

THE TOTAL QUANTITY CONTROL METHOD FOR HIGHWAY NETWORK PLANNING

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Abstract: Reviewing the developing process of highway network planning, this paper comprehensively introduced the main ideas, the main contents and working steps of the total quantity control method. It also pointed out the problems remaining for settlement.

Key words: Highway network planning, Theory, Method

1. PREFACE

As the base of national economy, transportation is strongly associated with social development, living conditions and national security. Highway transport, as a major mode of transportation, links up urban and rural areas. Today, with the rapid economic development in China, highway construction is becoming more important and urgent. On the one hand, highway construction is developing at an ever higher speed. On the other hand, there still remain several problems in this field such as shortage of funds and outstanding accounts. Therefore, with the aim at using investments more efficiently, strengthening management and macro-control on highway construction, and avoiding arbitrary, blindness and repetition in decision making so as to adapt highway construction to the national economic development, it is necessary not only to have a scientific highway network plan, but also to normalize and standardize the planning procedures by using an effective planning method and technique.

Prior to highway construction, highway network planning should be carried out to make rational highway structure and arrange construction implementation sequences so as to improve the traffic capacity, meet the increasing traffic demand, fully use the investments, and provide scientific basis for decision making. However, there is not a set of theories and methods suitable for developing countries in common use currently, so that the research to which appears more important for practice.

2. AN OVERVIEW OF THE HIGHWAY NETWORK PLANNING

Foreign scholars have conducted extensive research work on highway network planning. According to their own countries' economic development levels and transportation situations,

they put forward different methods. For example, on network scale determination, Russian scholars discovered the correlations between regional development level, freight volume and rational highway network mileage, and then offered a set of formulas for fixing the rational highway network mileage. Besides, they also applied multivariate regression analysis and correlation analysis to set up the linear function for regional network density. Many scholars in western countries also put forward similar theories and methods. All these achievements are very helpful to Chinese researchers.

Considering the characteristics of China's transportation situation, Chinese scholars also put forward many theories and methods on highway network planning. Particularly, since 1985, following the call of the state ministry of communications to carry out the research on transportation network planning, highway departments at all levels put great efforts in this field, and a lot of productive literatures were produced.

Thus far, there are two schools in the field of highway network planning techniques in China: the four-stage method and the total quantity control method. Based on OD data, the four-stage method predicts the future OD distribution according to the current OD distribution, assigns the predicted OD flows to the network in terms of the traffic flows of different routes. The whole process can be divided into four stages: traffic generations, traffic distribution, split mode and traffic assignment. The major merit of this method is that it can obtain sufficient traffic data and provide relatively reliable predictions while its major deficiency is that it is costly and time-consuming. The total quantity control method which was put forward by Xi'an Highway University considers the highway network as a whole, analyzes the possible variation tendency of the prime factors, which are closely related to the highway transport, and scientifically assign the predicted traffic volume to a well-structured highway network system. Compared with the four-stage method, it saves more time, labor and funds. Practice proves that it is very convenient, workable and more suitable for China's transportation conditions. But there is still great room for improvement in several aspects such as traffic assignment.

In addition to those contributions above, Chinese scholars also have brought many valuable insights and ideas in detailed chains of network planning procedures. For example, they introduced dynamic planning method, traffic zoning theory and other concepts to highway network planning. They also made many achievements in network structural optimization, investment decision modeling and other relevant aspects.

3. THE TOTAL QUANTITY CONTROL METHOD

The total quantity control method was put forward by the teaching and research section of Xi'an Highway University. Considering the highway network as a whole, this method analyzes the possible variation tendency of the prime factors that are closely related to the highway transport and scientifically assigns the predicted traffic volume to a well-structured highway network system. Its procedure diagram is shown in fig. 1.

The Total Quantity Control Method for Highway Network Planning

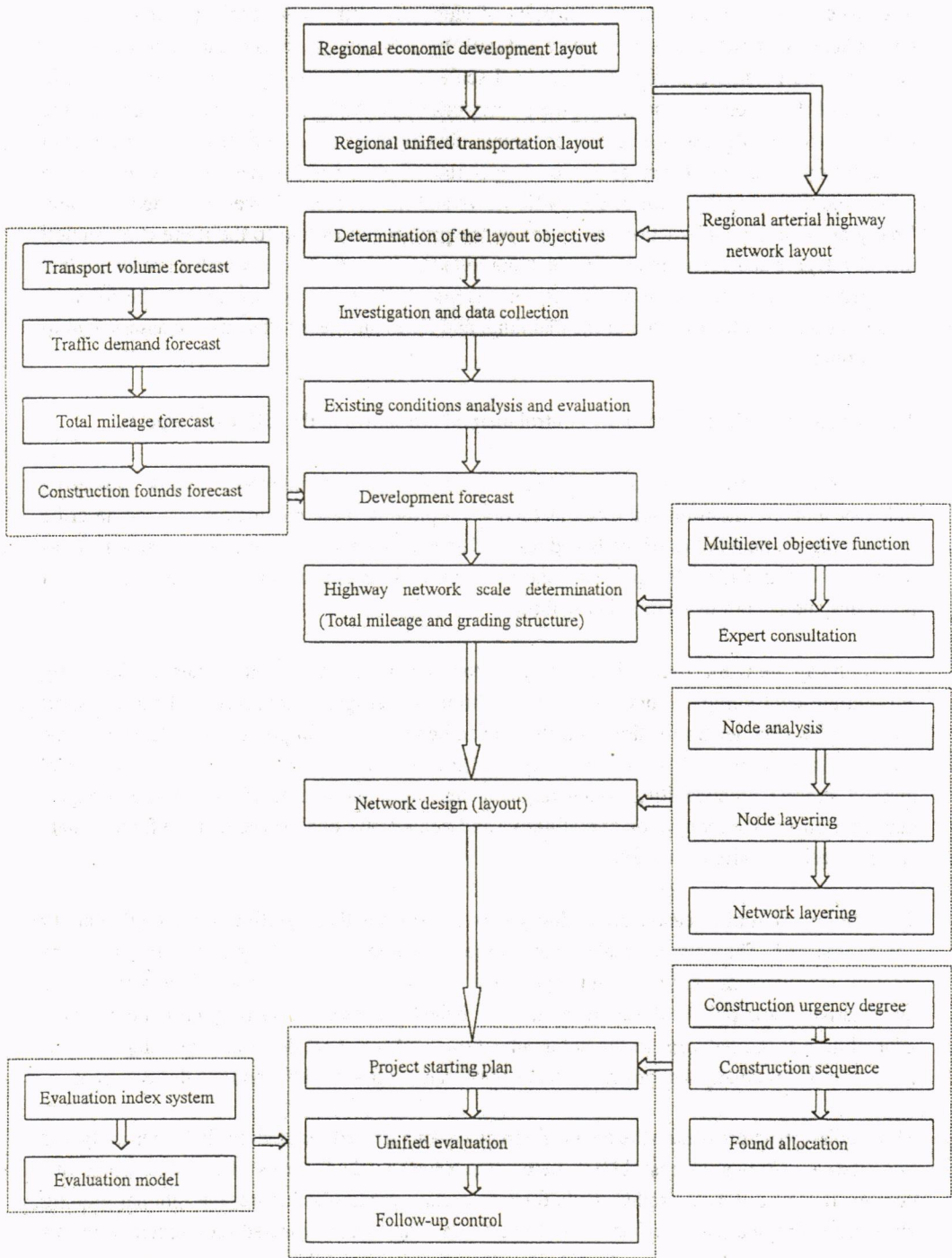


Fig.1 The procedure diagram of the total quantity control method

The basic ideal is to, from an overall point of view, reveal the main problems and the basic contradictions of the existing highway network by introducing its present road and traffic characteristic parameters, control the overall scale of construction by fixing the total traffic demand of the given area, determine the framework of the highway network by analyzing the characteristics of the regional social economic development and the distribution of regional productivity under the theory of unified transportation plan, break down the overall scale to every road by the assignment of the traffic flows and the process of investment decision, and finally arrange the construction sequences of the projects according to the route construction urgency degree and determine the implementation scheme by stages. It is such a procedure that is based on the several total quantities forecasting without OD survey, makes the network layout rationalized for the core of the planning, and takes the means of synthetic assessment to an optimization.

The main ideas of the total quantity control method are shown in the following aspects:

1). The road and traffic characteristic parameters, namely, the highway network evaluating index system, are the foundation of this theory. Employing these parameters, we can describe the existing characteristics of roads and traffic flows, and the service level quantitatively so as to lay solid foundation for present condition analyses, extension project schemes, lay-out programs and lay out evaluation in the future.

2). Highway network traffic forecasting is the technical crux of this theory. Obtaining appropriate controlling factors such as the volume of transport, the volume of the transport circular flow, the net traffic flow and the total mileage is very important to determining the rational highway network scale. No matter which model is applied, the total quantity control method stresses practicability, which requires the fine combination of modeling and expert consultation and the integration of qualitative and quantitative analysis so that the forecast data can be consistent with actual data.

3). Determination of a reasonable highway network scale is the objective of the total quantity control method. The network scale refers to the total mileage and the grading structure. The total mileage is composed of the mileage in use and the equivalent mileage. The former, as a quantitative factor, reflects the connectivity, while the latter, as a qualitative factor, indicates the adaptability of the network to the communications and transport demand. The integration of these two factors finely demonstrates the level of transportation and economic development.

The grading structure means the composition of various graded roads classified technically and quantitatively shows the distribution percentage of all roads in terms of mileage. Since one combination of different graded roads forms a certain grading structure, the rational grading structure is the one that satisfies a set of conditions and meets expected requirements. In this sense, the major task of network scale determination is to fix the rational total mileage and grading structure.

4). Network lay out optimization is the core of the total quantity control method. A rational

network pattern should be an effectively connecting system with maximal transportation benefits. Therefore, it is a gradual process of optimization to obtain a rational network lay out, in which network structure is expended from tree-like to net-like by the means of "optimized tree" principle. That is first to determine the "biggest importance tree" of a highway network by analyzing the importance of nodes and links, which represents the main trunk links in the network. Next, to add the optional links between the nodes with taking the link importance in the unit of mileage maximum to an objective function, and then to obtain the final optimized network.

5). Unified evaluation is the necessary means of the total quantity control method in weighing all alternatives. In multi-alternative evaluation, the unified evaluation is an indispensable step in that it can make a comprehensive analysis and give correct judgement. Thus, we can obtain a best balance point between meeting the traffic demand and taking a full use of investments, which not only solve the contradiction between the increasing traffic demand and the shortage of construction funds but also make the network lay out meet the requirements and objectives of the decision makers.

6). The traffic assignment on routes, the construction urgency degree and the decision of construction investment are basic means and important basis for the project implementation. According to the route construction urgency degree obtained previously, we can make an arrangement for construction sequences and select the priority routes that have grater route saturation degree values and might bring more benefits. It can not only improve the traffic capacity but also make the best use of the investments, in an another word, make the implementation of the project more scientific.

In short, the total quantity control method mainly solve the problems below: the existing network analysis and evaluation, the adaptability of the existing network to the future local economic development, the organic combination of highway network and other transport modes, the determination of the rational network scale, the rational network layout, the arrangement for construction sequences, the unified evaluation of network layout and the construction funds raising.

4. FINAL REMARKS

Over ten years of research and application, the total quantity control method has developed into a relatively perfect theory. As a new school in the field of highway network planning, this theory has helped to established rather complete models on traffic demand forecasting, rational scale determination, highway network optimization, construction sequence arrangement and other relevant aspects. As a theory with Chinese characteristics, the total quantity control method has been praised by experts at home and abroad as easy to learn, highly practicable, time and labor saving. It has also received positive results in practice. According to the feed back from users, compared with the four-step method, this method successfully helped save a lot of money for users in China.

The rapid speed of highway construction impels to deepen our research on the total quantity control method, for example, how to assign traffic volume more rationally; how to improve investment procedures and decision models so as to make them more practicable; how to make dynamic forecasting. Questions like these still remain to be discussed further.

Reviewing the developing process of highway network planning, this paper comprehensively introduced the main ideas, the main contents, the working steps and the mainly solving problems of the total quantity control method. The purpose of which is to promote the further improvement and development of theories and methods for highway network planning based on the existing research.

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