



Web-Based Record-Keeping Application – Key to Quick & Efficient Decision-Making for Maintenance of Indian Railways Passenger Coaches Improving Turnaround of Assets.

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Abstract

The maintenance of rolling stock in general and coaching stock in particular in Railway systems is a critical aspect to ensure safe, reliable, and efficient train operations. Rolling stock, including locomotives, coaches, and wagons, undergoes significant wear and tear during their operational lifecycle, necessitating timely and effective maintenance procedures. With the continuous increase in the number of these assets growing day by day, the related data is getting enormously very big in size. These data are quite voluminous to be analyzed by conventional methodologies and warrants modern web tools so that effective decisions could be taken in a time-bound manner. Timely availability of accurate data is key to effective decision-making in the process of maintenance of rolling stock and quick decision-making during effective train operation. Furthermore, the integration of modern technologies, enable railway operators to adopt a data-driven approach to decision-making, facilitating more informed and efficient maintenance strategies. In conclusion, the proposed web-based resource management system as a tool for the maintenance of Indian Railway rolling stocks will bring efficiency, data-driven decision-making, and proactive maintenance strategies to the railway industry. By harnessing the power of technology and real-time data, the tool empowers maintenance teams to operate with greater effectiveness, ultimately improving the reliability, safety, and performance of the entire railway network.

Keywords – Rolling Stock, data-driven decision-making, RMS

1. Introduction

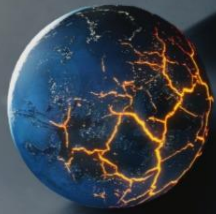
Throughout India's vast and varied terrain, the Indian Railways, one of the biggest and oldest railway networks in the world, provide essential transportation. The Indian Railways, which were first built during the British colonial era, have grown into an enormous network that connects cities, towns, and rural areas. It is essential to the economic and social development of the nation. Its vast network, covering more than 67,000 route kilometres, allows it to run numerous trains that transport millions of passengers and tons of freight each day. The Indian Railways is a vital component of the nation's transportation network due to its unparalleled scale. It not only makes it easier for people and goods to move around, but it also stimulates



trade, industry, and tourism, all of which contribute to economic growth. The railways play a vital role in the economy of India by offering a large number of people accessible and affordable modes of transportation, which promotes national unity and regional integration. The Indian Railways has made tremendous contributions, but it still faces many difficulties, especially in maintaining rolling stock and guaranteeing efficient train operations. Over 84,000 coaches make up the large fleet, making it a difficult task to manage maintenance for such a large inventory. The railway system is getting older, which means that more maintenance is needed and that malfunctions are more likely to occur. The railway network faces particular maintenance and safety challenges because it travels through a variety of landscapes, from plains to mountains, and experiences a range of weather. Heavy traffic in some railway corridors causes rolling stock, tracks, and other infrastructure elements to deteriorate over time. Maintaining passenger and freight safety is crucial, and any maintenance neglect may have dire repercussions. Making effective use of labor, equipment, and spare parts is essential to keeping the fleet of rolling stock operating at peak performance. Unplanned rolling stock downtime can cause schedule disruptions for trains, which can annoy passengers and cost money. Because of the size and complexity of the Indian Railways system, making wise decisions is crucial. Making timely, well-informed decisions can have a big influence on train services and maintenance operations. Making decisions quickly can optimize resource usage, minimize downtime, enhance safety, and avert possible malfunctions.

2. Difficulties in the traditional approach of record-keeping

Manual registers are used to record the vast amount of data created during rolling stock maintenance. This data primarily consists of details about defects and sub-defects, examination details, the date that different spare parts were fitted, and information about the makes of the passenger amenities items. Certain information is necessary when using this kind of rolling stock on trains. However, it is impossible to make snap decisions because some of these data are unavailable. It has also been frequently noted that certain recurring failures in any stock are only discovered after extensive data analysis, which could have been prevented if these were easily identified. Railways actively pursue the root cause analysis of all its failures. When the volume of Rolling Stocks increases and the number of maintenance staff is decreasing daily, it becomes a laborious task to manually record this data and analyze it later. This is because the analysis of a failure also takes many days to complete and involves numerous personnel. Similar to this, there are frequently a lot of ready coaches that could be used in train formation, but they cannot be nominated for train formation until they are physically verified, which takes a lot of time, because detailed data, such as the type of couplers and number of berths, is not available. For effective decision-making, a web-based application is therefore required to make record-keeping and data retrieval in the form of MIS reports easier.



3. Introducing the Resource Management System (RMS)

The Resource Management System (RMS) concept is used to improve decision-making and address the aforementioned issues with the traditional method of record-keeping. An RMS is a feature-rich web-based instrument that combines different maintenance facets. By giving real-time data on assets, such as maintenance schedules, installed subassemblies and their manufacturers, and details of various defects fixed on each rolling stock during previous maintenance operations, it simplifies rolling stock management. Allowance for data analysis to assess failure types, recurring failures, the number of stocks undergoing maintenance and the number of stocks ready for service following maintenance, among other factors. By utilizing advanced analytics, a wealth of information can be obtained, including the primary reason for failures, recurring issues with a specific vehicle, the number of days required for stock maintenance, an assessment of employee performance, and more. RMS provides a central platform for stakeholders to work together, access vital information, and make data-driven decisions. These stakeholders include engineers, decision-makers, and maintenance staff. Through resource allocation optimization, asset health monitoring, and effective communication facilitation, the RMS will enable Indian Railways to improve the overall performance, safety, and dependability of its rolling stock and train operations, thereby upholding its position as an essential component of the country's transportation infrastructure.

4. System Architecture of proposed Resource Management System

The proposed Resource Management System can be developed by using any modern web technologies depending upon budget, volume of data based on target maintenance depots.

Technologies proposed to be used:

- a) Server side: Laravel 9
- b) Database: MySQL 8
- c) Other technologies: HTML, CSS, JavaScript, Ajax etc.

MYSQL, Laravel 9 (a PHP framework), and other technologies are to be used in the development of the application. Using web hosting, especially Laravel, has a lot of benefits overall. Laravel is the most widely used PHP framework in 2023, per an interview.com survey [1]. For web developers, Laravel is a PHP framework with a sophisticated syntax that makes sense. It was created using MVC and is open source. It is renowned for its easy and quick coding style and needs very little configuration, along with an expressive syntax. To create web applications, it makes use of pre-existing components from different frameworks. Because it is simple to use, it shortens the framework's development time. It features a Laravel dependency manager in addition to a modular packaging system. Its key characteristics include accurate research, dependable performance, and ease of adaptability to any kind of business [2].



The following is a list of benefits of utilizing the Laravel framework [3]:

i.Blade Template Engine:

Blade, the template engine that comes with Laravel, is more powerful than PHP's template engine while being simpler. It adds convenience to website development by offering features such as legacy templates and file extensions, in addition to simple shortcuts for some PHP functions.

ii.Eloquent ORM:

The eloquent ORM in Laravel provides web developers with easy-to-use data that makes it easier and less time-consuming to deal with data. It allows them to write database queries using PHP syntax and they don't need to write or know SQL to update or change data.

iii.Laravel MVC Architecture:

Laravel is a PHP framework built on model-view-controller that allows for a clean separation of presentation and business logic. "Model-View-Controller" is an acronym for just that. It is a layout that divides the control process, the user interface, and the structure (logic, data management). Many advantages, including improved security, scalability, and high speed, are offered by the Laravel framework, which is built on the MVC architecture.

iv.Open Source and the large Community:

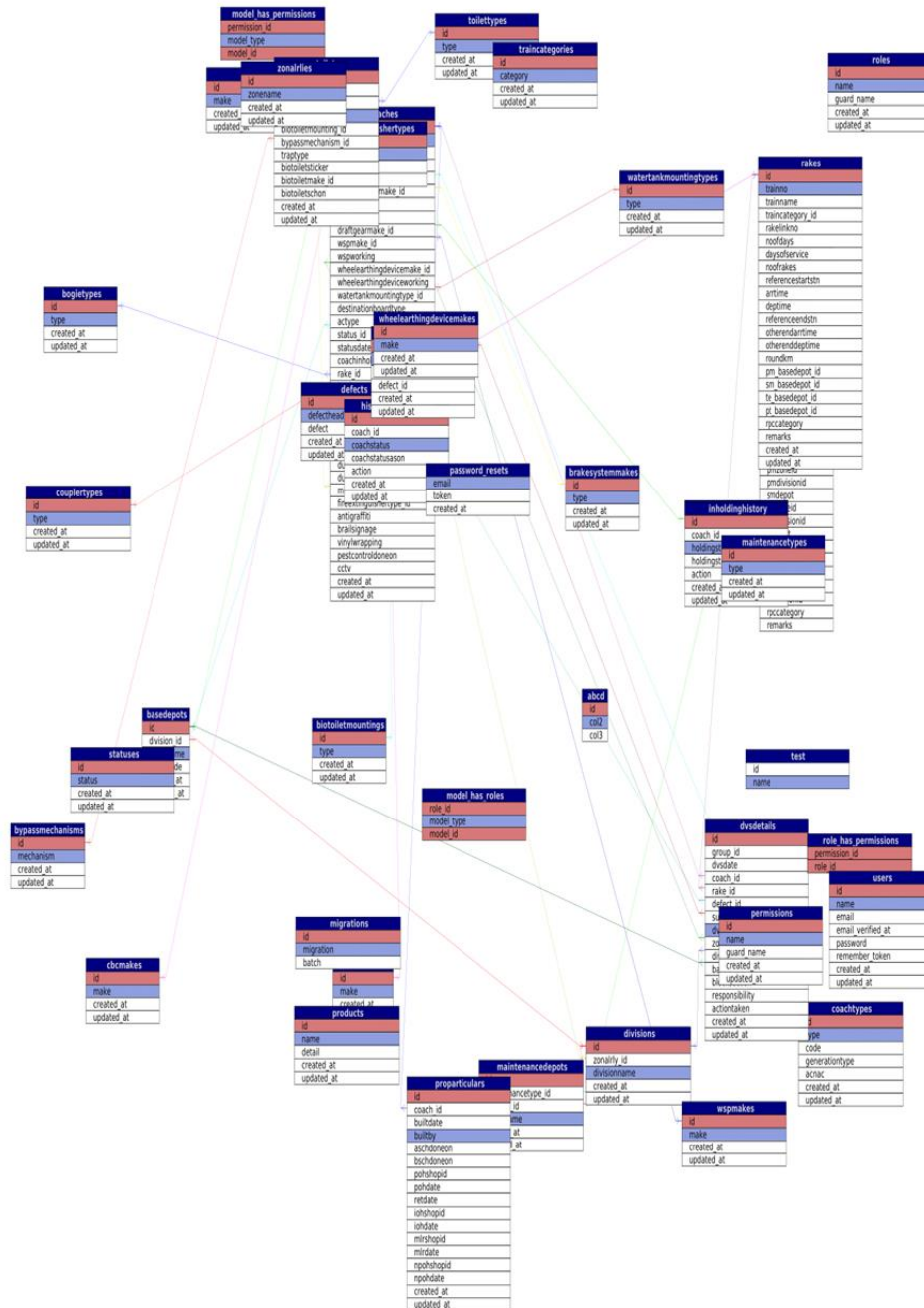
For web developers, there is Laravel, which is open-source. In addition to being more efficient and versatile, it offers a robust community support framework.

v.Object Oriented Libraries:

The Laravel PHP framework includes many libraries designed for developers with great features. Apart from the good functions of this Laravel framework, there are many reasons why organizations continue to use Laravel development services.

vi.Security

Laravel supports several basic security measures such as SQL injection, cross-site request response (CSRF), and cross-site scripting (XSS).



A typical ER Diagram of proposed Resource Management System

5. Process Flow of proposed system through Graphical User Interface

The application shall have following facilities:



- a) User Management System with requisite security management.
- b) Master Table having details of each coach.
- c) Tables having details of each spare fitted on the coaches along with makes.
- d) Table containing details of maintenance schedule of each coach.
- e) Details of all repairs undertaken in respect of each coach along with details of Defect/Sub-defects.
- f) Details of coaches whether they are running in any train or lying under any schedule/unscheduled maintenance.
- g) Various MIS Reports:
 - i.Coach Holding of any maintenance depots with options of data visualization in multi-dimension.
 - ii.Coach details under maintenance with details of defects/sub-defects.
 - iii.Ready Coaches for operational use along with all minute details of coaches.
 - iv.Root cause analysis of failure.
 - v.Advance analytics of data related to failure patterns, repetitive failures etc.
 - vi.Provision of customized reports as per fresh requirements.

5.1 GRAPHICAL USER INTERFACE

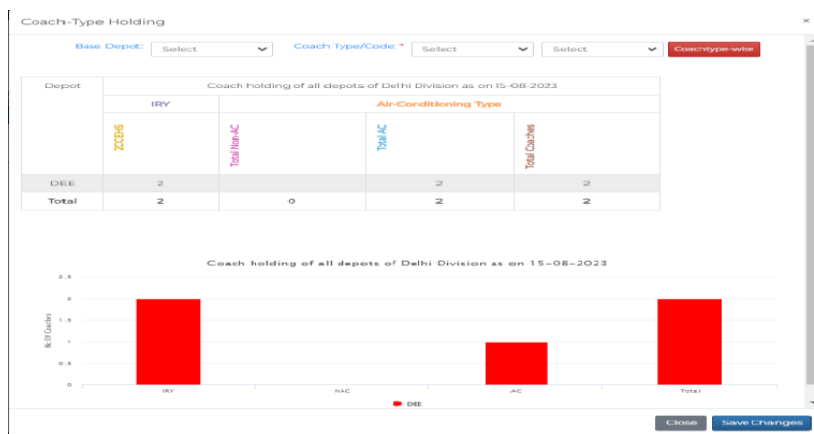
Some of the typical web forms proposed for the subject resource management system is appended below:

User Login



5.2 Coach Holding of a depot (Coach Type Wise)

This MIS report provides real-time coach holding of a maintenance depot indicating each types of coaches. It helps managers to have an idea of broad categories of types of coaches available for efficient decision making related to train formation and other planning where details of coaches are required.



5.3 Coach Holding of a depot (Coach Type Wise)

This MIS report provides real-time coach holding of a maintenance depot indicating the current status of various coaches under different status of services. It helps managers to have an idea of broad categories of types of coaches engaged in various services and for efficient decision making related to train formation and other planning where details of are required. This report will be extremely helpful in where an assessment is required to check whether any particular type of coaches have been put excessively under any particular services leading to deficiency.





6. Benefits of the proposed System

The intended benefits expected from the proposed system has been envisaged as below:

- a) The user shall have exact idea of all Coaches as to whether they are in active services or lying defective.
- b) The user shall have real-time coach holding of any depots.
- c) The user shall have details of all spares fitted in coaches so that if any spares gets defective, it will be known beforehand regarding make of sub-assembly which will ease maintenance.
- d) The user shall have increased availability of coaches & increased utilization leading to higher revenue.
- e) The user shall have detailed analysis of root cause failure leading to better maintenance practices leading to safe & smooth running of trains.
- f) The user shall be able to take data-driven decision-making leading to faster turnaround of assets.

7. Conclusion

It is quite evident that the proposed resource management system shall address all the issues with traditional approach and will assist in effective asset management & resource allocation. By adopting this modern approach to data management, Indian Railways can enhance its operational efficiency, decision-making capabilities, and overall performance. The successful implementation of the web-based tool could serve as a model for other railway networks worldwide looking to improve their record-keeping practices in the digital era of the work or suggest applications and extensions.

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