IoT based Load Detection System for Goods

Aryan Chawada[1], Nikita Bhosale[1], Atharv Patil[1], Chinmay Chitte[1], Makarand Mali[1],
Mrs. K. N. Kulkarni[2]
[1] *UG Student, Dept. of Civil Engineering, AISSMS College of Engineering, India*
[2] *Assistant Professor, Dept. of Civil Engineering, AISSMS College of Engineering, India*

Abstract: *The designing and testing of NIKITA-V1, an Internet of things-based mechanism, is presented in this article. Its purpose is to precisely solve the issues of underloading and overloading that Coal India Limited (CIL) encounters throughout the coal transportation process. Utilizing developments in data analytics and sensor technologies, NIKITA-V1 works in unison with AVINYA 3.0, a prototype meant to show off the capabilities of the suggested solution. The main component of the suggested technique is the mounting of load cells on every coal cart, which creates an advanced Internet of Things network that can provide weight data in real time to a centralized monitoring system. By use of sensors positioned strategically, NIKITA-V1 guarantees precise and prompt identification of loading irregularities, allowing proactive measures to sustain load balance and adherence to safety protocols. Prolonged testing of the prototype has produced good results, confirming the suggested solution's efficacy and dependability. In addition to addressing urgent operational difficulties, AVINYA 3.0 sets the framework for a dramatic change towards increased accuracy, efficiency, and accountability in coal transportation by giving CIL actionable data about coal-loading procedures. This study highlights how Internet of Things (IoT) technology may transform the way that cargo management is done in railway systems, leading to better operational performance, safety, and sustainability throughout the coal supply chain*

Keywords: **IoT, AVINYA 3.0, NIKITA V1, Real Time Monitoring, Web Server**

1. Introduction

The issue of railway wagon overloading and underloading during coal transportation has resulted in considerable financial losses for Coal India Limited (CIL), the country's major coal producer and supplier. Inaccurate coal loading has been demonstrated by the existing contractual technique of wagon loading with payloaders, which has led to significant fines for overloading and credit adjustments for underloading. Underloading caused CIL to spend Rs. 593 crores in the 2021–22 fiscal year alone—a sum that exceeds the Rs. 276 crores contract cost of wagon loading alone. In order to mitigate this pressing problem and maximize transportation expenses, CIL has determined that a digital solution utilizing sensors and Internet of Things (IoT) technologies is required.

By using a sensor-based Internet of Things system, coal loading levels can be monitored in real-time, giving precise information on how much coal is put into each wagon. A central control system will receive this real-time data, enabling prompt detection of any overloading or underloading situations. In order to guarantee accurate loading, the control system has the ability to detect, provide alerts to the loading staff, and start remedial action.

IoT technology integration will also make it easier to automate data gathering and analysis, doing away with the need for manual record-keeping and lowering the possibility of human mistake. By means of this automated method, CIL will have extensive insights on loading patterns, which will facilitate the identification of trends, optimization of loading procedures, and mitigation of overloading and underloading.

Using a sensor-based Internet of things solution would not only save money but also improve the environment. CIL may lessen the chance of spills during transportation by limiting overloading, minimizing environmental harm and encouraging sustainable practices. Additionally, precise loading will guarantee effective use of railroad wagons, minimizing the quantity of wagons needed for transportation and, as a result, fuel consumption.

CIL has a revolutionary potential to address the problem of overloading and underloading, reduce transportation costs, improve environmental sustainability, and expedite operations by implementing a digital solution utilizing sensors and IoT technologies. In the coal sector, CIL may establish itself as a leader by embracing innovation and utilizing technology to set new benchmarks for effectiveness and environmental responsibility.

1.1. Objectives

- Research the Effects of Coal Wagon Overloading and Underloading on Rail Tracks
- Gain Knowledge of the Internet of Things and How It Can Be Used in Civil Engineering
- Study Data Acquisition and Data Communication
- Choosing the parts for the Internet of Things system that will identify an overloaded or underloaded coal cart
- Developing the Circuit Diagram idea

2. Related Work

Technological sophistication rises in tandem with human intellect. The Internet of Things, or IoT, is a network of networked computer devices that connects mechanical and digital elements, such as machines, animals, and people. Without requiring direct human intervention, this makes it easier for data to be collected, processed, and transmitted across networks in an efficient manner. The rise of smart cities emphasizes the need for creative solutions across a range of industries, including agriculture. The creation of a smart weighing system designed for agricultural automation is a perfect example of this innovation.

Farmers can weigh their food by only putting it in a crate thanks to this technology. This smart weighing system goes beyond conventional weighing machines by including sensors and smart algorithms, turning them into intelligent machines that can measure items on their own and provide data for container monitoring via GSM modems.

3. Methodology

3.1. AVINYA 3.0

The top-down method was employed in the creation of AVINYA 3.0. *Figure 3.1 (Methodology of AVINYA 3.0)*

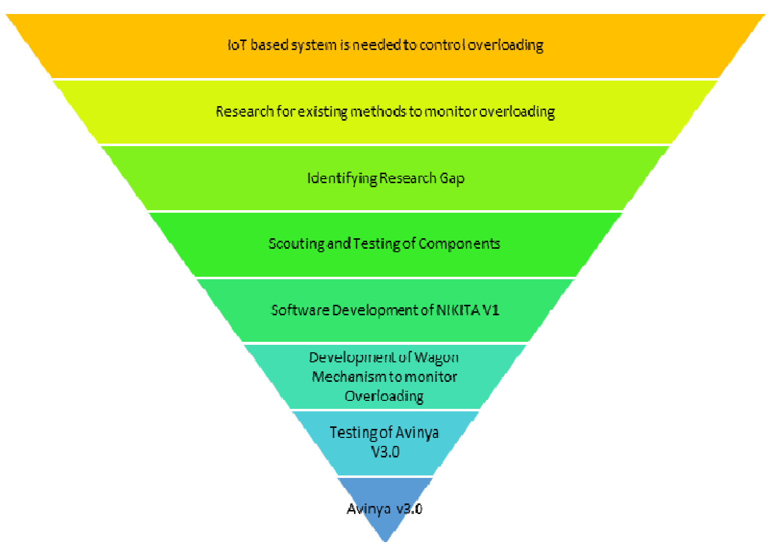


Figure 3. 1: Methodology of AVINYA 3.0

We attempted to optimize the device by cutting down on wire and improving precision without altering the current architecture of rail sensor networks, as this prototype has resemblance to the rail wagon.

This device displays *Figure 3.2 (AVINYA 3.0)* every loading scenario that we have configured. The gadget has an LCD screen and an LED light on its front face. The device's weight and loading status are shown on the LCD, and the same data is transmitted to a cloud that can be accessed from a distance. Additionally, for overload, underload, and safe limit, respectively, an LED light blinks red, blue, and green.

The gadget's heart, the NIKITA V1, is put in a box on the rear of the device. The ESP-32, the HX711 module, and the pins for the LCD and LED make up the NIKITA V1 board. Additionally, this prototype is currently powered by a DC 5V power supply.

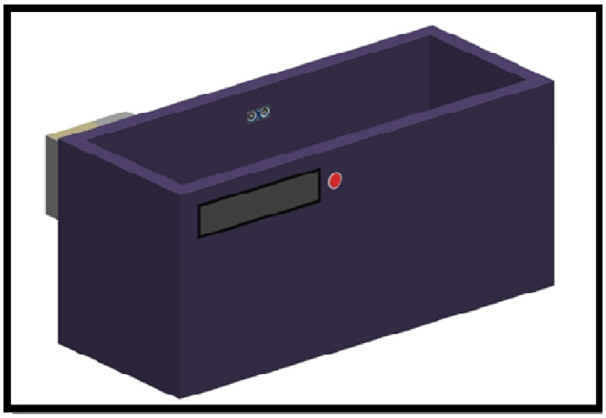
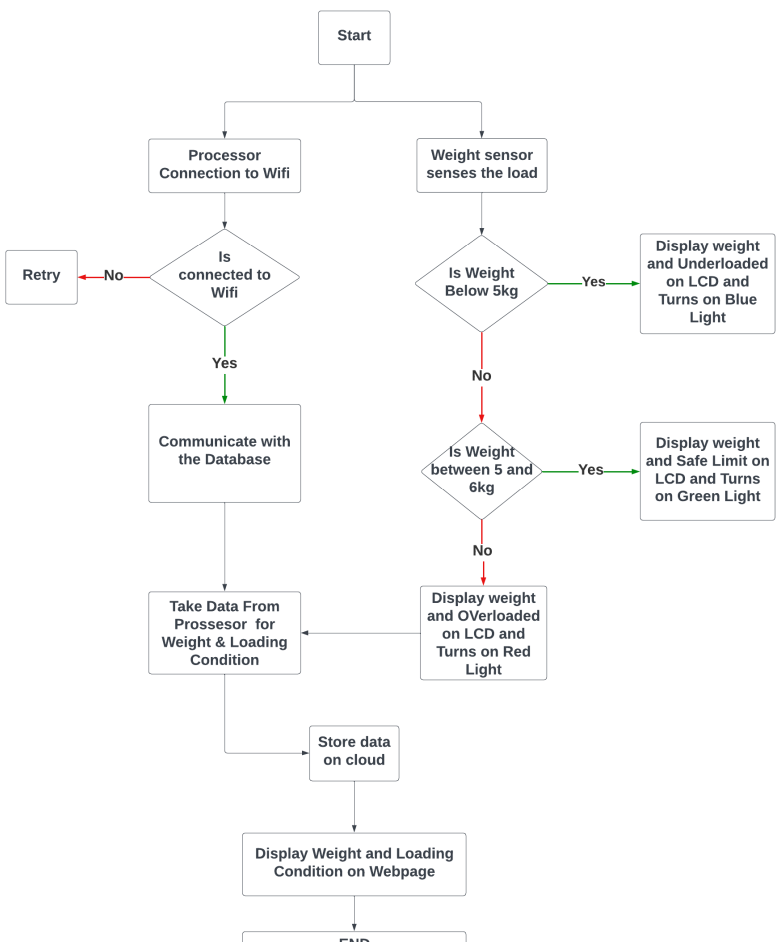


***Figure 3. 2:* AVINYA 3.0**

3.2. System Architecture



3.3 Components of NIKITA V1

In order to address the CIL issue, we have created a PCB that is both effective and

Figure 3. 3: System Flowchart

affordable to construct.

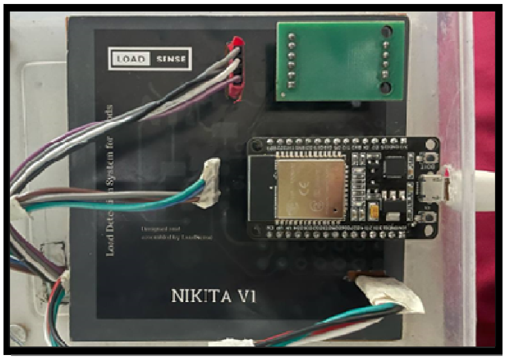


Figure 3. 1: **NIKITA V1**

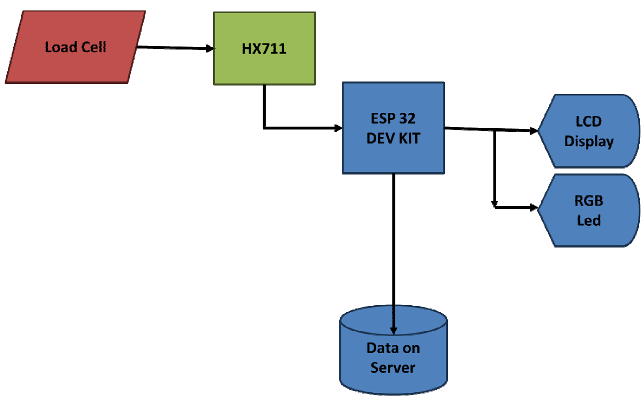


Figure 3. 5: Flowchart of Software

3.3.1. The ESP32 Dev Kit

With its robust ESP32 microcontroller and Wi-Fi and Bluetooth connections, this adaptable development board is perfect for Internet of Things projects and wireless applications.

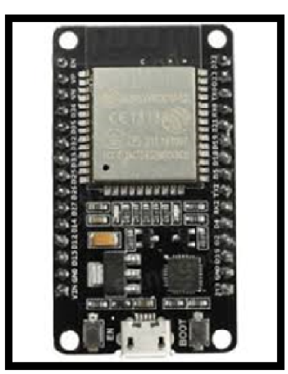


Figure 3. 6: ESP-32

3.3.2. HX711 Module

It is a specialized analog-to-digital converter (ADC) chip that is often used in conjunction with load cells to accurately translate analog weight measurements into digital signals. This process produces data that is consistent and dependable for a range of applications.

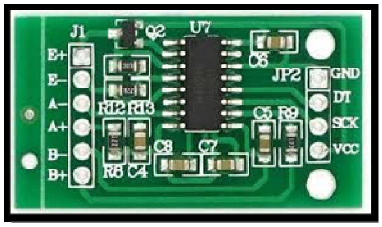


Figure 3. 7: HX711 Module

3.3.3. LCD 16x2 I2C

It is an I2C-compatible liquid crystal display module with a 16x2 character layout that makes it simple to integrate with microcontrollers like Arduino. It offers a practical solution to show data in projects ranging from straightforward devices to intricate systems.

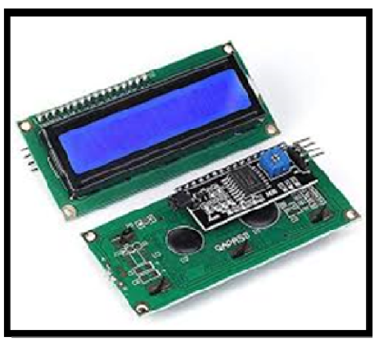


Figure 3. 8: LCD 16x2 I2C

3.4.4. LED

It is a small light-emitting diode that can blend red, green, and blue light to show a variety of hues. It may be used in electrical projects for ambiance, visual effects, and status indication.

Figure 3. 9: LED

3.4.5. Load Cell

This high-precision sensor is widely used in commercial, industrial, and do-it-yourself projects for applications including force measurement systems and weighing scales. It is made to detect weight accurately.

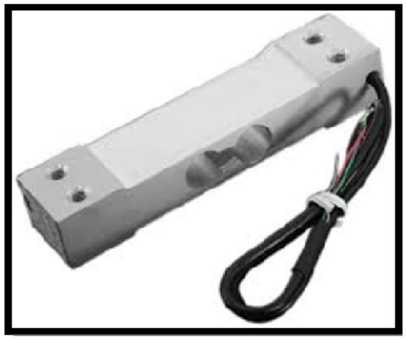


Figure 3. 10: Load Cell

3.4. Web Server

We developed a load detection system that stops rail coal wagons from being overloaded or underloaded after achieving our goals and testing our gadget. This method may be used to different transport vehicles and types of transportation, and it can also be used to identify any kind of products loading in the next update.

The data that is visible on the cloud may be shared in a portable format, such as an Excel sheet, and downloaded directly from the cloud.

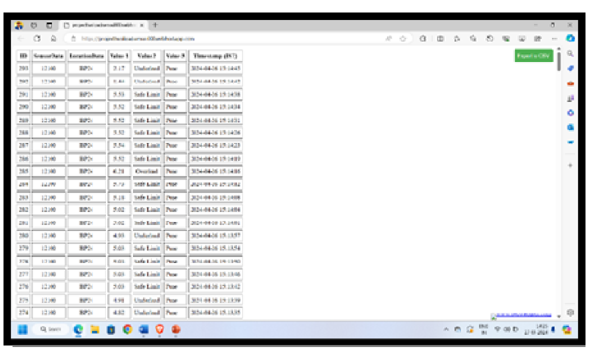


Figure 3. 11: Web Server

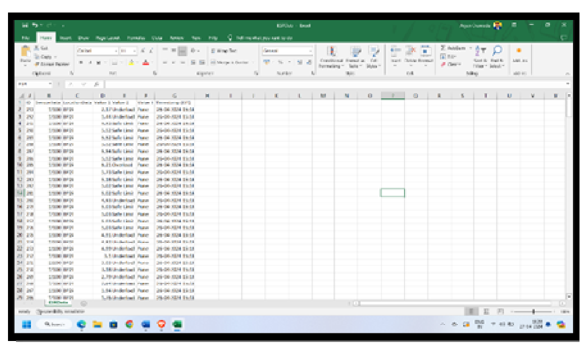


Figure 3. 12: Exported data in Excel

4. Results

4.1 underload

We utilize 4 kg of weights in a container to test our device for underloading conditions. This allows us to obtain exact data *(refer to Figure 4.1)*, which is then transferred to the cloud for remote access *(refer to Figure 4.2)*.

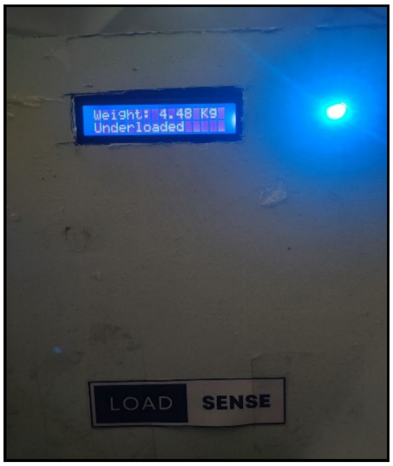
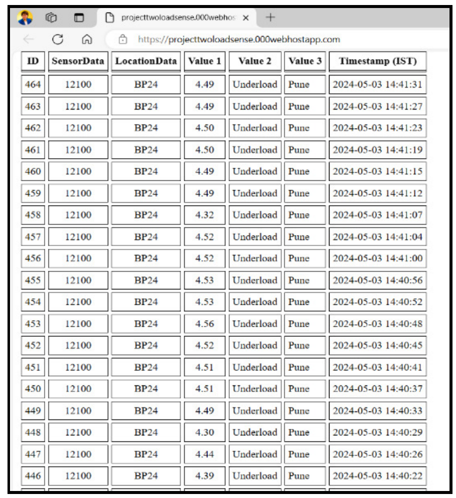


Figure 4. 1: Readings Displayed on LCD



https://projecttwoloadsense.000webhostapp.com

ID	SensorData	LocationData	Value 1	Value 2	Value 3	Timestamp (IST)
464	12100	BP24	4.49	Underload	Pune	2024-05-03 14:41:31
463	12100	BP24	4.49	Underload	Pune	2024-05-03 14:41:27
462	12100	BP24	4.50	Underload	Pune	2024-05-03 14:41:23
461	12100	BP24	4.50	Underload	Pune	2024-05-03 14:41:19
460	12100	BP24	4.49	Underload	Pune	2024-05-03 14:41:15
459	12100	BP24	4.49	Underload	Pune	2024-05-03 14:41:12
458	12100	BP24	4.32	Underload	Pune	2024-05-03 14:41:07
457	12100	BP24	4.52	Underload	Pune	2024-05-03 14:41:04
456	12100	BP24	4.52	Underload	Pune	2024-05-03 14:41:00
455	12100	BP24	4.53	Underload	Pune	2024-05-03 14:40:56
454	12100	BP24	4.53	Underload	Pune	2024-05-03 14:40:52
453	12100	BP24	4.56	Underload	Pune	2024-05-03 14:40:48
452	12100	BP24	4.52	Underload	Pune	2024-05-03 14:40:45
451	12100	BP24	4.51	Underload	Pune	2024-05-03 14:40:41
450	12100	BP24	4.51	Underload	Pune	2024-05-03 14:40:37
449	12100	BP24	4.49	Underload	Pune	2024-05-03 14:40:33
448	12100	BP24	4.30	Underload	Pune	2024-05-03 14:40:29
447	12100	BP24	4.44	Underload	Pune	2024-05-03 14:40:26
446	12100	BP24	4.39	Underload	Pune	2024-05-03 14:40:22

Figure 4.2: Data Access through Cloud

4.1 Safe Limit

We employ 5.50 kg of weights in a container to test our device for underloading conditions. This allows us to obtain exact data *(refer to Figure 4.3),* which is then transferred to the cloud for remote access *(refer to Figure 4.4)*.

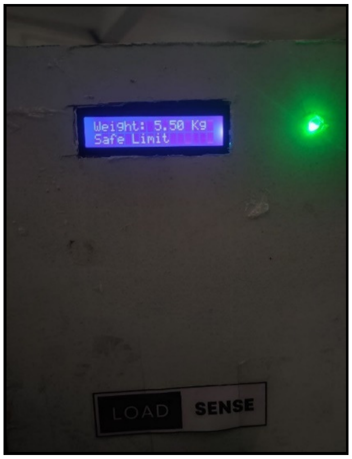


Figure 4.3: 5.50 Kg Displayed on LCD

ID	SensorData	LocationData	Value 1	Value 2	Value 3	Timestamp (IST)
556	12100	BP24	5.50	Safe Limit	Pune	2024-05-03 14:47:25
555	12100	BP24	5.55	Safe Limit	Pune	2024-05-03 14:47:21
554	12100	BP24	5.55	Safe Limit	Pune	2024-05-03 14:47:17
553	12100	BP24	5.55	Safe Limit	Pune	2024-05-03 14:47:13
552	12100	BP24	5.54	Safe Limit	Pune	2024-05-03 14:47:09
551	12100	BP24	5.54	Safe Limit	Pune	2024-05-03 14:47:06
550	12100	BP24	5.54	Safe Limit	Pune	2024-05-03 14:47:02
549	12100	BP24	5.54	Safe Limit	Pune	2024-05-03 14:46:58
548	12100	BP24	5.54	Safe Limit	Pune	2024-05-03 14:46:54
547	12100	BP24	5.54	Safe Limit	Pune	2024-05-03 14:46:50
546	12100	BP24	5.54	Safe Limit	Pune	2024-05-03 14:46:46
545	12100	BP24	5.52	Safe Limit	Pune	2024-05-03 14:46:43
544	12100	BP24	5.58	Safe Limit	Pune	2024-05-03 14:46:39
543	12100	BP24	5.59	Safe Limit	Pune	2024-05-03 14:46:35
542	12100	BP24	5.58	Safe Limit	Pune	2024-05-03 14:46:31
541	12100	BP24	4.31	Underload	Pune	2024-05-03 14:46:27
540	12100	BP24	4.81	Underload	Pune	2024-05-03 14:46:24
539	12100	BP24	4.81	Underload	Pune	2024-05-03 14:46:19
538	12100	BP24	4.81	Underload	Pune	2024-05-03 14:46:15

Figure 4.4: Data Access through Cloud

4.1 Overload

We apply 6-kilogram weights and store them in a container when testing our device to identify underloading conditions. This allows us to obtain exact data *(refer to Figure 4.5),* which is then transferred to the cloud for remote access *(refer to Figure 4.6).*

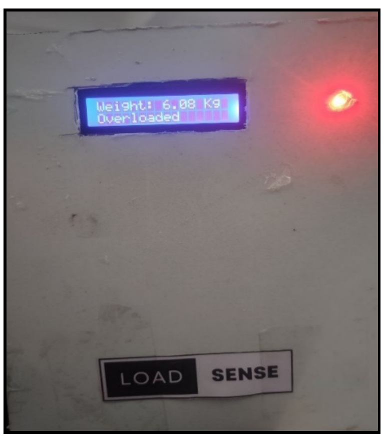


Figure 4.5: 6.00 Kg Displayed on LCD

ID	SensorData	LocationData	Value 1	Value 2	Value 3	Timestamp (IST)
566	12100	BP24	6.03	overload	Pune	2024-05-03 14:48:03
565	12100	BP24	5.92	Safe Limit	Pune	2024-05-03 14:48:00
564	12100	BP24	5.92	Safe Limit	Pune	2024-05-03 14:47:56
563	12100	BP24	5.92	Safe Limit	Pune	2024-05-03 14:47:52
562	12100	BP24	5.92	Safe Limit	Pune	2024-05-03 14:47:48
561	12100	BP24	5.92	Safe Limit	Pune	2024-05-03 14:47:44
560	12100	BP24	5.92	Safe Limit	Pune	2024-05-03 14:47:41
559	12100	BP24	5.86	Safe Limit	Pune	2024-05-03 14:47:37
558	12100	BP24	5.53	Safe Limit	Pune	2024-05-03 14:47:33
557	12100	BP24	5.50	Safe Limit	Pune	2024-05-03 14:47:29
556	12100	BP24	5.50	Safe Limit	Pune	2024-05-03 14:47:25
555	12100	BP24	5.55	Safe Limit	Pune	2024-05-03 14:47:21
554	12100	BP24	5.55	Safe Limit	Pune	2024-05-03 14:47:17
553	12100	BP24	5.55	Safe Limit	Pune	2024-05-03 14:47:13
552	12100	BP24	5.54	Safe Limit	Pune	2024-05-03 14:47:09
551	12100	BP24	5.54	Safe Limit	Pune	2024-05-03 14:47:06
550	12100	BP24	5.54	Safe Limit	Pune	2024-05-03 14:47:02
549	12100	BP24	5.54	Safe Limit	Pune	2024-05-03 14:46:58
548	12100	BP24	5.54	Safe Limit	Pune	2024-05-03 14:46:54

Figure 4.6: Data Access through Cloud

5. Conclusion

5.1. Conclusion

In summary, there are several advantages to tackling the issues of overloading and underloading in coal loading procedures, including lower costs, increased operational effectiveness, improved safety, and happier customers. Through the use of preventative measures, companies may save costs related to fuel consumption, equipment maintenance, and regulatory fines. Additionally, by simplifying processes, production objectives can be met more consistently. Additionally, putting safety first via effective load management reduces the likelihood of accidents and promotes a good safety culture, which boosts staff morale and enhances the reputation of the company. Concurrently, real-time insights into coal loading processes are made possible by the integration of digital solutions, especially sensors and IoT technology. This promotes transparency, helps discover optimization possibilities, and allows for data-driven decision-making. In the changing coal industry context, businesses may achieve operational excellence, maximize resource use, and discover opportunities for development through continuous monitoring and analysis of sensor-generated data.

To summarize, the integration of digital solutions and preventative measures against overloading and underloading is a revolutionary strategy for improving safety, efficiency, and decision-making in coal loading operations. Through the utilization of technology to enhance load management and the use of data analytics, establishments may attain financial benefits, enhance operational efficiency, and fortify their connections with stakeholders and consumers. In addition to addressing current issues, this all-encompassing strategy puts businesses in a competitive and successful long-term position within the ever-changing coal market.

5.2. Future Scope

- Suitable for a variety of transit modalities
- Suitable for many kinds of goods
- Remote data storage capability without network connectivity
- Creation of Applications
- The implementation of Real Time Monitoring with Integrated GPS

References

[1] Chawada, A., Bhosale, N., Patil, A., Chitte, C., Mali, M., & Kulkarni, K. N. (2024). IoT Mechanisms Detecting Loading of Goods: A Review. *International Research Journal of Engineering and Technology*. www.irjet.net

[2] Sonsare, P. M. (2018). IOT based Smart weighing system for Crate in Agriculture. *Article in International Journal of Computer Sciences and Engineering*. https://doi.org/10.26438/ijcse/v6i1.336341

[3] Harald Krueger, 1999, Parametric Modeling In Rail Capacity Planning, Proceedings of the 1999 Winter Simulation Conference

[4] D.J. Thompson, Railway noise and vibration: mechanisms, modelling and means of control, Oxford, (2009) pp. 399–435.

[5] P.J. Remington, Wheel / Rail Rolling Noise I, Theoretical Analysis, J. Acoust. Soc. Am. 81(6) (1987).

[6] K.H. Oostermeijer, A.W.M. Kok, Dynamic behavior of railway superstructure, HERON 45 (1) (2000) 25–34.

[7] M. Heckl, G. Hauck, R. Wettschureck, Structure-borne sound and vibration from rail traffic, J. Sound Vib. 193 (1) (1996) 175–184.