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Research of development goals on highway transportation safety in inner mongolia for building a moderately prosperous society

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Abstract. Development goals of highway transportation safety in Inner Mongolia for building a moderately prosperous society were researched to support the building of a moderately prosperous society in all respects of China in 2020. Firstly, two evaluation indicators, number of accidents and mortality in accidents per 100 million vehicle kilometers, were selected to evaluate safety of highway transportation. Relevant data from 2008 to 2015 related to the two evaluation indicators was used to forecast their values from 2016 to 2020 based on BP neural network. Results show that average decline rate per year from 2011 to 2020 of the two evaluation indicators is 3.5% which was calculated by using available actual values and forecasted values. At last, decline rate of number of accidents and mortality in accidents per 100 million vehicle kilometers was set to 40% in 2020 (compared with 2011) based on qualitative analyses of some work and policies of highway transportation safety implemented in Inner Mongolia for building a moderately prosperous society.

Key words. transportation engineering, development goals in a moderately prosperous society, BP neural network, number of accidents per 100 million vehicle kilometers, mortality in accidents per 100 million vehicle kilometers.

1. Introduction

Report of the Eighteenth National Congress of the Communist Party of China pointed out that China will complete the building of a moderately prosperous society in all respects in 2020 and transportation industry, as basic and leading industry and service industry of national economy and development of society, plays a significant supporting role. A safe, convenient, efficient, intelligent and sustainable transportation system is one of the requirements of a moderately prosperous society.

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Transportation safety, as the primary requirement of transportation, is a problem to be solved urgently in the process of building a moderately prosperous society.

At the same time, a moderately prosperous society in all respects should be a safe and stable society in which everybody lives and works in peace and contentment. A moderately prosperous society has many components and essential requirements, such as transportation safety, social stability, public place safety, public health, production safety, foodstuff safety, disaster prevention and reduction, population safety, environment safety and energy sources security.

In this context, it is benefit for transportation to support the building of a moderately prosperous society and safety and stability of a moderately prosperous society to study indicators of transportation safety and its development goals. In this paper, safety indicators and development goals of highway transportation in Inner Mongolia for building a moderately prosperous society were studied and availability of accident data of highway transportation was taken into account.

There are many researches about evaluation indicators of transportation safety and forecast of accident rate, however, there are few researches about transportation safety that is serving a moderately prosperous society. Xiang Aibing [1] set up an evaluation indicators system of Chinese transportation system under on the goal of building a moderately prosperous society in all aspects and forecasted the goals of transportation industry from six aspects, such as scale of transportation infrastructure network, ability of transportation industry supporting economy, service quality of transportation and etc. Luo Yun [2] put forward a concept of safe moderately prosperous society, and its development goal and principle and set up an safety indicators system from twelve aspects, such as transportation safety, production safety, foodstuff safety and etc for city of a moderately prosperous society with combining the need of administrative departments of Chinese government. The authors of this paper were entrusted by Department of Transportation of Inner Mongolia to do a project of development goals and indicators system of transportation for Inner Mongolia building a moderately prosperous society in all respects. This paper used the collected data and provided perspective in this project.

Table 1. The structural characteristics under different working conditions

Year	Number of accidents per 100 million vehicle kilometers	Mortality in accidents per 100 million vehicle kilometers
2008	4.696	6.493
2009	3.130	5.227
2010	5.099	8.988
2011	8.359	17.205
2012	7.495	11.907
2013	3.295	5.973
2014	3.578	5.568
2015	2.952	2.363

2. Evaluation indicators of highway transportation safety of Inner Mongolia

Road accident rate is a basic indicator of evaluating transportation safety, it refers to a relative relationship between accidents number, casualties number and population, number of registered motor vehicles, vehicle miles traveled during a certain period of time, in a country, a region or a specific location of road accidents. Road accident rate has several type, such as accident rate per 100 million vehicle kilometers, accident rate per one million vehicles, accident rate of population, comprehensive accident rate and etc [3, 4, 5]. Accident rate per 100 million vehicle kilometers reflects the relationship between vehicle number and vehicle kilometers. Two indicators, number of accidents and mortality in accidents per 100 million vehicle kilometers, were selected in this paper to evaluate the safety of highway transportation of Inner Mongolia.

Number of accidents per 100 million vehicle kilometers [6] is determined as follows:

$$R_{V1} = \frac{D_1}{V} \times 10^8 \,, \tag{1}$$

where R_{V1} is number of accidents per 100 million vehicle kilometers of Inner Mongolia;

D_1 is number of highway accidents in Inner Mongolia;

V is total vehicle kilometers of Inner Mongolia in a year.

Mortality in accidents per 100 million vehicle kilometers [6] is determined as follows:

$$R_{V2} = \frac{D_2}{V} \times 10^8 \,, \tag{2}$$

where R_{V2} is mortality in accidents per 100 million vehicle kilometers of Inner Mongolia;

D_2 is mortality in highway accidents in Inner Mongolia;

V is total vehicle kilometers of Inner Mongolia in a year.

Relevant data related to number of accidents and mortality in accidents per 100 million vehicle kilometers was collected from statistical yearbook of Inner Mongolia and Bureau of Safety Supervision of Department of Transportation of Inner Mongolia. Annual vehicle kilometers can be calculated by using data of ton-kilometer of freight, freight volume, number of trucks, person-kilometer of passenger, passenger volume and number of passenger vehicles which were collected from statistical yearbook of Inner Mongolia. Annual number of accidents and mortality in accidents were collected from Bureau of Safety Supervision of Department of Transportation of Inner Mongolia. Annual number of accidents and mortality in accidents per 100 million vehicle kilometers can be calculated based on formula (1) and (2) using vehicle kilometers, number of accidents and mortality in accidents. Table 1 shows the data of number of accidents and mortality in accidents per 100 million vehicle kilometers in Inner Mongolia from 2008 to 2015.

3. Forecast of indicators of transportation safety based on BP neural network

3.1. Forecast model of indicators of transportation safety

Artificial neural network is a mathematical model to process information using structure that is similar to synaptic connection in brain nerve. The back-propagation(BP) neural network is a typical method of multilayer feed-forward artificial neural networks, it is widely used in transportation field for its strong ability of nonlinear forecast. In this paper, number of accidents and mortality in accidents per 100 million vehicle kilometers are forecasted based on BP neural network. BP neural network is a kind of neural network with supervised learning, it has an input layer, an output layer and several hidden layers, data of input layer is mapped to hidden layer through matrix between layers, and signal of hidden layer is mapped to output layer. Then, the obtained signal in output layer is compared with the goal set in advance, if the actual error is larger than the expected error, error signal will be back propagated and weights in network will be adjusted, this process is repetitively implemented several times until output error from the network is smaller than the goal set in advance [7, 8, 9].

Forecast was conducted using data of number of accidents and mortality in accidents per 100 million vehicle kilometers in Inner Mongolia from 2008 to 2015. Data of the first 3 years was learning sample, data in fourth year was expectation of sample. For example, data from 2008 to 2010 was learning sample, data of 2011 was expectation of sample and 5 groups learning sample and expectation of sample can be obtained. A BP neural network with three layers that are an input layer, an output layer and a hidden layer was built. Although the more nodes a hidden layer has the more better the fitting effort will be, generalization ability of the model will weaken, conversely, if there are fewer nodes in a hidden layer, the fitting effort will not be so good and the forecast accuracy will decrease. After many tests, it was found that when the number of hidden layer is three, there is a good forecast accuracy. So, the number of hidden layer was set to three in this paper. In the built BP neural network, transfer function from input layer to hidden layer was sigmoid function, and transfer function from hidden layer to output layer was liner function.

3.2. Forecast result of indicators of transportation safety

Number of accidents per 100 million vehicle kilometers can be forecasted using the built model of BP neural network, the forecast results are showed in figure 1 and table 2. Average forecast error is 10.823% which was calculated using the forecast value and actual value of number of accidents per 100 million vehicle kilometers from 2011 to 2015. The forecast error is acceptable which shows the built model of BP neural network can be used for the forecast of number of accidents per 100 million vehicle kilometers. Number of accidents per 100 million vehicle kilometers from 2016 to 2020 was also forecasted and its value is 5.820 in 2020. Average decline rate per year of the indicator from 2011 to 2020 can be calculated using the indicator of 2011

and 2020, and table 2 shows the calculation method. The result shows that average decline rate of the indicator from 2011 to 2020 is 3.4%.

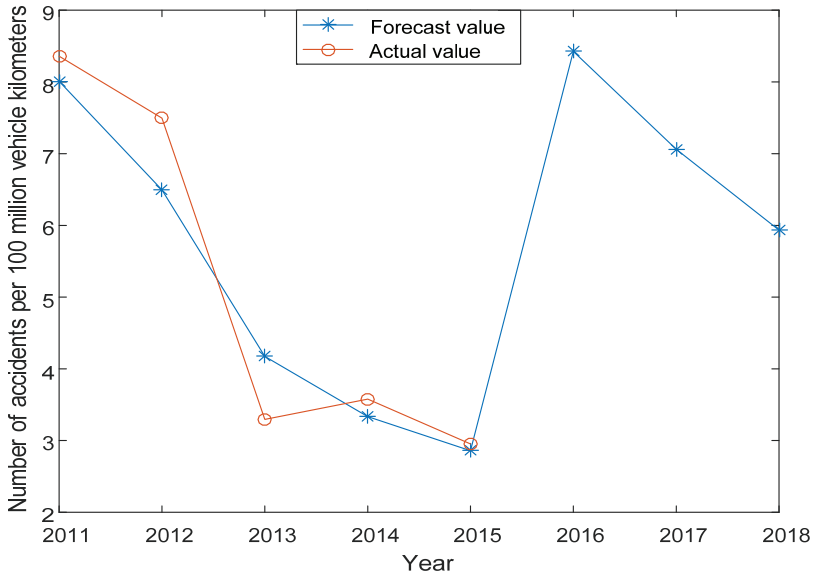

Fig. 1. Forecast values of number of accidents per 100 million vehicle kilometers in Inner Mongolia

Table 2. Forecast values of number of accidents per 100 million vehicle kilometers and its decline rate per year in Inner Mongolia

Year	Number of accidents per 100 million vehicle kilometers	Number of accidents per 100 million vehicle kilometers	Error rate (%)	Average error rate (%)
2011	8.009	8.359	4.183	10.823
2012	6.495	7.495	13.344	
2013	4.173	3.295	26.639	
2014	3.334	3.578	6.810	
2015	2.859	2.952	3.134	
2016	8.425	The method of calculating average decline rate per year: indicator of 2011 × (1 - average decline rate per year)^9 = indicator of 2020. Average decline rate per year of number of accidents per 100 million vehicle kilometers from 2011 to 2020 is 3.4% calculated with this method.		
2017	7.061			
2018	5.933			
2019	4.502			
2020	5.820			

Mortality in accidents per 100 million vehicle kilometers can be forecasted using the built model of BP neural network, the forecast results are showed in figure 2 and table 3. Average forecast error is 7.468% which was calculated using the forecast value and actual value of mortality in accidents per 100 million vehicle kilometers from 2011 to 2015. The forecast error is acceptable which shows the built model

of BP neural network can be used for the forecast of mortality in accidents per 100 million vehicle kilometers. Mortality in accidents per 100 million vehicle kilometers from 2016 to 2020 is also forecasted and its value is 5.820 in 2020. Average decline rate per year of the indicator from 2011 to 2020 can be calculated using the indicator of 2011 and 2020, and table 3 shows the calculation method. The result shows that average decline rate of the indicator from 2011 to 2020 is 3.5%.

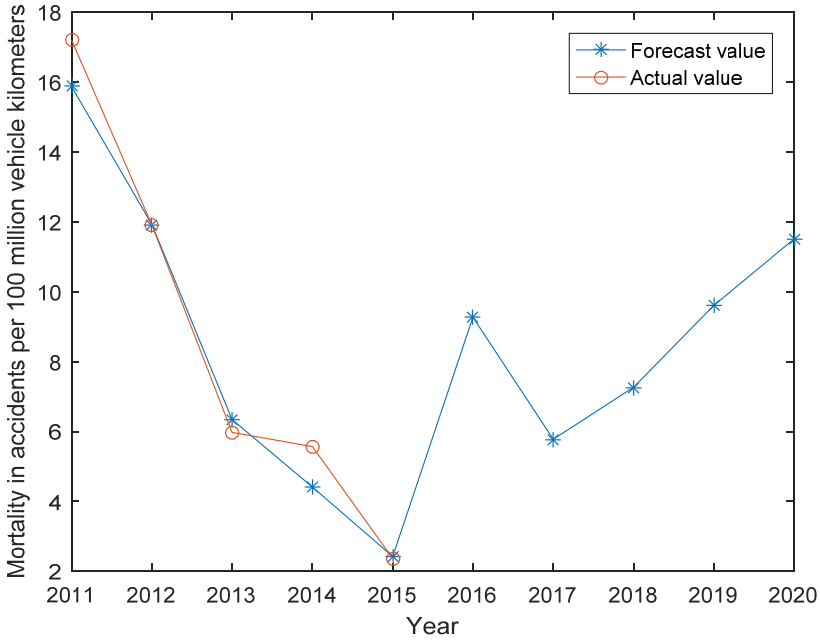

Fig. 2. Forecast values of mortality in accidents per 100 million vehicle kilometers in Inner Mongolia

Table 3. Forecast values of mortality in accidents per 100 million vehicle kilometers and its decline rate per year in Inner Mongolia

Year	Mortality in accidents per 100 million vehicle kilometers	Mortality in accidents per 100 million vehicle kilometers	Error rate (%)	Average error rate (%)
2011	15.874	17.205	7.736	7.46
2012	11.923	11.907	0.134	
2013	6.341	5.973	6.161	
2014	4.414	5.568	20.726	
2015	2.424	2.363	2.581	
2016	9.272	The method of calculating average decline rate per year: indicator of 2011 × (1 - average decline rate per year)^9 = indicator of 2020. Average decline rate per year of mortality in accidents per 100 million vehicle kilometers from 2011 to 2020 is 3.5% calculated with this method.		
2017	5.780			
2018	7.265			
2019	9.606			
2020	11.510			

4. Development goals of transportation safety of a moderately prosperous society

Much significance has been attached to transportation safety management in Inner Mongolia Autonomous Region during implementing of the Twelfth Five-Year Plan. Safety management of transportation enterprises has been implemented, supervision system of production safety has been improved, safety management of transportation practitioners has been strengthen and safety management of transportation has been strengthen. Governments and enterprises have further strengthen safety management of transportation since the major traffic accident occurred on 26, August, 2012. Department of Transportation of Inner Mongolia carried out a activity named safe transportation in the whole Inner Mongolia Autonomous Region in 2013 and promoted the condition of transportation safety to get better. At the same time, Department of Transportation of Inner Mongolia conducted standardized evaluations of production safety of transportation enterprises and advertised to transportation enterprises and specified the evaluation indicators issued by Ministry of Transport of the People's Republic of China with taking actual conditions of Inner Mongolia into consideration in 2013. All of those were aimed at improving transportation safety of Inner Mongolia.

Inner Mongolia Autonomous Region will further strengthen the supervision system of transportation safety during implementing of The Thirteenth Five-Year Plan, perfect the emergency guarantee system, strengthen the emergency response ability of highway transportation to deal with natural disasters and emergencies. Many policies, such as strengthening safety construction, ensuring the safe operation of traffic facilities, strengthening the construction of supervision system, strengthening the management of transportation safety production, strengthening the construction of emergency guarantee ability and improving the ability of treating emergency in all respects were formulated in the Development Plan of Highway and Waterway Transportation during Implementing of the Thirteenth Five-Year Plan of Inner Mongolia Autonomous Region.

In part two, average decline rate per year from 2011 to 2020 of number of accidents and mortality in accidents per 100 million vehicle kilometers is 3.5%. In order to realize the grand goals of building a moderately prosperous society in all respects, Inner Mongolia carried out a activity named safe transportation during implementing of the Twelfth Five-Year Plan and conducted standardized evaluations of production safety of transportation enterprises which laid a good foundation for improving transportation safety. The Thirteenth Five-Year Plan formulated scientific, comprehensive and effective safety construction, supervision and guarantee policies based on the Twelfth Five-Year Plan, and the level of transportation safety during implementing of the Twelfth Five-Year Plan should be higher than it of forecast with the support of those policies. Average decline rate per year of number of accidents and mortality in accidents per 100 million vehicle kilometers from 2011 to 2020 was set to 4% after discussing with experts of Ministry of Transport of the People's Republic and Department of Transportation of Inner Mongolia and it means that in order to ensure the implementing of building a moderately prosperous society in

all respects, decline rate of number of accidents and mortality in accidents per 100 million vehicle kilometers of Inner Mongolia was set to 40% in 2020 (compared with 2011).

5. Conclusion

Report of the Eighteenth National Congress of the Communist Party of China pointed out that China will complete the building of a moderately prosperous society in all respects in 2020 and transportation industry plays a significant supporting role. Transportation safety, as the primary requirement of transportation, has great significance for building a moderately prosperous society. Development goals of highway transportation safety in Inner Mongolia for building a moderately prosperous society were researched in this paper with the support of the project of development goals and indicators system of transportation for Inner Mongolia building a moderately prosperous society in all respects.

Firstly, two evaluation indicators, number of accidents and mortality in accidents per 100 million vehicle kilometers were selected to evaluate safety of highway transportation. Relevant data from 2008 to 2015 related to the two evaluation indicators was used to forecast their values from 2016 to 2020 based on BP neural network. Results show that average decline rate per year from 2011 to 2020 of the two evaluation indicators is about 3.5%. In order to ensure the implementing of building a moderately prosperous society, Inner Mongolia has carried out a lot of construction work of transportation safety during implementing of the Twelfth Five-Year Plan and also formulated many good policies for improving transportation safety in the Thirteenth Five-Year Plan, qualitatively, the level of transportation safety during implementing of the Thirteenth Five-Year Plan should be higher than it of forecast. Average decline rate per year of number of accidents and mortality in accidents per 100 million vehicle kilometers from 2011 to 2020 was set to 4% after discussing with experts and decline rate of the two indicators was set to 40% in 2020 (compared with 2011).

Study results of this paper quantitatively point out the work direction of transportation safety of the Thirteenth Five-Year Plan of Inner Mongolia which is benefit for quantitative evaluating of transportation safety work at the end of the Thirteenth Five-Year Plan and also is benefit for China and Inner Mongol complete the building of a moderately prosperous society in all respects.

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