construction machinery. The setting of the construction section of the work area needs to be coordinated with each section, and it should also be consistent with the overall progress of the construction. Therefore, the length of the construction section of the work area is set to meet the requirements of the traffic organization.

3.5 Downstream Transition Section of the Working Area

The purpose of establishing the downstream transition section is to guide vehicles to change their driving direction, change lanes and return to normal traffic as soon as possible. If the length of the downstream transition section is properly set, it is conducive to the smooth change of traffic flow. In general, the length of the downstream transition section should ensure the vehicle has sufficient distance to adjust the running state. According to relevant studies, the minimum length of the downstream transition section is 30 m.

3.6 Work Area Termination Section

The purpose of setting the termination section of the work area is to provide a road section for the driving vehicle to adjust the driving state, and at the same time, to eliminate the nervousness caused by the change of the driver's road conditions. To give the driver time to resume normal driving conditions, traffic signs such as lifting restrictions should be set at the end of the termination section. The formula for calculating L_Z is as follows:

$$L_Z = \frac{v}{3.6}t \quad (7)$$

In the formula:

L_Z- Termination section length,m.
v- The speed at which the vehicle passes termination section, km/h.
t- Driver response time, value is 2.5 s.

When the speed limit is 40 km/h, the length of the termination section is about 30 m; when the speed limit is 60 km/h , the length of the termination section is about 40 m. The "Circulation Maintenance Procedures" stipulates that the length of the termination section shall not be less than 30 m. A survey of many highway maintenance operations termination section found that the use of existing standards can better ensure the safety and traffic efficiency of vehicles in the termination section. Therefore, this paper suggests continuing to use the original standards. The length of the termination section should be no less than 30 m.

4. WORK AREA TRAFFIC ORGANIZATION MEASURES

4.1 Speed Limit in the Work Area

If the driving speed of the working area is not limited, the speed between the vehicles will become uneven. At the same time, the lane closure due to maintenance reasons leads to an increase in the accident rate. Therefore, the vehicle can be advanced at an average speed by limiting the travelling speed of the vehicle in the work section and reducing the speed difference among the vehicles. This can reduce the incidence of traffic accidents in the work area.

Table 3. S_3 Calculation table

Highway grade	Number of lanes	Q (vehicle/ hours)	S_3 (m)
highway	4	860	1505
First-class road	2	260	910
Second-class road	2	220	770
Third-class road	1	60	420

Table 4. L_s Calculation table

Closed lane width (m)Limit speed (km/h)	3.0	3.5	3.75
80	150	170	190
70	120	140	160
60	70	90	90
50	50	60	60
40	30	40	40
20	10		

Table 5. H Calculation table

Limit speed (km/h)	Longitudinal buffer length at different slopes (m)		
	-3%	-6%	-9%
80	130	144	154
70	105	116	124
60	85	92	97
50	65	70	75
40	50		
30	35		

Table 6. The recommended speed limit for road work area

Road type	Design speed (km/h)	Final limit speed (km/h)
Highway, First-class highway	120	70、80
	100	60、70
	80	40、50
	60	30、40
Second class road	60、80	40、30
Third-class road	30、40	20、30

Table 7. Safety signs for construction sections of the work area

Signs name	Set conditions and location	Function introduction
Road bar	The road bar is located around the road construction section.	Prevent vehicles from advancing or instructing vehicles to divert.
Cone traffic sign	It is located in the need to temporarily separate traffic flow, guide traffic, protect construction sites and personnel around the site.	Use with the road bar. Used to separate traffic flow and direct vehicles to bypass dangerous sections.
road work ahead XX km road work ahead XX m	Located in the appropriate position before the construction section.	Announcement of construction and location information.
Road Construction road closed XX km road closed XX m	The section is half-width closed or full-width closed. Located in front of the construction section.	Announcement of construction and location information.

Table 8. Construction road section warning signs

Signs name	Set conditions and location	Function introduction
Narrow on the right, Narrow on the life	The left and right sides are narrowed, and the traffic flow merges and a bottleneck occurs. The right and left narrowing signs should be set before the number of lanes are reduced.	Warnings that the driver's road width changes or the number of lanes decrease due to road construction, resulting in inconvenience. Driver driving carefully
Two-way traffic	The half-section of the road construction needs to be driven by road, and the two-way traffic sign should be installed at the appropriate location before the construction section.	Warning the driver will pay attention to the car in front

A speed limit that is too high or too low will reduce safety. The speed limit values of different grades of highways are shown in Table 6.

4.2 Layout of Traffic Signs and Markings in the Work Area

4.2.1 The layout of traffic signs

The road construction safety signs are arranged according to the "Road Traffic Signs and Markings" (GB57 68 — 2009). Work area construction marks generally include safety signs, warning signs, prohibition signs and indication signs. The specific content is introduced in Tables 7, 8 and 9.

The indication signs to be set in the work area are road engineering warning signs and vehicle distance confirmation signs. The road engineering warning signs are set 2 meters in front of the construction work area, and each set is 2 times. The vehicle distance confirmation signs are set in the road engineering warning signs 300, and each set is 2 times.

4.2.2 The layout of traffic markings

Road markings have the effect of restricting road traffic in defined signposts, arrows, text, facade markings, raised road markings and other facilities. Its specific functions are divided into different road use objects, stipulate different traffic routes, provide information to road users, protect road driving methods and road traffic safety. The traffic marking settings category is shown in Table 10.

5. DYNAMIC AUTOMATIC GENERATION SYSTEM FOR TRAFFIC ORGANIZATION PLAN OF HIGHWAY WORK AREA

The dynamic automatic generation system of the traffic organization scheme of the road operation area has made a comprehensive summary of the possible traffic organization schemes. The system can quickly generate an organization plan. The system is organized according to five types including straight lanes, corners, crossroads, special lanes and tunnels. From the maintenance view, it can be also classified into two-way four-lane, two-way six-lane, two-way eight-lane, two-way two-lane, single-lane, four-level highway, one-way two-lane, one-way three-lane, before the curve, after the curve, and at the bend Road sections, right-angled corners, continuous corners, reversed corners, turning corners, entrance lanes, exit

lanes, interchange entrances, interchanges, interchanges, main toll plazas, entrance ramp toll plazas, exit ramp toll plazas, crosses Cross-lane four-lane roads, two-way two-lane crossroads, two-way four-lane crossroads, four-lane roads with single-lane roads, circular cross-sections, single-hole tunnels, and two-hole tunnels. The traffic organization plan is shown in Table 11.

The form of traffic organization in the work area needs to change depending on the construction conditions. Common traffic organization programs are mainly divided into the following categories:

1) Half-closed and half-open traffic organization scheme

Generally, integral subgrade adopts half-closed half-pass form, which will change the direction of the half-normal one-way traffic flow. Close the construction of the other half of the middle section, using the opening of the central divider, so that the vehicle enters the other half to drive through the road, to the next central divider with the opening, and then back to the half. When half of the construction is completed, the other half will be constructed. The traffic organization plan is shown in Fig. 2.

2) Temporary construction traffic organization plan

The temporary construction traffic organization plan applies to maintenance projects with construction time within half a day. The traffic sign setting for such a scheme can be appropriately reduced. However, it is necessary to set a cone traffic sign, set a moving sign in the upstream transition section or be equipped with a traffic commander. The schematic diagram of the temporary construction traffic organization plan is shown in Fig. 3.

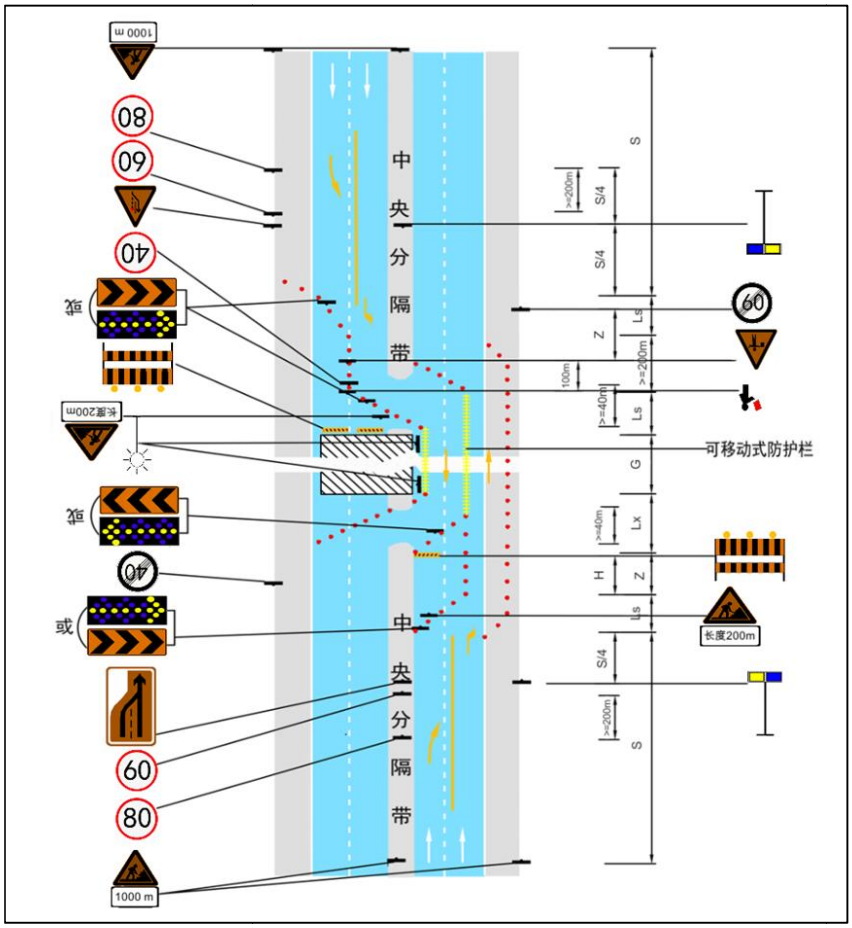

Fig. 2. The half-closed half-vehicle traffic organization plan

Table 9. Construction road section prohibition signs

Signs name	Set conditions and location	Function introduction
No entry	Set at the beginning of the construction section.	Prohibit vehicles from entering construction work sections.
No passing	Located in front of the construction section. The starting point for no overtaking sections.	The vehicle cannot pass that the road between the sign and the prohibition of the overtaking sign.
Lifting the prohibition of overtaking	Located at the end of the construction section. The end of the no passing section. Used in pairs with the no-passing signs.	Indicates that the end of the overtaking section is prohibited
Limit speed	Located in front of the construction section. The starting point of limit speed.	In the section indicating that the sign is to the front release speed limit sign, the vehicle travel speed ($\mathrm{km/h}$) is never allowed to exceed the value indicated by the mark.
Unrestricted speed	Located at the end of the construction section. Limit the end of the speed section. Used in pairs with speed limit signs.	Indicates the end of the speed limit section.
No parking	Use in the appropriate locations within transition sections, buffer sections, and working sections.	It is forbidden to park vehicles on this section temporarily or for a long time.

Table 10. Traffic marking settings category

Category	Function introduction
Warning section should set road text and guide arrow.	The road conditions ahead of the driver changed and the driver drove carefully. It also guides the driver to safely and smoothly into the construction section.
The upstream transition section sets the arrow, lane line, and invalid area stripe line.	Provide the vehicle with space to change the lane or change the direction of travel.
The buffer section should be equipped with a deceleration line, prohibiting speeding roads, and prohibiting lane changes.	Provide space for adjusting the speed of the vehicle after the lane change. Before the car arrives at the construction area.
The lane separation line is arranged in the construction area, and it is forbidden to change the lane.	To ensure the safety of driving, vehicles entering the construction area cannot overtake.
The downstream transition section sets the progressive display line of the arrow and the lane.	The vehicle in this section resumes normal driving. The vehicle lane is set to provide the driver with space to change the direction of travel.
The traffic marking of the termination section must be returned to the non-working area.	Traffic flow can resume normal driving, thus lifting the speed limit of the project.

Table 11. Traffic organization scheme output type

Type	The output type of traffic organization plan drawing
Double lane	Main road closed by the interchange
	One-way two-lanes closed inner lane uses roadbed for maintenance
	Long downhill one-way two-lanes closed inner lane for maintenance
Three lanes	One-way three-lanes highway closes the inner lane for maintenance
	Three-lanes closed inner two-lanes for maintenance
	Three-lanes highway closed outside lane for maintenance
	Long downhill three-lanes highway closed inside two-lanes for maintenance
Four lanes	Four-lanes highway closed outside lane for maintenance
	Long downhill four-lanes highway closed inside lane for maintenance
	Long downhill four-lanes highway closed outside lane for maintenance
	Four-lanes highway closed shoulder for maintenance
	Four-lanes highway borrows the opposite lane pass for maintenance (2)
	The four-lanes highway long downhill on the right section borrows the opposite lane pass for maintenance
	The four-lanes highway long downhill on the left section borrows the opposite lane pass for maintenance
	Four-lanes highway and first-class highway closed outside lane for maintenance - Confluence static sign
	Four-lanes highway closed inside lane for maintenance
	Four-lanes highway under heavy traffic flow closed inside of the half lane for maintenance
	Four-lanes highway closed outside lane for maintenance
	Four-lanes highway and first-class highway closed inside lane for maintenance
	Four-lanes highway and first-class highway closed outside lane for maintenance
	Long downhill four-lanes highway and first-class highway closed outside lane for maintenance
	Four-lanes highway and first-class road closed shoulder for maintenance
	Long downhill on the left two-way four-lanes highway closed half for maintenance
	Long downhill on the right two-way four-lanes highway closed half for maintenance
	Four-lanes closed half
	Two-way four-lanes closed half
	Four-lanes highway for temporary maintenance
	Four-lanes highway closed at night to borrow the opposite two-lanes pass for maintenance
	Four-lanes highway and first-class highway closed inside lane for maintenance
	Four-lanes highway and first-class highway closed outside lane for maintenance
	Set the separation line for maintenance in the same lane
Six lanes	Six-lanes highway and first-class highway closed inside lane for maintenance
	Six-lanes highway borrows the opposite two-lane pass for maintenance
	Six-lanes highway and first-class highway closed outside lane for maintenance
	Six-lanes highway closed inside lane for maintenance

Type	The output type of traffic organization plan drawing
	Six-lanes highway closed outside lane for maintenance
	Six-lanes highway under heavy traffic flow closed inside lane for maintenance
	Long downhill six-lanes highway closed inside lane for maintenance
	Long downhill six-lanes highway closed outside lane for maintenance
	Six-lanes highway and first-class highway closed inside lane for maintenance
	Six-lanes highway and first-class highway closed outside lane for maintenance
Eight lanes	Eight-lanes highway and first-class highway closed inside lane for maintenance
	Eight-lanes highway and first-class highway closed outside lane for maintenance
	Two-ways eight-lanes closed outside two-lanes
	Eight-lanes highway closed inside lane for maintenance
	Long downhill eight-lanes highway closed inside lane for maintenance
	Long downhill eight-lanes highway closed outside lane for maintenance
Highway and	Highways and first-class highway borrowed opposite lanes for maintenance
first-class	Highways and first-class highway are equipped with mobile signs for temporary maintenance
highway	Highway and first-class highway shoulders are manually moved for maintenance
	Long downhill on the right side borrows the opposite lane to the highway and the first-grade road for maintenance
	Long downhill on the left side borrows the opposite lane to the highway and the first-grade road for maintenance
	Highways and first-class highway borrow opposite lanes pass for maintenance
Second-class	Second-class highway, third-class highway two-ways pass for maintenance
highway, Third	Second-class highway, third-class highway two-ways alternate pass before cornering of curved road sections for maintenance
-class highway	Second-class highway, third-class highway two-ways pass before cornering of curved road sections for maintenance
	Second-class highway, third-class highway two-ways pass after cornering of curved road sections for maintenance
	Second-class highway, third-class highway two-ways alternate pass curved road sections for temporary maintenance
	Second-class highway, third-class highway two-ways alternate pass continuous curved road sections for maintenance
	Second-class highway, third-class highway two-ways alternate pass reverse curved road sections for maintenance
	Second-class highway, third-class highway two-ways pass camber sections for maintenance
	Second-class highway, third-class highway two-ways two-lanes alternate pass for temporary maintenance
Fourth-class	Two-lanes fourth-class highway closed single lane alternate pass for maintenance
highway	Two-lanes fourth-class highway curved road section closed single lane alternate pass for maintenance
	Single lane fourth-class highway closed single lane alternate pass for maintenance
	fourth-class highway alternate pass for temporary maintenance
Interchange	Interchange entrance mainline near the ramp or maintenance
	Interchange export mainline near the ramp or maintenance
	Interchange closed shoulders on the single lane of the ramp for maintenance
Mainline toll	Mainline toll plaza closed entrance inside lane for maintenance
plaza	Mainline toll plaza closed entrance middle lane for maintenance

Type	The output type of traffic organization plan drawing
	Mainline toll plaza closed entrance outside lane for maintenance
	Mainline toll plaza closed export inside lane for maintenance
	Mainline toll plaza closed export middle lane for maintenance
	Mainline toll plaza closed export outside lane for maintenance
	Ramp export toll plaza closed entrance lane for maintenance
	Ramp export toll plaza closed export lane for maintenance
	Ramp entrance toll plaza closed export lane for maintenance
	Ramp entrance toll plaza closed entrance lane for maintenance
bridge	Bridge deck of medium and small bridges closed lane for maintenance
	The starting point of the work area is less than 300 meters from the bridgehead closed lane for maintenance
	The starting point of the work area is greater than or equal to 300 meters from the bridgehead closed lane for maintenance
	Borrows the opposite lane to pass for bridge maintenance
	Bridge closed non-motor vehicle road for maintenance
tunnel	Single-hole two-ways tunnel alternate pass near the entrance for maintenance
	Single-hole two-ways tunnel alternate pass in the middle section for maintenance
	Single-hole two-ways medium and short tunnel alternate pass for maintenance
	Double hole one-way tunnel near the entrance for maintenance
	Double hole one-way tunnel in the middle section for maintenance
	Double hole one-way tunnel-group for maintenance
crossroads	Entrance closed and needed to borrow the opposite lane to alternate pass for maintenance
	Single lane entrance closed and this lane-keep in the pass for maintenance
	Export closed and needed to borrow the opposite lane two-ways pass for maintenance
	Single lane export closed and this lane-keep in the pass for maintenance
	Single lane fourth-class highway crossroads alternately pass for maintenance
Circular cross	Circular cross closed entrance inside lane for maintenance
	Circular cross closed entrance outside lane for maintenance
	Circular cross closed export inside lane for maintenance
	Circular cross closed export outside lane for maintenance
	Circular cross fully enclosed exit lane for maintenance
	Circular cross centre closed inside lane for maintenance
	Circular cross centre closed outside lane for maintenance

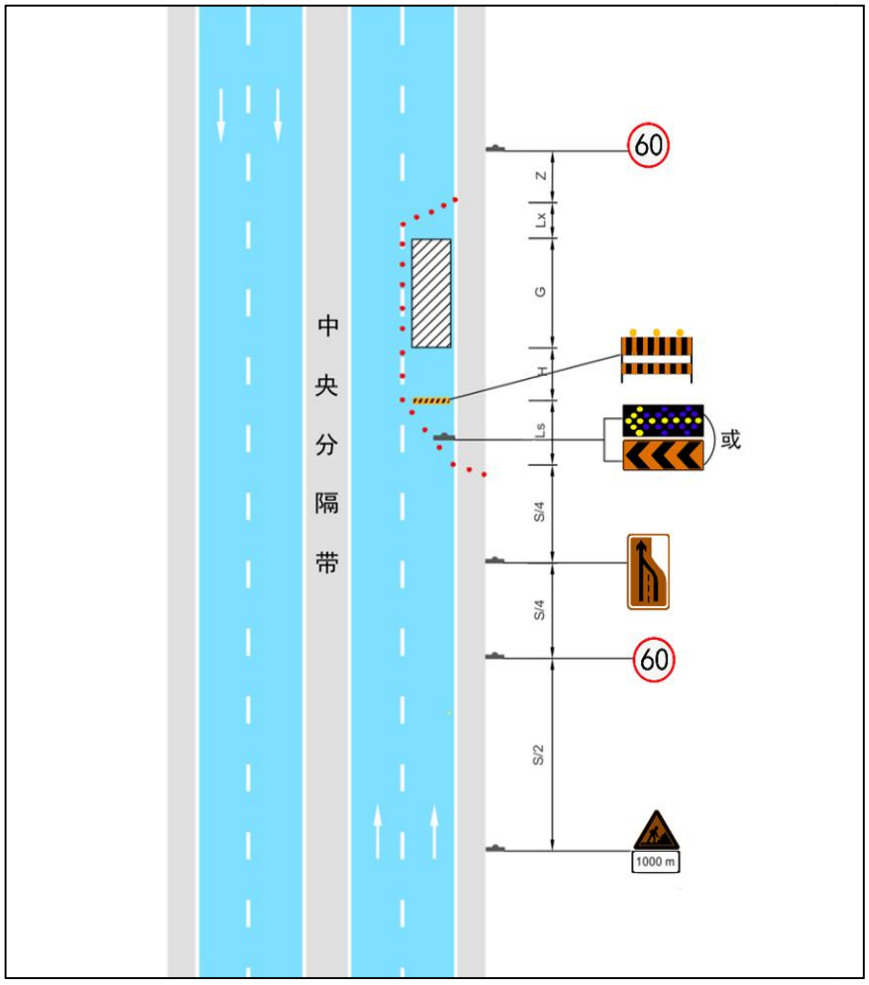

Fig. 3. The temporary construction traffic organization plan

6. CONCLUSION

To improve the traffic safety of highways and all grades of roads maintenance in China. This paper uses traffic simulation technology as an auxiliary means to systematically study the space layout of the road and the corresponding traffic organization problems in the maintenance work area. The theoretical calculation method of the length of each control section in the "Safety Operation Regulations for Highway Maintenance" was researched and summarized, which provided a theoretical basis for the establishment of the road segment simulation model. According to different road construction conditions, more than 10 kinds of traffic organization schemes were summarized, which provided convenience for the relevant transportation departments to carry out road construction.

ACKNOWLEDGEMENTS

The authors would like to thank editors and reviewers for their detailed reviews and constructive comments.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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