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Analysis of Factors Influencing Asphalt Pavement Work Quality in the Bungku – Bahodopi – Southeast Sulawesi Border Road Preservation Project

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ABSTRACT: This study investigates the critical factors influencing the quality of asphalt pavement work within the scope of the Bungku – Bahodopi – Southeast Sulawesi Border Road Preservation Project. Roads serve as indispensable terrestrial transportation infrastructure, pivotal for a nation's economic, social, cultural, and environmental prosperity. Premature degradation of road pavements before their designed service life presents a significant challenge, often attributed to factors such as vehicle axle overloading. However, other contributing elements like contractors' non-adherence to quality management systems, the use of substandard materials, malfunctioning equipment, and inadequate supervision also play substantial roles. This research aims to systematically identify distinct groups of factors affecting asphalt pavement work quality through Exploratory Factor Analysis (EFA) and to quantitatively assess their significant influence on quality using multiple linear regression. The findings from this study are anticipated to offer robust recommendations for enhancing road construction quality management and practices in similar infrastructure projects.

KEYWORDS: Analysis, Project, Pavement, Quality, Management.

INTRODUCTION

Road infrastructure forms the backbone of national transportation systems, facilitating diverse economic and social activities. The Bungku – Bahodopi – Southeast Sulawesi Border Road Preservation Project, covering an extensive 108 KM, represents a crucial segment of national roads with a flexible asphalt pavement type. Despite meticulous initial planning and design, premature deterioration of these pavements is a recurring issue. While excessive vehicle loads are frequently highlighted as a primary culprit, a broader spectrum of factors contributes to this problem. These include, but are not limited to, contractors' failure to comply with established quality management protocols, the incorporation of materials that do not meet specified standards, the deployment of equipment operating below optimal performance, and systemic deficiencies in supervisory oversight. Therefore, this study is imperative to comprehensively identify and categorize the multifarious factors affecting pavement work quality and to provide actionable recommendations aimed at elevating the quality standards of asphalt pavement construction.

LITERATURE REVIEW

The light ends produced by cracking reaction are removed in the stripper column. The off -gas from the stripper is sent to the fuel gas, but flared if it is under high pressure (Agsarini, P. 2015). And the paraffins and olefins in the column bottom stream are fed to the linear alkyl benzene alkylation unit. In order to recover enough heat from the bottom stream, it is necessary by passing where the paraffin stream is heated (Agsarini, P. 2015).

The existing body of literature offers valuable insights into the multifaceted nature of road pavement quality. Previous research has explored both intrinsic and extrinsic factors influencing the integrity and longevity of road infrastructure.

Ali, Lakawa, Hawa, & Sufrianto (2022) examined the interplay of internal factors (e.g., pavement bearing capacity, work methods, material quality) and external factors (e.g., vehicle loads, standing water) on road pavement work quality. Their findings suggested that robust internal factors could significantly mitigate the adverse impacts of external pressures (Ali, A. 2022). Similarly, Agsarini (2015) utilized regression analysis to evaluate the influence of internal factors (e.g., project management, human resources, equipment/material effectiveness) and external factors (e.g., economic conditions, government policies, regulations) on construction project performance, concluding that external factors notably affect project quality (Agsarini, P. 2015).

In the context of quality control, Wijaya (2023) assessed the effectiveness of rigid pavement quality control, underscoring that stringent quality control systems consistently lead to superior final product quality (Wijaya S. 2023). Anugrah, Firzan, & Febrianti (2022) focused on internal (e.g., material availability, work methods, labor motivation) and external (e.g., economic climate, weather, government regulations) impediments, identifying material supply delays and extreme weather as common hindrances to project quality (Anugrah, M.A. et al. 2022).

The concept of asphalt pavement work quality encompasses a set of inherent characteristics that define its ability to fulfill specified requirements and expectations. Optimal quality is a function of several interdependent factors, including adherence to technical specifications, the efficacy of implementation methods, and prevailing environmental conditions.

Technical Specifications: These foundational documents delineate the provisions, standards, and technical prerequisites essential for ensuring the quality, safety, and functional integrity of the completed work.

a. Material Specifications: Critical materials include asphalt (e.g., Asbuton Ex. PT. Putindo Bintech, Asphalt Hard Pen 60/70 Ex. PT. Pertamina), aggregates (e.g., 3/4" and 3/8" crushed stone from Kolono), and filler (e.g., stone dust from Kolono).
b. Asphalt Mixture Specifications: Determined rigorously through methods such as the Marshall Test, dictating the precise composition of Asphalt Concrete – Wearing Course (AC-WC) mixtures.
c. Implementation Specifications: Encompass the comprehensive procedures from site preparation, material procurement and mixing at the Asphalt Mixing Plant (AMP), to asphalt paving using an Asphalt Finisher, and subsequent compaction with rollers.
d. Quality Control (QC): Implemented post-compaction, involving systematic testing such as asphalt penetration tests, aggregate gradation analysis, and Marshall Stability tests of the asphalt mixture.

Factors Potentially Causing Quality Failure

Based on the literature and common construction challenges, a comprehensive set of factors was identified:

1. Material Factors (X1): Quality of aggregates, type and quality of asphalt, and filler.
2. Equipment and Technology Factors (X2): AMP capacity, paver performance, and compactor condition.
3. Labor and Skills Factors (X3): Competence of equipment operators, expertise of field workers, and level of discipline.
4. Project Management and Quality Control Factors (X4): Project planning and supervision, time management, and internal quality control systems.
5. Weather and Environmental Factors (X5): Rainfall, air temperature, and humidity during construction.
6. Traffic Load Factors (X6): Volume of traffic and incidence of heavy vehicle overloading.
7. Government Regulation and Policy Factors (X7): Compliance with national technical standards and specifications, environmental permits, and budget policies.
8. Subgrade Condition Factors (X8): Type and stability of the underlying soil, and effectiveness of drainage.
9. Social and Economic Factors (X9): Community support, material prices and availability, and labor market conditions.

Statistical Methods:

1. Factor Analysis: A multivariate statistical technique employed to identify underlying latent constructs or factors that explain the patterns of correlations among a set of observed variables (Hair, J. F. et al. 2010). Exploratory Factor Analysis (EFA) is particularly useful for reducing a large number of variables into a smaller, more manageable set of underlying factors.
2. Multiple Linear Regression: A statistical modeling technique used to predict the value of a dependent variable based on the values of two or more independent variables. This method quantifies the strength and direction of the linear relationship between the predictor variables and the outcome (Gujarati, D. N. 2009).

Data Collection

Primary data were gathered directly from project stakeholders, including engineers, supervisors, and experienced construction personnel involved in the asphalt pavement work. A structured questionnaire was designed and administered to collect perceptions on the identified factors. The questionnaire utilized a Likert scale to measure respondents' agreement or disagreement with statements related to each factor.

Table 1, represents the rerun column design specification.

Score	Description
1	Strongly Disagree / Very Poor
2	Disagree / Poor
3	Neutral / Fair
4	Agree / Good
5	Strongly Agree / Very Good

Research Variables

The independent variables (X1 to X9) were the identified factors potentially influencing pavement quality. The dependent variable was the 'Mutu Pekerjaan Perkerasan Aspal' (Quality of Asphalt Pavement Work), measured through a composite score derived from the questionnaire.

Data Analysis

The collected data underwent a multi-stage statistical analysis:

1. Descriptive Statistics: To characterize the sample and

responses.

2. Instrument Testing:
   a. Validity Test: Using Pearson correlation to determine if each questionnaire item accurately measures what it intends to measure. An item is considered valid if its r-count > r-table (with α=0.05).
   b. Reliability Test: Using Cronbach's Alpha to assess the internal consistency of the questionnaire. A construct is considered reliable if Cronbach's Alpha > 0.60.
3. Exploratory Factor Analysis (EFA): Applied to reduce the 9 initial variables into a smaller set of underlying factors. Key metrics evaluated included:
   a. Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy (> 0.50 for suitability).
   b. Bartlett's Test of Sphericity ($p < 0.05$ for suitability).
   c. Measure of Sampling Adequacy (MSA) for individual items (> 0.50).
   d. Communality values (> 0.50 indicating shared variance).
   e. Scree Plot and Eigenvalues (> 1.0) for determining the number of factors.
   f. Varimax rotation was used to achieve a simpler factor structure
4. Classical Assumption Tests (for Multiple Linear Regression): Prior to regression analysis, the following assumptions were verified:
   a. Normality Test: Kolmogorov-Smirnov test to check if residuals are normally distributed ($p > 0.05$).
   b. Multicollinearity Test: Variance Inflation Factor (VIF) and Tolerance values to ensure no high correlation among independent variables (VIF < 10, Tolerance > 0.1).
   c. Heteroscedasticity Test: Glejser test or scatter plots to check for constant variance of residuals ($p > 0.05$ for Glejser test).
   d. Autocorrelation Test: Durbin-Watson test to detect correlation among residuals (Durbin-Watson value between 1.5 and 2.5).
5. Multiple Linear Regression Analysis: Employed to analyze the significant influence of the identified factors (derived from EFA) on the asphalt pavement work quality. The regression model was defined as: $Y=\beta 0+\beta 1F1+\beta 2F2+\cdots+\beta kFk+\epsilon$ Where Y is the quality of asphalt pavement work, Fi are the extracted factors, βi are the regression coefficients, and ϵ is the error term.
   a. Partial Significance (t-test): To assess the individual contribution of each factor.
   b. Simultaneous Significance (F-test): To assess the overall contribution of all factors combined.

RESULTS AND DISCUSSION

Respondent Profile

The survey involved a diverse group of respondents, providing a comprehensive perspective. The demographic profile of the respondents in this study indicates a diverse yet predominantly experienced group of professionals.

Table 2 Respondent Characteristics

Characteristic	Frequency	Percentage
Education		
SLTA	20	57.14%
S1	15	42.86%
S2	-	-
Work Experience		
< 5 Tahun	12	34.29%
5 - 10 Tahun	17	48.57%
10 - 15 Tahun	1	2.86%
> 15 Tahun	5	14.29%
Gender		
Male	32	91.43%
Female	3	8.57%

In terms of educational background, the majority held a Senior High School (SLTA) qualification (57.14%), followed by those with a Bachelor's degree (S1) at 42.86%. No respondents were recorded as holding a Master's degree (S2). Regarding work experience, nearly half (48.57%) had between 5 to 10 years of experience, while 34.29% had less than 5 years. Respondents with over 15 years of experience accounted for 14.29%, and only a small fraction (2.86%) had between 10 to 15 years of experience. In terms of gender distribution, the sample was overwhelmingly male, comprising 91.43% of the respondents, whereas females represented only 8.57%. These characteristics suggest that the data was collected from a group with relevant field experience and technical familiarity, lending credibility to the insights drawn from their responses.

Instrument Validity

Validity test was conducted to examine the significance of the correlation coefficient (Pearson correlation) at significant level (α) of 0.05. The test used two-sided tests with significance level of 0.05. The test criteria were 1) if r_count > r_table, the variable was declared valid; and 2) when r_count < r_table, the variable was declared not valid. Since all instruments in the validity test had r_count significance (α) 5% > r table with 5% significance, the variable used was valid.

Table 3 Validity Test Results

Variabel	Indicator	Sig.(*2-tailed*)	α	r_{count}	r_{count} (r Product moment)	Criteria
Material (X1)	X_1.1	<0,001		0.912		Valid
	X_1.2	<0,001		0.895		Valid
	X_1.3	<0,001		0.841		Valid
	X_1.4	<0,001		0.827		Valid
Equipment and Technology (X2)	X_2.5	<0,001		0.888		Valid
	X_2.6	<0,001		0.891		Valid
	X_2.7	<0,001		0.873		Valid
	X_2.8	<0,001		0.856		Valid
Labor and Skills (X3)	X_3.9	<0,001		0.839		Valid
	X_3.10	<0,001		0.882		Valid
	X_3.11	<0,001		0.838		Valid
	X_3.12	<0,001		0.916		Valid
Project Management and Quality Control (X4)	X_4.13	<0,001		0.801		Valid
	X_4.14	<0,001		0.853		Valid
	X_4.15	<0,001		0.896		Valid
Weather and Environment (X5))	X_5.16	<0,001		0.866		Valid
	X_5.17	<0,001	0,05	0.893	0,334	Valid
	X_5.18	<0,001		0.865		Valid
Traffic Load (X6)	X_6.19	<0,001		0.894		Valid
	X_6.20	<0,001		0.893		Valid
	X_6.21	<0,001		0.908		Valid
Government Regulation and Policy (X7)	X_7.22	<0,001		0.863		Valid
	X_7.23	<0,001		0.893		Valid
	X_7.24	<0,001		0.906		Valid
Subgrade Conditions (X8)	X_8.25	<0,001		0.911		Valid
	X_8.26	<0,001		0.867		Valid
	X_8.27	<0,001		0.872		Valid
Social and Economic Factors (X9)	X_9.28	<0,001		0.859		Valid
	X_9.29	<0,001		0.901		Valid
	X_9.30	<0,001		0.896		Valid
Asphalt Pavement Work Quality (Y)	Y.31	<0,001		0.921		Valid
	Y.32	<0,001		0.859		Valid
	Y.33	<0,001		0.875		Valid

From the results of the validity test calculation in the table above, it can be seen that r_count > r_table, (0.334) all indicators on the questionnaire are declared valid, so that the data on each indicator can be analyzed further.

Instrument Reliability

Reliability test is conducted to determine the consistency of a questionnaire. Reliability test in this study, which examined the consistency of the research variable, used Cronbach's alpha values. When Cronbach's Alpha > 0.60, the variable is reliable. However, the variable in question is considered unreliable if its Cronbach's Alpha < 0.60.

Table 4 Reliability Test Results

Variable	*Cronbach's Alpha*	*Cronbach's Alpha* required	Criteria
Material (X1)	0.891	> 0.60	Reliable
Equipment and Technology (X2)	0.899	> 0.60	Reliable
Labor and Skills (X3)	0.892	> 0.60	Reliable
Project Management and Quality Control (X4)	0.804	> 0.60	Reliable
Weather and Environment (X5))	0.842	> 0.60	Reliable
Traffic Load (X6)	0.879	> 0.60	Reliable
Government Regulation and Policy (X7)	0.864	> 0.60	Reliable
Subgrade Conditions (X8)	0.858	> 0.60	Reliable
Social and Economic Factors (X9)	0.862	> 0.60	Reliable
Asphalt Pavement Work Quality (Y)	0.857	> 0.60	Reliable

As shown in table, all of the Cronbach's Alpha > 0.60, It follows that all the variables are reliable.

Exploratory Factor Analysis (EFA) Results

1. KMO and Bartlett's Test: The Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy was found to be 0.736 (well above the 0.5 threshold), and Bartlett's Test of Sphericity was significant (p<0.001), confirming the suitability of the data for factor analysis.

Table 5 KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.736
Bartlett's Test of Sphericity	Approx. Chi-Square	1019.711
	df	435
	Sig.	.000

2. Measure of Sampling Adequacy (MSA): Individual MSA values for all variables were greater than 0.50, further supporting their inclusion in the analysis.

Table Measure of Sampling Adequacy (MSA)

Sub Factor	MSA Count	Criteria
P1	0,644	> 0,50
P2	0,604	> 0,50
P3	0,733	> 0,50
P4	0,628	> 0,50
P5	0,771	> 0,50
P6	0,730	> 0,50
P7	0,714	> 0,50
P8	0,665	> 0,50
P9	0,783	> 0,50
P10	0,758	> 0,50
P11	0,587	> 0,50
P12	0,720	> 0,50
P13	0,581	> 0,50
P14	0,819	> 0,50
P15	0,713	> 0,50
P16	0,843	> 0,50
P17	0,826	> 0,50
P18	0,781	> 0,50
P19	0,907	> 0,50
P20	0,734	> 0,50
P21	0,787	> 0,50
P22	0,796	> 0,50
P23	0,690	> 0,50
P24	0,860	> 0,50
P25	0,789	> 0,50
P26	0,746	> 0,50
P27	0,771	> 0,50
P28	0,666	> 0,50
P29	0,798	> 0,50
P30	0,693	> 0,50

3. Communality: All variables exhibited extraction communality values greater than 0.50, indicating that a substantial portion of their variance was explained by the extracted factors.
4.

Table 6 Communality

Sub Factor	Initial	Extraction
P1	1,000	0,833
P2	1,000	0,770
P3	1,000	0,711
P4	1,000	0,727
P5	1,000	0,704
P6	1,000	0,838
P7	1,000	0,643
P8	1,000	0,691
P9	1,000	0,639
P10	1,000	0,800
P11	1,000	0,861
P12	1,000	0,805
P13	1,000	0,645
P14	1,000	0,774
P15	1,000	0,803
P16	1,000	0,742
P17	1,000	0,724
P18	1,000	0,606
P19	1,000	0,759
P20	1,000	0,796
P21	1,000	0,760
P22	1,000	0,757
P23	1,000	0,712
P24	1,000	0,802
P25	1,000	0,694
P26	1,000	0,750
P27	1,000	0,702
P28	1,000	0,712
P29	1,000	0,804
P30	1,000	0,745

5. Factor Extraction: The EFA resulted in the extraction of four principal factors based on eigenvalues greater than 1, explaining a cumulative variance of 74,359%. the number of extraction result factors will be seen.

Table 7 Factor Extraction

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	18.351	61.171	61.171	18.351	61.171	61.171	6.544	21.813	21.813
2	1.580	5.266	66.437	1.580	5.266	66.437	6.191	20.638	42.451
3	1.277	4.255	70.692	1.277	4.255	70.692	5.046	16.821	59.272
4	1.100	3.667	74.359	1.100	3.667	74.359	4.526	15.087	74.359
5	0.901	3.004	77.364						
6	0.823	2.743	80.107						
7	0.703	2.343	82.449						
8	0.663	2.210	84.659						
9	0.591	1.971	86.630						
10	0.541	1.804	88.434						
11	0.480	1.602	90.036						
12	0.413	1.375	91.411						
13	0.375	1.249	92.660						
14	0.362	1.205	93.865						
15	0.266	0.887	94.752						
16	0.249	0.829	95.582						
17	0.228	0.760	96.342						
18	0.202	0.674	97.016						
19	0.184	0.612	97.629						
20	0.148	0.494	98.122						
21	0.120	0.399	98.521						
22	0.103	0.342	98.863						
23	0.090	0.301	99.164						
24	0.078	0.260	99.423						
25	0.061	0.203	99.626						
26	0.043	0.143	99.769						
27	0.036	0.121	99.890						
28	0.018	0.061	99.951						
29	0.009	0.031	99.982						
30	0.005	0.018	100.000						

In addition to the total variance table, there is also a graph that explains the basis of calculation in determining the number of factors, seen in the Scree Plot graph. The shape of the Scree Plot graph that corresponds can be seen in Figure Scree Plot as follows:

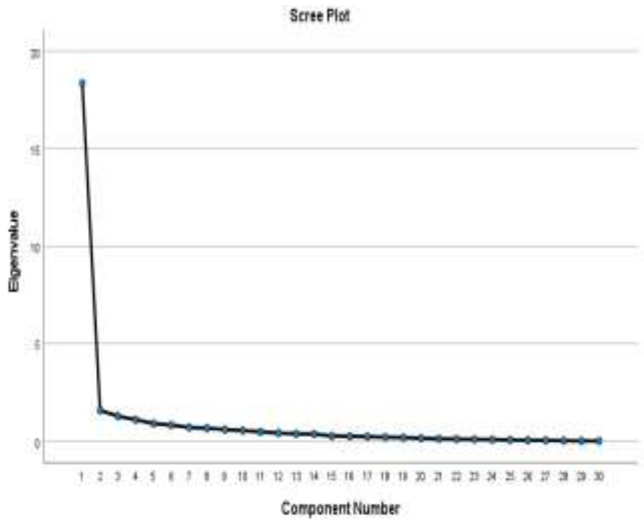

Figure 1 Scree Plot

In Figure Scree Plot it can be seen that the number of factors that will be formed when the Initial Eigenvalues are greater than 1.00. 4 factors have values greater than 1. So these 4 factors can explain the 30 original variables.

6. Rotated Components Matrix: The extracted variables will be rotated because usually the placement of variables is not right or there are still variables that do not match the factors. The rotation process is carried out on variables that pass the MSA test.

Table 8 Rotated Components Matrix

Rotated Component Matrix[a]				
	Component			
	1	2	3	4
P1	0.181	0.339	0.812	0.160
P2	0.320	0.161	0.785	0.158
P3	0.135	0.248	0.779	0.158
P4	0.280	0.191	0.673	0.399
P5	0.213	0.652	0.420	0.239
P6	0.280	0.814	0.195	0.243
P7	0.263	0.632	0.396	0.131
P8	0.406	0.637	0.300	0.174
P9	0.426	0.199	0.409	0.500
P10	0.489	0.041	0.210	0.717
P11	0.063	0.335	0.234	0.830
P12	0.548	0.275	0.215	0.619
P13	0.208	0.483	0.213	0.568
P14	0.626	0.261	0.486	0.280
P15	0.686	0.313	0.104	0.473
P16	0.684	0.337	0.375	0.141
P17	0.386	0.560	0.455	0.233
P18	0.629	0.326	0.169	0.275
P19	0.609	0.475	0.308	0.258
P20	0.407	0.438	0.570	0.338
P21	0.380	0.525	0.324	0.485
P22	0.392	0.713	0.149	0.270
P23	0.614	0.538	0.153	0.151
P24	0.467	0.548	0.163	0.507
P25	0.513	0.435	0.227	0.436
P26	0.699	0.407	0.245	0.189
P27	0.317	0.605	0.350	0.335
P28	0.378	0.447	0.343	0.501
P29	0.692	0.207	0.382	0.370
P30	0.639	0.375	0.417	0.145

These factors were then rotated using Varimax to enhance interpretability and named as follows:

a. Factor 1: Environmental and Quality Control Factors (F1): Comprising variables related to weather conditions, environmental impacts, and internal quality control mechanisms.
b. Factor 2: Equipment and Project Regulation Factors (F2): Encompassing variables related to the condition and utilization of equipment, as well as adherence to government regulations and policies.
c. Factor 3: Material and Workforce Competency Factors (F3): Grouping variables pertaining to the quality of construction materials and the skill level of the workforce.
d. Factor 4: Management and External Influences Factors (F4): Including aspects of project management effectiveness, traffic load impact, and broader socio-economic considerations.

Classical Assumption Tests Results

The regression analysis proceeded after confirming the fulfillment of classical assumptions:

1. Normality: The Kolmogorov-Smirnov test for normality of residuals yielded a significance value of p>0.05, indicating that the residuals were normally distributed.

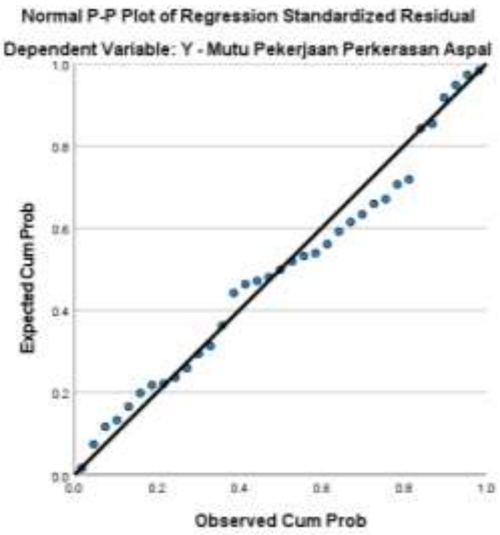

Figure 2 Normal Plot

The normal probability plot shows that the data points closely follow the diagonal line, indicating that the residuals of the regression model are normally distributed.

2. Multicollinearity: refers to a situation in which two or more independent variables in a multiple linear regression model exhibit a high degree of correlation. The presence of multicollinearity can lead to instability in the estimation of regression coefficients, thereby compromising the reliability and interpretability of the analysis results.

Table 9 Multicollinearity

Model		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	Factor 1 – Environmental and Quality Control Factors	0.192	5.211
	Factor 2 – Equipment and Project Regulation Factors	0.179	5.583
	Factor 3 – Material Quality and Traffic Disturbance Factors	0.369	2.710
	Factor 4 – Labor and Project Management Factors	0.312	3.201

Based on the table above, the Tolerance values for all independent variables are greater than 0.100, with Factor 1 = 0.192, Factor 2 = 0.179, Factor 3 = 0.369, and Factor 4 = 0.312. Additionally, all Variance Inflation Factor (VIF) values are less than 10.00, specifically Factor 1 = 5.211, Factor 2 = 5.583, Factor 3 = 2.710, and Factor 4 = 3.201. These results indicate that the regression model does not exhibit symptoms of multicollinearity.

3. Heteroscedasticity: The Glejser test (or inspection of the scatter plot of residuals vs. predicted values) showed no discernible pattern, suggesting that heteroscedasticity was not an issue (p>0.05).

Table 10 Heteroscedasticity

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-0.133	0.531		-0.250	0.805
	Factor 1 – Environmental and Quality Control	0.015	0.028	0.212	0.531	0.599
	Factor 2 – Equipment and Project Regulation	-0.019	0.029	-0.263	-0.636	0.529
	Factor 3 – Material Quality and Traffic Disturbance	0.015	0.038	0.109	0.380	0.707
	Factor 4 – Labor and Project Management	0.030	0.042	0.223	0.714	0.481

Based on the results of the Glejser test as shown in the table, all independent variables have significance values greater than 0.05. Specifically, Environmental and Quality Control Factors (0.599), Equipment and Project Regulation Factors (0.529), Material Quality and Traffic Disturbance Factors (0.707), and Labor and Project Management Factors (0.481). These results indicate that there is no significant relationship between the independent variables and the absolute value of the residuals. Therefore, it can be concluded that the regression model does not exhibit heteroscedasticity and meets the assumption of homoscedasticity, allowing it to be used for further analysis

4. Autocorrelation: The initial Durbin-Watson (DW) test yielded a value of 1.320, which falls below the lower bound (du = 1.7259), indicating the presence of positive autocorrelation in the regression model. To address this issue, the Cochrane-Orcutt transformation was applied.

Table 11 Autocorrelation

Model Summary[b]					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.927[a]	0.859	0.840	0.83666	1.747
a. Predictors: (Constant), LAG_TOTAL.F4, LAG_TOTAL.F1, LAG_TOTAL.F2, LAG_TOTAL.F3					
b. Dependent Variable: LAG_TOTAL.Y					

Following the transformation, the recalculated DW value increased to 1.747, which falls within the acceptable range of 1.7259 to 2.2741, confirming the absence of autocorrelation. Moreover, the model's R^2 value after transformation was 0.859, with an Adjusted R^2 of 0.840, indicating that the revised model remains highly predictive. Thus, the Cochrane-Orcutt method effectively resolved the autocorrelation problem and improved the model's validity for further analysis.

Multiple Linear Regression Analysis Results

The multiple linear regression model was developed to assess the influence of the four extracted factors on the quality of asphalt pavement work.

1. Partial Significance (t-test):
The following table presents the results of the partial significance test (t-test) conducted to determine the individual effect of each factor on the quality of asphalt pavement work. The results are evaluated against the critical t-value (t_table = 2.042, α = 0.05, df = 30).

Table 12 Partial Significance (t-test)

Variable	t-Value	t_table (α = 0.05, df = 30)	Decision
Factor 1 – Environmental and Quality Control	3.34	2.042	Significant (H_0 Rejected)
Factor 2 – Equipment and Project Regulation	2.375	2.042	Significant (H_0 Rejected)
Factor 3 – Material Quality and Traffic Disturbance	0.62	2.042	Not Significant (H_0 Accepted)
Factor 4 – Labor and Project Management	0.318	2.042	Not Significant (H_0 Accepted)

Based on the t-test results, Factor 1 (Environmental and Quality Control) and Factor 2 (Equipment and Project Regulation) have a significant influence on the quality of asphalt pavement work, as indicated by t-values greater than the critical value (3.340 > 2.042 and 2.375 > 2.042) and p-values less than 0.05. In contrast, Factor 3 (Material Quality and Traffic Disturbance) and Factor 4 (Labor and Project Management) do not show significant effects, with t-values below the threshold and p-values above 0.05. Therefore, improvements in pavement quality should primarily focus on environmental conditions, quality control, equipment, and regulatory aspects

Tabel 13, Simultaneous Significance (F-test):

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	156.654	4	39.164	49.959	0.000
Residual	23.517	30	0.784		
Total	180.171	34			

The F-test results demonstrated a statistically significant simultaneous influence of the four extracted factors (F1, F2, F3, F4) on the quality of asphalt pavement work. The calculated F-statistic was 49.959, which was significantly greater than the critical F-table value (e.g., 2.69 for appropriate degrees of freedom), with a significance level of $p<0.001$. This strongly indicates that the collective set of factors significantly predicts pavement work quality.

CONCLUSIONS

This study successfully identified and categorized the latent factors influencing the quality of asphalt pavement work in the Bungku – Bahodopi – Southeast Sulawesi Border Road Preservation Project through Exploratory Factor Analysis. Four distinct factors were identified: Environmental and Quality Control, Equipment and Project Regulation, Material and Workforce Competency, and Management and External Influences. Furthermore, the multiple linear regression analysis unequivocally demonstrated that these four factors collectively and individually exert a statistically significant influence on the overall quality of asphalt pavement work. The findings underscore the complex interplay of various elements beyond just traffic load, which must be diligently managed to ensure high-quality road infrastructure.

Based on the findings, the following recommendations are put forth:

1. Project management teams should prioritize and strategically optimize the identified significant factors, particularly focusing on robust environmental monitoring, stringent quality control measures, regular equipment maintenance, strict adherence to regulations, continuous workforce training, and proactive project management.
2. Policymakers and relevant government agencies should leverage these findings to refine existing technical standards and quality assurance protocols for road infrastructure projects. This includes developing more comprehensive guidelines that integrate all identified influential factors.
3. Future research could delve into the specific sub-components within each factor, using Confirmatory Factor Analysis (CFA) to validate the factor structure, and potentially exploring the moderating or mediating roles of other variables.

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