IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 6, March 2026
Impact Factor: 8.2

Tunnel Safety Automation with Rockfall or Landslide Detection and Smart Traffic Diversion System using PLC

Sonawane Anuradha Shivaji, Sonawane Sakshi Shivaji, Tangadkar Pranjal Rajesh, Dhomase Komal Shamrao, Ohol R. D.
Amrutvahini Sheti and Vikas Sanstha, Amrutvahini Polytechnic, Sangamner, Ahilyanagar, Maharashtra

Abstract: *Tunnels play a crucial role in modern transportation systems, especially in hilly or mountainous regions. However, they are prone to hazards such as vehicle accidents, fires, rockfalls, and landslides, which can result in severe damage and loss of life. To overcome these challenges, this project proposes an automated tunnel safety system using PLC (Programmable Logic Controller) that ensures real-time monitoring and control of tunnel operations.*
The system uses two IR sensors to monitor vehicle movement — one counts vehicles entering the tunnel, while the other counts those exiting. This helps track the number of vehicles currently inside the tunnel. A smoke sensor detects the presence of fire or smoke, while a vibration sensor detects rockfall or landslide vibrations within the tunnel. In case of any abnormal conditions, the PLC automatically triggers alarms, activates ventilation fans, and diverts traffic using indicator signals or barriers. This intelligent control system enhances tunnel safety by enabling early detection of hazards and ensuring timely automated responses without requiring human intervention.

Keywords: *Tunnels*

I. INTRODUCTION

Tunnels are critical components of modern transportation networks, but they are also susceptible to geological hazards like rockfalls. A rockfall, the dislodging of rock fragments from the tunnel's walls or ceiling, can cause catastrophic accidents, leading to loss of life and significant structural damage. Traditional safety measures often rely on manual monitoring and response, which can be slow and inefficient, especially during emergencies.
The proposed system introduces an automated solution using a PLC, a robust industrial computer, to create a reliable and rapid response system. By integrating sensors and traffic control elements, this system can instantly detect a hazard and execute a pre-programmed safety protocol, thereby safeguarding commuters and ensuring a swift, controlled response.

II. PROBLRM STATEMENT

Requirement of smart traffic diversion system avoid traffic congestion Colisions.
Tunnels are more likely to have landslides and rockfalls.
Delay in warning leads to delayed action.
Manual monitoring is slow and unsafe.

III. LITERATURE REVIEW

Tunnel safety is a critical concern in modern transportation systems, especially in hilly and mountainous regions where the risk of rockfall and landslides is high. Over the years, several researchers and engineers have proposed automation-based solutions to enhance tunnel safety and reduce accidents. This literature survey reviews existing work related to tunnel monitoring systems, rockfall detection technologies, and smart traffic diversion using Programmable Logic Controllers (PLC).

Early studies on tunnel safety mainly focused on manual monitoring systems and basic alarm mechanisms. These systems relied on human observation, which often resulted in delayed response times and increased risk to human life. With advancements in automation, researchers started integrating sensors and control systems to detect hazardous conditions in tunnels. The introduction of PLC-based systems marked a significant improvement due to their reliability, real-time processing capability, and ease of programming.

Rockfall and landslide detection has been an important research area. Various sensing technologies have been used, including vibration sensors, tilt sensors, seismic sensors, and infrared sensors. Studies suggest that vibration sensors can effectively detect ground movement caused by falling rocks, while tilt sensors help in identifying slope instability. Some researchers have also used image processing techniques and camera-based monitoring systems to detect landslides. However, these systems require high computational power and may not be suitable for real-time industrial applications compared to PLC-based systems.

In recent years, integration of IoT (Internet of Things) with tunnel safety systems has gained attention. IoT-based systems allow remote monitoring and data collection from sensors installed inside tunnels. While these systems provide better data analysis and predictive maintenance, they often depend on internet connectivity, which may not be reliable in remote areas. Therefore, PLC-based systems are still preferred for critical safety applications due to their robustness and independence from network issues.

Several studies have proposed the use of PLC for automatic tunnel control systems. PLCs can be programmed to continuously monitor sensor inputs and trigger alarms, warning signals, and traffic control mechanisms when abnormal conditions are detected. For example, when a rockfall is detected using sensors, the PLC can automatically activate warning lights, sirens, and close entry barriers to prevent vehicles from entering the tunnel. This reduces human intervention and ensures faster response.

Smart traffic diversion is another important aspect of tunnel safety. Researchers have developed systems where traffic is redirected to alternative routes using automated signboards and signal systems. PLC plays a key role in controlling these systems by processing sensor data and making decisions in real time. Some advanced systems also integrate traffic density monitoring to optimize diversion routes and reduce congestion.

In addition to detection and control, safety systems also include ventilation control, fire detection, and emergency lighting. Studies show that integrating all these systems into a single PLC-based architecture improves efficiency and coordination. For example, in case of a landslide, the system can simultaneously stop traffic, activate emergency lights, and send alerts to control rooms.

Despite these advancements, there are still challenges in implementing such systems. Environmental conditions like dust, moisture, and extreme temperatures can affect sensor performance. Maintenance and installation costs are also significant factors. However, with ongoing technological improvements, these challenges are gradually being addressed.

IV. FUTURE SCOPE

The future scope of tunnel safety automation systems using PLC (Programmable Logic Controller) is highly promising due to increasing infrastructure development, especially in hilly and mountainous regions. As transportation tunnels become more common, the need for intelligent, automated safety systems will continue to grow.

One major future advancement is the integration of IoT (Internet of Things) with PLC systems. Sensors installed in tunnels can continuously monitor parameters such as vibration, soil movement, moisture, and rock stability. This real-time data can be transmitted to cloud platforms for analysis, enabling early detection of landslides or rockfalls. This will significantly reduce accident risks and improve response time.

Another important scope is the use of AI (Artificial Intelligence) and Machine Learning. These technologies can analyze historical data and predict possible hazards before they occur. For example, AI can identify patterns in geological changes and warn authorities in advance, making the system more proactive rather than reactive.

The system can also be expanded with smart traffic management systems. In the future, integration with GPS and navigation apps can automatically divert vehicles away from unsafe tunnels. Smart signals, automated barriers, and real-time alerts can guide drivers safely, reducing congestion and preventing accidents.

Additionally, wireless communication technologies like 5G will enhance system efficiency by providing faster and more reliable data transfer. This will enable seamless communication between sensors, PLCs, control centers, and emergency services.

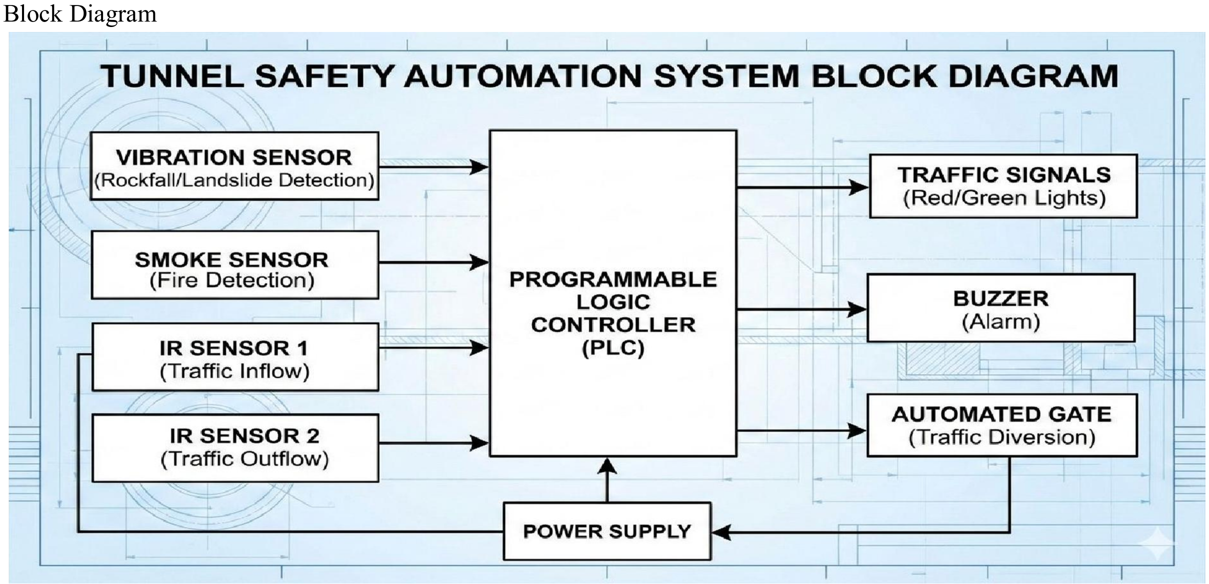
There is also scope for renewable energy integration, such as solar-powered sensors and systems, making the setup more sustainable and cost-effective, especially in remote locations.

Furthermore, the system can be implemented on a large scale in highways, rail tunnels, and mining industries, increasing its commercial and industrial applications. Governments and private sectors are likely to invest more in such safety technologies due to rising safety standards and regulations.

In conclusion, tunnel safety automation using PLC has a strong future with advancements in IoT, AI, and communication technologies. It will play a crucial role in building safer, smarter, and more efficient transportation systems.

V. ACTUAL METHODOLOGY FOLLOWED

Block Diagram



WORKING

Vehicle Monitoring using IR Sensors:

IR Sensor 1 (Entry Point): Detects and counts vehicles entering the tunnel.

IR Sensor 2 (Exit Point): Counts vehicles leaving the tunnel.

The PLC continuously compares both counts to determine how many vehicles are currently inside the tunnel.

Fire or Smoke Detection:

The **smoke sensor** continuously monitors air quality inside the tunnel.

If smoke concentration exceeds a threshold, the PLC activates:

Alarm buzzer and emergency lights to alert drivers.
Exhaust fan system to remove smoke and improve visibility.
Traffic diversion signals outside the tunnel to stop incoming vehicles.

Rockfall or Landslide Detection:

A **vibration sensor** placed at strategic points inside the tunnel detects any abnormal ground vibrations or rock movement.

When triggered, the PLC immediately:
Stops the entry of new vehicles.
Activates alarms and display boards.
Notifies the maintenance system (can be simulated with LEDs or relays).

Traffic Diversion Control:

If any emergency (fire, accident, or landslide) is detected, **traffic lights** or **barriers** outside the tunnel are controlled by PLC to divert vehicles to an alternate route.

Once the condition is resolved, normal traffic operation resumes automatically.

VI. ADVANTAGE

Real-time monitoring of vehicle movement inside the tunnel.
Early detection of fire, smoke, or rockfall to prevent accidents.
Automatic control of alarms, ventilation, and traffic diversion.
Reduces need for manual monitoring.
Enhances overall tunnel safety and traffic management.

VII. OBJECTIVES OF THE STUDY

To design and develop a PLC-based automated tunnel safety system.
To detect rockfall and landslide hazards using appropriate sensors.
To provide early warning alerts for accident prevention.
To implement smart traffic diversion during emergency situations.
To reduce human intervention and improve system reliability.
To enhance overall safety of tunnels and protect human life and property.