Road Design for Future Maintenance Problems and Possibilities
Hawzheen Karim\textsuperscript{1} and Rolf Magnusson\textsuperscript{2}

Abstract: This paper presents an investigation conducted to identify obstacles that prevent sufficient consideration of future road maintenance needs during the road planning and design phase. The investigation focuses on the road planning and design process within the Swedish Road Administration. For this reason the results are applicable for Nordic conditions concerning road design, maintenance, and climate. However, the results focus on general aspects of the planning and design process and ought to also be valid for other conditions outside the Nordic countries. The investigation was carried out using a method called “change analysis,” which consists of complementary steps for the analysis of problems, processes, and goals in order to identify necessary changes. The investigation identified several problems within the road planning and design process related to consulting, knowledge, planning and design activities, regulations, organization structure, and demands from other authorities. The identified problems, activities within the planning and design process, and goals for the process were analyzed. Based on these analyses the investigation identifies the most urgent needs for change in order to eliminate the problems that result in insufficient consideration of maintainability during the planning and design process.

DOI: 10.1061/(ASCE)0733-947X(2008)134:12(523)

CE Database subject headings: Highway and road design; Highway engineering; Maintenance.

Background
Road planning includes studying the conditions relevant for building new roads or improving old ones regarding transportation demands, climate, topography, geology, and material supplies. It also includes evaluations of consequences for society, transportability, traffic safety, and economic development.

Road design means selecting the dimensions of the road and its components, e.g., width of carriageway, road profile, and type of road equipment. The process of road planning and design is complicated due to the numerous components the road consists of and the different aspects that have to be considered for an optimal solution.

One important aspect is to consider the possibilities of performing future maintenance activities. Often the need for a specific maintenance measure is caused by problems only in a specific location on the road. The cost of carrying out these measures can be very high. Some of these problems could probably be considerably reduced by a more suitable design. The designers should take maintainability into consideration to a higher extent than today.

The actors involved in the planning and design process have different opinions about the reasons for improper consideration of maintainability. This investigation is carried out to identify the problems that prevent sufficient consideration of maintenance aspects and propose improvements using a method called “change analysis” (Goldkuhl and Röstlinger 1998).

Literature Review
Insufficient consideration of maintainability during the road planning and design process is a well-known problem for actors involved in this process and in maintenance activities. The problems of performing maintenance activities and their related costs are often subject for discussion. This is not reflected in the literature as the published research within the subject is very limited. Efforts have been made to compile the various factors in the road design that generate unnecessary maintenance needs (Gaffeny and Gane 1970). A study has been performed to create a new methodology for calculating the annual cost of road design with maintenance in mind (Olsson 1983).

Some other studies concerning pavement design, bridges, and specific roadside components also indirectly consider maintenance aspects. One study has determined the fill height of embankments whereby flattening of the slope proved to be cheaper than the installation of guardrails (Neuzil and Peet 1970).

Based on cost-benefit analysis, maintenance costs have been considered in simplified graphs to determine the need for road barrier installation (Wolford and Sicking 1997). Another study has compared different guardrail end terminals from a maintenance point of view (Mattingly and Ma 2002). Yet another study has concluded that a 100 year design life gives the lowest lifecycle cost for urban residential roads (Howard 1991).

\textsuperscript{1}Ph.D. Student, Royal Institute of Technology, School of Architecture and Built Environment, Department of Civil and Architectural Engineering, Brinellvägen 34, 100 44 Stockholm, Sweden; formerly, Ph.D. Student, School of Industrial Technology and Management, Road Technology, Dalarna Univ., 781 88 Borlänge, Sweden (corresponding author). E-mail: hah@du.se

\textsuperscript{2}Professor, School of Industrial Technology and Management, Road Technology, Dalarna Univ., 781 88 Borlänge, Sweden. E-mail: rmg@du.se

Note. Discussion open until May 1, 2009. Separate discussions must be submitted for individual papers. The manuscript for this paper was submitted for review and possible publication on April 17, 2007; approved on March 3, 2008. This paper is part of the \textit{Journal of Transportation Engineering}, Vol. 134, No. 12, December 1, 2008. ©ASCE, ISSN 0733-947X/2008/12-523–531/$25.00.
Objective and Delimitation of the Investigation

The aim of this investigation was to identify problems that obstruct due consideration of maintainability during the road planning and design process. The objective was also to identify urgent needs for changes to eliminate these problems. Measures to implement the identified changes were not included in this investigation. The result of the investigation is expected to contribute to the design of roads with decreased demand for unnecessary and costly maintenance measures.

The investigation focused on processes at the Swedish Road Administration (SRA), which is in charge of both country and urban roads in Sweden. SRA is also responsible for Swedish road design and maintenance specifications. Another reason for this delimitation was that the SRA was the initiator for this investigation. The investigation is also applicable for other Nordic road authorities as climate, design and construction traditions, and maintenance are basically similar in those counties. There is also no reason to believe that most of the results cannot be applicable for road planning and design outside Nordic countries.

Methodology

For identification and elimination of the problems that obstruct sufficient consideration of maintainability during the road planning and design process, it was necessary to evaluate the organization and its processes, its goals, and regulations. For this reason the investigation started with the collection of data concerning the following areas:

- Activities included in road planning and design;
- Actors involved in the activities;
- Goals and regulations that govern the activities;
- Documents that are created during planning and design process; and
- Organizational structure of the SRA.

The data were collected using interviews and a review of design-related documents. The main objective of the interviews was to invent situations perceived as problems by the actors involved in planning and design or in maintenance activities. A problem is defined as a situation that is experienced as unsatisfactory by the involved actors. Experiences from the situation deviate from the expected results or specific goals valid for the situation (Goldkuhl and Röstlinger 1998). Semistructured interviews were chosen to give respondents the possibility to answer in their own words to generate a discussion (Trost 2005). Four categories of actors were interviewed: consultants, maintenance contractors, persons involved in maintenance activities and in planning and design within the SRA. Experience, organizational role, and geographical locations were the main criteria for the choice of respondents. In total, 45 interviews were carried out with 53 persons. The interviews were recorded and saved as digital files.

The second part of the data collection was reviewing documents that describe the planning and design process, construction, and consignment (Vägverket 2004a,c,d,e,f,g,h). Other reviewed documents were guidelines for road planning and design (Vägverket 2004i) and documents that describe the purchasing process (Vägverket 2004b). These documents were examined to identify planning and designs activities, and the goals that govern these activities.

The collected data were analyzed using a method called change analysis, mostly used in the preliminary phases of investigations intended to develop organizations or work practices (Goldkuhl and Röstlinger 1998). This method consists of analyzing problems and goals, formulating the needs for changes, and deciding the change measures. In change analysis the following questions are gone through and answered:

- What are the problems?
- What are the activities?
- What are the goals to be fulfilled?
- What are the measures to be eliminated?
- What are the measures to fulfill the goals and eliminate the problems?
- What are the consequences that can be expected if the measures are conducted?
- Which combination of measures is the most optimal for the overall problem situation?

Change analysis in this investigation was conducted in four steps: analysis of problems, analysis of activities, analysis of goals, and analysis of the needs for change.

Analysis of Problems

The aim of this analysis was to obtain an overview of the situations identified as problems and to identify their causes and consequences. The analysis was carried out in four steps: formulation of problems, classification of problems, delimitation of problems, and analysis of the relations between the problems.

The problems were often described in many words and explained with a lot of examples in the interviews. Some problems described in different ways proved to be more or less the same problem. The problem description was then reformulated to combine several descriptions into one. The identification and formulation of the problems was carried out without any restriction concerning type or origin of the problems in order to create a realistic and comprehensive picture. The problem formulation was conducted gradually until the descriptions became less complicated, more distinctive, understandable, unique, well based, and descriptive.

The previous activity resulted in a list of problems that covered many different problem areas. To avoid working with all the problems at the same time and to create a basis for later analysis, a structure was created by classifying the problems into different problem areas. Similarities between the problems were identified, e.g., similar subjects, similar causes, or effects. Problems related to the same subjects, causes or consequences were included in the same problem area.

By delimitation of the problem areas those problem areas that would be included in the change analysis were specified. Due to time and resource restrictions, this investigation concentrated on the most urgent problem areas. Problems considered to be out of the scope of this investigation were excluded.

The next step was the analysis of relations between problems with the intention of identifying any likely relationship between the problems in order to understand the problem situation as a whole. Correlations between the problems were then analyzed through studying each problem individually to find its relation to other problems. This analysis was a cause/consequence correlation (Fig. 1). Problem C is caused by factors A and B (cause correlation). Problem C results in problem D (consequence correlation). Factors A and B have to be considered as problems as they are the underlying causes for problems C and D. To eliminate problems C and D both problems A and B should be eliminated. For each problem area, this principle was used to illustrate the relation between the problems in the form of a graph called...
The problem graph. These graphs were the bases for the evaluation of the problems during the analysis of need for change.

Analysis of Activities

The aim of this analysis was to evaluate the activities included in the planning and design process to understand how the process was conducted, identify problems not mentioned by the respondents, and correlate problems to activities. The planning and design process at SRA consists of four subprocesses: pre-study establishment, road investigation, work-plan establishment, and construction document establishment. In addition, this analysis also covered three other subprocesses: purchasing, construction, and consignment. The latter three subprocesses are not part of the planning and design process, but they still have a direct influence on that process.

Analysis of the activities began by describing action patterns within each subprocess to clarify how different documents were treated and how administration activities were performed within the processes. The sequences of the activities, the results of the activities, and the responsible actors were identified. Relations between the activities and between actors responsible for conducting the activities were illustrated by describing the flow of documents between different activities, methods of consulting and cooperation, as well as relations between actors.

Analysis of Goals Governing the Planning and Design Process

The analysis was carried out in three steps. The first step was to identify the goals that govern the planning and design process. These were identified both by reviewing documents in which the goals were documented and by analyzing the recorded interviews. Efforts were taken to differentiate between main goals and subgoals.

The second step, analysis of the relation between goals, aimed to determine in which way subgoals contribute to the fulfillment of each other and the main goals. The fulfillment of each goal was examined to determine if it has negative or positive contributions to the fulfillment of other goals.

The third step was the goal evaluation, which aimed to identify goals relevant for maintainability during planning and design.

This was done by examining how the existing goals contribute to the consideration of maintainability during planning and design.

Analysis of Need for Change

The intention of this analysis was to identify the most urgent needs for change. Earlier analyses of problems, activities, and goals constituted the basis for this analysis, which was conducted in two steps: evaluation of identified problems and formulation of the need for changes.

The evaluation of problems was done with the objective of determining the most important problems to be solved and to find out the problems pertinent to the needs for change. The problem graphs established during the analysis of problems were the main bases for this evaluation. During this activity the problems were divided into three different statuses according to the following criteria:

- No solution to the problem (NSP): if the problem has no solution or has a solution outside the scope of this investigation.
- Solved problem (SP): if the identified problem was already solved or in the process of being solved.
- Needs for change (NC): these problems seem urgent to eliminate and they can be eliminated by changes within the planning and design process.

For the last category of the problems, priority was set according to the following criteria:

- A problem that was the cause for several other problems.
- A problem that was connected to high costs or that can result in serious consequences.
- A problem that was crucial to the solution of another problem.
- A problem that was stressed during the interviews.
- A problem that was relatively simple to eliminate, thus generating a large positive effect for little effort.

Generally, a low priority was given to problems that could be solved entirely by solving another problem. The problems given the status NC were all given a priority according to the above-mentioned criteria. The sum of priorities from all criteria gave each problem the priority high or low. In the problem graphs the problems given high priority were then analyzed further by combining them and analyzing the consequences of changes. Based on this the most urgent needs for change were formulated. The aim of this activity was to indicate the needs for changes that could contribute to the elimination of the identified problems. The changes were identified without specifying any measures to fulfill them. In this phase of the investigation it was important to focus on the problems but also to study strengths and possibilities that the road authority and other involved actors in planning and design have.

Results

The following presents a description of the problems, the activities in the processes, the goals, and the identified needs for change.

Analysis of Problems

As mentioned before, this activity was carried out in four steps: identification and formulation of the problems, classification of problems, and delimitation of problems.
Identification and Formulation of the Problems

During the interviews the respondents presented more than 100 situations perceived as problems preventing sufficient consideration of maintainability. Most of the problems were identified during the interviews. A few more were identified during the analysis phases. The analyses reduced that number to 46 problems shown in the list of problems presented in the Appendix.

Classification of Problems

The problems identified and formulated in the previous activity, were classified into six problem areas:

1. Insufficient consulting: consulting between actors involved in maintenance activities and in planning and design is limited to only a few meetings. Several of those are arranged during the construction phase. Any design correction during this late phase will be difficult and costly to realize. This problem area includes Problems 3, 8, 9–11, 30–33, and 40–44.

2. Insufficient knowledge: this problem area contains problems related to knowledge regarding road planning and design and road maintenance. Insufficient consideration of maintainability often depends on the fact that project managers or consultants do not have sufficient knowledge about the costs and performance of maintenance activities. Included in this area are Problems 4, 12, 14, 13, 17, 24–29, and 42.

3. Regulations without maintainability consideration: regulations for the planning and design process are often created without sufficient consideration to maintainability, something which the consultants seldom are aware of. As a result, road designs consistent with these regulations will not cover maintainability aspects. This problem area includes Problems 12–14, 34, 35, and 42.

4. Insufficient planning and design activities: deficiency in planning and design activities results in choosing road designs that require costly and unnecessary maintenance activities. For example, the limited investment budget forces project managers and consultants to select cheaper road designs, which require costly maintenance measures. This problem area includes Problems 3, 5–16, 18–23, 36, 42, and 45.

5. Inadequate organization: problems in this area are related to the organizational structure of road authorities. A linear organization often leads to poor coordination between different processes and activities of road authorities, which results in poor exchange of knowledge and experience within the authorities. This problem area includes Problems 12, 30, and 37–43.

6. Demands from other authorities: during the planning and design phases, municipalities and county administrations present arguments and requirements that are perceived as more important than maintainability, which means that maintainability is often overlooked. This problem area includes Problem 46.

Delimitation of Problems

Subjects for further analysis were four problem areas: insufficient consulting, insufficient knowledge, regulations without maintainability consideration, and insufficient planning and design activities. These problem areas have a direct connection to the planning and design process.

The problem area concerning inadequate organization was excluded in this investigation as the organizations are frequently consulted in this area. The problem area concerning demands from other authorities was also excluded. Examination of these problems requires a more in-depth analysis of authorities such as municipalities, counties, and the European Union which requires a lot of work but with probably minimal benefit.

Analysis of Relations between Problems

This analysis revealed the causes and consequences of each problem. A structure in the form of graphs called “problem graphs” was created for the problems within each problem area (Figs. 2–5). These graphs constitute an important basis for identifying problems that caused other problems or were consequences of other problems and crucial for elimination of other problems according to the priority criteria.

Analysis of Activities

The analysis of activities made the correlation between planning and design activities more understandable. The divisions responsible for planning and design activities were identified together with other involved divisions at the SRA and other involved organizations. In addition, the inputs and outputs for each activity were illustrated. A few more problems mentioned in the problem list were identified during this analysis. This analysis also revealed in which activity a particular problem originated and also how difficult it could be to solve it.

Analysis of Goals Governing the Planning and Design Process

The SRA controls its activities through established goals and result demands formed on the basis of needs in society. The basis for these goals is the overall transportation-related policy goal that was established by the Swedish Parliament in 1998.
Identification of Goals

The overall transport-related policy goal in Sweden is a socio-economically efficient and long-term sustainable transport system for individuals and business communities throughout the country (Vägverket 2006). This comprehensive goal is clarified in six subgoals. For each subgoal, one or more long-term stage goals are established. Each stage goal is broken down into one or more operational goals, which are short-term goals formulated during the annual activity planning. The operational goals constitute the basis for the creation of several specific project goals for each road construction or road improvement project. These project goals, which are unique for each project, are formed during the road investigation subprocess.

Identification of Goals

To achieve the project goals for each road construction project, several measures are chosen. An important basis for selection...
of a particular measure is the SRA’s document “New construction and improvement—influence correlations” (Vägverket 2001), which describes the consequences of the different measures taken within the road transportation system. For example, to increase traffic safety on a specific road section, a reduction of the number of fatalities and severe injuries by a certain percentage can be formulated as a specific project goal. To achieve this project goal, measures such as separation of conflict points, level-separated intersections, safety barriers, and wildlife fences can be taken.

Usually, a selected measure that aims to achieve a specific project goal has a negative effect on other specific project goals for the same project, and thus conflicts between the goals arise. An example of such a conflict is the selection of speed-reduction measures, which increase traffic safety at the expense of traffic quality and accessibility. Other conflicts appear due to the restricted budget frame, which sets a limit for the selection of efficient measures. To reduce goal conflicts, measures are selected after balancing the different project goals. This balancing is often performed by using socioeconomic cost-benefit calculations. A specific measure seldom leads to achieving all the goals.

**Evaluation of Goals**

The analyses of goals revealed that the SRA has not established any clearly defined long-term goals concerning future maintenance and confirmed that this is a problem and a cause for other problems. None of the stage goals or operational goals cover maintainability even if the overall transportation-related policy goal indicates a cost-efficient transportation system. Absence of well-defined goals concerning maintainability leads to insufficient consideration of these aspects. Due to this fact, requirements to fulfill existing operational goals concerning other aspects often direct planning and design toward the selection of road designs that may require costly maintenance measures.

Nondocumented goals, e.g., the budget frame, also dictate planning and design. For each project, a budget is established during the road investigation subprocess. This budget is often set many years before the construction work begins. The presupposition and calculations in the budget can then be out of date, which means that the costs can be underestimated. This can force road authorities to select designs with low acquisition costs, which later may incur high maintenance costs.

**Analysis of Need for Change**

This analysis consisted of two phases: evaluation of problems and formulation of needs for change.

**Evaluation of Problems**

Based on the problem graphs, the identified problems were classified into four different status groups: thirty seven problems as “need for change” status (NC), seven problems as “no solution to the problem” status (NSP), and two problems as “solved problem” status (SP).

A prioritizing of the NC problems in accordance with the five criteria, mentioned in the section entitled “Methodology” resulted in 24 problems with high priority and 13 problems with lower priority (see the Appendix).

**Formulation of Need for Change**

On the basis of the problem and goal evaluations, several needs for change were identified. The most urgent need is the establishment of well-defined and long-term stage goals for road maintenance. These stage goals should be possible to break down into operational goals which give maintainability significance in the planning and design process. It must also be possible to evaluate the fulfillment of operational goals at the end of each road project. An optimal life-cycle cost including maintenance costs can be such an operational goal. Establishment of long-term stage goals for road maintenance will contribute to the elimination of Problems 5–8, 16, 21, 33, and 42.

During the planning and design process, there is a great need for well-structured systems for consulting and knowledge exchange between actors involved in maintenance activities and in planning and design. This consulting process has to be carried out by designated actors and through well-defined activities in accordance with the established guidelines. Consulting process expenses should be a specified component of the planning and design budget. Establishment of well-structured systems for consulting and knowledge exchange will contribute to the elimination of Problems 5, 7–9, 11–14, 17, 19–21, 23–29, 31–33, 38, 41, and 44.

Increased knowledge concerning road design in order to support future maintenance is needed within road authorities, contractors, and consultant firms. This knowledge is the basis for adequate consideration of maintainability. For this reason an efficient feedback system is required between the maintenance process to the planning and design process. An important part of such a system would be the registration of expenses for maintenance measures that have to be performed due to inappropriate road design. Increased knowledge concerning maintainability will contribute to the elimination of Problems 5, 7–9, 11–14, 16–20, 23–29, 31–34, 38, 41, and 45.

An evaluation process with clear guidelines should be carried out for each completed road project as a part of the quality assurance system. This process should ensure that the performance of maintenance measures is taken into consideration to a satisfactory degree for each road project. Implementation of an efficient evaluation process will contribute to the elimination of Problems 5, 7, 8, 17, 20, 30, 33, and 38.

There is a great need to complete guidelines, legislation, and other documents that govern planning and design with maintainance aspects. Consideration of maintenance aspects in these documents will contribute to the elimination of Problems 3, 5–7, 9–11, 12–14, 16–21, 23–25, 27–33, 38, 41, and 44.

Requests for quotations and other purchasing-related documents should contain clear guidelines concerning maintainability, e.g., requirements for maintenance management plans or requirements for optimization of life-cycle cost. Implementation of these changes in the request for quotations will contribute to the elimination of Problems 5, 6, 8, 18, 20, 29, 33, 38, 41, 44, and 45.

There is a need for increased incentives within the consulting firms to get them to pay more attention to maintainability during planning and design. Compensation in the form of bonus points during the evaluation of quotations can be an option for consulting firms that consider the maintainability aspects. Increased incentives will contribute to the elimination of Problems 5, 7, 8, 18, 29, 24, and 33.

**Discussion and Conclusions**

The problem analysis indicates a complex combination of problems that result in insufficient consideration of maintainability aspects during the road planning and design process. Many problems, e.g., Problems 13 and 12, belong to two or more problem...
areas (Figs. 3–5). Problem areas that contribute to the main problem are also affected by the existence of related problems found in other problem areas. For example, insufficient consulting leads to insufficient knowledge regarding maintainability, which leads to regulations without consideration of maintainability and inadequate planning and design (Fig. 6). On the other hand, regulations without consideration of maintainability result in insufficient consulting. This indicates that the problem areas are closely related. None of the problem areas can be completely eliminated in isolation of the other areas. On the other hand, the elimination of one problem area can also contribute to the elimination of problems in other problem areas.

The absence of a well-defined goal concerning maintenance is a fundamental source of inadequate consideration of maintainability aspects. This is also the reason why improper planning and design regarding maintainability is not considered as a problem. The nonexistence of such goals makes the road authority more concerned about the fulfillment of goals related to other aspects, e.g., aesthetic and traffic safety aspects, which often result in road designs with costly maintenance requirements.

The analysis of the activities, confirms the claims of the respondents regarding poor consulting among actors involved in maintenance activities and in planning and design. One reason for poor communication between the actors can be inadequate organizational structure of road authorities.

On the basis of the analysis of problems, activities, and goals the following needs for changes have been identified to eliminate insufficient consideration of maintainability aspects during the planning and design process:

- An urgent need to set-up well-defined and long-term goals for maintenance along with methods to evaluate the fulfillment of these goals.
- Development of well-structured systems for experience exchange and consultation among actors involved in maintenance activities and in the planning and design process.
- Increased knowledge regarding road maintenance among actors involved in planning and design.
- Development of a systematic evaluation process with clear guidelines for the examination of completed road projects to ensure adequate consideration of maintenance as part of a quality assurance system.
- Addition of maintainability in the planning and design-related guidelines, regulations, and other documents.
- Creation of guidelines and requirements for future maintenance considerations, which should be incorporated into requests for quotations and other purchasing-related documents.
- Creation of incentives for consultants to consider maintainability aspects during the planning and design process to a sufficient extent.

Implementation of these changes will contribute to design of roads that do not require unnecessary and costly maintenance measures. This will increase the efficiency of maintenance activities dealing with future challenges regarding funding gaps. Implementation of these changes requires further studies to establish effective and long-term solutions. It is important to avoid measures that require a lot of resources. At the same time, it must be realized that efforts toward change and development always require new resources. The optimal solution can be to select measures that can solve several problems simultaneously. It is also important to study all possible positive and negative consequences of these measures on the actors involved in planning and design.

Further studies will be conducted to create a life-cycle cost model. Such a model will contribute to sufficient consideration of maintainability aspects during road design. This model will constitute a basis on which to select the design that gives an optimal life-cycle cost. These studies will be conducted as case studies, initially including few road components. This model will then be developed to include other road components.

Acknowledgments

This paper was prepared from an investigation conducted within a doctoral project “Road design for lower maintenance” at Dalarna University. Financial support provided by the Swedish Road Administration through the Centre for Maintenance of Infrastructure (CDU) is gratefully acknowledged. Special thanks are extended to the members of the project control group and all the respondents for their contributions to the results of the investigation. The writers especially appreciate the assistance of Associate Professor Owen Ericsson and Mrs. Sarah Berglind.

Appendix. Problem List

P1: Road designs that cause unnecessary and costly maintenance measures.
   Evaluation: NC   Priority: high

P2: Insufficient consideration of maintainability during the road planning and design process.
   Evaluation: NC   Priority: high

P3: Requests for quotations and other purchasing documents do not consider maintainability aspects.
   Evaluation: NC   Priority: high

P4: The maintenance department often carries out the reconstruc-
tation of improper designs without informing the planning and design department about the problems with such designs.

Evaluation: NC Priority: low
P5: For curiosity, aesthetic reasons, or ambition to stimulate technical development, project managers, consultants, or architects select new designs or products without consideration of maintainability.

Evaluation: NC Priority: high
P6: Road authorities do not demand maintenance plan descriptions from consultants for the proposed road designs.

Evaluation: NC Priority: high
P7: Maintainability is easily forgotten during the planning and design process. The road authorities prioritize aspects such as environmental considerations or traffic safety more than maintainability aspects.

Evaluation: NC Priority: low
P8: Requests for quotations do not contain demands concerning consulting between the consultants and actors involved in the maintenance process. This makes the designers believe that maintainability is of less importance.

Evaluation: NC Priority: high
P9: A limited investment budget prevents sufficient consideration of maintainability during planning and design.

Evaluation: NC Priority: high
P10: Project managers are forced to keep the acquisition costs low during the calculation of project expenses.

Evaluation: NC Priority: high
P11: Project managers from road authorities rarely involve designers during the construction phases in order to reduce costs that might be incurred by new demands from the designers.

Evaluation: NC Priority: high
P12: The road authorities do not have an experience feedback process between actors involved in maintenance activities and in planning and design.

Evaluation: NC Priority: high
P13: The road authorities have no database for the collection of experiences regarding inappropriate road designs.

Evaluation: NC Priority: high
P14: The cost of maintenance measures due to improper road design is not properly pursued.

Evaluation: NC Priority: high
P15: It is difficult to calculate the costs for road maintenance measures before the work plans are established.

Evaluation: NPS
P16: Road authorities do not make life-cycle cost analyses for the proposed road designs during planning and design.

Evaluation: NC Priority: high
P17: The investment department does not get information from the maintenance department concerning costs and difficulties related to maintenance measures.

Evaluation: NC Priority: high
P18: Actors involved in planning and design process have no incentives that encourage sufficient consideration of maintainability during planning and design.

Evaluation: NC Priority: low
P19: Until roads have been in operation for a few years, it is hard to predict difficulties concerning maintainability.

Evaluation: NC Priority: low
P20: The road authorities often exclude maintainability in the final evaluation of road construction projects.

Evaluation: NC Priority: low
P21: The land redemption process is a time-consuming process that road authorities try to avoid by selecting designs which require less land redemption. Consideration of maintainability is then neglected.

Evaluation: NC Priority: high
P22: Due to delays in the road planning process caused by changes to the construction plan or prioritization of other projects, actual acquisition costs will exceed predicted costs. To keep the expenses within budget, road authorities are forced to select cheaper designs without consideration of maintainability.

Evaluation: SP
P23: Time and budget constraints force the road authorities to choose designs that are not optimal for maintenance.

Evaluation: NC Priority: low
P24: Road authorities rarely require that consultants must have knowledge of maintenance-related guidelines and regulations.

Evaluation: NC Priority: high
P25: During recruitment of designers and project managers, experience of maintenance is not considered as a qualification.

Evaluation: NC Priority: low
P26: The career of the designer often starts directly after graduation, without having any experience of road construction or road maintenance.

Evaluation: NC Priority: low
P27: Educational programs for actors involved in planning and design do not consider road maintainability.

Evaluation: NC Priority: high
P28: Road designers assume that maintainability is considered during the establishment of design-related guidelines and regulations. If they follow these guidelines they believe maintainability will be sufficiently considered.

Evaluation: NC Priority: high
P29: Road authorities do not require consultants to use maintenance experts to deal with maintenance-related questions.

Evaluation: NC Priority: high
P30: Road authority management has no appropriate established methods for following up the process performance.

Evaluation: NC Priority: low
P31: Consultants have insufficient financial resources to perform maintenance-related consulting on their own initiative.

Evaluation: NC Priority: low
P32: Limited investment budgets reduce consulting among actors involved in maintenance activities and planning and design.

Evaluation: NC Priority: high
P33: Consultants and road authorities underestimate maintainability problems due to inappropriate road designs.

Evaluation: NC Priority: low
P34: Absence of maintenance experts during the creation of design and planning-related regulations and guidelines.

Evaluation: NC Priority: high
P35: According to the public purchasing directive, the road authorities are not allowed to demand specific materials or products in the requests for quotations, even if experience shows that those
products contribute to reduced maintenance costs.

Evaluation: NPS

P36: Due to insufficient general rules for consulting works in architectural and engineering activities (ABK96) (Byggnadets Kontraktsskommite 1996) road authorities have a limited ability to claim compensation from consultants for the reconstruction expenses of improper road design.

Evaluation: NPS

P37: The status of actors involved in planning and design is sometimes considered higher than the status of maintenance actors, which contributes to the absence of consulting between the actors.

Evaluation: SP

P38: Information is improperly spread among different departments within the road authorities.

Evaluation: NC Priority: low

P39: Development of the different processes within the road authorities is carried out in isolation from each other. The organization as a whole is not optimized.

Evaluation: NPS

P40: Time, knowledge, and sometimes interest from management is sometimes not sufficient for the establishment of consultation guidelines between different departments and different processes.

Evaluation: NPS

P41: Road authorities have no guidelines for the coordination of different processes.

Evaluation: NC Priority: low

P42: Road authorities have no long-term goals concerning maintainability.

Evaluation: NC Priority: high

P43: Road authorities have an insufficient organizational structure to deal with the coordination of different processes.

Evaluation: NPS

P44: The maintenance department does not have enough time or resources to review work plans and other construction-related documents before the start of construction.

Evaluation: NC Priority: high

P45: The designers have no model for the calculation of maintenance costs for suggested road designs.

Evaluation: NC Priority: high

P46: Municipalities and county administrations present arguments that are perceived to be more important than maintenance aspects.

Evaluation: NPS

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