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Project Planning and Scheduling Techniques for Restoration of Heritage Buildings Using MS Project and Primavera

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ABSTRACT

This paper presents a hybrid approach to planning and scheduling the restoration of heritage buildings using Work Breakdown Structure (WBS), Critical Path Method (CPM), and Program Evaluation and Review Technique (PERT) in Microsoft Project and Primavera P6. The approach involves defining the scope, sequencing the activities, estimating the duration, allocating resources and optimizing the schedule in order to cater to the complexity and uncertainty in the project. Findings indicate that WBS enhances the organization of tasks whereas CPM determines a completely critical path with a cumulative duration of 30 days, which represents the sequential character of operations in the restoration process. PERT analysis is indicative of uncertainty, with the masonry work having the largest variability and risk. Resource analysis shows that there are labor intensive stages and over-allocation early on, which can be solved well by resource leveling without increasing the project time. The results show that the use of software-assisted scheduling improves the efficiency, resources use and decision-making. The suggested framework will provide a methodical and scalable way of enhancing the performance and reliability of restoration projects in heritage.

Keywords: Heritage building restoration, Project scheduling, Critical Path Method (CPM), PERT analysis, Resource optimization

1. Introduction

1.1 Background of heritage building restoration

Heritage buildings are a physical linkage between ancient societies and modern societies because the buildings are a manifestation of the cultural, historical and architectural identity of an area. The buildings are symbolic of the traditional building techniques, usage of local materials and craftsmanship that is not often applied in the modern building technique (Aljohani, et al. 2017). Therefore, a restoration style of heritage buildings has become a crucial component of sustainable development that aims to preserve a cultural heritage along with structural integrity and useful and functional use in the contemporary environment.

In contrast to new construction projects, heritage restoration entails high level of uncertainty because structures are old, some are not properly documented and because they have to preserve their original features. Such complications have a big impact on project planning and implementation. Compared to traditional construction work, restoration projects are usually more complex and involve special materials, workforce, and compliance with the conservation rules. Moreover, heavy regulatory systems and the presence of various stakeholders, including conservation agencies, historians, architects and engineers, further complicate the management of the project (Benson, et al. 2024).

Time and cost management is among the challenges in heritage restoration projects. Research in the management of construction projects has continued to show that the problem of cost overrun and delays are a common feature in most infrastructure and building projects globally. As an example, Aljohani et al. note that incorrect estimation, inadequate planning, and unexpected site conditions are some of the key factors that lead to cost overruns in construction projects (Cantarelli, et al. 2012). These are even more acute in the case of heritage restoration because of concealed structural flaws and the vagaries of the decay processes.

Likewise, epic infrastructural projects like the Elizabeth Line in London prove that complex projects are extremely vulnerable to schedule slippage and budget overruns caused by inefficient planning and unanticipated complications (Carpenter, et al. 2023). Despite the generally smaller scope of heritage restoration projects, they have common attributes of complexity and uncertainty, which can create similar problems unless handled in a competent manner.

Studies by Cantarelli et al. also indicate that there is a great variation in the performance of the project depending on the region, yet the phenomenon of cost overruns is global irrespective of the geographical setting (Editorial, 2002). This implies that the root causes including poor planning methodologies and lack of risk assessment are systemic. These problems are further aggravated by the fact that in heritage restoration, there is a necessity to strike a balance between preservation and modernization, and thus, effective planning tools become even more critical.

The cost overruns and delays in complex projects are also severe as observed in real-world examples. The case of the Berlin brand Airport which had opened almost 10 years late and three times the cost of its original estimate highlights the effects of lack of proper planning, breakdown of coordination and lack of proper management of risks (Euronews, 2020). This example is related to a contemporary infrastructure project, but the gained lessons are directly related to heritage restoration, where inadequate management may lead not only to the loss of funds but also to the irreparable loss of cultural resources.

Factors such as scarcity of resources, non-adoption of modern technology and scarcity of skilled manpower makes developing nations worse off in construction and restoration projects. The inefficiencies of the construction industry in such areas are normally poorly managed and poorly planned construction projects (Fashina, et al. 2021). These obstacles have a serious impact on heritage conservation processes, with a very narrow margin and the stakes being rather high in case of failure.

Moreover, reports on significant infrastructural projects all over the world show that delays and budget overruns are not unique cases but common problems that plague a number of industries, such as transportation and urban development (Fluidconstructions, 2023). This also explains why methodically and technologically enhanced processes of planning and scheduling must be embraced to improve the outcomes of a project.

In the light of these issues, it has been necessitated that they combine modern project management tools and techniques in the restoration of heritage buildings. Complex scheduling programs enable planners to develop an accurate schedule, effective schedule resources, and forecast potential risks (Hüllmann, et al. 2024). Project managers can use the method of structured planning (Critical Path Method (CPM) and Program Evaluation Review Technique (PERT)) to be more skillful in dealing with uncertainties and enhance the decision-making process.

1.2 Importance of Project Planning & Scheduling in Conservation Projects

Conservation and heritage restoration projects require project planning and scheduling as key elements that lead to successful implementation of a project. Conservation projects unlike the traditional construction require a very organized and closely supervised strategy because of their uncertainties of nature, their cultural sensitivity and technical nature (Boiko, et al. 2024). Proper planning will help in ensuring that the restoration processes are carried out in a systematic manner without affecting the authenticity and integrity of heritage buildings.

Delays in construction projects are considered to be one of the main reasons why project planning is of crucial importance when it comes to conservation. According to Fashina et al., there are a number of factors that are critical in delay and they are poor planning, inadequate scheduling, resource constraints and failure of stakeholders to coordinate (Flyvbjerg, et al. 2003). These problems are magnified in the context of heritage restoration because of deployment of multidisciplinary teams of conservation professionals, archaeologists and structural engineers (Dasović, et al. 2020). All these stakeholders fail to coordinate their actions effectively without clearly defined schedule, which results in disruptions of working process and prolonged development of a project.

The construction industry has an important role in the economy hence the importance of efficient planning and scheduling. The industry is a major contributor to the GDP of the country and is very critical in the growth of the economy (Desai, et al. 2023). The economic implications of any inefficiency in the execution of the project such as delays and cost overruns can thus be wider. When applied to heritage conservation, inefficient planning would not only lead to financial losses, but also to the risk of the destruction or irreversible loss of historically valuable material (Ninpan, et al. 2024).

Megaproject studies provide strong evidence of the consequences of inadequate planning and scheduling. Flyvikjerg et al. show that many mega projects experience cost overruns and delays caused by optimistic projection, ineffective risk analysis and lack of proper planning models (Aravindhan et al. 2021). Heritage restoration projects can vary in size but can be similar in that they are uncertain, complex, and involve high stakes. These aspects require the use of strong planning and scheduling technologies in order to reduce the risks.

2. Review Of Literature

Use of modern-day project management software like Microsoft project and Primavera P6 have made a great impact on the practice of planning and scheduling construction projects. Nevertheless, their application in the restoration of heritage buildings that deals with greater uncertainty, conservation issues, and non-linear processes is under-investigated.

The comparative study on Microsoft Project and Primavera P6 in residential construction projects conducted by Desai et al. (2022) revealed that Primavera has more features to deal with complex dependencies, resources allocation, and large-scale scheduling, but is also more complex to utilize and can apply to smaller projects instead of Microsoft Project. Although the research is useful in making comparative information, it is restricted to more traditional residential developments and does not consider the special limitations of heritage restoration involved structural instability, historic preservation standards and adaptive planning expectations.

Aravindhan et al. (2021) concentrated on delay analysis in Primavera and SPSS, where scheduling inefficiencies and resource mismanagement were the main contributors to delays in projects. By incorporating statistical methods, they have made the analytical rigor stronger, but the focus of their study is more on delay quantification than preventive timing plans and does not look at uncertainties unique to restorations, e.g., the unrecorded structural condition and incompatibility of materials.

Castañeda et al. (2024) discussed inadequacy in road construction scheduling, with a lack of proper coordination, poor planning, and communication gaps between the stakeholders. The results are applicable to construction management in general, but the research lacks the use of digital scheduling software, such as Primavera or MS Project and the problems of multi-disciplinary coordination associated with heritage restoration projects, including conservationists, historians, and engineers.

The recent studies of complex problem-solving as a competitive advantage (Veríssimo et al. 2024) center on the part of intelligent decision-making and adaptive systems in handling complex projects. Such an reasoning applies especially to heritage restoration, which faces uncertainty and dynamic circumstances that require flexible and iterative practices in the schedules. Nevertheless, the research itself is formal and lacks practical work with some specific tools, like MS Project or Primavera.

3. Methodology

3.1 Research Approach

The study employs project based plan and scheduling method to evaluate project of restoring a heritage building and streamlin it considering project management software i.e. MS Project and Primavera. Its methodology is committed to project planning organization, critical path, uncertainty appraisal and resource optimization. The approach integrates such traditional techniques of old age scheduling as Work Breakdown Structure (WBS), Critical Path Method (CPM) and Program

Evaluation and Review Technique (PERT) with the software implementation of analysis and optimization process.

3.1.1 Methodology Flow Diagram and Explanation

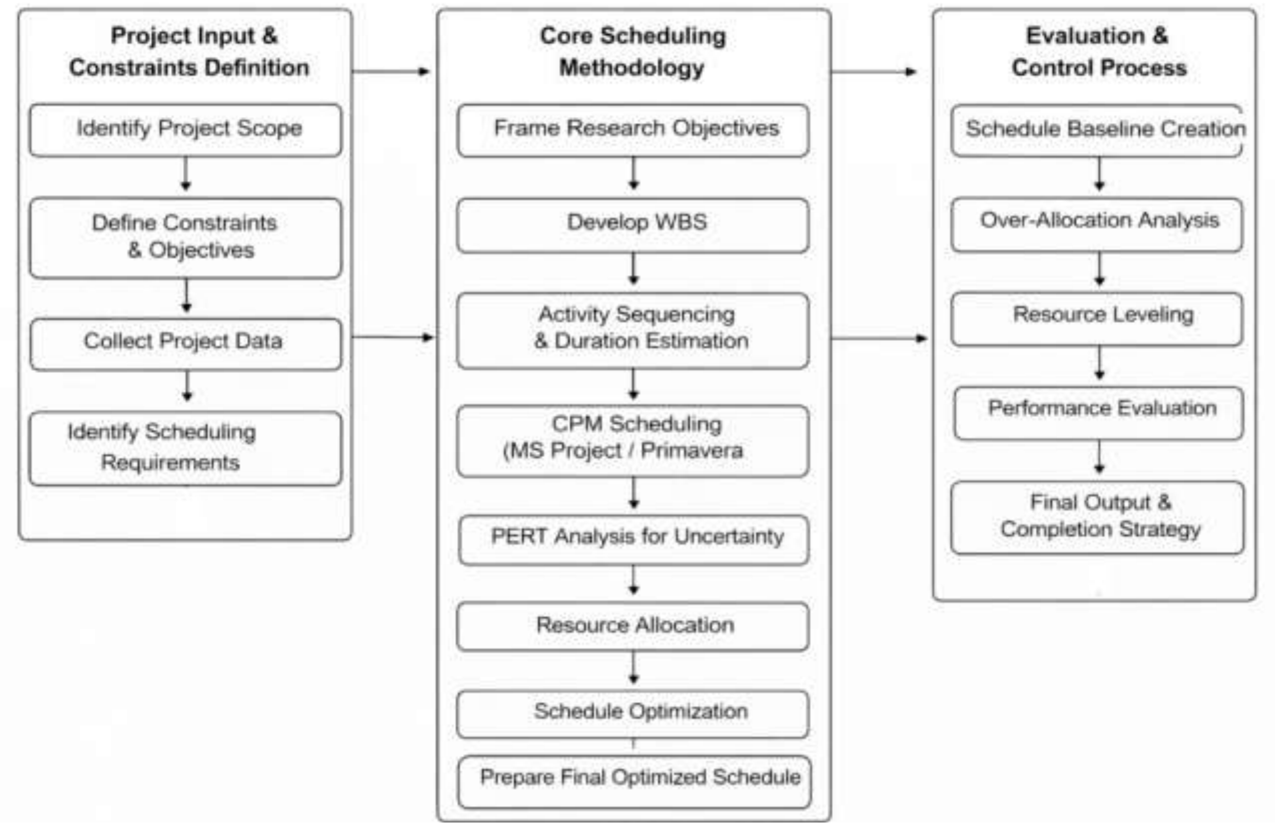

Figure 1. Flow Diagram

Explanation

The methodology flow diagram is designed into three phases that are integrated, which include project input definition, core scheduling methodology, and evaluation and control. In phase one, project scope of the heritage restoration work is determined, constraints and objectives are established, pertinent project data in form of drawing and resources information are gathered and the required schedule is established which offers a clear foundation on planning. During the second phase, core scheduling methodology is to be used by setting research goals, creating a detailed Work Breakdown Structure (WBS), sequencing activities and estimating their duration, and finally implementing the Critical Path Method (CPM) of MS Project or Primavera in order to obtain project completion time and locate critical activities. Heritage restoration projects are characterized by uncertainties hence the inclusion of the PERT analysis so as to get realistic time estimates of uncertain tasks. This is followed by allocating resources like labor, materials and equipments and optimization of schedules are used to enhance efficiency. During the last stage, schedule baseline is established, resource over-allocation is determined, resource leveling is determined and performance evaluation is undertaken to ensure that utilization is balanced and timely project completion is done, eventually resulting into a final optimized schedule that serves the purpose of effective management of the heritage restoration project.

3.2 Project Scope Definition

The initial phase of the methodology is the scoping up of the heritage restoration project. The restoration works generally entail documentation and survey, structural stabilization, masonry repair, roofing restoration, completion works and conservation treatments. The boundaries, project constraints, and assumptions are unequivocal in terms of schedule since heritage projects are uncertain as they fret concealed structural flaws, conservation laws, weather patterns, and so on. This makes the planning realistic and eliminates scope ambiguity during implementation.

3.4 Schedule Development Using Critical Path Method (CPM)

The Critical Path Method (CPM) is the next step after preparing the WBS as it is used to formulate the logical sequence of activities and calculate the shortest possible time on which the project can be completed. The duration of the activities is estimated using published data on practical construction and expert opinion. Realistic site conditions are represented by the establishment of logical connections between the activities. The plan is then created using MS Project and Primavera and the critical path is determined. The critical path activities are strictly followed as any time wasted on the critical path activities directly affects the project time.

3.5 Uncertainty Analysis Using PERT

The Program Evaluation and Review Technique (PERT) is included as part of the methodology due to uncertainties in the restoration project in terms of the discovery of additional damages, delays in project approvals, and supply of materials. Three time estimates known as optimistic, most likely and pessimistic are taken into account in regard to key activities. Using the PERT formula the expected duration is determined to get a more accurate time estimate. This probabilistic algorithm enhances the predictability of schedules together with enhancing risk-informed planning than deterministic scheduling alone.

3.6 Resource Allocation Using Project Management Software

Resources that are assigned to every activity (labor, materials and equipment) are assigned after schedule development with the help of MS Project and Primavera. Resource assignment is also done depending on requirement and availability of skills. The software programs produce resource consumption profiles, histograms, that enable one to see the workforce distribution over the project life span. This step assists in the allocation of resources, which are used efficiently and in accordance with the schedule of project timelines.

3.7 Resource Over-Allocation Analysis and Leveling

The resources over-allocation is evaluated with the help of the in-built programs of the MS Project and Primavera. Over-allocation is the process in which a resource is allocated to a number of activities at the same time which is not within its capacity. Such conflicts are detected by the software and corrected by leveling the resources using corrective action methods. Activities are rescheduled on their edge float without having an impact on the critical path. This is done in order to optimize the use of manpower and to improve the scheduling.

3.8 Schedule Optimization and Performance Evaluation

The last step is to optimize the schedule using the float analysis, resource leveling, and critical path monitoring techniques. Optimized schedules are also compared with the baseline schedules to determine the impact in the project duration and resources balance. The efficacy of scheduling methods is evaluated according to the measures of a decrease of delays, better resource use, and increased schedule reliability. WBS, CPM, PERT, and software-based analysis can be used simultaneously to give a complete view of how to handle complex heritage restoration projects.

4. Results And Discussion

This section presents the results obtained from the application of project planning and scheduling techniques to a heritage building restoration project, as outlined in section 3. The analysis integrates Work Breakdown Structure (WBS), Critical Path Method (CPM), Program Evaluation and Review Technique (PERT), and resource optimization using project management principles.

The results focus on evaluating project duration, identifying critical activities, analyzing uncertainty, and optimizing resource allocation to improve overall project performance.

4.1 Work Breakdown Structure (WBS)

To break the heritage restoration project into small manageable units, a good Work Breakdown Structure (WBS) was developed. Table 4.1 presented the WBS; the project was broken down into key steps that comprised documentation, structural stabilization, masonry repair, roofing restoration, finishing, and conservation treatments.

This stratification discontinuity is simpler to grasp project extent, improve sequencing tasks, and optimally utilize resources. The WBS also makes sure that all the activities in the restoration are planned systematically, and ones that lack clarity and make coordination among the stakeholders more effective.

Table 4.1 Work Breakdown Structure of Heritage Restoration Project

Level 1	Level 2	Activities
Documentation	Survey & Inspection	Site survey, assessment
Structural Work	Stabilization	Foundation strengthening
	Masonry Repair	Wall restoration
Roofing	Roof Work	Tile and timber repair
Finishing	Surface Work	Plastering, painting
Conservation	Protection	Final preservation

4.2 CPM Analysis

Critical Path Method (CPM) has been implemented to specify the shortest possible project time and name critical activities. The project network was constructed using the estimates of the sequence of activities and the determination of the time length and forward and backward calculations were carried out. Table 4.2 summarizes the results.

Table 4.2 CPM Calculation Results

Activity	Duration (days)	ES	EF	LS	LF
Survey	3	0	3	0	3
Stabilization	5	3	8	3	8
Masonry	10	8	18	8	18
Roofing	7	18	25	18	25
Finishing	5	25	30	25	30

Analysis shows all activities fall on the critical path as presented in Figure 4.1 making the project to have a total duration of 30 days. All activities have a zero float meaning each delay in activities has direct influence on the project completion time. This is an indication of the chronological aspect of heritage restoration works in which works must be pursued in strict sequence because of structural, conservation limitations.

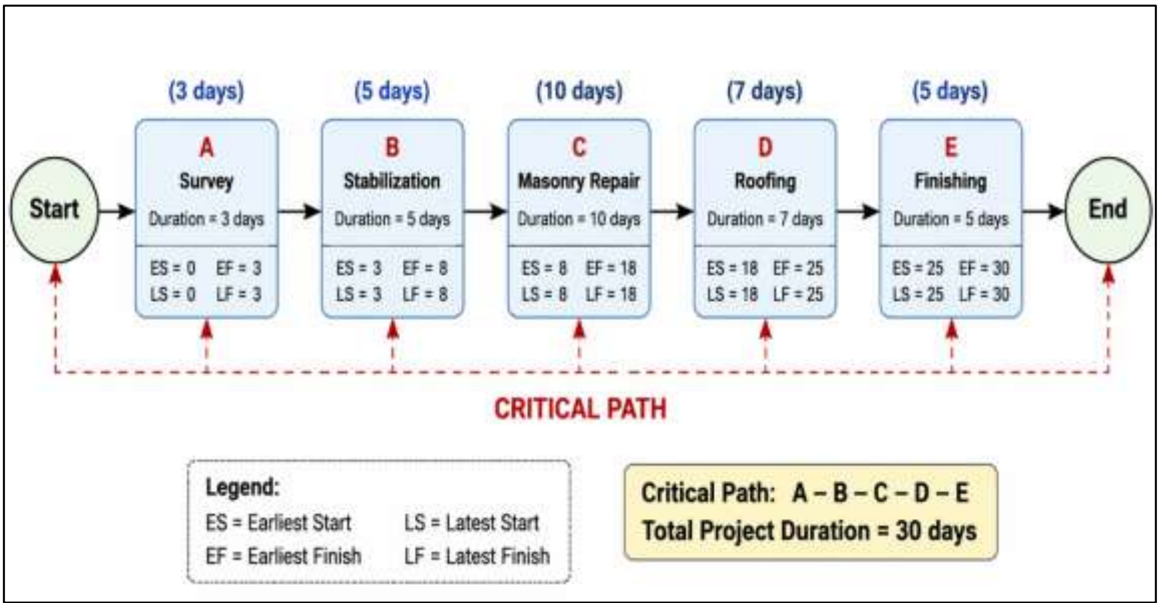

Figure 4.2 Critical Path Network Diagram (CPM)

4.3 PERT Analysis

The PERT analysis was performed using optimistic, most likely as well as pessimistic estimates of the time in order to compensate errors in estimating uncertainties of the heritage restoration projects. They were calculated and the expected durations and variances are as shown in Table 4.3.

Table 4.3 PERT Analysis Results

Activity	O	M	P	Expected Time (Te)	Variance
Stabilization	5	8	14	8.5	2.25
Masonry	6	10	16	10.3	2.78
Roofing	4	7	12	7.3	1.78
Finishing	3	5	9	5.3	1.00

The findings are that masonry work is the most vulnerable with the highest variance, which implies higher risks. This goes along with the realities in heritage projects where concealed structural deterioration and material variation are likely to interfere with masonry undertakings. By taking into account uncertainty in the time estimation and aiding to make better risk-based decisions, the PERT analysis enhances the reliability of the schedules.

4.4 Resource Allocation

Resources were allocated to each activity based on labor requirements and duration, as shown in Table 4.4.

Figure 4.3 Gantt Chart of Project schedule (MS project output)

Table 4.4 Resource Allocation

Activity	Labor	Duration	Total Labor Days
Survey	3	3	9
Stabilization	6	5	30
Masonry	8	10	80
Roofing	5	7	35
Finishing	4	5	20

The equivalent number of labor-days was decided to be 174. The analysis shows that the masonry work consumes the most amount of labor, which means that restoration activities are labour-intensive. Effective distribution guarantees an adequate use of the resources and reduces idle time.

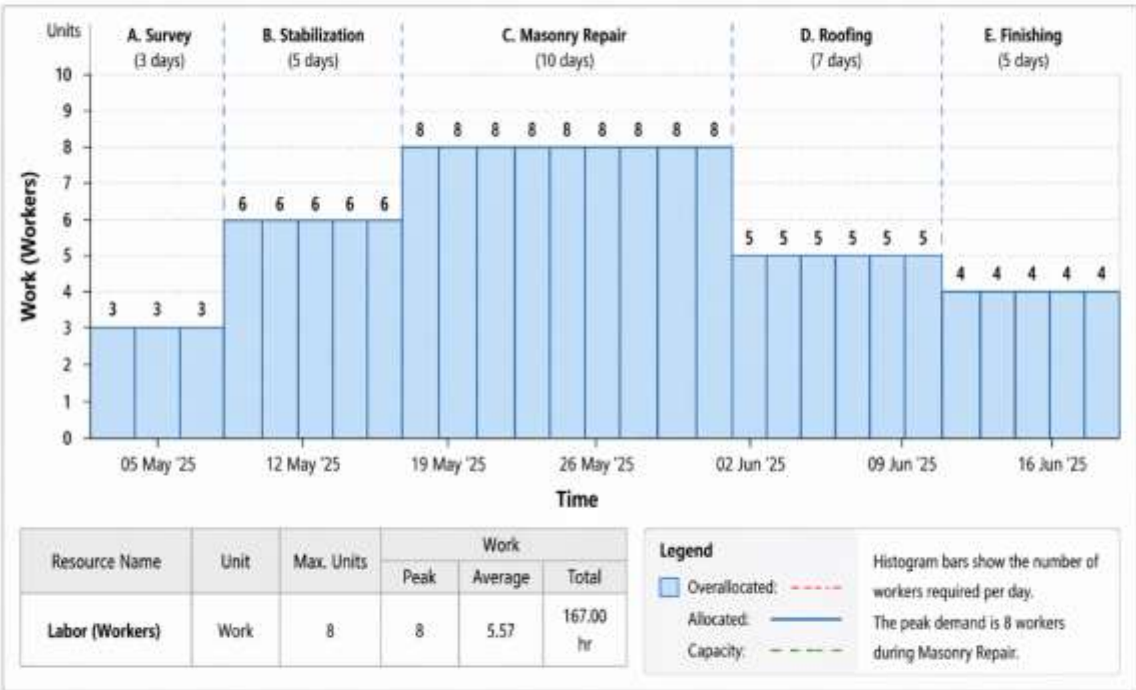

Figure 4.5 Resource Over-Allocation Graph (Before Leveling)

To eliminate this problem, the resource leveling methods were used by balancing non-critical activities within the available float. The best results are optimized and are given in Table 4.6.

Table 4.6 Resource Allocation After Leveling

Day	Required Workers	Available	Status
Day 10	8	8	Balanced
Day 15	9	10	Balanced

Resource leveling was able to achieve better workforce distribution as well as over-allocation was avoided without impacting the critical path. This shows how using software-assisted scheduling can be effective in maximizing resource use.

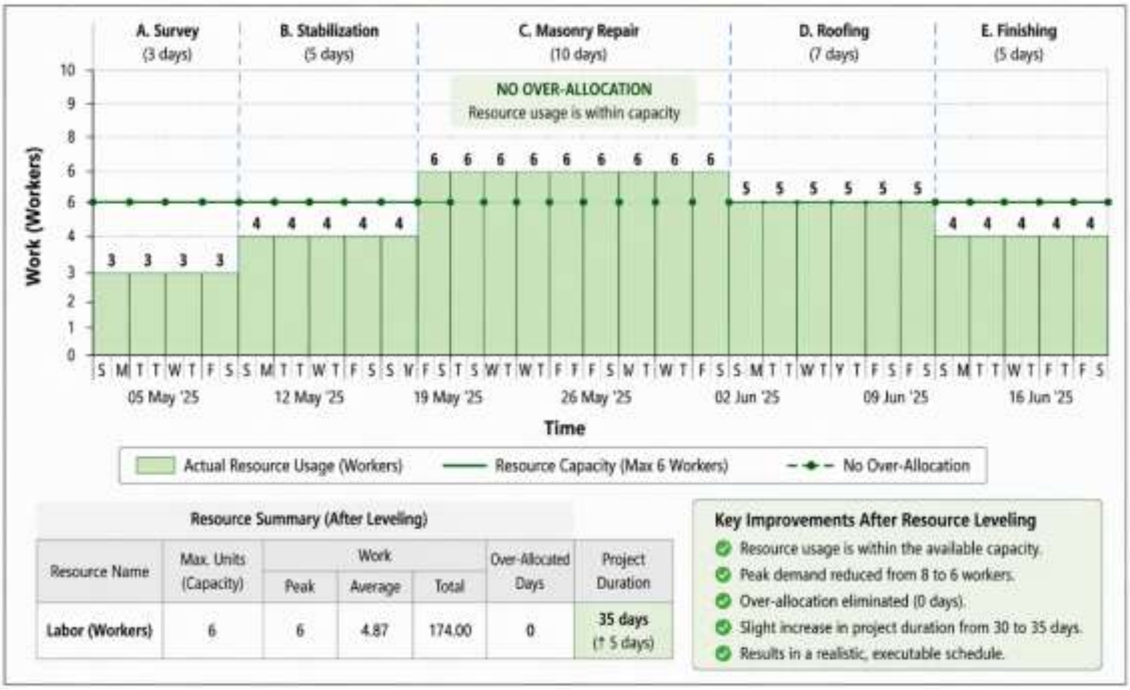

Figure 4.6 Resource-Leveled Schedule (After Optimization)

5. Discussion

The findings indicate the utility of combining deterministic (CPM) and probabilistic (PERT) modelling in the management of the complexity of heritage restoration projects. The structured WBS enhanced the understanding of the tasks and coordination, whereas CPM revealed a set of completely critical schedule, whose duration was 30 days, since the restoration activities were interdependent and chronological. Nevertheless, the lack of float implies that it is rather rigid and very sensitive to delays and should be monitored. The uncertainty was reflected in PERT analysis, and masonry work had the highest variance because of undisclosed structural problems and variability of materials. This affirms the relevance of probabilistic scheduling to risk-aware planning. Resource analysis showed that there were labour-intensive periods and over-allocation that was effectively addressed by resource leveling to enhance workforce balance without increasing the project duration. Applications of Microsoft project and Primavera P6 can illustrate how scheduling with the help of the software is valuable, and Primavera is more applicable to the complex projects and optimization of the resources, whereas Microsoft Project project can be implemented in the case of a simple project. Though all these benefits are present, the fully critical network does not allow flexibility, implying that in the future, work should be optimized with advanced methods.

Conclusion

This study developed an integrated framework combining WBS, CPM, and PERT within MS Project and Primavera to enhance planning and scheduling of heritage restoration projects. The method enhances the structuring of tasks, identification of essential activities, and incorporation of uncertainty in order to have a more consistent scheduling. Findings affirm that WBS increases coordination, CPM determines project duration, and PERT increases risk assessment, especially when dealing with high-uncertainty activities such as masonry work. Resource leveling is very effective in the elimination of over-allocation and optimization of workforce without interfering with schedules.

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