APPLICATION OF GREY-RELATED DECISION-MAKING METHODS TO THE EVALUATION OF ROAD PERFORMANCE FOR HIGH-GRADE HIGHWAY BASE MATERIALS

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ABSTRACT

This paper introduces the grey-related decision-making methods to the evaluation of road base materials for the purpose of providing more objective and scientific basis to the selection of high-grade highway base materials and the bettering of designs.

Keywords: Base materials Grey-related Decision-making Methods Lime Flying-ash crushed stone

1. GENERAL DESCRIPTION

The strength and weakness of road base depend on the road performance, and also greatly influence the strength of asphalt pavement, the quality and life of road performances. Therefore, the road base materials, in addition to their sufficient strength and rigidity, should also possess the anti-washing, anti-cracking and anti-fatigue performances. However, different road base materials make rather different performances on different targets, and sometimes they are very contradictory. Even the same material, due to its different gradations and proportioning, may perform differently. If a better road base material is to be selected, all the targets of its comprehensive road performances should be taken into consideration so that it can behave better comprehensively. Here, the evaluation problem for so many targets in the system is given rise to. Now, there do exist a lot of evaluation methods, such as weighted averages method, efficiency coefficient method and primary-secondary consideration method. However, before the application of these methods, all the targets must be under dimensional equation. Usually some subjective factors may get involved in it. Accordingly, the grey-related decision-making method is adopted in this paper to evaluate the multi-targets and multi-factors of road base materials in the hope of obtaining more objective results.

2. APPLICATION OF THE GREY-RELATED DECISION-MAKING METHOD TO THE EVALUATION OF ROAD BASE MATERIAL PERFORMANCES

The anti-washing, anti-fatigue and anti-cracking performances of road base materials such as lime flying-ash crushed stone in different gradations often behave greatly. In order to conduct comprehensive evaluation for their road performances and work out better road base materials to meet the needs of different climate conditions, different traffic situation, and different road grades, types and structures, lime flying-ash crushed stone is taken as a system to conduct comprehensive evaluation with the help of the anti-washing, anti-cracking and anti-fatigue performances. The following table lists the testing results on road performances of 6 different gradations lime flying-ash crushed stone.

Table 1. Testing results on road performances of lime flying-ash crushed stone.

Gradation	Anti-washing property (28d)	Anti-fatigue property (90d)	Anti-cracking property	
	5min washing ratio(g/min)	Stress level at 10^6 (Mpa)	Average temperature shrinkage (28d) (10^{-6}/℃)(60℃ -30℃)	Average dry shrinkage (7d) (10^{-6})
I	1.21	0.5163	11.59	35.30
II	1.08	0.4970	13.64	28.07
III	2.53	0.3307	11.25	43.10
IV	7.88	0.4436	16.67	34.57
V	4.23	0.4736	9.38	25.68
VI	7.38	0.4290	13.37	37.52

(1) If the road performances of lime flying-ash crushed stone are taken as event a_1, the event collection $A = \{a_1\}$. Hence, the gradation I is b_1, that gradation II is b_2, …., and that gradation VI is b_6. Therefore the total event collection $B = \{b_1, b_2, b_3, b_4, b_5, b_6\}$.

Hence: $S = \{S_{ij} = (a_i, b_j) \mid a_i \in A.\ b_j \in B\}$
$= \{S_{11}, S_{12}, S_{13}, S_{14}, S_{15}, S_{16}\}$

Here, anti-washing performance in 28 days is taken as target 1, anti-fatigue performance (corresponding stress in 10^6 loading circle) is taken as target 2, temperature shrinkage (average temperature shrinkage coefficient) is taken as target 3, and dry shrinkage (average shrinkage coefficient) is taken as target 4.

(2) Result order under target K (average) $U^{(k)}$ (K = 1, 2, 3, 4):

$U^{(1)} = (0.3, 0.27, 0.62, 1.95, 1.04, 1.82)$
$U^{(2)} = (1.15, 1.11, 0.74, 0.99, 1.06, 0.96)$
$U^{(3)} = (0.92, 1.08, 0.89, 1.32, 0.74, 1.06)$
$U^{(4)} = (1.02, 0.81, 1.25, 1.00, 0.75, 1.16)$

(3) From the above results, the result vector of S_{ij} can be U_{ij} (i= 1; j = 1, 2, …, 6,)

$U_{11} = (0.30, 1.15, 0.92, 1.02)$
$U_{12} = (0.27, 1.11, 1.08, 0.81)$
$U_{13} = (0.62, 0.74, 0.89, 1.25)$
$U_{14} = (1.95, 0.99, 1.32, 1.00)$
$U_{15} = (1.04, 1.06, 0.74, 0.75)$
$U_{16} = (1.82, 0.96, 1.06, 1.16)$

(4) The best result vector: as the material has anti-washing performance, the less the washing ratio, the better. Hence: $u^{(1)}_{i0j0} = \min_{\substack{i=1\\1\le j\le 6}}\{u^{(1)}_{ij}\} = 0.27$; as the material has the anti-fatigue performance, the greater the stress corresponding to 10^6, the better. Hence: $u^{(2)}_{i0j0} = \max_{\substack{i=1\\1\le j\le 6}}\{u^{(2)}_{ij}\} = 1.15$; as the material has the temperature shrinkage performance, the smaller the total average temperature shrinkage coefficient, the better. Hence; $u^{(3)}_{i0j0} = \min_{\substack{i=1\\1\le j\le 6}}\{u^{(3)}_{ij}\} = 0.74$; as the material has the dry shrinkage performance, the smaller the average dry shrinkage coefficient, the better. Hence; $u^{(4)}_{i0j0} = \min_{\substack{i=1\\1\le j\le 6}}\{u^{(4)}_{ij}\} = 0.75$; hence the most ideal result vector $u_{iojo} = (0.27, 1.15, 0.74, 0.75)$.

Through calculation the absolute grey related degree ε_{ij} (i = 1; j = 1, 2, …, 6)of u_y and $U_{iojo,}$
$\varepsilon_{11} = 0.948$, $\varepsilon_{12} = 0.932$, $\varepsilon_{13} = 0.788$, $\varepsilon_{14} = 0.560$, $\varepsilon_{15} = 0.599$, $\varepsilon_{16} = 0.562$.

From the above calculation, the orders of the comprehensive performances (anti-washing, anti-cracking and anti-fatigue) of different lime flying-ash crushed stone gradations are:
I > II > III > IV > V > VI.

In the above example, the four targets are treated equally. However, in practice, we may take different attention to each target. In this case, every target has different weight respectively:
η_k (k = 1, 2, 3, 4). Hence, the result order under target k is $\eta_k \mu^{(k)}$.

3. CONCLUSIONS

The application of grey-related decision-making method to the multi-targets evaluation of road base materials is a simple and practical one. With it, the subjective influence in the evaluation can be greatly reduced, and it can also provide more scientific basis for the better design of road materials.

4. REFERENCES

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