

## **Analysis of Factors Affecting the Quality Achievement of Road Preservation Work on the Long Segment Scheme of National Roads in West Sumatra**

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### **ABSTRACT**

The long segment road preservation scheme represents the government's effort to achieve strategic objectives for well-maintained roads and standards across the segments. Initially, all national road maintenance programs were implemented through self-management by individual road segment managers or Project Implementation Units (PPK), utilizing a conventional contract system executed periodically and focusing solely on the primary works for the effective road length. Routine maintenance of functional lengths was conducted by service users through self-management. Currently, the long segment road preservation scheme is set to replace conventional/self-management contracts, with the expectation of addressing longstanding issues. However, in practice, the implementation of the long segment road preservation projects still encounters challenges, as evidenced by instances of project delays resulting in penalties, substandard construction quality, and overdue project completion. Therefore, this research aims to identify the variables influencing the quality achievement of the long segment road preservation scheme and to ascertain which factors have the most significant impact. Utilizing the Delphi method, we gathered experts with relevant expertise in national road preservation under the long segment scheme in West Sumatra and collected their opinions. Based on the results of our survey, the factors deemed most significant by the experts affecting the quality achievement of the long segment road preservation are material factors, followed by equipment factors, quality testing standards, labor factors, and finally, work method factors. Consequently, several aspects warrant attention in future long segment road preservation projects to ensure quality achievement, including: (1) Utilizing materials that meet quality requirements, (2) Ensuring the suitability of the heavy equipment used, (3) Conducting regular calibrations of the Asphalt Mixing Plant (AMP) and other quality testing equipment, (4) Enhancing labor skills through various training programs, and (5) Adjusting work methods to align with other quality standards.

**Keywords:** road preservation; long segment; road quality; Delphi Method.

### **INTRODUCTION**

Initially, all national road maintenance programs were implemented through self-management until 2015 by individual road segment managers or Project Commitment Officials (PPK) for each national road segment, utilizing a conventional contract system executed periodically. Under this system, service providers focused solely on primary works related to the effective road length, while routine maintenance for functional lengths was conducted by service users through self-management. However, in practice, funding and the human resources available in the field were severely limited. Additionally, the risks associated with the quality of the work were fully borne by the service users. Consequently, achieving effectiveness and efficiency in the implementation of road preservation programs proved challenging [1]-[4].

The long segment concept represents a contracting system that allows for a single contract package encompassing multiple handling outputs. Service providers are responsible for routine maintenance (preservation) not only on effective segments but also on functional segments. This long segment road preservation policy involves addressing road preservation within a continuous segment length (which may encompass multiple sections) with the objective of achieving uniform road conditions,

specifically well-maintained and standardized roads throughout the segment [5], [6]. The contracted road length is typically around 50-100 km and comprises several road sections [7], [8].

The implementation of the long segment road preservation project still faces challenges, as evidenced by instances of projects incurring penalties for delays, poor construction quality, and overdue project completion [5]. According to the IRI survey results for the second semester of 2021, the Directorate General of Highways reported that in West Sumatra Province, the national road length in a well-maintained condition was 1,321.31 km (92.38%), while the length of national roads in poor condition was 108.94 km (7.62%). Overall, road stability in West Sumatra has shown improvement. However, when examined by category, the long segment preservation implemented since 2016 has yet to achieve optimal results, with roads classified as well-maintained continuously declining, while those in moderate and light damage categories have increased. Stakeholders have encountered difficulties in applying the established standards and comprehending the scope of work, resulting in ineffective execution of the long segment road preservation project to date [9], [10].

Given the ongoing issues in the implementation of the long segment road preservation project, this research employs the Delphi method to gather expert opinions on variables influencing the quality achievement of road preservation within the long segment scheme and to identify the significant factors affecting this quality achievement. Understanding these factors can serve as an evaluation tool for the Ministry of Public Works and Public Housing, particularly the Directorate of Road Preservation, as well as for all stakeholders involved in the long segment road preservation project, facilitating better project implementation in the future and ensuring road stability and programming are fulfilled [11], [12].

In the second section of this paper, the research methodology will be described, followed by the third section detailing the results and discussion, and concluding with the final section.

## RESEARCH METHODS

This research employs the Delphi method. Developed by Dalkey and his associates at the Rand Corporation in California during the 1960s, this method contrasts with traditional surveys, which utilize random samples to estimate outcomes from separate individuals within a target population. In contrast, the Delphi method relies on interaction with a panel of experts until a consensus is reached [13]-[15]. The validity of the Delphi study is not contingent on the number of participants surveyed but rather on the expertise of the panel members involved. The stages of the Delphi method are illustrated in Figure 1 below.

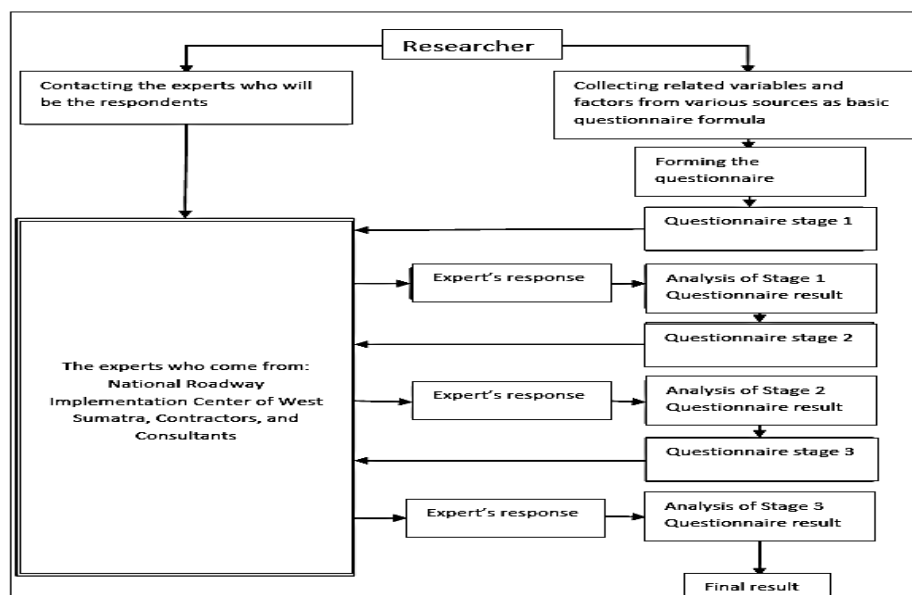


Figure 1. Stages of Model Analysis Construction Using the Delphi Method

The dataset was collected through a questionnaire over three rounds. The first round was conducted from July 4 to July 6, 2022. The second round took place from July 8 to July 10, 2022. The third round was held from July 12 to July 14, 2022. This dataset contains information related to labor factors, construction equipment factors, material factors, work method factors, and quality testing standards. A total of 30 respondents participated in the survey; after preliminary data processing, 24 respondents' data were deemed suitable for further analysis in this study. The respondent profile data can be found in Table 1 below.

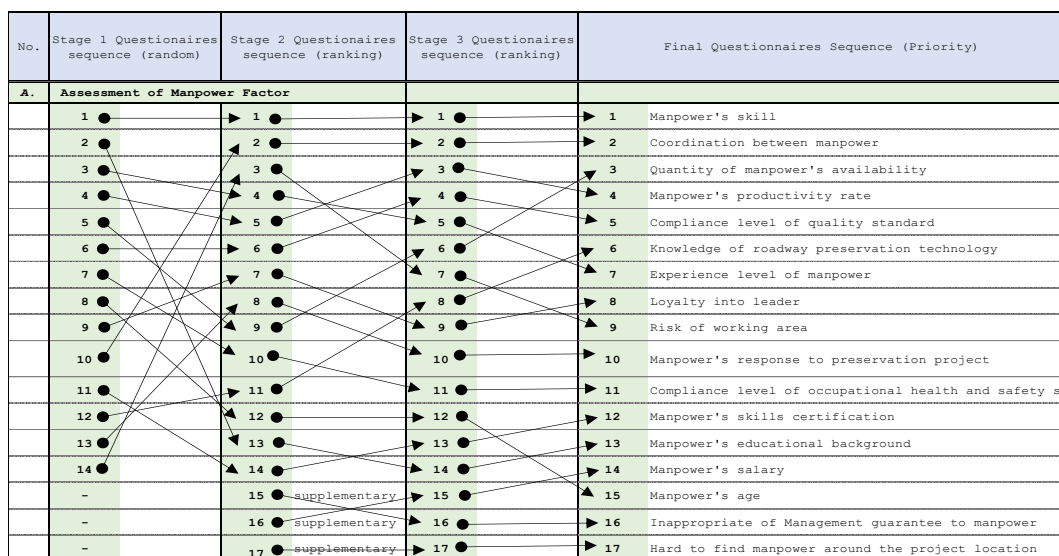
**Table 1.** Respondent Profile Data

Respondent Profile	Number (persons)
Gender	
Male	22
Female	2
Highest Education	
Bachelor's Degree	10
Master's Degree	14
Occupation	
BPJN	8
Consultant	8
Service Provider	8
Years of Work Experience	
1-5 years	1
6-10 years	0
11-15 years	3
16-20 years	6
≥ 21 years	14

## RESULT AND DISCUSSION

### The Impact of Labor Factor Variables on the Quality Achievement of Long Segment Road Preservation

The planning of field labor aims to ensure that each unit involved in road construction operates more effectively and efficiently, thereby achieving a higher level of productivity. Based on our analysis regarding the impact of labor factor variables on the quality achievement of long segment road preservation using the Delphi method, the results are presented in figure 1 below.



**Figure 1.** The influence of labor factor variables on achieving the quality of long road section preservation using the Delphi method,

### The Impact of Heavy Equipment Factor Variables on the Quality Achievement of Long Segment Road Preservation

The selection of equipment types to be used in a project is a crucial factor that influences the timely and accurate completion of tasks. During project execution, the maintenance and servicing of equipment, particularly heavy machinery, must be performed regularly to ensure that the equipment remains in good condition and ready for use. This is essential to prevent any disruptions during implementation due to equipment malfunctions. Based on our analysis of the impact of heavy equipment factor variables on the quality achievement of long segment road preservation using the Delphi method, the results are presented in figure 2 below.

No.	Stage 1 Questionnaires sequence (random)	Stage 2 Questionnaires sequence (ranking)	Stage 3 Questionnaires sequence (ranking)	Final Questionnaires Sequence (Priority)
<b>B. Assessment of Manpower Factor</b>				
1	1	1	1	1 Feasibility of heavy equipment's function
2	2	2	2	2 Heavy equipment compatibility to the project location
3	3	3	3	3 Heavy equipment's productivity
4	4	4	4	4 Technical condition of heavy equipment
5	5	5	5	5 Accuracy of heavy equipment's delivery to project location
6	6	6	6	6 Operator's skill in operating the heavy equipment
7	7	7	7	7 Heavy equipment's capacity
8	8	8	8	8 Heavy equipment's ownership for roadway preservation
9	9	9	9	9 Intensity of heavy equipment's maintenance
10	10	10	10	10 Quantity of heavy equipment
-	11	11 Supplementary	11	11 Availability of heavy equipment's spare parts

Figure 2. Ranking Fluctuations of Each Variable in the Equipment Factor

### The Impact of Material Factor Variables on the Quality Achievement of Long Segment Road Preservation

Indicates that material management requires diverse information regarding specifications, prices, and desired quality to yield optimal results for a project. The quality achievement of road construction is significantly influenced by the selection of materials to be used. The choice of construction materials for a road project necessitates effective management to facilitate the smooth progression of work. The selected materials must conform to standards and on-site conditions. In addition to ensuring quality, contractors must also consider the timeliness of material delivery and the quantity needed. Furthermore, attention should be given to the storage and placement of materials, as some materials are sensitive to environmental conditions. Proper placement of materials will also ease and expedite the work process. Based on our analysis of the impact of material factor variables on the quality achievement of long segment road preservation using the Delphi method, the results are presented in figure 3 below.

No.	Stage 1 Questionnaires sequence (random)	Stage 2 Questionnaires sequence (ranking)	Stage 3 Questionnaires sequence (ranking)	Final Questionnaires Sequence (Priority)
<b>C. Assessment of Material Factor</b>				
	1 ●	1 ●	1 ●	1 The precision of material's quality used
	2 ●	2 ●	2 ●	2 Related material sources availability to needs
	3 ●	3 ●	3 ●	3 Precision of material's delivery
	4 ●	4 ●	4 ●	4 Construction material's price fluctuation in market
	5 ●	5 ●	5 ●	5 Material's quantity precision in project location
	6 ●	6 ●	6 ●	6 Material's storage condition in project location
	7 ●	7 ●	7 ●	7 Distance of material to project location
	8 ●	8 ●	8 ●	8 Technical specification changing of material used
	9 ●	9 ●	9 ●	9 Substitution material's availability

Figure 3. Ranking Fluctuations of Each Variable in the Material Factor

#### The Impact of Work Method Factor Variables on the Quality Achievement of Long Segment Road Preservation

The work method is a critical factor in the management of road construction projects. The use of appropriate, practical, and safe methods significantly aids in the completion of construction work, ensuring that established targets for time, cost, and quality are achieved. Implementing construction methods that are suitable for field conditions will greatly facilitate project completion. Challenges arising from the long segment system with respect to work methods include the difficulty of changing the contractor's paradigm from merely being a construction executor to becoming a road segment manager. Prior to the introduction of the long segment system, contractors focused solely on specific project packages centered on particular segments. In contrast, the long segment system requires contractors to maintain the entire length of the road. This system is expected to transform contractors' work methods into more effective, efficient, and systematic approaches. Based on our analysis of the impact of work method factor variables on the quality achievement of long segment road preservation using the Delphi method, the results are presented in figure 4.

No.	Stage 1 Questionnaires sequence (random)	Stage 2 Questionnaires sequence (ranking)	Stage 3 Questionnaires sequence (ranking)	Final Questionnaires Sequence (Priority)
<b>D. Assessment of Working Methods Factor</b>				
	1 ●	1 ●	1 ●	1 Compatibility of working methods to quality test standard application
	2 ●	2 ●	2 ●	2 Compatibilty of working methods to material characteristic in project
	3 ●	3 ●	3 ●	3 Compatibility of working methods to standard and technical specification application
	4 ●	4 ●	4 ●	4 Compatibility of working methods to feasibility of heavy equipment's function in project
	5 ●	5 ●	5 ●	5 Compatibility of working methods to manpower's competence in project
	6 ●	6 ●	6 ●	6 Compatibility of working methods to social condition of society
	7 ●	7 ●	7 ●	7 Compatibility of working methods environmental condition

Figure 4. Ranking Fluctuations of Each Variable in the Work Method Factor

### The Impact of Quality Testing Standard Factor Variables on the Quality Achievement of Long Segment Road Preservation

Quality control encompasses actions such as testing, measurement, and inspection to determine whether construction activities and other related processes meet the established criteria. It is also important to understand that addressing quality issues begins from the project's inception and continues until its completion. During this period, project execution is divided into specific tasks, which are then assigned to respective fields based on their expertise. Therefore, all parties share a collective responsibility for maintaining quality. Based on our analysis of the impact of quality testing standard factor variables on the quality achievement of long segment road preservation using the Delphi method, the results are presented in figure 5 below.

No.	Stage 1 Questionnaires sequence (random)	Stage 2 Questionnaires sequence (ranking)	Stage 3 Questionnaires sequence (ranking)	Final Questionnaires Sequence (Priority)
E.	Assessment of Quality Standard Test of Roadway Preservation of Long Segment			
	1 ●	1 ●	1 ●	1 Routine calibration of Asphalt Mixing Plant (AMP)
	2 ●	2 ●	2 ●	2 Calibration of quality test equipment components
	3 ●	3 ●	3 ●	3 Compatibility between job mix formula and design mix formula
	4 ●	4 ●	4 ●	4 Competence of laboratory's skill
	5 ●	5 ●	5 ●	5 Technical condition of quality test equipment
	6 ●	6 ●	6 ●	6 Scheduling accuracy of material quality testing
	7 ●	7 ●	7 ●	7 Scheduling accuracy of work quality testing
	8 ●	8 ●	8 ●	8 Certification of equipment quality test
	9 ●	9 ●	9 ●	9 Sort of quality test equipment
	10 ●	10 ●	10 ●	10 Quantity of equipment quality test
	11 ●	11 ●	11 ●	11 Quality test equipment's spare parts availability

Figure 5. Ranking Fluctuations of Each Variable in the Quality Testing Standards Factor

### Factors Influencing the Quality Achievement of Long Segment Road Preservation

The IRI value is one of the indicators used to assess the quality achievement of long segment road preservation. A smaller IRI value indicates that the quality of long segment road preservation achieved is better. Based on our analysis using the Delphi method, it was found that the factor with the greatest influence on the quality achievement of long segment road preservation is the material factor, as shown in figure 6. In other words, to achieve a low IRI value, careful consideration must be given to the selection of materials used, including their quality, availability, and, importantly, the timeliness of their delivery.

No.	Stage 1 Questionnaires sequence (random)	Stage 2 Questionnaires sequence (ranking)	Stage 3 Questionnaires sequence (ranking)	Final Questionnaires Sequence (Priority)
F.	Assessment of Affecting Factors			
	1 ●	1 ●	1 ●	1 Material
	2 ●	2 ●	2 ●	2 Equipment
	3 ●	3 ●	3 ●	3 Quality Test Standard
	4 ●	4 ●	4 ●	4 Manpower
	5 ●	5 ●	5 ●	5 Working Methods

Figure 6. Ranking Fluctuations of Factors Influencing the Quality Achievement of Long Segment Road Preservation

## CONCLUSION

To achieve more optimal results in the implementation of long segment road preservation projects on national roads in West Sumatra, we offer several recommendations based on our research, which captured the opinions of experts in the field of long segment road preservation using the Delphi method. The recommendations are as follows: (1) Utilize materials that meet quality requirements in long segment road preservation projects. (2) Ensure the suitability of heavy equipment used in the execution of long segment road preservation projects. (3) Conduct regular calibrations of the Asphalt Mixing Plant (AMP) and other quality testing equipment. (4) Enhance labor skills by providing various training programs for workers. (5) Adapt work methods to the application of quality standards for long segment road preservation. The Delphi method employed in this study can still be further developed by integrating it with other quantitative analysis methods to yield more scientific results. Future research should also consider the latest systems for long segment projects, including the use of an e-catalog system for tenders, allowing for multiple service providers to be engaged throughout the project based on offers and the needs of each road segment manager

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