Volume 10, Issue 10, October – 2025 International Journal of Innovative Science and Research Technology
ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25oct945

The Role of FireFly Lighting Systems in Modern Underground Mines

Srisivanandhini M.[1]

[1]M. Tech., [1]Assistant Professor

[1]PG & Research Department of Computer Science Marudhar Kesari Jain college for Women Autonomous, Vaniyambadi-635751, India

Publication Date: 2025/10/30

Abstract: The FireFly Smart Lighting System is an advanced, Intelligent illumination solution designed specifically for the challenging environments of underground mining. Combining rugged LED hardware with programmable, multi-color lighting modes, FireFly enhances safety by providing real-time visual communication to underground personnel. The system enables dynamic demarcation of zones, emergency alerts, directional guidance during evacuations, and vehicle awareness, all centrally managed through smart control software. Its flexibility allows customization to align with site-specific safety protocols, improving operational efficiency and reducing risk. FireFly transforms traditional lighting into a proactive safety tool, supporting safer, smarter, and more connected mining operations.

Keywords: *FireFly, Smart Control Software, LED.*

How to Cite: Srisivanandhini M. (2025). The Role of FireFly Lighting Systems in Modern Underground Mines. *International Journal of Innovative Science and Research Technology*, 10(10), 1838-1843. https://doi.org/10.38124/ijisrt/25oct945

I. INTRODUCTION

In the high-risk environment of underground mining, clear communication and real-time hazard awareness are critical to ensuring worker safety. Traditional lighting systems, while functional for basic illumination, fall short in providing dynamic, situational awareness needed during emergencies such as seismic events, blasts, or sudden environmental hazards.

The FireFly Smart Lighting System represents a trans-formative approach to underground mine safety by combining rugged, high-performance LED modules with intelligent control capabilities. Beyond simply lighting the way, FireFly serves as a visual communication platform, guiding workers through complex and hazardous environments using color-coded lighting cues, alerts, and directional signals.

Through centralized control software and modular deployment, FireFly enables mine operators to rapidly respond to emergency scenarios, establish exclusion zones, and direct personnel toward safe areas in real time. Whether responding to a seismic event or assisting in post-blast inspections, FireFly enhances operational awareness and helps protect lives deep beneath the surface.

"FireFly Lighting System uses intelligent radiance to communicate the message to workers present in underground."

II. OVERVIEW OF SYSTEM CAPABILITIES

➢ *FireFly Empowers Mining Operations with a Wide Range of Safety and Operational Benefits:*

- Dynamic Zone Management: Instantly designate safe, unsafe, or seismic zones using visual lighting cues.
- Emergency Response & Evacuation Guidance: Visually direct workers during fires, seismic events, or other emergencies.
- Real-Time Alerts: Respond immediately to changing underground conditions with automated lighting triggers.
- Traffic & Personnel Awareness: Improve visibility of vehicles and personnel movement in confined spaces.
- Data Integration: Backhaul data from environmental and geotechnical sensors, enhancing situational awareness.
- Post-Event Inspections: Provide enhanced illumination for safer and more effective inspections following seismic or blast events.

Each FireFly unit is enclosed in a compact, industrial-grade housing, engineered to withstand harsh underground conditions. The system allows control at multiple levels — individual lights, defined zones, or entire sites — making it a flexible solution for diverse underground operations.

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25oct945

III. MODULE FOR LED LIGHTING

The purpose-built FireFly Module enhances underground safety by supporting clearer visibility during evacuations and emergency responses. Designed for intuitive use, the system improves workflow and most importantly ensures greater safety for workers.

Operating on +48VDC, the multi-coloured, addressable LED modules deliver reliable emergency and evacuation lighting levels in underground environments. Proudly designed and manufactured in Australia, FireFly offers a safe and dependable lighting solution.

- The Rugged design is used to built for underground mining areas
- FireFly UPS Control Panel is used for Powered and control
- Operates beyond a wide ELV voltage range of 6-60VDC
- 802.11g/n Wi-Fi and BLE 5.0 wireless technologies are used to provide a redundant communication path in case of cable failure.
- Each FireFly module is capable of tracking and positioning Wi-Fi/Bluetooth tags with an accuracy of 10 to 20 meters.
- Wireless connectivity also serves as a data backhaul for additional environmental sensors.

- *Supports Dynamic Lighting Configurations with A Broad Range of Color Selections.*

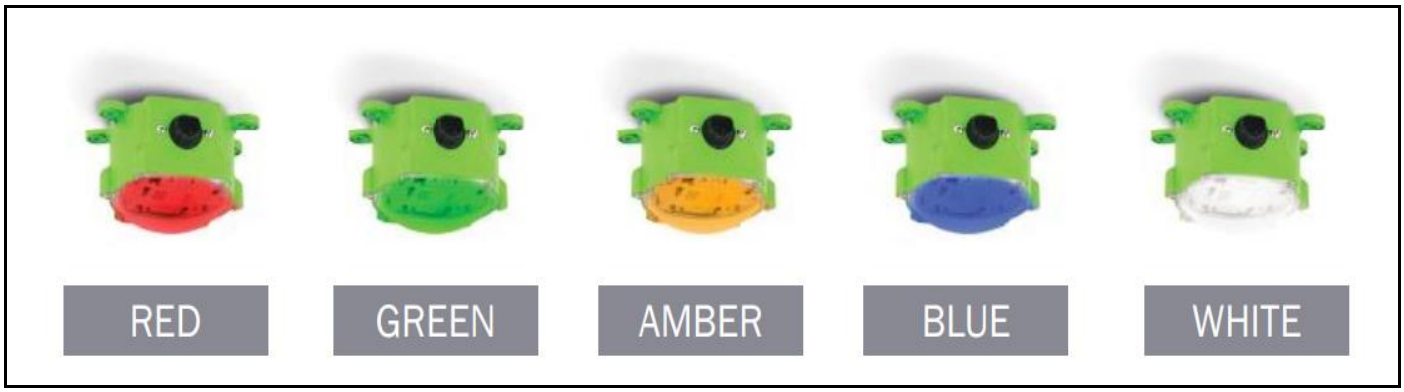

Fig 1 Multiple Modes and Colours of LED Light

Table 1 Supports Dynamic Lighting Configurations with A Broad Range of Color Selections

MULTIPLE OPERATION
ON
FLASHING
FORWARD TRAILING
BACKWARD TRAILING
INSPECTION

It supports a broad range of select-able colors—including red, green, amber, blue, and white—enabling clear, color-coded signaling across the site. It offers multiple operating modes such as steady illumination, flashing alerts, and directional trailing sequences for enhanced guidance during emergency situations.

Lighting behavior is fully customization to align with site-specific safety protocols and operational requirements. Both standard lighting functions and emergency alert configurations—including color selection and response modes—can be tailored to integrate seamlessly with existing safety management systems and procedures.

IV. MINE DEMARCATION

- *Demarcation and Zoning*

FireFly Smart Lighting provides an effective solution for the daily demarcation and zoning of underground mine sites. By leveraging programmable lighting modules—each capable of displaying multiple colors and operating modes—the system enables clear, visual communication of area-specific conditions and access permissions.

- *The Flexible Design Supports a Wide Range of use Cases.*

- ✓ Amber flashing lights can designate dedicated travel ways.
- ✓ Red static lighting may indicate an active Seismic Level 1 event.
- ✓ Site-wide red flashing can serve as an immediate visual alert for high-priority emergency evacuations.

This intelligent zoning capability allows operators to adapt demarcation strategies in real time, aligning with dynamic operational needs and established safety protocols.

- *Vehicle Awareness*

FireFly Smart Lighting improves underground traffic management by delivering real-time visual indicators of vehicle movement. Strategically placed lights automatically activate in front of and behind heavy vehicles to signal their

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25oct945

approach, increasing visibility and situational awareness for both operators and surrounding personnel.This intelligent lighting system actively reduces the risk of collisions, alleviates traffic congestion, and promotes safer interactions between vehicles and personnel—particularly in the confined and challenging conditions of underground environments.

V. INTELLIGENT EVACUATION SYSTEM

Guidance is provided by FireFly Smart Lights based on lighting as to the shortest route to were a 'green' is safe zone or mine exit.

FireFly Smart Lighting provides a visible cue reflecting the current safety level in designated mine areas.

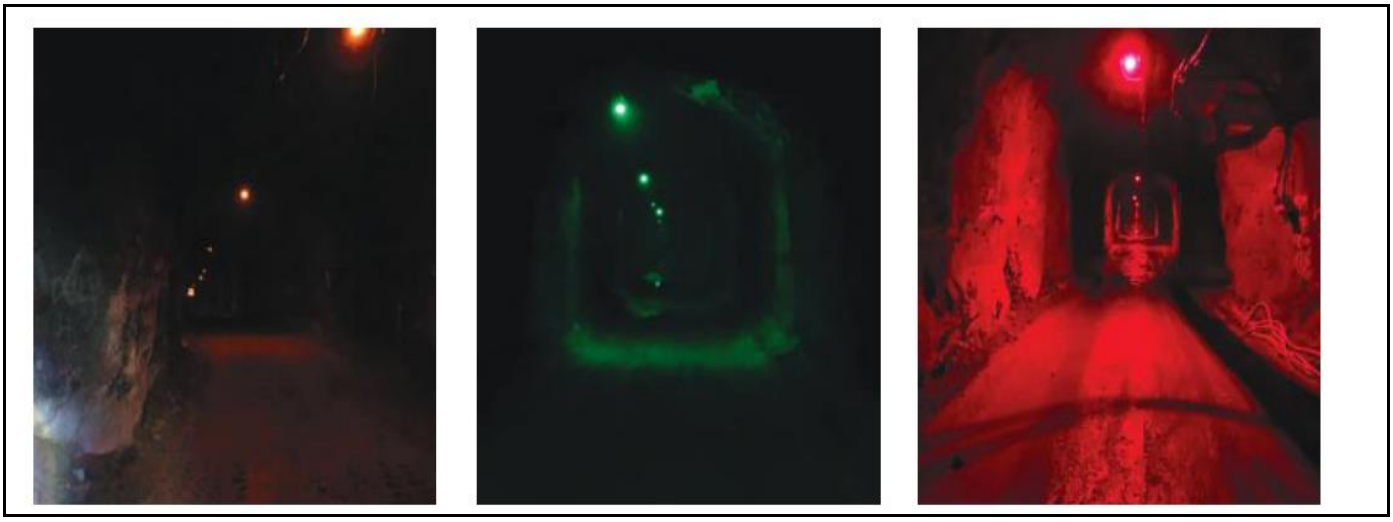

Fig 2 Intelligent Evacuation System

In the event of a seismic event, FireFly delivers real-time visual alerts and evacuation guidance to affected areas.

➢ *FireFly UPS Control Panel*

Intelligent Power and Control for Underground Lighting the FireFly UPS Control Panel is a smart, decentralized power management solution purpose-built for controlling underground LED lighting circuits. Offered in a wall-mounted configuration, it delivers a +48VDC power supply and supports up to four independent lighting strings, each accommodating up to 30 FireFly LED Lighting Modules.Engineered for both resilience and scalability, the system provides battery-backed power and integrated communication to connected modules.The system supports both autonomous operation as a standalone lighting controller and networked deployment with a centralized server for seamless integration into broader site-wide smart lighting infrastructure.

➢ *Features*

- *Multi-Mode Lighting Control*
  Supports four distinct operating modes and five select-able LED colors for customization signaling.

- *High-Output Audible/Visual Alert*
  Equipped with an externally mounted IP65-rated 105dB siren and LED beacon for high-visibility alerts.

- *External Alert Integration*
  Includes external connection ports to support additional sirens or strobe lights in underground drifts.

- *Flexible Network Interfaces*
  Offers both copper and fiber optic external connection ports for versatile networking options.

- *Multiple Connectivity Protocols*
  Compatible with Wi-Fi, Ethernet, RS485, Modbus/TCP, and CAN Bus for seamless integration into existing systems.

- *Third-Party LED Compatibility*
  Capable of driving both addressable and non-addressable LED strip lighting from other manufacturers.

- *High-Capacity Power Supply*
  48VDC, 20A total output (5A per output string), suitable for demanding industrial lighting applications.

- *Integrated 7.5" LCD Display*
  Onboard color LCD screen for intuitive programming, status monitoring, and local management.

- *Auto-Discovery of LED Devices*
  Simplifies installation and setup with automatic detection and configuration of connected LED devices.

- *Centralized Monitoring*
  Enables site-wide management via a local web-based application for real-time control and diagnostics.

- *Intelligent Battery Management*
  Includes battery protection, conditioning, and monitoring to ensure reliable operation under all conditions.

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25oct945

- *Internal Temperature Monitoring*
  Continuously monitors internal temperature to protect system components and ensure optimal performance.

- *Wall-Mountable Design*
  Easy-to-install form factor suitable for surface mounting in a variety of environments.

- *External Protective Roll Cage*
  Provides mechanical protection against impact in rugged or high-traffic areas.

- *IP65 Ingress Protection*
  Dust-tight and water-resistant enclosure suitable for harsh industrial or mining environments.

- *Durable Construction*
  Built with powder-coated stainless steel for long-term corrosion resistance and durability.

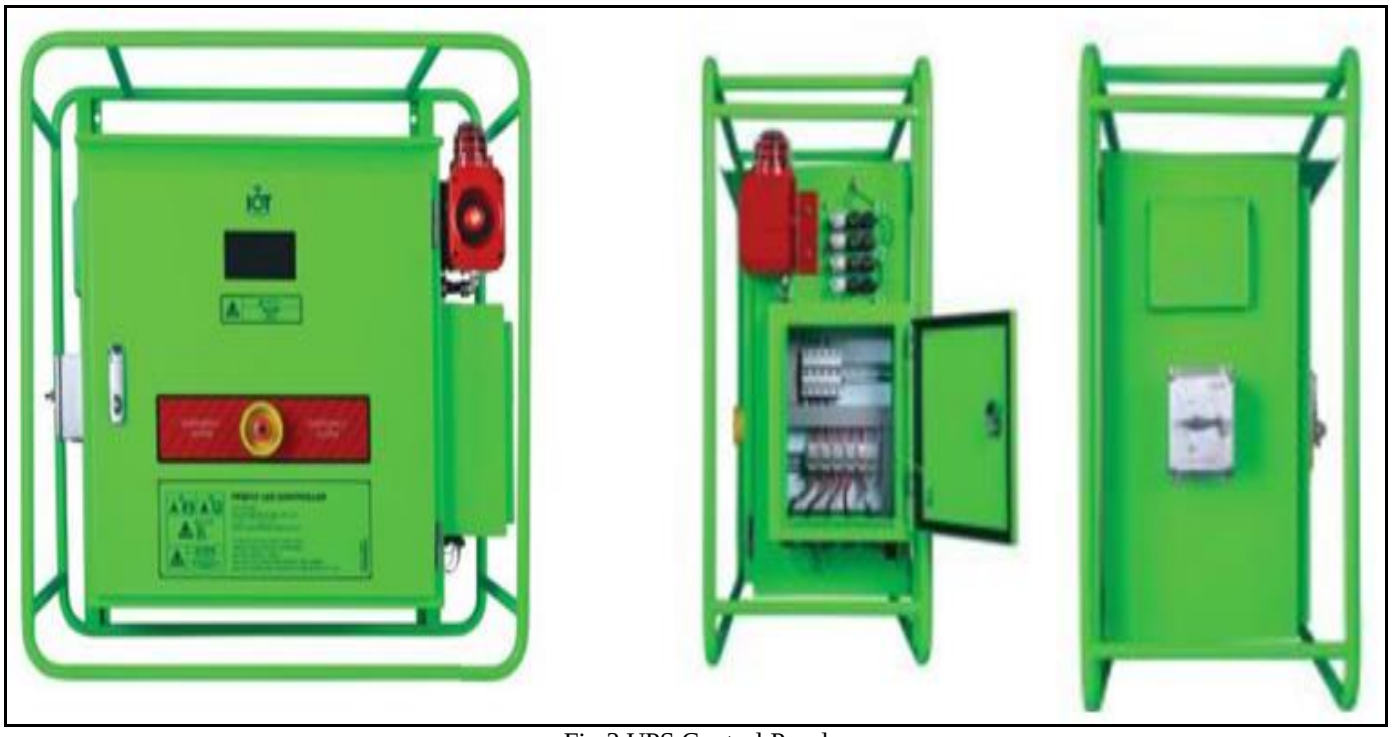

Fig 3 UPS Control Panel

VI. LIGHTING CONTROL SOFTWARE

The underground FireFly Smart Lighting System is centrally managed by the FireFly Smart Lighting Control Server, which coordinates multiple FireFly UPS Control Panels installed throughout the mine. These UPS Control Panels supply battery-backed power and maintain communication with the FireFly LED Lighting Modules, ensuring continuous operation even in the event of a power disruption.

Each FireFly UPS Control Panel can function independently as a standalone lighting cell or be connected to the central server, enabling integration into a site-wide smart lighting network. This modular architecture allows for scalable deployment based on site requirements.

The FireFly Smart Lighting Control Server can be deployed on-site as either a physical server or a virtual machine. It hosts all necessary software components required for centralized lighting control, system diagnostics, and real-time monitoring.

➢ *Server Software Components:*

- Linux Debian Server – Stable and secure operating system platform
- Web Application – Intuitive browser-based interface for configuration and monitoring
- NGINX Web Server – High-performance web server for efficient content delivery
- MQTT Broker – Lightweight messaging protocol for reliable communication between devices
- SQL Database – Centralized storage for system data, logs, and configurations
- System Monitoring – Real-time performance and health tracking of connected devices

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25oct945

➢ *Smart Lighting Software Control System*

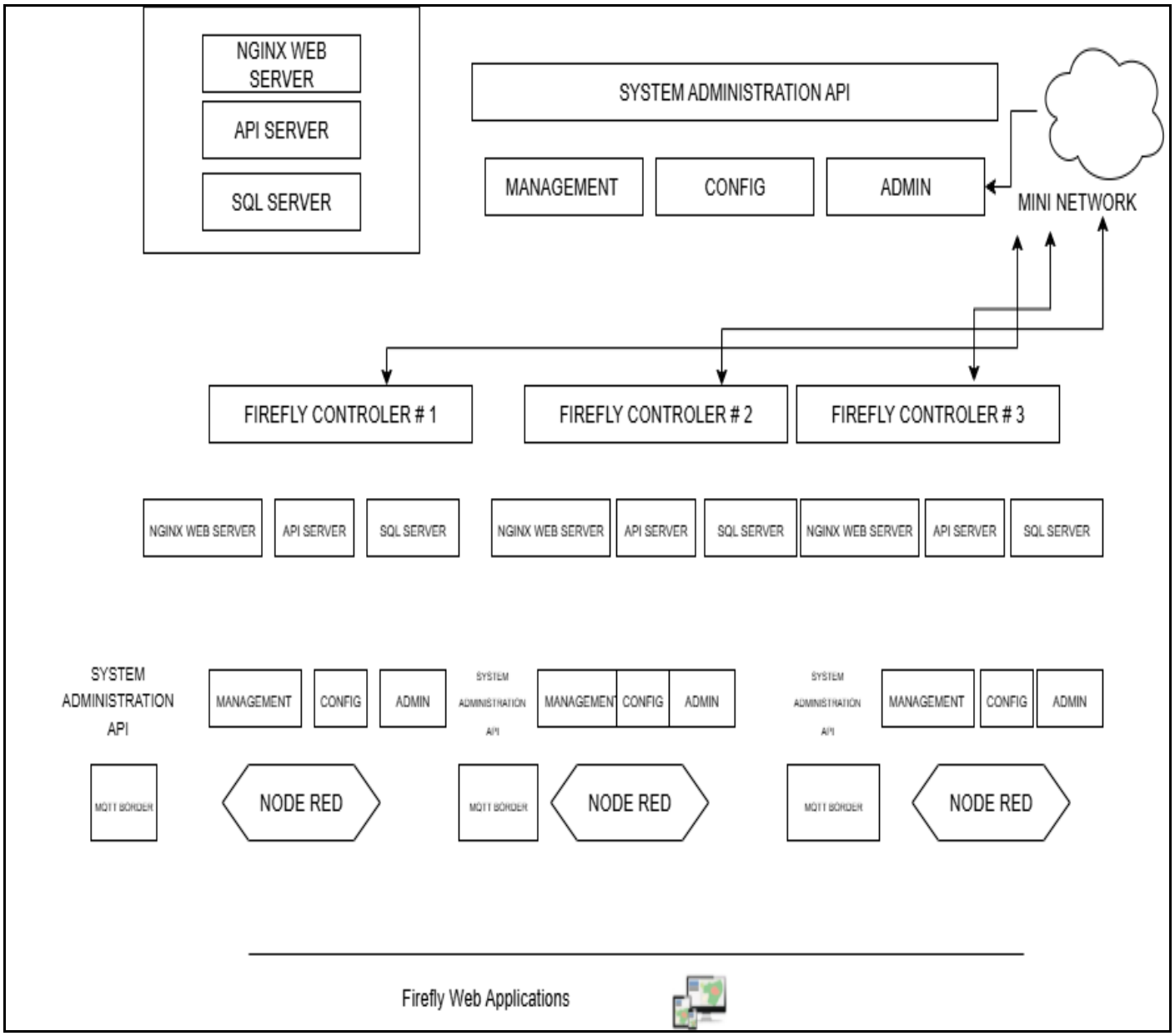

Fig 4 Smart Lighting Control Software System

VII. APPLICATIONS

The FireFly Smart Lighting System introduces an advanced layer of safety and operational efficiency for underground mining environments. By combining intelligent illumination with user-friendly control software, FireFly delivers a robust and reliable solution for visual navigation, situational awareness, and real-time alerting. This smart lighting platform enhances visibility, streamlines communication, and supports proactive safety management in challenging underground conditions.

➢ *FireFly Smart Lighting is Used for:*

- Underground personnel
- Electrical managers
- Production managers
- Geoscience managers

VIII. CONCLUSION

The FireFly Smart Lighting System revolutionizes underground mine safety by combining illumination with intelligent communication. Its multi-color, multi-mode capability allows for clear demarcation of zones, real-time emergency alerts, and vehicle movement indication. This enhances situational awareness and supports faster, safer decision-making in high-risk environments. Built for durability, FireFly performs reliably in harsh underground conditions. Overall, it serves as a critical safety infrastructure that supports both daily operations and emergency response.

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25oct945

REFERENCE

[1]. Anitha Vijayalakshmi & M. Nesa Sudha," Illumination and Communication Using LED as Light Source in Underground Mines"
[2]. Pratap Singh Yadav, Nitai Pal, Dheeraj Kumar, S. Vamsi Krishna," LEDs Lighting Arrangements for Underground Mines"
[3]. M. Petrov," Operation of lighting systems in underground mines"
[4]. H. Van Graan, J. S. Greyson, J. H. Viljoen & N. B. Strydom," Underground Lighting in the Gold Mining Industry"
[5]. Pratap Singh Yadav "LEDs Lighting Arrangements for Underground Mines" July 2015