COMPREHENSIVE PROJECT EVALUATION SYSTEM FOR GRADE-SEPARATED RAIL-ROAD INTERSECTION

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Abstract

This study has tried to apply a comprehensive project evaluation system, focusing on grade-separated intersection, in order to undertake it considering broader economic, social and environmental factors. As a case study, this study applies this system to JR Senseki-Line Project in Sendai, Japan.

Keywords: Rail road intersection
Topic Area: E1 Assessment and Appraisal Methods

1. Background and purpose

Currently there are more than 35,000 level-crossings of roads and railways in Japan, about 1,000 of them are classified as “Bottle –neck crossings” (crossings which shut more than 40 minutes per a rush hour or which crosses more than 50,000 car hour a day). These level-crossings have caused a lot of effects on urban functions mainly mentioned below.

1) Traffic accidents occurred at crossings (445 accidents, 125 dead in 2001)
2) Traffic jams (loss incurred by the Japanese economy by “Bottle –neck crossings” is estimated to be about 50 billion us dollars)
3) Area separation by level railway, which decreases urban traffic and degrades image of living environment.
4) Environmental degradation , such as noise, traffic and its pollution

More than 170 intersection projects have been put into practice in order to address these problems. Now intersection projects are receiving high policy priority by Japanese Government because they contribute to sustainable urban development.

Projects have been evaluated by using cost-benefit-analysis, which assesses time saving and other associated costs of drivers. But other important items which are difficult to estimate in money terms, such as environment, are not included in project evaluations. As a result, elevated structures, which might cause significant environmental impacts, have been adopted in disregard of residents’ preferences, only because they appear to cost less than underground structure.

This study has therefore made an attempt to develop a comprehensive evaluation system in order to undertake comprehensive project evaluation (focusing on grade-separated intersection) considering broader economic, social and environmental factors.

2. Comprehensive project evaluation system

Benefit items of intersection projects can be divided into two groups;

Group1: Items which can be easily quantified in money term

1) Time saving for drivers and passengers
2) Reduction in fuel consumption

3) Cost incurred by traffic accidents
4) Value of new land use after intersection, etc

Group 2: Items which can not be easily quantified in money term

5) Impact on living environment
6) Harmonization with the scenery
7) Revitalization of local area
8) Enhancement of safety, etc

Drawing on the evaluation framework discussed in Nakamura(2002), this system sets these benefit items in a tree diagram and assigns weight to each item. Assessors who give weight should be chosen from groups of stakeholders, should also have proper understanding of each item. Each item would be graded on the scale of 1 to 5 by the assessors.

As a result, Projects would be evaluated on a 100-point scale, and project decision can be made on the basis of these scores.

$$\text{Total Score} = \sum_{i} Wi \cdot Pi$$

Wi : weight of item i
Pi : score of item i

This study basically sets following conditions for a project to be evaluated with a higher score.

1) Included in the list of “Bottle –neck crossings
2) Have synergy effects with urban redevelopment projects
3) Environmental consideration for residents is made
4) Implementation process is well set

It is important to cover project effects in full detail. But the more is the number of items, the less is the impact of each effect because each weight gets smaller. Correspondingly it is important to avoid possible double counts get rid of effect duplication as much as possible. That is why this study eliminates items which have insignificant impact or relevance with intersection projects. The effect items in the form of tree diagram are shown as Figure 1.

“Environment” has 3 items shown above, but it should have, in fact, few more items like vibration, TV interference, influence to groundwater. In this study, they are eliminated, because vibration is associated with noises, TV interference must be addressed by cable, and influence on groundwater is difficult to evaluate clearly.

This study applies scores on the scale of 1 to 5 for each item in order to quantify the effects. If the weight were assigned to data measurement itself, it would be sensitive to the unit of measurement and the result cannot be compared. For example, when a project satisfies legal criteria or has no problem in its implementation, it can get the rank 3.

It is preferable for evaluation criteria to be as quantitative as possible. But some of them are quite difficult to quantify. In general, following strategy is adopted in quantifying each items.

1) In case of numerical measures, ranking is done directly based on the ranges of value.
2) In case of quantitative but structured information, selected conditions are first set and ranking is done one the basis of number of conditions satisfied.
3) In case of value-based quantitative information, ranking is done based on other good or bad examples.

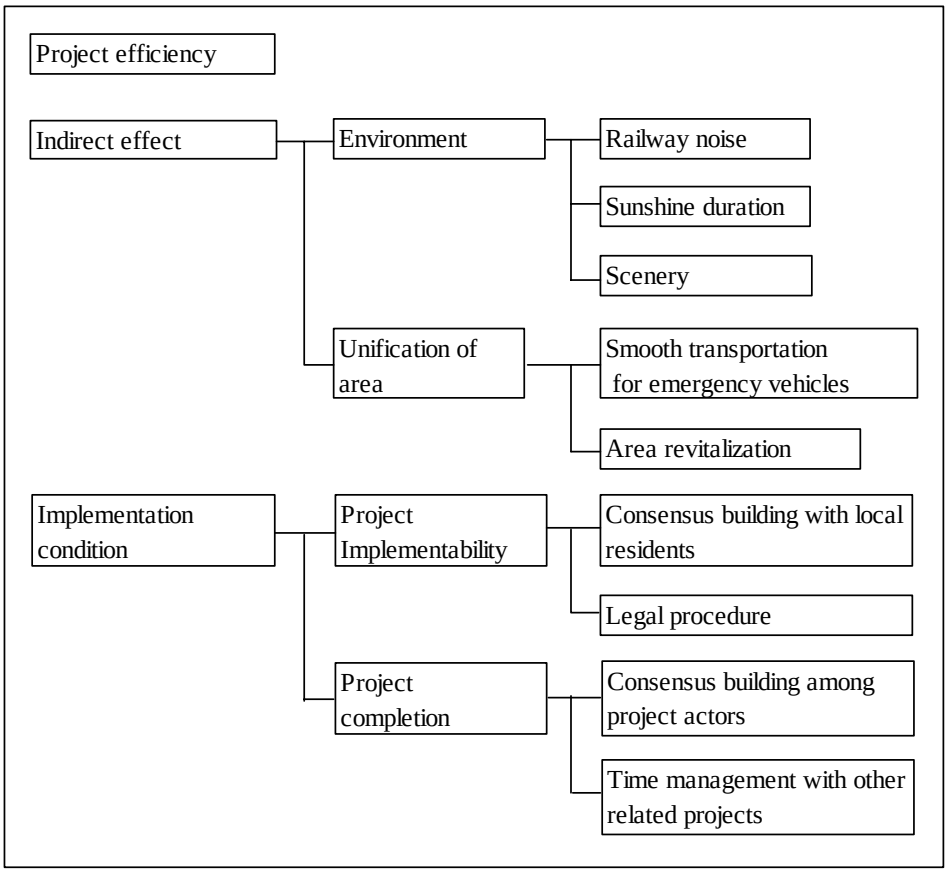

Figure 1 Tree diagram of project effects

3. Application of the proposed evaluation system to JR-Senseki-Line Project

JR-Senseki-Line, connecting Sendai and Ishinomaki City, is 50.5km long. 3.9km of this level line, connecting Aobadai-Dori Station and Rikuzenharanomaki Station, was converted to underground structure in March of 2000. This project was planned in conjunction with a land readjustment project at the east entrance area of Sendai Station where land had been remained undeveloped. Key features of this project are as follows.

1) Adopting underground structure, considering the surrounding environment and scenery.

2) Rendering seamless connection with an existing subway at Sendai Station

3.1. Project efficiency

Under project Efficiency, this study evaluates following items.

1) Time saving for drivers and passengers
2) Reduction in fuel consumption
3) Cost incurred by traffic accidents
4) Value of new land use after intersection, etc
5) Time saving for drivers by avoiding of detouring
6) Time saving for passengers by rendering seamless connection with an existing subway
7) Time saving for passengers due to speed up of trains in track alignment

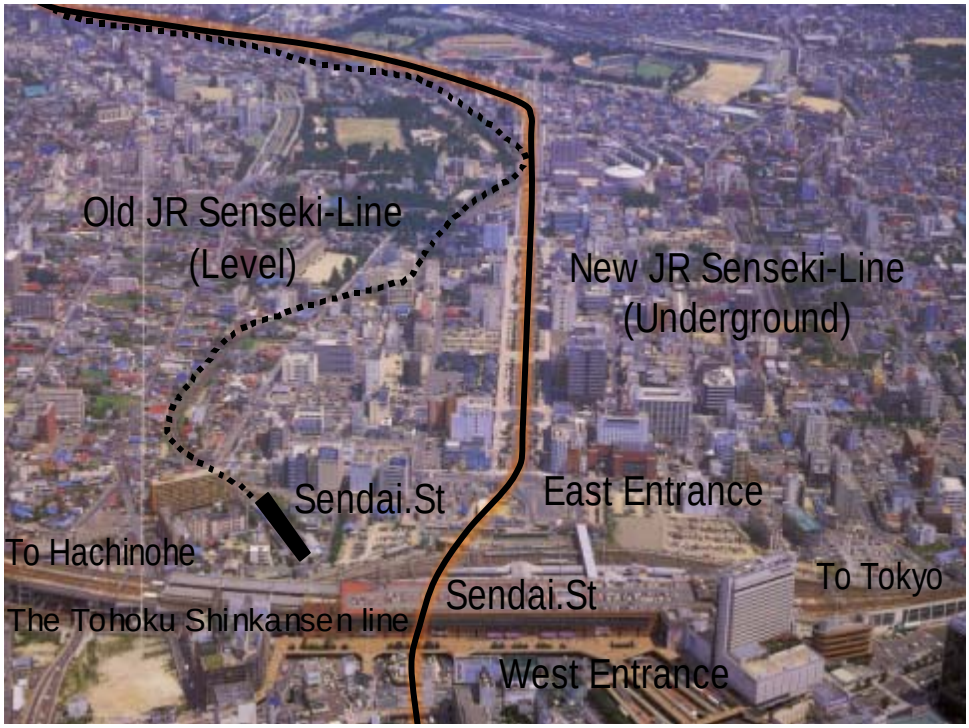

Figure 2 Intersection Project of JR Senseki-Line in Sendai

Project efficiency is evaluated on a scale of 1 to 5 according to cost-benefit ratio, using the data taken by Sendai-City in 2000.

5: 3.0<B/C
4: 2.0<B/C<3.0
3: 1.5<B/C<2.0
2: 1.0<B/C<1.5
1: B/C<1.0

Present value (in the year 2000) of total benefit can be evaluated by summing up each benefit for 50 years considering discount rate (4%).

B=1.14 billon US$

Present value of project cost

C=0.73 billion US$

Consequently, Cost-benefit-ratio B/C for this project is 1.56. The rank is therefore assigned to be 3.

3.2. Indirect effect

3.2.1. Railway noise

Level of railway noise is required to be better after construction of intersection by law in Japan. A situation which satisfies the law can be considered as rank 3. If the project satisfies 60dB (at 12.5m from tracks, 1.2m high) criteria set by law for constructing new structures, it can get a higher rank.

5: Satisfying all the terms below

- Noise levels better at every structure
- Half of the noise levels expected to be less than 60dB
- Noise levels better at every story of rail-side buildings
- Implementation of noise control measures

4: Satisfying 3 of them above
3: Satisfying 2 of them above
2: Satisfying 1 of them above
1: Satisfying none of them above

This project's rank is 5 because noise level has been far better by adopting an underground structure.

3.2.2. Sunshine duration

Criteria for sunshine duration are determined by ordinances. When it is satisfied, this can be ranked as 3. If there is no impact along the project area, the rank is 5.

5: Sunshine duration kept as it is in all the project area
3: Satisfying legal criteria
1: Unsatisfying legal criteria

In this project, there is no adverse impact because of the underground structure. The rank is 5.

3.2.3. Scenery

Criteria for scenery are quite ambiguous in Japan. This study put 3 criteria for judging "comfortable" or "uncomfortable" when the structure is viewed. They are oppressive feeling, harmony with surroundings, and greening.

5: Satisfying all the terms below
- Measures taken for addressing oppressive feeling
- Measures taken for ensuring harmony with surroundings
- Greening area around elevating structure or above underground structure

4: Satisfying 2 of them above
3: Satisfying 1 of them above
1: Satisfying none of them above

In this project, green way was constructed above the underground structure. There is no degradation because the structure is underground. The rank is 5.

3.2.4. Smooth transportation for emergency vehicles

Sense of security is expected to be upgraded by addressing level crossings, such as areas where police stations or fire stations are located along crossing roads.

5: Satisfying all the terms below
- Police stations or fire stations located on either side of crossing roads within about 1 km.
- At least one of crossing roads designated as emergency transport roads
- Addressing roads whose height limit less than 4.5m.

4: Satisfying 2 of them above
3: Satisfying 1 of them above
1: Satisfying none of them above

In this project, 2 of the above terms are satisfied. The rank is 4.

3.2.5. Area revitalization

Areas separated by railway can be integrated by addressing the problem of level crossings. One of the positive effects is revitalizing undeveloped side of stations. It means that balanced development can be expected. It is sometimes realized as synergetic effect

with land adjustment project. Besides market expantion and more usage of public services can be expected.

5: Satisfying all the terms below

- Addressing undeveloped side of stations
- Market expansion such as new shopping malls
- Increased usage of public services, such as libraries, community centers, sports facilities

4: Satisfying 2 of them above

3: Satisfying 1 of them above

1: Satisfying none of them above

In this project, all the terms are satisfied. The rank is 4.

3.3. Implementation condition

Currently with raising of environmental awareness among citizens, consensus building with local residents is more important for project implementation. Besides time management is required from the viewpoint of efficiency. In what follows, implementation condition of this project will be evaluated.

3.3.1. Consensus building with local residents

The degree of consensus with local residents is difficult to determine quantitatively. But it can be judged based on some quantitative information such as public hearing with local residents, public involvement in planning etc.

5: Satisfying all the terms below

- Briefing meeting with local residents regularly held
- More than 80% of residents in favor
- Organized opposition not being faced
- Land acquisition by force not necessary.

4: Satisfying 3 of them above

3: Satisfying 2 of them above

2: Satisfying 1 of them above

1: Satisfying none of them above

In this project, some land had to be acquired by force. But it satisfies 3 terms. The rank is 4.

3.3.2. Legal procedure

It is required to start as soon as possible when a project is decided. Smoothness of implementation should be judged in the context of legal procedure, such as city planning, environmental assessment, design consultation.

5: Feasibility works completed and project ready for design consultation and environmental assessment

3: Feasibility works completed but project not ready for design consultation and environmental assessment

1: Feasibility works not completed

In this project, the coordination of project with city planning is considered not well clarified because it had been changed after project approval. The assigned rank score is therefore 3.

3.3.3. Consensus building among project actors

It is necessary that local government and railway company should come to an agreement about project implementation before starting. National government accordingly approve the project.

5: Local government and railway company having an agreement about a project implementation

3: Despite some of disagreement issues about a project, no adverse influence on project implementation.

1: Local government and railway company not having an agreement about a project implementation yet.

In this project, consultation on sharing cost burden had not bet finished. The rank is 3.

3.3.4. Time management with other related projects

Project period is sometimes prolonged because land for temporary railway need to be arranged by land readjustment project. When an offer for land purchase is rejected, the project cannot often follow the given schedule. It is necessary to judge whether other related projects have any influence on time management of intersection.

5: Other projects have been already started and supported intersection project implementation.

3: Other projects are under planning and may need some more time.

1: Other projects have not been planned.

In this project, land readjustment project in the east entrance area had been already started and supported intersection project implementation. The rank is 5.

4. Evaluation Result

Table 1 Evaluation Result

Evaluation Items		Score	Weight	Score of this project	Perfect Score
Project efficiency		3	8.5	25.6	42.6
	Subtotal		8.5	25.6	42.6
Indirect effect	Railway noise	5	1.6	8.1	8.1
	Sunshine duration	5	1.5	7.5	7.5
	Scenery	5	1.4	7.2	7.2
	Smooth Transportation for Emergency Vehicles	4	1.9	7.7	9.7
	Area revitalization	5	0.8	4.0	4.0
	Subtotal		7.3	34.5	36.5
Implementation condition	Consensus building with local residents	4	1.7	6.8	8.5
	Legal procedure	3	0.3	1.0	1.7
	Consensus building among actors	3	1.4	4.3	7.1
	Time management with other related projects	5	0.7	3.5	3.5
	Subtotal		4.2	15.6	20.9
Total		3.79	20.0	75.8	100.0

Total score of this project is 76, as illustrated in table 1. Figure3 shows ranking score for project efficiency, indirect effect, and condition of implementation. As for project efficiency, the score stays at 60% because the rank is 3. But as for indirect effect, the score reaches 95% because it is highly evaluated on environmental aspects by adopting underground structure. Indirect effect makes up for lack of project efficiency.

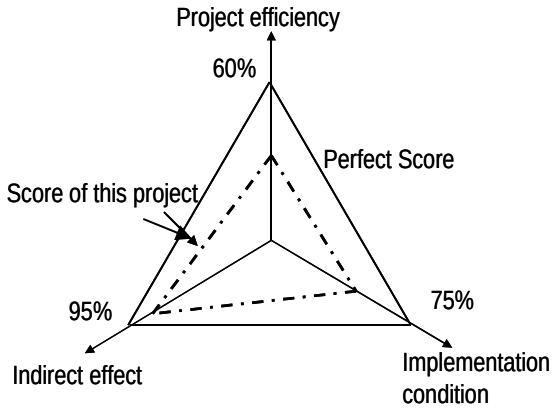

Figure 3 Ranking Scores

5. Evaluation in case of elevated structure (on the assumption that it were adopted)

If elevated structure were adopted in this project, how would the total score change?

5.1. Change of project efficiency

As for benefit, original effects occurred by intersection are the same as in the case of underground structure. But time saving of changing to an existing subway will be diminished from 6 to 4 minutes. Therefore total benefit will be reduced from 1.14 billion to 1.10 billion US $. As for cost, present value of the project cost will be 0.47 billion US $. Consequently the rank will be 4 because B/C raises to 2.34 from 1.56.

5.2. Change of Indirect Effect and Project Implementation

5.2.1. Railway Noise

It should be difficult to satisfy “Half of them are expected to be less than 60dB” and “Noise levels will be better at every story of rail-side buildings”. The rank will be changed from 5 to 3.

5.2.2. Sunshine duration

It cannot be denied that elevated structure would have some influence on sunshine duration. The rank will be 3 from 5.

5.2.3. Scenery

It is thought that oppressive feeling would be worse for residents nearby. The rank will be changed from 5 to 3.

5.2.4. Consensus building with local residents

The rank goes down to 3 from 4, assuming more difficulty of land acquisition.

5.3. Evaluation result in case of elevated structure

Considering changes mentioned above, total score will be 73. It is 3 point lower than

underground structure. The difference is not large enough, but it means choice of underground structure is superior to the elevated one. Project cost of elevated one is superior to that of underground one, but decrease of environmental score due to worsening of indirect effect gave this result.

Most of the problems mentioned in chapter 1 can be solved by this evaluation system. Traditionally, the structure has been decided on the basis of project cost, or cost benefit analysis. Comprehensive evaluation can be realized in public projects by adopting the proposed system.

Secondly, comprehensible and transparent results can be given to residents. It is expected to contribute to consensus building with them. Projects considering community needs of environment have been more important. Intersection projects need huge amount of cost, and give large impact on city function. Project evaluation system is more expected to deal with whole effects considering indirect effects.

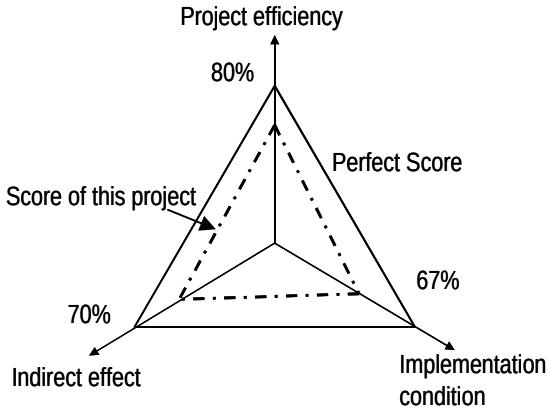

Figure 4 Ranking Scores in Elevated Structure

6. Conclusions

This study has developed and proposed a comprehensive evaluation system for grade-separated rail-road intersection. This system is put into practice on a project in order to check the appropriateness of it. This intersection project made JR level line to underground, which located in Sendai city. This project decision has been confirmed to be correct by comparing with the case of elevation, because the score of underground was superior to that of elevation.

The merits of using this system are as follows.

1) Project decision can be made taking into account wider range of cost and benefit items such as environment, and thereby make it possible to select economically efficient, and environmentally friendly projects.

2) Project actors can ensure accountability and can obtain consent of the local residents more easily than before.

Some issues of this system should be studied. Subjective evaluation should be eliminated as much as possible in this system. It should be considered that project criteria include more numerical items in order to promote objective decision. Correspondingly weight of each item should be assigned objectively. For example, having them reviewed by neutral bodies including academic experts.

This system should respond to changing of social and economic needs. It means review of evaluation criteria and weight of each item at some intervals. For example, weight of environment is considered to be getting more important. But it is not clear that it will be

more important in the future. It also has some rooms for improvement in terms of project efficiency or condition of implementation will be superior in order to address financial problems.

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