

# The Study of the Regional Road Service Level Comprehensive Evaluation Based on Fuzzy Comprehensive Evaluation Method

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**Abstract**—There is a certain ambiguity in the definition of regional road level of service. But the road network is gradational. In order to achieve the evaluation of the regional road service levels, this paper does field research and reference large amounts of data literature, constructs a multi-level fuzzy comprehensive evaluation model on the basis of analysis of the regional road service level valuation index from the micro, meso and macro level, and then we evaluate the regional road level of service. Verified by an example, evaluation can response to the service level of road network comprehensively, the multi-level fuzzy comprehensive evaluation model achieves good results in the evaluation of the regional road service levels.

**Index Terms**—Evaluation index system, fuzzy comprehensive evaluation method, regional road traffic, service level

## I. INTRODUCTION

Regional road service level reflects the system performance the transportation system or traffic flow in a time or the extent of the maximum volume of traffic that traffic reaches, that is traffic flow state. Comprehensive evaluation of road service level can not only qualitatively measure the status of the transport system in a time, but also point to the traffic flow affluence of a certain infrastructure, realizing control and adjustment to traffic flow through taking traffic control measures and traffic management solutions.

## II. ANALYSIS ON REGIONAL ROAD SERVICE LEVEL INDEX SYSTEM

Establishing road traffic service level index system is a core and key link of urban road traffic service level evaluation. Refer to the achievement of domestic and foreign experts and scholars, primarily divide into microcosmic, medium and macroscopic three levels with the scale of space division, and determine the service level of regional road evaluation index, as shown in the Table I.

1) Speed<sup>[1]</sup>: Speed means the average speed of all the vehicles that through a point in a specific time. We use

the distance of vehicles in unit time to express it, and the unit is km/h. Speed is taken to evaluate microcosmic traffic status, the important index to measure the unobstructed degree of road, and also the effective index to reflect the effect of traffic management.

- 2) Flow<sup>[2]</sup>: The number of vehicles that through a section in a certain amount time, the unit is vehicles/h. Flow is also called volume of traffic. It is the basic data that describes the state of the road traffic and reflects the congestion degree of road traffic, and it is also an important index that predicts the state of traffic safety.
- 3) Density<sup>[3]</sup>: This index is the number of vehicles in the driveway of unit length in a time, the unit is vehicles/(km• per driveway). Density is the index that describes the congestion degree, reflects the space distribution status of vehicles that on the road, and is the measurement of road load degree.

TABLE I: REGIONAL ROAD SERVICE LEVEL INDEX SYSTEM

	Macroscopic level	Medium level	Microcosmic level
Regional road service level	rate of the smooth flow of regional road network	rate of the smooth flow of road network	speed
	rate of regional road network congestion	rate of road network congestion	
	regional road network load degree	space load degrees	flow
	regional road network load margin	space load margin	density

- 4) Rate of the smooth flow of road network: Within the designated area, it is the ratio of the number of smooth flow roads and all of the roads concluded in this area. The index describes the unblocked degree of regional road network, and is the measurement of the overall status of the area.
- 5) Rate of road network congestion: Within the designated area, it is a rate of the number of congestion roads and all of the roads concluded in this area. This index describes the congestion degree of regional road network, is the measurement of the overall status of the area, and can be used to evaluate the effect of traffic management.

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- 6) Space load degrees: It is the ratio of the space traffic and transport capacity at a moment in road network. This index describes the extent of use of the road overall capacity, reflecting the utilization of road resources in the space, the index can provide the basis for traffic control.
- 7) Space load margin: It is the ratio of the remainder of the road network which can carry the traffic and the maximum capacity of and road network at some time. This indicator describes the residual rate of road resources in space, reflecting the proportion of road space available resources can be used as a reference for traffic organization and induced.
- 8) Rate of the smooth flow of regional road network: It is the ratio of the number of regions service levels in the smooth level and the number of the regional road network at some point in macro level. This index describes the degree of patency of the macro-regional road network road, is a measure of the overall situation of the macro-regional traffic, and its changes can be used to evaluate the effect of a wide range of traffic management.
- 9) Rate of regional road network congestion: This index is the ratio of the number of the level of service in a congested area and the number of all regions included in the regional road network in designated areas at some point. This index describes the degree of macro-regional road network congestion, a measure of the overall status of the macro-regional traffic, can be used to evaluate the effect of a wide range of traffic management.
- 10) Regional road network load degree: This index is the ratio of the traffic flow of the regional road network in the spatial distribution and the capacity of the regional road network in the spatial distribution in a moment. This index describes the extent of use of the overall capacity of the macro road network, reflecting the utilization of the macro-network of road resources in the space, the index can provide the basis for a wide range of traffic control.
- 11) Regional road network load margin: This index is the ratio of the traffic of the remainder of the regional road network which can carry and maximum capacity of the regional road network in some point. This index describes the remaining rate of the regional road resources in the space, reflecting the proportion of available resources on the regional road space, the index can provide the basis for a wide range of traffic control.

### III. FUZZY COMPREHENSIVE EVALUATION MODEL

In different traffic management departments, the road service level evaluation rating has a certain ambiguity. But the road network structure has the micro, meso and macro three levels. Fuzzy comprehensive evaluation method<sup>[4]</sup> is a comprehensive evaluation of the method based on fuzzy mathematics. The multi-level fuzzy comprehensive evaluation method<sup>[5]</sup> is applied to fuzzy systems with different levels of consideration, so this paper evaluates the level of service of the regional road with multi-level fuzzy

comprehensive evaluation method.

#### A. Set the Elements of Evaluation Systems

According to the definition of the index, the rate of the smooth flow of road network and the rate of road network congestion are the duality relation. The space load degrees and the space load margin are also the duality relation. So we can only use the rate of the smooth flow of road network and the space load margin to evaluate the service level of regional road.

According to the index system, the model evaluation factor set is as follows:

$$U = \{U_1, U_2, U_3\} = \{\text{Micro-level of service, Meso-level of service, Macro-level of service}\}$$

And the subset of the evaluation factors sets are as follows:

$$U_1 = \{u_{11}, u_{12}, u_{13}\} = \{\text{Speed, Flow, Density}\}$$

$$U_2 = \{u_{21}, u_{22}\} = \{\text{Rate of the smooth flow of road network, Space load margin}\}$$

$$U_3 = \{u_{31}, u_{32}\} = \{\text{Rate of the smooth flow of regional road network, Regional road network load margin}\}$$

#### B. Establishment of a Comprehensive Evaluation Set

According to the needs of road traffic service level evaluation, we set 4 grades, and they are smooth flow grade, slow moving grade, traffic congestion grade, severe congestion grade. The judgment set is as follows:

$$V = \{v_1, v_2, v_3, v_4\} = \{\text{smooth flow grade, slow moving grade, traffic congestion grade, severe congestion grade}\}$$

#### C. Weight of Evaluation Elements Subset

There are many methods to determine the weight of evaluation elements subset, such as order relation method<sup>[6]</sup>, entropy method, eigenvector method<sup>[7]</sup>, weighting statistics method<sup>[8]</sup> and so on. In this paper, we use the method which combines the judgment method of subjective experience and expert advice method.

The weights of the evaluation factors set are as follows:

$$A = [a_1, a_2, a_3] \quad (1)$$

The weights of the elements of each subset of are as follows:

$$A_1 = [a_{11}, a_{12}, a_{13}] \quad (2)$$

$$A_2 = [a_{21}, a_{22}] \quad (3)$$

$$A_3 = [a_{31}, a_{32}] \quad (4)$$

#### D. Implementation of Fuzzy Comprehensive Evaluation

According to the actual survey data of regional road transport system, we do quantitative estimates for each evaluation index by fuzzy mathematics and precise mathematical methods. Then every member of the judge panel of experts evaluates each index according to definitive assessment of the grade standards. Assume that the measured microscopic speed ( $u_{11}$ ) is 25.6km/h, and the judge panel has 20 members, including 7 the speed at the level of "congestion

( $v_3$ )". Therefore, the value of the evaluation of the index is  $7/20 = 0.35$ . And so, we can draw each subset of  $u_i (i = 1, 2, 3)$  evaluation decision matrix  $R_i (i = 1, 2, 3)$  of the single factor:

$$R_1 = \begin{bmatrix} r_{111} & r_{112} & r_{113} & r_{114} \\ r_{121} & r_{122} & r_{123} & r_{124} \\ r_{131} & r_{132} & r_{133} & r_{134} \end{bmatrix} \quad (5)$$

$$R_2 = \begin{bmatrix} r_{211} & r_{212} & r_{213} & r_{214} \\ r_{221} & r_{222} & r_{223} & r_{224} \end{bmatrix} \quad (6)$$

$$R_3 = \begin{bmatrix} r_{311} & r_{312} & r_{313} & r_{314} \\ r_{321} & r_{322} & r_{323} & r_{324} \end{bmatrix} \quad (7)$$

We can obtain formula according to weight coefficient vector and evaluation of decision-making matrix of the single elements:

$$B_i = A_i \times R_i = [b_{i1}, b_{i2}, b_{i3}, b_{i4}] (i = 1, 2, 3) \quad (8)$$

According to fuzzy comprehensive evaluation results based on single elements, we can obtain comprehensive evaluation decision matrix in subset in  $U$ .

$$R = \begin{bmatrix} B_1 \\ B_2 \\ B_3 \end{bmatrix} = \begin{bmatrix} b_{11} & b_{12} & b_{13} & b_{14} \\ b_{21} & b_{22} & b_{23} & b_{24} \\ b_{31} & b_{32} & b_{33} & b_{34} \end{bmatrix} \quad (9)$$

Finally, according to the weighting coefficient for each subset vectors  $A$  and comprehensive evaluation decision matrix  $R$  from  $U$ , We can obtain fuzzy comprehensive evaluation of the level of road service in the region.

$$B = A \times R = [a_1, a_2, a_3] \begin{bmatrix} B_1 \\ B_2 \\ B_3 \end{bmatrix} = [b_1, b_2, b_3, b_4] \quad (10)$$

#### IV. EXAMPLE APPLICATIONS

We investigate the road network of part of provinces and cities in the research process. This paper selects a regional road network in Guangxi province as the object and use multi-level fuzzy comprehensive evaluation method to evaluate the regional road service level.

##### A. Determine the Weights of Evaluation Indexes

Each sub-centralization weight (Primary weight) is as follows:

$$A = [0.3, 0.3, 0.4] \quad (11)$$

The weight in each subset of the elements  $U_i (i = 1, 2, 3)$  (secondary weight) is as follows:

$$A_1 = [a_{11}, a_{12}, a_{13}] = [0.4, 0.3, 0.3] \quad (12)$$

$$A_2 = [a_{21}, a_{22}] = [0.55, 0.45] \quad (13)$$

$$A_3 = [a_{31}, a_{32}] = [0.6, 0.4] \quad (14)$$

##### B. Construct Judge Matrix

According to the research data obtained, the expert group does the judgment of the evaluation results. We can get the decision matrix in each subset evaluation of the various elements  $u_i (i = 1, 2, 3)$ .

$$R_1 = \begin{bmatrix} 0.2 & 0.4 & 0.3 & 0.1 \\ 0.1 & 0.2 & 0.4 & 0.3 \\ 0.1 & 0.3 & 0.4 & 0.2 \end{bmatrix} \quad (15)$$

$$R_2 = \begin{bmatrix} 0.5 & 0.2 & 0.2 & 0.1 \\ 0.5 & 0.2 & 0.2 & 0.1 \end{bmatrix} \quad (16)$$

$$R_3 = \begin{bmatrix} 0.6 & 0.2 & 0.1 & 0.1 \\ 0.6 & 0.2 & 0.1 & 0.1 \end{bmatrix} \quad (17)$$

##### C. Regional Road Service Level Fuzzy Comprehensive Evaluation

According to the evaluation index weight coefficient vector  $A_i$  and evaluation of decision matrix  $R_i$ , we can get comprehensive evaluation of each subset  $u_i (i = 1, 2, 3)$ .

$$R = \begin{bmatrix} B_1 \\ B_2 \\ B_3 \end{bmatrix} = \begin{bmatrix} 0.14 & 0.31 & 0.36 & 0.19 \\ 0.5 & 0.2 & 0.2 & 0.1 \\ 0.6 & 0.2 & 0.1 & 0.1 \end{bmatrix} \quad (18)$$

Finally, according to the weighting coefficient for each subset vectors  $A_i$  and comprehensive evaluation decision matrix  $R$  from  $U$ , We can obtain fuzzy comprehensive evaluation of the level of road service in the region.

$$B = A \times R = [0.432, 0.233, 0.208, 0.127] \quad (19)$$

The evaluation results show that smooth, crowding, congestion, serious congestion of the four levels of evaluation results are 0.432, 0.233, 0.208, 0.127. Smooth grade evaluation value is the largest of the four evaluation levels, this result shows that the regional road network level of service is at a smooth level and the vehicle in the road network can drive smoothly.

#### V. CONCLUSION

- 1) This paper studies the evaluation of the level of service in regional road network, analyzes the evaluation indicators from the micro, meso and macro perspective. And it gives the definition and calculation method of the evaluation indexes.
- 2) This paper builds a multi-level fuzzy comprehensive evaluation model on the basis of the analysis the service

evaluation in the regional road network level. We take a regional road network in Guangxi for example, and we verify the evaluation model. The model achieves good results.

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