WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: **www.ijrpr.com** ISSN 2582-7421

THE ROLE OF PUBLIC-PRIVATE PARTNERSHIPS (PPPS) IN HIGHWAY DEVELOPMENT

MR. SAGAR ASARAM KALE[1], PROF. M.D. MATA[2]

DEPARTMENT OF CIVIL ENGINEERING, SHRI SANT GADGE BABA COLLEGE OF ENGINEERING AND TECHNOLOGY, BHUSAWAL-425201

ABSTRACT:

This paper examines the use of Public-Private Partnerships (PPPs) in developing highway infrastructure, with a focus on India's national highway programs. We review various PPP models (BOT, DBFOT, EPC, HAM, etc.), their risk-sharing structures, and legislative frameworks. A detailed case study of the Damoh–Hatta–Gaisabad–Simariya (SH-55) highway project under the Engineering-Procurement-Construction (EPC) model in Madhya Pradesh is presented. Traffic surveys, financial data, and risk analyses are used to compare the performance of EPC versus traditional PPP (e.g. BOT/HAM) approaches. Results show that, for medium-scale highways with moderate traffic, the EPC model offers faster completion and lower financial risk to private partners, albeit with greater government fiscal burden. The paper concludes with best-practice recommendations for selecting and structuring PPP models in highway projects.

Keywords: Public-Private Partnerships (PPPs); Highway Development; Infrastructure Financing; Traffic Analysis; EPC Model; India.

Introduction

Road networks are vital national assets, carrying roughly 65% of freight and 85% of passenger traffic in India. In fact, even though National Highways constitute only about 2% of the total road length, they handle nearly 40% of this traffic. By facilitating the movement of people and goods, highways underpin economic growth, commerce, and regional connectivity. For example:

-They provide essential support for transporting people between cities and rural areas.
-They enable large volumes of goods to reach markets efficiently.
-They connect distant regions and enable national integration.
-They support both internal (inter-state) and international trade logistics.

Poor road quality or connectivity can dramatically raise transport costs and isolate producers. In India, the road network is one of the world's largest, spanning about 3.34 million km (including 65,569 km of National Highways and 130,000 km of State Highways). Despite this extensive network, funding constraints and competing public priorities (health, education, defense, etc.) have often delayed critical highway projects.

In response, Public-Private Partnerships (PPPs) have emerged as a key solution for highway development. A PPP is a long-term contract in which private firms finance, design, build, and often operate infrastructure assets under government oversight. Such arrangements allow governments to leverage private capital and expertise, accelerating projects that might otherwise be unaffordable. Ideally, the private partner bears construction, financial, or operational risks in exchange for toll revenues or availability payments. In theory, PPPs can introduce innovation and efficiency, improve project management, and ensure on-time delivery.

However, PPPs also introduce challenges. They require detailed legal frameworks and contracts to clearly allocate risks and responsibilities. Misalignment of public and private objectives (e.g. profit vs. service) can lead to disputes or renegotiations. Accountability and transparency are critical, as is careful planning for changing future conditions. For these reasons, thorough analysis of PPP projects is essential to ensure they deliver public benefits.

This paper addresses several objectives in the context of Indian highway development. We first explain the structure and variants of PPP models (BOT, Annuity, EPC, HAM, etc.), focusing on risk allocation and delivery mechanisms. We then review India's highway development history, including the National Highway Development Programme (NHDP) phases and the growing role of PPPs in accelerating road expansion. A core component is a case study of an EPC highway project (Damoh–Hatta–Gaisabad–Simariya, SH-55) in Madhya Pradesh, detailing its implementation framework and contractual arrangements. Using traffic surveys, cost data, and risk analyses, we evaluate the EPC model's performance for this project. Finally, we compare EPC to other PPP models (BOT/HAM) in terms of cost-efficiency, timeline, and risk distribution, drawing conclusions about best practices for highway PPP projects.

Literature Review

Recent research highlights both the promise and pitfalls of PPPs in roads. Hakim and Meehan (2024) review four U.S. toll-road PPP projects, noting that budget shortfalls have driven governments to transfer highway costs to users via long-term concessions. They find that while such PPPs can improve efficiency and generate upfront capital, they often involve very long lease periods (35–75 years) and expose partners to traffic demand uncertainties. In a bibliometric overview, Esperilla-Niño-de-Guzmán et al. (2024) systematically map 30 years of PPP road research using tools like VOS viewer. Their analysis identifies key trends, methodologies, and knowledge gaps in the literature, showing an exponential growth in highway PPP studies over recent decades. These reviews underscore that while PPPs can mobilize private resources and expertise, factors like financing risk, contract design, and governance remain crucial issues. Other studies (e.g. Castelblanco et al. 2024; Nusriadi et al. 2024) develop models for financial flexibility and governance in PPP toll projects, reflecting the field's current focus on risk management and value for money.

In summary, the literature shows that PPPs have been widely applied in highway infrastructure but with mixed outcomes. Success depends on matching the right model to project conditions, and on strong public oversight. Our work builds on these findings by applying them in the Indian context and through new empirical analysis of a real highway project.

Methodology

This study uses a combined analytical and case-study methodology. First, we review India's institutional framework (legal, financial, and institutional) for highway PPPs, particularly the role of bodies like the National Highways Authority of India (NHAI) and policies such as NHDP and Bharatmala. We classify PPP models and outline their contractual features and risk-sharing profiles.

For the empirical part, we conduct an in-depth **case study of the SH-55 highway project** in Madhya Pradesh (Damoh–Hatta–Gaisabad–Simariya, 73.265 km two-lane upgrade). This project was procured under an Engineering-Procurement-Construction (EPC) contract (100% government-funded). We collected data on existing road conditions, design parameters, traffic volumes, and project finances from project reports and field surveys. Key steps include:

- **Traffic Analysis:** Conducting a field traffic survey (counting vehicles at Damoh, Hatta, and Gaisabad) to determine Average Daily Traffic in Commercial Vehicles per Day (CVPD). We use Indian Roads Congress (IRC) standards to categorize traffic levels and select delivery modes.
- **Cost Categorization:** Comparing the total project cost (₹231.97 crore) against standard project-size categories (Table 6.3) to infer recommended procurement models.
- **Risk Assessment:** Creating a risk allocation matrix (Table 6.4) for different models (EPC, BOT-Toll, BOT-Annuity, HAM, item-rate) to evaluate which party bears construction, financial, and revenue risks.
- **Timeline Evaluation:** Comparing project schedule drivers under EPC vs. BOT/HAM. This includes consideration of the time for financial closure and revenue arrangements as per Table 6.5.

Data from the SH-55 case are analyzed following standard engineering economics and PPP assessment methods. For example, we apply IRC classification thresholds (see Table 6.2) to the measured traffic (633 CVPD) and to determine suitable procurement modes. We compare our findings to established best practices and the literature to ensure consistency.

Results

Traffic Volume: The field survey found an average of about **633 commercial vehicles per day (CVPD)** on SH-55 (Damoh–Hatta–Gaisabad) for 2025. According to IRC traffic categories, this falls in the **"Moderate Traffic"** range (150–750 CVPD). In practice, projects with moderate traffic are typically executed under EPC contracts in India (Table 6.2). Thus, the observed traffic level supports the use of an EPC model for this highway.

Project Cost: The total awarded cost for SH-55 was **₹231.97 crore** (Table 5.1). Indian highway project classifications label this as a **Medium-scale project** (₹100–500 Cr). Medium projects are usually government-funded (EPC), since toll revenues would be insufficient to attract a PPP concessionaire. Thus, cost analysis also favors EPC over a toll-based PPP for this project.

Risk Allocation: Table 6.4 (reproduced below) compares how different delivery modes allocate key risks. In the EPC model (design-build fully government-funded), the contractor primarily bears construction risk but **no revenue risk** (since the government retains traffic risk).

In contrast, a BOT-Toll model places revenue risk on the private party. HAM (Hybrid Annuity) shares revenue risk 40/60 (Government/Private). EPC leaves financial and O&M risks to the government. In summary, **EPC minimizes risk for the contractor** (only construction risk) and shifts revenue/financial risk entirely to the government. This makes EPC relatively "low-risk" for bidders but potentially high-risk fiscally for the public sector.

Risk Type	EPC (Contractor / Govt)	BOT-Toll (Contractor / Govt)	HAM (Contractor / Govt)	Item-Rate (Contractor / Govt)
Construction Risk	Contractor	Contractor	Contractor	Government (shared)
Financial Risk	Government	Contractor	Government	Government
Revenue/Traffic Risk	Government	Contractor	Government	Government
Contractor's Exposure	Medium	High	Medium-Low	Very Low
Government's Exposure	High	Low	High	Very High

Implementation Schedule: An EPC contract, being fully funded, **avoids any delay for financial closure**. Table 6.5 (below) shows that EPC projects can start immediately after DPR approval, whereas PPP modes typically incur 6–12 months of financial negotiations. For a two-year (24-month) project, this means EPC can finish on schedule, while BOT/HAM projects effectively take ~30 months in practice. This confirms that EPC offers a faster timeline for medium-term projects.

Parameter	**EPC Model**	**BOT (Toll)**	**BOT (Annuity)**	**HAM Model**
Project Funding	100% Govt.	Private financed	Private (Annuity)	40% Govt. + 60% Private
Financial Closure Time	Not required	~6–12 months	~6–12 months	~6–8 months
Revenue Risk Bearer	Govt.	Private	Govt.	Govt.
Implementation Speed	**Faster**	Slower	Slower	Moderate
Suitability for 2-year project	Highly suitable	Not suitable	Not suitable	Suitable (>3yr)

Summary of Case Results: All analyzed factors – moderate traffic (633 CVPD), medium project cost (~₹232 Cr), the pattern of risk allocation, and fast completion needs – consistently favor the **EPC delivery model** for SH-55. In particular, the elimination of toll/revenue risk and absence of financing delays makes EPC the most pragmatic choice for this specific highway project.

Discussion

The case study illustrates a common scenario in highway PPP decisions. For projects of this scale (medium cost, moderate traffic), EPC (i.e. full public funding with private execution) can outperform conventional PPP (BOT/HAM). The government takes on more fiscal risk in EPC, but this trade-off yields clear advantages: **quicker delivery and certainty** in project finance. In contrast, BOT or HAM models would impose revenue risk on a private operator and introduce financing delays, which can hamper timely completion of relatively small highways.

This finding is consistent with Hakim and Meehan (2024), who noted that while toll-based PPPs can be efficient, they tend to involve very long concessions and require robust revenue projections. Our analysis supports the idea that short-term, medium-cost projects with uncertain traffic are poor candidates for toll concessions. Conversely, large inter-city corridors with high traffic might still justify PPP tolling. Our study suggests that **proper model selection is crucial**: governments should match project characteristics to delivery mode.

From a policy perspective, India's experience has evolved accordingly. Early NHDP phases heavily relied on BOT-Toll, but later phases (III/IV) increasingly used BOT-Annuity and EPC/HAM to mitigate traffic risk. The current strategy (Bharatmala) and State road agencies often reserve toll PPP for proven high-demand corridors. This case reinforces that approach.

Finally, the comparative risk and time analyses (Tables 6.4–6.5) provide a framework for other project evaluations. For practitioners, these tables highlight how contractual choices shift burdens. For example, EPC's transfer of almost all financial risk to the public sector means **strict budgetary discipline and oversight** are needed. However, it removes complex toll-finance negotiations. These insights can help policymakers and engineers design PPP contracts that balance incentives with development goals.

Conclusion

Highway development is critical for economic growth and connectivity. PPP frameworks – including models like EPC – have become essential tools to overcome public funding limits. This study finds that for the Damoh–Hatta–Simariya highway (SH-55) case, the **Engineering-Procurement-Construction (EPC) model** is clearly the most suitable. With moderate traffic (633 CVPD) and a medium-scale budget (₹232 Cr), the project did not justify a toll concession. EPC allowed immediate project start-up, eliminated revenue risk for the contractor, and ensured on-time delivery, albeit at higher fiscal exposure for the government.

More generally, our analysis suggests that **EPC or similar availability-based contracts** are preferable for smaller highway projects where toll revenue is uncertain. For larger projects with high traffic, PPP tolling can still play a role. Key to success is aligning the PPP structure with project needs: proper risk allocation, robust legal agreements, and realistic demand forecasts. In future work, similar evaluations of diverse highway projects (e.g. long greenfield corridors, urban expressways) would further clarify optimal PPP strategies.

REFERENCES:

1. Shrestha, B.; Shrestha, P.P. (2024). Buildings 14(9):2622.
2. Hakim, S. (2024). Evaluation of PPPs in Highways.
3. Esperilla-Niño-de-Guzmán, Y.Y., et al. (2024). Sustainability 16(4):1430.
4. Gifford, J.L., et al. (2024). Public Management Review.
5. Castelblanco, G., et al. (2024). Construction Management and Economics 42(9):802821.
6. Nusriadi, L., et al. (2024). Journal of Infrastructure, Policy and Development 8(4):3259.
7. Deep, S., et al. (2024). ASCE J. of Infrastructure Systems.
8. Koirala, S. (2024). Samsad Journal.
9. Lee, E.H., et al. (2025). Socio-Economic Planning Sciences.
10. Hou, Y., et al. (2025). Collusion prevention in PPP highway projects (Elsevier article).
11. Mazher, K.M., et al. (2025). Frontiers in Built Environment.
12. Nguyen, T., et al. (2025). Journal article on Vietnam tolled highway PPP risk (SAGE).