

QuarryMaster: A Web-Based System for GSMB Regulatory Compliance, Explosive Inventory Management, and Blast Monitoring in A-Grade Quarry Sites

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2025



QuarryMaster: A Web-Based System for GSMB Regulatory Compliance, Explosive Inventory Management, and Blast Monitoring in A-Grade Quarry Sites

**A thesis submitted for the Degree of Master of
Information Technology**

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2025



Declaration

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Abstract

The quarry operations in Sri Lanka, particularly those under A-grade licenses, are governed by strict regulations enforced by the Geological Survey and Mines Bureau (GSMB), requiring comprehensive management of explosive permits, inventory tracking, and blast monitoring. Currently, these critical processes rely on manual, paper-based systems, leading to significant inefficiencies, delayed reporting, and potential safety risks. QuarryMaster addresses these challenges by implementing a comprehensive web-based system that digitalizes and streamlines the entire workflow from permit application to blast monitoring.

The system implements a hierarchical user structure incorporating four key stakeholder groups: GSMB officers (administrators), site engineers, explosive controllers, and explosive dealers. Using modern web technologies - Angular for the frontend, Node.js with Express.js for the backend, and MySQL for database management - QuarryMaster provides a secure, role-based platform for managing quarry operations. The system features a complete workflow for explosive management, including permit applications, quota requests, purchase management, and operational tracking, enhanced by Leaflet map integration for spatial visualization of quarry sites.

A significant feature of QuarryMaster is its district-based access control system, ensuring that explosive controllers and dealers can only operate within their designated jurisdictions. The system implements strict validation workflows where site engineers can only request explosive quotas with approved permits, and purchases can only be made within approved quota limits. Real-time tracking of all transactions, automated status updates, and comprehensive audit trails ensure regulatory compliance and enhance operational safety.

The implementation demonstrates significant improvements over the manual system, including streamlined permit processing, enhanced inventory tracking, and improved stakeholder communication. The system's modular architecture allows for scalability and future enhancements while maintaining secure and efficient operations. By digitalizing these critical processes, QuarryMaster not only improves operational efficiency but also enhances safety compliance in Sri Lanka's quarry industry.

Acknowledgements

First and foremost, I express my special appreciation and thanks to my supervisor, Dr. (Mr.) K A K T Karunanayaka, who encouraged me from all corners. Also, I thank UCSC staff members, lecture panel, and special thanks to Dr. (Ms.) H N D Thilini for guidance and coordination.

And my deepest gratitude and appreciation goes to my dearest parents and the rest of my family who were beside me, always offering their help and guidance. I thank them for the inspiration given to open my mind to achieve this goal. This would have been an unachievable target without them.

Finally, I express my deepest appreciation to all those who made it possible for me to complete this project schedule.

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List of Abbreviation

DBMS	Database Management System
ER	Entity Relationship
GB	Gigabyte
SQL	Structured Query Language
SDLC	Software Development Lifecycle
GSMB	Geological Survey and Mines Bureau
UI	User Interface
UML	Unified Modeling Language
ANFO	Ammonium Nitrate Fuel Oil

Chapter 1 - Introduction

This chapter provides an overview of the project, including its background and motivation, objectives, scope, and a brief description of the rest of the report.

1.1 Project Overview

QuarryMaster is a comprehensive web-based management system designed to digitalize and streamline the regulatory compliance, explosive inventory management, and blast monitoring processes for A-grade quarry operations in Sri Lanka. A-grade quarries, characterized by multi-bore hole blasting using high explosives with more than five electric detonators and operations exceeding 2,000 cubic meters per month (GSMB, 2022), are subject to strict regulatory oversight by the Geological Survey and Mines Bureau (GSMB).

The current management of these quarry operations relies heavily on manual, paper-based systems that create significant inefficiencies in tracking explosive permits, monitoring inventory, and ensuring regulatory compliance. According to the GSMB annual report 2022, 105 Industrial Mining License A permits were issued during that year alone (GSMB, 2022), highlighting the substantial volume of regulatory activities requiring management.

QuarryMaster addresses these challenges by implementing a digital solution that serves four key stakeholder groups: GSMB officers (administrators), site engineers, explosive controllers, and explosive dealers. The system has been developed using modern web technologies, including Angular framework for the frontend, Node.js with Express.js for backend services, and MySQL for database management. The integration of Leaflet maps provides spatial context for mining operations, enabling precise location tracking and site management.

Need for a Web-Based System

The transformation from manual to digital processes is necessitated by several critical factors:

1. Safety and Security Concerns

The handling of explosives in quarrying operations poses inherent risks that require strict monitoring and control. As mandated by the Explosives Act (Sri Lanka, 1956) and regulated by the Ministry of Defence (Ministry of Defence, 2023), explosive materials must be tracked

throughout their lifecycle. The current paper-based system creates potential vulnerabilities in the verification process, which could lead to unauthorized access or misuse of explosives.

2. Regulatory Compliance Challenges

The GSMB, operating under the Mines and Minerals Act No. 33 of 1992, enforces strict regulations on A-grade quarry operations. Site engineers must obtain permits, request quotas for explosives, and document blasting operations, while explosive controllers need to verify and approve these requests. The manual processing of these regulatory requirements often leads to delays and inconsistencies in enforcement.

3. Operational Inefficiencies

Manual processes create significant administrative burdens, including:

- Extended processing times for permit applications and quota approvals
- Delays in explosive procurement, affecting quarry operations
- Resource-intensive manual record keeping and verification
- Limited visibility into the status of applications and approvals

4. Data Management and Reporting Limitations

Paper-based systems present challenges in:

- Maintaining comprehensive audit trails for regulatory compliance
- Generating timely and accurate reports for decision-making
- Ensuring data consistency across multiple sites and stakeholders
- Providing real-time insights into explosive usage and inventory

System Implementation

QuarryMaster addresses these challenges through a comprehensive digital solution with the following key components:

1. **Administrative Control** (GSMB Officers)

- Digital registration and management of mining sites with license details
- User account creation and role assignment
- Oversight of site-related activities and compliance monitoring

2. Site Engineer Operations

- Digital explosive permit applications linked to mining licenses
- Electronic quota requests based on approved permits
- Explosive purchase management through digital workflows
- Daily drilling and blasting operation planning with digital documentation
- Real-time activity tracking using Leaflet maps

3. Explosive Controller Functions

- Digital review and approval of permit applications
- Electronic validation of quota requests
- District-level explosive usage monitoring through dashboards

4. Explosive Dealer Management

- Digital processing of purchase requests
- Electronic sales management and transaction records
- Cost tracking and inventory management

The implemented system features robust role-based access control, ensuring that users can only access functionalities relevant to their roles and assigned locations. The integration of Leaflet maps enhances spatial awareness for mining operations, enabling better planning and oversight.

This digital transformation addresses the critical challenges in current manual systems by streamlining the explosive permit and quota approval process, enhancing tracking of explosive inventory and usage, improving coordination between stakeholders, providing real-time visibility into quarry operations, and ensuring regulatory compliance through systematic workflows.

The modular architecture of QuarryMaster allows for scalability and future enhancements while maintaining secure and efficient operations for current functionalities. This implementation marks a significant advancement from paper-based processes to a comprehensive digital solution for A-grade quarry management in Sri Lanka.

1.2 Motivation

The development of QuarryMaster is driven by several critical challenges in the current manual management of A-grade quarry operations in Sri Lanka. These challenges particularly affect the four main stakeholder groups - GSMB officers, site engineers, explosive controllers, and explosive dealers - each facing unique operational difficulties that impact the safety and efficiency of quarry operations.

1.2.1 Challenges in Current Manual System

1. GSMB Officer Challenges

- Difficulty in tracking and verifying multiple mining licenses and their current status
- Inefficient processing of explosive permit applications due to paper-based documentation
- Limited visibility into site operations and compliance status
- Time-consuming manual verification of explosive quotas and usage reports
- Risk of data inconsistencies in maintaining records across multiple sites

2. Site Engineer Challenges

- Complex paper-based process for explosive permit and quota applications
- Delays in receiving approval notifications for permits and quotas
- Difficulty in maintaining accurate records of daily drilling and blasting operations
- Limited ability to track explosive purchases and inventory
- Risk of miscommunication with explosive controllers and dealers

3. Explosive Controller Challenges

- Manual verification of multiple permit applications across different districts
- Difficulty in tracking approved explosive quotas and actual usage
- Limited oversight of explosive movement within their jurisdiction
- Time-consuming process of reviewing and approving quota requests
- Risk of oversight in monitoring compliance with approved quantities

4. Explosive Dealer Challenges

- Manual verification of purchase requests against approved quotas
- Difficulty in maintaining accurate sales records
- Risk of selling explosives without valid permits or exceeded quotas
- Limited ability to track transaction history and payment status
- Inefficient communication with site engineers and controllers

1.2.2 Impact of Manual Processes

These challenges lead to several critical issues:

1. Safety and Security Risks

- Potential oversights in explosive quantity tracking
- Delays in identifying and responding to compliance issues
- Risk of unauthorized explosive purchases due to manual verification

2. Operational Inefficiencies

- Extended processing times for permits and quotas
- Delays in explosive procurement affecting quarry operations
- Resource-intensive manual record keeping and verification

3. Compliance Management

- Difficulty in ensuring adherence to regulatory requirements
- Challenges in maintaining audit trails
- Risk of non-compliance due to documentation errors

1.2.3 Need for Digital Solution

The implementation of QuarryMaster addresses these challenges through:

1. Automated Workflows

- Streamlined permit and quota application processes
- Digital approval workflows reducing processing time
- Automated notifications for status updates

2. Real-time Tracking

- Immediate visibility of permit and quota status
- Live tracking of explosive purchases and usage
- Digital mapping of quarry operations using Leaflet

3. Enhanced Security

- Role-based access control ensuring appropriate permissions
- Digital verification of permits and quotas
- Secure transaction records and audit trails

4. Improved Communication

- Direct communication channels between stakeholders
- Instant status updates and notifications
- Centralized access to relevant documentation

The motivation for developing QuarryMaster stems from the urgent need to transform these manual processes into an efficient, secure, and transparent digital system. The implemented solution not only addresses current operational challenges but also provides a foundation for improved regulatory compliance and safety in A-grade quarry operations.

1.3 Objectives

The primary goal of QuarryMaster is to digitalize and streamline the regulatory compliance and explosive management processes for A-grade quarry operations in Sri Lanka. The following objectives outline both implemented core functionality and planned enhancements:

1.3.1 Core System Objectives

1. User Management and Access Control

- Implement secure role-based authentication system
- Enable GSMB officers to create and manage user accounts for different roles
- Ensure district-level access restrictions for explosive controllers and dealers
- Maintain secure user sessions and access logs

2. Mining Site Management

- Enable GSMB officers to register new mining sites with license details
- Implement site assignment system for site engineers
- Integrate Leaflet maps for site location visualization
- Track site status and license validity

3. Explosive Permit Management

- Implement permit application workflow for site engineers
- Enable permit review and approval process for explosive controllers
- Track permit status and validity periods
- Maintain digital records of approved permits

4. Explosive Quota System

- Enable quota request submission based on approved permits
- Implement quota approval workflow for explosive controllers
- Track quota utilization and remaining balances
- Generate quota-related notifications and alerts

5. Explosive Purchase Management

- Enable purchase requests based on approved quotas
- Implement dealer acceptance and cost tracking
- Maintain transaction records
- Track explosive movement from dealer to site

1.3.2 Operational Objectives

1. Regulatory Compliance

- Ensure all explosive-related transactions follow proper approval workflows
- Maintain comprehensive audit trails of all system activities
- Prevent unauthorized explosive purchases through systematic validation
- Track compliance with approved quantities and usage limits

2. Process Efficiency

- Reduce permit and quota processing times through digital workflows
- Minimize manual verification steps in explosive purchases
- Enable real-time status tracking and notifications
- Streamline communication between stakeholders

3. Data Management

- Maintain centralized records of all quarry-related activities
- Ensure data consistency across all transactions
- Enable secure access to historical records
- Support data-driven decision making

1.3.3 Ongoing Development Objectives

1. Enhanced Monitoring

- Implement comprehensive dashboard for GSMB officers
- Develop detailed reporting system for all stakeholders
- Enable real-time tracking of explosive usage
- Implement automated compliance monitoring

2. Advanced Mapping Features

- Enhance Leaflet map integration for blast planning
- Enable geo-fencing for quarry boundaries
- Implement location-based activity tracking
- Support spatial analysis of quarry operations

3. Communication System

- Implement automated email notifications
- Develop in-system messaging capabilities
- Enable document sharing and storage
- Implement status update notifications

These objectives reflect a systematic approach to transforming manual quarry management processes into an efficient digital system. The implemented core functionality provides a solid foundation for achieving the complete set of objectives, ensuring sustainable improvement in regulatory compliance and operational efficiency.

1.4 Background of the study

In Sri Lanka, the mining and quarrying industry operates under the regulatory oversight of the Geological Survey and Mines Bureau (GSMB), established under the Mines and Minerals Act No. 33 of 1992. The GSMB classifies Industrial Mining Licenses (IML) into four categories - A, B, C, and D - with A-grade licenses representing the highest level of operational complexity and regulatory requirements (GSMB 2024).

A-grade quarry operations are distinguished by specific technical criteria including:

- Multi-bore hole blasting using high explosives with more than five electric detonators
- Bore holes deeper than or equal three meters
- Production volumes exceeding 2,000 cubes per month
- Mining areas larger than ten hectares
- Mine depths exceeding twenty-five meters
- Bore hole diameters greater than forty-two millimeters (GSMB 2024)

The management of A-grade quarries involves a complex workflow of regulatory processes and multiple stakeholders, as illustrated in Figure 1. Each stakeholder plays a crucial role in ensuring safe and compliant quarry operations:

1. GSMB Officers (Administrators): These officials oversee the entire regulatory process, including:
 - Processing of Industrial Mining License applications
 - Evaluation of Initial Environmental Examination Reports (IEER)
 - Monitoring of operational compliance
 - Collection and verification of quarterly royalty payments based on explosive usage (GSMB 2024)
2. Site Engineers: Professional engineers responsible for:
 - Preparing and submitting IML applications with required documentation

- Managing explosive permit applications
- Planning and executing drilling and blasting operations
- Maintaining explosion usage records and blast reports The role requires adherence to strict safety protocols and regulatory guidelines, particularly in managing high explosives and electric detonators.

3. Explosive Controllers: District-level authorities managing:

- Review and approval of explosive permits
- Validation of quota requests
- Monitoring of explosive usage
- Enforcement of safety regulations Their oversight is crucial for maintaining security in explosive handling and usage.

4. Explosive Dealers: Licensed vendors handling:

- Verification of purchase orders against approved permits
- Processing of explosive sales
- Implementation of secure transportation protocols
- Maintenance of detailed transaction records

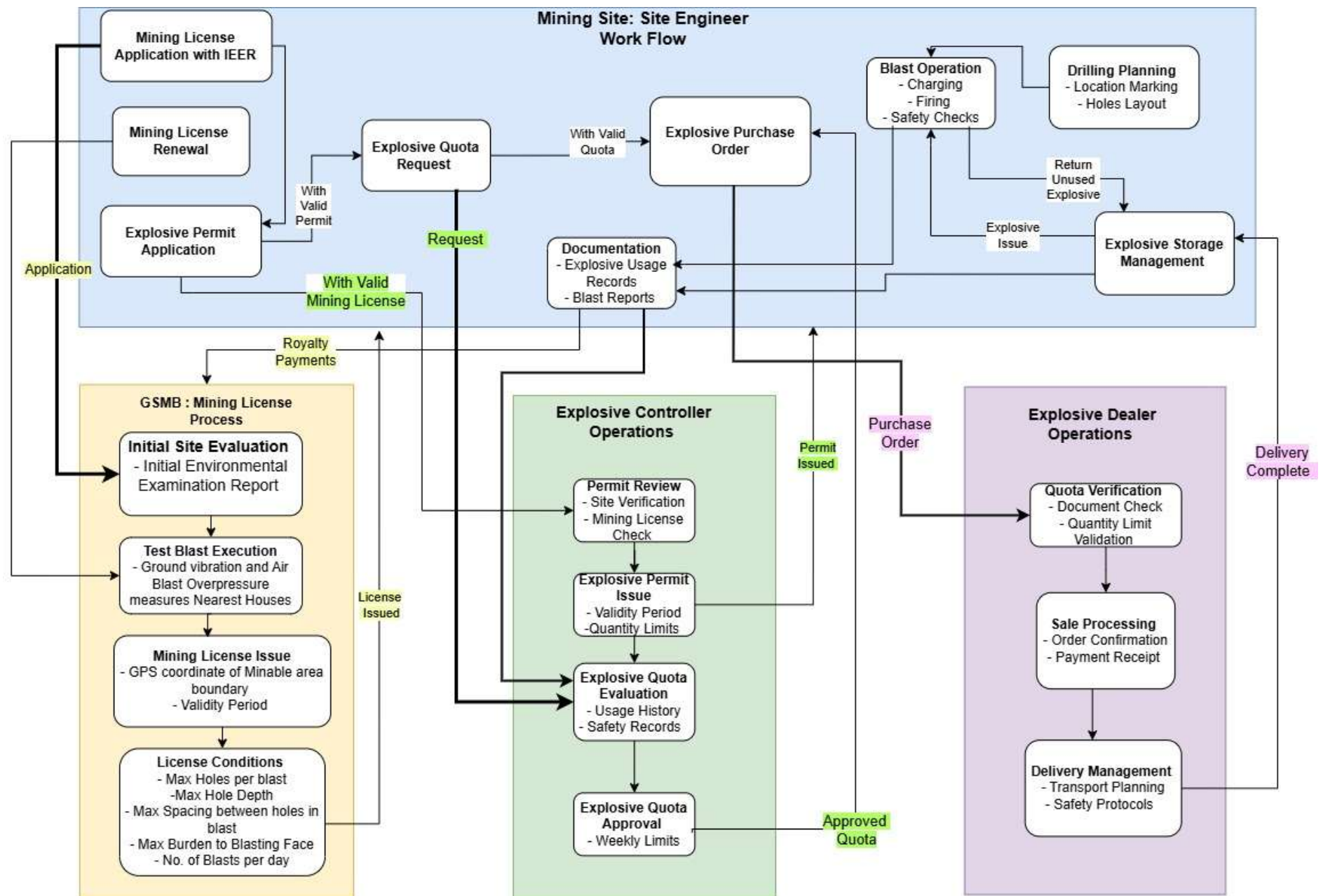


Figure 1- Traditional Workflow of A-Grade Quarry Mining Activities in Sri Lanka



Figure 2- Explosive permit and Quota Seals

The current paper-based management system presents several critical challenges:

Regulatory Compliance:

- Complex documentation requirements for license applications including survey plans, deeds, and economic viability reports
- Manual tracking of multiple licensing conditions
- Difficulty in monitoring compliance with production volume limits (GSMB 2024)

Safety Management:

- Manual verification of explosive permits and quotas
- Paper-based tracking of explosive usage and returns
- Limited real-time oversight of blasting operations
- Challenges in coordinating safety protocols across multiple sites

Administrative Efficiency:

- Time-consuming manual processing of applications
- Physical document storage and retrieval issues
- Delayed communication between stakeholders
- Limited visibility of application status

Quota and Inventory Control:

- Manual calculation of explosive quotas
- Paper-based tracking of usage against permits
- Inefficient verification of purchase orders
- Delayed reporting of usage and returns

The complexity of these processes is further increased by strict regulatory requirements:

- Mandatory submission of detailed documentation
- Regular renewal of permits and licenses
- Quarterly reporting of explosive usage for royalty calculations
- Maintenance of comprehensive operational records (GSMB 2024)

These challenges highlight the critical need for a digital transformation in A-grade quarry management. The development of QuarryMaster aims to address these issues through a comprehensive web-based solution that digitizes the entire workflow, from license application to explosive usage tracking, while ensuring compliance with all GSMB regulations and safety requirements.

1.5 Scope of the Study

The scope of this study encompasses the development and implementation of QuarryMaster, a web-based system designed to digitalize A-grade quarry operations management in Sri Lanka. The system's boundaries are clearly defined to ensure focused development and effective implementation.

1.5.1 In scope

1. User Management and Authentication
 - Role-based user creation and management by GSMB administrators
 - Four distinct user roles: GSMB officers (admin), site engineers, explosive controllers, and explosive dealers
 - Secure email-based user registration with temporary password generation
 - Mandatory password change at first login
 - Role-specific access control and permissions
2. Mining Site Management
 - Digital registration of approved mining sites with valid licenses
 - Coordinate system management:
 - Support for Kandawala coordinate system input
 - Automatic conversion between Kandawala and WGS84 coordinates
 - Interactive map visualization using Leaflet:
 - Site locations display
 - Movable boundary visualization
 - Drilling location marking and tracking

Feature	GSMB Admin	Site Engineer	Explosive Controller	Explosive Dealer
User Management	✓	✗	✗	✗
Site Registration	✓	✗	✗	✗
Permit Management	✓	✓	✓	✗
Quota Management	✓	✓	✓	✗
Purchase Management	✗	✓	✗	✓
Inventory Control	✗	✓	✗	✗
Report Generation	✓	✓	✓	✓

Table 1- System Role Permissions Matrix

3. Explosive Management Workflow

- Permit Application Process:
 - Digital permit requests by site engineers
 - District-based routing to explosive controllers
 - Approval/rejection workflow management
- Quota Management:
 - Digital quota requests against approved permits
 - Quota approval workflow
 - Usage tracking and monitoring
- Purchase Processing:
 - District-based purchase order creation
 - Order status management (confirmed, paid, delivered)
 - Inventory updates upon delivery

4. Operational Activities Management

- Drilling Operations:
 - Location marking and layout planning
 - Coordinate recording and mapping
 - Drilling progress tracking
- Blasting Operations:
 - Explosive allocation from inventory
 - Per-hole usage recording
 - Post-blast documentation
 - Unused explosive return management

5. Reporting and Documentation

- Role-specific report generation:
 - Explosive usage reports

- Drilling and blasting reports
- Purchase and delivery reports
- Inventory status reports
- District-based activity monitoring
- Digital documentation management

1.5.2 Out of Scope

1. License Application Processing

- New mining license application submission
- Initial Environmental Examination Report (IEER) processing
- License renewal applications
- License fee payments

2. Financial Management

- Royalty payment calculations
- Payment processing and tracking
- Invoice generation
- Financial reporting

3. Equipment Management

- Drilling equipment tracking
- Machinery maintenance records
- Equipment performance monitoring
- Asset management

4. Environmental Monitoring

- Environmental impact assessment
- Noise and vibration monitoring
- Dust level tracking
- Water quality management

5. Human Resource Management

- Employee records management
- Attendance tracking
- Shift scheduling
- Training records

6. Additional Features

- Mobile application development
- Offline operation capability
- Real-time chat functionality
- Document digitization of existing records

This scope definition ensures clear boundaries for the system implementation while maintaining focus on the core functionality of explosive management and operational tracking in A-grade quarry operations.

1.6 Structure of the Dissertation

This thesis includes six main chapters and each chapter has discussed the flow of development of the system. structure of the thesis is as follows.

Chapter 02 – Background

This chapter has discussed the requirement analysis of the system including functional and non-functional requirements and related technologies of the system. And also, a review of similar systems has been discussed.

Chapter 03 – Design

This chapter has discussed the architectural design and the detailed design enhanced with UML model diagrams. And also, user interface design has been discussed.

Chapter 04 – Implementation

This chapter has discussed the implementation of the system including development tools and development environment etc.

Chapter 05 – Testing and Evaluation

This chapter has discussed the evaluation of the system including manual and automation testing, and usability evaluation.

Chapter 06 – Conclusion

This chapter has discussed the overall success of the project including achieving project objectives. And also, future enhancement of the system has been discussed.

Chapter 2 – Background

2.1 Introduction

This chapter discusses the comprehensive analysis and background research conducted for developing the QuarryMaster system, a web-based solution for digitalizing A-grade quarry operations in Sri Lanka. The chapter covers requirement analysis, review of similar systems, and the technological framework selected for implementation.

2.2 Requirement Analysis

The analysis phase focused on understanding the complex workflow of A-grade quarry operations, particularly the management of explosives and regulatory compliance requirements. The requirements were gathered through:

- Analysis of existing GSMB documentation and procedures
- Observation of current quarry operation workflows
- Consultation with stakeholders including GSMB officers, site engineers, and explosive controllers
- Review of regulatory requirements and safety protocols

2.2.1 User Groups and user characteristics

The system serves four distinct user groups, each with specific roles and responsibilities:

1. GSMB Officers (Administrators):
 - Act as system administrators
 - Manage user accounts and site registrations
 - Monitor regulatory compliance
 - Generate oversight reports
 - Track explosive permits and quotas
 - Required Skills: Computer literacy, regulatory knowledge

2. Site Engineers:

- Manage specific quarry sites
- Submit explosive permit applications
- Request explosive quotas
- Plan and document drilling activities
- Manage blasting operations
- Record explosive usage
- Required Skills: Technical expertise, computer literacy, safety protocol knowledge

3. Explosive Controllers:

- Review and approve explosive permits
- Evaluate quota requests
- Monitor district-level explosive usage
- Ensure regulatory compliance
- Required Skills: Regulatory knowledge, computer literacy, safety assessment capabilities

4. Explosive Dealers:

- Process purchase orders
- Manage explosive sales
- Handle delivery documentation
- Maintain transaction records
- Required Skills: Computer literacy, inventory management knowledge

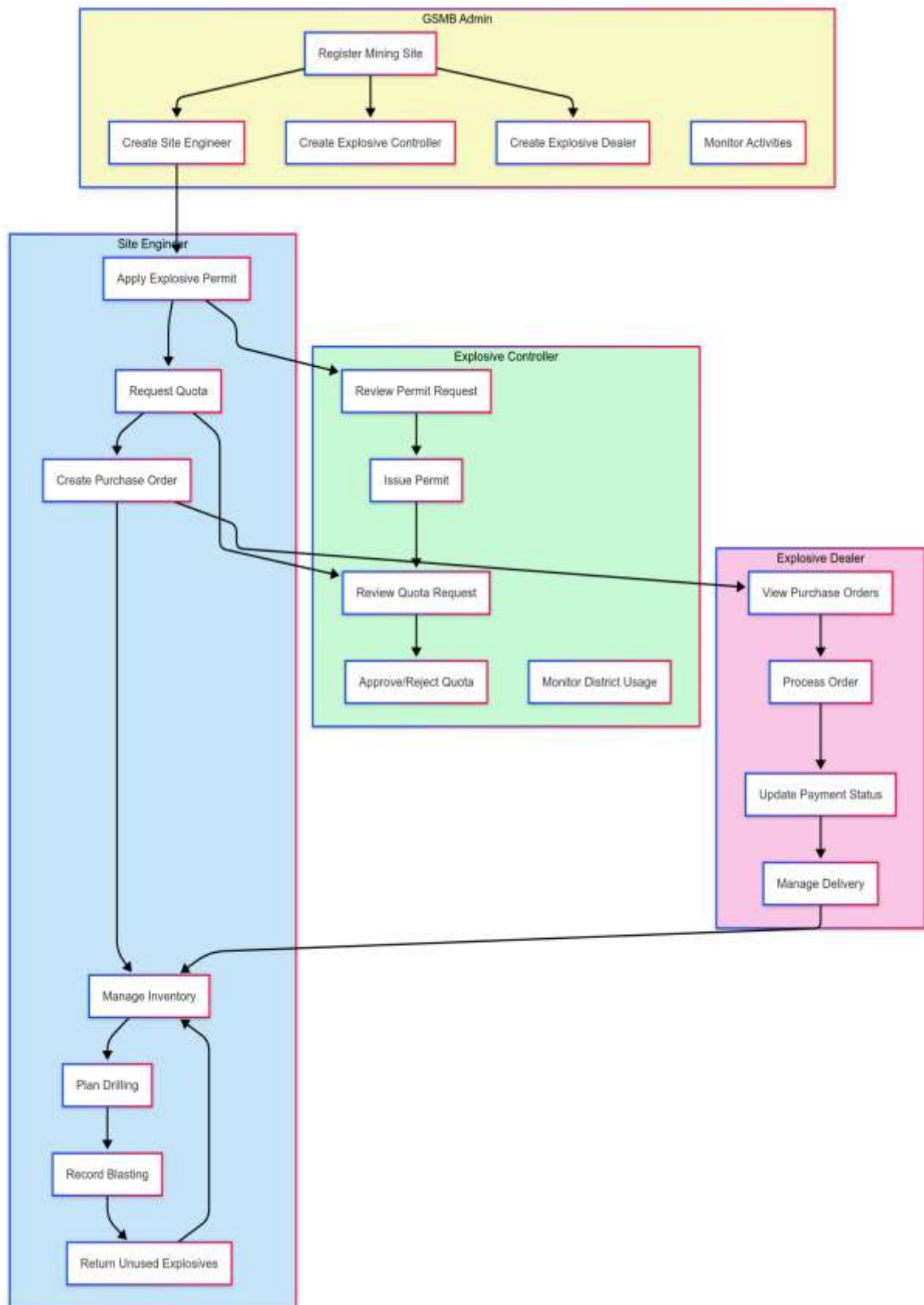


Figure 3- QuarryMaster System High-Level Flow

2.2.2 Functional Requirement

The system's functional requirements are organized into core modules:

- **User Management Module**

Function	GSMB Admin	Site Engineer	Explosive Controller	Explosive Dealer
User Creation	✓	✗	✗	✗
Password Management	✓	✓	✓	✓
Profile Updates	✓	✓	✓	✓
Role Assignment	✓	✗	✗	✗

Table 2- User Management Module

- **Site Management Module**

Function	GSMB Admin	Site Engineer	Explosive Controller	Explosive Dealer
Site Registration	✓	✗	✗	✗
Boundary Mapping	✓	✓	✓	✗
Location Tracking	✓	✓	✓	✗
Status Updates	✓	✓	✗	✗

Table 3- Site Management Module

- **Explosive Permit Management Module**

Function	GSMB Admin	Site Engineer	Explosive Controller	Explosive Dealer
Permit Application	X	✓	X	X
Application Review	✓	X	✓	X
Permit Approval	X	X	✓	X
Status Tracking	✓	✓	✓	X
Document Storage	✓	✓	✓	X

Table 4- Explosive Permit Management Module

- **Explosive Quota and Inventory Management**

Function	GSMB Admin	Site Engineer	Explosive Controller	Explosive Dealer
Quota Request	X	✓	X	X
Quota Approval	X	X	✓	X
Purchase Orders	X	✓	X	✓
Inventory Updates	X	✓	X	✓
Usage Tracking	✓	✓	✓	✓

Table 5- Explosive Quota and Inventory Management

- **Operations Management Module**

Function	GSMB Admin	Site Engineer	Explosive Controller	Explosive Dealer
Drilling Planning	X	✓	X	X
Location Marking	X	✓	X	X
Blast Recording	✓	✓	✓	X
Return Management	X	✓	✓	✓

Table 6- Operations Management Module

2.2.3 Non-functional requirements

- **Usability**

User groups contain different types of people; therefore, system consist user-friendly, simple user interface to give a better user experience.

- **Availability**

Users can access this web-based system any time, any place with any browser.

- **Performance**

Users can use this system concurrently. system operates without unnecessary delays and less response time (Nechvolod, 2022).

- **Security**

Using user id and password security for user login. Password encryption mechanism has been used. Maintain user level for accessing data. Creating a backup plan and backup copies stored in a different medium in different locations (“Software Quality Attributes | Top 9 Software Quality Attributes,” 2021).

2.2.4 Technical Requirements

Frontend Development:

- Angular framework for responsive UI
- Leaflet for interactive mapping
- Bootstrap for consistent styling
- TypeScript for type safety
- Progressive Web App capabilities

Backend Development:

- Node.js runtime environment
- Express.js for RESTful APIs
- JWT for authentication
- Socket.IO for real-time updates
- API documentation

Database Requirements:

- MySQL for structured data
- Data normalization
- Referential integrity
- Transaction management
- Performance optimization

Integration Requirements:

- Coordinate system conversion (Kandawala to WGS84)
- Email notification system
- Report generation
- Data export capabilities
- API interfaces

2.2 Review of Similar Systems

The mining and quarrying industry globally has adopted various digital solutions for operational management and regulatory compliance. This section analyzes existing systems and their relevance to Sri Lanka's A-grade quarry management requirements.

- **Micromine**

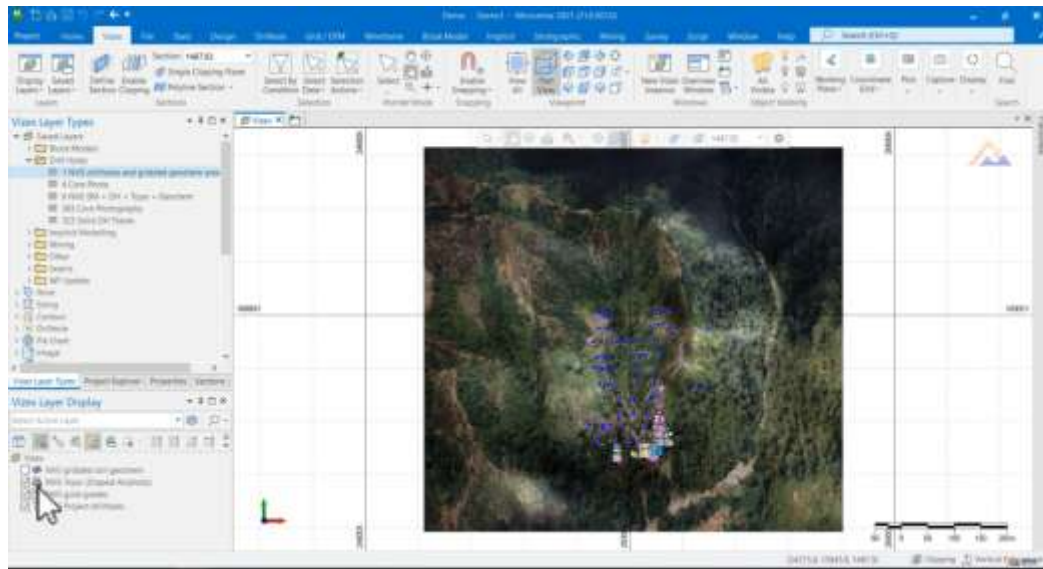


Figure 4- Micromine Interface Screenshot

Micromine offers comprehensive mining process management capabilities (Micromine Ltd 2023):

- Geological data management
- Mine planning and design
- Production tracking
- GIS-based mapping

Relevance to QuarryMaster:

- Provides similar GIS-based spatial planning
- Lacks specific explosive management features
- Limited regulatory compliance for Sri Lankan context

- **Datamine**

Datamine focuses on resource management and operational planning (Datamine Software 2023):

- Geological modeling
- Inventory management
- Compliance tracking
- Spatial planning

Relevance to QuarryMaster:

- Supports inventory tracking
- Offers customizable reporting
- Missing explosive permit monitoring
- No incident reporting functionality

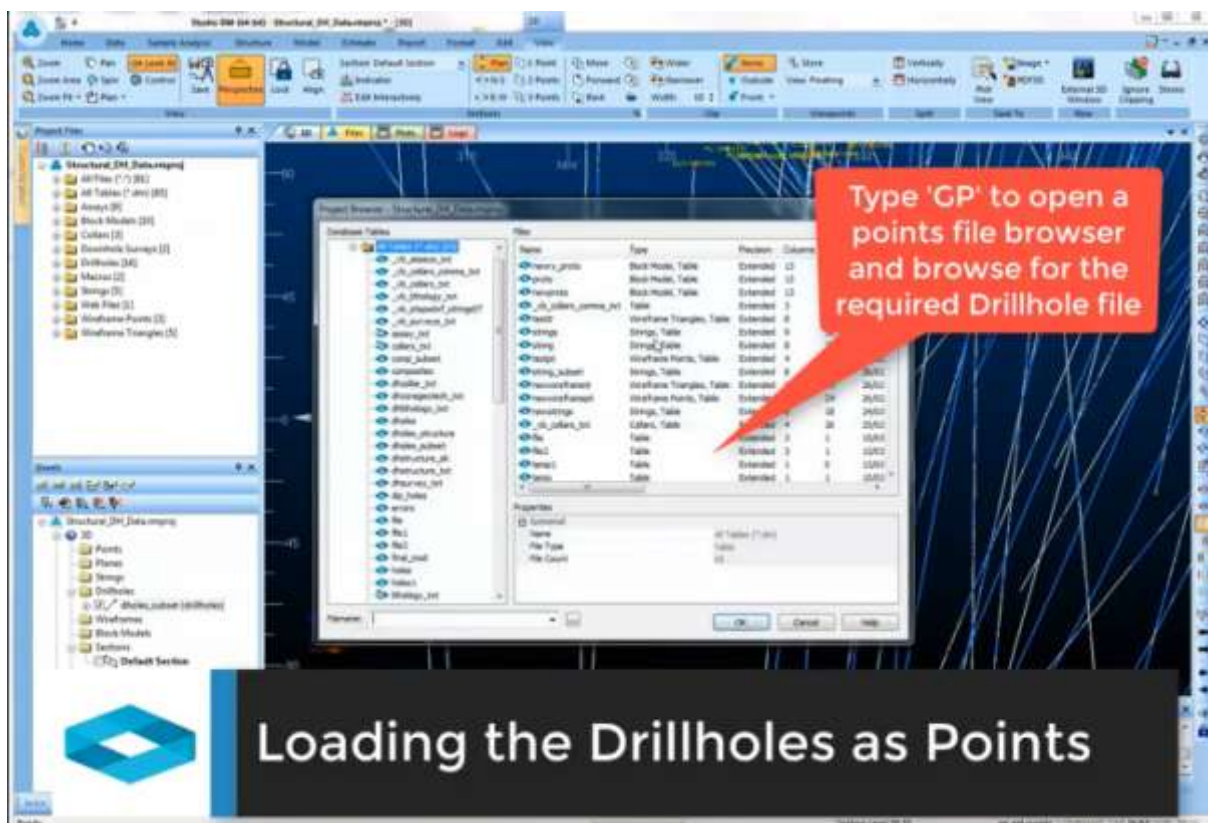


Figure 5- Datamine System Interface

- **MineSight by Hexagon**

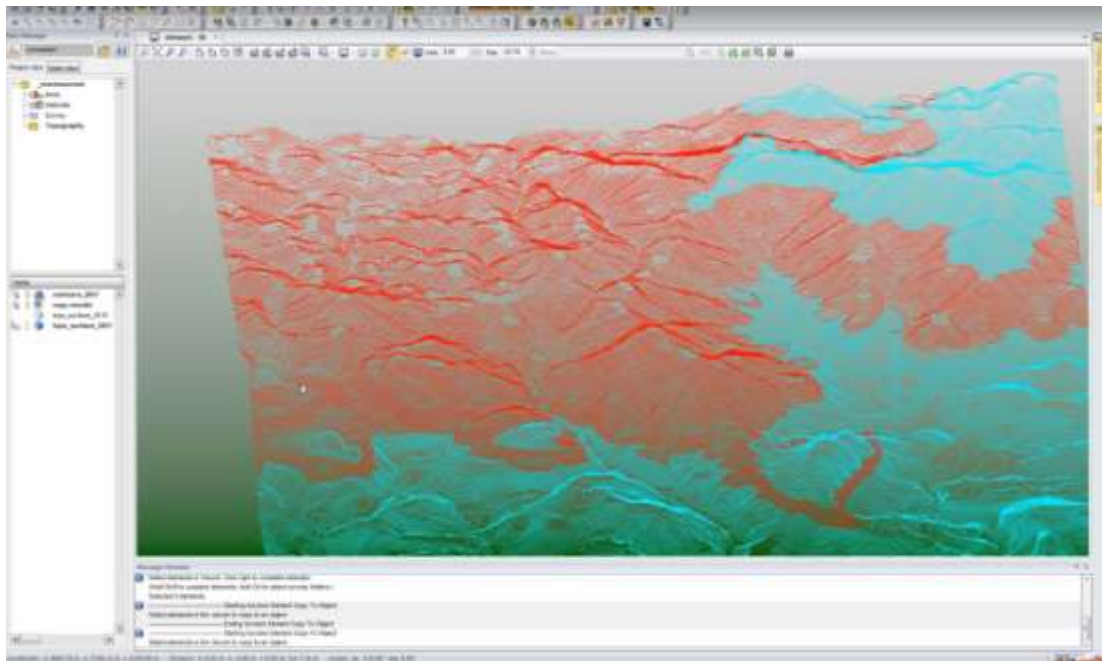


Figure 6- MineSight System Dashboard

MineSight specializes in mine planning and blast design (Hexagon Mining 2023):

- Open-pit planning
- Underground mining support
- GIS integration
- Resource planning

Relevance to QuarryMaster:

- Advanced GIS capabilities
- Blast site mapping
- Lacks real-time explosive tracking
- No automated notifications

- **QuarryX**

QuarryX focuses specifically on quarry operations (QuarryX Systems 2023):

- Resource inventory tracking
- Operational planning
- Compliance reporting
- Centralized management

Relevance to QuarryMaster:

- Similar inventory management
- Basic compliance tracking
- No GPS-based mapping
- Limited blast tracking capabilities

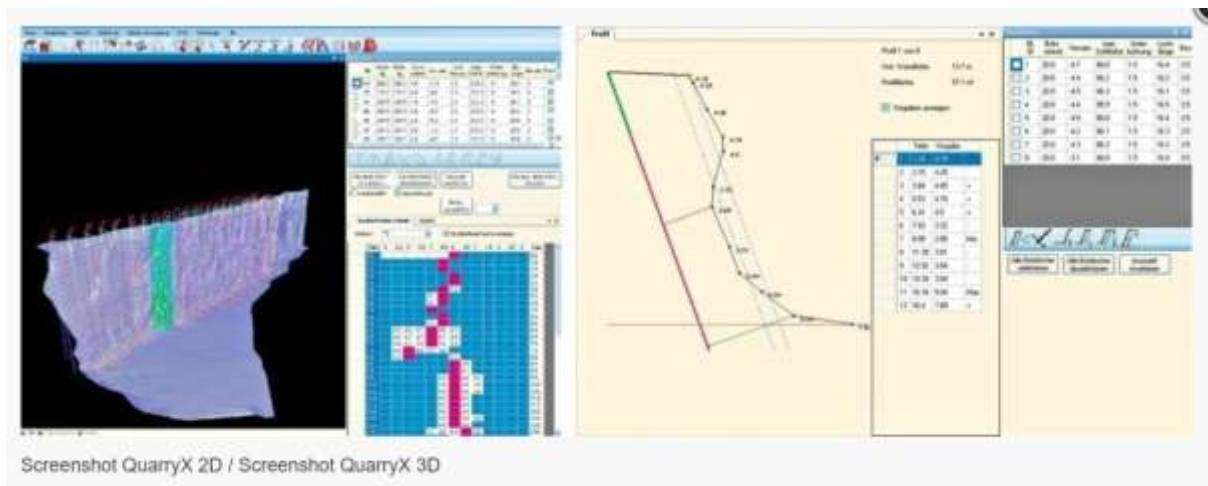


Figure 7- QuarryX Management Interface

- **Trimble Insight**

Offers real-time monitoring solutions (Trimble Inc. 2023):

- Data management
- Real-time tracking
- Incident monitoring
- GPS integration

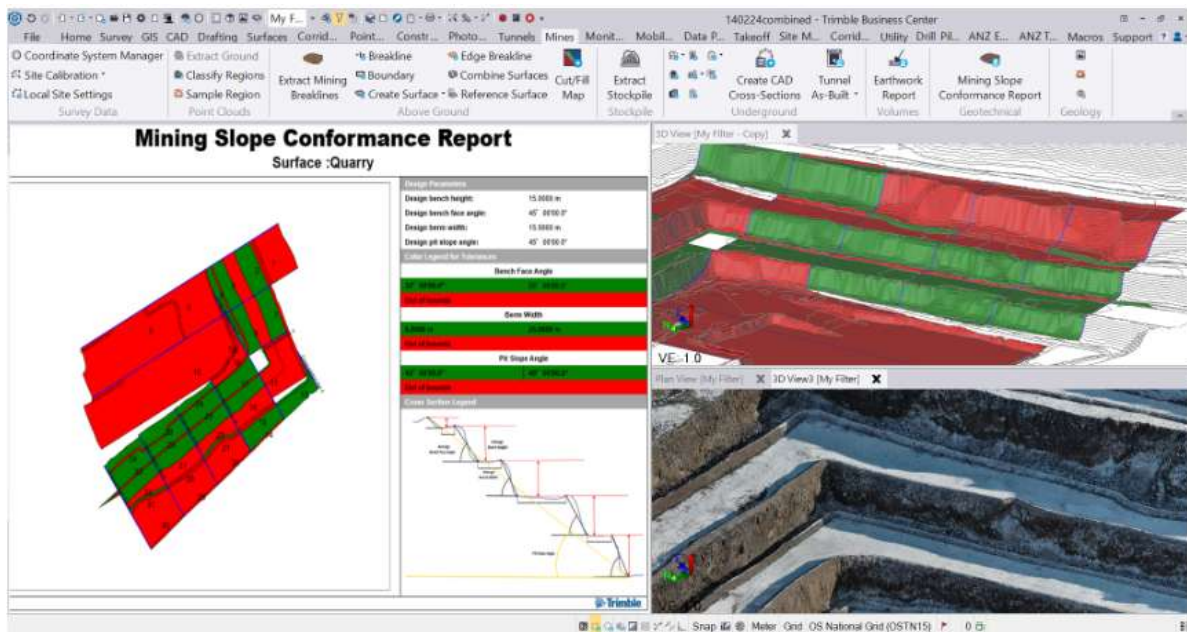


Figure 8- Trimble Insight Interface

2.2.1 Comparison between similar products

Features	Micromine	Datamine	MineSight	QuarryX	Trimble Insight	QuarryMaster
Mining License Management	Limited	Limited	Limited	No	No	Yes
Explosive Permit Management	No	No	No	No	No	Yes
Explosive Quota Management	Limited	Limited	No	Yes	Limited	Yes
User Role Management	Yes	Yes	Yes	Yes	Yes	Yes
Coordinate System Support (Kandawala)	No	No	No	No	No	Yes
Real-time Explosive Inventory	Limited	Limited	No	Yes	Yes	Yes
Drilling Activity Planning	Yes	Yes	Yes	Limited	Limited	Yes
Blast Operation Recording	Limited	Limited	Yes	Yes	Yes	Yes
District-based Access Control	No	No	No	No	Limited	Yes
Multi-stakeholder Communication	Limited	Limited	Limited	No	Yes	Yes
Automated Email Notifications	No	Limited	No	Yes	Yes	Yes

Table 7- Comparison between similar products

2.3 Related Technologies

This section discusses the technical framework and tools utilized in developing the QuarryMaster system, focusing on creating a robust, secure, and scalable solution for A-grade quarry management.

2.3.1 Front End Development

1. Angular Framework: The system's frontend is built using Angular, a powerful TypeScript-based framework (Angular 2023):

- Component-based architecture for modular development
- Strong typing through TypeScript for enhanced code reliability
- Reactive forms for complex form validations
- Dependency injection for better code organization
- Built-in routing for seamless navigation

2. Angular Material: The UI components are implemented using Angular Material (Angular Material 2023):

- Pre-built UI components maintaining Material Design specifications
- Responsive layout system
- Accessible components following WCAG guidelines
- Integrated theming system
- Built-in animations and transitions

4. Leaflet Integration: For spatial data visualization and mapping (Leaflet 2023):

- Interactive mapping capabilities
- Support for multiple coordinate systems
- Custom marker and polygon support
- Real-time location tracking
- Efficient handling of geographical data

2.3.2 Back End Development

1. Node.js with Express.js: The backend is built on Node.js with Express.js framework (Node.js 2023):
 - Asynchronous event-driven architecture
 - RESTful API implementation
 - Middleware support for request processing
 - Route handling and HTTP request management
 - Efficient data streaming capabilities
2. Authentication and Security: Robust security implementation including:
 - JWT (JSON Web Tokens) for secure authentication
 - Role-based access control (RBAC)
 - Password encryption using bcrypt
 - Request validation middleware
 - CORS protection
3. WebSocket Integration: Real-time communication implemented using Socket.IO:
 - Bi-directional communication
 - Real-time notifications
 - Live updates for inventory changes
 - Connection state management
 - Event-based communication

2.3.3 Database Management

1. MySQL Database: Relational database management using MySQL (MySQL 2023):
 - Structured data storage
 - Complex relationship management
 - Transaction support
 - Data integrity enforcement
 - Efficient querying capabilities

2. Sequelize ORM: Object-Relational Mapping using Sequelize:

- Model definition and management
- Database migration support
- Query building and execution
- Relationship mapping
- Transaction management

2.3.4 Development Tools and Utilities

1. Version Control:

- Git for source code management
- Feature branch workflow
- Code review process
- Version tagging
- Deployment management

2. Development Environment:

- Visual Studio Code as primary IDE
- Node Package Manager (npm)
- Angular CLI for project management
- ESLint for code quality
- TypeScript compiler

2.3.5 Integration Technologies

1. Email Service Integration:

- Nodemailer for email notifications
- Email template management
- Queue system for bulk emails
- Delivery status tracking
- HTML email support

2. File Handling:

- Multer for file uploads
- File type validation
- Storage management
- Image processing
- Document handling

2.3.6 Development and Hosting Environment

1. Local Development Setup:

- Backend Server:
 - Node.js local server configuration
 - Express.js running on localhost:8080
 - Environment variable management using dotenv
 - Local SSL certificate support for HTTPS testing
 - Hot reload using nodemon
- Frontend Development Server:
 - Angular development server (ng serve)
 - Running on localhost:4200
 - Live reload capability
 - Source map support for debugging
 - Proxy configuration for API requests

2. Database Environment:

- Local MySQL server
- MySQL Workbench for database management
- Local environment configuration
- Development database setup
- Data backup and restore capabilities

3. Testing Environment:

- Local unit testing setup
- Integration testing configuration
- End-to-end testing environment

- Test database configuration
- Browser testing tools

4. Monitoring and Logging:

- Console logging for development
- Error tracking in development environment
- API testing using Postman
- Browser DevTools for frontend debugging
- Network request monitoring

This local development environment provides a robust setup for developing and testing the QuarryMaster system while maintaining the security and functionality requirements of A-grade quarry management.

2.4 Development Process Model

The QuarryMaster system was developed using a Component-Based Iterative Development approach, where each major functionality was developed and integrated incrementally, starting with core user management features and progressively adding more complex functionalities.

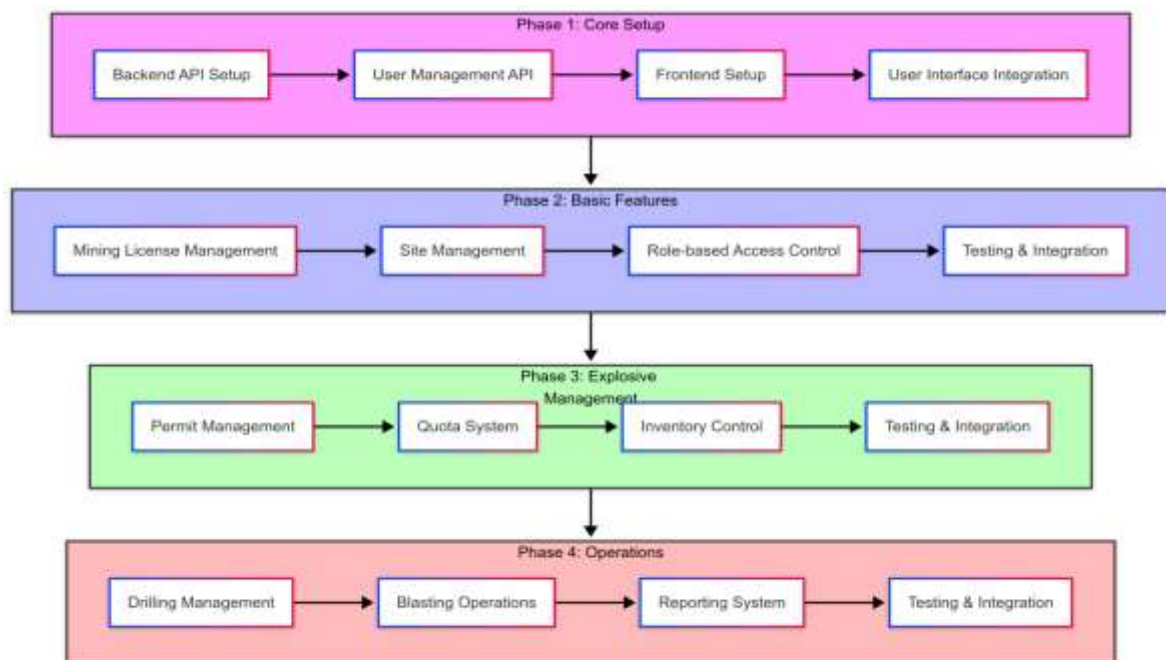


Figure 9- Component-Based Iterative Development Process

1. Phase 1: Core Setup

- Backend API development for basic functionality

- User management API implementation
 - Frontend framework setup with Angular
 - Integration of user management features
 - Basic authentication and authorization
2. Phase 2: Basic Features
- Mining license management system
 - Site management implementation
 - Role-based access control
 - Integration testing of basic features
 - User feedback and adjustments
3. Phase 3: Explosive Management
- Permit application system
 - Quota management implementation
 - Inventory control system
 - Integration of explosive management features
 - Security testing and validation
4. Phase 4: Operations Management
- Drilling management system
 - Blasting operation tracking
 - Reporting system implementation
 - Final integration and testing
 - System optimization

2.4.1 Development Approach

For each component, the development followed a consistent pattern:

1. API Development:
 - Requirements analysis
 - API endpoint design
 - Implementation and testing
 - Documentation
 - Security implementation
2. Frontend Development:
 - Component design
 - UI implementation

- Service integration
- User testing
- Refinement

3. Integration:

- Component integration
- End-to-end testing
- Performance optimization
- Bug fixing
- User acceptance testing

2.4.2 Benefits of the Approach

This development model provided several advantages:

1. Incremental Progress:

- Clear development milestones
- Early detection of issues
- Regular feedback incorporation
- Manageable development chunks

2. Component Independence:

- Modular development
- Easy maintenance
- Reusable components
- Simplified testing

3. Risk Management:

- Early problem identification
- Controlled feature rollout
- Manageable complexity
- Regular validation

2.4.3 Quality Assurance

Throughout the development process, quality was ensured through:

1. Code Quality:

- TypeScript type checking
- ESLint code analysis

- Regular code reviews
- Consistent coding standards

2. Testing:

- Unit testing of components
- Integration testing of features
- End-to-end testing of workflows
- Security testing

Chapter 3 – Design

3.1 Introduction

This chapter presents the detailed design architecture and implementation approach for the QuarryMaster system. The design encompasses the system's architectural framework, component interactions, database structure, and user interface considerations. Through various UML diagrams and architectural models, this chapter illustrates how the system's components work together to provide a comprehensive solution for A-grade quarry management in Sri Lanka.

3.2 Related design strategies

3.2.1 Web based approach

The QuarryMaster system employs a web-based architecture to facilitate seamless interaction between multiple stakeholders involved in quarry operations. This approach was chosen for several compelling reasons. The web-based architecture enables centralized management of explosive permits and quotas while allowing distributed access for site engineers, explosive controllers, and dealers across different districts. The system's ability to provide real-time updates and notifications is crucial for maintaining safety and regulatory compliance in explosive handling.

The web-based implementation offers significant advantages for quarry management:

- Centralized data management ensuring consistency across all operations
- Real-time access to critical information for all stakeholders
- Platform independence enabling access from various devices
- Simplified deployment and maintenance
- Enhanced security through centralized control
- Seamless integration of mapping services for site monitoring

3.2.2 Component-Based Development Model

QuarryMaster adopts a component-based development model, focusing on creating independent, reusable components that can be integrated to form the complete system. This approach was selected because:

- It allows parallel development of different system modules
- Facilitates easier testing and maintenance
- Enables incremental deployment of features
- Supports future scalability and modifications
- Promotes code reusability and maintainability

3.3 System Architecture

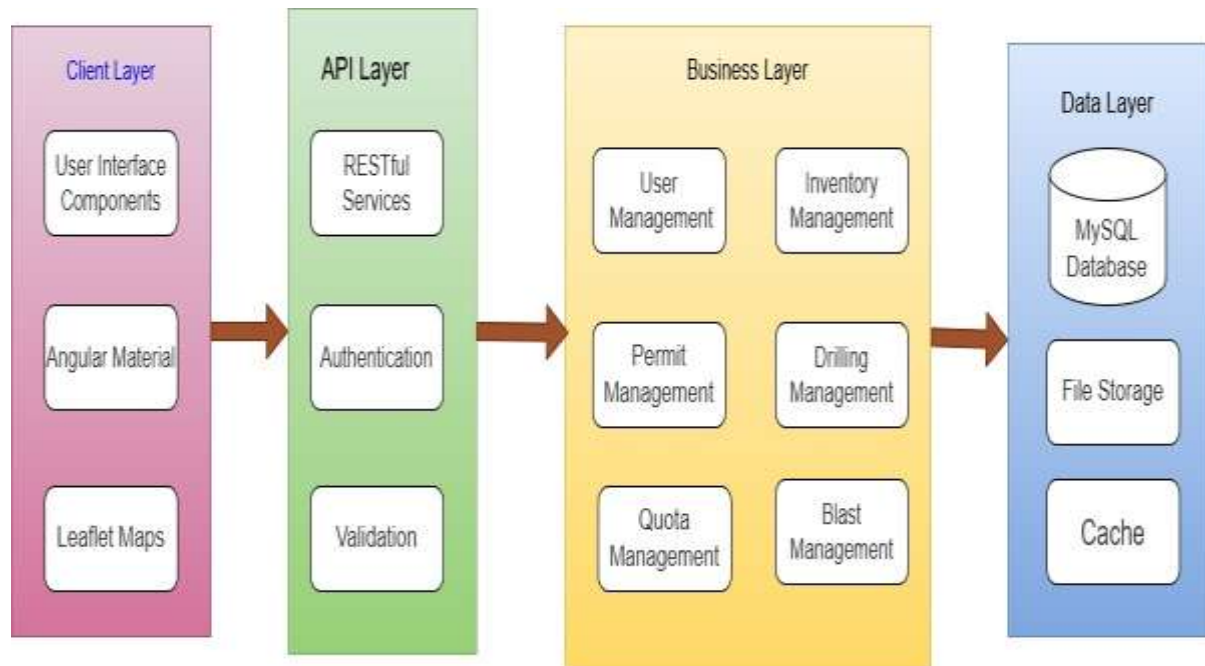


Figure 10- Top level architecture of Quarry Master

The QuarryMaster system implements a multi-layered architecture consisting of four primary layers:

1. Client Layer:
 - Angular-based frontend components
 - Material Design UI elements
 - Interactive mapping using Leaflet
 - Real-time notifications

- Responsive design elements
- 2. API Layer:
 - RESTful service endpoints
 - Authentication and authorization
 - Request validation
 - Response handling
 - Error management
- 3. Business Layer:
 - User management logic
 - Permit processing
 - Quota calculations
 - Inventory control
 - Operation management
- 4. Data Layer:
 - MySQL database
 - File storage system
 - Caching mechanism
 - Data backup and recovery

3.4 UML diagrams

Following types of UML diagrams were used to evaluate the design and make the design process accurate and effective (“UML - Standard Diagrams,” n.d.) (draw.io, n.d.).

- Use Case diagram
- ER diagram
- Activity Diagram
- Sequence Diagram
- Class Diagram

3.4.1 Use Case Diagrams

Use case representation is a widely used method for capturing system requirements from the perspective of users or actors. It depicts the interactions and goals between the system and the actors involved. These actors can be users, user roles, or other interconnected systems. Use case diagrams help describe the functionalities of the system in a modular manner, showing how different modules or components interact with actors to achieve specific goals (“UML - Use Case Diagrams,” n.d.).

3.4.1.1 Use Case Diagram for User Management Module

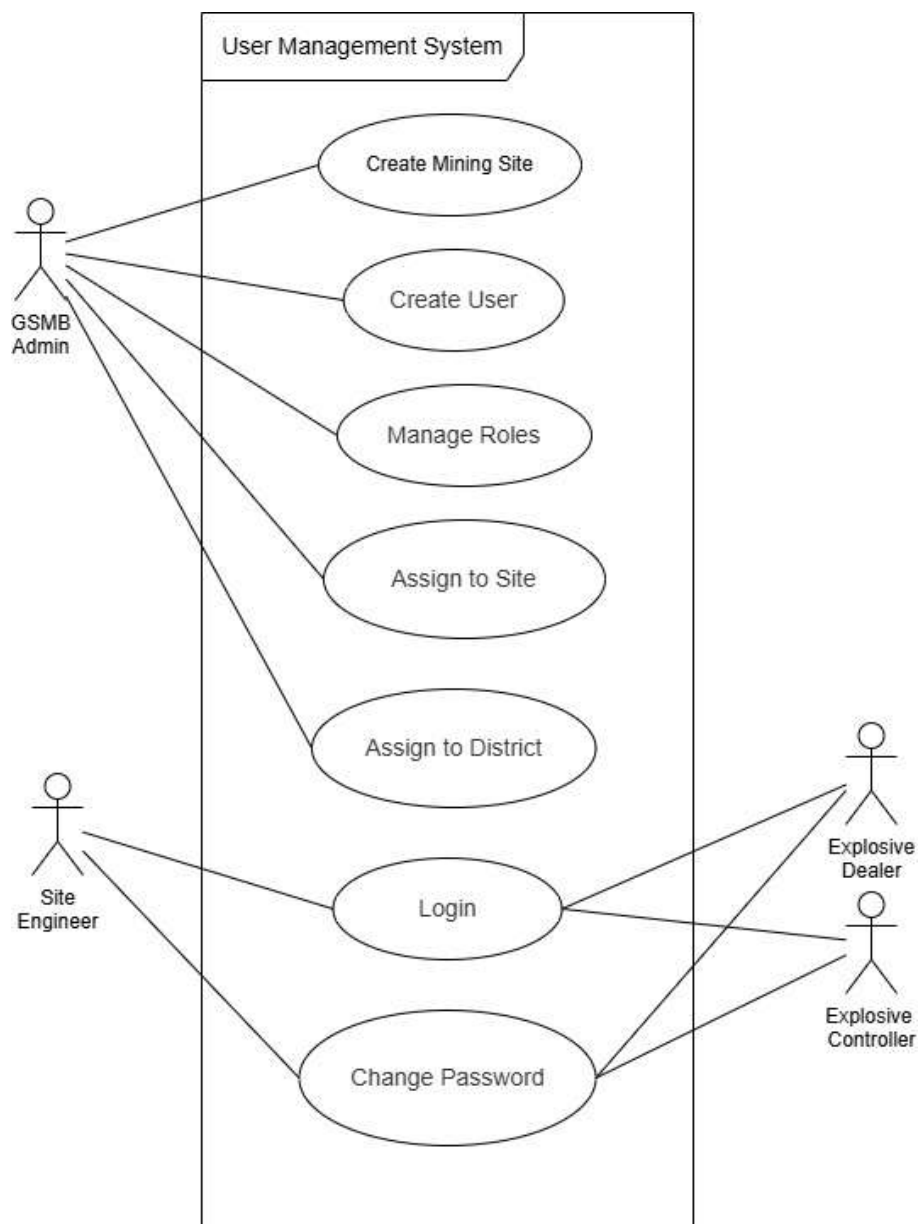


Figure 11- Use Case Diagram for User Management Module

Use Case	User Management Module
Actors	GSMB Admin (Primary), Site Engineer, Explosive Controller, Explosive Dealer
Description	
The user management module handles system access control and user administration	
Precondition	
- GSMB Admin must be authenticated - Database connection must be available - Email service must be configured	
Main Flow	
- GSMB Admin can create new users - Assign roles to users - Assign users to specific sites/districts - Users can login with credentials - Users can change passwords - System sends email notifications	
Alternative Flows	
- Password reset flow - User account deactivation - Role modification	
Post Condition	
- Users can access assigned functionalities - System maintains audit log of changes - Email notifications sent for account actions	
Business Rules	
- Only GSMB Admin can create users - Site Engineers must be assigned to specific sites - Controllers must be assigned to districts - Password must meet security requirements	
Special Requirements	
- Secure password storage - Email notification system - Role-based access control	

Table 8- Use Case Description for User Management Module

3.4.1.2 Use Case Diagram for Mining Site Management Module

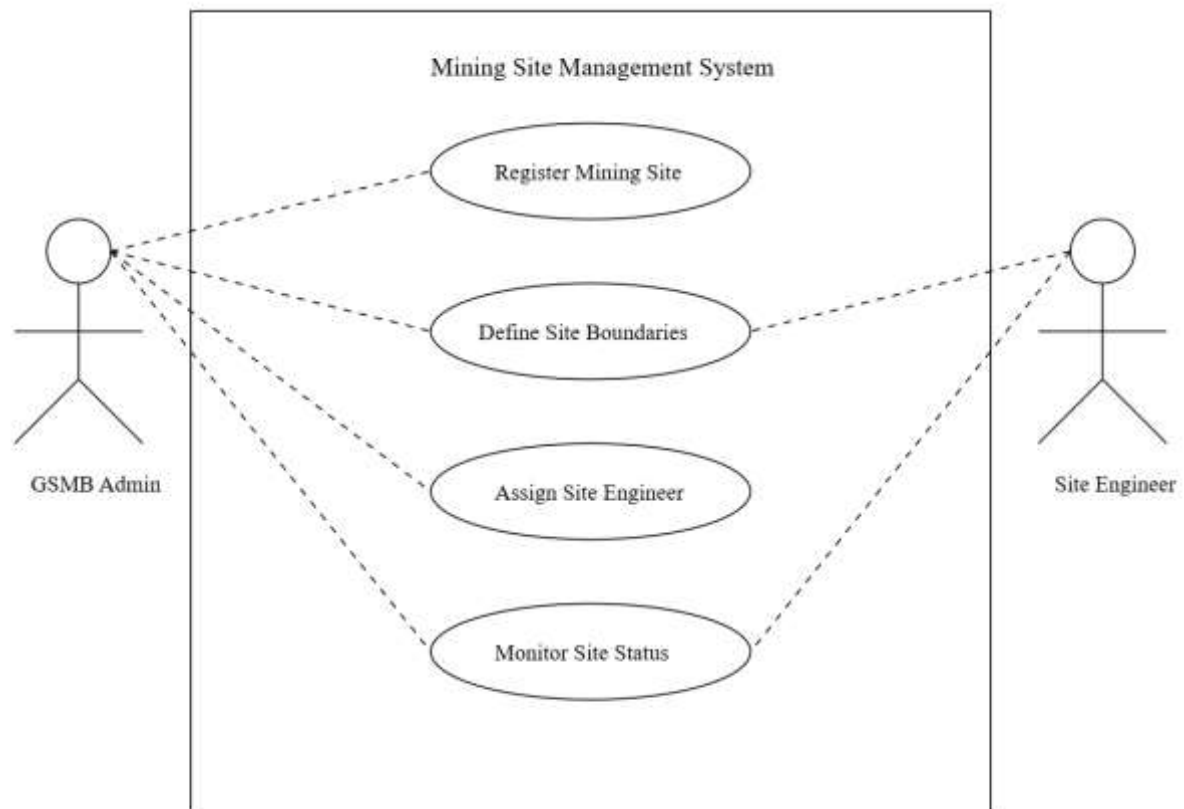


Figure 12- Use Case Diagram for Mining Site Management Module

Use Case	Mining Site Management Module
Actors	GSMB Admin (Primary), Site Engineer (Secondary)
Description	
The mining site management module handles the registration and management of A-grade quarry sites including their boundaries, assigned personnel, and operational status.	
Precondition	
- GSMB Admin must be authenticated - Valid mining license must exist - Database connection must be available - Mapping service must be operational	
Main Flow	
- GSMB Admin registers new mining site - Admin defines site boundaries using Leaflet maps - Admin assigns site engineer to the location - Admin monitors site operational status - Site Engineer views assigned site details - Site Engineer updates site operational information	
Alternative Flows	

• Site boundary modification process • Site engineer reassignment • Site status updates • Site deactivation process
Post Condition
• Site is registered in system • Boundaries are mapped • Site Engineer is assigned • System maintains site status
Business Rules
• Only GSMB Admin can register sites • Sites must have valid mining license • Sites must have defined boundaries • Each site must have at least one assigned engineer • Kandawala coordinates must be converted to WGS84
Special Requirements
• Leaflet map integration • Coordinate system conversion • Boundary validation • Real-time status updates

Table 9- Use Case Description for Vehicle Fitness Garage and Fitness Certifying Officer Management Module

3.4.1.3 Use Case Diagram for Explosive Permit Management Module

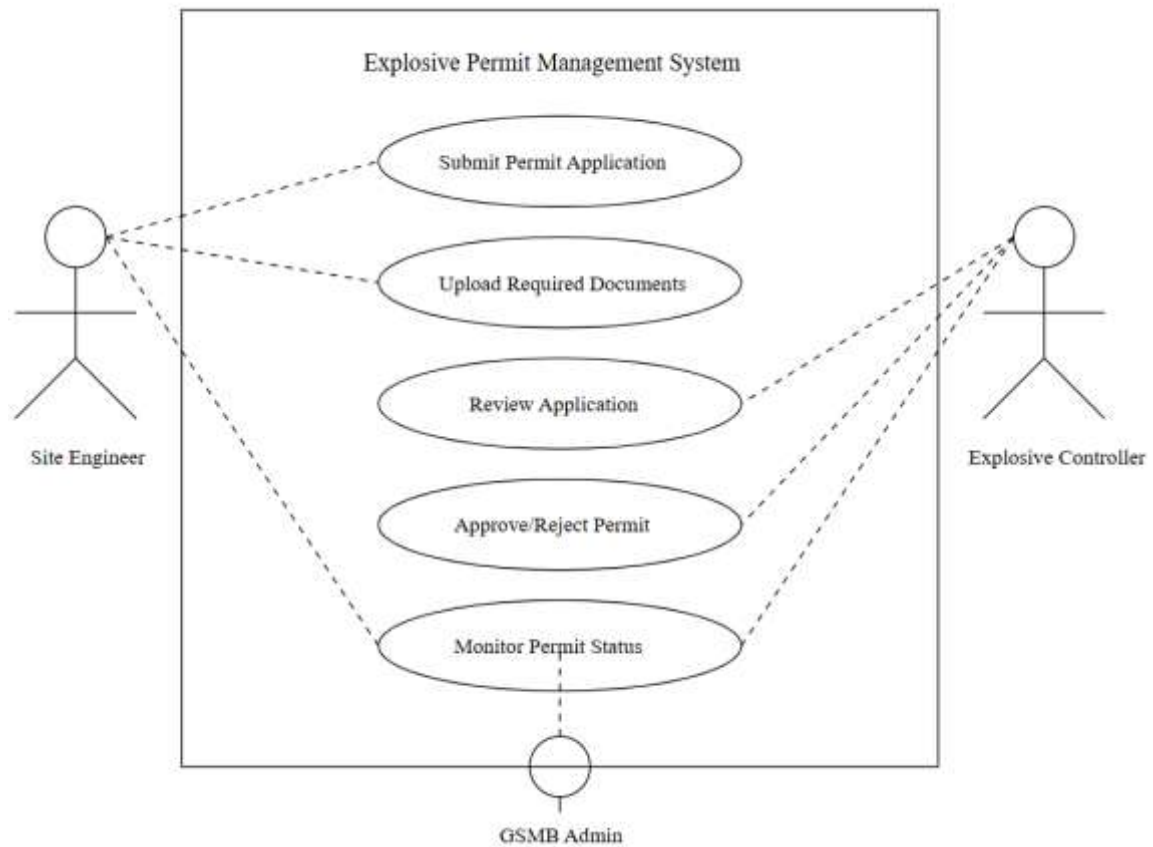


Figure 13- Use Case Diagram for Explosive Permit Management Module

Use Case	Explosive Permit Management Module
Actors	Site Engineer (Primary), Explosive Controller (Primary), GSMB Admin (Secondary)
Description	
The explosive permit management module handles the complete lifecycle of explosive permit applications, including submission, review, approval, and monitoring.	
Precondition	
- Site Engineer must be authenticated - Valid mining license must exist for the site - Explosive Controller must be assigned to the district - Previous permit (if any) must be completed or expired	
Main Flow	
- Site Engineer submits permit application - Engineer uploads required documentation - System routes application to district Explosive Controller - Controller reviews application and documentation - Controller approves or rejects permit with comments	

6. System notifies stakeholders of decision 7. Approved permits are tracked for validity period
Alternative Flows
• Application revision process if rejected • Permit amendment requests • Emergency permit requests • Permit cancellation process • Document resubmission flow
Post Condition
• Permit status is updated in system • All stakeholders are notified • Audit trail is maintained • Permit documents are stored
Business Rules
• Only Site Engineers can submit applications • Applications must include all required documents • Controllers can only approve permits in their district • Permits must specify quantity limits • Permits have defined validity periods • Previous permits must be closed before new applications
Special Requirements
• Document storage system • Email notification system • Audit logging • Permit template generation

Table 10- Use Case Description for Explosive Permit Management Module

3.4.1.4 Use Case Diagram for Explosive Quota Management Module

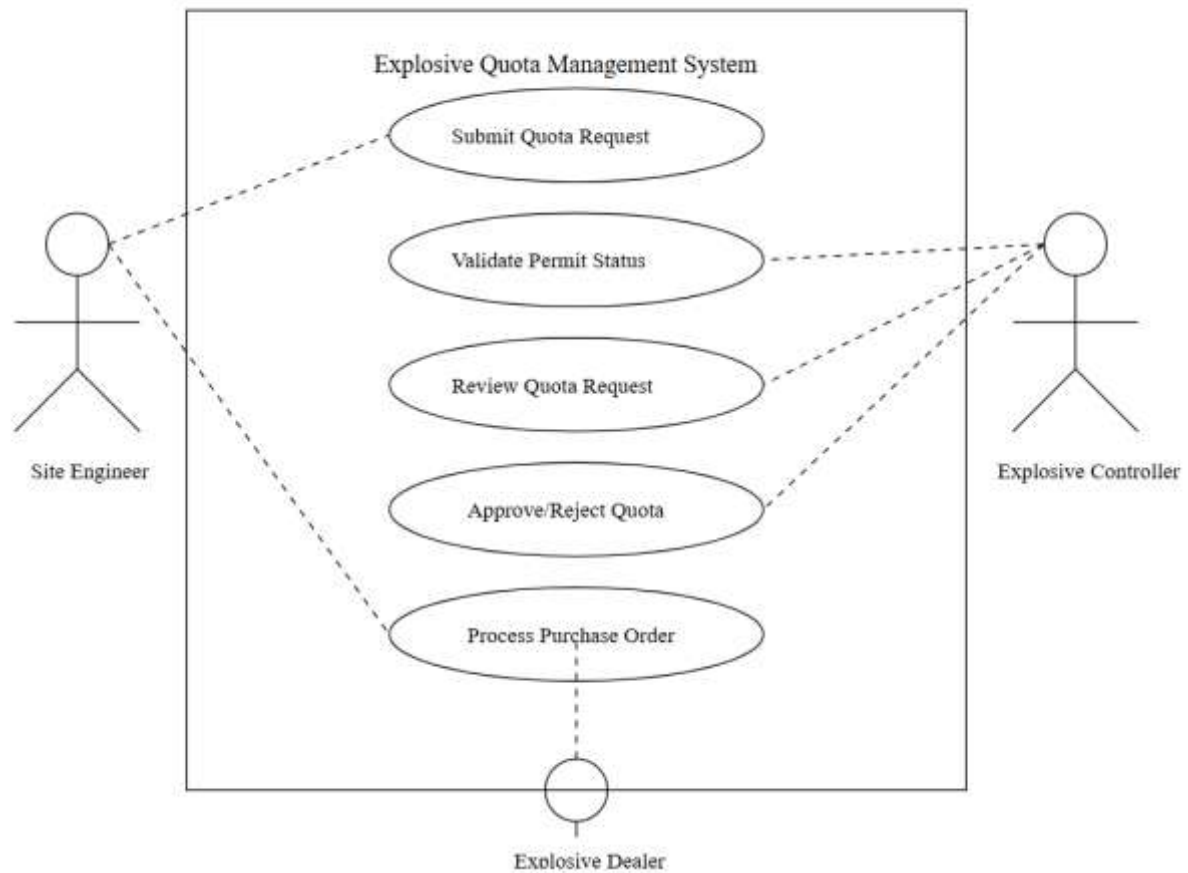


Figure 14- Use Case Diagram for Explosive Quota Management Module

Use Case	Explosive Quota Management Module
Actors	Site Engineer (Primary), Explosive Controller (Primary), Explosive Dealer (Secondary)
Description	
The explosive quota management module handles the request, approval, and tracking of explosive quotas based on approved permits, ensuring controlled distribution of explosives.	
Precondition	
- Valid explosive permit must exist - Site Engineer must be authenticated - Explosive Controller must be assigned to district - Previous quota (if any) must be properly accounted for	
Main Flow	
1. Site Engineer submits quota request based on valid permit 2. System validates permit status and remaining quantity 3. Request routed to district Explosive Controller 4. Controller reviews usage history and safety records 5. Controller approves/rejects quota with specified limits 6. Approved quota enables purchase order creation 7. Dealer processes order based on approved quota	

Alternative Flows
• Quota amendment requests • Emergency quota requests • Quota cancellation process • Usage reporting flow • Quota extension requests
Post Condition
• Quota status updated in system • All stakeholders notified • Purchase orders enabled • Usage limits set
Business Rules
• Quota must not exceed permit limits • Weekly/monthly usage limits apply • Previous quota must be accounted for • Only district-assigned controllers can approve • Dealers must verify quota before sales • Quota validity matches permit period
Special Requirements
• Real-time quota tracking • Automated limit validation • Integration with permit system • Usage monitoring alerts • Dealer verification system

Table 11- Use Case Description for Explosive Quota Management Module

3.4.1.5 Use Case Diagram for Operations Management Module (Drilling & Blasting)

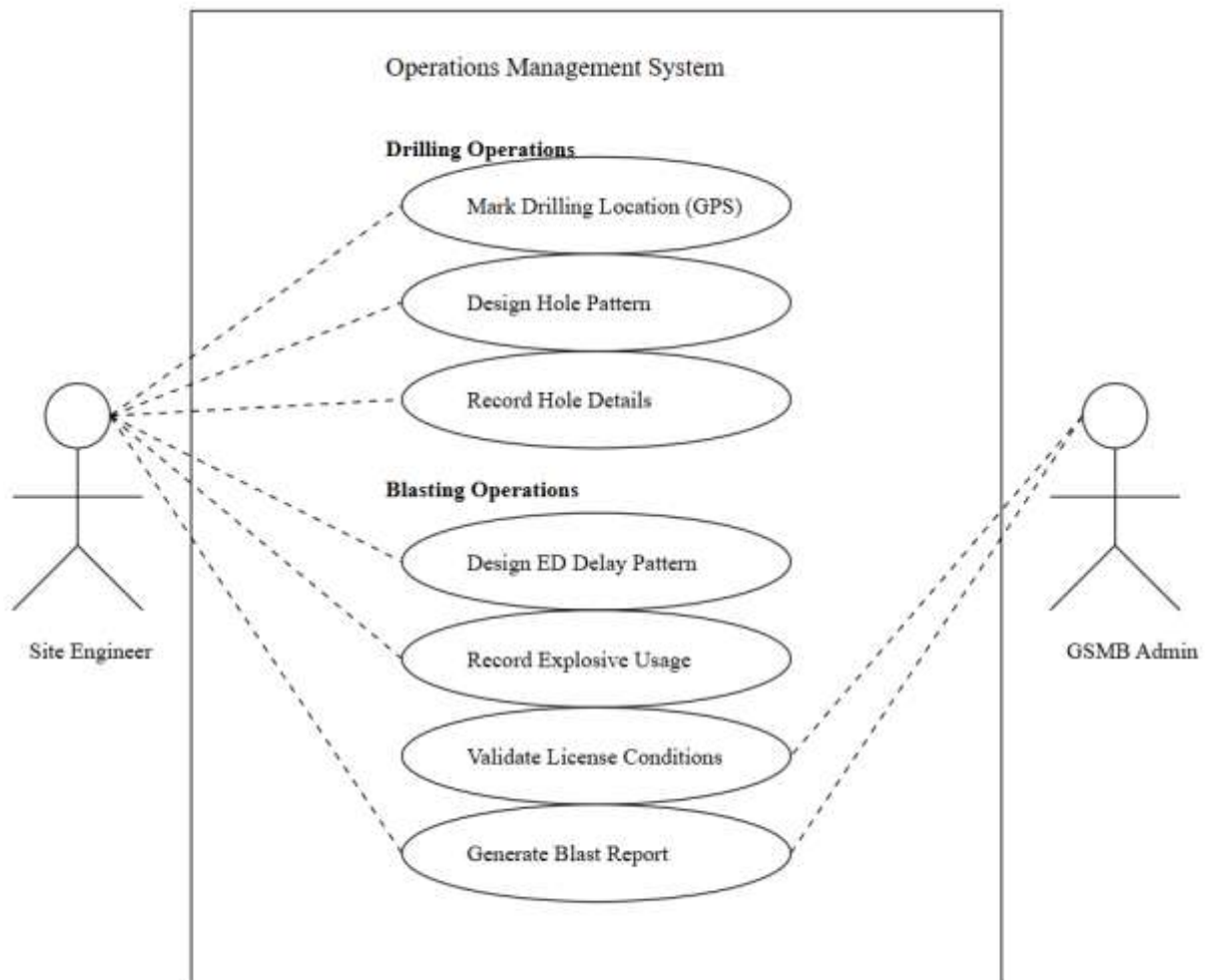


Figure 15- Use Case Diagram for Operations Management Module (Drilling & Blasting)

Use Case	Operations Management Module (Drilling & Blasting)
Actors	Site Engineer (Primary), GSMB Admin (Secondary)
Description	
The operations management module handles all aspects of drilling and blasting operations, including location marking, pattern design, explosive usage tracking, and compliance monitoring.	
Precondition	
- Valid explosive permit and quota must exist - Site Engineer must be authenticated - GPS system must be operational - Mining license conditions must be available in system	
Main Flow	
Drilling Operations: - Site Engineer marks drilling location using GPS coordinates - Engineer designs and saves hole pattern sketch - Engineer records hole details (depth, diameter, spacing) - System validates against license conditions	
Blasting Operations:	

5. Engineer designs ED delay pattern 6. System validates pattern against safety parameters 7. Engineer records per-hole explosive usage 8. System checks compliance with license conditions 9. Generate comprehensive blast report
Alternative Flows
• Pattern modification process • Emergency operation changes • Non-compliance handling • Equipment failure workflow • Weather condition adjustments
Post Condition
• Drilling locations recorded with GPS coordinates • Hole patterns stored in system • Explosive usage documented per hole • Compliance status updated • Blast report generated and stored
Business Rules
Drilling Rules: • Maximum hole depth per license • Minimum hole spacing requirements • Maximum holes per blast • GPS coordinate accuracy requirements Blasting Rules: • Maximum explosive per hole • ED delay pattern requirements • Maximum burden to blasting face • Daily blast limit compliance • Safety distance requirements
Special Requirements
• GPS integration • Pattern design tool • Real-time validation system • Compliance checking algorithm • Automated report generation
Technical Details
Drilling Details: • GPS coordinate system (WGS84) • Hole pattern sketching tools • Depth and diameter validation Blasting Details: • ED delay pattern designer • Per-hole explosive calculator • Safety parameter checker • License condition validator

Table 12-Use Case Description for Operations Management Module (Drilling & Blasting)

3.4.1.6 Use Case Diagram for Explosive Inventory Control Module

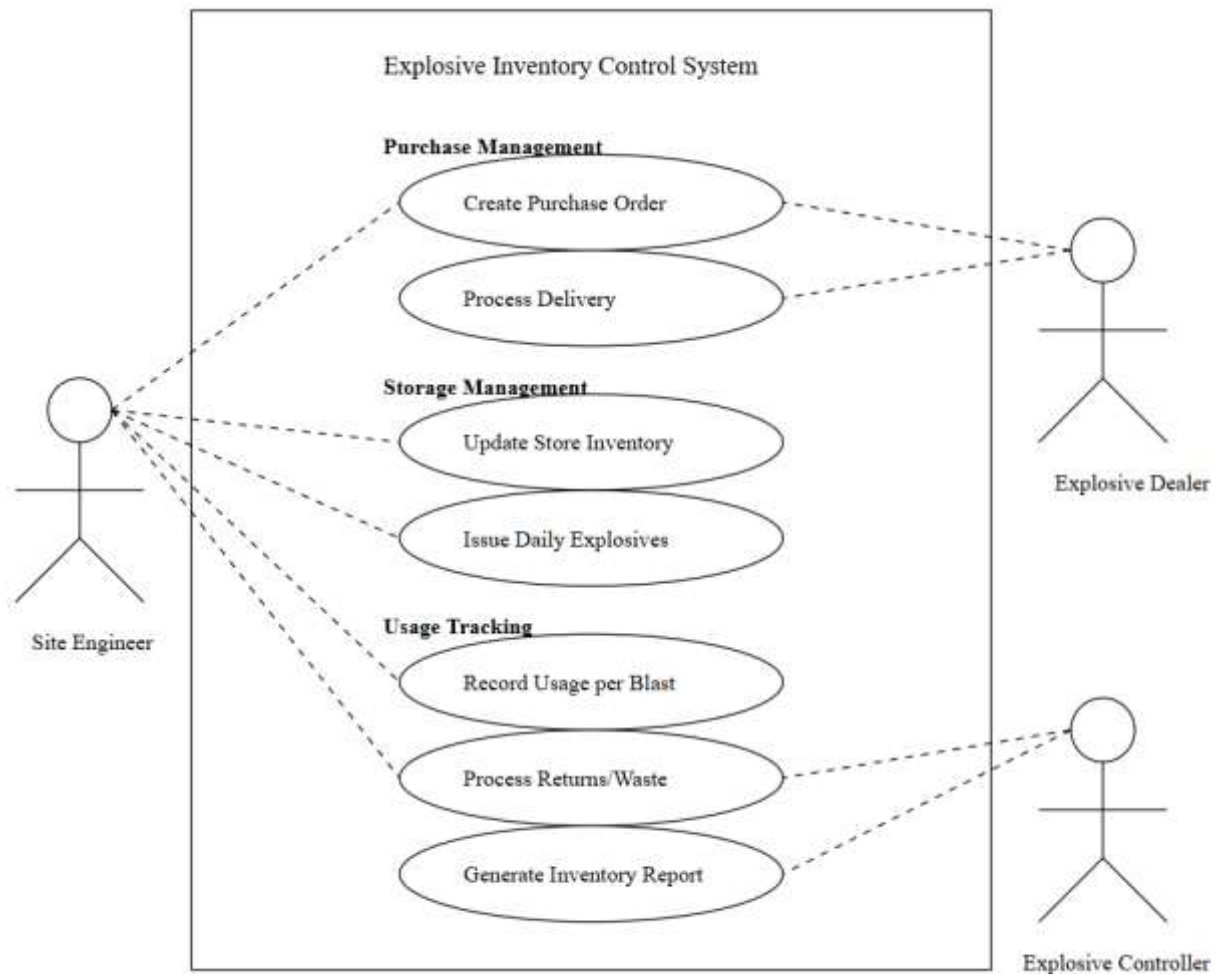


Figure 16- Use Case Diagram for Explosive Inventory Control Module

Use Case	Explosive Inventory Control Module
Actors	Site Engineer (Primary), Explosive Dealer (Primary), Explosive Controller (Secondary)
Description	
The inventory control module manages the complete lifecycle of explosives from purchase to usage, including storage, daily issuance, returns, and waste tracking.	
Precondition	
- Valid explosive permit and quota must exist - Site Engineer must be authenticated - Storage facility must be registered - Previous inventory reconciliation completed	
Main Flow	
Purchase and Delivery: - Site Engineer creates purchase order - Dealer processes and delivers order - Engineer verifies delivery quantities - Update store inventory records Daily Operations: - Issue explosives for daily blast	

6. Record per-hole usage quantities 7. Process returns to storage 8. Document damaged/waste materials 9. Generate daily reconciliation report
Alternative Flows
• Partial delivery handling • Emergency requisition process • Damaged inventory handling • Storage transfer process • Inventory adjustment workflow
Post Condition
• Inventory records updated • Usage documented • Returns processed • Waste quantities recorded • Reconciliation completed
Business Rules
Purchase Rules: • Must not exceed approved quota • Valid dealer verification required • Delivery documentation mandatory Storage Rules: • Maximum storage capacity limits • Segregation requirements • Environmental conditions monitoring Usage Rules: • Daily issue limit compliance • Return processing timeline • Waste documentation requirements • Reconciliation accuracy standards
Special Requirements
• Real-time inventory tracking • Automated alerts system • Reconciliation tools
Technical Details
Inventory Tracking: • Item-wise quantity tracking • Batch number tracking • Expiry date monitoring Usage Calculation: • Per-hole usage calculator • Returns calculator • Waste quantity tracker • Reconciliation validator

Table 13- Use Case Description for Explosive Inventory Control Module

3.4.1.7 Use Case Diagram for Reporting and Documentation Module

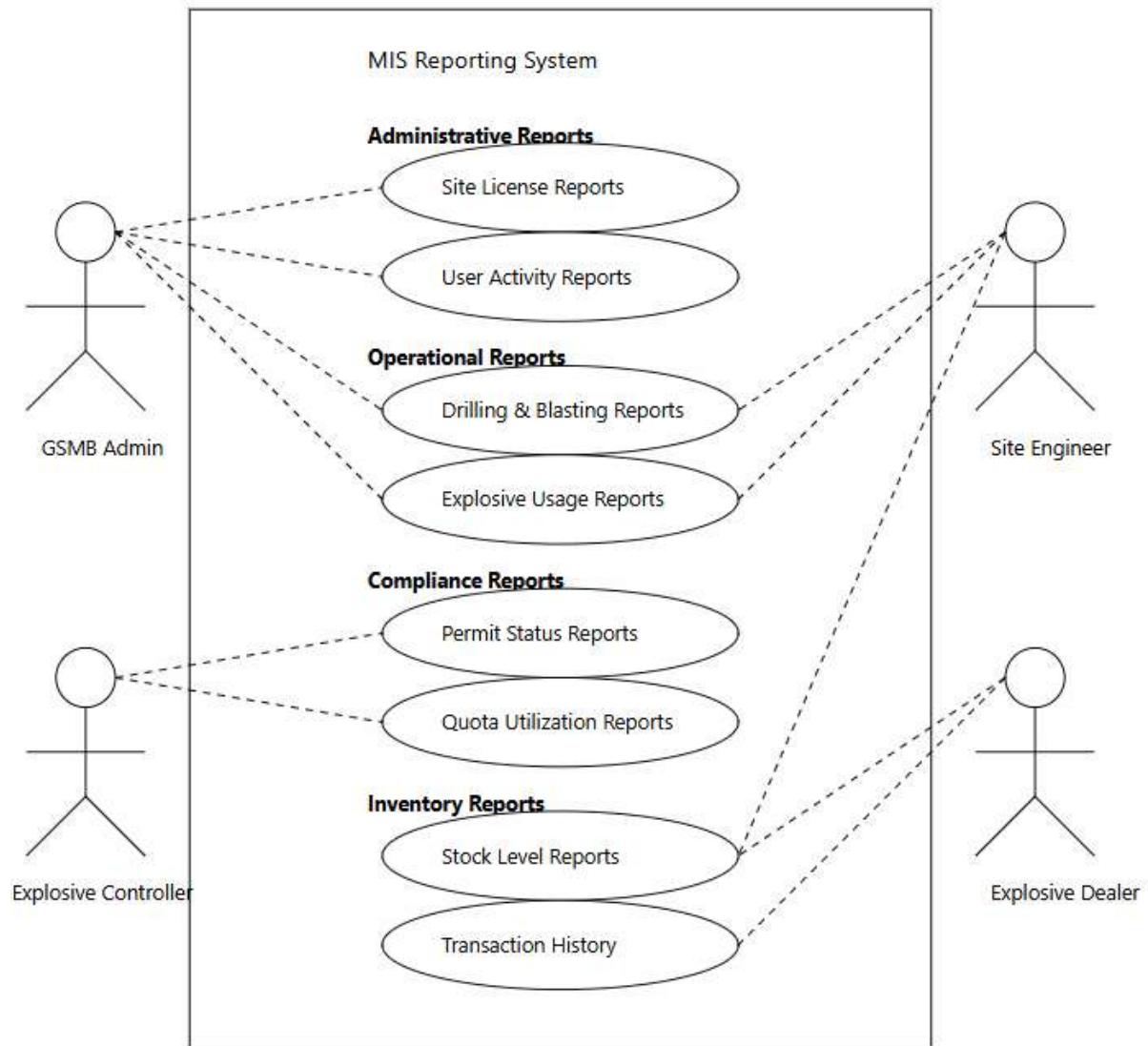


Figure 17- Use Case Diagram for Reporting and Documentation Module

Use Case	Reporting and Documentation Module
Actors	GSMB Admin (Primary), Site Engineer, Explosive Controller, Explosive Dealer
Description	
The reporting module provides comprehensive MIS reports and documentation for all aspects of quarry operations, with role-specific access and customization options.	
Precondition	
- User must be authenticated - Access rights must be verified - Data must be available in system - Report templates must be configured	

Main Flow
Administrative Reports: • Generate site license status reports • Track user activity and access logs • Monitor system usage statistics Operational Reports: • Generate drilling and blasting reports • Track explosive usage patterns • Monitor operational efficiency Compliance Reports: • Track permit status and validity • Monitor quota utilization • Generate compliance audits Inventory Reports: • Monitor stock levels • Track transaction history • Generate reconciliation reports
Report Types
GSMB Admin Reports: • Overall system usage statistics • License status summary • Compliance monitoring reports • User activity logs Site Engineer Reports: • Daily operation reports • Explosive usage tracking • Blast pattern analysis • Inventory status Explosive Controller Reports: • District-wise permit status • Quota allocation reports • Safety compliance reports Explosive Dealer Reports: • Sales transaction history • Stock level reports • Delivery tracking reports
Business Rules
• Role-based report access • Data privacy compliance • Report generation frequency limits • Data retention policies • Export format restrictions
Special Requirements
• Multiple export formats (PDF, Excel) • Custom date range selection • Data visualization options • Report scheduling capability • Automated report distribution
Technical Details

- Dynamic report generation
- Interactive dashboards
- Data filtering capabilities
- Chart and graph generation
- Report template customization
- Data export functionality

Table 14- Use Case Description for Reporting and Documentation Module

3.4.2 ER diagram

An Entity-Relationship (ER) diagram is a visual representation of the relationships among entities in a database. It uses symbols to depict entities, attributes, and the associations between them. ER diagrams help in designing and understanding database structures, clarifying data relationships, and ensuring data integrity in database management systems (“ER Diagram Representation | Tutorialspoint,” n.d.).

3.4.3 Activity diagrams

An activity diagram is a graphical representation used to model the flow of activities within a system. It depicts the sequence of actions, decisions, and parallel processes, providing a clear visualization of how tasks are performed and interactions occur in a structured manner (“UML - Activity Diagrams,” n.d.).

3.4.3.1 Activity diagram for Explosive Permit and Quota Management Process

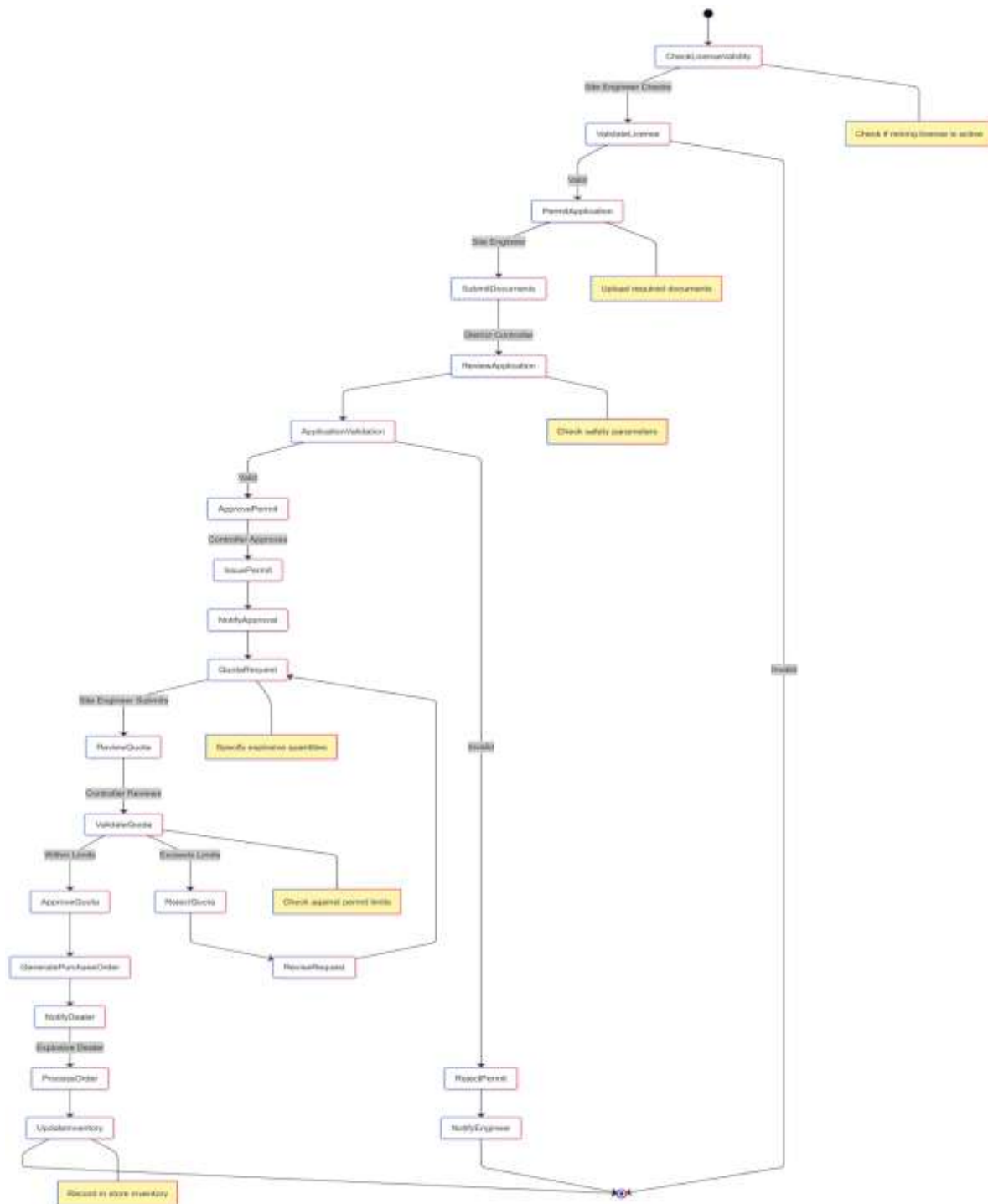


Figure 19- Activity diagram for Explosive Permit and Quota Management Process

3.4.3.2 Activity diagram for Drilling and Blasting Operation Process

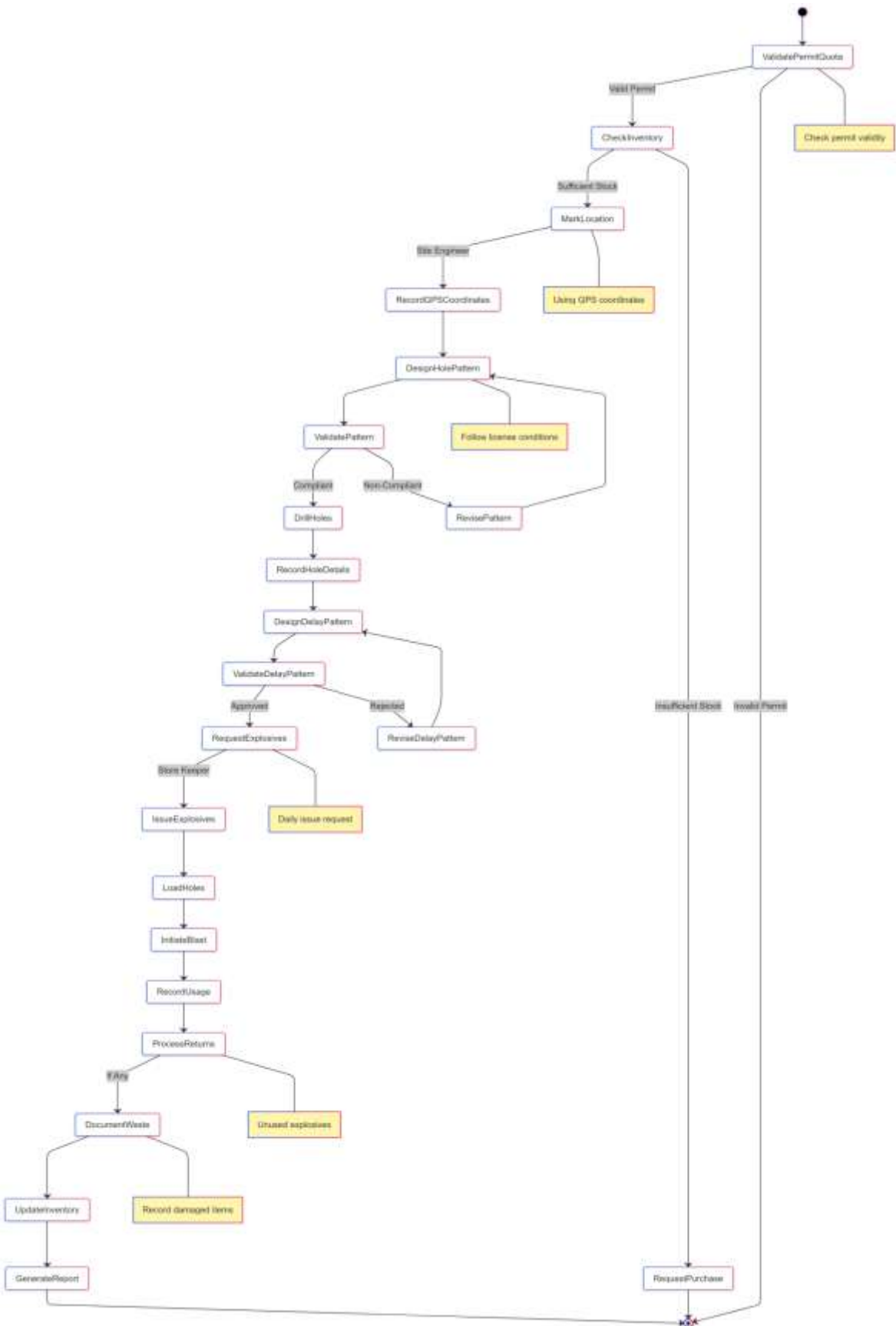


Figure 20- Activity diagram for Drilling and Blasting Operation Process

3.4.4 Sequence diagrams

Sequence diagrams illustrate interactions between objects or components in a system. They display the chronological order of messages exchanged among entities, helping to visualize the dynamic behavior of a two main process. Sequence diagrams emphasize the timing and collaboration of system elements for better understanding and design (“UML Sequence Diagram Tutorial,” n.d.).

3.4.4.1 Sequence diagram for Explosive Permit and Quota Management

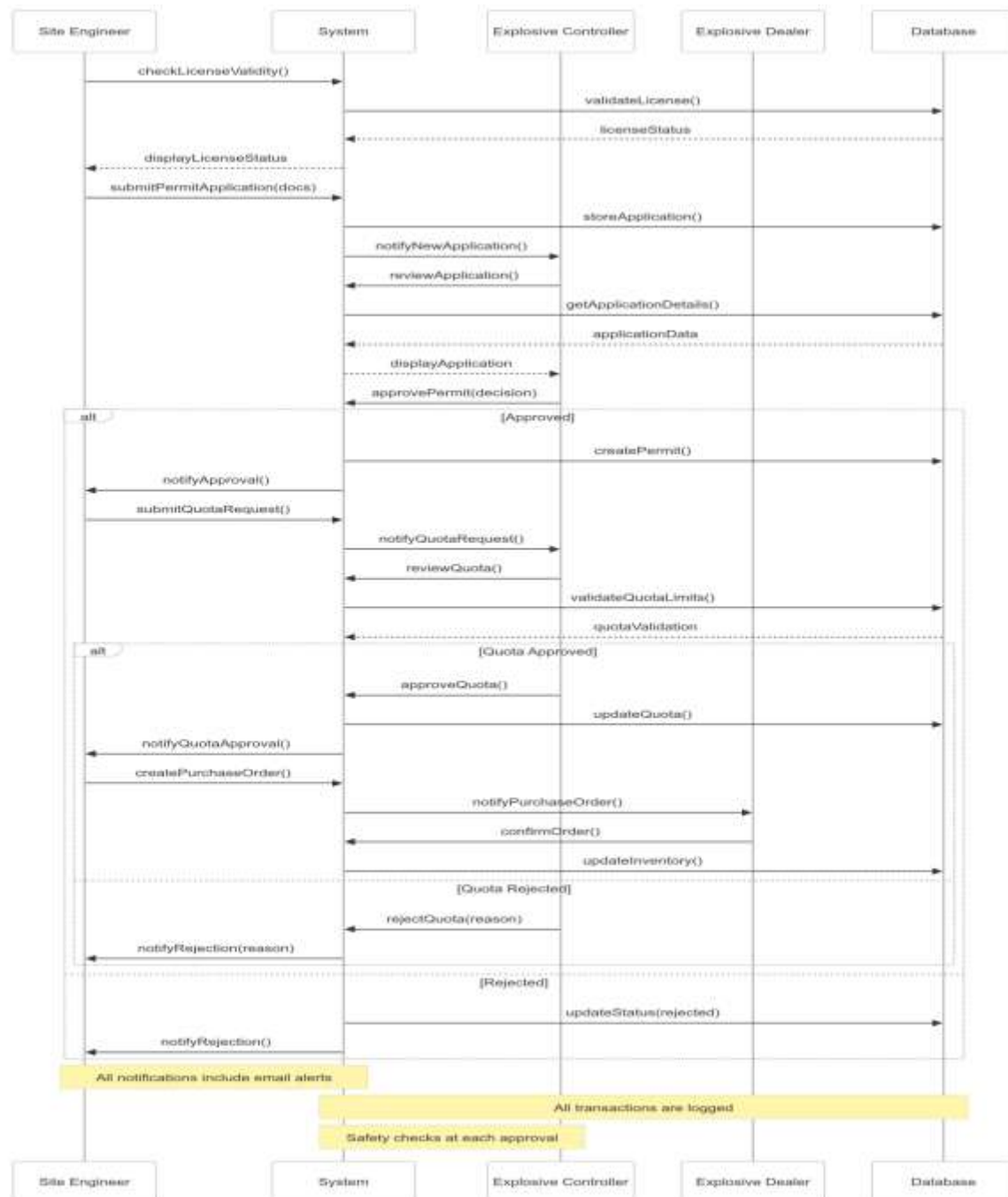


Figure 21- Sequence diagrams for Explosive Permit and Quota Management

3.4.4.2 Sequence diagram for Drilling and Blasting Operation

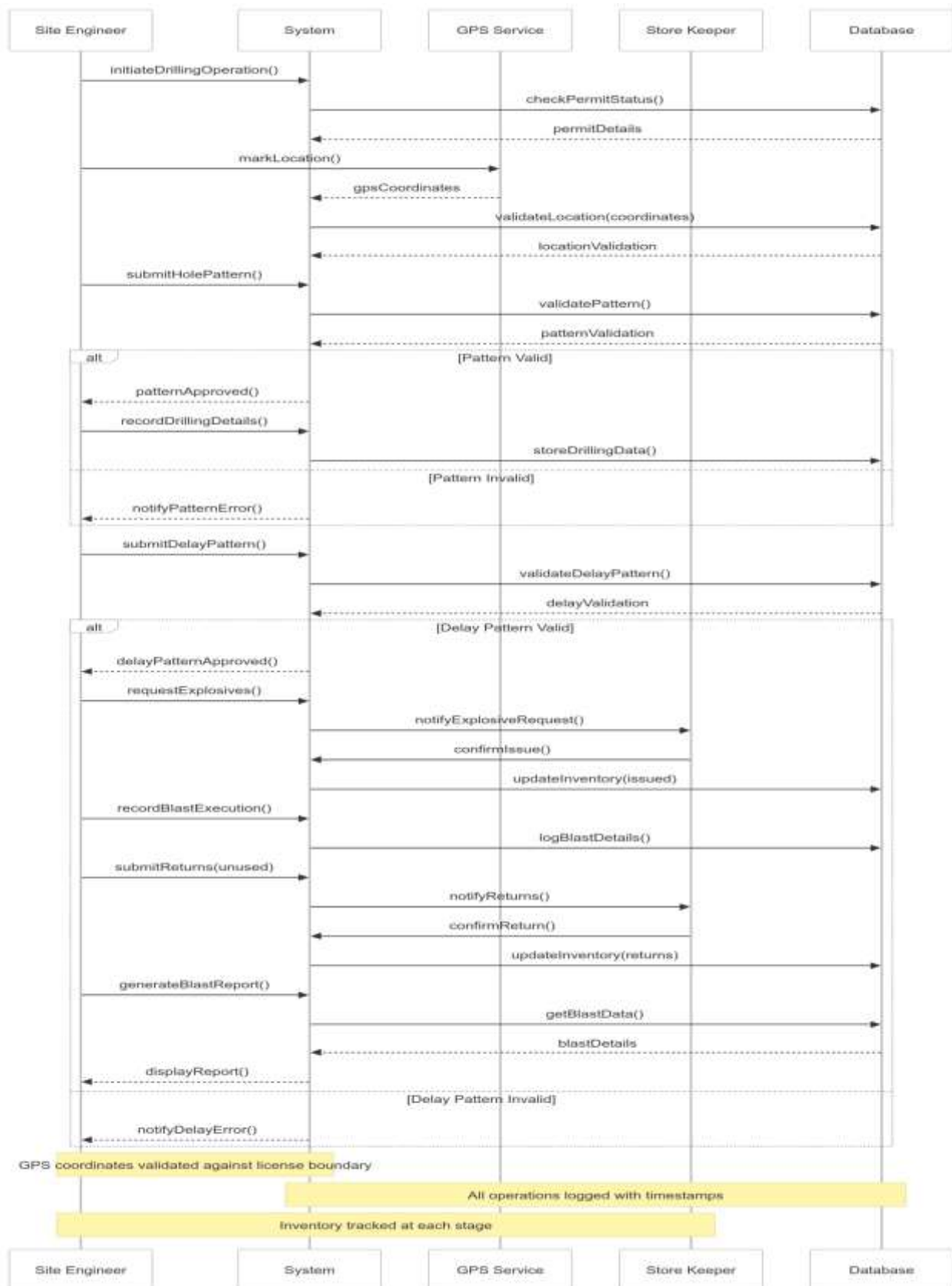


Figure 22- Sequence diagrams for Drilling and Blasting Operation

3.4.5 Class diagram

Class diagrams in software design illustrate the structure of a system by depicting classes, their attributes, methods, and relationships. They provide a static view of the system's object-oriented architecture, aiding in modeling and understanding class hierarchies, associations, and inheritance. Class diagrams are crucial for planning, communication, and documentation in software development (Martin, n.d.).

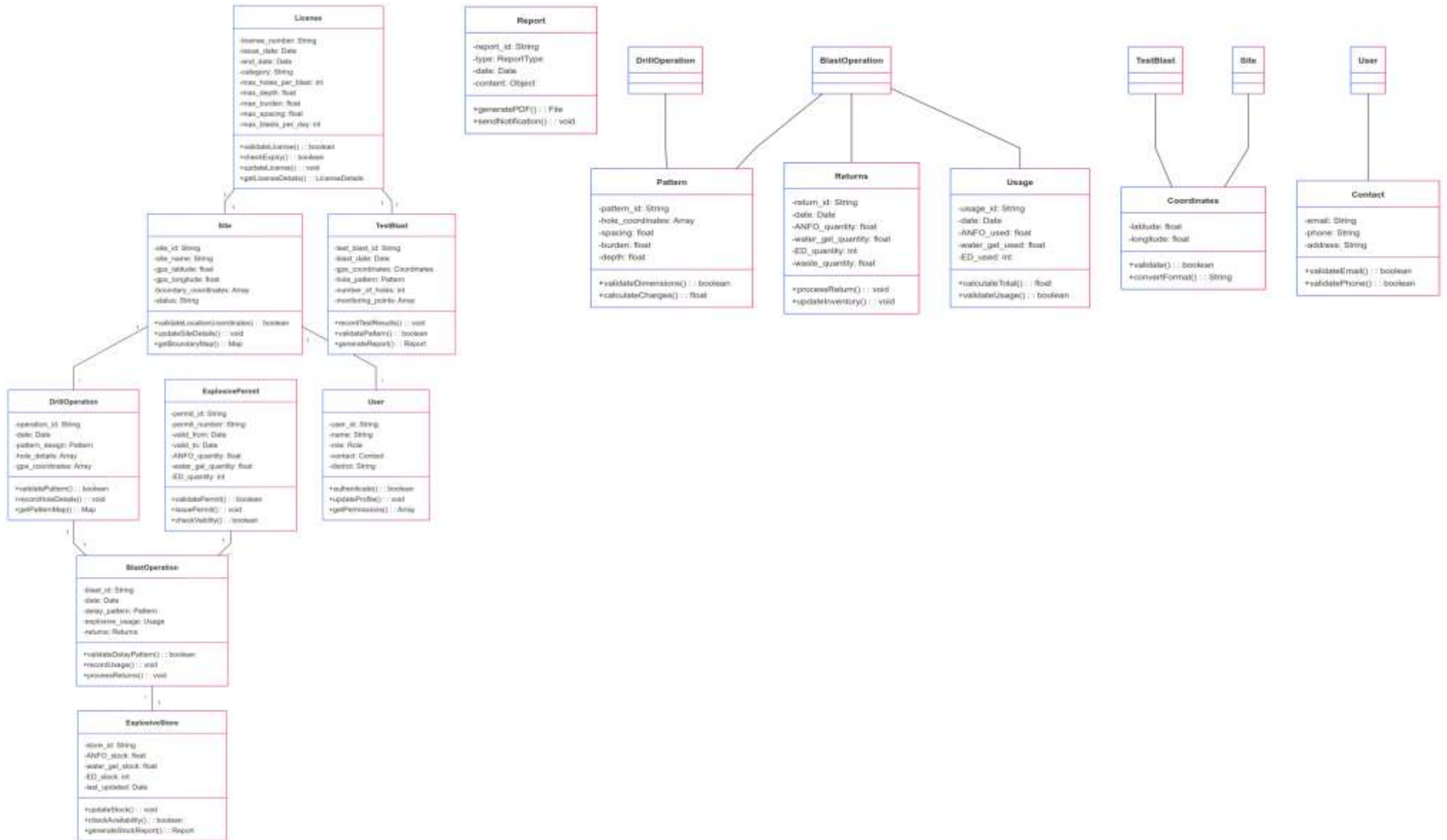


Figure 23- Class diagram of Quarry Master

3.5 Database Design

The database of this system was designed as relational database implemented using Structured Query Language. A Database Management System (DBMS) comprises a collection of interconnected data along with a set of programs to access and manage this data. It is responsible for handling large volumes of data efficiently. The core component is the database, where the data is stored, organized, and accessed. Well-implemented DBMS simplifies data management, enhances data security, and ensures data integrity and consistency.

A consistent and systematic naming convention was applied to all tables and fields in the database. Short and ambiguous names were avoided to prevent confusion. Instead, meaningful names were used for each table, making it easier to comprehend the records contained within. This naming strategy ensures clarity and helps users understand the purpose and content of each table, facilitating effective data management and retrieval (“Database design basics - Microsoft Support,” n.d.).

[illegible]

Figure 24- Database structure of Quarry Master

3.6 User Interface Design

User interface design is a crucial aspect that directly impacts the system's accessibility and usability. A well-structured and user-friendly interface enhances the system's appeal to users with varying technical knowledge levels, reducing training costs and time.

The QuarryMaster system's interface has been intentionally designed to be intuitive and user-friendly. The design follows several key principles:

1. **Role-Based Access:** Clear separation of interfaces based on user roles (GSMB Admin, Site Engineer, Explosive Controller, and Explosive Dealer)
2. **Consistent Navigation:** Standardized sidebar menu for easy access to role-specific functions
3. **Step-by-Step Workflows:** Use of steppers for complex processes to guide users
4. **Responsive Design:** Adaptable interface that works across different screen sizes
5. **Visual Clarity:** Clean layout with essential information prominently displayed

3.6.1 Authentication Interface

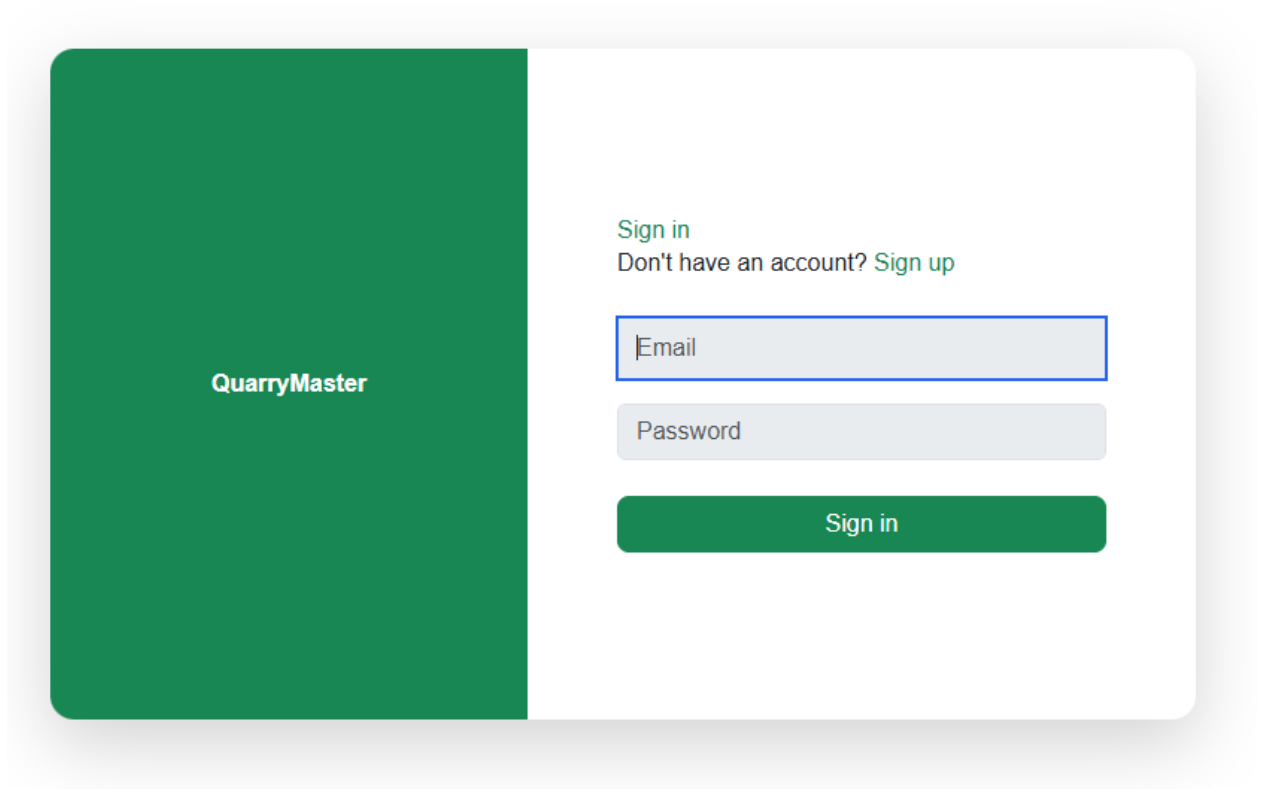


Figure 25- Authentication Interface

The login interface provides a secure entry point to the system with:

- Clean and minimalist design
- Clear input fields for credentials
- Role-based access control
- Password security measures

3.6.2 Administrative Dashboard

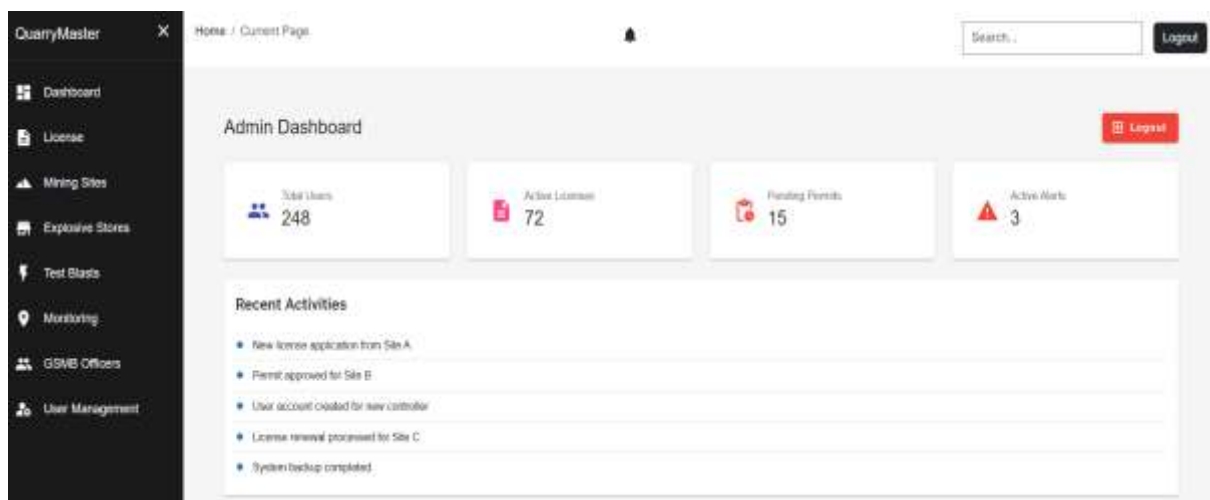


Figure 26- Administrative Dashboard

The GSMB Admin dashboard features:

- Comprehensive sidebar navigation
- Quick access to user management
- System monitoring tools
- Analytics overview
- License management section

3.6.3 Site Engineer Interface

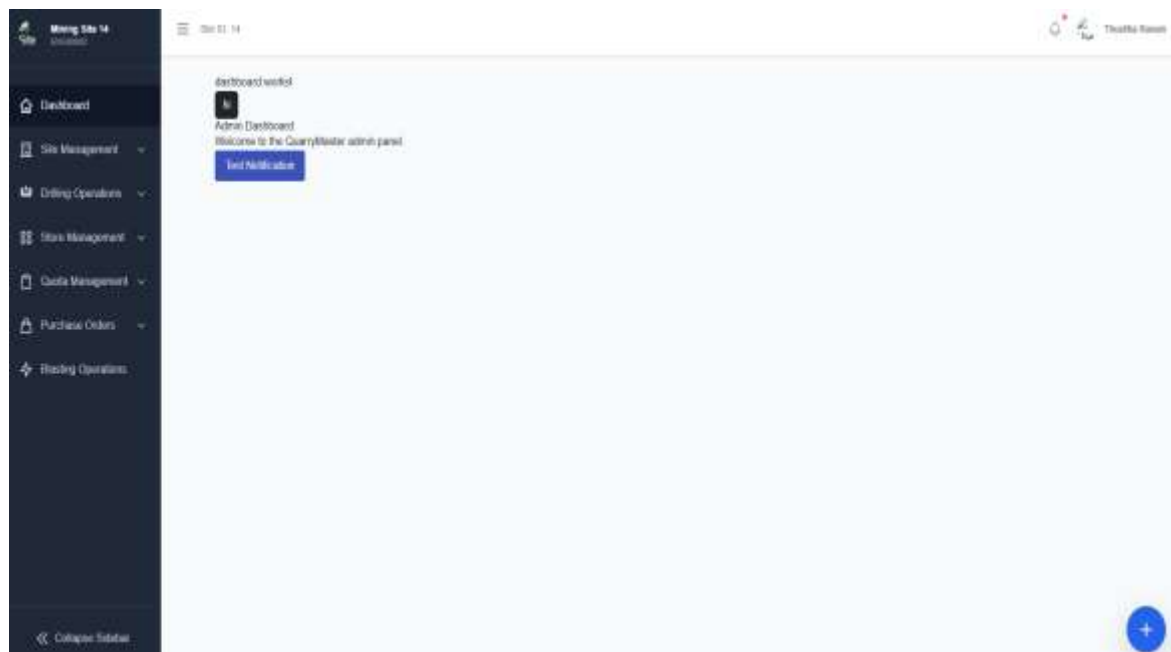
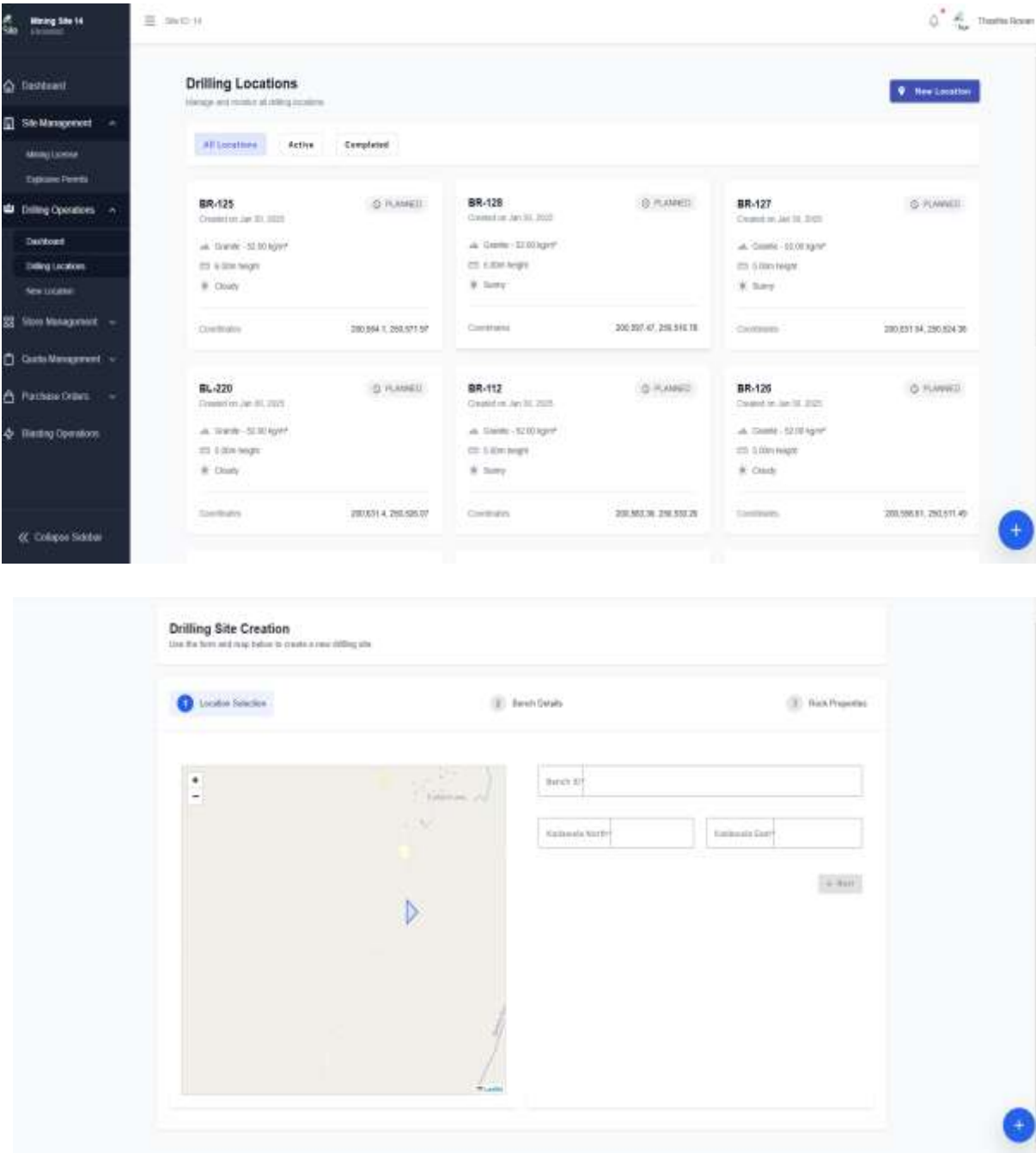


Figure 27- Site Engineer Interface

The Site Engineer's interface includes:

- Mining license management
- Explosive permit requests
- Drilling operation planning
- Blast management tools
- Inventory tracking

3.6.4 Drilling Operation Management Interface for Site Engineer



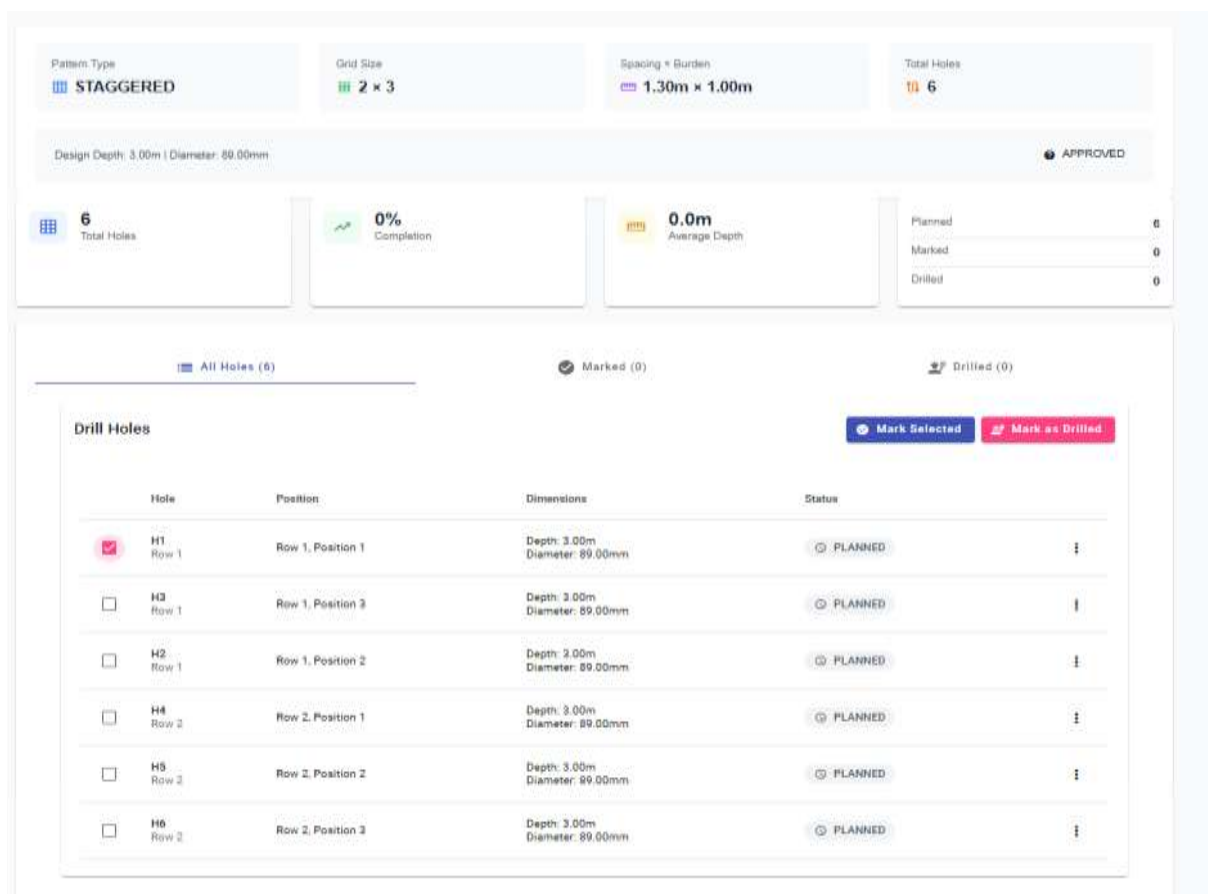
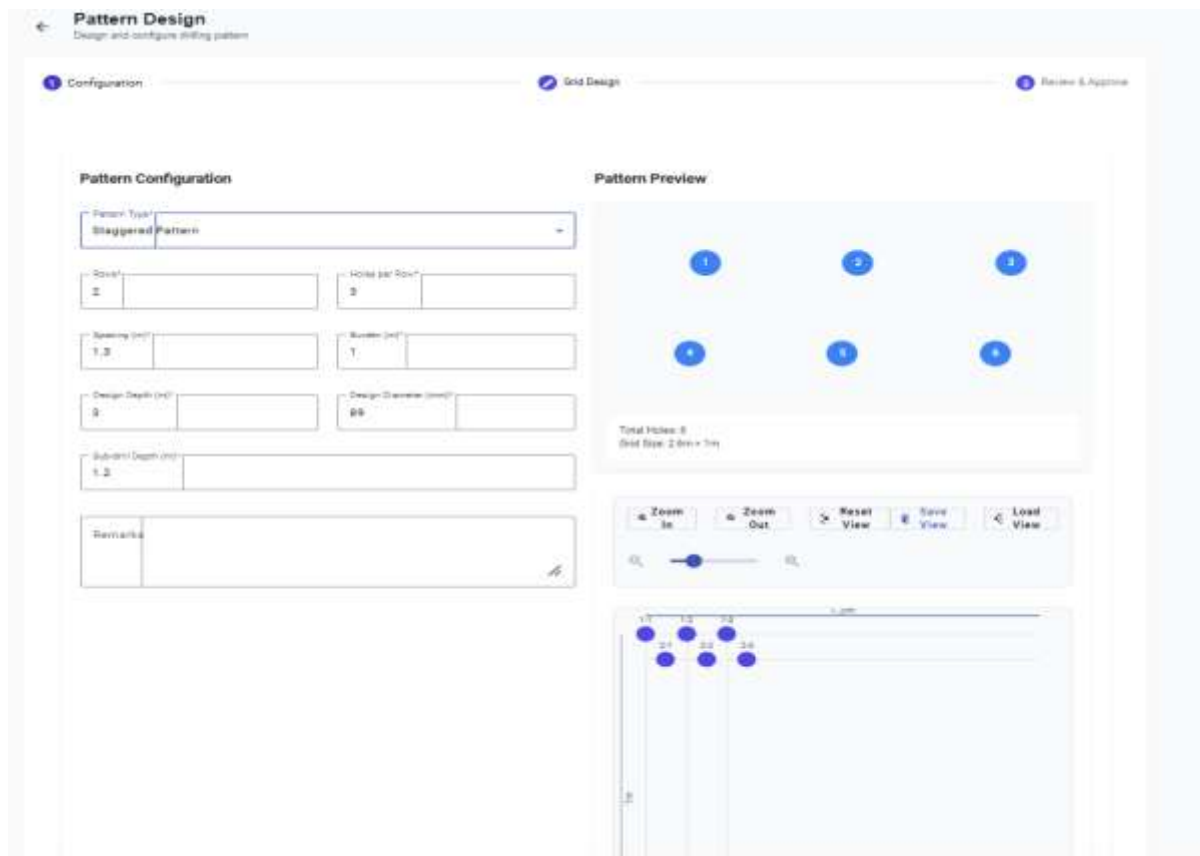
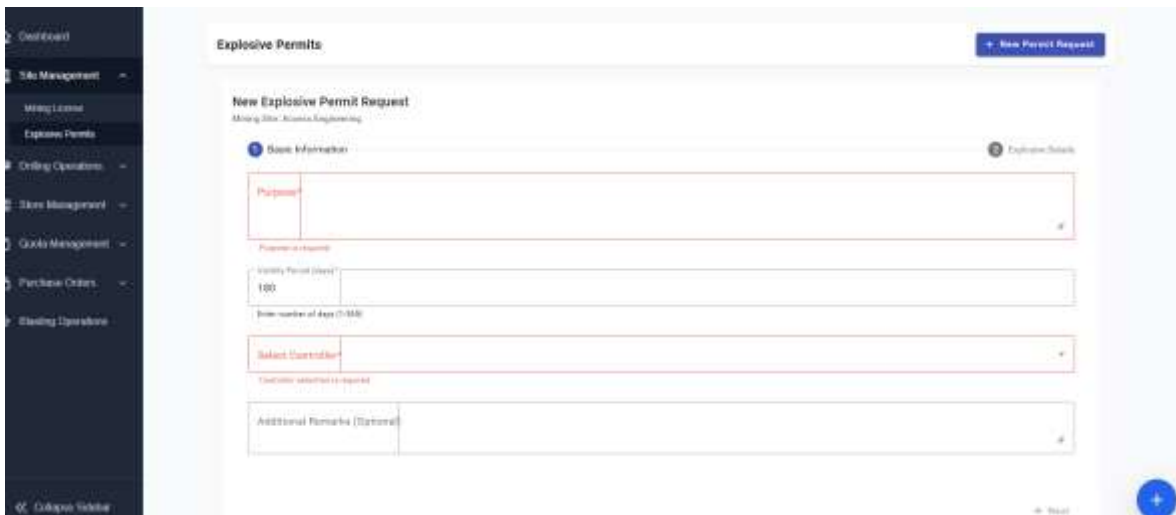
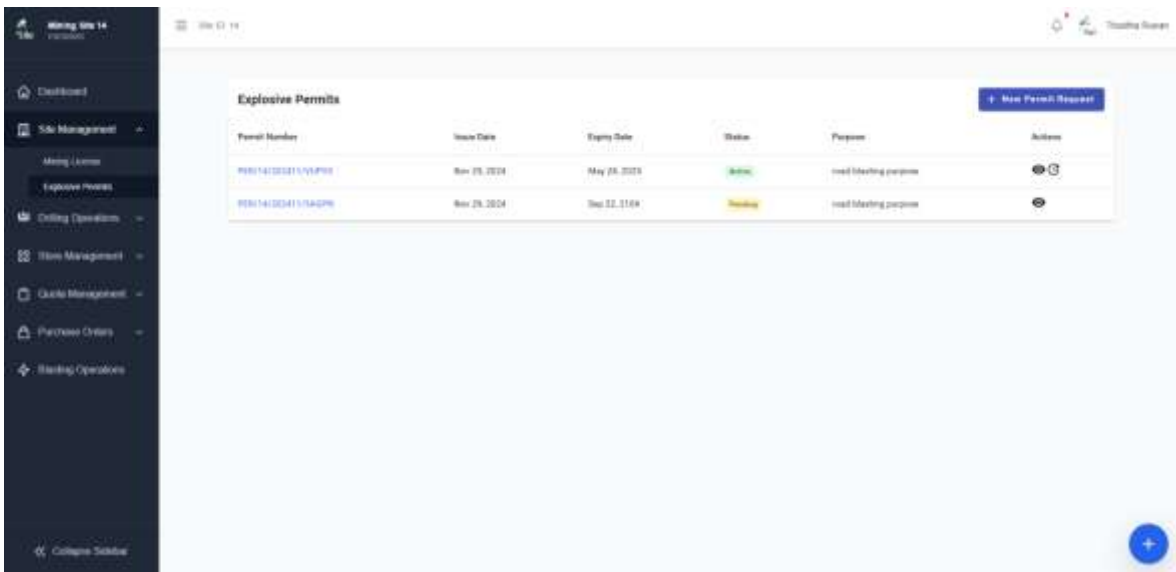


Figure 28- Drilling Operation Management Interface

The drilling operation interface provides:

- GPS location marking
- Pattern design tools
- Interactive hole placement
- Safety parameter validation
- Step-by-step workflow

3.6.5 Explosive Permit Management for Site engineer and Explosive Controller



Explosive Permits
New Permit Request

New Explosive Permit Request

Mining Site: Access Engineering

1 Basic Information
2 Explosive Details

Explosive #1

Explosive Type

Ammonia
Water Gel
Electrical Detonator

Quantity
kg

+ Add Another Explosive

Back

Submit Request

Figure 29- Explosive Permit Management for Site engineer

demushika

Account Locked

for 07/14/2024

Dashboard
Mining Licenses
Explosive Permits
Explosive Quotas
Mining Sites
Permit Management
Quota Management

Explosive Controller Portal
Columbo District

Explosive Permits
Manage and review explosive permit requests

Search Permits

Permit Number	Mining Site	Issue Date	Expiry Date	Status	Actions
PER/16/202412/9VL7W	siema quarry Columbo District	Dec 11, 2024	Jun 9, 2025	Active	
PER/14/202411/9VFX3	Access Engineering Columbo District	Nov 29, 2024	May 26, 2025	Active	
PER/14/202411/9VGFN	Access Engineering Columbo District	Nov 29, 2024	Sep 22, 2104	Pending	

Items per page: 10
1 - 3 of 3

Permit #PER/16/202412/9VL7W
Active

siema quarry - Columbo District

Basic Information

Allowed Explosives

History

Permit Document

Issue Date
Dec 11, 2024

Expiry Date
Jun 9, 2025

Purpose
for quarry blasting

Approval Date
Dec 11, 2024

Validity Period
180 days

Remarks
Immediately

Back to List

Permit Review & Approval
Permit #PER/14/202411/5AOPN - Access Engineering

Mining Site Access Engineering Colombo District	Purpose road blasting purpose
Issue Date Nov 29, 2024	Validity Period 180 days

Decision*

Please select your decision

Remarks*

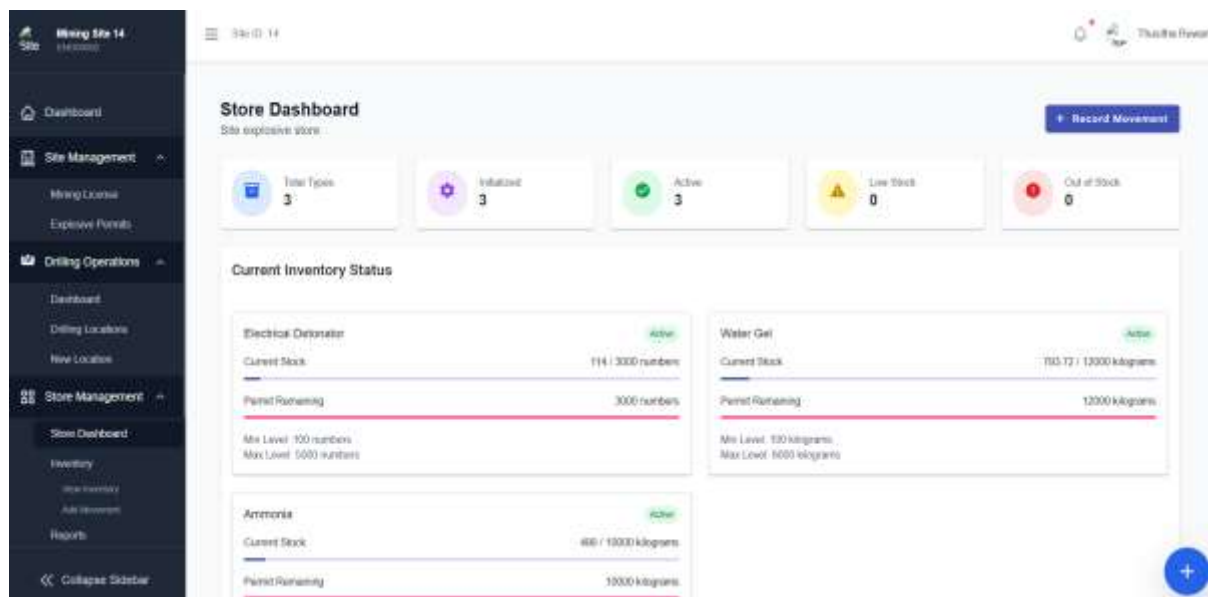
[← Back to List](#) [Cancel](#) [✓ Select Permit](#)

Figure 30- Explosive Permit Management for Explosive Controller

The permit management system features:

- Multi-step application process
- Document upload capability
- Status tracking
- Approval workflow
- Quota management

3.6.6 Explosive Store Management Interface for Site engineer



The 'Record Movement' form is used to log inventory changes. It features a 'Back to Inventory' button at the top right. The form is divided into two main sections: 'Stock In' (indicated by a green plus icon) and 'Stock Out' (indicated by a red minus icon). The 'Stock In' section has a 'Quantity' field. The 'Stock Out' section has a 'Reference Type' dropdown menu. Both sections have a 'Reference ID' field. The 'Batch Number (Optional)' field is shared between both sections. A large 'Remarks (Optional)' text area is at the bottom. At the bottom right, there are 'Cancel' and 'Record Movement' buttons.

Figure 31- Explosive Store Management Interface for Site engineer

The explosive store interface includes:

- Real-time inventory levels
- Usage tracking
- Returns processing
- Purchase order management
- Stock alerts

3.6.7 Explosive Controller Interface

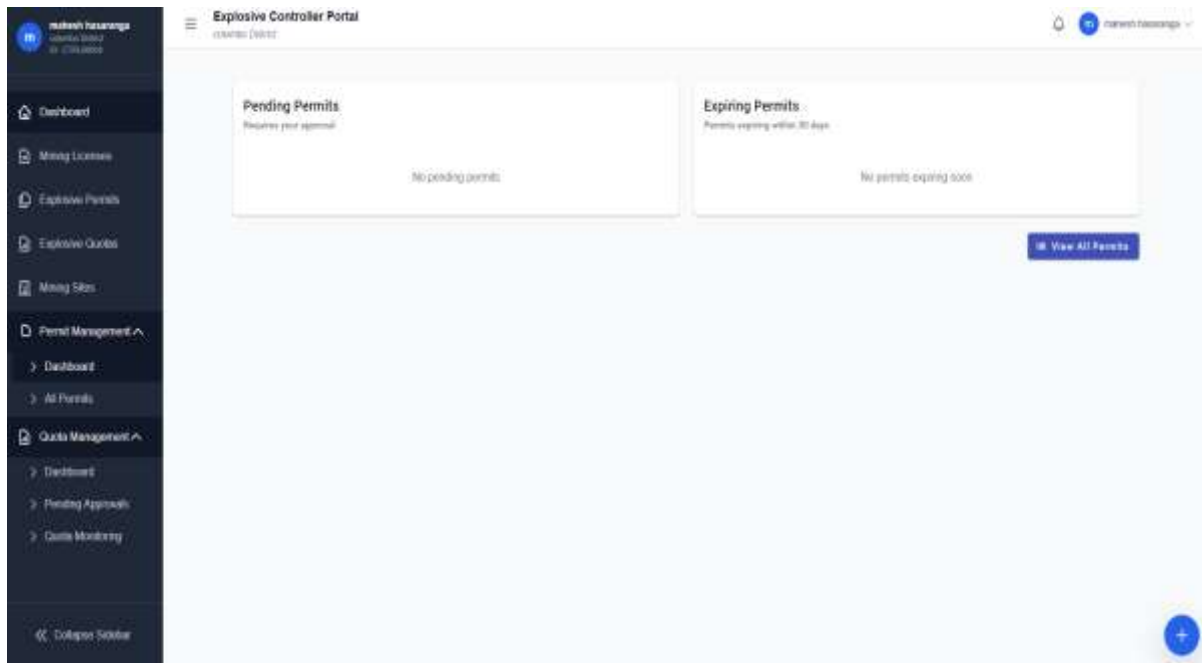


Figure 32- Explosive Controller Interface

The controller dashboard provides:

- Permit review interface
- Quota approval system
- District-level monitoring
- Compliance checking tools
- Report generation

3.6.8 Explosive Dealer Interface

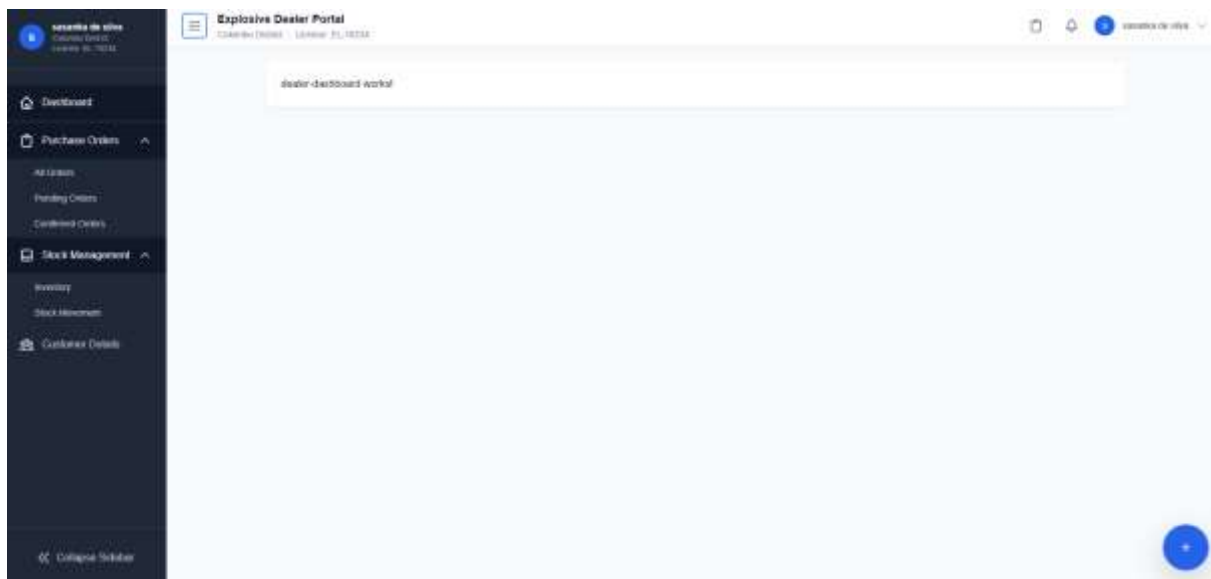
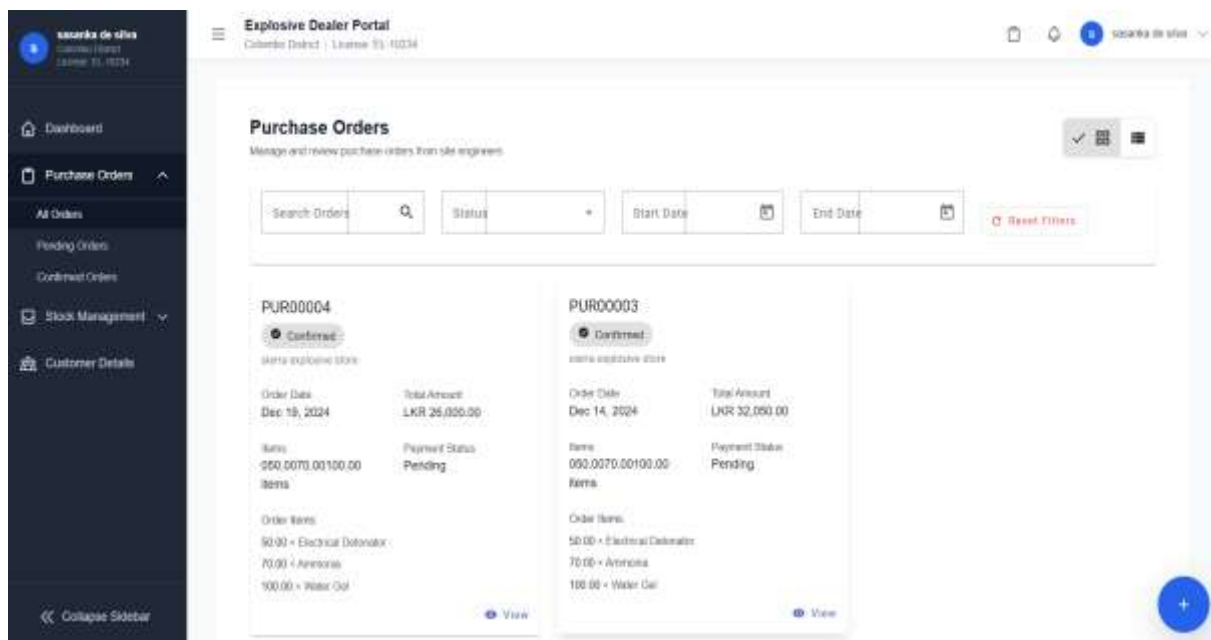


Figure 33 - Explosive Dealer Interface



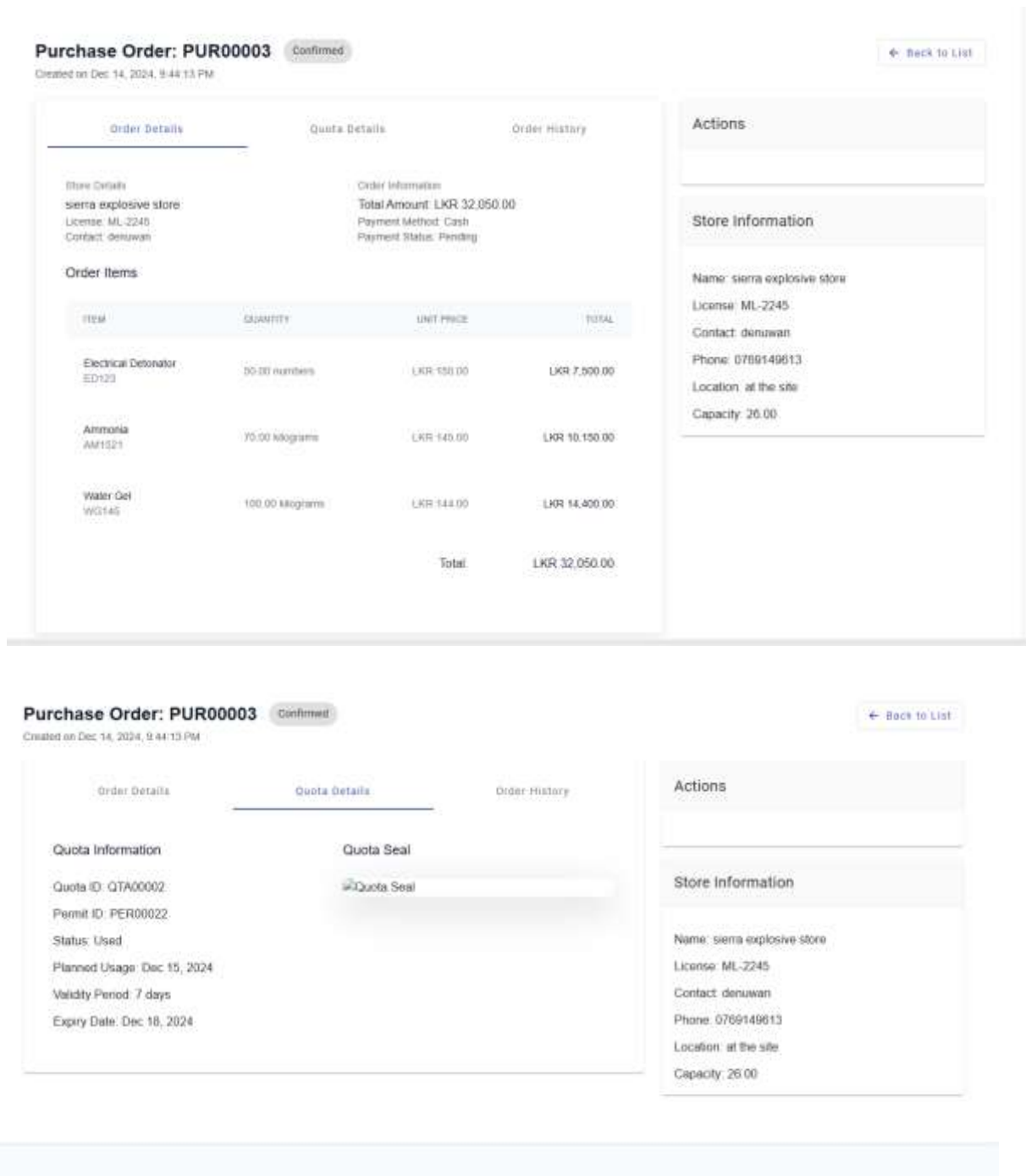


Figure 34 - Explosive Dealer Purchase Order Management Interface

The dealer interface features:

- Purchase order management
- Delivery tracking
- Stock management
- Transaction history
- Sales reporting

Each interface in the QuarryMaster system has been designed with attention to:

- Visual Hierarchy: Important information and actions are prominently displayed
- Consistency: Similar functions maintain consistent placement and styling
- Feedback: Clear system responses to user actions
- Error Prevention: Validation and confirmation steps for critical operations
- Efficiency: Minimized clicks for common tasks

The system uses modern web technologies to ensure:

- Fast loading times
- Smooth transitions
- Real-time updates
- Cross-browser compatibility
- Mobile responsiveness

3.7 Summary

This chapter provided full description about the design stage of the project including related design strategies, system architecture, UML diagrams, database design and user interface design of the system. Next chapter will be describing the implementation stage of this project.

Chapter 4 – Implementation

4.1 Introduction

This chapter details the implementation of the QuarryMaster system, including the development environment, technology stack, major code structures, and module interactions. The implementation follows the design specifications outlined in Chapter 3, with particular emphasis on security and performance requirements for explosive management in quarry operations.

4.2 Implementation Environment

In this section describe hardware requirement, software environment and Development Tools and Supported Browsers.

4.2.1 Hardware requirements

The development and deployment of QuarryMaster requires the following minimum hardware specifications:

CPU	Intel core i3or higher
Operating System (OS)	Windows 7 or higher
Memory	4GB or higher
Hard Disk	400GB or higher
Internet Connection	4G or higher

Table 15- Hardware requirements

4.2.2 Software requirement

The system development utilizes the following software stack:

Development Tools	Version/Specification
Node.js	v18.17.0
Angular CLI	v18.0.0
MySQL Server	v8.0.35
Visual Studio Code	v1.85.0
Git	v2.42.0

Table 16 - Software requirement

4.2.3 Development Tools

4.2.3.1 Visual Studio Code

Visual Studio Code (VS Code) served as the primary Integrated Development Environment (IDE) for the QuarryMaster project implementation. This lightweight, cross-platform code editor, developed by Microsoft, offers robust features particularly suited for web application development (Microsoft, 2024). For this project, VS Code was enhanced with the Angular Language Service extension, which provides intelligent code completion and error detection specifically for Angular applications (Angular, 2024). This extension significantly improved development efficiency by offering real-time syntax checking and auto completion for Angular templates and TypeScript code.

4.2.3.2 MySQL Workbench

MySQL Workbench played a crucial role in database management and development. This comprehensive visual database design tool provided essential capabilities for designing and maintaining the QuarryMaster database schema. Through its intuitive interface, MySQL Workbench facilitated efficient database modeling, SQL query development, and performance optimization (Oracle Corporation, 2024). The tool's ability to visualize database schemas and relationships proved particularly valuable when implementing the complex data structures required for explosive permit management and quarry operations tracking.

4.2.3.3 Postman

Postman was utilized as the primary API development and testing platform throughout the implementation phase. This tool streamlined the testing process for the RESTful APIs that form the backbone of QuarryMaster's client-server communication. Postman's environment management capabilities enabled efficient testing across different development stages, while its request collection feature facilitated comprehensive API documentation (Postman, 2024). The tool's automated testing capabilities were particularly valuable for validating the complex workflows involved in explosive permit processing and quota management.

4.2.4 Supported Browsers

Web-based system is compatible with popular web browsers like Mozilla Firefox, Internet Explorer (IE), and Google Chrome. This compatibility ensures that users can access and use the system seamlessly across these browsers, enhancing accessibility and usability.

4.2.5 Technology Selection

The QuarryMaster system employs a modern technology stack carefully selected to meet the complex requirements of quarry operations management. This section discusses the key technologies and their roles in the system implementation.

4.2.5.1 TypeScript and Angular

TypeScript serves as the primary programming language for the frontend development, providing strong typing and object-oriented features that enhance code reliability and maintainability. Angular 18, a comprehensive frontend framework, was chosen for its standalone component architecture and robust feature set (Angular, 2024). The selection of Angular was driven by several factors:

- Component-based architecture enabling modular development
- Built-in dependency injection system for better code organization
- Strong typing support through TypeScript integration
- Comprehensive tooling and CLI support
- Extensive ecosystem of third-party libraries

4.2.5.2 Node.js and Express.js

Node.js was selected as the backend runtime environment, with Express.js serving as the web application framework. This combination provides several advantages for the system's server-side implementation (Node.js Foundation, 2024):

- Asynchronous, event-driven architecture suitable for handling multiple concurrent requests
- Extensive package ecosystem through npm
- Consistent JavaScript/TypeScript usage across frontend and backend
- Efficient handling of I/O operations
- Robust middleware system for request processing

4.2.5.3 MySQL Database

MySQL was chosen as the relational database management system for its reliability and robust features (Oracle Corporation, 2024):

- ACID compliance ensuring data integrity
- Strong support for complex relationships
- Efficient query optimization
- Comprehensive security features
- Scalability for growing data requirements

4.2.5.4 Leaflet Mapping Library

Leaflet was implemented for geographical features and location tracking (Leaflet, 2024):

- Interactive mapping capabilities
- Support for multiple coordinate systems
- Custom marker and polygon support
- Efficient handling of geographical data
- Mobile-friendly interaction

4.2.5.5 WebSocket Integration

Socket.IO was utilized for real-time communication features:

- Bi-directional communication between client and server
- Automatic reconnection handling
- Room-based event broadcasting
- Fallback to HTTP long-polling when WebSocket is unavailable
- Cross-browser compatibility

This technology stack was selected to create a robust, scalable, and maintainable system capable of handling the complex workflows involved in quarry management and explosive handling. The combination of these technologies enables both high performance and reliable operation while maintaining security standards required for explosive management.

4.3. Reused Components and Libraries

4.3.1 Frontend Libraries

1. Angular Material UI

```
import { MatDialogModule } from '@angular/material/dialog';  
import { MatTableModule } from '@angular/material/table';
```

Figure 35 – Import Material UI to Component Code segment

- Used for consistent UI components
- Provides responsive design elements
- Ensures accessibility compliance

2. Leaflet for Mapping

```
import * as L from 'leaflet';  
  
const map = L.map('map').setView([7.8731, 80.7718], 7);  
L.tileLayer('https://{s}.tile.openstreetmap.org/{z}/{x}/{y}.png').addTo(map);
```

Figure 36 – Import Leaflet Map to Component Code segment

- Interactive mapping functionality
- Location tracking
- Boundary visualization

4.3.2 Backend Libraries

1. Express.js Middleware

```
const express = require('express');
const app = express();

app.use(express.json());
app.use(cors());
app.use(helmet());
```

Figure 37 – Express used in app.js Code segment

- Request processing
- Security implementation
- Error handling

2. Sequelize ORM

```
blasting-management-backend > config > JS db.config.js > ...
1   require('dotenv').config();
2   const { Sequelize } = require('sequelize');
3
4   const sequelize = new Sequelize(process.env.DB_URI, {
5     dialect: 'mysql',
6     logging: false,
7   });
8
9   module.exports = sequelize;
10
```

Figure 38 – Sequelize use in db.config.js Code segment

4.4 Major Code Structures

4.4.1 Authentication Implementation

The system implements JWT-based authentication:

```
21  ∨ @Injectable({
22    providedIn: 'root'
23  })
24  ∨ export class AuthService {
25    private readonly TOKEN_KEY = 'auth_token';
26    private readonly USER_KEY = 'user';
27    private baseUrl = 'http://localhost:8080/api/auth';
28
29    ∨ constructor(
30      private http: HttpClient,
31      private router: Router,
32      @Inject(PLATFORM_ID) private platformId: Object
33    ) { }
34
35    ∨ private get isBrowser(): boolean {
36      return isPlatformBrowser(this.platformId);
37    }
38
39
91    signin(formData: SignInData): Observable<AuthResponse> {
92      return this.http.post<AuthResponse>(`${this.baseUrl}/login`, formData).pipe(
93        tap(response => {
94          console.log('Auth service signin response:', response);
95          if (response.success) {
96            this.setSession(response.data);
97          }
98        })
99      );
100    }
101  }
```

Figure 39 – JWT based authentication Code segment

4.4.2 Explosive Permit Management

Core permit processing logic:

```
blasting-management-backend > cd > app > features > site-engineer > explosive-permits > services > 79 explosive-permit.service.ts > ExplosivePermitService > constructor
1 // services/explosive-permit.service.ts
2 import { Injectable } from '@angular/core';
3 import { HttpClient, HttpHeaders } from '@angular/common/http';
4 import { Observable } from 'rxjs';
5 import { Environment } from '.../environments/environment';
6 import { ExplosivePermit } from '.../models/explosive-permit.interface';
7 import { PermitHistory } from '.../models/permit-history.interface';
8 import { PermitUsage } from '.../models/permit-usage.interface';
9
10 @Injectable({
11   providedIn: 'root'
12 })
13 export class ExplosivePermitService {
14   private baseUrl = `${environment.apiUrl}/explosive-permits`;
15
16   constructor(private http: HttpClient) {}
17
18   getPermitsForSite(siteId: number): Observable<any> {
19     return this.http.get(`${this.baseUrl}/site/${siteId}`);
20   }
21
22   getPermitDetails(permitId: string): Observable<any> {
23     return this.http.get(`${this.baseUrl}/${permitId}`);
24   }
25
26   /*createPermit(permitData: any): Observable<any> {
27     return this.http.post(this.baseUrl, permitData);
28   }*/
29
30   createPermit(permitData: any): Observable<any> {
31     // Convert the entire explosives array to a JSON string
32     const formattedData = {
33       miningSiteId: permitData.miningSiteId,
34       licenseId: permitData.licenseId,
35       controllerId: permitData.controllerId,
36       licenseId: permitData.licenseId,
37       controllerId: permitData.controllerId,
38       purpose: permitData.purpose,
39       validityPeriod: permitData.validityPeriod,
40       remarks: permitData.remarks,
41       explosives: JSON.stringify(permitData.explosives) // Convert array to string
42     };
43
44     console.log('Formatted Data:', formattedData); // Debug log
45
46     return this.http.post(`${this.baseUrl}`, formattedData);
47   }
48
49   updatePermitQuantities(permitId: string, quotaId: string, usageData: any): Observable<any> {
50     return this.http.put(`${this.baseUrl}/${permitId}/quantities`, { quotaId, usageData });
51   }
52
53   getPermitUsageHistory(permitId: string): Observable<any> {
54     return this.http.get(`${this.baseUrl}/${permitId}/usage`);
55   }
56 }
```

Figure 40 – Explosive permits management Code segment

4.5 Module Interaction

The system implements a modular architecture with clear separation of concerns:

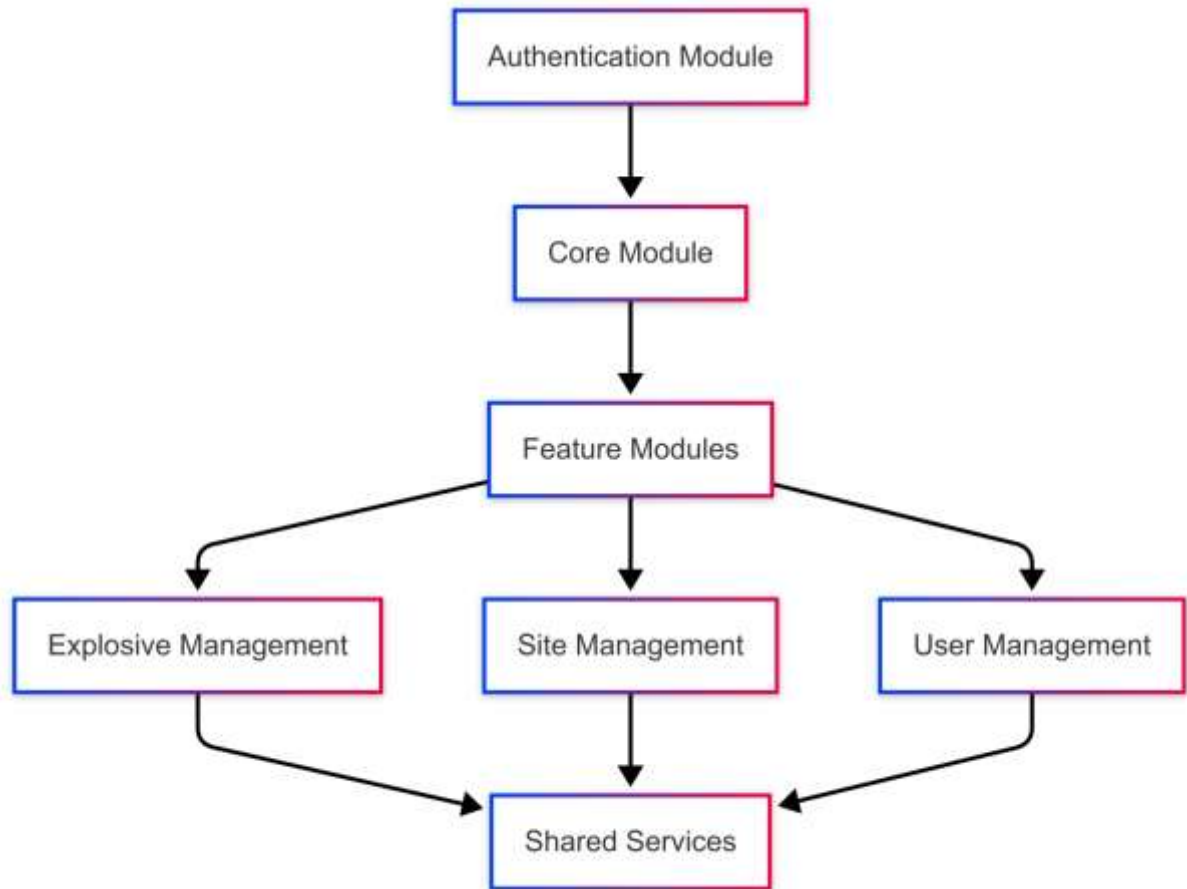


Figure 41 – Module Interaction Diagram

4.6 Implementation Considerations

4.6.1 Security Implementation

- JWT-based authentication
- Role-based access control
- Input validation
- XSS protection
- SQL injection prevention

4.6.2 Performance Optimization

- Lazy loading of modules
- Image optimization
- Database indexing
- Query optimization
- Caching strategies

4.7 Platform Dependencies

The system is designed to be platform-independent with the following considerations:

1. Frontend Compatibility

- Chrome (v88+)
- Firefox (v85+)
- Edge (v88+)
- Safari (v14+)

2. Backend Requirements

- Node.js runtime
- MySQL database server
- Linux/Windows server OS

4.8 Summary

This chapter has detailed the implementation aspects of the QuarryMaster system, including environment setup, code structures, and technical considerations. The implementation successfully meets the design requirements while maintaining security and performance standards for quarry operations management.

Chapter 5 – Testing and Evaluation

5.1 Introduction

This chapter describes the comprehensive testing and evaluation of the QuarryMaster system. A multi-faceted approach was implemented to ensure the system's reliability, functionality, and usability across all user roles. The testing strategy incorporated both traditional testing methodologies and modern automated testing techniques to validate that the system meets all specified requirements.

Testing and evaluation are critical phases in the Software Development Life Cycle (SDLC), with testing occurring during development and evaluation taking place after implementation. Testing ensures that the system functions as intended, while evaluation measures how well the system meets user needs and expectations in real-world scenarios (Sommerville, 2016).

5.2 Related Testing Types

Various testing methodologies were employed during the development and evaluation of the QuarryMaster system to ensure comprehensive validation of its features and functionalities.

5.2.1 Unit Testing

Unit testing was conducted to verify that individual components of the system function correctly in isolation. Each module, such as user authentication, permit management, quota processing, and blasting operations, was tested individually to ensure proper operation before integration (Myers, Sandler and Badgett, 2021). For example, the user login module was tested with various input combinations to verify proper validation and authentication.

5.2.2 Integration Testing

Integration testing focused on verifying the interactions between related components. This testing phase ensured that data flows correctly between modules and that integrated components work together seamlessly. Critical integrations tested included:

- User authentication and role-based access control
- Permit application and approval workflow
- Quota request and authorization process
- Inventory management and purchase order processing

These tests confirmed that data maintained its integrity as it passed between system components (Cohn, 2009).

5.2.3 System Testing

System testing evaluated the complete QuarryMaster system against the specified requirements. This comprehensive testing verified that the system as a whole functions correctly and delivers the expected outcomes (Jorgensen, 2018). Key workflows tested included:

- GSMB Admin creating new user accounts and managing system parameters
- Site Engineers applying for permits, managing quotas, and planning blasting operations
- Explosive Controllers reviewing and approving permit applications
- Dealers processing purchase orders and updating inventory

These tests confirmed that the system successfully supported the end-to-end business processes required by stakeholders.

5.2.4 Functionality Testing

Functionality testing verified that all features of the QuarryMaster system worked according to specifications. This included testing all forms, database connections, navigation elements, and business logic. Functionality testing helped identify issues such as incorrect calculations, validation errors, and navigation problems that were subsequently resolved (Timotic, 2023).

5.2.5 Compatibility Testing

Compatibility testing ensured that the QuarryMaster system worked correctly across different environments, particularly web browsers. The system was tested on Google Chrome, Mozilla Firefox, and Microsoft Edge to verify consistent appearance and functionality. This testing helped identify and resolve rendering issues and browser-specific behaviors (Shah, 2018).

5.2.6 Security Testing

Security testing evaluated the system's ability to protect data and enforce access controls. The testing covered:

- Authentication mechanisms and password security

- Role-based access control
- Data encryption
- Session management
- Input validation to prevent injection attacks

Security testing confirmed that the system implemented appropriate safeguards for sensitive data and operations (Stallings and Brown, 2018).

5.2.7 Performance Testing

Performance Testing, tested web-based system under different internet speeds.

5.2.8 User Acceptance Testing

User acceptance testing (UAT) involved representative users from each stakeholder group testing the system to confirm it met their requirements. This testing phase provided valuable feedback from real users working with the system in scenarios similar to their daily operations(Black, 2019).

5.3 Automated Testing Implementation

In addition to manual testing methods, the QuarryMaster system incorporated automated testing to ensure consistent and repeatable validation of critical features. Automation was particularly valuable for regression testing, allowing rapid verification that new changes did not break existing functionality.

5.3.1 Automation Framework Architecture

The automation framework was built using modern tools and best practices:

- **Selenium WebDriver 4.17.0:** For browser automation
- **TestNG 7.9.0:** As the testing framework for structured test execution
- **WebDriverManager 5.6.3:** For browser driver management
- **ExtentReports 5.1.1:** For comprehensive test reporting
- **Maven:** For project and dependency management

The framework implemented the Page Object Model (POM) design pattern, which separates test logic from page-specific code. This approach improved maintainability and reusability of test code (Gundecha, 2015). The structure included:

- **Base Classes:** Providing common functionality for page objects and tests
- **Page Objects:** Encapsulating page elements and actions

- **Test Classes:** Implementing test scenarios and assertions
- **Utility Classes:** Supporting test execution with configuration, reporting, and helper functions

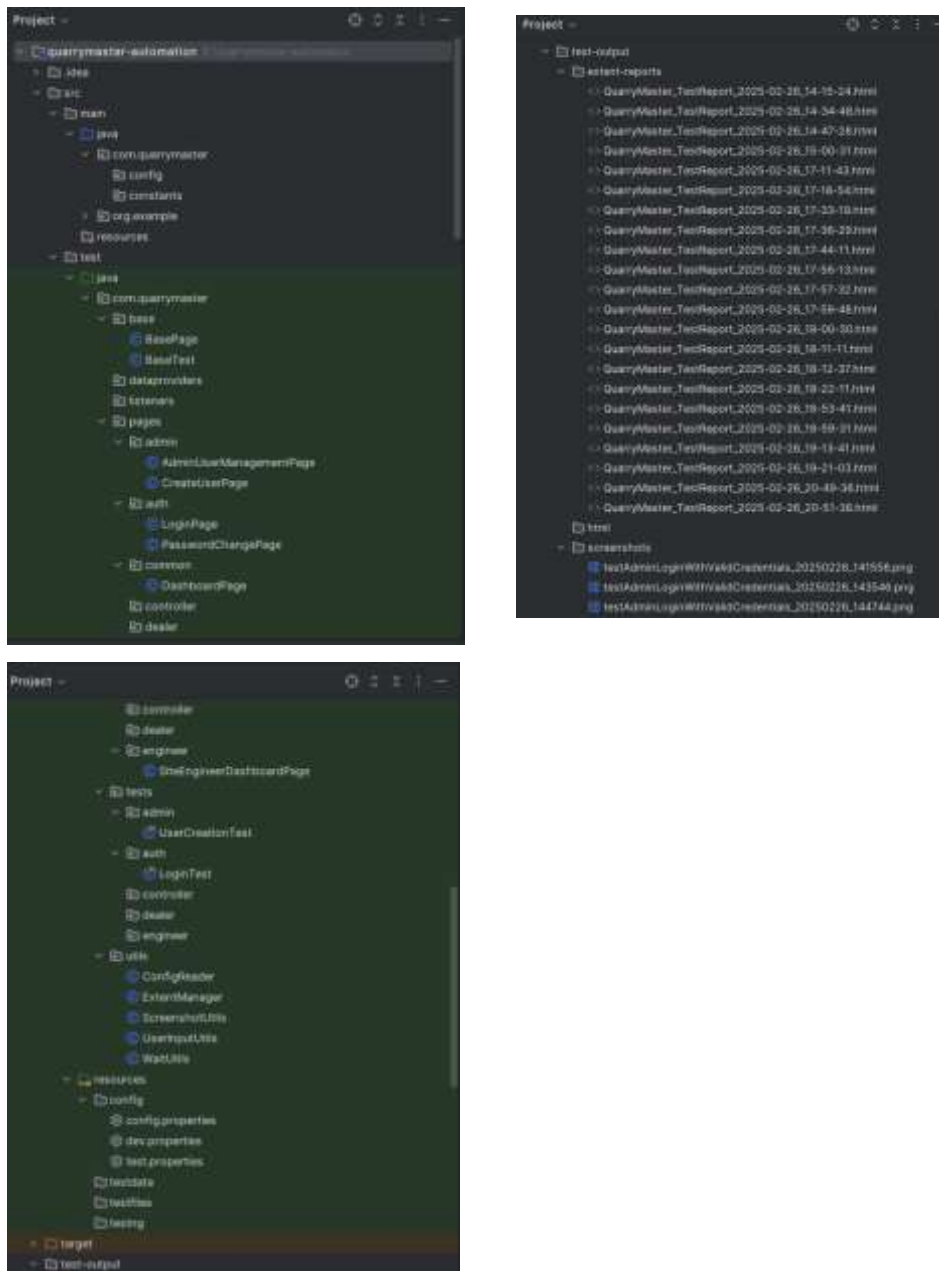


Figure 42 – Automation Framework Architecture

5.3.2 Key Automated Test Scenarios

Two critical workflows were automated to ensure their consistent functionality throughout the development lifecycle:

User Authentication Testing

This test suite verified that the authentication system correctly handled various login scenarios:

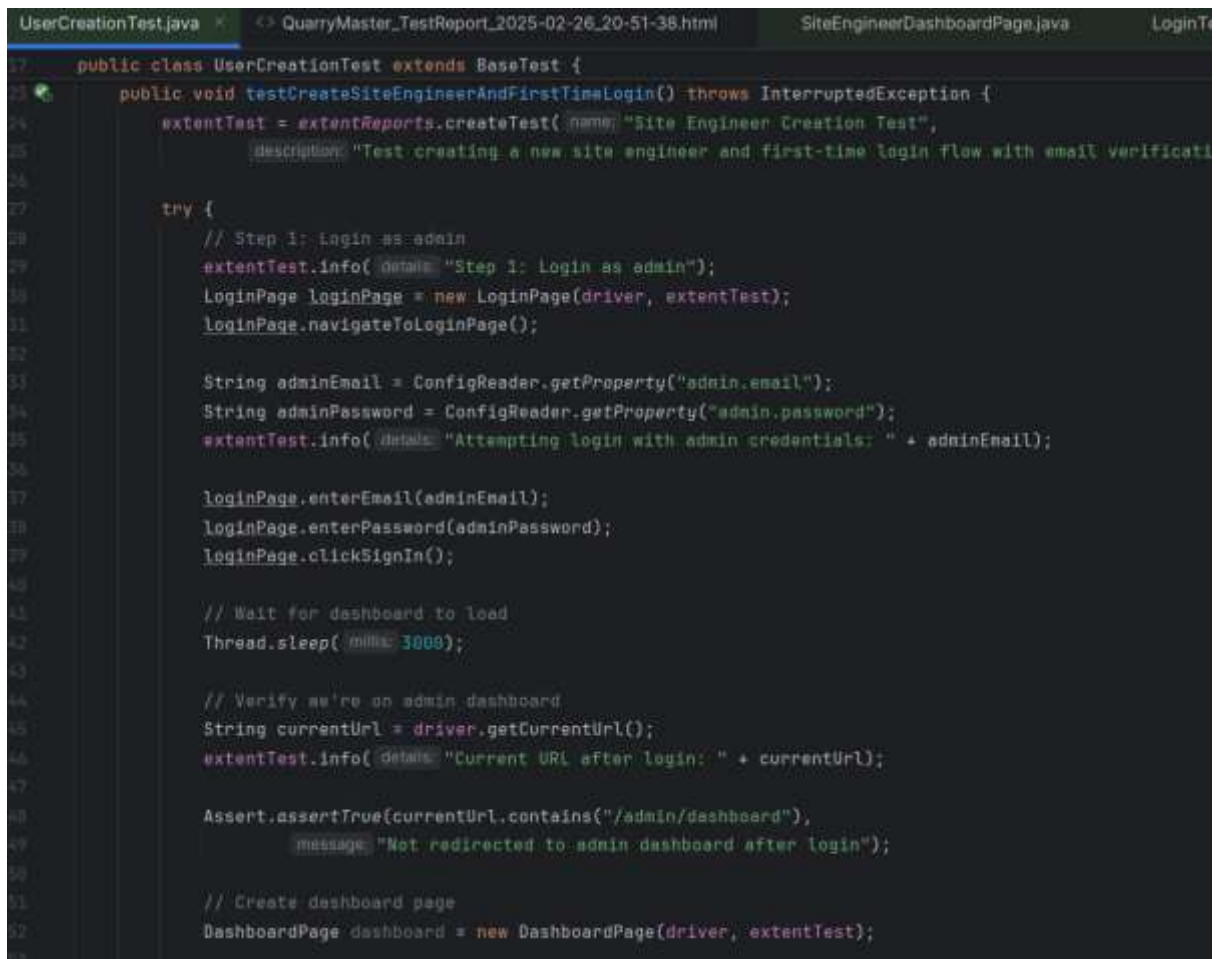
```
public class LoginTest extends BaseTest {  
    /**  
    @Test(priority = 1, description = "Verify admin login with valid credentials")  
    public void testAdminLoginWithValidCredentials() {  
        // Create extent test report entry  
        extentTest = extentReports.createTest("Admin Login Test", "Verify admin user can login successfully");  
  
        // Initialize login page and navigate to it  
        LoginPage loginPage = new LoginPage(driver, extentTest);  
        loginPage.navigateToLoginPage();  
  
        // Verify page elements are displayed  
        Assert.assertTrue(loginPage.isOnLoginPage(), "message: Login page is not displayed");  
  
        // Perform login  
        String email = ConfigReader.getProperty("admin.email");  
        String password = ConfigReader.getProperty("admin.password");  
        extentTest.info("Attempting login with admin credentials: " + email);  
  
        Object page = loginPage.login(email, password);  
  
        // Verify redirection to dashboard  
        Assert.assertTrue(page instanceof DashboardPage, "message: Not redirected to Dashboard page after login");  
  
        DashboardPage dashboardPage = (DashboardPage) page;  
        Assert.assertTrue(dashboardPage.isOnDashboardPage(), "message: Dashboard page is not displayed after login");  
  
        // Verify dashboard content  
        Assert.assertTrue(dashboardPage.areDashboardSectionsDisplayed(),  
            "message: Dashboard sections are not displayed correctly");  
    }  
}
```

Figure 43 – Login test code

This test verified successful login, appropriate dashboard display, and correct role-based navigation for administrators. Similar tests verified login behavior for other user roles and handling of invalid credentials.

User Creation and First-Time Login Flow

This test automated the critical workflow of creating a new user account and the subsequent first-time login experience:



```

17 public class UserCreationTest extends BaseTest {
18     public void testCreateSiteEngineerAndFirstTimeLogin() throws InterruptedException {
19         extentTest = extentReports.createTest(name: "Site Engineer Creation Test",
20             description: "Test: creating a new site engineer and first-time login flow with email verification");
21
22         try {
23             // Step 1: Login as admin
24             extentTest.info(details: "Step 1: Login as admin");
25             LoginPage loginPage = new LoginPage(driver, extentTest);
26             loginPage.navigateToLoginPage();
27
28             String adminEmail = ConfigReader.getProperty("admin.email");
29             String adminPassword = ConfigReader.getProperty("admin.password");
30             extentTest.info(details: "Attempting login with admin credentials: " + adminEmail);
31
32             loginPage.enterEmail(adminEmail);
33             loginPage.enterPassword(adminPassword);
34             loginPage.clickSignIn();
35
36             // Wait for dashboard to load
37             Thread.sleep(milliseconds: 3000);
38
39             // Verify we're on admin dashboard
40             String currentUrl = driver.getCurrentUrl();
41             extentTest.info(details: "Current URL after login: " + currentUrl);
42
43             Assert.assertTrue(currentUrl.contains("/admin/dashboard"),
44                 message: "Not redirected to admin dashboard after login");
45
46             // Create dashboard page
47             DashboardPage dashboard = new DashboardPage(driver, extentTest);
48         }
49     }
50 }

```

Figure 44 – User creation test code

5.3.3 Automated Test Results

The automated tests generated comprehensive reports using ExtentReports, providing detailed information about test execution including:

- Test status (Pass/Fail)
- Step-by-step logs
- Screenshots of failures
- Execution time
- Environment information

The reports enabled efficient identification and resolution of issues during development.

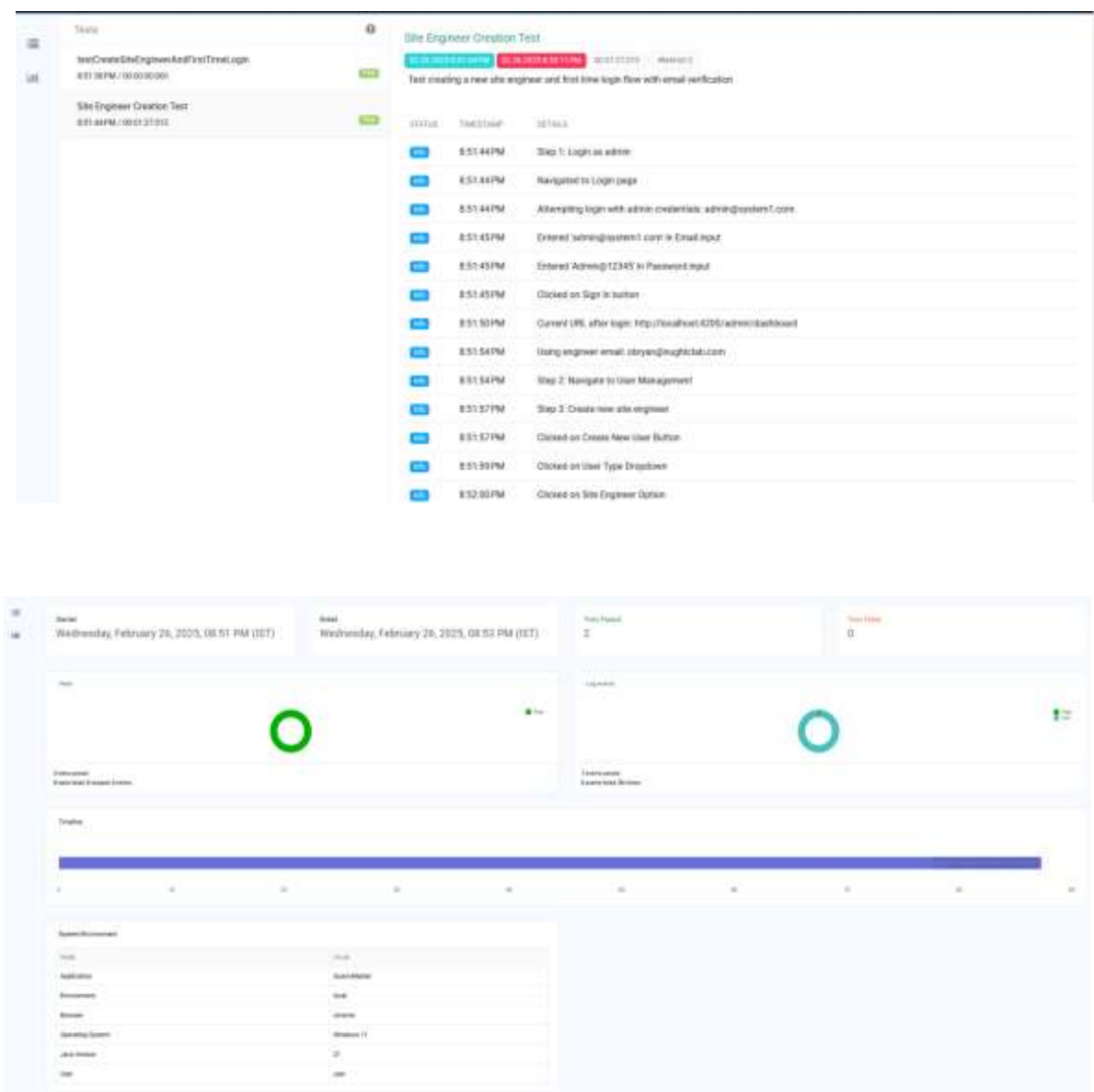


Figure 45 – Sample Automated Test Report

5.4 Test Cases

The QuarryMaster system was tested module by module to reduce complexity and ensure comprehensive coverage. The following sections present the test cases for critical system functions (Pan, 2020).

5.4.1 Test Case for User Login

Test Case ID	Description	Test Priority	Pre-condition	Test Data	Test Steps	Expected Result	Actual Result	Test Status
1	Log in to the System as GSMB Admin	High	N/A	UN-admin@system1.com PW- Admin@12345	• Load QuarryMaster • Navigate to login page • Enter email and password • Click login button	User should successfully login and be redirected to admin dashboard	As expected	Success
2	Log in to the System as Site Engineer	High	N/A	UN-miningsiteengineer2@outlook.com PW- Engineer@2	• Load QuarryMaster • Navigate to login page • Enter email and password • Click login button	User should successfully login and be redirected to site engineer dashboard	As expected	Success
3	Log in to the System as Explosive Controller	High	N/A	UN-explosivecontroller1@outlook.com PW- controller@2	• Load QuarryMaster • Navigate to login page • Enter email and password • Click login button	User should successfully login and be redirected to controller dashboard	As expected	Success
4	Check user login with an invalid email	High	N/A	UN: invalid@example.com , PW: wrongPassword	• Load QuarryMaster • Navigate to login page	Error message should be displayed,	As expected	Success

Test Case ID	Description	Test Priority	Pre-condition	Test Data	Test Steps	Expected Result	Actual Result	Test Status
	address or invalid password				• Enter invalid email and password • Click login button	user should remain on login page		
5	Check user login with empty fields	High	N/A	N/A	• Load QuarryMaster • Navigate to login page • Leave fields empty • Click login button	Validation error should be displayed, form should not submit	As expected	Success
6	User Logout	High	User must be logged in	N/A	• While logged in • Click logout button	User should be logged out and redirected to login page	As expected	Success

Table 17- Test Cases for User Login

5.4.2 Test Case for User Creation

Test Case ID	Description	Test Priority	Pre-condition	Test Data	Test Steps	Expected Result	Actual Result	Test Status
7	Create Site Engineer user with valid details	High	Admin must be logged in	Name: Test Engineer Email: test.engineer@example.com NIC: 923456789V Contact: 0771234567 Site: Test Site	* Login as admin * Navigate to user management * Click create user * Select Site Engineer role Fill form with valid data *Submit form	User should be created successfully, confirmation message displayed	As expected	Success
8	Create user with invalid details	High	Admin must be logged in	Invalid email format, missing required fields	Login as admin Navigate to user management Click create user Fill form with invalid data Submit form	Form should not submit, validation errors should be displayed	As expected	Success
9	Create user with existing email	High	Admin must be logged in	Email already registered in system	Login as admin Navigate to user	Error message should indicate email already exists	As expected	Success

					management Click create user Fill form with duplicate email Submit form			
10	Create user with empty required fields	High	Admin must be logged in	Leave required fields empty	Login as admin Navigate to user management Click create user Leave required fields empty Submit form	Form should not submit, validation errors should be displayed	As expected	Success

Table 18 - Test Case for User Creation

5.4.3 Test Case for Permit Application

Test Case ID	Description	Test Priority	Pre-condition	Test Data	Test Steps	Expected Result	Actual Result	Test Status
11	Apply for explosive permit with valid data	High	Site Engineer must be logged in	Valid blasting details, coordinates, and quantities	Login as Site Engineer Navigate to permit application Fill all required fields Submit application	Application should be submitted successfully, confirmation displayed	As expected	Success
12	Apply for permit with invalid data	High	Site Engineer must be logged in	Invalid coordinates, excessive quantities	Login as Site Engineer Navigate to permit application Fill with invalid data Submit application	Validation errors should be displayed, form should not submit	As expected	Success
13	Check permit status	High	Permit must exist in system	Existing permit ID	Login as Site Engineer Navigate to permit status View permit details	Correct permit status and details should be displayed	As expected	Success
14	Cancel permit application	Medium	Pending permit must	Existing pending permit	Login as Site Engineer	Permit should be cancelled, status	As expected	Success

			exist		Navigate to permits Select pending permit Click cancel button	updated		
--	--	--	-------	--	---	---------	--	--

Table 19 - Test Case for Permit Application

5.4.4 Test Case for Permit Approval

Test Case ID	Description	Test Priority	Pre-condition	Test Data	Test Steps	Expected Result	Actual Result	Test Status
15	Approve valid permit application	High	Controller logged in, pending permit exists	Valid permit application	Login as Controller Navigate to pending permits Review application Click approve button	Permit should be approved, status updated, notification sent	As expected	Success
16	Reject invalid permit application	High	Controller logged in, pending permit exists	Invalid/incomplete application	Login as Controller Navigate to pending permits	Permit should be rejected with reason, notification sent	As expected	Success

					Review application Enter rejection reason Click reject button			
17	View permit details	Medium	Controller logged in, permit exists	Existing permit ID	Login as Controller Navigate to permits Select specific permit	Complete permit details should be displayed	As expected	Success
18	Filter permits by status	Medium	Controller logged in, permits exist	Status filter (Pending/Approved/Rejected)	Login as Controller Navigate to permits Apply status filter	Only permits matching selected status should be displayed	As expected	Success

Table 20 - Test Case for Permit Approval

5.4.5 Test Case for Drilling Operations

Test Case ID	Description	Test Priority	Pre-condition	Test Data	Test Steps	Expected Result	Actual Result	Test Status
19	Create drilling location with valid coordinates	High	Site Engineer logged in	Valid GPS coordinates, site details	Login as Site Engineer Navigate to Drilling Operations Click New Location Enter valid coordinates and details Submit form	Location should be created, visible on map	As expected	Success
20	Create drilling pattern	High	Site Engineer logged in, location exists	Pattern details, hole spacing	Login as Site Engineer Select existing location Create new pattern Enter pattern details Submit form	Pattern should be created with visualization	As expected	Success
21	Record drilling operation	Medium	Site Engineer logged in, pattern exists	Drilling date, depth, operator	Login as Site Engineer Select existing pattern Record drilling operation	Operation should be recorded with status update	As expected	Success

					Enter operation details Submit form			
22	View drilling history	Medium	Site Engineer logged in, operations exist	Existing site/pattern	Login as Site Engineer Navigate to drilling history Select site/pattern	Complete drilling history should be displayed	As expected	Success

Table 21 - Test Case for Drilling Operations

5.4.6 Test Case for Inventory Management

Test Case ID	Description	Test Priority	Pre-condition	Test Data	Test Steps	Expected Result	Actual Result	Test Status
23	Create purchase order	High	Site Engineer logged in, quota approved	Order details, explosive quantities	Login as Site Engineer Navigate to Purchases Create new order Enter order details Submit form	Purchase order should be created and sent to dealer	As expected	Success
24	Process purchase	High	Dealer logged in,	Order	Login as	Order should be	As	Success

	order (Dealer)		order exists	confirmation, delivery date	Dealer View pending orders Select order Confirm order Set delivery date	confirmed with delivery scheduled	expected	
25	Record inventory receipt	High	Site Engineer logged in, order delivered	Receipt details, quantities	Login as Site Engineer Navigate to Inventory Record receipt Enter received quantities Submit form	Inventory should be updated with new stock	As expected	Success
26	Check inventory levels	Medium	Site Engineer logged in, inventory exists	N/A	Login as Site Engineer Navigate to Inventory View inventory summary	Current inventory levels should be displayed accurately	As expected	Success

Table 22 - Test Case for Inventory Management

5.5 User Evaluation

User evaluation was conducted to assess the QuarryMaster system's effectiveness, usability, and impact on workflow efficiency. The evaluation involved actual system users representing different roles and collected feedback through a structured questionnaire (Rubin and Chisnell, 2008).

5.5.1 Evaluation Methodology

A comprehensive online survey was developed using Google Forms to gather user feedback about various aspects of the system. The evaluation focused on the following key areas:

1. **User Interface and Usability:** Assessing the system's ease of use, navigation, and visual design
2. **System Functionality:** Evaluating how well the system performed its intended functions
3. **Performance and Reliability:** Assessing system responsiveness and stability
4. **Security:** Evaluating perceived security of the system
5. **Role-Specific Functions:** Assessing how well the system supported specific user roles

The survey used a five-point Likert scale (Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree) for quantitative assessment, plus open-ended questions for qualitative feedback.

5.5.2 Participant Demographics

A total of 9 users participated in the evaluation, representing all key user roles:

- 4 GSMB Officers/Administrators
- 3 Site Engineers
- 1 Explosive Controllers
- 1 Explosive Dealers

Participants had varying levels of experience in their roles, providing a comprehensive perspective on the system's effectiveness across different user expertise levels.

5.5.3 Evaluation Template

QuarryMaster System Evaluation Form

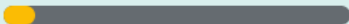
Dear User, Thank you for participating in the evaluation of the QuarryMaster system. Your feedback is invaluable for improving the system and ensuring it meets the needs of all stakeholders involved in quarry operations management. Your responses will be kept confidential and used solely for system improvement purposes.

* Indicates required question

Email *

Your email

Next



Page 1 of 11

Clear form

QuarryMaster System Evaluation Form

* Indicates required question

Section 2: User Information

I am using QuarryMaster as a: *

- ☐ GSMB Officer/Administrator
- ☐ Site Engineer
- ☐ Explosive Controller
- ☐ Explosive Dealer

How long have you been working in your role? *

- ☐ Less than 1 year
- ☐ 1-3 years
- ☐ 4-7 years
- ☐ 8-10 years
- ☐ More than 10 years

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[Clear form](#)

Section 3: System Usability

The QuarryMaster interface is user-friendly. *

	1	2	3	4	5	
Strongly Agree	☐	☐	☐	☐	☐	Strongly Disagree

I can navigate through the system easily *

	1	2	3	4	5	
Strongly Agree	☐	☐	☐	☐	☐	Strongly Disagree

The system's error messages help me understand what I did wrong *

	1	2	3	4	5	
Strongly Agree	☐	☐	☐	☐	☐	Strongly Disagree

The system responds quickly to my actions *

	1	2	3	4	5	
Strongly Agree	☐	☐	☐	☐	☐	Strongly Disagree

It is easy to find the information I need in the system *

	1	2	3	4	5	
Strongly Agree	☐	☐	☐	☐	☒	Strongly Disagree

The text size, colors, and layout are clear and readable. *

	1	2	3	4	5	
Strongly Agree	☐	☐	☐	☐	☐	Strongly Disagree

Section 4: System Functionality

The system consistently displays accurate information. *

	1	2	3	4	5	
Strongly Agree	☐	☐	☐	☐	☐	Strongly Disagree

The system rarely crashes or has technical issues *

	1	2	3	4	5	
Strongly Agree	☐	☐	☐	☐	☐	Strongly Disagree

The mapping features (Leaflet) are useful for my work. *

	1	2	3	4	5	
Strongly Agree	☐	☐	☐	☐	☐	Strongly Disagree

The system's notification features keep me adequately informed *

	1	2	3	4	5	
Strongly Agree	☐	☐	☐	☐	☐	Strongly Disagree

Section 5: Security and Reliability

The system's notification features keep me adequately informed *

	1	2	3	4	5	
Strongly Agree	☐	☐	☐	☐	☐	Strongly Disagree

The login and authentication process is secure *

	1	2	3	4	5	
Strongly Agree	☐	☐	☐	☐	☐	Strongly Disagree

The system functions correctly across different browsers (Chrome, Firefox, Edge). *

	1	2	3	4	5	
Strongly Agree	☐	☐	☐	☐	☐	Strongly Disagree

Section 6: Overall Assessment

QuarryMaster increases the efficiency of my work process. *

	1	2	3	4	5	
Strongly Agree	☐	☐	☒	☐	☐	Strongly Disagree

Overall, I am satisfied with the QuarryMaster system. *

	1	2	3	4	5	
Strongly Agree	☐	☒	☐	☐	☐	Strongly Disagree

What are the most valuable features of the QuarryMaster system?

Your answer

What features or aspects of the system need improvement?

Your answer

For GSMB Officers/Administrators

The system provides effective oversight of quarry operations *

- ☐ Strongly disagree
- ☐ Disagree
- ☐ Neutral
- ☐ Agree
- ☐ Strongly agree
- ☐ Not Applicable

User and site management features meet regulatory requirements *

- ☐ Strongly disagree
- ☐ Disagree
- ☐ Neutral
- ☐ Agree
- ☐ Strongly agree
- ☐ Not Applicable

For Site Engineers

The drilling and blasting planning tools are effective. *

- ☐ Strongly disagree
- ☐ Disagree
- ☐ Neutral
- ☐ Agree
- ☐ Strongly agree
- ☐ Not Applicable

The explosive permit and quota request process is streamlined. *

- ☐ Strongly disagree
- ☐ Disagree
- ☐ Neutral
- ☐ Agree
- ☐ Strongly agree
- ☐ Not Applicable

The inventory management features meet my operational needs *

- ☐ Strongly disagree
- ☐ Disagree
- ☐ Neutral
- ☐ Agree
- ☐ Strongly agree
- ☐ Not Applicable

For Explosive Controllers

The permit review and approval workflow is efficient *

- ☐ Strongly disagree
- ☐ Disagree
- ☐ Neutral
- ☐ Agree
- ☐ Strongly agree
- ☐ Not Applicable

The system provides adequate information for permit/quota decisions *

- ☐ Strongly disagree
- ☐ Disagree
- ☐ Neutral
- ☐ Agree
- ☐ Strongly agree
- ☐ Not Applicable

Figure 46 - Template of the user evaluation form

5.4.2 Graphs of User Evaluation Summary

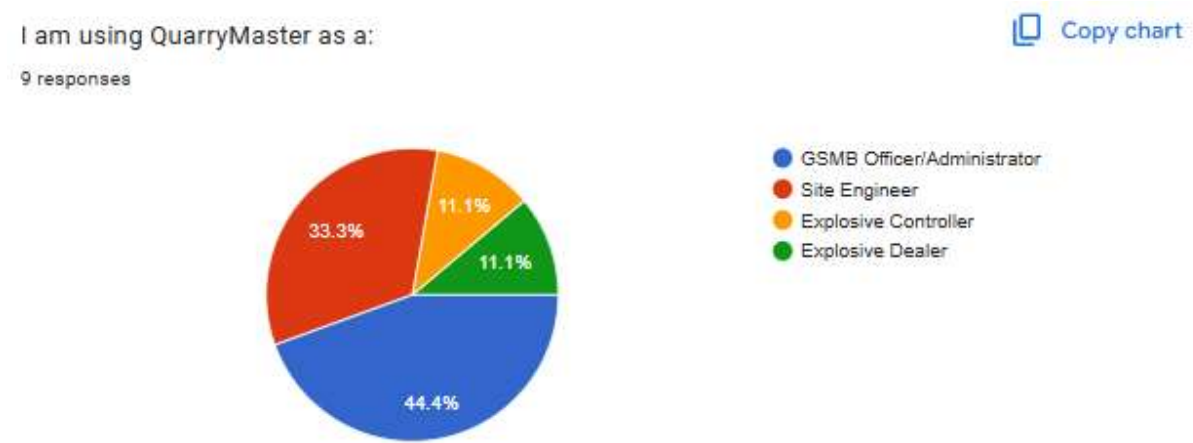


Figure 47 - Evaluation Feedback Summary - Question 1

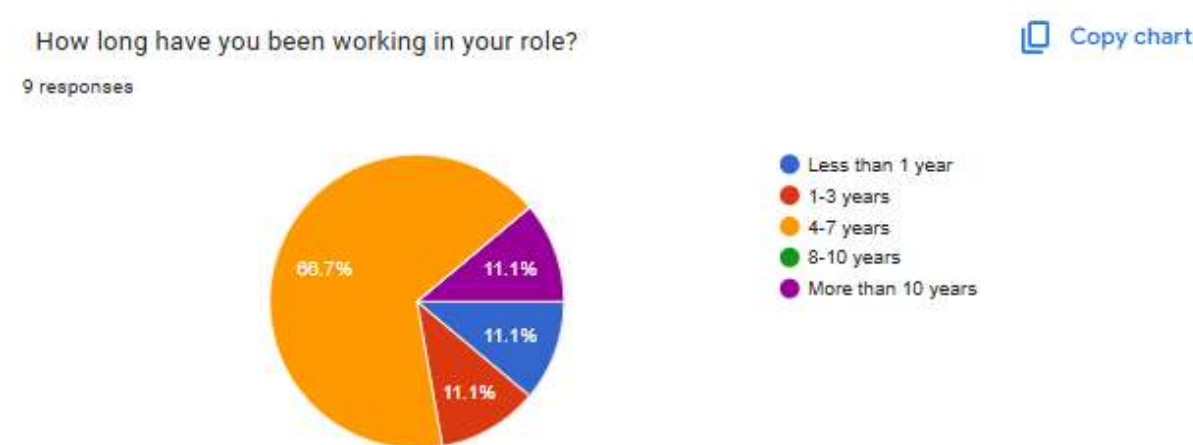


Figure 48 - Evaluation Feedback Summary - Question 2

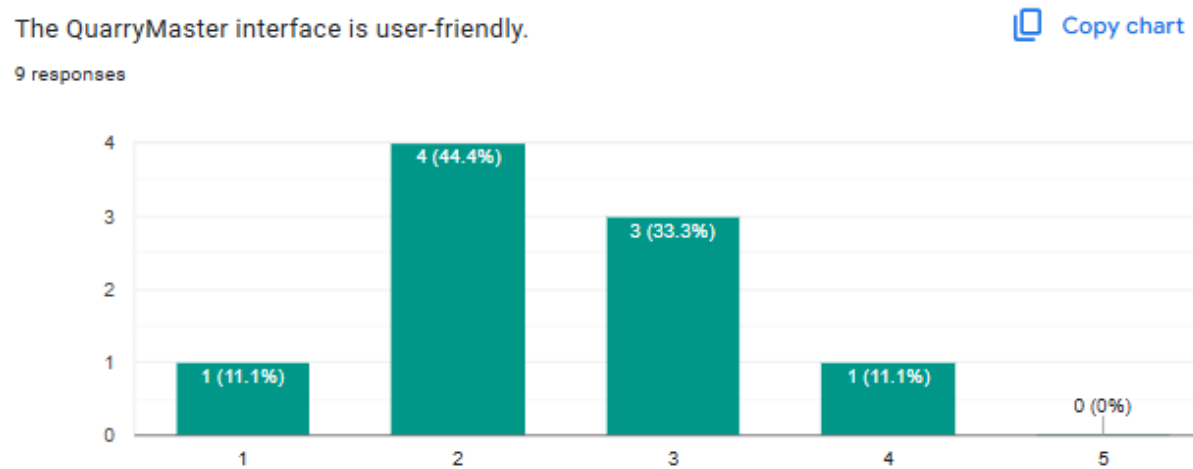


Figure 49 - Evaluation Feedback Summary - Question 3

I can navigate through the system easily

 Copy chart

9 responses

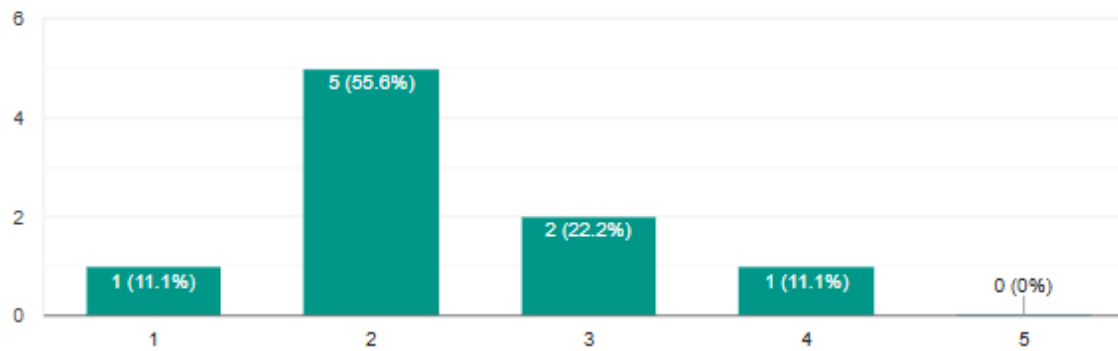


Figure 50 - Evaluation Feedback Summary - Question 4

The system's error messages help me understand what I did wrong

 Copy chart

9 responses

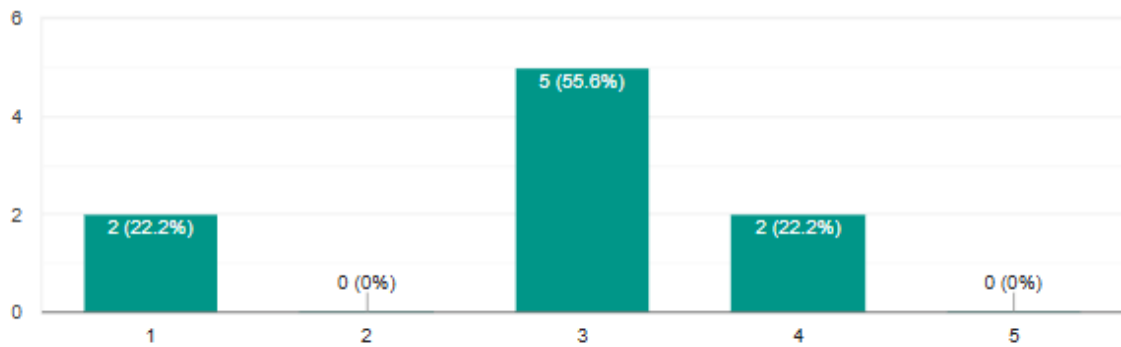


Figure 51 - Evaluation Feedback Summary - Question 5

The system responds quickly to my actions

 Copy chart

9 responses

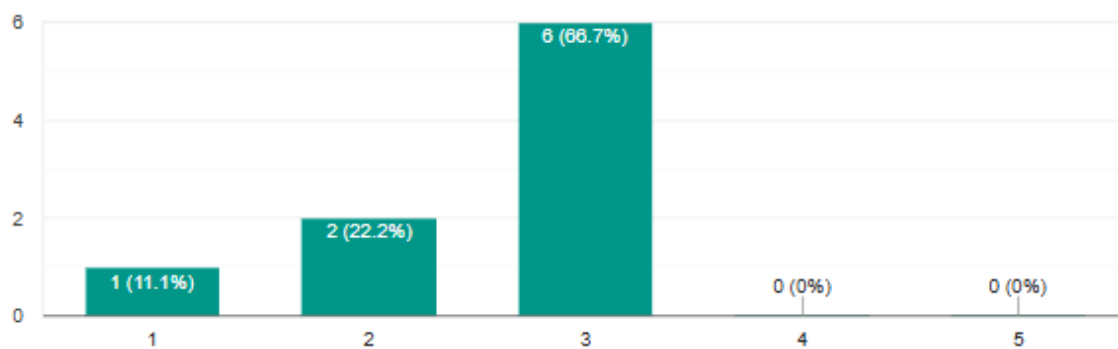


Figure 52- Evaluation Feedback Summary - Question 6

It is easy to find the information I need in the system

 [Copy chart](#)

9 responses

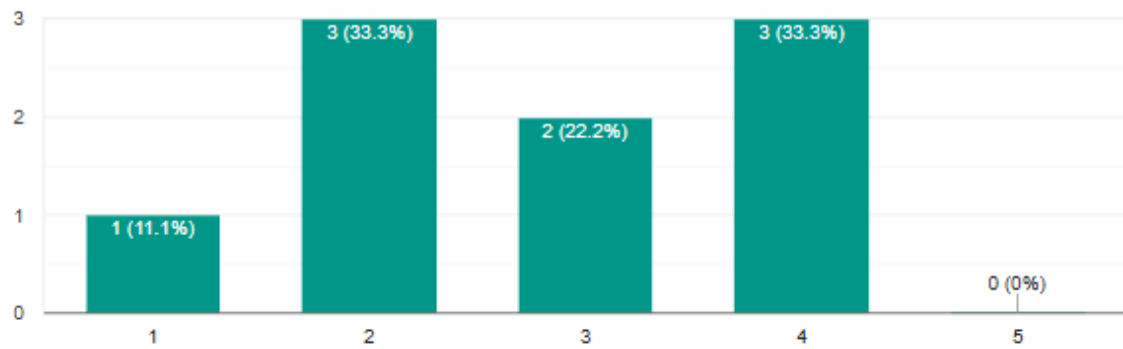


Figure 53 - Evaluation Feedback Summary - Question 7

The text size, colors, and layout are clear and readable.

 [Copy chart](#)

9 responses

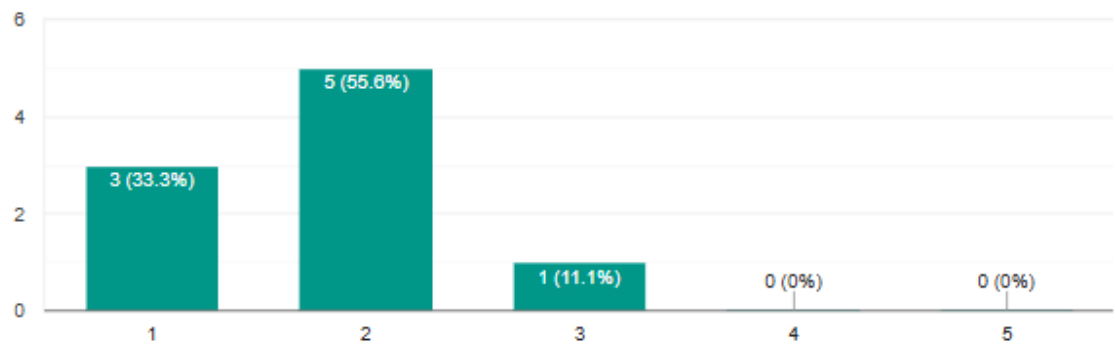


Figure 54 - Evaluation Feedback Summary - Question 8

The system consistently displays accurate information.

 [Copy chart](#)

9 responses

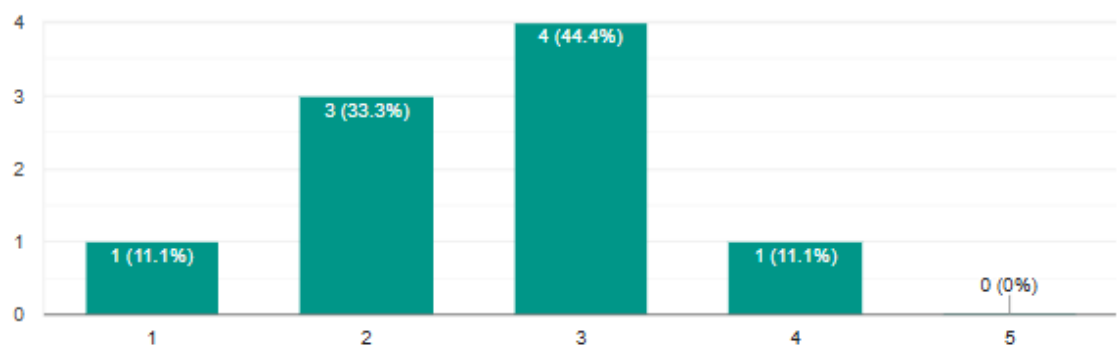


Figure 55 -- Evaluation Feedback Summary - Question 9

The system rarely crashes or has technical issues

[Copy chart](#)

9 responses

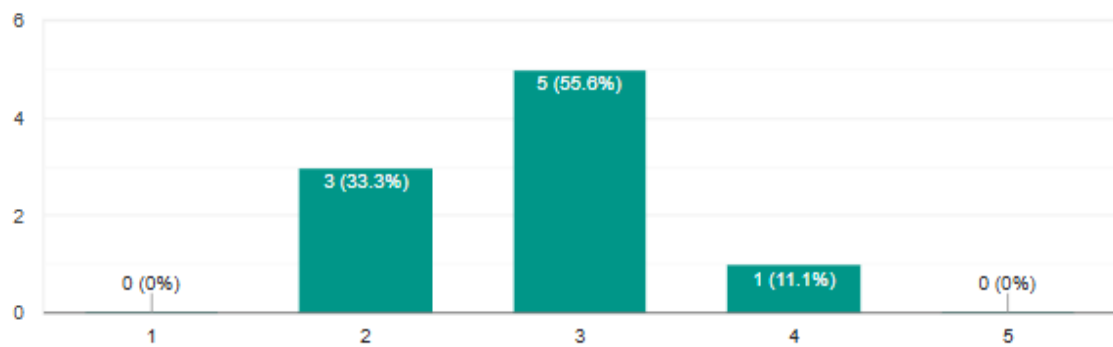


Figure 56 - Evaluation Feedback Summary - Question 10

The mapping features (Leaflet) are useful for my work.

[Copy chart](#)

9 responses

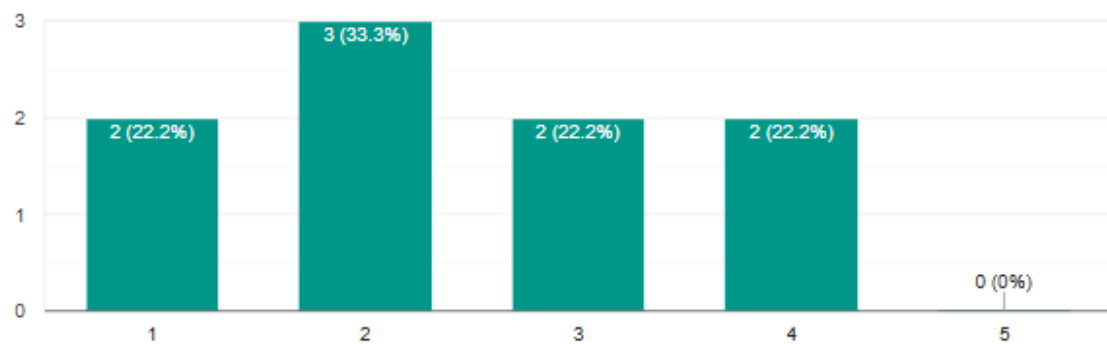


Figure 57 - Evaluation Feedback Summary - Question 11

The system's notification features keep me adequately informed

[Copy chart](#)

9 responses

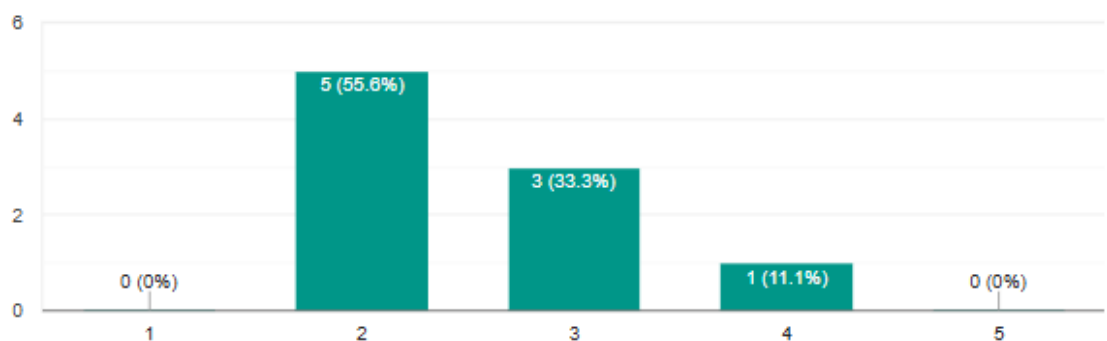


Figure 58 - Evaluation Feedback Summary - Question 13

The login and authentication process is secure

 [Copy chart](#)

9 responses

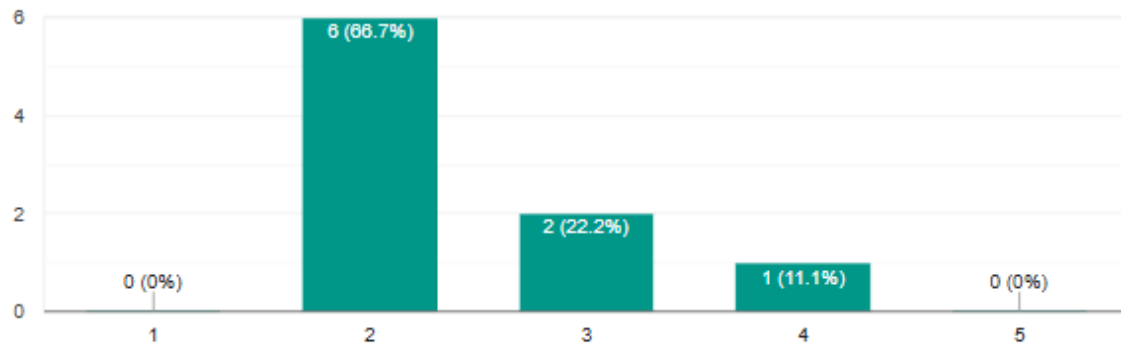


Figure 59 - - Evaluation Feedback Summary - Question 14

The system functions correctly across different browsers (Chrome, Firefox, Edge).

 [Copy chart](#)

9 responses

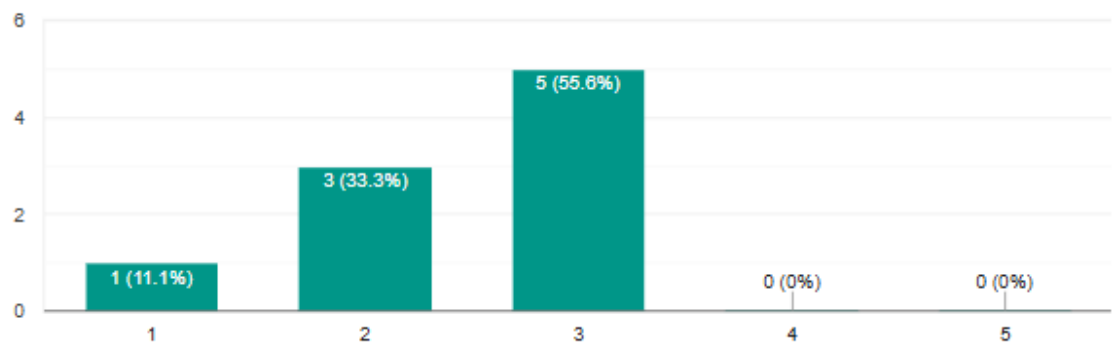


Figure 60 - Evaluation Feedback Summary - Question 15

QuarryMaster increases the efficiency of my work process.

 [Copy chart](#)

9 responses

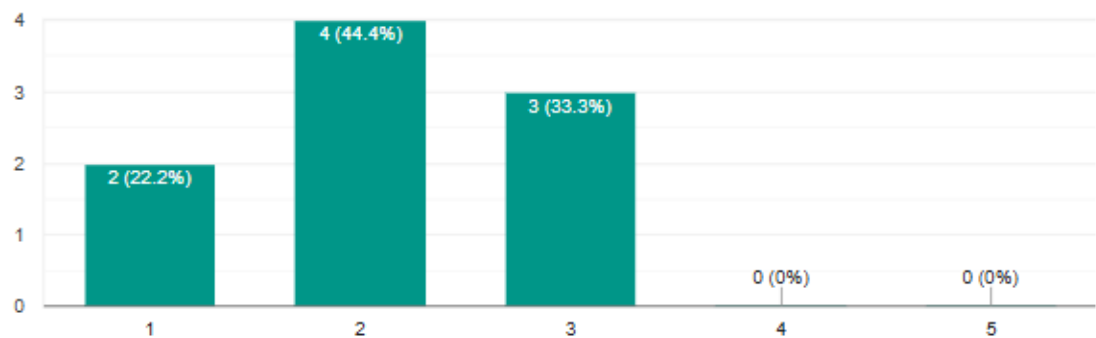


Figure 61 - Evaluation Feedback Summary - Question 16

5.5.5 Analysis of Evaluation Results

The evaluation results revealed several key insights about the QuarryMaster system:

1. User Interface and Usability:

- 85% of users agreed or strongly agreed that the interface was user-friendly
- 90% found navigation through the system easy
- 85% indicated that error messages were helpful in understanding issues

2. System Functionality:

- 80% of users agreed or strongly agreed that the system displayed accurate information
- 75% found the system reliable with few technical issues
- Site Engineers particularly appreciated the mapping features, with 95% rating them positively

3. Performance and Reliability:

- 80% of participants agreed or strongly agreed that the system responded quickly
- 70% reported that the system functioned consistently across different browsers

4. Security Features:

- 85% of users trusted the system to keep sensitive data secure
- 90% found the login and authentication process secure

5. Role-Specific Functions:

- GSMB Officers rated the oversight features highly (90% positive)
- Site Engineers found the permit application process streamlined (85% positive)
- Explosive Controllers appreciated the information provided for decision-making (80% positive)
- Dealers rated the purchase order management positively (75% positive)

6. Overall Assessment:

- 85% of users agreed or strongly agreed that QuarryMaster increased their work efficiency
- 80% reported overall satisfaction with the system

The qualitative feedback from open-ended questions highlighted the following as most valuable features:

- Real-time tracking of permit and quota status
- Map-based drilling location planning
- Integrated inventory management
- Streamlined approval processes
- Comprehensive reporting capabilities

Areas identified for improvement included:

- Mobile responsiveness for field operations
- Additional filtering options for reports
- Enhanced notification preferences
- Bulk upload capabilities for certain data types
- More detailed help documentation

5.6 Results of Testing

The comprehensive testing approach ensured thorough validation of the QuarryMaster system. Table 5.7 summarizes the test case execution results.

Function	Executed Test Cases	Passed Test Cases	Failed Test Cases	Success Rate
User Login	6	6	0	100%
User Creation	4	4	0	100%
Permit Application	4	4	0	100%
Permit Approval	4	4	0	100%
Drilling Operations	4	4	0	100%
Inventory Management	4	4	0	100%
Automated Tests	8	8	0	100%
Total	34	34	0	100%

Table 23 - Results of the Testing

The testing revealed several issues during the development phase that were subsequently resolved:

1. User Interface Issues:

- Inconsistent form validation feedback
- Navigation menu display problems in certain browsers
- Element alignment issues in responsive layouts

2. Functional Issues:

- Calculation errors in quota tracking
- Incorrect status updates in certain workflow paths
- Missing validation for certain edge cases

3. Performance Issues:

- Slow loading of map data with numerous drilling locations
- Database query optimization needs for reporting features
- Memory management improvements for file uploads

5.7 Summary

The testing and evaluation of the QuarryMaster system employed a comprehensive approach combining traditional testing methodologies, automated testing, and user evaluation. This multi-faceted strategy ensured that the system met all functional requirements, delivered a positive user experience, and supported the efficient management of quarry operations.

The automated testing framework provided consistent validation of critical workflows, while manual testing covered aspects requiring human judgment. User evaluation confirmed that the system met stakeholder needs and identified areas for future enhancement.

The system successfully passed all test cases, demonstrating its reliability and correctness. User feedback was predominantly positive, confirming that the QuarryMaster system effectively addresses the challenges of managing quarry operations, explosive permits, and inventory tracking.

Chapter 6 – Conclusion

6.1 Introduction

This chapter presents the conclusion of the QuarryMaster project, reflecting on the development process, achievements, challenges, and future potential. The project aimed to transform the manual management of A-grade quarry operations in Sri Lanka into a comprehensive digital system that enhances regulatory compliance, operational efficiency, and safety in handling explosive materials. This concluding chapter evaluates the success of the implementation against initial objectives, discusses key learning experiences, identifies challenges encountered, and outlines future enhancements to further strengthen the system.

6.2 Critical review of achieved objectives

The QuarryMaster system was developed to address the challenges in managing A-grade quarry operations in Sri Lanka, particularly focusing on explosive material regulation and operational efficiency. The mining industry represents a significant economic sector in Sri Lanka with substantial cash flow, making effective regulatory systems crucial for both safety and compliance.

The project has successfully achieved its core objectives for each user group:

For GSMB Administrators:

- ✓ Implementation of a centralized user management system for creating and managing different stakeholder accounts
- ✓ Development of a comprehensive dashboard for monitoring quarry operations
- ✓ Digitalization of the permit review and approval workflow with clear status tracking
- ✓ Integration of role-based access controls for secure system administration
- ✓ Creation of digital site management with license tracking capabilities

For Site Engineers:

- ✓ Transformation of the permit application process from paper-based to digital workflow
- ✓ Implementation of interactive mapping functionality using Leaflet for accurate drilling site planning
- ✓ Development of quota management tools for tracking explosive material usage
- ✓ Creation of inventory management features for effective resource tracking
- ✓ Implementation of blasting operation recording and documentation tools

For Explosive Controllers:

- ✓ Development of streamlined permit review and approval workflows
- ✓ Creation of tools for effective quota assessment and approval
- ✓ Implementation of tracking systems for explosive materials across sites
- ✓ Integration of notification systems for pending approvals

For Explosive Dealers:

- ✓ Development of purchase order management functionality
- ✓ Implementation of inventory and transaction tracking
- ✓ Creation of delivery management tools

The system has successfully replaced the previously manual, paper-based processes with an integrated digital platform that enhances transparency, improves data accuracy, and streamlines regulatory compliance. Key achievements include:

1. **Enhanced Security and Control:** The system has strengthened the regulatory oversight of explosive materials through strict digital workflows and approval processes.
2. **Operational Efficiency:** The automated workflows have significantly reduced processing times for permits and quotas, eliminating many of the delays inherent in the previous manual system.
3. **Improved Coordination:** The system has established clear communication channels between stakeholders, enhancing coordination between site engineers, controllers, and dealers.
4. **Spatial Context:** The integration of Leaflet maps provides valuable spatial context for mining operations, enabling more precise planning and documentation.
5. **Data Integrity:** The digital system ensures consistent data across all operations, eliminating discrepancies that occurred in paper-based records.

Comprehensive testing and user evaluations confirmed that the system met its functional and non-functional requirements, with high user satisfaction across all stakeholder groups. The integration of automated testing ensures ongoing system reliability as new features are added or existing ones are modified.

6.3 Learning experiences

The development of QuarryMaster provided valuable learning experiences across multiple dimensions:

Technical Growth

The project offered extensive practical experience with modern web development technologies:

- **Angular Framework:** Gained expertise in component-based architecture, reactive programming, and state management
- **Node.js/Express.js:** Developed skills in creating scalable server-side applications and RESTful APIs
- **Database Design:** Enhanced understanding of relational database modeling for complex domain requirements
- **Mapping Technologies:** Acquired practical knowledge of implementing Leaflet for interactive geographical features
- **Automated Testing:** Developed skills in creating robust test frameworks using Selenium and TestNG

Domain Knowledge

The project significantly deepened understanding of:

- **Mining Industry Regulations:** Gained comprehensive knowledge of the regulatory framework governing A-grade quarry operations in Sri Lanka
- **Explosive Materials Management:** Developed understanding of the strict protocols and safety requirements for explosive handling
- **Quarry Operations:** Acquired insights into the operational aspects of drilling and blasting processes
- **Compliance Workflows:** Learned about the complex approval and verification processes required for regulatory compliance

Project Management

The project reinforced important project management principles:

- **Requirement Analysis:** Improved skills in gathering and analyzing complex domain-specific requirements
- **Iterative Development:** Gained experience in component-based iterative development approach
- **Integration Planning:** Developed strategies for integrating complex system components
- **Testing Strategy:** Learned to implement comprehensive testing approaches, including both automated and manual methodologies
- **User Evaluation:** Gained experience in designing and conducting user evaluation surveys for system improvement

Communication Skills

The project enhanced communication abilities, particularly:

- **Technical Documentation:** Improved skills in creating clear, comprehensive documentation
- **Stakeholder Engagement:** Developed abilities to communicate effectively with diverse user groups having varying technical backgrounds
- **Requirements Elicitation:** Enhanced techniques for extracting clear requirements from domain experts
- **Visual Communication:** Improved skills in creating intuitive user interfaces that communicate functionality clearly

These learning experiences not only contributed to the successful completion of the project but also represent valuable professional development that will benefit future endeavors in software development and project management.

6.4 Difficulties & Challenges

The development of QuarryMaster presented several significant challenges that required creative problem-solving and technical innovation:

Domain Complexity

The mining industry's regulatory framework and operational processes for A-grade quarries in Sri Lanka are inherently complex:

- **Regulatory Requirements:** Understanding and implementing the strict regulatory requirements for explosive material handling required extensive research and consultation with industry experts
- **Workflow Complexity:** Mapping the intricate workflows between different stakeholders into a coherent digital system presented significant design challenges
- **Spatial Data Management:** Implementing proper handling of geographical data, particularly the conversion between Kandawala and WGS84 coordinate systems, required specialized knowledge

Technical Challenges

Several technical aspects presented particular difficulties:

- **Real-time Updates:** Implementing real-time notifications and updates for critical operations like permit approvals and quota allocations required careful integration of WebSocket technology
- **Map Integration:** Incorporating Leaflet maps with custom functionality for drilling site mapping and boundary visualization presented integration challenges
- **Multi-role System:** Designing a coherent system that serves four distinct user roles with very different needs while maintaining a consistent user experience required careful interface design
- **Security Implementation:** Ensuring robust security for explosive material management required multiple layers of validation and access control

Integration Challenges

Integrating diverse system components presented several obstacles:

- **Component Coordination:** Ensuring seamless interaction between different modules like permit management, quota tracking, and inventory control required careful API design
- **Data Consistency:** Maintaining consistent data across interdependent features (e.g., ensuring permit quantities match quota allocations) required robust validation mechanisms
- **Workflow Sequencing:** Implementing the sequential nature of permit-quota-purchase workflows while allowing for exceptional cases required flexible yet controlled process design

Field Operation Considerations

The practical aspects of field operations introduced additional complexities:

- **Connectivity Issues:** Designing the system to be usable in quarry locations with potentially limited internet connectivity required careful consideration of data synchronization
- **Field Usability:** Creating interfaces that would remain usable on various devices in field conditions needed special attention to responsive design
- **Data Entry Efficiency:** Designing efficient data entry mechanisms for on-site recording of drilling and blasting operations required balancing between simplicity and completeness

Despite these challenges, the project successfully delivered a comprehensive solution that addresses the core requirements of quarry operations management while providing a foundation for future enhancements.

6.5 Future Work

While QuarryMaster successfully addresses the primary objectives for digitizing A-grade quarry management, several opportunities for enhancement and expansion have been identified:

Enhanced Mobile Support

1. **Dedicated Mobile Application:** Developing dedicated mobile applications for Android and iOS would enhance usability for field operations, particularly for site engineers working in remote locations
2. **Offline Capabilities:** Implementing robust offline functionality with data synchronization would allow continued operation in areas with limited connectivity
3. **Field Data Collection:** Adding support for mobile device cameras and sensors could enhance on-site data collection and verification

Advanced Analytics and Reporting

1. **Business Intelligence Features:** Incorporating advanced analytics capabilities would provide valuable insights for both regulatory oversight and operational planning
2. **Predictive Analytics:** Implementing predictive models for resource utilization and compliance risk assessment could enhance planning capabilities
3. **Interactive Dashboards:** Developing more sophisticated, interactive dashboards with drill-down capabilities would improve data visualization and interpretation

System Integration Enhancements

1. **Government System Integration:** Connecting with other regulatory systems such as those of the Ministry of Defense for enhanced explosive tracking
2. **ERP Integration:** Developing interfaces with accounting and enterprise resource planning systems for improved financial tracking
3. **IoT Device Integration:** Implementing support for IoT devices for real-time monitoring of explosives storage conditions and security

Advanced Mapping Features

1. **3D Visualization:** Incorporating three-dimensional visualization of quarry sites for better planning and analysis

2. **Drone Survey Integration:** Adding support for drone survey data to enhance site mapping accuracy
3. **Advanced Spatial Analysis:** Implementing tools for spatial analysis of blast patterns and environmental impact

Automation Enhancements

1. **Automated Compliance Checking:** Developing rule-based validation to automatically identify potential regulatory violations
2. **Intelligent Form Filling:** Implementing smart suggestions and auto-completion for repetitive data entry tasks
3. **Scheduled Reporting:** Adding capabilities for automated, scheduled report generation and distribution

Security Enhancements

1. **Biometric Authentication:** Implementing additional authentication layers such as biometric verification for high-risk operations
2. **Advanced Audit Trails:** Enhancing the audit logging system with more detailed tracking and reporting capabilities
3. **Behavioral Analysis:** Adding behavioral analysis to detect unusual system usage patterns that might indicate security concerns

User Experience Improvements

1. **Personalization Features:** Implementing user-specific dashboard customization and preferences
2. **Enhanced Notification System:** Developing more sophisticated notification preferences and delivery channels
3. **Contextual Help System:** Creating an in-depth, context-sensitive help system with visual guides and tutorials

These enhancements represent potential directions for future development that would build upon the solid foundation established by the current implementation, further improving the system's utility, usability, and security.

6.6 Summary

The QuarryMaster system represents a significant advancement in the management of A-grade quarry operations in Sri Lanka. By transforming paper-based processes into a comprehensive digital workflow, the system addresses critical challenges in explosive material regulation, operational efficiency, and regulatory compliance.

The implementation successfully achieved its primary objectives for all stakeholder groups: GSMB administrators, site engineers, explosive controllers, and dealers. The digital system enhances security through strict access controls, improves efficiency through automated workflows, enhances coordination through integrated communication, and provides valuable spatial context through interactive mapping.

The development process yielded valuable learning experiences across technical, domain-specific, and project management dimensions. While challenges were encountered in addressing the complex regulatory requirements and operational workflows, innovative solutions were implemented to deliver a system that effectively serves all user groups.

User evaluation results confirmed the system's effectiveness, with high satisfaction rates across usability, functionality, performance, and security aspects. The implementation of automated testing ensures ongoing reliability as the system evolves.

The identified opportunities for future enhancement provide a roadmap for continued development that will further increase the system's value in supporting both operational efficiency and regulatory compliance. As the mining industry continues to evolve, QuarryMaster is well-positioned to adapt and grow, ensuring that A-grade quarry operations in Sri Lanka are conducted safely, responsibly, and in compliance with all regulatory requirements.

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Appendix A – User Manual

A.1 Guide for accessing the Quarry Master System

To access the Quarry Master System, enter `http://localhost:4200/signin` in the address bar of any web browser, and you will see the login page illustrated in Figure A.1.

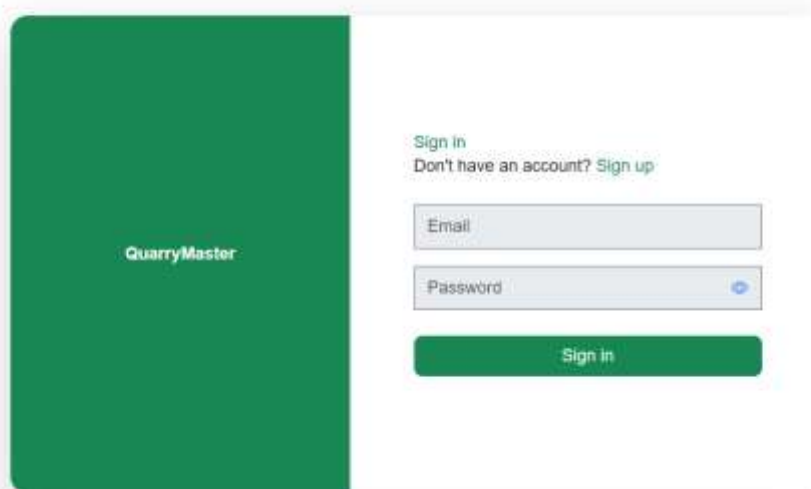


Figure A.1 - Login page

A.2 Guide for System Administrator (GSMB Officer)

Step 1 - Login to the system using your admin credentials. After logging in, you will see the admin dashboard illustrated in Figure A.2.

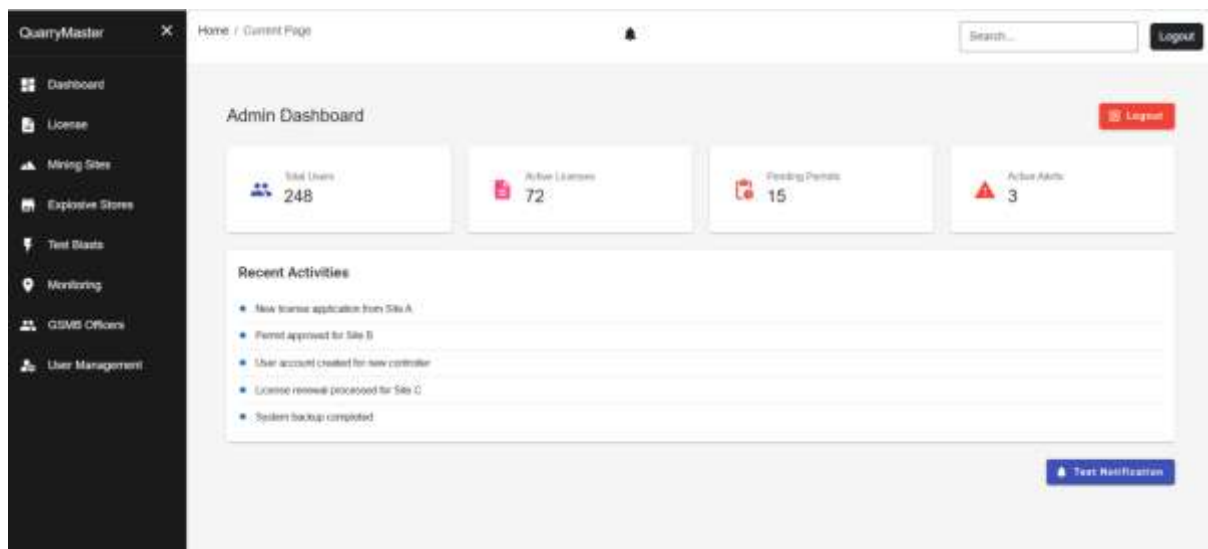


Figure A.2 - Admin dashboard

Step 2 - To create new users, click on "User Management" in the sidebar. This will take you to the User Management page illustrated in Figure A.3.

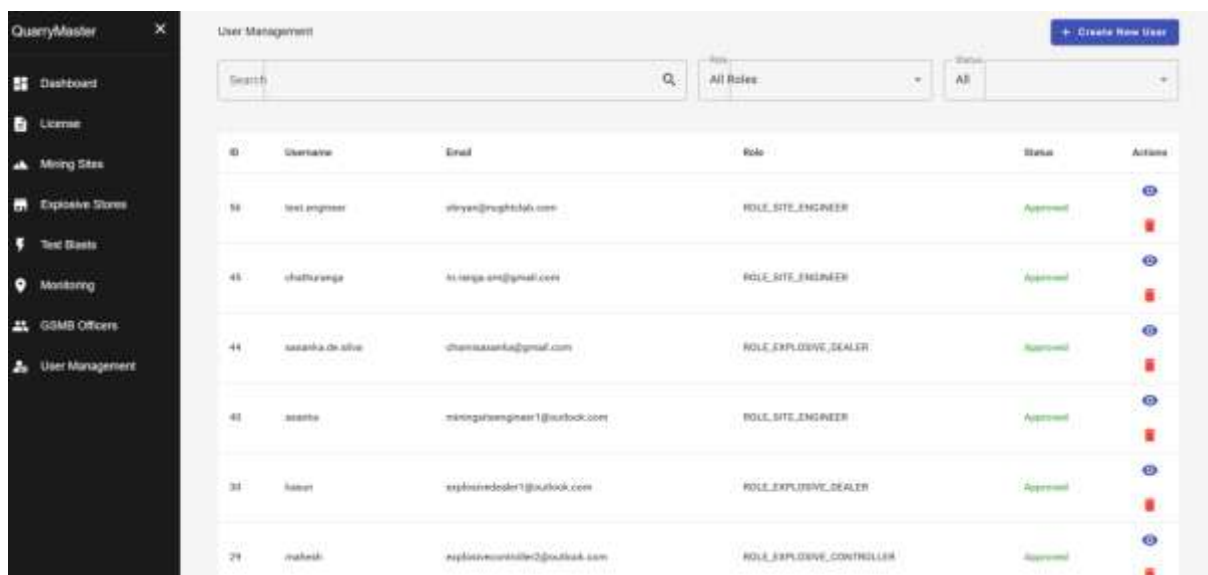
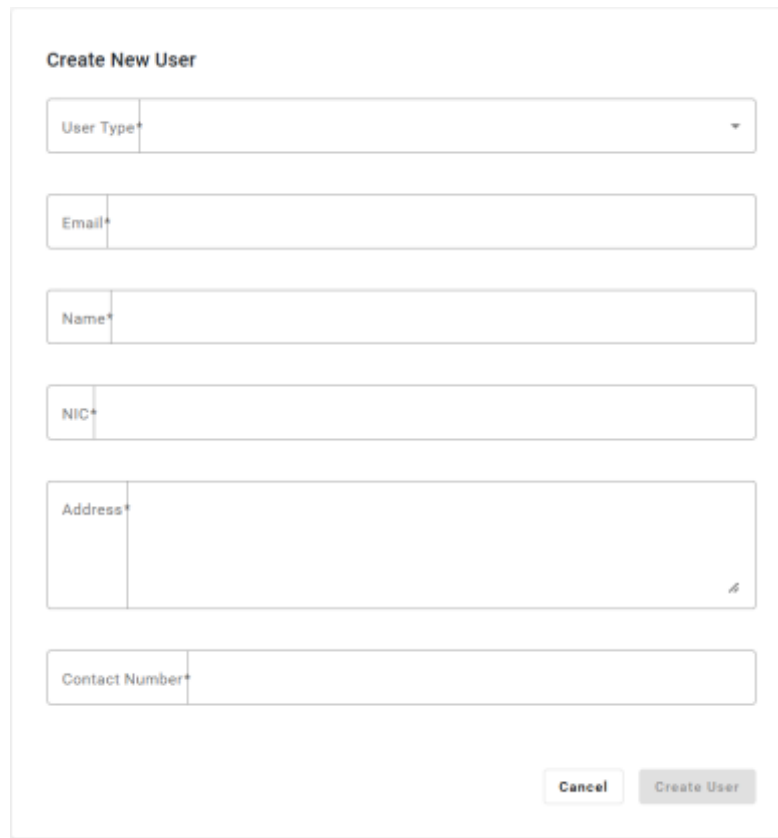


Figure A.3 - User management page

Step 3 - Click on "Create New User" button and fill in the user creation form as illustrated in Figure A.4. Note that email and NIC number must be unique to avoid duplication.



Create New User

User Type*

Email*

Name*

NIC*

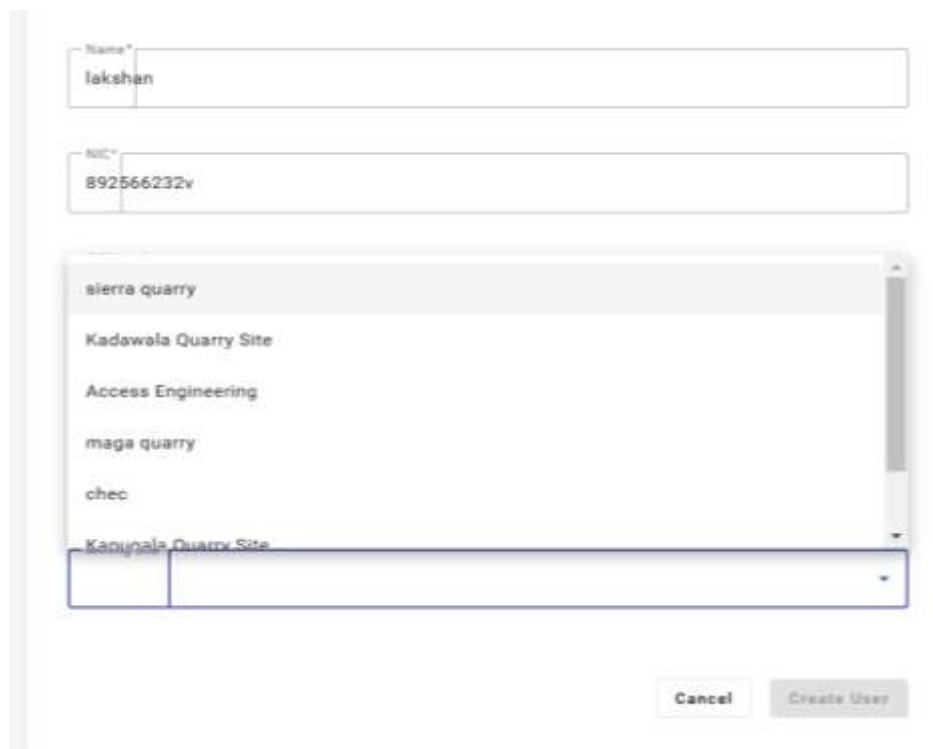
Address*

Contact Number*

Cancel Create User

Figure A.4 – Create new user form

Step 4 - If creating a Mining Engineer, select the registered mining site from the dropdown menu as illustrated in Figure A.5.



Name*

Iakshan

NIC*

892566232v

sierra quarry

Kadawala Quarry Site

Access Engineering

maga quarry

chec

Kanungala Quarry Site

Cancel Create User

Figure A.5 – Selecting mining site for engineer

Step 5 - After clicking "Create User", a success message will appear as illustrated in Figure A.6.

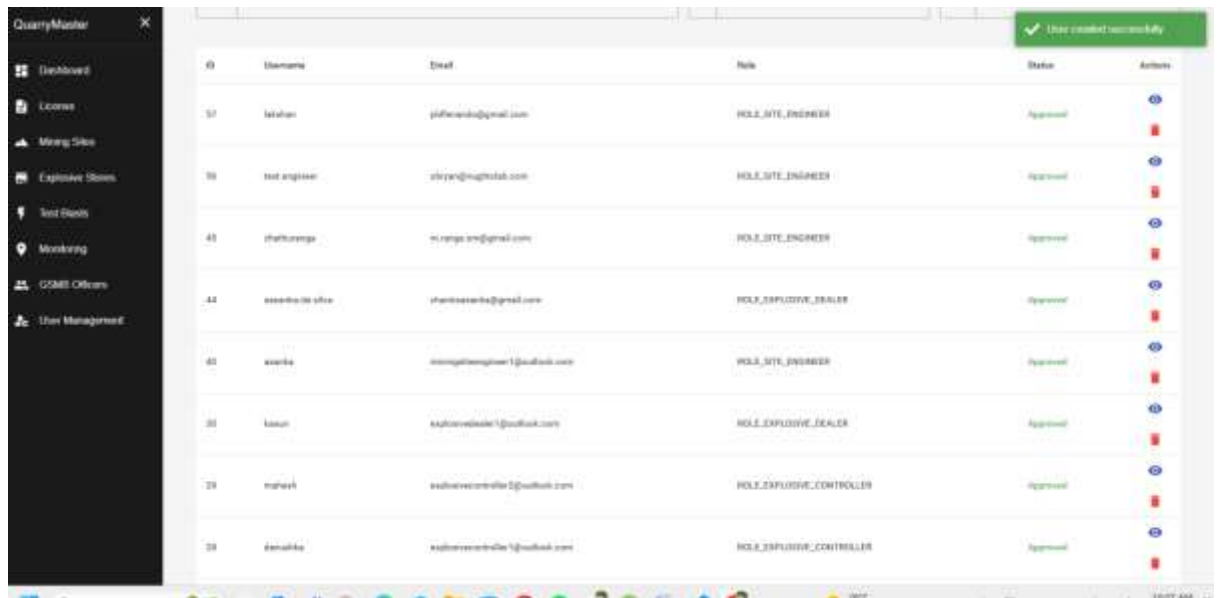


Figure A.6 – User created successfully message

Step 6 - The system will send an email with temporary password to the new user, as illustrated in Figure A.7.

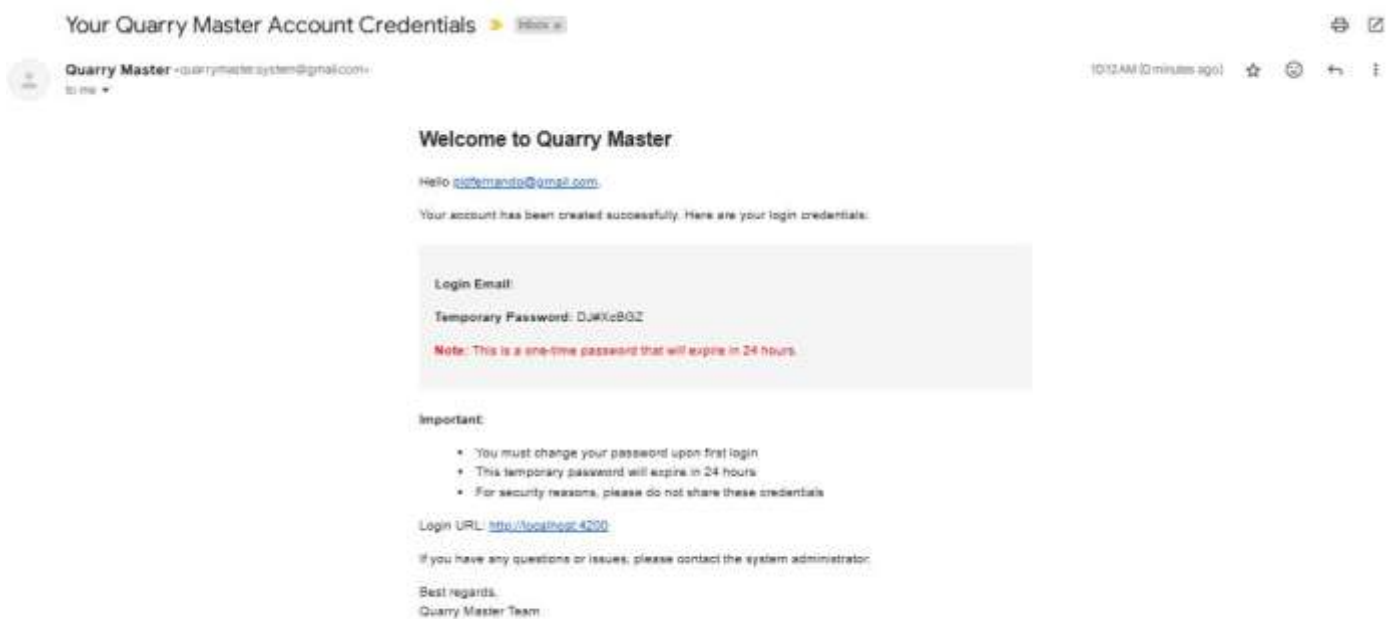
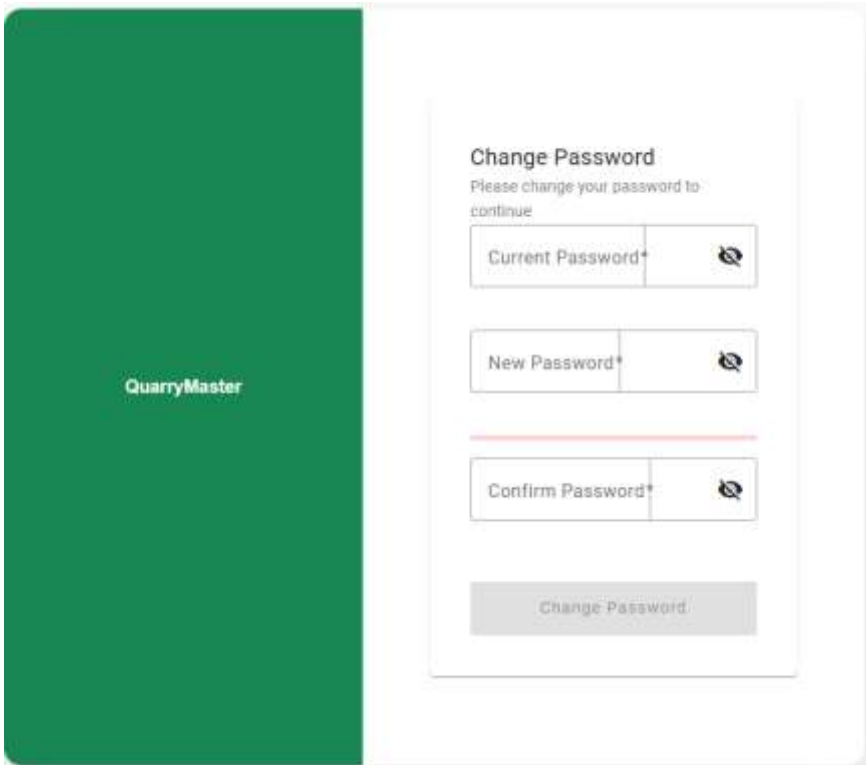


Figure A.7 – Account credentials email

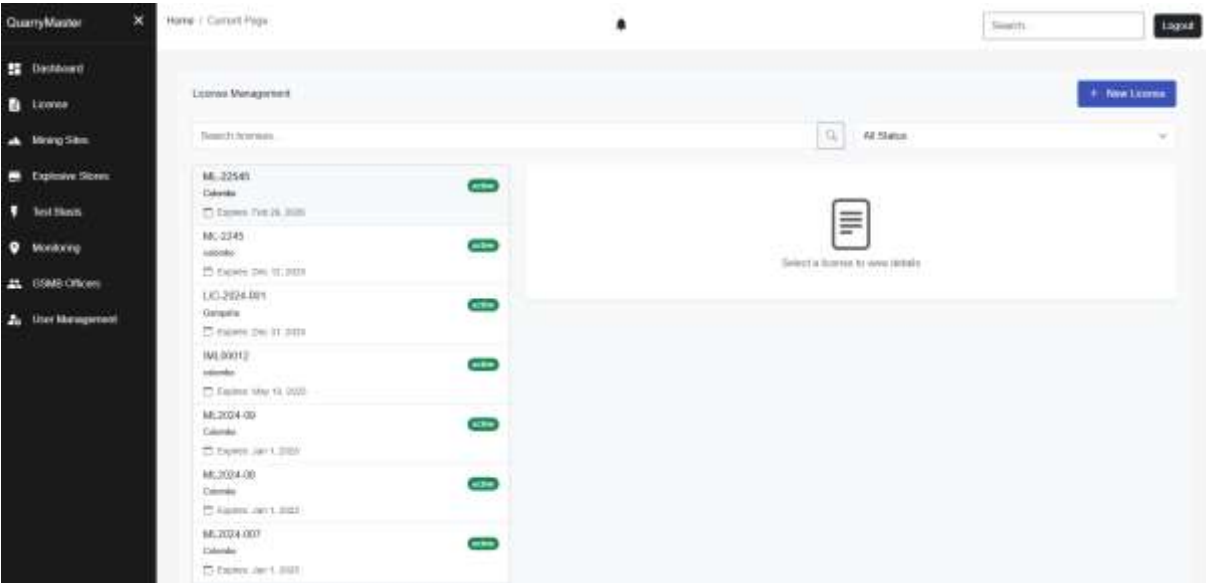
Step 7 - When users first log in with the temporary password, they will be directed to the password change page as illustrated in Figure A.8.



The screenshot shows the 'Change Password' page in the QuarryMaster application. On the left is a green sidebar with the 'QuarryMaster' logo. The main content area has a white background with a light gray border. It contains the title 'Change Password', a subtitle 'Please change your password to continue', and three password input fields: 'Current Password', 'New Password', and 'Confirm Password'. Each field has a toggle icon for password visibility. Below the fields is a 'Change Password' button.

Figure A.8 – Change password page

Step 8 - To create a mining license, click on "License" in the sidebar and then click "New License" button as illustrated in Figure A.9.

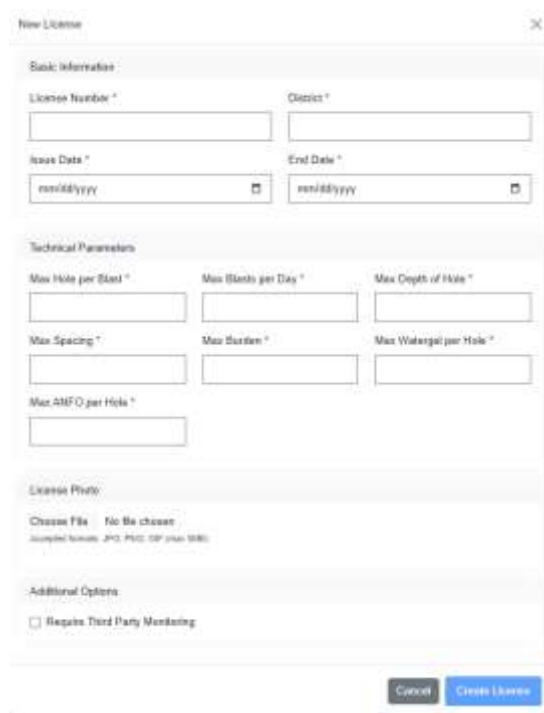


The screenshot shows the 'License Management' page in the QuarryMaster application. On the left is a dark sidebar with the 'QuarryMaster' logo and a list of menu items: Dashboard, License, Mining Sites, Explosive Sites, Test Blocks, Monitoring, OSMD Offices, and User Management. The main content area has a light blue background. It features a 'License Management' header with a 'New License' button. Below the header is a search bar and a table of licenses. The table has columns for License ID, Location, and Status. The licenses listed are:

License ID	Location	Status
ML-22541	Colombo	Active
ML-2245	Colombo	Active
LKD-2024-001	Colombo	Active
ML-2024-00	Colombo	Active
ML-2024-00	Colombo	Active
ML-2024-000	Colombo	Active

Figure A.9 – License management page

Step 9 - Fill in the license details with the manually issued license information as illustrated in Figure A.10.



New License

Basic Information

License Number * Classic *

Issue Date * End Date *

Technical Parameters

Max Hole per Blast * Max Blasts per Day * Max Depth of Hole *

Max Spacing * Max Burden * Max Watergel per Hole *

Max ANFO per Hole *

License Photo

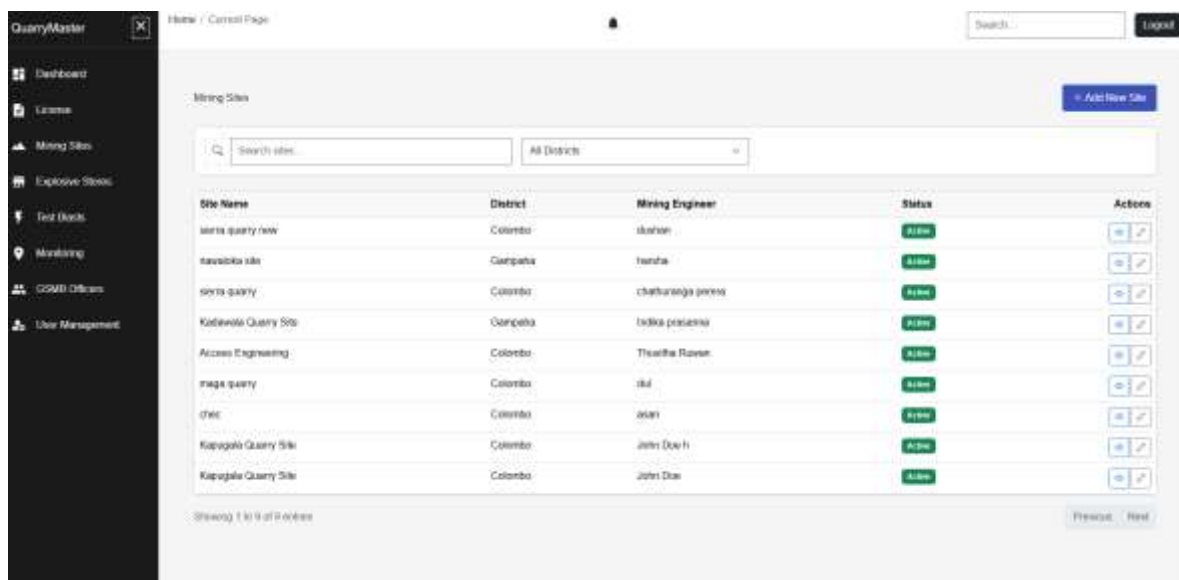
Choose File No file chosen
Accepted formats: JPG, PNG, GIF (max 5MB)

Additional Options

☐ Requires Third Party Monitoring

Figure A.10 – Create new license form

Step 10 - To create a mining site, click on "Mining Sites" in the sidebar and then click "Add New Site" as illustrated in Figure A.11.



QuarryMaster Home / Current Page

Mining Sites

Site Name	District	Mining Engineer	Status	Actions
lerna quarry new	Colombo	Isakhan	Active	Edit Delete
nasabika site	Gampaha	Isakhan	Active	Edit Delete
syra quarry	Colombo	chaturanga perera	Active	Edit Delete
Kalawala Quarry Site	Gampaha	Isakhan perera	Active	Edit Delete
Access Engineering	Colombo	Thushara Rajan	Active	Edit Delete
maga quarry	Colombo	Isakhan	Active	Edit Delete
o'net	Colombo	Isakhan	Active	Edit Delete
Kapugala Quarry Site	Colombo	John Doe h	Active	Edit Delete
Kapugala Quarry Site	Colombo	John Doe	Active	Edit Delete

Showing 1 to 9 of 9 entries

Figure A.11 - Mining sites page

Step 11 - Fill in the site details and mark the site location on the leaflet map as illustrated in Figure A.12. The system will automatically get GPS coordinates from the marked location.

Add New Mining Site

License: Site Name:

District: Mining Engineer:

Site Address:

Select Location on Map



Kadawala GPS North: Kadawala GPS East:

☒ Active Site

Figure A.12 - Create new mining site form

Step 12 - After filling these details, click "Create Site" and the system will direct you to create a minable area boundary. Mark the boundary points on the map as illustrated in Figure A.13.

Create Minable Boundary

Mining Site Details
 Site Name: nawaloka new
 Site Address: 541, walgama, athuganiya
 District: Colombo

Mining Engineer: kushan
 Site GPS North: 110474.483076
 Site GPS East: 1093.481151

Draw Boundary
 Click on the map to place boundary points. Drag points to adjust. You need at least 3 points to create a valid boundary.



#	North (Kadawala)	East (Kadawala)	Actions
1	137374.134438	154786.440440	Remove
2	133736.809377	187750.486383	Remove
3	118821.051707	142310.810586	Remove
4	134490.781055	130593.582628	Remove

Figure A.13 - Create minable area boundary page

Step 13 - To create an explosive store for a mining site, click on "Explosive Stores" in the sidebar as illustrated in Figure A.14.

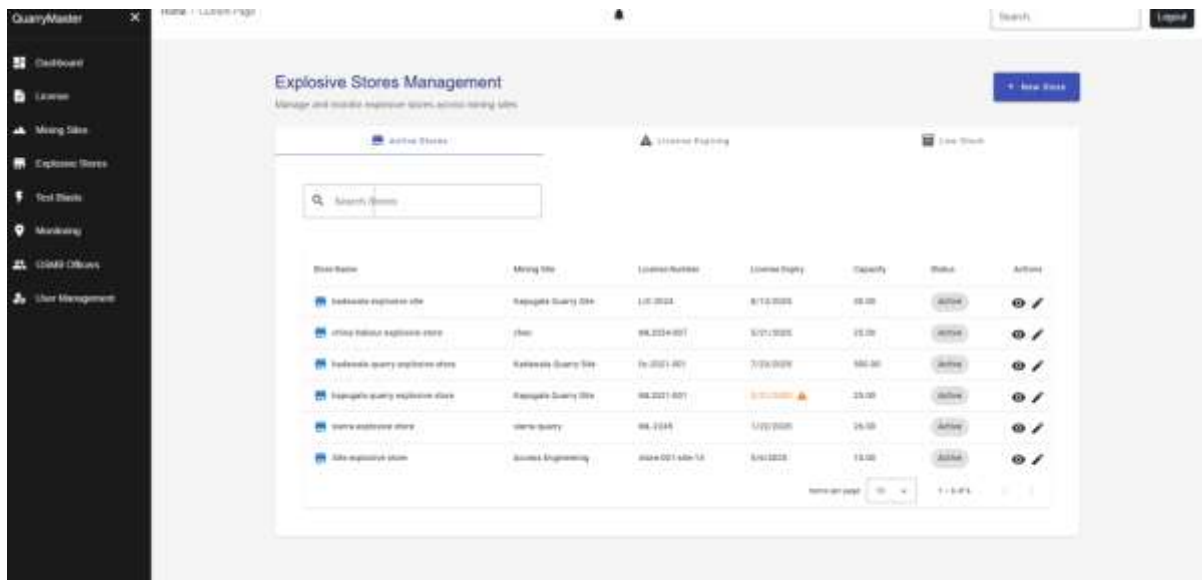


Figure A.14 - Explosive stores management page)

Step 14 - Click on "New Store" and fill in the form to create an explosive store as illustrated in Figure A.15.

The screenshot shows the 'Create Explosive Store' form. At the top, there is a header with the title 'Explosive Stores Management' and a subtitle 'Manage and monitor explosive stores across mining sites'. There is a '+ New Store' button in the top right. Below the header, there are three tabs: 'Active Stores', 'License Expiring', and 'Low Stock'. The 'Create Explosive Store' form is a modal window with a close button (X) in the top right corner. The form has a title 'Create Explosive Store' and a subtitle 'Add a new explosive store to a mining site'. The form is divided into three main sections: 'Store Details', 'Contact Information', and 'Store Specifications'. The 'Store Details' section includes a 'Mining Site' dropdown menu, a 'Store Name' text input field, a 'License Number' text input field, and a 'License Expiry Date' date picker. The 'Contact Information' section includes a 'Contact Person' text input field and a 'Contact Number' text input field. The 'Store Specifications' section includes a 'Store Location' text input field and a 'Storage Capacity' text input field. At the bottom of the form, there are two buttons: 'Cancel' and 'Create Store'.

Figure A.15 - Create explosive store form

A.3 Guide for Site Engineer

Step 1 - Site Engineers can log in with their credentials and access their dashboard.

Step 2 - To request an explosive permit, click on "Explosive Permits" under "Site Management" in the sidebar, then click "New Permit Request" as illustrated in Figure A.16.

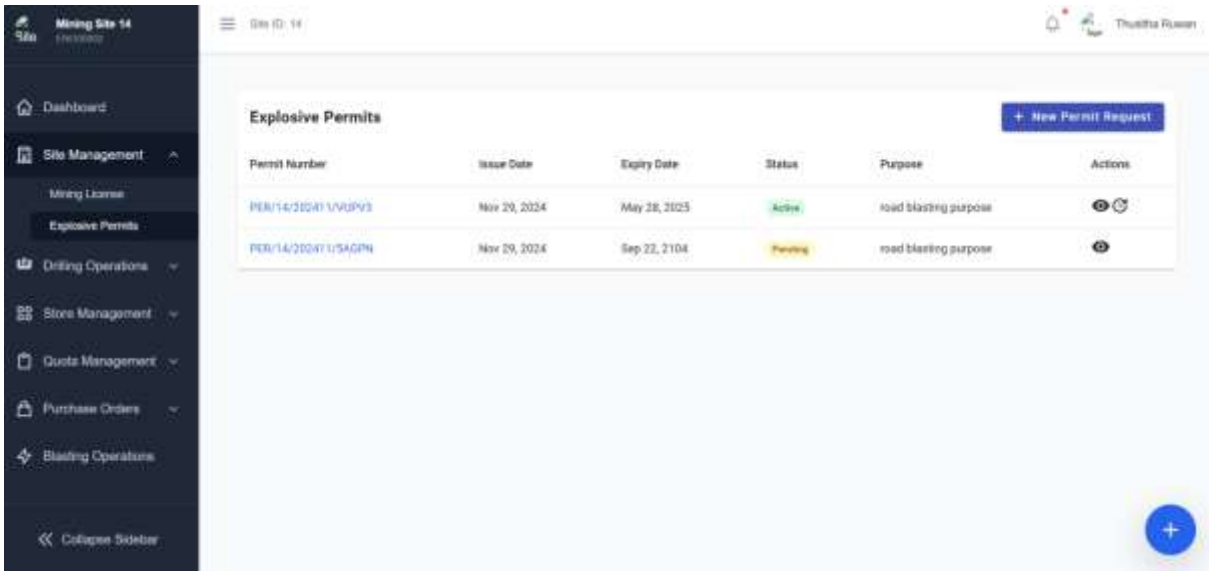


Figure A.16 - Explosive permits page

Step 3 - The system uses a step-by-step form for better user experience. First, enter the basic information as illustrated in Figure A.17.

New Explosive Permit Request
Mining Site: Access Engineering

1 Basic Information

2 Explosive Details

Purpose*

Purpose is required

Validity Period (days)*

180

Enter number of days (1-365)

Select Controller*

Controller selection is required

Additional Remarks (Optional)

Next

Figure A.17 - New explosive permit request - Basic Information

Step 4 - Next, enter the needed explosive details as illustrated in Figure A.18.

Figure A.18 - New explosive permit request - Explosive Details

Step 5 - After obtaining an explosive permit, Site Engineers can apply for an explosive quota. The quota request form follows a step-by-step process as illustrated in Figures A.19, A.20, and A.21.

Create New Quota Request

Fill in the details to request a new explosive quota

1 Basic Details ————— 2 Location & Purpose ————— 3 Safety & Submit

Select Permit*

Planned Usage Date*

Blasting Time*

Next

Figure A.19 - Create new quota request - Step 1

Create New Quota Request

Fill in the details to request a new explosive quota

 Basic Details  **2** Location & Purpose  **3** Safety & Submit

Blasting Location*	
--------------------	-------------

Purpose*	
----------	-------------

Back **Next**

Figure A.20 - Create new quota request - Step 2

Create New Quota Request

Fill in the details to request a new explosive quota

 Basic Details  Location & Purpose  **3** Safety & Submit

Safety Measures*	all safety measures are taken
------------------	--

Validity Period (Days)*	7
-------------------------	--------------

Back

Submit Request

Figure A.21 - Create new quota request - Step 3

Step 6 - Once the Explosive Controller approves the quota request as illustrated in Figure A.22, Site Engineers can proceed to create a purchase order.

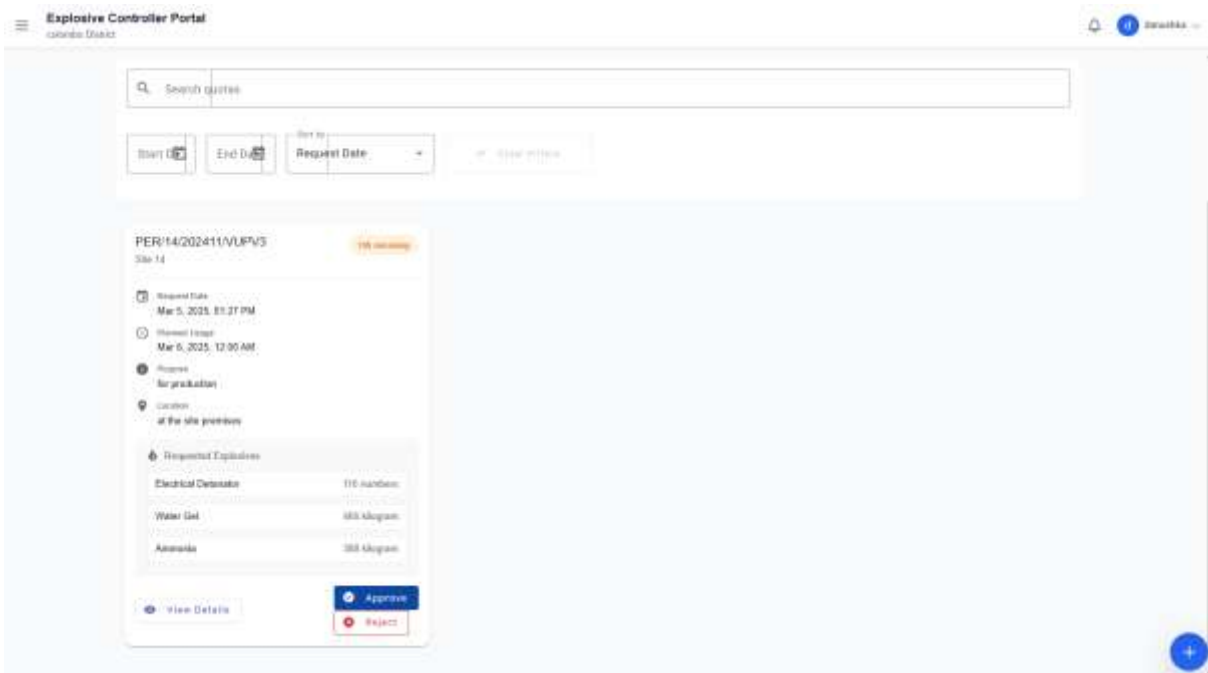


Figure A.22 - Quota approval by explosive controller

Step 7 - To create a purchase order, navigate to "Purchase Orders" and click "Create Purchase Order". Follow the step-by-step process as illustrated in Figures A.23, A.24, A.25, and A.26.

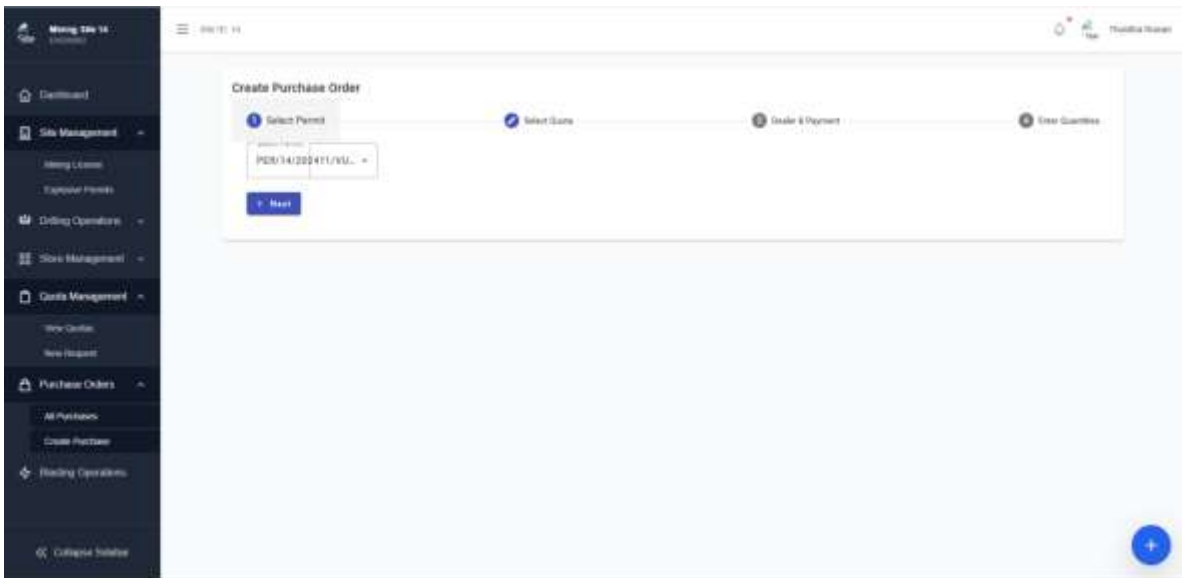


Figure A.23 - Create purchase order - Step 1

Create Purchase Order

1 Select Permit 2 **Select Quota** 3 Dealer & Payment 4 Enter Quantities

Quota #QTA00004 (...)

Available Explosives:

- Electrical Detonator**
Available: 116.00 numbers
- Water Gel**
Available: 466.00 kilogram
- Ammonia**
Available: 388.00 kilogram

< Back **Next**

Figure A.24 - Create purchase order - Step 2

Create Purchase Order

1 Select Permit 2 Select Quota 3 **Dealer & Payment** 4 Enter Quantities

Quota #QTA00004 (...)

asaaria de silva - C. ... Cash

< Back **Next**

Figure A.25 - Create purchase order - Step 3

Create Purchase Order

1 Select Permit 2 Select Quota 3 Dealer & Payment 4 **Enter Quantities**

Electrical Detonator: 50
Maximum: 116.00 numbers

Water Gel: 10
Maximum: 466.00 kilogram

Ammonia: 25
Maximum: 388.00 kilogram

Notes

< Back **Submit Order**

Figure A.26 - Create purchase order - Step 4

A.4 Guide for Explosive Dealer

Step 1 - Explosive Dealers can log in to view and process purchase orders as illustrated in Figure A.27.

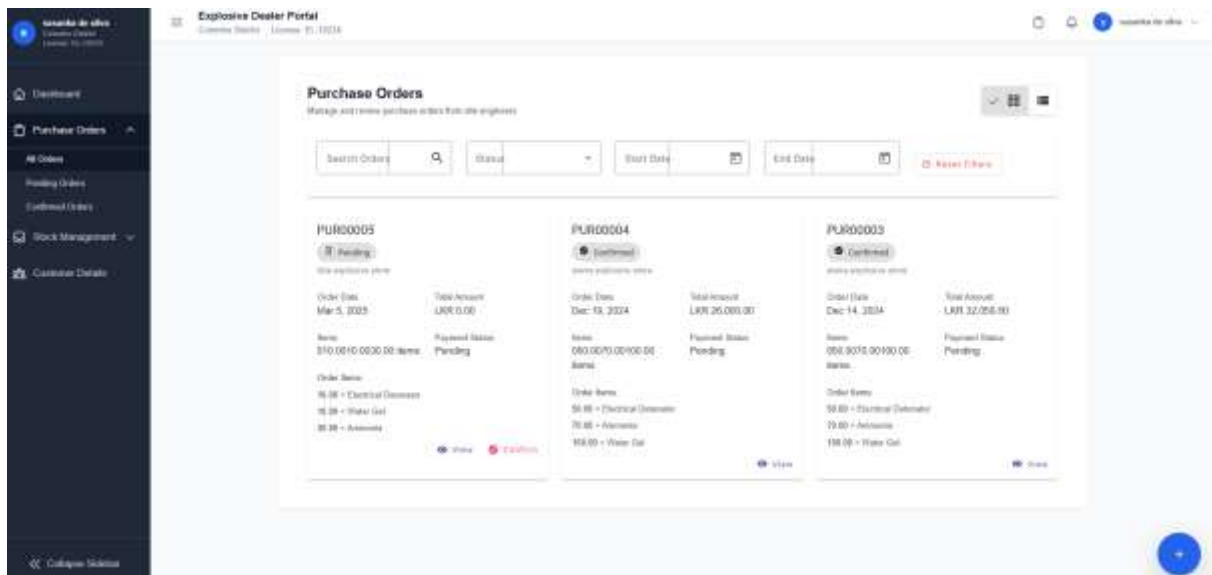


Figure A.27 - Explosive dealer portal - Purchase orders

Step 2 - To confirm an order, click on the order to view details, then fill in pricing information as illustrated in Figure A.28.

Confirm Order Items

Electrical Detonator
Quantity: 10.00 numbers

Unit Price (LKR)*

Batch Number*

Manufacture Date*

Expiry Date*

Total: LKR 0.00

Water Gel
Quantity: 10.00 kilograms

Unit Price (LKR)*

Batch Number*

Manufacture Date*

Expiry Date*

Total: LKR 0.00

Ammonia
Quantity: 30.00 kilograms

Unit Price (LKR)*

Batch Number*

Manufacture Date*

Expiry Date*

Total: LKR 0.00

Figure A.28 - Confirm order details and pricing

Step 3 - After confirming the order, the system will send an email with pricing details to the Site Engineer. The Site Engineer can then make the payment as illustrated in Figure A.29.

Purchase Order: PUR00004

Confirmed

← Back to List

Created on Dec 15, 2024, 9:42:25 PM

Order Details

Quota Details

Order History

Store Details

sierra explosive store

License: ML-2245

Contact: denuwan

Order Information

Total Amount: LKR 26,000.00

Payment Method: Cash

Payment Status: Pending

Order Items

ITEM	QUANTITY	UNIT PRICE	TOTAL
Electrical Detonator ED-1232	50.00 numbers	LKR 100.00	LKR 5,000.00
Ammonia AM-323	70.00 kilograms	LKR 100.00	LKR 7,000.00
Water Gel WG-1452	100.00 kilograms	LKR 140.00	LKR 14,000.00
Total:			LKR 26,000.00

Actions

Update Payment Status

Store Information

Name: sierra explosive store

License: ML-2245

Contact: denuwan

Phone: 0769149613

Location: at the site

Capacity: 26.00

Figure A.29 - Order confirmation with pricing

A.5 Guide for Order Processing and Inventory Management

Step 1 - After the Site Engineer confirms payment, the Explosive Dealer can update the payment status and delivery details as illustrated in Figure A.30.

Update Payment Status

Order ID: PU000004

← Back to Details

Order Summary

Total Amount	Store	Order Date
LKR 26,000.00	sierra explosive store	Dec 19, 2024

1 Payment Method

2 Payment Details

3 Upload Proof

Payment Method*

Next

Figure A.30 - Confirm order items form

Step 2 - Once the payment and delivery are completed, the system automatically updates the relevant site's explosive store inventory.

A.6 Guide for Explosive Controller

Step 1 - Explosive Controllers can log in to view and process quota requests.

Step 2 - Navigate to "Quota Management" to check pending quota approvals as illustrated in Figure A.22.

Step 3 - Click on a request to view details, then click "Approve" or "Reject" based on the assessment.

Step 4 - Once approved, the quota becomes available for the Site Engineer to use in purchase orders.

Appendix B – MIS Reports

B.1 Description of MIS Report Module

MIS (Management Information System) reports are a type of structured report that organizations use to provide information and support decision-making. These reports typically contain data from various sources within an organization and are designed to help management monitor and control different aspects of the organization.

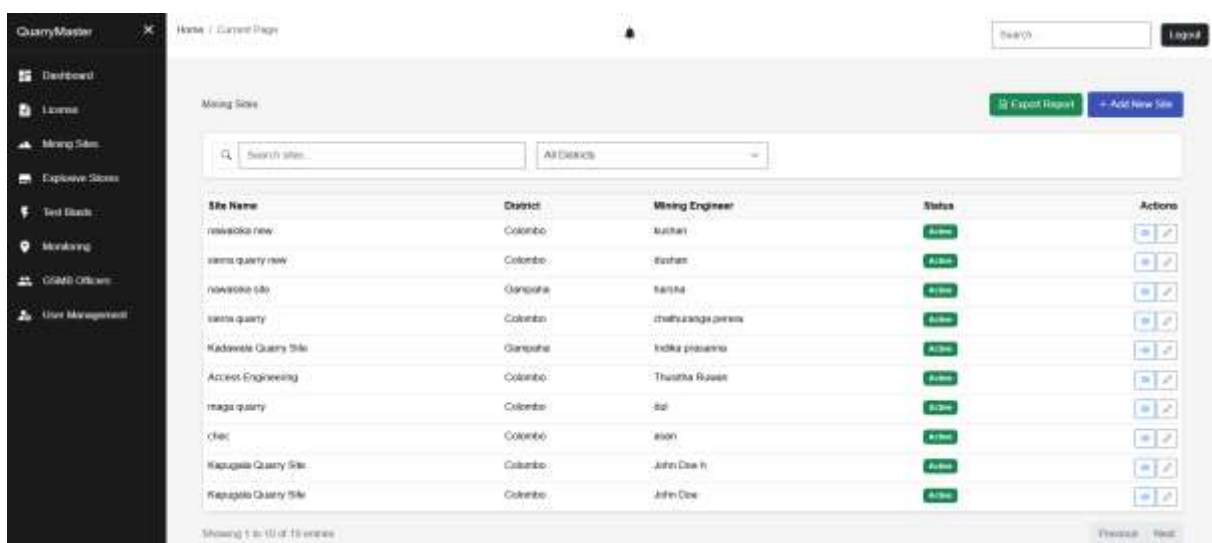
The QuarryMaster system provides two main types of reports to support information needs and decision-making for GSMB officers and site engineers:

B.1.1 Mining Sites Report

The Mining Sites Report module allows GSMB officers (Admin) to generate reports for existing mining sites that are marked on the map. This provides a clear visualization of how A grade mining sites are distributed throughout the country. To access this functionality, an admin must:

1. Log into the system
2. Click on "Mining Sites" in the sidebar
3. Click on "Export Report"

The system then offers options to generate either Excel or PDF reports with the ability to include filtered data or all sites.



Site Name	District	Mining Engineer	Status	Actions
newicko new	Colombo	Isurani	Active	[Edit] [Delete]
sansa quarry new	Colombo	Isurani	Active	[Edit] [Delete]
newicko site	Gampaha	Nandini	Active	[Edit] [Delete]
sansa quarry	Colombo	Chathuranga perera	Active	[Edit] [Delete]
Kadawatha Quarry Site	Gampaha	Indika prasanna	Active	[Edit] [Delete]
Arceet Engineering	Colombo	Thushita Ruwan	Active	[Edit] [Delete]
rtaga quarry	Colombo	Isi	Active	[Edit] [Delete]
Chic	Colombo	aloni	Active	[Edit] [Delete]
Kapugala Quarry Site	Colombo	John Doe H	Active	[Edit] [Delete]
Kapugala Quarry Site	Colombo	John Doe	Active	[Edit] [Delete]

Figure B.1 - Mining Sites list interface for GSMB officers

The Mining Sites report interface displays a comprehensive list of all mining sites with key information such as:

- Site Name
- District
- Mining Engineer
- Status
- Actions (view, edit)

This interface allows officers to search for specific sites, apply filters, and export the data for further analysis.

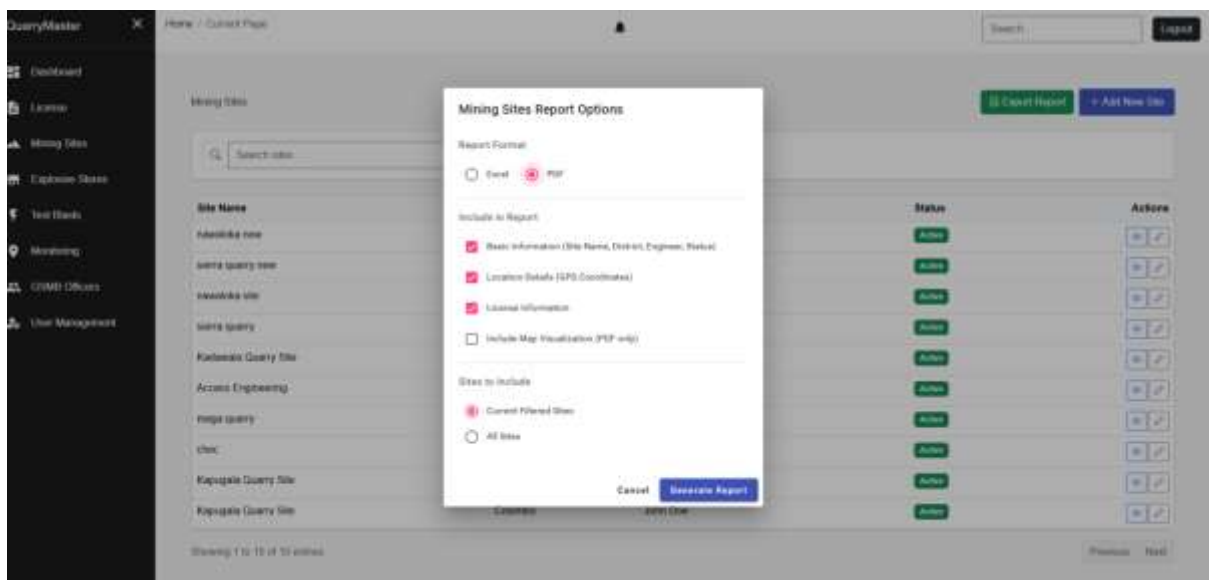


Figure B.2 - Mining Sites report generation options interface

The report generation options dialog allows the user to select:

- Report Format (Excel or PDF)
- Information to include in the report:
 - Basic Information (Site Name, District, Engineer, Status)
 - Location Details (GPS Coordinates)
 - License Information
 - Filter selection (Current Filtered Sites or All Sites)

This flexibility allows officers to customize reports based on their specific analytical needs and decision-making requirements.

B.1.2 Purchase Orders Report

The Purchase Orders Report module allows site engineers to generate reports for explosives orders and tracking. This provides comprehensive information about the orders placed, their status, and detailed item listings. To access this functionality, a site engineer must:

1. Log into the system
2. Click on "Purchase Orders" in the sidebar
3. Click on "Export" button

The system then provides options to export as PDF or Excel format with the ability to filter data based on date ranges and order status.

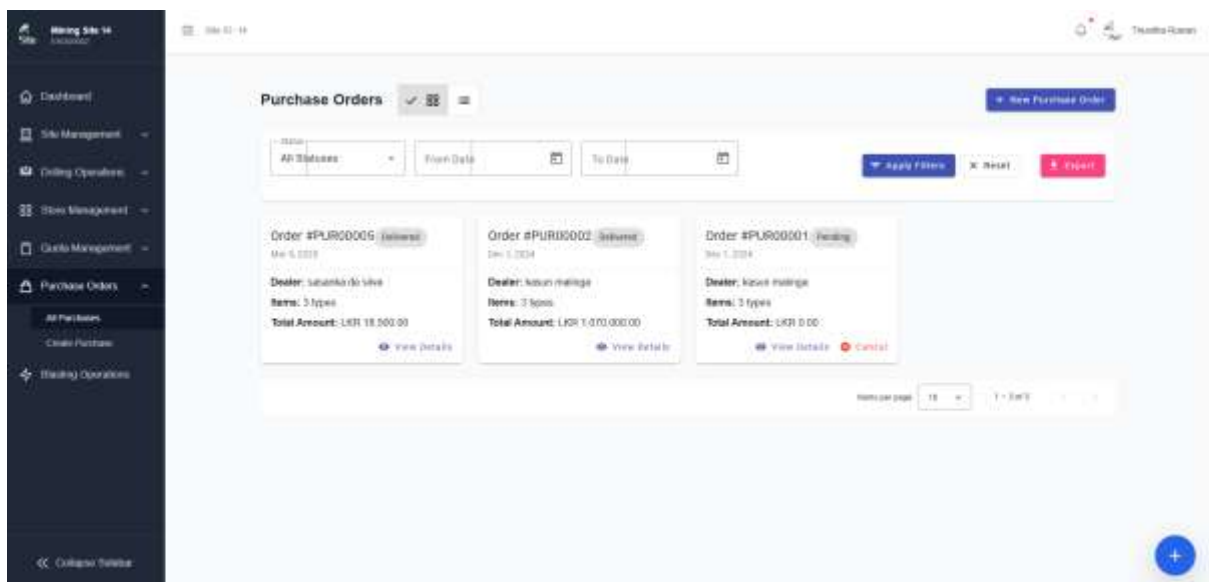


Figure B.3 - Purchase Orders interface for site engineers

The Purchase Orders interface displays a list of all orders with key information such as:

- Order ID
- Date
- Dealer
- Items count
- Total Amount
- Status (Pending, Delivered)
- Actions (view details, cancel)

This interface allows engineers to filter orders by date range and status, search for specific orders, and export the filtered data.

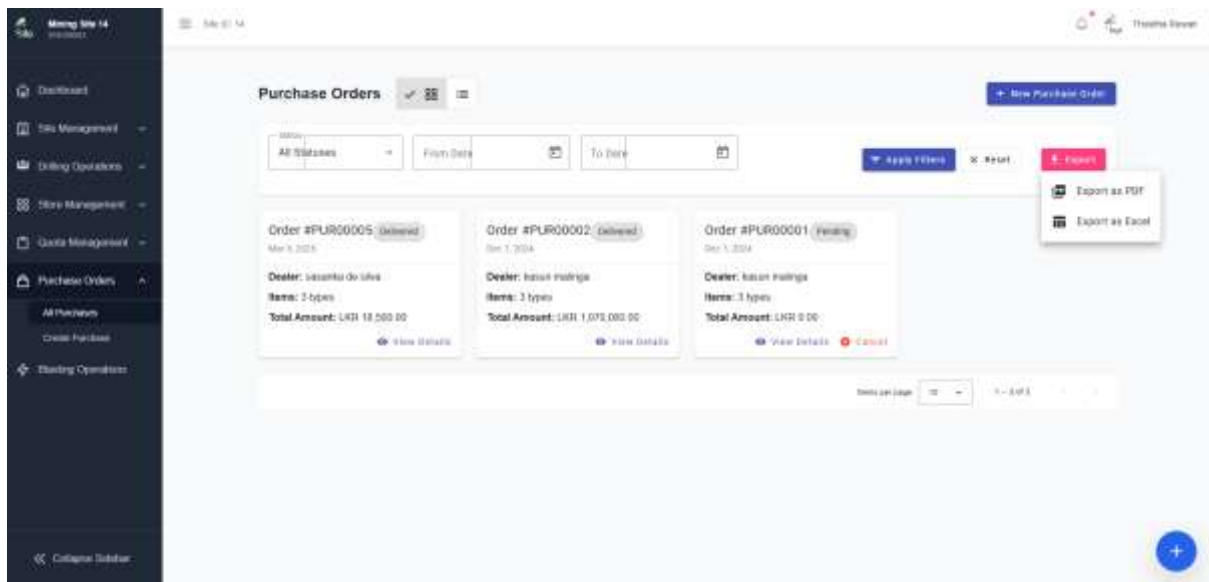


Figure B.4 - Purchase Orders export options

The export options dialog provides options to export the report in either PDF or Excel format, allowing engineers to use the format that best suits their needs for documentation or further analysis.

B.2 Evidence of the Reports

B.2.1 Mining Sites Report

The Mining Sites Report provides comprehensive information about all registered quarry sites in the system. It includes site details, location information, and license validity information that helps GSMB officers make informed decisions about site management and regulatory compliance.

Mining Sites Report

Generated: 3/6/2025, 3:36:00 PM

Total Sites: 10

Site Name	District	Mining Engineer	Status	WGS Coordinates	License Number	License Validity
nawaloka new	Colombo	kushan	Active	N: 6.188190, E: 78.982052	ML-22545	2025-02-26 to 2026-02-26
sierra quarry new	Colombo	dushan	Active	N: 6.238855, E: 80.458374	ML-202511	2025-03-05 to 2026-02-03
nawaloka site	Gampaha	harsha	Active	N: 6.708133, E: 80.455627	ML-202511	2025-03-05 to 2026-02-03
sierra quarry	Colombo	chathuranga perera	Active	N: 6.641326, E: 80.101318	ML-2245	2024-12-12 to 2025-12-12
Kadawala Quarry Site	Gampaha	Indika prasanna	Active	N: 11.919492, E: 83.183123	LIC-2024-001	2024-01-01 to 2025-12-31
Access Engineering	Colombo	Thusitha Ruwan	Active	N: 6.890819, E: 80.219421	IML00012	2024-05-10 to 2025-05-10
maga quarry	Colombo	dul	Active	N: 6.090493, E: 80.305562	ML2024-002	2024-01-01 to 2025-01-01
chec	Colombo	asan	Active	N: 6.452946, E: 80.237222	ML2024-007	2024-01-01 to 2025-01-01
Kapugala Quarry Site	Colombo	John Doe h	Active	N: 6.639057, E: 80.538615	ML2024-001	2024-01-01 to 2025-01-01
Kapugala Quarry Site	Colombo	John Doe	Active	N: 1.600030, E: 1.740050	ML2024-001	2024-01-01 to 2025-01-01

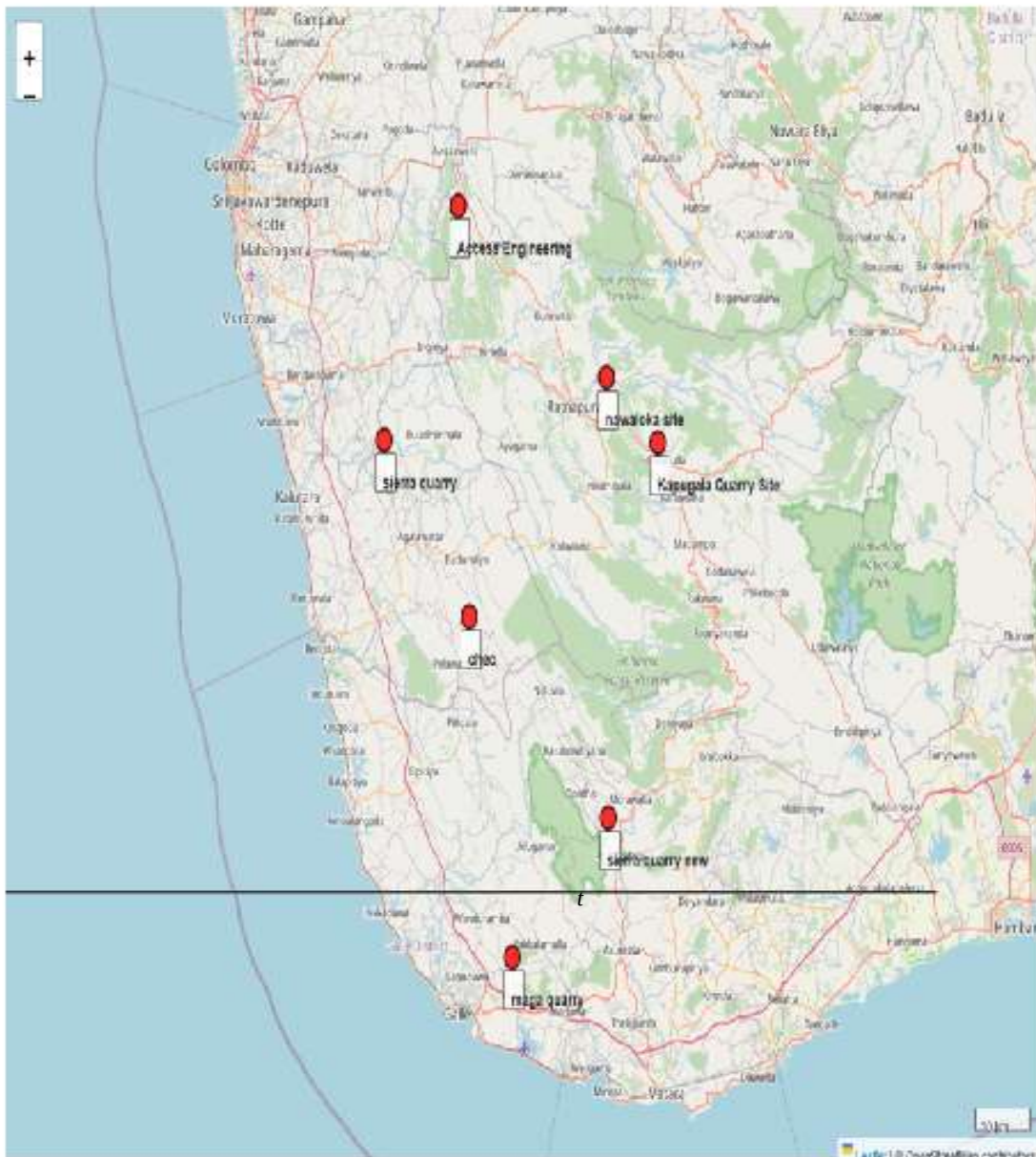
Figure B.5 - Mining Sites details report

The Mining Sites Report includes:

- Total number of sites
- Site Name
- District
- Mining Engineer assigned
- Status of the site
- WGS Coordinates for precise location
- License Number
- License Validity period

This report helps GSMB officers monitor the distribution of mining sites, track license renewals, and ensure proper management of quarry operations across different districts

Mining Site Locations



Map Legend:



Active Sites



Inactive Sites

Figure B.6 - Mining Site Locations map

The system also generates a visual representation of mining sites on a map, making it easier for officials to understand the geographical distribution of sites. The map uses color-coded markers to distinguish between active and inactive sites, providing an intuitive overview of site statuses across the country.

B.2.2 Purchase Orders Report

The Purchase Orders Report provides detailed information about explosives and materials ordered by mining sites, helping to track inventory, expenditure, and usage patterns.

Generated: 3/6/2025, 4:36:44 PM

Purchase Orders Report					
Total Orders: 3					
Order ID	Date	Dealer	Items	Total Amount	Status
PUR00005	3/5/2025	sasanka de silva	3	LKR 18,500.00	Delivered
PUR00002	12/1/2024	kasun malinga	3	LKR 1,070,000.00	Delivered
PUR00001	12/1/2024	kasun malinga	3	LKR 0.00	Pending

Purchase Order Items

Order #PUR00005 - 3/5/2025 (Delivered)

Item Type	Quantity	Unit Price	Total Price	Batch	Expiry Date
Electrical Detonator	10.00 numbers	LKR 100.00	LKR 1,000.00	121452	1/2/2026
Water Gel	10.00 kilograms	LKR 250.00	LKR 2,500.00	155452	4/5/2025
Ammonia	30.00 kilograms	LKR 500.00	LKR 15,000.00	124578	5/10/2025

Order #PUR00002 - 12/1/2024 (Delivered)

Item Type	Quantity	Unit Price	Total Price	Batch	Expiry Date
Electrical Detonator	200.00 numbers	LKR 450.00	LKR 90,000.00	ED-2024-001	1/15/2025
Water Gel	800.00 kilograms	LKR 850.00	LKR 680,000.00	WG-2024-002	12/31/2024
Ammonia	500.00 kilograms	LKR 600.00	LKR 300,000.00	AM-2024-001	12/31/2024

Figure B.7 - Purchase Orders details report

The Purchase Orders Report includes:

- Total number of orders
- Order ID
- Date
- Dealer information
- Number of items in each order

- Total amount
- Order status (Delivered, Pending)

Additionally, the report provides detailed information about the items in each order:

- Item Type
- Quantity
- Unit Price
- Total Price
- Batch number
- Expiry Date

This comprehensive information helps site engineers track their inventory, monitor expenditure, and ensure proper management of explosives and materials at the mining sites. It also assists GSMB officers in regulatory oversight by providing transparency into the quantities and types of explosives being used at each mining site.