A STUDY ON ASSESSMENT OF EXPRESSWAY FOCUSSING ON LINK DESIGN

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Abstract: The aim of this paper is to build an expressway assessment system focussing on link design and to give a principle for expressways in Eastern Asia countries in the future. In the system, expressways are assessed from the two aspects of road utilization and route environment. The system can work as total assessment system after aspects, items in each aspect and indicators in each item are weighted. As computing each weight, the system uses AHP (Analytical Hierarchy Process) based on binary paired comparisons. We applied the system for expressways in Japan and in transportation developed countries (Great Britain, France, Germany and United States). The results indicate that the system is useful in assessing expressway and representing effect of road improving projects such as increasing lanes, tree planting, or developing pavement.

1. INTRODUCTION

In considering future road investment, there will be more debates concerning the level of road development in Eastern Asia countries including Japan compared with various European countries and the United States. This highlights the importance of establishing indicators for comparison and assessment and of providing the people with an expression of overall that will be more easily understood.

This research is targeting intercity expressways in order to formulate a system for the general assessment of link design by extracting the various factors that make up link design and appraising each factor separately. Moreover, the system will be used to assess the link design of Japan's expressways compared with expressways overseas and also for a sensitivity analysis to assess the impact of implementing measures to improve link design.

2. METHOD OF ASSESSMENT

Firstly this research will take the link design of expressways from the two aspects of road utilization and route environment, and items to be assessed and assessment indicators will be established for each aspect. At the same time, applying an analytic hierarchy process (AHP), each assessment item and assessment indicator will be weighted. In addition, the results of the weightings and assessment indicator data for each object category are used to make a general assessment of expressway link design.

The AHP is a decision-making technique for making various standard assessments under uncertain conditions. It has many applications including the determination of an order of priority for road development and the selection of pedestrian routes.

Complicated problems are first broken down into classes and the factors in each class are then made binary pared comparisons. Weightings between the factors in each class are determined by using the concept of characteristic values from the resulting comparison matrix. When the weightings between the factors in each class have been determined, the results are used to calculate weightings for all classes.

The comparison matrix is derived by means of questionnaire surveys, the weightings between each factor being calculated for each respondent. Consequently, the final weightings are obtained from the average values from all respondents. The more complicated the question, the greater the probability for inconsistent responses to the binary pared comparison. To overcome this problem, a consistency index is used to test for inconsistent responses and responses with a bad consistency index are excluded.

Figure 1 shows the flow of a general assessment with respect to the link design of an intercity expressway.

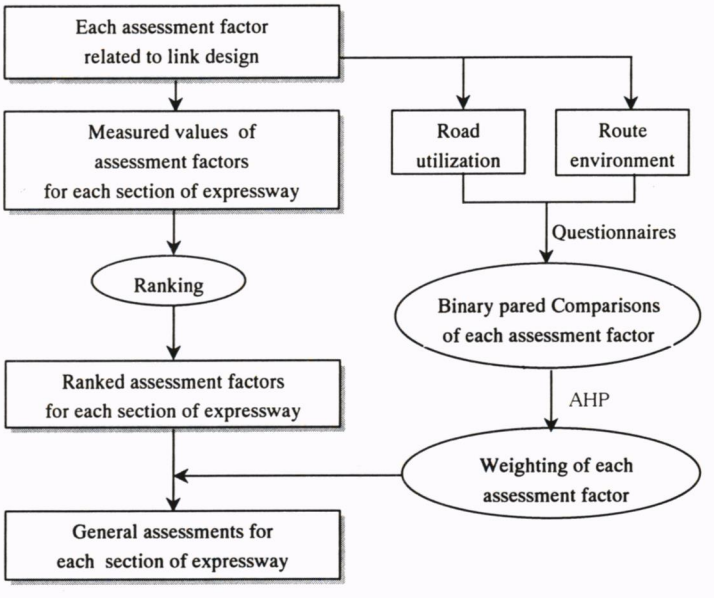


Figure 1. Assessment flow

3. ITEMS TO BE ASSESSED

3.1 Outline

In this research, the two aspects of road utilization and route environment are considered in assessing the link design of an intercity expressway. However, uninhabited flat land and mountainous land along the route is regarded as not being affected economically with respect to residents and is given the highest ranking for route environment.

According to the idea mentioned above, it is necessary to define each item to be assessed with respect to link design of road utilization and route environment.

The three items based on road utilization are consisted of convenience, safety and comfort. However, in order to assess appropriately the link design of road utilization, it is important to define independently the contents of each three items. Therefore, in this research, each three item is defined from different psychological utility of drivers of convenient, safety and comfort. Convenience means psychological utility of drivers for traveling at constant high speed and operation without concern for braking. Safety means psychological utility of drivers for worry-free travel or no traffic accidents. Comfort means visual and psychological utility of drivers for road facilities, for example, wide lanes or road side greening. By reason of these different utilities of drivers, that is to say, each three item is independent with others.

The three items to be assessed with respect to route environment are scenery, noise and district separation. Scenery means visual utility of roadside inhabitants for road facilities. Noise means auditory utility of inhabitants for no traffic noise. District separation means psychological utility of inhabitants for no separation of districts.

Definitions of items to be assessed are shown in Tables 1 and 2.

Table 1. Items to be assessed under road utilization

Item	Definition
Convenience	- Enables travel at constant high speed (to arrive at destination on schedule) - Enables operation without concern for braking
Safety	- Worry-free travel - Worry-free entry and exit - Enables emergency stopping (wide shoulders) - Worry-free night travel (adequate lighting) - Worry-free wet travel (non-skid)
Comfort	- Wide lanes, multiple lanes - No sense of blockage or oppression (few tunnels, subways, canals) - Good visibility, field of view - Median strip and roadside greening

Table 2. Items to be assessed under route environment

Item	Definition
Scenery	- Uninhibited view from road - Beautiful structure - Route planting
Noise	- Residential areas sound insulated - Separated from residential areas
District separation	- District is not separated (narrow road, many crossings)

Figure 2 shows assessment indicators corresponding to each item to be assessed. Here the general assessment of intercity expressway link design is expressed as a 4-stage classification. Stage 1 corresponds to assessment aspects, Stage 2 corresponds to items to be assessed, Stage 4 corresponds to assessment indicators. Stage 3 classes have been introduced because of the many road utilization safety assessment indicators.

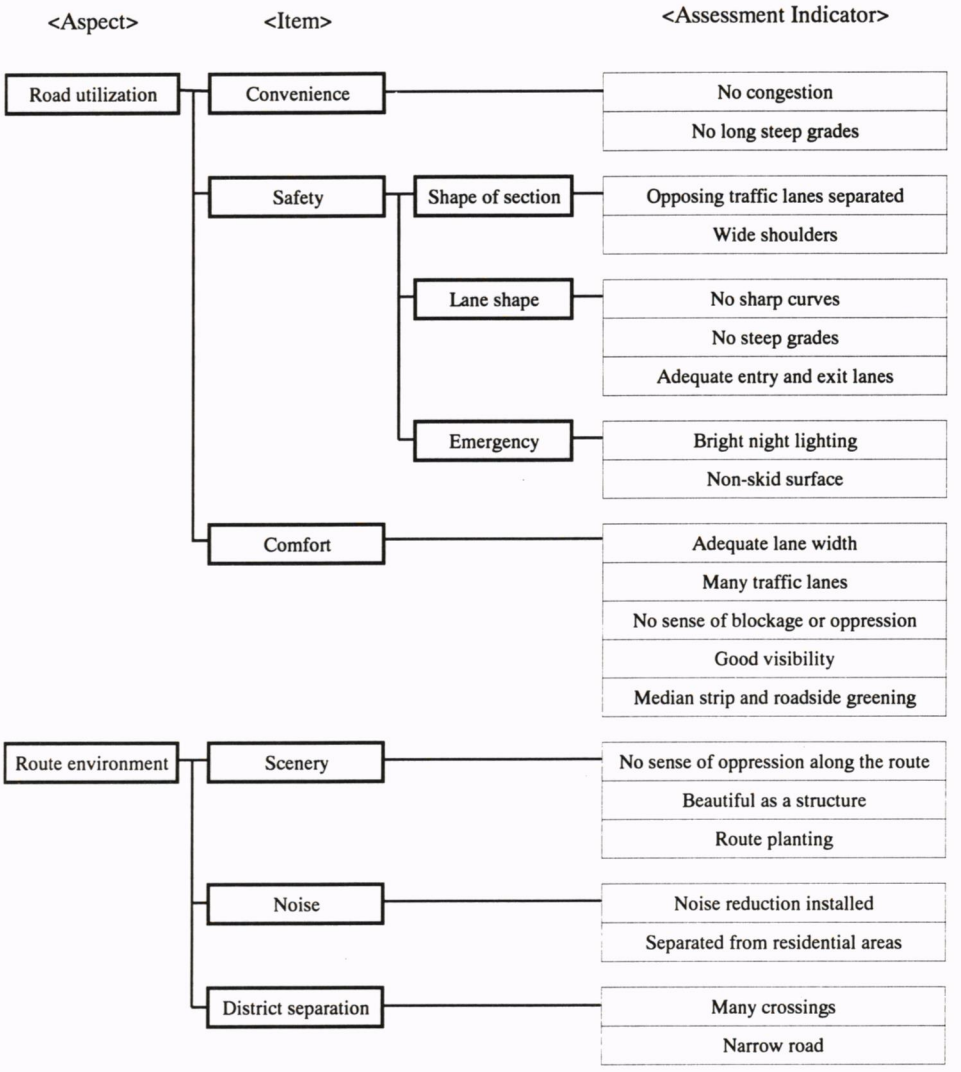


Figure 2. Expressway link design assessment indicators

3.2 Calculation of Assessment Indicators

Table 3 shows an assessment indicator calculation form. Weightings are applied after the data for each assessment indicator have been ranked in five classes.

Table 3. Assessment indicator calculation form

Aspect	Item	Assessment indicator	Calculation formula
Road utilization	Convenience	No congestion	Traffic volume/number of lanes
		No long steep grades	(Total length - length of sections with more than 500 m of continuous grade exceeding 3%)/total length
	Safety	Opposing traffic lanes separated	Length of divided sections/total length
		Wide shoulders	Length of sections with shoulders wider than 2.5 m/total length
		No sharp curves	Length of sections with radius greater than 500 m/total length
		No steep grades	Length of sections with grade less than 3%/total length
		Adequate entry and exit lanes	(Number of entry lanes x length of entry lane sections) + (Number of exit lanes x length of exit lane sections)
		Bright night lighting	Number of lights/total length
		Non-skid surface	(Length of sections with permeable paving + length of anti-slip processed sections)/total length
	Comfort	Adequate lane width	S (Lane width x section length)/total length
		Many traffic lanes	S (Number of lanes x lane length)/total length
		No sense of blockage or oppression	(Total length - length of tunnel, underground and canal sections)/total length
		Good visibility	1 - (Length of tunnel, underground and canal sections + length of sections fitted with sound-insulated walls without windows)/total length
		Median strip and roadside greening	(Length of median strip planted with shrubbery + length of sections with roadsides planted with greenery)/(total length x 2)
Route environment	Scenery	No sense of oppression along the route	Length of sections not elevated/total length
		Beautiful as a structure	Length of sections designed for appearance/total length
		Route planting	Length of landscaped sections/total length
	Noise	Noise reduction installed	Length of sound-insulated sections/total length
		Separated from residential areas	S (Distance of typical locations from residential land)/number of locations
	District separation	Many crossings	Number of grade separation crossings/total length
		Narrow road	S (Road width x section length)/total length

4. QUESTIONNAIRE SURVEY

A binary pared comparison survey for each aspect, assessment item and assessment indicator is conducted and AHP is used to determine weightings for each aspect, item and indicator. Figure 3 shows an example of binary pared comparison questionnaire.

Sixteen specialists who were experienced academics, administrators or researchers conducted the questionnaire survey on Wednesday, November 12, 1997. Figures 4 and 5 show the results of weighting each aspect, item and indicator. Figure 4 shows weights (out of 10 points) for each tree and Figure 5 shows overall weights (out of 100 points) for each indicator.

Question 1.

Which do you think more important between the following two indicators about Convenience from the aspect of Road utilization?

	far more Important	more Important	a little more Important		a little more Important	more Important	far more Important	
No Congestion	7	5	3	1	3	5	7	No long steep grades

Figure 3. An example of binary pared comparison questionnaire

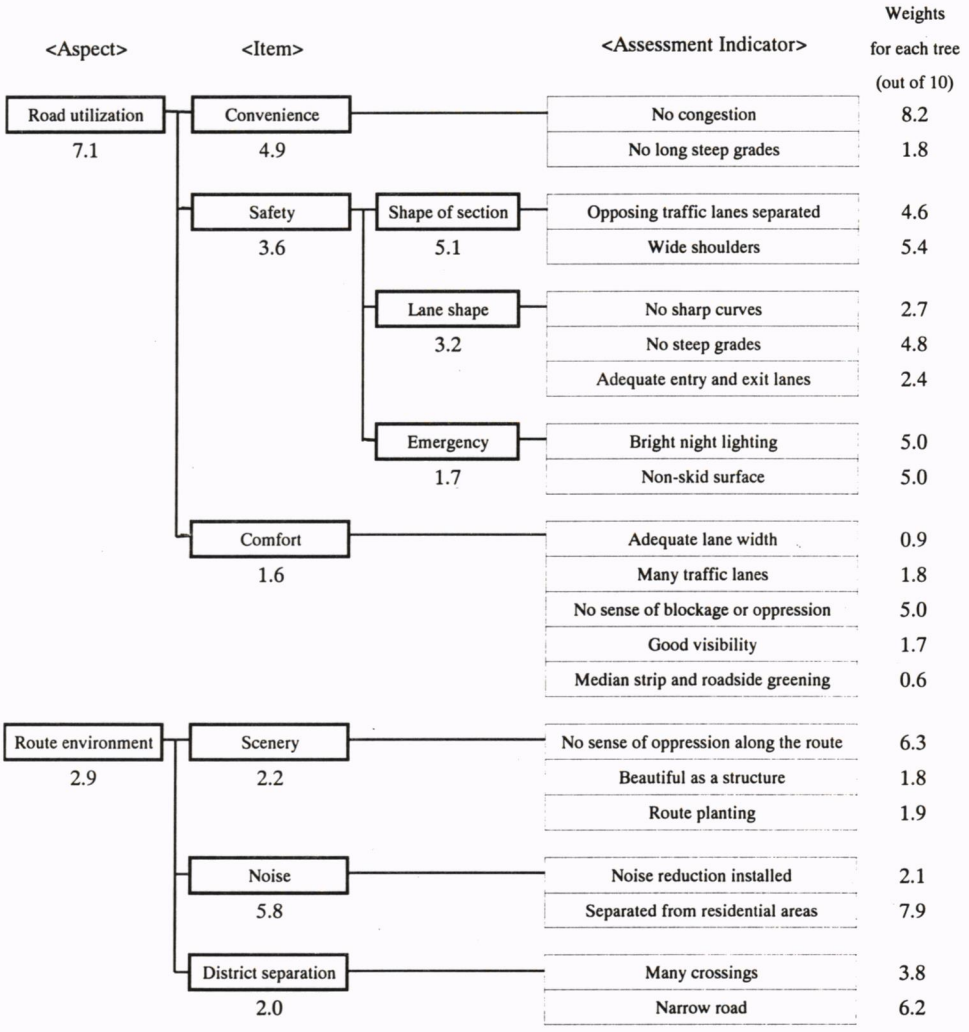


Figure 4. Results of weighting

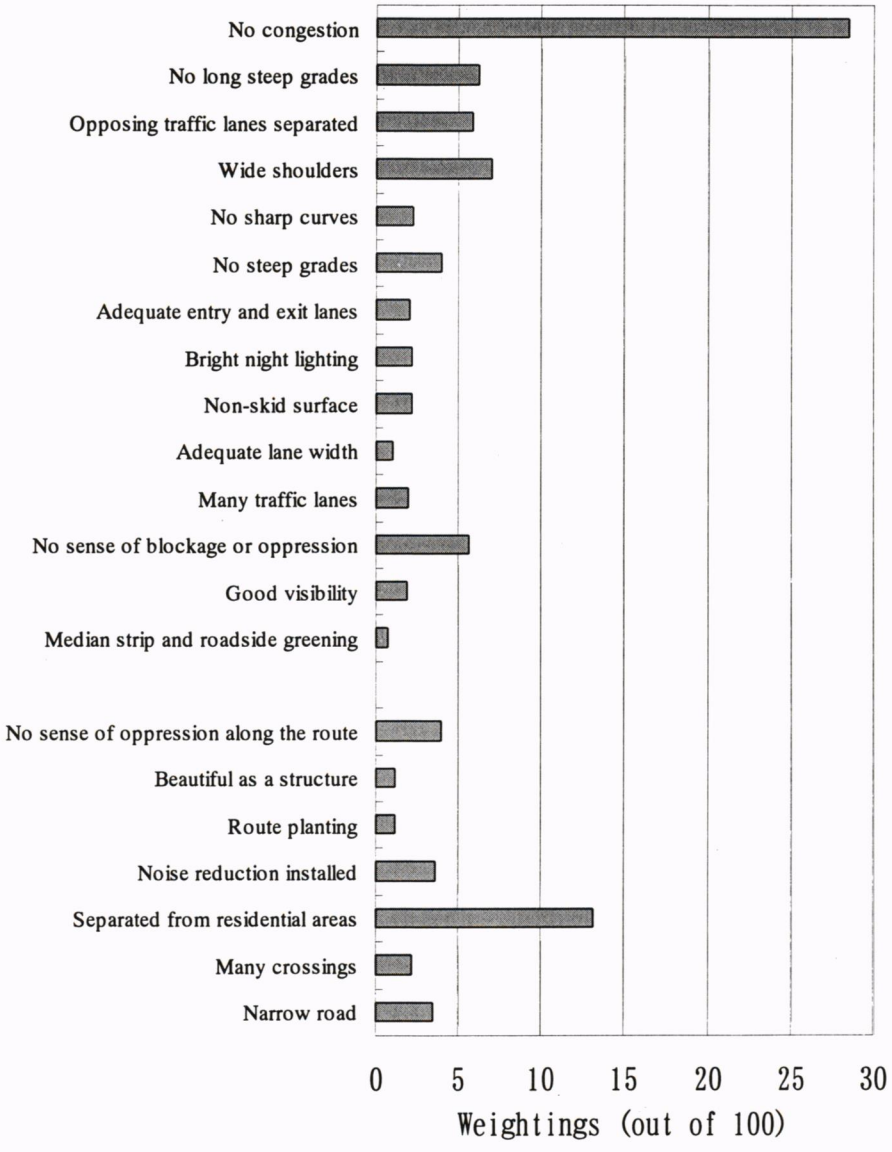


Figure 5. Overall weightings of assessment indicators

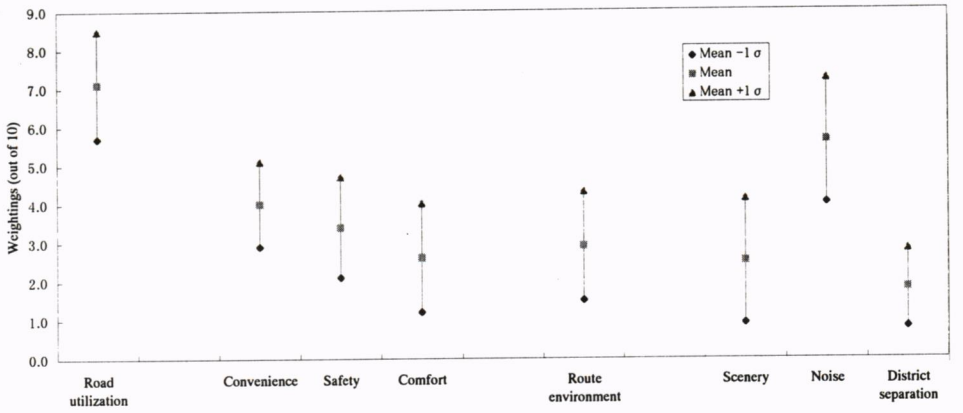


Figure 6. Means and ranges for assessment viewpoints and items

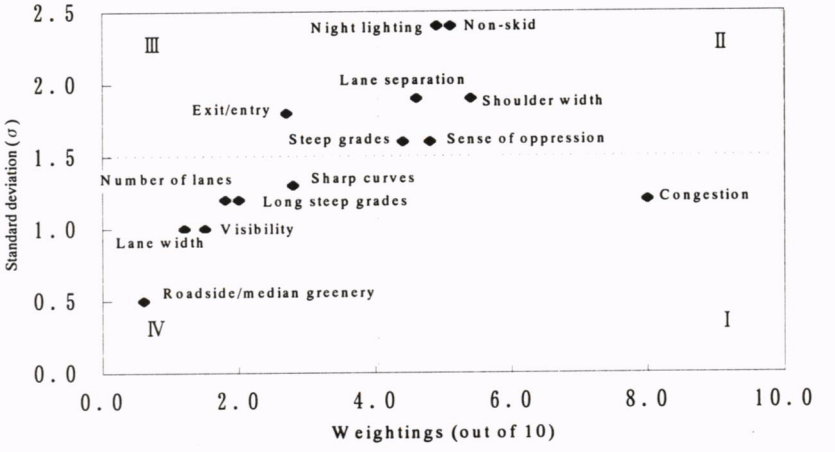


Figure 7. Weightings and standard deviations of assessment indicators (Road utilization)

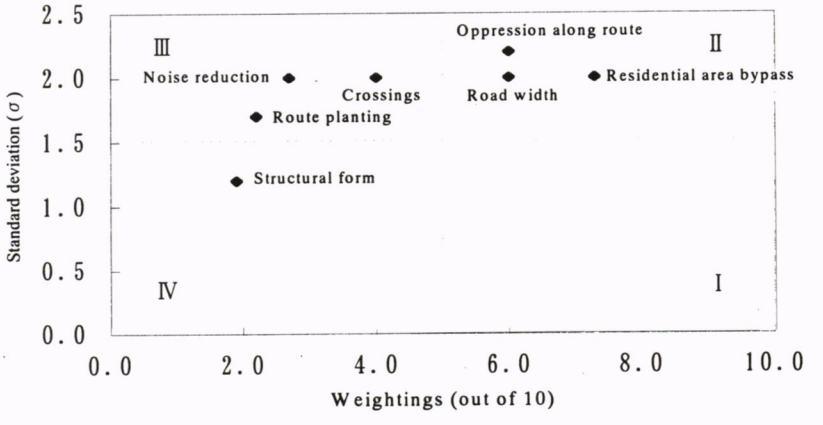


Figure 8. Weightings and standard deviations of assessment indicators (Route environment)

Figure 6 shows the mean weighting and standard deviation for each assessment viewpoint and assessment item according to the questionnaire survey. The standard deviations for each viewpoint and item are greater than 1.0 indicating a considerable scatter in the responses.

Figures 7 and 8 show plots of assessment indicator weightings and standard deviations for road utilization and route environment respectively. These plots are broken into four areas (I: large weighting, small sigma, II: weighting and sigma are both large, III: small weighting, large sigma, IV: weighting and sigma are both small.) On this occasion, the indicator in area I (congestion) is an extremely important indicator perceived by many of the respondents to be important. On the other hand, the indicators in area IV (median and roadside greening, lane width, number of lanes, long steep grades, structural form, etc.) were considered by many respondents to be comparatively unimportant. There were divergent opinions about the indicators in areas II and III (night lighting, lane separation, shoulder width and most of the route environment indicators) and care will be needed when these are reflected in measures, etc.

5. TESTING THE ASSESSMENT SYSTEM

5.1 Case Study Survey Sections

Here, the appropriateness of the assessment system (whether the assessment scores are in agreement with sensual perceptions) is tested by applying the assessment system to sections of intercity expressways in Japan that are generally believed to be of high level and sections that are believed to be of low level.

5.2 General Assessment Results

Figure 9 lists the general assessment results out of 100 points in the case study survey sections from the point of view of road utilization and route environment. Figure 9 also shows the results assessed in five ranks A to E. Here A = 90 points or more, B = 85 to 90 points, C = 75 to 85 points, D = 65 to 75 points and E = less than 65 points.

On examining the results in Figure 9, we see that the Tohokudo (Tochigi to Kanuma, Morioka to Takisawa) and Kan'etsudo (Higashi-Matsuyama to Hanazono) with high scores in both road utilization and route environment are in the highest A rank. Also, the Chuodo and Yamagatado with particularly bad lane shapes have low scores for road utilization but are ranked in C or D because their route environment scores are almost ideal. The Meishin Expressway (Kyoto Minami to Ibaragi) with low scores for both viewpoints is in E rank.

Thus, the results of assessment for the case study survey sections are in reasonable agreement with actual sensual perceptions and we can believe that the assessment system is appropriate.

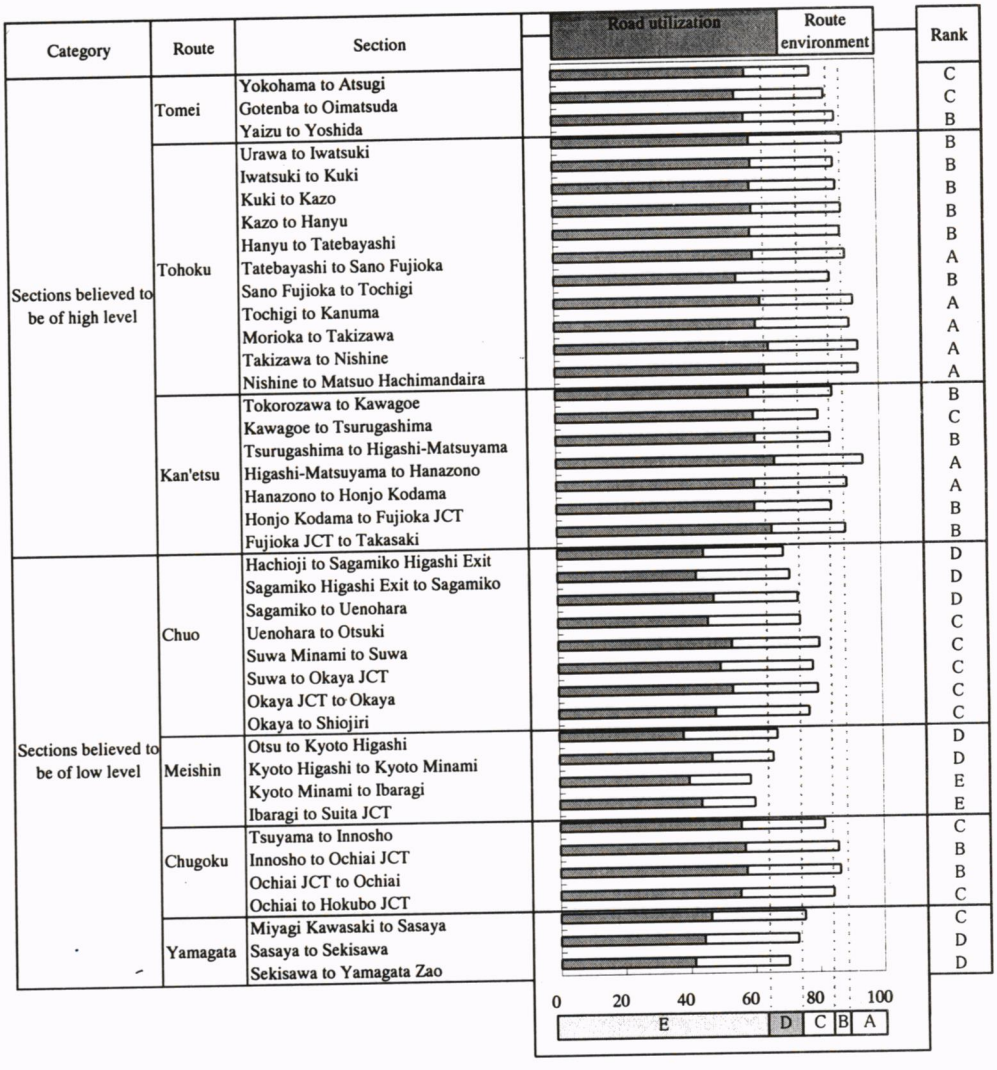


Figure 9. General assessment results (out of 100)

6. INTERNATIONAL COMPARISON OF EXPRESSWAY LINK DESIGN

As discussed at the beginning, it is important to study how Japanese expressways compare with those of Europe and the United States.

Here, for a comparison of the link design levels of expressways in Japan and various European countries, this assessment system is applied to the trunk roads in U.K., France and Germany and the Tomei Expressway shown in Photos 1 to 4. The results are shown in Figure 10. The assessment indicator data for the European roads were calculated from photos and videos.

Photo 1. Japanese expressway (Tomei Expressway)

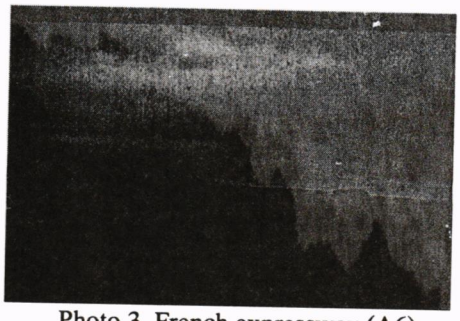


Photo 3. French expressway (A6)

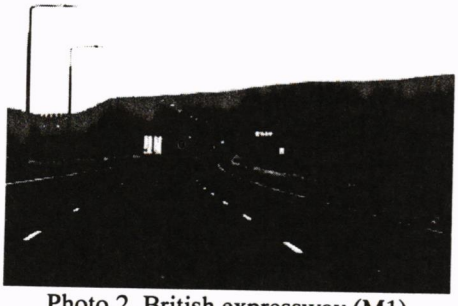
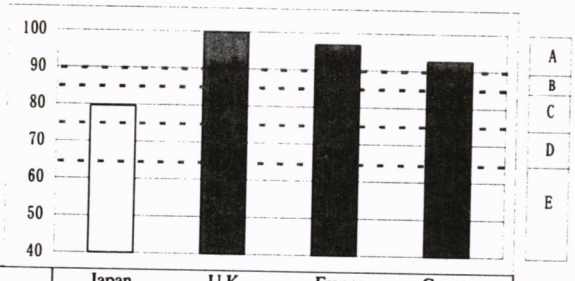


Photo 2. British expressway (M1)

Photo 4. German expressway (A5)



Item	Japan Tomei Yokohama-Atsugi	U.K. M40 London-Oxford	France A6 Paris-Marseille	Germany A5 Frankurt-Darmstadt
Convenience	84	100	100	84
Safety	90	100	93	93
Comfort	71	98	87	100
Road utilization	84	100	95	90
Scenery	61	100	100	100
Noise	72	100	100	100
District separation	72	100	100	100
Route environment	69	100	100	100
Overall assessment	80	100	97	93

Figure 10. International comparison of expressway link design

These results show that the measured sections of the European expressways all fall within A rank and differ widely from the link design levels of the C-ranking Tomeido (Yokohama

to Atsugi). Especially large differences are seen in comfort of road utilization and in the route environment aspect.

7. MEASURES FOR IMPROVING EXPRESSWAY LINK DESIGN

Measures such as adding more traffic lanes, installing lighting and route greening would probably improve link design and greatly lift the scores and ranking of the relevant sections. Examples of improving the link design of expressways through such measures are shown in Figures 11 to 13.

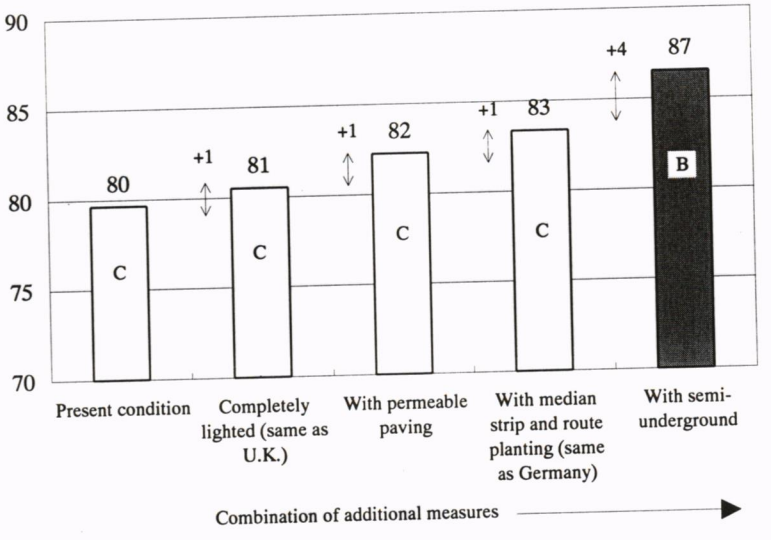


Figure 11. Results of measures on Tomei Expressway (Yokohama to Atsugi)

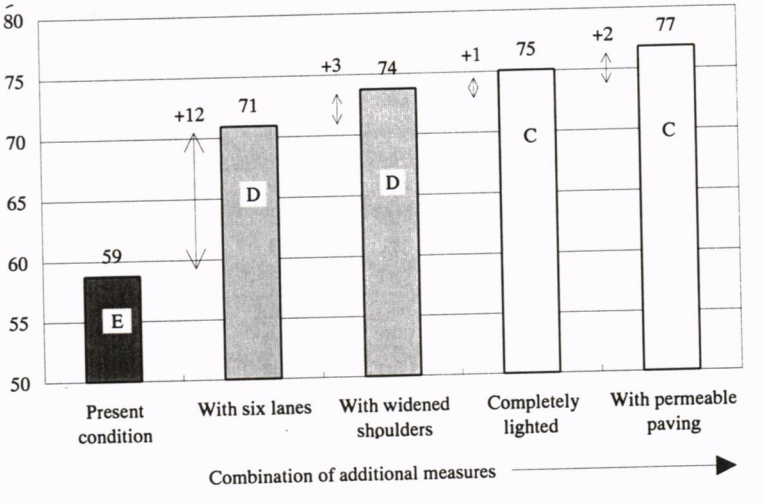


Figure 12. Results of measures on Meishin Expressway (Kyoto Minami to Ibaragi)

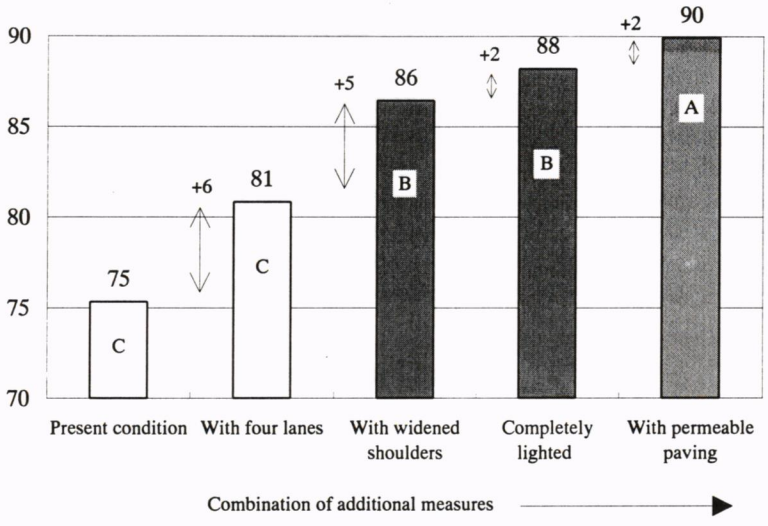


Figure 13. Results of measures on Yamagata Expressway (Miyagi Kawasaki to Sasaya)

For the Tomei Expressway (Yokohama to Atsugi), adding lighting over the total length as in U.K. and median and roadside greening and route planting as in Germany would leave the scores practically unchanged and the ranking would remain in C. However, if the total length were to be made semi-underground, the route environment would be greatly improved and the ranking would be B.

In the case of the Meishin Expressway (Kyoto Minami to Ibaragi) and the Yamagatado (Miyagi Kawasaki to Sasaya), measures such as more lanes, wider shoulders and lighting throughout would greatly improve the scores. In the Yamagatado in particular the effect of all four measures would lift the link design level ranking to A.

8. CONCLUSION

In this research we have constructed a system that is capable of making general assessments of expressway link design. We have shown that Japan's expressways are at an extremely low level compared with advanced European countries but that some improvements could be effected by a combination of certain measures.

However, assessment method in this study based on AHP have the following several problem; 1) validity of assessment indicators and its classification, 2) bias caused by the questionnaire survey under imaging situation, and so on.

Therefore, for the future, we shall aim at perfecting the system by improving the objective questionnaire survey method and accumulating more data.

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