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Evaluation of Schedule and Risk Analysis for Construction Projects Through Failure Mode and Effects Analysis

by

Malik Ahsan Hassan

A thesis submitted in partial fulfillment for the
degree of Master of Science

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In humble reverence and unwavering devotion, I dedicate the entirety of this thesis to Allah Almighty, seeking His divine guidance as I embark on this scholarly journey

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I am dedicating all my thesis work to Allah Almighty; indeed, his mercy prevails over his wrath. Also, to Muhammad(PBUH), the Divine Servant Leader, who has changed my life.

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(Malik Ahsan Hassan)

Abstract

Effective project management in construction is essential for the successful completion of complex projects within stipulated timelines and budgets. The integration of advanced project scheduling tools and risk analysis methodologies plays a pivotal role in enhancing project outcomes. This thesis explores the utilization of Failure Mode and Effects Analysis (FMEA) in conjunction with Primavera, widely adopted project management software, to evaluate project schedules and assess potential risks for construction projects.

The primary objective of this research is to establish a comprehensive framework that combines the usefulness of Primavera and FMEA to enhance project planning and risk management. The study begins by reviewing existing literature on project scheduling, risk analysis, and FMEA within the context of construction projects. The theoretical foundation establishes a basis for the integration of these methodologies, highlighting the potential benefits in terms of improved project outcomes and mitigation of potential disruptions and risks. The research methodology encompasses case studies of real-world construction projects, employing both qualitative and quantitative analysis. The integration of Primavera with FMEA technique allows for a systematic identification of failure modes, assessment of their effects, and prioritization of risks based on severity, occurrence, and detectability. This integrated approach enables project managers to proactively address potential risks during the scheduling phase, leading to better-informed decisions and improved project performance.

The findings of the study represent the advantages of integrating FMEA with Primavera for construction project management. The identification and assessment of critical failure modes provide insights into potential schedule delays, cost overruns, and other project disruptions. By quantifying risks and their potential impacts, project stakeholders can allocate resources more efficiently, implement targeted risk mitigation strategies, and enhance overall project resilience. In conclusion, this thesis contributes to the existing body of knowledge in construction project management by demonstrating the effectiveness of integration scheduling with Failure Mode and Effects Analysis through Primavera. The proposed framework empowers project managers to optimize project schedules while proactively addressing potential risks. The results highlight the significance of adopting a holistic approach that combines advanced scheduling tools with comprehensive risk assessment techniques for achieving successful project outcomes in the construction industry.

Keywords: Primavera, Failure Mode and Effects Analysis, Risk, Construction Project.

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Abbreviations

BIM	Building Information Modeling
CPM	Critical Path Method
D	Detection
ES	External Stakeholder
EVM	Earned Value Management
FEVM	Fuzzy Expected Value Method
FFMEA	Fuzzy Failure Mode and Effect Analysis
FMEA	Failure Mode and Effect Analysis
GSD	Global Software Development
IPS	Intelligent Planning System
IS	Internal Stakeholder
O	Occurrence
PERT	Program Evaluation Review Technique
PMST	Project Management Software Tools
PRA	Primavera Risk Analysis
RBS	Risk Breakdown Structure
RCS	Radar Cross-Section
RPN	Risk Priority Number
S	Severity
WBS	Work Breakdown structure

Chapter 1

Introduction

This chapter deals with the general idea of schedule development and risk assessment for construction projects by introduction of scheduling and risk management concepts, a statement of the problem, objectives, Research question, the research methodology, Significance of study, and organization of the study.

1.1 Introduction of Scheduling and Risk Management

Project management planning lists sustainable activities, milestones in a project. Yahootkar and Gil [2] explain the values of schedule pressure on a project. If the expected schedule is delayed, extra resources, such as money, labor, and developing technology, may be compulsory to get the project on track. This not only affects the outcome of the project but also affects the organization's status among stakeholders.

Project planning has received a lot of attention in recent years. Time management is critical in a construction project because it must deal with many interdependent activities performed by skilled workers. A study conducted by Ribeirinho et al. [1] found that keeping a construction project on schedule can be a major challenge, as most activities are still performed manually. Additionally, the construction industry is facing a shortage of skilled workers, requiring creative time management methods. To survive in this competitive industry, 80% of the respondents believe that effective changes need to be made, especially in cost and time strategies.

The planner's experience can shorten deadlines if tasks can be performed concurrently, but only if other resources are available [3]. Management in the construction industry requires a complementary, interdisciplinary and flexible approach to capture the changing nature of risk factors (qualitative and quantitative).

Therefore, when developing a risk assessment model for construction projects, it is required to focus on manufacturing available tools to use a combined approach. Dziadosz and Rejment [4] argue that risk analysis is the process of prioritizing risks for further analysis or action by evaluating and combining their probability and impact. The key benefit of this process is that it allows project managers to reduce uncertainty and focus on high-priority risks.

Quantitative risk analysis is the process of numerically analyzing the impact of identified risks on the overall project objectives. The main benefit of this process is that it generates quantitative risk information to support decision-making and reduce project uncertainty [5]. The risk management plan addresses the tools and measures that can be used to manage and control events that could negatively impact the project.

1.2 Problem Statement

The construction industry is characterized by its complex and dynamic nature, often involving complex schedules, multiple stakeholders, and huge number of interconnected activities. Effective project management and risk assessment are essential to ensure successful project execution, timely completion, and cost-effectiveness. The incorporation of advanced techniques such as Failure Mode and Effects Analysis with latest project management software such as Primavera has been great challenge for improving the project planning, risk assessment and management in the construction sector. Meanwhile, there is a lack of in-depth research focusing on the investigation and effectiveness of the combined coordination of FMEA with Primavera for planning and risk reduction/mitigation.

The main challenge lies in identifying, analysing, and mitigating potential failure patterns that can impede project progress and introduce risk factors. Traditional project management practices often focused on schedules without considering complex potential risks, leading to unforeseen delays and/or incomplete/fail projects. The integration of FMEA into project management practices, particularly through widely used software such as Primavera, has the potential to provide a comprehensive framework for simultaneous risk assessment and schedule analysis, which allows better decision making and appropriate resources allocation.

As a result, there is a requirement to discover a method to analyze risk as a support point for decision-makers through integration of FMEA using Primavera as a technology backbone in the context of construction project management. Through this research, it aimed to contribute provide a systematic approach to deal with schedule uncertainties and potential risks simultaneously.

1.3 Research Questions

Based on the above argument, the present study will focus on three main questions.

Research Question 1

What are the key challenges and limitations associated with implementing Failure Mode and Effects Analysis (FMEA) along with Primavera risk analysis and project scheduling, and how do these challenges affect the overall effectiveness of the approach in real-world construction scenarios?

Research Question 2

How does the incorporation of FMEA in project-based management process influence the proactive mitigation of potential construction project risks and their corresponding impacts on the project schedules?

Research Question 3

To what extent does the integration of FMEA enhance the accuracy of risk identification and assessment of construction projects, whose scheduling is managed through Primavera?

1.4 Research Objectives

The general objective of the project is to design a systematic approach to project planning while minimizing or mitigating potential risks. To achieve this objective, the project organization will attempt to maintain the highest standards of work.

- To accomplish the project scheduled, successful, and/or timely completion.
- To minimize the risks that are present throughout the project's life cycle.

1.5 Significance of the Study

Planning construction projects includes listing tasks, activities, and milestones, along with expected start and end dates. The importance of planning in construction projects cannot be overlooked, as it plays a vital role in the success of any project.

Planning will ensure the project is completed on time and within budget. It describes not only the pace of work but also the manner in which the task is performed. In addition, the schedule also determines the method and order in which documents will be sent. It allows for adjustments to account for changes and unforeseen events.

Performing risk assessments before project initiation, both while the project is underway and after completion, helps managers identify potential risks and develop mitigation and reduction plans to minimize those risks. Risk assessments help managers determine the significance or severity of potential risks. It also helps managers avoid risks that can lead to financial loss.

In the existing literature, there is no approach that reflects the direct impact of risk factors at specific points in the project schedule. This study focuses on implementing the FMEA risk assessment methodology by synchronizing it with project planning. It is argued that FMEA can provide a useful and practical method for understanding, analyzing, and managing risks and delays.

1.6 Organization of the Study

This study is divided into five chapters. Below is a brief overview of each chapter:

- The basic introduction, problem statement, research questions, objectives, and significance of the study are provided in Chapter 1
- literature is covered in Chapter 2, review the general idea of scheduling, risk management, history, and detailed explanation of risk analysis FMEA method .
- The research methodology is explained in Chapter 3.
- The selected methodology is applied to a case study in Chapter 4.
- Discussion, Conclusions, limitations, and recommendations for future studies are provided in Chapter 5.

Chapter 2

Literature Review

Literature related to the research topic is divided into three phases.

First, the document is reviewed for planning and schedule management using various construction management software to describe the concept of “resource allocation”. The second step is to review the literature related to risk, risk management, and risk management in construction to describe the concept of “risk”. In the third step, the documentation will be reviewed for failure mode and effects analysis (FMEA), which is one of the risk identification methods

2.1 Scheduling for Construction Management

The resource management in construction projects, focusing on an accelerated project with limited time. It is carried out in two phases; first, the project schedule is prepared using Primavera software and resource leveling is done for different activities. The study highlights the importance of resource management in construction projects, as it involves managing workers, materials, and machines in a coordinated and timely manner. The duration and cost of a construction project depend directly on available resources, are important factors for successful implementation. Project attributes are presented, including the project schedule, required labor, and incurred costs. Labor is calculated based on the drawings and experience of experts in the field. This article presents a comprehensive framework for resource management, focusing on labor as a resource element in construction according to Nagaraju and Reddy [6].

Another article [7] compares project management software (PMST) tools with the aim to identify the right tool for project planning and management. The results help project managers to assess their strengths and weaknesses, providing valuable information for selecting the right tools for successful project management.

2.1.1 General Overview of Schedule Management

Development of a project schedule comes after describing the work breakdown structure, identifying interdependencies between activities, aligning them, estimating task durations, and identifying associated risks. A Gantt chart is a type of bar chart that shows project progress. It is one of the most significant tools used in planning and managing schedules for multipart projects. [9].Priya et al. [10] communicated that proper planning and scheduling are crucial to prevent the project planning delays and losses. Due to poor planning and scheduling, a significant amount of time, money and resources are wasted each year in the construction industry. Construction projects are increasing in number and complexity with globalisation. With the aid of project planning software, the amount of documentation required to plan such projects can be decreased. Schedule management planning is performed during the project planning phase and is considered part of the project management plan. It is helpful to create a project schedule because it allows the project manager to summarize the start and finish times for each individual task that is a part of the project, providing a graphical representation of the project's potential duration. Project schedule creation is a complicated job, which entails defining activities, organizing them, choosing activity milestones, and then carrying out the plan. The construction industry in India is facing challenges such as overhead costs, time occupation, and poor project management. Primavera P6 supports efficient planning by assigning two relationships to each activity, reducing floating time, enabling visual assessment, and enabling resource management.

However, the industry is still having problems such as increased costs and delays due to poor planning and scheduling according to Vipin Kumar [8].

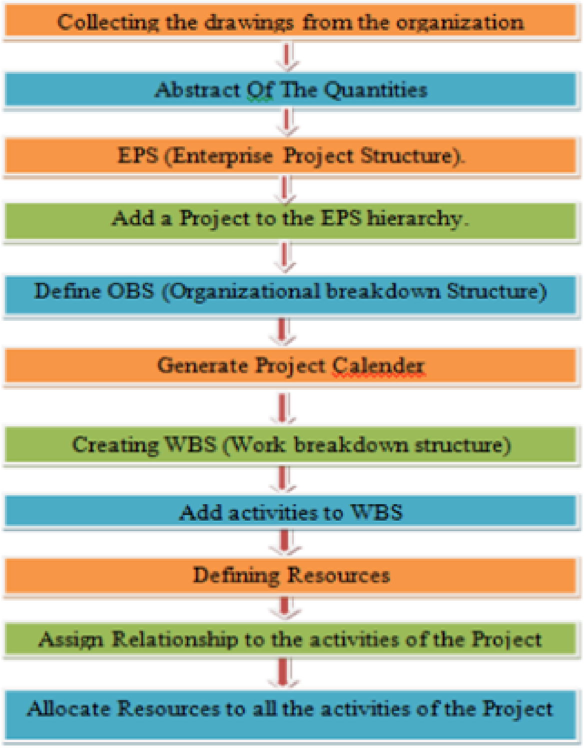


FIGURE 2.1: Structuring of Project in Primavera

Usually, Primavera software is used to plan and oversee a residential project. By examining the outcomes, one can suggest a method that is more suitable for the residential project

Project management analysis in a multi-project environment is important, especially when resource capacity is being maximized. Simulating system dynamics using extensive field research with a effective developer shows the values of planned project management policies. This rigorous cycle can affect an organization's ability to meet project milestones for the long term. Capturing resources can ensure timely delivery of business-critical projects but the absence of free resources or hire staff affects the performance and reduces the productivity of the workforce [2].

2.1.2 Challenges of Project Scheduling

Project planning involves the process of determining the start and end dates of project activities as well as their interdependencies. It plays an important role in project management but it often comes with various challenges. One of the main challenges in project planning is the presence of uncertainties and risks. Some researchers have focused on incorporating uncertainty into project planning models. For example, Vanhoucke et al. [11] proposed a robust project planning model that takes uncertainty about activities duration into account and allows for proactive decision-making in the event of uncertainty. Another challenge is resource's constraint planning, where resource availability and allocation must be considered. Zhang et al. [12] developed a multi-objective optimization method for planning resource-constrained projects, considering both project completion time and resource usage.

Dynamic project scheduling poses a challenge in environments where project characteristics such as activity duration and resource availability change over time. To deal with scenario, a dynamic scheduling algorithm presented that adaptively adjusts project schedules based on real-time data [13]. Another study conducted in Czech Republic addressed the maturity of planning methods for medium and large enterprises. This study included in-depth interviews and semi-structured interviews with a focus on mid-sized companies. Pandemic has led to a better understanding of integrated planning approaches and investments in complex software solutions [14].

As the resources are very important in construction projects and optimizing them is crucial for efficient project execution. Proper planning and scheduling are essential to ensuring quality, on-time completion, on-budget work, and a comfortable workplace [15].

Manupati et al. presented the idea of mobile agent-based commercial approach to integrate the production functions in a distributed manner using Protégé software and XML schemas. This approach is effective in reducing production cycle times and maintaining production flexibility while realizing achievable process plans [16].

Population growth and technological developments are increasing the demand for energy, prompting the consideration of alternative energy sources such as biogas. The construction activities of biogas plant are analyzed through critical path method [17].

2.1.2.1 Project Scheduling with Different Software

The construction planning management is affected by the natural environment, both objectively and subjectively, causing disruption or obstruction. However, the use of building information modeling (BIM) and BIM5D software during the actual construction process allows timely tracking of resource requirements, equipment needs, and capital requirements. This comprehensive construction schedule management mode ensures timely monitoring of quality and safety issues, error logging, data integration, and error correction [18].

The ultimate goal of an enterprise is to generate profits and satisfy the consumption/needs of the community by using various economic resources. The productivity refers to the relationship between resources used in the production of goods and services. Increased productivity leads to higher revenue for shareholders, managers, employees, and the community. Productivity refers to the collective production of all the individual resources of a company [20]. Varsani, et al. [21] stated that the proper planning and scheduling are essential for construction projects to reduce delays and save time, money, and resources. With globalization, complex projects require a lot of paperwork and time management. Project planning software can help to reduce the paperwork and time. An alert mechanism is necessary for success and failure. This study aimed to plan and monitor an industrial project using Primavera software and proposed measures for future projects.

Intelligent planning system (IPS) helps project managers to find near-optimal allocation of labor, materials, equipment, and space based on project goals and constraints. The IPS uses simulation techniques to allocate resources and prioritize activities while considering building factors. It allows what-if analysis and schedule adjustments based on unforeseen conditions. Authors compared this system with

Primavera and Microsoft Project and demonstrated its effectiveness in achieving near-optimal scheduling [19].

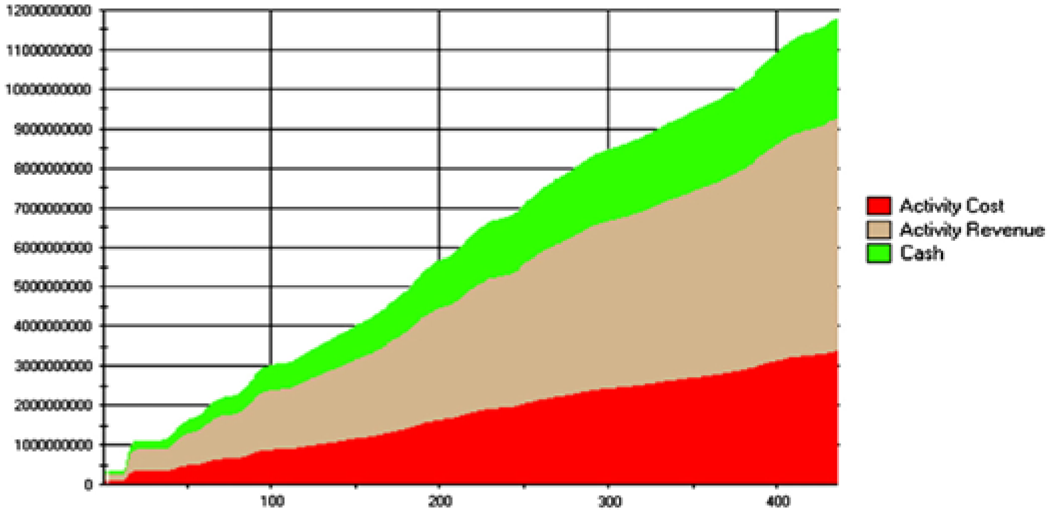


Figure 2.2: Cash Flow Forecast for Project

The construction professionals often use scheduling software to load schedules without considering critical paths. The radar cross-section (RCS) calculations show virtual flutter because the resource relationships are ignored. Deleting ghost floats can cause non-critical operations to become resource-critical, resulting in incorrect float values [22]. The construction industry is vital to Malaysia's economic development and achieving the 2020 vision. Proper planning is essential for smooth project execution. The best schedule meets key goals such as quality, on-time delivery, budget, and a safe work environment. Othman [23] investigated the planning and scheduling in construction projects focusing on multi-story construction projects and S-curve production using Microsoft Project software. A case study is used to evaluate and analyze construction schedules, revealing project plans, work sequences, and relationships between activities. The findings could benefit both project management practice and education.

The project organizations face challenges in scheduling with shared resources and optimizing unscheduled capacity across multiple projects. A multi-agent approach including multi-project portfolio agents, resource agents, and project agents, is proposed to support resource scheduling and planning decisions in such a way that all these processes are integrated. The approach produces near-optimal solutions [24].

2.1.3 Resource Allocation

Resource allocation involves allocating resources such as personnel, equipment, and budget to project activities in an optimal way. Efficient resource allocation is critical to project success and requires consideration of various factors. One challenge in resource allocation is allocating limited resources to multiple projects. Shtub et al. proposed a multi-project resource allocation model that optimizes resource allocation for multiple projects, taking into account project priorities, resource availability, and dependencies of projects [25].

Another challenge is dynamic resource allocation, where resource availability and demand change over time. A dynamic resource allocation model is developed that takes into account real-time resource availability and project progress to optimize resource allocation for construction projects [26]. Resource allocation in a distributed project environment can be difficult due to coordination and geographic dispersion issues. Therefore, an integrated collaborative resource allocation framework is proposed that shares information and makes decisions among distributed project teams [27].

A literature study highlighted that proper planning and scheduling are critical for Metro rail construction projects to reduce delays and control costs. With globalization, construction projects are becoming more complex, requiring comprehensive planning and scheduling software. The case study shows the weaknesses of the current project management system and the importance of effective planning. Contributing factors to delays include lack of knowledge about advanced monitoring methods, lack of trained staff, lack of adequate capital flow, regional festivals, unusually prolonged monsoon rains, no sand due to legal restrictions, and late delivery of resources [28]. Studying project management in a multi-project environment is very important, especially when resource capacity is limited. The policy of running on schedule can lead to very tight cycle, leading to delays in subsequent projects and lower productivity [2].

Construction management projects face complex environments, uncertainty, and time constraints. Project managers struggle to identify best practices for project planning using critical path methodologies and look for tools to increase job completion and save budget. A case study was conducted by P. Samp explores the strategies used by construction project managers to manage on-time project handover. Research reveals that project managers must deal with variables such as punctuality, budget, and cost that are difficult to control [29]. Sahu and Jain examined the process of overseeing the construction of a ”residential colony” in Bhopal, Madhya Pradesh. They compared planned progress with actual progress using Primavera P6 project management software. This software supports activity duration, resource analysis, risk analysis, and communication between project participants [30].

2.1.4 Project Time and Cost Trade-Off.

The trade-off between project time and cost refers to the managing project schedules and costs to achieve the optimal balance between on-time completion and cost control. Yu et al. proposed a hybrid approach that combines critical path methodology and earned value management to identify critical activities and analyze project time and cost [31]. However, the major challenge is identify the most cost-effective project schedule. Zhang et al. developed a multi-objective optimization model that takes into account the project's time, cost, and quality objectives to aid in decision-making for analyzing the trade-offs between time and cost [32].

In addition, project risk management also plays an important role in the time-cost trade-off of a project. A risk-based framework is suggested that integrates risk assessment, risk mitigation, and schedule control to optimize the trade-off between time and cost of the project in cases of uncertainty [33].Planning, scheduling, and control are critical stages in projects that require targeted techniques to improve cost, schedule, and operational performance. Primavera P6 software is used for the planning and scheduling of two-story residential buildings. The project aims to prepare the construction of two-story residential buildings in Dindugal, focusing on technology, task definition, resource estimation, and interaction between different tasks. This approach reduced the time, costs, and resources while ensuring that the projects are completed on time [34].

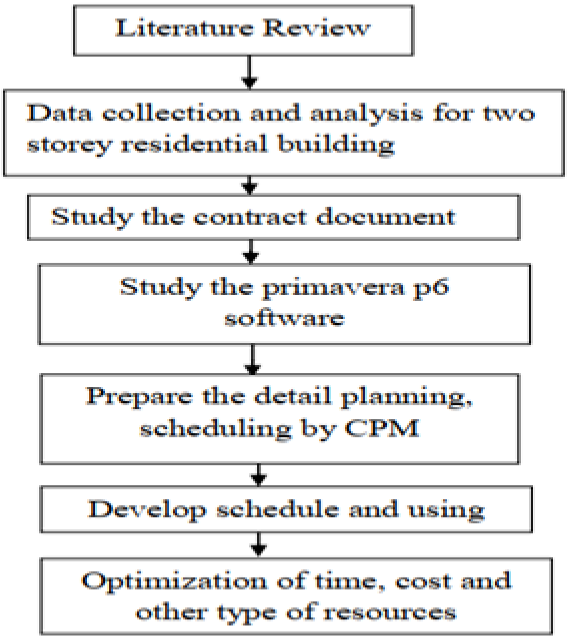


Figure 2.3: Methodology Flow Charts

As the construction industry is ever-changing with an emphasis on tool and equipment characteristics, communication techniques, and effective management techniques. Nimbal and Jamadar attempted to implement Primavera P6 computerized project management software for planning, scheduling, and resource allocation for a residential building. The results showed that the project completion time was reduced from 640 days to 434 days through the use of Primavera software. The project manager should be well aware of the schedule and prioritize the tasks to complete it. Primavera P6 software has proven to be an effective tool for monitoring and controlling construction projects, minimizing time spent on updating efforts [35].Another study also claimed that Primavera software is used for construction projects, improving planning, scheduling, resource allocation, and time management, ensuring successful project outcomes, and reducing delays [36].

Planning and scheduling are critical in large infrastructure projects, with software such as Primavera P6 and Microsoft Office Project enabling efficient planning and resource allocation [38].

Figure 2.4: Financial Planning

The impact of contractor attributes on project success is examined from a post-construction evaluation perspective. A questionnaire survey identified nine groups, including safety, quality, past performance, environment, management, technical aspects, resources, organization, experience, size or project type, and financing. Logistic regression technique is used to predict the probability of project success [37].

Niazi et al. identified 19 critical challenges for successful global software development (GSD) project management from the perspective of customers and suppliers. The two-stage approach, using a systematic literature review and questionnaire survey, showed a positive correlation between the results. GSD organizations should address these challenges to increase project success [39].

2.1.5 Project Management Success Factor

A key framework for optimizing cost and schedule management of IT projects is presented in Cost and Time Project Management Success (CTPMS). A study of 899 projects from a major bank found positive effects on project managers, scope, schedule, delays, and formal authority, while harmful effects were hazardous to the team size and distribution of project managers. The outcomes can help decision makers purposefully allocate resources, improve staffing, and allocate team members across multiple projects. CTPMS is a valuable tool that enables organizations to develop skills and ensure the success of their projects [40].

Critical path method (CPM), a method used in construction industry since 1950s, has not been fully accepted. A survey gathered stakeholder views on the applicability, effectiveness, and necessity of employee qualification for planning. The article discusses recommendations for consistency in CPM planning for industry improvement [41].

Project management is crucial to the performance of the organization and achieving its goals in a timely manner. Schedule management, a process of controlling and monitoring the entire work process, has a positive impact on the effectiveness of project management. This research can help organizations to identify and use time management plans for improvement of business processes [42].

Harsh et al.stated that proper planning and scheduling are crucial for construction projects, reducing delays and reducing costs. Primavera P6 software can help reduce paperwork and improve resource flow, while an alerting mechanism alerts organizations to potential successes and failures [43].

Planning and scheduling are critical in construction projects, meeting complexity and reducing delays. Plan accordingly by using software like Primavera and MS Project for efficient document management [44].

Two new mixed-integer linear programming (MILP) models are suggested for planning resource-constrained multi-mode projects focusing on mode selection, resource allocation, and sequence variables. These patterns improve performance by eliminating symmetric solutions and adding redundant sequence constraints. They provided simpler structures, increased flexibility, and outstanding performance when operations are long [45].

2.2 Risk Management

The sustainability of project operations, including financial, social, and environmental aspects, is critical to project management. A literature review from 1987 to 2018 highlights the computational procedures for optimizing durability problems. An integrated framework with feedback functions is proposed[47]. Effective project management is crucial for construction projects, ensuring within budget and on-time delivery. Proper planning, scheduling, resource allocation, and updates are essential to optimizing projects and maximizing revenues[46].

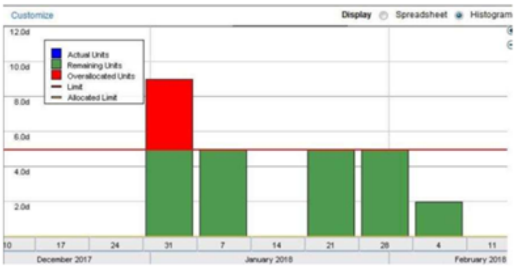


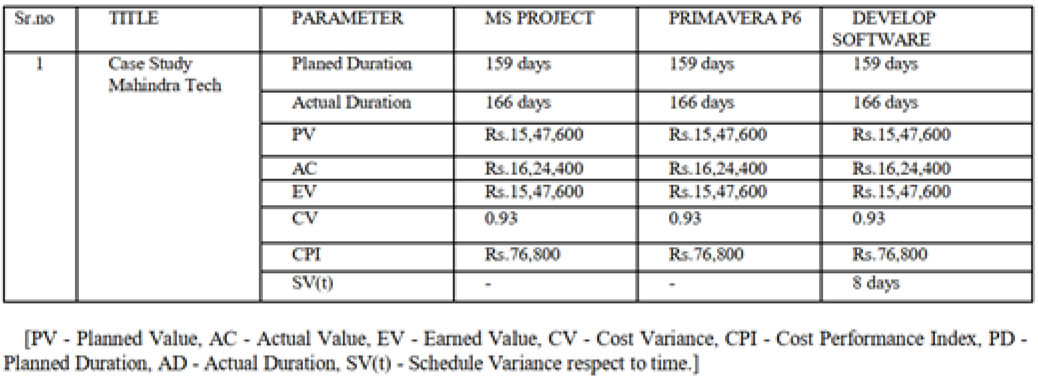
FIGURE 2.5: Over Allocation of Resources

2.2.1 General Overview on Risk Management

Risk management is a key aspect of an organization's decision-making process and involves identifying, assessing, and minimizing potential risks to achieve business objectives. Risk management is the process of understanding, analyzing, and resolving uncertainties that may affect an organization's ability to achieve its objectives. It includes both identifying potential risks and implementing appropriate strategies to manage them effectively.

Table 2.1: Comparison between MS/Project and Primavera

Descriptions	**Primavera**	**MS Project**
Baselines	Supports unlimited baselines	Supports 11 baselines only
Multiple User Access	Allow number of users to work on one project	Does not allow multiple user to work on one project
Issues and Risks	Allows issue and risk recording	Lacks feature of tracking risks and issues
Multiple Activity Relationship	We can establish multiple relationship among two activities e.g. Finish-to-Finish and Start-to-Start relationship among two activities	No such thing available in MS Project. We can create only one relationship between activities
Web Supporting	Any information, document and plan could be converted to HTML with the help of primavera software	It does not convert information, document and plan to HTML
Project Website	In this software, we can establish a project website including complete project information like issues, risks. Reports, resources, activities, WBS and all things that are entered in software	It doesn't provide any feature of creating website
Tracking, viewing and multiple Project Creation	It allows the creation of multiple projects, viewing, and tracking.	We can create multiple projects in MS Project as well but doesn't track multiple projects.



Sr.no	TITLE	PARAMETER	MS PROJECT	PRIMAVERA P6	DEVELOP SOFTWARE
1	Case Study Mahindra Tech	Planed Duration	159 days	159 days	159 days
		Actual Duration	166 days	166 days	166 days
		PV	Rs.15,47,600	Rs.15,47,600	Rs.15,47,600
		AC	Rs.16,24,400	Rs.16,24,400	Rs.16,24,400
		EV	Rs.15,47,600	Rs.15,47,600	Rs.15,47,600
		CV	0.93	0.93	0.93
		CPI	Rs.76,800	Rs.76,800	Rs.76,800
		SV(t)	-	-	8 days

[PV - Planned Value, AC - Actual Value, EV - Earned Value, CV - Cost Variance, CPI - Cost Performance Index, PD - Planned Duration, AD - Actual Duration, SV(t) - Schedule Variance respect to time.]

Figure 2.6: Comparisons between Management Software

The Monte Carlo method is an important tool in project management, focusing on estimating the project size, anticipated duration, workload, and project schedule. It is applicable to complex projects with high technology risk, large investments, and a long duration. This method is more practical and comprehensive than other methods. So, it makes more sense in risk management.

However, it has limitations, such as high accuracy that requires too many repetitive calculations and considerations while requiring accurate historical data. The Monte Carlo method is used mainly in MATLAB with statistical tools like Norm PDF, Single Function, and Norm Function [48].

Construction projects often face cost and time excesses. Earned value management (EVM) is a technique for evaluating project performance and highlighting corrective actions [49].

2.2.2 Risk Definition

Risk identification is a fundamental step in risk management. Risk can be understood as the possibility that an event or action will harm the organization's goals. The International Organization for Standardization (ISO) defines risk as "the impact of uncertainty on objectives" (ISO, 2018). This definition emphasizes the uncertain nature of risk and its potential impact on achieving desired outcomes.

Additionally, risks can be classified different categories, such as strategic risks, operational risks, financial risks, compliance risks, and reputation risks. Hillson and Murray explained these categories in their book, ”Understanding and Managing Risk Attitudes”.

They emphasized that a holistic approach to risk management must address all of these risk aspects to ensure effective decision-making and control. Risk management is an important principle that helps organizations navigate uncertainty and protect their goals. By systematically identifying, assessing, and responding to risk, organizations can improve decision-making and their overall resilience [50]. Delays in construction projects and cost overruns are a serious problem for any company, especially in developing countries where the problems are more severe. The construction industry is vital to economic growth and job opportunities; however, it also faces obstacles such as tight deadlines and budgets. Project goals for cost, time, quality, and productivity can be affected by overruns.

In order to minimize the negative impacts on project cost and schedule, an attempt is made to identify the main causes of overspending in the construction industry. Emphasizing the importance of managing them quickly to prevent negative impacts on projects.

Forty-four project excess factors are detected and classified into four categories: project scope, management, legal constraints encountered, and site resources. The top five factors include delays in obtaining permits, poor supervision, unrealistic schedules, unforeseen field conditions, and a lack of trained professionals [51].

The construction industry is very important for under-developing countries, contributing to socio-economic development. Project cost and time are important factors, and sustainable practices are the key factors. EVM data, Primavera P6, and PMBOK software provide performance metrics for project success. Project management agencies should ensure project management and budget compliance [52]. A review related to project control systems, earned value analysis, optimization tools, and decision support systems highlights the need for using analytical models, early warning systems, and integration [53].

2.2.3 Risk Management

Risk management involves a series of processes to proactively identify, assess, and respond to risks. The first step in risk management is risk identification, which involves systematically identifying potential risks that could affect the organization's objectives. This can be done through various techniques such as brainstorming, checklists, and expert opinions [54]. Once the risks have been identified, the next step is a risk assessment. This involves assessing the likelihood and potential impact of each identified risk. Risk assessment techniques can range from qualitative methods, such as the risk matrix, to more quantitative methods, such as probability modeling and Monte Carlo simulations [55].

After assessing the risks, the organization must develop appropriate risk response strategies. These strategies may include risk avoidance, risk mitigation, risk transfer, or risk acceptance. The choice of response strategy depends on the organization's risk tolerance and the cost-benefit analysis of each option [56].

Implemented risk response strategies must be regularly monitored and reviewed to ensure their effectiveness. Risk management is an iterative process that requires continuous monitoring and updating of risk assessments as the business environment changes [57].

Project managers use Monte Carlo simulations to estimate the probability of project completion. The program evaluation review technique (PERT) used since 1950s presents uncertainty about the duration of the operation. The output distribution using different distributions is investigated and found no significant difference between the networks [58].

Planning is also crucial to managing construction projects, as it helps engineers' complete projects on time and within budget. However, many projects fail due to the estimated time of the projects, which requires a risk management process. The schedule risk analysis using Monte Carlo simulations is analyzed for residential projects showing project duration of 96 days. Sensitivity analysis shows that the most sensitive activity, "Ceramic Wall Tiles", affects the completion date [59].

2.2.3.1 Risk Identification

This involves systematically identifying both internal and external risks and understanding their potential causes and consequences. Several methods and techniques have been suggested in the literature for risk identification [60]. Building information modeling (BIM) is an important collaborative process in the architecture, engineering, and construction industry, improving the quality of information and enabling design decisions. BIM can create a common language for project components and systems, integrating it with the assets and equipment management phases. The right knowledge and experience are essential for a successful BIM implementation. BIM can help with dynamic querying, statistical research on construction schedules, engineering, resources, and costs, reducing project overspending, and saving resource supplies [61]. Conventional project management assumes fixed deadlines but recognizing deadline uncertainty improves the value of decision-making. An easy-to-follow approach is presented to integrate uncertainty into management decision-making without modifying routine procedures [62].

2.2.3.2 Risk Analysis

Risk analysis involves the assessment of identified risks to determine their probability of occurrence and potential impact. This process helps prioritize risks and allocate appropriate resources to mitigate them. There are various quantitative and qualitative techniques for risk analysis, such as probability and impact assessment, risk mapping, and risk scoring [63]. Risk analysis is important in project selection and construction coordination because it helps estimate the probability of occurrence and the extent of damage. Three methods are presented, each having some advantages and disadvantages. These methods differ in method, subjectivity and data type affecting the quality of the results [4]. The design and implementation of risk analysis is conducted for 20 low-income housing units on the cost and schedule risks bases. The project aims to provide a guide that clarifies and simplifies the cost and schedule risk assessment process for construction sites using the PMBOK and Primavera risk analysis (PRA) guidelines. The project strives to deliver the project within budget, on time, with the quality required by the customer, based on the scope of work required, minimizing incidental accommodation issues, improving level of life and environment. The project objectives include executing the project within budget, on time, with the quality required by the client, reducing the problem of random housing, improving the environment and people's living standards, and significantly reducing the gap between the income of this segment and the price of housing provided [64].

Construction projects face uncertainty and risk, which makes timelines critical for successful implementation. Schedule delays are common due to uncertainty, making identification and analysis of potential impacts essential. The effect of uncertainty on project duration is investigated in the Indian context. Critical path method (CPM) is widely used for planning active networks; however, it is deterministic due to uncertainty. Non-deterministic scheduling methods such as PERT, probabilistic network evaluation techniques (PNET), critical sequence planning (CCS), and Monte Carlo Simulation (MCS)are evaluated by comparing the effects of different distributions and simulations [65].

An enterprise-level model is presented to analyze schedule risks, focus on best practices and planning processes, create a project work breakdown structure, and develop a rigid schedule [66].

2.2.3.3 Risk Response

Risk response refers to actions taken to address identified risks. This step involves developing and implementing strategies to mitigate or exploit risks, depending on their nature and impact. Risk response strategies may include risk avoidance, risk transfer, risk mitigation, risk acceptance, or risk exploitation [67].

India's information technology revolution in 2000 led to an increase in urban real estate inflation, promoting apartments as an alternative to hostels. The apartment development process is analyzed using STAADPRO and MS Excel software, providing in-depth knowledge of planning and research [68].

2.2.3.4 Risk Review

Risk review is the process of continuously monitoring and evaluating the effectiveness of risk management activities. This includes periodically reviewing and updating risk assessments, response strategies, and risk management plans. A risk assessment helps identify any new risks, reassess existing risks, and ensure that the risk management process remains effective over time [69].

2.3 Risk Management in Construction Sector

Risk management in the construction sector is described as weak, incomplete, vague, outdated, and slow to respond to changing conditions. Renault and Agumba argue that they become more important in the implementation phase of construction projects after identifying and analyzing project risks. The analysis results identify the responsibilities of the project participants, thereby applying effective mitigation plans to the project before or during the occurrence of risks [70].

Construction projects face uncertainty that can lead to delays and cost overruns. Timelines are critical to successful implementation but they are often influenced by a variety of uncertainties. Effective risk management and analysis are essential to achieve project goals in terms of cost, time, quality, and safety. Construction projects face cost and schedule risks, which can be minimized by better planning and analysis, consistent cost estimates, and recording cost and time values [71, 72].

2.4 Causes of Construction Risk Factor

A study reported by Hamka [73] identified five very high-risk hazards, i.e., workers being hit by a hatch cover or falling container; workers who slip, trap, or fall; workers trapped by containers; workers hit by trucks; and a truck that was hit by a dock crane.

The most common root causes are unclear SOPs, corroded parts, bad weather, chaotic operating rooms, improper staff recruitment and training, and unclear regulations. Project risk management is critical to project success as it involves identifying, recording, and reporting risks at every stage. Managing these risks responsibly is important to avoid project closures, incur higher costs, and ensure on-time delivery.

Project managers can use tools such as exposure probabilities models and matrices to document predicted risks and analyze risks using guidelines such as probability, impact, exposure, and risk infection. Effective risk management involves four key steps: identify, analyze, manage, and control risks. Continuous learning and improvement are essential for project managers to improve process efficiency [74].

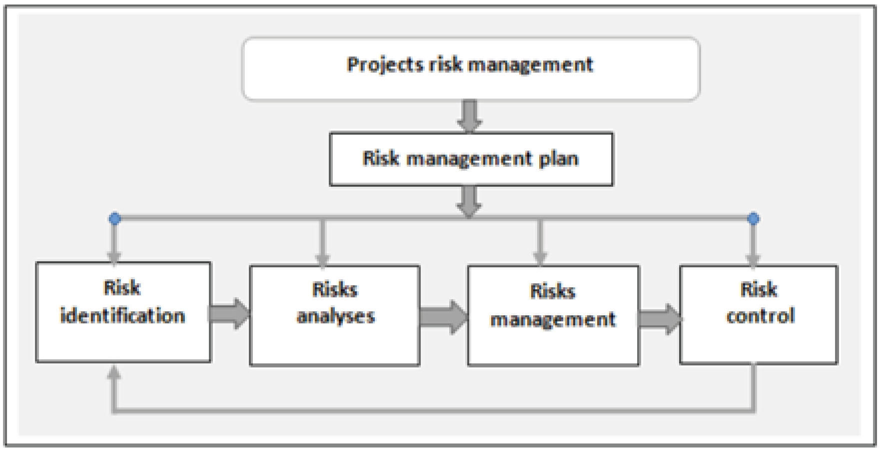


FIGURE 2.7: Risk Management Process

2.4.1 Client – Owner Related Factors

The complexity and uncertainty of global economies pose significant risks to the efficient functioning and growth of organizations. The urgency of these issues is increasing due to economic instability and an increase in external and internal factors. A human resource risk management approach has been developed that focuses on prevention. The implementation of this approach ensures uninterrupted and sustainable operations, achieving target directions, increasing customer confidence, maximizing profits, and effectively redistributing resources [75].

2.4.2 Contractor Related Factors

Supply chains have evolved rapidly to increase productivity, reduce costs, and meet the needs of emerging markets. However, supply chain complexity hinders visibility and control, leading to the risk of disruption. Supply chain risks are effectively analyzed by focusing on supply chain risk management (SCRM) and developing a research framework.

Another study stated that there are different risk transfer instruments, each with advantages and disadvantages. Options have upfront costs, uncertain, hard-to-produce futures, and need cash for contingencies. Farmers associations can use options-based strategies as a starting point and consider more challenging tools after building their skills [77].

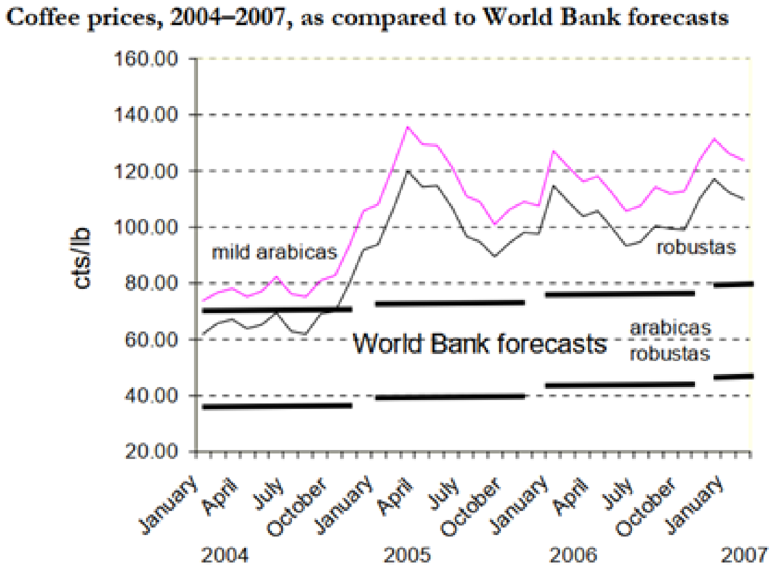


FIGURE 2.8: Compared Coffee Price with Word Bank Forecasts

The impact of risk on the supply chain is also considered along with implementation measures and risk reduction strategies. The study included bibliographic analysis, a conceptual model of supply chain risk analysis, and three manuscripts focusing on risk mitigation policies.

It contributes to the research area of SCRM by providing additional guidance, conceptual modeling, simulations, and mathematical modeling, and recommends better and powerful supply chain design and management [76].

2.4.3 Consultant Related Factors

Recent studies have shown that human resource factors, including education, skilled human resources, and professionals, have a significant impact on risk management and overall business performance. A selected sample and regression analysis showed a positive relationship between these factors and risk management. Companies should hire risk management professionals to utilize their skills/expertise while focusing on development of their skills through off-job training. This approach strengthens the risk management department and improves the company's overall performance [78].

2.4.4 Labor Related Factors

Occupational health and safety training includes knowledgeable employees and contracted individuals to enhance the company's safety knowledge and skills. The main objective is to develop employee’s health-safety-and-environment (HSE) accountability, accident awareness, and prevention. Training focuses on identifying hazards, implementing preventive measures, and minimizing negative impacts on people, processes, and assets, especially in high-risk situations. Employers must provide training on safe and healthy work, transfer workers to new jobs, and inform workers about work procedures based on laws, regulations, and good practices [81]. Small and medium enterprises (SMEs) face challenges such as low productivity, poor quality products, poor marketing, and low finance. To improve health and safety conditions, workplace risk assessment is an essential tool in enterprise risk management. This self-help tool enables employers and companies to identify and assess workplace risks, implement cost-effective measures, and prioritize hazardous situations. Risk assessment avoids dependence on outside experts and ensures that SMEs are not overwhelmed with paperwork or regulations [82].

2.4.5 Legal Communication Related Factors

Systematic risk management policies and procedures are required including clear language and risk management. In a case study, it is noted that inappropriate boilerplate language hindered communication and understanding of remedies. This ambiguity can lead to serious financial and reputational consequences, such as legal risk and possible lawsuits. Taking systematic approaches to drafting legal contracts and managing risks can avert these legal storms [79]. An executive report explores legal risk management in large enterprises, focusing on 34 senior in-house attorneys and compliance officers. The study aims to deepen the debate about best practices and address ethical questions posed by legal risks [80].

Figure 2.9: Risk Communications

2.4.6 Material and Equipment Related Factors

Identifying and assessing the risks associated with the transportation of construction goods using concrete mixes is assessed by focusing on the complexity and dynamics of the system. The FMEA calculation and analysis method should be used to assess the severity and importance of risks [83].

A case study reported demonstrating the integration of lean construction, sustainability, and BIM into an undergraduate construction management planning course addressing industry challenges and improving engagement and understanding [85].

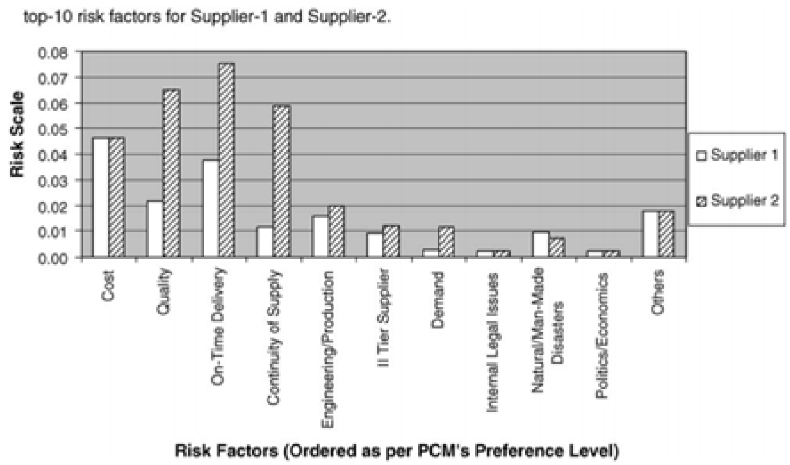


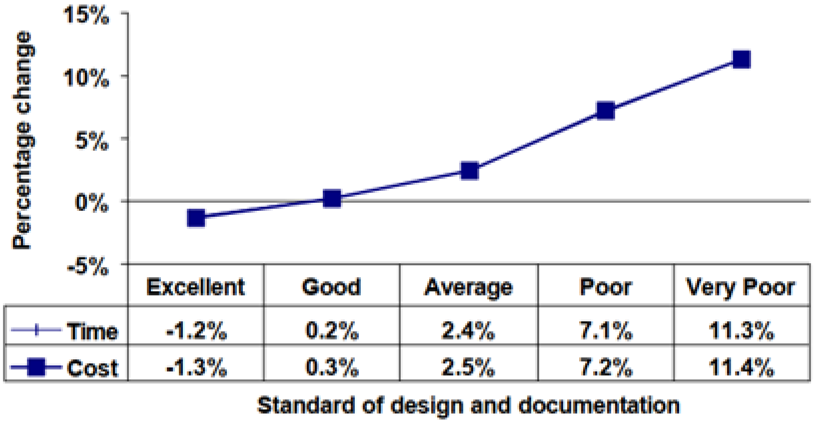
FIGURE 2.10: Top 10 Risk Factors

An integrated approach is proposed to manage input supply chain risk, identify input risk factors, create a hierarchical classification structure, develop AHP methodology, and test the system [84].

2.4.7 Design Related Factors

A computerized system for planning the construction of high-rise buildings is developed using balanced line technology and expert systems. The system combines flexible unit networks, multi-level LOB schemes, databases, and expert system modules. Tested on a sixteen story building project, it is proven to be user-friendly and reliable [86].

An Australian study found that poor design and documentation had a significant impact on the performance and efficiency of construction projects. Poor quality leads to delays, rework, and modifications, increasing lead times. project time and costs. Research was conducted to identify factors that influence the quality of design, documentation, and proposed improvements [87].



	Excellent	Good	Average	Poor	Very Poor
Time	-1.2%	0.2%	2.4%	7.1%	11.3%
Cost	-1.3%	0.3%	2.5%	7.2%	11.4%

Average time and cost allowance included at tender stage

FIGURE 2.11: Compression of Standard of Design Change

2.4.8 Contract Related Factors

The project risk management is discussed including definitions, market trends, cons, and roles in enterprise risk management. The objective is to establish a literature review, develop research topics, and encourage faculty collaboration. It also provides a comprehensive list of resources for future study of project risk management [88].

Businesses face challenges in project planning, which can be improved by looking at buffers. The critical string method uses three types of buffers; project cache, source cache, and resource cache. Buffer management is crucial for doing critical sequence planning as short buffers cause delays and violate scheduling concepts [89]. Another research study summarizes lessons learned from the conceptual literature, case studies, and third parties, which compares theoretical and practical risk perception and management, and recommends better risk management [90].

2.4.9 External Related Factors

The occurrence of natural disasters and the damage caused by extreme climate events have been increased significantly in recent years. Human interference with the natural environment creates new socio-natural hazards, including climate change events. Degradation of natural resources and vulnerability of developing countries impede their ability to recover from extreme events [91].

An annual report discloses the weather risk posed by the Indian power generation and transmission companies. The results show that most companies use derivatives, lacking information on weather risk management and management techniques [92].

2.4.10 Manager Related Factor

Mashali (2020) over 100 research papers examine stakeholder management (SM) are compiled in this study. It points out gaps in the literature, such as the dearth of BIM-based SM studies and the need for more research into how SM influences projects throughout their life cycles [95]. Another study investigates how focal projects in international projects are managed and how external project stakeholders affect projects. Project stakeholder research, stakeholder research, and international projects are three research streams that it supports in this paper. The thesis offers fresh perspectives on project interaction in global contexts by investigating stakeholder-related phenomena from the perspectives of stakeholders and a focal project [96].

2.4.11 Finance Related Factors

The volatility of the European food market has exposed agribusinesses to risk and uncertainty. The price risk management strategies are evaluated at different stages of the supply chain revealing diverse perceptions and relationships [71]. The financial risk management in the Ministry of Defense of the Slovak Republic is also examined emphasizing its importance in the management of public institutions. The ministry has adopted internal regulations on financial risk management aiming to improve management quality, support cost-effective fiscal policy, maintain discipline, and streamline spending. The document highlights risks such as collusion, conflicts of interest, fraud, secondary risks, and residual risks [93].

The critical success factors have been analyzed for effective risk management procedures in the financial industry. The data is collected from financial institutions in Thailand, including banks, stock exchanges, insurance, securities, and wealth management. Seven factors have been identified as key to improving the effectiveness of risk management processes emphasizing the importance of senior management support and confidence in the financial sector [94].

2.4.12 Process Related Factor

To ascertain the efficacy of digital interventions in enhancing positive behavioral factors and treating a variety of behavioral outcomes, this study reviews and meta-analyses by (Akinosun 2021). It was discovered that these interventions had no impact on clinical outcomes or unhealthy behaviors [99].

Due to inadequate accounting for severe abnormalities of risk factors, such as severe hypertension or heavy smoking, Framingham scoring understates absolute risk. The risk grows as people age as a result of plaque burden accumulation. Inappropriate treatment selection and incorrect risk assessment may result from this. In older patients, relative risk estimates might be more helpful [100].

2.4.13 Employee Related Factor

This study focuses by Collier (2007) on the value of corporate social responsibility (CSR) in organizations, especially those that operate internationally. It implies that in order to ensure ethical decision-making and risk management, employees must be inspired and committed to CSR practices. According to the paper, strategy and direction ought to foster staff members' commitment to CSR [97].

With a focus on firm value and financial performance, the paper examines the V. L. Cris´ostomo, F. de Souza Freire, and F. C. De Vasconcellos (2011) examine the link between corporate social responsibility (CSR) and business performance in Brazil. Although there is no relationship between CSR and financial performance, content analysis and regression analysis show a negative correlation between CSR and firm value. Research advances knowledge about CSR in developing economies [98].

2.5 Failure Mode and Effect Analysis (FMEA)

Uncertainty and risk are frequent features of large-scale construction projects, leading to significant failure. A combined approach using FMEA and ISO 31000 was developed to identify, assess, and control risks.

A mixed integer programming (MIP) model is also formulated to select optimized risk response strategies. Two heuristic algorithms self-adaptive imperial competition and invasive weed optimization were developed to address the MIP model. The model is applied to a high-rise residential building as a case study and demonstrates its effectiveness in predicting appropriate responses to project risks and improving the objectives of the project [101].

FMEA is a systematic approach to identifying and preventing system, product, and process problems before they occur. However, its limited use in improving the design has been criticized. To start FMEA, a spreadsheet containing information about the system is created by prioritizing failure modes and risk priority numbers [102].

2.5.1 Utilization of FMEA

Failure Modes and Effects Analysis (FMEA) is a systematic technique used to identify and evaluate potential errors or risks associated with a process, product, or system. FMEA is widely used in various industries to proactively assess and mitigate risks. FMEA is also used in the automotive industry for identifying potential defects in the manufacturing process. It is also discussed that how FMEA helps prioritize risks and guides to take preventive actions to improve product quality and safety [69].

FMEA is also applied to reduce risks during project implementation for an automobile company. This method identified potential failure patterns and suggested improvements in assembly processes, equipment maintenance, and supplier actions. A team should closely monitor FMEA implementation to facilitate access to information and feedback [105].

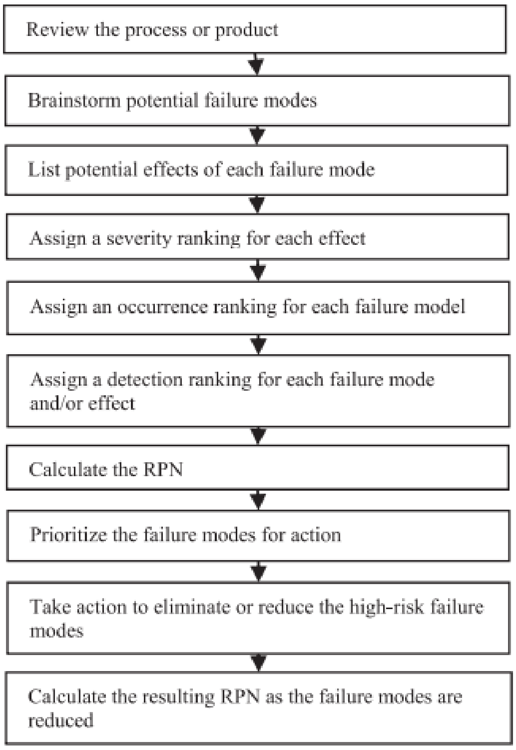


Figure 2.12: Steps for FMEA Implementation

Similarly, FMEA is implemented in healthcare to improve patient safety and prevent medical errors. A case study highlighted that FMEA could be used to analyze medication errors in hospitals leading to the implementation of effective preventive measures [103].

The consistency of traditional and advanced FMEA is examined for IT risk assessment. The improved FMEA framework, a composite framework to reduce consistency in traditional FMEA, is tested in two iterations. The results show that the improved FMEA model is more consistent than the traditional FMEA. The advanced framework consists of four main steps: risk requirements, identification, analysis, and evaluation. The framework has been validated and tested by experts in a case study by making design changes and the addition of a threat source variable [104].

2.5.2 FMEA in Construction Risk Management

FMEA can also be applied in the construction industry to effectively manage risk and improve project performance. Kouhnavard et al. discussed the use of FMEA for risk identification and analysis in construction projects. They highlight the benefits of using FMEA as a proactive risk management tool to prevent construction issues and increase project success rates [106].

In addition, FMEA is also implemented to manage risks in the construction of offshore wind farms. The research demonstrated how FMEA can help to identify potential failures, assess their impact, and implement effective risk control measures in offshore construction projects [107].

An integrated methodology of Fuzzy Expected Value Method (FEVM) and Fuzzy Failure Mode and Effects Analysis (FFMEA) is developed to identify and analyze risks in complex infrastructure projects, such as a subway project with an elevated railway corridor. Research includes surveying primary data, identifying key risk activities, and analyzing their likelihood, impact, severity, detectability, occurrence, and prioritization. Integrated approach provides multiple severity levels and risk metrics making it easy for project managers to apply appropriate mitigations [108].

The risk management measures in road construction are analyzed during the COVID-19 pandemic. A questionnaire survey was conducted to collect primary data and research showing time overrun risks, safety risks, health and environmental risks, cost overrun risks, financial risks, economic risks, force majeure and ecological risks, political, legal and social risks, organizational risks. Contractual risk, quality risk, design risk and technical specifications are the most important risk factors. Identifying, assessing and responding to risks has a significant impact on success criteria such as a well-planned project schedule, compliance with safety standards, financial arrangements, economics and contractual agreements [109].

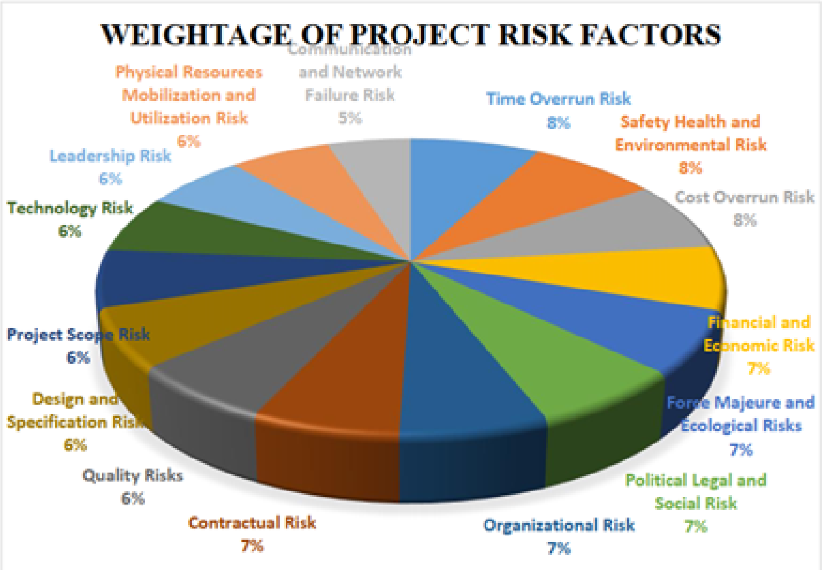


Figure 2.13: Project Risk Factors

2.5.3 Benefits of FMEA

The use of FMEA offers a number of advantages in risk management in various sectors. FMEA helps organizations identify potential risks early in the design or planning phase, helping to improve product quality, reduce costs, and improve safety. Authors emphasize the proactive nature of FMEA, which allows organizations to prevent failures before they happen [110].The benefits of FMEA in the manufacturing industry have also been highlighted. It is explained that how FMEA facilitates the identification of critical failure modes and their associated impacts enabling organizations to prioritize risks and efficiently allocates resources to mitigate them. The importance of FMEA is emphasized in continuous improvement efforts and achieving higher levels of quality and reliability [111].

Failure modes and effects analysis (FMEA) is a reliability management technique used in various industries to ensure the safety and reliability of systems, services, and projects. However, the traditional risk prioritization numerical (RPN) approach has been criticized for its inherent flaws. Research focuses on improving traditional FMEA, such as health care plan failure, risk assessment, extended FMEA, gray theory, risk assessment, and fuzzy inference. The study highlights the limitations of traditional FMEA and the most common methods to improve them. Scientific measures are used to minimize biasness and rigorous bibliometrics tools to objectively analyze selected documents [112]. Building information modeling (BIM) is gaining popularity in the construction industry including construction managers, architects, and engineering firms increasingly investing in this technology. Research includes literature reviews, case studies, and interviews with a focus on visualization, 3D coordination, cost estimation, pre-fabrication, construction planning and supervision along with construction modeling [113].

2.6 Types of FMEA

Failure modes and effects analysis (FMEA) is a structured approach used in various industries to identify and prioritize potential failure modes in a process, product or system. There are many different types of FMEA, each with a distinct purpose and use. Researchers frequently use the following types:

- **Design FMEA**

This type of FMEA is used during the product or system design phase. It focuses on identifying potential error modes related to product design, including materials, components, and their interactions. This study proposes the Christian Spreafico and Agung Sutrisno (2023) [121] method to support Social Failure Mode and Impact Analysis (SFMEA) using AI-based chatbots. This method includes 84 specific questions based on known errors, design theory and syntactic structures.

Tested in three case studies, this approach supports socially sustainable design for a variety of products, but has limitations due to chatbot filters.

- **System FMEA**

A system FMEA evaluates the entire system or process as a whole, taking into account the interactions and dependencies between components, subsystems, and processes. It is used to identify risks from a high-level system perspective.The Fuzzy FMEA-AHP method is proposed to analyze logistics system failures during the COVID-19 pandemic, identify 12 failures and propose preventive measures.This method can help logistics companies, supply chain partners and customers in managing risks[120].

- **Process FMEA**

The FMEA process is performed during manufacturing or assembly. It aims to identify and prioritize potential error modes in the manufacturing process, including equipment, processes and operator actions.

A. Korsunovs (2022) [122] presents a preliminary method for modelling robotic manufacturing processes in the MBSE environment, automating several steps and automatically generating an FMEA process. This top-down approach to systems engineering addresses the weaknesses of FMEA and creates efficiencies in the design and development of manufacturing processes.

- **Functional FMEA**

Functional FMEA focuses on identifying failure modes related to the intended function of a product or system, ensuring that it operates as expected in a variety of situations.

Cruz-Rivero, L. and Méndez-Hernández, M.L (2022) [123] evaluate the functionality of a prototype methane and carbon dioxide dosing device developed to measure livestock emissions. Using Failure Modes and Effects Analysis (FMEA) and Fuzzy Logic (FL), the device is validated to identify potential failure modes that affect operation and prevent the prototype from performing its function. The study presents a Mamdani-style intelligent fuzzy system, supported in the MATLAB Fuzzy Inference System toolbox, to generate a risk prioritization index. The FMEA model is used to address the shortcomings and improve accuracy.

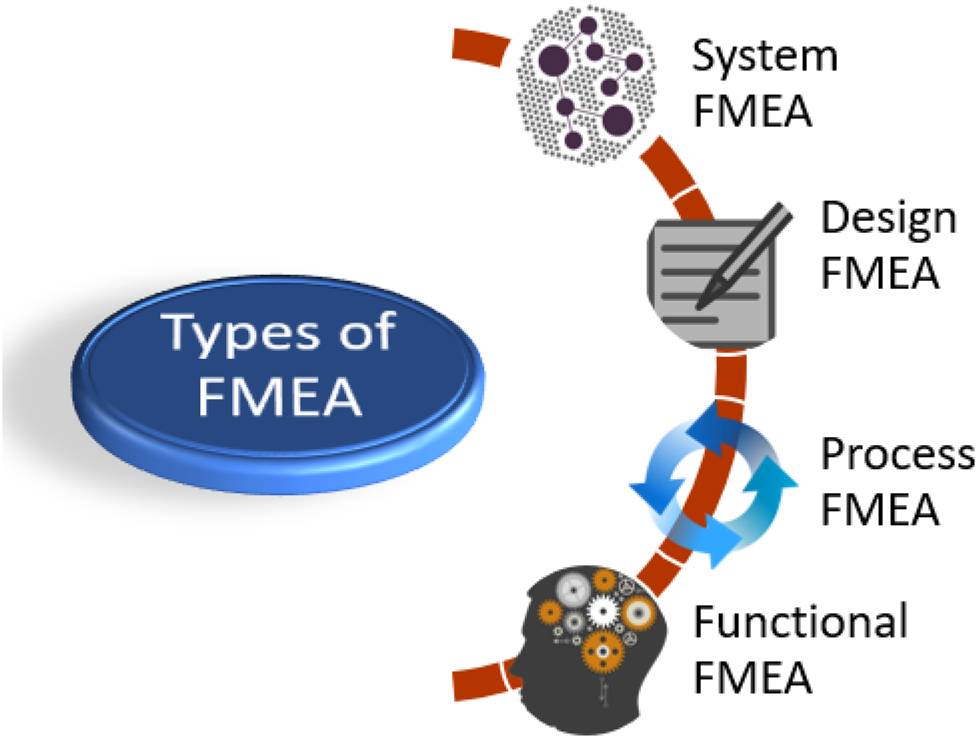


FIGURE 2.14: Types of FMEA

2.7 Summary of Literature Review

The construction industry plays a central role in global infrastructure development with projects ranging from small-scale residential construction to large-scale infrastructures. The success of these projects depends heavily on effective project management, especially in terms of completion time and risk analysis. This literature summarizes the key themes and findings from previous research related to scheduling and Failure Mode and Effects Analysis (FMEA) for construction project management.

The construction projects are complex and subject to various uncertainties and risks such as budget overruns, delays, safety issues, and quality problems. To minimize these risks, construction managers use a variety of tools and techniques. FMEA has gained popularity as a systematic method for identifying and assessing potential failure modes and their consequences in a construction project. Its proactive nature makes it a valuable tool for risk management.

Table 2.2: Summary of Risk Factors Reported in Literature

Risk Factor	**References**
Owner	[75]
Manager	[95, 96]
Employee	[97, 98]
Consultant	[78]
Government	[79, 80]
Customer	[76, 77]
Material	[83-85]
Financial	[71, 93]
Labor	[81, 82]
Land Building, Equipment	[84]
Design	[86, 87]
Processes	[99, 100]
External	[91, 92]

Researchers have developed various methods and frameworks for analyzing risks in the management of construction projects.

These methods typically present various systematic approaches, which involve identifying critical project components, applying different tool for risk assessment and incorporating the results of risk analysis for management of the construction projects. After reviewing the literature on risk analysis in construction, a total of thirteen major risk factors have been identified and summarized in the following

Table 2.2. Integration of Primavera software with FMEA and scheduling for construction project management may improve the project planning and risk analysis. Although, the existing literature reported the potential benefits of implementing FMEA and scheduling individually; however, their combined benefits have not been explored frequently. As construction projects become increasingly complex and risk-prone, adopting such integrated approach would be critical for achieving successful outcomes.

2.8 Research Gap

Although numerous studies have addressed project planning, risk management, and the application of Failure Mode and Effects Analysis (FMEA) in different industries; however, there is still room for improvement by using Primavera as a project management tool. Hence the purpose of this thesis is to fill this gap by implementing a combination of schedule analysis and risk assessment through FMEA using Primavera as the technology backbone. Despite the recognized importance of effective project planning and risk management in construction projects, there is a lack of in-depth research that brings these two important aspects together in one unified framework. Past research studies often treated schedule analysis and risk assessment as separate entities whiling ignoring the potential benefits that may arise from applying them together. By combining these two approaches, the current research work aims to fill this gap and provide a more holistic approach to the management of construction projects. In addition, although FMEA has been widely recognized and adopted in industries such as manufacturing, automotive, and aerospace, its full potential and adaptability in the construction sector has still not fully explored.

There is clearly a lack of empirical studies demonstrating the practicality, effectiveness, and challenges associated with the application of FMEA techniques to construction projects. Therefore, this research document attempts to investigate the effectiveness of adapting FMEA for the construction project, especially when combined with Primavera, popular project management software.

Nagaraju and Reddy's [6] study on resource management in construction projects, focusing on accelerated, limited-time projects, involves Primavera software scheduling and resource levelling for various activities. Vipin Kumar [8] states that Schedule management is a crucial aspect of project planning, allowing project managers to summarize start and finish times for individual tasks, providing a graphical representation of the project's potential duration. Vanhoucke et al. [11] proposed a robust project planning model that considers uncertainty about activities duration and resource constraints, enabling proactive decision-making in uncertain situations.

Zhang et al. [12] developed a multi-objective optimization method for resource constrained projects, utilizing Primavera P6 software for efficient monitoring and control. Effective project management is crucial for construction projects, ensuring budget and on-time delivery through proper planning, scheduling, resource allocation, and updates to optimize projects and maximize revenues [46].

Risk identification is the systematic process of identifying and documenting potential risks affecting a project, organization, or system, using various methods and techniques in literature [60]. Construction projects face uncertainties, leading to delays and cost overruns. Effective risk management and analysis minimize these risks through better planning, consistent cost estimates, and accurate record-keeping [71,72]. FMEA is a systematic technique used in various industries to identify potential failures or risks, prioritize risks, and guide preventive actions to improve product quality and safety [69].

In addition, there is a scarcity of studies investigating the integration of Primavera with FMEA for construction risk and schedule analysis. Although, various construction project management tools have evolved significantly; however, a little has been explored as to how these tools can coordinate with risk assessment techniques such as FMEA.

That's why; this study aims to elucidate the potential synergy between Primavera's planning capabilities and FMEA's risk identification and mitigation strategies for construction projects. The aim is not only to contribute to the scholarly literature by filling gaps in the current knowledge but also to provide practical information to practitioners of construction and management. The results of this study have the potential to improve project planning, reduce delays, improve risk management strategies, and ultimately more successful outcomes of construction project.

In the next chapter, this method will be explained in detail. Construction project planning using Primavera software and analyze the impact of risk factors with FMEA.

Chapter 3

Research Methodology

In previous chapter, a comprehensive literature is covered and consequently, the framework of research methodology is determined. The research methodology is comprised on two major stages; scheduling and risk management process. The stages to manage risk are displayed as risk identification, risk quantification, risk reduction, and risk monitoring. The first three steps are also recognized as the risk management process and include identification risk factors, assessment of the impact of the risk over time, and finally development of a strategy to mitigate the risk. The brief description of research methodology is as follow:

Scheduling

Step 1: Define the project activities and plan the schedule management.

Step 2: Determine sequence activities.

Step 3: Estimate resources and estimate duration.

Step 4: Project schedule.

Step 5: Monitor and control.

Risk Management Process

Step 1: Risk factors commonly encountered in construction projects have been identified after studying the literature.

Step 2: The parameters of RPN severity, occurrence, and detectability are evaluated using a Google survey to determine the RPN value for each risk factor.

Step 3: Critical risk factors are selected based on RPN values.

Step 4: The duration of these factors is calculated using three different methods.

Step 5: Serious risk factors are taken into account and minimize them into the project schedule.

Step 6: The results are compared with the base schedule to take the essential action.

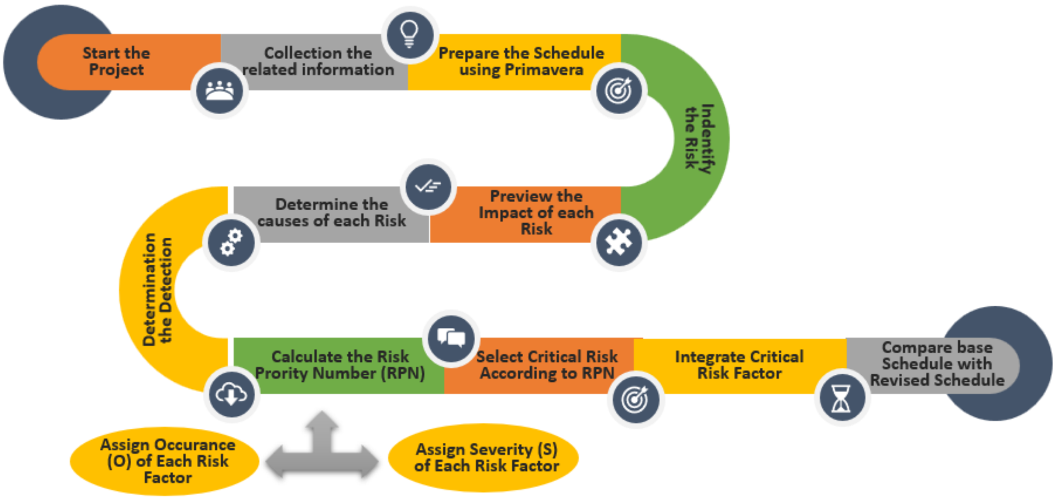


FIGURE 3.1: Flow Chart of Research Methodology

Details of the method will be elaborate in detail in the following sections:

3.1 Scope Management Plan

It is one of the important components of the project plans. It describes how the scope of the project i.e., everything to be done, will be developed. It elaborates the definition and the process that how the scope will be validated, controlled, and monitored. Scope management plan comprises of the following components:

- Collecting the requirements
- Project scope description is prepared
- Development of WBS through Project scope
- Process for the verification of scope
- Controlling the scope in monitoring and control

3.2 Resource Management Plan

Management of resources is an essential part of any project. The resource plan is a guiding tool which aids in the managing of resource till the end of the project. Resources plan comprises of:

- Team members roles and responsibilities
- Organization charts
- Staff planning
- Process of resource acquirement
- Training needed to improve skills
- How to conduct performance reviews
- Reward and recognition

The main objective of human resource planning is to ensure the appropriate participation of project resources and their contribution to project success.

3.2.1 Roles and Responsibilities

Roles and responsibilities play an important role in the completion and success of the project. All team members must clearly know their responsibilities and roles in order to be successful.

3.2.2 WBS Development

It is the hierarchical decomposition of the project deliverables into inter-dependent smaller and easily manageable components up to the work package level. It results in more simple and better management of schedule and cost accompanied with the ease of the monitoring and controlling the project.

3.3 Cost Management Plan

This process is used to know how the project cost will be budgeted, monitored, estimated, managed, and controlled. This process provides direction, procedures, and guidance to manage the cost.

Table 3.1: Responsibility Matrix

Type of calculation	**Primary Responsible**	**Assisted by**
Management cost	Project Manager	Procurement Manager
Architecture & design cost	Manager Procurement	Architecture Supervisor
Civil work cost	Manager Procurement	Civil Supervisor
Plumbing work cost	Manager Procurement	Mechanical Supervisor
Electrician work cost	Manager Procurement	Electrical Supervisor

3.3.1 Units of Measurement

Following are the unit of measures for certain elements to be used in the project.

Table 3.2: Units of Measurement

Sr. No.	**Elements**	**Unit of Measure**
1	Currency Used	Pakistani Rupees

Table 3.2: Units of Measurement

Sr. No.	**Elements**	**Unit of Measure**
2	Cost Needed	Weekly Basis
3	Transport Expenses	Days
4	HR Cost	Man Hours
5	Overhead Expenses	Telephone Bills, Utilities
6	Hardware Expenses	Branded/Local
7	Software	Registered/ Unregistered/ CDs

3.4 Schedule Management

Schedule plan provides guidelines on how to develop a schedule and how to execute the project according to the schedule. Schedule provides information of the project status at any particular time to project team, sponsors, and other stakeholders. Schedule plan is developed with the aim to define the project schedule method, which will be used by the team to create the schedule of the project and also monitor the schedule at particular time.

3.4.1 Schedule Control

In this process, the goal is to monitor the status of the schedule over time.

3.4.2 Schedule Threshold

Threshold is defined as the limits which are acceptable by the project schedule. Acceptable level of threshold for the project will be +1%. In case, if schedule is about to cross this level, a change request of schedule would be generated to control the schedule or re-adjust the baseline.

3.5 Risk Management

The risk management plan addresses the tools and measures that can be used to manage and control events that could negatively impact the project. This plan includes:

- Identification of risk
- Prioritization / evaluation of risk
- Assessment of risk
- Planning the risk response
- Tracking, reporting, and monitoring the risk
- Risk response owner

Guiding Principles

The obligation for managing the risks is that it should be shared by the relevant stakeholders of the project.

FIGURE 3.2: Risk Analysis and Management Procedure

Nevertheless, project manager decides what response strategy to be adopted. Project manager is also responsible to inform the funding agency or sponsor of the project if any contract modification is required.

3.6 Risk Management Process

3.6.1 Risk Identification

A risk is an unknown event that can have a positive or negative impact on the project. This can prevent the project from progressing as planned. Risks can be identified by internal stakeholders or by external stakeholders. Some risks are obvious because they are inherent to the project or have occurred before. Risk identification is an ongoing process that takes place throughout the project. The risk register is revised with modifications to risk factors. Since risk identification is an ongoing process, any risks discovered during the project life-cycle needs to be brought to the project manager's attention via email or in writing.

3.6.2 Risk Analysis

This process determines the probability and impact of the hazard on the project. This is also known as cause-and-effect analysis. In this project, the risk will be evaluated by using three elements; severity, occurrence, and detection. The risk assessment process includes the following steps:

- Identify the potential errors that can occur and specify by severity (S).
- Determine the probability of occurrence of each failure by (O).
- List of controls existing in the project to specify detection indicators according to (D)

Calculate the RPN by using S, O, and D.

3.6.2.1 Determination of Severity Ratings

Determining the severity of a failure mode is an important step in failure mode and effects analysis (FMEA) as well as other risk assessment methods. FMEA is a systematic approach used to identify potential errors, their causes, and their impact on the entire system or process. Severity assessment helps prioritize error types based on their potential consequences, allowing organizations to focus on the biggest and most important issues first.

Following is the procedure to determine severity:

- **Analysis of Consequences**

Evaluate the potential effects or consequences of the identified failure mode. Consider what would happen if the failure is occurred and the severity of the impact on safety, performance, environment, or other critical factors.

- **Specify Severity**

Use a defined qualitative scale or a numerical scale to assess the severity of the consequences. The scale should be designed so that a higher score corresponds to more severe consequences.

The specific criteria for assigning severity ratings may vary by industry or application.For example, a typical severity rating scale is given in Table 3.3.

Table 3.3: FMEA Ranking (Severity) for Construction Projects

Effect	**Severity**	**Ranking**
None	No effect	1
Very Minor	The system operates with minimal intervention	2
Minor	The operating system has some performance degradation	3
Very Low	The operating system suffers significant performance degradation	4
Low	The system cannot be used without damage	5
Moderate	The system cannot be used due to minor damage	6

Table 3.3: FMEA Ranking (Severity) for Construction Projects

Effect	**Severity**	**Ranking**
High	The system cannot be used due to hardware damage	7
Very High	The system is unusable with destructive failure	8
Hazardous with warning	Highest impact of system operating errors with warnings	9
Hazardous without warning	The highest impact of operating the system without warning	10

- **Record Results**

Record the failure mode, identify the relevant severity rating and rationale for that rating in the FMEA document or risk assessment report.

3.6.2.2 Determination of Occurrence Ratings

Occurrence determination is a process used in risk assessment to assess the likelihood of occurrence an event or hazard. Occurrence ratings help to estimate the likelihood of a particular risky event occurring within a given time frame. The purpose of assigning occurrence ratings is to prioritize risks based on their likelihood of occurrence, which can then be used to allocate resources and implement risk mitigation measures.

Incident ratings are typically expressed using qualitative or numerical descriptions as displayed in Table 3.3 to classify the likelihood of a risk event occurrence. The specific criteria and scales used may vary depending on the risk assessment method or industry standard used. Here are some general steps for determining incident ratings in a risk assessment:

- **Identify Risk Events**

Clearly define the risk events. They could be anything from an accident at work to a cyber security breach.

- **Collecting Data and Information**

Collect relevant data and information to assess the likelihood of a risky event occurrence. This could involve historical data, expert judgment, industry statistics, or any other relevant source.

- **Data Analysis**

Use the collected data to estimate the likelihood of a risky event occurrence. Consider factors such as the frequency of past events, trends, contributing factors, and changes in the environment that may affect the likelihood of a future event incidence.

- **Define Occurrence Rating**

Based on the analysis, assign an occurrence rating to the risk event. As mentioned earlier, this can be qualitative or quantitative, where 1 represents the lowest probability and 10 represents the highest probability) For example, a typical occurrence rating scale could be as following Table 3.4.

Table 3.4: FMEA Ranking of Occurrence for Construction Projects

Description of Failure	**Failure Probability**	**Ranking**
Remote: Failure is unlikely	<1 in 15 Lac	1
Low: Relatively few failures	1 in 1.5 Lac	2
	1 in 15 Thousand	3
Moderate: Occasional failures	1 in 2 Thousand	4
	1 in 4 Hundred	5
	1 in Eighty	6
High: Repeated failures	1 in Twenty	7
	1 in Eight	8

Table 3.4: FMEA Ranking of Occurrence for Construction Projects

Description of Failure	**Failure Probability**	**Ranking**
	1 in Three	9
Very High: Failure is almost inevitable	>1 in Two	10

- **Consider Context and Time**

Consider the context of the risk and the timeframe while conducting the assessment. Some risks may have different probabilities under specific conditions or may change over time.

- **Validation and Modification**

Ensure that the incident rating specified is reasonable and supported by the data and analysis. Where appropriate, seek feedback and validation from subject matter experts or stakeholders.

3.6.2.3 Listing detectability of Each Failure Mode

The detection index evaluates the probability of detecting the occurrence of a particular failure mode before it damages the system or process. The purpose of this assessment is to identify patterns of errors that may not be immediately apparent but can have serious consequences if left undetected/unattended. Following is the detailed procedure to record detect-ability:

- **Identify the Potential Detection Methods**

The detection methods can be physical testing, automatic sensors, monitoring systems, alarms, inspections, operator checks, or any other means of identifying faults.

- **Evaluate the Effectiveness**

The effectiveness of each detection method in detecting a specific failure mode should be carefully checked. Consider the ability of each detection method to detect the failure mode before it has serious consequences.

- **Specify a Detection Assessment Procedure**

Use a predefined qualitative scale or a numerical scale to evaluate detection mode. Scales should be designed so that low scores correspond to more efficient and reliable detection while higher scores represent obscure detection of failure. For example, a typical detection rating scale is provided Table 3.5.

TABLE 3.5: FMEA Ranking of Detection for Construction Projects

Detection	**Likelihood of Detection**	**Ranking**
Almost Certain	Inspection will reveal the underlying cause	1
Very High	There is a very high chance that testing will reveal the underlying cause	2
High	It's high chance that testing will reveal the underlying cause	3
Moderately High	Moderately High chance the control will detect	4
Moderate	Moderate chance the control will detect	5
Low	Low chance the control will detect cause	6
Very Low	Very low chance the control will detect cause	7
Remote	Remote chance the control will detect cause	8
Very Remote	Very remote chance the control will detect cause	9
Absolutely Uncertain	Control cannot detect potential cause	10

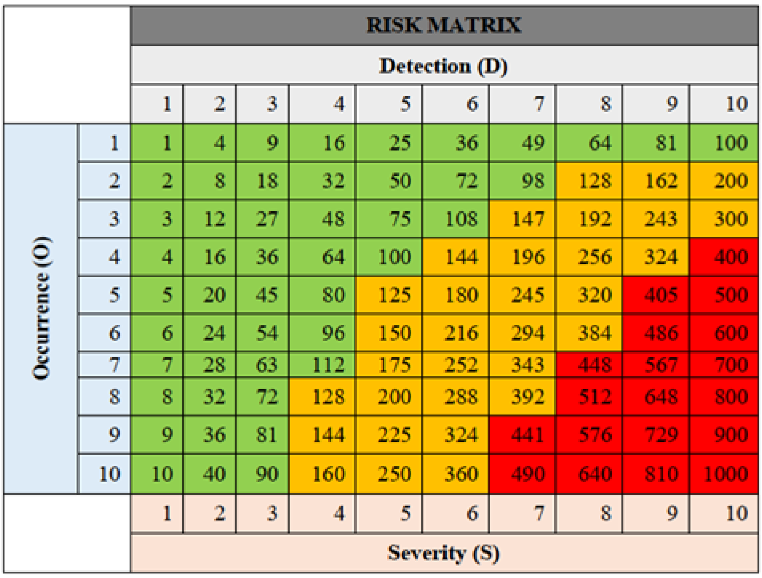
Detection ranking is important in determining the overall risk priority number (RPN) in FMEA, which is calculated by multiplying severity, number of occurrences, and detection score. High RPN values indicate a higher failure rate, requiring immediate attention and risk mitigation measures. Like severity ratings, determining detectability is an iterative process that may involve reviewing and adjusting the ratings based on new information or changes in the system. Regular review and improvement of detection methods are essential for ensuring that the potential defects are quickly identified and addressed to avoid serious consequences.

3.6.3 Calculation of RPN Value for Each Risk Factor

To calculate the RPN for each risk factor in the failure mode and effects analysis, three factors must be determined: severity (S), occurrence (O), and detection (D). The RPN value is calculated by multiplying these ratings by three.

$$Risk\ priority\ number = Severity\ \times Occurrence\ \times Detection\ \ldots\ldots\ldots\ldots(3.1)$$

This value helps prioritize risk. Higher RPN values indicate higher risk, requiring more mitigation efforts and attention. [115].



		RISK MATRIX									
		Detection (D)									
		1	2	3	4	5	6	7	8	9	10
Occurrence (O)	1	1	4	9	16	25	36	49	64	81	100
	2	2	8	18	32	50	72	98	128	162	200
	3	3	12	27	48	75	108	147	192	243	300
	4	4	16	36	64	100	144	196	256	324	400
	5	5	20	45	80	125	180	245	320	405	500
	6	6	24	54	96	150	216	294	384	486	600
	7	7	28	63	112	175	252	343	448	567	700
	8	8	32	72	128	200	288	392	512	648	800
	9	9	36	81	144	225	324	441	576	729	900
	10	10	40	90	160	250	360	490	640	810	1000
		1	2	3	4	5	6	7	8	9	10
		Severity (S)									

Figure 3.3: Risk Assessment Matrix

In the matrix, the important risk factors are shown in red and orange colors having RPN values equal or greater than 400 and 125, respectively. The determination of threshold values of RPN may vary from case to case; however, the generally used threshold value is 124. The green color portion shows rather safe or less critical RPN values.

Remember that RPN values are approximate measure and serve as a guide for prioritization. As higher RPN value indicates a higher-priority risk, it is essential to consider the context of the system or process being analyzed and use of technical judgment to decide which risks need immediate attention and mitigation measures. The RPN values can also be used to compare different risk factors and identify opportunities for risk reduction or process improvement.

3.7 Risk Mitigation

Efforts will be made to minimize the impact of identified risks. After calculating the RPN value, critical risk factors are recognized and then steps are taken to reduce/mitigate these risks. The risk reduction and/or mitigation are considered as strategic practice activities.

Chapter 4

Case Study and Results

The research methodology defined in the previous chapter 3 would be implemented and tested on the construction of a hospital building, which is selected as a case study project with the formal permission of competent authority.

In this case study, The Basic project and reference project by RPN value (for significant risk factors) are project timelines.

4.1 Project Title and Cost

Construction of New Block of Hospital G-9/1, Islamabad

Project Cost

Total project cost is estimated to be Rs. 1164 million (Rs. 1.164 billion).

4.1.1 Baseline Project without Risk Factors

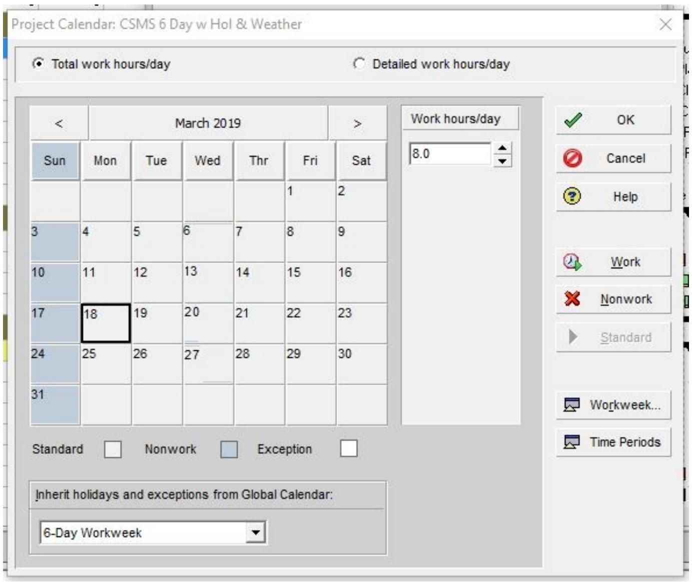
The case study project is the construction of a new block of hospital building having 250-beds. A construction firm "M/S King Crete Builders Pvt. Ltd." participated in the comparative bidding process and won the contract of this project.

Both the project activities and schedule were prepared by using Primavera software. This case study aims to explain how time and cost are reflected in project schedules and activities, and the results are then used to highlight important risk factors.

4.1.2 Units of Measurement & Calendar

- Duration of activities: No. of days
- To measure Human Resource: No. of man-hours
- Calendar to be used: Customized calendar of M/S King Crete Builders (Pvt.) Ltd.

4.1.3 Resource Calendars



Project Calendar: CSMS 6 Day w Hol & Weather

● Total work hours/day ○ Detailed work hours/day

March 2019

Sun	Mon	Tue	Wed	Thr	Fri	Sat
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

Work hours/day: 8.0

Standard ☐ Nonwork ☐ Exception ☐

Inherit holidays and exceptions from Global Calendar: 6-Day Workweek

FIGURE 4.1: Calendar of Working and Non-Working Days

All resources are acquired in the beginning of the project or as and when required basis. The working conditions for the project are 8 hours a day and 6-days a week.

Hence, all the staff will work for 48 hours per week or may vary as required for the project.

4.2 Constraints Setting

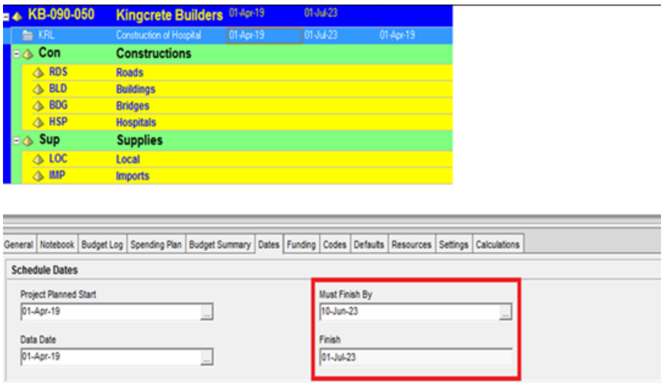
4.2.1 Types of Constraints

Generally, there are two types of constraints;

- Project level constraints
- Activity level constraints

Project Level Constraints

The constraint applied at project level is “Must Finish By” to the project completion date. The planned start date of the project is April 1, 2019 and the completion date was June 10, 2023.It is shown in Figure 4.2



KB-090-050	Kingcrete Builders	01-Apr-19	01-Jul-23	
KRL	Construction of Hospital	01-Apr-19	01-Jul-23	01-Apr-19
Con	Constructions			
RDS	Roads			
BLD	Buildings			
BDG	Bridges			
HSP	Hospitals			
Sup	Supplies			
LOC	Local			
IMP	Imports			

Schedule Dates

Project Planned Start: 01-Apr-19

Data Date: 01-Apr-19

Must Finish By: 10-Jun-23

Finish: 01-Jul-23

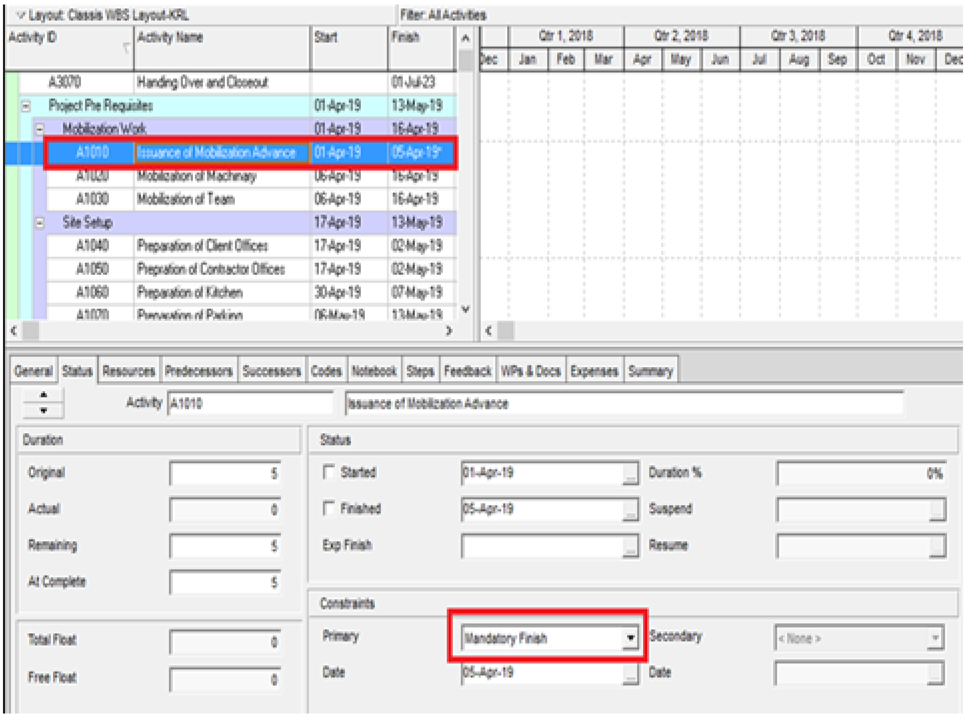
Figure 4.2: Project Level Constraint Setting

Activity Level Constraint

Following activity level constraints are applied on the project.

4.2.2 Mandatory Finish Constraint

One activity level constraint is applied on activity **A1010** i.e., issuance of mobilization advance. It is followed by mobilization of machinery and mobilization of team. It is a constraint that team and machinery shall not be mobilized until the mobilization advance is issued. It is reflected in the Figure 4.3.



Layout: Classis WBS Layout-KRL
Filter: All Activities

Activity ID	Activity Name	Start	Finish
A3070	Handing Over and Closeout		01-Jul-23
Project Pre Requisites		01-Apr-19	13-May-19
Mobilization Work		01-Apr-19	16-Apr-19
A1010	Issuance of Mobilization Advance	01-Apr-19	05-Apr-19*
A1020	Mobilization of Machinary	06-Apr-19	16-Apr-19
A1030	Mobilization of Team	06-Apr-19	16-Apr-19
Site Setup		17-Apr-19	13-May-19
A1040	Preparation of Client Offices	17-Apr-19	02-May-19
A1050	Prepration of Contractor Offices	17-Apr-19	02-May-19
A1060	Preparation of Kitchen	30-Apr-19	07-May-19
A1070	Preparation of Parking	06-May-19	13-May-19

Activity A1010 Issuance of Mobilization Advance

Duration
Original 5
Actual 0
Remaining 5
At Complete 5
Total Float 0
Free Float 0

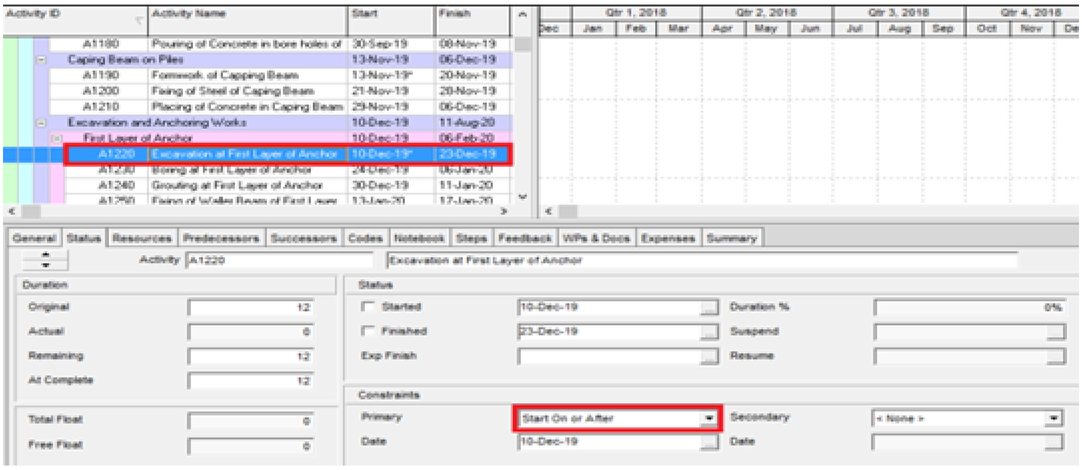
Status
☐ Started 01-Apr-19
☐ Finished 05-Apr-19
Exp Finish
Duration % 0%
Suspend
Resume

Constraints
Primary Mandatory Finish
Date 05-Apr-19
Secondary < None >
Date

FIGURE 4.3: Mandatory Finish Constraint Setting

4.2.3 Start On or After Constraint

This constraint is applied on two activities i.e., **A1190** and **A1220**. Activity **A1190** is "formwork of capping beam" and activity **A1220** is "excavation of first layer of anchor". Both of these activities are followed by "pouring of concrete" and it is obvious that after pouring the concrete, a time span is required to get the concrete dry. So, the lag time is given in both activities by applying "start on or after" constraint. Both these activities and their constraints are display in Figure 4.4.



Activity ID	Activity Name	Start	Finish
A1180	Pouring of Concrete in bore holes of	30-Sep-19	08-Nov-19
Caping Beam on Piles		13-Nov-19	06-Dec-19
A1190	Formwork of Capping Beam	13-Nov-19*	20-Nov-19
A1200	Fixing of Steel of Caping Beam	21-Nov-19	28-Nov-19
A1210	Placing of Concrete in Caping Beam	29-Nov-19	06-Dec-19
Excavation and Anchoring Works		10-Dec-19	11-Aug-20
First Layer of Anchor		10-Dec-19	06-Feb-20
A1220	Excavation at First Layer of Anchor	10-Dec-19*	23-Dec-19
A1230	Boring at First Layer of Anchor	24-Dec-19	06-Jan-20
A1240	Grouting at First Layer of Anchor	30-Dec-19	11-Jan-20

Activity A1220 Excavation at First Layer of Anchor

Duration
Original 12
Actual 0
Remaining 12
At Complete 12
Total Float 0
Free Float 0

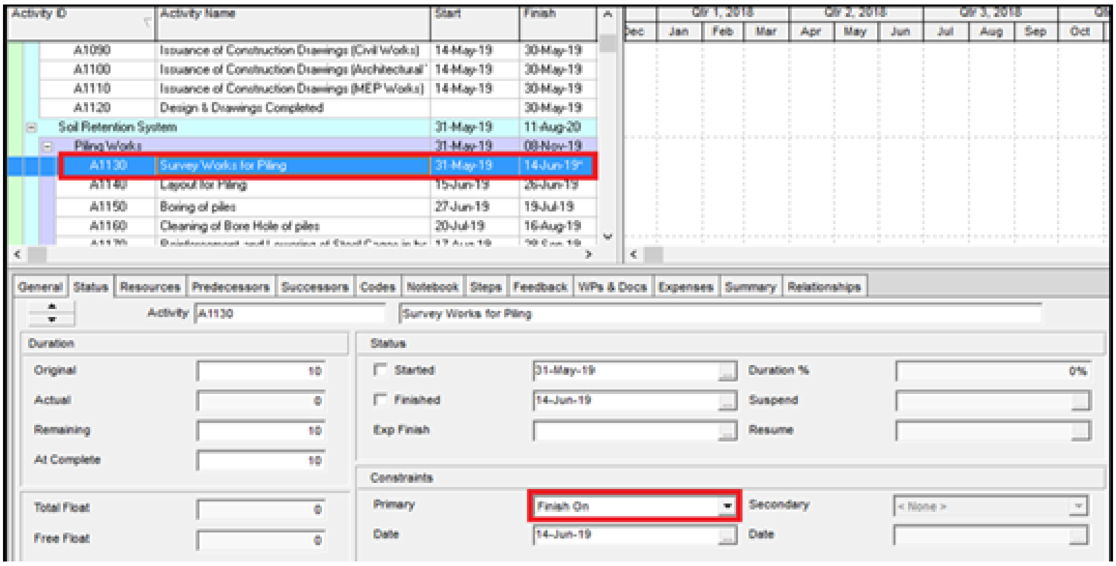
Status
☐ Started 10-Dec-19
☐ Finished 23-Dec-19
Exp Finish
Duration % 0%
Suspend
Resume

Constraints
Primary Start On or After
Date 10-Dec-19
Secondary < None >
Date

FIGURE 4.4: Start On or After Constraint Setting

4.2.4 Finish On Constraint

This constraint is also applied on activity **A1130** "survey work of piling".



Activity ID	Activity Name	Start	Finish
A1090	Issuance of Construction Drawings (Civil Works)	14-May-19	30-May-19
A1100	Issuance of Construction Drawings (Architectural'	14-May-19	30-May-19
A1110	Issuance of Construction Drawings (MEP Works)	14-May-19	30-May-19
A1120	Design & Drawings Completed		30-May-19
Soil Retention System		31-May-19	11-Aug-20
Piling Works		31-May-19	08-Nov-19
A1130	Survey Works for Piling	31-May-19	14-Jun-19*
A1140	Layout for Piling	15-Jun-19	26-Jun-19
A1150	Boring of piles	27-Jun-19	19-Jul-19
A1160	Cleaning of Bore Hole of piles	20-Jul-19	16-Aug-19

Activity A1130 Survey Works for Piling

Duration
Original 10
Actual 0
Remaining 10
At Complete 10
Total Float 0
Free Float 0

Status
☐ Started 31-May-19
☐ Finished 14-Jun-19
Exp Finish
Duration % 0%
Suspend
Resume

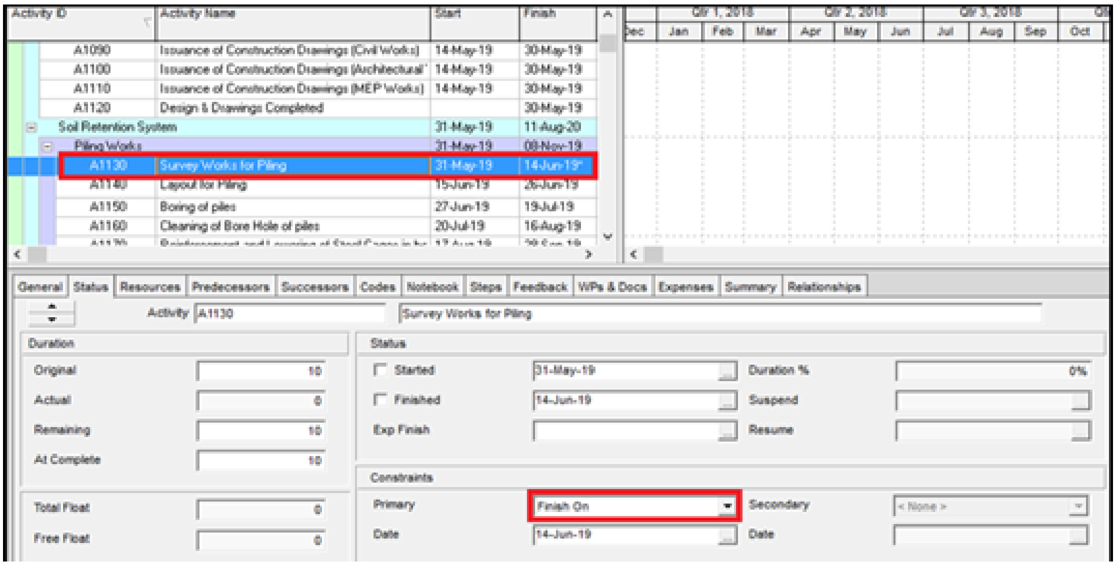
Constraints
Primary Finish On
Date 14-Jun-19
Secondary < None >
Date

FIGURE 4.5: Finish On Constraint Setting

It is being followed by "layout for piling". Since layout for piling can't start till the completion of survey work for piling; therefore, a constraint is applied that survey work should "finish on" by the date of start of layout for piling. It is displayed in Figure 4.5.

4.2.5 Finish On or Before Constraint

This constraint is applied on the activity **A3050**, which is “testing and commissioning”.



Activity ID	Activity Name	Start	Finish
A1090	Issuance of Construction Drawings (Civil Works)	14-May-19	30-May-19
A1100	Issuance of Construction Drawings (Architectural	14-May-19	30-May-19
A1110	Issuance of Construction Drawings (MEP Works)	14-May-19	30-May-19
A1120	Design & Drawings Completed		30-May-19
Soil Retention System		31-May-19	11-Aug-20
Piling Works		31-May-19	08-Nov-19
A1130	Survey Works for Piling	31-May-19	14-Jun-19*
A1140	Layout for Piling	15-Jun-19	26-Jun-19
A1150	Boring of piles	27-Jun-19	19-Jul-19
A1160	Cleaning of Bore Hole of piles	20-Jul-19	16-Aug-19

Activity A1130 Survey Works for Piling

Duration
Original 10
Actual 0
Remaining 10
At Complete 10
Total Float 0
Free Float 0

Status
☐ Started 31-May-19
☐ Finished 14-Jun-19
Exp Finish
Duration % 0%
Suspend
Resume

Constraints
Primary Finish On
Date 14-Jun-19
Secondary < None >
Date

Figure 4.6: Finish On or Before Constraint Setting

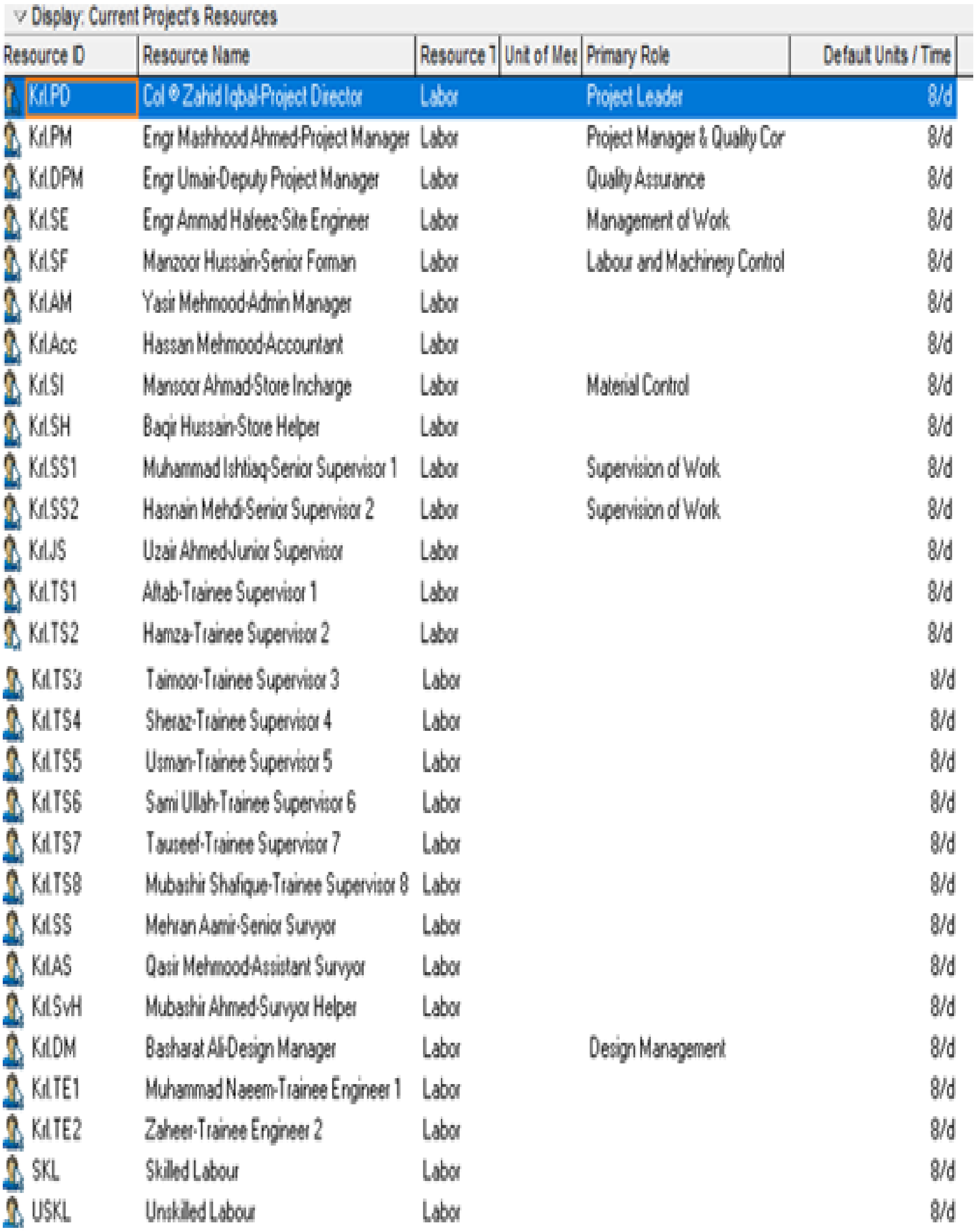
After this activity, the deliverable will be handed over to client and it is mandatory that testing and commissioning is completed before formal hand-over to the client.

Therefore, the constraint “Finish on or before” is applied on this activity. It is shown in Figure 4.6.

4.3 Resources and Roles Assignment

There are 75 resources deploy to complete the project, some of the employed resources are as shown in the resource dictionary. The resources dictionary show Employee name, Primary role and units/Time.

Figure 4.7. It also shows the roles assigned to different resources.



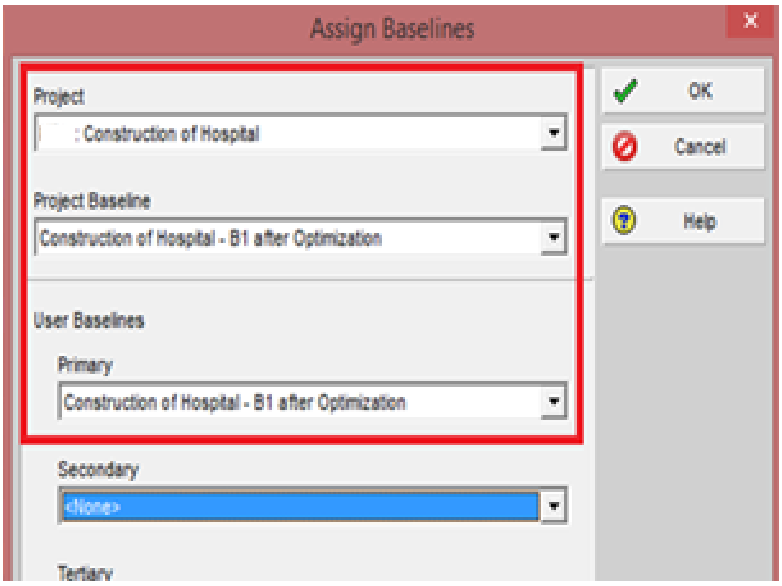
Display: Current Project's Resources

Resource ID	Resource Name	Resource T	Unit of Mea	Primary Role	Default Units / Time
Krl.PD	Col ® Zahid Iqbal-Project Director	Labor		Project Leader	8/d
Krl.PM	Engr Mashhood Ahmed-Project Manager	Labor		Project Manager & Quality Cor	8/d
Krl.DPM	Engr Umair-Deputy Project Manager	Labor		Quality Assurance	8/d
Krl.SE	Engr Ammad Haleez-Site Engineer	Labor		Management of Work	8/d
Krl.SF	Manzoor Hussain-Senior Forman	Labor		Labour and Machinery Control	8/d
Krl.AM	Yasir Mehmood-Admin Manager	Labor			8/d
Krl.Acc	Hassan Mehmood-Accountant	Labor			8/d
Krl.SI	Mansoor Ahmad-Store Incharge	Labor		Material Control	8/d
Krl.SH	Baqir Hussain-Store Helper	Labor			8/d
Krl.SS1	Muhammad Ishtiaq-Senior Supervisor 1	Labor		Supervision of Work	8/d
Krl.SS2	Hasnain Mehdi-Senior Supervisor 2	Labor		Supervision of Work	8/d
Krl.JS	Uzair Ahmed-Junior Supervisor	Labor			8/d
Krl.TS1	Aftab-Trainee Supervisor 1	Labor			8/d
Krl.TS2	Hamza-Trainee Supervisor 2	Labor			8/d
Krl.TS3	Taimoor-Trainee Supervisor 3	Labor			8/d
Krl.TS4	Sheraz-Trainee Supervisor 4	Labor			8/d
Krl.TS5	Usman-Trainee Supervisor 5	Labor			8/d
Krl.TS6	Sami Ullah-Trainee Supervisor 6	Labor			8/d
Krl.TS7	Tauseef-Trainee Supervisor 7	Labor			8/d
Krl.TS8	Mubashir Shafique-Trainee Supervisor 8	Labor			8/d
Krl.SS	Mehran Aamir-Senior Survyor	Labor			8/d
Krl.AS	Qasir Mehmood-Assistant Survyor	Labor			8/d
Krl.SvH	Mubashir Ahmed-Survyor Helper	Labor			8/d
Krl.DM	Basharat Ali-Design Manager	Labor		Design Management	8/d
Krl.TE1	Muhammad Naeem-Trainee Engineer 1	Labor			8/d
Krl.TE2	Zaheer-Trainee Engineer 2	Labor			8/d
SKL	Skilled Labour	Labor			8/d
USKL	Unskilled Labour	Labor			8/d

FIGURE 4.7: Resources Deployment and Assignment of Roles to Complete the Project

4.4 Project Baseline

The project first baseline is assigned after optimization as shown in Figure 4.8.



Project
: Construction of Hospital

Project Baseline
Construction of Hospital - B1 after Optimization

User Baselines

Primary
Construction of Hospital - B1 after Optimization

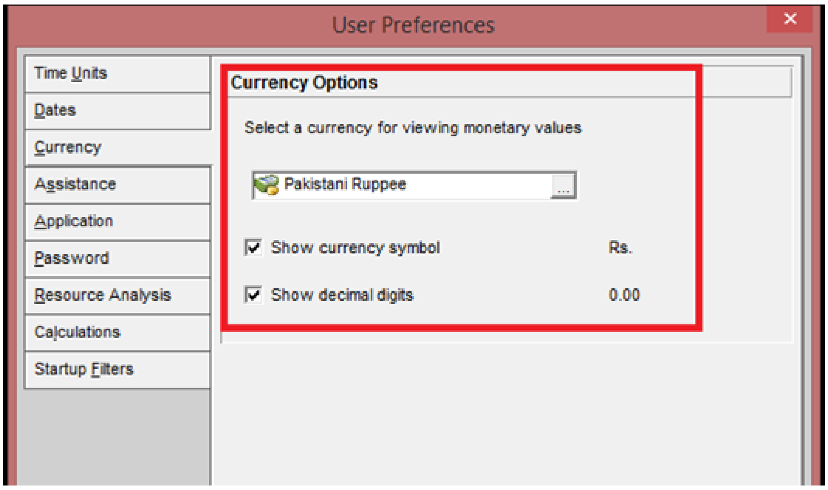
Secondary
<None>

Tertiary

FIGURE 4.8: Setting of Project Baseline

4.4.1 Mandatory Tasks

Currency Setting



Currency Options

Select a currency for viewing monetary values

Pakistani Ruppee

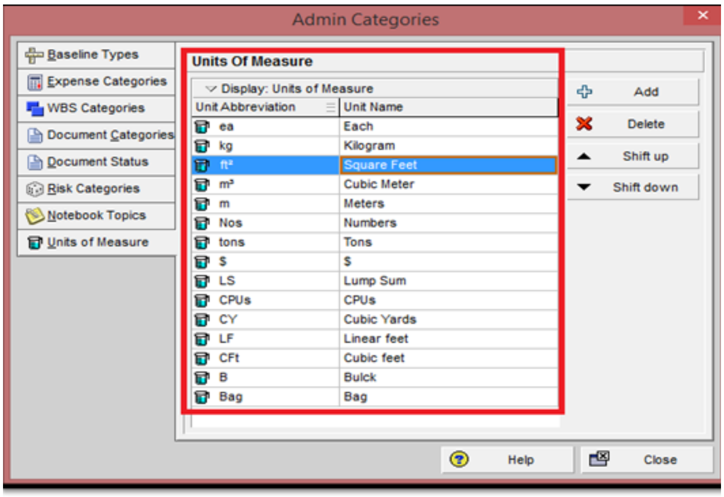
☑ Show currency symbol Rs.

☑ Show decimal digits 0.00

FIGURE 4.9: Currency Setting for Cost Measurement

The project cost will be measured in Pak Rupees (PKR) as shown Figure 4.9.

4.4.2 Material Unit Setting

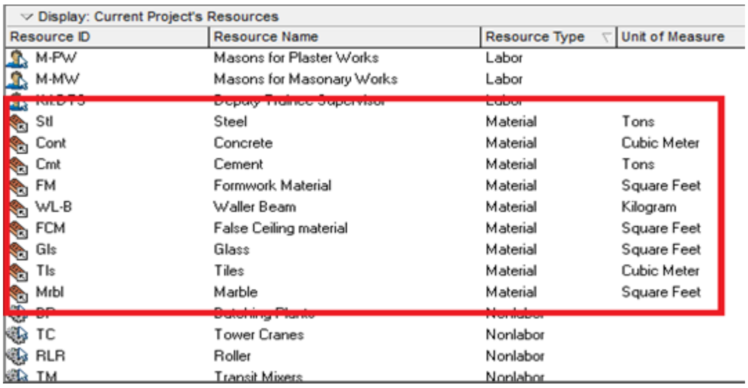


Units Of Measure

Display: Units of Measure

Unit Abbreviation	Unit Name
ea	Each
kg	Kilogram
ft^2	Square Feet
m^3	Cubic Meter
m	Meters
Nos	Numbers
tons	Tons
$	$
LS	Lump Sum
CPUs	CPUs
CY	Cubic Yards
LF	Linear feet
CFt	Cubic feet
B	Bulck
Bag	Bag

FIGURE 4.10: Units Setting of Materials for Project



Display: Current Project's Resources

Resource ID	Resource Name	Resource Type	Unit of Measure
M-PW	Masons for Plaster Works	Labor	
M-MW	Masons for Masonary Works	Labor	
KILDTS	Deputy Trainee Supervisor	Labor	
Stl	Steel	Material	Tons
Cont	Concrete	Material	Cubic Meter
Cmt	Cement	Material	Tons
FM	Formwork Material	Material	Square Feet
WL-B	Waller Beam	Material	Kilogram
FCM	False Ceiling material	Material	Square Feet
Gls	Glass	Material	Square Feet
Tls	Tiles	Material	Cubic Meter
Mrbl	Marble	Material	Square Feet
BP	Batching Plants	Nonlabor	
TC	Tower Cranes	Nonlabor	
RLR	Roller	Nonlabor	
TM	Transit Mixers	Nonlabor	

FIGURE 4.11: Used Materials in the Project and their Units

The method of material's unit setting is displayed in Figure 4.10. The materials used in the project and their respective units are shown in Figure 4.11.

4.4.3 Fiscal Year Setting

The fiscal year for the project is starting from 1st day of July every year and ends on 30th June of the consecutive year as represented in Figure 4.12.

Project Settings

Character for separating code fields for the WBS tree .

Fiscal year begins on the 1st day of July

Baseline for earned value calculations

● Project baseline ○ User's primary baseline

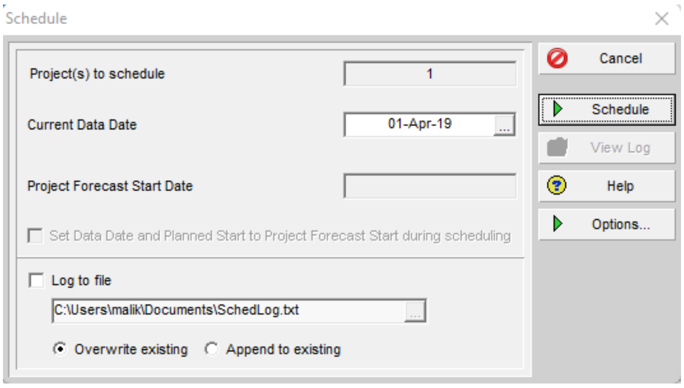
Define Critical Activities

○ Total Float less than or equal to 0h

● Longest Path

FIGURE 4.12: Fiscal Year Setting for Project

4.4.4 Schedule Log for Baseline Planning and Execution



Project(s) to schedule 1

Current Data Date 01-Apr-19

Project Forecast Start Date

☐ Set Data Date and Planned Start to Project Forecast Start during scheduling

☐ Log to file

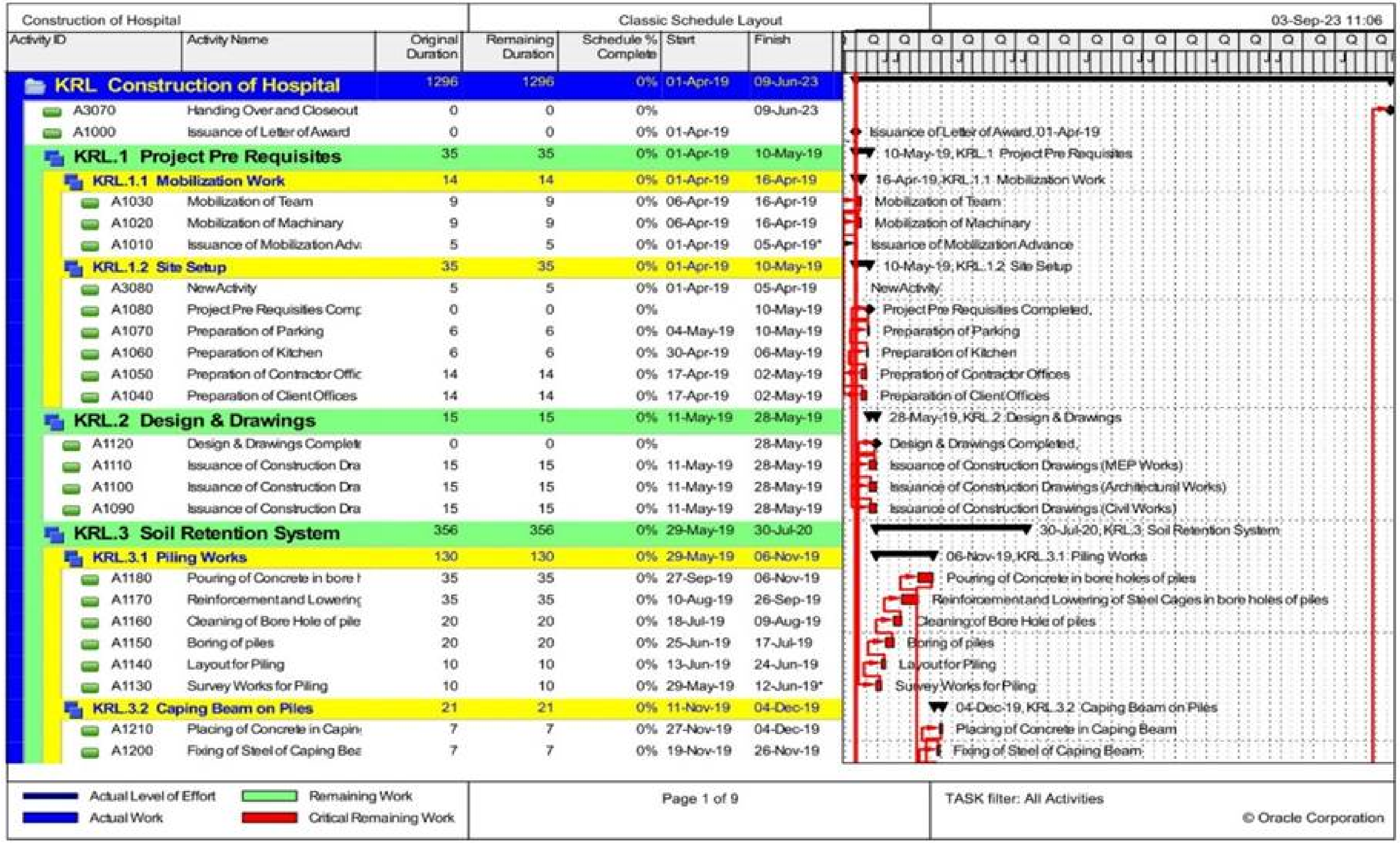
C:\Users\malik\Documents\SchedLog.txt

● Overwrite existing ○ Append to existing

FIGURE 4.13: Schedule Log for Project

The schedule log setting for baseline planning and execution is represented in 4.13.

The total project duration is **1296 days** for baseline project schedule after insert all activities, their durations, and other relevant information in Primavera as showed in Figure 4.14. The front page of primavera shown in Figure 4.14 and remaining pages 2 to 9 are shown in Appendix-B.



Construction of Hospital | Classic Schedule Layout | 03-Sep-23 11:06

Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
KRL	**Construction of Hospital**	1296	1296	0%	01-Apr-19	09-Jun-23
A3070	Handing Over and Closeout	0	0	0%		09-Jun-23
A1000	Issuance of Letter of Award	0	0	0%	01-Apr-19	
KRL.1	**Project Pre Requisites**	35	35	0%	01-Apr-19	10-May-19
KRL.1.1	**Mobilization Work**	14	14	0%	01-Apr-19	16-Apr-19
A1030	Mobilization of Team	9	9	0%	06-Apr-19	16-Apr-19
A1020	Mobilization of Machinary	9	9	0%	06-Apr-19	16-Apr-19
A1010	Issuance of Mobilization Adv	5	5	0%	01-Apr-19	05-Apr-19*
KRL.1.2	**Site Setup**	35	35	0%	01-Apr-19	10-May-19
A3080	NewActivity	5	5	0%	01-Apr-19	05-Apr-19
A1080	Project Pre Requisites Comp	0	0	0%		10-May-19
A1070	Preparation of Parking	6	6	0%	04-May-19	10-May-19
A1060	Preparation of Kitchen	6	6	0%	30-Apr-19	06-May-19
A1050	Prepration of Contractor Offic	14	14	0%	17-Apr-19	02-May-19
A1040	Preparation of Client Offices	14	14	0%	17-Apr-19	02-May-19
KRL.2	**Design & Drawings**	15	15	0%	11-May-19	28-May-19
A1120	Design & Drawings Complete	0	0	0%		28-May-19
A1110	Issuance of Construction Dra	15	15	0%	11-May-19	28-May-19
A1100	Issuance of Construction Dra	15	15	0%	11-May-19	28-May-19
A1090	Issuance of Construction Dra	15	15	0%	11-May-19	28-May-19
KRL.3	**Soil Retention System**	356	356	0%	29-May-19	30-Jul-20
KRL.3.1	**Piling Works**	130	130	0%	29-May-19	06-Nov-19
A1180	Pouring of Concrete in bore I	35	35	0%	27-Sep-19	06-Nov-19
A1170	Reinforcement and Lowering	35	35	0%	10-Aug-19	26-Sep-19
A1160	Cleaning of Bore Hole of pile	20	20	0%	18-Jul-19	09-Aug-19
A1150	Boring of piles	20	20	0%	25-Jun-19	17-Jul-19
A1140	Layout for Piling	10	10	0%	13-Jun-19	24-Jun-19
A1130	Survey Works for Piling	10	10	0%	29-May-19	12-Jun-19*
KRL.3.2	**Caping Beam on Piles**	21	21	0%	11-Nov-19	04-Dec-19
A1210	Placing of Concrete in Capin	7	7	0%	27-Nov-19	04-Dec-19
A1200	Fixing of Steel of Caping Bea	7	7	0%	19-Nov-19	26-Nov-19

Page 1 of 9

TASK filter: All Activities

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Figure 4.14: Complete Baseline Schedule of the Project

4.5 Risk Analysis and Management

The brief procedure of risk analysis can be described as follows:

- First of all, the risk factors are identified through extensive literature review.
- Then, a survey formed is prepared based on the shortlisted based on risk factors and the responses are gathered through online Google survey sharing option.
- The RPN values obtained through survey responses are used to highlight the critical risk factors.
- The respective durations of the critical risk factors are calculated by using three different methods and additional activities have been identified based on risk factors.
- After computing the durations of the activities, they are included in the project schedule.
- The results helps to prepare a revised schedule and the baseline project schedule are compared.

In order to accomplish the study, the risk analysis and management is classified into five phases, with each phase clearly presenting the different steps required to achieve the research objectives. The steps constitute risk identification, response gathering, risk assessment, curation of critical risk factors, and rescheduling.

4.5.1 Step #1: Risk Identification

The first phase of this study covers a comprehensive literature review to identify all the risks commonly encountered during construction projects. The literature review helps to sum up all the important risks faced and they are used to study the damage mode and analyze its effects as well as its applicability in the construction industry.

The material of literature review includes the electronic sources, textbook reviews, journal, conference, and thesis publications along with other data sources. Then, the responses are obtained from experts through a questionnaire survey to evaluate the risk factors and to shortlist the most critical risks factors by using FMEA approach.

As communicated by Derakhshanfar et al.[116] that the outermost level (Level 1) of risk factors is grouped under the broader heading of "project risk".

Table 4.1: Major Risks Levels

Level 1	**Level 2**	**Level 3**
Project Risk	Internal Stakeholder	Owner Manager Employee
	External Stakeholder	Consultant Government Customer
	Resources	Material Financial Labor Land Building, Equipment
	Technology	Design Processes
	Unforeseeable	External

At level 2, the risk factors are sorted in 5 categories to form a risk analysis structure (RBS).

At Level 3, there are 13 types of risks that take into account after an extensive literature review. The categorization of risk factors in three levels is represented in Table 4.1

4.5.2 Step #2: Collection of Responses

The main data source for this study is a questionnaire survey. This survey has been structured to get online responses. The survey is set up on a Google Form website that is accessible to all users, and the survey is sent as a link for participants to provide their responses and feedback. Experts in the field of construction are contacted to get the appropriate risk response. The probability of occurrence, severity, and the detection of each risk factor is rated by the respondent experts. Consequently, the numbers of responses collected were 280. The severity, occurrence, and detection ratings are used to compute the risk priority number. The survey form is provided in Appendix "A" used to evaluate defined risk factors .

4.5.2.1 Reliability Analysis

The first 30 responses were used to test the reliability of the data. Usually, the Cronbach alpha technique is used to perform reliability testing, which is a statistic measure to assess the internal consistency or reliability of a set of items or questions. It measures the extent to which all elements of a measurement instrument (survey/questionnaire) could assess the same basic concept or characteristic. The results of the first 30 responses of survey are enlisted for all variables and items in Table 4.2.

The internal stakeholders (IS) variable having none item represents a Cronbach's Alpha value of 0.9098, which is the highest value among all the variables in the Table 4.2. The resources (R) variable consists of 12 items and achieved a value of 0.9064; whereas, the Technology (T) consists of 6 items and obtained a value of 0.7255. The unforeseeable (UFS) variable contains 3 items and attained a value of 0.6482. There are nine items in external stakeholders (ES) variable and achieved a value of 0.7992.

All of the constructs are found to be reliable because the Cronbach's alpha values should be greater than 0.60 and it can be observed in Table 4.2 that all variables have attained higher values than the threshold limit.

Table 4.2: Cronbach's Alpha Results

Variable	**Number of Items**	**Cronbach's Alpha**
Internal Stakeholders	9	0.9098
External Stakeholders	9	0.7992
Resources	12	0.9064
Technology	6	0.7255
Unforeseeable	3	0.6482

4.5.3 Step #3: Risk Quantification

Risk is assessed using Failure Mode and Effects Analysis. The risk priority number , which is the main application tool of FMEA, is measured through recorded values of severity (S), occurrence (O) and detect-ability (D) of risk factors. The rating scale for all risk factors ranges from 1 to 10 as illustrated in Table 3.5 (Chapter 3).

4.5.3.1 Calculation of RPN Values

After obtaining the ratings of severity (S), occurrence (O), and detectability parameter through questionnaire, the RPN value is measure for each risk factor and conscripted in Table 4.3.

Table 4.3: RPN Calculations of Risk Factors

Funct: Name	**Failure Mode**	**Failure Effect**	**S**	**Potential Causes**	**O**	**D**	**RPN**
Project Risk	Internal Stakeholder	Owner	7	fails to arrange adequate funds/resources	7	8	392

Table 4.3: RPN Calculations of Risk Factors

Funct: Name	**Failure Mode**	**Failure Effect**	**S**	**Potential Causes**	**O**	**D**	**RPN**
		Manager	9	could not assign resources according to scheduling	9	8	648
		Employee	4	violates safety protocols/ fails to follow instructions and lacks the required skills/training	4	4	64
	External Stakeholder	Consultant	3	fails to identify potential risks/hazards timely	2	4	24
		Govt:	3	permits are delayed and/or rejected by the regulatory bodies	3	5	45
		Customer	5	fails to provide timely feedback	4	5	100
	Resources	Material	4	supplier delivers sub-standard/defective materials	4	5	80
		Financial	5	the financer delays funding requests	5	4	100
		Labor	5	the organization does not address employee's grievances	4	3	60
		Land, Equipment	3	supplier fails to provide necessary repair and maintenance services timely	4	4	48

Table 4.3: RPN Calculations of Risk Factors

Funct: Name	**Failure Mode**	**Failure Effect**	**S**	**Potential Causes**	**O**	**D**	**RPN**
	Technology	Design	4	fails to meet project specifications and undermines safety features	4	5	80
		Processes	8	parameters and critical quality control measures are not synchronized	8	8	512
	Unforeseeable	External	9	like natural disasters/political unrest and economic instability	9	8	648

It can be observed in Table 4.3 that there are three (manager, processes, and external) most critical risk factors based on the criteria defined in risk assessment matrix.

The RPN value of owner (392) falls in the medium risk category (greater than 125 and lower than 400) and therefore, highlighted by orange color.

Whereas, the most critical risks factors are highlighted by red color having the values equal to or higher than 400 as represented in Table 4.4.

Table 4.4: Shortlisted Critical Risk Factor Based on RPN Values

Critical Risk Factor	**RPN Value**
Owner	392
Manager	648
Processes	512

Table 4.4: Shortlisted Critical Risk Factor Based on RPN Values

Critical Risk Factor	**RPN Value**
External	648

4.5.4 Step #4: Calculation of the Corresponding Durations of Activities for Critical Risk Factors

A methodology of three alternative methods is used to calculate the respective durations of the critical risk factors.

Method 1: Duration Based on RPN and Percentage Impact

This method is based on the published literature[117, 118], which relates different RPN intervals with the percentage durations of critical factor and serves as a guide to changes the RPN values into project duration.

Table 4.5: Changes in Impact Percentages on Project Duration with respect to RPN Intervals (taken from Ahmed 2014 & Dumlu 2020)

RPN Value	**Impact (% of Project Duration)**
901-1000	15.0%
751-900	12.5%
601-750	10.0%
451-600	8.0%
301-450	5.0%
151-300	3.0%
0-150	Insignificant delay

The variations in percentages of impact with respect to RPN intervals are displayed in the Table 4.5.

For example, a risk factor with a value between 901 and RPN of 1000 has a 15% impact on the duration of the project by following this method; the durations of critical risk factors are computed and listed Table 4.6.

Table 4.6: Changes in Duration's of Critical Risk Factors

Critical Risk Factor	**RPN Value**	**Impact on Project Duration (1296 days)**	**Duration (Days)**
Owner	392	5%	65 Days
Manager	648	10%	130 Days
Processes	512	8%	104 Days
External	648	10%	130 Days

It can be observed in Table 4.6 that 5% impact of the owner risk factor on project duration may increase the project duration by 65 days. Similarly, the manager and external risk factors have 10% impact each and increase the project duration by 130 days. Whereas, the processes related risk factor has 8% impact on the project duration and may increase the duration up to 104 days.

Method 2: Duration Based on the Severity Rating

The duration is estimated according to the severity ratings of critical risk factors. Here, the severity parameter is the base point for converting risk factors into activity duration. As shown in Table 4.7, the respective durations critical risk factors are computed based on the severity ratings.

Table 4.7: Criteria to Compute Duration's of Risk Factors Based on the Severity Ratings (taken from Dumlu 2020)

Severity Rating	**Description**	**Duration**
10	Dangerously High	26-30 Days
9	Extremely High	21-25 Days

Table 4.7: Criteria to Compute Duration's of Risk Factors Based on the Severity Ratings (taken from Dumlu 2020)

Severity Rating	**Description**	**Duration**
8	Very High	18-20 Days
7	High	16-18 Days
6	Moderate	13-15 Days
5	Low	11-13 Days
4	Very Low	8-10 Days
3	Minor	6-8 Days
2	Very Minor	3-5 Days
1	None	0-2 Days

The mid-point values of duration intervals are used to compute the durations of critical risk factors based on the severity ratings and the results are documented in Table 4.8.

Table 4.8: Computed Duration's of Risk Factors Based on the Severity Ratings

Critical Risk Factor	**Severity Rating**	**Duration (Days)**
Owner	7	17 Days
Manager	9	23 Days
Processes	8	19 Days
External	9	24 Days

As a result of this method, it can be observed that the owner risk factor may increase the project duration by 17 days. Similarly, the manager, process, and external risk factors may increase the duration by 23, 19, and 24 days, respectively. The average range of duration selected from Table 4.7.

Method 3: Duration Based on RPN Ratio and Total Project Time

The RPN values of the shortlisted critical risk factors are divided by the cumulative value of RPN of all the risk factors. After obtaining the ratios for each critical risk factor, they are multiplied by the total duration of the project as illustrated by the formulae in equations 4.1 and 4.2.

$$RPN Ratio = \frac{RPN value of critical factor}{Cumulative value of RPN} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{(4.1)}$$

$$Duration\ of\ Critical\ Factor = RPN\ Ratio\ \times Total\ Project\ Duration\ \ldots \textit{(4.2)}$$

The total duration varies from project to project. The corresponding duration can be calculated by taking into account the duration of the any project. The total duration of the reference project is 1296 days according to the baseline schedule. By the using formulae in equations 4.1 and 4.2, the duration of each critical risk factor is calculated and listed in Table 4.9.

TABLE 4.9: Duration's of Risk Factors Dased on RPN Ratio and Total Project Time

Critical Risk Factor	**RPN Value**	**Total RPN Value**	**RPN Ratio in total**	**Duration (Days)**
Owner	392	2621	0.15	194 Days
Manager	648	2621	0.25	324 Days
Processes	512	2621	0.20	259 Days
External	648	2621	0.25	324 Days

First of all, calculate the cumulative value of RPN (risk priority number) by adding all the RPN values of all risk factors shown in Table 4.3, which is 2621. After that, as per equation 4.1, find the RPN ratio of the critical risk factors (owner, manager, processes, and external), which is 0.15, 0.25, 0.20, and 0.25, respectively.

By applying equation 4.2, the computed project durations for owner, manager, processes, and external risk factors are 194, 324, 259, and 324 days, respectively as shown in Table 4.9.

4.5.4.1 Determination of Critical Activities and Durations

Activities are identified within the framework of the project according to the critical risk factors. The risk factors are associated with the durations of the project activities. If critical risk factors affect different activities or phases of the project, the duration of each activity is calculated by averaging the total duration of the relevant risk factors according the above defined three methods.

TABLE 4.10: Critical Risk Factor and Relevant Activates

CRF	**Activities of Critical Risk Factor**
Owner	Brake down the funds allocation- Basement 1 to 3 Brake down the funds allocation- Ground floor to 3rd Floor Brake down the funds allocation- 4th floor to 7th floor
Manager	Assigned activities/ resources according to scheduling linked to all floors
Processes	Mis-arrangement of mechanical installation team right after masonry work in – 1st floor Mis-arrangement of mechanical installation team right after masonry work in – 4th floor Mis-arrangement of mechanical installation team right after masonry work in – 6th floor
External	Change in landscaping of project and forecasting before stating of activities of scope, sub-structure, super structure and finishing work.

These activities would be re-arranged in the project schedule based on the three methods define above. For the first method, the time spans of the risk factors have been calculated by dividing an activity into sub-activities and obtain the corresponding valve of each activity. The corresponding values for operations are given in Table 4.11.

Table 4.11: Breakdown of Activity Duration's According to Method-1

Most Critical Risk Factor	**Delay (In Days)**	**Activities of Critical Risk Factor**	**Reliable value**
Owner	65 Days	Brake down the funds allocation- Basement 1 to 3 Brake down the funds allocation- Ground floor to 3rd Floor Brake down the funds allocation- 4th floor to 7th floor	21.67
Manager	130 Days	Assigned activities/ resources according to scheduling linked to all floors	11.81
Processes	104 Days	Mis-arrangement of mechanical installation team right after masonry work in – 1st floor 4th floor 6th floor	34.66
External	130 Days	Change in landscaping of project and forecasting before stating of activities of scope, sub-structure, super structure and finishing work.	32.5

For the second alternative, the durations of the risk factors are also calculated. The corresponding values for operations are shown in Table 4.8. In this method, the corresponding gains of sub-activities are found by dividing the duration of each risk factor by the number of sub-division operations of the critical risk factor. The results of second method are displayed in Table 4.12.

Table 4.12: Breakdown of Activity Duration's According to Method-2

Most Critical Risk Factor	**Delay (In Days)**	**Activities of critical Risk Factor**	**Reliable value**
Owner	17 Days	Brake down the funds allocation-Basement 1 to 3 Brake down the funds allocation-Ground floor to 3rd Floor Brake down the funds allocation-4th floor to 7th floor	5.67
Manager	23 Days	Assigned activities/ resources according to scheduling linked to all floors	2.09
Processes	19 Days	Mis-arrangement of mechanical installation team right after masonry work in – 1st floor 4th floor 6th floor	6.33
External	24 Days	Change in landscaping of project and forecasting before stating of activities of scope, sub-structure, super structure and finishing work.	6

Similarly for the third method, the durations of the risk factors are also calculated. The corresponding values for operations are shown in Table 4.9. Again, the corresponding gains of sub-activities are found by dividing the duration of each risk factor by the number of sub-division operations of the critical risk factor and the results of minimizing the critical risk factor through 3rd method are shown in Table 4.13.

TABLE 4.13: Breakdown of Activity Durations According to Method-3

Most Critical Risk Factor	**Delay (In Days)**	**Activities of Critical Risk Factor**	**Reliable value**
Owner	194 Days	Brake down the funds allocation-Basement 1 to 3 Brake down the funds allocation-Ground floor to 3rd Floor Brake down the funds allocation-4th floor to 7th floor	64.7
Manager	324 Days	Assigned activities/ resources according to scheduling linked to all floors	29.4
Processes	259 Days	Mis-arrangement of mechanical installation team right after masonry work in – 1st floor 4th floor 6th floor	86.3
External	324 Days	Change in landscaping of project and forecasting before stating of activities of scope, sub-structure, super structure and finishing work.	81

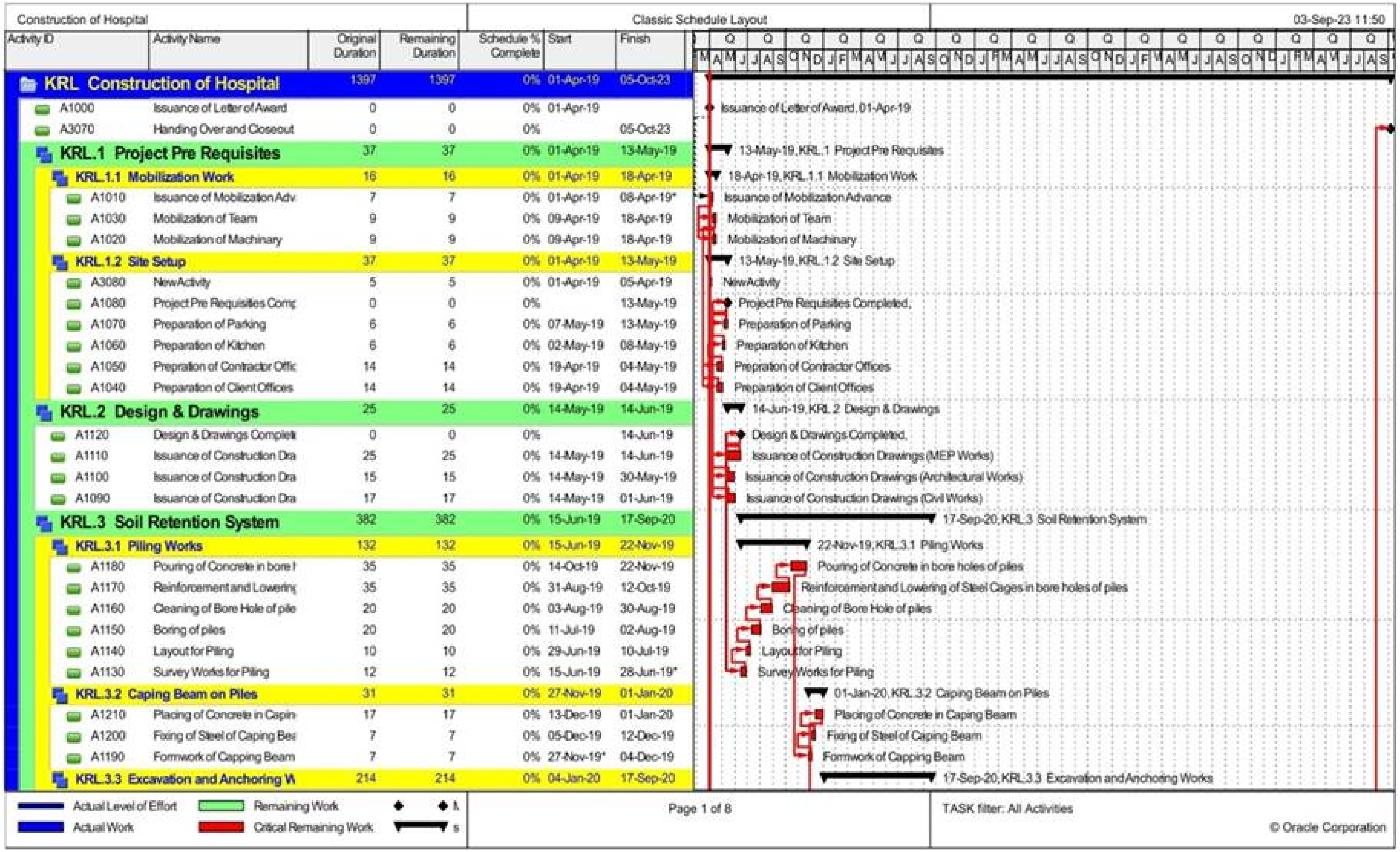
After determining the durations of the relevant activities, they are included in the project schedule.

The duration values have been rounded to the nearest integer while adding new activities to the project and revised schedule are prepared accord to results of three methods.

4.5.5 Step #5: Re-Scheduling

Based on the computed durations of activities by using three methods, the re-scheduling done for each method and the total duration of the project is found. However, after quantification of critical risk factors, the delays due to these risk factors are calculated using three different methods. In first method, the durations of critical risk factors are computed based on RPN values with respect to percentage impact. The final result shows that project duration is increased up to 101 days after incorporating the critical risk factors and the project would be completed in 1397 days instead of 1296 days.

The second method considers the severity ratings for calculation of durations of critical risk factors. Through this method, the overall project duration is increased up to 20 days and the revised project schedule represents that it may completed in 1316 days. The third method is based on the RPN ratio with respect cumulative value of RPN and total project duration. The maximum project duration is observed through this method and the total duration is raised up to 1556 days by contributing 260 days in the baseline schedule of the project. Again, the Primavera software is used for re-scheduling and the results of primavera first pages of all three methods are shown below and remaining pages are shown in Appendix-C.



Construction of Hospital — Classic Schedule Layout — 03-Sep-23 11:50

Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
KRL	**Construction of Hospital**	1397	1397	0%	01-Apr-19	05-Oct-23
A1000	Issuance of Letter of Award	0	0	0%	01-Apr-19	
A3070	Handing Over and Closeout	0	0	0%		05-Oct-23
KRL.1	**Project Pre Requisites**	37	37	0%	01-Apr-19	13-May-19
KRL.1.1	**Mobilization Work**	16	16	0%	01-Apr-19	18-Apr-19
A1010	Issuance of Mobilization Adv	7	7	0%	01-Apr-19	08-Apr-19*
A1030	Mobilization of Team	9	9	0%	09-Apr-19	18-Apr-19
A1020	Mobilization of Machinary	9	9	0%	09-Apr-19	18-Apr-19
KRL.1.2	**Site Setup**	37	37	0%	01-Apr-19	13-May-19
A3080	NewActivity	5	5	0%	01-Apr-19	05-Apr-19
A1080	Project Pre Requisites Comp	0	0	0%		13-May-19
A1070	Preparation of Parking	6	6	0%	07-May-19	13-May-19
A1060	Preparation of Kitchen	6	6	0%	02-May-19	08-May-19
A1050	Prepration of Contractor Offic	14	14	0%	19-Apr-19	04-May-19
A1040	Preparation of Client Offices	14	14	0%	19-Apr-19	04-May-19
KRL.2	**Design & Drawings**	25	25	0%	14-May-19	14-Jun-19
A1120	Design & Drawings Complet	0	0	0%		14-Jun-19
A1110	Issuance of Construction Dra	25	25	0%	14-May-19	14-Jun-19
A1100	Issuance of Construction Dra	15	15	0%	14-May-19	30-May-19
A1090	Issuance of Construction Dra	17	17	0%	14-May-19	01-Jun-19
KRL.3	**Soil Retention System**	382	382	0%	15-Jun-19	17-Sep-20
KRL.3.1	**Piling Works**	132	132	0%	15-Jun-19	22-Nov-19
A1180	Pouring of Concrete in bore l	35	35	0%	14-Oct-19	22-Nov-19
A1170	Reinforcement and Lowering	35	35	0%	31-Aug-19	12-Oct-19
A1160	Cleaning of Bore Hole of pile	20	20	0%	03-Aug-19	30-Aug-19
A1150	Boring of piles	20	20	0%	11-Jul-19	02-Aug-19
A1140	Layout for Piling	10	10	0%	29-Jun-19	10-Jul-19
A1130	Survey Works for Piling	12	12	0%	15-Jun-19	28-Jun-19*
KRL.3.2	**Caping Beam on Piles**	31	31	0%	27-Nov-19	01-Jan-20
A1210	Placing of Concrete in Capin	17	17	0%	13-Dec-19	01-Jan-20
A1200	Fixing of Steel of Caping Bea	7	7	0%	05-Dec-19	12-Dec-19
A1190	Formwork of Capping Beam	7	7	0%	27-Nov-19*	04-Dec-19
KRL.3.3	**Excavation and Anchoring W**	214	214	0%	04-Jan-20	17-Sep-20

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TASK filter: All Activities

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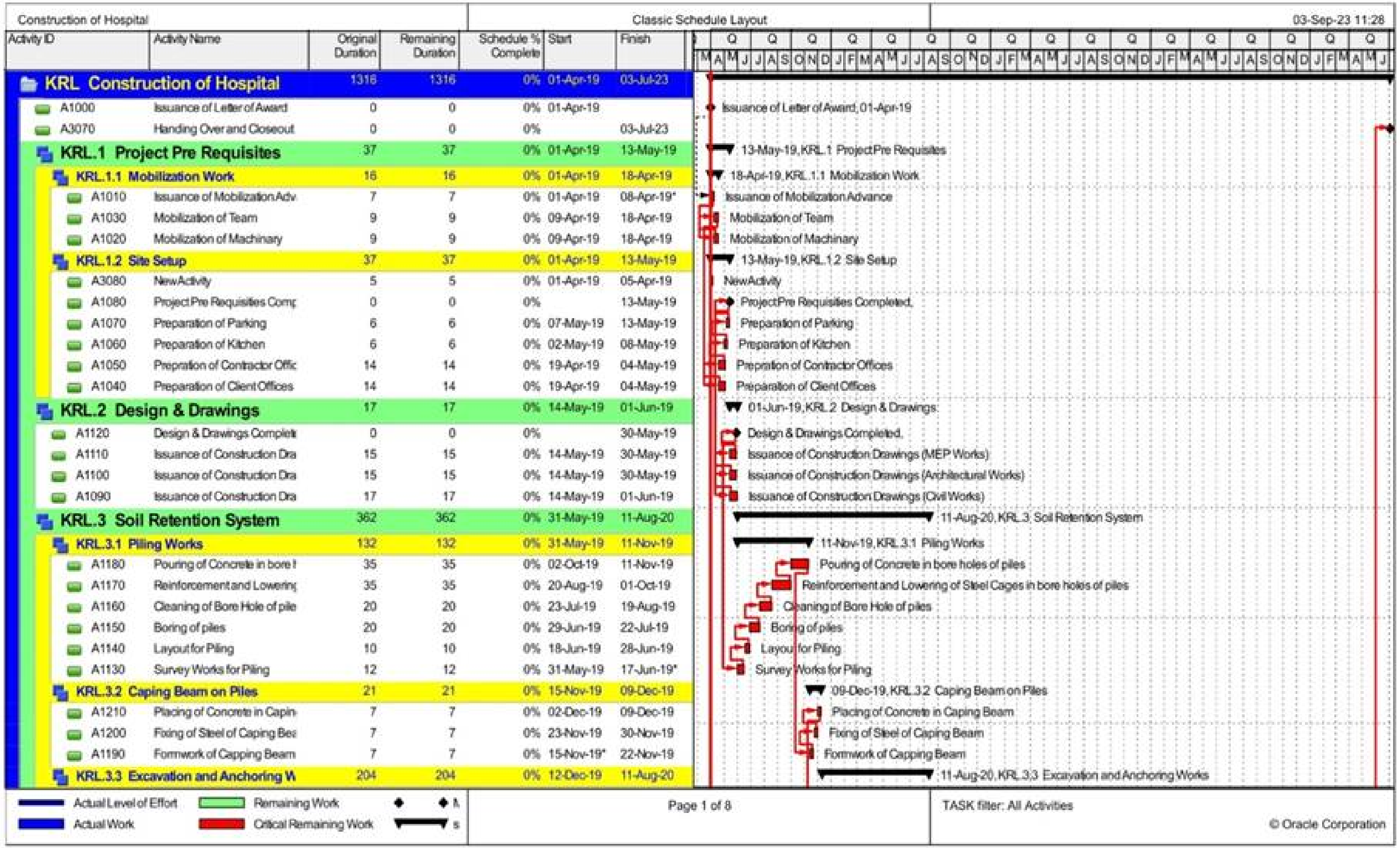
Figure 4.15: Re-Scheduling of Activities Based on Method-1



Construction of Hospital | Classic Schedule Layout | 03-Sep-23 11:28

Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
KRL Construction of Hospital		1316	1316	0%	01-Apr-19	03-Jul-23
A1000	Issuance of Letter of Award	0	0	0%	01-Apr-19	
A3070	Handing Over and Closeout	0	0	0%		03-Jul-23
KRL.1 Project Pre Requisites		37	37	0%	01-Apr-19	13-May-19
KRL.1.1 Mobilization Work		16	16	0%	01-Apr-19	18-Apr-19
A1010	Issuance of Mobilization Adv	7	7	0%	01-Apr-19	08-Apr-19*
A1030	Mobilization of Team	9	9	0%	09-Apr-19	18-Apr-19
A1020	Mobilization of Machinary	9	9	0%	09-Apr-19	18-Apr-19
KRL.1.2 Site Setup		37	37	0%	01-Apr-19	13-May-19
A3080	New Activity	5	5	0%	01-Apr-19	05-Apr-19
A1080	Project Pre Requisites Comp	0	0	0%		13-May-19
A1070	Preparation of Parking	6	6	0%	07-May-19	13-May-19
A1060	Preparation of Kitchen	6	6	0%	02-May-19	08-May-19
A1050	Prepration of Contractor Offic	14	14	0%	19-Apr-19	04-May-19
A1040	Preparation of Client Offices	14	14	0%	19-Apr-19	04-May-19
KRL.2 Design & Drawings		17	17	0%	14-May-19	01-Jun-19
A1120	Design & Drawings Complet	0	0	0%		30-May-19
A1110	Issuance of Construction Dra	15	15	0%	14-May-19	30-May-19
A1100	Issuance of Construction Dra	15	15	0%	14-May-19	30-May-19
A1090	Issuance of Construction Dra	17	17	0%	14-May-19	01-Jun-19
KRL.3 Soil Retention System		362	362	0%	31-May-19	11-Aug-20
KRL.3.1 Piling Works		132	132	0%	31-May-19	11-Nov-19
A1180	Pouring of Concrete in bore I	35	35	0%	02-Oct-19	11-Nov-19
A1170	Reinforcement and Lowering	35	35	0%	20-Aug-19	01-Oct-19
A1160	Cleaning of Bore Hole of pile	20	20	0%	23-Jul-19	19-Aug-19
A1150	Boring of piles	20	20	0%	29-Jun-19	22-Jul-19
A1140	Layout for Piling	10	10	0%	18-Jun-19	28-Jun-19
A1130	Survey Works for Piling	12	12	0%	31-May-19	17-Jun-19*
KRL.3.2 Caping Beam on Piles		21	21	0%	15-Nov-19	09-Dec-19
A1210	Placing of Concrete in Capin	7	7	0%	02-Dec-19	09-Dec-19
A1200	Fixing of Steel of Caping Bea	7	7	0%	23-Nov-19	30-Nov-19
A1190	Formwork of Capping Beam	7	7	0%	15-Nov-19*	22-Nov-19
KRL.3.3 Excavation and Anchoring W		204	204	0%	12-Dec-19	11-Aug-20

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TASK filter: All Activities

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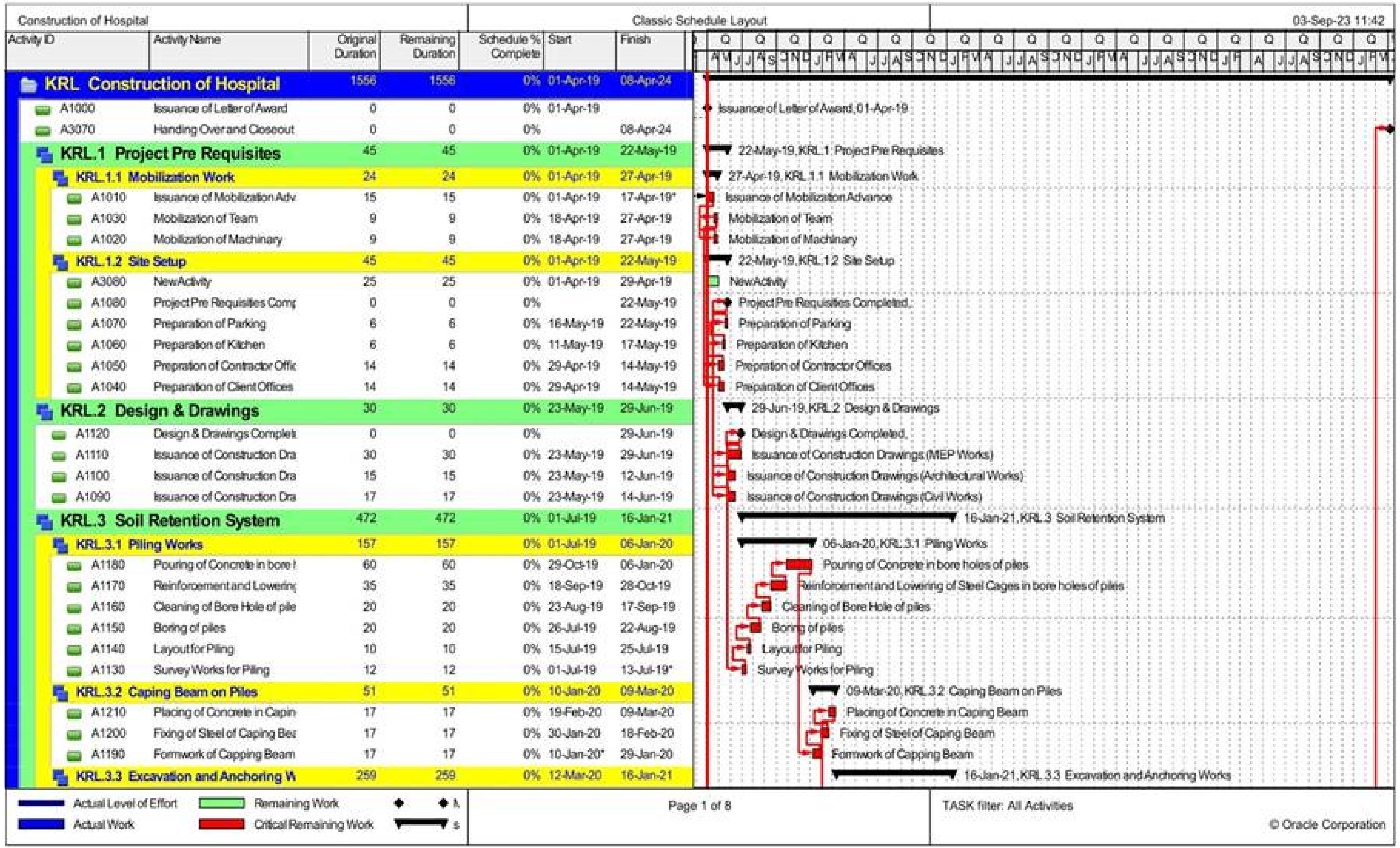
Figure 4.16: Re-Scheduling of Activities Based on method-2



Construction of Hospital

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Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
KRL	**Construction of Hospital**	1556	1556	0%	01-Apr-19	08-Apr-24
A1000	Issuance of Letter of Award	0	0	0%	01-Apr-19	
A3070	Handing Over and Closeout	0	0	0%		08-Apr-24
KRL.1	**Project Pre Requisites**	45	45	0%	01-Apr-19	22-May-19
KRL.1.1	**Mobilization Work**	24	24	0%	01-Apr-19	27-Apr-19
A1010	Issuance of Mobilization Adv	15	15	0%	01-Apr-19	17-Apr-19*
A1030	Mobilization of Team	9	9	0%	18-Apr-19	27-Apr-19
A1020	Mobilization of Machinary	9	9	0%	18-Apr-19	27-Apr-19
KRL.1.2	**Site Setup**	45	45	0%	01-Apr-19	22-May-19
A3080	NewActivity	25	25	0%	01-Apr-19	29-Apr-19
A1080	Project Pre Requisites Comp	0	0	0%		22-May-19
A1070	Preparation of Parking	6	6	0%	16-May-19	22-May-19
A1060	Preparation of Kitchen	6	6	0%	11-May-19	17-May-19
A1050	Prepration of Contractor Offic	14	14	0%	29-Apr-19	14-May-19
A1040	Preparation of Client Offices	14	14	0%	29-Apr-19	14-May-19
KRL.2	**Design & Drawings**	30	30	0%	23-May-19	29-Jun-19
A1120	Design & Drawings Complet	0	0	0%		29-Jun-19
A1110	Issuance of Construction Dra	30	30	0%	23-May-19	29-Jun-19
A1100	Issuance of Construction Dra	15	15	0%	23-May-19	12-Jun-19
A1090	Issuance of Construction Dra	17	17	0%	23-May-19	14-Jun-19
KRL.3	**Soil Retention System**	472	472	0%	01-Jul-19	16-Jan-21
KRL.3.1	**Piling Works**	157	157	0%	01-Jul-19	06-Jan-20
A1180	Pouring of Concrete in bore l	60	60	0%	29-Oct-19	06-Jan-20
A1170	Reinforcement and Lowering	35	35	0%	18-Sep-19	28-Oct-19
A1160	Cleaning of Bore Hole of pile	20	20	0%	23-Aug-19	17-Sep-19
A1150	Boring of piles	20	20	0%	26-Jul-19	22-Aug-19
A1140	Layout for Piling	10	10	0%	15-Jul-19	25-Jul-19
A1130	Survey Works for Piling	12	12	0%	01-Jul-19	13-Jul-19*
KRL.3.2	**Caping Beam on Piles**	51	51	0%	10-Jan-20	09-Mar-20
A1210	Placing of Concrete in Capin	17	17	0%	19-Feb-20	09-Mar-20
A1200	Fixing of Steel of Caping Bea	17	17	0%	30-Jan-20	18-Feb-20
A1190	Formwork of Capping Beam	17	17	0%	10-Jan-20*	29-Jan-20
KRL.3.3	**Excavation and Anchoring W**	259	259	0%	12-Mar-20	16-Jan-21

▬ Actual Level of Effort	🟩 Remaining Work	◆ ◆ M
▬ Actual Work	🟥 Critical Remaining Work	▼▬▼ s

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TASK filter: All Activities

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FIGURE 4.17: Re-Scheduling of Activities Based on method-3

4.6 The Impact of Risk Factors on Project Cost

There are numerous parameters that influence a construction project and may not be limited to only few/certain. Therefore, it would be more reliable to change the common FMEA ranking coefficient into RPN value. This transformation criterion of ranking into percentage impact in terms of cost is established by Abdelgawad et al. [119]. It can be noticed in Table 4.14 that the different rankings of risk factors have different weight percentage impacts on the cost of the project.

Users can identify risk factors followed by evaluation criteria, depending on the nature, scope, and objectives of the project. The list of critical risk factors has been identified by using the same logic of conventional FMEA provided in Table 4.4. Each risk factor must be divided into several classes (Very High, High, Moderate, Low and Very Low) according to the scale (From 1 to 10).

Table 4.14: Impact of Risk Factors on the Project Cost (Adopted from M Abdelgawad,AR Fayek 2010)

Ranking	**Description of Failure**	**% Cost Impact**
1	Very Low	1% of project cost.
2	Low	Cost increase is 1% and 4% of project cost.
3		
4	Medium	Cost increase is 4% and 7% of project cost.
5		
6		
7	High	Cost increase is 7% and 10% of project cost.
8		
9		
10	Very High	10% of project cost.

The total cost of the project varies from project to project depending on its characteristics and complexity. The risk factor's cost will be calculated for the current case study by using the defined criteria in Table 4.14. The percentage impact on cost, the level failure and the relevant cost of risk factors are displayed in Table 4.15. As mentioned earlier, the cost of the baseline project was Rs.1164 million.

TABLE 4.15: Cost Calculations of Risk Factors

Critical Risk Factor	**RPN Value**	**Description of Failure**	**% Cost Impact**	**Cost (In million)**
Owner	392	Medium	5 %	58.2
Manager	648	High	8 %	93.12
Processes	512	High	8 %	93.12
External	648	High	8%	93.12

It can be observed in Table 4.15 that the owner risk factor contributes 5% in the cost of the project and may increase the project cost to Rs. 58.2 million. Similarly, the manager, processes, external risk factors all have an 8% cost impact individually and add up to Rs. 279.36 million to the total project. In this way, the total project's cost is raised to Rs. 1501/- million after including the cost of critical risk factors.

4.7 Findings of Case Study

The important findings of the case study can be described in two steps.

- By evaluating the results of FMEA process
- By analyzing the results of the planning process

First, the risk factors are summarized through literature and then the severe/critical risk factors from the case study are quantified through FMEA process.

The failure modes of risk factors, their failure effect and RPN values are shown in Table 4.16. The critical risk factors (owner, manager, processes, and external) are highlighted through orange and red colors.

TABLE 4.16: Quantification of Critical Risk Factors Based on RPN Value

Failure Mode	**Failure Effect**	**RPN (SxOxD)**
Internal Stakeholders	Owner	392
	Manager	648
	Employee	64
External Stakeholders	Consultant	24
	Government	45
	Customer	100
Resources	Material	80
	Financial	100
	Labor	60
	Land, Building, Equipment	48
Technology	Design	80
	Processes	512
Unforeseeable	External	648

Owner's Risk Factor

This category of risk factor is important at Level 3. However, this factor is the most important in causing interruptions during execution of the project. This is mainly due to the risk factor “not organizing enough funds/resources (RPN=392)”.

Manager’s Risk Factor

This is schedule related risk factor and also considered important. This is mainly due to the reason of ”not being able to allocate resource based on schedule (RPN=648)”.

Processes Related Risk Factor

This is a schedule related risk factor, which affects the progress of the project. This is due to the ”non-synchronized critical quality control parameters and measures (RPN=512)”.

External Risk Factor

This risk factor also significantly influences the progress of the project. This is due to the ”occurrence of events such as natural disasters, political, and economic instability (RPN=648)”.

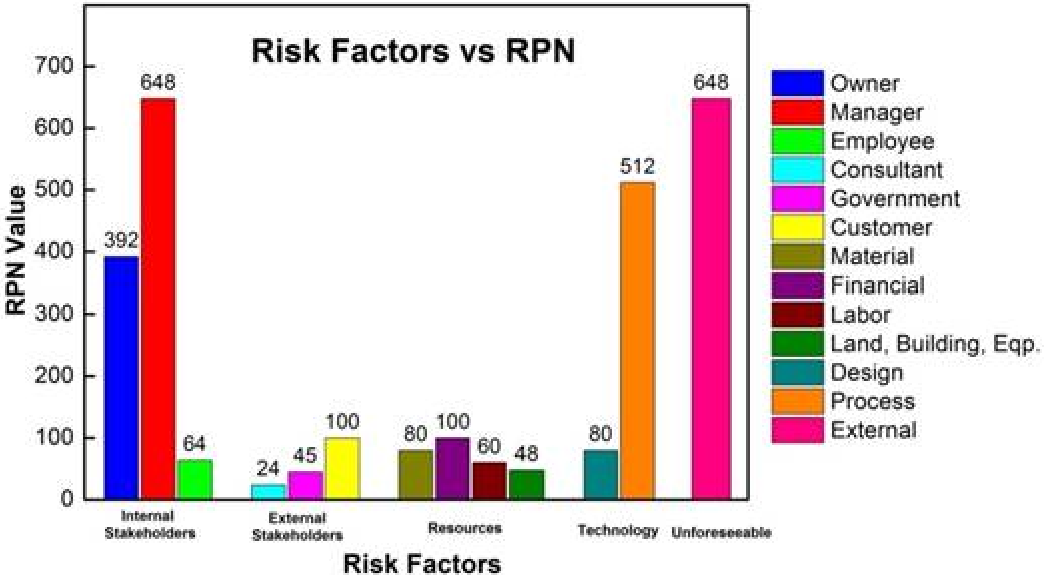

FIGURE 4.18: Graphical Representation of Risk Factors vs RPN Values

In short, the overview of risk factors shown in Figure 4.18 provides a clear idea about the critical risks for the project. Whereas, based on these results, a risk management plan is necessary to deal with them. Therefore, critical risk factors should be assessed individually for appropriate risk management actions.

After quantification of critical risk factors, the delay durations related to these risks factors are calculated by using three different methods. Then, they are converted into activities and included in the project base schedule. As a result, the revised schedules based on three methods have been prepared for construction of the hospital project.

The re-scheduling results of these three methods are:

- The duration of the project based on first method is 1397 days.
- The project duration based on second method is 1316 days.
- The project duration based on third method is 1556 days.

Additionally, the critical risk factors affect the overall cost of the project. In this case study the basic cost of the project was Rs.1164 million; however, after accommodation the critical risk factors, the total cost of the project is increased up to Rs.1501 million.

Chapter 5

Discussion and Conclusion

This chapter presents the conclusions and future recommendation of the study. First, a brief discussion outlines the main steps to accomplish the study and then conclusions are presented based on the results. Finally, the limitations of the current study and future directions are presented.

5.1 Discussion

As the current research work shows that the time is the most important parameter for construction projects and emphasizes on predicting disruptions and taking remedial measures to ensure project success. This study aims to establish a methodology for quantifying the project scheduling activities and identifying potential delays in construction projects and then incorporating the Risk Priority Number (RPN) of Failure Mode and Effects Analysis (FMEA) into critical risk factor using three different methods and then re-scheduling of activities by using Primavera software. The current study consists of six main steps:

- The first step is to identify those factors that cause delays in construction projects and then classification of risk factors into different groups such as owner and contractor etc through an extensive literature review and subjective assessment. In this way, thirteen risk factors are identified.

- A questionnaire is designed based on these identified risk factors and the responses are gathered from experts, who are working on construction projects.
- After that the baseline schedule of the activities is created for the project using Primavera software.
- FMEA is applied, assigning a score to each parameter (severity, occurrence, and detection) via Google questionnaire survey for calculation of RPN values against each risk factor. Critical risk factors are quantified based on their RPN values using risk assessment matrix.
- After quantification of critical risk factors, three different methods were used to determine their effects on the project durations
- Each delay element is considered an activity in all three methods and after incorporating the critical risk factor its duration is included in the project and re-scheduling is done for three all three methods.
- After re-scheduling of the activities, the change in project cost is computed due to the critical risk factor

In this study, the risk factors are classified and analysed through Failure Mode and Effects Analysis (FMEA) allowing a comprehensive assessment of delays. Furthermore, the effect of critical risk factors on the project cost is also analyzed.

5.2 Conclusion

This research evaluates the significant risk factors and their ranking for construction of a hospital project. Among thirteen identified risk factors through literature review, only four critical risk factors (owner, manager, processes, and external) have been quantified through ratings of severity, occurrence, and detection accompanied with the calculation of risk priority number (RPN).

Whereas, the RPN values of remaining nine risk factors; employee, consultant, government, customer, material, financial, labor, land-building-equipment, and design are in the least impact range (less than 125) according to the risk priority matrix.

The main aim is to compare and confirm the impact of critical risk factors on project duration. It is observed through baseline project schedule that the project can be completed in 1296 days. However, after quantification of critical risk factors, the delays due to these risk factors are calculated using three different methods. In first method, the durations of critical risk factors are computed based on RPN values with respect to percentage impact. This method transforms the RPN values into the durations of project activities using the RPN intervals against the percentage impact on the total project duration. The final result shows that project duration is increased up to 101 days after incorporating the critical risk factors and the project would be completed in 1397 days instead of 1296 days.

The second method considers the severity ratings for calculation of durations of critical risk factors. The risk factors are converted into activity durations with respect the severity parameter. Through this method, the overall project duration is increased up to 20 days and the revised project schedule represents that it may completed in 1316 days. The third method is based on the RPN ratio with respect cumulative value of RPN and total project duration. In this method, the individual RPN values of the critical risk factors are divided by the total RPN value of all the risk factors to get RPN ratio. The maximum project duration is observed through this method and the total duration is raised up to 1556 days by contributing 260 days in the baseline schedule of the project.The analysis shows that the minimum, intermediate and maximum duration of the project have been observed for the methods 2, 1 and 3, respectively.

The project's duration varies from project to project depending on its characteristics and importance. The use of any specific method among three (described above) depends on the characteristics of the project and the authorities that execute the project.

Although the duration of the project is minimum for second method but it has least impact and risk on schedule. Also, the critical risk factors effect on the overall project cost. In this case study the basic cost of the project is Rs.1164 million. After determining the critical risk factors, the cost of these factors is calculated using "cost impact method". By using this method, the cost of critical risk factors is computed because these factors cause interruptions during the execution of the project. As a result, the total cost of the project is increased to Rs.1501 million.

As expected, the completion date of the revised project is later than the reference project. The main finding is that risk factors tend to lengthen project schedules, underscoring their importance in construction projects. The implementation of this method in construction projects involves analyzing potential risk factors and supporting decision-making during the risk assessment.

Finally, the FMEA-based approach to delay analysis in construction projects has been shown to be satisfactory and useful for risk assessment in such projects. This approach allows delay risk to be integrated as an activity in the project schedule. It provides a practical way to use FMEA in construction projects and helps potential users design alternative strategies to reduce risk. It is important to note that different methods can be used to evaluate the risk factors. Furthermore, the proposed methods can be improved to include different risk factors, user preferences, and business strategies.

5.3 Limitations of Research

The effectiveness of the Failure Mode and Effects Analysis (FMEA) technique is highly dependent on the quality of the input data and the expertise of those performing the analysis. If the data used for analysis is inaccurate, incomplete, or out of date, it may lead to unreliable conclusions having potential error patterns and their impact. In addition, the thesis may have limitations on generalization. The results and conclusions of the study may be influenced by the specific construction projects, industry, or geographic region selected for analysis. The variety and complexity of construction projects in different contexts can affect the transferability of results to other scenarios, making it difficult to apply the results collectively.

Finally, the thesis may encounter limitations related to time constraints and the dynamic nature of construction projects. Construction schedules and risks may change rapidly due to unforeseen circumstances, market volatility, regulatory changes, and other external factors.

Due to the time-consuming research process, the conclusions drawn from the analysis may not fully capture the real-time dynamics of construction projects, which may limit the practical applicability of the project results. Although, this research work offers valuable insights into the application of FMEA for risk analysis and scheduling for construction projects; however, the above-mentioned limitations should be acknowledged to ensure a balance and accurate interpretation of the findings

5.4 Future Research Directions

Multi-Project Analysis

Expand the study to assess the applicability of FMEA to time and risk analysis in complex projects involving multiple interconnected construction projects. This may involve exploring how the risks of one project can spread to other projects as part of a larger program.

Industry Case Studies

Apply an FMEA-based approach to real time ongoing construction projects and document the results. This may involve working with construction companies to analyze specific projects and assess how FMEA affects decision-making, risk reduction, and project success.

Analysis of Uncertainty and Sensitivity

Incorporate uncertainty and sensitivity analysis into the FMEA process to quantify the impact of variations in input parameters on analysis results. This can help in understanding the strength of FMEA-based analysis and prioritizing critical risks.

Long-term Effects and Learning

Investigate the long-term effects of implementing FMEA-based schedules and risk analysis on the performance of construction project. Evaluate whether lessons learned from the previous projects are effectively applied to subsequent projects by leading to continual improvement of risk management activities.

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Appendix

Appendix-A

Research Questionnaire

Dear Respondent;

I am an MS Scholar at Capital University of Science and Technology, and my research topic for completion of my MS thesis is "**Evaluation of Schedule and Risk Analysis for Construction Project Through Failure Mode and Effects Analysis**".

I'm conducting this poll for purely intellectual and educational purpose. Your valued opinion and favor to accomplish this research survey would be immensely helpful and highly appreciated.

Sincerely,

Malik Ahsan Hassan

This questionnaire contains two sections. Kindly respond to all of the statements.

If there is no exact choice present, kindly select the most appropriate choice.

Section-I

Please tick () in the box for the appropriate answer.

1. **Gender**

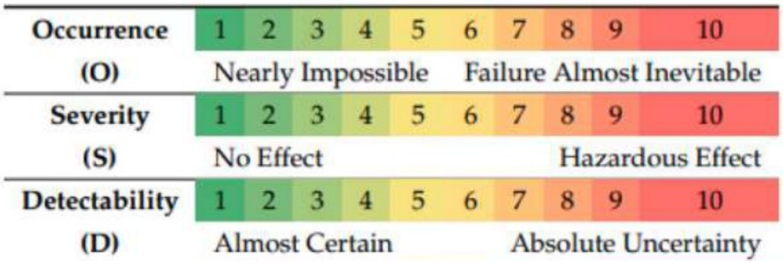
Male
Female

2. **Age:**

Below 25	25-30	30-35	35-40
40-45	45-50	Above 50	

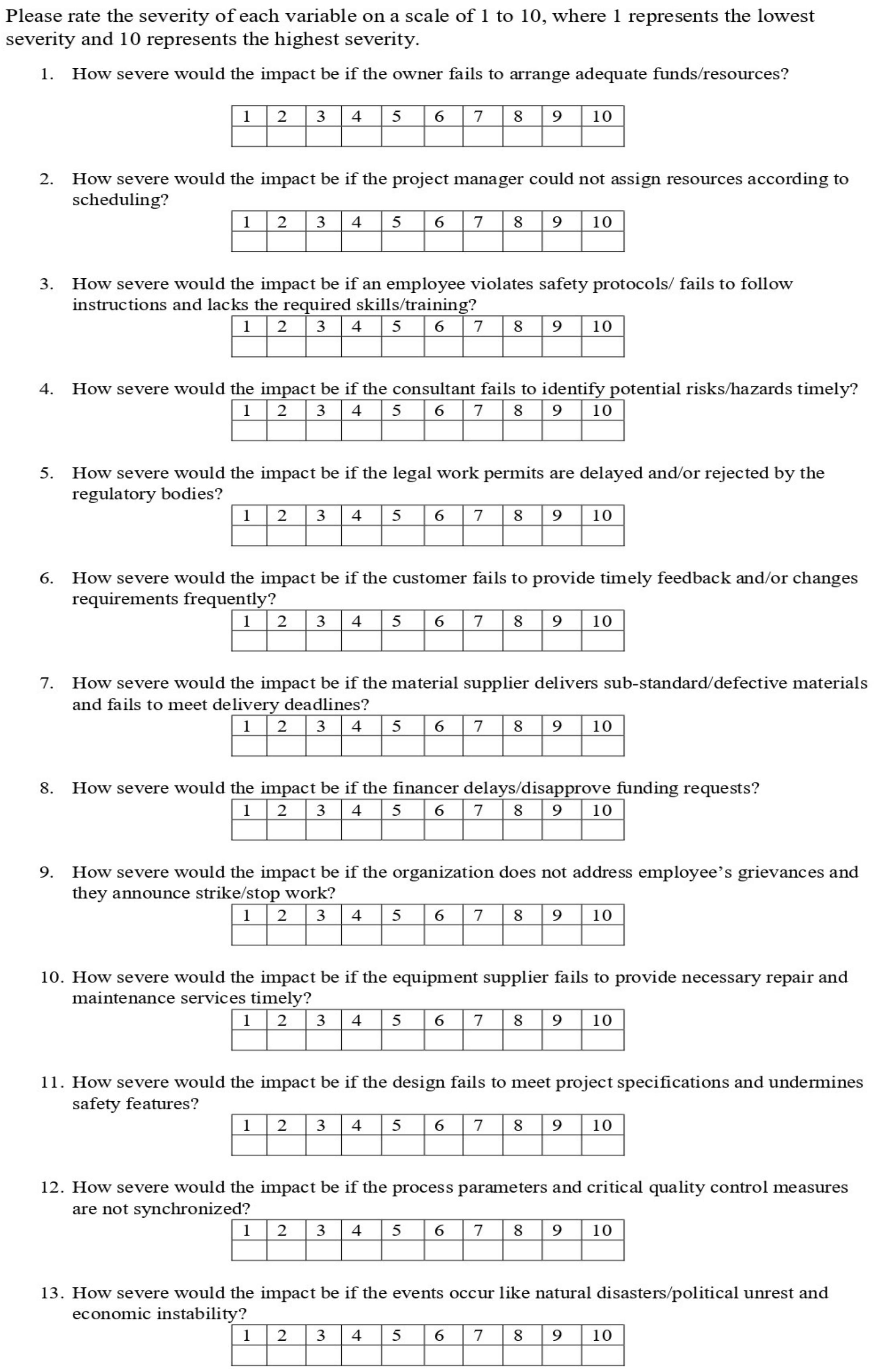
3. **Education:**Matric Intermediate or equalent Graduation Master PhD

4. **Experience** (in years): ______________________________



Occurrence	1	2	3	4	5	6	7	8	9	10
(O)	Nearly Impossible					Failure Almost Inevitable				
Severity	1	2	3	4	5	6	7	8	9	10
(S)	No Effect							Hazardous Effect		
Detectability	1	2	3	4	5	6	7	8	9	10
(D)	Almost Certain						Absolute Uncertainty			

Section-II Please rate and mark each statement on a scale from 1 to 10 based on the criteria explained above according your knowledge/experience



Please rate the severity of each variable on a scale of 1 to 10, where 1 represents the lowest severity and 10 represents the highest severity.

1. How severe would the impact be if the owner fails to arrange adequate funds/resources?

1	2	3	4	5	6	7	8	9	10

2. How severe would the impact be if the project manager could not assign resources according to scheduling?

1	2	3	4	5	6	7	8	9	10

3. How severe would the impact be if an employee violates safety protocols/ fails to follow instructions and lacks the required skills/training?

1	2	3	4	5	6	7	8	9	10

4. How severe would the impact be if the consultant fails to identify potential risks/hazards timely?

1	2	3	4	5	6	7	8	9	10

5. How severe would the impact be if the legal work permits are delayed and/or rejected by the regulatory bodies?

1	2	3	4	5	6	7	8	9	10

6. How severe would the impact be if the customer fails to provide timely feedback and/or changes requirements frequently?

1	2	3	4	5	6	7	8	9	10

7. How severe would the impact be if the material supplier delivers sub-standard/defective materials and fails to meet delivery deadlines?

1	2	3	4	5	6	7	8	9	10

8. How severe would the impact be if the financer delays/disapprove funding requests?

1	2	3	4	5	6	7	8	9	10

9. How severe would the impact be if the organization does not address employee’s grievances and they announce strike/stop work?

1	2	3	4	5	6	7	8	9	10

10. How severe would the impact be if the equipment supplier fails to provide necessary repair and maintenance services timely?

1	2	3	4	5	6	7	8	9	10

11. How severe would the impact be if the design fails to meet project specifications and undermines safety features?

1	2	3	4	5	6	7	8	9	10

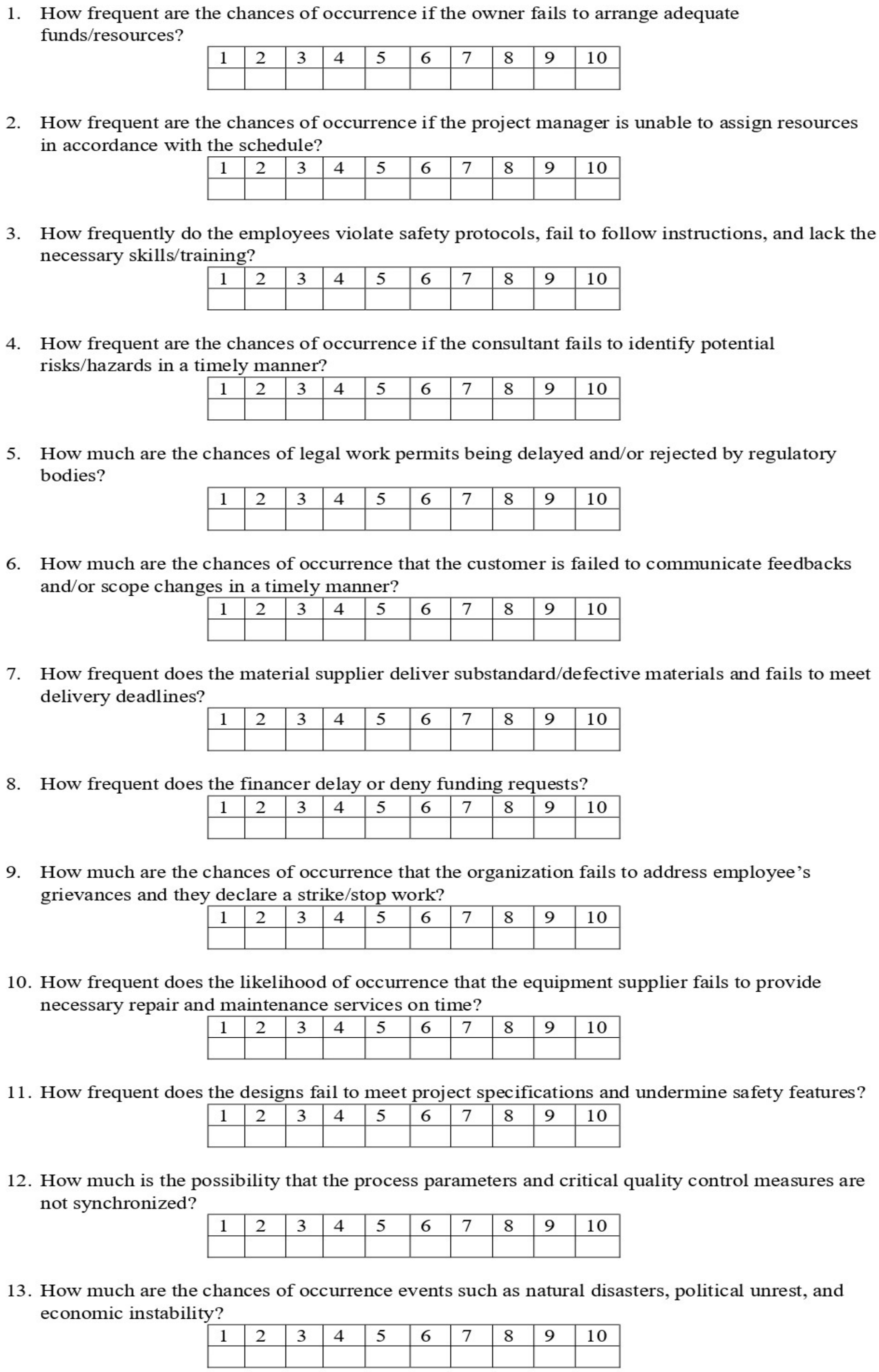
12. How severe would the impact be if the process parameters and critical quality control measures are not synchronized?

1	2	3	4	5	6	7	8	9	10

13. How severe would the impact be if the events occur like natural disasters/political unrest and economic instability?

1	2	3	4	5	6	7	8	9	10

Scoring Instructions: Please rate each variable on a scale of 1 to 10, where 1 represents a low likelihood of occurrence and 10 represents a high likelihood of occurrence.



1. How frequent are the chances of occurrence if the owner fails to arrange adequate funds/resources?

1	2	3	4	5	6	7	8	9	10

2. How frequent are the chances of occurrence if the project manager is unable to assign resources in accordance with the schedule?

1	2	3	4	5	6	7	8	9	10

3. How frequently do the employees violate safety protocols, fail to follow instructions, and lack the necessary skills/training?

1	2	3	4	5	6	7	8	9	10

4. How frequent are the chances of occurrence if the consultant fails to identify potential risks/hazards in a timely manner?

1	2	3	4	5	6	7	8	9	10

5. How much are the chances of legal work permits being delayed and/or rejected by regulatory bodies?

1	2	3	4	5	6	7	8	9	10

6. How much are the chances of occurrence that the customer is failed to communicate feedbacks and/or scope changes in a timely manner?

1	2	3	4	5	6	7	8	9	10

7. How frequent does the material supplier deliver substandard/defective materials and fails to meet delivery deadlines?

1	2	3	4	5	6	7	8	9	10

8. How frequent does the financer delay or deny funding requests?

1	2	3	4	5	6	7	8	9	10

9. How much are the chances of occurrence that the organization fails to address employee's grievances and they declare a strike/stop work?

1	2	3	4	5	6	7	8	9	10

10. How frequent does the likelihood of occurrence that the equipment supplier fails to provide necessary repair and maintenance services on time?

1	2	3	4	5	6	7	8	9	10

11. How frequent does the designs fail to meet project specifications and undermine safety features?

1	2	3	4	5	6	7	8	9	10

12. How much is the possibility that the process parameters and critical quality control measures are not synchronized?

1	2	3	4	5	6	7	8	9	10

13. How much are the chances of occurrence events such as natural disasters, political unrest, and economic instability?

1	2	3	4	5	6	7	8	9	10

Instructions: Please rate the level of detection for each variable on a scale of 1 to 10, with 1 being the high level of detection and 10 being the can't of detection.

1. How would you rank the likelihood of detection the owner's failure to arrange adequate funds/resources?

1	2	3	4	5	6	7	8	9	10

2. How would you rank the chances of detection that the project manager is unable to assign resources in accordance with the schedule?

1	2	3	4	5	6	7	8	9	10

3. How would you rank the frequency of detection for employees who violate safety protocols, fail to follow instructions, and lack the necessary skills/training?

1	2	3	4	5	6	7	8	9	10

4. How would you rank the consultant's failure to detect potential risks/hazards in a timely manner?

1	2	3	4	5	6	7	8	9	10

5. How would you rank the chances of detection for the legal work permits being delayed and/or rejected by regulatory bodies?

1	2	3	4	5	6	7	8	9	10

6. How would you rank the likelihood of detection when a customer is failed to communicate feedbacks and/or scope changes in a timely manner?

1	2	3	4	5	6	7	8	9	10

7. How would you rank the frequency of detection for the material supplier delivering substandard/defective materials and/or failing to meet delivery deadlines?

1	2	3	4	5	6	7	8	9	10

8. How would you rate the chances of detection that the financer may delay or reject funding requests?

1	2	3	4	5	6	7	8	9	10

9. How would you rate the frequency of detection when an organization fails to address employee's grievances and they declare a strike/stop work?

1	2	3	4	5	6	7	8	9	10

10. How would you rank the likelihood of detection when an equipment supplier fails to provide necessary repair and maintenance services on time?

1	2	3	4	5	6	7	8	9	10

11. How would you rate the frequency of detection ill designs that fail to meet project specifications and compromise safety features?

1	2	3	4	5	6	7	8	9	10

12. How would you rank the chances of detection of non-synchronized process parameters and critical quality control measures?

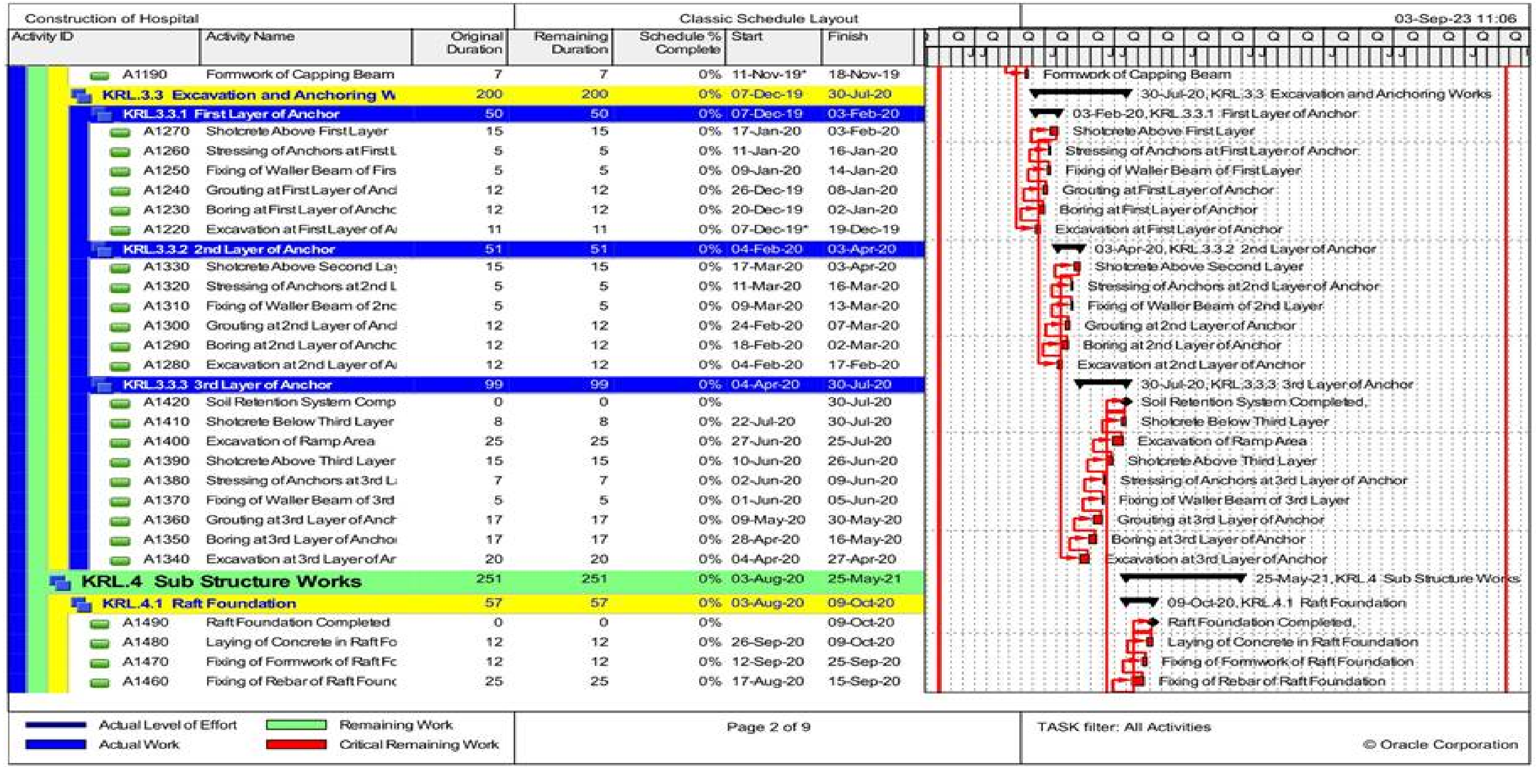
1	2	3	4	5	6	7	8	9	10

13. How would you rank the frequency of detection of events such as natural disasters, political unrest, and economic instability?

1	2	3	4	5	6	7	8	9	10

Appendix-B

Complete Baseline Schedule of the Project



Construction of Hospital | Classic Schedule Layout | 03-Sep-23 11:06

Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
A1190	Formwork of Capping Beam	7	7	0%	11-Nov-19*	18-Nov-19
KRL.3.3 Excavation and Anchoring W		200	200	0%	07-Dec-19	30-Jul-20
KRL.3.3.1 First Layer of Anchor		50	50	0%	07-Dec-19	03-Feb-20
A1270	Shotcrete Above First Layer	15	15	0%	17-Jan-20	03-Feb-20
A1260	Stressing of Anchors at First L	5	5	0%	11-Jan-20	16-Jan-20
A1250	Fixing of Waller Beam of Firs	5	5	0%	09-Jan-20	14-Jan-20
A1240	Grouting at First Layer of Anc	12	12	0%	26-Dec-19	08-Jan-20
A1230	Boring at First Layer of Anchc	12	12	0%	20-Dec-19	02-Jan-20
A1220	Excavation at First Layer of A	11	11	0%	07-Dec-19*	19-Dec-19
KRL.3.3.2 2nd Layer of Anchor		51	51	0%	04-Feb-20	03-Apr-20
A1330	Shotcrete Above Second Lay	15	15	0%	17-Mar-20	03-Apr-20
A1320	Stressing of Anchors at 2nd L	5	5	0%	11-Mar-20	16-Mar-20
A1310	Fixing of Waller Beam of 2nc	5	5	0%	09-Mar-20	13-Mar-20
A1300	Grouting at 2nd Layer of Anc	12	12	0%	24-Feb-20	07-Mar-20
A1290	Boring at 2nd Layer of Anchc	12	12	0%	18-Feb-20	02-Mar-20
A1280	Excavation at 2nd Layer of A	12	12	0%	04-Feb-20	17-Feb-20
KRL.3.3.3 3rd Layer of Anchor		99	99	0%	04-Apr-20	30-Jul-20
A1420	Soil Retention System Comp	0	0	0%		30-Jul-20
A1410	Shotcrete Below Third Layer	8	8	0%	22-Jul-20	30-Jul-20
A1400	Excavation of Ramp Area	25	25	0%	27-Jun-20	25-Jul-20
A1390	Shotcrete Above Third Layer	15	15	0%	10-Jun-20	26-Jun-20
A1380	Stressing of Anchors at 3rd L	7	7	0%	02-Jun-20	09-Jun-20
A1370	Fixing of Waller Beam of 3rd	5	5	0%	01-Jun-20	05-Jun-20
A1360	Grouting at 3rd Layer of Anch	17	17	0%	09-May-20	30-May-20
A1350	Boring at 3rd Layer of Ancho	17	17	0%	28-Apr-20	16-May-20
A1340	Excavation at 3rd Layer of Ar	20	20	0%	04-Apr-20	27-Apr-20
KRL.4 Sub Structure Works		251	251	0%	03-Aug-20	25-May-21
KRL.4.1 Raft Foundation		57	57	0%	03-Aug-20	09-Oct-20
A1490	Raft Foundation Completed	0	0	0%		09-Oct-20
A1480	Laying of Concrete in Raft Fo	12	12	0%	26-Sep-20	09-Oct-20
A1470	Fixing of Formwork of Raft Fc	12	12	0%	12-Sep-20	25-Sep-20
A1460	Fixing of Rebar of Raft Founc	25	25	0%	17-Aug-20	15-Sep-20

🟦 Actual Level of Effort	🟩 Remaining Work
🟦 Actual Work	🟥 Critical Remaining Work

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TASK filter: All Activities

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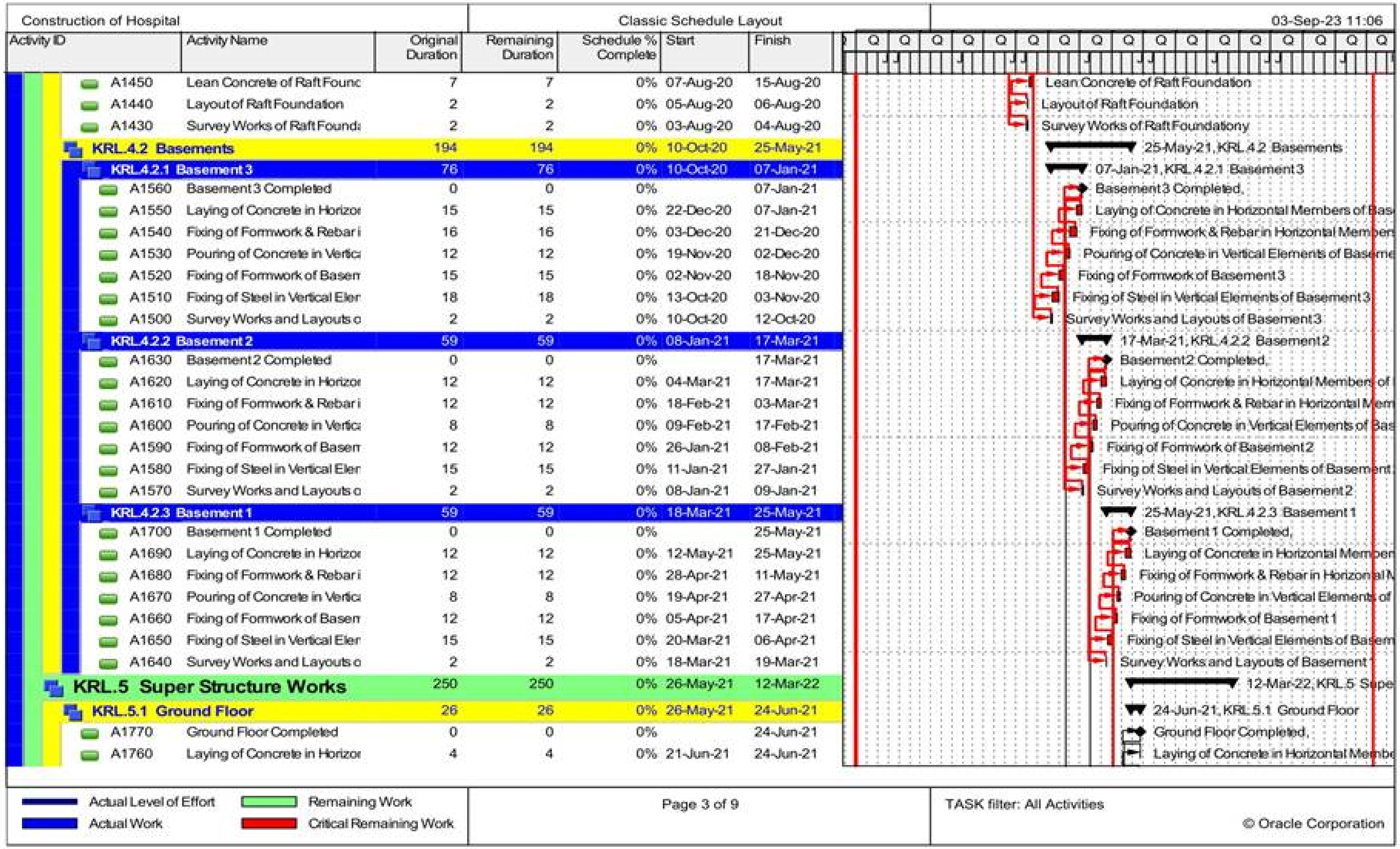

Construction of Hospital | Classic Schedule Layout | 03-Sep-23 11:06

Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
A1450	Lean Concrete of Raft Founc	7	7	0%	07-Aug-20	15-Aug-20
A1440	Layout of Raft Foundation	2	2	0%	05-Aug-20	06-Aug-20
A1430	Survey Works of Raft Founda	2	2	0%	03-Aug-20	04-Aug-20
KRL.4.2 Basements		194	194	0%	10-Oct-20	25-May-21
KRL.4.2.1 Basement 3		76	76	0%	10-Oct-20	07-Jan-21
A1560	Basement 3 Completed	0	0	0%		07-Jan-21
A1550	Laying of Concrete in Horizor	15	15	0%	22-Dec-20	07-Jan-21
A1540	Fixing of Formwork & Rebar i	16	16	0%	03-Dec-20	21-Dec-20
A1530	Pouring of Concrete in Vertica	12	12	0%	19-Nov-20	02-Dec-20
A1520	Fixing of Formwork of Basem	15	15	0%	02-Nov-20	18-Nov-20
A1510	Fixing of Steel in Vertical Eler	18	18	0%	13-Oct-20	03-Nov-20
A1500	Survey Works and Layouts o	2	2	0%	10-Oct-20	12-Oct-20
KRL.4.2.2 Basement 2		59	59	0%	08-Jan-21	17-Mar-21
A1630	Basement 2 Completed	0	0	0%		17-Mar-21
A1620	Laying of Concrete in Horizor	12	12	0%	04-Mar-21	17-Mar-21
A1610	Fixing of Formwork & Rebar i	12	12	0%	18-Feb-21	03-Mar-21
A1600	Pouring of Concrete in Vertica	8	8	0%	09-Feb-21	17-Feb-21
A1590	Fixing of Formwork of Basem	12	12	0%	26-Jan-21	08-Feb-21
A1580	Fixing of Steel in Vertical Eler	15	15	0%	11-Jan-21	27-Jan-21
A1570	Survey Works and Layouts o	2	2	0%	08-Jan-21	09-Jan-21
KRL.4.2.3 Basement 1		59	59	0%	18-Mar-21	25-May-21
A1700	Basement 1 Completed	0	0	0%		25-May-21
A1690	Laying of Concrete in Horizor	12	12	0%	12-May-21	25-May-21
A1680	Fixing of Formwork & Rebar i	12	12	0%	28-Apr-21	11-May-21
A1670	Pouring of Concrete in Vertica	8	8	0%	19-Apr-21	27-Apr-21
A1660	Fixing of Formwork of Basem	12	12	0%	05-Apr-21	17-Apr-21
A1650	Fixing of Steel in Vertical Eler	15	15	0%	20-Mar-21	06-Apr-21
A1640	Survey Works and Layouts o	2	2	0%	18-Mar-21	19-Mar-21
KRL.5 Super Structure Works		250	250	0%	26-May-21	12-Mar-22
KRL.5.1 Ground Floor		26	26	0%	26-May-21	24-Jun-21
A1770	Ground Floor Completed	0	0	0%		24-Jun-21
A1760	Laying of Concrete in Horizor	4	4	0%	21-Jun-21	24-Jun-21

▬ Actual Level of Effort	🟩 Remaining Work
▬ Actual Work	🟥 Critical Remaining Work

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TASK filter: All Activities

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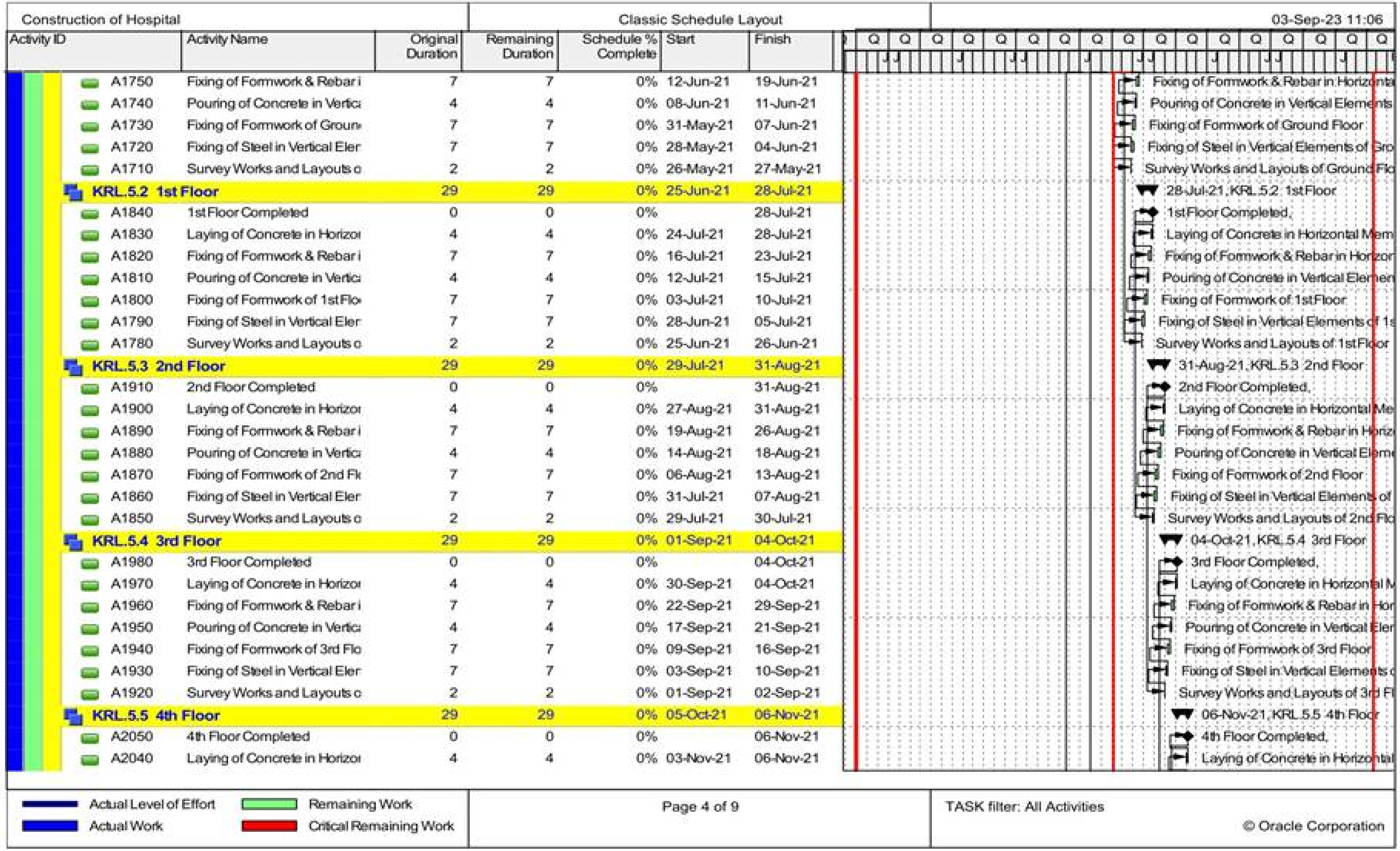

Construction of Hospital | Classic Schedule Layout | 03-Sep-23 11:06

Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
A1750	Fixing of Formwork & Rebar i	7	7	0%	12-Jun-21	19-Jun-21
A1740	Pouring of Concrete in Vertic	4	4	0%	08-Jun-21	11-Jun-21
A1730	Fixing of Formwork of Groun	7	7	0%	31-May-21	07-Jun-21
A1720	Fixing of Steel in Vertical Eler	7	7	0%	28-May-21	04-Jun-21
A1710	Survey Works and Layouts o	2	2	0%	26-May-21	27-May-21
KRL.5.2 1st Floor		**29**	**29**	**0%**	**25-Jun-21**	**28-Jul-21**
A1840	1st Floor Completed	0	0	0%		28-Jul-21
A1830	Laying of Concrete in Horizor	4	4	0%	24-Jul-21	28-Jul-21
A1820	Fixing of Formwork & Rebar i	7	7	0%	16-Jul-21	23-Jul-21
A1810	Pouring of Concrete in Vertic	4	4	0%	12-Jul-21	15-Jul-21
A1800	Fixing of Formwork of 1st Flo	7	7	0%	03-Jul-21	10-Jul-21
A1790	Fixing of Steel in Vertical Eler	7	7	0%	28-Jun-21	05-Jul-21
A1780	Survey Works and Layouts o	2	2	0%	25-Jun-21	26-Jun-21
KRL.5.3 2nd Floor		**29**	**29**	**0%**	**29-Jul-21**	**31-Aug-21**
A1910	2nd Floor Completed	0	0	0%		31-Aug-21
A1900	Laying of Concrete in Horizor	4	4	0%	27-Aug-21	31-Aug-21
A1890	Fixing of Formwork & Rebar i	7	7	0%	19-Aug-21	26-Aug-21
A1880	Pouring of Concrete in Vertic	4	4	0%	14-Aug-21	18-Aug-21
A1870	Fixing of Formwork of 2nd Fl	7	7	0%	06-Aug-21	13-Aug-21
A1860	Fixing of Steel in Vertical Eler	7	7	0%	31-Jul-21	07-Aug-21
A1850	Survey Works and Layouts o	2	2	0%	29-Jul-21	30-Jul-21
KRL.5.4 3rd Floor		**29**	**29**	**0%**	**01-Sep-21**	**04-Oct-21**
A1980	3rd Floor Completed	0	0	0%		04-Oct-21
A1970	Laying of Concrete in Horizor	4	4	0%	30-Sep-21	04-Oct-21
A1960	Fixing of Formwork & Rebar i	7	7	0%	22-Sep-21	29-Sep-21
A1950	Pouring of Concrete in Vertic	4	4	0%	17-Sep-21	21-Sep-21
A1940	Fixing of Formwork of 3rd Flo	7	7	0%	09-Sep-21	16-Sep-21
A1930	Fixing of Steel in Vertical Eler	7	7	0%	03-Sep-21	10-Sep-21
A1920	Survey Works and Layouts o	2	2	0%	01-Sep-21	02-Sep-21
KRL.5.5 4th Floor		**29**	**29**	**0%**	**05-Oct-21**	**06-Nov-21**
A2050	4th Floor Completed	0	0	0%		06-Nov-21
A2040	Laying of Concrete in Horizor	4	4	0%	03-Nov-21	06-Nov-21

Actual Level of Effort	🟩 Remaining Work
Actual Work	🟥 Critical Remaining Work

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TASK filter: All Activities

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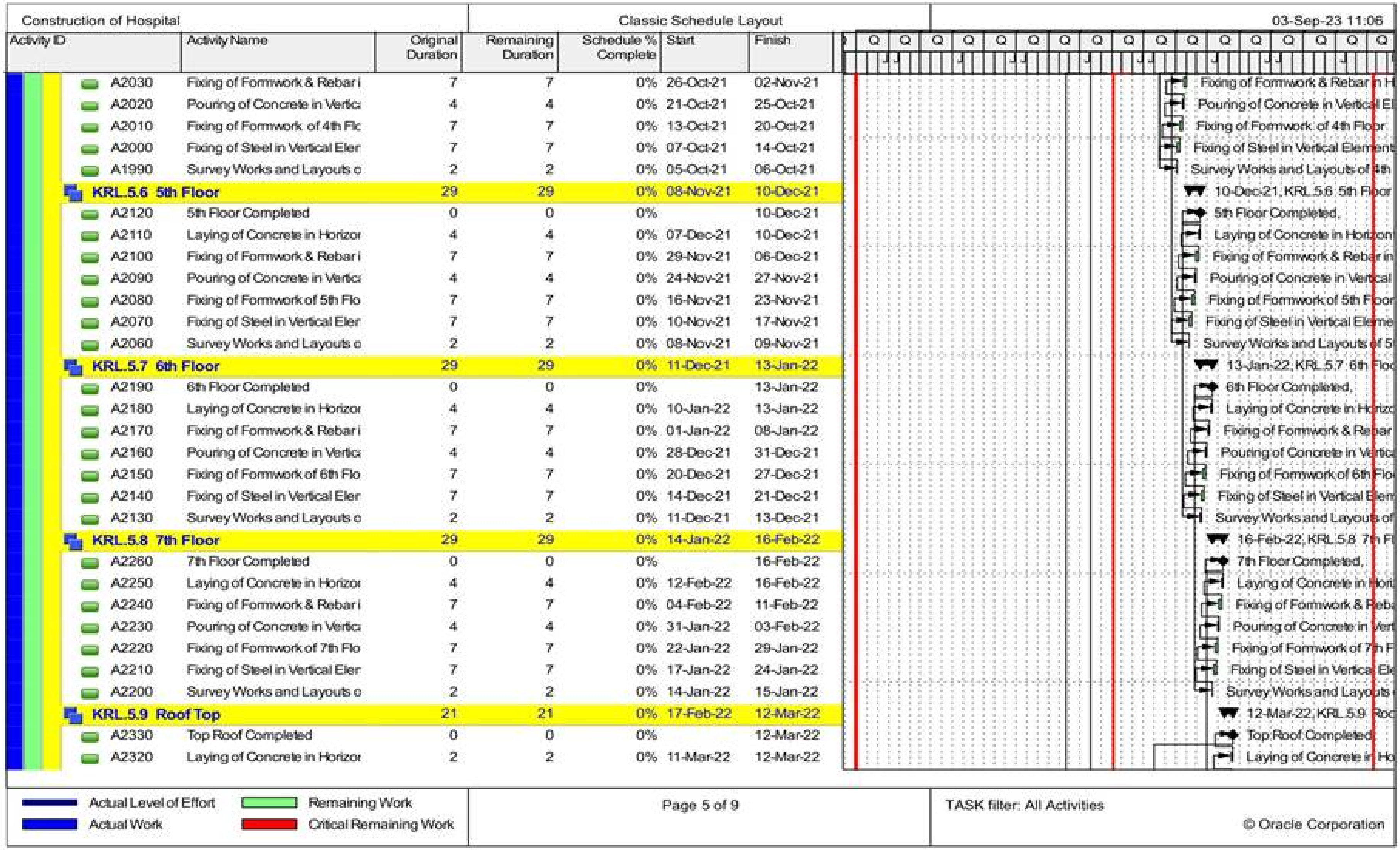

Construction of Hospital

Classic Schedule Layout

03-Sep-23 11:06

Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
A2030	Fixing of Formwork & Rebar i	7	7	0%	26-Oct-21	02-Nov-21
A2020	Pouring of Concrete in Vertic	4	4	0%	21-Oct-21	25-Oct-21
A2010	Fixing of Formwork of 4th Flc	7	7	0%	13-Oct-21	20-Oct-21
A2000	Fixing of Steel in Vertical Eler	7	7	0%	07-Oct-21	14-Oct-21
A1990	Survey Works and Layouts o	2	2	0%	05-Oct-21	06-Oct-21
KRL.5.6 5th Floor		**29**	**29**	**0%**	**08-Nov-21**	**10-Dec-21**
A2120	5th Floor Completed	0	0	0%		10-Dec-21
A2110	Laying of Concrete in Horizor	4	4	0%	07-Dec-21	10-Dec-21
A2100	Fixing of Formwork & Rebar i	7	7	0%	29-Nov-21	06-Dec-21
A2090	Pouring of Concrete in Vertic	4	4	0%	24-Nov-21	27-Nov-21
A2080	Fixing of Formwork of 5th Flo	7	7	0%	16-Nov-21	23-Nov-21
A2070	Fixing of Steel in Vertical Eler	7	7	0%	10-Nov-21	17-Nov-21
A2060	Survey Works and Layouts o	2	2	0%	08-Nov-21	09-Nov-21
KRL.5.7 6th Floor		**29**	**29**	**0%**	**11-Dec-21**	**13-Jan-22**
A2190	6th Floor Completed	0	0	0%		13-Jan-22
A2180	Laying of Concrete in Horizor	4	4	0%	10-Jan-22	13-Jan-22
A2170	Fixing of Formwork & Rebar i	7	7	0%	01-Jan-22	08-Jan-22
A2160	Pouring of Concrete in Vertic	4	4	0%	28-Dec-21	31-Dec-21
A2150	Fixing of Formwork of 6th Flo	7	7	0%	20-Dec-21	27-Dec-21
A2140	Fixing of Steel in Vertical Eler	7	7	0%	14-Dec-21	21-Dec-21
A2130	Survey Works and Layouts o	2	2	0%	11-Dec-21	13-Dec-21
KRL.5.8 7th Floor		**29**	**29**	**0%**	**14-Jan-22**	**16-Feb-22**
A2260	7th Floor Completed	0	0	0%		16-Feb-22
A2250	Laying of Concrete in Horizor	4	4	0%	12-Feb-22	16-Feb-22
A2240	Fixing of Formwork & Rebar i	7	7	0%	04-Feb-22	11-Feb-22
A2230	Pouring of Concrete in Vertic	4	4	0%	31-Jan-22	03-Feb-22
A2220	Fixing of Formwork of 7th Flo	7	7	0%	22-Jan-22	29-Jan-22
A2210	Fixing of Steel in Vertical Eler	7	7	0%	17-Jan-22	24-Jan-22
A2200	Survey Works and Layouts o	2	2	0%	14-Jan-22	15-Jan-22
KRL.5.9 Roof Top		**21**	**21**	**0%**	**17-Feb-22**	**12-Mar-22**
A2330	Top Roof Completed	0	0	0%		12-Mar-22
A2320	Laying of Concrete in Horizor	2	2	0%	11-Mar-22	12-Mar-22

Actual Level of Effort

Actual Work

Remaining Work

Critical Remaining Work

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TASK filter: All Activities

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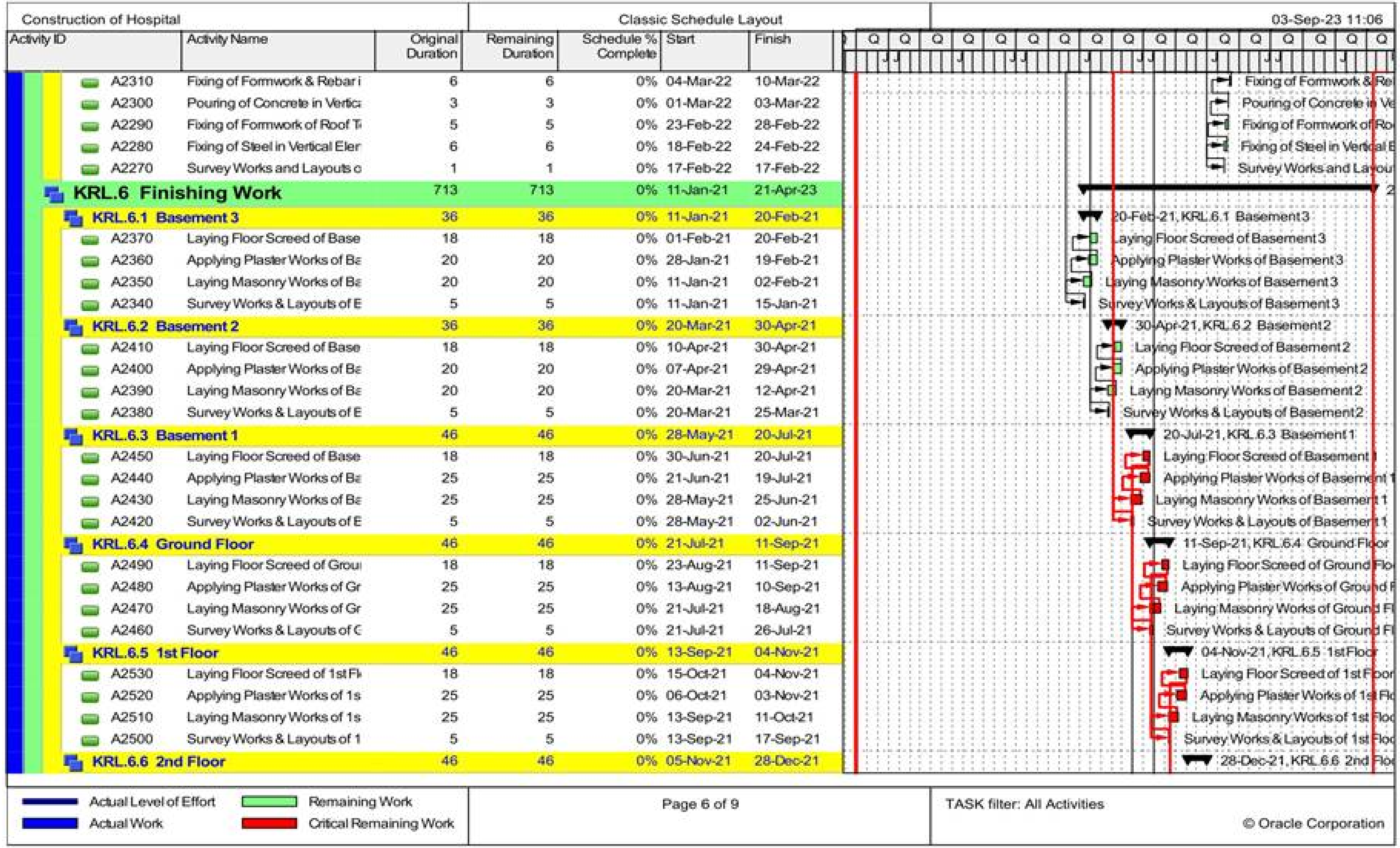

Construction of Hospital | Classic Schedule Layout | 03-Sep-23 11:06

Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
A2310	Fixing of Formwork & Rebar i	6	6	0%	04-Mar-22	10-Mar-22
A2300	Pouring of Concrete in Vertic:	3	3	0%	01-Mar-22	03-Mar-22
A2290	Fixing of Formwork of Roof T	5	5	0%	23-Feb-22	28-Feb-22
A2280	Fixing of Steel in Vertical Eler	6	6	0%	18-Feb-22	24-Feb-22
A2270	Survey Works and Layouts o	1	1	0%	17-Feb-22	17-Feb-22
KRL.6 Finishing Work		713	713	0%	11-Jan-21	21-Apr-23
KRL.6.1 Basement 3		36	36	0%	11-Jan-21	20-Feb-21
A2370	Laying Floor Screed of Base	18	18	0%	01-Feb-21	20-Feb-21
A2360	Applying Plaster Works of Ba	20	20	0%	28-Jan-21	19-Feb-21
A2350	Laying Masonry Works of Ba	20	20	0%	11-Jan-21	02-Feb-21
A2340	Survey Works & Layouts of E	5	5	0%	11-Jan-21	15-Jan-21
KRL.6.2 Basement 2		36	36	0%	20-Mar-21	30-Apr-21
A2410	Laying Floor Screed of Base	18	18	0%	10-Apr-21	30-Apr-21
A2400	Applying Plaster Works of Ba	20	20	0%	07-Apr-21	29-Apr-21
A2390	Laying Masonry Works of Ba	20	20	0%	20-Mar-21	12-Apr-21
A2380	Survey Works & Layouts of E	5	5	0%	20-Mar-21	25-Mar-21
KRL.6.3 Basement 1		46	46	0%	28-May-21	20-Jul-21
A2450	Laying Floor Screed of Base	18	18	0%	30-Jun-21	20-Jul-21
A2440	Applying Plaster Works of Ba	25	25	0%	21-Jun-21	19-Jul-21
A2430	Laying Masonry Works of Ba	25	25	0%	28-May-21	25-Jun-21
A2420	Survey Works & Layouts of E	5	5	0%	28-May-21	02-Jun-21
KRL.6.4 Ground Floor		46	46	0%	21-Jul-21	11-Sep-21
A2490	Laying Floor Screed of Grou	18	18	0%	23-Aug-21	11-Sep-21
A2480	Applying Plaster Works of Gr	25	25	0%	13-Aug-21	10-Sep-21
A2470	Laying Masonry Works of Gr	25	25	0%	21-Jul-21	18-Aug-21
A2460	Survey Works & Layouts of G	5	5	0%	21-Jul-21	26-Jul-21
KRL.6.5 1st Floor		46	46	0%	13-Sep-21	04-Nov-21
A2530	Laying Floor Screed of 1st Fl	18	18	0%	15-Oct-21	04-Nov-21
A2520	Applying Plaster Works of 1s	25	25	0%	06-Oct-21	03-Nov-21
A2510	Laying Masonry Works of 1s	25	25	0%	13-Sep-21	11-Oct-21
A2500	Survey Works & Layouts of 1	5	5	0%	13-Sep-21	17-Sep-21
KRL.6.6 2nd Floor		46	46	0%	05-Nov-21	28-Dec-21

▬	Actual Level of Effort	🟩	Remaining Work
▬	Actual Work	🟥	Critical Remaining Work

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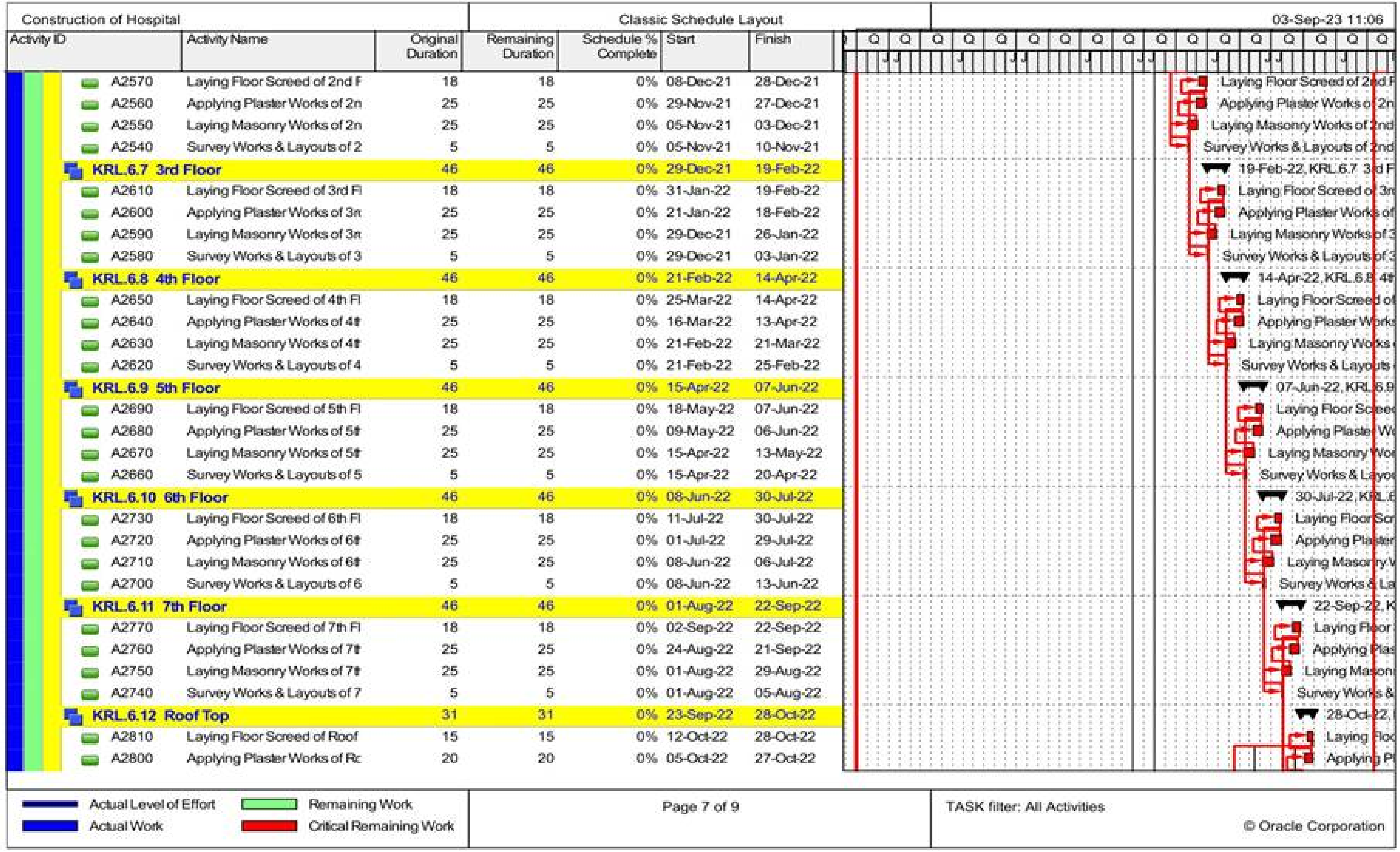

Construction of Hospital | Classic Schedule Layout | 03-Sep-23 11:06

Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
A2570	Laying Floor Screed of 2nd F	18	18	0%	08-Dec-21	28-Dec-21
A2560	Applying Plaster Works of 2n	25	25	0%	29-Nov-21	27-Dec-21
A2550	Laying Masonry Works of 2n	25	25	0%	05-Nov-21	03-Dec-21
A2540	Survey Works & Layouts of 2	5	5	0%	05-Nov-21	10-Nov-21
KRL.6.7	**3rd Floor**	46	46	0%	29-Dec-21	19-Feb-22
A2610	Laying Floor Screed of 3rd Fl	18	18	0%	31-Jan-22	19-Feb-22
A2600	Applying Plaster Works of 3r	25	25	0%	21-Jan-22	18-Feb-22
A2590	Laying Masonry Works of 3r	25	25	0%	29-Dec-21	26-Jan-22
A2580	Survey Works & Layouts of 3	5	5	0%	29-Dec-21	03-Jan-22
KRL.6.8	**4th Floor**	46	46	0%	21-Feb-22	14-Apr-22
A2650	Laying Floor Screed of 4th Fl	18	18	0%	25-Mar-22	14-Apr-22
A2640	Applying Plaster Works of 4t	25	25	0%	16-Mar-22	13-Apr-22
A2630	Laying Masonry Works of 4t	25	25	0%	21-Feb-22	21-Mar-22
A2620	Survey Works & Layouts of 4	5	5	0%	21-Feb-22	25-Feb-22
KRL.6.9	**5th Floor**	46	46	0%	15-Apr-22	07-Jun-22
A2690	Laying Floor Screed of 5th Fl	18	18	0%	18-May-22	07-Jun-22
A2680	Applying Plaster Works of 5t	25	25	0%	09-May-22	06-Jun-22
A2670	Laying Masonry Works of 5t	25	25	0%	15-Apr-22	13-May-22
A2660	Survey Works & Layouts of 5	5	5	0%	15-Apr-22	20-Apr-22
KRL.6.10	**6th Floor**	46	46	0%	08-Jun-22	30-Jul-22
A2730	Laying Floor Screed of 6th Fl	18	18	0%	11-Jul-22	30-Jul-22
A2720	Applying Plaster Works of 6t	25	25	0%	01-Jul-22	29-Jul-22
A2710	Laying Masonry Works of 6t	25	25	0%	08-Jun-22	06-Jul-22
A2700	Survey Works & Layouts of 6	5	5	0%	08-Jun-22	13-Jun-22
KRL.6.11	**7th Floor**	46	46	0%	01-Aug-22	22-Sep-22
A2770	Laying Floor Screed of 7th Fl	18	18	0%	02-Sep-22	22-Sep-22
A2760	Applying Plaster Works of 7t	25	25	0%	24-Aug-22	21-Sep-22
A2750	Laying Masonry Works of 7t	25	25	0%	01-Aug-22	29-Aug-22
A2740	Survey Works & Layouts of 7	5	5	0%	01-Aug-22	05-Aug-22
KRL.6.12	**Roof Top**	31	31	0%	23-Sep-22	28-Oct-22
A2810	Laying Floor Screed of Roof	15	15	0%	12-Oct-22	28-Oct-22
A2800	Applying Plaster Works of Rc	20	20	0%	05-Oct-22	27-Oct-22

▬	Actual Level of Effort	🟩	Remaining Work
▬	Actual Work	🟥	Critical Remaining Work

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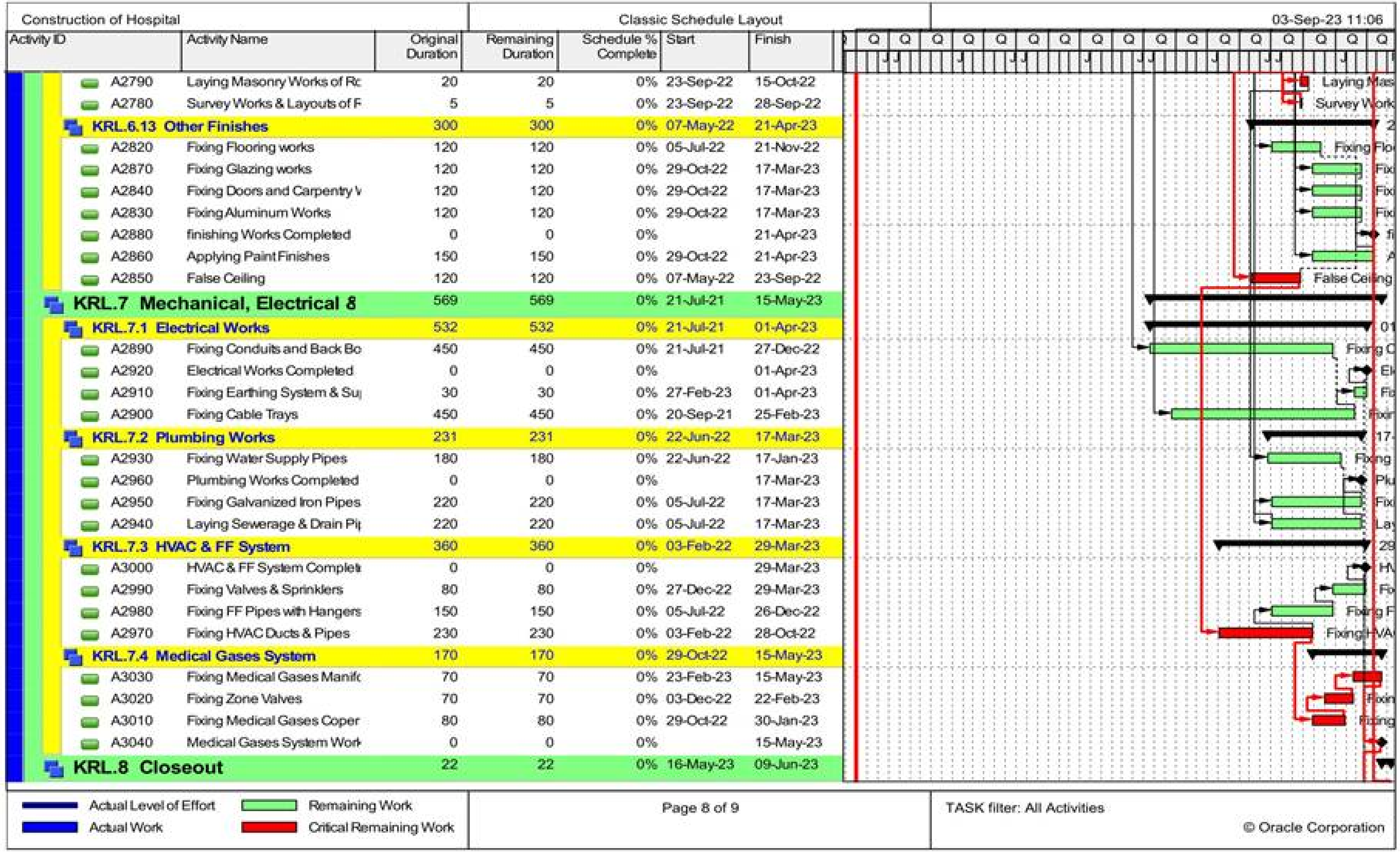

Construction of Hospital | Classic Schedule Layout | 03-Sep-23 11:06

Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
A2790	Laying Masonry Works of Rc	20	20	0%	23-Sep-22	15-Oct-22
A2780	Survey Works & Layouts of F	5	5	0%	23-Sep-22	28-Sep-22
KRL.6.13	**Other Finishes**	300	300	0%	07-May-22	21-Apr-23
A2820	Fixing Flooring works	120	120	0%	05-Jul-22	21-Nov-22
A2870	Fixing Glazing works	120	120	0%	29-Oct-22	17-Mar-23
A2840	Fixing Doors and Carpentry V	120	120	0%	29-Oct-22	17-Mar-23
A2830	Fixing Aluminum Works	120	120	0%	29-Oct-22	17-Mar-23
A2880	finishing Works Completed	0	0	0%		21-Apr-23
A2860	Applying Paint Finishes	150	150	0%	29-Oct-22	21-Apr-23
A2850	False Ceiling	120	120	0%	07-May-22	23-Sep-22
KRL.7	**Mechanical, Electrical &**	569	569	0%	21-Jul-21	15-May-23
KRL.7.1	**Electrical Works**	532	532	0%	21-Jul-21	01-Apr-23
A2890	Fixing Conduits and Back Bo	450	450	0%	21-Jul-21	27-Dec-22
A2920	Electrical Works Completed	0	0	0%		01-Apr-23
A2910	Fixing Earthing System & Su	30	30	0%	27-Feb-23	01-Apr-23
A2900	Fixing Cable Trays	450	450	0%	20-Sep-21	25-Feb-23
KRL.7.2	**Plumbing Works**	231	231	0%	22-Jun-22	17-Mar-23
A2930	Fixing Water Supply Pipes	180	180	0%	22-Jun-22	17-Jan-23
A2960	Plumbing Works Completed	0	0	0%		17-Mar-23
A2950	Fixing Galvanized Iron Pipes	220	220	0%	05-Jul-22	17-Mar-23
A2940	Laying Sewerage & Drain Pi	220	220	0%	05-Jul-22	17-Mar-23
KRL.7.3	**HVAC & FF System**	360	360	0%	03-Feb-22	29-Mar-23
A3000	HVAC & FF System Complet	0	0	0%		29-Mar-23
A2990	Fixing Valves & Sprinklers	80	80	0%	27-Dec-22	29-Mar-23
A2980	Fixing FF Pipes with Hangers	150	150	0%	05-Jul-22	26-Dec-22
A2970	Fixing HVAC Ducts & Pipes	230	230	0%	03-Feb-22	28-Oct-22
KRL.7.4	**Medical Gases System**	170	170	0%	29-Oct-22	15-May-23
A3030	Fixing Medical Gases Manifc	70	70	0%	23-Feb-23	15-May-23
A3020	Fixing Zone Valves	70	70	0%	03-Dec-22	22-Feb-23
A3010	Fixing Medical Gases Coper	80	80	0%	29-Oct-22	30-Jan-23
A3040	Medical Gases System Worl	0	0	0%		15-May-23
KRL.8	**Closeout**	22	22	0%	16-May-23	09-Jun-23

Actual Level of Effort
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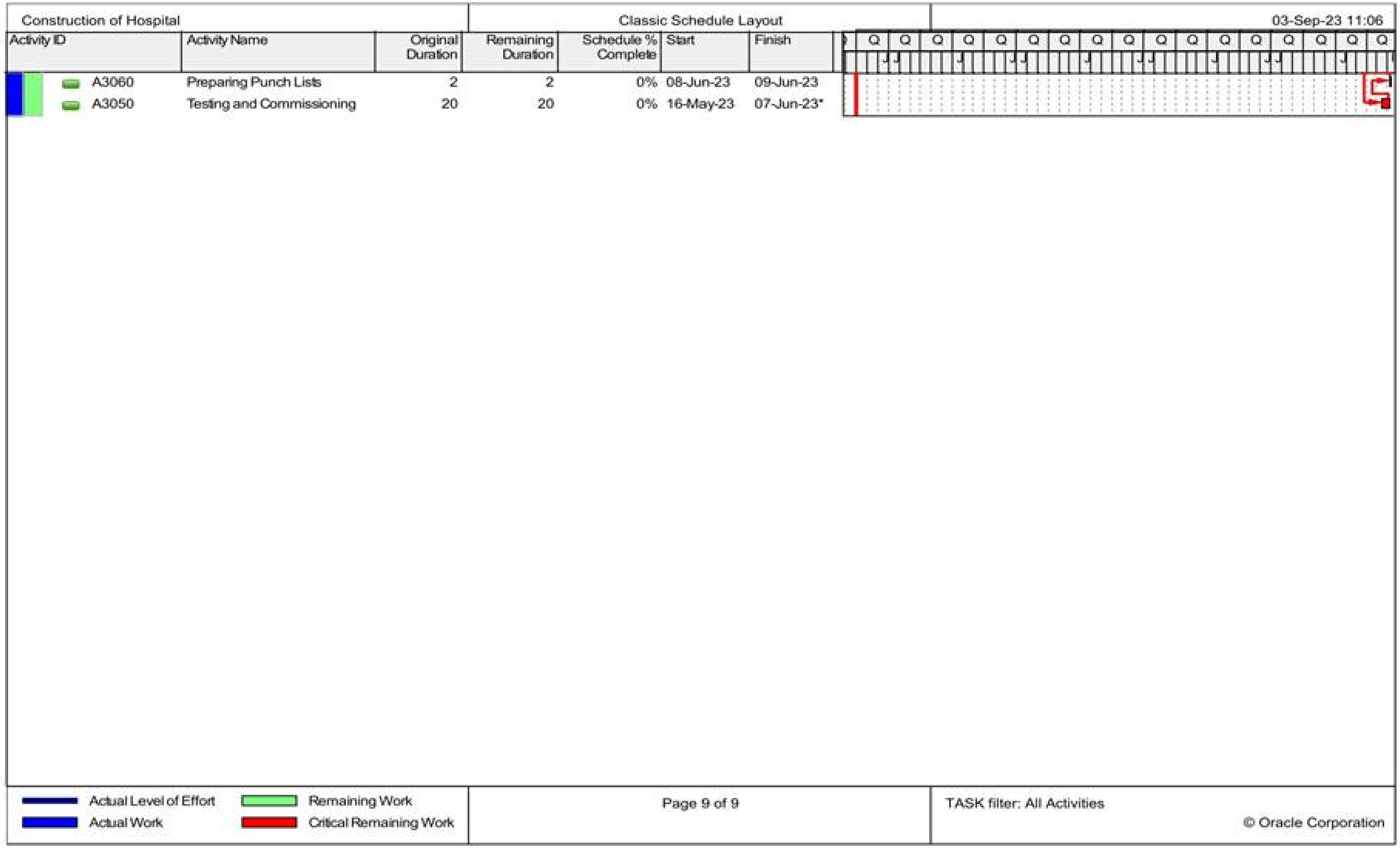

Construction of Hospital

Classic Schedule Layout

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Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
A3060	Preparing Punch Lists	2	2	0%	08-Jun-23	09-Jun-23
A3050	Testing and Commissioning	20	20	0%	16-May-23	07-Jun-23*

▬ Actual Level of Effort
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🟩 Remaining Work
🟥 Critical Remaining Work

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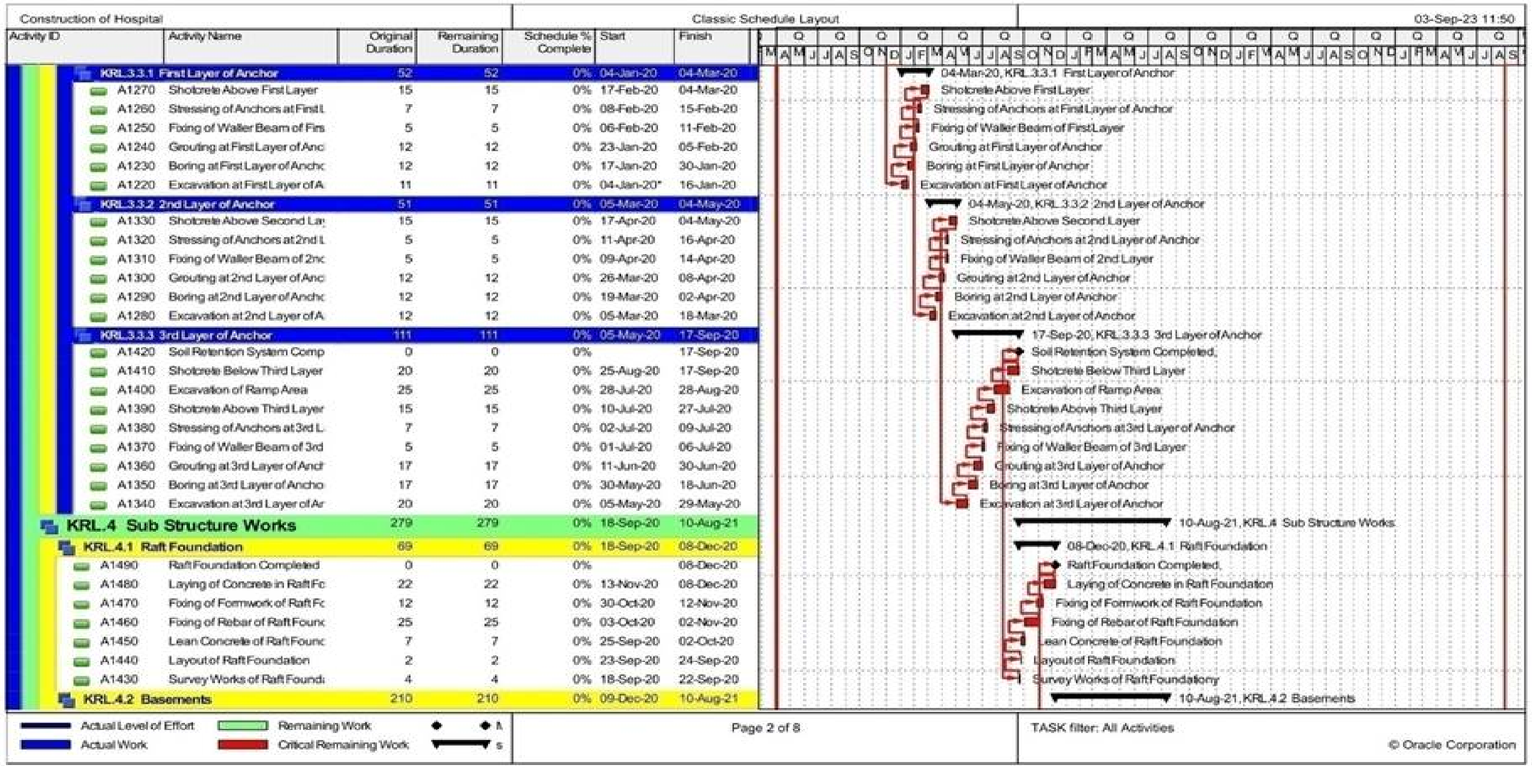
Appendix-C

Re-Scheduling of Activities Based on Method-1



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Classic Schedule Layout

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Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
KRL.3.3.1 First Layer of Anchor		52	52	0%	04-Jan-20	04-Mar-20
A1270	Shotcrete Above First Layer	15	15	0%	17-Feb-20	04-Mar-20
A1260	Stressing of Anchors at First L	7	7	0%	08-Feb-20	15-Feb-20
A1250	Fixing of Waller Beam of Firs	5	5	0%	06-Feb-20	11-Feb-20
A1240	Grouting at First Layer of Anc	12	12	0%	23-Jan-20	05-Feb-20
A1230	Boring at First Layer of Anchc	12	12	0%	17-Jan-20	30-Jan-20
A1220	Excavation at First Layer of A	11	11	0%	04-Jan-20*	16-Jan-20
KRL.3.3.2 2nd Layer of Anchor		51	51	0%	05-Mar-20	04-May-20
A1330	Shotcrete Above Second La	15	15	0%	17-Apr-20	04-May-20
A1320	Stressing of Anchors at 2nd L	5	5	0%	11-Apr-20	16-Apr-20
A1310	Fixing of Waller Beam of 2nc	5	5	0%	09-Apr-20	14-Apr-20
A1300	Grouting at 2nd Layer of Anc	12	12	0%	26-Mar-20	08-Apr-20
A1290	Boring at 2nd Layer of Anchc	12	12	0%	19-Mar-20	02-Apr-20
A1280	Excavation at 2nd Layer of A	12	12	0%	05-Mar-20	18-Mar-20
KRL.3.3.3 3rd Layer of Anchor		111	111	0%	05-May-20	17-Sep-20
A1420	Soil Retention System Comp	0	0	0%		17-Sep-20
A1410	Shotcrete Below Third Layer	20	20	0%	25-Aug-20	17-Sep-20
A1400	Excavation of Ramp Area	25	25	0%	28-Jul-20	28-Aug-20
A1390	Shotcrete Above Third Layer	15	15	0%	10-Jul-20	27-Jul-20
A1380	Stressing of Anchors at 3rd L	7	7	0%	02-Jul-20	09-Jul-20
A1370	Fixing of Waller Beam of 3rd	5	5	0%	01-Jul-20	06-Jul-20
A1360	Grouting at 3rd Layer of Anch	17	17	0%	11-Jun-20	30-Jun-20
A1350	Boring at 3rd Layer of Ancho	17	17	0%	30-May-20	18-Jun-20
A1340	Excavation at 3rd Layer of Ar	20	20	0%	05-May-20	29-May-20
KRL.4 Sub Structure Works		279	279	0%	18-Sep-20	10-Aug-21
KRL.4.1 Raft Foundation		69	69	0%	18-Sep-20	08-Dec-20
A1490	Raft Foundation Completed	0	0	0%		08-Dec-20
A1480	Laying of Concrete in Raft Fc	22	22	0%	13-Nov-20	08-Dec-20
A1470	Fixing of Formwork of Raft Fc	12	12	0%	30-Oct-20	12-Nov-20
A1460	Fixing of Rebar of Raft Founc	25	25	0%	03-Oct-20	02-Nov-20
A1450	Lean Concrete of Raft Founc	7	7	0%	25-Sep-20	02-Oct-20
A1440	Layout of Raft Foundation	2	2	0%	23-Sep-20	24-Sep-20
A1430	Survey Works of Raft Found	4	4	0%	18-Sep-20	22-Sep-20
KRL.4.2 Basements		210	210	0%	09-Dec-20	10-Aug-21

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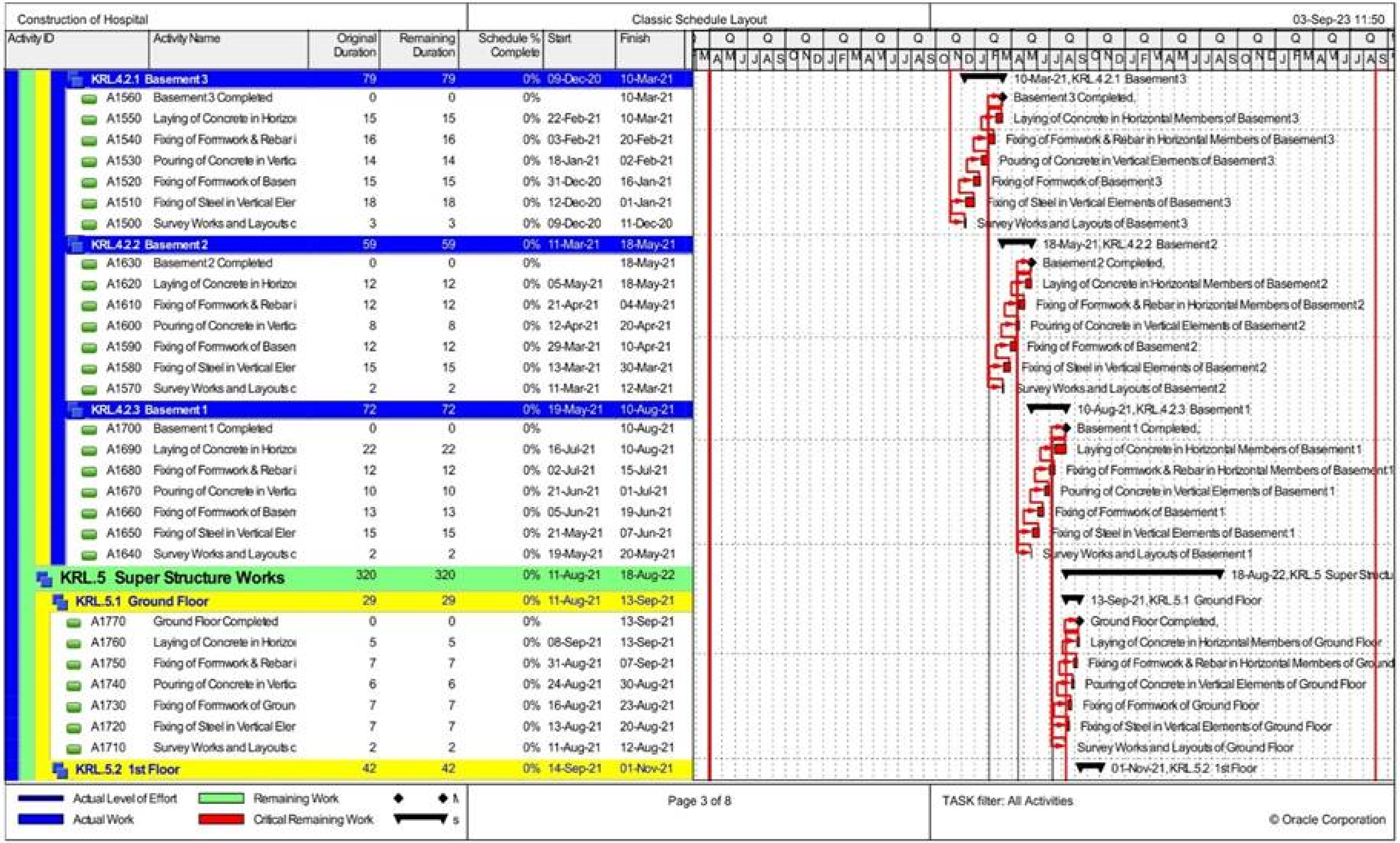

Construction of Hospital

Classic Schedule Layout

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Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
KRL.4.2.1	Basement 3	79	79	0%	09-Dec-20	10-Mar-21
A1560	Basement 3 Completed	0	0	0%		10-Mar-21
A1550	Laying of Concrete in Horizo	15	15	0%	22-Feb-21	10-Mar-21
A1540	Fixing of Formwork & Rebar i	16	16	0%	03-Feb-21	20-Feb-21
A1530	Pouring of Concrete in Vertic	14	14	0%	18-Jan-21	02-Feb-21
A1520	Fixing of Formwork of Basen	15	15	0%	31-Dec-20	16-Jan-21
A1510	Fixing of Steel in Vertical Eler	18	18	0%	12-Dec-20	01-Jan-21
A1500	Survey Works and Layouts c	3	3	0%	09-Dec-20	11-Dec-20
KRL.4.2.2	Basement 2	59	59	0%	11-Mar-21	18-May-21
A1630	Basement 2 Completed	0	0	0%		18-May-21
A1620	Laying of Concrete in Horizo	12	12	0%	05-May-21	18-May-21
A1610	Fixing of Formwork & Rebar i	12	12	0%	21-Apr-21	04-May-21
A1600	Pouring of Concrete in Vertic	8	8	0%	12-Apr-21	20-Apr-21
A1590	Fixing of Formwork of Basen	12	12	0%	29-Mar-21	10-Apr-21
A1580	Fixing of Steel in Vertical Eler	15	15	0%	13-Mar-21	30-Mar-21
A1570	Survey Works and Layouts c	2	2	0%	11-Mar-21	12-Mar-21
KRL.4.2.3	Basement 1	72	72	0%	19-May-21	10-Aug-21
A1700	Basement 1 Completed	0	0	0%		10-Aug-21
A1690	Laying of Concrete in Horizo	22	22	0%	16-Jul-21	10-Aug-21
A1680	Fixing of Formwork & Rebar i	12	12	0%	02-Jul-21	15-Jul-21
A1670	Pouring of Concrete in Vertic	10	10	0%	21-Jun-21	01-Jul-21
A1660	Fixing of Formwork of Basen	13	13	0%	05-Jun-21	19-Jun-21
A1650	Fixing of Steel in Vertical Eler	15	15	0%	21-May-21	07-Jun-21
A1640	Survey Works and Layouts c	2	2	0%	19-May-21	20-May-21
KRL.5	**Super Structure Works**	320	320	0%	11-Aug-21	18-Aug-22
KRL.5.1	**Ground Floor**	29	29	0%	11-Aug-21	13-Sep-21
A1770	Ground Floor Completed	0	0	0%		13-Sep-21
A1760	Laying of Concrete in Horizo	5	5	0%	08-Sep-21	13-Sep-21
A1750	Fixing of Formwork & Rebar i	7	7	0%	31-Aug-21	07-Sep-21
A1740	Pouring of Concrete in Vertic	6	6	0%	24-Aug-21	30-Aug-21
A1730	Fixing of Formwork of Groun	7	7	0%	16-Aug-21	23-Aug-21
A1720	Fixing of Steel in Vertical Eler	7	7	0%	13-Aug-21	20-Aug-21
A1710	Survey Works and Layouts c	2	2	0%	11-Aug-21	12-Aug-21
KRL.5.2	**1st Floor**	42	42	0%	14-Sep-21	01-Nov-21

Actual Level of Effort
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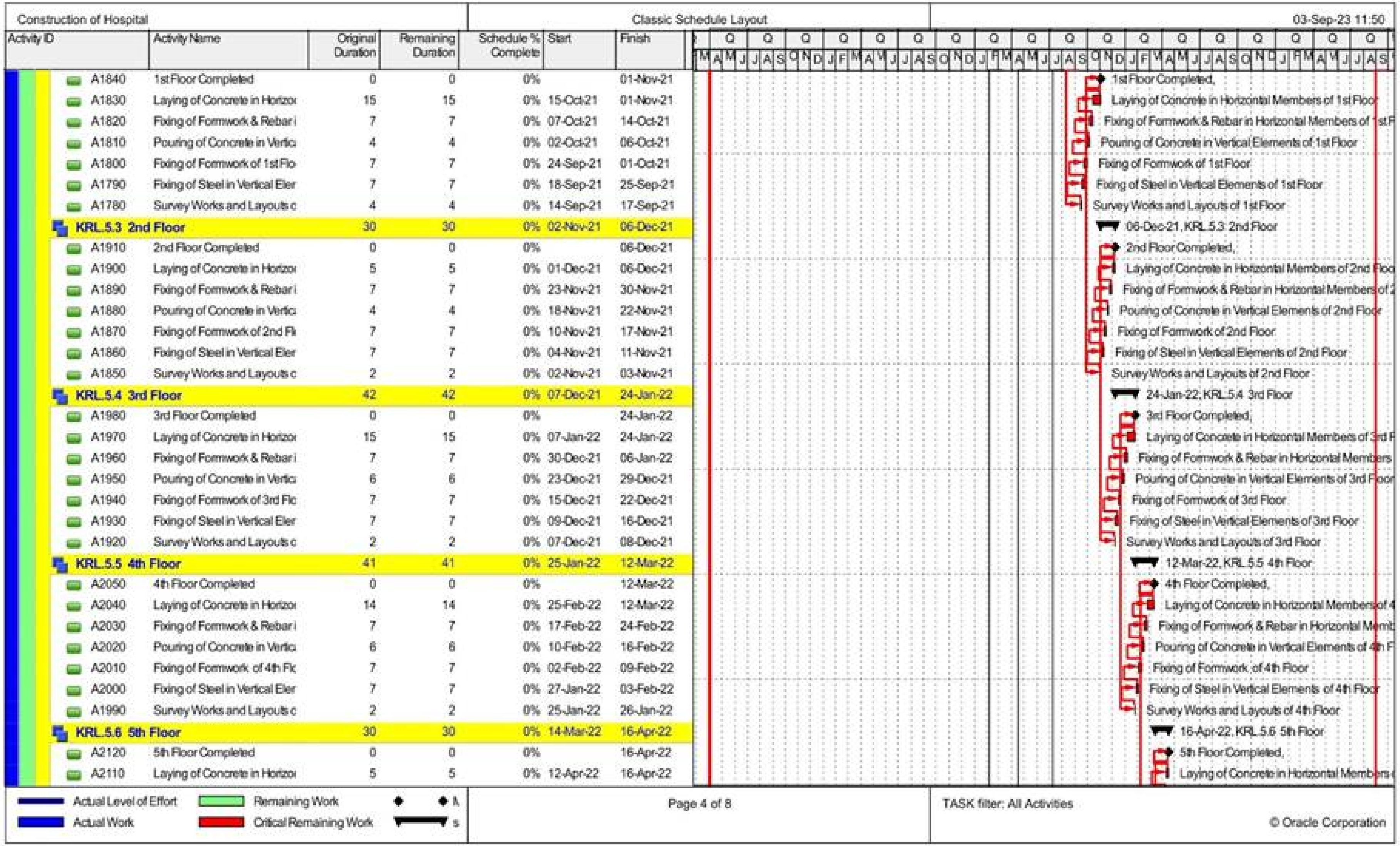

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Classic Schedule Layout

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Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
A1840	1st Floor Completed	0	0	0%		01-Nov-21
A1830	Laying of Concrete in Horizo	15	15	0%	15-Oct-21	01-Nov-21
A1820	Fixing of Formwork & Rebar i	7	7	0%	07-Oct-21	14-Oct-21
A1810	Pouring of Concrete in Vertic	4	4	0%	02-Oct-21	06-Oct-21
A1800	Fixing of Formwork of 1st Flo	7	7	0%	24-Sep-21	01-Oct-21
A1790	Fixing of Steel in Vertical Eler	7	7	0%	18-Sep-21	25-Sep-21
A1780	Survey Works and Layouts c	4	4	0%	14-Sep-21	17-Sep-21
KRL.5.3 2nd Floor		30	30	0%	02-Nov-21	06-Dec-21
A1910	2nd Floor Completed	0	0	0%		06-Dec-21
A1900	Laying of Concrete in Horizo	5	5	0%	01-Dec-21	06-Dec-21
A1890	Fixing of Formwork & Rebar i	7	7	0%	23-Nov-21	30-Nov-21
A1880	Pouring of Concrete in Vertic	4	4	0%	18-Nov-21	22-Nov-21
A1870	Fixing of Formwork of 2nd Fl	7	7	0%	10-Nov-21	17-Nov-21
A1860	Fixing of Steel in Vertical Eler	7	7	0%	04-Nov-21	11-Nov-21
A1850	Survey Works and Layouts c	2	2	0%	02-Nov-21	03-Nov-21
KRL.5.4 3rd Floor		42	42	0%	07-Dec-21	24-Jan-22
A1980	3rd Floor Completed	0	0	0%		24-Jan-22
A1970	Laying of Concrete in Horizo	15	15	0%	07-Jan-22	24-Jan-22
A1960	Fixing of Formwork & Rebar i	7	7	0%	30-Dec-21	06-Jan-22
A1950	Pouring of Concrete in Vertic	6	6	0%	23-Dec-21	29-Dec-21
A1940	Fixing of Formwork of 3rd Flo	7	7	0%	15-Dec-21	22-Dec-21
A1930	Fixing of Steel in Vertical Eler	7	7	0%	09-Dec-21	16-Dec-21
A1920	Survey Works and Layouts c	2	2	0%	07-Dec-21	08-Dec-21
KRL.5.5 4th Floor		41	41	0%	25-Jan-22	12-Mar-22
A2050	4th Floor Completed	0	0	0%		12-Mar-22
A2040	Laying of Concrete in Horizo	14	14	0%	25-Feb-22	12-Mar-22
A2030	Fixing of Formwork & Rebar i	7	7	0%	17-Feb-22	24-Feb-22
A2020	Pouring of Concrete in Vertic	6	6	0%	10-Feb-22	16-Feb-22
A2010	Fixing of Formwork of 4th Fl	7	7	0%	02-Feb-22	09-Feb-22
A2000	Fixing of Steel in Vertical Eler	7	7	0%	27-Jan-22	03-Feb-22
A1990	Survey Works and Layouts c	2	2	0%	25-Jan-22	26-Jan-22
KRL.5.6 5th Floor		30	30	0%	14-Mar-22	16-Apr-22
A2120	5th Floor Completed	0	0	0%		16-Apr-22
A2110	Laying of Concrete in Horizo	5	5	0%	12-Apr-22	16-Apr-22

Actual Level of Effort
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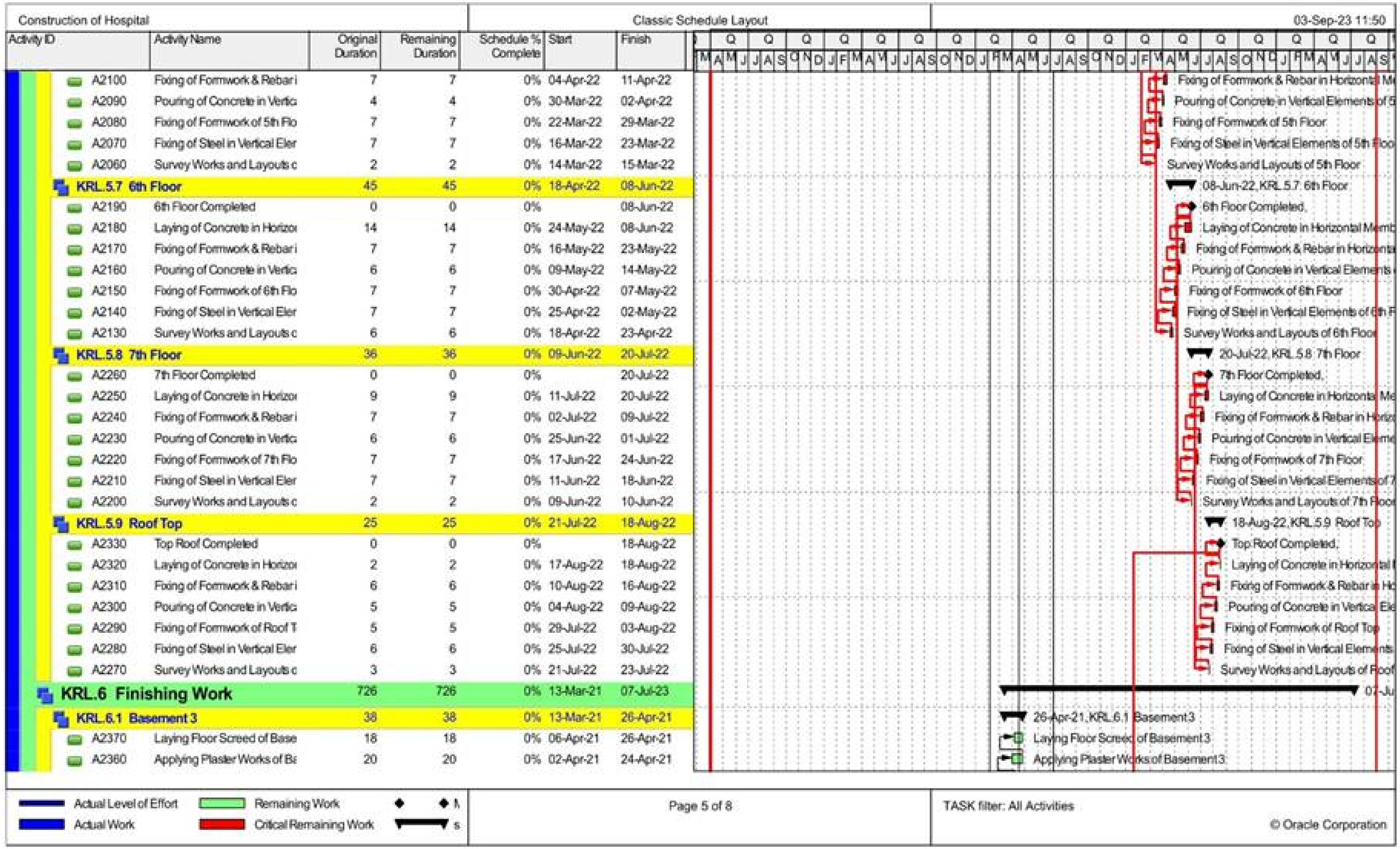

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Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
A2100	Fixing of Formwork & Rebar i	7	7	0%	04-Apr-22	11-Apr-22
A2090	Pouring of Concrete in Vertic	4	4	0%	30-Mar-22	02-Apr-22
A2080	Fixing of Formwork of 5th Flo	7	7	0%	22-Mar-22	29-Mar-22
A2070	Fixing of Steel in Vertical Eler	7	7	0%	16-Mar-22	23-Mar-22
A2060	Survey Works and Layouts c	2	2	0%	14-Mar-22	15-Mar-22
KRL.5.7 6th Floor		45	45	0%	18-Apr-22	08-Jun-22
A2190	6th Floor Completed	0	0	0%		08-Jun-22
A2180	Laying of Concrete in Horizor	14	14	0%	24-May-22	08-Jun-22
A2170	Fixing of Formwork & Rebar i	7	7	0%	16-May-22	23-May-22
A2160	Pouring of Concrete in Vertic	6	6	0%	09-May-22	14-May-22
A2150	Fixing of Formwork of 6th Flo	7	7	0%	30-Apr-22	07-May-22
A2140	Fixing of Steel in Vertical Eler	7	7	0%	25-Apr-22	02-May-22
A2130	Survey Works and Layouts c	6	6	0%	18-Apr-22	23-Apr-22
KRL.5.8 7th Floor		36	36	0%	09-Jun-22	20-Jul-22
A2260	7th Floor Completed	0	0	0%		20-Jul-22
A2250	Laying of Concrete in Horizor	9	9	0%	11-Jul-22	20-Jul-22
A2240	Fixing of Formwork & Rebar i	7	7	0%	02-Jul-22	09-Jul-22
A2230	Pouring of Concrete in Vertic	6	6	0%	25-Jun-22	01-Jul-22
A2220	Fixing of Formwork of 7th Flo	7	7	0%	17-Jun-22	24-Jun-22
A2210	Fixing of Steel in Vertical Eler	7	7	0%	11-Jun-22	18-Jun-22
A2200	Survey Works and Layouts c	2	2	0%	09-Jun-22	10-Jun-22
KRL.5.9 Roof Top		25	25	0%	21-Jul-22	18-Aug-22
A2330	Top Roof Completed	0	0	0%		18-Aug-22
A2320	Laying of Concrete in Horizor	2	2	0%	17-Aug-22	18-Aug-22
A2310	Fixing of Formwork & Rebar i	6	6	0%	10-Aug-22	16-Aug-22
A2300	Pouring of Concrete in Vertic	5	5	0%	04-Aug-22	09-Aug-22
A2290	Fixing of Formwork of Roof T	5	5	0%	29-Jul-22	03-Aug-22
A2280	Fixing of Steel in Vertical Eler	6	6	0%	25-Jul-22	30-Jul-22
A2270	Survey Works and Layouts c	3	3	0%	21-Jul-22	23-Jul-22
KRL.6 Finishing Work		726	726	0%	13-Mar-21	07-Jul-23
KRL.6.1 Basement 3		38	38	0%	13-Mar-21	26-Apr-21
A2370	Laying Floor Screed of Base	18	18	0%	06-Apr-21	26-Apr-21
A2360	Applying Plaster Works of Ba	20	20	0%	02-Apr-21	24-Apr-21

Actual Level of Effort | Remaining Work | ◆ ◆ M
Actual Work | Critical Remaining Work | s

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TASK filter: All Activities

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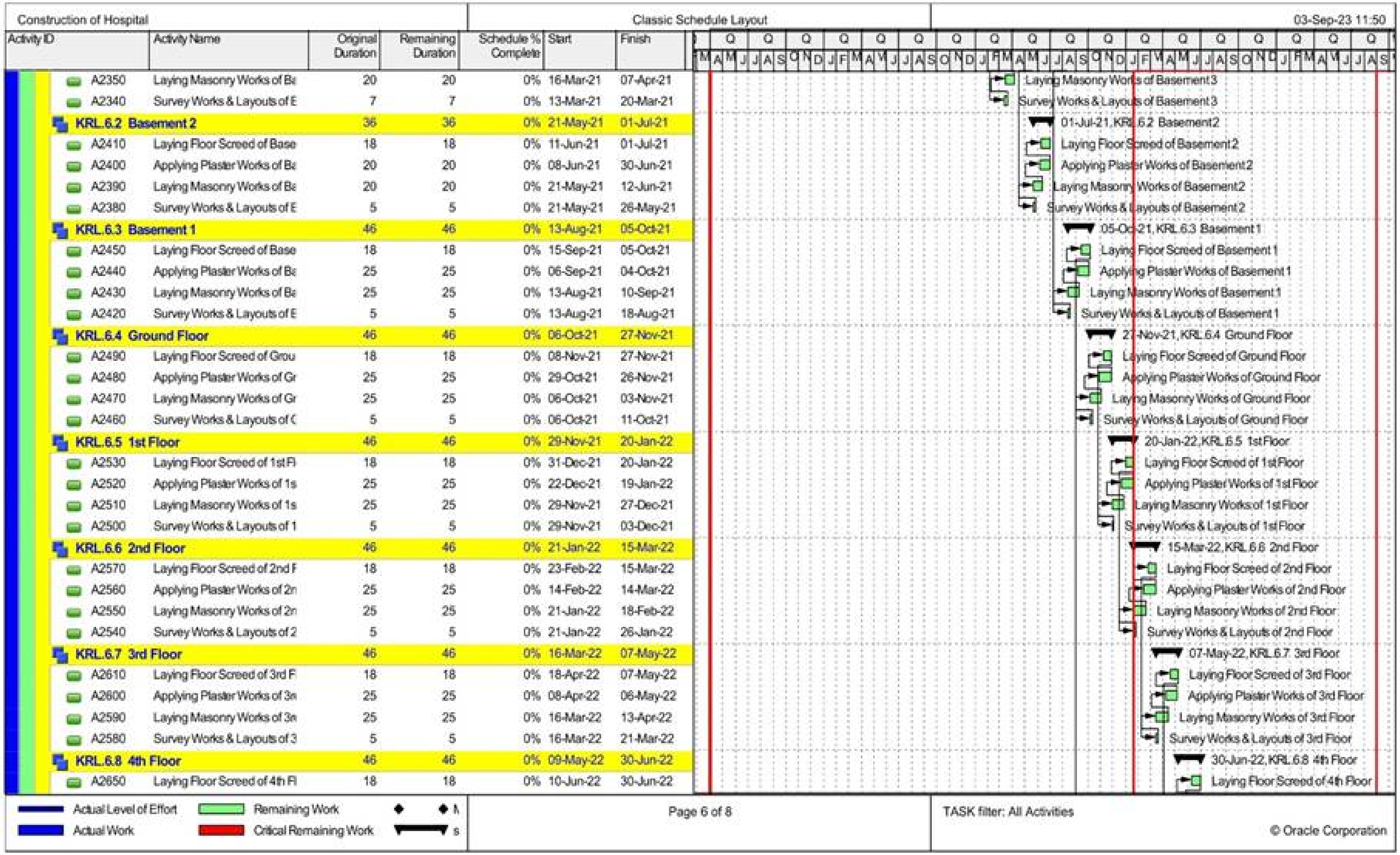

Construction of Hospital | Classic Schedule Layout | 03-Sep-23 11:50

Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
A2350	Laying Masonry Works of Ba	20	20	0%	16-Mar-21	07-Apr-21
A2340	Survey Works & Layouts of E	7	7	0%	13-Mar-21	20-Mar-21
KRL.6.2 Basement 2		36	36	0%	21-May-21	01-Jul-21
A2410	Laying Floor Screed of Base	18	18	0%	11-Jun-21	01-Jul-21
A2400	Applying Plaster Works of Ba	20	20	0%	08-Jun-21	30-Jun-21
A2390	Laying Masonry Works of Ba	20	20	0%	21-May-21	12-Jun-21
A2380	Survey Works & Layouts of E	5	5	0%	21-May-21	26-May-21
KRL.6.3 Basement 1		46	46	0%	13-Aug-21	05-Oct-21
A2450	Laying Floor Screed of Base	18	18	0%	15-Sep-21	05-Oct-21
A2440	Applying Plaster Works of Ba	25	25	0%	06-Sep-21	04-Oct-21
A2430	Laying Masonry Works of Ba	25	25	0%	13-Aug-21	10-Sep-21
A2420	Survey Works & Layouts of E	5	5	0%	13-Aug-21	18-Aug-21
KRL.6.4 Ground Floor		46	46	0%	06-Oct-21	27-Nov-21
A2490	Laying Floor Screed of Grou	18	18	0%	08-Nov-21	27-Nov-21
A2480	Applying Plaster Works of Gr	25	25	0%	29-Oct-21	26-Nov-21
A2470	Laying Masonry Works of Gr	25	25	0%	06-Oct-21	03-Nov-21
A2460	Survey Works & Layouts of (	5	5	0%	06-Oct-21	11-Oct-21
KRL.6.5 1st Floor		46	46	0%	29-Nov-21	20-Jan-22
A2530	Laying Floor Screed of 1st Fl	18	18	0%	31-Dec-21	20-Jan-22
A2520	Applying Plaster Works of 1s	25	25	0%	22-Dec-21	19-Jan-22
A2510	Laying Masonry Works of 1s	25	25	0%	29-Nov-21	27-Dec-21
A2500	Survey Works & Layouts of 1	5	5	0%	29-Nov-21	03-Dec-21
KRL.6.6 2nd Floor		46	46	0%	21-Jan-22	15-Mar-22
A2570	Laying Floor Screed of 2nd F	18	18	0%	23-Feb-22	15-Mar-22
A2560	Applying Plaster Works of 2n	25	25	0%	14-Feb-22	14-Mar-22
A2550	Laying Masonry Works of 2n	25	25	0%	21-Jan-22	18-Feb-22
A2540	Survey Works & Layouts of 2	5	5	0%	21-Jan-22	26-Jan-22
KRL.6.7 3rd Floor		46	46	0%	16-Mar-22	07-May-22
A2610	Laying Floor Screed of 3rd F	18	18	0%	18-Apr-22	07-May-22
A2600	Applying Plaster Works of 3r	25	25	0%	08-Apr-22	06-May-22
A2590	Laying Masonry Works of 3r	25	25	0%	16-Mar-22	13-Apr-22
A2580	Survey Works & Layouts of 3	5	5	0%	16-Mar-22	21-Mar-22
KRL.6.8 4th Floor		46	46	0%	09-May-22	30-Jun-22
A2650	Laying Floor Screed of 4th Fl	18	18	0%	10-Jun-22	30-Jun-22

Actual Level of Effort
Actual Work
Remaining Work
Critical Remaining Work

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TASK filter: All Activities

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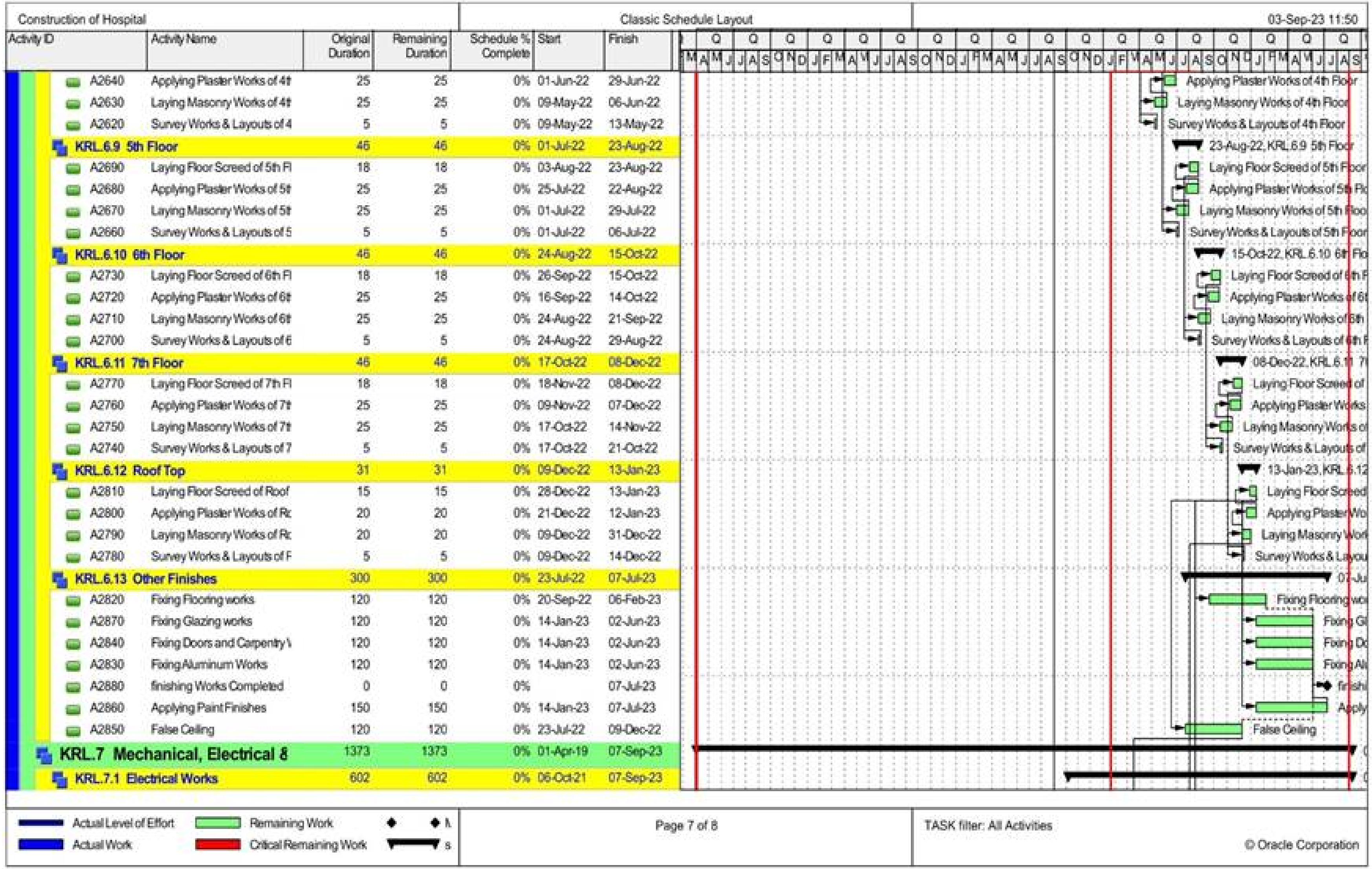

Construction of Hospital | Classic Schedule Layout | 03-Sep-23 11:50

Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
A2640	Applying Plaster Works of 4t	25	25	0%	01-Jun-22	29-Jun-22
A2630	Laying Masonry Works of 4t	25	25	0%	09-May-22	06-Jun-22
A2620	Survey Works & Layouts of 4	5	5	0%	09-May-22	13-May-22
KRL.6.9 5th Floor		46	46	0%	01-Jul-22	23-Aug-22
A2690	Laying Floor Screed of 5th Fl	18	18	0%	03-Aug-22	23-Aug-22
A2680	Applying Plaster Works of 5t	25	25	0%	25-Jul-22	22-Aug-22
A2670	Laying Masonry Works of 5t	25	25	0%	01-Jul-22	29-Jul-22
A2660	Survey Works & Layouts of 5	5	5	0%	01-Jul-22	06-Jul-22
KRL.6.10 6th Floor		46	46	0%	24-Aug-22	15-Oct-22
A2730	Laying Floor Screed of 6th Fl	18	18	0%	26-Sep-22	15-Oct-22
A2720	Applying Plaster Works of 6t	25	25	0%	16-Sep-22	14-Oct-22
A2710	Laying Masonry Works of 6t	25	25	0%	24-Aug-22	21-Sep-22
A2700	Survey Works & Layouts of 6	5	5	0%	24-Aug-22	29-Aug-22
KRL.6.11 7th Floor		46	46	0%	17-Oct-22	08-Dec-22
A2770	Laying Floor Screed of 7th Fl	18	18	0%	18-Nov-22	08-Dec-22
A2760	Applying Plaster Works of 7t	25	25	0%	09-Nov-22	07-Dec-22
A2750	Laying Masonry Works of 7t	25	25	0%	17-Oct-22	14-Nov-22
A2740	Survey Works & Layouts of 7	5	5	0%	17-Oct-22	21-Oct-22
KRL.6.12 Roof Top		31	31	0%	09-Dec-22	13-Jan-23
A2810	Laying Floor Screed of Roof	15	15	0%	28-Dec-22	13-Jan-23
A2800	Applying Plaster Works of Ro	20	20	0%	21-Dec-22	12-Jan-23
A2790	Laying Masonry Works of Ro	20	20	0%	09-Dec-22	31-Dec-22
A2780	Survey Works & Layouts of F	5	5	0%	09-Dec-22	14-Dec-22
KRL.6.13 Other Finishes		300	300	0%	23-Jul-22	07-Jul-23
A2820	Fixing Flooring works	120	120	0%	20-Sep-22	06-Feb-23
A2870	Fixing Glazing works	120	120	0%	14-Jan-23	02-Jun-23
A2840	Fixing Doors and Carpentry \	120	120	0%	14-Jan-23	02-Jun-23
A2830	Fixing Aluminum Works	120	120	0%	14-Jan-23	02-Jun-23
A2880	finishing Works Completed	0	0	0%		07-Jul-23
A2860	Applying Paint Finishes	150	150	0%	14-Jan-23	07-Jul-23
A2850	False Ceiling	120	120	0%	23-Jul-22	09-Dec-22
KRL.7 Mechanical, Electrical 8		1373	1373	0%	01-Apr-19	07-Sep-23
KRL.7.1 Electrical Works		602	602	0%	06-Oct-21	07-Sep-23

Actual Level of Effort | Remaining Work
Actual Work | Critical Remaining Work

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TASK filter: All Activities

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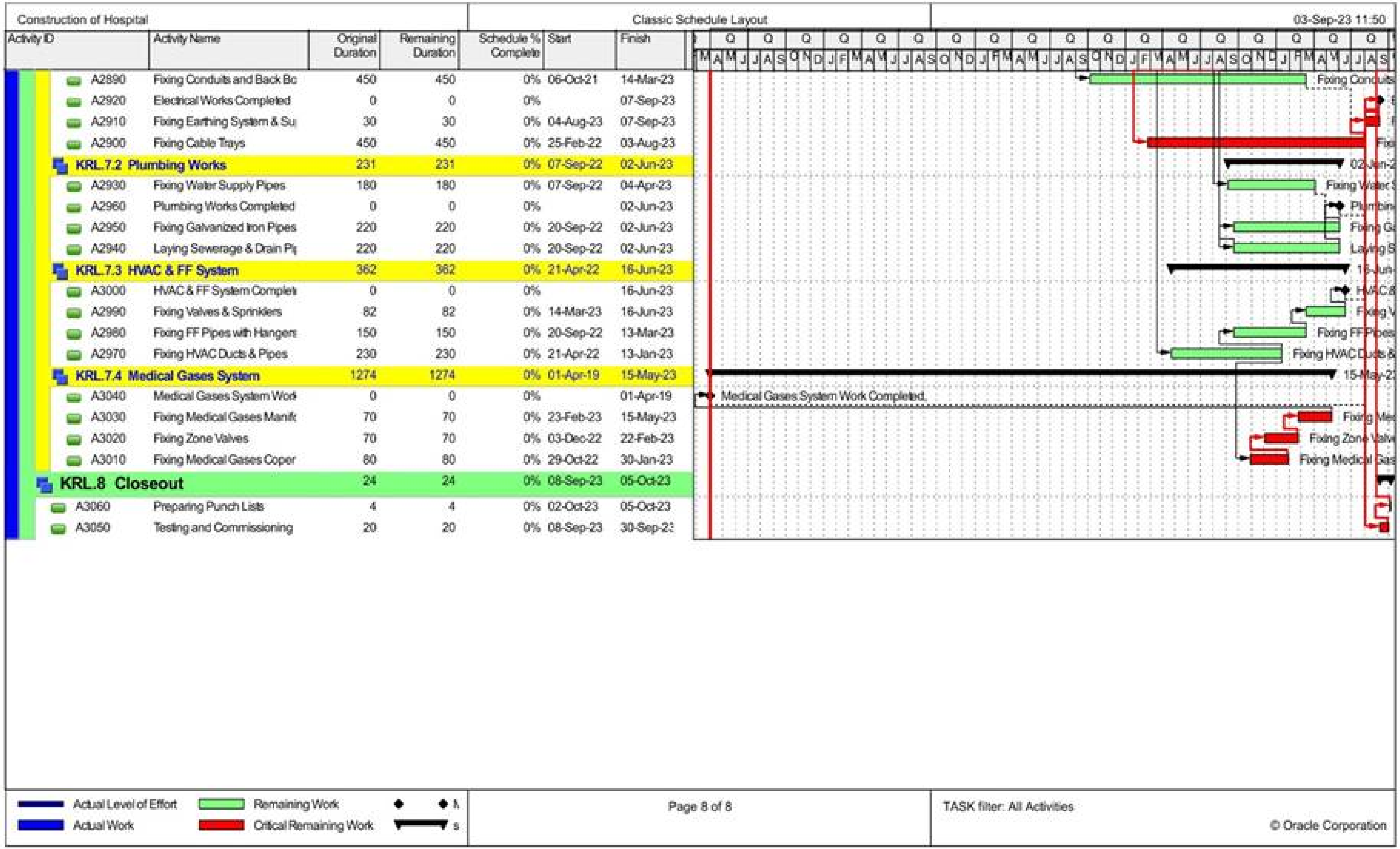

Construction of Hospital | Classic Schedule Layout | 03-Sep-23 11:50

Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
A2890	Fixing Conduits and Back Bo	450	450	0%	06-Oct-21	14-Mar-23
A2920	Electrical Works Completed	0	0	0%		07-Sep-23
A2910	Fixing Earthing System & Su	30	30	0%	04-Aug-23	07-Sep-23
A2900	Fixing Cable Trays	450	450	0%	25-Feb-22	03-Aug-23
KRL.7.2 Plumbing Works		231	231	0%	07-Sep-22	02-Jun-23
A2930	Fixing Water Supply Pipes	180	180	0%	07-Sep-22	04-Apr-23
A2960	Plumbing Works Completed	0	0	0%		02-Jun-23
A2950	Fixing Galvanized Iron Pipes	220	220	0%	20-Sep-22	02-Jun-23
A2940	Laying Sewerage & Drain Pi	220	220	0%	20-Sep-22	02-Jun-23
KRL.7.3 HVAC & FF System		362	362	0%	21-Apr-22	16-Jun-23
A3000	HVAC & FF System Complet	0	0	0%		16-Jun-23
A2990	Fixing Valves & Sprinklers	82	82	0%	14-Mar-23	16-Jun-23
A2980	Fixing FF Pipes with Hangers	150	150	0%	20-Sep-22	13-Mar-23
A2970	Fixing HVAC Ducts & Pipes	230	230	0%	21-Apr-22	13-Jan-23
KRL.7.4 Medical Gases System		1274	1274	0%	01-Apr-19	15-May-23
A3040	Medical Gases System Work	0	0	0%		01-Apr-19
A3030	Fixing Medical Gases Manif	70	70	0%	23-Feb-23	15-May-23
A3020	Fixing Zone Valves	70	70	0%	03-Dec-22	22-Feb-23
A3010	Fixing Medical Gases Coper	80	80	0%	29-Oct-22	30-Jan-23
KRL.8 Closeout		24	24	0%	08-Sep-23	05-Oct-23
A3060	Preparing Punch Lists	4	4	0%	02-Oct-23	05-Oct-23
A3050	Testing and Commissioning	20	20	0%	08-Sep-23	30-Sep-23

🟦 Actual Level of Effort
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🟥 Critical Remaining Work
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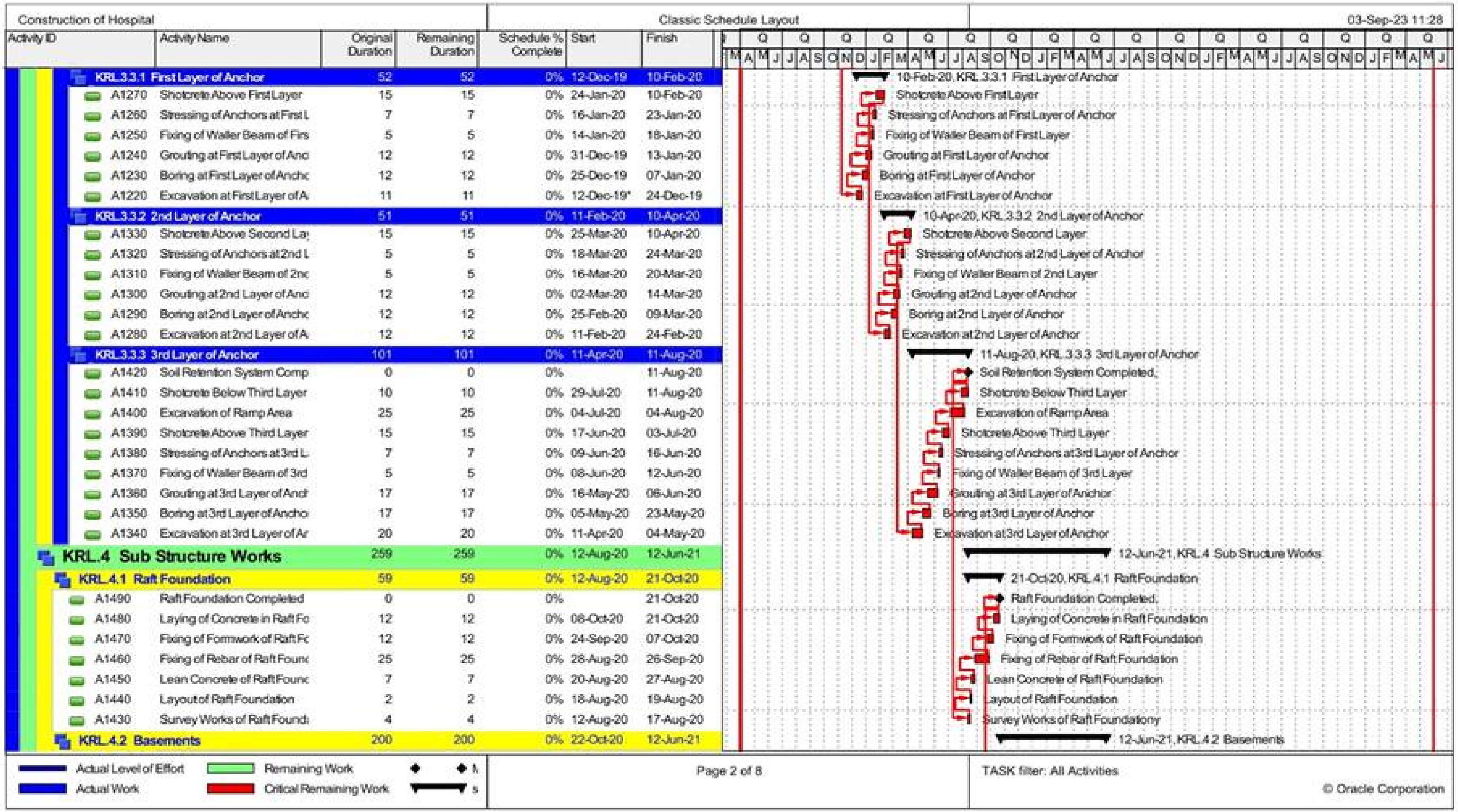
TASK filter: All Activities

Re-Scheduling of Activities Based on Method-2



Construction of Hospital

Classic Schedule Layout

03-Sep-23 11:28

Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
KRL.3.3.1	First Layer of Anchor	52	52	0%	12-Dec-19	10-Feb-20
A1270	Shotcrete Above First Layer	15	15	0%	24-Jan-20	10-Feb-20
A1260	Stressing of Anchors at First L	7	7	0%	16-Jan-20	23-Jan-20
A1250	Fixing of Waller Beam of Firs	5	5	0%	14-Jan-20	18-Jan-20
A1240	Grouting at First Layer of Anc	12	12	0%	31-Dec-19	13-Jan-20
A1230	Boring at First Layer of Anchc	12	12	0%	25-Dec-19	07-Jan-20
A1220	Excavation at First Layer of A	11	11	0%	12-Dec-19*	24-Dec-19
KRL.3.3.2	2nd Layer of Anchor	51	51	0%	11-Feb-20	10-Apr-20
A1330	Shotcrete Above Second La	15	15	0%	25-Mar-20	10-Apr-20
A1320	Stressing of Anchors at 2nd L	5	5	0%	18-Mar-20	24-Mar-20
A1310	Fixing of Waller Beam of 2nc	5	5	0%	16-Mar-20	20-Mar-20
A1300	Grouting at 2nd Layer of Anc	12	12	0%	02-Mar-20	14-Mar-20
A1290	Boring at 2nd Layer of Anchc	12	12	0%	25-Feb-20	09-Mar-20
A1280	Excavation at 2nd Layer of A	12	12	0%	11-Feb-20	24-Feb-20
KRL.3.3.3	3rd Layer of Anchor	101	101	0%	11-Apr-20	11-Aug-20
A1420	Soil Retention System Comp	0	0	0%		11-Aug-20
A1410	Shotcrete Below Third Layer	10	10	0%	29-Jul-20	11-Aug-20
A1400	Excavation of Ramp Area	25	25	0%	04-Jul-20	04-Aug-20
A1390	Shotcrete Above Third Layer	15	15	0%	17-Jun-20	03-Jul-20
A1380	Stressing of Anchors at 3rd L	7	7	0%	09-Jun-20	16-Jun-20
A1370	Fixing of Waller Beam of 3rd	5	5	0%	08-Jun-20	12-Jun-20
A1360	Grouting at 3rd Layer of Anch	17	17	0%	16-May-20	06-Jun-20
A1350	Boring at 3rd Layer of Ancho	17	17	0%	05-May-20	23-May-20
A1340	Excavation at 3rd Layer of Ar	20	20	0%	11-Apr-20	04-May-20
KRL.4	**Sub Structure Works**	259	259	0%	12-Aug-20	12-Jun-21
KRL.4.1	**Raft Foundation**	59	59	0%	12-Aug-20	21-Oct-20
A1490	Raft Foundation Completed	0	0	0%		21-Oct-20
A1480	Laying of Concrete in Raft Fo	12	12	0%	08-Oct-20	21-Oct-20
A1470	Fixing of Formwork of Raft Fc	12	12	0%	24-Sep-20	07-Oct-20
A1460	Fixing of Rebar of Raft Founc	25	25	0%	28-Aug-20	26-Sep-20
A1450	Lean Concrete of Raft Founc	7	7	0%	20-Aug-20	27-Aug-20
A1440	Layout of Raft Foundation	2	2	0%	18-Aug-20	19-Aug-20
A1430	Survey Works of Raft Found	4	4	0%	12-Aug-20	17-Aug-20
KRL.4.2	**Basements**	200	200	0%	22-Oct-20	12-Jun-21

▬	Actual Level of Effort	🟩	Remaining Work
▬	Actual Work	🟥	Critical Remaining Work

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TASK filter: All Activities

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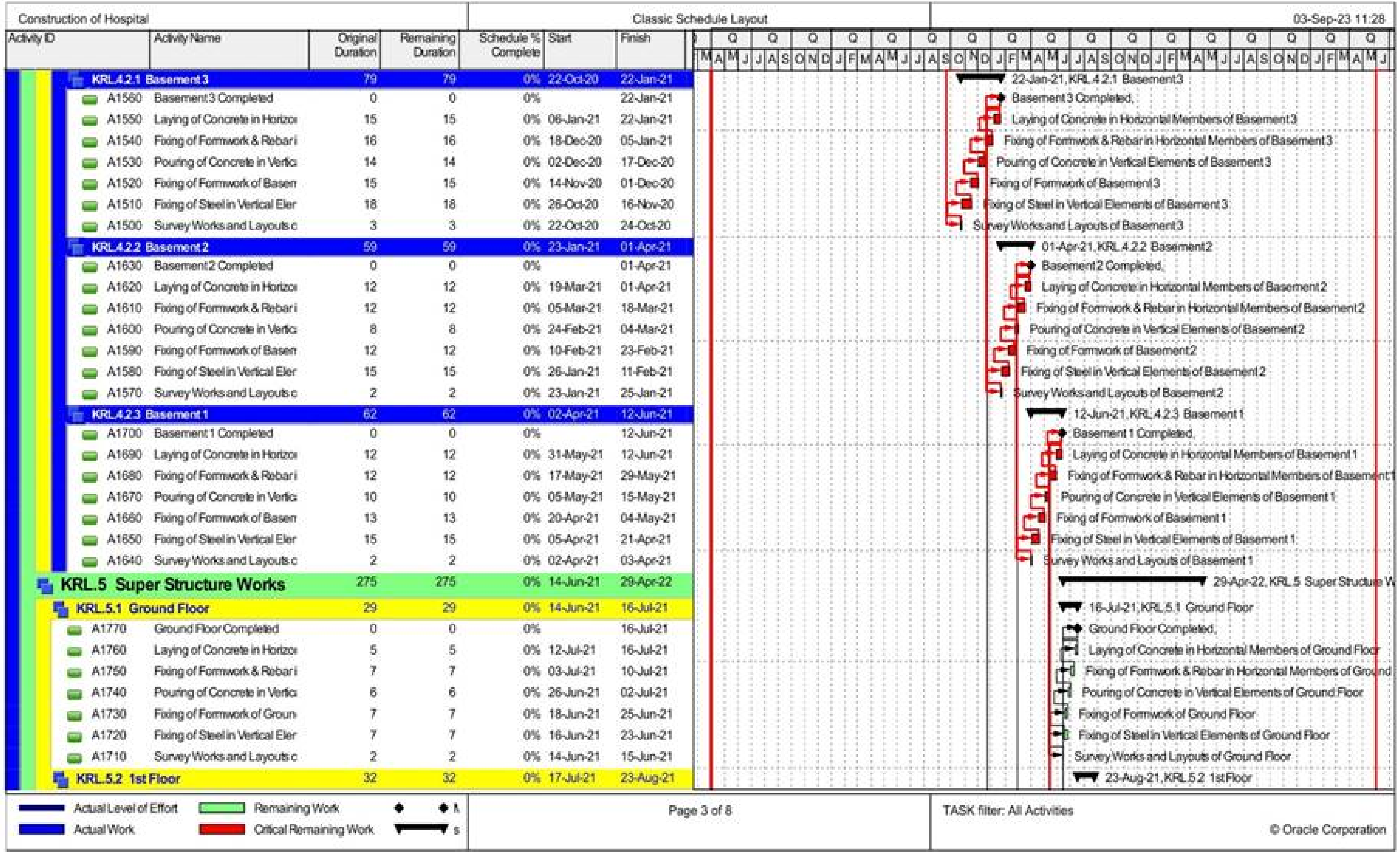

Construction of Hospital | Classic Schedule Layout | 03-Sep-23 11:28

Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
KRL.4.2.1	Basement 3	79	79	0%	22-Oct-20	22-Jan-21
A1560	Basement 3 Completed	0	0	0%		22-Jan-21
A1550	Laying of Concrete in Horizo	15	15	0%	06-Jan-21	22-Jan-21
A1540	Fixing of Formwork & Rebar i	16	16	0%	18-Dec-20	05-Jan-21
A1530	Pouring of Concrete in Vertic	14	14	0%	02-Dec-20	17-Dec-20
A1520	Fixing of Formwork of Basem	15	15	0%	14-Nov-20	01-Dec-20
A1510	Fixing of Steel in Vertical Eler	18	18	0%	26-Oct-20	16-Nov-20
A1500	Survey Works and Layouts c	3	3	0%	22-Oct-20	24-Oct-20
KRL.4.2.2	Basement 2	59	59	0%	23-Jan-21	01-Apr-21
A1630	Basement 2 Completed	0	0	0%		01-Apr-21
A1620	Laying of Concrete in Horizo	12	12	0%	19-Mar-21	01-Apr-21
A1610	Fixing of Formwork & Rebar i	12	12	0%	05-Mar-21	18-Mar-21
A1600	Pouring of Concrete in Vertic	8	8	0%	24-Feb-21	04-Mar-21
A1590	Fixing of Formwork of Basem	12	12	0%	10-Feb-21	23-Feb-21
A1580	Fixing of Steel in Vertical Eler	15	15	0%	26-Jan-21	11-Feb-21
A1570	Survey Works and Layouts c	2	2	0%	23-Jan-21	25-Jan-21
KRL.4.2.3	Basement 1	62	62	0%	02-Apr-21	12-Jun-21
A1700	Basement 1 Completed	0	0	0%		12-Jun-21
A1690	Laying of Concrete in Horizo	12	12	0%	31-May-21	12-Jun-21
A1680	Fixing of Formwork & Rebar i	12	12	0%	17-May-21	29-May-21
A1670	Pouring of Concrete in Vertic	10	10	0%	05-May-21	15-May-21
A1660	Fixing of Formwork of Basem	13	13	0%	20-Apr-21	04-May-21
A1650	Fixing of Steel in Vertical Eler	15	15	0%	05-Apr-21	21-Apr-21
A1640	Survey Works and Layouts c	2	2	0%	02-Apr-21	03-Apr-21
KRL.5	**Super Structure Works**	275	275	0%	14-Jun-21	29-Apr-22
KRL.5.1	**Ground Floor**	29	29	0%	14-Jun-21	16-Jul-21
A1770	Ground Floor Completed	0	0	0%		16-Jul-21
A1760	Laying of Concrete in Horizo	5	5	0%	12-Jul-21	16-Jul-21
A1750	Fixing of Formwork & Rebar i	7	7	0%	03-Jul-21	10-Jul-21
A1740	Pouring of Concrete in Vertic	6	6	0%	26-Jun-21	02-Jul-21
A1730	Fixing of Formwork of Groun	7	7	0%	18-Jun-21	25-Jun-21
A1720	Fixing of Steel in Vertical Eler	7	7	0%	16-Jun-21	23-Jun-21
A1710	Survey Works and Layouts c	2	2	0%	14-Jun-21	15-Jun-21
KRL.5.2	**1st Floor**	32	32	0%	17-Jul-21	23-Aug-21

Actual Level of Effort | 🟩 Remaining Work | ◆ ◆ M
Actual Work | 🟥 Critical Remaining Work | s

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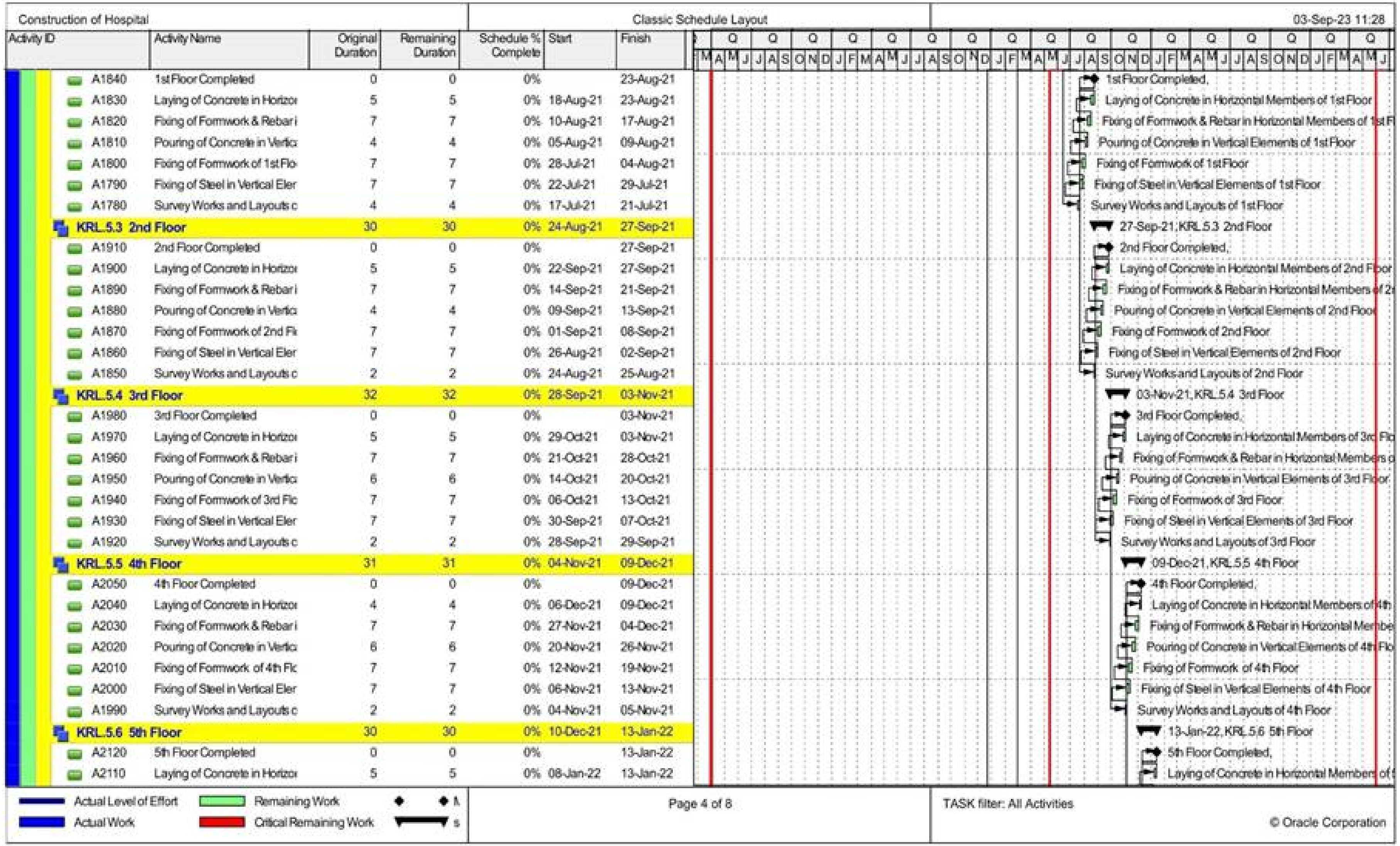

Construction of Hospital

Classic Schedule Layout

03-Sep-23 11:28

Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
A1840	1st Floor Completed	0	0	0%		23-Aug-21
A1830	Laying of Concrete in Horizo	5	5	0%	18-Aug-21	23-Aug-21
A1820	Fixing of Formwork & Rebar i	7	7	0%	10-Aug-21	17-Aug-21
A1810	Pouring of Concrete in Vertic	4	4	0%	05-Aug-21	09-Aug-21
A1800	Fixing of Formwork of 1st Flo	7	7	0%	28-Jul-21	04-Aug-21
A1790	Fixing of Steel in Vertical Eler	7	7	0%	22-Jul-21	29-Jul-21
A1780	Survey Works and Layouts c	4	4	0%	17-Jul-21	21-Jul-21
KRL.5.3 2nd Floor		**30**	**30**	**0%**	**24-Aug-21**	**27-Sep-21**
A1910	2nd Floor Completed	0	0	0%		27-Sep-21
A1900	Laying of Concrete in Horizo	5	5	0%	22-Sep-21	27-Sep-21
A1890	Fixing of Formwork & Rebar i	7	7	0%	14-Sep-21	21-Sep-21
A1880	Pouring of Concrete in Vertic	4	4	0%	09-Sep-21	13-Sep-21
A1870	Fixing of Formwork of 2nd Fl	7	7	0%	01-Sep-21	08-Sep-21
A1860	Fixing of Steel in Vertical Eler	7	7	0%	26-Aug-21	02-Sep-21
A1850	Survey Works and Layouts c	2	2	0%	24-Aug-21	25-Aug-21
KRL.5.4 3rd Floor		**32**	**32**	**0%**	**28-Sep-21**	**03-Nov-21**
A1980	3rd Floor Completed	0	0	0%		03-Nov-21
A1970	Laying of Concrete in Horizo	5	5	0%	29-Oct-21	03-Nov-21
A1960	Fixing of Formwork & Rebar i	7	7	0%	21-Oct-21	28-Oct-21
A1950	Pouring of Concrete in Vertic	6	6	0%	14-Oct-21	20-Oct-21
A1940	Fixing of Formwork of 3rd Flc	7	7	0%	06-Oct-21	13-Oct-21
A1930	Fixing of Steel in Vertical Eler	7	7	0%	30-Sep-21	07-Oct-21
A1920	Survey Works and Layouts c	2	2	0%	28-Sep-21	29-Sep-21
KRL.5.5 4th Floor		**31**	**31**	**0%**	**04-Nov-21**	**09-Dec-21**
A2050	4th Floor Completed	0	0	0%		09-Dec-21
A2040	Laying of Concrete in Horizo	4	4	0%	06-Dec-21	09-Dec-21
A2030	Fixing of Formwork & Rebar i	7	7	0%	27-Nov-21	04-Dec-21
A2020	Pouring of Concrete in Vertic	6	6	0%	20-Nov-21	26-Nov-21
A2010	Fixing of Formwork of 4th Flc	7	7	0%	12-Nov-21	19-Nov-21
A2000	Fixing of Steel in Vertical Eler	7	7	0%	06-Nov-21	13-Nov-21
A1990	Survey Works and Layouts c	2	2	0%	04-Nov-21	05-Nov-21
KRL.5.6 5th Floor		**30**	**30**	**0%**	**10-Dec-21**	**13-Jan-22**
A2120	5th Floor Completed	0	0	0%		13-Jan-22
A2110	Laying of Concrete in Horizo	5	5	0%	08-Jan-22	13-Jan-22

Actual Level of Effort
Actual Work
Remaining Work
Critical Remaining Work
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TASK filter: All Activities

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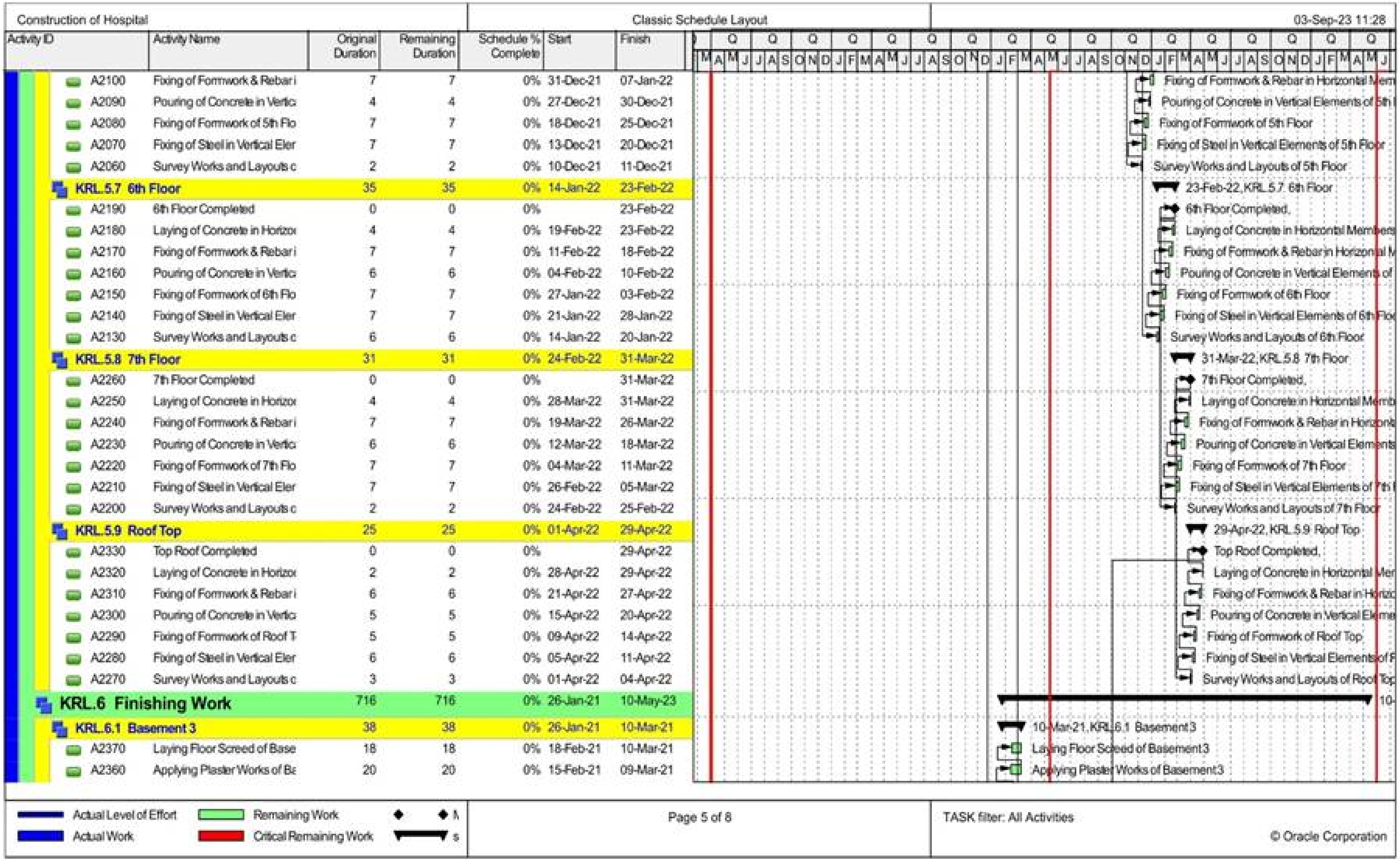

Construction of Hospital

Classic Schedule Layout

03-Sep-23 11:28

Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
A2100	Fixing of Formwork & Rebar i	7	7	0%	31-Dec-21	07-Jan-22
A2090	Pouring of Concrete in Vertic	4	4	0%	27-Dec-21	30-Dec-21
A2080	Fixing of Formwork of 5th Flo	7	7	0%	18-Dec-21	25-Dec-21
A2070	Fixing of Steel in Vertical Eler	7	7	0%	13-Dec-21	20-Dec-21
A2060	Survey Works and Layouts c	2	2	0%	10-Dec-21	11-Dec-21
KRL.5.7 6th Floor		**35**	**35**	**0%**	**14-Jan-22**	**23-Feb-22**
A2190	6th Floor Completed	0	0	0%		23-Feb-22
A2180	Laying of Concrete in Horizo	4	4	0%	19-Feb-22	23-Feb-22
A2170	Fixing of Formwork & Rebar i	7	7	0%	11-Feb-22	18-Feb-22
A2160	Pouring of Concrete in Vertic	6	6	0%	04-Feb-22	10-Feb-22
A2150	Fixing of Formwork of 6th Flo	7	7	0%	27-Jan-22	03-Feb-22
A2140	Fixing of Steel in Vertical Eler	7	7	0%	21-Jan-22	28-Jan-22
A2130	Survey Works and Layouts c	6	6	0%	14-Jan-22	20-Jan-22
KRL.5.8 7th Floor		**31**	**31**	**0%**	**24-Feb-22**	**31-Mar-22**
A2260	7th Floor Completed	0	0	0%		31-Mar-22
A2250	Laying of Concrete in Horizo	4	4	0%	28-Mar-22	31-Mar-22
A2240	Fixing of Formwork & Rebar i	7	7	0%	19-Mar-22	26-Mar-22
A2230	Pouring of Concrete in Vertic	6	6	0%	12-Mar-22	18-Mar-22
A2220	Fixing of Formwork of 7th Flo	7	7	0%	04-Mar-22	11-Mar-22
A2210	Fixing of Steel in Vertical Eler	7	7	0%	26-Feb-22	05-Mar-22
A2200	Survey Works and Layouts c	2	2	0%	24-Feb-22	25-Feb-22
KRL.5.9 Roof Top		**25**	**25**	**0%**	**01-Apr-22**	**29-Apr-22**
A2330	Top Roof Completed	0	0	0%		29-Apr-22
A2320	Laying of Concrete in Horizo	2	2	0%	28-Apr-22	29-Apr-22
A2310	Fixing of Formwork & Rebar i	6	6	0%	21-Apr-22	27-Apr-22
A2300	Pouring of Concrete in Vertic	5	5	0%	15-Apr-22	20-Apr-22
A2290	Fixing of Formwork of Roof T	5	5	0%	09-Apr-22	14-Apr-22
A2280	Fixing of Steel in Vertical Eler	6	6	0%	05-Apr-22	11-Apr-22
A2270	Survey Works and Layouts c	3	3	0%	01-Apr-22	04-Apr-22
KRL.6 Finishing Work		**716**	**716**	**0%**	**26-Jan-21**	**10-May-23**
KRL.6.1 Basement 3		**38**	**38**	**0%**	**26-Jan-21**	**10-Mar-21**
A2370	Laying Floor Screed of Base	18	18	0%	18-Feb-21	10-Mar-21
A2360	Applying Plaster Works of Ba	20	20	0%	15-Feb-21	09-Mar-21

▬	Actual Level of Effort	🟩	Remaining Work	◆	◆ M
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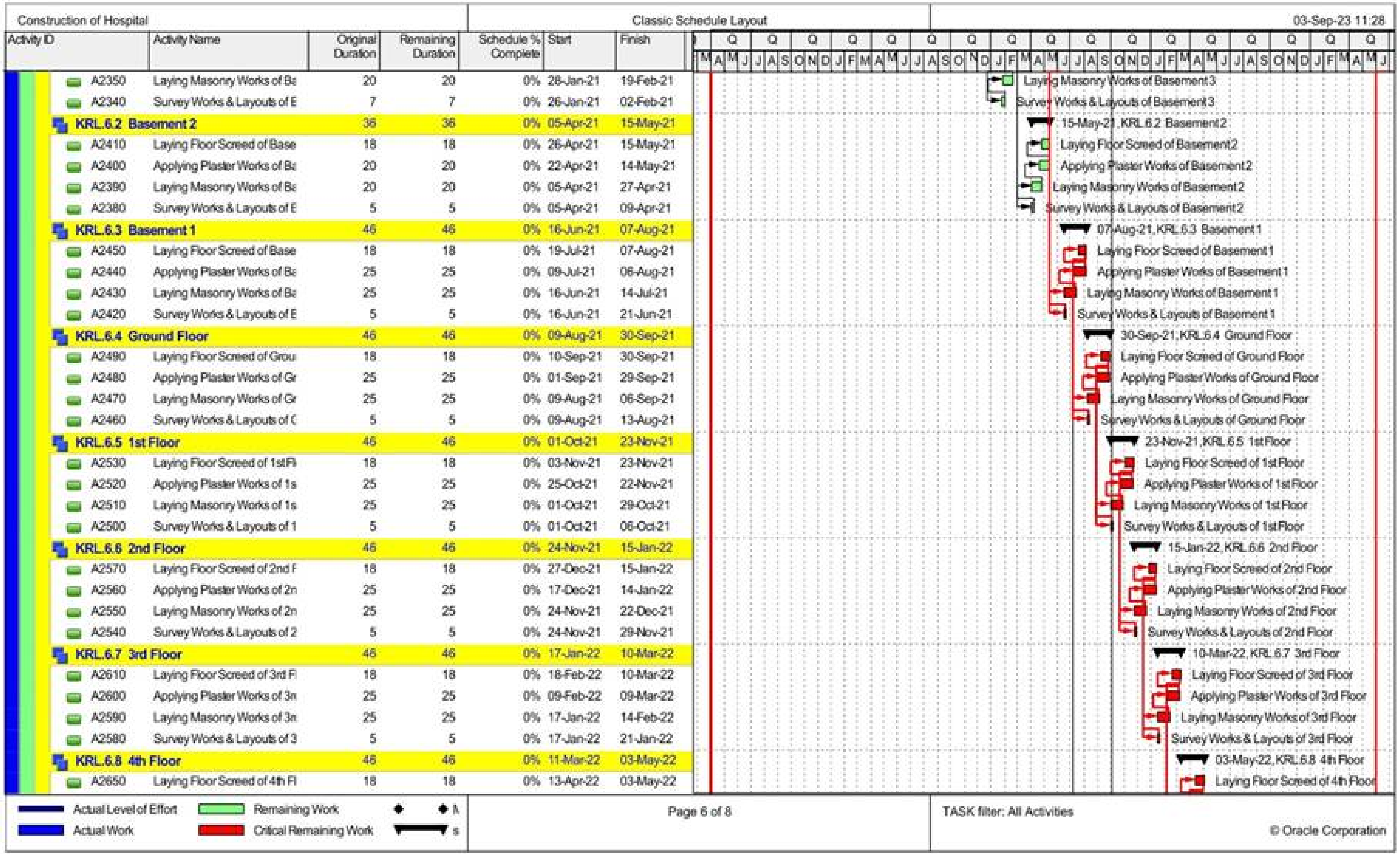

Construction of Hospital | Classic Schedule Layout | 03-Sep-23 11:28

Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
A2350	Laying Masonry Works of Ba	20	20	0%	28-Jan-21	19-Feb-21
A2340	Survey Works & Layouts of E	7	7	0%	26-Jan-21	02-Feb-21
KRL.6.2 Basement 2		36	36	0%	05-Apr-21	15-May-21
A2410	Laying Floor Screed of Base	18	18	0%	26-Apr-21	15-May-21
A2400	Applying Plaster Works of Ba	20	20	0%	22-Apr-21	14-May-21
A2390	Laying Masonry Works of Ba	20	20	0%	05-Apr-21	27-Apr-21
A2380	Survey Works & Layouts of E	5	5	0%	05-Apr-21	09-Apr-21
KRL.6.3 Basement 1		46	46	0%	16-Jun-21	07-Aug-21
A2450	Laying Floor Screed of Base	18	18	0%	19-Jul-21	07-Aug-21
A2440	Applying Plaster Works of Ba	25	25	0%	09-Jul-21	06-Aug-21
A2430	Laying Masonry Works of Ba	25	25	0%	16-Jun-21	14-Jul-21
A2420	Survey Works & Layouts of E	5	5	0%	16-Jun-21	21-Jun-21
KRL.6.4 Ground Floor		46	46	0%	09-Aug-21	30-Sep-21
A2490	Laying Floor Screed of Grou	18	18	0%	10-Sep-21	30-Sep-21
A2480	Applying Plaster Works of Gr	25	25	0%	01-Sep-21	29-Sep-21
A2470	Laying Masonry Works of Gr	25	25	0%	09-Aug-21	06-Sep-21
A2460	Survey Works & Layouts of C	5	5	0%	09-Aug-21	13-Aug-21
KRL.6.5 1st Floor		46	46	0%	01-Oct-21	23-Nov-21
A2530	Laying Floor Screed of 1st Fl	18	18	0%	03-Nov-21	23-Nov-21
A2520	Applying Plaster Works of 1s	25	25	0%	25-Oct-21	22-Nov-21
A2510	Laying Masonry Works of 1s	25	25	0%	01-Oct-21	29-Oct-21
A2500	Survey Works & Layouts of 1	5	5	0%	01-Oct-21	06-Oct-21
KRL.6.6 2nd Floor		46	46	0%	24-Nov-21	15-Jan-22
A2570	Laying Floor Screed of 2nd F	18	18	0%	27-Dec-21	15-Jan-22
A2560	Applying Plaster Works of 2n	25	25	0%	17-Dec-21	14-Jan-22
A2550	Laying Masonry Works of 2n	25	25	0%	24-Nov-21	22-Dec-21
A2540	Survey Works & Layouts of 2	5	5	0%	24-Nov-21	29-Nov-21
KRL.6.7 3rd Floor		46	46	0%	17-Jan-22	10-Mar-22
A2610	Laying Floor Screed of 3rd Fl	18	18	0%	18-Feb-22	10-Mar-22
A2600	Applying Plaster Works of 3n	25	25	0%	09-Feb-22	09-Mar-22
A2590	Laying Masonry Works of 3n	25	25	0%	17-Jan-22	14-Feb-22
A2580	Survey Works & Layouts of 3	5	5	0%	17-Jan-22	21-Jan-22
KRL.6.8 4th Floor		46	46	0%	11-Mar-22	03-May-22
A2650	Laying Floor Screed of 4th Fl	18	18	0%	13-Apr-22	03-May-22

Actual Level of Effort | Remaining Work | ◆ ◆ M
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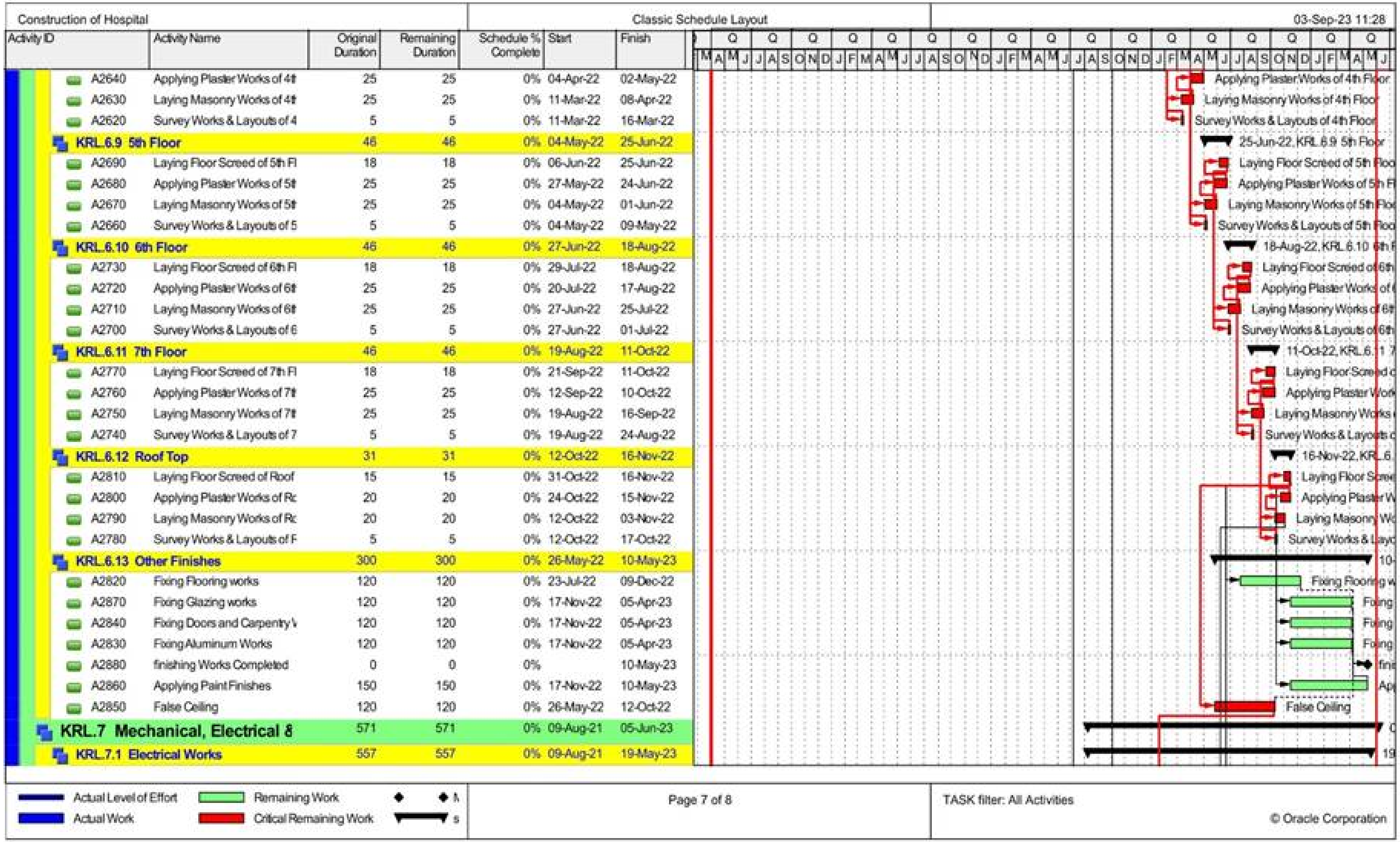

Construction of Hospital | Classic Schedule Layout | 03-Sep-23 11:28

Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
A2640	Applying Plaster Works of 4t	25	25	0%	04-Apr-22	02-May-22
A2630	Laying Masonry Works of 4t	25	25	0%	11-Mar-22	08-Apr-22
A2620	Survey Works & Layouts of 4	5	5	0%	11-Mar-22	16-Mar-22
KRL.6.9	**5th Floor**	46	46	0%	04-May-22	25-Jun-22
A2690	Laying Floor Screed of 5th Fl	18	18	0%	06-Jun-22	25-Jun-22
A2680	Applying Plaster Works of 5t	25	25	0%	27-May-22	24-Jun-22
A2670	Laying Masonry Works of 5t	25	25	0%	04-May-22	01-Jun-22
A2660	Survey Works & Layouts of 5	5	5	0%	04-May-22	09-May-22
KRL.6.10	**6th Floor**	46	46	0%	27-Jun-22	18-Aug-22
A2730	Laying Floor Screed of 6th Fl	18	18	0%	29-Jul-22	18-Aug-22
A2720	Applying Plaster Works of 6t	25	25	0%	20-Jul-22	17-Aug-22
A2710	Laying Masonry Works of 6t	25	25	0%	27-Jun-22	25-Jul-22
A2700	Survey Works & Layouts of 6	5	5	0%	27-Jun-22	01-Jul-22
KRL.6.11	**7th Floor**	46	46	0%	19-Aug-22	11-Oct-22
A2770	Laying Floor Screed of 7th Fl	18	18	0%	21-Sep-22	11-Oct-22
A2760	Applying Plaster Works of 7t	25	25	0%	12-Sep-22	10-Oct-22
A2750	Laying Masonry Works of 7t	25	25	0%	19-Aug-22	16-Sep-22
A2740	Survey Works & Layouts of 7	5	5	0%	19-Aug-22	24-Aug-22
KRL.6.12	**Roof Top**	31	31	0%	12-Oct-22	16-Nov-22
A2810	Laying Floor Screed of Roof	15	15	0%	31-Oct-22	16-Nov-22
A2800	Applying Plaster Works of Rc	20	20	0%	24-Oct-22	15-Nov-22
A2790	Laying Masonry Works of Rc	20	20	0%	12-Oct-22	03-Nov-22
A2780	Survey Works & Layouts of F	5	5	0%	12-Oct-22	17-Oct-22
KRL.6.13	**Other Finishes**	300	300	0%	26-May-22	10-May-23
A2820	Fixing Flooring works	120	120	0%	23-Jul-22	09-Dec-22
A2870	Fixing Glazing works	120	120	0%	17-Nov-22	05-Apr-23
A2840	Fixing Doors and Carpentry \	120	120	0%	17-Nov-22	05-Apr-23
A2830	Fixing Aluminum Works	120	120	0%	17-Nov-22	05-Apr-23
A2880	finishing Works Completed	0	0	0%		10-May-23
A2860	Applying Paint Finishes	150	150	0%	17-Nov-22	10-May-23
A2850	False Ceiling	120	120	0%	26-May-22	12-Oct-22
KRL.7	**Mechanical, Electrical &**	571	571	0%	09-Aug-21	05-Jun-23
KRL.7.1	**Electrical Works**	557	557	0%	09-Aug-21	19-May-23

Actual Level of Effort	Remaining Work	◆ ◆ M
Actual Work	Critical Remaining Work	s

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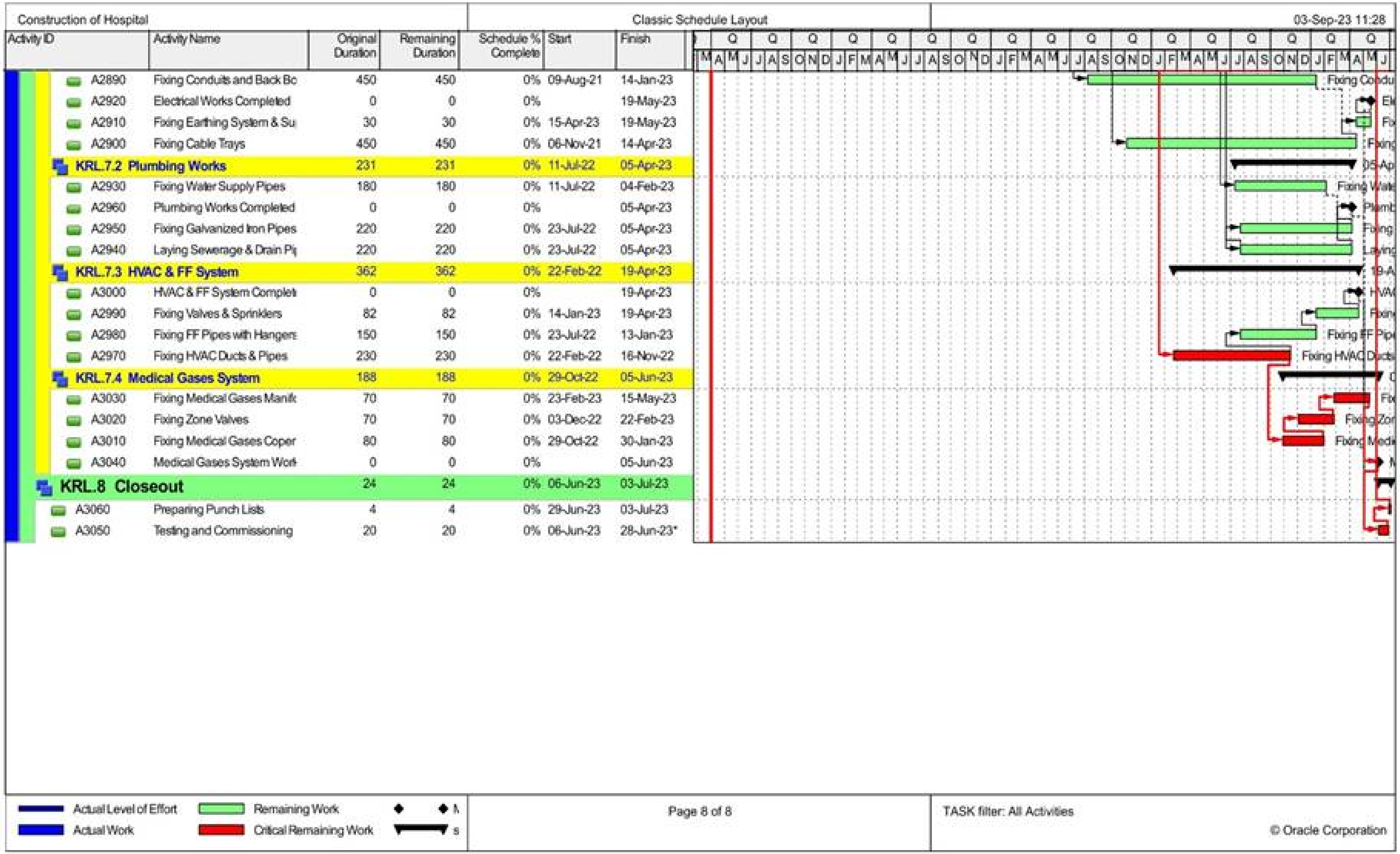

Construction of Hospital

Classic Schedule Layout

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Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
A2890	Fixing Conduits and Back Bo	450	450	0%	09-Aug-21	14-Jan-23
A2920	Electrical Works Completed	0	0	0%		19-May-23
A2910	Fixing Earthing System & Su	30	30	0%	15-Apr-23	19-May-23
A2900	Fixing Cable Trays	450	450	0%	06-Nov-21	14-Apr-23
KRL.7.2	**Plumbing Works**	231	231	0%	11-Jul-22	05-Apr-23
A2930	Fixing Water Supply Pipes	180	180	0%	11-Jul-22	04-Feb-23
A2960	Plumbing Works Completed	0	0	0%		05-Apr-23
A2950	Fixing Galvanized Iron Pipes	220	220	0%	23-Jul-22	05-Apr-23
A2940	Laying Sewerage & Drain Pi	220	220	0%	23-Jul-22	05-Apr-23
KRL.7.3	**HVAC & FF System**	362	362	0%	22-Feb-22	19-Apr-23
A3000	HVAC & FF System Complet	0	0	0%		19-Apr-23
A2990	Fixing Valves & Sprinklers	82	82	0%	14-Jan-23	19-Apr-23
A2980	Fixing FF Pipes with Hangers	150	150	0%	23-Jul-22	13-Jan-23
A2970	Fixing HVAC Ducts & Pipes	230	230	0%	22-Feb-22	16-Nov-22
KRL.7.4	**Medical Gases System**	188	188	0%	29-Oct-22	05-Jun-23
A3030	Fixing Medical Gases Manifc	70	70	0%	23-Feb-23	15-May-23
A3020	Fixing Zone Valves	70	70	0%	03-Dec-22	22-Feb-23
A3010	Fixing Medical Gases Coper	80	80	0%	29-Oct-22	30-Jan-23
A3040	Medical Gases System Work	0	0	0%		05-Jun-23
KRL.8	**Closeout**	24	24	0%	06-Jun-23	03-Jul-23
A3060	Preparing Punch Lists	4	4	0%	29-Jun-23	03-Jul-23
A3050	Testing and Commissioning	20	20	0%	06-Jun-23	28-Jun-23*

▬ Actual Level of Effort	🟩 Remaining Work	◆ ◆ M	Page 8 of 8
▬ Actual Work	🟥 Critical Remaining Work	▬ s	TASK filter: All Activities

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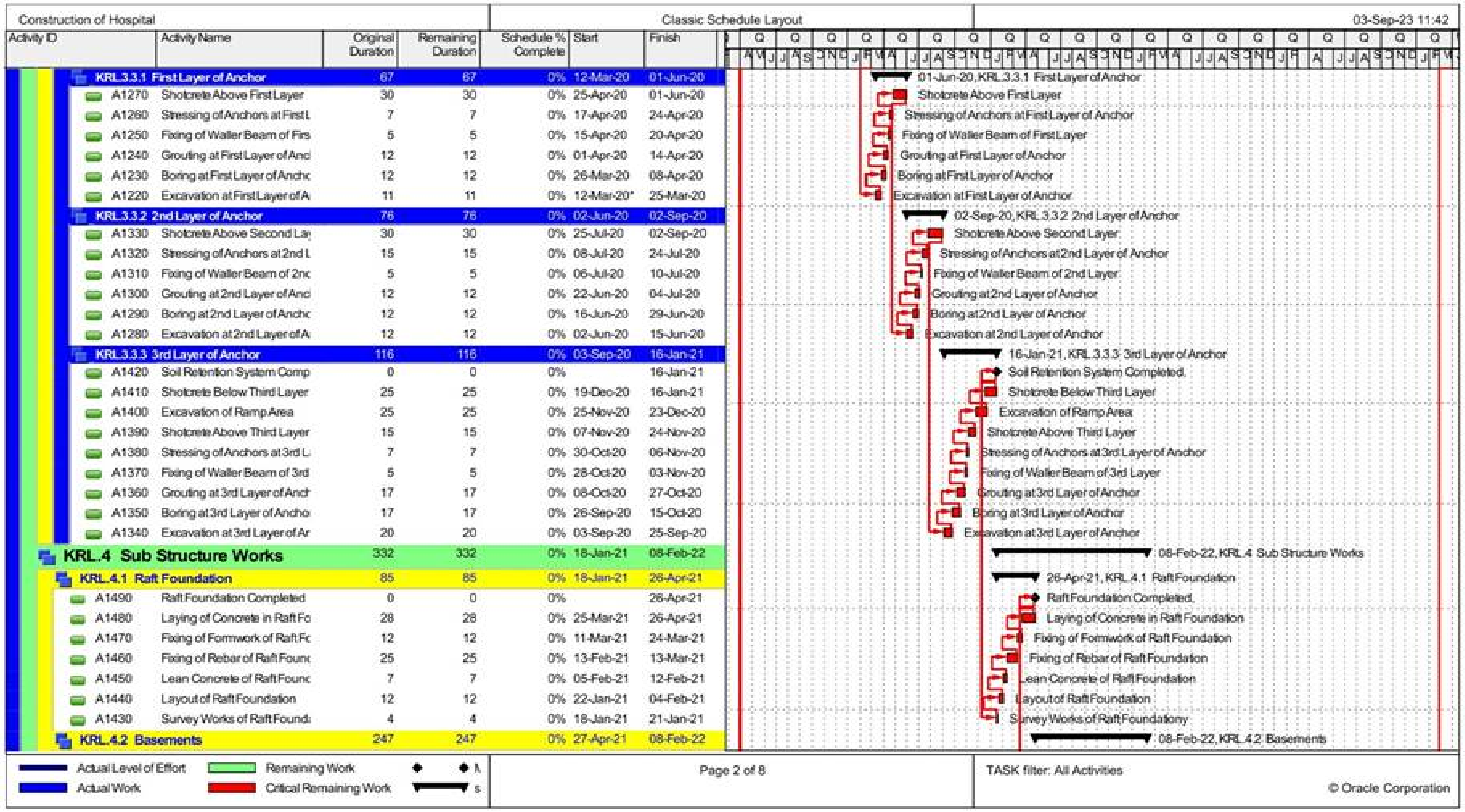
Re-Scheduling of Activities Based on Method-3



Construction of Hospital

Classic Schedule Layout

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Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
KRL.3.3.1	**First Layer of Anchor**	67	67	0%	12-Mar-20	01-Jun-20
A1270	Shotcrete Above First Layer	30	30	0%	25-Apr-20	01-Jun-20
A1260	Stressing of Anchors at First L	7	7	0%	17-Apr-20	24-Apr-20
A1250	Fixing of Waller Beam of Firs	5	5	0%	15-Apr-20	20-Apr-20
A1240	Grouting at First Layer of Anc	12	12	0%	01-Apr-20	14-Apr-20
A1230	Boring at First Layer of Anchc	12	12	0%	26-Mar-20	08-Apr-20
A1220	Excavation at First Layer of A	11	11	0%	12-Mar-20*	25-Mar-20
KRL.3.3.2	**2nd Layer of Anchor**	76	76	0%	02-Jun-20	02-Sep-20
A1330	Shotcrete Above Second La	30	30	0%	25-Jul-20	02-Sep-20
A1320	Stressing of Anchors at 2nd L	15	15	0%	08-Jul-20	24-Jul-20
A1310	Fixing of Waller Beam of 2nc	5	5	0%	06-Jul-20	10-Jul-20
A1300	Grouting at 2nd Layer of Anc	12	12	0%	22-Jun-20	04-Jul-20
A1290	Boring at 2nd Layer of Anchc	12	12	0%	16-Jun-20	29-Jun-20
A1280	Excavation at 2nd Layer of A	12	12	0%	02-Jun-20	15-Jun-20
KRL.3.3.3	**3rd Layer of Anchor**	116	116	0%	03-Sep-20	16-Jan-21
A1420	Soil Retention System Comp	0	0	0%		16-Jan-21
A1410	Shotcrete Below Third Layer	25	25	0%	19-Dec-20	16-Jan-21
A1400	Excavation of Ramp Area	25	25	0%	25-Nov-20	23-Dec-20
A1390	Shotcrete Above Third Layer	15	15	0%	07-Nov-20	24-Nov-20
A1380	Stressing of Anchors at 3rd L	7	7	0%	30-Oct-20	06-Nov-20
A1370	Fixing of Waller Beam of 3rd	5	5	0%	28-Oct-20	03-Nov-20
A1360	Grouting at 3rd Layer of Anch	17	17	0%	08-Oct-20	27-Oct-20
A1350	Boring at 3rd Layer of Ancho	17	17	0%	26-Sep-20	15-Oct-20
A1340	Excavation at 3rd Layer of Ar	20	20	0%	03-Sep-20	25-Sep-20
KRL.4	**Sub Structure Works**	332	332	0%	18-Jan-21	08-Feb-22
KRL.4.1	**Raft Foundation**	85	85	0%	18-Jan-21	26-Apr-21
A1490	Raft Foundation Completed	0	0	0%		26-Apr-21
A1480	Laying of Concrete in Raft Fo	28	28	0%	25-Mar-21	26-Apr-21
A1470	Fixing of Formwork of Raft Fc	12	12	0%	11-Mar-21	24-Mar-21
A1460	Fixing of Rebar of Raft Founc	25	25	0%	13-Feb-21	13-Mar-21
A1450	Lean Concrete of Raft Founc	7	7	0%	05-Feb-21	12-Feb-21
A1440	Layout of Raft Foundation	12	12	0%	22-Jan-21	04-Feb-21
A1430	Survey Works of Raft Founda	4	4	0%	18-Jan-21	21-Jan-21
KRL.4.2	**Basements**	247	247	0%	27-Apr-21	08-Feb-22

Actual Level of Effort
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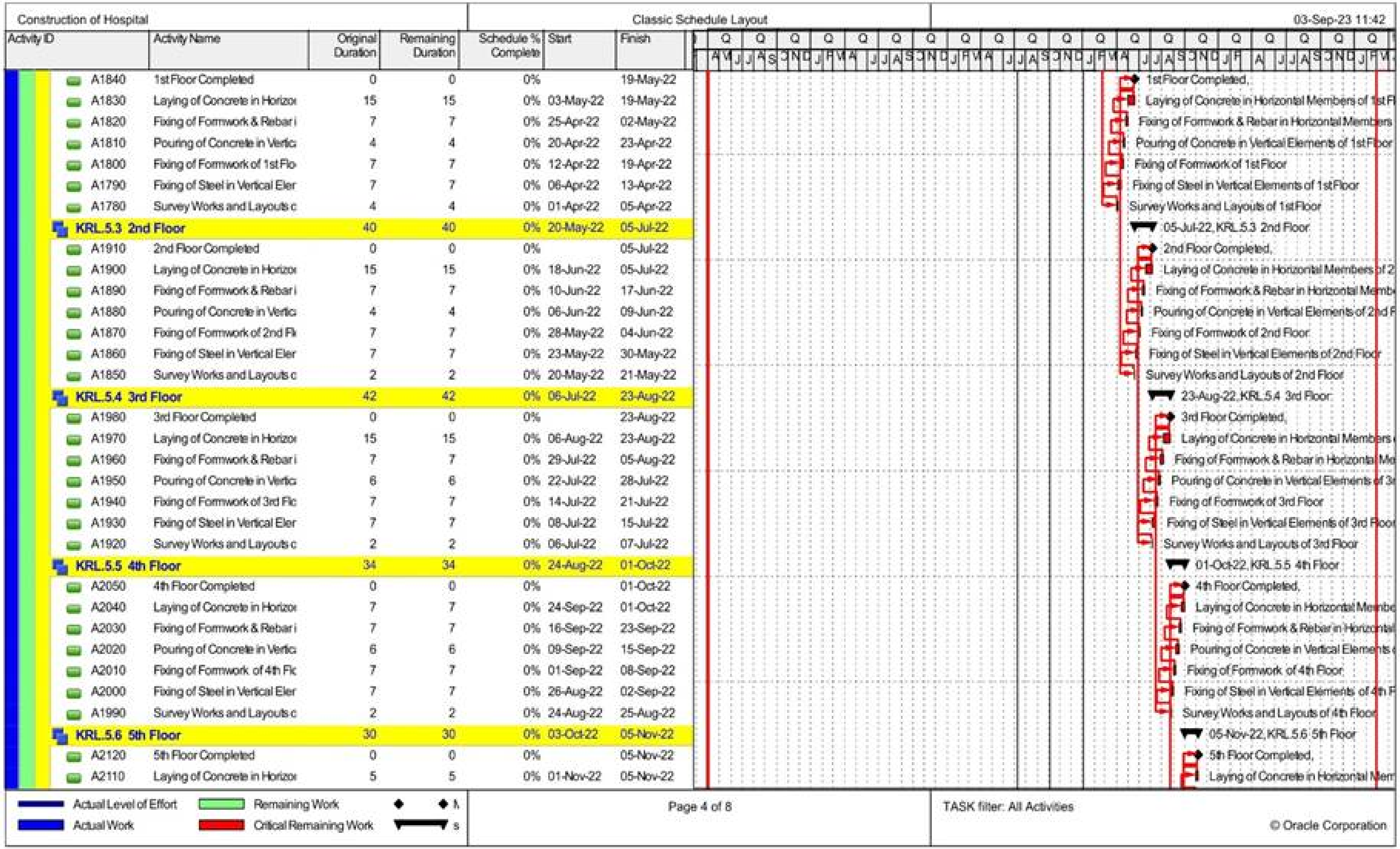

Construction of Hospital

Classic Schedule Layout

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Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
A1840	1st Floor Completed	0	0	0%		19-May-22
A1830	Laying of Concrete in Horizo	15	15	0%	03-May-22	19-May-22
A1820	Fixing of Formwork & Rebar i	7	7	0%	25-Apr-22	02-May-22
A1810	Pouring of Concrete in Vertic	4	4	0%	20-Apr-22	23-Apr-22
A1800	Fixing of Formwork of 1st Flo	7	7	0%	12-Apr-22	19-Apr-22
A1790	Fixing of Steel in Vertical Eler	7	7	0%	06-Apr-22	13-Apr-22
A1780	Survey Works and Layouts c	4	4	0%	01-Apr-22	05-Apr-22
KRL.5.3 2nd Floor		**40**	**40**	**0%**	**20-May-22**	**05-Jul-22**
A1910	2nd Floor Completed	0	0	0%		05-Jul-22
A1900	Laying of Concrete in Horizo	15	15	0%	18-Jun-22	05-Jul-22
A1890	Fixing of Formwork & Rebar i	7	7	0%	10-Jun-22	17-Jun-22
A1880	Pouring of Concrete in Vertic	4	4	0%	06-Jun-22	09-Jun-22
A1870	Fixing of Formwork of 2nd Fl	7	7	0%	28-May-22	04-Jun-22
A1860	Fixing of Steel in Vertical Eler	7	7	0%	23-May-22	30-May-22
A1850	Survey Works and Layouts c	2	2	0%	20-May-22	21-May-22
KRL.5.4 3rd Floor		**42**	**42**	**0%**	**06-Jul-22**	**23-Aug-22**
A1980	3rd Floor Completed	0	0	0%		23-Aug-22
A1970	Laying of Concrete in Horizo	15	15	0%	06-Aug-22	23-Aug-22
A1960	Fixing of Formwork & Rebar i	7	7	0%	29-Jul-22	05-Aug-22
A1950	Pouring of Concrete in Vertic	6	6	0%	22-Jul-22	28-Jul-22
A1940	Fixing of Formwork of 3rd Flc	7	7	0%	14-Jul-22	21-Jul-22
A1930	Fixing of Steel in Vertical Eler	7	7	0%	08-Jul-22	15-Jul-22
A1920	Survey Works and Layouts c	2	2	0%	06-Jul-22	07-Jul-22
KRL.5.5 4th Floor		**34**	**34**	**0%**	**24-Aug-22**	**01-Oct-22**
A2050	4th Floor Completed	0	0	0%		01-Oct-22
A2040	Laying of Concrete in Horizo	7	7	0%	24-Sep-22	01-Oct-22
A2030	Fixing of Formwork & Rebar i	7	7	0%	16-Sep-22	23-Sep-22
A2020	Pouring of Concrete in Vertic	6	6	0%	09-Sep-22	15-Sep-22
A2010	Fixing of Formwork of 4th Flc	7	7	0%	01-Sep-22	08-Sep-22
A2000	Fixing of Steel in Vertical Eler	7	7	0%	26-Aug-22	02-Sep-22
A1990	Survey Works and Layouts c	2	2	0%	24-Aug-22	25-Aug-22
KRL.5.6 5th Floor		**30**	**30**	**0%**	**03-Oct-22**	**05-Nov-22**
A2120	5th Floor Completed	0	0	0%		05-Nov-22
A2110	Laying of Concrete in Horizo	5	5	0%	01-Nov-22	05-Nov-22

Actual Level of Effort	Remaining Work	◆ ◆ M
Actual Work	Critical Remaining Work	s

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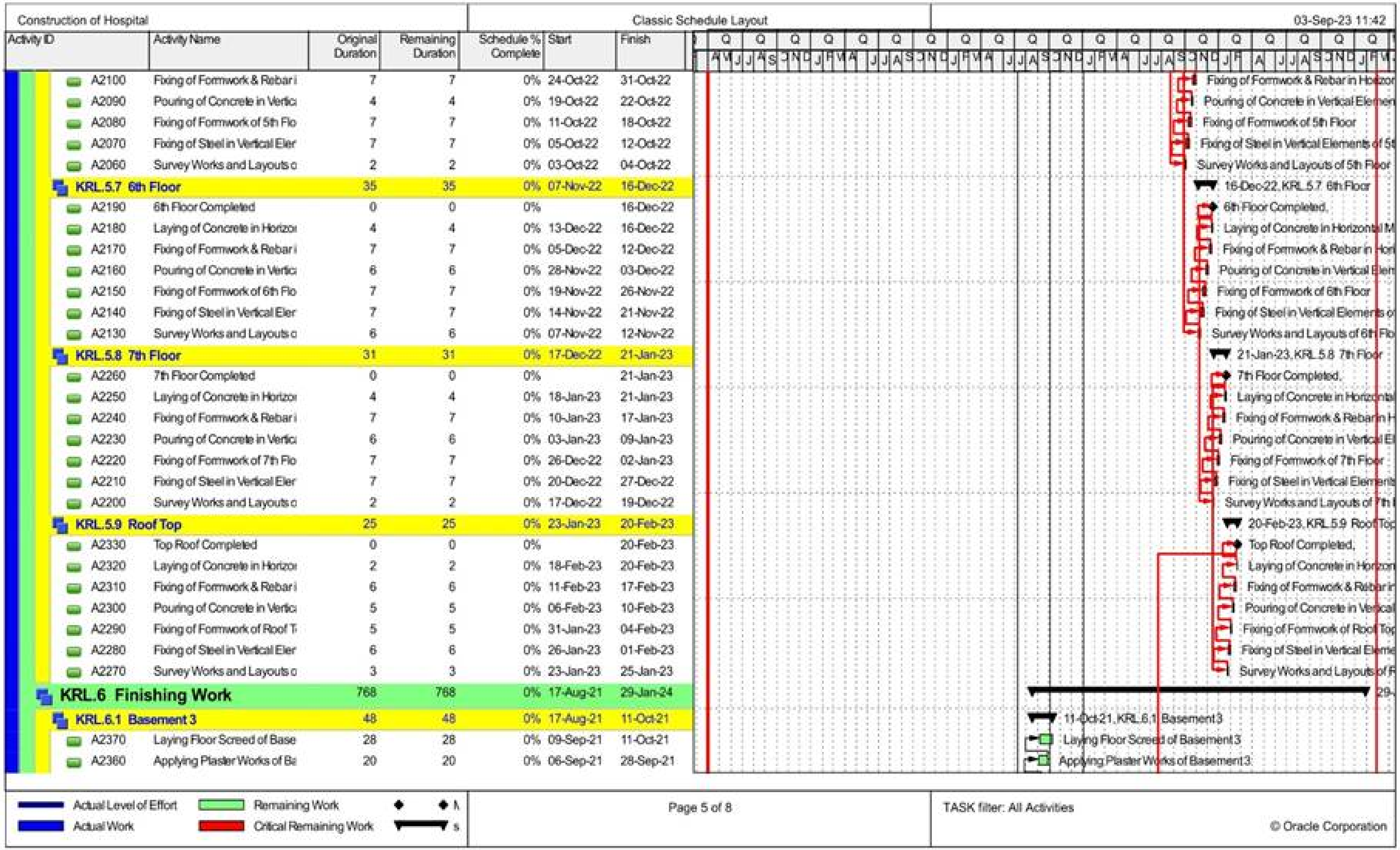

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Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
A2100	Fixing of Formwork & Rebar i	7	7	0%	24-Oct-22	31-Oct-22
A2090	Pouring of Concrete in Vertic	4	4	0%	19-Oct-22	22-Oct-22
A2080	Fixing of Formwork of 5th Flo	7	7	0%	11-Oct-22	18-Oct-22
A2070	Fixing of Steel in Vertical Eler	7	7	0%	05-Oct-22	12-Oct-22
A2060	Survey Works and Layouts o	2	2	0%	03-Oct-22	04-Oct-22
KRL.5.7 6th Floor		35	35	0%	07-Nov-22	16-Dec-22
A2190	6th Floor Completed	0	0	0%		16-Dec-22
A2180	Laying of Concrete in Horizor	4	4	0%	13-Dec-22	16-Dec-22
A2170	Fixing of Formwork & Rebar i	7	7	0%	05-Dec-22	12-Dec-22
A2160	Pouring of Concrete in Vertic	6	6	0%	28-Nov-22	03-Dec-22
A2150	Fixing of Formwork of 6th Flo	7	7	0%	19-Nov-22	26-Nov-22
A2140	Fixing of Steel in Vertical Eler	7	7	0%	14-Nov-22	21-Nov-22
A2130	Survey Works and Layouts o	6	6	0%	07-Nov-22	12-Nov-22
KRL.5.8 7th Floor		31	31	0%	17-Dec-22	21-Jan-23
A2260	7th Floor Completed	0	0	0%		21-Jan-23
A2250	Laying of Concrete in Horizor	4	4	0%	18-Jan-23	21-Jan-23
A2240	Fixing of Formwork & Rebar i	7	7	0%	10-Jan-23	17-Jan-23
A2230	Pouring of Concrete in Vertic	6	6	0%	03-Jan-23	09-Jan-23
A2220	Fixing of Formwork of 7th Flo	7	7	0%	26-Dec-22	02-Jan-23
A2210	Fixing of Steel in Vertical Eler	7	7	0%	20-Dec-22	27-Dec-22
A2200	Survey Works and Layouts o	2	2	0%	17-Dec-22	19-Dec-22
KRL.5.9 Roof Top		25	25	0%	23-Jan-23	20-Feb-23
A2330	Top Roof Completed	0	0	0%		20-Feb-23
A2320	Laying of Concrete in Horizor	2	2	0%	18-Feb-23	20-Feb-23
A2310	Fixing of Formwork & Rebar i	6	6	0%	11-Feb-23	17-Feb-23
A2300	Pouring of Concrete in Vertic	5	5	0%	06-Feb-23	10-Feb-23
A2290	Fixing of Formwork of Roof T	5	5	0%	31-Jan-23	04-Feb-23
A2280	Fixing of Steel in Vertical Eler	6	6	0%	26-Jan-23	01-Feb-23
A2270	Survey Works and Layouts o	3	3	0%	23-Jan-23	25-Jan-23
KRL.6 Finishing Work		768	768	0%	17-Aug-21	29-Jan-24
KRL.6.1 Basement 3		48	48	0%	17-Aug-21	11-Oct-21
A2370	Laying Floor Screed of Base	28	28	0%	09-Sep-21	11-Oct-21
A2360	Applying Plaster Works of Ba	20	20	0%	06-Sep-21	28-Sep-21

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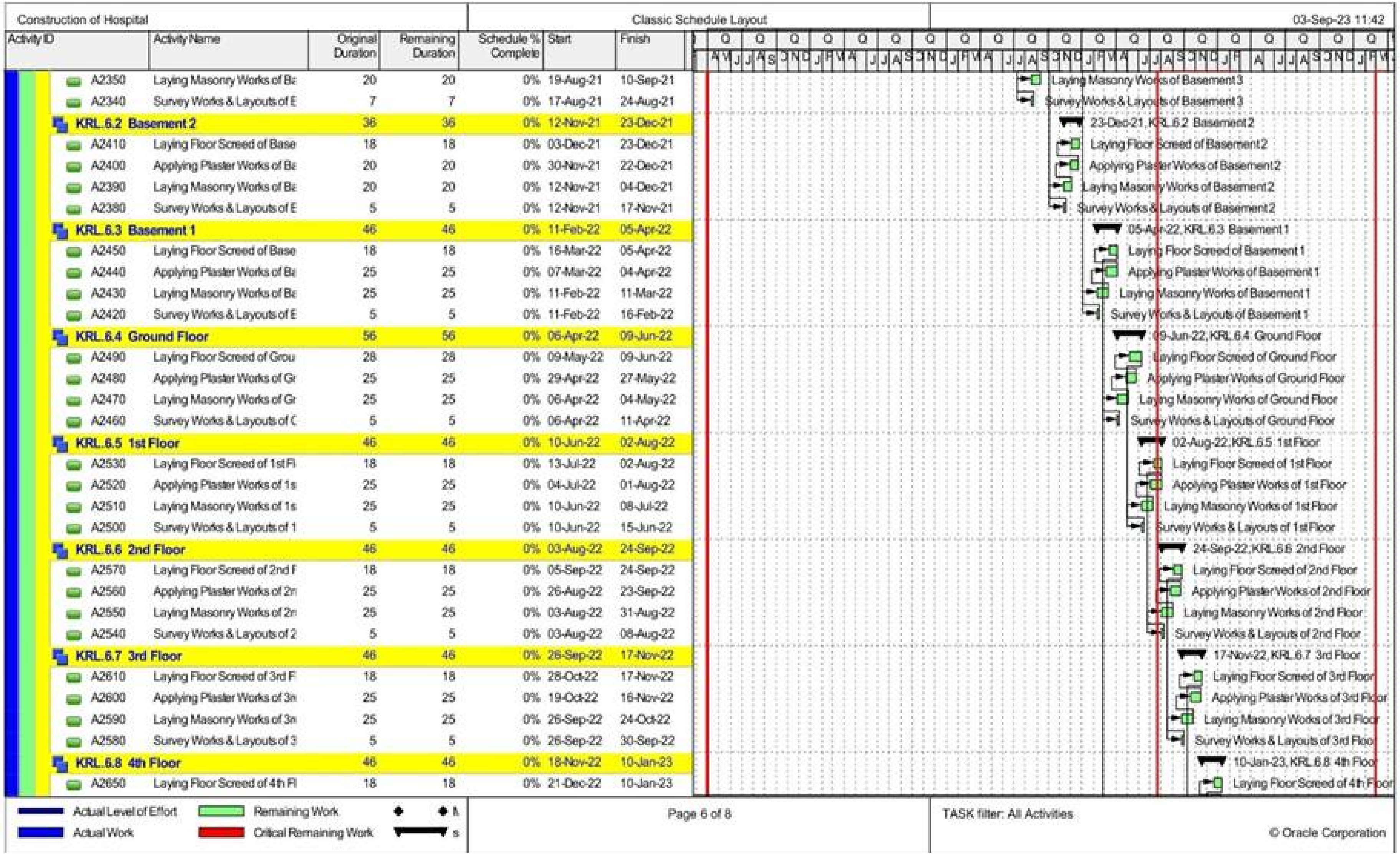

Construction of Hospital

Classic Schedule Layout

03-Sep-23 11:42

Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
A2350	Laying Masonry Works of Ba	20	20	0%	19-Aug-21	10-Sep-21
A2340	Survey Works & Layouts of E	7	7	0%	17-Aug-21	24-Aug-21
KRL.6.2 Basement 2		**36**	**36**	**0%**	**12-Nov-21**	**23-Dec-21**
A2410	Laying Floor Screed of Base	18	18	0%	03-Dec-21	23-Dec-21
A2400	Applying Plaster Works of Ba	20	20	0%	30-Nov-21	22-Dec-21
A2390	Laying Masonry Works of Ba	20	20	0%	12-Nov-21	04-Dec-21
A2380	Survey Works & Layouts of E	5	5	0%	12-Nov-21	17-Nov-21
KRL.6.3 Basement 1		**46**	**46**	**0%**	**11-Feb-22**	**05-Apr-22**
A2450	Laying Floor Screed of Base	18	18	0%	16-Mar-22	05-Apr-22
A2440	Applying Plaster Works of Ba	25	25	0%	07-Mar-22	04-Apr-22
A2430	Laying Masonry Works of Ba	25	25	0%	11-Feb-22	11-Mar-22
A2420	Survey Works & Layouts of E	5	5	0%	11-Feb-22	16-Feb-22
KRL.6.4 Ground Floor		**56**	**56**	**0%**	**06-Apr-22**	**09-Jun-22**
A2490	Laying Floor Screed of Grou	28	28	0%	09-May-22	09-Jun-22
A2480	Applying Plaster Works of Gr	25	25	0%	29-Apr-22	27-May-22
A2470	Laying Masonry Works of Gr	25	25	0%	06-Apr-22	04-May-22
A2460	Survey Works & Layouts of C	5	5	0%	06-Apr-22	11-Apr-22
KRL.6.5 1st Floor		**46**	**46**	**0%**	**10-Jun-22**	**02-Aug-22**
A2530	Laying Floor Screed of 1st Fl	18	18	0%	13-Jul-22	02-Aug-22
A2520	Applying Plaster Works of 1s	25	25	0%	04-Jul-22	01-Aug-22
A2510	Laying Masonry Works of 1s	25	25	0%	10-Jun-22	08-Jul-22
A2500	Survey Works & Layouts of 1	5	5	0%	10-Jun-22	15-Jun-22
KRL.6.6 2nd Floor		**46**	**46**	**0%**	**03-Aug-22**	**24-Sep-22**
A2570	Laying Floor Screed of 2nd F	18	18	0%	05-Sep-22	24-Sep-22
A2560	Applying Plaster Works of 2n	25	25	0%	26-Aug-22	23-Sep-22
A2550	Laying Masonry Works of 2n	25	25	0%	03-Aug-22	31-Aug-22
A2540	Survey Works & Layouts of 2	5	5	0%	03-Aug-22	08-Aug-22
KRL.6.7 3rd Floor		**46**	**46**	**0%**	**26-Sep-22**	**17-Nov-22**
A2610	Laying Floor Screed of 3rd F	18	18	0%	28-Oct-22	17-Nov-22
A2600	Applying Plaster Works of 3r	25	25	0%	19-Oct-22	16-Nov-22
A2590	Laying Masonry Works of 3r	25	25	0%	26-Sep-22	24-Oct-22
A2580	Survey Works & Layouts of 3	5	5	0%	26-Sep-22	30-Sep-22
KRL.6.8 4th Floor		**46**	**46**	**0%**	**18-Nov-22**	**10-Jan-23**
A2650	Laying Floor Screed of 4th Fl	18	18	0%	21-Dec-22	10-Jan-23

▬ Actual Level of Effort	🟩 Remaining Work	◆	◆ M
▬ Actual Work	🟥 Critical Remaining Work	▬	s

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TASK filter: All Activities

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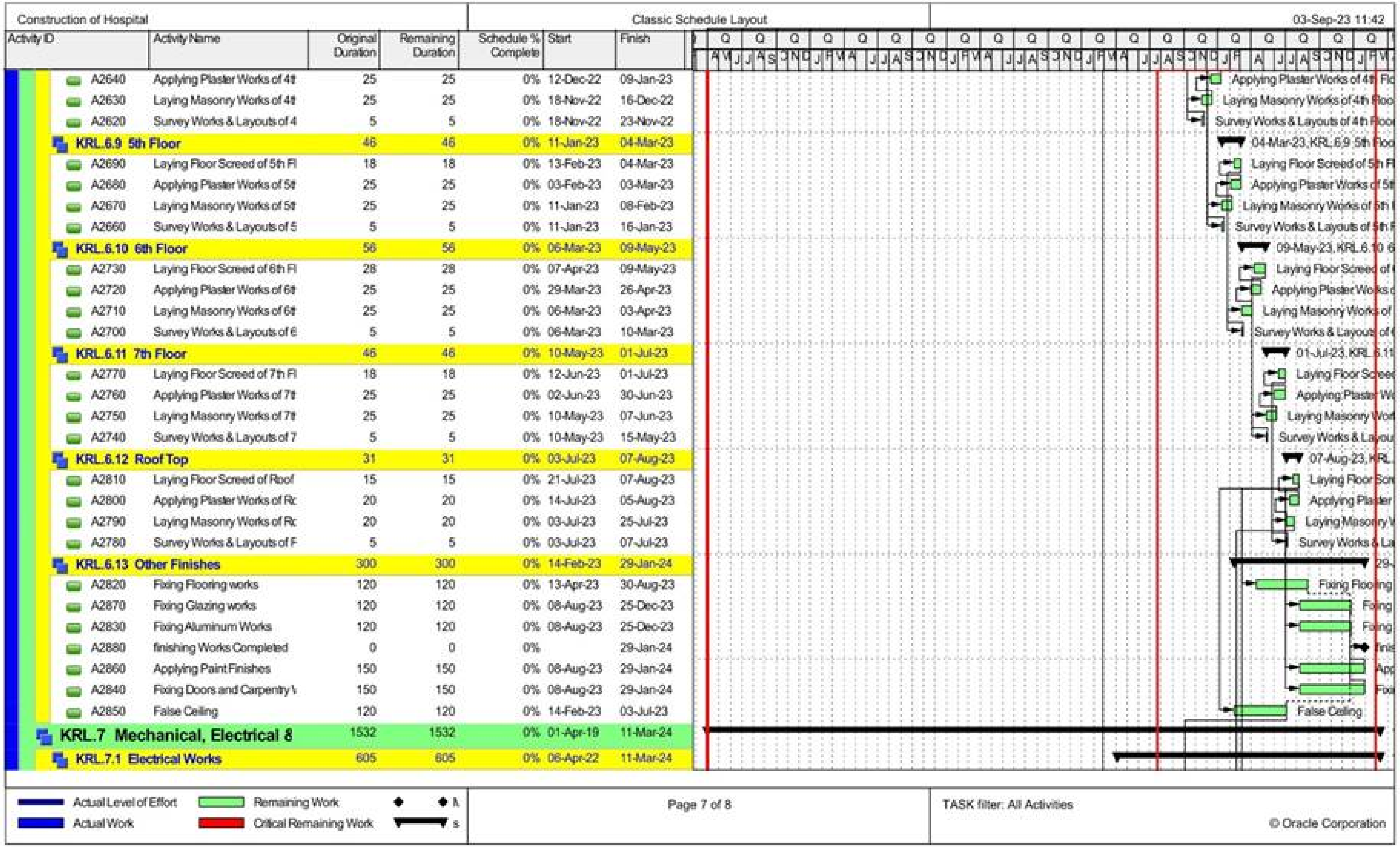

Construction of Hospital

Classic Schedule Layout

03-Sep-23 11:42

Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
A2640	Applying Plaster Works of 4th	25	25	0%	12-Dec-22	09-Jan-23
A2630	Laying Masonry Works of 4th	25	25	0%	18-Nov-22	16-Dec-22
A2620	Survey Works & Layouts of 4	5	5	0%	18-Nov-22	23-Nov-22
KRL.6.9 5th Floor		46	46	0%	11-Jan-23	04-Mar-23
A2690	Laying Floor Screed of 5th Fl	18	18	0%	13-Feb-23	04-Mar-23
A2680	Applying Plaster Works of 5th	25	25	0%	03-Feb-23	03-Mar-23
A2670	Laying Masonry Works of 5th	25	25	0%	11-Jan-23	08-Feb-23
A2660	Survey Works & Layouts of 5	5	5	0%	11-Jan-23	16-Jan-23
KRL.6.10 6th Floor		56	56	0%	06-Mar-23	09-May-23
A2730	Laying Floor Screed of 6th Fl	28	28	0%	07-Apr-23	09-May-23
A2720	Applying Plaster Works of 6th	25	25	0%	29-Mar-23	26-Apr-23
A2710	Laying Masonry Works of 6th	25	25	0%	06-Mar-23	03-Apr-23
A2700	Survey Works & Layouts of 6	5	5	0%	06-Mar-23	10-Mar-23
KRL.6.11 7th Floor		46	46	0%	10-May-23	01-Jul-23
A2770	Laying Floor Screed of 7th Fl	18	18	0%	12-Jun-23	01-Jul-23
A2760	Applying Plaster Works of 7th	25	25	0%	02-Jun-23	30-Jun-23
A2750	Laying Masonry Works of 7th	25	25	0%	10-May-23	07-Jun-23
A2740	Survey Works & Layouts of 7	5	5	0%	10-May-23	15-May-23
KRL.6.12 Roof Top		31	31	0%	03-Jul-23	07-Aug-23
A2810	Laying Floor Screed of Roof	15	15	0%	21-Jul-23	07-Aug-23
A2800	Applying Plaster Works of Rc	20	20	0%	14-Jul-23	05-Aug-23
A2790	Laying Masonry Works of Rc	20	20	0%	03-Jul-23	25-Jul-23
A2780	Survey Works & Layouts of F	5	5	0%	03-Jul-23	07-Jul-23
KRL.6.13 Other Finishes		300	300	0%	14-Feb-23	29-Jan-24
A2820	Fixing Flooring works	120	120	0%	13-Apr-23	30-Aug-23
A2870	Fixing Glazing works	120	120	0%	08-Aug-23	25-Dec-23
A2830	Fixing Aluminum Works	120	120	0%	08-Aug-23	25-Dec-23
A2880	finishing Works Completed	0	0	0%		29-Jan-24
A2860	Applying Paint Finishes	150	150	0%	08-Aug-23	29-Jan-24
A2840	Fixing Doors and Carpentry V	150	150	0%	08-Aug-23	29-Jan-24
A2850	False Ceiling	120	120	0%	14-Feb-23	03-Jul-23
KRL.7 Mechanical, Electrical &		1532	1532	0%	01-Apr-19	11-Mar-24
KRL.7.1 Electrical Works		605	605	0%	06-Apr-22	11-Mar-24

🟦 Actual Level of Effort
🟦 Actual Work
🟩 Remaining Work
🟥 Critical Remaining Work
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TASK filter: All Activities

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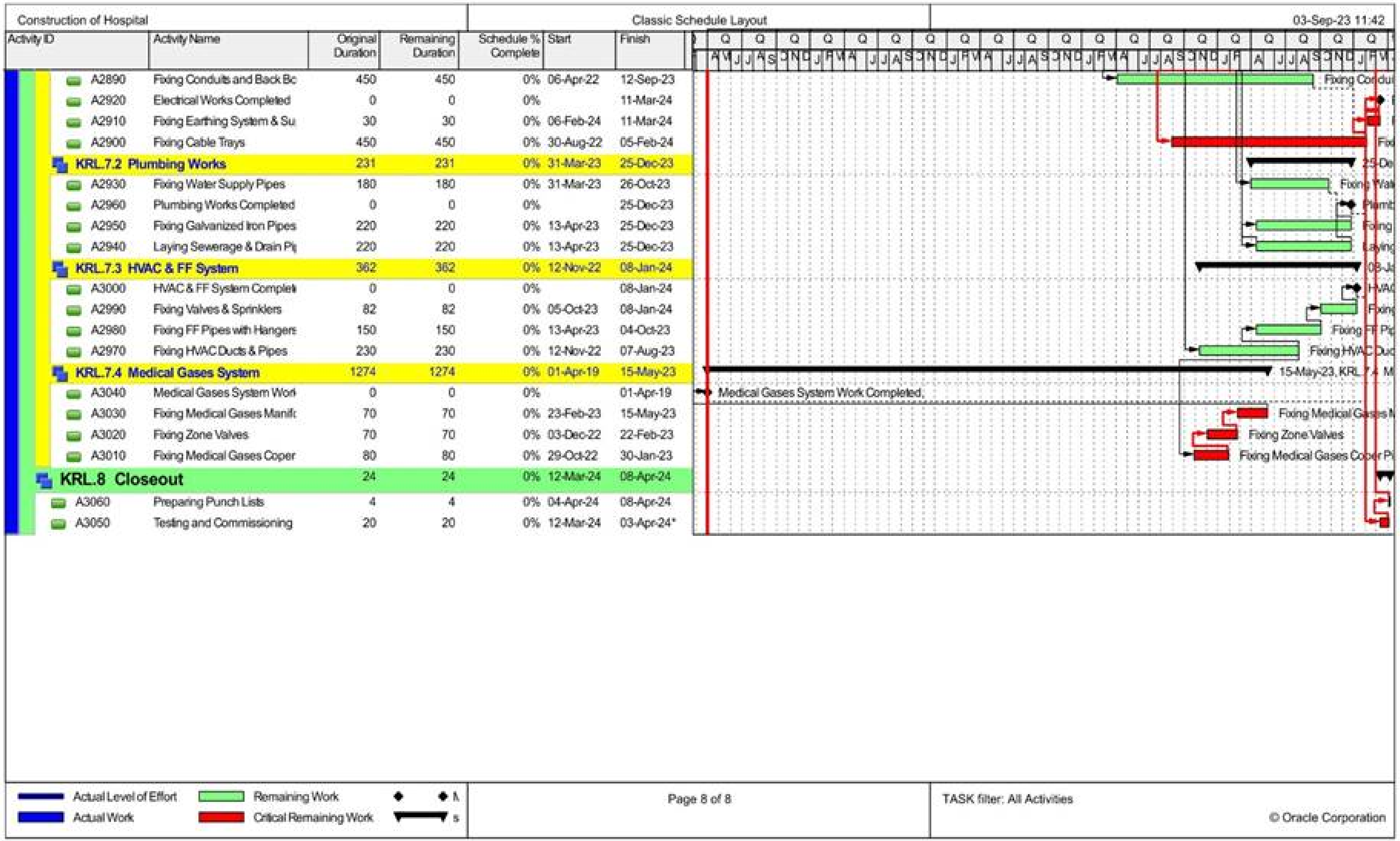

Construction of Hospital

Classic Schedule Layout

03-Sep-23 11:42

Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish
A2890	Fixing Conduits and Back Bc	450	450	0%	06-Apr-22	12-Sep-23
A2920	Electrical Works Completed	0	0	0%		11-Mar-24
A2910	Fixing Earthing System & Su	30	30	0%	06-Feb-24	11-Mar-24
A2900	Fixing Cable Trays	450	450	0%	30-Aug-22	05-Feb-24
KRL.7.2 Plumbing Works		231	231	0%	31-Mar-23	25-Dec-23
A2930	Fixing Water Supply Pipes	180	180	0%	31-Mar-23	26-Oct-23
A2960	Plumbing Works Completed	0	0	0%		25-Dec-23
A2950	Fixing Galvanized Iron Pipes	220	220	0%	13-Apr-23	25-Dec-23
A2940	Laying Sewerage & Drain Pi	220	220	0%	13-Apr-23	25-Dec-23
KRL.7.3 HVAC & FF System		362	362	0%	12-Nov-22	08-Jan-24
A3000	HVAC & FF System Complet	0	0	0%		08-Jan-24
A2990	Fixing Valves & Sprinklers	82	82	0%	05-Oct-23	08-Jan-24
A2980	Fixing FF Pipes with Hangers	150	150	0%	13-Apr-23	04-Oct-23
A2970	Fixing HVAC Ducts & Pipes	230	230	0%	12-Nov-22	07-Aug-23
KRL.7.4 Medical Gases System		1274	1274	0%	01-Apr-19	15-May-23
A3040	Medical Gases System Wor	0	0	0%		01-Apr-19
A3030	Fixing Medical Gases Manif	70	70	0%	23-Feb-23	15-May-23
A3020	Fixing Zone Valves	70	70	0%	03-Dec-22	22-Feb-23
A3010	Fixing Medical Gases Coper	80	80	0%	29-Oct-22	30-Jan-23
KRL.8 Closeout		24	24	0%	12-Mar-24	08-Apr-24
A3060	Preparing Punch Lists	4	4	0%	04-Apr-24	08-Apr-24
A3050	Testing and Commissioning	20	20	0%	12-Mar-24	03-Apr-24*

Actual Level of Effort
Actual Work
Remaining Work
Critical Remaining Work

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