COMPREHENSIVE EVALUATION OF FREEWAY SURFACE CONDITIONS BASED ON USER'S SATISFACTION

Abstract: A road generally has a variety of characteristics and there are several elements which diversely affect the traffic safety and pleasantness and service expenses, etc. in time of operation. Among several elements, the evenness indicating the condition of a road surface not only operates as a determinant controlling a rough or smooth ride but it also gives a considerable effect on safety concerns.

This research is aimed at comprehensively evaluating the condition of a road surface of a highway in consideration of its users. This research conducted an overall evaluation of a road surface condition by adding qualitative data, or a driver's evenness to the existing quantitative elements, whereas the existing research put its focus on a correlation analysis with quantitative factors and qualitative factors through a statistical method.

As for an evaluation method, this research conducted an overall evaluation by using Gray System Theory which makes possible an integrated evaluation.

The analyzed data on the influence of data value observed by comprehensively evaluating a variety of elements could be used as a secondary means of the decision-making process in relation to road maintenance.

Key Words: Gray System Theory, roughness, User's Satisfaction, Freeway Surface Conditions

1. Research background and objective

Generally, a road not only is an important means to accommodate the flow and safety of vehicles, but also changes the travel type of drivers depending on various geometrical conditions, road surface conditions, and traffic operation situations. Of them, the road surface conditions (evenness, etc.) not only act as a critical factor to control the comfortableness of car users, but also have a considerable effect on traffic safety. These road surface conditions and road evenness can cause problems in car safety as their conditions are inferior, and have a higher possibility to be connected to a big accident when a serious problem such as tire damage, etc. takes place, increasing social costs.
Especially, a highway has characteristics such as heavy traffic and long distance high speed travel, so it is very important to control and maintain the evenness of road surfaces. According to the improvement of customer satisfaction levels through improving the evenness of road surfaces, 2007 internal data of Road Office of Korea Expressway Corporation, the road surface conditions are the most important factor except for recent traffic information among the measurable indices and importance of highway user satisfaction levels (See Fig. 1).

![Fig.1: Customer satisfaction index and importance by road surface conditions](image)

Such indices to indicate the evenness of a highway include IRI, QI, PrI, PSI, etc., and the index used to measure and judge the evenness of a highway currently in our country is IRI, an international standard. IRI (International roughness index) is professionally called an average rectified slope, an average of rectified slopes at each data point (or level point) read in a reference interval, whose unit is m/km (mm/m) or in/mi. Currently, Korea Expressway Corporation wants to maintain and control the evenness of a road surface above a certain level in order to enhance the satisfaction and safety of highway users, whose reference is shown in Table 1.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Range</th>
<th>Evaluation</th>
<th>Condition</th>
<th>Control plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.5 or less</td>
<td>Very excellent</td>
<td>Security of pleasant driving comfortableness</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>1.5 ~ 2.5</td>
<td>Excellent</td>
<td>Good driving comfortableness</td>
<td>Preventive maintenance</td>
</tr>
<tr>
<td>3</td>
<td>2.5 ~ 3.5</td>
<td>Common</td>
<td>Reduction of driving comfortableness due to partial vibrations</td>
<td>Repair maintenance</td>
</tr>
<tr>
<td>4</td>
<td>3.5 ~ 5.0</td>
<td>Inferior</td>
<td>Feeling of uncomfortableness during travel</td>
<td>Improvement</td>
</tr>
<tr>
<td>5</td>
<td>5.0 or more</td>
<td>Very inferior</td>
<td>Necessity of speed reduction due to inferior travel property</td>
<td>Urgent improvement</td>
</tr>
</tbody>
</table>

Table 1 Highway evenness grade classification criteria

However, the method of measuring and evaluating the highway road surface conditions
currently in our country considers the factors of road infrastructure only, but doesn’t consider the satisfaction level of the drivers who actually use the road. The previous researches added correlation analysis between quantitative factors and qualitative factors, etc. through a statistical method, whereas this research aims to evaluate road surface conditions using a grey system theory enabling synthetic evaluation including qualitative data, a driver satisfaction level for road surface conditions, in the previous quantitative factors (See Fig. 2).

Fig 2: Research background and objective

2. Research execution method

This research is conducted in a total of 4 steps such as investigation of related literature, evaluation methodology and case study, conclusion, and future research plans. The investigation of related literature reviews difference from this research by reviewing data on evenness measurement and evaluation through the review of domestic and overseas literature, and the evaluation methodology and case study conducts synthetic evaluation at the investigation point through a grey system theory, a theoretical basis for synthetic evaluation to be used in this research (including user satisfaction levels). Finally, it is supposed to discuss the meaning, future research challenge, etc. of synthetic evaluation by comparing it with the previous evaluation (IRI) method.

3. INVESTIGATION OF RELATED LITERATURE

3.1 Investigation of Domestic Literature

Domestic literature mainly realizes the evaluation to measure and control the evenness of a road.

Seong-Ho Kim et al. (2001) measured the evenness of Jungbu Highway using a piece of investigation equipment, ARIA (Automated Road Image Analyzer), and researched its
features. As a result, they analyzed the evenness between CRCP (Continuously Reinforced Concrete Pavement) and JCP (Jointed Concrete Pavement) and figured out that the IRI in the CRCP section is excellent, and analyzed the correlation between surface defects (cracks) and IRI in a 1km section and examined that JCP (Jointed Concrete Pavement) has a correlation with cracks.

Gook-Han Kim et al. (2002) compared and analyzed the measurement error of IRI and PrI evenness and clarified that the kinds of measurement equipment can have an effect on errors, in their research on the correlation between evenness indices IRI and PrI.

Hyung-Chul Mun et al. (2008) analyzed the pavement condition of 3 factors such as cracks, plastic deformation and longitudinal evenness, general evaluation factors of asphalt pavement, based on Seoul and other city’s road pavement investigation data in the pavement evaluation index development of paved roads of the cities, and developed pavement evaluation indices necessary for making a decision to maintain city’s roads.

3.2 Investigation of Overseas Literature

In United States, researches on road surface evenness have been actively conducted since 1960s by AASHO (American Association of Highway Officials). As a researcher who tried to measure and evaluate evenness considering road users for the first time, Nakamura and Michael (1963) at Purdue University carried out researches for 30 persons at the sixty test sections (within 40-mile radius) located at Lafayette, Indiana. The investigation result showed that the important factors are pavement conditions, evaluators, and relationships between pavement and experimenters, and that the unimportant factors are pavement types, evaluator types, and relationships between pavement types and evaluators.

Nair, Hudson and Lee (1985) of University of Texas at Austin conducted a research to expand the researches of Carey and Irick by verifying the conception of pavement availability, and developed a formula to predict durability using a linear recursion formula, which includes evenness indices reflecting the recognition reactions of road users and the change according to expectations as a model considering drivers.

Kevan Shafizadeh, Fred Mannering, and Linda Pierce (2002) examined the evenness of road surfaces by dividing each highway into 2,180 sections for 56 experimenters in order to analyze the evenness of road surfaces and the property of users, and compared and analyzed the physical evenness values of roads and the comfortableness (evenness) values of users. Their research result showed that the important factors are IRI, car noises, travel speed, maintenance duration, road use familiarity by dividing the variables having a deep relationship with road surface evenness into important factors and unimportant factors.

3.3 Summary and Difference from this Research

As a result of reviewing domestic and overseas literature, domestic literature showed insufficient efforts to synthetically evaluate the road surface conditions by considering user satisfaction levels, and overseas literature showed researches on the effect of driver properties on some passengers by measuring various variables of roads and selecting factors affecting evenness. However, the previous researches have a limit of being unable to reflect user’s opinion enough in order to evaluate and control roads, and being unable to consider various factors of road evenness. So this research aims to synthetically evaluate the road surface condition of highways by considering user satisfaction levels along with the major evaluation indices that have been utilized from the past.
case study via investigation points and analysis methodology

4. Investigation Items and Contents by Investigation Points and Evaluation Indices

The investigation point executed in this research is the Seochang~Ansan section on the Youngdong Highway, which was selected based on the following conditions, the investigation routes and sections being shown in Fig.3:

- Does the object route hold various pavement conditions?
- Are there high traffic volume and many users?
- Is it possible to investigate various conditions by selecting as long a route as possible?
- Including other considerations such as route extension, traffic volume (passenger cars and large cars), opening year, etc.

The selection of evaluation indices is very important for the execution of synthetic evaluation, so this research took into account the indices to indicate the road surface conditions through the previous literature investigation first of all, and added some investigation items for users. Especially, this research took a look at the possibility that evaluation indices can be grouped according to the grey category criterion, judged whether it can be indicated as good or bad, and selected it as shown in Table 2 below finally.

<table>
<thead>
<tr>
<th>Division</th>
<th>Section (unidirectional)</th>
<th>Number of lanes (bidirectional)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seochang~Ansan</td>
<td>18.0km</td>
<td>8,6</td>
</tr>
<tr>
<td>Ansan~Shingal</td>
<td>23.8km</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>41.8km</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 2  Evaluation index selection criterion

<table>
<thead>
<tr>
<th>Division</th>
<th>Criterion</th>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Road surface condition evaluation index used in the previous literature</td>
<td>IRI, surface damage rate</td>
</tr>
<tr>
<td>2</td>
<td>Evaluation index available in synthetic evaluation</td>
<td>Noise, user satisfaction level</td>
</tr>
<tr>
<td>3</td>
<td>Index with clear reference setting of observation values</td>
<td>IRI, surface damage rate, noise, user satisfaction level</td>
</tr>
</tbody>
</table>

Investigations to collect data by evaluation indices were conducted on 20th July ~ 14th August 2009, weekdays except for weekends. Investigation time was clear daytime. Total investigators were 30 persons: 24 male drivers and 6 female drivers, most of whom are male. User satisfaction levels were divided into 1 to 5 depending on the road surface conditions of
the driving sections: 1 is the best condition and 5 is the worst condition. It was also investigated whether the evenness is allowable for a driver to drive (200m interval).

4.1 Analysis Methodology: Gray System Theory (GST)

The grey system theory to be use in the integrated evaluation methodology of this research is a theory proposed by Julong Deng in China in 1982, is a method used to execute diagnosis and trend predictions depending on irregular sight series data and the past and present conditions, and strives for the synthetic evaluation of quantitative and qualitative items based on evaluation indices used in vehicle and pedestrian environments for the pedestrian sections in the domestic road traffic field (Jin-Gak Lee, 2009). This theory shows a similar type to the fuzzy theory, and has a conception of the category (black) containing the actually observed or measured data (Whitening Value). Therefore, this has an advantage to deal with uncertain information, and a point relatively different from the fuzzy theory in that a standardized value can be converted or evaluated between variables (indices) with different scales. The gray system theory has a gray value existing within the range of minimum value and maximum value first of all, which can be expressed by Eq. (1) as follows:

$$\Xi \in [\underline{\Xi}, \overline{\Xi}]$$  \hspace{1cm} (1)

where $\underline{\Xi}$ is minimum value and $\overline{\Xi}$ is maximum value.

Besides, let the observed or determined value (Whitening Number) be $\hat{\Xi}$, it can be express by Eq. (2) as follows:

$$\Xi \in [\underline{\Xi}, \overline{\Xi}]$$ \hspace{1cm} (2)

The observed value can be expressed with matrices by categories depending on gray clustering (groups), which can be largely divided into 3 groups as follows:

1. Group for the object (section, point, etc.) to evaluate (k, k=1, 2, ..., n)
2. Item group for the selected evaluation indices (e.g.: V/C, speed, accident numbers, etc., i(i=1, 2, ..., m)
3. Gray category group to evaluate superiority or inferiority (e.g.: excellent, good, medium, poor, etc., j(j=1, 2, ..., p))

4.2 Grey System Theory Evaluation Steps via Case Study

4.2.1 Step 1: Standardization of evaluation index units by grey categories

The selected indices can be expressed in terms of matrices by items as shown in Eq. (3), and standardized in terms of units by dividing the variable having maximum value among categories by each item value as shown in Eq. (4). Thus the varied maximum value becomes 1, and the variables by each category are converted into a weight value corresponding to it.
where the column indicates the evaluation index to evaluate and the row indicates the evaluation criterion for the evaluation index.

\[
\lambda_{ij} = \frac{\chi_{ij}}{m_{1} \leq i \leq m_{2}, \chi_{ij}} \quad \lambda = \begin{bmatrix} \lambda_{11} & \lambda_{12} & \cdots & \lambda_{1p} \\ \lambda_{21} & \lambda_{22} & \cdots & \lambda_{2p} \\ \vdots & \vdots & \ddots & \vdots \\ \lambda_{m1} & \lambda_{m2} & \cdots & \lambda_{mp} \end{bmatrix}
\]  

(4)

The evaluation indices selected in this research are set in terms of criteria and ranges depending on grey categories, and standardized in terms of indices: categories are divided into total 4 kinds such as excellent, good, medium and poor. Besides, the configuration of grey categories for each evaluation index was prepared based on domestic and overseas literature.

<table>
<thead>
<tr>
<th>Evaluation index</th>
<th>Grey Category</th>
<th>Excellent</th>
<th>Good</th>
<th>Medium</th>
<th>poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRI*</td>
<td></td>
<td>1.5</td>
<td>1.5~2.5</td>
<td>2.5~3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>User investigated value**</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Noise***</td>
<td></td>
<td>50</td>
<td>50~60</td>
<td>60~70</td>
<td>70</td>
</tr>
<tr>
<td>Surface damage rate****</td>
<td></td>
<td>2</td>
<td>2~5</td>
<td>5~10</td>
<td>10</td>
</tr>
</tbody>
</table>

Standardization of each category unit(step 1) has a matrix having maximum value 1 on the evaluation index as follows:

When standardizing unit of each category (stage 1), the following determinant will be obtained with 1 as maximum value of evaluation index:

\[
\lambda = \begin{bmatrix} 0.43 & 0.43 & 0.71 & 1.00 \\ 0.40 & 0.40 & 0.60 & 1.00 \\ 0.71 & 0.71 & 0.86 & 1.00 \\ 0.20 & 0.20 & 0.60 & 1.00 \end{bmatrix}
\]  

(5)

To make a functional formula needed to develop evaluation methods by category, minimum value of evaluation index will be expressed as 0. When the determinant is recomposed based on minimum to maximum range for each Grey Category, the following determinant is obtained.
Stage 2: Matrix of observed data and standardization of unit

In Stage 2, unit of evaluation indices of subjects or sections will be standardized. When expressing the observed data with $D = \{d_{11}, d_{12}, \cdots, d_{m1}, d_{12}, \cdots, d_{m2}, \cdots, d_{mn}\}$, it can standardize the unit by item as shown in Eq. (4).

$$D = \begin{bmatrix} d_{11} & d_{12} & \cdots & d_{1n} \\ d_{21} & d_{22} & \cdots & d_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ d_{m1} & d_{m2} & \cdots & d_{mn} \end{bmatrix}$$ \hspace{1cm} (6)

$$d_{ki}^\theta = \frac{d_{ki}^l}{\max_{1 \leq i \leq m} \{d_{i1}^l, d_{i2}^l, \cdots, d_{in}^l\}} \hspace{1cm} (7)$$

$$D = \begin{bmatrix} d_{11} & d_{12} & \cdots & d_{1n} \\ d_{21} & d_{22} & \cdots & d_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ d_{m1} & d_{m2} & \cdots & d_{mn} \end{bmatrix}$$ \hspace{1cm} (8)

In the matrix, the column indicates the number of objects or points to evaluate, and the row indicates the number of evaluation indices. The Table 4 and Table 5 below show the observed values and the unit-standardized values depending on the grey evaluation.

<table>
<thead>
<tr>
<th>Table 4</th>
<th>Observed values by evaluation indices and sections(example)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Division</td>
<td>IRI</td>
</tr>
<tr>
<td>---------</td>
<td>-----</td>
</tr>
</tbody>
</table>

1398
Table 5: Standardization of observed values by evaluation indices and sections (example)

<table>
<thead>
<tr>
<th>Division</th>
<th>IRI</th>
<th>User satisfaction level</th>
<th>Noise</th>
<th>Surface damage rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.65</td>
<td>0.67</td>
<td>0.98</td>
<td>0.08</td>
</tr>
<tr>
<td>2</td>
<td>0.70</td>
<td>0.77</td>
<td>0.99</td>
<td>0.17</td>
</tr>
<tr>
<td>3</td>
<td>0.73</td>
<td>0.66</td>
<td>0.98</td>
<td>0.11</td>
</tr>
<tr>
<td>4</td>
<td>0.73</td>
<td>0.61</td>
<td>0.98</td>
<td>0.17</td>
</tr>
<tr>
<td>5</td>
<td>0.54</td>
<td>0.51</td>
<td>0.98</td>
<td>3.99</td>
</tr>
<tr>
<td>6</td>
<td>0.67</td>
<td>0.55</td>
<td>0.97</td>
<td>0.10</td>
</tr>
<tr>
<td>7</td>
<td>0.63</td>
<td>0.64</td>
<td>0.98</td>
<td>0.12</td>
</tr>
<tr>
<td>8</td>
<td>0.53</td>
<td>0.62</td>
<td>0.98</td>
<td>0.03</td>
</tr>
<tr>
<td>9</td>
<td>0.67</td>
<td>0.63</td>
<td>0.98</td>
<td>0.12</td>
</tr>
<tr>
<td>10</td>
<td>0.79</td>
<td>0.76</td>
<td>0.98</td>
<td>0.20</td>
</tr>
</tbody>
</table>

4.2.3 Step 3: Definition of grey model functions and evaluation of grey categories

Step 3 calculates the standardized values by grey categories. At this time, the observed values are arranged by the functional formula depending on category ranges. In here, the observed values can be expressed with a functional formula $f_{y_i}(d_u)$ based on category range, and the observed values are divided into less than the minimum value, within each category range, greater than the maximum value, etc., which is expressed as <Table 4>. Besides, <Table 5> illustrates the functional formulae by grey categories of IRI among evaluation indices.

Table 6 Functional formula by grey categories

<table>
<thead>
<tr>
<th>Division</th>
<th>Functional formula</th>
<th>Division</th>
<th>Functional</th>
</tr>
</thead>
</table>

1399
4.2.4 Step 4: Calculation of weight values between evaluation indices and consideration of correlation

The calculation of weight values between evaluation indices is necessary to execute the synthetic and standardized evaluation for the evaluation object section. The calculated weight values are used as synthetic evaluation indices along with the values calculated through the grey functional formula in the previous step 3.

\[
\eta_y = \frac{\lambda_y}{\sum_{j=1}^{m} \lambda_j} = \frac{\lambda_y}{\lambda_1 + \lambda_2 + \cdots + \lambda_m} \quad (9)
\]

and

\[
\sum_{j=1}^{m} \eta_y = 1 \quad (10)
\]
\[ \sigma_{kj} = \sum_{i=1}^{m} f_{ij} (d_{ki}) \eta_{ij} \quad (11) \]

Step 4 calculates the weight values between evaluation indices to execute the standardized evaluation. The total score is calculated by multiplying the value calculated according to the grey functional formula by each evaluation index in Step 3. The Table 6 below calculates the weight values between the selected evaluation indices.

<table>
<thead>
<tr>
<th>( \eta )</th>
<th>Excellent</th>
<th>Good</th>
<th>Medium</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRI</td>
<td>0.246</td>
<td>0.246</td>
<td>0.267</td>
<td>0.250</td>
</tr>
<tr>
<td>User satisfaction level</td>
<td>0.230</td>
<td>0.230</td>
<td>0.225</td>
<td>0.250</td>
</tr>
<tr>
<td>Noise</td>
<td>0.410</td>
<td>0.410</td>
<td>0.321</td>
<td>0.250</td>
</tr>
<tr>
<td>Surface damage rate</td>
<td>0.115</td>
<td>0.115</td>
<td>0.187</td>
<td>0.250</td>
</tr>
<tr>
<td>-</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

4.2.5 Step 5: Selection of the maximum value among grey categories (total score calculation)

Array the values calculated via Eq.(10) in Step 4 by grey categories, and then use the highest score item among them as the synthetic evaluation index in that object section.

\[ \sigma_{i} = \{ \sigma_{k1}, \sigma_{k2}, \ldots, \sigma_{kp} \} \quad (12) \]

\[ \sigma_{ij} = \max_{1 \leq k \leq \rho} \{ \sigma_{ki} \} \]

\[ = \max_{1 \leq k \leq \rho} \{ \sigma_{k1}, \sigma_{k2}, \ldots, \sigma_{kp} \} \quad (13) \]

The finally calculated scores have a value between 0 and 1, and at this time the total sum of the scores by grey categories becomes 1. Of these values, the maximum value is taken as the final evaluation value for that object. As a result of synthetic evaluation for the total 72 sections between Shingal~Seochang on the Youngdong Highway, the object district for this research, of total 72 sections, 16 sections were analyzed as excellent category, 51 sections as medium category, and 5 sections as poor.

Table 9 Comparison of synthetic evaluation (example)

<table>
<thead>
<tr>
<th>Division</th>
<th>Excellent</th>
<th>Good</th>
<th>Medium</th>
<th>Poor</th>
<th>IR I</th>
<th>Evaluation</th>
<th>Division</th>
<th>Excellent</th>
<th>Good</th>
<th>Medium</th>
<th>Poor</th>
<th>IR I</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.1745</td>
<td>0.104</td>
<td>0.4554</td>
<td>0.266</td>
<td>2.2</td>
<td>Medium</td>
<td>6</td>
<td>0.2091</td>
<td>0.152</td>
<td>0.4371</td>
<td>0.201</td>
<td>2.3</td>
<td>Medium</td>
</tr>
<tr>
<td>2</td>
<td>0.1268</td>
<td>0.110</td>
<td>0.4232</td>
<td>0.339</td>
<td>2.4</td>
<td>Medium</td>
<td>7</td>
<td>0.1842</td>
<td>0.136</td>
<td>0.4335</td>
<td>0.245</td>
<td>2.2</td>
<td>Medium</td>
</tr>
<tr>
<td>3</td>
<td>0.1227</td>
<td>0.069</td>
<td>0.5290</td>
<td>0.279</td>
<td>2.5</td>
<td>Medium</td>
<td>8</td>
<td>0.2681</td>
<td>0.174</td>
<td>0.3335</td>
<td>0.223</td>
<td>1.8</td>
<td>Excellent</td>
</tr>
<tr>
<td>4</td>
<td>0.1193</td>
<td>0.101</td>
<td>0.5269</td>
<td>0.252</td>
<td>2.5</td>
<td>Medium</td>
<td>9</td>
<td>0.1578</td>
<td>0.113</td>
<td>0.4935</td>
<td>0.235</td>
<td>2.3</td>
<td>Excellent</td>
</tr>
</tbody>
</table>
And currently it is a medium score, but 45 sections occupy more than 20% of poor scores, which has a high possibility of moving toward poor scores at the current state, so it needs concentrated maintenance.

When comparing the result of using the maximum score (synthetic evaluation) with the IRI value, an existing evaluation index, there are sections which show differences between the IRI values and synthetic evaluation results. A total of 33 sections show different results, among which the number of sections of which synthetic evaluation results are lower than those of IRI values is 28.

To use these values when managing road surface, first of all, it is necessary to select sections to manage based on the synthetic evaluation results, and after that set sections which show relatively low scores compared to existing IRI values as secondary management section. Since indices which show higher values among evaluation indices have higher probability of change, it is necessary to pay attention to them through further comparison.

5. Conclusion and future research challenge

5.1 Conclusion

In order to make it available as a method for the improvement of the satisfaction for the users who use highways, the provision of a pleasant travel environment on the highway, and the maintenance of the road, this research investigated the user satisfaction level for the road surface conditions, and then carried out evaluation by sections by directly using it for the measurement of evenness by sections. The synthetic evaluation of road surface conditions considering road users is expected to be helpful for overcoming the limit of evenness evaluation methods for existing managers and maintaining the satisfaction level of drivers and passengers to a certain level by synthetically evaluating and judging the current road conditions. In addition, this is expected to be used as a auxiliary means to support determination for the judgment to control and maintain roads using this and to be useful for improving a maintenance system.

5.2 Future research challenge

This research conducted synthetic evenness evaluation to measure and reflect the road surface conditions considering users. This is an outcome realized in a situation that the evaluation of road surface conditions considering users is not yet researched in Korea, having a considerable meaning.

This research conducted user investigation partially, so it seems that experiments should be conducted by extending this and dividing vehicle properties and other various factors. And it is judged that a plan to prepare criteria for experiment, etc. should be prepared. Besides, seeking a plan to use this research in a research to predict the road pavement conditions and develop road maintenance as a method will be helpful for the maintenance of road surface in practice.

Finally, in Korea the research on road users and road surface evenness could not proceed actively, so it seems that researches on driver features and road surface correlation suitable for the domestic situations should be conducted. Positive researches are necessary through diversification of indices to enhance road efficiency, think of environments, and consider
users. It seems that user satisfaction levels should be enhanced and safe and convenient road maintenance should be realized by providing a more pleasant travel environment using this.

Reference

Journal
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