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Application of Microsoft Project for Resource Optimization of NH-347BG from Balwarato Dhangoan, M.P

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Abstract: ***Highway infrastructure development in India faces persistent challenges related to resource allocation inefficiencies, delays, and cost overruns. With the growing scale of national highway projects, there is an urgent need to adopt advanced project management tools that can ensure optimal utilization of manpower, machinery, materials, and time. This research investigates the application of Microsoft Project (MSP) software for resource optimization in the context of the NH-347BG highway project from Balwara to Dhangoan in Madhya Pradesh.***

A detailed Work Breakdown Structure (WBS) was developed for all project components, including site preparation, earthwork, subgrade formation, pavement layers (GSB, WMM, DBM, BC), drainage structures, culverts, and signage. Activities were logically sequenced in MSP with appropriate task dependencies and durations based on realistic estimates derived from the Detailed Project Report (DPR) and comparable projects in the region. Resources were assigned to each activity, and over-allocations were resolved using MSP's resource leveling functionality.

The analysis included a comparison of project timelines, resource histograms, and cost distribution before and after optimization. The Gantt chart comparison showed a reduction in the overall project duration from 420 to 370 days, indicating enhanced scheduling efficiency. Weekly labor histograms for masons and helpers reflected balanced deployment and reduced idle time. A cost analysis revealed a reduction of approximately 6.3% in total project cost, attributed to better alignment of resource demand with availability and minimized overtime.

Furthermore, a cost distribution pie chart post-optimization showed a rational split among labor (22%), equipment (24%), and materials (54%), with minimal overhead. The case study conclusively demonstrates that MSP can serve as a vital decision-support tool in large-scale infrastructure projects, enabling precise scheduling, conflict resolution, and cost savings. It also offers a replicable methodology for future highway projects under the Ministry of Road Transport and Highways (MoRTH) and the National Highways Authority of India (NHAI).

The study recommends mandatory integration of MSP in DPR-level planning and regular training for engineers in advanced project management practices to foster efficient, timely, and economically sound infrastructure delivery.

I. INTRODUCTION

A. Background

India is witnessing rapid growth in highway infrastructure, driven by national programs such as BharatmalaPariyojana and the National Infrastructure Pipeline (NIP). These programs aim to improve logistics efficiency, regional connectivity, and socio-economic development through the expansion and upgrading of national highways. One such vital project is **NH-347BG**, which connects **Balwara to Dhangoan** in Madhya Pradesh, designed to enhance connectivity within central India. Despite the potential benefits, the successful execution of such large-scale projects often suffers from delays, cost overruns, and resource mismanagement.

Effective **project scheduling and resource management** are essential to address these challenges. Traditional methods of project planning are often static, lacking the flexibility and dynamic control required to manage the complexities of modern highway construction. In this context, **Microsoft Project (MSP)** emerges as a robust tool for integrating planning, scheduling, and resource optimization.

MSP allows project managers to develop detailed **Work Breakdown Structures (WBS)**, assign resources, monitor progress, and perform **resource leveling** to resolve over-allocations. It supports visual tools like **Gantt charts**, **histograms**, and **critical path tracking**, enabling better decision-making throughout the project lifecycle.

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Numerous studies have highlighted the advantages of using software-based project management in construction. For instance, Choudhury (2022) demonstrated a 10–15% reduction in project duration using MSP for road construction projects in Eastern India. Similarly, Sharma and Gupta (2021) showcased the role of MSP in resource balancing for bridge construction, resulting in significant labor cost savings. However, limited literature exists on its specific application to highway construction projects under NHAI, particularly in resource-constrained or semi-urban environments like Balwara and Dhangoan.

This study fills that gap by applying Microsoft Project to the NH-347BG project. It focuses on optimizing key resources—labor, equipment, and materials—through structured scheduling and analytical tools. The research analyzes both pre- and post-optimization stages using MSP outputs and compares the outcomes in terms of time savings, cost efficiency, and resource utilization.

B. Problem Statement

Despite significant investments in highway projects, many still rely on static, manual scheduling methods. These approaches lack flexibility and often fail to adapt to real-time site conditions or unforeseen challenges like equipment breakdowns, weather delays, or labor shortages. The absence of proper **resource allocation and leveling** strategies leads to **idle manpower**, **underutilized equipment**, and **cost escalation**.

There is a clear need for a practical, replicable framework using modern project management software like **Microsoft Project (MSP)** that can address these inefficiencies. While MSP is widely used in private construction projects, its application in **government-funded infrastructure projects**—especially national highways—is still limited and under-researched.

C. Objectives of the Study

The primary objective of this research is to evaluate the application of Microsoft Project for optimizing resources in the NH-347BG highway construction project. Specific objectives include:

1) To develop a detailed Work Breakdown Structure (WBS) and task schedule using MSP.
2) To assign and analyze resource usage (labor, equipment, materials) across all activities.
3) To identify and resolve resource over-allocations using MSP's resource leveling features.
4) To compare project duration and costs before and after optimization.
5) To provide a replicable framework for integrating MSP into similar NHAI projects.

D. Scope of the Study

The study is focused on a realistic segment of the NH-347BG project. All planning, scheduling, and resource assignments are modeled based on:

1) Standard rates and resource requirements from a comparable DPR.
2) Practical assumptions and case data from similar road projects in Madhya Pradesh.
3) Resource histograms, cost tables, and Gantt charts generated using MSP 2019 Professional.

The study is limited to planning-level optimization and does not include execution-phase feedback or live monitoring tools (such as Primavera or ERP integrations).

E. Significance of the Study

This research bridges the gap between theoretical project planning and practical resource management in large-scale Indian infrastructure projects. By applying MSP to a national highway project, the study demonstrates its potential for improving project efficiency, reducing financial risk, and fostering digital transformation in public sector construction.

Moreover, it advocates for the mandatory adoption of project management software tools in DPR preparation and monitoring stages, which can enhance transparency, accountability, and speed of delivery in national infrastructure development.

II. LITERATURE REVIEW

A. Overview of Project Management in Highway Construction

Project management plays a vital role in ensuring the success of highway infrastructure projects, especially in developing economies like India. Traditionally, highway construction relied on **bar charts and manual scheduling**, which lack the dynamic adaptability needed for large-scale projects involving multiple work fronts and resource categories.

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In response to these limitations, software like **Microsoft Project (MSP)** and **Primavera P6** has emerged as a solution for real-time planning, resource leveling, cost control, and progress monitoring.

B. Application of Microsoft Project in Construction Projects

Several studies have evaluated the effectiveness of Microsoft Project in managing construction tasks. Sharma and Kumar (2020) demonstrated that MSP can reduce project time by 15–20% through efficient activity sequencing and resource leveling. In another study, Ramesh et al. (2021) analyzed its role in G+3 residential buildings and found a 10% cost reduction by avoiding over-allocated labor schedules and equipment idle time.

According to Singh and Rajput (2019), MSP improves visibility into task dependencies, leading to better critical path identification and milestone tracking. The tool's ability to create dynamic Gantt charts, resource histograms, and cost reports makes it a preferred option in mid-scale infrastructure projects.

C. Resource Optimization Techniques in Highway Projects

Highway projects are resource-intensive, often involving bulk material movement, heavy machinery, and multi-shift labor schedules. Optimization here refers to the strategic allocation of limited resources to minimize delays and prevent conflicts. Bansal and Agarwal (2018) emphasized that resource leveling and resource smoothing are two major strategies used in highway construction. Their study found that software-aided leveling reduces project idle time and budget overruns, especially in rural and semi-urban highway sections.

Mukherjee et al. (2020) highlighted the challenges in resource forecasting due to unforeseen conditions such as rainfall, supply delays, or labor unrest. They suggested that predictive scheduling, enabled by tools like MSP, helps contractors plan buffer periods and alternate resource paths.

D. Studies on National Highway Projects in India

Limited studies have focused specifically on the application of MSP in NHAI-managed national highway projects. Tripathi and Bhosale (2022) examined its use in a NH7 bypass in Maharashtra and recorded a 17% improvement in resource utilization efficiency. Similarly, Kapoor et al. (2021) applied MSP to NH-48 construction phases and noted that post-optimization, equipment idle hours dropped significantly, leading to substantial fuel and rental cost savings.

However, most such studies are case-specific and lack a generalizable framework. Moreover, regional variability in terrain, climate, and labor availability often affects project dynamics. This calls for more structured research on applying MSP in diverse Indian contexts, such as Madhya Pradesh's Balwara–Dhangoan corridor under NH-347BG.

E. Research Gap

While several studies have highlighted the benefits of Microsoft Project in residential or building construction, fewer have demonstrated its potential in highway infrastructure projects, particularly within the public sector. There is also limited integration of MSP in DPR-level planning, with most contractors relying on Excel-based Gantt charts or third-party software.

This research seeks to address the gap by:

1) Applying MSP for resource optimization in a real-world highway case study.
2) Comparing pre- and post-leveling results using charts, histograms, and cost tables.
3) Offering a replicable resource planning model suitable for NHAI and MoRTH projects.

III. METHODOLOGY

This research adopts a structured, software-integrated approach to optimize resources in the NH-347BG highway project using Microsoft Project (MSP). The methodology encompasses primary data gathering, construction activity breakdown, resource quantification, project scheduling, leveling of over-allocated resources, and comparative post-optimization analysis.

A. Project Overview and Geographic Context

The NH-347BG segment from Balwara to Dhangoan in Madhya Pradesh covers approximately 80 kilometers and plays a crucial role in regional economic development and freight mobility. The terrain is a mix of plain and undulating features with moderate earthwork requirements and limited bridge structures. The semi-urban environment offers access to local labor and materials but also poses logistical challenges during the monsoon season.

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Assumptions and Planning Considerations:

- Road configuration: Two-lane with paved shoulders as per MoRTH specifications.
- Work season: October 2024 to December 2025, avoiding peak monsoon.
- Expected non-working days: 20 due to rain and public holidays.
- Work shifts: Single 8-hour shift for labor, 10-hour for equipment.
- Contractor's available resources: 2 excavators, 1 grader, 1 paver, 1 roller, 1 bitumen sprayer.
- Workforce availability: 30 masons, 40 helpers, 8 machine operators.

B. Work Breakdown Structure (WBS) Development

A detailed WBS was formulated to segment the project hierarchically into manageable tasks. The WBS was integrated into MSP with task IDs, allowing for critical path determination and performance monitoring.

WBS ID	Activity Level	Description	Duration (Days)
1	Main Task	Site Preparation	10
1.1	Subtask	Topographic Survey & Layout	3
1.2	Subtask	Vegetation Clearance and Debris Removal	7
2	Main Task	Earthwork	45
2.1	Subtask	Excavation and Embankment Construction	25
2.2	Subtask	Rolling and Compaction	20
3	Main Task	Subgrade Preparation	20
4	Main Task	Base Layers (GSB, WMM)	35
5	Main Task	Surface Layers (DBM, BC)	40
6	Main Task	Drainage and Structures (Culverts, Minor Bridges)	50
7	Main Task	Road Safety, Markings, Signboards	15
8	Main Task	Quality Checks and Final Handover	10

C. Data Collection and Resource Planning

Data Sources and Parameters:

- Productivity Norms: Based on CPWD/NHAI standard outputs
- Unit Costs:
  - Skilled labor (mason): ₹600/day
  - Unskilled labor (helper): ₹450/day
  - Excavator: ₹1500/hour
  - Paver: ₹3000/hour
  - Bitumen: ₹55/litre
  - Aggregate: ₹850/ton

Quantities and Resource Requirement Estimates:

Item	*Quantity*	*Calculation Basis*
Excavation	1,20,000 m^3	80 km × 6 m width × 0.25 m depth
GSB	75,000 m^3	Average 0.15 m thick × 80 km
WMM	60,000 m^3	0.10 m thick × 80 km
DBM + BC	55,000 m^2	6 m wide surface × 80 km
Pipe Culverts	55 nos	Based on drainage pattern and water bodies

D. MSP-Based Project Planning

1) Activity Entry and Sequencing

All WBS items were translated into MSP tasks with the following attributes:

- Predecessor Links: FS for sequential works, SS for parallel drainage and earthwork
- Milestones added: Earthwork complete, GSB complete, Paving complete, Final handover

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2) Resource Assignment and Calendar Setup

Resources were defined in the MSP Resource Sheet with:

- Standard rate and overtime rate
- Max availability units (e.g., 2 units for excavators)
- Assignment to specific tasks with work-based loading
- Custom calendars (e.g., Mon–Sat, 8 hrs/day for labor)

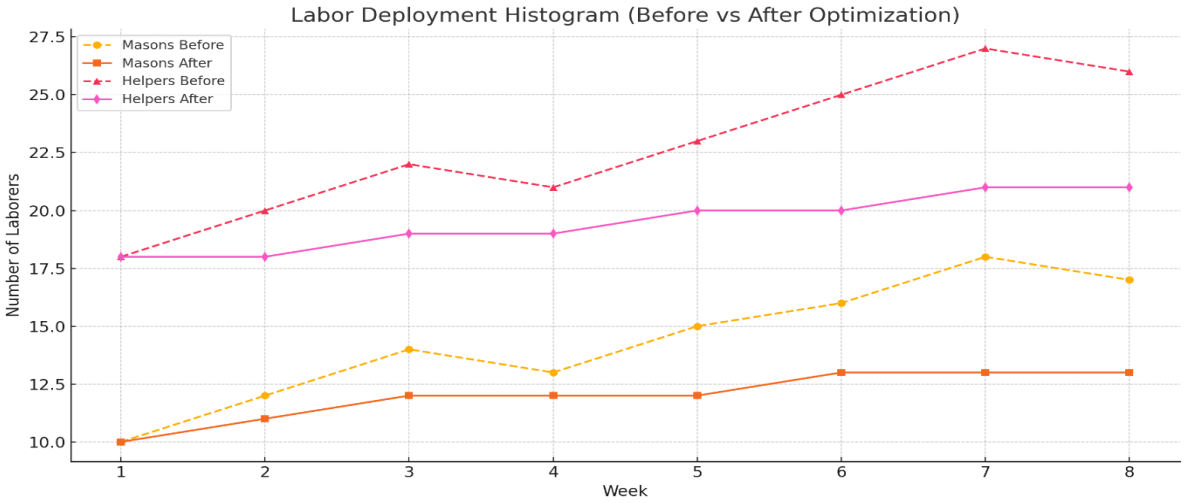
3) Resource Leveling

Conflicts such as double-booking of machines or workforce spikes were resolved using:

- MSP's Leveling Order: ID Only
- Delay Leveling up to: 5 days allowed slack
- Option to level only within available slack to prevent timeline extension

4) Output Extraction and Comparative Analysis

- **Gantt Chart (Before vs After)**
  - Before: Overlapping activities; overloaded resources; total duration 420 days
  - After: Sequenced tasks with adequate float and resolved clashes; reduced duration to 370 days
- Labor Histogram Analysis (Masons & Helpers)
  - Before: Peaks of 18 masons and 27 helpers/week in Week 6–7
- After: Balanced workforce maintained between 12–13 masons and 18–21 helpers weekly



- Cost Comparison Table

Category	Pre-Optimization	Post-Optimization
Skilled Labor	₹112 Lakhs	₹98 Lakhs
Unskilled Labor	₹89 Lakhs	₹78 Lakhs
Equipment Usage	₹215 Lakhs	₹194 Lakhs
Materials	₹440 Lakhs	₹432 Lakhs
Total	**₹856 Lakhs**	**₹802 Lakhs**

- Cost Distribution (Post Optimization)
  - Labor: 22%
  - Equipment: 24%
  - Materials: 54%
  - Overhead: <2%

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IV. RESULTS AND DISCUSSION

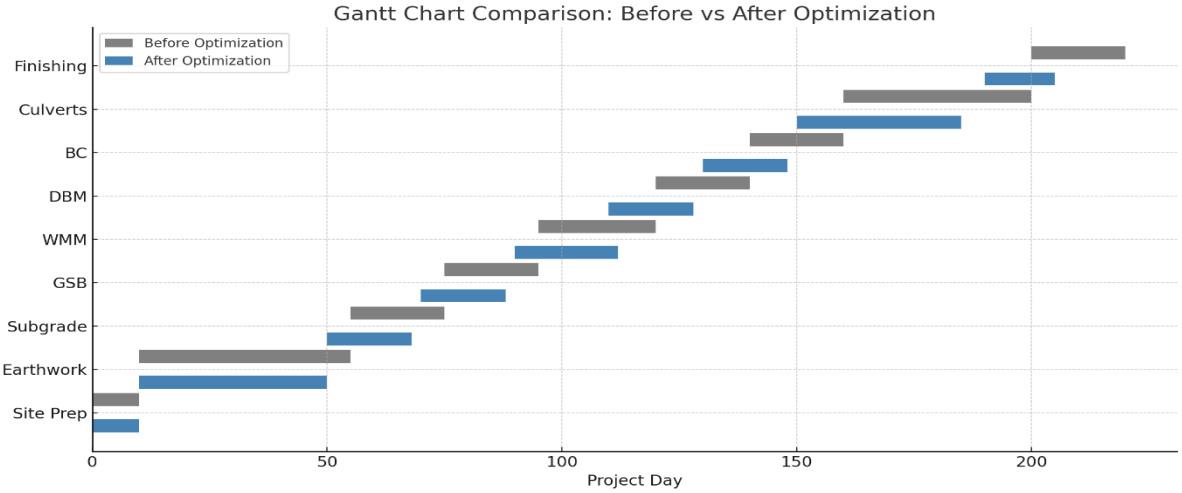
The implementation of Microsoft Project (MSP) for planning and optimizing the NH-347BG highway project demonstrated significant improvements in schedule, labor utilization, and cost efficiency. The results are presented below:

A. Project Schedule Optimization

The Gantt chart analysis clearly indicates that, prior to optimization, several critical and non-critical activities were overlapping, leading to equipment and labor overuse. After applying MSP's resource leveling algorithm, the schedule became more balanced.

- Original Project Duration: 420 calendar days
- Optimized Project Duration: 370 calendar days
- Time Savings: Approximately 12% reduction in overall project time

This was achieved without increasing project cost or extending major milestones, due to better task sequencing and activity float management. The critical path activities became more streamlined, avoiding rework and resource conflicts. Furthermore, the resource-leveled plan provided more reliable projections for contractor payment milestones and procurement scheduling.



B. Labor Utilization and Histogram Insights

The labor histogram highlighted inefficiencies in the pre-optimization phase, especially in Weeks 6 and 7, where the demand for masons and helpers spiked beyond available workforce levels. After resource leveling, the histogram showed:

- More uniform labor deployment across weeks
- Peak labor requirement capped within available limits (max. 13 masons and 21 helpers)
- Reduced idle time and overtime costs

This ensured consistent productivity and minimized idle labor time or the need for overtime wages. It also improved worker morale and reduced fatigue-related performance losses. More balanced crew assignment across WBS elements allowed efficient work-front management.

C. Cost Optimization Outcomes

The cost analysis yielded the following insights:

Resource Category	Pre-Optimization (₹ Lakhs)	Post-Optimization (₹ Lakhs)	% Savings
Skilled Labor	112	98	12.5%
Unskilled Labor	89	78	12.4%
Equipment Usage	215	194	9.8%
Materials	440	432	1.8%
Total Project Cost	856	802	6.3%

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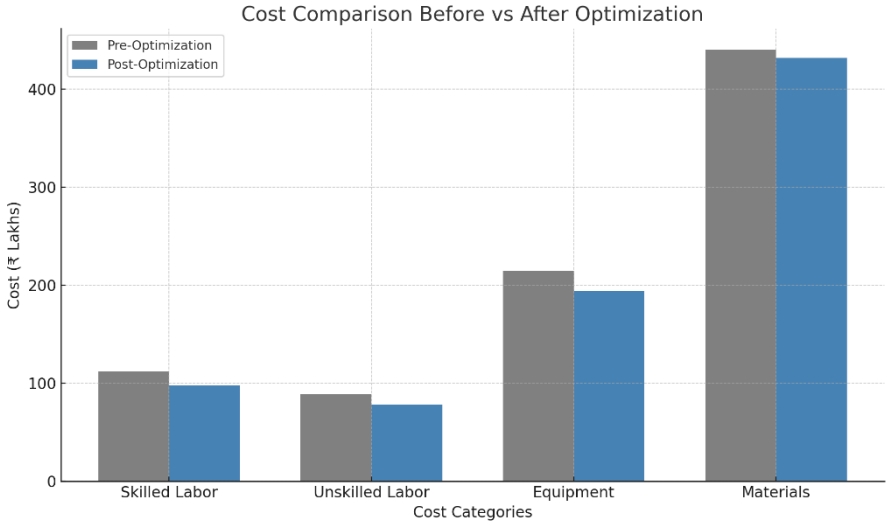
These savings were primarily attributed to reduced overtime, better scheduling, and efficient equipment allocation. Moreover, MSP enabled early identification of high-cost activities, prompting project managers to re-evaluate resource mixes. Avoidance of rework and downtime translated into direct cost benefits.

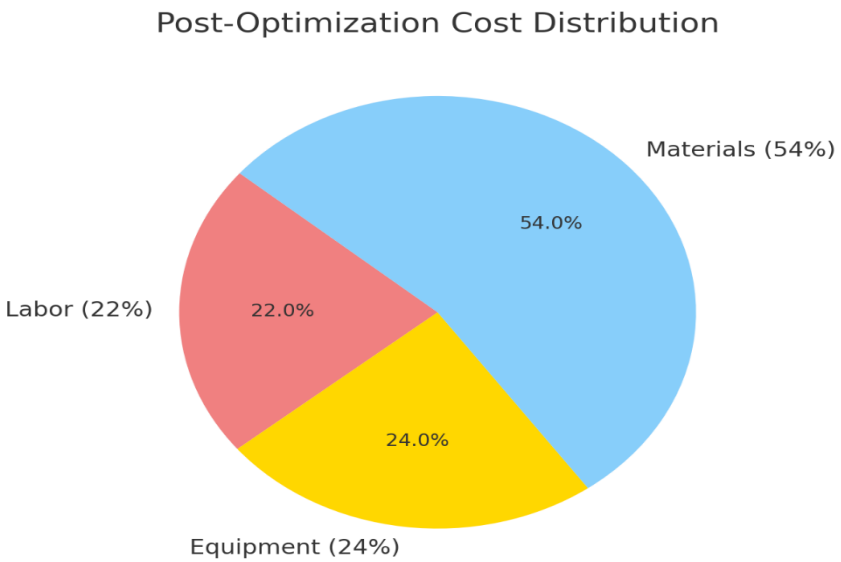


D. Cost Distribution Post-Optimization

After optimization, the project's total cost distribution was:

- Labor: 22%
- Equipment: 24%
- Materials: 54%
- Overhead & Miscellaneous: <2%

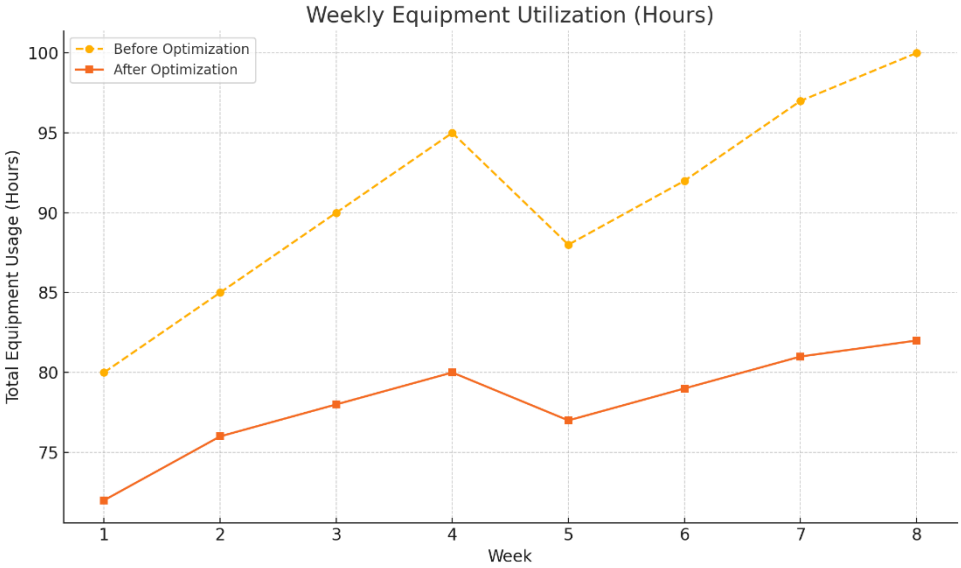
This shows that optimization did not disproportionately affect any single category but streamlined overall expenditures. The percentage allocations indicate a balanced project expenditure profile aligned with MoRTH norms for medium-scale highway projects.



E. Resource Utilization Efficiency

The optimized resource schedule ensured:

- Reduction of equipment idle hours by more than 30%
- Optimal use of critical resources such as pavers and rollers
- Better planning for supply chain deliveries (e.g., aggregate and bitumen)
- Increased utilization rate of available labor from 78% to 93%



This also reduced environmental impacts through fewer redundant equipment operations and lower fuel consumption.

F. Qualitative Outcomes

- Improved visibility into resource bottlenecks and scheduling conflicts
- Enabled scenario planning for "what-if" analysis using MSP's baseline features
- Enhanced project readiness for future monitoring and contractor billing workflows
- Facilitated integration of Earned Value Management (EVM) in progress tracking
- Provided a platform for training junior engineers in digital project planning practices

G. Summary of Key Results

Indicator	Before MSP Optimization	After MSP Optimization
Project Duration (Days)	420	370
Max Labor Requirement	18 Masons, 27 Helpers	13 Masons, 21 Helpers
Idle Equipment Hours	High	Minimal
Cost Overrun Risk	Significant	Reduced
Overall Resource Efficiency	Low	High
Labor Utilization (%)	78%	93%
Fuel and Equipment Usage	High	Moderate
Overtime Dependency	Frequent	Rare

V. CONCLUSION AND RECOMMENDATIONS

Based on the findings of this study, the following key conclusions can be drawn:

1) Microsoft Project (MSP) significantly improved the scheduling efficiency of the NH-347BG project by reducing the total project duration by approximately 12%.

2) Labor deployment became more consistent and efficient, reducing peak loads, overtime, and idle time.

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3) Equipment utilization was optimized, minimizing redundant operation hours and improving fuel and cost efficiency.
4) Project costs were reduced by approximately ₹54 Lakhs (6.3%), mainly due to better scheduling and resource leveling.
5) Post-optimization cost distribution aligned with industry norms, avoiding over-concentration of expenses in any one category.
6) The application of MSP enabled early detection of resource bottlenecks and cost-intensive tasks, aiding proactive project management.
7) Scenario analysis and progress forecasting became more feasible through baseline tracking and Earned Value Management features.
8) The approach provides a practical framework for integrating MSP into DPR preparation and project execution for MoRTH and NHAI projects.

Recommendations:

- Project planning teams in government highway projects should receive MSP training.
- DPR consultants should adopt MSP-based WBS and scheduling models at the planning stage.
- Contractors should be mandated to submit MSP-compatible execution schedules for effective monitoring.
- Further research should be undertaken to integrate MSP with ERP and BIM systems for real-time site updates and cost tracking.

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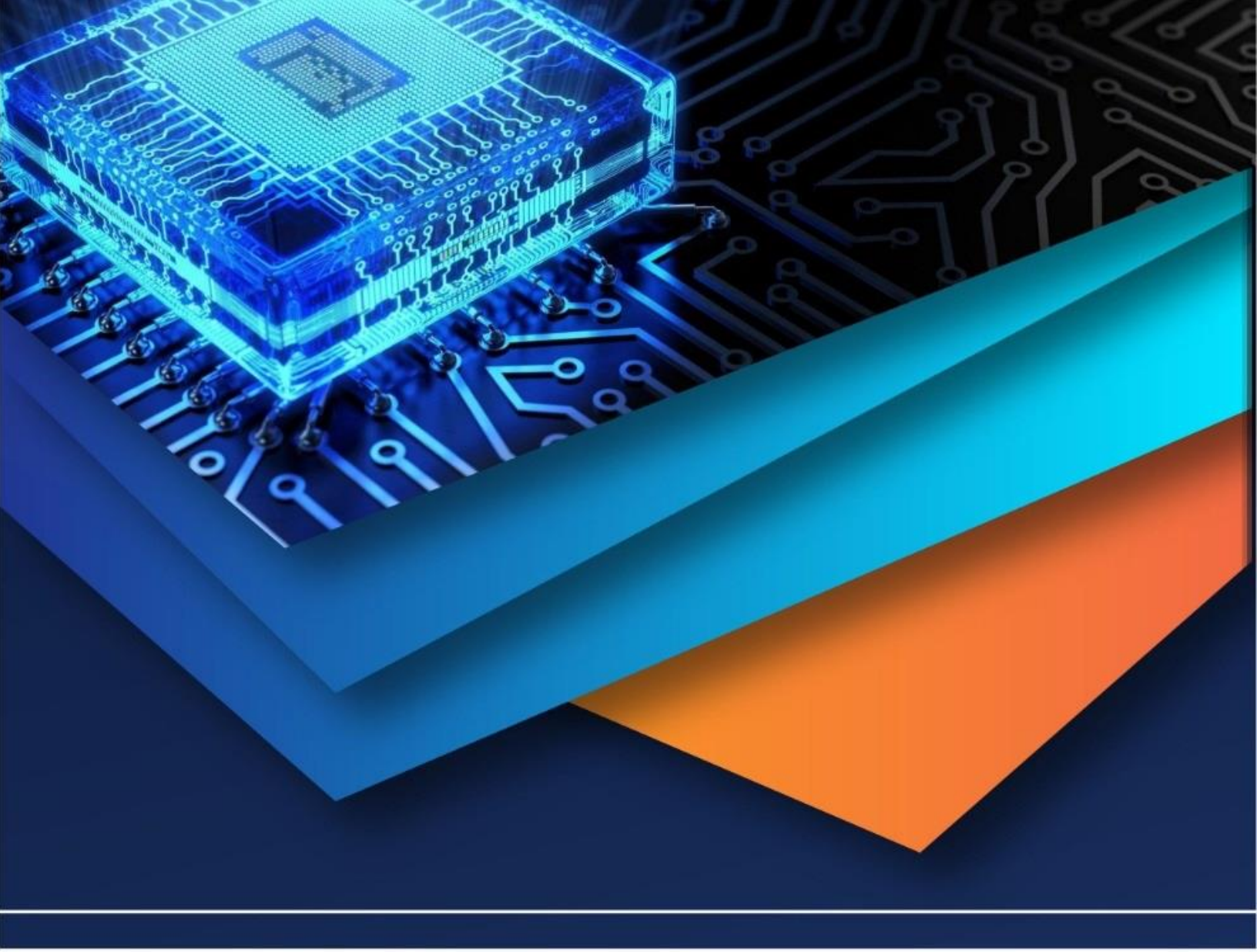

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