Research on Pavement Preventive Maintenance Decision-making Method Based on BIM Technology

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Abstract. The essence of preventive maintenance decision-making is to make decisions for different preventive maintenance measures and different road conditions. Based on the principle of selecting preventive maintenance measures for asphalt pavement, this paper constructs an asphalt pavement preventive maintenance model. It relies on BIM technology and uses Analytic Hierarchy Process (AHP) as a research method to determine the preventive maintenance decision of asphalt pavement. It is obtained by matrix calculation. Develop the best preventive maintenance measures for asphalt pavement.

Keywords: Asphalt Pavement, Preventive Maintenance, Bim Technology, Analytic Hierarchy Process (Ahp), Decision Method

1. Introduction
The essence of preventive maintenance decision-making is to make decisions for different preventive maintenance measures and different road conditions. It is necessary to combine qualitative and quantitative methods in decision science to make decisions on preventive maintenance measures [1-4]. More applications mainly include: life cycle cost analysis method, benefit cost method, artificial neural network, genetic algorithm, fuzzy set theory and analytic hierarchy process (AHP) [5-6].

The analytic hierarchy process (AHP) is a multi-attribute decision analysis method that combines qualitative and quantitative. It was proposed by Roazann W. Saaty, an American operations researcher, in the 1970s. This method is suitable for solving decision-making problems with complex decision-making target structure and lack of data [7-8]. The specific thinking is similar to the decision-making process and judgment process of a complex problem. In the specific implementation process, it is through the establishment of a judgment matrix of pairwise comparison, which combines many complex factors with the personal factors of the decision maker in a layered and step-by-step manner, and expresses it in a quantitative form through logical thinking.

This paper elaborates on the principles of selecting preventive maintenance measures for asphalt pavements, and constructs a model for preventive maintenance of asphalt pavements. It relies on BIM technology and uses Analytic Hierarchy Process (AHP) as a research method to determine preventive maintenance decisions for asphalt pavements. Method to get the best preventive maintenance measures for asphalt pavement.
2. BIM modeling
As an information carrier, BIM technology can integrate and share all data throughout its life cycle. Therefore, for the same road, in order to achieve rapid data transmission and information sharing, the design of different disciplines should be completed in a unified BIM environment.

The sequence of creating 3D roads in PowerCivil is shown in Figure 1.

![Figure 1. Basic flow chart of modeling](image)

(1) Establish a three-dimensional terrain model
The alignment of the route, the horizontal linear design and the vertical section design, and the later filling and excavation of earth and rock are all based on the original topography, so the original topography is very important in the road design. Digital Terrain Models DTM (Digital Terrain Models) are three-dimensional triangles obtained by computer processing based on the elevation information collected in the actual terrain.

In PowerCivil, the feature of the terrain model is defined as Terrain, and the software provides a set of powerful tools to create, edit, analyze and use terrain models. Terrain models can be created through graphics files (such as elevation points, contour lines), data files (DTM, Tin, txt, PointCloud) and other data files in different formats; and the ground models can be merged, cut and edited according to requirements.

(2) Horizontal and vertical geometry
The road horizontal alignment design is to determine the horizontal alignment of the road centerline, and the longitudinal section alignment design is to determine the ups and downs of the route. The design of flat and vertical lines should try to meet the requirements of flat and vertical line combinations, and provide a smooth, coordinated, smooth, and drainage line combination.

(3) Cross-sectional design
The main purpose of the cross-sectional design of the route is to determine the shape of the road surface, the type of subgrade, and the summary of the engineering quantity. Highway cross-sections mainly include traffic lanes, central dividers, road shoulders, and side slopes.

3. Database design based on BIM
3.1. Database requirements analysis
Before establishing a database, it is necessary to conduct research and analysis on the needs of the database, and make a clear plan for the data information required by the database and the functions that it hopes to achieve, so as to establish a good foundation for the subsequent design.

The function of the road maintenance database of the paper is mainly to store a large amount of road surface inspection data in a centralized manner; on the basis of the inspection data, the performance indicators are evaluated and graded according to the evaluation criteria in the specification; on the basis of the road inspection data in previous years A certain prediction model is used to predict the road performance in the next few years; preliminary maintenance plan selection is made based on the data obtained from detection or prediction; and arbitrary queries such as detection data and evaluation results in the database are realized, and can be created according to requirements Statistical data and visual processing.
3.2. Database conceptual structure design
According to the above analysis of database requirements, determine the entities in the database and plan their relationships, as shown in Figure 3.

3.3. Visual interface design
Based on the analysis of data and entity relationships, the database is designed into four sub-menus: data management, road condition evaluation, road performance prediction, and maintenance decision-making. The data management sub-menu can realize the functions of adding and deleting data. It has two sub-interfaces for adding routes and adding sections. Other operations are carried out in the data management interface; road condition evaluation has two functions: query inspection data and evaluation of inspection data; performance Prediction has the function of querying detection data and prediction data; maintenance decision-making can query detection data or prediction data, and determine the preliminary maintenance plan of the road section.

4. Preventive maintenance decision model
According to the concept of analytic hierarchy process, starting from the four levels of target level, criterion level, index and plan level, a three-level evaluation system is adopted to determine the preventive maintenance decision-making program of asphalt pavement. The determination of various indicators is extended with the target as the center. When selecting the indicators, the target decomposition, indicator refinement, and layered analysis are oriented to clarify the logical relationship between the indicators, and establish a clear, simple, comprehensive, and hierarchical Evaluation System.
4.1. Calculate the weight of each evaluation index

(1) Construct a judgment matrix. After the establishment of the entire index system, the weight of each index must be determined. That is, to decompose the overall goal hierarchically, compare at the same level, determine the importance of different indicators to the upper-level elements, sort them according to importance, and assign values to quantify.

Assuming that the element $Z_k$ of the previous layer is the judgment criterion of the element $Y_1 \cdots Y_n$ of the next layer, and has a dominant relationship with the $Y_1 \cdots Y_n$ of the next layer, now compare the importance of $Y_1 \cdots Y_n$ relative to $Z_k$, and according to the different importance it presents The sex gives the corresponding weight, and $Y_{pq}$ represents the relative importance of factor p and factor q under the criterion level Z. If there are n elements, a pairwise comparison matrix can be constructed, as shown in formula (1).

$$
\begin{bmatrix}
  Y_{11} & Y_{12} & \cdots & Y_{1n} \\
  Y_{21} & Y_{22} & \cdots & Y_{2n} \\
  \vdots & \vdots & \ddots & \vdots \\
  Y_{n1} & Y_{n2} & \cdots & Y_{nn}
\end{bmatrix}
$$

(1)

In order to minimize the subjective factors in the decision-making process, this method generally uses a judgment scale of 1-9 to quantify the relative importance of the indicators at the same level, as shown in Table 2.

The intermediate value of the two $Y_{pq}$ in Table 2 can rank the importance of the two indicators. If the importance ranking is between "two elements are of equal importance" and "p element is slightly more important than q element", then $Y_{pq} = 2$ can be obtained. If the importance ranking is between "p element is slightly more important than q element" and "p element is obviously more important than q element", then $Y_{pq} = 4$ can be obtained, and so on.

4.2. Standardized processing of indicators

In general, the benefit-type and cost-type are defined as quantitative indicators. The larger the former, the better, and the smaller the latter, the better. In Table 1, in the preventive maintenance method of asphalt pavement, the benefit index is Y21 and the cost index is Y22. The qualitative indicators (Y11, Y12, Y13, Y14) and (Y31, Y32, Y33, Y34) generally choose language variables to quantify them. According to the regulations and with reference to the requirements of the regulations, the decision-making index characteristics of preventive maintenance are divided into five grades: excellent, good, medium, inferior and poor. At the same time, the expert consultation method is used to determine the $r_{pq}$ score of each qualitative index. Standardize each quantitative index and qualitative index in the plan layer. The conditions of each indicator are summarized in Table 1 for each qualitative indicator rating standard, and a matrix related to the evaluation indicators of the scheme is constructed, as shown in Table 1.

| Serial number | Y11 | Y12 | Y13 | Y14 | Y31 | Y32 | Y33 |
|---------------|-----|-----|-----|-----|-----|-----|-----|
| Range         | Excellent | Excellent | Subalternation | Excellent | Subalternation | Excellent | Excellent |
| (1.0,0.8)     | Good | General | Medium | Secondary | Subalternation | Good | Good |
| (0.8,0.6)     | Medium | General | Lower | Lower | Low | Medium | Medium |
| (0.6,0.4)     | Medium | General | Difficulties | Secondary | Subalternation | Medium | Medium |
| (0.4,0.2)     | Medium | General | Serious | Secondary | Subalternation | Medium | Medium |
| (0.2,0)       | Medium | General | Very serious | Secondary | Subalternation | Medium | Subalternation |
4.3. Sorting different scenarios

After completing the standardized processing of quantitative and qualitative indicators, a fuzzy membership matrix of Z is constructed to provide a basis for comprehensive ranking. The three weights of technology Z1, economy Z2, and environment Z3 are calculated with the fuzzy membership matrix to calculate the 10 factors of the scheme layer and the weight of the highest ranking. This step is the comprehensive ranking of the layers. From the scheme layer of the lowest level, the matrix calculations are performed step by step until the target layer. Finally, according to the calculated value of each preventive maintenance measure, the best preventive maintenance measure is determined.

5. Conclusions

Relying on BIM technology, this paper uses Analytic Hierarchy Process (AHP) to construct an asphalt pavement preventive maintenance model, and uses Analytic Hierarchy Process as a research method for decision-making on preventive maintenance measures for asphalt pavements. It adopts four levels: target layer, criterion layer, index and plan layer. The levels constitute a three-level evaluation system; the weight of each evaluation index is calculated by constructing a judgment matrix and a single-level ranking; the qualitative index is quantitatively valued through the expert consultation method; and the preventive maintenance measures are determined through the matrix calculation results.

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