# Analysis of Tamping Cycles Based on the Conditions of Railways Components

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## Introduction

The study addresses the importance of efficient railway maintenance by analyzing how the conditions of Railways Components, like sleepers and ballast aggradation, influence track leveling degradation. Using data from aggregate gradation tests, inspections, and monitoring by an autonomous track geometry measurement system (ATGMS), a predictive model was developed to optimize tamping cycles and resource management based on the condition of the permanent way.

## Experimental work

The study adopts a structured approach divided into six main stages:

a) Selection of case study sites;

b) On-site data and sample collection from the case studies;

c) Aggregate gradation tests of the samples and calculation of ballast aggradation levels;

d) Execution of tamping operations in the case studies;

e) Monitoring of degradation indicators in the case studies through linear and exponential regression analysis;

f) Definition of tamping cycles based on the case study results.

Figure 1. Tamping machine

Figure 2. Example of ballast sample collection

## Results

### Concrete sleeper

Figure 4 shows the evolution of track quality indicators (TQI) under different ballast conditions over six months after tamping. Figure 5, on the other hand, presents the most appropriate trend line for each condition analyzed.

With this, it was possible to predict the transported volume until reaching the engineering limit (TQI of 9) and to define the new tamping cycle for concrete (Figure 3).

| Condition | MTBT |
|---|---|
| Previous cycle | 100 |
| New cycle for ballast aggradation | 40 |
| New cycle for clean ballast | 102 |

Figure 3. New Tamping Cycles for Concrete Sleeper. Author (2024)

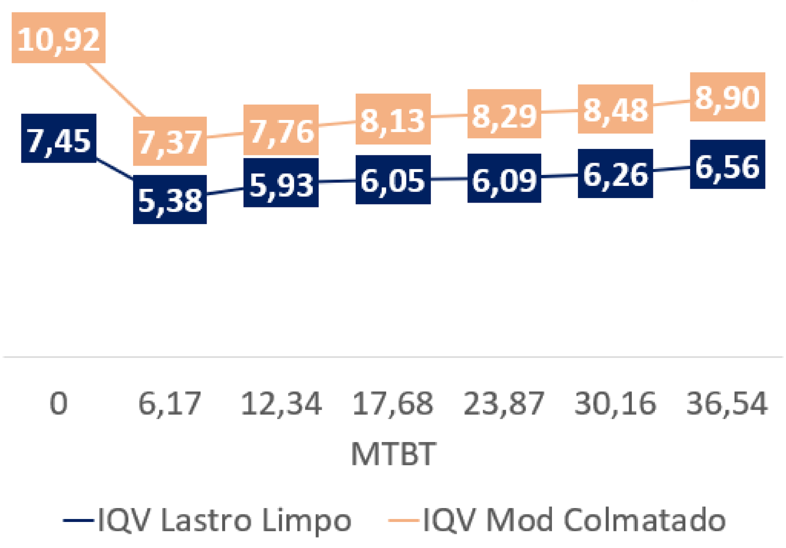



Figure 4. TQI Degradation Results by Ballast Fouling Group in Concrete. Author (2024).

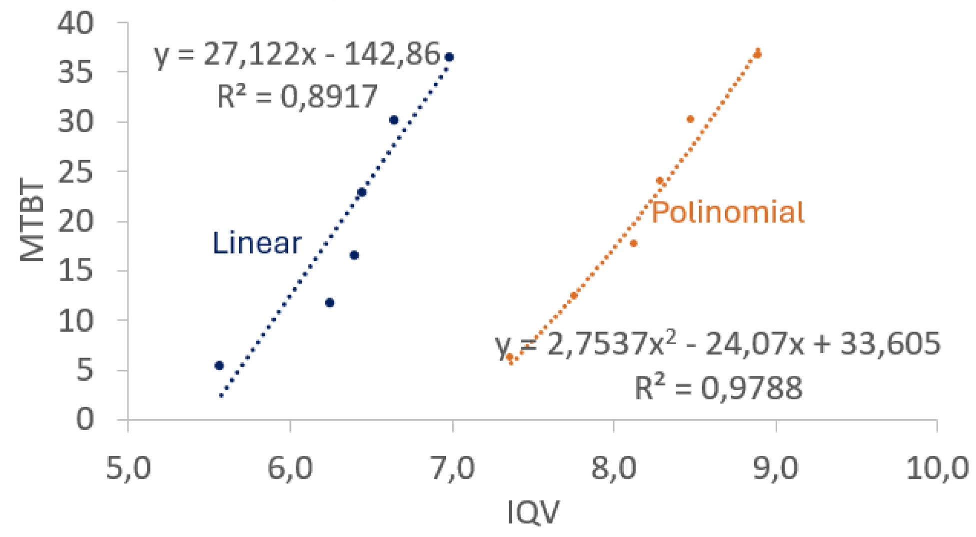



Figure 5. Trend Line of Degradation Due to Ballast Fouling in Concrete. Author (2024).

### Wooden sleeper

As done for locations with concrete sleepers, the same analyses were carried out for wooden ones. Thus, it was possible to predict the transported volume until reaching the engineering limit (TQI of 9) and to define the new tamping cycles for wood.

| Condição | MTBT |
|---|---|
| Ciclo Anterior | 80 |
| Novo Ciclo Lastro Colmatado | 50 |
| Novo Ciclo Lastro Não Colmatado | 70 |

Figure 6. New Tamping Cycles for Wooden Sleeper. Author (2024)

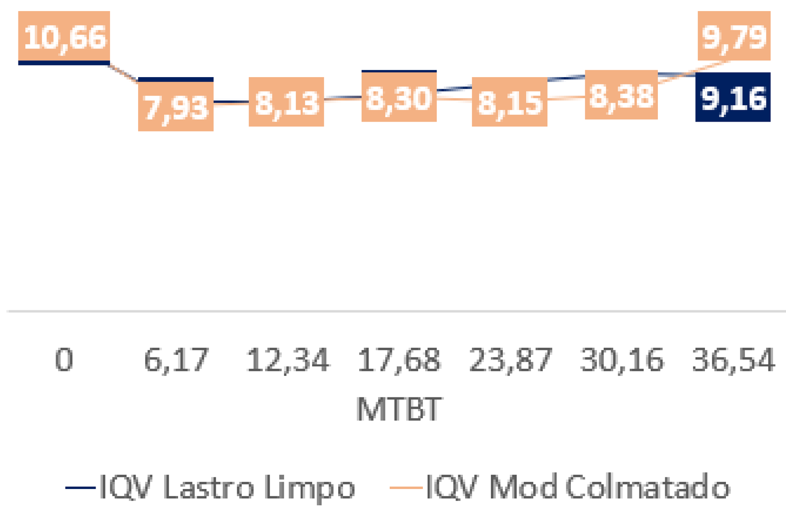



Figure 7. TQI Degradation Results by Ballast Fouling Group in Wooden. Author (2024).

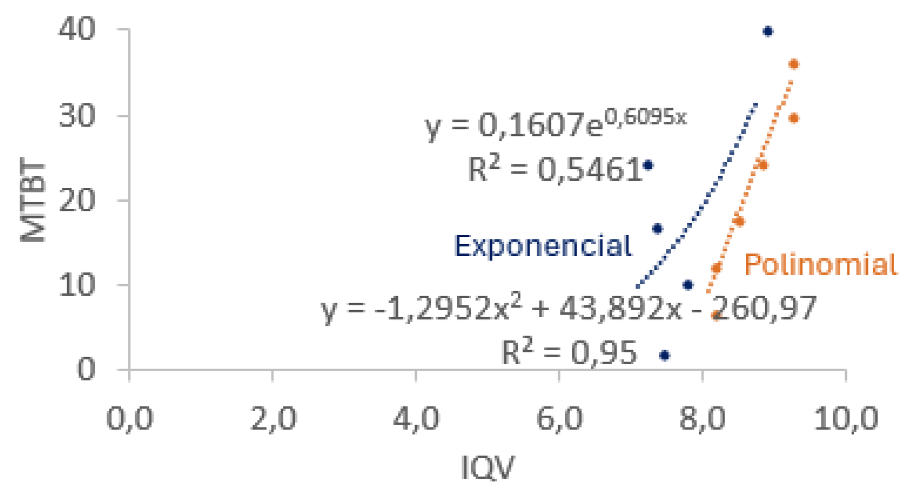



Figure 8. Trend Line of Degradation Due to Ballast Fouling in Wooden. Author (2024).

## Conclusions

The study confirmed the extent to which ballast aggradation accelerates track degradation, requiring more frequent tamping. The analysis enabled the prediction of maintenance durability based on transported volume, allowing for accurate resource forecasting. The importance of maintenance is emphasized, along with the need for further research into other factors affecting railway efficiency.

Figure 9. Example of Sample Collection. Author (2024).

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