Index Design of Urban Pavement Management based on AHP

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Abstract. In order to scientifically measure the management and law enforcement level of each section of the city and to build a comprehensive model of pavement management indicators, we use the key performance method and analytic hierarchy process to set up 11 first-level indexes and 43 second-level indexes. In this paper, through the development of urban pavement management evaluation program, to accurately measure the overall level of urban pavement management and regional distribution differences, to provide a theoretical basis for improving the level of urban pavement management and balanced regional development of the city.

1. Introduction
With the improvement of urbanization level in China, the responsibilities of urban pavement management are becoming more and more complex, which puts forward new requirements for the construction of urban management team and the requirements of law enforcement. How to refine and standardize the evaluation of urban pavement management level under the background of economic transformation is a new proposition and challenge for urban law enforcement.

Many scholars at home and abroad have conducted research on urban management. Darkhani et al. discussed the positive influence of landscaping on urban management, pointed out that it should decrease the deterioration and decline of urban green spaces in urban landscape [1]. Within the framework of numerical simulation and optimal control of partial differential equations, Vázquez-Méndez et al. conducted the mathematical modelling and optimal management of urban road networks, and put forward suggestions for improvement of urban management [2]. Osorio-Lird et al. applied Markov chains and Monte Carlo simulation to develop performance models for the management of urban pavement networks, it played an active role in the development of urban pavement management [3]. In order to address the multidimensional challenges involved in advancing the sustainability of pavement systems, Santos et al. discussed the capability of the proposed decision support system in a case study, and finally a multi-criteria decision analysis method was used to find the best compromise solution for pavement management [4].

There are also studies on urban management in China. Based on DEA and cluster analysis, Zhu and others evaluated the urban appearance and environmental hygiene in Anhui Province, pointing out that the urban environment was the important foundation of urban development, and the key to displaying the level of urban modernization and improving the comprehensive functions of the city [5]. Gao and others pointed out that environmental problems and resource waste caused by construction waste, such as occupying land, polluting water body, destroying city appearance,
seriously affected the in-depth development of circular economy in China, and put forward the main measures to reduce construction waste, which promoted the development of circular economy of construction waste[6]. This paper will draw on some indicators and emphases of the above literature, combines with the practice of urban management in China, and constructs an index model of urban pavement comprehensive management.

2. Construction of Pavement Management Performance Evaluation Index System

2.1. The ideas and principles of establishing index system
The establishment of the index system should follow the principle of scientific and feasibility and the principle of combination of qualitative and quantitative. According to the ideas and principles of the index system, and on the basis of extensive listening to the reports and suggestions of the citizens, city administrators, relevant experts and relevant media, the performance evaluation index system of road control and post management in Huanghelou Street, Wuchang District is established. It is including the 11 aspects: exposed garbage, sweeping and cleaning, illegal occupation, construction dregs, construction sites, landscaping, lake and water affairs, municipal facilities, facade environment, three guarantees, feeding and planting. It has built a total of 43 indicators. According to the needs of urban management and daily management experience, setting the assessment criteria of each index, such as Table 1.

| Evaluation project          | Evaluation items | Evaluation criteria                                                                 |
|-----------------------------|------------------|--------------------------------------------------------------------------------------|
| Exposed garbage(A1)         | Domestic garbage(B1) | There is no exposed domestic garbage in roads, back streets, residents of the community, township streets, along the highway and traffic window. |
|                             | Construction garbage(B2) | There is no exposed construction garbage in roads, back streets, residents of the community, township streets, along the highway and traffic window. |
| Sweeping and cleaning (A2)  | Garbage containers(B3) | Garbage containers are beautiful, neat, without stain or damage. No one or four garbage hook-arm truck containers, garbage cans or uncovered trash pools shall be placed on the main and secondary roads. |
|                             | Burning garbage(B4) | It is prohibited to burn leaves, garbage, straw, asphalt, felt, rubber, plastics, leather or other wastes in open-air sites, near trunk lines or in public garbage collection containers. |
|                             | Pavement cleaning(B5) | Roadways sidewalks and standing and lying stones should be cleaned regularly to keep the road clean, free of dirt, dust, oil and other dirt. |
|                             | Facility cleaning(B6) | Traffic guardrails, traffic signs, noise barriers, road brand, bus stop, newsstands, convenient bicycle shed, electrical boxes and other boxes, kiosks, sheds, viaducts, pedestrian bridges, underpass bridge, bridge body, roof, obstructed ball and other urban facilities should be cleaned regularly, to keep clean and have no dust. |
| Illegal occupation (A3)     | Business occupation(B7) | No urban roads, green belts, bridges, underground passages and other public places shall be occupied for processing and marketing food and beverage. Food and beverage shall not be processed and operated beyond doors and windows in street catering stores, nor shall they unauthorized occupy urban roads, green belts, bridges, underground passages and other public places to store goods, arrange stalls and sell goods. And operators of street stores shall not sell, operate or display commodities beyond doors or outside windows. |
|                             | Vehicle occupation (B8) | It is forbidden to wash and repair vehicles in public places such as urban roads and squares. And it is forbidden to use motor vehicles to sell all kinds of goods in main and secondary roads and window areas. |
| **Construction dregs** (A4)                          | **Occupation and encirclement** (B9) | The construction areas of store decoration, road maintenance and construction and all kinds of pipeline construction should be standardized. |
|-----------------------------------------------|----------------------------------|----------------------------------------------------------------------------------------------------------------------------------|
| **Barrier-free passageway** (B10)           |                                  | No facilities shall be set up on the barrier-free passageway, and no barrier-free passageway shall be encroached upon.               |
| **Non-motor vehicle** (B11)                  |                                  | Non-motor vehicles are lined at fixed points, placed neatly, and the front of the car is consistent.                              |
| **Mud-free transportation** (B12)            |                                  | Dregs transport vehicles transport without mud.                                                                               |
| **Transport process** (B13)                  |                                  | Dregs transport vehicles are not over-high, over-limit or over-load.                                                            |
| **Pavement pollution** (B14)                 |                                  | No dregs pollution on the pavement.                                                                                             |
| **Pile dregs** (B15)                         |                                  | There is no construction dregs dumping pile on both sides of the road within sight.                                          |
| **Flushing facilities** (B16)                |                                  | Unearthed site has washing facilities.                                                                                         |
| **Ground hardening** (B17)                   |                                  | The entrance and exit of construction site has hardening ground.                                                                |
| **Standardize encirclement** (B18)           |                                  | The construction site and the municipal engineering regulations shall be fenced. The enclosure shall be made of hard materials with a height of not less than 1.8 m. And the height of the stacking materials and construction waste on the inside of the construction enclosure shall not exceed the top of the enclosure. |
| **Fence condition** (B19)                    |                                  | The fence of construction site should be intact without damage. And it should be regularly cleaned and have no obvious stains.   |
| **Civilized construction** (B20)             |                                  | It is strictly forbidden to pile up construction materials and debris outside the construction wall. There is no dust and sewage around the construction site. |
| **Bare soil in the construction site** (B21) |                                  | Bare soil should use dust-proof screen or have simple plant greening coverage.                                                 |
| **Waste garbage** (B22)                      |                                  | There is no exposed garbage in the park, green belt of the city. And there should be clean and have no waste.                  |
| **Vegetation cleansing** (B23)               |                                  | The green leaves of the trees are clean and there is not covered with serious dust.                                            |
| **Garden facilities** (B24)                  |                                  | The green station stone, tree hole cover and other facilities are intact.                                                      |
| **Bare soil in the green belt** (B25)        |                                  | There is no exposed loess in the green belt and tree cave.                                                                      |
| **Civilized work** (B26)                     |                                  | Garden construction specifications should be rounded up, the work is civilized, and the job site is cleaned up in time.        |
| **Road waterlogging** (B27)                  |                                  | There is no obvious waterlogging in the road.                                                                                |
| **Civilized work** (B28)                     |                                  | The land construction specifications should be rounded up and the operation site should be timely cleaned up.                 |
| **Cover condition** (B29)                    |                                  | If the well cover or trench cover is damaged, displaced or lost, an obvious warning sign shall be set up.                    |
| **Road damage** (B30)                        |                                  | There is no apparent damage, subsidence and fracture on municipal roads and bridges, so it has no impact on vehicles and pedestrian traffic. |
| **Step brick condition** (B31)               |                                  | Stepping bricks and standing and lying stones are in good condition without defect, damage, subsidence and fracture loosening. |
| **Stumble pile** (B32)                       |                                  | The road is smooth without stumbling pile.                                                                                  |
| **Pedestrian ramp** (B33)                    |                                  | It is forbidden for merchants of all units to set up ramps with concrete, wood, steel and other materials in the stone pavement of the sidewalk station. |
| **Facilities in good condition** (B34)       |                                  | Other facilities such as bus stops, traffic guardrails, newspaper reading rails, lamp poles, city sculptures, seats, stuck piles and balls are intact and undamaged. |
| A9 | Illegal advertisement(B35) | Building advertisement: there is no illegal advertisement for the facade of the street building. Cottage signage: no signs can be set for operating stores. Pole advertising: do not use streetlight poles to set up business advertisements. Promotional banner: there is no non-publicity banner without violation settings. |
|---|---|---|
| B36 | Disordered hanging | It is forbidden to dry and hang items on public facilities such as guardrails, street trees, green belts, and street signs in urban roads and other public places. |
| B37 | Signboard compliance | One shop and one brand should be used for the establishment of front-facing signs. The top of the sign must be 50 cm below the bottom line of the second floor window or level with the bottom of the second floor balcony. If the front-facing signs are painted and the font is incomplete, they should be repaired or replaced. |
| B38 | Wall and window cleansing | Regularly cleaning store windows and the wall, and keep it clean and tidy. Commercial stores shall not depict and propagate at random. |
| B39 | Overhead pipeline | The overhead cable of electric power, telecommunications, cable television and network communication should be standardized and orderly. |
| B40 | National flag management | The national flag shall be hung in a prominent position, and placed at the center of a higher or prominent position. And the national flag shall not be damaged, defiled, faded or substandard. |
| B41 | Illegality and disorder | There is no graffiti writing, posting and depicting on the road walls, gates and public facilities. And there is no illegal distribution of small business card in the streets of primary and secondary roads. |
| B42 | Three guarantees | There is no illegal operation in the area of three guarantees. And responsible person should sign the three guarantees. |
| A11 | Feeding and planting | Shall not raise poultry and livestock and occupy space to grow vegetables. |

2.2. The setting of index weight

Through Delphi method prediction and interviews with citizens, city administrators and relevant experts, combined with field research in some cities of China, the relevant importance of each factor was determined.

The combined weight is calculated from each individual indicator according to the weight, and the calculation procedure is as follows. Take the first combination as an example: The first step is to calculate the product of each line of the judgement matrix $A$.

$$M1=2, M2=0.5.$$  

The second step, calculate $M_i$ to open $n$ times: $P_i = \sqrt[4]{M_i}$, $P_2 = \sqrt{0.5}$. The third step, the vector $P$ is normalized, deriving $w = (0.6, 0.33)$. The fourth step is consistency test, deriving the maximum characteristic value: $\lambda_{max} = \sum_{i=1}^{4}(AW)_{ii} = 0.665$. The fourth step is consistency test, deriving the maximum characteristic value: $\lambda_{max} = \sum_{i=1}^{4}(AW)_{ii} = 0.665$. The consistency index is: $CI=0.0011$, $CR=0.011$ (second order need not be modified) <0.1 (passing inspection). Here are the final results of some combinations, for example: judgment matrix A6–B26, judgment matrix A8–B34 and judgment matrix A9–B41, and other combinations proceed in the same way.

(1) Judgment matrix A6–B26. (Compared with the case of target of landscaping A6, the relative importance of criterion layer of B22, B23, B24, B25 and B26 is shown on Table 2).

| A6 | B22 | B23 | B24 | B25 | B26 | W |
|---|---|---|---|---|---|---|
| B22 | 1 | 5 | 5 | 2.5 | 1 | 0.557 |
| B23 | 1.05 | 1 | 1 | 1/2 | 1/5 | 0.071 |
| B24 | 1.05 | 1 | 1 | 1/2 | 1/5 | 0.071 |
| B25 | 0.4 | 2 | 2 | 1 | 0.4 | 0.144 |
| B26 | 1 | 5 | 5 | 2.5 | 1 | 0.557 |

$\lambda_{max} = 5.001, CI = (5.001-5)/4=0.0003, CR=0.0003/1.12=0.0003 < 0.1$. 

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Note: Table 2. Judgment matrix A6–B26.
(2) Judgment matrix A8–B34. (Compared with the case of target of A8, the relative importance of criterion layer of B29, B30, B31, B32, B33 and B34 is shown on Table 3).

(3) Judgment matrix A9–B41. (Compared with the case of target of A9, the relative importance of criterion layer of B35, B36, B37, B38, B39, B40 and B41 is shown on Table 4).

Table 3. Judgment matrix A8–B34.

| Ai   | B29 | B30 | B31 | B32 | B33 | B34 | W     |
|------|-----|-----|-----|-----|-----|-----|-------|
| B29  | 1/3 | 4/3 | 3   | 1   | 2   | 0.187|
| B30  | 3/4 | 1   | 3/4 | 3/4 | 1.5 | 0.103|
| B31  | 1/3 | 1   | 1   | 1   | 2   | 0.138|
| B32  | 6   | 1/2 | 2/3 | 1/2 | 1/2 | 0.069|

\[ \lambda_{max} = 6.001 \quad CI = (6.001 - 6)/5 = 0.0002 \quad CR = 0.0002/1.24 = 0.0002 < 0.1. \]

The above results indicate that the judgment matrix satisfies the consistency check.

2.3. Index weight optimization of pavement management evaluation system

The pavement control post performance appraisal system is optimized by performance prism. In the process of optimizing the design, the Work Attitudes Index and the Negative Index were introduced to reflect the principle of people-oriented. Comprehensive and complete pavement management performance evaluation index system and its weight are shown on Table 5.

Table 5. Pavement performance evaluation index system and its weight.

| Evaluation project          | weight | Evaluation items          | Hierarchical single sorting weight | Hierarchical total ranking weight |
|-----------------------------|--------|---------------------------|------------------------------------|----------------------------------|
| Exposed garbage(A1)        | 0.054  | Domestic garbage(B1)      | 0.670                              | 0.036                            |
|                             |        | Construction garbage(B2)  | 0.330                              | 0.018                            |
| Sweeping and cleaning(A2)  | 0.100  | Garbage containers(B3)     | 0.140                              | 0.014                            |
|                             |        | Burning garbage(B4)        | 0.430                              | 0.043                            |
|                             |        | Pavement cleaning(B5)      | 0.290                              | 0.029                            |
|                             |        | Facility cleaning(B6)      | 0.140                              | 0.014                            |
| Illegal occupation(A3)     | 0.064  | Business occupation(B7)    | 0.243                              | 0.0156                           |
|                             |        | Vehicle occupation(B8)     | 0.243                              | 0.0156                           |
|                             |        | Occupation and encirclement(B9) | 0.243                           | 0.0156                           |
|                             |        | Barrier-free passageway(B10) | 0.243                          | 0.0156                           |
| Construction dregs(A4)     | 0.108  | Non-motor vehicle(B11)     | 0.028                              | 0.0016                           |
|                             |        | Mud-free transportation(B12) | 0.375                           | 0.040                            |
|                             |        | Transport process(B13)     | 0.375                              | 0.040                            |
|                             |        | Pavement pollution(B14)    | 0.125                              | 0.014                            |
|                             |        | Pile dregs(B15)            | 0.125                              | 0.014                            |
| Construction sites(A5)     | 0.295  | Flushing facilities(B16)   | 0.267                              | 0.079                            |
|                             |        | Ground hardening(B17)      | 0.267                              | 0.079                            |
|                             |        | Standardize encirclement(B18)| 0.133                         | 0.039                            |
|                             |        | Fence condition(B19)       | 0.067                              | 0.020                            |
|                             |        | Civilized construction(B20)| 0.133                              | 0.039                            |
|                             |        | Bare soil in the construction site(B21)| 0.133                      | 0.039                            |
| Landscaping(A6)            | 0.110  | Waste garbage(B22)         | 0.357                              | 0.039                            |
|                             |        | Vegetation Cleansing(B23)  | 0.071                              | 0.008                            |
|                             |        | Garden facilities(B24)     | 0.071                              | 0.008                            |

The above results indicate that the judgment matrix satisfies the consistency check.
### Table 1: Urban Road Management Indicators

| Indicator                          | Value 1 | Value 2 |
|-----------------------------------|---------|---------|
| Bare soil in the green belt(B25)  | 0.144   | 0.016   |
| Civilized work(B26)               | 0.357   | 0.039   |
| Road waterlogging(B27)            | 0.670   | 0.313   |
| Civilized work(B28)               | 0.330   | 0.157   |
| Lake and water affairs(A7)        | 0.047   |         |
| Municipal facilities(A8)          | 0.128   |         |
| Cover condition(B29)              | 0.414   | 0.053   |
| Road damage(B30)                  | 0.138   | 0.018   |
| Step brick condition(B31)         | 0.103   | 0.013   |
| Stumble pile(B32)                 | 0.138   | 0.018   |
| Pedestrian ramp(B33)              | 0.138   | 0.018   |
| Facilities in good condition(B34) | 0.069   | 0.008   |
| Facade environment(A9)            | 0.078   |         |
| Illegal advertisement(B35)        | 0.150   | 0.012   |
| Disordered hanging(B36)           | 0.100   | 0.008   |
| Signboard compliance(B37)         | 0.150   | 0.012   |
| Wall and window cleansing(B38)    | 0.100   | 0.008   |
| Overhead pipeline(B39)            | 0.250   | 0.018   |
| National flag management(B40)     | 0.150   | 0.012   |
| Illegality and disorder(B41)      | 0.100   | 0.008   |
| Three Guarantees(B42)              | 1.000   | 0.008   |
| Feeding and planting(B43)         | 1.000   | 0.008   |

### 3. Conclusion

Previously, most domestic and foreign scholars focused on one aspect of urban management research. In this research, through the use of key performance assessment method and analytic hierarchy process, the road comprehensive management index model is constructed, and 11 first-level indicators and 43 second-level indicators are established. The results of this study show that construction sites, landscaping, municipal facilities and sanitation play a very important role in urban pavement management. Urban managers should increase the management of important indicators such as construction sites and landscaping on the basis of comprehensive management of the city. It provides a new theoretical basis for improving the level of urban road management and regional balanced development.

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