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

Introduction

The Indian Railways, one of the largest and oldest railway networks in the world, serves as the lifeline of transportation across the vast and diverse landscape of India. Established during the British colonial era, the Indian Railways has evolved into a colossal system connecting cities, towns, and remote areas, playing a pivotal role in the country's economic and social development. With an extensive network spanning over 67,000 route kilometers, it operates a plethora of trains carrying millions of passengers and tons of freight every day.

The scale of the Indian Railways is unparalleled, making it an integral part of the country's transport infrastructure. It not only facilitates the movement of people and goods but also serves as a catalyst for economic growth by promoting trade, industry, and tourism. The railways contribute significantly to India's economy, providing affordable and accessible transportation options to a vast population, thereby fostering regional integration and national cohesion. Despite its significant contributions, the Indian Railways faces various challenges, particularly in maintaining rolling stock and ensuring smooth train operations. With an extensive fleet of more than 84,000 coaches, managing maintenance for such a massive inventory is a daunting task. A considerable portion of the railway infrastructure is aging, leading to increased maintenance requirements and higher susceptibility to breakdowns. The railway network traverses' diverse terrains, from plains to mountains, and experiences varied weather conditions, presenting unique challenges in maintenance and safety. Certain railway corridors witness heavy traffic, resulting in continuous wear and tear of rolling stock, tracks, and other infrastructure components. Ensuring the safety of passengers and freight is of utmost importance, and any lapses in maintenance can have severe consequences. Efficiently allocating resources, such as labor, tools, and spare parts, becomes critical in maintaining the rolling stock fleet at an optimal level. Unplanned downtime of rolling stock can disrupt train schedules, leading to passenger inconveniences and revenue loss. The vastness and complexity of the Indian Railways system, effective decision-making is paramount. The ability to make informed choices promptly can significantly impact maintenance operations and train services. Quick decision-making can prevent potential breakdowns, reduce downtime, improve safety, and optimize resource utilization.

Difficulties in the traditional approach of record-keeping

The voluminous data generated during maintenance of Rolling stock which mainly includes details of defects/sub-defects, examination details, date of fitment of various spares, passenger amenities items including information related to their makes are recorded in manual registers. Some of these details are required when such Rolling Stock are running on Trains. However, due to non-availability of some these data, quick decisions are not possible. It has also been observed quite often that some repetitive failures on any stock is realized only after significant analysis of data which could have been avoided if these are known without much efforts. Root cause analysis of every failure is an important activity undertaken by Railways. Similarly, it takes many days to conclude the analysis of a failure and it involves many personnel's so recording these data manually and analyzing later on is a cumbersome task when volume of Rolling Stocks is increasing and maintenance staff is decreasing day by day. Similarly, many a times many ready coaches are available which could be used in train formation but due to non-availability of detailed data like type of couplers, no of berths etc. such coaches cannot be nominated for train formation before physically verifying them which takes a lot of time. Therefore, there is a need for a web-based application to facilitate record-keeping and retrieval of data in the form of MIS reports for efficient decision making.

Introducing the Resource Management System (RMS)

To address the above-mentioned challenges in traditional method of record-keeping and enhance decision-making, the concept of a Resource Management System (RMS) comes into play. An RMS is a comprehensive web-based tool that integrates various aspects of maintenance. It streamlines the management of rolling stock by providing real-time data on asset which includes details of various maintenance schedules, details of sub-assemblies fitted including their makes, details of various defects attended on every Rolling Stock during past maintenance activities. Provision for analysis of data to evaluate failure type, repetitive failures, no of stocks which are under maintenance and nos of stock which are ready for service after maintenance etc. Leveraging advanced analytics enables many information like main cause of failures, repetitive failures on any particular vehicle, days taken in maintenance of stock, evaluation of performance of manpower etc. RMS serves as a central platform for stakeholders, including maintenance personnel, engineers, and decision-makers, to collaborate, access critical information, and make data-driven decisions. By optimizing resource allocation, monitoring asset health, and facilitating efficient communication, the RMS will empower Indian Railways to enhance the reliability, safety, and overall performance of its rolling stock and train operations, thus maintaining its status as a vital pillar of India's transportation infrastructure.

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:

(i)Server side: Laravel 9

(ii)Database: MySQL 8

(iii)Other technologies: HTML, CSS, JavaScript, Ajax etc.

The application is intended to be built using Laravel 9 (a PHP framework), MYSQL and other technologies. Overall, there are many advantages and benefits to using web hosting, especially Laravel. According to a survey made by interview.com, Laravel is the most popular PHP framework in 2023 [1]. Laravel is a PHP framework for web applications with elegant syntax that makes sense for web professionals. It is open source and built with MVC. It requires very little configuration and an expressive syntax and is known for its simple and fast coding style. It reuses existing components of various frameworks to build web applications. It reduces the development time of the framework as it is easy to use. It has a modular packaging system and a Laravel dependency manager. It has important features, reliable performance, accurate research and easy adaptability to any type of business [2]. The advantages of using the Laravel framework are detailed as under [3]:

Blade Template Engine
Laravel comes with blade template engine which is simple but very powerful compared to PHP template engine. 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

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.
Laravel MVC Architecture
Laravel is an MVC based PHP framework that provides precise separation between the presentation layer and business logic. MVC stands for model, view and controller. It is a design that separates structure (logic, data handling), appearance (UI) and control process (interface). The Laravel framework is based on MVC and offers many features such as high performance, enhanced security and scalability.

Open Source and the large Community

Laravel is open-source for web developers. It also has a strong community support framework that makes it more efficient and flexible.

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.

Security

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

PROCESS FLOW OF PROPOSED SYSTEM THROUGH GRAPHICAL USER INTERFACE

A typical ER Diagram of proposed Resource Management System is illustrated below.
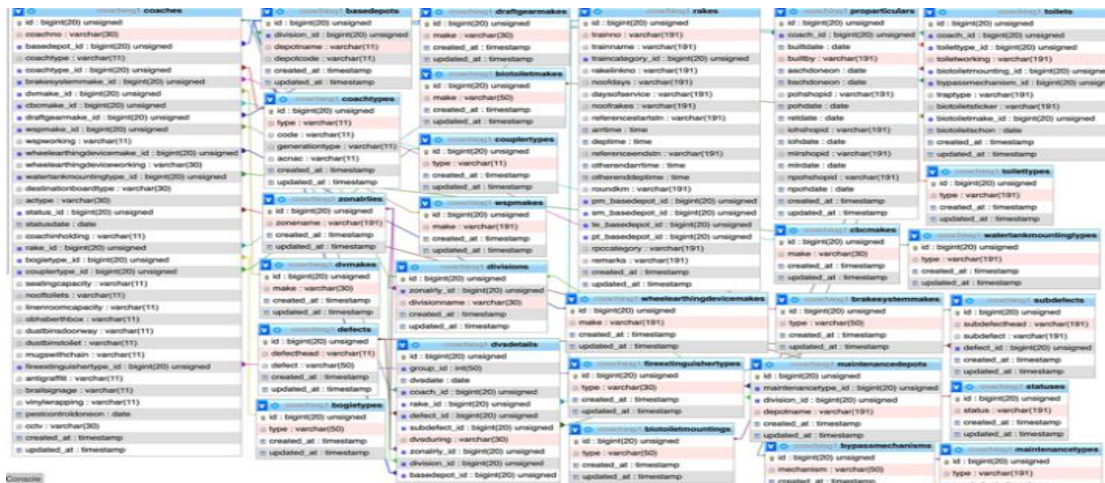
The application shall have following facilities:

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:
 a.   Coach Holding of any maintenance depots with options of data visualization in multi-dimension.
 b.   Coach details under maintenance with details of defects/sub-defects.
 c.   Ready Coaches for operational use along with all minute details of coaches.
 d.   Root cause analysis of failure.
 e.   Advance analytics of data related to failure patterns, repetitive failures etc.
 f.   Provision of customized reports as per fresh requirements.
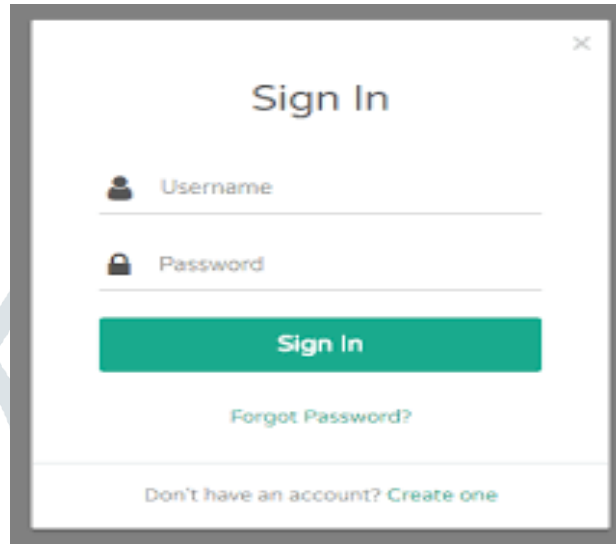
BENEFITS OF THE PROPOSED SYSTEM

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.

GRAPHICAL USER INTERFACE

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

User Login

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.
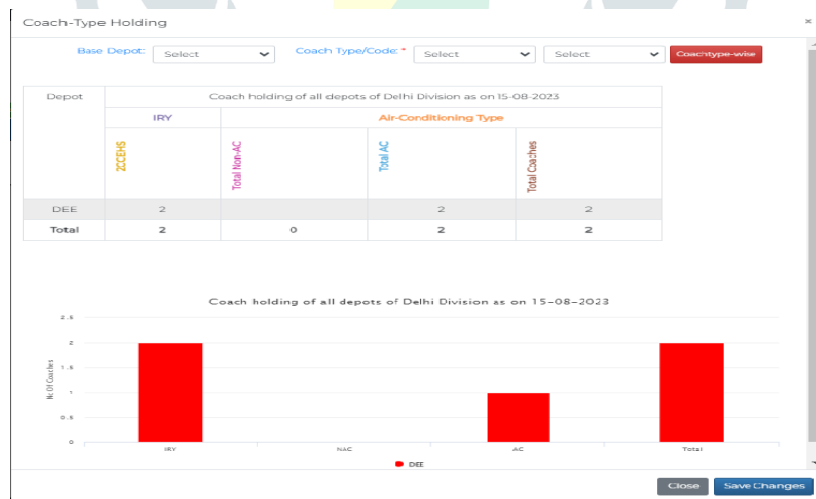
Coach Holding of a depot (Coach Type Wise)

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.

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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