

Road Damage Assessment and Treatment Costs on the Sidoarjo Mansahan Road in Banggai Regency

Faizal^{1*}, Arief Setiawan¹, Syamsul Arifin¹

¹Master of Civil Engineering Program, Universitas Tadulako, Palu, Indonesia

Corresponding author: Faizal

Abstract

This study assesses pavement surface damage and its relationship with estimated treatment costs on the Sidoarjo–Mansahan road in Moilong, Banggai Regency, Central Sulawesi, Indonesia. Visual distress observations were evaluated using the pavement condition index, referred to as IKP in the source study. The road is reported as 1,850 m long and 4 m wide, and the condition results contain 30 sample units. Treatment quantities were combined with local unit price analyses; the results chapter identifies the 2023 Banggai price basis. The arithmetic mean IKP was 70.90 on a scale from 0 to 100, with individual values ranging from 22 to 100. The recorded distresses included potholes, alligator cracking, edge cracking, patching, and raveling. Twenty sample units with paired condition and cost records were used to reproduce the cost regression. Costs excluding mobilization ranged from IDR 573,207.68 to IDR 32,775,069.65. The fitted equation was $Y = -0.4802X + 39.6578$, where X is IKP and Y is cost in million Indonesian rupiah, with $R^2 = 0.6074$. Lower condition scores were associated with higher estimated treatment costs. However, treatment categories and quantities also influence expenditure, and the fitted line should be used only as a local descriptive relationship. Segment-level assessment is necessary because the road-wide average conceals severely deteriorated units.

Keywords: pavement condition index; road distress; treatment cost; flexible pavement; Banggai Regency.

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I. INTRODUCTION

Road maintenance decisions require both an assessment of physical condition and an estimate of the resources needed for repair. A road-wide condition score can summarize an asset, but it cannot by itself identify every location requiring urgent intervention. Distress type, severity, and extent must therefore be recorded at the sample-unit level before treatment quantities and costs are assigned.

The pavement condition index provides a structured visual assessment of surface distress. In the Indonesian source study, this index is denoted IKP. It expresses the observed pavement condition on a scale from 0 to 100, with higher values representing better condition. The deduct-value approach connects distress observations to an index that can support maintenance planning [1, 2]. Visual assessment describes the pavement at the time of inspection; it does not directly measure structural capacity or predict future deterioration.

The Sidoarjo–Mansahan road serves passenger and freight movement in Moilong, Banggai Regency. Local surface defects create a practical need to relate condition information to repair expenditure. Maintenance involves choosing suitable work items, estimating their quantities, and applying unit prices rather than relying solely on a general condition category [3]. The present article condenses the 2024 master's thesis [4] into a case study of condition assessment and treatment cost. Its objectives are to summarize the recorded pavement condition, identify the treatment needs represented in the source records, and reproduce the association between IKP and estimated cost using the available paired data.

II. MATERIALS AND METHODS

2.1 Study area and source data

The study concerns a flexible pavement road in Moilong, Banggai Regency, Central Sulawesi. The results chapter reports a road length of 1,850 m and a width of 4 m. Primary observations comprise distress types, dimensions, severity, and station locations. The survey equipment included measuring tapes, writing materials, a camera, and spray paint for station marking. Secondary information included road records and cost inputs obtained from the local public works context. This article uses the thesis condition and cost tables as its numerical source [4]; no additional field survey was undertaken.

The condition table contains 30 sample units, generally 61 m long. Its final listed boundary is STA 1+830, whereas the road description and final cost record extend to STA 1+850. The last 20 m cannot be reconciled from these tables alone. Accordingly, the reported mean is treated as the unweighted mean of the 30 listed condition values, rather than an area-weighted assessment of a fully reconciled 1,850 m survey. Twenty units have paired IKP and treatment cost entries. Units absent from the paired table were not assigned an assumed cost of zero.

2.2 Pavement condition assessment

The assessment follows the deduct-value framework described in the thesis and pavement maintenance literature [1, 2]. Each recorded distress is identified by type, severity, and measured quantity. For area-based distress, density is calculated as the distressed area divided by the sample-unit area, multiplied by 100. Appropriate measurement conventions are required for distresses expressed in other units. Deduct values are read from the corresponding distress curves, summed, and corrected using the applicable corrected deduct-value procedure.

$$IKP_i = 100 - CDV_i \quad (1)$$

$$\text{Mean IKP} = (\sum IKP_i) / n \quad (2)$$

Here, CDV_i is the corrected deduct value for sample unit i and $n = 30$ for the condition summary. As an illustrative source calculation, STA 0+000–0+061 has a total deduct value of 46, a corrected deduct value of 33, and an IKP of 67. IKP is a dimensionless index rather than the percentage of pavement area that is damaged. Because condition labels differ between the source chapters, this article emphasizes the numerical values and avoids reproducing the inconsistent rating distribution.

2.3 Treatment quantities and cost estimation

Treatment needs were selected from the recorded defect type and severity. The thesis identifies patching for potholes, local surface treatment for selected cracking or raveling, and reconstruction for severely distressed units. These are the source study's proposed treatments rather than outcomes of completed repair work. The unit price analysis combines labor, materials, equipment, and overhead and profit. Work quantities are multiplied by their applicable unit prices and summed to obtain the segment estimate [3, 4].

$$C_i = \sum (Q_{ij} \times U_j) \quad (3)$$

In Equation (3), C_i is the estimated cost for segment i , Q_{ij} is the quantity of work item j , and U_j is its unit price. The results chapter identifies HSPK Kabupaten Banggai 2023 as its price basis, while the methodology chapter refers to a 2020 revised analysis. Costs are therefore retained as historical estimates reported in the thesis, without inflation adjustment or a claim that they represent current procurement prices. The analysis uses the column labeled costs excluding mobilization. The separate mobilization-inclusive column is not pooled with these values because several entries are inconsistent with a uniform addition of the listed general expenses.

2.4 Regression analysis

Ordinary least squares regression was reproduced from the 20 paired records in thesis Table 4.64. IKP was the explanatory variable and the treatment cost excluding mobilization, converted to million IDR, was the response. The model is $Y = a + bX$. Its coefficient of determination is $R^2 = 1 - \sum(Y_i - \hat{Y}_i)^2 / \sum(Y_i - \bar{Y})^2$. This provides an in-sample measure of the variation represented by the fitted line. It does not establish a causal effect or an externally validated prediction model.

III. RESULTS AND DISCUSSION

3.1 Condition variation along the road

The 30 condition values sum to 2,127, giving a mean IKP of 70.90. The minimum is 22 at STA 1+525–1+586 and the maximum is 100 in nine units. Seven units have IKP below 50: STA 0+122–0+183, 0+244–0+305, 0+366–0+427, 0+549–0+610, 0+671–0+732, 1+525–1+586, and 1+708–1+769. These units demonstrate why a relatively high mean does not remove the need for localized intervention. The value 70.90 is retained, but its classification as “good” in the thesis summary is not generalized because another source table uses different category boundaries.

Table 1 Summary of the source condition and cost records

Measure	Value
Reported road length and width	1,850 m and 4 m
Condition sample units	30
Mean IKP	70.90
Minimum and maximum IKP	22 and 100
Units with IKP below 50	7 of 30
Units with IKP equal to 100	9 of 30
Paired condition and cost records	20

Measure	Value
Minimum cost excluding mobilization	IDR 573,207.68
Maximum cost excluding mobilization	IDR 32,775,069.65

The treatment records include potholes, alligator cracking, edge cracking, patching, and raveling. These defects require different responses even where their aggregate IKP values are similar. Potholes generally require localized repair, while extensive or severe distress can trigger a larger intervention. Defect dimensions remain important because the same condition score can represent different areas or volumes of work. Traffic loading and drainage are plausible contributors discussed in the thesis, but no measured axle-load or drainage variable enters the regression; their individual effects cannot be estimated from this analysis.

3.2 Treatment costs and paired records

Table 2 reproduces the paired values used in the regression. Six units are assigned the same maximum estimate of IDR 32,775,069.65, consistent with the source's reconstruction treatment category. The smallest estimate, IDR 573,207.68, occurs at STA 0+488–0+549 with IKP 72. The repeated maximum values indicate that treatment selection introduces a step in the costs rather than a smooth response to every one-point change in IKP. The sum of the 20 listed costs is IDR 224,104,737.91, calculated from the displayed source entries. This is a subtotal of the paired records, not a reconciled total project budget.

Table 2 IKP and estimated treatment cost excluding mobilization

Station range	IKP	Cost in IDR
0+000 - 0+061	67	701,958.94
0+061 - 0+122	50	599,630.49
0+122 - 0+183	32	32,775,069.65
0+183 - 0+244	51	965,879.43
0+244 - 0+305	32	32,775,069.65
0+305 - 0+366	50	4,295,047.38
0+366 - 0+427	26	32,775,069.65
0+427 - 0+488	91	888,716.86
0+488 - 0+549	72	573,207.68
0+610 - 0+671	55	2,194,846.49
0+671 - 0+732	46	32,775,069.65
0+732 - 0+793	70	979,842.18
0+793 - 0+854	81	1,058,229.56
0+976 - 1+037	56	1,273,794.84
1+342 - 1+403	88	3,480,791.54
1+464 - 1+525	92	3,480,791.54
1+525 - 1+586	22	32,775,069.65
1+647 - 1+708	91	3,480,791.54
1+708 - 1+769	30	32,775,069.65
1+769 - 1+850	83	3,480,791.54

Source: paired records in thesis Table 4.64 [4]. The final station label follows the cost table; the corresponding condition table ends at STA 1+830. Decimal punctuation has been normalized without altering monetary values.

3.3 Relationship between IKP and estimated cost

Recalculation produces the following model, which agrees with the linear equation in the source abstract when the response is expressed in million IDR:

$$Y = -0.4802X + 39.6578 \quad (4)$$

$$R^2 = 0.6074; n = 20 \quad (5)$$

The negative slope indicates that higher IKP is associated with lower estimated cost within the observed sample. Approximately 60.74% of the observed cost variation is represented by the fitted line. The source results narrative also prints an X^2 term, but the regression of the paired records reproduces the linear equation in (4), not a quadratic equation. The unit conversion is essential: using the coefficients as if Y were measured directly in rupiah would misstate the cost by a factor of one million.

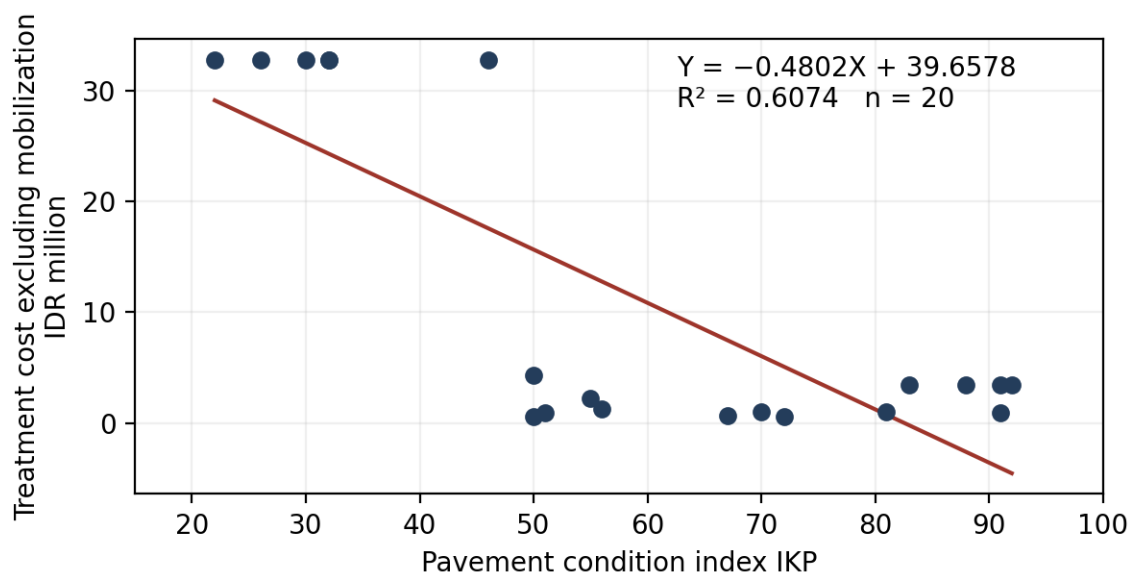


Figure 1 Reproduced IKP and treatment cost regression

The plot shows a cluster of reconstruction estimates at low IKP and smaller localized repair estimates at higher IKP. Consequently, the fitted slope should not be interpreted as a universal marginal cost of a one-point deterioration. Treatment quantities, unit prices, and the chosen intervention help determine the response. Several higher-IKP units have the same displayed estimate, while relatively similar IKP values can have different costs.

The fitted line predicts zero expenditure at an IKP of approximately 82.6 and negative expenditure above that value. Such predictions are physically unsuitable, even though observed scores extend to 92. This confirms that the line is a descriptive association and should not be used as a standalone budgeting rule. Operational estimates should retain nonnegative work quantities and explicit intervention categories. A larger dataset could compare category-based or constrained models, but such models have not been fitted or validated in this article.

3.4 Maintenance implications and limitations

The findings support a segment-based maintenance plan. Low-scoring units should be inspected in detail to confirm the appropriate repair depth and treatment extent, while higher-scoring units can be assessed for localized preventive or corrective work. Priorities should consider safety, connectivity, and available budgets alongside condition. The estimates provide an initial engineering basis for comparing treatment needs but do not constitute a life-cycle cost analysis or a budget optimization result.

The study is limited to one road and a single set of visual condition observations. The unweighted road mean, inconsistent final station boundaries, and unreconciled cost accounting limit the precision of road-wide conclusions. The regression uses 20 paired records rather than all 30 condition units, contains repeated category-based costs, and has no independent validation sample. No p-values, confidence intervals, deterioration forecasts, or measured traffic effects are claimed. Before procurement or expanded modeling, the original survey sheets, full cost workbook, price basis, and allocation of general expenses should be reconciled.

IV. CONCLUSION

The Sidoarjo–Mansahan source survey records a mean IKP of 70.90 across 30 units, with values ranging from 22 to 100. The dispersion of scores and seven units below 50 show that an average condition score can conceal important localized repair needs. Potholes, cracking, patching, and raveling provide the engineering basis for selecting segment-level treatments.

For the 20 available paired records, estimated treatment costs excluding mobilization range from IDR 573,207.68 to IDR 32,775,069.65. Reproduced ordinary least squares regression yields $Y = -0.4802X + 39.6578$, with Y in million IDR and $R^2 = 0.6074$. The association is useful for describing this dataset, but intervention categories and defect quantities must be retained for practical costing. Source record reconciliation and independent validation are required before using the model for prediction or adopting a final project budget.

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