REGIONAL INTEGRATED TRANSPORTATION NETWORK LAYOUT PLANNING

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Abstract: Research on feasible planning method and theory of the regional integrated transportation network is a pressing issue in order to fully achieve the network’s global efficiency and optimize the use of transportation resources in national economy. Based on the analysis of the discrepancy between regional and urban integrated transportation planning, this paper proposed the basic contents, a four-level method, which includes macro, medium, micro and implementation levels to conduct the node-link-area hierarchy planning process, and process of the regional integrated transportation network layout planning. In addition, combining with case study, by adopting the layered planning method, a practical regional integrated transportation hub and corridor layout scheme was given in consideration of the demand forecast in the years ahead. This paper will be instructive in designing the framework of regional integrated transportation network.

Key words: integrated transportation network; network layout planning; transportation corridor; network node

1 Introduction

Due to the imbalance of Chinese regional economy and an extensive economic growth style, nowadays the discrepancy between transportation supply and demand has been aggravated (Lu, 1998). As a result, taking into account China’s specific situation, it is necessary to set up an integrated and harmoniously developed regional transportation network, in order to improve the global efficiency and effectiveness of Chinese transportation, suit social-economic development objective, and satisfy demand in various development phases.

The core objectives of regional integrated transportation system planning are to determine integrated transportation hub layout, modal split and structure optimization in corridors, network layout and the priority of project implementation of the system. The current research regarding regional integrated network layout planning is mainly focused on metropolitan areas in a strategic and qualitative manner (Chen, 2003), whereas specific transportation network layout and node planning are rarely involved (Zhang, 1993, 2002). As to modal split and structure optimization within corridors, relevant research is focused on passenger

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transportation; freight transportation is much less discussed (Juan, 1983). On the whole, a theoretic and methodological research framework, which systematically combines qualitative and quantitative analysis in order to meet the needs of regional transportation network development, has not yet been developed.

In this paper, the ‘region’ indicates social and geographical areas which embody certain operation features and economic objectives.

2 Discrepancy Analysis Between Regional and Urban Integrated Transportation Planning

Due to the differences in terms of jurisdiction, economy, population and industry, a significant discrepancy between regional and urban transportation planning exists which manifests itself in the following aspects:

(1) Planning range
Regional transportation planning is usually for a whole area which is comparatively large; in addition, there exist many undeveloped districts. By contrast, urban transportation planning is limited to the planned districts of a city, with a small planning range. The planned areas are often construction lands.

(2) Transportation mode composition
The main transportation modes within a region are mainly composed of rail, road, air, and water transportation with a sparse network layout. For urban transportation, pedestrians, bicycles, cars and public transit account for the primary travel modes. Moreover, urban transportation has dense road, public transit and mass transit networks.

(3) Travel demand generation mechanism
Regional travel demand is mainly from social production and consumption, while the mechanism of urban trip demand depends upon land use patterns. For example, residential districts are important trip generation sources, whereas factories, government agencies and commercial centers are significant trip attraction sources.

(4) Modeling theories
As to a region, due to its different features from cities, the traditional four-stage method is no longer completely applicable. It is necessary to develop new modeling theories. The modeling of urban transportation planning is based on resident trip survey data and adopts the traditional ‘four-step’ method.

3 Methodologies and Procedures for Regional Integrated Transportation Network Layout Planning

3.1 Contents
Departing from national and regional development strategies and taking into consideration relevant development planning, the kernel of regional integrated transportation network layout planning is to build an integrated and harmoniously
developed harmoniously developed transportation network based on regional characteristics and travel demand trend analysis. It includes: Development strategies and total travel demand forecast, Planning of important nodes and transportation corridors, Modal split and coordination within corridors, Integrated transportation hub planning, Project construction order analysis.

3.2 Methodologies and procedures

Regional integrated transportation network planning has proven to be a very complicate process. As a result, according to regional features and travel demand characteristics, this paper develops a four-level method, which includes macro, medium, micro and implementation levels to conduct the node-link-area hierarchy planning process. Details about the procedures and the flow chart are shown in figure 1.

4 Demand Forecast Analysis

Owing to the specific features of regional passenger and freight travel demand forecast, it is hardly possible to carry out large-scale traffic surveys. This paper thus proposes a new forecast methodology in which there are two main points: one is passenger and freight trip generation and attraction for each traffic zones; the other is modal split within corridors.

4.1 Node selection and traffic zone division

In order to fully understand transportation sources and the traffic flow among them, the studied region is divided into several traffic zones in light of certain principles and administrative jurisdictions when analyzing transportation network demand. The node-importance degree method was used to select a couple of nodes in each traffic zones. The calculation formula is given as follows:

\[ M_i = (\alpha_1 \cdot \frac{I_{1a}}{I_{1a}} + \alpha_2 \cdot \frac{I_{2a}}{I_{2a}} + \alpha_3 \cdot \frac{I_{3a}}{I_{3a}}) \cdot \alpha_4 \times 100\% \]  

In which, \( M_i \): the importance of the ith node; \( I_{ia} \): the average value of the ith element of the ith node.
indicators for all the nodes in the area; \( I_i \): the \( i \)th indicator; \( \alpha_i \): the weight of the indicators for the \( i \)th node, which is determined by relevant analysis results; \( \alpha_q \): the correction coefficient, which considers such elements as hub locations for various transportation modes, military bases.

Then based on the principle of hierarchical cluster analysis, the general distance of standardized Euclidean distance was adopted to determine the important nodes, secondary important ones and the ordinary ones. The formula is as follows:

\[
|X_i - X_j| = \sum (X_{ik} - X_{jk})^2 / S_k^2 \quad (k = 1, 2, \ldots, m)
\]

In which, \( X_i \): the \( i \)th sample with \( m \) indicators. It can be described as \( X_i = (X_{i1}, X_{i2}, \ldots, X_{im}) \); \( X_{ik} \) suggests the \( k \)th indicator value of the \( i \)th sample; \( S_k \): the variance of variable \( X_k \).

4.2 Transportation generation forecast

By studying the interaction between land use and travel demand, travel demand forecast models based on node land use analysis can be built.

4.3 Modal split forecast in corridors

After comprehensively analyzing service properties of all the transportation modes, their applicability to different travel demands, and mode selection mechanism, the Logit model combined with modal share curves was employed to forecast passenger and freight modal split in corridors.

5 Case Study

This paper takes the ‘National Integrated Transportation Network Layout Planning’ project which is completed by the authors and their research group, as the study case. Based on the above analysis, in our project, the country was divided into 31 traffic areas which contains 147 nodes. The forecasting results of passenger and freight trip generations and attractions are shown in figure 2.

![Figure 2. Trip generations and attractions of passenger and freight in 2020](image)

(a) trip generations and attractions of passenger   (b) trip generations and attractions of freight

By building passenger modal share models, the modal split of rail and road transportation was obtained and given in table 1.

Meanwhile, the distance-modal share curve was developed in figure 3 to forecast modal split of the two modes in corridors.
Table 1. Forecasting results of passenger modal split by the Logit model

<table>
<thead>
<tr>
<th>Traffic Modes</th>
<th>Distances(km)</th>
<th>50</th>
<th>100</th>
<th>200</th>
<th>400</th>
<th>800</th>
<th>1200</th>
<th>1500</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Earnings(Yuan)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highway</td>
<td>2000</td>
<td>89.64</td>
<td>75.63</td>
<td>57.84</td>
<td>26.98</td>
<td>2.86</td>
<td>0.14</td>
<td>0.03</td>
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<tr>
<td></td>
<td>1200</td>
<td>90.02</td>
<td>75.85</td>
<td>61.79</td>
<td>22.61</td>
<td>3.01</td>
<td>2.67</td>
<td>0.01</td>
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<tr>
<td></td>
<td>600</td>
<td>90.4</td>
<td>76.07</td>
<td>65.74</td>
<td>18.24</td>
<td>3.16</td>
<td>2.2</td>
<td>0.01</td>
</tr>
<tr>
<td>Railway</td>
<td>2000</td>
<td>10.54</td>
<td>24.37</td>
<td>42.16</td>
<td>73.02</td>
<td>92.23</td>
<td>91.94</td>
<td>89.64</td>
</tr>
<tr>
<td></td>
<td>1200</td>
<td>9.98</td>
<td>24.15</td>
<td>38.21</td>
<td>77.39</td>
<td>93.75</td>
<td>94.3</td>
<td>92.64</td>
</tr>
<tr>
<td></td>
<td>600</td>
<td>9.42</td>
<td>23.93</td>
<td>34.26</td>
<td>81.76</td>
<td>96.27</td>
<td>96.66</td>
<td>95.62</td>
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<tr>
<td>Civil aviation</td>
<td>2000</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>7.92</td>
<td>7.92</td>
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<td>-</td>
<td>-</td>
<td>3.24</td>
<td>4.03</td>
<td>7.35</td>
</tr>
<tr>
<td></td>
<td>600</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.57</td>
<td>1.14</td>
<td>4.37</td>
</tr>
</tbody>
</table>

Figure 3. Distance-modal share curve of railway and highway in corridors
Figure 4. The assignment result of highway transportation volume in 2020

(a) the assignment result of passenger (b) the assignment result of freight

Figure 5. The assignment result of railway transportation volume in 2020

Using the OD table obtained from the previous forecasting results, trips for rail and road were assigned to the respective network and we obtained traffic volume in the network. The results of assignment are shown in figure 4, figure 5 and figure 6.

Ten national transportation corridors are planned in which five are from west to east; the others are from south to north. Moreover, 31 national transportation hubs are also proposed as figure 7 shows.
6 Conclusions

This paper presents and discusses the fundamental concepts, contents, procedures and detailed methods of regional integrated transportation network layout planning after analyzing its specific characteristics. In addition, based on demand forecast analysis, this paper employs node-link-area hierarchy planning process and gives a planning scheme of China’s national integrated transportation network in future years. This research would be meaningful and instructive for future work in the country’s regional transportation network layout planning.

References: