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ASSESSMENT OF INDICATORS, MANAGEMENT OF ENGINEERING COST AND TRANSPORTATION INFRASTRUCTURE WORKS

Kênia Vitor da Paixão
Doutoranda PGDRA – UFRO.
Endereço: Porto Velho, Rondônia, Brasil
Email: keniavpaixao@gmail.com

Paulo de Tarso de Sousa Tupan
Pós-graduação em Avaliações e Perícias (FARO)l.
Endereço: Porto Velho, Rondônia, Brasil
Email: paulopericia@uol.com.br

Fabrício Moraes de Almeida
PhD in Physics (UFC), with post-doctorate in Scientific Regional Development (DCR/CNPq)- Production Engineering Specialist (FUNIP). Researcher of the Doctoral and Master Program in Regional Development and Environment (PGDRA/UFRO).
Endereço: Porto Velho, Rondônia, Brasil
E-mail: dr.fabriciomoraes001@gmail.com

Abstract

This article analyzes the main indicators used to assess road infrastructure and Special Engineering Works (OAEs) within the context of the State Department of Highways and Public Transportation (DER/RO). The technical criteria that guide the inspection, maintenance, and evaluation of highways and special engineering works in the State of Rondônia are presented, with an emphasis on Brazilian standards, especially Technical Standards NBR 14.653-1 and NBR 14.653-2. Quantitative and qualitative methods, as well as practical management and investment prioritization approaches, are designed to ensure the safety, functionality, and durability of these structures. The objective was to develop, observe, describe, and document the services performed over the years, observing the asset's useful life and state of conservation. Data were collected through a property survey of field data and reports available through November 2023. The inventory of works will contribute to the efficient management of the Department's assets and enable the optimization of resources and the guarantee of the asset's useful life.

Keywords: Indicator Management; Heritage inventory; Road heritage; Highway assessment; Conservation of special works of art.

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1. Introduction

Rondônia stands out as an agro-industrial and strategic logistics hub in Brazil's Northern Region, with expressive agricultural production and a vast territorial extension. Its transportation infrastructure, especially the highway network, plays a fundamental role in regional integration and in the flow of agricultural production. However, significant challenges persist regarding the maintenance and planning of the road network, requiring innovative solutions and advanced technologies.

The State Department of Highways and Transportation (DER/RO) is of great importance to the State of Rondônia, playing a fundamental role in the maintenance and implementation of the state highway infrastructure, in ensuring traffic safety for citizens, and in supporting the transportation of agricultural production.

Thus, with the increase in vehicle users, traffic has been growing day by day. Defects in road surfaces, such as potholes and other types of damage, may occur at any time, depending on actual conditions and the service life of the roadway. These defects can be particularly dangerous for vehicles traveling on highways. The State Department of Highways and Transportation (DER/RO), which is responsible for transportation infrastructure, must monitor and maintain road surface quality in order to improve traffic safety. The evaluation of road quality has been identified as a critical issue related to the possibility of making the transportation system more comfortable, efficient, and safe.

In this context, the presence of various types of damage resulting from road use may compromise the energy efficiency associated with transportation, as it leads to increased fuel consumption and reduced service life of vehicle components and systems, especially brakes and suspensions. Potholes generate not only vibration in tires and suspension systems but also deformation of the rubber, causing energy losses and increasing rolling resistance.

Furthermore, highways and Special Engineering Works (OAEs) constitute critical elements of transportation infrastructure, requiring accurate evaluations to ensure their safe and efficient operation. Modern engineering relies on standardized indicators and systematic inspections to diagnose the structural and functional condition of these works, guiding management practices and public investments. This section aims to present the main indicators adopted in Brazil and their practical applications.

Indeed, the management of highway infrastructure indicators includes pavement condition indicators, which assess road surfaces through roughness, cracking, deformation, and wear, helping to determine the Road Condition Index (RCI), which is essential for diagnostics and maintenance planning (DNIT Manual, 2025). Traffic flow and capacity indicators allow analysis of average daily traffic volume and highway capacity, which are essential for identifying bottlenecks and planning improvements. Road safety indicators relate accident rates and locations to infrastructure quality, promoting improvements in safety factors.

Regarding the evaluation of Special Engineering Works (OAEs), structural and visual inspections are performed to assess surface conditions, cracking, corrosion, and deformation. Standard NBR 9452 establishes three key inspection

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parameters: structural (safety and stability), functional (adequacy of use and clearance), and durability (remaining service life of the structure). Load capacity and safety are verified to ensure that OAEs can support the expected loads, considering changes in use and traffic since their construction. Maintenance and conservation activities include monitoring interventions and repairs, using techniques such as concrete injection, carbon fiber reinforcement, and other modern structural strengthening technologies.

Thus, the objective of this section is to prepare, verify, describe, document, and record the collection of data on highways and Special Engineering Works (OAEs), observing the asset's service life and conservation status in a consolidated manner, supported by photographic reports.

2. Theoretical Foundations

Road infrastructure plays a fundamental role in economic and social development. It enables the flow of agricultural and industrial production, facilitates access to health, education, and leisure services, and promotes regional integration. In urban contexts, the road network directly influences mobility and the population's quality of life.

Despite its importance, the State of Rondônia faces challenges related to the maintenance, modernization, and expansion of its road network. A significant portion of the highways presents structural problems, such as potholes, inadequate signage, and lack of shoulders.

Silva et al. (2022) demonstrate that Cost Engineering applied to civil construction and infrastructure is a branch of engineering that establishes standards, criteria, and methodologies for budgeting and cost estimation in an enterprise. Indeed, cost engineering is directly related to construction services, focusing on material flows, consumption, labor, and financial perspectives, with its work beginning during project design and extending through project completion. The analysis of data related to management and budgeting in engineering has been relevant since the second half of the nineteenth century, due to the expansion of railway use in the country, which made it necessary to create frameworks to analyze long-term investments.

However, due to the discontinuity or absence of investments in infrastructure, there is a loss of economic competitiveness, increased logistics costs, and higher accident rates. Investment in road infrastructure requires strategic planning, the use of modern technologies, and the adoption of effective public policies. Concession models and public–private partnerships have been adopted as alternatives to expand financing capacity and improve management of the road network.

By analyzing the annual technical reports from 2010 to 2023, it is observed that DER/RO serves the 52 municipalities of Rondônia and, according to State Decree No. 27,282, manages a total of 5,496.52 km of highways. This network consists of 1,629.44 km of paved highways based on the Continuous Visual Survey (LVC) and 3,867.08 km of unpaved highways, as shown in Table 1 and the Road Network Map in Figure 1.

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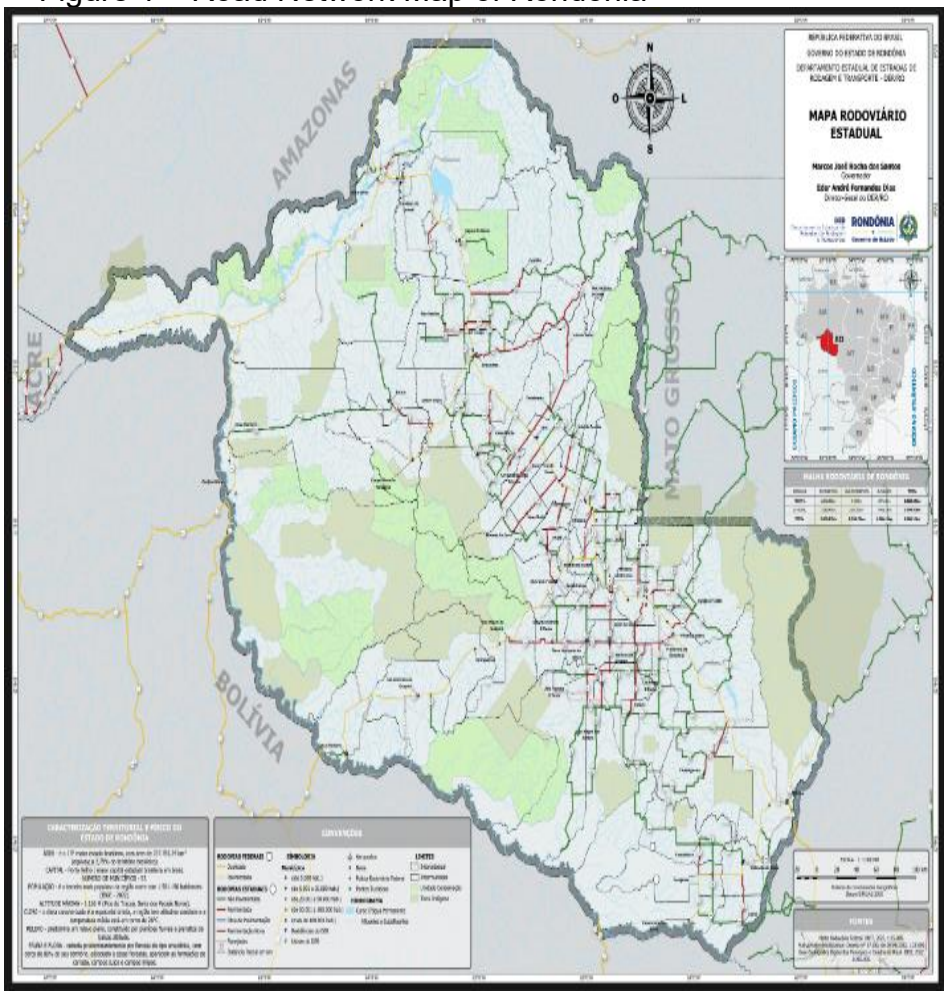
Table 1 – Highways under DER/RO jurisdiction

PAVEMENT TYPE	SEGMENTS	PERCENTAGE	EXTENSION (km)
Single-lane paved	132	26,79%	1.472,70
Dual-lane paved	157	2,85%	156,74
Unpaved	191	67,15%	3.690,86
Planned	2	3,21%	176,22
TOTAL	**482**	**100,00%**	**5.496,52**

Source: Prepared by the authors (2025).

The inspections were carried out in loco, based on the Visual Survey of the current conservation status of wooden bridges, culverts, concrete bridges, and mixed bridges.

Figure 1 – Road Network Map of Rondônia



Source: Cartography of Conservation Status – RO. DER, 2025a.

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The development and execution of the technical research included analysis by region, size, and duration of works. In the Northern region, temporary construction sites are commonly used. For paving and primary surfacing works, the following durations were adopted: small-scale projects – 6 months; medium-scale projects – 12 months; and large-scale projects – 24 months.

To define the limits between project size categories, data from completed projects and works under DER/RO were analyzed according to their nature, resulting in the classification proposals presented in Table 2.

Table 2 – Classification of Works by Size

Nature of Works	**Project Size**		
	Small-scale	**Medium-scale**	**Large-scale**
Special Engineering Works (OAEs)	Total Deck Area (m²) 261.857,95	Total Deck Area (m²) 43.095,80	Total Deck Area (m²) 33.202,30
Cataloged Quantity	729	25	7

Source: Prepared by the authors (2025).

3. Methodology, Techniques, and Technology

This study adopts an applied, observational, and descriptive–inferential research design, with a quantitative and qualitative approach, aimed at evaluating and valuing Special Engineering Works (OAEs) within the road network of the State of Rondônia, Brazil.

The methodological framework integrates field data collection, standardized technical inspections, and statistical analysis procedures to support infrastructure management and decision-making processes. The unit of analysis comprises OAEs, including reinforced concrete bridges, composite bridges, and wooden bridges.

Data collection was conducted through systematic field surveys, following standardized inspection protocols established by Associação Brasileira de Normas Técnicas, particularly NBR 9452, NBR 14653-1, and NBR 14653-2. These standards provide the technical basis for inspection, classification, and valuation of infrastructure assets.

Field data included variables such as geographic location, structural typology, geometric characteristics, construction materials, and apparent structural conditions. Structural assessments considered three key parameters defined by NBR 9452:

- structural performance (safety and stability),
- functional performance (adequacy of use and clearance),
- durability (remaining service life).

The collected data were organized into structured databases and subjected to statistical treatment. The analytical procedures included: (i) descriptive statistics (mean, standard deviation, and coefficient of variation); (ii) inferential analysis using confidence intervals and hypothesis testing; (iii) comparative analysis between different types of OAEs;

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(iv) exploratory regression models to identify relationships between structural condition and influencing variables (e.g., age, material, and traffic load).

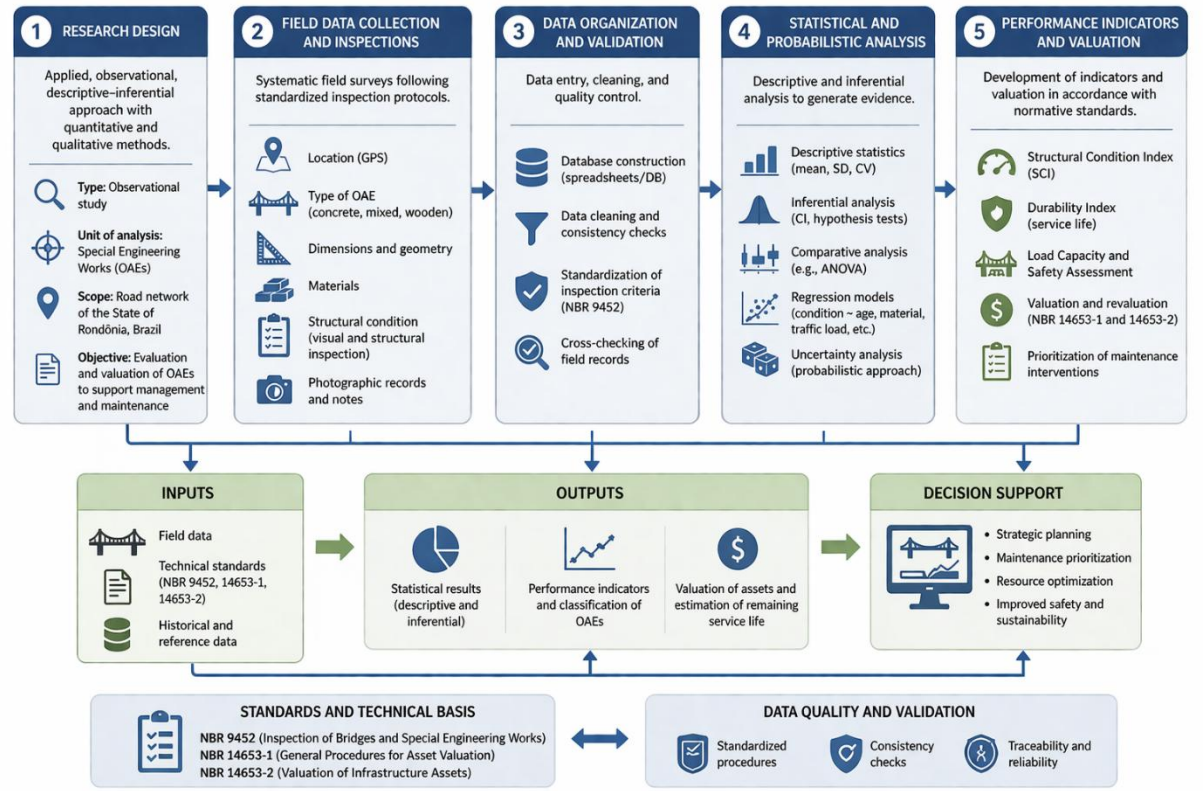
To ensure data reliability and consistency, validation procedures were adopted, including cross-checking field records, standardization of inspection criteria, and adherence to normative guidelines. Uncertainty associated with measurements and classifications was considered through probabilistic approaches.

Additionally, a set of performance indicators was developed to support infrastructure management, enabling the prioritization of maintenance interventions and optimization of resource allocation. These indicators contribute to improving safety conditions, extending the service life of assets, and enhancing environmental and economic sustainability.

The overall methodological workflow (Figure 2) can be summarized as follows:

(1) field data collection;
(2) data organization and validation;
(3) statistical and probabilistic analysis;
(4) development of performance indicators;
(5) support for planning and decision-making in infrastructure management.

Figure 2 – Fluxograma metodológico da pesquisa



Source: Prepared by the authors (2026), based on NBR 9452 and NBR 14653 (Associação Brasileira de Normas Técnicas), and on statistical analysis procedures applied to infrastructure assessment.

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4. Cost Management and Transportation Infrastructure Works

It is essential to highlight the importance of performing cost estimates for transportation infrastructure works, a task recognized for its complexity. This process involves defining average costs derived from historical information and standardized solutions, playing a crucial role in planning by estimating the value of works similar to previous projects.

The difficulty in classifying and appropriating costs for transportation infrastructure projects is notable, given the influence of numerous elements in their formation. Nevertheless, despite these complexities, it must be considered that the information provided by the General Directorate through the Continuous Visual Survey (LVC) is sufficiently detailed to allow for a thorough and individualized assessment. The absence of a comprehensive record or database containing information and construction standards for highways and Special Engineering Works (OAEs), components of the Road Network of the State of Rondônia, as well as the dimensions of the right-of-way areas, represents a significant limitation.

To characterize the Road Network of the State of Rondônia, the State Road Plan of the Road Network of Rondônia was used, along with a study/diagnosis of the Special Engineering Works (OAEs) and the Continuous Visual Survey (LVC) carried out by the Department.

It is important to note that the data analysis presented addresses only aspects such as mileage of single- and dual-lane highways, types of surface layers used (without specification of thicknesses), and dimensions of the Special Engineering Works (OAEs). This work also provides an overview of the current state of conservation of the analyzed elements.

5. Criteria and Determination of Infrastructure Asset Values

For the determination of infrastructure asset values, the Replacement Cost Method was adopted, which, according to Standards NBR 14.653-1 and NBR 14.653-2, identifies the value of an asset based on the unit value calculated using DNIT models and previously executed works, with the objective of reaching market value. For estimating the values related to highways, the assets were grouped by 15 Regional Units. Regarding right-of-way areas, a width of 15 meters on each side from the roadway centerline was adopted, totaling 30 meters in width.

The paving works cataloged by the State Department of Highways and Transportation were considered in compliance with State Decree No. 27,282 of June 29, 2022. The survey of Special Engineering Works (OAEs) was conducted by Civil Engineer Paulo de Tarso de Sousa Tupan (ART No. 2320238500246205), appointed by Ordinance No. 2248 as Civil Engineer – Appraiser (0041449762), Vice-President of the Infrastructure Asset Evaluation and Revaluation Committee TC-25 (Works), under Ordinance No. 2466 (0042081935).

5.1. Residual Value of highways

Residual value is an estimate of the value that an asset will have at the end of its useful life. In the case of highways, service life depends on factors such as pavement type, climatic conditions, and traffic volume. The evaluation of residual value is useful for government entities and companies that hold highways as assets,

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helping them plan maintenance, reconstruction, or determine the accounting value of these assets. The methodology for calculating residual value varies according to the accounting standards or valuation practices adopted by the entity.

For paved highways, the residual value corresponds to 50%, since paved roads are subject to less severe weathering due to the protection provided by the asphalt layer, particularly against rainfall and traffic effects. For unpaved highways, the residual value corresponds to 20%, as rural roads (natural subgrade) are more exposed to weathering, especially rainfall and traffic, due to the lack of surface protection.

5.2. Depreciation Factors

Depreciation is a natural process of asset deterioration over time. In the case of highways, depreciation is caused by factors such as climatic variation, vehicle traffic, and lack of maintenance.

Depreciation may be classified into two types:

- Physical depreciation, caused by the natural wear of the asset;
- Functional depreciation, caused by the loss of asset value due to obsolescence.

5.2.1. The Rross-Heidecke Depreciation Method

Highways were classified according to their state of conservation. The Ross-Heidecke method proposes calculating physical depreciation based on the age and conservation condition of the asset, generally using the highway's useful life. Valuation using the Replacement and Reproduction Cost Method with depreciation determines the value of improvements in a new condition by estimating the costs of their components, from which depreciation is subtracted.

Table 3 – Highway Classification

CLASS	ESTADO DE CONSERVAÇÃO
CLASS 1	Excellent
CLASS 2	Good
CLASS 3	Fair
CLASS 4	Poor

Source: Prepared by the authors (2025).

5.2.2. Weighted Depreciation

Considering highway lengths and depreciation rates corresponding to each class, the weighted average depreciation percentages were determined, as shown in Table 4.

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Table 4 – Weighted Percentage – Paved Highways

ITEM	DETERIORATION LEVEL	KM	PERCENTAGE OF QUANTITY	ROSS-HEIDECKE PHYSICAL DEPRECIATION	WEIGHTED PERCENTAGE
Class 1	Fair	664.96	41.00%	14.20%	5.82%
Class 2	Between Fair and Minor Repairs	324.64	20.00%	33.80%	6.76%
Class 3	Minor and Major Repairs	114.96	7.00%	65.30%	4.57%
Class 4	Major Repairs	524.88	32.00%	86.70%	27.74%
TOTAL		**1,629.44**		**45.00%**	

Source: Prepared by the authors (2025).

6. Analysis of Statements of State-Cataloged Highways

A total of 1,629.44 km of paved highways were evaluated**,** corresponding to 2.68% single-lane roads and 2.9% dual-lane roads**,** and 3,867.08 km of natural subgrade and primary surface roads, with primary surfacing and natural subgrade representing 70.4% of the total highway network of the State, as shown in Tabela 5**.**

Table 5 – Classification of the State Road Network by Surface Type

Road Network Classification	Carriageway Type	Length (km)	Share (%)
Paved Roads	Single Carriageway	1,472.70	26.8
Paved Roads	Dual Carriageway	156.74	2.9
Total Paved Network	—	**1,629.44**	**29.7**
Unpaved Roads (Natural Subgrade with Primary Surface Treatment)	Single Carriageway	3,867.08	70.4
Total Road Network	—	**5,496.52**	**100.0**

Source: Authors' elaboration based on official road inventory data. Terminology and classification follow DNIT, World Bank, and AASHTO standards.

6.1. Evaluation of State Highway Infrastructure Assets

Table 6 – Evaluation of Infrastructure Assets – Highways

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INFRASTRUCTURE ASSET	UNIT	EXTENSION / AREA	AVERAGE PRICE (R$/m²)	REPRODUCTION PRICE	% DEPRECIATION	DEPRECIATED PRICE
Dual-lane paved highways (right and left sides)	km	156.74	2,198,697.15	R$ 344,623,791.47	45.00%	R$ 189,543,085.31
Single-lane paved highways	km	1,472.70	2,198,697.15	R$ 3,238,021,294.49	45.00%	R$ 1,780,911,711.97
TOTAL		**1,629.44**		**R$ 3,582,645,085.96**		**R$ 1,970,454,797.28**

Source: Prepared by the authors (2025).

6.2. Classification Level by Conservation Class of State-Managed Highways

The classification was performed according to the distribution shown in the table below, considering the total extension of 1,629.44 km**.** The highways were classified into four conservation classes, with the respective mileage for each level, as described in Table 7**.**

Table 7 – Types of Pavement of State-Managed Highways

CLASS	EXTENSION (km)
Class 1 – Annual corrective intervention up to 10.0 m² within a 1,000 m segment	664.96
Class 2 – Annual corrective intervention between 10.0 and 50.0 m² within a 1,000 m segment	324.64
Class 3 – Annual corrective intervention between 50.0 and 100.0 m² within a 1,000 m segment	114.96
Class 4 – Annual corrective intervention exceeding 100.0 m² within a 1,000 m segment	524.88
TOTAL (km)	**1,629.44**

Source: Prepared by the authors (2025).

6.3.1. Average Price and The DNIT/PMG Table

The Average Reproduction Price (PMG) is a tool used to estimate the total cost of a highway project, including direct and indirect costs. It is developed by the National Department of Transport Infrastructure (DNIT**)** in partnership with the Getulio Vargas Foundation (FGV) and is based on historical cost data adjusted to reflect current market conditions.

The PMG is divided into eight cost groups and is used to estimate the cost of services and materials required for highway construction. Table 8 shows more than three billion Brazilian reais in total depreciated reproduction values for the implementation of highways in the State of Rondônia.

Figure 3 was prepared based on data collected in the field, such as type of work, dimensions, materials used, and structural conditions. The analyzed data were processed using statistical methods. Figure 2 presents the analysis of the following data:

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Figure 3 – Type of structure, dimensions, materials used, and structural conditions.

1. Mobilization and Demobilization (CM1)
This topic includes the costs of mobilizing and demobilizing equipment and personnel for the execution of the project.

2. Local Administration (CM2)
This topic includes local administration costs, such as salaries, benefits, and indirect costs.

3. Construction Site (CM3)
This topic includes the costs of setting up the construction site, such as the infrastructure necessary for the execution of the project.

4. Earthworks, Drainage and OAC, Complementary Works, Signage and Environmental Protection (CM4)
This topic includes the costs of earthworks, drainage, complementary works, signage, and environmental protection.

5. Production, Acquisition, and Transportation of Bituminous Material (CM5)
This topic includes the costs of production, acquisition, and transportation of bituminous material.

6. Paved Road Network of Rondônia
This topic includes information about the paved road network of Rondônia, including the number of highways, the length of paved roads, and the type of pavement.

7. Adopted Criteria
This topic includes the criteria adopted for preparing the table of average reproduction prices.

8. Overall Average Price (PMG)
The overall average price of a project is calculated by adding the Average Reproduction Cost (CMG) and the Indirect Cost Rate (BDI). The CMG is the average reproduction cost of the cost items in the table, while the BDI is an index that represents the project's indirect costs. Examples of these costs include administration, financing, and insurance.

Source: Prepared by the authors (2025).

7. Analysis of Estimated Budgets for Unpaved Highways

Unpaved roads play an important role in connectivity and access to rural and remote regions. Unlike paved highways, they consist of natural soil subgrades and primary surface layers, as shown in Table 8**.**

Table 8 – Highways with Natural Subgrade and Primary Surface. Extension of Unpaved Highways

TYPE	EXTENSION (km)	%
Unpaved single-lane highways	3,690.86	67.15

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TYPE	EXTENSION (km)	%
Planned	170.22	3.21
TOTAL (km)	**3,867.08**	**70.36**

Source: Prepared by the authors (2025).

The classification was carried out according to the distribution shown in the table below, considering the total extension of 3,867.08 km**.** The highways were classified into four deterioration classes, with estimated percentages per class, presenting the mileage at each level, as described in Table 9**.**

Table 9 – Types of Highways with Natural Subgrade. Classification Level by Class

CLASS TYPE	EXTENSION (km)
Class 1 – Annual corrective intervention at an estimated rate of 25%	966.77
Class 2 – Annual corrective intervention at an estimated rate of 25%	1,160.12
Class 3 – Annual corrective intervention at an estimated rate of 25%	1,353.48
Class 4 – Annual corrective intervention at an estimated rate of 25%	386.71
TOTAL (km)	**3,867.08**

Source: Prepared by the authors (2025).

7.1. Estimated Budget for Unpaved Highways

The estimated budget for unpaved highways is an approximate calculation of the total construction cost and is used for planning, management, and decision-making purposes. It is calculated based on historical data and consists of several cost items, over a previously defined extension of 7.0 km, including earthworks, base layers (primary surface), transportation, and complementary works. This corresponds to a total value of R$ 4,335,307.53**,** and for 1 km, the value corresponds to R$ 619,329.65**.** Therefore, for an extension of 3,867.08 km, the total depreciated value corresponds to R$ 2,394,997,291.34**.**

From the data presented in Table 9**,** it is easy to observe that this amount is significant, representing an important investment for the development of the State of Rondônia. This value results from the sum of the costs of all items involved in the construction of unpaved highways, including both direct and indirect costs.

Table 9 – Weighted Depreciation of Unpaved Highways – Estimated / Weighted Depreciation of Rural Roads (Natural Subgrade)

ITEM	DETERIORATION LEVEL	KM	QUANTITY PERCENTAGE	ROSS-HEIDECKE PHYSICAL DEPRECIATION	WEIGHTED AVERAGE
Class 1	Fair	966.77	25.00%	14.20%	0.035500000

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ITEM	DETERIORATION LEVEL	KM	QUANTITY PERCENTAGE	ROSS-HEIDECKE PHYSICAL DEPRECIATION	WEIGHTED AVERAGE
Class 2	Between Fair and Minor Repairs	1,160.12	30.00%	33.80%	0.101399650
Class 3	Minor and Major Repairs	1,353.48	35.00%	65.30%	0.228550338
Class 4	Major Repairs	386.71	10.00%	86.70%	0.086700448
				Weighted Depreciation	**45.22%**

Source: Prepared by the authors (2025).

Table 10 and Table 11 presents the weighted depreciation data for rural highways with primary surface/natural subgrade according to the Ross-Heidecke table, with conservation states ranging from fair to major repairs (weighted) and depreciated age, resulting in a weighted physical depreciation of 45.22%**.** The total evaluated value of these highways is R$ 1,312,098,220.63**,** which may be used for planning and management purposes of the State's road infrastructure.

Table 10 – Depreciation of Rural Highways with Primary Surface / Natural Subgrade

ROSS-HEIDECKE TABLE	
Conservation State (Ross-Heidecke) – 3	Fair to Major Repairs – Weighted
Age as % of Useful Life (Ross-Heidecke)	20% – 40% – 60% – 80%
Physical Depreciation – Factor K (Ross-Heidecke)	45.22%
Depreciation of Natural Subgrade Highways	R$ 1,082,899,070.71
Total Depreciated Reproduction Price	**R$ 1,312,098,220.63**

Source: Ross-Heidecke Table.

Table 11 – Conservation State of Unpaved Highways / Depreciation of Rural Highways (Natural Subgrade)

DETERIORATION LEVEL	CONSERVATION STATE	AGE AS % OF USEFUL LIFE	ROSS-HEIDECKE PHYSICAL DEPRECIATION
Class 1	Fair	20%	14.20%
Class 2	Between Fair and Minor Repairs	40%	33.80%
Class 3	Minor and Major Repairs	60%	65.30%
Class 4	Major Repairs	80%	86.70%

Source: Ross-Heidecke Table

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8. SPECIAL ENGINEERING WORKS (OAEs) ON STATE-MANAGED HIGHWAYS

Special Engineering Works (OAEs) are structures that allow the passage of vehicles, pedestrians, or other means of transportation over or under natural or artificial obstacles. They are essential to road infrastructure, as they ensure the continuity of highways even in the presence of obstacles. OAEs can be classified into different types according to construction material, structural system, and function.

The main types of OAEs are:

(a) Bridges**:** structures that allow the passage of vehicles or pedestrians over natural obstacles, such as rivers, lakes, or ravines;
(b) Viaducts**:** structures that allow the passage of vehicles or pedestrians over artificial obstacles, such as railways, highways, or urban roads;
(c) Footbridges**:** structures that allow pedestrian crossings over natural or artificial obstacles;
(d) Tunnels: structures that allow the passage of vehicles or pedestrians beneath natural obstacles, such as rivers, lakes, or ravines.

8.1. Importance of OAE Evaluation and Residual Value of OAEs

The evaluation of OAEs is an important process for the planning and management of road infrastructure. The valuation results may be used for purposes such as:

- Prioritizing maintenance and conservation of OAEs: the valuation allows identification of OAEs in poorer conservation conditions, which should therefore be prioritized for maintenance and rehabilitation;
- Investing in the construction of new OAEs: valuation data may be used to estimate the cost of building new OAEs, supporting decision-making regarding the feasibility of new projects;
- Seeking financing for OAE improvements: valuation results may support obtaining financing for infrastructure improvements through loans, financing mechanisms, or public–private partnerships.

The useful life of concrete and mixed bridges is considered to be 50 years**,** whereas the useful life of wooden bridges and culverts is considered to be 5 years**,** based on the legal warranty established in Article 618 of the Brazilian Civil Code.

To estimate the conservation status and the percentage of useful life, the study/diagnosis of OAEs in the Road Network of the State of Rondônia was used, based on State Decree No. 27,282 of June 29, 2022**,** and the Continuous Visual Survey (LVC) provided by the company RTA Engenheiros Consultores Ltda.

According to the OAE study/diagnosis, the structures were classified based on field surveys conducted by Civil Engineer Paulo de Tarso de Sousa Tupan, CREA-MA No. 2613/D, in coordination with the Asphalt Plant Coordination Unit (COUSA) and the Administrative and Financial Coordination Unit (CAF)**.** The OAEs were classified into five levels of deterioration**,** with the corresponding deck areas at each level. By weighting highway lengths and deck areas with depreciation percentages for each class, the average depreciation percentages were obtained.

Finally, considering the valuation methodology presented in the previous sections and applying the appropriate standardization, the weighted depreciation percentages for each type of OAE are presented in Table 12**, as** follows.

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Table 12 – Percentage Distribution of OAEs

TYPE OF STRUCTURE	%
Concrete bridges	37.44
Wooden bridges	28.44
Mixed bridges (concrete/steel)	10.90
Mixed bridges (wood/concrete)	0.95
Culverts (wood/steel)	0.47
Wooden culverts	21.80

Source: Prepared by the authors (2025).

8.2. Quantitative Overview of Special Engineering Works (OAEs)

The databases demonstrate the evaluation of Special Engineering Works (OAEs) in the State of Rondônia, considering State Decree No. 27,282/2022, dated June 29, 2022, which authorized the valuation of these assets. This process involves determining the market value of tangible infrastructure assets.

The State of Rondônia has a total of 211 OAEs, consisting of 79 concrete bridges**,** 23 mixed bridges (concrete/steel)**,** 2 mixed bridges (concrete/wood)**,** 60 wooden bridges**,** 1 wood/steel culvert**,** and 46 wooden culverts**.**

The total extension of OAEs is 7,446.40 meters, including 4,045.52 meters of concrete bridges**,** 854.24 meters of mixed bridges (concrete/steel)**,** 88.40 meters of mixed bridges (concrete/wood)**,** 1,899.94 meters of wooden bridges**,** 18.10 meters of concrete/steel culverts, and 527.40 meters of wooden culverts**.**

Data analysis demonstrates that the evaluation of OAEs in the State of Rondônia, authorized by State Decree No. 27,282/2022**,** constitutes a process that involves determining the market value of tangible assets.

8.3. The Ross-Heidecke Depreciation Method

When a valuation is performed using the Cost Quantification Method, the value of improvements in a new condition is estimated based on the reproduction of their component costs, and the final result is obtained by subtracting the depreciation portion of the improvement.

The Ross-Heidecke method proposes calculating physical depreciation by considering the conservation state and apparent age, generally using the useful life of the structure. Physical depreciation occurs due to intrinsic causes related to the asset, such as age, physical wear resulting from use, exposure to weather conditions, and lack of maintenance.

Physical depreciation should correspond to the amount required to be invested in a potential intervention to restore the asset to a condition equivalent to new. Depreciation calculations were considered in relation to specific types of engineering interventions, depending on the case.

Thus, technical engineering intervention types may include: paved and unpaved roadways; concrete bridges; mixed bridges (concrete/steel); mixed bridges (concrete/wood); mixed bridges (steel/wood); bridges; and wooden culverts, as shown in Table 13**.**

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Table 13 – Conservation State of Bridges

TABLE – DESIGN SERVICE LIFE (DSL)	
SYSTEM	**MINIMUM DSL (YEARS)**
Structure	> 50 years, in accordance with ABNT NBR 8681
Internal floors	> 13
External vertical enclosure	> 40
Internal vertical enclosure	> 20
Roofing	> 20
Plumbing and sanitation systems	> 20
Considering maintenance periodicity and procedures in accordance with ABNT NBR 5674 and the specifications in the operation and maintenance manual delivered to the user, prepared in compliance with ABNT NBR 14037.	

Source: Prepared by the authors (2025).

9. NON-STATE-MANAGED HIGHWAYS

According to State Decree No. 27,282/2022, which establishes the road segments that have been state-managed and those intended for future state incorporation, the values of non-state-managed highways were estimated, as presented in Table 14 below.

Table 14 – Non-State-Managed Highways

INFRASTRUCTURE ASSET EVALUATION – NON-STATE-OWNED HIGHWAYS						
INFRASTRUCTURE ASSET	UNIT	LENGTH / AREA	AVERAGE PRICE (R$/m²)	REPRODUCTION COST	% DEPRECIATION	DEPRECIATED VALUE
Paved Highways with Dual Carriageways (Right and Left)	km	2.48	2,198,697.15	R$ 5,452,768.93	45.00%	R$ 2,999,022.91
Paved Highways with Single Carriageways	km	26.49	2,198,697.15	R$ 58,243,487.53	45.00%	R$ 32,033,918.14
Unpaved (Natural Surface) Highways	km	1,441.57	619,329.65	R$ 892,807,039.23	45.22%	R$ 489,123,946.73
TOTAL		**1,470.54**		**R$ 956,503,295.70**		**R$ 524,156,887.79**

Source: Prepared by the authors (2025).

Thus, Table 14 demonstrates the characteristics of the valuation of road infrastructure assets related to non-state-managed highways in the State of Rondônia. The total valuation of these road infrastructure assets amounts to R$ 524,156,887.79**,** covering a total extension of 1,470.54 km**,** consisting of 2.48 km of dual-lane paved highways**,** 26.49 km of single-lane paved highways, and 1,441.57 km of highways with primary surfacing and natural subgrade**.**

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Indeed, this value may be used for planning and management purposes of the State's road infrastructure. For example, the State may use this valuation to:

(a) prioritize maintenance and conservation of highways;
(b) invest in the construction of new highways; and
(c) seek financing for improvements to road infrastructure.

9.1. NON-STATE-MANAGED SPECIAL ENGINEERING WORKS (OAEs)

The management and valuation of non-state-managed infrastructure assets are important for the development of the State of Rondônia. Indeed, the valuation results may be used to improve the population's quality of life and promote the State's economic development.

Special Engineering Works (OAEs), similarly to highways, include assets that are intended for future state incorporation. A total of 52 bridges fall into this category, with a combined deck area of 12,791.36 m² and a reproduction cost of R$ 125,100,321.57**,** resulting in a depreciated value of R$ 93,484,121.91**,** as shown in Table 15 below.

Table 15 – Non-State-Managed Special Engineering Works

INFRASTRUCTURE ASSET EVALUATION – SPECIAL ENGINEERING STRUCTURES (OAEs)						
INFRASTRUCTURE ASSET	UNIT	AREA	AVERAGE PRICE (R$/m²)	REPRODUCTION COST	% DEPRECIATION	DEPRECIATED VALUE
Special Engineering Structures (OAE) – Concrete Bridge – Dual Carriageway	m²	8,134.22	11,663.31	R$ 94,871,882.81	22.06%	R$ 73,938,945.31
Special Engineering Structures (OAE) – Composite Bridges (Concrete/Steel) – Dual Carriageway	m²	1,316.00	14,398.17	R$ 18,947,991.72	29.26%	R$ 13,403,494.80
Special Engineering Structures (OAE) – Composite Bridges (Concrete/Wood) – Single Carriageway	m²	169.95	5,317.21	R$ 903,660.13	56.37%	R$ 394,253.53
Special Engineering Structures (OAE) – Timber Bridge	m²	1,902.60	3,272.20	R$ 6,225,690.34	43.56%	R$ 3,513,551.60
Special Engineering Structures (OAE) – Small Bridges / Culverts	m²	1,268.60	3,272.20	R$ 4,151,096.56	46.19%	R$ 2,233,876.67
SUBTOTALS		**12,791.36**		R$ 125,100,321.57		R$ 93,484,121.91
TOTAL VALUE						R$ 93,484,121.91

Source: Prepared by the authors (2025).

10. FINAL CONSIDERATIONS

In general terms, the management of indicators and the inventory of infrastructure assets constitute essential instruments and tools to ensure quality and efficiency in the management of assets of the State Department of Highways and Transportation. The implementation of the proposed recommendations will significantly contribute to resource optimization and maximization of asset service life.

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In accordance with the procedures established by the State Department of Highways and Transportation (DER) for the inventory of infrastructure assets, this document provides citizens with information regarding actions undertaken, including the construction of highways and bridges. It is undeniable that infrastructure quality has a significant impact on the economic and social development of each region of the State.

Therefore, the objective of this article is to provide support for accounting disclosure in financial and asset statements, as well as to support planning activities—specifically in the road infrastructure sector—promoting efficiency and contributing to improving the quality of life of the population of Rondônia, while maintaining transparency in all actions undertaken by the State of Rondônia.

Finally, data analysis was based on databases available up to November 2023**.** The indicators were defined according to the strict application of Brazilian standards, such as NBR 9452, which are indispensable for the effective evaluation and management of road infrastructure and Special Engineering Works (OAEs). The integration of quantitative and qualitative methods and the use of emerging technologies strengthen maintenance management and engineering practices for these essential assets, ensuring their functionality, safety, and longevity.

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