Countermeasure Research and Application of Beijing-Taipei Expressway Based on Variable Message Signs

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Abstract Variable Message Signs (VMS) is one of the important components of Advanced Traveler Information Systems, which provides drivers with dynamic traffic guidance Information of the road ahead. Drivers are guided to choose the best travel route, to avoid the congested sections and optimize the operation of the road network, to realize the reasonable distribution of traffic flow in the road network. Based on the project of The Beijing-Taipei Expressway (Shandong section), this paper summarizes the existing service level of the Beijing-Taipei Expressway, summarizes, and analyzes the existing problems of the variable message signs, and on this basis, puts forward countermeasures and suggestions for the variable message signs to improve travel efficiency and enhance user satisfaction.

1 Introduction

The Shandong section of Beijing-Taipei Expressway is in the middle and west of Shandong province, running through the north and south of Shandong province, connecting dezhou, Jinan, Tai 'an, Jining, Zaozhuang and other 5 large and medium-sized cities and 17 counties and cities along the route. It is an important part of Shandong province's expressway network layout plan "nine vertical, five horizontal, one ring, seven links". The reconstruction and expansion project are to improve the national and provincial highway network, to meet the needs of the development of the national comprehensive transport channel, but also to improve the highway capacity and service level, is to implement the national and provincial regional strategy, It plays a positive role in speeding up the construction of modern comprehensive transportation system, strengthening the construction of "safe transportation" and promoting the development of regional tourism resources and tourism.

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At present, the traffic service mode of Beijing-Taipei Expressway can be roughly divided into Application terminal, variable message signs, vehicle-mounted terminal, traffic broadcast and so on. Among them, the most frequently used information service means is APP terminal, which can use mobile phones, portable android device, and other ways to obtain traffic information through the communication network. It is simple and convenient to use, without extra cost, and can obtain traffic information anytime and anywhere. However, the usage rate of most APP terminals is only about 70%.

The variable message signs are suitable for releasing variable information, as well as weather information and advertising. Drivers and passengers can intuitively understand the conditions of the road ahead, and its service objects are mainly motorists. The variable message signs have the advantages of intuitive performance and strong system stability. However, the existing information boards have the disadvantages of poor pertinence, users can not actively obtain information, the obtained information cannot be stored, and the construction cost is high. To better improve the traffic information service capacity of Jingtai Expressway and explore the way to obtain higher user satisfaction, this paper studies countermeasures based on variable message signs [1].

2 Beijing-Taipei Expressway Service Level

The Shandong section of the Beijing-Taipei expressway, located on a major highway in Shandong province, is expected to see more than 40,000 traffic per day by 2023 and more than 86,000 by 2047. According to the analysis of work availability report, the proportion of vehicle types in each section of the project is predicted as follows (Table 1):

At present, passenger transport will continue to increase, the proportion of small buses will rise. After the opening of relevant railways in the region, part of long-distance passenger traffic will be diverted, and the proportion of buses will decrease year by year. Because the transport efficiency of large trucks is significantly higher

Table 1 Forecast table of the proportion of future vehicles on the project Road

Year	Van (%)	In the van (%)	Big trucks (%)	Heavy trucks (%)	Container (%)	Car (%)	Bus (%)	All (%)
2023	7.10	3.80	5.60	21.60	2.80	56.40	2.70	100.00
2025	7.00	3.80	5.70	21.60	2.90	56.40	2.60	100.00
2035	6.60	3.70	5.90	21.70	3.10	56.60	2.40	100.00
2040	6.40	3.70	6.00	21.80	3.20	56.70	2.20	100.00
2042	6.30	3.70	6.00	21.80	3.30	56.70	2.20	100.00
2045	6.20	3.60	6.10	21.90	3.40	56.80	2.00	100.00
2047	6.10	3.60	6.10	21.90	3.50	56.80	2.00	100.00

than that of medium and small trucks. Accordingly, the proportion of large trucks such as large trucks, extra-large cargo and containers will increase while that of small and medium cargo will decrease. Due to the large volume of traffic, the service means currently designed is difficult to meet the needs of users, so it is necessary to study better service means on this basis.

3 Analysis of Traffic Guidance Status of Variable Message Signs

According to the survey of Highway Travel Service conducted in the early stage, the analysis shows that at present, the way for travel users to obtain road information is navigation software, accounting for 74.29%, and the attention to road signs and LED display, accounting for 16.64%. Users' attention to WeChat public accounts (Shandong Expressway, Shandong Expressway Traffic Police, etc.) is 5.55%, followed by FM traffic broadcasting and website users (microblog, official website) (Fig. 1).

It can be seen from the above chart that the variable message signs accounts for less than 20% of users' access to road information. Through analysis, the reasons are as follows:

3.1 The Content of Variable Intelligence Board is Inaccurate and Lacks Real-Time

The variable message signs provide real-time traffic information to the driver, and the driver receives and responds to the induced information, to achieve the purpose of rational distribution of traffic flow [2]. In the process of the driver's path choice decision, the road condition information displayed by the variable message signs
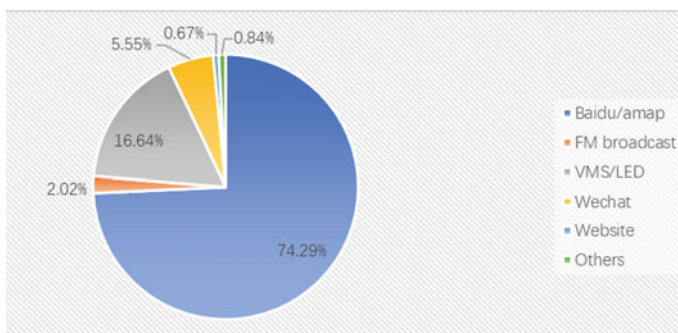

Fig. 1 Proportion of the way that travel users get road information

has a great influence on the driver's path choice behavior. If the road condition information displayed by the variable message signs is accurate, the driver will make an appropriate path choice according to the information. On the contrary, drivers' choices may lead to more congestion on congested roads and worse road network performance. But the driver in the process of driving, his route choice behavior is not only related to the accuracy of the content of the variable message signs, more associated with the real-time performance of the variable message signs information, from the collection network status to pass information to the driver, from the pilot receives information to respond according to the information needs to be a certain reaction time, and the path of the congestion status may change at any time.

3.2   Variable Message Signs Is Unreasonable and Counterproductive

The compliance rate of drivers to the variable message signs has a direct impact on the distribution of traffic flow in the road network and has a very important impact on the operation and management of the road network. But the driver on the size of the variable message signs induction information compliance rate has always been difficult to determine, on the one hand, the driver itself to variable message signs trust in a certain extent, affected the compliance rate of the variable message signs induction information, the driver to the variable message signs trust is higher, the more likely they were to change their travel path according to the variable message signs. Impact driver for variable message signs, on the other hand, inducing factors of information compliance rate is varied, the driver's perception of the variable message signs kimono properties affect the driver's behavior, the driver's travel properties may also affect its decisions, even the driver's personal attributes to a certain extent, also affect the route choice behavior [3]. Moreover, the public's recognition of the variable message signs continues to improve, and the size of the driver's compliance rate to the variable message signs induced information will also change. Too high or too low compliance rate of drivers to the variable message signs will lead to uneven distribution of traffic flow in the road network, and the inducing effect will be counterproductive.

3.3   The Layout of Variable Message Signs Is Unreasonable, and the Effect Is Not Good

Whether the variable message signs can achieve the expected induction effect in the road network depends largely on whether the layout of the variable message signs in the road network is reasonable. Induced effects, to maximize the variable message signs variable message signs layout position to keep proper distance

with the driver, otherwise, the pilot induced information has been received too late diverted into congestion area, and the distance is too large, the driver in advance to choose diversions of traffic, the unobstructed replacement path have new congestion, and originally congested roads has returned to normal, The variable message board cannot achieve the desired induction effect. Furthermore, at present, most variable message signs are mainly arranged on urban expressways, and the induced information provided is mostly the road condition information of expressways, while the variable message signs are basically not arranged on other paths. The road network information obtained by drivers is one-sided and incomplete, leading to drivers unable to make correct decisions according to the variable message signs induced information.

4 Research on Standards and Specifications

Follow the recommendations in the traffic information issued by the Road Traffic Information Service through the variable intelligence board in GB-T 29103-2012. Traffic information can be classified in different ways as follows:

- According to the timeliness of traffic information is divided into dynamic information and static information. The details are as follows (Table 2)

Table 2 Information classification

Information classification	Describe objects	The specific content
Dynamic information	Traffic information	Ice, water, snow, congestion, traffic volume, average speed, etc.
	Meteorological information	Wind, visibility, estimated duration, etc.
	Control information	Tunnel closure, lane closure, estimated duration, etc.
	Event information	Location, size, cause, severity, expected duration, etc.
	Response	Detour route, speed limit, etc.
	Traffic information	Ice, water, snow, congestion, traffic volume, average speed, etc.
Static information	Basic Tunnel Information	Length of tunnel, number of tunnel lanes, distance to entrance/exit, etc.
	Traffic restriction information	Limit height, width, speed limit, articles, etc.
	The service information	Rescue, consultation, emergency calls, etc.

- According to the form of release, it can be divided into text information, graphic information, and image information.

In the figure, green is used for smooth driving areas, yellow is used for slow driving areas, red is used for congested areas. The image information resolution should be no less than 320×200, the image refresh rate should be no less than 10 frames per second, and the image continuous playback time should be no less than 5 s. Image traffic information should not be used on the variable message signs.

Through the compilation of instructions to view, through the video image dynamic release of some complex information, has the characteristics of comprehensive and diverse information, comprehensive expression, large amount of information, rely on the existing technical means to achieve image information release, need to have relatively high-cost investment, and the release of images have certain restrictions. So, these uses are regulated.

5 Study on Traffic Guidance Countermeasures of Variable Message Signs

5.1 Real-Time Variable Message Signs Display Content

The traffic guidance information displayed by the variable message signs plays a role by influencing the driver's path choice behavior, and its effect depends on the driver's response to the information [4]. Since the driver's behavior is active and conscious rather than passive, the driver's opinion of information accuracy will affect their trust in information. Therefore, the accuracy of traffic information determines the reaction behavior of drivers. High-quality traffic information can achieve good results, while low-quality traffic information not only cannot induce traffic well, but even lead to the weakening of drivers' trust in information, affecting drivers to take correct and reasonable driving behavior. To ensure that the variable message signs can provide accurate and real-time induction information, it is suggested to combine the data of ETC portal frame with the cooperation of Internet companies to do real-time road condition analysis of traffic big data [5]. In addition, based on the existing historical data of Internet companies, the traffic congestion in special periods such as peak hours and holidays can be analyzed in advance, and the model data algorithm of cloud can be used to make traffic guidance in advance. Besides, the key road information should be highlighted, such as font width or flashing, to attract the driver's attention. In addition, the display of day and night should be different to accommodate the difference in light.

5.2 Front-End Awareness Device and Event Release

Taipei high-speed reconstruction after, there will be a lot of intelligence equipment installation, these sensors to upload data and alarm information, the wisdom of the highway platform and third-party system event information can be released on the variable message signs linkage, is different from the traditional artificial release induced traffic information, improve the variable message signs information release ability. The types of warning messages that can be issued jointly include congestion event, rescue event, accident event and road-related construction event; Temperature and humidity alarm and visibility alarm uploaded by temperature and humidity sensor and visibility detector; Video detection events reported by cameras, such as pedestrians, vehicles going backwards, objects thrown on the road, construction, and other video detection events; Congestion alarm provided by radar congestion detection. As information sources, the above event types can be used to realize fully automatic and full-process intelligent traffic guidance in a real sense with the help of fully automatic information board publishing technology.

5.3 Reasonably Variable Message Signs Compliance Ratio

The obedience rate of drivers to the inducible information of the variable message signs largely depends on the driver's correct perception of the congestion degree of the path displayed by the variable message signs. The color classification is too bright for the traffic congestion situation displayed by red, yellow, and green colors. It is suggested to add multiple colors. In addition, due to the different driving experience and culture, the perceived road congestion degree is also different. In addition, drivers also want more detailed information about the cause, duration and, if possible, real-time video of traffic conditions so that they can make more accurate decisions based on that information. Finally, it is also important to construct a route selection model that considers drivers' personal attributes, travel attributes, cognition and obedience to the variable message signs, and even environmental attributes for studying drivers' obedience rate to the variable message signs.

5.4 Standardize the Display Form of Variable Message Signs

Text variable message signs can clearly convey information to the driver, but the display space is limited. The variable form of the graph is more informative and easier to understand. In difficult visual conditions (such as low brightness, fast display, etc.), graphic symbol information is superior to text information both in recognition speed and distance. Another advantage is that graphics are not limited by language, if the design pattern image, intuitive, different countries, different nationalities, different

language drivers can understand and read. However, graph information requires drivers' higher attention and longer reading distance. The layout of the variable message signs with text and text is more complex, and the traffic state is displayed by graphics, while the text is simply supplemented. Whether it is text or graphics, it is generally matched with the corresponding color to warn the driver. Green indicates that the road is smooth, yellow indicates that the road is moving slowly, and red indicates that the traffic is congested. When the driver cannot see all the information of Chinese characters clearly, he can make a corresponding decision on the road condition according to the graphic information and different colors. Text variable message signs is suitable for displaying clear instructions or releasing simple information. The upstream of the main entrance ramp is released in the form of text, and the main line is released in the form of graphics, and the text and text mixed variable message signs is suitable for laying in the upstream of the main road exit.

5.5 *Planning the Location of the Variable Intelligence Board*

Only by reasonably planning the placement position of the variable message signs and reserving the appropriate reaction time for the driver can the variable message signs achieve the expected induction effect. First, determine the traffic node where the variable message signs needs to be set, and determine the final position of the variable message signs according to the road environmental conditions of the section where the node is located, combined with other static traffic signs, and then according to the external conditions of the road condition [6]. Furthermore, the appropriate distance between the position of the variable message signs and the driver should be reasonably determined according to the different situations of the induced information category of the variable message signs. Drivers should be informed in advance of accidents, construction and other congestion information that lasts for a long time, leaving enough time for drivers to change lanes to avoid congestion; However, for general traffic congestion information, it is not necessary to inform drivers too early, to avoid many drivers choosing to change routes and forming new congestion on alternative routes. In addition, the number and density of variable message signs should be increased, not only on urban expressways, but also on urban trunk roads, or even on branch roads, to provide more information about congestion paths and alternative paths, to facilitate drivers to make correct decisions.

6 Conclusions

This paper studies the countermeasures of variable message signs under the condition of standard specification. Variable message signs is not only a kind of traffic information release mode, but also a kind of traffic guidance control system [7, 8]. Reasonable variable message signs obedience ratio, guide the driver to choose the best

path; Standardize the display form of variable message signs to meet the regional needs of different drivers; The location of the variable message signs is planned, and reasonable reaction time is reserved for drivers, to provide drivers with more traffic guidance information. The research results guide drivers to obtain effective traffic information, reduce the probability of frequent congestion and congestion on the Beijing-Taipei Expressway, enhance the level of traffic service informatization, improve the quality of public travel service, and enhance the image of public service. Due to the limited funds and time of the project, this paper only analyzes the countermeasures of the variable message signs. Specific data analysis, algorithms and strategies are also key steps to improve the ability of variable information service. To achieve efficient and timely traffic guidance and improve traffic, further research in these aspects should be carried out in the later stage.

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