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MICRO-SIMULATION OF DESIRED SPEED FOR TEMPORARY WORK ZONE WITH A NEW CALIBRATION METHOD

ABSTRACT

Nowadays, the studies of parameter calibration for long-term work zones are limited to driver behaviour and car-following parameters, and no research was found related to calibration of the desired speed distributions during temporary work zones. Obtaining realistic results from simulations of temporary work zones is difficult. Thus, it would be valuable for gaining more valid simulation data if a method of calibrating the desired speed distribution could be applied for traffic simulation model of highway temporary work zones. The calibration method was proposed in five steps: (1) collect and analyse data, (2) plot the travel speed cumulative frequency curves and calibrate the desired speed distribution, (3) conduct simulation runs, (4) validate the simulation results, and (5) propose a new calibration method, which was assessed by T-tests, and the results are very promising. Finally, a simplified calibration method called "Five-Point Method" is presented and the recommended values of five-point are given.

KEY WORDS

traffic simulation; parameter calibration; desired speed distribution; temporary work zone; Vissim;

1. INTRODUCTION

With the development of the transportation industry in China, more and more highways are falling into disrepair because the transportation agencies cannot keep pace with the rapid development of traffic. Inevitably, this leads to some serious early damage phenomena on highways, such as water damage, deformation, cracks, potholes and land subsidence, etc. Extending the service life of these roads would require preventive maintenance, minor repairs, and/or engineering to be carried out as soon as early signs of the damage are noted. Accomplishing this level of maintenance would create a significant increase in temporary work zones on the highway system. To avoid the inconvenience caused to normal traffic during construction on the existing roadways, the "open while working" maintenance operation is often adopted. However, work zones tend to cause hazardous conditions for vehicle drivers and maintenance workers because they generate conflicts between maintenance activities and the traffic, and therefore aggravate the existing traffic conditions. For example, most maintenance activities will reduce the number of available lanes. Affected by sudden disturbances, the drivers exhibit dangerous driving behaviours such as speed changes, dramatic changes in direction, and surprise encroachments. All of these responses will increase the accident potential. Through the analysis of the accident statistics, Schonfeld P and Chien S [1] showed that the number of highway traffic accidents in work zones accounted for 2% ~ 3% of those on the highways. Asad JK and

Aemal JK [2] argued that the traffic accident rates in work zones feature sharp increase based on the analysis of traffic data. Furthermore, three studies [3, 4, 5] indicated that work zone crashes were more severe than other crashes.

In view of serious safety problems in work zones, a significant amount of research has been conducted. The traditional methods to study the characteristics of work zones are to manually collect data in the field using static survey instruments along a specific road and analyse the data. This method is time-consuming, labour-intensive, and sometimes dangerous - especially on roadways with high traffic volumes that make it difficult to safely perform the field measurement. In addition, data collected using this method are often too limited with respect to the research needs. Therefore, micro-simulation is increasingly a preferred method of traffic analysis for today's transportation professionals because "simulation is safer, less expensive and faster than field implementation and testing" [6]. It is a useful tool to effectively analyse and evaluate the proposed improvements and alternatives. For example, a temporary work zone can be simulated for different lane closures and its effect found before implementing it.

Vissim which is used in this study is a microscopic time step and behaviour-based simulation model. Any model created in Vissim needs to be calibrated to sufficiently represent field conditions. The default values provided by the software developers for these parameters in a simulation model are only applicable to rather specific circumstances which are often not specified in detail by the software provider. Calibration is the process in which the input parameters are refined so that the model accurately replicates the observed traffic conditions [7]. In calibration the parameters are adjusted so that the model outputs are similar to the observed data [8]. Various parameters that can be calibrated in Vissim are acceleration, desired speed, and clearance distance, emergency stopping distance, waiting time before diffusion, lane change distance, standstill distance, minimum headway and other Wiedemann parameters. *Table 1* shows the research development of calibrating parameters.

In most cases, Wiedemann parameters are used to calibrate simulation models, rather than detailed driving characteristics such as the desired speed. Speed was usually considered as a critical parameter, which had great effects on road safety especially in work zones. Carried out on the detailed study of vehicle speeds at work zones, Pain concluded that the value of speed depends on the traffic volume, lane closure, traffic controls, and the location of the work zone. Richards SH and Dudek CL [31] determined the necessity of slowdowns when driving past work zones, and implemented speed limit guidelines to improve traffic safety. Virginia PS and Chard WL [32] studied the effects of speed distribution, speed limit, and lane closures on vehicle speed patterns in work zones. Migletz J et al. [33] analysed the characteristics of vehicle speed and the relationship between the speed and safety level, then proposed the recommended values for speed limits and a method of implementing speed limits. In Vissim, the desired speed is an important parameter that has great effect on travelling speeds, which is defined as a distribution rather than a fixed value. Park B and Qi H [34] believed that the default desired speed distribution in Vissim may be higher than the actual distribution of the desired speed by comparing the simulation travel time and measured travel time. Zhao XF, Huang ZY and Lin HF [35] argued that the desired speed distribution is an important parameter in Vissim, and modifying the desired speed distribution would influence the difference between the simulation speed and the measured speed. Peng WX et al. [36] pointed out that the default linear distribution of desired speed in Vissim is not suitable for real traffic conditions.

In this paper, the researchers chose to calibrate the desired speed in Vissim, which is an important parameter that has a significant influence on achievable travel speeds, roadway capacity, and travel time. This article is the first to propose a new calibration method for the desired speed distribution for temporary work zones, which is referred to as the "Five-Points Method". The proposed method does not intend to replace the existing calibration methods. On the contrary, it complements the traditional calibration of micro-simulation models, such as the calibration of Wiedemann parameters. It can also provide a means to create extensive amounts of valid data that do not require field data collection. This article focuses on proposing a new method to calibrate the desired speed distribution for temporary work zones where none exist.

This article is organized as follows: the need for proposing a new method to calibrate the desired speed distribution is identified in this section. The methods for the field data collection are described in the next section. Data collection and analysis are shown in Section 3. The simulations conducted to demonstrate the feasibility of the calibration method and analysis of the results are in Section 4. A new calibration method for the desired speed distributions for temporary work zone is proposed in Section 5. Conclusions and future works are provided in the final section.

2. OBJECT OF STUDY

The temporary work zone chosen for this study is located on the XuChang-WeiShi Highway in Henan Province. The XuChang-WeiShi Highway has two through lanes in each direction with a design speed of 120 km/h. The section of the temporary work zone, between the beginning of Longitudinal Buffer Area and the end of Activity Area, is a single lane adjacent to the construction with a 60 km/h speed limit.

Table 1 – Summary of parameter calibration research literature results

Years	Scholars	Research results
1991	Benekohal RF [9]	Established a parameter calibration process framework for microscopic traffic simulation model initially.
1998	Hellinga BR [10]	Improved the parameter calibration framework based on the research of Benekohal, which has become a widely adopted parameter calibration framework.
2001	Lee DH et al. [11]	Combined with specific parameters calibration algorithm [genetic algorithm] to propose the framework of simulation model calibration.
2002	Richard D et al. [12]	Pointed out that the road network model parameters should be calibrated according to the actual intersection traffic conditions, so that the model meets the intersection traffic characteristics.
2002	Hourdakis J et al. [13]	Proposed a new model calibration theory to use different evaluation results model calibration for many times.
2004	Gomes G and May A [14]	Developed and calibrated a Vissim model for a congested freeway and investigate the relative impacts of several driver behaviour parameters.
2004	Jian S and Yang XG [15]	Used Latin square method to calibrate the parameters of the Vissim simulation.
2005	Jie S [16]	Used multiple evaluation index to quantitative calibration and combined observation simulation animation for qualitative calibration.
2006	Yang H et al. [17]	Calibrated driver behaviour parameters and gave reasonable value range of these parameters.
2006	Li ZM and Yan XY [18]	Designed a traffic simulation model parameters calibration method based on genetic algorithm, and used the calibration method for the simulation of an intersection in Shijiazhuang city.
2007	Ciuffo BF et al. [19]	Performed a sensitivity analysis first and proposed a simulation model parameters calibration process.
2007	Jian S et al. [20]	Used genetic algorithm to calibrate the parameters of driver behaviour model for East Gate area in Hefei.
2008	Chitturi MV et al. [21]	Selected default model parameters and the driver behaviour model parameters for obtaining the value of capacity and queue length, and designed a simulation model calibration method.
2008	Lee JB and Ozbay K [22]	Improved SPSA algorithms combined with flow and density used in the model calibration for highways, and used K-S test method to validate the simulation model.
2009	Li YX [23]	Used genetic algorithm and SPSA algorithm to calibrate the parameters for studying the traffic capacity of the bus lane, and the automatic calibration program was developed by using VB language and MATLAB software.
2010	Yang W [24]	Established parameters calibration method based on orthogonal test for the segments of urban expressway entrances and exits, and calibrated the parameters of car-following models and lane-changing models.
2010	Ting H [25]	Proposed a method for weaving area to calibrate multi-objective planning based on genetic algorithm, and developed an automatic calibration program by using C# language and MATLAB software.
2010	Yu Z et al. [26]	Proposed a parameter calibration method based on SPSA algorithm, and its research object was the area of Beijing West Ring ZiZhu Bridge to the space bridge.
2011	Zhang CC and Niu XQ [27]	Calibrated the parameters of intersection traffic simulation model, and recommended the values of calibrated parameters.
2012	Quan Y et al. [28]	Chose the average queue length and the traffic flow as the evaluation index, and calibrated six parameters in Vissim.
2012	Liu CC [29]	Built the highway work zone simulation model in Vissim, and used the orthogonal test to calibrate the parameters based on the measured data.
2013	Hu XH and Yu Z [30]	SPSA algorithm combined with genetic algorithms to form the SPGA algorithm for calibrating massive transportation network simulation model in Vissim.

This temporary work zone was chosen first of all for its representativeness. The highway from XuChang to WeiShi, built in 2005, is an important part of the road network in Henan Province, so premature damage has inevitably occurred on this section and the temporary work zones in this area are typical for preventive maintenance or minor repairs engineering. A secondary feature is the mix of vehicles and traffic conditions; the vehicles mainly include passenger cars and a moderate proportion of heavy goods vehicles and the traffic flow is typically free-flow. The design of the road in this section is also amenable to study, because the road is relatively straight and curves have extra-large radii (5500 m) and longitudinal grade less than 0.5%, so the operation effects of the design on driving can be ignored.

3. DATA COLLECTION AND ANALYSIS

3.1 Data collection

Field data collection was performed during two days (13~14 November, 2013). In the field, researchers noted that heavy goods vehicles (HGVs) had different characteristics compared with passenger cars (Cars), which might result in different preferences for speed. Thus, two separate databases were created, one for Cars and one for HGVs and both contain vehicle speeds and traffic volume. To minimize the impacts of other factors, field data collection was conducted only during daytime from 7:00 a.m. to 6:00 p.m. For the entirety of data collection time period, the traffic flow was free flowing and the weather was clear.

For this study, vehicle speeds were measured by hand-held radar gun (error range = ± 2 km/h) at four selected sites in the temporary work zone (*Figure 1*). A manual count method was used to collect the traffic volume from video that was recorded in the field. This allowed the videotapes to be reviewed in the laboratory – a safer environment than the roadside.

3.2 Data analysis

Various statistical methods can be used to analyse vehicle speed data. These methods are chosen based on the focus of the study, and include descriptive statistics, K-S tests, and T-tests. In this paper, the K-S test showed that speed data were consistent with a normal distribution (*Table 2*), and T-tests were performed to compare the “measured” and “simulated” speeds. And the null hypothesis H0 of T-tests was that the measured mean speeds of Cars and HGVs were equal to the simulated mean speeds of Cars and HGVs respectively, which was applicable to all the T-tests mentioned in this paper. In addition, the Pauta Criterion method was adopted to remove the effects of abnormal data which have large statistical deviation of the numerical results. And the abnormal data will lead to simulated results far from the reality. If the measured data obey normal distribution, Pauta Criterion can be expressed as:

$$P(|x-\mu| > 3\sigma \le 0.003 \qquad (1)$$

where μ is the mathematical expectation of normal distribution

σ is the variance of normal distribution

There is tiny probability that the value of the measured data is greater than $\mu+3\sigma$ or less than $\mu-3\sigma$, so these measured data should be eliminated. Therefore, out of 463 measured speed observations, 457 valid samples were obtained, of which 209 valid samples were Cars and the remaining samples were HGVs. The descriptive statistics without abnormal data are shown in *Table 3*.

Descriptive statistics showed that 74.9% of Cars were driven at speeds of 70 km/h ~ 110 km/h, while

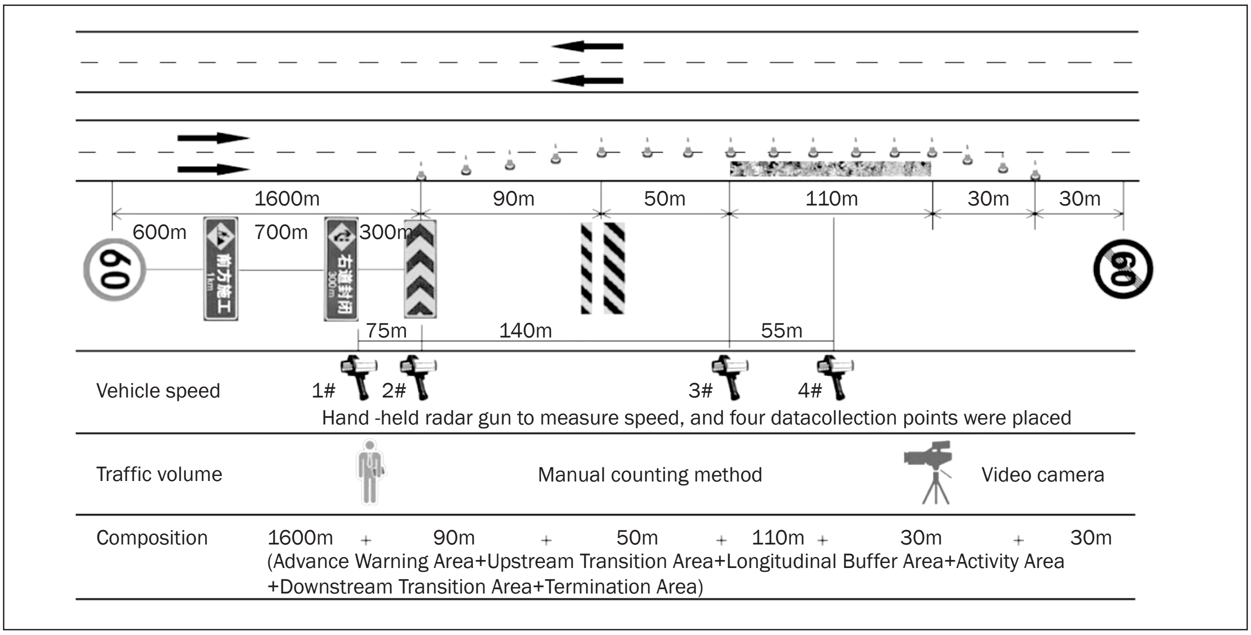


Figure 1 – The schematic diagram of the temporary work zone

Table 2 – Results of Kolmogorov-Smirnov Test

Statistical items		Measured speed of Cars	Measured speed of HGVs
Sample size		209	248
Normal parameters^{a,b}	Mean	93.9	71
	Std.Deviation	17.824	8.608
Most extreme differences	Absolute	0.071	0.063
	Positive	0.069	0.063
	Negative	-0.071	-0.057
Kolmogorov-Smirnov Z		1.037	0.998
Asymp. Sig. (2-tailed)		0.232	0.272

Note: a. Test distribution is Normal.
b: Calculated from data.

Table 3 – Descriptive statistics without abnormal data

Vehicle Types	Sample size	Mean	Minimum	Maximum	Median	Mode	Standard deviation
Cars	209	93.9	43	141	97	101	17.824
HGVs	248	71.0	45	107	71	72	8.608

63.5% of HGVs were driven at speeds of 65 km/h ~ 80 km/h during active temporary work zones. The compliance rate with the construction speed limit was 2.37% for Cars and 9.52% for HGVs. The average speed of Cars was 93.9 km/h, which was 33.9 km/h higher than the speed limit of 60 km/h. Similarly, the average speed of HGVs was 71.0 km/h, 21 km/h higher than the speed limit. Both the average speeds of Cars and HGVs were lower during construction than 106.2 km/h and 78.6 km/h, respectively, which were measured when the temporary work zone was not in effect. The lack of other speed controlling factors on the sight enabled a good representation of the desired speeds in the work zone. At this location, the only method of speed control was a speed limit sign indicating 60 km/h. Therefore, speeds measured both with and without the temporary work zone in place were higher than the speed limit. However, the average speed in the work zone was significantly less than without work zone indicating that the work zone interfered with the normal traffic flow. Given the lack of existing calibration research on the speed distributions for temporary work zones, the researchers used these data to propose a new method to calibrate the desired speed distribution for temporary work zones in Vissim.

3.2.1 The travelling speed cumulative frequency curve

The travelling speed cumulative frequency curve was found to be a good fit for the desired speed distribution. Based on the statistics of valid field data, the travelling speed cumulative frequency curves of Cars and HGVs were plotted in *Figure 2*, respectively.

As *Figure 2*a shows, the curve for Cars became gradually steeper at eight percentile and flattened out around 83 percentile. *Figure 2*b shows that the curve for HGVs became gradually steeper from the 20 percentile and flatter after 84 percentile. Taking into account the different types of vehicles, the 15th percentile (V15) and 85th percentile (V85) values of the travel speed cumulative frequency curve can be considered as two critical control points. The shape of curves was also similar to the typical “S” curve. Curves were relatively flat below V15 and above V85, while relatively steep between V15 and V85. In addition, the V15 of Cars and HGVs was 71.0 km/h and 60.5 km/h, respectively, while the corresponding V85 was 106.2 km/h and 77.0 km/h, respectively.

3.2.2 The desired speed distribution

The desired speed distribution was composed of the speed intervals and the cumulative frequency of each interval. In this study, the travelling speed cumulative frequency curves were considered to be the desired speed distribution. As noted previously, V15 and V85 were of great importance for the travelling speed cumulative frequency curve, so V15 and V85 can be defined as the minimum and maximum of the desired speed distribution. In order to make the simulation results as realistic as possible, other control points were determined by equisection method (*Table 4*). The travel speeds taken from *Figure 2* were assumed to be the desired speeds correspondingly (*Table 4*).

4. SIMULATION AND ANALYSIS

4.1 Simulation environment

According to the field conditions, the road networks were created in Vissim. The highway had two lanes in each direction with one lane under an active work

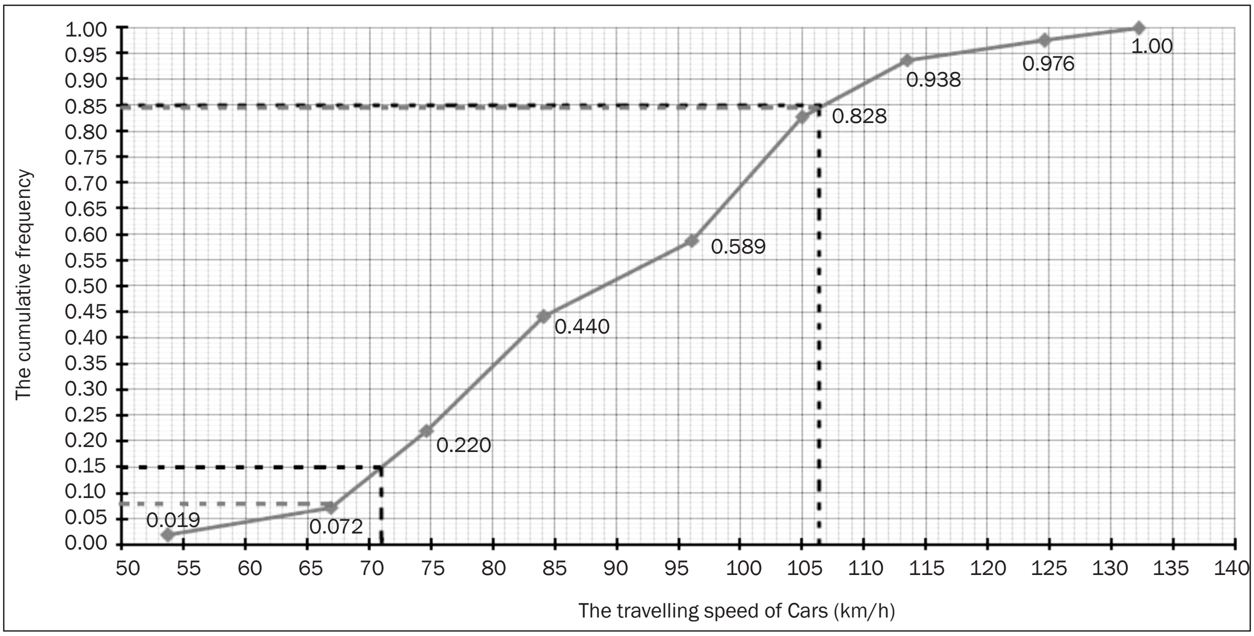


Figure 2a – The travelling speed cumulative frequency curves for Cars

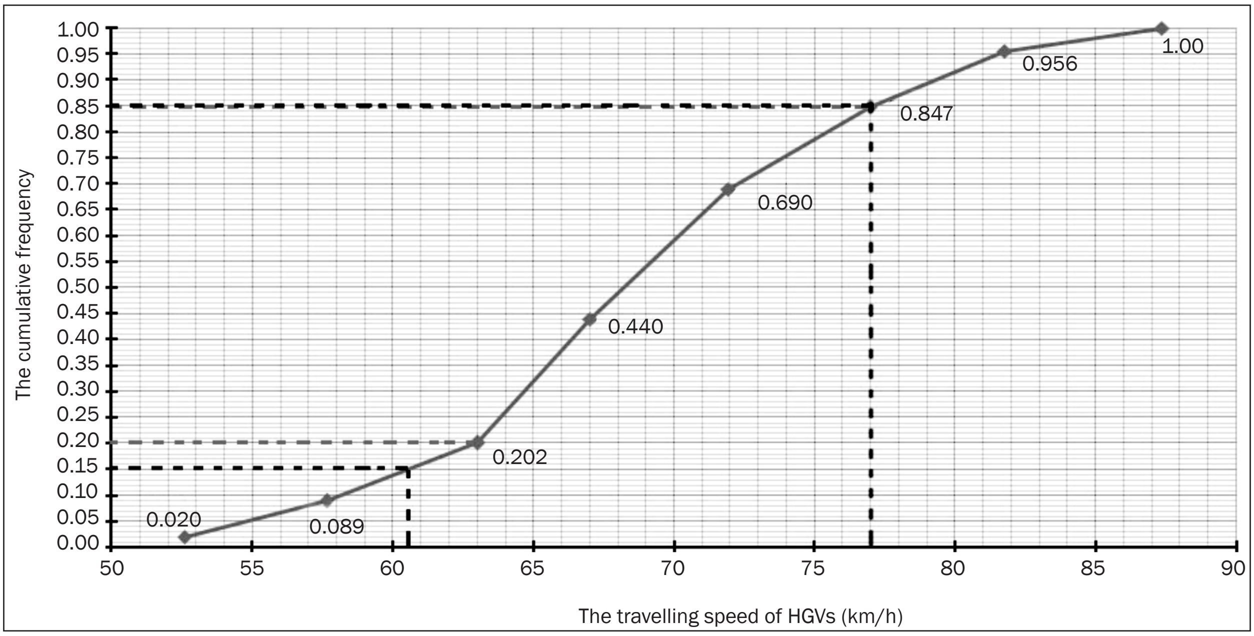


Figure 2b – The travelling speed cumulative frequency curves for HGVs

Table 4 – The desired speeds

Desired speed cumulative frequency	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Desired speeds of Cars (km/h)	71.0	74.8	77.3	81.0	83.3	89.0	94.8	97.0	100.2	103.1	106.2
The desired speeds of HGVs (km/h)	60.5	63.2	64.5	65.5	66.7	68.2	69.5	71.0	72.4	74.8	77.0

zone. The lanes were 3.5 meters wide each. Other parameters required data from the field to maintain consistency with actual traffic conditions including traffic volume, vehicle type, traffic composition and the desired speed distributions which were initially calibrated in *Figure 3*. The researchers found that the implementation of this work zone and the resulting lane reduction lead to the formation of conflict areas. With proper settings for driving rules, the traffic operations would remain smooth. In the final model, four data collection points were set at the same locations as the field, and the output was equal to the field measured mean speed.

4.2 Initial calibration of desired speed distribution

Based on the data in *Table 2*, the desired speed distributions were calibrated by setting the critical control points for the curves (*Figure 3*).

4.3 Simulation results and analysis

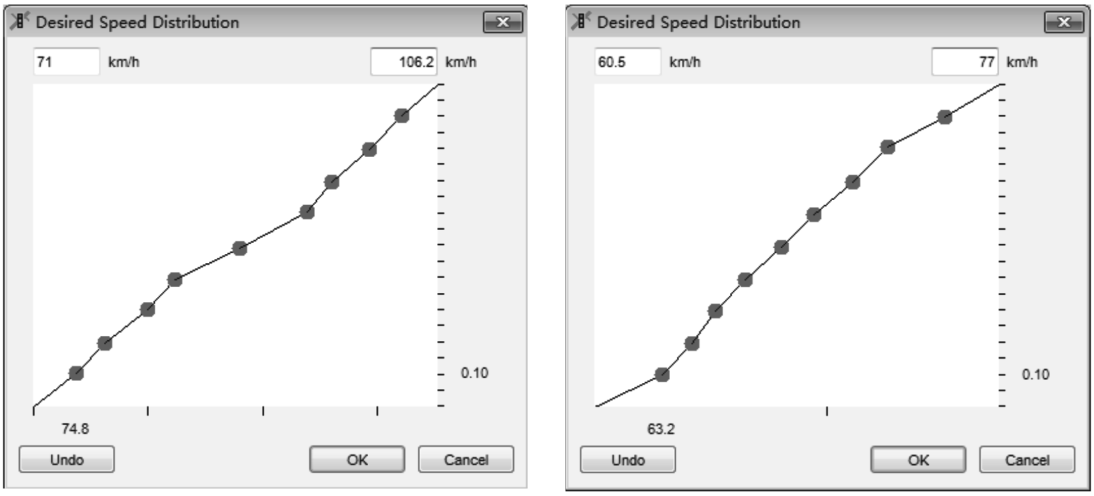
Four groups of data collected from the field were used in the simulation. What needs to be explained is that an equivalent hourly traffic volume in passenger cars was calculated for the site using the HGV adjustment factors of 1.5, and the conversion has been done shown in *Table 5*. As *Table 5* shows, the simulated speeds were significantly lower than the measured speeds in all groups, and the mean relative errors for Cars and HGVs were 16.49% and 8.88%, respectively. T-tests showed that p-values of Cars and HGVs were 0.000 and 0.003, respectively, less than 0.05. This indicated that there were significant differences between the measured mean speeds and the corresponding simulated speeds. Therefore, the initial calibrations of the desired speed distributions were not reliable, and the adjustments were revised.

4.4 Further calibration and analysis

To obtain more promising simulation results, factor k for the numerical relationship between the travel speed and the desired speed should be proposed. According to the mean ratio of the measured and simulated speeds (*Table 6*), the adjustment can be expressed as:

$$V_D = kV_T \tag{2}$$

where: V_D is the desired speed; V_T is the travelling speed; and k is 1.200 for Cars and 1.098 for HGVs. The adjustment value, k, would be used to re-calibrate the desired speed distribution for determining new values (*Table 7*).



(a) Cars

(b) HGVs

Figure 3 – The calibrated desired speed distribution

Table 5 – Summary of traffic parameters and the speeds

Groups	Traffic volume (pcu/h)	Traffic composition (Cars : HGVs)	Measured mean speed of Cars (km/h)	Simulated speed of Cars (km/h)	Relative error for Cars	Measured mean speed of HGV (km/h)	Simulated speed of HGV (km/h)	Relative error for HGVs
1	441	91 : 207	93.8	80.1	14.61%	71.2	64.5	9.41%
2	558	62 : 136	100.4	78.0	22.31%	72.5	64.5	11.03%
3	392	91 : 177	94.3	79.5	15.69%	69.5	64.4	7.34%
4	435	77 : 276	91.5	79.3	13.33%	69.9	64.5	7.73%

Table 6 – Analysis of the measured and simulated speeds

Vehicle Types	Groups	Measured mean speed (km/h)	Simulated speed (km/h)	Differences of the measured and simulated speed (km/h)	Ratio of the measured and simulated speed
Cars	1	93.8	80.1	13.7	1.171
	2	100.4	78.0	22.4	1.287
	3	94.3	79.5	14.8	1.186
	4	91.5	79.3	12.2	1.154
	Mean				1.200
HGVs	1	71.2	64.5	6.7	1.104
	2	72.5	64.5	8.0	1.124
	3	69.5	64.4	5.1	1.079
	4	69.9	64.5	5.4	1.084
	Mean				1.098

Table 7 – New desired speeds with factor k

Desired speed cumulative frequency	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Desired speeds of Cars (km/h)	85.2	89.8	92.8	97.2	100.0	106.8	113.8	116.4	120.2	123.7	127.4
Desired speeds of HGVs (km/h)	66.4	69.4	70.8	71.9	73.2	74.9	76.3	78.0	79.5	82.1	84.5

Table 8 shows that the adjusted simulated speeds were close to the corresponding measured mean speeds. The mean relative errors for Cars and HGVs were 3.59% and 2.24%, respectively.

In *Table 9*, the p-value of Levene's Test for Equality of Variances was 0.091, higher than 0.05, so the variances for mean speeds of Cars between the measured and the simulated were equal. And T-tests showed the p-values of Cars and HGVs were 0.125, higher than 0.05. In *Table 10*, the p-value of Levene's Test for Equality of Variances was 0.013, less than 0.05, so the variances for mean speeds of HGVs between the measured and the simulated were not equal, and T-tests showed the p-values of HGVs were 0.100, higher than 0.05. Thus, the addition of the adjustment factor for the second round of calibrations for the desired speed distributions was valid and the results of simulation were representative of the actual field conditions.

5. A NEW CALIBRATION METHOD FOR DESIRED SPEED DISTRIBUTION

5.1 Five-Point Method

Considering that the previous calibration method called Ten-Point Method is complicated and time-consuming, the "Five-Point Method" was proposed. Whether Cars or HGVs, the desired speed differences of adjacent control points were approximate within the

Table 8 – Comparison of simulated results with factor k

Vehicle types	Groups	Measured mean speeds (km/h)	Previously simulated speeds (km/h)	Simulated speed with factor k (km/h)	Relative error of measured mean speeds and new simulated speeds
Cars	1	93.8	80.1	92.3	1.60%
	2	100.4	78.0	91.0	9.36%
	3	94.3	79.5	91.3	3.18%
	4	91.5	79.3	91.7	0.22%
HGVs	1	71.2	64.5	69.2	2.81%
	2	72.5	64.5	69.2	4.55%
	3	69.5	64.4	69.1	0.58%
	4	69.9	64.5	69.2	1.00%

cumulative frequency range of 10% ~ 40% and 60% ~ 90% respectively (*Table 7*), so were the slopes. Therefore, five critical control points were reserved to propose the "Five-Point Method" (*Table 11*).

5.2 Comparison and validation

Figure 4 shows the comparison of different desired speed distributions, including the former calibrated by the Ten-Point Method (a, b) and the latter calibrated by the Five-Point Method (c, d). The distributions calibrated by the Five-Point Method had approximate shapes with the previous method. A comparison among the field-measured and various simulated speeds are shown in *Figure 5*. The "Default (without speed limit)" represents the speeds simulated by adopting the default desired speed distributions without speed limit, the "Default (with speed limit)" represents the adoption of the default desired speed distributions with a speed limit enforced; the "Ten-Point Method" and "Five-Point Method" were the speeds simulated by adopting the desired speed distributions with different calibration methods.

Figure 5 shows the simulated speeds of "Default (without speed limit)" were much higher than the measured speeds overall except for the speed of Cars in Group 4. This difference is caused by the lack of consideration of the effects of the temporary work zone settings in the simulation. The simulated speeds of "Default [with speed limit]"were significantly lower than the measured and simulated speeds, because the compliance rate settings for speed limits in Vissim are not flexible enough to adapt to the temporary work zone, so the simulated vehicles would drive

Table 9 – Results of T-tests for Cars

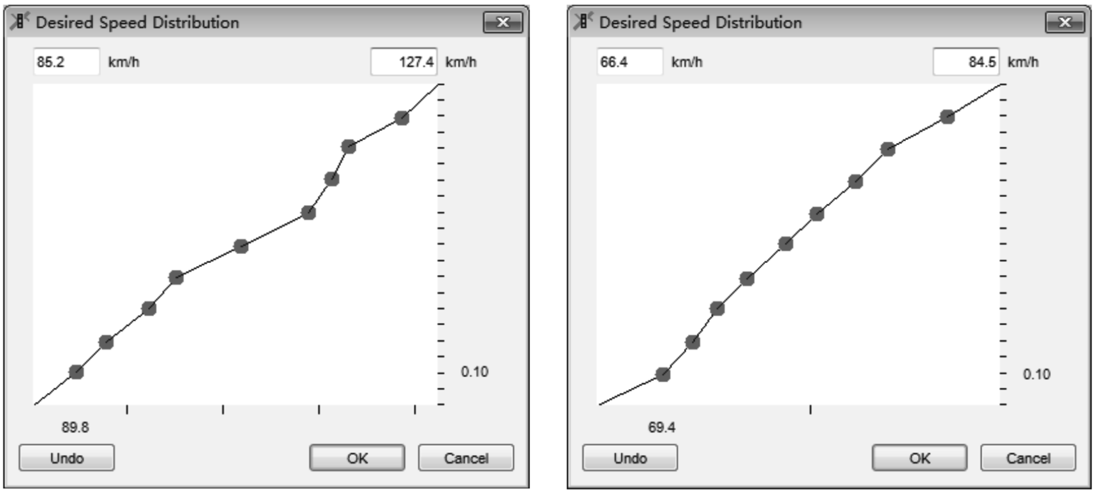
		Levene's Test for Equality of Variances		T-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. Error difference	95% Confidence interval of the difference	
									Lower	Upper
The mean speeds of Cars	Equal variances assumed	4.055	0.091	1.02	6	0.125	3.425	1.94	-2.76	6.71
	Equal variances not assumed			1.02	3.204	0.164	3.425	1.94	-3.97	7.92

Table 10 – Results of T-tests for HGVs

		Levene's Test for Equality of Variances		T-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. Error difference	95% Confidence interval of the difference	
									Lower	Upper
The mean speeds of HGVs	Equal variances assumed	12.33	0.013	1.575	6	0.054	1.600	0.682	-0.5947	2.74
	Equal variances not assumed			1.575	3.043	0.100	1.600	0.682	-1.0792	3.23

Table 11 – Recommended values of the "Five-Point Method"

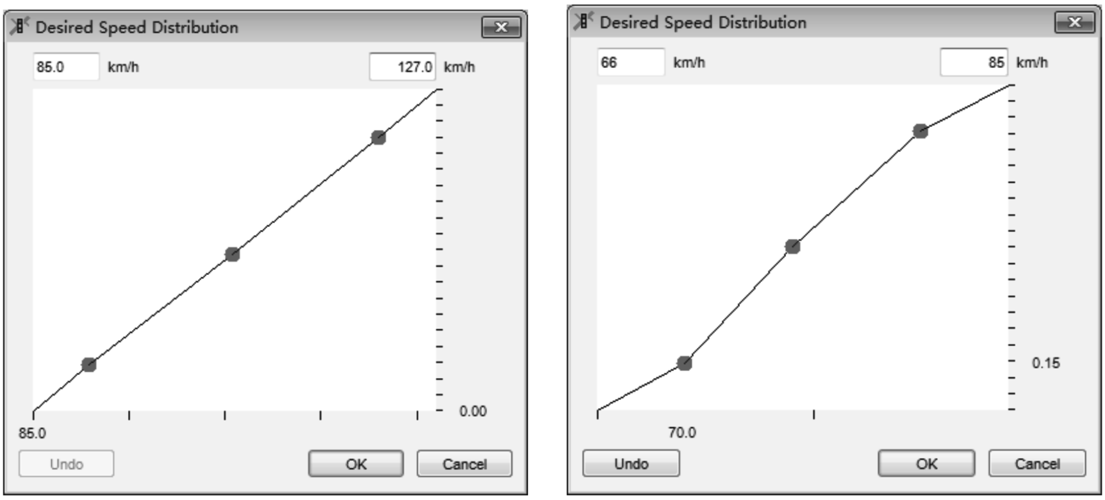
Cumulative frequency of desired speed distribution	0%	15%	50%	85%	100%
Desired speed of Cars(km/h)	85	91	106	121	127
Desired speed of HGVs (km/h)	66	70	75	81	85


Desired Speed Distribution
85.2 km/h 127.4 km/h

Desired Speed Distribution
66.4 km/h 84.5 km/h

(a) Ten-Point method (Cars)

(b) Ten-Point method (HGVs)


Desired Speed Distribution
85.0 km/h 127.0 km/h

Desired Speed Distribution
66 km/h 85 km/h

(a) Five-Point method (Cars)

(b) Five-Point method (HGVs)

Figure 4 – Comparison of the desired speed distributions calibrated by two methods

consistently around 60 km/h. Comparing the speeds in reality and in the simulation with the default speed distribution, the importance of calibrating the desired speed distribution was very evident.

After analysing the results of two calibration methods, both were relatively close to the reality. The Ten-Point Method was validated previously. In reference to the Five-Point Method, T-tests showed that p-values were 0.111 for Cars and 3.324 for HGVs. Thus, we had reason to believe that the simulated speeds were very close to the real speeds. The mean relative error for Cars in the "Default without speed limit" was 5.19% and 22.19% for HGVs – significantly higher than either the Ten-Point or Five-Point relative error measures. The mean relative error of the Ten-Point Method was 3.59 % for Cars, and 2.24 % for HGVs. This can be compared to relative error from the Five-Point Method which was 3.64% for Cars and 1.43% for HGVs. Thus, the desired speed distributions calibrated using the Five-Point Method were also effective, and the convenience was greater than using the Ten-Point Method. Therefore, the Five-Point Method was suitable for calibrating the traffic simulation model in highway temporary work zones.

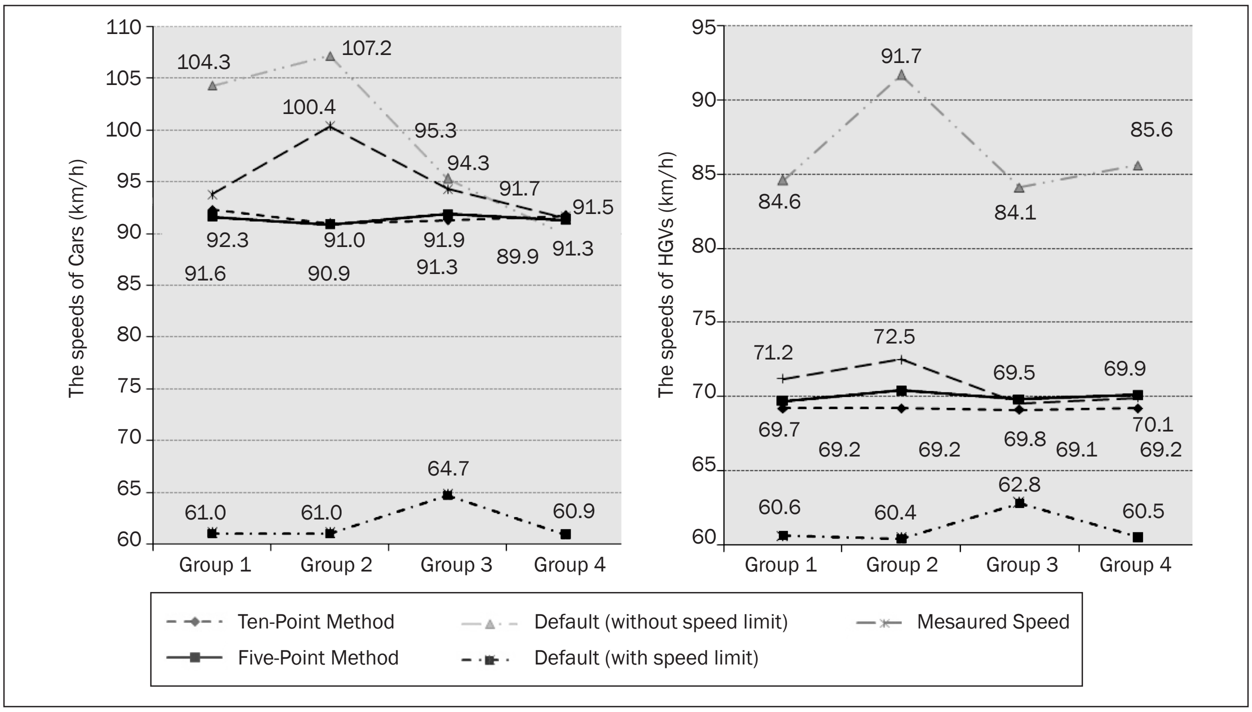


Figure 5 – Comparison among the measured and different simulated speeds

6. CONCLUSIONS AND FUTURE WORK

Parameter calibration is essential for microscopic traffic simulation models. However, the existing studies of parameter calibration are limited to driver behaviour parameters and car-following parameters, and do not address the calibration methods to focus on the desired speed distribution for temporary work zones. The vehicle speed played a vital role in the studies, especially in work zones with respect to road safety, and the desired speed is an important parameter in Vissim that has a significant influence on the achievable travel speeds, roadway capacity, travel time, etc. Thus, it would be valuable for micro-simulation if the desired speed distribution could be calibrated simply and usefully. This study is motivated by the need to complement the traditional calibration of micro-simulation models. This paper is the first to propose a new calibration method for the desired speed distribution for temporary work zones, called the "Five-Point Method". The calibration method was proposed in five steps: (1) data collection and analysis, (2) plotting of the travelling speed cumulative frequency curves and calibration of the desired speed distribution, (3) simulation runs and validation of the simulation results, and (4) proposal of a new calibration method. The simulations of four sets of field data were performed; the results show that the calibration method is promising, when adopting factor k between the desired speed and the travelling speed. The proposed k for Cars and HGVs are 1.200 and 1.098, respectively. The results of simulations which adopted the Ten-Point Method to calibrate the desired speed distribution shows that the average relative errors between the measured speed and the simulation speed are 2.76% for Cars, and 1.56% for HGVs. Considering that the previous method of calibration is complicated and time-consuming, a simplified calibration method, the "Five-Point Method", is provided with the recommended values for each control point. Compared to 5.19% of Cars and 22.19% of HGVs in the simulation adopted the default desired speed distribution without calibration, the average relative error came down to 3.64% of Cars, and 1.43% of HGVs by using the Five-Point Method to calibrate the desired speed distribution. Therefore, the desired speed distributions calibrated using the Five-Point Method were kept as simple as possible, while still retaining the realistic distributions at 95% confidence level.

To arrive at a more realistic representation of the drivers' behaviour, calibrating a single parameter may not provide a global optimal solution. More research is needed for combining the calibrated desired speed distribution with the calibration of the driver behaviour parameters. Recommendations for future research include revising the "Five-Point Method" under different traffic conditions such as congested highways.

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一种用于临时养护区微观仿真模型中期望速度的标定新方法

摘要

目前针对长期养护区参数标定的研究仅局限于驾驶员行为参数和跟车行为参数，而对于临时养护区中期望速度分布的标定研究还存在着空白。通过临时养护区的仿真实验难以获得真实有效的数据，而如果能够有一种应用于高速公路临时养护区交通仿真模型中期望速度分布的标定方法，则能够获得更加真实的仿真数据。该标定方法分为五个步骤：（1）采集与分析数据；（2）绘制行驶速度累计频率曲线图并标定期望速度分布；（3）进行仿真实验；（4）验证仿真结果；（5）提出一种新的标定方法。该方法经过T检验后发现其结果十分理想。最后，提出了一种名为简化后的标定方法，称为“五点法”，并给出了五点法中取值的建议值。

关键词

交通仿真；参数标定；期望速度分布；临时养护区；Vissim

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