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EVALUATION FOR IMPROVEMENT PLAN OF HIGHWAYS BY APPLYING VALUE ENGINEERING

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Abstract: Highway improvement and maintenance have supplied the economic development and enhanced our life convenience greatly. However the economic and social conditions changed heavily in Japan. The long period economic inactivation, the low birthrate and longevity constrain the investment to public projects strictly. The public works meet the criticism for the estimation of the effect and the mismatching between the projects and the local needs with any new highway improvement project contemporaneously. In this study, I applied VE (Value Engineering) as an evaluation approach for the highway improvement plans. The work started with the function definition and finished with the proposal of design principles on improvement plan. Finally, the study verified the effect of VE as a valid approach for the evaluation of highway improvement plans to help us to choose the best plan fitting with all of conditions and limitations.

Key Words: improvement plan, highways' functions, Value Engineering, evaluation

1. INTRODUCTION

Highways have various functions in the field of economic, living, and country security, etc. The different priority of these functions would induce different improvement plan. Thus, we could say the decision of function priority play an essential role in the highway design. It requests us to pick out all functions and arrange them thoroughly. The new evaluating approach with high operationality is necessary here.

Furthermore, as the financial difficulties of the governments, it has become impossible to construct all of the planned highways in a short period. Thus, it became a very serious topic for the governments to reduce the construction costs in Japan.

VE is known as a managerial method and useful tool for cost management in the production process, and it has been widely applied in the various kinds of productive activities including the field of public works. However, concrete examples of VE applied in the stage of function arrangement are few up to now.

This research applies VE for a local high-grade highway project. Our work started with the function definition and finished with the decision of improvement plan. The aim of the study is to verify the effect of VE as a valid approach for road improvement plan and to develop the VE technique in this procedure.

2. WHAT IS VE AND WHY I HAVE CHOSEN VE?

2.1 What is VE?

Though the definition of VE differs among the ages and persons, according to VE Research Group of SANNO Management Institute (1999), "VE are the systematic efforts directed toward function study of products and services in order to obtain certainly the necessary functions with the minimum lifecycle costs." Here, "necessary functions" mean the functions that users require for products or services, including performance, reliability, operationality, conservativeness, safety and design, which are necessary in every step from the production stage to the disposal stage.

In a case of applying VE, five principles are requested.

i) User is first
ii) Function is the most important
iii) Modification must be by creation
iv) Team design and
v) Value increasing.

Among the above 5 principles, the "value increasing" principle is the base of the cost reduction.

The value of a product or a service means a degree of satisfaction when a user purchases the product or the service and enjoys it. Usually, it is shown by the following formula.

V (value) = F (function) / C (cost)

And there are two patterns of value improvement that make the cost reduction.

A. Function maintenance and cost reduction
F: same level / C: reduce = V: increase
B. Function improvement and cost reduction
F: improve / C: reduce = V: increase

Here, we have to be careful that the functions dealt here are "necessary functions". Unnecessary functions are said to be no use or excess. Therefore, to reduce cost by removing unnecessary functions is considered as a major VE activity.

To write it more popularly, VE is an activity to reduce the cost by removing the unnecessary functions, or providing an alternative of material or approach when the current ones will cost too much. Another words of saying, through VE, cost decreasing could be obtained by removing the unnecessary functions and the excessive parts of the functions, or seeking/developing an alternative that decreases the cost without lowering the level of function.

VE study includes the following steps generally.

<u>A. Definition of functions:</u>
i. Information collection
ii. Defining functions
iii. Functions arrangements
<u>B. Evaluation of functions:</u>
iv. Cost analysis according to functions

v. Evaluating functions
vi. Selecting the study objective function

C. Preparation of alternatives:
vii. Preparing substitute alternatives
viii. Evaluating the alternatives roughly
xi. Evaluating the alternatives concretely
x. Evaluating the alternatives in more detail level

2.2 Why I Have Chosen VE?

Cost management techniques include following three methods – IE, QC and VE, in a chronological order.

a. IE (Industrial Engineering)
IE is the activity that finds the overburden, waste and unevenness in materials flow and workers' behavior, and then to get rid of them. Thus IE is based on the observation of the materials flow and the workers' behavior. As the result of an IE activity, a cost decreasing is approached by increasing the efficiency.

b. QC (Quality Control)
QC is on the basis of the observation of products or outputs of a business activity. By understanding of the inferiority and the fluctuation accurately, a QC activity is seeking its causes and taking action with them so that we can maintain the management in a good level and control the quality of the products or the outputs. As the result of the QC activities, a cost decreasing is realized on the basis of the decreasing of the inferior goods and the reducing of the time for repairing.

c. VE (Value Engineering)
Focusing on the roles/aims of a product/output or a business, and seeks to clarify it (called "function" in a VE activity), VE is an activity to reduce the cost by removing the unnecessary functions when they are found, or providing an alternative of the material or the approach for the function having been judged costing too much. As the result of the VE activities, a cost decreasing is obtained either by removing the unnecessary functions and the excessive parts of the functions, or by seeking/developing an alternative that decreases the cost without lowering the level of function.

VE can be applied wherever cost and/or performance improvement is desired. That improvement can be measured in terms of monetary aspects and/or other critical factors such as productivity, quality, time, environmental impact, and durability.

Construction industry is basically an individual build-to-order manufacturing, and also has the production condition, in Japan, as the separation of design and execution of work. VE, which is easier to provide cost decreasing by in-company efforts among the three management techniques – IE, QC and VE, receives recognition from the characteristics of this production condition.

For civil engineering works such as highways and buildings, which tend to be one-time applications, VE is applied on a project-to-project basis. Since these are one-time capital

projects, VE must be applied as early in the design cycle as feasible to achieve maximum benefits. Changes or redirection of design can be accomplished without extensive redesign, large implementation cost, and schedule impacts.

In ACTION GUIDE FOR REDUCING THE COST OF PUBLIC WORKS and ACTION PLAN FOR REDUCING THE COST OF PUBLIC WORKS published by the Japanese government in 1997, VE is positioned as a measure contributing cost reduction. Furthermore, ON THE IMPLEMENTATION OF VE METHOD IN MINISTRY OF CONTRUCTION (see Infrastructure Development Institute of Japan, 1998) was notified toward every local construction bureaus from Director of the Engineering Affair's Management Division of Minister's Secretariat in Japan. This tells that, in order to reduce cost without lowering the quality and to clarify its effect, VE study group that consists of several experts should be set up at the design stage and VE should be implemented. Therefore, the aim of VE in Japan is to reduce the cost without lowering the quality.

The effect of VE and the implementation timing are closely related. Generally, earlier the implementation timing is, higher the effect is. (refer to, for example, Ando & Asami, 2002)

A. Planning stage:

By understanding and evaluating clients' requirements in the form of function and proposing a novel alternative, the effect of VE is effectively reflected on project business plan.

B. Preliminary design stage:

The cost review that mainly aims to reduce cost, and comparison of several alternatives are attempted. Big effect of VE is expectable because the limitation in extent of examination is small.

C. Detail design stage:

In this stage, the adoption of novel alternative is impossible. However, we can find VE object theme by selecting certain component, such as the selection of construction material, the way of construction management, structural base form, and so on. Therefore, we can propose alternative plan, and implementation of VE is worthwhile.

One of the most important issues in implementing VE is defining functions. On the other hand, there is no definite definition of functions, so that if we give different definitions to certain objective, the results would be completely different. For example, if we position bypass function around city as only an "elimination of through traffic", an alternative plan might ignore important function such as "formulation of organic road network by connecting bypass and existing roads". In other word, if the definition of function is not suitable, VE itself is going to be no use. (refer to Ando, 2003)

3. OBJECTIVE HIGHWAY AND SURROUND AREAS

The objective highway for the case study is shown in Figure 1. This highway is long about 45km. The region where the highway locates is an area with a local city surrounded by the mid-mountainous areas with rich nature. Furthermore, the local city is an international tourist city, which has lots of historical houses.

The present national highways in this area are almost two lanes excluding a few four lane highways in the central area of the local city. Furthermore, there are no parallel routes, so when a highway is damaged by heavy rains or others accidences, no substitute route is available. As results, the congestion occurs frequently and the disaster-prevention ability is very low.

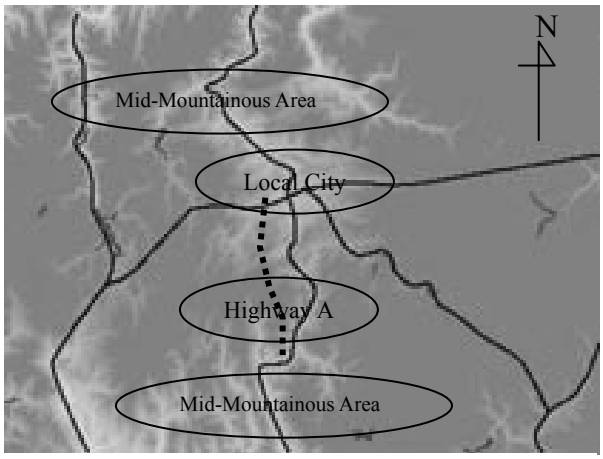

Figure 1. Location of Highway A

The role of the objective highway being considered in this study is to connect areas, make the transport smooth and enhance the attraction of this region. As a local high-grade highway, the functions of "communication, cooperation, and connection" should be supplied generally, and the cooperation is the most important function for this highway project.

Additionally, according to the current improvement plan, the design speed of this highway is 60km/h and is defined as the road of the 1st group (means expressway locating in the countryside) and the 3rd class. Furthermore, it should be two lanes based on the forecasted traffic flows and the Road Structure Ordinance of Japan.

4. FLOWCHART AND STEPS OF VE

4.1 Flowchart of study

The flowchart of the study is shown in Figure 2.

Firstly, the basic data of present condition and the future plan should be collected.

Moreover, based on these collected data, the improvement plan or its proposal will be decided by applying Value Engineering approach.

Finally, by comparing the plan induced by VE approach with the present plan (proposal) based on the conventional approach, the sum up effect of cost reducing will be calculated.

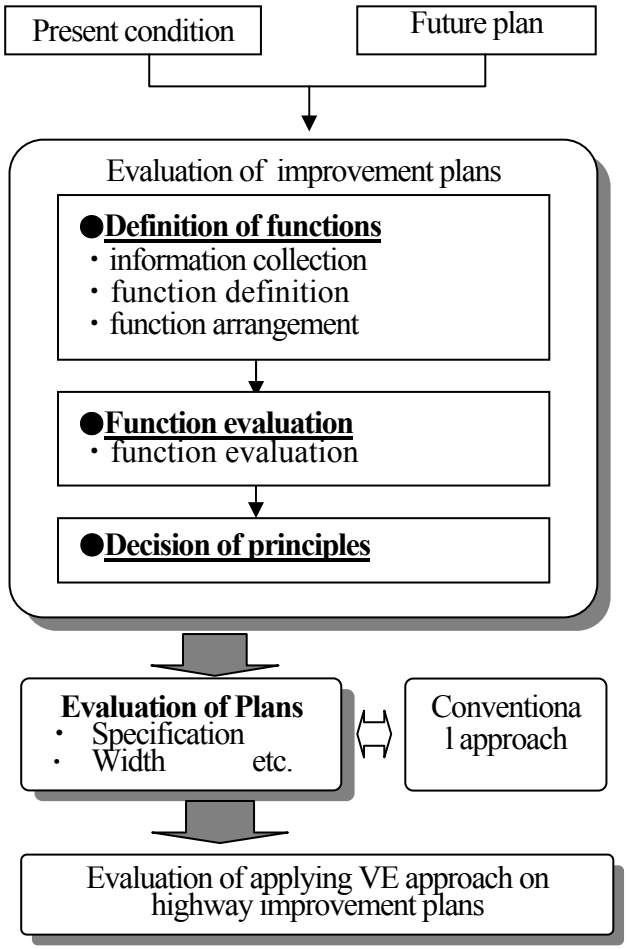

Figure 2. Flowchart of Study

4.2 Steps of VE in the study

Since I focus on the arrangement of functions when applying VE in this study,

the process of VE is shorter than the general ones. The stages and steps included in this study can be discussed respectively.

- There is no reason to change the three steps in definition of function, stage-A.
- Contrast, in stage-B, only the step v, functions evaluation, is necessary.
- In stage-C, the decision of plan is induced directly so we need not to prepare alternatives and what we need is to introduce one step, making decision for principles to displace all steps in this stage.

As the result, a process including the following five steps is set in this case study.

I. Information collection
II. Defining functions
III Functions arrangement
IV. Functions evaluation
V. Proposal and Decision of principles

The VE Workshop Group consists of specialists from various fields including traffic planning, road design, environmental assessment, landscape, structure engineering, soil engineering, construction management and architecture etc. All the opinions from different standpoints are considered together in our workshop.

5. FUNCTION EVALUATING BY VE

5.1 Information Collection

First, the VE study group collected the information including the following basic data.

<u>Information of expected performance</u>
-Speed: 60-80 km/h
-Type of interchange: cubic
-Road grade: high
<u>Information of residents' expectation</u>
-To clear up the congestion in the present route
-To provide a substitute route in emergency
<u>Information of the road network planning</u>
-Having been set as a local high-grade highway
-The role of supporting communication and cooperation among areas
-The role of resolving the congestion
<u>Information of the road design</u>
-1st group 3rd class road
-Design speed: 60km/h
-Traffic volume: urban area=15,600-37,500veh/day; countryside=13,600-22,800veh/day

5.2 Defining Functions

Function definition is required to separate the mixed functions and category them into various types. However, due to the vague or abstract definition of road in the related law in Japan,

various interpretations may be rational. Furthermore, the basic technique of VE, “avoid generalities”, and the inclination of questioning the necessity of all the specified functions are the base of our work.

The function of a highway could include the contents like standard and classification of road, driveway and traffic lanes, median strip, shoulder, environmental facility zone and tree-planting zone, bridge and overpass, ramp, speed change lane, frontage road etc.

To make the definition of function easy to analysis, the description is preferred to be written as [something makes some ability available] rather than [some abilities are available]. For example, [the road supports the cooperation between areas] is better than [there is cooperation between those areas]. Functions defined clearly could be classified into two types: primary functions and secondary functions.

The primary functions are the concrete purposes of one or several feasibilities, and the secondary functions are the approaches to attain a certain purpose.

Eight basic functions and 33 secondary functions are picked out in this study by the above rule. Some of them are shown in Table 1.

Table 1. Definition of Functions on Highway A

Theme	Function	Primary	Secondary	Others
Local High-Grade Highway (Highway A)	Supporting cooperation among regions	○		
	Form a local belt in south-north direction	○		
	Supply high speed service for car users	○		60km/h
	Relief congestion in operating roads	○		Urban area
	Maintain comfort ability of driving	○		
	Secure safety of driving	○		
	Improve living environment	○		
	Protect natural environment	○		
	Shorten travel time among cities		○	
	Exclude passing traffic		○	Urban area
	Better access to railway stations		○	
	Secure sidewalk		○	
	Supply safe driving environment in winter		○	Snow/iced
	Supply safe driving environment in disaster		○	
	……			

5.3 Functions Arrangement

Functions definition in the former step will be arranged in this step by their correlation to endure the following step could be executed smoothly. Figure 3 shows the function hierarchy with three levels. The first level is the main purpose of this project, the second level is the basic functions and the third level is the secondary functions.

As a result, “support the cooperation among regions in this area” was selected as the main function at the first level. Moreover, in order to achieve this first level function, it is necessary to achieve functions at the next level, such as– “supply high speed service”, “relief congestion in operating roads”, “secure safety”, “protect natural environment”, etc.

Similarly, to attain the functions at the second level, the functions at the third level are requested. For example, to attain the "maintain comfort ability of driving", one function in second level, we need to achieve eight functions at third level, such as "eliminate influence by uneven road", "supply enough driving space" and so on.

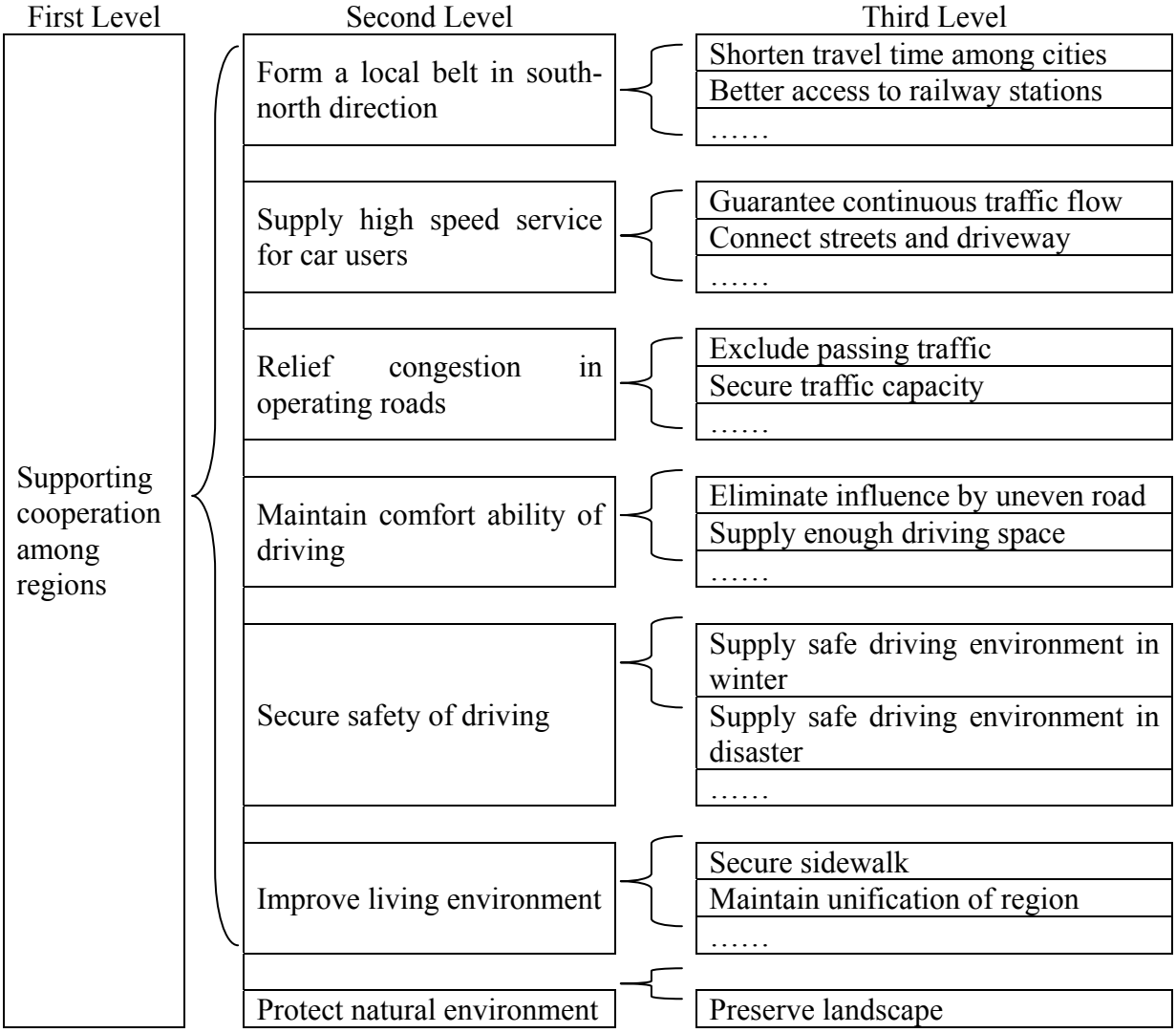

Figure 3 Summary of functions for Highway A

5.4 Functions Evaluation

In the function evaluation step, the importance level of functions should be evaluated and the rank of functions should be decided. In this study, to evaluate functions at the second level in Figure 3 is the object.

Though there are several approaches to determine the domination between functions, FD (Forced Decision) approach is applied here. In FD approach, each function will be compared with other functions respectively, the dominating one will get "1" point, by contract the dominated one gets "0". Then, the sum of point decides the rank of importance.

In this study, the unique evaluation for the whole objective highway seems to be unreasonable

as the importance of functions is different from by section. Therefore, The VE Workshop Group divided the highway as two parts, the part in the urban area and the part in the countryside (also called as the mid-mountainous area). Then, the evaluations of functions for both parts can be made respectively and the results are shown in the Table 2.

In the urban are, the function of "relief the congestion in the operating road" has the highest importance index. However, in the mid-mountainous area, the function of "relief the congestion in the operating road" becomes the function with the lowest importance index, and the function of "secure safety of driving" becomes the most important one comparing to the other functions.

Table 2A. Results of Importance Judgment Classified by Functions (in Urban Area)

Study of the Highway A Improvement Plan (Forced Decision Method)

No.	Function	Function No. 1	2	3	4	5	6	7	Temporary Total	Horizontal Total	Importance W (Point / P)
1	Form a local belt in south-north direction		0	0	0	0	1	1	2	3	10.7%
2	Supply high speed service for car users	1		0	1	1	1	1	5	6	21.4%
3	Relief congestion in operating roads	1	1		1	1	1	1	6	7	25.0%
4	Maintain comfort ability of driving	1	0	0		0	1	1	3	4	14.3%
5	Secure safety of driving	1	0	0	1		1	1	4	5	17.9%
6	Improve living environment	0	0	0	0	0		1	1	2	7.1%
7	Protect natural environment	0	0	0	0	0	0		0	1	3.6%
	Total Points = P									28	100.0%

(if there is any "0" in "Temporary total", "Horizontal total" would be "Temporary total" + 1)

1. The dominance of each function is judged by round-robin tournament. (winner = "1", loser = "0")
2. This is just one of the method of importance judgment, not absolute.

Table 2B. Results of Importance Judgment Classified by Functions (in Countryside)

Study of the Highway A Improvement Plan (Forced Decision Method)

No.	Function	Function No. 1	2	3	4	5	6	7	Temporary Total	Horizontal Total	Importance W (Point / P)
1	Form a local belt in south-north direction		1	1	0	0	0	1	3	4	14.3%
2	Supply high speed service for car users	0		1	0	0	0	0	1	2	7.1%
3	Relief congestion in operating roads	0	0		0	0	0	0	0	1	3.6%
4	Maintain comfort ability of driving	1	1	1		0	1	1	5	6	21.4%
5	Secure safety of driving	1	1	1	1		1	1	6	7	25.0%
6	Improve living environment	1	1	1	0	0		1	4	5	17.9%
7	Protect natural environment	0	1	1	0	0	0		2	3	10.7%
	Total Points = P									28	100.0%

(if there is any "0" in "Temporary total", "Horizontal total" would be "Temporary total" + 1)

1. The dominance of each function is judged by round-robin tournament. (winner = "1", loser = "0")
2. This is just one of the method of importance judgment, not absolute.

6. PROPOSAL AND DECISION MAKING FOR THE IMPROVEMENT PRINCIPLES

The priorities of all functions as the evaluation results on the functions will be the starting point to make the proposal for the improvement principles.

6.1 Discussion and Proposal for the Design Principles

Following the flowchart shown in Figure 4, the design principles for the highway

improvement planning is discussed and proposed respectively.

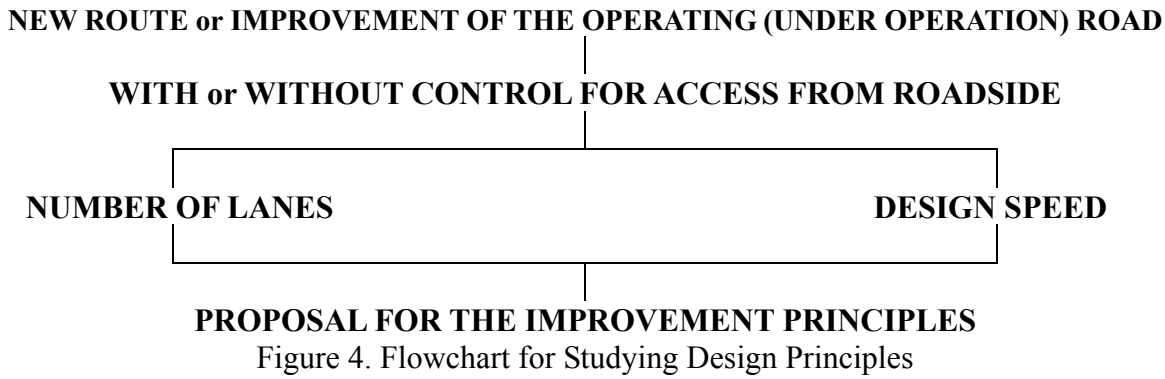

Figure 4. Flowchart for Studying Design Principles

Topic 1: NEW ROUTE or IMPROVEMENT OF THE OPERATING (UNDER OPERATION) ROAD

In the urban area, the most important function was evaluated as the function "relief congestion in operating roads". A new route can not only decentralize the traffic to the certain area but also separate the traffics moving in the area and the traffics passing through the area. Furthermore a new route can supply higher speed service for the traffics which is the second important function. Thus, a new route was proposed in the urban area for the objective highway.

On the other hand, in the countryside area, the most important function for the objective area was evaluated as "secure safety of driving". Considering the safety living in the roadside, we proposed to improve the operating road since there are many sections being closed or restricted in cases of heavy rain or snow. This kind improvement can also make us "maintain comfort ability of driving" and "improve living environment". However, in a section where it is too difficult to improve the operating road as the limitation of geographical features, a bypass was proposed to the planner.

Topic 2: WITH or WITHOUT CONTROL FOR ACCESS FROM ROADSIDE

In the urban area, the function "relief congestion in operating roads" is the most important function that will be realized by eliminating the traffics passed by the objective area through a separated bypass. Further, a bypass without stopping signal in the intersections can allow the traffics drive in a high speed that was evaluated as the second important function. Moreover, to "secure safety of driving" (the third important function) and "maintain comfort ability of driving" (the fourth important function), we proposed to adopt the structure with control for access from roadside.

However, in the countryside area, to avoid that the residents living in the roadside cannot get out of the danger in cases of disaster or a traffic accident, we proposed to adopt the road structure without control for access.

Topic 3: NUMBER OF LANES

Number of lanes has to be decided by the planned traffic flow that collected in the step of information collection. However, since the standard of traffic capacity is different with the classification of the highway/road, the results of the function evaluation should be referred.

In the urban area, the planned traffic flow in a section is 33,900veh/day, therefore four lanes in a total are necessary. As there are two lanes in the operating road, the additional two lanes are needed in the new route of highway.

In the countryside area, the planned traffic flow in a section is 13,600-22,800veh/day. According to the Road Structure Ordinance (see Japan Road Association, 1984A), four lanes should be secured. However, two lanes are enough when we calculated in terms of the traffic capacity (see Japan Road Association, 1984B). We proposed to adopt the standard in the latter to determine the highway as two lanes by considering the economic limitations and the other factors.

Topic 4: DESIGN SPEED

At first, we discussed about the highway in the countryside area. The result of the functions evaluation for the countryside area shows that the most important function is "secure safety of driving". Further, comparing to the function "supply high speed service for car users" which was evaluated as the function ranked the second from the bottom, the function "protect natural environment" is more important. We proposed the design speed to be 60km/h, which is the minimum of the standard for the local high-grade highway, so that the improvement planning will be limited to change the geographical features as less as possible.

In the urban area, 80km/h that is the maximum of the standard for the local high-grade highway had been discussed since the function "supply high speed service for car users" is the second important function of the highway for the urban area. However, the proposals of "new route" and "road structure with control for access from roadside" will play very important roles for the most important function "relief congestion in operating roads" and the other function including that "supply high speed service for car users". To let the users drive in a stable speed in the highway, we finally suggested to adopt the 60km/h as the design speed for the urban area, too.

6.2 Summary: PROPOSAL FOR THE IMPROVEMENT PRINCIPLES

By summarizing the above discussion and proposals for all topics, the principles for the improvement planning of highway can be listed as the followings.

A. Urban area
- -New route
- -With control for access from roadside
- -2 lanes for the new route
- -Design speed=60km/h

B. Countryside area
- -Improving of the operating road, but partly bypass in a new route
- -Without control for access from roadside
- -2 lanes in total
- -Design speed=60km/h

As the results, the improvement planning is changed from a new route to the improving the

operating road in the countryside area. That makes us achieve to decrease the construction cost in total.

7. RESULTS ACHIEVED FROM THIS STUDY

Through the VE study activities, we also achieved some more than what I expected. Some of them can be summarized in the followings.

7.1 Effects and Potential of VE

As it is needed to reduce the cost of public work today, VE displays its greatest force. Up to now, we have implemented the highway planning by emphasizing the efficient traffic function between the areas and by taking into account the affect on the area economically. These are the planning mainly focusing on the connecting function of highways and the structure of highways. Today, as being put to the reconsideration of the infrastructure development concept, it is not enough to consider only the traffic function or the effects on the main areas. It is also very important to look carefully at the area where the highway passes through and to focus up the needs of the smaller living areas. In other words, it is necessary to think about "what is needed for highway?" and "how to construct highway?" from the viewpoint of the users and the roadside residents, and then to capture precisely the functions made the highways to be felt familiar. Further, by proposing the clear concept respective to the unique function of the area, more effectiveness and consensus can be achieved in VE and in highway planning and construction finally.

7.2 Definition of Functions in VE for Highway Planning and Design

It is easy to understand the importance of the appropriate definition of functions from what I had mentioned so far. Here, I show the process to achieve the "appropriate definition of function", and the points needed to be paid attention to.

A. Clarify the objective of VE

We need to clarify the objective of VE based on the implementation timing (refer to Chapter 2) and the implementation form before defining function. For example, at the beginning of routing, the objective of VE could be highway itself. On the other hand, at the stage of detail design, the construction material might be considered as the objective of VE.

B. Express the certain function briefly from the THING's point of view

Express clearly, objectively and briefly the certain "functions" and "purposes" that users and the designer had intended. And express from the THING's viewpoint, not from the human's viewpoint. For example, in the case that highway itself is the objective of VE, it is preferable to express like "let automobile get through", not from the viewpoint of the third party like "automobile runs through".

C. Express in a way being easy to quantify

The effect of the easily quantified expression would appear notably when we express limiting conditions or evaluate the functions. For example, if we define the function as "let

automobile get through", it would be easier to express the capacity condition like 18,000veh/day or 2,400veh/h. On the other hand, the expression like "formation of automobile traffic network" makes it difficult to evaluate quantitatively.

D. Generally abstraction of the expression

A generally abstracted expression will lead to ideas on the radical alternative. Especially, abstraction of verbs used in definition of function is important. For example, defining the function of speed restriction sign as "to notify the speed limit", rather than as "to sign the speed limit", has an effect to get an idea of radical alternative plan such as removing the sign itself and notifying in some other ways.

E. Clarify the limiting condition

Assuming the function we defined above as a narrow one, the function including limiting condition would be a broad one. Limiting condition is essential to "achieve necessary function certainly". For example, one of the limiting conditions for highway design, in which traffic demand is used, is "traffic capacity".

F. Make the classification of functions clearly

In VE, function is classified into usage function and valuable function according to its characteristics, basic function and secondary function according to its level of importance, and necessary function and unnecessary function according to its necessity. Generally, usage function would be basic function, and valuable function and unnecessary function would often be placed as secondary function. However, this logic cannot work reversely. Here is one example about the bridge, which is placed as a symbol of town. Though the symbolic function is not a usage function but a valuable function, it should be classified as the basic function instead of the secondary function.

G. Others

As mentioned before, there is a possibility that pursuit of definition of function might cause change of the standard. Obviously, if the change of the standard is not acceptable, VE should be done with treating it as the limiting condition. Generally, in terms of the purposes of VE is to reduce the construction cost, changing of standard would be the effective alternative with the proviso that the basic functions are maintained. As the results, other transportation means might be the alternatives and these have become easier to be realized now than before due to the reorganization of the government ministries (Ministry of Construction and Ministry of Transport have been reorganized as the same Ministry).

Thus the highway design should not be done with the fixed standards. We should define the functions of the objective highway comprehensively. Then, it is necessary to classify the limiting conditions as the necessary and the unnecessary ones. On the other hand, the modification like an illegal reduction of lane width, which might reduce the necessary functions, should not be done without any consideration. Whatever the case might be, this is what should be implemented with an adequate examination from the viewpoint of traffic engineering and so on.

7.3 Limitation of VE

The history of applying VE for Japanese public works is still short, so that many problems are faced to. Some of them are discussed below.

A. Restriction from laws and briefs

Road Structure Ordinance and the design briefs guarantee a certain level of quality without considering the variation of engineers' level. Their effects on the improvement of the quality of highway planning and design are very huge. On the other hand, the standard values and minimum value of various elements would, in a certain situation, limit the proposal of highway standard reexamination. The laws and briefs are expected to be more flexible.

B. Further technical improvement of highway and traffic engineering is necessary

There is a critical condition in achieving flexibility as the result of change in the laws and briefs. The relationship between the technical standard and the service level (function) should be analyzed precisely and in detail. If not judged correctly from the highway and traffic engineering, there is the possibility that the level of basic function comes down.

C. Training of highway engineers being familiar with VE

For the implementation of VE, VE engineer is of course important. However, highway engineer being familiar with VE, who does not have to be the professional VE engineer, is essential since they can be the coordinators and it would streamline the VE team.

D. Improvement of quantity survey ability of design engineers

Until today, due to the separation of design, construction and management, the ability of design engineers on quantity survey is not necessarily high. However, reducing costs is placed as main purpose in VE. Minimization of the life-cycle cost can be achieved only after knowing construction cost and management cost. One alternative that could be taken is introducing professional of corresponding fields into the VE team. However, in order to streamline the VE team and to implement VE smoothly, improving the ability of design engineers in quantity survey is also necessary.

In addition to the above, the other tacks, such as operating cost, responsibility of the result, and training of VE operator, could be listed.

8. CONCLUSION

This paper investigated the definition of "functions of road", especially "highway", because the "functions" are involved with VE. As a conclusion, I proposed that it is necessary to implement highway planning in the coming years by treating VE as a new viewpoint of highway planning, too.

Japanese government is trying a structural reform. The budget of the public works are reduced these days. Thus now is the best time to develop VE for the public works. It is important to provide maximum effects for Japanese citizens with a limited budget. The effects mean here to provide for whole national land. Therefore, with the mind-set "make crisis into chance", reducing the life-cycle cost of public works without reducing the quality is a new challenge imposed on us, the engineers in Japan. I propose to try to minimize the risk as well as to challenge in a courageous manner.

In July 2003, Japanese Ministry of Land Infrastructure and Transport renewed a part of Road Structure Ordinance. The changes fit with what were mentioned in this paper. This means that

what I was hoping had started from the national level. However, as mentioned in this paper, there are still many problems left. I hope further discussion will be made in the near future, and come up with the best possible measures.

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