

# INCEPTION REPORT

**Road/Highway/Bridge Project**

**Location: Bhopal, Bhopal, Madhya Pradesh, India**

Generated on: 14 October 2025

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- Senior Bridge Engineer (Shri Sanjay Mandal)

- Highway cum Pavement Engineer (Shri Nabin Kumar Niyogi)
- Material cum Geotechnical Engineer-Geologist (Shri Avik Kumar Mandal)
- Senior Survey Engineer (Shri Dilip Kumar Dey)
- Traffic and Safety Expert (Shri B. Mallikarjuna Setty)
- Environmental Specialist (Shri Nagendra Kumar)
- Quantity Surveyor/Documentation Expert (Shri Manoj Kumar Sinha)
- Land Acquisition Expert (Shri Sangram Kumar Singh)
- Utility Expert (Shri Parantapa Das)
- Task Assignment for Sub-Professional Staff
- Project Coordinator (To be Named)
- Highway CAD cum Pavement Engineer (To be Named)
- Bridge Design Engineer (To be Named)
- Hydrologist-cum-Drainage Engineer (To be Named)
- Traffic Engineer (To be Named)
- Financial Expert (To be Named)
- Resettlement & Rehabilitation Specialist (To be Named)
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## 1.0 Executive Summary

Executive Summary: RFP Inception Report

**Project Title:** Consultancy Services for Preparation of Detailed Project Report for Development of Economic Corridors, Inter Corridors, Feeder Routes and Coastal Roads to improve efficiency of freight movement in India (Lot 1/Madhya Pradesh/Package-3)

**Client:** National Highways Authority of India (NHAI)

**Consultant:** M/s LEA Associates South Asia Pvt Ltd

**Contract Date:** April, 2017

**Report Context:** This inception report, prepared from Bhopal, Madhya Pradesh, articulates the Consultant's understanding of the project scope, objectives, and proposed methodology for the preparation of Detailed Project Reports (DPRs) for key road sections within Madhya Pradesh. This initiative is pivotal in enhancing the state's freight movement efficiency and contributing to the broader national Bharatmala Pariyojna objectives.

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### 1. Project Overview and Objectives

The National Highways Authority of India (NHAI) has entrusted M/s LEA Associates South Asia Pvt Ltd with the consultancy services for the preparation of Detailed Project Reports (DPRs) for two critical road stretches in Madhya Pradesh. This project, categorized under Lot-1/Madhya Pradesh/Package-3, aims to develop strategic economic corridors and inter-corridors. The overarching objective is to improve the efficiency, safety, and capacity of freight movement within India, thereby fostering economic growth and regional connectivity in Madhya Pradesh.

The proposed developments are aligned with the Ministry of Road Transport and Highways (MoRTH) standards and NHAI's vision for a robust national highway network. This inception report serves as a foundational document, outlining the consultant's approach to fulfilling the Terms of Reference (ToR) and delivering a comprehensive, technically sound, and economically viable DPR.

## 2. Scope of Services

The consultancy services encompass the complete preparation of Detailed Project Reports, from feasibility assessment through to detailed engineering designs and statutory clearances. Key components of the scope, as per the contract agreement and NHAI guidelines, include:

- **Feasibility Study:** Comprehensive assessment of project viability, including preliminary engineering, traffic analysis, and socio-economic profiling.
- **Detailed Engineering Surveys & Investigations:** Topographic surveys, traffic studies, geotechnical investigations, hydrological studies, and material surveys.
- **Geometric Design:** Optimization of horizontal and vertical alignments, intersection designs, and road furniture in accordance with Indian Road Congress (IRC) standards.
- **Pavement Design:** Design of flexible and/or rigid pavements based on traffic projections, subgrade characteristics, and IRC guidelines.
- **Structure Design:** Detailed design of bridges, culverts, flyovers, underpasses, and other cross-drainage structures.
- **Environmental & Social Impact Assessments (EIA/SIA):** Identification of environmental and social impacts, preparation of Environmental Management Plans (EMP) and Resettlement Action Plans (RAP) in compliance with national regulations and applicable international standards (e.g., ADB/World Bank guidelines as noted in the ToR).
- **Economic & Financial Analysis:** Evaluation of the project's economic viability and financial sustainability.
- **Detailed Cost Estimates:** Preparation of item-wise detailed cost estimates based on MoRTH Standard Data Book and prevailing market rates.

- **Preparation of Bid Documents:** Compilation of all necessary technical and financial documentation for subsequent tender processes.

### 3. Project Stretches

The consultancy services pertain to two distinct road sections within Madhya Pradesh, totaling approximately 335.1 kilometers, as detailed below:

S. No.	Classification	Name of Corridor	Stretch (Route)	Start Point (Coordinates)	End Point (Coordinates)	Length (km)
1	Economic Corridor	Sagar-Varanasi	Sagar-Garhakota-Damoh-Raipur-Katni section of NH-934	Sagar (23.838805, 78.737807)	Katni (23.870014, 80.361474)	193.0
2	Inter Corridor	Vidisha-Malthone	Vidisha-Saletara-Kurvai-Bina-Khimsala-Malthone section of SH-19, SH-14, SH-42A and SH-42	Vidisha (23.517449, 77.797208)	Malthone (24.3030959, 78.5255114)	142.1
		Total Length				335.1

### 4. Proposed Methodology and Approach

The consultant will adopt a structured, multi-disciplinary approach, adhering strictly to NHAI specifications, MoRTH guidelines, IRC codes, and Bureau of Indian Standards (BIS) for all aspects of the DPR preparation. The methodology will encompass the following key stages:

#### 4.1. Inception and Data Collection:

- \* Detailed review of all project documents, contract agreement, and existing reports.
- \* Initial reconnaissance of the project stretches to understand ground realities, challenges, and opportunities.
- \* Compilation of available secondary data including topographical maps, revenue maps, administrative boundaries, traffic data, and environmental/social baseline information.
- \* Stakeholder consultations with local authorities, public representatives, and potentially affected persons.

#### 4.2. Field Surveys and Investigations:

- \* **Topographic Surveys:** High-precision DGPS/Total Station surveys for accurate ground modeling, cross-sections, and longitudinal profiles, referencing relevant IRC:SP:19 and MoRTH guidelines.
- \* **Traffic Studies:** Classified traffic volume counts (7-day data, as per checklist), Origin-Destination (O-D) surveys, axle load surveys, and speed & delay studies. Traffic projections will be carried out as per IRC:108.
- \* **Geotechnical Investigations:** Sub-surface exploration through boreholes, Standard Penetration Tests (SPT), and laboratory testing for soil and rock properties, crucial for pavement and foundation designs.
- \* **Material Surveys:** Identification and testing of potential construction material sources (quarries, borrow areas) within economic lead distances.
- \* **Hydrological Surveys:** Assessment of existing drainage patterns, flood levels, and design discharge for cross-drainage structures.

#### 4.3. Engineering Design:

\* **Geometric Design:** Preparation of optimal horizontal and vertical alignments considering design speed, safety, existing features, and land acquisition minimization, adhering to IRC:73, IRC:SP:84, and MoRTH specifications.

\* **Pavement Design:** Detailed design for new and existing pavement layers, considering traffic loads, material properties, and environmental factors, in accordance with IRC:37 (flexible pavements) and IRC:58 (rigid pavements).

\* **Structural Design:** Detailed design of bridges (IRC:5, IRC:6, IRC:21, IRC:78), culverts, minor bridges, flyovers, and vehicular/pedestrian underpasses, including hydraulic and structural computations.

\* **Drainage Design:** Design of surface and subsurface drainage systems, including culverts, side drains, and cross-drainage structures.

\* **Road Furniture and Safety Features:** Design of road markings, signage, crash barriers, and other safety appurtenances as per IRC standards.

#### 4.4. Environmental and Social Safeguards:

\* **Environmental Impact Assessment (EIA) & Environmental Management Plan (EMP):** Comprehensive assessment of potential environmental impacts (air, water, noise, biodiversity) and formulation of mitigation measures, incorporating suggestions from ADB/World Bank/NHAI (as stated on Page 11 of the contract). Compliance with MoEF&CC regulations will be ensured.

\* **Social Impact Assessment (SIA) & Resettlement Action Plan (RAP):** Detailed assessment of social impacts, identification of Project Affected Persons (PAPs), determination of eligibility criteria, and preparation of a comprehensive RAP, guided by ADB's Handbook on Resettlement/World Bank Guidelines/Government of India Guidelines (as applicable and stated on Page 11 of the contract). Public consultations will be integral to this process.

#### 4.5. Economic and Financial Analysis:

- \* Evaluation of project benefits (e.g., reduced Vehicle Operating Costs, travel time savings, accident reduction) against costs.
- \* Calculation of economic indicators such as Economic Internal Rate of Return (EIRR) and Net Present Value (NPV).
- \* Preliminary financial assessment to determine project viability and funding mechanisms.

#### 4.6. Cost Estimation and Report Finalization:

- \* Preparation of detailed Quantity Estimates for all items of work based on engineering designs and mass haul diagrams.
- \* Analysis of rates for all items of work using MoRTH Standard Data Book and current market rates, including material, labor, and machinery costs.
- \* Compilation of a comprehensive Cost Estimate, broken down package-wise, including provisions for environmental and social safeguards.
- \* Preparation of a consolidated DPR comprising all technical, environmental, social, economic, and financial reports, adhering to NHAI's reporting requirements.

#### 5. Key Challenges and Mitigation Strategies

The successful execution of this project may involve several challenges, including:

- \* **Land Acquisition & Utility Shifting:** Complexities in land acquisition and relocation of public utilities (water pipelines, electricity lines, communication cables).
- \* **Environmental & Forest Clearances:** Obtaining timely clearances from various regulatory bodies for environmental and forest impacts.
- \* **Public Consultations:** Effective engagement with diverse stakeholders to address concerns and build consensus.



\* **Traffic Management:** Ensuring smooth traffic flow during extensive field surveys and future construction.

The consultant's mitigation strategy will involve proactive engagement with NHAI, state government departments, and local communities, leveraging extensive experience in similar projects across India. A dedicated team will focus on accelerating statutory clearances and managing public interface effectively.

## 6. Expected Outcomes

Upon completion, the DPRs for these economic and inter-corridors will provide NHAI with:

- \* A meticulously planned and engineered blueprint for upgrading the identified road sections.
- \* Optimized designs ensuring safety, durability, and efficient freight movement.
- \* Comprehensive environmental and social safeguard plans ready for implementation.
- \* Robust cost estimates and financial analyses to facilitate informed decision-making for project execution.
- \* Enhanced regional connectivity within Madhya Pradesh, supporting industrial growth and socio-economic development, thereby reinforcing Bhopal's strategic role as a hub for state infrastructure planning.

## 7. Consultant's Commitment

M/s LEA Associates South Asia Pvt Ltd is committed to delivering high-quality, comprehensive, and timely DPRs in full compliance with the contract agreement, NHAI's stringent quality standards, and all relevant national and international best practices. Our multi-disciplinary team of experts, equipped with advanced tools and methodologies, is dedicated to ensuring the successful realization of this vital infrastructure project for Madhya Pradesh.





## 2.0 Introduction

The following content is structured for the 'Introduction' section of an RFP Inception Report, incorporating all client inputs and adhering to specified professional and technical guidelines.

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### 1.0 Introduction

This Inception Report outlines the understanding, proposed approach, and preliminary work plan for the "Consultancy Services for Preparation of Detailed Project Report for Development of Economic Corridors, Inter Corridors, Feeder Routes and Coastal Roads to improve efficiency of freight movement in India" for **Lot-1/Madhya Pradesh/Package-3**. The report is submitted by M/s LEA Associates South Asia Pvt Ltd (hereinafter referred to as "the Consultant") to the National Highways Authority of India (NHAI) (hereinafter referred to as "the Client"), pursuant to the Contract Agreement executed on April 07, 2017.

This inception phase marks the formal commencement of the consultancy services, aiming to establish a clear framework for the subsequent detailed project report (DPR) preparation. The project is strategically vital for enhancing freight movement efficiency within the state of Madhya Pradesh, with administrative oversight and coordination from Bhopal, the state capital, providing a central point for stakeholder engagement and logistical support.

### 1.1 Project Background

The National Highways Authority of India (NHAI), under the Ministry of Road Transport and Highways, Government of India, has been entrusted with the ambitious "Bharatmala Pariyojana." A key component of this national initiative is the development of a robust network of Economic Corridors, Inter Corridors, Feeder Routes, and Coastal Roads designed to significantly improve the efficiency and speed of freight movement across the country.

The present assignment falls under Lot-1/Madhya Pradesh/Package-3 and focuses on critical road infrastructure within Madhya Pradesh. This package specifically addresses two distinct but interconnected stretches: an Economic Corridor segment, the Sagar-Katni section of NH-934 (part of the larger Sagar-Varanasi Economic Corridor), and an Inter Corridor segment, the Vidisha-Malthone section (comprising SH-19, SH-14, SH-42A, and SH-42). These routes are vital for connecting key production and consumption centers, facilitating trade, and reducing logistics costs in the region.

## 1.2 Project Objectives

As per the Terms of Reference (ToR), the primary objectives of these consultancy services are to:

- **Establish Viability:** Conduct comprehensive assessments to establish the technical, economic, and financial viability of the proposed project stretches.
- **Detailed Project Report (DPR) Preparation:** Prepare detailed project reports suitable for the development of the identified economic corridors and inter-corridors.
- **Infrastructure Upgrade:** Design and plan for the upgrading of these corridors to at least 4-lane access-controlled configurations. Depending on projected traffic volumes and strategic importance, provisions for 6-laning with access control may also be required for specific stretches.
- **Efficiency Enhancement:** The overarching goal is to prepare implementable designs and documentation that contribute directly to improving the efficiency of freight movement, reducing travel times, and enhancing road safety.
- **Stakeholder Consultation:** Mandatorily consult with relevant State/Central Government departments, authorities, corporations, and bodies dealing with freight movement to thoroughly assess project requirements and ensure alignment with regional development goals.

## 1.3 Scope of Services

The scope of services for this consultancy encompasses a comprehensive range of activities required for DPR preparation, as detailed in Appendix A of the Contract Agreement. Key aspects include:

- **Road Widening and Improvement:** Proposals for widening and improving existing roads, prioritizing utilization of existing Right of Way (RoW) to minimize land acquisition. Where necessary, provisions for short bypasses, service roads, alignment corrections, and intersection improvements will be considered for enhanced efficiency and cost-effectiveness.
- **Land Acquisition & Utility Relocation:** Detailed assessment and documentation for land acquisition as per revenue records/maps. This includes preparation of draft notifications (3a, 3A, and 3D) for land acquisition and meticulous planning for utility relocation, involving coordination with various user agencies.
- **Toll Plaza and Amenities:** Study and design of suitable locations for toll plazas (if applicable), along with planning for essential wayside amenities required for modern tolled highways.
- **Traffic Segregation and Safety:** Consideration of measures to segregate local and slow-moving traffic from main traffic flows, including the provision of service roads and fencing where necessary, to enhance both efficiency and safety.
- **Environmental and Social Safeguards:** Preparation of comprehensive Environmental Management Plans (EMP) and Resettlement Action Plans (RAP) in accordance with relevant guidelines (ADB, World Bank, and Government of India), ensuring the project's sustainability and responsible development.
- **Design & Documentation:** Preparation of 'good for construction' drawings, quantity estimates, and bid documents for EPC/PPP contracts.
- **Site Investigations:** Conducting all necessary engineering surveys, including topographical surveys, pavement condition assessments, structural strength evaluations, and geotechnical explorations to inform detailed designs.

The consultancy services are structured for a duration of 11 months, emphasizing timely delivery of high-quality reports and documentation.

#### 1.4 Project Locations

The "Lot-1/Madhya Pradesh/Package-3" includes the following two critical stretches:

**Table 1.4.1: Project Stretches for Lot-1/Madhya Pradesh/Package-3**

S.No.	Classification	Name of Corridor	Start Point (Coordinates)	End Point (Coordinates)	Stretch (Route)	Length (km)
1	Economic Corridor	Sagar-Varanasi	Sagar (23.838805, 78.737807)	Katni (23.870014, 80.361474)	Sagar-Garhakota-Damoh-Raipur-Katni section of NH-934	193
2	Inter Corridor	Vidisha-Malthone	Vidisha (23.517449, 77.797208)	Malthone (24.3030959, 78.5255114)	Vidisha-Saletara-Kurvai-Bina-Khimsala-Malthone section of SH-19, SH-14, SH-42A and SH-42	142.1
Total Length						335.1

These stretches, totaling 335.1 km, are situated within the state of Madhya Pradesh, contributing to its intra-state and inter-state connectivity, and are integral to the broader national highway development program.

#### 1.5 Consulting Team

The Consultant, M/s LEA Associates South Asia Pvt Ltd, has mobilized a dedicated and experienced team for the execution of this assignment. The key personnel, as confirmed during the contract negotiations, are:

- **Team Leader cum Senior Highway Engineer:** Shri Rajesh Kumar Patyal
- **Senior Bridge Engineer:** Shri Sanjay Mandal
- **Highway cum Pavement Engineer:** Shri Nabin Kumar Niyogi
- **Traffic and Safety Expert:** Shri B Mallikarjuna Setty
- **Land Acquisition Expert:** Shri Sangram Kumar Singh
- **Utility Expert:** Shri Parantapa Das
- **Quantity Surveyor/Documentation:** Shri Manoj Kumar Sinha

This multidisciplinary team possesses the requisite expertise in highway engineering, bridge design, traffic management, pavement technology, land acquisition, utility management, and contract documentation, ensuring a holistic approach to DPR preparation.

#### 1.6 Applicable Standards and Guidelines

All services performed under this contract will strictly adhere to the latest editions and revisions of the following standards, guidelines, and specifications:

- **National Highways Authority of India (NHAI) Guidelines:** All relevant manuals, policies, and directives issued by NHAI.
- **Ministry of Road Transport & Highways (MoRT&H) Specifications:** Standard Specifications for Road and Bridge Works, Standard Data Book for Analysis of Rates, and other relevant circulars and guidelines.
- **Indian Roads Congress (IRC) Codes:** Comprehensive set of codes and standards for highway design, construction, safety, and maintenance, including:
  - IRC:108 for traffic projection methodologies.
  - IRC:SP:19 for topographical surveys.
  - IRC:SP:16 for pavement roughness surveys.
  - IRC:81 for pavement structural strength surveys.

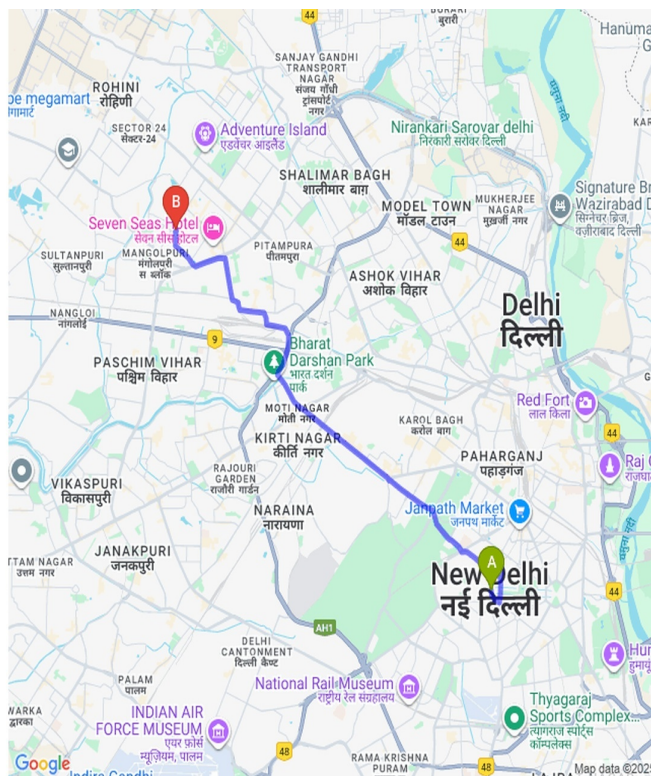
- IRC:78 for geo-technical and sub-soil explorations.
- IRC-SP:35 and IRC-SP:40 for supplementary testing of distressed bridges.
- **Bureau of Indian Standards (BIS):** Applicable Indian Standards for materials, testing, and construction practices.
- **Environmental and Social Safeguard Policies:** Guidelines from international funding agencies such as the Asian Development Bank (ADB) (e.g., Hand Book on Resettlement, A Guide to Good Practice 1998, as amended) and the World Bank, along with Government of India Guidelines, as applicable for Resettlement Action Plans (RAP) and Environmental Management Plans (EMP).
- **Contractual Conditions:** General Conditions of Contract (GC) and Special Conditions of Contract (SC) as appended to the Contract Agreement.

Adherence to these standards will ensure the development of robust, sustainable, and high-quality project designs, contributing to the overall success of the Bharatmala Pariyojana in Madhya Pradesh.

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### 3.0 Site Appreciation



*Delhi logistics route planning: Seven Seas Hotel to New Delhi.*





*Aerial land use showing agricultural plots, rural roads, and structures.*



*Aerial imagery of a proposed linear project corridor with survey points.*



*Proposed infrastructure alignment with chainage on aerial survey map.*

## 1.6 Site Appreciation: Bhopal, Madhya Pradesh

This section provides a detailed appreciation of the project site, focusing on Bhopal, the capital city of Madhya Pradesh, India. It outlines the geographical, environmental, socio-economic, and infrastructural characteristics pertinent to the execution of road development projects, integrating the requirements specified in the Request for Proposal (RFP) document.

### 1.6.1 Project Location Overview

The proposed projects, falling under the Economic Corridors, Inter Corridors, and Feeder Routes initiatives, are centered around Bhopal, Madhya Pradesh. As a prominent administrative, educational, and industrial hub, Bhopal's strategic location necessitates robust and efficient road infrastructure for enhanced freight movement and regional



connectivity. The city, known as the "City of Lakes," presents a unique blend of urban development and natural landscape, demanding a holistic engineering approach.

### 1.6.2 Geographical and Topographical Context

Bhopal is situated on the Malwa plateau, characterized by an undulating terrain with varying elevations and numerous natural and artificial water bodies. This topographical diversity has significant implications for road alignment, geometric design, and drainage systems.

- **Terrain:** The topography ranges from relatively flat urban stretches to rolling and undulating sections, with the presence of isolated hills and numerous lakes (e.g., Upper Lake, Lower Lake). This directly influences horizontal and vertical alignment design, requiring careful consideration of sight distances as per IRC guidelines (e.g., IRC:38, IRC:66). For specific hill road sections, if applicable, the supplementary requirements for hill roads as detailed in RFP Supplement I (e.g., Clause 2.2, 4.11(1), 4.11.2.1(ii)) will be rigorously applied, especially concerning gradient, hairpin bends, and slope stability.
- **Water Bodies:** The extensive network of lakes and smaller water bodies mandates comprehensive hydrological and hydraulic investigations for all proposed cross-drainage structures, including culverts, minor, and major bridges. This will adhere to IRC Special Publication No. 13 ("Guidelines for the Design of Small Bridges and Culverts") and IRC:5 ("Standard Specifications & Code of Practice for Road Bridges, Section I General Feature of Design"), as stipulated in RFP Clause 4.11.4.2.

### 1.6.3 Climatic Conditions

Bhopal experiences a humid subtropical climate with three distinct seasons: summer, monsoon, and winter. The monsoon season, typically from June to September, is a critical factor for project planning and execution.

- **Monsoon Rainfall:** The region receives significant rainfall during the monsoon months, which impacts construction activities, site accessibility, and necessitates robust drainage solutions. This mandates detailed design of complete drainage systems and disposal points for storm water, as per RFP Clause 2.5(xiv) and 4.12.4.

- **Temperature Variations:** Extreme temperatures during summer can affect material properties and construction methodologies, requiring adherence to MoRTH specifications for road and bridge works (RFP Clause 10.7(iv), 4.12.5).
- **Implications for Surveys & Construction:** Weather patterns necessitate careful scheduling of field surveys (e.g., traffic counts, topographic surveys) to ensure data accuracy and efficiency. Construction sequencing must account for monsoon disruptions to minimize delays and prevent damage to unfinished works.

#### 1.6.4 Socio-Economic and Land Use Profile

As a growing urban center, Bhopal exhibits a diverse land-use pattern, ranging from densely populated residential and commercial areas to peri-urban and agricultural zones. The historical industrial context (e.g., the Union Carbide incident) highlights the importance of rigorous environmental and social considerations.

- **Land Use:** The project corridors will traverse areas with varied land use (agricultural, commercial, forest, residential) as identified during road inventory surveys (RFP Clause 4.11.3.1(ii)). This complex environment makes land acquisition and resettlement a critical and sensitive component of the project.
- **Population Density:** Densely populated areas necessitate careful planning for minimizing land acquisition, avoiding disruption to community life, and managing traffic during construction. This aligns with RFP Clause 2.3 regarding avoiding land acquisition where possible and submitting land acquisition details.
- **Utilities and Encroachments:** The presence of existing utility services (overhead and underground) and potential encroachments within the Right-of-Way (ROW) is anticipated (RFP Clause 4.11.2.2, 4.11.3.1(xiv)). This mandates detailed utility mapping using Ground Penetrating Radar (GPR) and Induction Locator or equivalent technologies to a depth of 4m for accurate identification and relocation planning, as specified in RFP Clause 4.11.2.2. The NHAI Policy Circular No. Technical 215/2016 for utility shifting will be strictly followed.
- **Social Impact:** The project's impact on local populations, including potential displacement and livelihood impacts, will be thoroughly assessed through social analysis in accordance with MoRTH/World Bank/ADB Guidelines (RFP Clause 4.2). The social

analysis report will address socio-economic profiles, indigenous people, poverty alleviation, gender, and land acquisition and resettlement (RFP Clause 4.2).

#### 1.6.5 Existing Infrastructure and Traffic Profile

Bhopal's existing road network comprises National Highways (NH), State Highways (SH), Major District Roads (MDR), and Other District Roads (ODR). The traffic profile typically includes a mix of passenger vehicles, local and slow-moving traffic, and a significant component of freight movement, essential for the economic corridors.

- **Road Network Condition:** Initial reconnaissance surveys (RFP Clause 4.11.1) will identify existing pavement conditions, geometric deficiencies, and potential black spots (RFP Clause 4.12.1(xi)). Pavement investigations, including Benkelman Beam Deflection (BBD) or Falling Weight Deflectometer (FWD), roughness surveys (Bump Integrator/IRI as per IRC:81-1997, IRC:SP:16), and detailed road inventory surveys (RFP Clause 4.11.3), will inform strengthening and widening proposals.
- **Traffic Characteristics:** Traffic surveys, including Classified Traffic Volume Count, Origin-Destination and Commodity Movement, Axle Loading, Intersection Volume Count, and Speed-Delay Characteristics (RFP Clause 4.9), will be conducted at identified survey stations. This data will be crucial for accurate traffic demand estimates (RFP Clause 4.9.3), capacity analysis (RFP Clause 4.12.2), pavement design (RFP Clause 4.12.4), and intersection design (RFP Clause 4.9.4). The segregation of local and slow traffic from main traffic and provision of service roads and fencing will be considered where necessary (RFP Clause 2.4, 4.12.2).
- **Structures:** An inventory and condition survey of all existing bridges, culverts, and other structures (RFP Clause 4.11.4.1) will be undertaken. For distressed structures, supplementary testing and load carrying capacity assessment will be carried out as per IRC:SP:35, IRC:SP:40, and IRC:SP:37 (RFP Clause 4.11.4.3).

#### 1.6.6 Geological and Material Characteristics

The geological formations in and around Bhopal primarily consist of Deccan Traps (basaltic rock) and underlying Vindhyan sandstone, with significant stretches of black cotton soil in the Malwa region.

- **Sub-soil Conditions:** Geotechnical investigations and sub-surface explorations will be conducted as per IRC:78 (RFP Clause 4.11.4.4) to determine soil and rock properties, crucial for foundation design of bridges, structures, and high embankments. Boring locations and depths will be finalized in consultation with NHAI officers.

- **Construction Materials:** Locally available construction materials will be identified, surveyed, and tested to determine their suitability for various components of the work (RFP Clause 4.11.5). The assessment will include techno-economic principles and consideration of "Environment friendly materials" such as fly-ash and other industrial byproducts, adhering to MoRTH circular No. RW/NH-33044/53/2013-S&R(R) dated 20th November 2013, and Gazette notification no. S.O.254 (E) dated 25.01.2016 for fly-ash usage within 300 km of thermal power stations (RFP Amendment-1, Clause 4.12.5). Mass haul diagrams and quarry charts will be prepared (RFP Clause 4.11.5).

#### 1.6.7 Environmental Sensitivities

Environmental considerations are paramount, especially given Bhopal's natural assets and historical context.

- **Ecological Features:** The presence of lakes, potentially forested areas (if project alignment passes through), and associated flora and fauna will necessitate detailed Environmental Impact Assessment (EIA) and Environmental Management Plans (EMP) in accordance with Government of India, State Government, and World Bank/ADB Guidelines (RFP Clause 10.7(iv)).

- **Clearances:** Obtaining necessary project-related clearances (environment, forest, wildlife from MOEF, Railways for ROB/RUBs, Irrigation Department, etc.) will be a key project activity (RFP Clause 10.11).

#### 1.6.8 Conclusion

The appreciation of Bhopal's site conditions – its undulating terrain, monsoon climate, diverse land use, existing infrastructure complexities, and socio-environmental sensitivities – underpins the proposed methodology for the project. Our approach, in strict adherence to the detailed TOR, relevant IRC, MoRTH, BIS, and NHAI standards, and leveraging

advanced survey and design technologies (LiDAR, GPR, CAD software), is well-equipped to navigate these challenges and deliver a sustainable, efficient, and safe road infrastructure solution. The comprehensive survey and investigation plan, coupled with a robust design and clearance strategy, will ensure meticulous project preparation adapted to the specific conditions encountered in Bhopal.



## 4.0 Approach and Methodology

### Methodology for Detailed Project Report (DPR) Preparation

This section outlines the comprehensive methodology adopted for the preparation of the Detailed Project Report (DPR) for the development of Economic Corridors, Inter Corridors, Feeder Routes, and Coastal Roads in Lot-1/Madhya Pradesh/Package-3. The proposed methodology is designed to ensure a well-coordinated, inter-disciplinary, and integrated approach, adhering to the highest professional standards, relevant Indian codes, and international best practices, with a strong focus on timely delivery, quality management, and sustainable solutions.

The project encompasses the following stretches within Madhya Pradesh:

\* **Economic Corridor (Sagar-Varanasi):** Sagar to Katni section of NH-934 (approx. 193 km).

\* **Inter Corridor (Vidisha-Malthone):** Vidisha to Malthone section of SH-19, SH-14, SH-42A, and SH-42 (approx. 142.1 km).

\* **Total Length:** 335.1 km.

#### 1. General Approach

The Consultant will adopt a well-coordinated, inter-disciplinary integrated approach to engage key staff and stakeholders throughout the assignment. The methodology will focus on:

\* **Timely Completion:** Strict adherence to the work plan through close monitoring and efficient resource deployment.

\* **Effective Quality Management:** Implementation of a robust Quality Assurance Plan (QAP) for all activities.

\* **Mitigation Measures:** Proactive identification and planning for negative environmental and social impacts.

\* **Innovative Applications:** Exploration and incorporation of innovative engineering solutions and advanced technologies for optimal project outcomes.

\* **Stakeholder Consultation:** Regular interaction with the National Highways Authority of India (NHAI) Project Director and Regional Officer, as well as other relevant government agencies and local communities in Madhya Pradesh.

## 2. Phased Execution of Services

The services will be rendered in a professional manner through seven distinct stages, fulfilling all Terms of Reference (TOR) requirements:

- **Stage 1: Inception Report (IR)**
- **Stage 2: Feasibility Report (FR)**
- **Stage 3: Land Acquisition (LA) & Clearances I Report**
- **Stage 4: Detailed Project Report (DPR)**
- **Stage 5: Technical Schedules**
- **Stage 6: Draft 3D Publication Report**
- **Stage 7: Clearances II Report**

Preliminary design work will commence without awaiting the full completion of the Feasibility Study. Stages 3, 5, 6, and 7 will run in parallel with Stages 2 and 4 to optimize the project timeline.

## 3. Data Collection Strategy

A robust data collection strategy, encompassing both secondary data review and primary field surveys, will be implemented.

### 3.1 Secondary Data Review

All relevant existing data and information for the project corridors within Madhya Pradesh will be collected and reviewed. This includes, but is not limited to:

- \* Survey maps, topographic maps, satellite imageries, air photographs, and geological maps.
- \* Previous study reports, Detailed Project Reports (DPRs), and District Survey Reports (DSRs).
- \* Existing traffic count data (including IHMCL data), Origin-Destination (O-D) data, and commodity movement data.
- \* Material sources and lead maps.
- \* Details of existing bridges, culverts, and other structures, including as-built drawings, design High Flood Levels (HFL), and bore-log details.
- \* Road inventory, road condition records, and historical maintenance data.
- \* Climatic data (temperature, rainfall, wind), flood flow data, and seismological data.
- \* Local development plans being implemented or proposed for future implementation by local bodies in Madhya Pradesh.

### 3.2 Primary Field Surveys and Investigations

Competent team members, under the direction and supervision of the Team Leader and respective Key Personnel, will conduct comprehensive field surveys and investigations. These will include:

#### 3.2.1 Topographic Surveys

The objective is to capture essential ground features for improvements and cost estimation.

\* **Technology:** Mobile LiDAR (Light Detection and Ranging) or equivalent technology will be adopted to achieve horizontal accuracy of 2 cm or better and vertical accuracy of 2 cm or better, with more than 50 points measured per square meter for land-based surveys. For aerial-based surveys, the accuracy will be 5 cm or better for both horizontal and vertical, with more than 10 points per square meter. DGPS and Auto Level will be used for check point surveys.

\* **Scope:** Surveys will cover the existing road, proposed realignments, bypasses, bridge locations, and approach roads. The survey corridor will extend a minimum of 30m beyond either side of the centerline of the proposed divided carriageway or land boundary, whichever is more.

**Deliverables:** Raw DGPS data, point cloud data, 1:1000 scale topographic maps, 50cm contour maps, cross-sections at 1m intervals in .dwg format. For Mobile LiDAR, 360-degree panoramic images will be provided; for Aerial LiDAR, ortho-images.

\* **Standards:** All topographic surveys will conform to IRC guidelines.

### 3.2.2 Sub-surface Utility Detection

\* **Technology:** Ground Penetrating Radar (GPR), Induction Locator, or equivalent technologies will be used to accurately map and resolve all sub-surface utilities up to a depth of 4m.

\* **Scope:** Coverage and mapping of all sub-surface utilities within the project Right-of-Way (RoW), especially under additional carriageway width.

\* **Deliverables:** Utility maps in PDF, JPEG, and AutoCAD formats, differentiating between live electric cables, metallic utilities, and other utilities.

### 3.2.3 Traffic Surveys

Traffic surveys will be carried out to establish traffic demand estimates, growth rates, and inform geometric design.

\* **Classified Traffic Volume Count Survey (CTVC):** Utilizing Indian Highways Management Company Limited (IHMCL) ATCC systems where available. For uncovered stretches, the DPR consultant will conduct CTVC surveys for 7 continuous days (direction-wise) using ATCC systems or equivalent technologies, meeting accuracy levels of >95% for classification and >98% for counting after validation.

\* **Origin-Destination (O-D) and Commodity Movements Surveys:** 1-day (24-hour, both directions) surveys at locations finalized with NHAI, focusing on congested towns. Random sample basis for four-wheeled vehicles, including weight and commodity type information for trucks.

\* **Turning Movement Surveys:** For 1-day (24-hour) at major and minor intersections to estimate peak hour traffic and identify requirements for grade-separated structures. Methodology as per IRC:SP:41-1994.

\* **Axle Load Surveys:** In both directions at suitable locations (on project road stretches) on a random sample basis for trucks (empty and loaded) for 2 normal days (24 hours), using axle load pads or sophisticated instruments. To determine Vehicle Damage Factors (VDF) and Gross Vehicle Weight (GVW)/Single Axle Load (SAL) distributions.

\* **Speed-Delay Surveys:** Moving car surveys to determine running and journey speeds, identifying sections with traffic flow problems.

\* **Pedestrian/Animal Cross Traffic Surveys:** To determine the necessity of viaducts for safety.

\* **Truck Terminal Surveys:** Analysis of O-D and other surveys to assess requirements for present and future truck terminals.

\* **Standards:** All traffic surveys will adhere to IRC codes (e.g., IRC:102, IRC:SP:19).

### 3.2.4 Road and Pavement Investigations

\* **Road Inventory Surveys:** Detailed collection of existing road and pavement features (terrain, land-use, carriageway width, surfacing type, shoulder type/width, sub-grade type, curves, intersections, structures, utilities, arboriculture, drainage, design speed).

\* **Pavement Composition:** Trial pits (interval as per IRC:SP:19) to ascertain material type and thickness, and subgrade type/condition.

\* **Pavement Condition Surveys:** Visual inspection and measurements (rut depth with straight edges) for surface distress (cracking, raveling, potholes, edge break), shoulder, embankment, and drainage conditions.

\* **Pavement Roughness:** Using Bump Integrator or similar instruments (calibrated as per World Bank publications) along outer wheel paths for two runs each direction. Results in BI and IRI, analyzed for homogenous segments.

\* **Pavement Structural Strength:** Falling Weight Deflectometer (FWD) in accordance with IRC:115-2014 or IRC:117-2015.

\* **Subgrade Characteristics and Strength:** In-situ density and moisture content, Field CBR using DCP, Characterization (grain size, Atterberg limits), Laboratory moisture-density characteristics (modified compaction), and Laboratory CBR (unsoaked and 4-day soak compacted at three energy levels) and swell. For problematic soils, permeability and consolidation will also be determined. Testing frequency will be based on homogenous segments or soil types.

\* **Material Investigations:** Identification of sources (including fly-ash/slag), quarry sites, and borrow areas. Field and laboratory testing of materials for suitability and quality, recommending use based on techno-economic principles. Mass haul diagram and quarry charts.

\* **Laboratory:** Material testing will be carried out at the Consultant's own laboratory, approved by NHAI.

\* **Standards:** All road and pavement investigations will adhere to MoRTH guidelines and relevant IRC/BIS publications (e.g., IRC:81-1997, IRC:SP:19).

### 3.2.5 Investigations for Bridges and Structures

\* **Inventory:** Detailed inventory of all existing structures (bridges, viaducts, ROB/RUBs, culverts) as per IRC:SP:35 guidelines for bridges and tabular form for culverts.

\* **Hydraulic and Hydrological Investigations:** In accordance with IRC:SP:13 and IRC:5. Information on HFL, LWL, HTL, LTL, discharge velocity from records and local inquiries. Desk study of topography, rainfall, storm duration, soil characteristics, and vegetation cover to assess catchment areas.

\* **Condition Surveys:** Thorough inspection of existing structures, reports on condition, and supplementary testing as per IRC:SP:35 and IRC:SP:40 for distressed structures.

\* **Load Carrying Capacity Assessment:** As per IRC:SP:37, using analytical, correlation, or load testing methods.

\* **Remaining Service Life:** Assessment of retainable bridges/structures with and without strengthening/rehabilitation.

\* **Geo-technical Investigations and Sub-Soil Exploration:** For proposed bridges, ROB, tunnels, viaducts, interchanges, high embankments, and other necessary locations. Borings will be planned based on structure length (e.g., one abutment and at least one intermediate location for structures >6m and <60m, each abutment and pier for >60m).

\* **Standards:** All investigations will be as per MoRTH guidelines and relevant IRC/BIS publications. Geotechnical investigations will be performed as per IRC:78 by NHAI empanelled geotechnical consultants.

### 4. Data Analysis & Design Philosophy



The collected data will be rigorously analyzed using industry-standard software and methodologies to inform the detailed designs.

#### 4.1 Traffic Demand Estimates & Analysis

\* **Forecasting:** Estimates will be made for 30 years from completion, considering past trends, population growth, per capita income, elasticity of transport demand, socio-economic development plans, and land use patterns.

\* **Scenarios:** Optimistic, pessimistic, and most likely traffic growth scenarios for five-yearly intervals.

\* **Components:** Normal, generated, induced, and diverted traffic will be estimated.

\* **Impacts:** Toll charges and competing facilities will be factored into the estimates.

\* **Software:** HDM-IV or other internationally recognized forecasting techniques will be used, calibrated to local conditions in Madhya Pradesh.

\* **Standards:** Analysis will be in accordance with IRC:102.

#### 4.2 Pavement Design & Evaluation

\* **Strengthening & New Pavement Design:** For existing roads, bypasses, and shoulders, considering traffic studies and life-cycle costing.

\* **Design Alternatives:** Both rigid and flexible pavement options will be evaluated based on life-cycle costing and techno-economic considerations.

\* **Input Parameters:** Rigorous testing and evaluation will determine design inputs. Methodology will include basic assumptions, design input values, rationale, and control criteria.



\* **Overlay Design:** For existing 2-lane pavements, strengthening requirements will account for existing pavement strength and remaining life. Provision of regulating layer and crack inhibiting layer.

\* **Innovative Techniques:** Geo-synthetics and cold/hot pavement recycling will be considered for economy.

\* **Maintenance:** Development of maintenance and strengthening requirements, periodicity, and timing of treatments.

\* **Standards:** Primarily based on IRC publications, MoRT&H Circulars, and international practices.

#### 4.3 Bridge & Structure Design

\* **General Arrangement Drawings (GAD):** Preparation of GADs and Alignment Plans showing salient features. Multiple alternatives with cost-benefit implications will be submitted to NHAI for approval.

\* **Detailed Design:** Post-GAD approval, detailed designs and working drawings for all components (superstructure, substructure, foundations, bearings, expansion joints, protection works) as per IRC codes/guidelines.

\* **ROBs:** Preliminary GADs for ROBs will be prepared and pursued with Indian Railways authorities for approval.

\* **Existing Structures:** Dismantling/reconstruction will be avoided where possible. Widening/reconstruction or repair/rehabilitation measures (as per IRC:SP:40) will be proposed for inadequate or distressed structures.

\* **Innovative Structures:** Innovative, aesthetically pleasing structures with minimum joints will be designed where feasible.

\* **Standards:** Designs will conform to IRC codes, MoRT&H guidelines, and Indian Railways standards. Geotechnical design for foundations as per IRC:78.

#### 4.4 Embankment Design

\* **Material Utilization:** Maximum utilization of locally available materials consistent with economy.

\* **Fly Ash Usage:** Mandatory use of fly ash within 300 km from Thermal Power Stations, as per MoEF Gazette Notification No. S.O.254 (E) dated 25.01.2016 and subsequent amendments.

\* **High Embankments:** Detailed analysis and design for embankments greater than 6m, including protection works and traffic safety features.

\* **Retaining Structures:** RCC retaining walls or RE (Reinforced Earth) walls will be considered where land is inadequate for embankment slopes, based on techno-economic suitability and NHAI approval.

\* **Standards:** Designs will conform to relevant IRC publications.

#### 4.5 Drainage Design

\* **Roadside Drainage:** System design integrated with cross-drainage for the entire project length.

\* **Special Provisions:** Drainage provisions for super-elevated carriageways, high embankments, cut sections, and urban areas.

\* **Outfall Points:** Locations of turnouts/outfall points with details of outfall structures fitting into natural contours. Separate drawing sheets for every 5km stretch.

\* **Standards:** Designs will conform to relevant IRC publications.

#### 4.6 Geometric Design

- \* **Identification of Deficiencies:** Based on reconnaissance and topographic surveys, sections with geometric deficiencies will be identified, and suitable improvements will be suggested.
- \* **Accident Analysis:** Compilation of accident statistics to identify black spots, investigate causes, and propose cost-effective remedial measures.
- \* **Elements:** Longitudinal profile, horizontal alignment, cross-sectional elements (including refuge lanes at 2km intervals), junctions, intersections, interchanges, bypasses, and service roads.
- \* **Sight Distances:** Verification for available sight distances as per standard norms, with appropriate markings and signs for non-adherence areas.
- \* **Traffic Flow & Level of Service:** Detailed analysis to establish widening requirements for different horizon periods.
- \* **Cross Roads:** Examination of options for closely spaced cross roads (grade-separated structures, service roads, access closures).
- \* **Pedestrian Crossings:** Design of grade-separated pedestrian crossings (viaducts) for large pedestrian/animal traffic.
- \* **Service Roads:** Design and details for parallel service roads in urbanized locations.
- \* **Standards:** Designs will adhere to IRC publications and MoRT&H Circulars.

#### 4.7 Traffic Safety Features, Road Furniture, and Markings

- \* **Design:** Suitable traffic safety features and road furniture including traffic signals, signs, markings, overhead sign boards, crash barriers, delineators.

- \* **Location:** Locations clearly indicated in reports and drawings.

- \* **Standards:** Designs will conform to relevant IRC publications.

#### 4.8 Arboriculture and Landscaping

- \* **Plan:** Appropriate plan for tree planting (specifying type), horticulture, and floriculture on surplus RoW land to beautify the highway.

- \* **Existing Vegetation:** Retention of existing trees/plants to the extent possible. Transplantation proposals where feasible.

#### 4.9 Toll Plaza, Weighing Stations, Parking & Rest Areas

- \* **Toll Plaza:** Identification of possible location(s) based on traffic studies and existing physical features, designed as per IRC:84.

- \* **Weighing Stations:** Selection of suitable sites, designed to identify and penalize overloaded vehicles. Type of weighing system (state-of-the-art) will be recommended.

- \* **Parking & Rest Areas:** Selection of suitable sites and separate designs. Common facilities (petrol pump, first-aid, police office, restaurant) will be planned at approximately 50km intervals, adhering to OISD guidelines for petrol pumps.

- \* **Standards:** Designs will conform to relevant IRC publications.

#### 5. Environmental and Social Impact Assessment (ESIA)

Detailed environmental and social impact assessments will be undertaken in accordance with Government of India standards, World Bank/ADB guidelines (as applicable), and NHAI requirements.

- **Environmental Impact Assessment (EIA):**

- Preliminary environmental screening and baseline condition documentation.

- Assessment of potential significant impacts and identification of mitigation measures.
- Analysis of alternatives (with and without project scenarios).
- Emphasis on environmental enhancement measures (cultural property, bus bays, landscape, water bodies, borrow area redevelopment).
- Preparation of Bill of Quantities (BOQ) and technical specifications for environmental works.
- Establishment of monitoring networks for air, water, and noise pollution.
- Costing of mitigation measures and budgeting for environmental staffing/training.
- Preparation of application forms and obtaining forestry and environmental clearances from SPCBs and MOEF on behalf of NHAI.
- Identification and planning for tree plantation and transplantation as per IRC guidelines.
- Reporting: Stand-alone EIA reports including Executive Summary, Project Description, Environmental Setting, Impact Identification, Alternatives Analysis, Public Consultation Process, Legal Framework, and Environmental Management Plan (EMP).
- **Social Assessment (SA):**
  - Baseline socio-economic and census surveys (25% socio-economic, 100% census) to assess impacts on people, properties, and livelihoods.
  - Identification of mechanisms to improve project designs to meet stakeholder needs.
  - Preparation of Land Acquisition Plan (LAP) and assistance to NHAI in land acquisition under various Acts (e.g., NH Act, 1956).
  - Drafting of 3a, 3A, and 3D notifications.
  - Preparation of Resettlement and Rehabilitation Plan (RAP), assessing income restoration strategies and relocation site suitability.
  - Assessment of impact on poor and vulnerable groups.
  - Development of entitlement matrix.
  - Assessment of social issues (indigenous people, gender, HIV/AIDS, child labor).
  - Implementation budgets, funding sources, and task schedules.

- Institutional arrangements for entitlement delivery and capacity building.
- Internal and external monitoring plans, key indicators, and grievance redress mechanism.
- Full documentation of consultations with affected persons.
- Reporting: Stand-alone SA/RAP reports including Executive Summary, Project Description, Objectives, Need for Resettlement, Public Consultation, PAP Definition/Eligibility, Survey Results, Legal Framework, Monitoring/Evaluation, Implementation Schedule, Budget.

## 6. Cost Estimation, Viability & Financing Options

### 6.1 Estimation of Quantities and Project Costs

\* **Detailed Estimates:** Preparation of detailed estimates for quantities (considering designs and mass haul diagram) and project costs for the entire project (civil package-wise).

\* **Unit Rates:** Detailed analysis for computing unit rates based on MoRTH's Standard Data Book and market rates, considering manpower, machinery, and materials.

\* **Verification:** Project cost estimates will be checked against rates for similar ongoing works under NHAI/World Bank/ADB financed road projects in India.

### 6.2 Viability and Financing Options

#### \* **Economic Analysis:**

\* Carried out for each traffic homogenous link and for the overall project using HDM-IV or other internationally recognized life-cycle costing models.

\* Assessment of existing road capacity and effects on Vehicle Operating Costs (VOC).



- \* Quantification of economic benefits (reduced congestion, travel distance, maintenance costs, accident reduction, time value).

- \* Estimation of Economic Internal Rate of Return (EIRR) and Net Present Value (NPV) over a 30-year period, with and without time/accident savings.

- \* Sensitivity analysis for different scenarios (cost/benefit variations, delays).

- \* **Financial Analysis:**

- \* Study of financial viability under a commercial format and different user fee scenarios/funding options (BOT, Annuity, Hybrid Annuity, EPC).

- \* Financial Internal Rate of Return (FIRR), projected income statements, balance sheets, and fund flow statements.

- \* Sensitivity analysis for probabilistic scenarios.

- \* Identification, assessment, and mitigation of risks (construction delays/overrun, traffic volume, revenue shortfalls, operating costs, exchange rate, interest rate, force majeure).

- \* Suggestion of positive ways to enhance project viability and furnish different financial models.

- \* **Standards:** Analysis parameters and models will be approved by NHAI.

## 7. Quality Assurance System (QAS)

A detailed Quality Assurance Plan (QAP) will be prepared and implemented to ensure the highest quality of deliverables.

- **Policy:** Adherence to the Consultant's in-house quality policy for all assignments.

- **Components:** The QAP will cover all activities including surveys, investigations, data analysis, design, and documentation. It will detail:

- TOR/Client requirements.
- Manpower responsibilities (performance, checking, approval).
- Equipment specifications, calibration, and accuracy levels.
- Applicable Standards/Codes (IRC, MoRTH, BIS, international standards).
- Regulatory requirements.
- Safety and environmental considerations.
- Training programs.
- Data verification protocols.
- Documentation and retrieval systems.
- Detailed work procedures.
- Standard proforma for data recording.
- **Approval:** The QAP document will be discussed and finalized with NHAI officers immediately upon contract award and submitted as part of the Inception Report. Fieldwork and design activities will commence only after NHAI approval of the QAP.

## 8. Reporting and Deliverables

All reports, documents, and drawings will be submitted separately for each traffic homogenous link of the project road, where applicable, and as specified in Enclosure-III of the TOR.

\* **Format:** Submissions will be in bound volumes (not spiral binding) and electronic format (floppy-diskettes/CDs) with editable soft copies.

\* **Content:** Reports will indicate sources of data and model relationships with complete details.

\* **Key Deliverables (by stage):**

- \* **Stage 1: Inception Report:** Project appreciation, detailed methodology, task assignment, manning schedule, work program, data collection proforma, design standards, cross-sections, key plan, linear plan, local development plans, QAP, draft design standards, proposed corridor alignment, and bypass identification.
- \* **Stage 2: Feasibility Report:** Executive summary, NHAI overview, project description (alternatives), methodology, socio-economic profile, indicative design standards, traffic surveys/analysis, environmental screening, preliminary social assessment, preliminary LA/R&R plan, cost estimates, economic/financial analysis, conclusions/recommendations. Includes Technical Specifications, Rate Analysis, Cost Estimates, Bill of Quantities, and basic field data as appendices, plus draft 3(a) publication report.
- \* **Stage 3: LA & Clearances I Report:** Details of proposed NH centerline, RoW limits, land ownership, utility positions/relocation, environmental/forest clearances, detailed LA schedules, draft 3(a), 3(A) and 3(D) notifications, and resettlement action plan.
- \* **Stage 4: Detailed Project Report (DPR):** Main Report, Design Report, Materials Report, Engineering Report, Drainage Design Report, Economic and Financial Analysis Report, Environmental Assessment Report (including EMP & RAP), package-wise bid documents, and 'good for construction' drawings.
- \* **Stage 5: Technical Schedules:** Civil Work Contract Agreement.
- \* **Stage 6: Draft 3D Publication Report:** Based on actual land requirement after field survey and discussion with revenue department, including legible cadastral maps. Deliverable includes publication of 3(D) notification for 90% of length.
- \* **Stage 7: Clearances II Report:** Final project-related clearances (environment, forest, wildlife from MOEF, Railways for ROB/RUBs, Irrigation Deptt, etc.), liaison with utility owning agencies for estimates.
- \* **Data and Software Handover (TOR 13):** All basic and processed data (engineering investigations, traffic studies, topographic, rate analysis, economic/financial) and any project-specific software (financial model) will be handed over to NHAI on floppies/CDs at final report submission.

## 9. Project Team and Resources

The Consultant will field a multi-disciplinary team of qualified and experienced personnel as detailed in the technical proposal, complemented by adequate sub-professional staff.

\* **Key Personnel:** Team Leader-cum-Senior Highway Engineer, Senior Bridge Engineer, Highway cum Pavement Engineer, Material-cum-Geotechnical Engineer, Senior Survey Engineer, Traffic and Safety Expert, Environmental Specialist, Quantity Surveyor/Documentation Expert, Land Acquisition Expert, and Utility Expert.

\* **Site Office:** An office will be established in Madhya Pradesh (e.g., Bhopal or near the project corridor) manned by senior personnel during surveys and investigations. All project-related office work will primarily be conducted from this site office.

\* **Equipment & Software:** All necessary equipment, software (e.g., CADD, MX Road, Civil 3D, STAAD Pro, HDM-4, GIS tools), and reference materials will be procured by the Consultant.

## 10. Utility Shifting Protocol

Adhering to NHAI Policy Circular No. Technical 215/2016 dated 19.09.2016, the Consultant will manage utility shifting processes.

\* **Estimate Procurement:** Responsible for procuring utility shifting estimates from concerned utility agencies. Estimates will detail existing and proposed utility shifting with offsets, certifying the essentiality for project development.

\* **Estimate Verification:** Verification of estimates against current applicable Schedule of Rates of the agency and market rates for non-SoR items. A certification of verification with remarks on variations will be submitted to NHAI.

\* **Utility Expert:** Appointment of a utility expert at a sub-professional level (3 months) with relevant technical expertise, possibly including retired state government utility officials, to assist in the process.

\* **Sub-surface Mapping:** Accurate mapping and resolution of all sub-surface utilities up to 4m depth using GPR, Induction Locator, or equivalent technologies.

\* **No Upgradation Undertaking:** Ensure submission of "no upgradation" undertaking by utility agencies, as per standards, for necessary technical changes (e.g., pole height, underground cables, casing of pipelines).

## 11. Land Acquisition Protocol

- **Details Collection:** Land acquisition details, including ownership, will be collected from revenue records/maps in Madhya Pradesh.
- **Draft Notification:** Consultant will submit draft 3a, 3A, and 3D notifications for land acquisition, as per NHAI proforma, in both Hindi and English languages.
- **Consultation:** Land acquisition reports will be prepared in consultation with affected persons, NGOs, and concerned government agencies.
- **Cadastral Mapping:** Digitization of cadastral/land revenue maps to precisely match original maps for extracting plot dimensions and areas, ensuring accuracy of 1mm or higher in a 1:1000 scale map.

## 12. Conclusion

This comprehensive methodology, integrating advanced technologies, adherence to national and international standards, and continuous stakeholder engagement, ensures the successful and efficient preparation of the Detailed Project Report for the designated highway stretches in Madhya Pradesh. The Consultant is committed to delivering a high-quality, implementable DPR that supports the development of an efficient freight movement network in India.

## 5.0 Task Assignment and Manning Schedule

The following outlines the detailed task assignments for the key professional and sub-professional personnel designated for the "Consultancy Services for preparation of DPR for development of Economic Corridors, Inter Corridors, Feeder Routes and Coastal Roads to Improve the efficiency of freight movement in India (Lot-1/Madhya Pradesh/Package-3)" project. These assignments are aligned with the project's Terms of Reference (TOR) and industry best practices, ensuring comprehensive project delivery in Madhya Pradesh.

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### 1. Task Assignment for Key Professional Staff

The Consultant's team comprises highly qualified and experienced professionals, each assigned specific roles and responsibilities to ensure the successful execution of the Detailed Project Report (DPR) preparation, adhering to the highest standards of quality, accuracy, and efficiency.

#### 1.1. Team Leader cum Senior Highway Engineer (Shri Rajesh Kumar Patyal)

The Team Leader (TL) serves as the overall project manager and the primary point of contact with the Client (NHAI). This role demands a blend of technical expertise, strategic leadership, and effective communication to steer the project in Madhya Pradesh.

##### \* Overall Project Management & Coordination:

- \* Responsible for the strategic planning, execution, and successful completion of all project stages as per the TOR and contract agreement.

- \* Ensure seamless coordination among all team members, sub-consultants, and external agencies throughout the project lifecycle.



- \* Serve as the main liaison with NHAI, coordinating all project-related communications, submissions, and approvals.

- \* **Technical Oversight & Guidance:**

- \* Guide, supervise, and monitor the work of all technical experts, ensuring adherence to project scope, quality standards, and timelines.

- \* Oversee the review and finalization of alignment options based on techno-economic and environmental-social viability studies, particularly considering the topographical and socio-economic conditions prevalent in Madhya Pradesh.

- \* Provide expert solutions to complex engineering challenges, ensuring compliance with IRC, MoRTH, and NHAI guidelines.

- \* Lead the preparation and finalization of all project reports, including the Inception Report, Feasibility Report, and Detailed Project Report (DPR), ensuring their quality and completeness.

- \* Oversee the development of interactive 3D Virtual Reality (VR) simulated environments for design visualization and stakeholder engagement, as required.

- \* **Client & Stakeholder Engagement:**

- \* Provide technical assistance to NHAI on queries raised during pre-bid meetings and post-concession award phases.

- \* Ensure timely submission of all deliverables as per the agreed-upon schedule and facilitate necessary client reviews and approvals.

- \* **Quality Assurance & Risk Management:**

- \* Implement and monitor the project's Quality Assurance Plan (QAP) for all field studies, investigations, design, and documentation activities.

- \* Proactively identify potential project risks and develop mitigation strategies to ensure smooth project progress.

## **1.2. Senior Bridge Engineer (Shri Sanjay Mandal)**

The Senior Bridge Engineer is responsible for all aspects of bridge and structural design, rehabilitation, and associated surveys.

### **\* Structural Inventory & Condition Assessment:**

- \* Coordinate, guide, and supervise the inventory and condition surveys of all existing bridges, culverts, and other cross-drainage (CD) structures along the project corridor.
- \* Assess the structural integrity and functional adequacy of existing structures, identifying those requiring rehabilitation, widening, or reconstruction.

### **\* Design & Engineering:**

- \* Develop cost-effective and innovative design solutions for new bridges, flyovers, ROB/RUBs, culverts, and other structures, strictly in accordance with IRC codes (e.g., IRC:5, IRC:SP:13, IRC:SP:35, IRC:SP:40, IRC:78), MoRTH specifications, and BIS standards.
- \* Lead the preparation of General Arrangement Drawings (GADs) and detailed structural designs, including superstructure, substructure, and foundation designs.
- \* Coordinate with geotechnical experts for sub-soil investigations and hydraulic experts for hydrological data analysis to inform structural designs.
- \* Supervise the use of advanced structural design software (e.g., STAAD Pro, RM) for analysis and detailing.
- \* Suggest unconventional construction solutions like box pushing or precast elements where technically and economically feasible.

**\* Quality & Quantity Management:**

- \* Finalize data formats and requirements for field studies pertaining to bridges and structures.
- \* Verify quantities and costs associated with the rehabilitation or reconstruction of structures.
- \* Ensure all designs account for regional factors such as seismic activity and hydrological patterns specific to Madhya Pradesh.

**1.3. Highway cum Pavement Engineer (Shri Nabin Kumar Niyogi)**

This role focuses on the geometric design of the highway, pavement engineering, and material suitability.

**\* Highway Design & Geometry:**

- \* Conduct, coordinate, and analyze various highway engineering surveys and investigations, including topographical, road inventory, and condition surveys.
- \* Develop detailed geometric designs for the highway, including horizontal and vertical alignments, super-elevation, cross-sections, and intersections/interchanges, utilizing advanced CADD software (e.g., MX Road, Civil 3D, Softdesk).
- \* Design all project facilities such as bus bays, rest areas, and service roads, considering local requirements and traffic segregation.

**\* Pavement Design & Materials:**

- \* Conduct pavement condition surveys (e.g., Falling Weight Deflectometer (FWD) as per IRC:115-2014 or IRC:117-2015), sub-grade investigations, and material characterization.

- \* Perform pavement design (flexible and rigid) and overlay design as per IRC:37 and IRC:58, respectively, for new construction and strengthening of existing pavements.
- \* Carry out pavement options studies and life-cycle cost analysis (e.g., using HDM-4) to recommend the most techno-economically viable pavement solutions.
- \* Identify sources of construction materials (e.g., aggregates, binder, soil) and determine their suitability through laboratory testing, adhering to MoRTH specifications and BIS standards.

**\* Economic Analysis & Documentation:**

- \* Assist in carrying out the economic analysis (EIRR, NPV) for the project, including "with" and "without time and accident savings" scenarios.
- \* Verify quantities for pavement and highway-related works and contribute to the preparation of various project reports and EPC Bid Documents.

**1.4. Material cum Geotechnical Engineer-Geologist (Shri Avik Kumar Mandal)**

This expert is responsible for all geotechnical investigations, material characterization, and design of earthworks and foundations.

**\* Geotechnical Investigations & Analysis:**

- \* Finalize data formats and requirements for field studies related to sub-soil exploration for bridges, structures, and embankments.
- \* Plan and coordinate comprehensive field and laboratory investigations for both materials and geotechnical aspects, ensuring compliance with IRC:78 and relevant BIS codes.
- \* Conduct detailed geotechnical investigations for structures (foundations), high embankments, and road pavements.

- \* Interpret geotechnical data, establish soil and rock properties, and recommend Safe Bearing Capacity (SBC) for foundations and embankments.

- \* **Design of Earthworks & Ground Improvement:**

- \* Design embankments, hill cuts, and Reinforced Earth (RE) walls, considering regional geological and seismic factors.

- \* Analyze and recommend appropriate ground improvement measures for areas with problematic soils (e.g., soft clays, expansive soils), drawing upon relevant IRC guidelines.

- \* Oversee the use of geotechnical design software for slope stability analysis (e.g., XSTABL, RESSA, ReSlope) and settlement computations (e.g., FOSSA).

### **1.5. Senior Survey Engineer (Shri Dilip Kumar Dey)**

The Senior Survey Engineer leads all topographical survey activities, ensuring precision and accuracy of all spatial data.

- \* **Survey Planning & Execution:**

- \* Formulate and coordinate all activities related to topographical surveys, including establishing horizontal and vertical control points (GTS benchmarks, DGPS) as per IRC:SP:19.

- \* Supervise detailed topographical surveys using modern techniques such as Mobile/Aerial LiDAR or equivalent technologies (as per TOR 4.11.2.2) to capture ground features, existing infrastructure, and land use patterns.

- \* **Data Processing & Mapping:**

- \* Routinely check and validate the accuracy of all survey data collected.

- \* Process raw survey data to generate Digital Terrain Models (DTM), contour maps (50 cm interval), longitudinal sections (1m interval), and cross-sections (1m interval).

- \* Ensure all ground features are accurately transferred onto drawings and maps.

- \* Assist highway and CAD engineers in preparing base maps for design.

- \* **Land Acquisition Support:**

- \* Coordinate all survey activities necessary for the preparation of Land Acquisition Proposals, including demarcation of Right of Way (ROW) and property boundaries.

### **1.6. Traffic and Safety Expert (Shri B. Mallikarjuna Setty)**

This expert is responsible for traffic studies, demand forecasting, safety audits, and designing traffic management and safety features.

- \* **Traffic Studies & Forecasting:**

- \* Plan, organize, and conduct comprehensive traffic surveys, including Classified Traffic Volume Counts (using ATCC systems as per TOR 4.9.2), Origin-Destination (O-D) surveys, Axle Load Surveys (TOR 4.9.5), and Speed-Delay surveys (TOR 4.9.6).

- \* Analyze collected traffic data and project future traffic demand for a 30-year design period, considering regional socio-economic growth, elasticity of transport demand, and other development plans in Madhya Pradesh.

- \* **Road Safety & Management:**

- \* Conduct thorough road safety audits at various stages of project preparation, identifying black spots and proposing remedial measures.

- \* Suggest appropriate carriageway configurations based on traffic projections and desired Level of Service (LoS).



- \* Design comprehensive traffic management plans, including traffic control features (signals, signs, markings), geometric improvements for intersections/junctions, and provisions for vulnerable road users (pedestrians, animals).

- \* **Economic & Financial Analysis:**

- \* Contribute to the economic and financial analysis of the project, focusing on benefits from reduced congestion, travel time savings, and accident cost reduction.

- \* Plan and design toll plaza locations, layouts, and toll collection methods, considering operational efficiency and user facilities.

### **1.7. Environmental Specialist (Shri Nagendra Kumar)**

The Environmental Specialist ensures the project complies with all environmental regulations and integrates sustainable practices.

- \* **Environmental Assessment & Management:**

- \* Organize and coordinate baseline environmental surveys (air, water, noise, ecological features, cultural properties) along the project corridor.

- \* Conduct Environmental Impact Screening and a detailed Environmental Impact Assessment (EIA) for the project, adhering to MoEF, ADB, World Bank, and NHAI guidelines (TOR 4.13.1).

- \* Identify potential environmental impacts (positive and negative) during pre-construction, construction, and operation phases and formulate appropriate mitigation measures.

- \* Develop a comprehensive Environmental Management Action Plan (EMAP) and monitoring mechanisms.

- \* **Clearances & Consultations:**

- \* Prepare and process applications for all necessary environmental and forest clearances from relevant state and central government departments (including MoEF).

- \* Organize and conduct public consultations and stakeholder engagement activities to address environmental concerns and incorporate community feedback.

- \* **Social Aspects & Documentation:**

- \* Assist in conducting Social Impact Assessment (SIA) and preparing the Resettlement Action Plan (RAP), in coordination with the Land Acquisition and R&R experts.

- \* Contribute to the Land Acquisition Plan and Report.

### **1.8. Quantity Surveyor/Documentation Expert (Shri Manoj Kumar Sinha)**

This role is critical for accurate quantity estimation, cost control, and comprehensive documentation.

- \* **Quantity Estimation & Costing:**

- \* Prepare detailed Bills of Quantities (BoQ) for all civil works items, including earthwork, pavement, structures, drainage, and road furniture, in accordance with MoRTH specifications.

- \* Develop detailed cost estimates for the entire project based on current Schedule of Rates (SoR) and market rates applicable in Madhya Pradesh.

- \* Conduct rate analysis for all work items.

- \* **Contract & Documentation:**

- \* Assist in the preparation of bid/tender documents, including technical specifications, special conditions of contract, and payment schedules.

- \* Ensure all project documentation (reports, drawings, calculations) is maintained systematically and complies with NHAI requirements.
- \* Verify quantities and costs mentioned in various project reports and submissions.

### **1.9. Land Acquisition Expert (Shri Sangram Kumar Singh)**

The Land Acquisition Expert is responsible for the systematic process of land acquisition, in line with legal frameworks.

#### **\* Land Records & Mapping:**

- \* Collect and verify revenue maps and land records from relevant authorities in Madhya Pradesh.
- \* Digitize cadastral maps and accurately align them with the proposed improved highway alignment.

#### **\* Notification & Coordination:**

- \* Prepare all relevant land acquisition schedules and draft notifications (Form 3(a), 3(A), and 3(d)) as per the National Highways Act, 1956, and Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013.
- \* Coordinate with district revenue authorities for joint measurement surveys and subsequent processing of land acquisition.

#### **\* Social Safeguards Integration:**

- \* Work closely with the Social Development/R&R Specialist to ensure that the land acquisition process is integrated with Resettlement & Rehabilitation (R&R) planning and implementation.

### **1.10. Utility Expert (Shri Parantapa Das)**

This expert manages the identification, planning, and relocation of all utilities along the project corridor.

**\* Utility Identification & Mapping:**

\* Identify and inventory all existing overhead and underground utilities (e.g., electricity lines, water pipelines, gas pipelines, telecommunication cables) along the project corridor using non-intrusive technologies such as Ground Penetrating Radar (GPR) or Induction Locators (as per Checklist page 126).

\* Map the identified utilities with precise chainage and offset details.

**\* Relocation Planning & Coordination:**

\* Develop detailed utility relocation plans to minimize disruption to services and avoid conflicts with the proposed highway design.

\* Conduct site visits and engage in extensive liaison with relevant utility-owning agencies (e.g., Madhya Pradesh Electricity Board, Public Health Engineering Department) to obtain necessary approvals and coordinate relocation works.

\* Prepare cost estimates for utility shifting and ensure these are integrated into the overall project cost.

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## **2. Task Assignment for Sub-Professional Staff**

The sub-professional staff provides essential technical and administrative support, working under the direct supervision of the key personnel.

### **2.1. Project Coordinator (To be Named)**

\* **Role:** Monitor, guide, and support the Consultants Team in the successful completion of services, including pre-construction activities.

\* **Responsibilities:** Maintain constant liaison with the Client (NHAI) on behalf of the Team Leader. Assist in monitoring project progress, resource allocation, and adherence to timelines. Facilitate internal team meetings and coordination.

## **2.2. Highway CAD cum Pavement Engineer (To be Named)**

\* **Role:** Provide essential CAD and pavement engineering support to the Highway cum Pavement Engineer and Team Leader.

\* **Responsibilities:** Prepare computerized designs and drawings for highway geometrics (alignments, cross-sections, intersections), pavement details, and road furniture. Assist in reviewing results of various surveys and investigations. Assist in finalizing rehabilitation options and pavement designs.

## **2.3. Bridge Design Engineer (To be Named)**

\* **Role:** Assist the Senior Bridge Engineer in all aspects of structural design and drawing preparation.

\* **Responsibilities:** Prepare computerized bridge and structural designs and working drawings, including detailing of reinforcement. Perform structural analysis for minor structures under the guidance of the Senior Bridge Engineer.

## **2.4. Hydrologist-cum-Drainage Engineer (To be Named)**

\* **Role:** Support in hydrological studies and design of drainage systems.

\* **Responsibilities:** Conduct hydrological data collection and analysis. Assist the Bridge Engineer and Highway Engineer in the hydraulic design of bridges and culverts. Prepare designs for comprehensive road drainage systems, including culverts, side drains, and outfall structures.

### 2.5. Traffic Engineer (To be Named)

\* **Role:** Assist the Traffic and Safety Expert in conducting traffic surveys and analysis.

\* **Responsibilities:** Carry out classified traffic volume counts, O-D surveys, speed-delay studies, and axle load surveys. Assist in the analysis of traffic data, forecasting, and developing traffic management plans.

### 2.6. Financial Expert (To be Named)

\* **Role:** Provide support for economic and financial analysis.

\* **Responsibilities:** Prepare input data for financial analysis and calculation of financial rate of return. Assist in assessing the financial viability of the project and documenting financial analysis. Provide support for risk allocation matrix. Assist in evaluation of proposals for bidders.

### 2.7. Resettlement & Rehabilitation Specialist (To be Named)

\* **Role:** Support in Social Impact Assessment and R&R planning.

\* **Responsibilities:** Carry out Social Impact Assessment (SIA) and develop a Resettlement and Rehabilitation (R&R) framework. Conduct public consultations and engagement with communities, NGOs, and government agencies. Assist in the preparation of Resettlement Action Plans (RAPs) and Land Acquisition Reports.

### 2.8. Soil/Material Engineer (To be Named)

\* **Role:** Assist the Material cum Geotechnical Engineer in material investigations and testing.

\* **Responsibilities:** Conduct field and laboratory testing of construction materials (e.g., soil, aggregates, bitumen). Assist in identifying material sources and assessing their suitability.



## 2.9. Pavement Engineer (To be Named)

\* **Role:** Support the Highway cum Pavement Engineer in pavement design activities.

\* **Responsibilities:** Assist in pavement condition surveys, data analysis (e.g., BBD/FWD data), and overlay design calculations. Prepare pavement design drawings and specifications.

## 2.10. Geo-Technical Engineer (To be Named)

\* **Role:** Assist the Material cum Geotechnical Engineer in geotechnical investigations and analysis.

\* **Responsibilities:** Assist in planning and executing field geotechnical investigations (e.g., boreholes, SPT). Process and interpret geotechnical data. Assist in slope stability analysis and foundation design calculations.

## 2.11. Environmental Engineer (To be Named)

\* **Role:** Support the Environmental Specialist in environmental studies and documentation.

\* **Responsibilities:** Assist in collecting baseline environmental data. Support in preparing environmental impact assessments, environmental management plans, and applications for clearances. Assist in community consultations on environmental issues.

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This detailed assignment of tasks ensures a clear delineation of responsibilities and a coordinated effort towards achieving the project objectives for the development of economic corridors in Madhya Pradesh.

## 6.0 Proposed Cross Sections

The 'cross\_sections' section outlines the foundational geometric elements of the proposed highway, critical for ensuring optimal functionality, safety, and economic viability. This section details the approach to developing appropriate cross-sectional designs that align with the project objectives and comply with relevant national and international standards, specifically tailored for the topographical and environmental characteristics of Bhopal, Madhya Pradesh, India.

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### 1. Introduction and Objectives

Cross-sectional design is a fundamental component of highway engineering, dictating the spatial arrangement of various road elements and their relationship to the surrounding terrain and land use. The primary objective is to develop a robust and sustainable design that:

- \* Accommodates projected traffic volumes and vehicle types efficiently.
- \* Ensures the safety of all road users, including motorists, pedestrians, and non-motorised transport (NMT).
- \* Integrates effective drainage systems for storm water management, crucial in regions experiencing monsoon seasons like Madhya Pradesh.
- \* Minimises land acquisition and utility relocation requirements wherever feasible.
- \* Facilitates future expansion while maintaining structural integrity and operational efficiency.
- \* Adheres strictly to the guidelines and specifications issued by the Indian Roads Congress (IRC), Ministry of Road Transport & Highways (MoRTH), Bureau of Indian

Standards (BIS), and National Highways Authority of India (NHAI).

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## 2. Scope of Cross-Sectional Design

The scope of work for cross-sectional design, as derived from the Request for Proposal (RFP) and best engineering practices, encompasses:

- **Topographic Survey Data Utilisation:** Processing detailed topographic surveys (including LiDAR or equivalent technology) to generate a highly accurate Digital Terrain Model (DTM) for precise cross-section generation. This will include cross sections at 1m intervals along the final centreline, and at closer intervals at curve points, minor streams, and intersections for accurate earthwork and profile correction calculations. For feasibility-stage alignment plans, cross-sections will be captured at 50m intervals.
- **Geometric Elements Delineation:** Detailed design of all cross-sectional elements, including carriageway widths, medians, shoulders, drainage systems, and provisions for non-motorized transport.
- **Embankment and Cutting Design:** Specific design considerations for embankments exceeding 6m in height, or those constructed in poor soil conditions, ensuring stability and density requirements are met.
- **Urban and Rural Contexts:** Development of distinct typical cross-sections (TCS) for various road segments, accounting for rural, semi-urban, and urban environments within Bhopal.
- **Drainage Integration:** Comprehensive design of surface and sub-surface drainage systems within the cross-section to manage storm water runoff effectively and prevent pavement damage, with disposal points identified.
- **Utility Accommodation and Relocation:** Identification of existing utilities (overground and underground) and design of suitable corridors for their accommodation or relocation within the proposed Right of Way (ROW).
- **Road Safety Features:** Integration of passive and active safety features, road furniture, and lighting where required.

- **Future Widening Provisions:** Designing cross-sections with inherent flexibility to accommodate future expansion, including the scheme for carriageway widening.

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### 3. Design Standards and Guidelines

All cross-sectional designs will strictly adhere to the latest editions of the following Indian standards and best international practices:

- **Indian Roads Congress (IRC) Codes:**

- **IRC:37:** Guidelines for the Design of Flexible Pavements.
- **IRC:58:** Guidelines for the Design of Rigid Pavements for Highways.
- **IRC:73:** Geometric Design Standards for Rural (Non-Urban) Highways.
- **IRC:86:** Geometric Design Standards for Urban Roads.
- **IRC:SP:23:** Guidelines for Roadside Drainage.
- **IRC:SP:48:** Guidelines on Geometric Design of Rural Roads.
- **IRC:SP:84:** Guidelines for Safety in Construction Zones.
- **IRC:SP:99:** Manual for Planning, Design, and Operation of Pedestrian Facilities.
- **IRC:SP:103:** Guidelines for Design of Embankment on Soft Soils.
- **IRC:SP:115:** Guidelines for Design of Road Over Bridges (ROB).
- **Ministry of Road Transport & Highways (MoRTH):**
  - Specifications for Road and Bridge Works (latest edition, commonly known as the "Green Book").
  - Circulars and guidelines related to geometric design, safety, and environmental considerations.
- **National Highways Authority of India (NHAI):**

- Specific guidelines and directives pertinent to project implementation and design philosophy.

- **Bureau of Indian Standards (BIS):**

- Relevant codes for materials and construction practices.

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#### 4. Methodology for Cross-Section Generation

The methodology for developing and refining cross-sections will involve the following stages:

- **4.1. Data Acquisition and Processing:**

- **High-Resolution Topographic Survey:** Utilisation of Mobile LiDAR or equivalent technology to acquire dense point cloud data, forming the basis for a highly accurate DTM.

- **Ground Truthing:** Verification and validation of the DTM through traditional survey methods and detailed reconnaissance to ensure accuracy of existing ground features and spot levels.

- **Utility Mapping:** Comprehensive mapping of all existing subsurface utilities (up to 4m depth) using Ground Penetrating Radar (GPR) and Induction Locator technologies, processed into utility maps (PDF, JPEG, AutoCAD) for integration into the design.

- **4.2. Preliminary Cross-Sectional Analysis (Feasibility Stage):**

- **Existing Cross-Sections:** Analysis of existing road cross-sections to identify deficiencies, constraints, and opportunities for improvement.

- **Corridor Optimisation:** Initial determination of the optimal ROW and identification of potential land acquisition (LA) requirements and utility relocation zones based on preliminary alignment and proposed widening schemes.

- **Indicative Typical Cross-Sections (TCS):** Development of a range of indicative TCS for varying terrain and land use conditions (e.g., plain, rolling, built-up areas, bridge approaches) at 50m intervals for initial project evaluation.

#### • 4.3. Detailed Cross-Sectional Design (Detailed Project Report Stage):

- **Refined DTM and Alignment:** Utilisation of the refined DTM and final horizontal and vertical alignment for detailed cross-section generation using advanced highway design software (e.g., MXROAD, Civil 3D).
- **1m Interval Cross-Sections:** Generation of cross-sections at every 1m interval along the final centreline, and at closer intervals (e.g., 0.5m) at critical locations such as horizontal curves, major/minor stream crossings, and intersections, to ensure precise earthwork calculations and profile correction course design.
- **Embankment Design:** Detailed design of embankment slopes, benching, and protection measures, especially for heights exceeding 6m or in problematic soil conditions prevalent around Bhopal, referencing IRC:SP:103 and geotechnical investigations. Consideration for density requirements will extend to lesser height embankments in poor soil.
- **Drainage Design:** Integration of detailed drainage elements, including side drains, cross-drainage structures (culverts, causeways), and subsurface drains, based on hydrological and hydraulic analyses for storm water management.
- **NMT and Pedestrian Facilities:** Design of footpaths, cycle tracks, and safe pedestrian crossings (underpasses/overpasses) in urban and high-density areas, considering user-oriented facilities and local demand in Bhopal.
- **Roadside Appurtenances:** Delineation of space for road furniture, lighting, crash barriers, and utility corridors, ensuring adequate clearances.
- **Refuge Lanes:** Provision of refuge lanes (50m length) at every 2km interval along the highway, as specified.
- **Cross-sections for structures:** Generation of cross-sections for major and minor streams, encompassing the channel profile, bed levels, bank levels, and ground levels upstream and downstream, as per IRC Special Publication No. 13 and IRC:5.
- **Future Widening Scheme:** Each typical cross-section drawing will clearly indicate the scheme for future widening of the carriageway, including the necessary ROW provisions.

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#### 5. Key Cross-Sectional Elements and Considerations

The following table provides an overview of the key elements and design considerations for typical cross-sections, incorporating specific requirements for Bhopal and national standards.

**Table 1: Key Cross-Sectional Elements and Design Considerations**

Element	Design Considerations	Applicable Standards
Carriageway	Number of Lanes: Based on traffic projections (AADT, PCU/day) and Level of Service (LOS) requirements. Lane Widths: Standard widths (e.g., 3.5m per ...	IRC:73 (Rural), IRC:86 (Urban), MoRTH Specifications
Median	Type: Depressed, raised, or flush, depending on terrain, urbanisation, and safety requirements. Width: Sufficient for channelization, glare protect...	IRC:73, IRC:86, MoRTH Specifications
Roadside Drainage	Side Drains: Design of earthen, lined, or covered drains (e.g., trapezoidal, V-shaped, rectangular) to efficiently collect and channel storm water....	IRC:SP:23 (Guidelines for Roadside Drainage), MoRTH Specifications
Embankment/Cutting Slopes	Stability: Design based on geotechnical investigations, soil properties, and slope stability analysis. Height/Soil Conditions: Specific designs for...	IRC:SP:103 (Embankment on Soft Soils), MoRTH Specifications, relevant BIS codes for soil testing.
Right of Way (ROW)	Limits: Delineation of proposed ROW based on final cross-sectional requirements, ensuring adequate space for all elements, including future widenin...	IRC:66 (Recommended Practice for Sight Distance), NHAI guidelines.



Element	Design Considerations	Applicable Standards
Non-Motorised Transport (NMT) & Pedestrian Facilities	Footpaths/Cycle Tracks: Provision in urban and semi-urban stretches, ensuring adequate width and separation from vehicular traffic. Grade Separated...	IRC:SP:99 (Pedestrian Facilities), IRC:SP:50 (Guidelines on Urban Drainage), local municipal guidelines.
Utilities	Corridors: Identification of dedicated corridors for existing and proposed utilities (water mains, sewers, gas/oil pipes, electric/telephone lines,...	MoRTH Circulars, relevant local authority guidelines (e.g., Bhopal Municipal Corporation, Madhya Pradesh Electricity Board).
Road Furniture & Safety Features	Lighting: Provision in urban areas, intersections, and critical stretches. Crash Barriers/Guardrails: Installation at locations with high embankmen...	IRC:35 (Road Markings), IRC:67 (Road Signs), IRC:119 (Road Safety Audit), MoRTH Specifications.
Future Widening	Scheme: The typical cross-section drawings will explicitly illustrate the scheme for future widening of the carriageway, including the potential fo...	NHAI directives, long-term traffic forecasts.

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## 6. Development of Typical Cross-Sections (TCS)

A series of distinct Typical Cross-Sections (TCS) will be developed to address the diverse conditions encountered along the project corridor in Bhopal. These will cover, but not be limited to:

- **Rural Plain/Rolling Terrain:** Standard cross-sections with appropriate carriageway widths, shoulders, and open drainage systems.
- **Built-up/Urban Sections:** Incorporating provisions for footpaths, cycle tracks, covered drains, utility ducts, and street lighting. Emphasis will be on optimising space within

constrained ROWs, which is common in developing urban areas like Bhopal.

- **High Embankment/Deep Cut Sections:** Cross-sections with stabilised slopes, protective measures (e.g., retaining walls, gabions), and specific drainage arrangements.
- **Bridge Approaches:** Transitions from standard road cross-sections to bridge widths, including special drainage and slope protection.
- **Intersections and Junctions:** Customised cross-sections to accommodate turning movements, channelisation islands, and refuge areas, ensuring smooth and safe traffic flow.
- **Toll Plaza and Ancillary Facilities:** Cross-sections for dedicated toll lanes, parking areas, and service blocks.

The proposed TCS will be presented graphically, clearly indicating all dimensions, components, materials, and relevant design parameters.

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## 7. Deliverables for Inception Report

In the Inception Report, this section will include:

- A detailed methodology for collecting and processing topographic data for cross-section generation.
- A proposed framework for developing various TCS based on identified land use and terrain characteristics within Bhopal.
- Indicative design standards to be adopted for key cross-sectional elements.
- A plan for addressing specific challenges related to embankment design in poor soil conditions and high water table areas.
- Confirmation of survey intervals (50m for feasibility plots, 1m for detailed design, closer at critical points).
- A strategy for integration of utility mapping into cross-sectional design.

This comprehensive approach to cross-sectional design will ensure that the proposed highway infrastructure is not only functionally efficient and safe but also resilient and adaptable to future demands and environmental conditions in Bhopal, Madhya Pradesh.

## 7.0 Draft Design Standards

The following detailed professional content is prepared for the 'design\_standards' section of the RFP inception report, aligning strictly with the client's input, professional English, and referencing relevant Indian and international standards for projects in Bhopal, Bhopal, Madhya Pradesh, India.

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### 1. DESIGN STANDARDS AND METHODOLOGY

#### 1.1 Introduction

This section outlines the comprehensive design standards and methodologies that the Consultant shall adopt for the Detailed Project Report (DPR) preparation, encompassing rehabilitation, upgrading, and improvement of freight movement-related infrastructure. Our approach is rooted in delivering technically sound, economically viable, socially acceptable, and environmentally sustainable designs, fully compliant with the client's requirements and prevailing best practices. All design activities will be meticulously executed to ensure the generation of "good for construction" drawings and robust project documentation.

#### 1.2 Governing Standards and Guidelines

The Consultant shall primarily adhere to the latest editions and amendments of all relevant Indian codes and specifications, supplemented by international standards where specific aspects are not fully covered.

##### 1.2.1 Statutory and Client-Specific Guidelines

The project design and documentation will be governed by:

**\* Ministry of Road Transport & Highways (MoRT&H) Specifications and Circulars:**

The latest "Specifications for Road and Bridge Works" (Fifth Revision and subsequent amendments) shall be the primary reference. All MoRT&H circulars relevant to highway development and freight movement infrastructure will be mandatorily consulted.

**\* Indian Roads Congress (IRC) Codes and Special Publications (IRC:SP):** All applicable IRC codes for highway design, pavement design, bridge design, road safety, and other related aspects will be rigorously applied. Specific IRC references are detailed in the subsequent sections.

**\* Bureau of Indian Standards (BIS):** Relevant BIS standards for materials, testing, and construction practices will be integrated into the design.

**\* National Highways Authority of India (NHAI):** All specific strategies, methodologies, guidelines, and directives issued by NHAI for DPR preparation, value engineering, quality audit, and safety audit will be strictly followed.

**\* Lending Agencies:** Requirements and guidelines of international lending agencies such as ADB, World Bank, and JICA for Environmental Impact Assessment (EIA), Environmental Management Plans (EMP), and Resettlement Action Plans (RAP) will be incorporated as applicable.

**\* Model Concession/Contract Agreements:** The latest Model Concession Agreements for PPP/EPC projects (including IRC:SP:84 or IRC:SP:87 for four/six-laning, and relevant IRC codes for long bridges) will guide the preparation of bid documents and design parameters.

**\* State/Central Governments and Authorities:** Relevant regulations, policies, and requirements from State and Central Governments, authorities, Corporations, and bodies dealing with freight movement works in Madhya Pradesh will be consulted and integrated into the project design.

### 1.2.2 Adoption of International Best Practices

For any aspects not explicitly covered by MoRT&H, IRC, or BIS standards, particularly for specialized or innovative solutions, internationally recognized standards and best practices (e.g., British Standards, AASHTO, etc.) will be proposed for NHAI's approval. This will be detailed in the Inception Report for finalization in consultation with NHAI.

### 1.2.3 Notations and Abbreviations

All notations, abbreviations, and symbols used in reports, documents, and drawings shall strictly conform to **IRC:71 (latest edition)** – "Recommended Practice for the use of Metric Units and Notation for Drawings".

### 1.3 Core Design Principles

The design process will be guided by the following fundamental principles:

- **Value Engineering:** Continuously seeking cost-effective and efficient solutions without compromising quality, functionality, or safety throughout the project lifecycle.
- **Quality Assurance (QA) and Quality Audit (QA):** A detailed Quality Assurance Plan (QAP) will be implemented for all field studies, investigations, design, and documentation activities to ensure accuracy, consistency, and compliance with standards.
- **Road Safety Audit (RSA):** Mandatory road safety audits will be conducted at various stages of the project (Feasibility, Preliminary Design, and Detailed Design) as per Supplement-III of the TOR, to proactively identify and mitigate potential safety hazards for all road users.
- **Economic and Financial Viability:** Designs will be optimized to ensure the project's economic and financial viability through rigorous analysis.
- **Environmental and Social Feasibility:** Designs will integrate measures to minimize negative environmental and social impacts, including rehabilitation, resettlement, and environmental management plans.
- **Sustainability:** Emphasis on "environmentally friendly materials," assessment of alternative pavement materials/technologies for reduced GHG emissions, and consideration of life cycle costs (LCC).

- **User-Oriented Facilities:** Designs will prioritize the convenience, comfort, and safety of road users, incorporating necessary facilities en-route.
- **Accessibility and Traffic Segregation:** Where necessary, designs will provide for segregation of local and slow-moving traffic from main thoroughfares to enhance efficiency and safety.

#### 1.4 Key Design Elements and Methodologies

##### 1.4.1 Highway Geometric Design

Geometric design will optimize road functionality, safety, and capacity, considering local terrain, traffic characteristics, and future expansion needs.

- **Reconnaissance and Surveys:**

- Detailed topographic surveys using Mobile LiDAR or equivalent technology (meeting 2cm horizontal and vertical accuracy, >50 points/sqm for land-based; 5cm horizontal and vertical accuracy, >10 points/sqm for aerial-based). DGPS and Auto Level for check points.
- Raw DGPS data, point cloud data, 1:1000 topographic maps, 50cm contour maps, cross-sections at 1m intervals in \*.dwg format will be deliverables.
- Traditional methods (Total Station/Auto Level) will be used in shadow areas.
- Survey corridor will extend a minimum of 30m beyond either side of the proposed carriageway or land boundary, or more where adjustments/improvements are needed, or 100m at existing road crossings.
- Field notes, reference pillars, bench marks, and boundary pillars will be established as per IRC guidelines (e.g., IRC:25:1967).
- Longitudinal sections at 1m intervals, cross-sections at 1m intervals covering sufficient spot levels for profile correction and earthwork calculations.
- Mapping of all important physical features and utility services (over- and underground) along the alignment. Sub-surface utility mapping using Ground Penetrating Radar (GPR), Induction Locator, or equivalent technologies up to 4m depth, differentiating utility types,



and generating utility maps.

- Strip plans for proposed improvements, land acquisition schedules, and utility removals will be prepared.

- **Alignment Design:**

- Longitudinal Profile, Horizontal Alignment, and Cross-sectional Elements (including refuge lanes (50m) at every 2km intervals).
- Verification of available sight distances as per **IRC:66-1976 (latest edition)** – "Recommended Practice for Sight Distance on Rural Highways". Appropriate markings and signs will be provided for non-adherence.
- Consideration of bypass alignments for congested locations as per **IRC:SP:20-2002 (latest edition)** – "Rural Roads Manual".

- **Intersections and Junctions:**

- Identification and design of suitable intersections, including at-grade, grade-separated structures, and interchanges based on traffic flow analysis, Level of Service (LOS), overall economy, and operational safety.
- Design of grade-separated pedestrian crossings (viaducts) for high pedestrian/animal traffic.
- Solutions for closely spaced cross-roads to reduce at-grade crossings.

- **Service Roads:**

- Design of parallel service roads in urbanized locations and built-up areas to cater to local traffic and ensure access control.

- **Road Furniture and Safety Features:**

- Design of traffic signals, signs (overhead sign boards), markings, crash barriers, delineators, and other road furniture as per **IRC:67 (latest edition)** – "Code of Practice for Road Signs" and **IRC:35 (latest edition)** – "Code of Practice for Road Markings".

- **Toll Plazas, Weighing Stations, Parking and Rest Areas:**

- Identification of suitable locations and detailed design of toll plazas as per **IRC:84 (latest edition)** – "Guidelines for Provision of Service Facilities on National Highways".

- Design of weighing stations, parking areas, and rest areas with common facilities (petrol pump, first-aid, police office, restaurant) at approximately 50 km intervals.

- **Arboriculture and Landscaping:**

- Plans for tree planting (specifying type), horticulture, floriculture on surplus Right-of-Way (ROW) land to enhance aesthetics and environment. Preservation of existing trees/plants and transplantation where feasible.

- **Traffic Management during Construction:**

- Detailed plans for traffic management and safety during the construction period will be prepared.

#### 1.4.2 Pavement Design

Pavement design will be rigorous, considering both flexible and rigid options, based on detailed traffic analysis and material properties.

- **Pavement Type Selection:**

- Strengthening of existing road pavements and design of new pavements, including bypasses and shoulders.
- Evaluation of both flexible and rigid pavement options based on life-cycle costing (LCC) and techno-economic considerations.
- Designs will primarily be based on IRC publications, notably **IRC:37 (latest edition)** – "Guidelines for the Design of Flexible Pavements" and **IRC:58 (latest edition)** – "Guidelines for the Design of Plain Jointed Rigid Pavements for Highways".

- **Design Inputs:**

- Design inputs (traffic data, material properties) will be derived from rigorous testing and evaluation of their suitability and in-service performance.
- Traffic projections will incorporate normal, generated, induced, and diverted traffic, considering different growth scenarios (optimistic, pessimistic, most likely) for a 30-year design period as per **IRC:106 (latest edition)** – "Guidelines for Capacity of At-Grade Intersections" and **IRC:SP:73 (latest edition)** – "Guidelines for Traffic Management for

Construction Zones".

- Axle load surveys will be conducted as per **IRC:SP:19-2001 (latest edition)** – "Manual for Survey of Highway Pavements".

- **Overlay Design:**

- For existing pavements, overlay thickness will be calculated based on existing pavement strength (remaining life), condition (roughness, cracking), and sub-grade characteristics.

- Provisions for regulating layers and crack-inhibiting layers will be included where necessary.

- Pavement structural strength surveys will be conducted using Falling Weight Deflectometer (FWD) in accordance with **IRC:115-2014** or **IRC:117-2015**, as applicable.

- Latest strengthening techniques like geo-synthetics and cold/hot pavement recycling will be considered for economy.

- **Shoulder Design:**

- Paved shoulders will be designed as an integral part of the main carriageway pavement.

- Granular shoulders will be designed considering both drainage and structural requirements.

- **Maintenance Strategy:**

- The pavement design task will include developing maintenance and strengthening requirements, periodicity, and timing of treatments.

#### 1.4.3 Embankment Design

Embankment designs will prioritize the use of local materials and ensure stability under various conditions.

- **Material Utilization:**

- Maximum utilization of locally available materials, including fly ash, consistent with economy.

- As per MoRT&H circular No. RW/NH-33044/53/2013-S&R(R) dated 20th November 2013, and Gazette notification No. S.O.254 (E) dated 25.01.2016 (and subsequent amendments), use of fly ash within 300 km from Thermal Power Stations is mandatory.

- **Stability Analysis:**

- Detailed analysis and design for all embankments of height greater than 6m, or those in poor soil conditions, or where density considerations are critical (even for lesser heights), will be carried out based on relevant IRC publications.
- Design will include requirements for protection works and traffic safety features.

#### 1.4.4 Bridge and Structure Design

Designs for bridges and structures will be comprehensive, considering inventory, structural integrity, hydraulic conditions, and geotechnical aspects.

- **Inventory and Assessment:**

- Inventory of all existing structures (bridges, viaducts, ROB/RUBs, culverts, underpasses) will be prepared. For bridges, viaducts, and ROB/RUBs, parameters will conform to **IRC:SP:35-1990 (latest edition)** – "Guidelines for Inspection and Maintenance of Bridges".
- Condition and structural assessment surveys will be performed. Distressed structures will undergo supplementary testing as per **IRC:SP:35** and **IRC:SP:40 (latest edition)** – "Guidelines for Repair and Rehabilitation of Bridges".
- Load carrying capacity (rating) of existing bridges will be assessed as per **IRC:SP:37-2007 (latest edition)** – "Guidelines for Evaluation of Load Carrying Capacity of Bridges", using analytical/correlation methods, and load testing if necessary.
- Remaining service life of retainable structures will be established.

- **Hydraulic and Hydrological Investigations:**

- Studies will be conducted for all drainage structures as per **IRC:SP:13-2004 (latest edition)** – "Guidelines for the Design of Small Bridges and Culverts" and **IRC:5-1998 (latest edition)** – "Standard Specifications & Code of Practice for Road Bridges, Section I - General Features of Design".

- Information on High Flood Level (HFL), Low Water Level (LWL), Lowest Bed Level (LBL), scour depth, design discharge, linear/effective linear waterway, and historical hydraulic functioning will be collected.

- **Geotechnical Investigations and Sub-Soil Exploration:**

- Investigations for proposed structures and high embankments will be carried out as per **IRC:78-2000 (latest edition)** – "Standard Specifications and Code of Practice for Road Bridges, Section VII - Foundations and Substructure".
- The minimum scope of geotechnical investigations for bridges and structures will be as follows:

S.No.	Description (Overall Length)	Location of Boring
1	6 - 30 m	One abutment location and at least one intermediate location between abutments for structures having more than one span
2	30 – 60 m	One abutment location and at least one intermediate location between abutments for structures having more than one span
3	> 60 m	Each abutment and each pier location

- Deviations from this scheme require NHAI approval. Borings will extend to sufficient depth below suitable foundation levels to determine strata nature, properties, safe bearing capacity, proneness to artesian conditions, seismic disturbance, and other engineering properties.

- Sub-soil exploration and testing will be conducted by MoRT&H empanelled Geotechnical Consultants.

- **Structural Design:**

- Preparation of General Arrangement Drawings (GADs) and Alignment Plans, detailing salient features (alignment, overall length, span arrangement, cross-section,

deck/founding levels, type of components) based on hydraulic, geotechnical studies, cost-effectiveness, and ease of construction. Preliminary designs and cost-benefit alternatives will be provided for NHAI approval.

- Detailed design and working drawings will be prepared as per relevant IRC codes/guidelines (e.g., **IRC:6 (latest edition)** – "Standard Specifications and Code of Practice for Road Bridges, Section II - Loads and Stresses", **IRC:112 (latest edition)** – "Code of Practice for Concrete Road Bridges").
- Designs for Road Over Bridges (ROBs) will require approval from Indian Railways authorities, and for structures over irrigation/waterway channels from respective authorities.
- Design and working drawings for protection and/or river training works will be furnished.
- Dismantling/reconstruction will be avoided where possible. Widening/reconstruction for inadequate carriageway width will follow MoRT&H guidelines.
- Repair/rehabilitation measures for existing structures will be proposed as per **IRC:SP:40**.
- Detailed designs for underpasses, overpasses, and interchanges will be carried out.
- Appropriate designs for retaining walls (RCC or Reinforced Earth (RE) walls) will be provided for inadequate embankment slopes.
- Innovative, aesthetically pleasing, and topography-appropriate structures with minimum joints will be designed wherever feasible.

#### 1.4.5 Drainage System Design

A comprehensive and integrated drainage system will be designed to ensure efficient water management.

##### • **Roadside and Cross-Drainage:**

- Design of roadside drainage systems and their integration with proposed cross-drainage structures for the entire project length.
- Special drainage provisions for super-elevated carriageways, high embankments, road segments in cuts, and urban areas.



- **Outfall Points:**

- Locations of turnouts and outfall points with detailed outfall structures, fitting into natural contours, will be provided. Separate drawings for every 5 km stretch will be prepared.

#### 1.4.6 Material Investigations

Thorough investigations will be conducted to identify and evaluate construction materials.

- **Source Identification and Testing:**

- Identification of sources (quarry sites, borrow areas, fly-ash/slag), undertaking field and laboratory testing to determine suitability for various work components.
- Establishing quality and quantity of construction materials.
- Preparation of mass haul diagrams and quarry charts.

- **Environmentally Friendly Materials:**

- Assessment of alternative pavement materials and technologies (e.g., cold/hot recycling, geo-synthetics) for substantial reduction in GHG emissions and least life cycle cost (LCC), as per MoRT&H circulars.

#### 1.5 Specific Considerations for Hill Roads

While the primary project location is Bhopal, Madhya Pradesh, which is not typically classified as a hill road region, the comprehensive nature of NHAI's TOR mandates the Consultant's readiness to address hill road specific challenges if any section of the project traverses such terrain. Should the detailed alignment reveal segments with hilly topography, the following additional design standards will be adopted:

- **Design for Hilly Terrain:**

- Designs will consider specific aspects related to hill regions, including terrain, topographic conditions, extreme weather, and altitude effects.
- Provisions for tunnels (if required) will be designed as per **IRC:SP:91 (latest edition)** – "Guidelines for Design and Construction of Tunnels". Geotechnical investigations will



focus on rock strata and fault identification.

- Design of protective works, slope stabilization measures, erosion control, landslide control/protection, snow drift control/snow clearance measures, and avalanche protection measures will be incorporated.

- Steep gradients and hairpin bends will be avoided through realignments or structures where feasible.

- **Pavement Design for Hill Roads:**

- Pavement design will account for heavy rainfall, frost action, intensive snow/avalanche activity, thermal stresses (day-night temperature differences), and damage from tracked vehicles during snow clearance operations.

- **Drainage System for Hill Roads:**

- Enhanced drainage systems will be designed to manage numerous water courses and continuous gradients typical of hills, including roadside drains, catch water drains, interceptors, and sub-surface/sub-grade drainage.

- **User Facilities:**

- Design of scenic overlooks and watering points will be included where appropriate for the terrain.

- Traffic safety features will include elements specific to hill roads.

## 1.6 Quality Assurance Plan (QAP) and Safety Audit

The Consultant will develop and implement a detailed Quality Assurance Plan (QAP) covering all project stages and activities.

### 1.6.1 Quality Assurance Plan (QAP)

The QAP will delineate procedures for:

- \* Topographic surveys (LiDAR, DGPS, Total Station, Auto Level).

- \* Traffic surveys (volume counts, O-D, commodity movement, speed-delay, axle load).
- \* Engineering surveys and investigations (road inventory, pavement condition/roughness, structural strength, sub-grade characteristics, material sources, geotechnical, hydraulic, hydrological).
- \* Design activities (geometric, pavement, structures, drainage, road safety, utilities, environmental, social).
- \* Documentation and reporting.

#### 1.6.2 Road Safety Audit (RSA)

Road Safety Audits will be performed at the following stages as per Supplement-III (Additional requirement for safety audit) of the TOR, utilizing comprehensive checklists to ensure no critical safety aspects are overlooked:

- **Stage F – During Feasibility Study:**

- Review of proposed alignment, junction strategy, road users, vehicle types, width options, departures from standards, provisions for non-motorized transport.
- Assessment of scheme's fit into its environs and road hierarchy, drainage, climatic conditions, landscaping, services, lay-bys, footpaths, pedestrian crossings, access management, emergency vehicle access, public transport, future widening, staging, and adjacent development.
- Detailed review of visibility and potential conflicts at new/existing road interfaces and junctions.

- **Stage 1 – Completion of Preliminary Design:**

- A repeat of Stage F aspects, with a focus on specific design features and their safety implications, ensuring alignment with safety objectives.

- **Stage 2 – Completion of Detailed Design:**

- Verification that all issues raised in previous stages have been resolved.

- Detailed review of the design from a road safety viewpoint, including implications for future maintenance (speed limits, road signs and markings, visibility, maintenance of street lighting, central reserves, skid-resistance, agriculture, safety fences).
- Specific review of layouts for T, X, Y-junctions, roundabouts, and traffic signal installations.

This structured approach to design standards and methodology ensures that all project components for freight movement infrastructure in Bhopal, Madhya Pradesh, are developed to the highest professional and technical standards.

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## 8.0 Work Programme

### WORK PROGRAMME

#### 1.0 Introduction

This Work Programme outlines the detailed plan and methodology for the provision of Consultancy Services for the preparation of Detailed Project Reports (DPR) for the development of Economic Corridors, Inter-Corridors, Feeder Routes, and Coastal Roads. This specific report focuses on **Lot-1/Madhya Pradesh/Package-3**, encompassing the **Sagar-Katni section of NH-934 (193 km)** and the **Vidisha-Malthone section of SH-19, SH-14, SH-42A, and SH-42 (142.1 km)**, totaling a length of **335.1 km** within the state of Madhya Pradesh, India. The content herein is prepared to address the requirements stipulated in the Request for Proposal (RFP) and reflects our commitment to delivering a comprehensive and high-quality inception report, with our firm's operational base anchored in Bhopal, Madhya Pradesh, to ensure efficient regional coordination and resource deployment.

#### 2.0 Project Objectives

The primary objectives of these consultancy services, as understood from the Terms of Reference (TOR), are to:

- \* Establish the technical, economical, and financial viability of the project stretches.
- \* Prepare detailed project reports for the proposed development, targeting a minimum of 4-lane access-controlled configurations, with provisions for 6-laning in specific sections as dictated by traffic projections and feasibility.
- \* Ensure rigorous adherence to national and international standards, specifically those prescribed by the Indian Roads Congress (IRC), Ministry of Road Transport & Highways (MoRTH), Bureau of Indian Standards (BIS), and National Highways Authority of India (NHAI).

- \* Facilitate stakeholder consultation with relevant State and Central Government authorities, corporations, and bodies associated with freight movement, to accurately assess and integrate project requirements.

### 3.0 Scope of Services

The scope of services to be delivered under this assignment encompasses, but is not limited to, the following key areas:

- \* **Detailed Engineering Design:** Horizontal and vertical alignment, cross-sections, embankments (including those in poor soil conditions or exceeding 6m in height), structures (bridges, culverts, ROB/RUBs, underpasses, flyovers), and comprehensive drainage systems.
- \* **Intersection Design:** Identification and detailed design of various types of intersections.
- \* **Value Engineering and Project Costing:** Optimization of design and materials for cost-effectiveness, leading to detailed cost estimates and Bill of Quantities (BOQ).
- \* **Economic and Financial Analysis:** Assessment of project viability, including traffic revenue forecasting (if applicable) and cost-benefit analysis.
- \* **Contract Packaging and Implementation Schedule:** Development of logical contract packages and a realistic implementation roadmap.
- \* **Land Acquisition (LA) and Utility Relocation:** Preparation of detailed strip plans, land acquisition requirements, and schemes for the relocation of existing utility services (both over- and underground).
- \* **Environmental and Social Safeguards:** Preparation of Environmental Impact Assessment (EIA), Environmental Management Plan (EMP), Social Impact Assessment (SIA), and Resettlement Action Plan (RAP) in accordance with GoI and lending agency policies.

\* **Ancillary Facilities Design:** Design of toll plazas, weighing stations, parking areas, and rest areas, along with any other user-oriented facilities.

\* **Clearances and Approvals:** Assistance in obtaining all necessary statutory and regulatory clearances from various authorities (e.g., MoEF, Railways, Irrigation Dept.).

#### 4.0 Project Phasing and Deliverables

The project execution will be systematically phased into seven (7) stages, as stipulated in the TOR. Each stage culminates in specific deliverables, adherence to which is crucial for project continuity and payment eligibility. The submission schedule and associated contract value percentages are summarized in Table 4.1.

**Table 4.1: Project Phasing, Key Deliverables, and Payment Schedule**

S. No.	Stage No.	Deliverable Title	Indicative Month of Submission	Payment Percentage (%)
1	Stage 1	Final Inception Report (IR)	Month 2	15%
2		Final Alignment Report	Month 3	10%
3	Stage 2	Final Feasibility Report (including Draft 3(a) Report)	Month 4	5%
4		Final Land Acquisition Report (including Draft 3(A) Report)	Month 5	10%
5		Submission of Clearance Proposals	Month 6	5%

S. No.	Stage No.	Deliverable Title	Indicative Month of Submission	Payment Percentage (%)
6	Stage 4	Submission of Draft DPR	Month 8	10%
7		Approval of Final DPR	Month 9	10%
8	Stage 5	Approval of Technical Schedules	Month 10	5%
9	Stage 6	Final 3D Publication Report	Month 10	10%
10	Stage 7	Clearance - Stage I Approval	Month 11	5%
11	Stage 7	Clearance - Stage II/Final Approval	Month 11	5%
12		Retention (released after 3 years)	N/A	10%
		Total Contract Value		100%
13		Bonus on submission of clearances within 1 month of alignment finalization	N/A	2.5%

## 5.0 Methodology and Approach

Our approach integrates a multi-disciplinary team, advanced technologies, and adherence to established standards to ensure accuracy, quality, and timely completion of the project.

### 5.1 General Approach



We will adopt a well-coordinated, inter-disciplinary, and integrated approach, assimilating key staff and stakeholders into a cohesive team. Our methodology will focus on:

- \* **Timely Completion:** Close monitoring against the work plan.
- \* **Effective Quality Management:** Implementing a robust Quality Assurance Plan (QAP).
- \* **Mitigation Measures:** Proactive identification and addressal of negative environmental and social impacts.
- \* **Innovative Applications:** Utilizing modern technologies and best practices for design and analysis.

## 5.2 Detailed Methodology per Key Area

### 5.2.1 Reconnaissance & Alignment Studies

- \* **Data Collection:** In-depth study of existing land width (ROW), topographic maps, satellite imageries, aerial photographs, geological maps, catchment area maps, contour plans, flood flow data, and seismological data relevant to Madhya Pradesh.
- \* **Ground Reconnaissance:** Immediate field visits after initial data review to identify topographical features, land use patterns, existing physical features within and outside ROW, and potential alignment alternatives (including bypasses, ROBs/Flyovers, pedestrian crossings).
- \* **Alignment Optimization:** Focus on minimizing land acquisition and integrating existing infrastructure where feasible. The rationale for selected alignment options will be documented thoroughly.

### 5.2.2 Traffic Surveys & Forecasting

- \* **Survey Planning:** Proposing and obtaining NHAI approval for traffic survey station locations, considering strategic points on the Sagar-Katni and Vidisha-Malthone stretches,

as well as interconnecting corridors.

**\* Data Collection:**

**\* Classified Traffic Volume Count:** Utilizing Automatic Traffic Counter-cum-Classifiers (ATCC) systems (or equivalent technologies like Pneumatic Tube Detector, Inductive Detector Loop, Video Image Detection, Infrared Sensor) for 7 continuous days (direction-wise), ensuring classification accuracy >95% and counting accuracy >98% as per MoRTH specifications.

**\* Origin-Destination (O-D) Surveys:** Conducted at strategic locations to understand traffic patterns.

**\* Axle Load Surveys:** To determine pavement design requirements.

**\* Data Analysis and Forecasting:**

\* Applying sound and proven forecasting techniques for a 30-year period from project completion.

\* Developing traffic demand estimates for optimistic, pessimistic, and most likely growth scenarios at five-yearly intervals.

\* Assessing the impact of competing facilities and toll charges on traffic demand.

\* Estimating normal, generated, induced, and diverted traffic as per IRC guidelines.

### **5.2.3 Topographic & Engineering Surveys**

**\* Technology Deployment:** Use of Mobile/Aerial LiDAR or equivalent technology for detailed topographic surveys along the existing road and proposed realignments. This includes capturing 360-degree panoramic images or ortho-images of the entire highway length and adjoining areas.

**\* Field Surveys:**

- \* Surveying within the existing Right of Way (ROW) and extended corridors for proposed widening schemes.
- \* Detailing all features: structures (bridges, culverts), utilities (O/H and underground), huts, buildings, fencing, trees (girth > 0.3m), oil/gas lines.
- \* Establishing reference pillars and benchmarks as per IRC:SP:19.
- \* Developing Digital Terrain Models (DTM) from survey data.

**5.2.4 Geotechnical & Sub-Soil Investigations**

\* **Scheme Development:** Preparation of a detailed boring scheme (locations and depths) for NHAI approval, adhering to IRC:78 guidelines.

\* **Execution:** Sub-soil exploration and testing through MoRTH empanelled Geotechnical Consultants.

**\* Testing:**

\* Boreholes for approach road pavement at each major change in pavement condition/deflection readings or at 2 km intervals (whichever is less) to a depth of at least 2m below embankment base or rock level.

\* Appropriate field and laboratory tests on collected samples to determine suitability of materials, Safe Bearing Capacity (SBC), settlement characteristics, and artesian conditions.

\* All reports to be in relevant IRC Code formats.

\* **Design Recommendations:** Providing recommendations for foundation types, depths, and ground improvement measures for poor soil conditions, particularly relevant in

different geological zones of Madhya Pradesh.

### 5.2.5 Pavement Investigations & Design

\* **Road Inventory Surveys:** Detailed collection of existing road and pavement features as per HDM-IV input requirements, including terrain, land-use, carriageway/shoulder widths, surfacing types, sub-grade soil types, horizontal/vertical curves, intersections, retaining structures, water bodies, cut/fill heights, ROW, culverts/bridges, utilities, arboriculture, drainage, and design speed.

\* **Pavement Evaluation:**

\* Conducting Pavement Condition Surveys (as per IRC:SP:19).

\* Pavement Roughness Surveys (as per IRC:SP:16).

\* Pavement Structural Strength Surveys using Falling Weight Deflectometer (FWD) or Benkelman Beam Deflection (BBD) tests (as per IRC:81 or other NHAI approved methods).

\* **Pavement Design:**

\* Designing new pavements and strengthening existing pavements using HDM-IV software, following IRC guidelines (e.g., IRC:37 for flexible pavements, IRC:58 for rigid pavements) and MoRTH specifications.

\* Assessing alternative pavement materials and technologies (e.g., fly-ash/slag) for GHG emission reduction and life cycle cost optimization, as per MoRTH circular No. RW/NH-33044/53/2013-S&R(R) dated 20th November 2013.

\* Designing granular shoulders, considering drainage and structural requirements.

### 5.2.6 Bridge & Structure Design

\* **Hydraulic & Hydrological Studies:** Detailed investigations as per IRC:SP:13 and IRC:5 to determine High Flood Level (HFL), Low Water Level (LWL), Low Bed Level (LBL), erodibility of bed/scour level, design discharge, linear/effective linear waterway, and freeboard for approach roads.

\* **Foundation Design:** Determination of likely foundation depths, SBC, and engineering properties of sub-soil based on geotechnical data.

\* **Structural Design:**

\* Preparation of General Arrangement Drawings (GADs) and alignment plans for all proposed structures (new and rehabilitation).

\* Detailed design calculations for all structures (bridges, culverts, ROB/RUBs, flyovers, underpasses) considering seismic and wind loads (as per IRC:6 and BIS codes), corrosion resistance, and relevant IRC codes.

\* Value analysis/engineering will be applied to optimize structural solutions.

#### **5.2.7 Environmental & Social Impact Assessment (EIA/SIA) and Resettlement Action Plan (RAP)**

\* **Environmental Screening & Assessment:** Initial Environment Examination (IEE) based on IRC:SP:19, identifying macro-level environmental issues (forests, water bodies, heritage sites), baseline pollution monitoring (air, water, noise), and preliminary impact analysis.

\* **Mitigation & Management:** Proposing feasible mitigation measures, preparing an Environmental Management Plan (EMP), and formulating green belt development with indigenous plant species relevant to Madhya Pradesh.

\* **Social Impact Assessment:** Conducting baseline socio-economic and census surveys to assess impacts on people, properties, and livelihoods. Identifying Project Affected Persons (PAPs) and vulnerable groups.

**\* Resettlement Action Plan (RAP):**

\* Developing an entitlement matrix based on ADB Handbook on Resettlement, World Bank Guidelines, or Government of India R&R Policy, as applicable.

\* Detailed implementation budgets, funding sources, and task schedules.

\* Establishing monitoring and evaluation arrangements, including a grievance redress mechanism.

\* Public consultations with affected persons, NGOs, and government agencies.

\* **Land Acquisition Plans:** Preparation of detailed Kilometer-wise Land Acquisition Plans (LAP) based on digitized cadastral/land revenue maps, including ownership details and acquisition costs. Drafting of 3(a), 3(A), and 3(D) notifications in Hindi and English.

#### **5.2.8 Utility Identification & Relocation**

\* **Survey:** Comprehensive identification of existing overhead and underground utilities within the ROW using GPR (Ground Penetrating Radar), Induction Locator, or equivalent technologies.

\* **Consultation & Planning:** Engaging with concerned local authorities and utility-owning agencies (electricity, water, telecom, gas) to develop detailed utility relocation plans (URP).

\* **Cost Estimation:** Preparing itemized cost estimates for relocation activities, including cross-highway crossings, for submission to relevant departments.

#### **5.2.9 Economic & Financial Analysis**

\* **Cost Estimates:** Preparation of detailed project cost estimates (civil works, environmental/social safeguards) based on MoRTH's Standard Data Book and prevailing market rates in Madhya Pradesh.

\* **Bill of Quantities (BOQ):** Detailed BOQ for all work items based on final designs.

\* **Viability Assessment:** Conducting economic and financial analyses to determine project viability and recommend the preferred mode of implementation.

#### 5.2.10 Drafting & Documentation

\* All reports, drawings, and documentation will adhere strictly to NHAI/MoRTH formats and standards.

\* CAD software will be used for all engineering drawings, ensuring accuracy and consistency.

\* Robust document control and retrieval systems will be maintained.

### 6.0 Resource Mobilization

Our firm commits to mobilizing a highly qualified and experienced team, along with essential equipment and software, to ensure the successful execution of this project.

#### 6.1 Key Personnel

A dedicated multi-disciplinary team, comprising seasoned professionals with relevant experience in similar highway projects, will be deployed. The proposed key personnel and their respective man-month allocations for the 11-month project duration are as follows:

**Table 6.1: Key Personnel and Man-Month Schedule**

S. No.	Position	Total Man-Months (MM)
1	Team Leader cum Senior Highway Engineer	11



S. No.	Position	Total Man-Months (MM)
2	Senior Bridge Engineer	5
3	Highway cum Pavement Engineer	5.5
4	Material-cum-Geo-technical Engineer	6
5	Senior Survey Engineer	7
6	Traffic and Safety Expert	5
7	Environmental Specialist	4
8	Quantity Surveyor/Documentation Expert	6
9	Land Acquisition Expert	11
10	Utility Expert	4
	Total Key Personnel Man-Months	64.5

## 6.2 Equipment & Software

The following essential equipment and software will be utilized:

\* **Survey Equipment:** Mobile/Aerial LiDAR systems, Total Stations, Auto Levels, Drones for aerial imagery.

\* **Traffic Survey Equipment:** ATCC systems (Pneumatic Tube Detectors, Inductive Detector Loops, Video Image Detection, Infrared Sensors).

\* **Geotechnical Equipment:** Boring rigs, field testing apparatus (SPT, DCP), laboratory testing equipment.

- \* **Pavement Evaluation Equipment:** FWD (Falling Weight Deflectometer), BBD (Benkelman Beam Deflection) apparatus, ROMDAS for roughness surveys.
- \* **Utility Detection:** GPR (Ground Penetrating Radar), Induction Locators.
- \* **Software:**
- \* **CAD Software:** AutoCAD Civil 3D, MXROAD, InRoads/SOFTDESK for highway design.
- \* **Structural Design:** STAAD.Pro, RM Bridge for bridge and structure analysis and design.
- \* **Pavement Design:** HDM-4 for pavement performance modeling and design.
- \* **Traffic Modeling:** VISUM, VISSIM, or similar for traffic simulation and forecasting.
- \* **Project Management:** MS Project for scheduling and resource management.
- \* **GIS Software:** ArcGIS, QGIS for spatial data analysis and mapping.
- \* **Office Productivity:** Microsoft Office Suite.

### 6.3 Project Office

A fully equipped project office will be established in a strategically suitable location within Madhya Pradesh, preferably Bhopal, to ensure efficient coordination, data management, and client interaction. This office will be furnished with all necessary communication facilities, computing resources, and printing capabilities to support the project team.

### 7.0 Quality Assurance Plan (QAP)

Our firm operates under an in-house quality policy that mandates strict adherence to quality assurance procedures for all consultancy assignments. A project-specific Quality Assurance Plan (QAP) document will be submitted immediately upon award, covering all aspects of the project lifecycle, from field studies and investigations to design,

economic/financial analysis, and documentation. The QAP will detail:

- \* **TOR/Client Requirements:** Clear understanding and mapping of all requirements.
- \* **Manpower Responsibility:** Defined roles for performance, checking, and approval stages.
- \* **Equipment Calibration & Accuracy:** Protocols for equipment maintenance and precision.
- \* **Applicable Standards/Codes:** Reference to IRC, MoRTH, BIS, NHAI, and other relevant national/international standards.
- \* **Regulatory Compliance:** Ensuring conformity with local and statutory regulations in Madhya Pradesh and India.
- \* **Safety & Environmental Considerations:** Integration of safety protocols and environmental best practices.
- \* **Training:** Continuous professional development for personnel.
- \* **Data Verification:** Robust procedures for data collection, validation, and analysis.
- \* **Documentation & Retrieval System:** Structured archiving and easy access to project documents.
- \* **Detailed Work Procedures:** Standardized methods for all project activities.
- \* **Standard Proforma:** Templates for data recording and reporting.

The field and design activities will commence only after the QAP is formally approved by NHAI.

## 8.0 Work Schedule

The overall project duration is 11 months. A high-level work schedule, detailing the stages and major activities, is presented in Table 8.1. This schedule is indicative and will be refined in consultation with NHAI during the inception phase.

**Table 8.1: High-Level Work Schedule**

S. No.	Stage / Major Activity	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11
I. Stage 1: Inception & Project Setup												
1.1	Contract Sign-off & Mobilization	X										
1.2	QAP Submission & Approval	X	X									

S. N o.	Stage / Major Activity	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11
1.3	Initial Data Collection & Reconnaissance	X	X									
1.4	Submission of Inception Report (IR)		X									
II. Stage 2: Feasibility & Alignment Studies												
2.1	Traffic Surveys & Analysis		X	X								

S. N o.	Stage / Major Activity	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11
2.2	Topographic & Engineering Surveys		X	X								
2.3	Geotechnical Investigations			X	X							
2.4	Preliminary Alignment Design			X								
2.5	Submission of Final Alignment Report			X								

S. N o.	Stage / Major Activity	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11
2.6	Feasibility Analysis & Reporting				X							
2.7	Submission of Final Feasibility Report				X							
III. Stage 3: LA & Clearances I Report												
3.1	Social & Environmental Surveys			X	X							



S. N o.	Stage / Major Activity	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11
3.2	LA Plan & Utility Relocation Plan Preparation				X	X						
3.3	Draft 3(a), 3(A), 3(D) Notifications					X						
3.4	Submission of Final LAR Report					X						
3.5	Initial Clearance Proposals					X	X					

S. N o.	Stage / Major Activity	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11
3.6	Submission of Clearance Proposals						X					
IV. Stage 4: Detailed Project Report (DPR)												
4.1	Detailed Pavement Design						X	X				
4.2	Detailed Structural Design						X	X				

S. N o.	Stage / Major Activity	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11
4.3	Detailed Road & Drainage Design							X	X			
4.4	Economic & Financial Analysis							X	X			
4.5	DPR Compilation & Draft DPR Submission								X			
4.6	NHA I Review & Comments									X		

S. N o.	Stage / Major Activity	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11
4.7	Final DP R S ubmission & Approval									X		
V. Stage 5: Technical Schedules												
5.1	Draft Technical Schedules									X		
5.2	Final Technical Schedules Approval										X	

S. N o.	Stage / Major A ctivity	Mon th 1	Mon th 2	Mon th 3	Mon th 4	Mon th 5	Mon th 6	Mon th 7	Mon th 8	Mon th 9	Mon th 1 0	Mon th 1 1
VI. S tage 6: D raft 3D Publ icati on R epor t												
6.1	Prep arati on & Sub miss ion o f 3D Rep ort										X	
VII. Stag e 7: Clea ranc es II Rep ort												
7.1	Clea ranc e - S tage I Ap prov al										X	

S. N o.	Stage / Major Activity	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11
7.2	Clearance - Stage II/Final Approval											X

## 9.0 Reporting and Coordination

Effective communication and coordination are paramount for the project's success.

\* **Continuous Interaction:** The Consultant shall maintain continuous interaction with the assigned Project Director and Regional Officer, NHAI (likely within the Madhya Pradesh region, given the project stretches and our operational context) and seek their inputs at all stages.

\* **Monthly Progress Reports:** Concise monthly progress reports will be submitted by the 5th day of the following month, detailing activities, personnel induction/de-induction, and overall progress.

\* **Site Visits:** NHAI and other Government officials are welcome to visit project sites to supervise field investigations and survey works. Prior intimation will be provided for key activities such as boring and surveys.

\* **Meetings:** Frequent meetings with NHAI officials will be held at our Bhopal office or NHAI HQ, as required, to discuss progress, resolve issues, and ensure alignment.

## 10.0 Standards and Codes

All project activities, designs, and reports will strictly adhere to the latest editions of the following standards and specifications:

\* **Indian Roads Congress (IRC) Codes:** For all aspects of highway design, geometrics, pavement design, bridge design, materials, traffic, safety, and investigations (e.g., IRC:37, IRC:58, IRC:6, IRC:5, IRC:SP:13, IRC:SP:19, IRC:SP:35, IRC:SP:40, IRC:SP:55, IRC:SP:84, IRC:SP:87).

\* **Ministry of Road Transport & Highways (MoRTH) Specifications:** For Road and Bridge Works, ensuring quality and constructability.

\* **National Highways Authority of India (NHAI) Manuals and Guidelines:** For design, project preparation, land acquisition, and environmental/social safeguards.

\* **Bureau of Indian Standards (BIS) Codes:** For material testing, structural design (e.g., IS:1893 for seismic design).

\* **Relevant Environmental and Social Safeguard Policies:** Government of India guidelines, World Bank, and ADB guidelines, as applicable.

\* **Motor Vehicles Act, 1988:** For third-party motor vehicle liability insurance.



## 9.0 Development

### 3.0 DEVELOPMENT METHODOLOGY

#### 3.1 Introduction and Project Context

This section outlines the comprehensive development methodology proposed for the preparation of the Detailed Project Report (DPR) for the "Development of Economic Corridors, Inter Corridors, Feeder Routes and Coastal Roads to improve efficiency of freight movement in India (Lot 1/Madhya Pradesh/Package-3)". The project, commissioned by the National Highways Authority of India (NHAI), aims to enhance national freight logistics by upgrading critical road infrastructure within Madhya Pradesh.

The specific project stretches under this package are:

- 1. Sagar-Katni Section of NH-934:** This 193 km segment forms part of the Sagar-Varanasi Economic Corridor, crucial for enhancing connectivity in the northeastern part of Madhya Pradesh. The corridor's start point is Sagar (23.838805, 78.737807) and end point is Katni (23.870014, 80.361474).
- 2. Vidisha-Malthone Section of SH-19, SH-14, SH-42A and SH-42:** This 142.1 km inter-corridor route connects Vidisha (23.517449, 77.797208) to Malthone (24.3030959, 78.5255114) in central Madhya Pradesh, improving regional freight movement efficiency.

The total length of the project stretches is 335.1 km. Our approach aligns with the core objective of establishing the technical, economical, and financial viability of these corridors, culminating in a robust and implementable DPR package. While the project stretches are located in various parts of Madhya Pradesh, administrative and logistical coordination will leverage key state centers, including Bhopal, which serves as the capital and a critical administrative hub for state-level approvals and policy alignment.

#### 3.2 Overall Development Philosophy

Our philosophy for DPR preparation is founded on a multi-disciplinary, integrated approach, emphasizing value engineering, quality assurance, and road safety. We are committed to delivering a DPR that is technically sound, economically justified, financially viable, socially inclusive, and environmentally sustainable, in strict adherence to NHAI's vision for improving freight movement efficiency. This involves:

- **Integrated Planning:** Combining expertise across highway engineering, structures, traffic, geotechnical, materials, environment, social safeguards, and financial analysis.
- **Value Engineering:** Identifying opportunities for cost optimization without compromising quality, safety, or functional performance.
- **Quality & Safety Audits:** Integrating road safety audits (RSA) at various design stages and implementing a comprehensive Quality Assurance Plan (QAP) across all field studies, investigations, and design activities.
- **Sustainability:** Designing solutions that minimize environmental impact, ensure social equity, and offer long-term operational efficiency.
- **Stakeholder Engagement:** Continuous consultation with NHAI, relevant State/Central Government authorities (including those in Bhopal for state-level clearances), local bodies, and project-affected people.

### 3.3 Proposed Methodology for Core Development Activities

The following subsections detail our proposed methodology for key development activities, as per the Terms of Reference (ToR) and NHAI guidelines.

#### 3.3.1 Geometric Design

Our methodology for geometric design will focus on optimizing alignment, improving safety, and enhancing operational efficiency, considering the terrain variability in Madhya Pradesh, from plains to rolling topography.

- **Reconnaissance and Alignment Studies (ToR Clause 4.11.1, 4.12.3):**

- Initial reconnaissance surveys using available maps (topographic, geological, cadastral) and drone/LiDAR data to identify congested locations, geometric deficiencies, and potential bypass/realignment options around urban centers such as Sagar, Katni, Vidisha, and Malthone.
- Traverse lines along identified alternative alignments to select the most suitable option based on techno-economic considerations, minimizing land acquisition and environmental impact.
- Field notes will document existing traffic patterns, soil conditions, and drainage aspects.
- **Detailed Topographic Surveys (ToR Clause 4.11.2):**
  - Detailed topographic surveys using Mobile LiDAR or equivalent technology (as per **IRC:SP:19**) extending a minimum of 30m beyond either side of the proposed divided carriageway or land boundary, as applicable. This will generate a high-resolution Digital Terrain Model (DTM).
  - Surveys will be expanded at grade-separated intersection locations and where alignment adjustments are necessary due to developments or encroachments.
  - Installation of Reference Pillars and Bench Marks (RCC M15, 15x15x45cm) at 250m intervals, connected to GTS Bench Marks, as per **IRC:71** and **NHAI guidelines**.
- **Design of Geometric Elements (ToR Clause 4.12.3):**
  - Design standards will primarily be based on **IRC publications (e.g., IRC:73, IRC:38)** and **MoRTH Circulars**, with international standards adopted where IRC/BIS are silent (ToR Clause 4.5).
  - Development of a high-speed highway with a minimum 4-lane access-controlled configuration. Consideration will be given to 6-laning in certain high-traffic stretches based on traffic projections.
  - Detailed designs for horizontal and vertical alignments, superelevation, and cross-sections using CADD software (e.g., MXROAD, Civil 3D), ensuring "good for construction" drawings.
  - Identification and design of suitable intersections (at-grade and grade-separated structures like underpasses, flyovers, interchanges), considering site conditions, turning movements, level of service, and safety.

- Design of parallel service roads in urbanized locations and other areas to segregate local and slow-moving traffic, improving efficiency and safety.
- Proposals for grade-separated pedestrian/animal crossings where high cross-traffic is identified (ToR Clause 4.9.7).

### 3.3.2 Pavement Design

Pavement design will be rigorous, considering both new construction and strengthening of existing sections, with a focus on long-term performance and cost-effectiveness.

- **Pavement Investigations (ToR Clause 4.11.2.2, 4.12.4):**

- Road inventory surveys (terrain, land-use, carriageway/shoulder width, surfacing type, sub-grade soil, geometric features, structures, utilities, drainage).
- Pavement condition surveys including Benkelman Beam Deflection (BBD) tests (as per **IRC:81**) and roughness surveys (using ROMDAS or equivalent, as per **IRC:SP:16**) to assess structural strength and ride quality.
- Field and laboratory testing of subgrade soils to determine CBR values under soaked and field conditions, and in-situ CBR by Dynamic Cone Penetrometer (DCP) tests.

- **Design Alternatives (ToR Clause 4.12.4):**

- Evaluation of both flexible (as per **IRC:37**) and rigid (as per **IRC:58**) pavement design options for new construction (additional lanes, bypasses) and overlays for existing roads.
- Life-cycle cost analysis (LCCA) and techno-economic considerations will determine the most appropriate pavement type.
- For existing pavements, overlay thickness requirements will be calculated for homogenous segments, including regulating layers and crack-inhibiting layers where needed.

- **Innovative Techniques (ToR Clause 4.12.4):**

- Consideration of modern techniques like geo-synthetics, cold/hot pavement recycling, and utilization of industrial byproducts (e.g., fly ash within 300 km from Thermal Power Stations, as per MoEF circulars) and waste materials where technically feasible and

economically viable.

- **Paved Shoulders:** Designed as an integral part of the main carriageway pavement, ensuring consistent structural integrity and safety.

### 3.3.3 Bridge and Structure Design

Designs will cover all major and minor cross-drainage structures, ensuring structural integrity, hydraulic efficiency, and long-term durability.

- **Inventory and Condition Survey (ToR Clause 4.11.2.2, 4.12.1):**

- Detailed inventory of existing culverts, bridges, and other structures (type, size, span, location, condition).
- Condition assessment to identify rehabilitation or reconstruction needs.

- **Hydraulic and Geotechnical Studies (ToR Clause 4.12.5):**

- Conduct of detailed hydraulic and hydrological investigations for bridge design and river training works, potentially including physical/mathematical model studies at recognized institutions if required (Supplement II).
- Geo-technical investigations (boreholes, soil/rock testing) for foundations of all structures, high embankments, and road pavements, as per **IRC:78** and **BIS codes**.
- Recommendation of Safe Bearing Capacity (SBC) of soil for foundations and embankments.

- **Detailed Design (ToR Clause 4.12.1, 4.12.5):**

- Preparation of General Arrangement Drawings (GADs) and detailed construction drawings for new bridges, viaducts, subways, and grade-separated structures (e.g., ROBs/RUBS as per Indian Railways standards).
- Finalization of span arrangements, deck levels, founding levels, and bridge components based on hydraulic and geotechnical studies, cost-effectiveness, and ease of construction.
- Design of protective works and river training works where necessary.
- Emphasis on innovative, aesthetically pleasing, and minimum-joint structures.

- Coordination with Indian Railways for ROB/RUB approvals and Irrigation/Waterway Authorities for structures crossing water bodies.

#### 3.3.4 Material and Geotechnical Investigations

A thorough understanding of subsurface conditions and material availability is critical for design and construction.

- **Planning and Coordination (ToR Clause 4.11.3.2):**

- Detailed planning and coordination of field and laboratory geotechnical investigations (soil and rock) for bridges, structures, and high embankments.
- Identification of suitable borrow areas and quarries for construction materials within the region of Madhya Pradesh, assessing their quality and estimated quantities.

- **Testing and Analysis (ToR Clause 4.11.3.2):**

- Sampling and testing of aggregates, binders, and other construction materials to conform to **MoRTH specifications** and **IRC/BIS codes**.
- Interpretation of sub-soil data to inform foundation design, embankment stability, and ground improvement measures.

- **Design and Recommendations:**

- Detailed geotechnical design for approach embankments, including slope stability analysis, settlement computations, and ground improvement techniques (e.g., geo-synthetics, stone columns) for problematic soils.
- Recommendations for proper restoration of borrow and quarry areas post-exploitation.

#### 3.3.5 Traffic Studies and Demand Forecasting

Accurate traffic data and robust forecasting are foundational for pavement design, geometric design, and economic/financial analysis.

- **Traffic Surveys (ToR Clause 4.9):**



- Seven-day classified traffic volume counts (using IHMCL data where available, otherwise manual counts) covering all vehicle types.
- Turning movement surveys (as per **IRC:SP:41-1994**) at major intersections to estimate peak hour traffic.
- Axle load surveys using axle load pads or sophisticated instruments to determine load and load characteristics.
- Speed-delay surveys (moving car method) to identify congested sections and traffic flow problems.
- Origin-Destination (O-D) and commodity movement surveys to understand freight patterns.
- Pedestrian/animal cross-traffic surveys at relevant locations.
- Truck terminal surveys to assess requirements at suitable en-route locations.
- **Demand Estimates (ToR Clause 4.10):**
  - Traffic demand estimates for 30 years from project completion, considering past trends, population/income growth, elasticity of transport demand, socio-economic development plans, and land-use patterns in Madhya Pradesh.
  - Forecasting will be done for optimistic, pessimistic, and most likely scenarios, with growth factors at five-yearly intervals.
  - Estimation of generated, induced, and diverted traffic.
  - Assessment of the impact of toll charges and any competing facilities on traffic projections.

### 3.3.6 Road Safety Features and Furniture

Road safety will be an inherent component of the design.

- **Safety Audit (ToR Clause 2.4, Supplement III):**
  - Road Safety Audits (RSA) will be conducted at various stages of the DPR preparation, as per **MoRTH guidelines** and **IRC:SP:88**.



- **Design of Features (ToR Clause 4.12.11):**

- Detailed design of traffic signals, signs (as per **IRC:67**), road markings (as per **IRC:35**), overhead signboards, crash barriers, and delineators.
- Location of these features will be indicated in reports and drawings.

- **Arboriculture and Landscaping (ToR Clause 4.12.11):**

- Development of an appropriate plan for tree planting (indigenous species), horticulture, and floriculture on surplus Right-of-Way (ROW) land to enhance aesthetics and environment, retaining existing trees wherever possible.

### 3.3.7 Toll Plaza, Weighing Stations, and Amenities

Strategic planning for user-oriented facilities is crucial for operational efficiency and revenue generation.

- **Toll Plaza Design (ToR Clause 4.12.12):**

- Identification of optimal toll plaza location(s) based on traffic studies and physical features, aiming for efficient toll collection on an access-controlled highway (as per **IRC:84**).
- Design of the toll plaza and associated office-cum-residential complex.

- **Weighing Stations, Parking Areas, and Rest Areas (ToR Clause 4.12.12):**

- Selection of suitable sites for these facilities, ideally at approximately 50 km intervals.
- Provision for common facilities such as petrol pumps, first-aid medical facilities, police offices, and restaurants.
- Recommendation for appropriate weighing systems to identify overloaded vehicles.

### 3.3.8 Land Acquisition and Utility Relocation

Efficient management of land acquisition and utility relocation is paramount to project implementation.

- **Land Acquisition (LA) Plan (ToR Clause 3.1, 4.13.2.3):**

- Collection of land ownership details from revenue records/maps.
- Preparation of detailed Land Acquisition Plans and reports.
- Submission of draft 3(a), 3(A), and 3(D) notifications as per **NH Act, 1956**, in both Hindi and English.
- Joint site visits and discussions with concerned revenue departments.

- **Utility Relocation Plan (ToR Clause 3.2, 4.2):**

- Identification of all existing utility services (overground and underground) within the ROW, potentially using technologies like Ground Penetrating Radar (GPR) and Induction Locator.
- Preparation of kilometre-wise Utility Relocation Plans (URP) and cost estimates for relocation, coordinating with concerned utility-owning agencies (e.g., electricity, water, telecom) as per **NHAI policy circular No. Technical 215/2016 dated 19.09.2016**.

### 3.3.9 Environmental and Social Impact Assessment (ESIA)

A detailed ESIA will be conducted to address potential impacts and propose mitigation measures.

- **Environmental Assessment (ToR Clause 4.13):**

- Detailed Environmental Impact Assessment (EIA) and preparation of an Environmental Management Plan (EMP) in accordance with **Government of India, World Bank/ADB guidelines**.
- Establishment of a monitoring network for air, water, and noise pollution during construction and operation phases.
- Formulation of a green belt with indigenous plant species and design of water recharge pits.
- Obtaining necessary forestry and environmental clearances from respective authorities (State Pollution Control Boards, MoEF).

- **Social Assessment (ToR Clause 4.13.2):**

- Baseline socio-economic and census surveys to assess impacts on people, properties, and livelihoods.
- Preparation of a Resettlement and Rehabilitation (R&R) Plan and Resettlement Action Plan (RAP) (as per **ADB's Hand Book on Resettlement, World Bank Guidelines, and Government of India R&R Policy**).
- Stakeholder discussions and public consultations to ensure project design meets community needs and addresses concerns.
- Assessment of income restoration strategies and suitability of relocation sites.

### 3.3.10 Economic and Financial Viability Analysis

The project's viability will be thoroughly assessed under various scenarios.

- **Cost Estimates (ToR Clause 5.1):**

- Preparation of detailed quantity estimates (considering design and mass haul diagrams) and project cost for the entire project (civil packages wise), based on **MoRTH's Standard Data Book** and prevailing market rates.

- **Economic Analysis (ToR Clause 5.2):**

- Economic analysis considering all on-going and future road/transport infrastructure projects and development plans in the project area, evaluating the project's overall societal benefits.

- **Financial Analysis (ToR Clause 6.1):**

- Assessment of financial viability under different implementation modes (EPC/BOT), user fee scenarios, and funding options.
- Calculation of Financial Internal Rate of Return (FIRR), projected income statements, balance sheets, and fund flow statements.
- Sensitivity analysis for various probabilistic scenarios.

- Identification, assessment, and mitigation measures for all associated risks (construction delays, cost overruns, traffic volume, revenue shortfalls, etc.).
- Proposing strategies to enhance project viability.

#### 3.3.11 Contract Packaging and Deliverables

The output will be structured to facilitate seamless project tendering and implementation.

- **Documentation:** Preparation of DPRs, cost estimates, rate analyses, detailed Bill of Quantities (BOQ), and bid documents suitable for execution through EPC/PPP contracts.
- **Drawings:** Generation of "good for construction" drawings for all project components, including plan and profile drawings (1:250V and 1:2500H scale), cross-sections (50m intervals), typical cross-sections, detailed working drawings for structures, road furniture, toll plazas, and schematic diagrams for various features.
- **Reports:** Submission of all required reports as per the phased reporting schedule outlined in the ToR (Inception Report, Feasibility Report, Strip Plan & Clearances I, Draft DPR, Technical Schedules, Draft 3D Publication Report, Clearances II Report).

#### 3.4 Integration of Standards and Best Practices

Our work will be guided by established national and international standards to ensure the highest quality and safety.

- **Indian Standards:** Strict adherence to the latest guidelines and circulars of **MoRTH**, relevant publications of the **Indian Roads Congress (IRC)**, and the **Bureau of Indian Standards (BIS)**.
- **International Standards:** For aspects not covered by IRC/BIS, relevant international standards (e.g., AASHTO, British Standards) will be adopted in consultation with NHAI (ToR Clause 4.5).
- **Technology Integration:** Utilization of advanced software tools such as MXROAD/Civil 3D for geometric design, STAAD Pro/RM for structural analysis, HDM-4 for pavement and economic analysis, and specialized geotechnical software (e.g., XSTABL, FOSSA,

MSEW) for complex analyses. For surveys, Mobile LiDAR, GPR, and Total Stations will be deployed for high accuracy and efficiency.

### 3.5 Coordination and Stakeholder Engagement

Effective communication and coordination are central to our approach.

- **NHAI Interaction:** Continuous interaction with the assigned Project Director and Regional Officer, NHAI, for clarification, input, and approval at all stages of DPR preparation. Weekly updates will be provided via the PIMS system.
- **Government Agencies:** Regular consultation and coordination with relevant State/Central Government authorities, including those in Bhopal, for various clearances (Environment, Forest, Railways, Irrigation, Utilities) and alignment with development plans.
- **Local Bodies & Communities:** Engagement with local bodies and communities through public consultation meetings to address concerns related to land acquisition, R&R, environmental impacts, and to incorporate local needs into the project design.

### 3.6 Expected Outcomes

Upon completion, the DPR will provide:

- A technically robust and optimized design for the upgrade of the Sagar-Katni section of NH-934 and the Vidisha-Malthone section of SH-19, SH-14, SH-42A, and SH-42.
- Clear documentation of the project's economic justification and financial viability under various scenarios.
- Comprehensive environmental and social management plans, including detailed R&R strategies.
- "Good for Construction" drawings, detailed Bill of Quantities, and tender documents ready for international/local competitive bidding on an EPC/PPP basis.
- All necessary project-related clearances secured, enabling direct progression to project implementation without delays.

This detailed methodology ensures a structured, high-quality, and compliant approach to delivering the DPR, facilitating NHAI's objectives for improved freight movement in Madhya Pradesh.

## 10.0 Quality Assurance Plan

The following detailed professional content outlines the Quality Assurance (QA) framework for the consultancy services, as required for the RFP inception report. This framework is meticulously aligned with the National Highways Authority of India (NHAI) requirements, Indian Road Congress (IRC) standards, Ministry of Road Transport & Highways (MoRTH) specifications, Bureau of Indian Standards (BIS), and international best practices where applicable, with a specific focus on project delivery within Bhopal, Madhya Pradesh, India.

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### QUALITY ASSURANCE (QA) FRAMEWORK

The project, focused on the development of economic corridors, inter-corridors, and feeder routes within and around Bhopal, Madhya Pradesh, India, necessitates an unwavering commitment to quality across all phases of the consultancy services. Our Quality Assurance (QA) framework is designed to ensure that all deliverables are accurate, reliable, compliant, and meet the highest professional standards, thereby safeguarding the Client's legitimate interests and ensuring value for money.

#### 1. Introduction & Quality Commitment

As per the General Conditions of Contract (Clause 3.1, Page 7), the Consultants are obligated to "perform the Services and carry out their obligations hereunder with all due diligence, efficiency and economy, in accordance with generally accepted professional techniques and practices, and shall observe sound management practices, and employ appropriate advanced technology and safe and effective equipment, machinery, materials and methods." This commitment is further underpinned by principles of Fairness and Good Faith (Clause 8, Page 31), ensuring transparent and equitable project execution.

Our core philosophy is to integrate quality management into every aspect of the project lifecycle, from initial surveys to final report submission, ensuring that all aspects of this critical infrastructure development for Bhopal and the surrounding regions of Madhya Pradesh are delivered to the highest possible standards.



## 2. Quality Assurance Plan (QAP) - Foundational Document

A comprehensive Quality Assurance Plan (QAP) is a mandatory deliverable and forms a cornerstone of our inception report. As stipulated in the Terms of Reference (Clause 3.11, Page 49; STAGE 1, Page 81), the detailed Draft QAP Document will be submitted immediately upon contract award, discussed, and finalized with the concerned NHAI officers. It is imperative that this QAP is approved by NHAI before any field work commences.

The QAP will systematically cover all activities, including:

- \* **Field Studies and Investigations:** Engineering surveys, traffic surveys, material, geo-technical, and sub-soil investigations, road and pavement investigations.
- \* **Design & Documentation Activities:** Investigation and design of bridges & structures, environmental and R&R assessment, economic and financial analysis, drawings and documentation.
- \* **Process Control:** Preparation, checking, approval, and filing of calculations; identification and traceability of project documents (Clause 3.11, Page 49; STAGE 1, Page 81).

Furthermore, our QAP will detail:

- \* **TOR/Client Requirements:** Explicit mapping of project activities to contractual obligations.
- \* **Manpower Responsibility:** Clear delineation of roles at performance, checking, and approval stages (Appendix II, Page 311).
- \* **Equipment & Calibration:** Specification of equipment, calibration schedules, and required accuracy levels.

- \* **Applicable Standards/Codes:** Reference to all relevant IRC, MoRTH, BIS, and other national/international standards.
- \* **Regulatory Requirements:** Procedures to conform to all local and statutory regulations in Bhopal, Madhya Pradesh.
- \* **Safety and Environmental Considerations:** Integration of safety protocols and environmental best practices.
- \* **Training:** Programs to ensure personnel proficiency.
- \* **Data Verification:** Methods for ensuring the integrity and accuracy of collected data.
- \* **Documentation and Retrieval System:** Structured approach for managing all project documents.
- \* **Detailed Work Procedures:** Step-by-step methodologies for critical tasks.
- \* **Standard Performa:** Templates for consistent data recording (Appendix II, Page 311).

### 3. Personnel Qualification, Deployment, and Responsibility

The successful execution of the services hinges on the deployment of appropriately qualified and experienced personnel (Clause 4.1, Page 23). Our team, comprising key personnel such as the Team Leader cum Senior Highway Engineer, Senior Bridge Engineer, Highway cum Pavement Engineer, Traffic and Safety Expert, Material-cum-Geo-technical Engineer-Geologist, Senior Survey Engineer, Environmental Specialist, Quantity Surveyor/Documentation Expert, Land Acquisition Expert, and Utility Expert (Enclosure-I, Page 312), will be deployed to ensure specialized expertise across all project facets.

Key aspects of personnel quality assurance include:

\* **Client Approval:** Key personnel and Sub-consultants listed in Appendix B are subject to Client approval, with biographical data submitted for review (Clause 4.3, Page 23).

\* **Task Assignment & Manning Schedule:** Detailed task assignments (Form-T-6, Page 363) and a comprehensive manning schedule (Appendix B, Page 5) will ensure optimal resource allocation and continuity.

\* **Personnel Replacement Policy:** Stringent conditions govern the removal and/or replacement of personnel, with penalties applied for unauthorized changes to discourage disruptions and maintain team quality (Clause 4.5, Page 24; Page 366). Undertakings from both personnel and the consulting firm guarantee the accuracy of CVs and commitment to project duration (Form-T11, Page 292, 293).

\* **Responsibility Matrix:** The QAP will clearly identify personnel responsible for carrying out, preparing, checking, and verifying various activities, fostering accountability at every stage (Clause 3.11, Page 49; STAGE 1, Page 81).

#### 4. Adherence to Technical Standards and Methodologies

All services will be performed in strict accordance with the Applicable Law (Clause 3.2, Page 7), MoRTH Specifications, relevant IRC Codes, and BIS Standards, ensuring technical robustness and compliance with national guidelines for road construction.

##### 4.1. Field Surveys & Investigations

\* **Topographic Surveys:** Employing **Mobile LiDAR or equivalent technology** for high accuracy, achieving fundamental horizontal and vertical accuracy of 2 cm or better for land-based surveys and 5 cm or better for aerial surveys. A minimum of 50 points per square meter (land) or 10 points per square meter (aerial) will be measured. Accuracy will be verified via check point surveys using DGPS and Auto Level (Clause 4.11.2, Page 60). Surveys will extend a minimum of 30 m beyond the proposed divided carriageway or land boundary (Clause 4.11.2, Page 61).

\* **Sub-surface Utility Detection: GPR (Ground Penetrating Radar) and Induction Locator or equivalent technologies** will be deployed for accurate identification and

mapping of underground utilities (Page 341, 363, 477).

\* **Geotechnical & Sub-soil Investigations:** Conducted as per **IRC:78**. The scheme for boring locations and depths will be prepared by Consultants and approved by NHAI. Investigations will be carried out through MoRTH empanelled geotechnical consultants, with reports conforming to IRC prescribed formats. Rigorous testing will be applied to problematic soils (Clause 4.11.4, Page 67; Page 62).

\* **Material Investigations:** Identification of local sources (quarry sites, borrow areas) for construction materials, undertaking field and laboratory testing to determine suitability as per **MoRTH's Standard Data Book**. Emphasis will be placed on "**Environment friendly materials**," including mandatory use of fly-ash within 300 km of Thermal Power Stations, as per Gazette notification No. S.O.254 (E) dated 25.01.2016 (Clause 4.11.4.2, Page 67; Clause 4.12.5, Page 74). Mass haul diagrams will be prepared.

\* **Pavement Condition Surveys:** Utilisation of **Falling Weight Deflectometer (FWD)** or Benkelman Beam Deflection for pavement strength evaluation, complemented by Roughness Surveys using ROMDAS or equivalent. Axle Load Surveys will adhere to **IRC:SP:19** (Page 463; Page 119).

\* **Traffic Surveys:** Detailed Classified Traffic Volume Counts, Origin-Destination (O-D) and Commodity Movement Surveys, and Speed and Delay studies will be conducted following relevant IRC codes, including **IRC:102** and **IRC:108** (Clause 4.9, Page 55; Page 118-119).

#### 4.2. Design & Engineering

\* **Geometric Design:** Compliance with **IRC guidelines** for horizontal alignment, vertical profile, cross-sectional elements (including refuge lanes at 2km intervals), junctions, intersections, interchanges, bypasses, and urban service roads (Clause 4.12, Page 70-72).

\* **Pavement Design:** Based on rigorous testing and evaluation, considering both rigid and flexible design options. The most appropriate design will be established on life-cycle costing and techno-economic principles. Overlay design will account for existing pavement

strength and remaining life (Clause 4.12.4, Page 72).

\* **Bridge & Structure Design:** Compliance with **IRC:SP:35** (Guidelines for Inventory), **IRC:13** (Design of Small Bridges and Culverts), **IRC:5** (Standard Specifications for Road Bridges, Section I), and **IRC:78** (for Geotechnical investigation). Preparation of General Arrangement Drawings (GAD) and detailed engineering drawings will be a core deliverable (Clause 4.11.4.1, Page 67; Clause 4.12.6, Page 74).

\* **Embankment Design:** Detailed analysis and design for embankments exceeding 6m in height will adhere to relevant **IRC publications**, with emphasis on maximum utilization of locally available materials, including fly-ash where feasible (Clause 4.12.5, Page 73).

\* **Environmental & Social Safeguards:** Comprehensive Environmental Impact Assessment (EIA), Environmental Management Plan (EMP), and Rehabilitation and Resettlement (R&R) Studies will be carried out to meet the requirements of lending agencies (ADB/World Bank/JICA) and Government of India guidelines (Clause 2.2, Page 47; Clause 4.13, Page 75).

\* **Road Safety Audit:** A mandatory component, safety audits will be integrated into the design process at various stages, as per **Supplement-III of the TOR** (Page 103, 484), to identify and mitigate potential hazards proactively.

## 5. Documentation, Review, and Approval Process

Our quality assurance framework ensures a systematic approach to documentation, rigorous internal review, and timely client approvals.

• **Comprehensive Reporting:** All stipulated reports and documents, including the Inception Report, Feasibility Report, Detailed Project Report (DPR), Environmental Assessment Report, RAP, Technical Specifications, Rate Analysis, Cost Estimates, Bill of Quantities (BOQ), Drawing Volume, Land Acquisition Report, Clearances II Report, and Monthly Progress Reports, will be submitted as per Appendix A/E (Clause 3.8, Page 22) and within the specified timeframes (Appendix B, Appendix III, Page 325).

- **"Good for Construction" Drawings:** A critical deliverable is the submission of "good for construction" drawings for all engineering components (Clause 2.2, Page 47; Clause 10.9, Page 92).
- **Internal Quality Checks:** Our QAP mandates systematic internal checking and approval of all calculations, designs, and project documents, ensuring strict adherence to technical parameters and document traceability (Appendix II, Page 311).
- **Client Review and Approval:** Mandatory prior written approvals will be sought for key actions, including personnel appointments, sub-contracting, and changes in scope (Clause 3.7, Page 22). All designs and drawings, particularly for major structures like ROBs/RUBs, will obtain final approval from relevant authorities (e.g., Railways), and environmental clearances from MoEF (Clause 2.2, Page 47; Clause 3.9, Page 49).
- **Data & Software Submission:** All basic and processed data from field studies, investigations, reports, and drawings will be submitted in digital format (floppy diskettes/CDs) to NHAI upon submission of the Final Report (Clause 13, Page 93).
- **Proof Consultant:** We acknowledge that NHAI may appoint a Proof Consultant to independently supervise and verify our work, including field investigations, survey work, design work, and pre-construction activities (Clause 11.3, Page 93).

## 6. Accountability and Risk Mitigation

To underpin our commitment to quality and manage potential risks, specific accountability measures and risk mitigation strategies are embedded in the contract.

- **Responsibility for Accuracy:** The Consultant bears full responsibility for the accuracy of all collected data, designs, drawings, estimates, and other details. We undertake to indemnify the Authority against any inaccuracy that may surface during project implementation due to deficiencies in our services (Clause 7.1.1, Page 29; Clause 7.4.1, Page 31).
- **Retention Money:** An amount equivalent to 10% of the contract value will be retained for accuracy of design and quantities, to be released after completion of civil contract works or three years from the completion of consultancy services, whichever is earlier. This can be substituted by a Bank Guarantee of the same amount (Clause 7.2, Page 29).



- **Professional Liability Insurance (PLI):** The Consultant is required to take out and maintain Professional Liability Insurance covering errors and omissions, effective for a period of five years beyond the completion of consultancy services or as per Applicable Law, whichever is higher (Clause 9.1(c), Page 31).

- **Penalties for Deficiency:**

- **Error/Variation:** Penalties will be imposed for variations exceeding +/- 15% in main quantities (e.g., earthwork, GSB, WMM, bituminous works, concrete, reinforcing steel) or overall project cost. Similarly, penalties apply for inaccuracies in survey, investigation, or design work as detailed in the RFP (Clause 7.3.1, Page 30).

The penalty structure for inaccuracies in survey/investigation/design work is as follows:

S No	Item	Penalty (% of contract value)
1	Topographic Surveys (horizontal alignment mismatch, cross-section mismatch, defective coordinates)	0.5 to 1.0
2	Geotechnical Surveys (incomplete, improperly analyzed data, substrata different from actual)	0.5 to 1.0
3	Traffic data varying by >25% on resurvey	0.2 to 0.5
4	Axle load data varying by >25% on resurvey	0.20 to 0.5
5	Structural Designs unsafe or grossly over-safe	1.0 to 2.0

- **Delay:** A penalty equal to 0.05% of the contract price per day, subject to a maximum of 5% of the contract value, will be imposed for delays in completion of services (Clause 7.3.2, Page 30).



- **Limits:** The total amount of recovery from all penalties shall be limited to 10% of the Consultancy Fee (Clause 7.3.3, Page 30).
- **Action for Deficiency in Services:** In addition to financial penalties, major deficiencies in the Detailed Project Report (DPR) resulting in time and cost overruns or adverse effects on NHAI's reputation may lead to warnings or debarment of the consultant for a specified period (Clause 7.4.2, Page 31).

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## 11.0 Checklists

### Checklists for RFP Inception Report

This section outlines the comprehensive checklists to be utilized during the Inception Report phase, ensuring a systematic, thorough, and compliant approach to project initiation. These checklists are designed to meticulously verify all project parameters, preliminary investigations, and planning activities in adherence to NHAI, MoRTH, IRC, and BIS standards, specifically tailored to the project context within Bhopal, Madhya Pradesh, India. Their application guarantees precision, quality, and full alignment with the project's Terms of Reference (ToR) from the outset.

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#### 1. Inception Report (IR) Content and Deliverables Checklist

This checklist directly reflects the expected content and deliverables for the Inception Report submission, ensuring all aspects of project appreciation, methodology, resource allocation, and initial planning are addressed.

**Project Name:** [To be filled by Consultant]

**Consultant's Name:** [To be filled by Consultant]

**Date of Review:** [To be filled by Consultant]

S.No.	SECTION OF THE REPORT	DETAILS/SPECIFICATIONS	REFERENCE STANDARD/GUIDELINE	YES/NO/NA	REMARKS/STATUS
1.	Executive Summary	Concise overview of the project, key findings, and recommendations of the Inception Report.	IRC:SP:19, MoRTH Guidelines		
2.	Project Appreciation				
2.1	Location of site office	Confirmation of proposed site office location and facilities in Bhopal, Madhya Pradesh.	NHAI Guidelines, Project Requirement		
2.2	Review of scope of ToR and gap identification	Detailed review of the Terms of Reference (ToR), identification of any ambiguities or gaps, and proposed resolutions.	Project ToR, NHAI Guidelines		

S.No.	SECTION OF THE REPORT	DETAILS/SPECIFICATIONS	REFERENCE STANDARD/GUIDELINE	YES/NO/NA	REMARKS/STATUS
2.3	Key departments identified for various documents	Identification and initial engagement strategy for all relevant client and external departments (e.g., NHAI, PWD, Forest Dept., Utility Providers i...	NHAI Protocol, State/Local Authorities		
2.4	Project description	Verification of start and end locations, chainage details, and villages/districts covered within the Bhopal region.	Project ToR, NHAI Records		
2.5	Project location map	Inclusion of project alignment on State and District Maps (Madhya Pradesh/Bhopal).	IRC:SP:19, NHAI Standards		
2.6	Site photos and data of project alignment	Representative photographic documentation and preliminary data of the existing project alignment in Bhopal.	MoRTH Quality Assurance Manual		

S.No.	SECTION OF THE REPORT	DETAILS/SPECIFICATIONS	REFERENCE STANDARD/GUIDELINE	YES/NO/NA	REMARKS/STATUS
2.7	Overview of land use plans	Preliminary assessment of land-use patterns (agricultural, commercial, forest, residential etc.) along the corridor in Bhopal @ every kilometer.	IRC:SP:19, Local Planning Documents		
2.8	Overview of existing pavement conditions	Initial assessment of existing pavement conditions (Number of Lanes, Type of Pavement - Flexible/Rigid/ Surfaced/Unsurfaced).	IRC:SP:19, MoRTH Guidelines		
2.9	Existing right of way (ROW) details	Preliminary assessment of existing ROW details along the project corridor in Bhopal.	NHAI Guidelines, Revenue Records		
2.10	Number/Location of major and minor bridges	Identification and preliminary location of major and minor bridges, culverts, and other structures.	IRC:SP:19, NHAI Standards		

S.No.	SECTION OF THE REPORT	DETAILS/SPECIFICATIONS	REFERENCE STANDARD/GUIDELINE	YES/NO/NA	REMARKS/STATUS
2.11	Number/Location of level crossings	Identification and preliminary location of existing railway level crossings.	IRC:SP:19, Railway Guidelines		
2.12	Number/Location of ROB and RUB	Identification and preliminary location of existing Road Over Bridges (ROB) and Road Under Bridges (RUB).	IRC:SP:19, Railway Guidelines		
2.13	Any other details relevant to the project	Capture any additional project-specific details critical for the inception phase in Bhopal.	Project ToR, Site-specific observations		
3.	Approach Methodology				
3.1	Engineering survey and investigations	Detailed plan for conducting all required engineering surveys and investigations (reconnaissance, topographical, traffic, geotechnical, hydrological...	IRC Codes (e.g., SP:19, 108, 102), MoRTH Specifications		

S.No.	SECTION OF THE REPORT	DETAILS/SPECIFICATIONS	REFERENCE STANDARD/GUIDELINE	YES/NO/NA	REMARKS/STATUS
3.2	Design of road, pavements and structures	Outline of proposed methodology for design of road geometrics, pavements, and structures, referencing relevant IRC codes and MoRTH specifications.	IRC Codes (e.g., 73, 58, 6, 112), MoRTH Specifications		
3.3	Environment and social impact assessment	Initial plan for environmental and social impact assessment (EIA/SIA) and Resettlement & Rehabilitation (R&R;) framework.	MoEF&CC; Guidelines, NHAI R&R; Policy		
3.4	Estimation of project cost, viability and financing options	Methodology for preliminary project cost estimation, viability assessment, and identification of financing options.	MoRTH Data Book, NHAI Costing Guidelines		
3.5	Any other details relevant to the project	Additional methodological aspects unique to the Bhopal project.	Project ToR, Best Industry Practice		



S.No.	SECTION OF THE REPORT	DETAILS/SPECIFICATIONS	REFERENCE STANDARD/GUIDELINE	YES/NO/NA	REMARKS/STATUS
4.	Task Assignment and Manning Schedule				
4.1	Number of key personnel provided	Confirmation of proposed key personnel (Team Leader, Senior Survey Engineer, Material-cum-Geotechnical Engineer, Traffic & Safety Expert, etc.).	RFP Requirements, NHAI Standards		
4.2	Specific tasks assigned to each key personnel	Clear delineation of specific tasks and responsibilities for each key personnel.	RFP Requirements, Project Organization Chart		
4.3	Manning schedule for key personnel	Detailed manning schedule for all key and support personnel, including their deployment at the Bhopal site.	RFP Requirements, Project Schedule		

S.No.	SECTION OF THE REPORT	DETAILS/SPECIFICATIONS	REFERENCE STANDARD/GUIDELINE	YES/NO/NA	REMARKS/STATUS
4.4	Number of key personnel deployed at site	Confirmation of the number of key personnel who will be physically present at the Bhopal project site.	RFP Requirements, Site Deployment Plan		
5.	Proforma for data collection	Sample formats/proforma for all data collection activities (road inventory, traffic, pavement, soil, materials, social, environmental) tailored for...	IRC, MoRTH, NHAI Formats		
6.	Indicative design standards and cross sections	Proposed indicative design standards (geometric, pavement, structural) and typical cross-sections for various road categories, consistent with IRC/...	IRC:73, IRC:SP:23, MoRTH Specifications, NHAI Standards		
7.	Development plans				

S.No.	SECTION OF THE REPORT	DETAILS/SPECIFICATIONS	REFERENCE STANDARD/GUIDELINE	YES/NO/NA	REMARKS/STATUS
7.1	Overview of development plans being implemented/proposed by local bodies	Review of any ongoing or proposed development plans by local bodies (e.g., Bhopal Municipal Corporation, Town & Country Planning Dept.) in the proj...	Local Government Plans, Master Plans		
7.2	Overview of impact of such development plans	Assessment of the potential impact of such development plans on field investigations, design, and land acquisition strategies.	Risk Assessment, Stakeholder Consultation		
8.	Quality Assurance Plan (QAP)				
8.1	Engineering surveys and investigation	Specific QA/QC procedures planned for engineering surveys and investigations.	NHAI Quality Assurance Manual, MoRTH QAP		
8.2	Traffic surveys	Specific QA/QC procedures planned for traffic surveys.	NHAI Quality Assurance Manual, MoRTH QAP		

S.No.	SECTION OF THE REPORT	DETAILS/SPECIFICATIONS	REFERENCE STANDARD/GUIDELINE	YES/NO/NA	REMARKS/STATUS
8.3	Material geotechnical and sub-soil investigations	Specific QA/QC procedures planned for material, geotechnical, and sub-soil investigations.	NHAI Quality Assurance Manual, MoRTH QAP		
8.4	Road and pavement investigations	Specific QA/QC procedures planned for road and pavement investigations.	NHAI Quality Assurance Manual, MoRTH QAP		
8.5	Investigation and design of bridges and structures	Specific QA/QC procedures planned for investigation and design of bridges and structures.	NHAI Quality Assurance Manual, MoRTH QAP		
8.6	Environment and R&R; assessment	Specific QA/QC procedures planned for environmental and R&R; assessments.	NHAI Quality Assurance Manual, MoRTH QAP		
8.7	Economic and financial analysis	Specific QA/QC procedures planned for economic and financial analysis.	NHAI Quality Assurance Manual, MoRTH QAP		

S.No.	SECTION OF THE REPORT	DETAILS/SPECIFICATIONS	REFERENCE STANDARD/GUIDELINE	YES/NO/NA	REMARKS/STATUS
8.8	Drawing and documentation	Specific QA/QC procedures planned for all drawings and documentation.	NHAI Quality Assurance Manual, MoRTH QAP		
8.9	Any other details relevant to the project	Additional QAP aspects unique to the Bhopal project.	Project ToR, Best Industry Practice		
8.10	Discussion of draft QAP document with client	Plan for finalizing the QAP in consultation with NHAI officers, covering all aspects from surveys to documentation.	NHAI Protocol		
8.11	Approval of final QAP document by client	Confirmation of the process for obtaining NHAI approval for the comprehensive QAP.	NHAI Protocol		
9.	Draft design Standards				

S.No.	SECTION OF THE REPORT	DETAILS/SPECIFICATIONS	REFERENCE STANDARD/GUIDELINE	YES/NO/NA	REMARKS/STATUS
9.1	Geometric design standards of highway (Plain)	Presentation of proposed draft geometric design standards for highways (plain terrain applicable to Bhopal region), including any justified deviation.	IRC:73, MoRTH Standards		
9.2	Geometric design standards of highway (Hilly)	[Not applicable for Bhopal region, but retained for comprehensive template]	IRC:52, MoRTH Standards	N/A	
10.	Conclusions and recommendations				
10.1	Conclusions and recommendations	Overall conclusions derived from the inception phase activities and key recommendations for subsequent project stages.	Project ToR, Consultant's Expertise		

S.No.	SECTION OF THE REPORT	DETAILS/SPECIFICATIONS	REFERENCE STANDARD/GUIDELINE	YES/NO/NA	REMARKS/STATUS
10.2	Report fulfils project objectives and scope as per RFP	Confirmation that the Inception Report addresses all project objectives and scope as per the RFP and ToR.	Project ToR, RFP Objectives		
10.3	Report reviewed for errors and omissions	Statement on internal review process for errors/omissions.	Internal QA/QC Procedures		
10.4	Compliance report prepared on client observations	Plan for preparing a compliance report for any client observations or feedback.	NHAI Feedback Mechanism		

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## 2. Preliminary Road Safety Audit Checklist (Stage F - During Feasibility Study)

While the Inception Report sets the stage, early consideration of road safety aspects, as per NHAI's "SUPPLEMENT I: ADDITIONAL REQUIREMENT FOR SAFETY AUDIT," is critical. This checklist outlines the key areas to be reviewed during the feasibility study stage, with initial planning and consideration commencing in the inception phase.

**Project Name:** [To be filled by Consultant]

**Consultant's Name:** [To be filled by Consultant]



**Date of Review:** [To be filled by Consultant]

S.No.	CONTENTS	ITEMS	ASPECTS TO BE CHECKED	YES/NO/NA	REMARKS/STATUS
A	General	Safety implications of the scheme beyond its physical limits i.e. how the scheme fits into its environs and road hierarchy	Analysis of how the proposed alignment integrates with the existing road network in Bhopal and its broader safety context, considering future devel...		
		Departures from standards	Identification of any proposed deviations from IRC/MoRTH safety standards and justification thereof.		
		Cross-sectional variation	Assessment of safety implications arising from proposed variations in cross-sections along the corridor.		
		Drainage	Review of proposed drainage provisions for potential safety hazards (e.g., ponding, skidding risks) in the Bhopal climate.		

S.No.	CONTENTS	ITEMS	ASPECTS TO BE CHECKED	YES/NO/NA	REMARKS/STATUS
		Climatic conditions	Consideration of local climatic factors (e.g., monsoon, fog) in Bhopal and their impact on road safety design.		
		Landscaping	Evaluation of landscaping proposals for potential sightline obstructions or other safety concerns.		
		Services apparatus	Assessment of safety implications related to existing and proposed utility services apparatus within the ROW.		
		Lay-byes	Adequacy and safety of proposed lay-byes.		
		Footpaths	Provision and safety of footpaths for pedestrians.		

S.No.	CONTENTS	ITEMS	ASPECTS TO BE CHECKED	YES/NO/NA	REMARKS/STATUS
		Pedestrian crossings	Adequacy, visibility, and safety of proposed pedestrian crossings, especially in urban/semi-urban areas of Bhopal.		
		Access (minimize number of private accesses)	Review of proposed access control measures to minimize conflicts.		
		Emergency vehicles	Ensuring adequate provisions for emergency vehicle access and movement.		
		Public Transport	Integration of public transport facilities (bus stops, bus bays) with safety in mind.		
		Future widening	Consideration of safety implications of potential future widening.		

S.No.	CONTENTS	ITEMS	ASPECTS TO BE CHECKED	YES/NO/NA	REMARKS/STATUS
		Staging of contracts	Assessment of safety during construction phases and potential impact of phased project implementation.		
		Adjacent development	Consideration of existing and planned adjacent developments in Bhopal and their impact on road safety.		
B	Safety and operational implications of proposed alignment and junction strategy	With particular references to expected road users and vehicle types likely to use the road	Evaluation of the overall alignment and junction strategy from a road safety perspective, considering a mix of vehicle types and non-motorized traf...		
C	Width options considered for various sections	Assessment of safety impacts due to varied width options for different road sections.			

S.No.	CONTENTS	ITEMS	ASPECTS TO BE CHECKED	YES/NO/NA	REMARKS/STATUS
D	Provision of pedestrians, cyclists and intermediate transport	Ensuring safe and adequate provisions for non-motorized and intermediate transport users.			
A1	General	Departures from standards	(Already covered under A)		
		Cross-sectional variation	(Already covered under A)		
		Drainage	(Already covered under A)		
		Climatic conditions	(Already covered under A)		
B1	General	(Repeats A, A1)			
B2	Local Alignment	Visibility	Assessment of sight distances, stopping sight distances, and visibility at critical locations.		

S.No.	CONTENTS	ITEMS	ASPECTS TO BE CHECKED	YES/NO/NA	REMARKS/STATUS
		New/Existing road interface	Safety assessment at transition points between new and existing road sections.		
		Safety Aids on steep hills	[Not applicable for Bhopal's predominantly plain/rolling terrain, but included for comprehensive template consideration]	N/A	
		Minimise potential conflicts	Design measures to minimize conflict points between different traffic streams.		
B3	Junctions	Layout	Evaluation of proposed junction layouts for safety and efficiency.		
		Visibility	Ensuring adequate visibility at all junctions for approaching traffic.		

S.No.	CONTENTS	ITEMS	ASPECTS TO BE CHECKED	YES/NO/NA	REMARKS/STATUS
B4	Non-Motorised road users Provision	Pedestrians	Dedicated provisions and safety measures for pedestrians.		
		Cyclists	Dedicated provisions and safety measures for cyclists.		
		Non-motorised vehicles	Provisions for other non-motorized vehicles prevalent in Bhopal.		
B5	Signs and Lighting	Lighting	Adequacy and effectiveness of proposed lighting, especially at junctions and critical sections.		
		Signs/Markings	Clarity, consistency, and visibility of proposed road signs and markings as per IRC.		
B6	Construction and Operation	Buildability	Consideration of safety during the construction phase.		



S.No.	CONTENTS	ITEMS	ASPECTS TO BE CHECKED	YES/NO/NA	REMARKS/STATUS
		Operational	Overall operational safety of the road once commissioned.		
		Network Management	Integration with broader network management strategies for safety.		

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### 3. Initial Utility Shifting Assessment and Planning Checklist

Effective planning for utility shifting is crucial for avoiding project delays and cost overruns. This checklist outlines the essential steps for preliminary assessment and planning of utility removals in the inception phase, following NHAI guidelines (Policy Circular No. 215/2016).

**Project Name:** [To be filled by Consultant]

**Consultant's Name:** [To be filled by Consultant]

**Date of Review:** [To be filled by Consultant]

S.No.	SECTION OF THE CHECKLIST	DETAILS/SPECIFICATIONS	REFERENCE STANDARD/GUIDELINE	YES/NO/NA	REMARKS/STATUS
1.	Identification of Existing Utilities				

S.No.	SECTION OF THE CHECKLIST	DETAILS/SPECIFICATIONS	REFERENCE STANDARD/GUIDELINE	YES/NO/NA	REMARKS/STATUS
1.1	Identification of overground utilities in ROW	Comprehensive identification of all visible overground utilities (e.g., electrical poles/lines, communication poles/cables, water pipelines, signag...	NHAI Policy (215/2016), MoRTH Guidelines		
1.2	Identification of underground utilities using GPR, Induction Locator or equivalent technologies	Plan for deploying GPR, Induction Locator, or equivalent technologies for detection and mapping of underground utilities (e.g., water, sewer, gas, ...	NHAI Policy (215/2016), Best Industry Practice		
2.	Utility Mapping and Coordination				
2.1	Preparation of preliminary strip plan for existing utilities	Development of a preliminary strip plan clearly showing locations, types, and extent of all identified existing utilities with chainage and offsets.	NHAI Policy (215/2016), IRC:SP:19		

S.No.	SECTION OF THE CHECKLIST	DETAILS/SPECIFICATIONS	REFERENCE STANDARD/GUIDELINE	YES/NO/NA	REMARKS/STATUS
2.2	Identification of utility owners/agencies in Bhopal	Compilation of a comprehensive list of all utility owners/agencies (e.g., MPSEB, Municipal Corporation Bhopal, BSNL, private operators) for the ide...	NHAI Protocol, Local Government Directory		
2.3	Planning for initial consultation with utility agencies	Outline of strategy and schedule for initial consultations with identified utility owners/agencies to discuss shifting requirements, feasibility, a...	NHAI Policy (215/2016), Stakeholder Engagement Plan		
3.	Preliminary Impact Assessment				
3.1	Assessment of utility impact on proposed alignment	Preliminary evaluation of the direct impact of existing utilities on the proposed road alignment and structures.	Project Design Considerations		

S.No.	SECTION OF THE CHECKLIST	DETAILS/SPECIFICATIONS	REFERENCE STANDARD/GUIDELINE	YES/NO/NA	REMARKS/STATUS
3.2	Assessment of utility impact on project schedule and cost	Initial estimate of potential delays and costs associated with utility identification, relocation planning, and actual shifting activities.	Risk Assessment, NHAI Policy (215/2016)		
3.3	Planning for detailed utility relocation plans	Outline of the process for preparing detailed utility relocation plans, including proposed new alignments, technical specifications, and preliminary..	NHAI Policy (215/2016), MoRTH Guidelines		
4.	Documentation and Reporting				
4.1	Compilation of all utility-related data and observations	Organization and compilation of all collected data, maps, and initial assessment findings related to utilities for inclusion in the Inception Report.	NHAI Reporting Standards		

S.No.	SECTION OF THE CHECKLIST	DETAILS/SPECIFICATIONS	REFERENCE STANDARD/GUIDELINE	YES/NO/NA	REMARKS/STATUS
4.2	Inclusion of utility strategy in Inception Report	Ensure that a clear strategy for addressing utility shifting, including timelines and coordination mechanisms, is presented in the Inception Report.	Project ToR, NHAI Guidelines		

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## 12.0 Summary and Conclusion

### Summary and Conclusion

#### 1. Project Overview and Objectives Confirmation

This Inception Report delineates the initial phase of the "Consultancy Services for preparation of Detailed Project Report (DPR) for development of Economic Corridors, Inter Corridors, Feeder Routes and Coastal Roads to improve the efficiency of freight movement in India under Bharatmala Pariyojna (Lot-1/Madhya Pradesh/Package-3)." The project is strategically vital for enhancing intra-state and inter-state connectivity, aligning with the national objective of improving logistical efficiencies and promoting economic growth across Madhya Pradesh.

The consultancy specifically focuses on two key stretches within Madhya Pradesh, as detailed in the Terms of Reference (ToR):

\* **Economic Corridor (Sagar-Katni):** A 193 km section of NH-934 (Sagar-Garhakota-Damoh-Raipur-Katni), aimed at strengthening the backbone of freight movement through a critical economic zone.

\* **Inter Corridor (Vidisha-Malthone):** A 142.1 km section comprising SH-19, SH-14, SH-42A, and SH-42 (Vidisha-Saletara-Kurvai-Bina-Khimsala-Malthone), designed to connect important production and consumption centres, thus optimizing supply chain logistics.

The total project length encompasses 335.1 km of significant highway development. LEA Associates South Asia Pvt. Ltd. confirms a comprehensive understanding of the project objectives, which are to deliver a technically robust, economically viable, and environmentally sustainable DPR to the National Highways Authority of India (NHAI), ultimately contributing to the infrastructure development vision for Madhya Pradesh, with its administrative and economic hub in Bhopal.

#### 2. Scope of Services & Key Deliverables (Inception Phase)

The Inception Phase, as documented in this report, has successfully established the foundational understanding and operational framework for the subsequent DPR stages. Key activities undertaken and deliverables achieved include:

- **Project Appreciation:** A thorough review and understanding of the project's macro and micro context, including its strategic importance to Madhya Pradesh's freight movement and economic corridors.
- **ToR and Gap Identification:** A detailed analysis of the Terms of Reference (ToR) to identify the full scope of services, reporting requirements, and any potential gaps or areas requiring clarification.
- **Methodology Adoption:** Definition of the proposed methodologies for conducting the Feasibility Study (Stage 2) and the subsequent detailed engineering design, traffic surveys, socio-economic assessments, and environmental impact studies.
- **Resource Mobilization:** Deployment of key personnel, including the General Manager (Highways), Highway Engineers, and Senior Bridge Engineers, and establishment of initial project management protocols.
- **Initial Data Collection:** Commencement of preliminary data collection, including a review of available topographical maps, satellite imagery, and existing reports pertaining to the project corridors.
- **Stakeholder Identification:** Identification of key stakeholders, including relevant government departments in Madhya Pradesh (e.g., PWD, Forest Dept.) and local administrative bodies, crucial for future coordination and clearances.
- **Risk Identification:** Preliminary identification of potential project risks and mitigation strategies.

### 3. Alignment with Terms of Reference (ToR)

This Inception Report has been meticulously prepared to align fully with the requirements outlined in Appendix A and Appendix I of the RFP, specifically the "Terms of Reference (TOR) Consultancy Services for Project Description." All elements prescribed for the Inception Report, as per the NHAI's DPR Checklist - Stage 1 (Structures), have been



addressed, ensuring comprehensive coverage of Project Appreciation, site office setup, review of ToR, identification of key departments, and initial project description details. The report establishes the consultant's full compliance with the stipulated contractual obligations for this initial stage.

#### 4. Initial Findings and Strategic Approach

The inception phase has reinforced the complex yet critical nature of the project. The stretches traversing diverse terrains and socio-economic landscapes across Sagar, Katni, Vidisha, and Malthone districts present unique engineering and planning challenges. Our strategic approach for the subsequent stages will be underpinned by:

- **Integrated Planning:** A holistic perspective integrating highway design, structural engineering for bridges and cross-drainage structures, traffic management, socio-economic considerations, and environmental stewardship.
- **Standard Adherence:** Strict adherence to national and international standards, including IRC (Indian Road Congress) codes, MoRTH (Ministry of Road Transport and Highways) specifications, BIS (Bureau of Indian Standards) guidelines, and NHAI best practices.
- **Technology Integration:** Leveraging advanced surveying techniques (e.g., Total Station, GPS, DTM-based software) and engineering design software to ensure precision and efficiency in data collection and design.
- **Sustainable Development:** Emphasis on developing infrastructure solutions that are resilient, sustainable, and minimize adverse environmental and social impacts, particularly in sensitive areas within Madhya Pradesh.

#### 5. Recommendations and Way Forward

Based on the Inception Report's findings and confirmed understanding, the following recommendations guide the immediate next steps:

- **Mobilization for Feasibility Study:** Prompt mobilization of survey teams for detailed topographic surveys, geotechnical investigations, traffic surveys (including IHMCL data analysis as per IRC:108), and environmental/social impact assessments as per DPR

#### Checklist - Stage 2 (Feasibility Report).

- **Detailed Site Investigations:** Commencement of comprehensive site reconnaissance, including utility mapping, preliminary land acquisition surveys, and identification of critical structures (e.g., ROB/RUB locations, major/minor bridges).
- **Stakeholder Engagement:** Initiate formal consultations with relevant district administrations in Madhya Pradesh and local communities to gather essential ground-level data and address preliminary concerns.
- **Data Analysis & Preliminary Design:** Begin the analysis of collected data to inform preliminary design standards, alignment options, and indicative cost estimates for both highway and structural components.
- **Environmental & Social Baseline:** Establish baseline environmental and social data to facilitate detailed impact assessments.

#### 6. Commitment and Quality Assurance

LEA Associates South Asia Pvt. Ltd. reaffirms its unwavering commitment to delivering a DPR for the subject project that is of the highest professional quality, technically sound, and fully compliant with NHAI's requirements and national standards. Our experienced team, led by seasoned professionals like Mr. Sujoy Sinha, General Manager (Highways), is dedicated to executing the project with diligence, integrity, and technical excellence. We are confident that this project will significantly contribute to improving freight movement and connectivity in Madhya Pradesh, furthering the state's and nation's economic progress.

## 13.0 Compliances

### Compliances

This section outlines the comprehensive framework of compliances governing the Consultancy Services for the preparation of Detailed Project Report (DPR) for the development of Economic Corridors, Inter Corridors, Feeder Routes, and Coastal Roads to improve the efficiency of freight movement in India (Lot-1/Madhya Pradesh/Package-3). All activities undertaken by M/s LEA Associates South Asia Private Limited (hereinafter referred to as "the Consultants") shall strictly adhere to the contractual obligations, statutory regulations, and industry best practices prevalent in Bhopal, Madhya Pradesh, India.

#### 1. Contractual Compliances

The Consultants shall abide by all terms and conditions stipulated in the Contract for Consultant's Services, including the General Conditions of Contract (GCC), Special Conditions of Contract (SCC), and all Appendices thereto. Key contractual compliance aspects include:

- **Governing Law and Jurisdiction (GC 1.3):** The Contract, its meaning, interpretation, and relation between parties are governed by the Applicable Laws of India. Courts at New Delhi shall have exclusive jurisdiction over matters arising out of or relating to this Agreement.
- **Taxes and Duties (GC 1.10 & SC 1.10):** Unless otherwise specified in the SCC, the Consultants shall pay all taxes, duties, fees, and other impositions levied under the Applicable Law. SC 1.10 clarifies that the Consultants and personnel shall pay all such levies under existing, amended, or enacted laws prevailing seven days before the bid submission date. NHAI shall perform duties regarding tax deduction as lawfully imposed. Service Tax, as per NHAI circulars, is payable extra by the Client upon submission of proof of deposit to the tax authority.
- **Confidentiality (GC 3.3):** The Consultants, their Sub-consultants, and personnel shall not, during or within two (2) years after contract expiration, disclose any proprietary or

confidential information related to the Project without prior written consent from the Client.

• **Insurance (GC 3.5 & SC 3.5):** The Consultants shall secure and maintain, and ensure any Sub-consultants secure and maintain, at their own cost, insurances as approved by the Client. This includes:

- Third-Party motor vehicle liability insurance as per Motor Vehicles Act, 1988.
- Third-Party liability insurance with a minimum coverage of Rs. 1.00 million.
- Professional Liability Insurance (PLI) for a period of five years beyond completion of consultancy services or as per Applicable Law, whichever is higher, with coverage not exceeding total payments for Professional Fees and Reimbursable Expenditures, or proceeds from other insurance, whichever is higher. The policy must be from an Indian insurance company, specify "Any One Accident" and "Aggregate limit on the policy," and not be cancelled mid-term without NHAI's consent.

• Employer's liability and worker's compensation insurance as per Applicable Law.

• **Reporting Obligations (GC 3.8 & Appendix A):** Adherence to the stipulated reporting requirements and submission schedule as detailed in Appendix A, including Inception Report, Feasibility Report, LA & Clearances Reports, Detailed Project Report (DPR), Technical Schedules, and Draft 3D Publication Report.

• **Personnel Replacement (GC 4.5):** Replacement of key personnel is subject to stringent conditions and potential remuneration reductions, with specific penalties for non-compliance or debarment from future NHAI projects as detailed in the GCC.

• **Dispute Settlement (GC 9.1 & 9.2, SC 9.2):** All disputes shall initially be settled amicably. Failing this within thirty (30) days, matters may be submitted to arbitration in accordance with the Arbitration & Conciliation Act, 1996, of India.

• **Performance Security (LOI Clause 7):** The Consultants shall furnish an unconditional Bank Guarantee for 10% of the total contract value, valid for three years beyond the date of completion of services or civil works contract, whichever is earlier.

• **Integrity Pact:** A formal Integrity Pact has been signed between NHAI and M/s LEA Associates South Asia Private Limited to prevent corruption and ensure transparency throughout the tender and contract execution process (Appendix to Amendment-2 of RFP, dated April 07, 2017).

## 2. Statutory and Regulatory Compliances

The Consultants shall ensure full compliance with all relevant Indian laws, acts, rules, and regulations applicable to highway projects in Madhya Pradesh.

### 2.1 Environmental Compliances

Environmental clearances are a critical component, requiring adherence to guidelines issued by the Ministry of Environment, Forest and Climate Change (MoEF&CC), Government of India, and the Madhya Pradesh Pollution Control Board (MPPCB).

#### • **Environmental Impact Assessment (EIA) & Environmental Management Plan (EMP) (Appendix A, Clause 4.13.1):**

- Conduct preliminary environmental screening and detailed EIA as per MoEF&CC notifications (e.g., EIA Notification, 2006, and subsequent amendments).
- Establish baseline environmental conditions (air, water, noise, biodiversity).
- Assess potential significant impacts during pre-construction, construction, and operation phases and identify mitigation measures.
- Develop a comprehensive EMP, including Bill of Quantities (BOQ) and technical specifications for environmental works.
- Obtain necessary Environmental Clearance from the Competent Authority (MoEF&CC or State Environment Impact Assessment Authority - SEIAA, Madhya Pradesh).
- **Forest Clearance (Appendix A, Clause 4.13.1):** Secure Stage I and Stage II Forest Clearances under the Forest (Conservation) Act, 1980, from the MoEF&CC for any forest land diversion. This includes compensatory afforestation plans and obtaining necessary permits from the concerned District Forest Office.
- **Wildlife Clearance (Appendix A, Clause 4.13.1):** If the project impacts any Protected Areas (National Parks, Wildlife Sanctuaries) or critical wildlife habitats, obtain clearance under the Wildlife (Protection) Act, 1972, from the National/State Board for Wildlife.
- **Consent to Establish/Operate:** Obtain necessary consents from the Madhya Pradesh Pollution Control Board (MPPCB) under the Water (Prevention and Control of Pollution)

Act, 1974, and the Air (Prevention and Control of Pollution) Act, 1981, for project activities, including establishing construction camps, aggregate crushers, and hot mix plants.

## 2.2 Social and Resettlement Compliances

### • **Social Assessment & Resettlement Action Plan (RAP) (Appendix A, Clause 4.13.2 & 4.13.4):**

- Conduct baseline socio-economic and census surveys of Project Affected People (PAPs) to assess impacts on people, properties, and livelihoods.
- Develop an Entitlement Matrix for PAPs based on identified impacts, adhering to GoI/NHAI policies and guidelines of international lending agencies (e.g., ADB/World Bank, if applicable).
- Prepare a detailed RAP, including implementation budgets, institutional arrangements, and internal/external monitoring plans.
- Ensure robust public consultation processes, engaging PAPs, NGOs, and government agencies.

## 2.3 Land Acquisition Compliances

• **Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 (LARR Act, 2013):** All land acquisition processes shall strictly comply with the provisions of the LARR Act, 2013, and the National Highways Act, 1956.

• **Land Acquisition Plan (LAP) (Appendix A, Clause 4.13.2):** Prepare detailed LAP, including digital cadastral maps, land ownership details, and costs based on revenue records and realistic rates. This involves preparing all necessary schedules and draft notifications (e.g., 3(a), 3(A), and 3(D), 3(G) under the NH Act, 1956).

## 2.4 Labour and Safety Compliances

Adherence to labour laws and safety regulations is paramount to ensure the well-being of all personnel and safe project execution.



- **The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 (BOCW Act):** Compliance with provisions for registration of establishments, working hours, welfare amenities (crèches, canteens, first aid), safety measures, and appointment of safety officers.
- **The Contract Labour (Regulation and Abolition) Act, 1970:** Compliance for registration of contractors and licenses for engaging contract labour, and provision of essential welfare and safety amenities.
- **The Minimum Wages Act, 1948:** Ensuring payment of minimum wages as prescribed by the Government of Madhya Pradesh for various categories of workers.
- **The Employee's Provident Funds and Miscellaneous Provisions Act, 1952:** Contribution to provident fund for eligible employees.
- **The Employee's State Insurance Act, 1948:** Provision of health insurance and other benefits to eligible employees.
- **Employees Compensation Act, 1923:** Provision of compensation to workers in case of injury or death during employment.
- **Construction Site Safety Regulations:**
  - Provision of Personal Protective Equipment (PPE) to all workers (helmets, safety shoes, high-visibility vests, etc.).
  - Implementation of comprehensive safety management plans, including regular safety audits and risk assessments.
  - Safe access and egress points, especially for excavations and elevated work platforms.
  - Clear signage, barricades, and traffic management plans at work sites.
  - Emergency preparedness and response procedures.

## 2.5 Quality and Technical Standards

All design, engineering, and documentation activities shall strictly conform to the latest guidelines and standards:



- **Indian Roads Congress (IRC) Codes:** All relevant IRC publications shall be followed for geometric design, pavement design, bridge design, traffic surveys, material testing, and other highway engineering aspects.
- **Ministry of Road Transport and Highways (MoRTH) Specifications:** Technical specifications for road and bridge works, circulars, and manuals issued by MoRTH shall be adopted.
- **Bureau of Indian Standards (BIS) Codes:** Relevant BIS codes shall be applied for material specifications, testing procedures, and structural design components.
- **National Highways Authority of India (NHAI) Manuals and Policies:** NHAI-specific manuals, guidelines, and policy circulars shall be integrated into the project methodology.

#### 2.6 Utility Shifting Compliances (Appendix A, Clause 4.12.8 & Policy Circulars)

- **NHAI Policy Circulars:** Strict adherence to NHAI Policy Circulars (e.g., No. Technical 215/2016 dated 19.09.2016, and others referenced on page 98 of the RFP) for utility shifting.
- **Identification and Relocation Plans:** Prepare detailed utility relocation plans based on accurate surveys (using GPR, Induction Locator, or equivalent technologies) for existing overhead and underground utilities (electricity, water, telecommunication, etc.).
- **Estimates and Approvals:** Procure utility shifting estimates from concerned utility-owning agencies, verify these estimates against applicable Schedule of Rates (SoR) and market rates, and obtain final approval from relevant authorities (e.g., Electricity Board, Water Supply Department in Madhya Pradesh) and NHAI. The estimates shall be prepared with engineering maps detailing existing and proposed utility shifting, certifying the essentiality of shifting for the Project Highway.

#### 3. Key Project-Specific Undertakings and Securities

- **Key Personnel Availability:** Undertakings from all key personnel affirming their availability for the entire duration of the project, as submitted in their CVs and confirmed during contract negotiations.

- **Fly Ash Utilization (Appendix A, Clause 4.12.5):** Mandatory consideration and utilization of fly ash as a construction material within 300 km from Thermal Power Stations, as per Gazette notification No. S.O.254 (E) dated 25.01.2016.
- **Retention Money (GC 7.2):** An amount equivalent to 10% of the contract value shall be retained at the end of the contract for accuracy of design and quantities. This will be released after the completion of civil contract works or after three years from the completion of consultancy services, whichever is earlier.
- **Penalties (GC 7.3):** Penalties shall be imposed for significant errors/variations in main quantities (exceeding +/- 15%), inaccuracies in survey/investigation/design work (as per predefined table), or delays in completion of services. The total recovery from all penalties shall be limited to 10% of the Consultancy Fee.

#### 4. Reporting and Monitoring

The Consultants shall establish a robust reporting and monitoring mechanism to ensure continuous compliance with all contractual and statutory requirements. This includes:

- Regular progress reports detailing compliance status for environmental, social, labour, and safety aspects.
- Internal audits and checks to verify adherence to quality standards and design specifications.
- Prompt communication with the Client regarding any non-compliance issues and proposed corrective actions.
- Maintaining comprehensive documentation and records for all compliance-related activities, readily available for inspection and auditing by the Client or its designated representatives.

By rigorously adhering to these compliance measures, M/s LEA Associates South Asia Private Limited is committed to delivering a high-quality DPR that is technically sound, environmentally sustainable, socially responsible, and legally compliant within the project area of Bhopal, Madhya Pradesh.



## Appendix A: IRC Codes Reference

For road and highway projects in Bhopal, Madhya Pradesh, engineers and project managers primarily refer to the codes and standards published by the **Indian Roads Congress (IRC)**. These codes provide guidelines for various aspects of road design, construction, maintenance, and safety.

Here's a list and summary of relevant IRC codes, including the ones you specifically requested, with their relevance to projects in Bhopal:

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### Key IRC Codes for Road/Highway Projects in Bhopal

#### I. General Design & Geometric Standards

##### 1. IRC:SP:84: Guidelines for Urban Roads

\* **Summary:** This Special Publication provides comprehensive guidelines for the planning, design, construction, and maintenance of roads within urban areas. It covers aspects like geometric design for urban environments, intersections, grade separations, road furniture, utilities, drainage, provision for pedestrians and cyclists, and environmental considerations specific to cities.

**Relevance to Bhopal:** *Highly critical for all road projects within\* Bhopal city limits, including arterial roads, collector streets, and local streets. It guides how urban infrastructure is integrated with road design.*

##### 2. IRC:73: Geometric Design Standards for Rural (Non-Urban) National Highways (and often referred for SH/MDR)

\* **Summary:** Specifies the geometric design parameters for National Highways in rural (non-urban) areas, including horizontal curves, vertical curves, sight distances, super-elevation, pavement width, shoulders, median, and gradient. Many State Highways (SH) and Major District Roads (MDR) also refer to these standards.

\* **Relevance to Bhopal:** Applicable for highway stretches passing through the rural outskirts of Bhopal or connecting Bhopal to other cities, guiding the design of new highways or upgrading existing ones outside the core city.

### 3. IRC:SP:88: Guidelines on Geometric Design of Urban Roads and Intersections

\* **Summary:** A more detailed guide specifically focusing on the geometric design of urban roads and various types of intersections (at-grade, grade-separated). It complements IRC:SP:84 by providing granular details on intersection layout, channelization, turning radii, and traffic flow management.

\* **Relevance to Bhopal:** Extremely important for designing efficient and safe intersections within Bhopal city, which often experiences high traffic volumes and complex traffic movements.

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## II. Pavement Design

### 4. IRC:37: Guidelines for the Design of Flexible Pavements

\* **Summary:** This code outlines the methodology for designing flexible pavements (bituminous/asphalt pavements) for various traffic loads and subgrade conditions. It covers design principles, material characterization, traffic load estimation, subgrade strength evaluation (CBR), and procedures for determining the required thickness of different pavement layers.

\* **Relevance to Bhopal:** Absolutely essential for almost all new road construction and major rehabilitation projects in Bhopal, as flexible pavements are predominantly used due to their cost-effectiveness and ease of construction/maintenance.

### 5. IRC:58: Guidelines for the Design of Plain Jointed Rigid Pavements for Highways (and sometimes urban roads)

\* **Summary:** Provides detailed guidelines for the design of rigid pavements (concrete pavements), including considerations for slab thickness, joint spacing, dowel bars, tie bars, and sub-base design. It factors in traffic volume, subgrade strength, and environmental

conditions.

\* **Relevance to Bhopal:** Relevant for high-traffic corridors, bus rapid transit (BRT) routes, specific urban intersections, or industrial areas in Bhopal where rigid pavements might be preferred due to their longer design life and ability to withstand heavier loads.

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### III. Traffic Management & Road Safety

#### 6. IRC:5: Standard Specifications & Code of Practice for Road Bridges - General Features of Design (Loading)

\* **Clarification:** You mentioned IRC:5 for "traffic standards." Please note that \*\*IRC:5 primarily deals with the *General Features of Design and Loading* for Road Bridges, not general traffic standards for roads.\*\* It specifies the types of loads (dead load, live load, impact, wind, seismic, etc.) that must be considered for bridge design.

\* **Summary:** Lays down the fundamental principles and various loads to be accounted for when designing road bridges, culverts, and other cross-drainage structures.

\* **Relevance to Bhopal:** Crucial for any project involving the construction or major rehabilitation of bridges, flyovers, underpasses, or large culverts within or around Bhopal, ensuring structural integrity and safety.

• **For Traffic Standards (as you intended for IRC:5), please refer to the following codes:**

#### 7. IRC:67: Code of Practice for Road Signs

\* **Summary:** Specifies the design, dimensions, symbols, colours, and placement of various types of road signs (regulatory, cautionary, informational, and guide signs) to ensure uniformity and clarity for road users.

\* **Relevance to Bhopal:** Essential for all road projects to ensure proper traffic guidance, safety, and regulation across the city and on connecting highways.

#### 8. IRC:35: Code of Practice for Road Markings

\* **Summary:** Provides standards for the design, dimensions, colours, and application of pavement markings (e.g., centerlines, edge lines, lane markings, pedestrian crossings, stop lines, arrow markings) to guide and control traffic.

\* **Relevance to Bhopal:** Crucial for managing traffic flow, delineating lanes, indicating permissible movements, and enhancing pedestrian safety on all types of roads within Bhopal.

#### 9. IRC:SP:41: Guidelines on Traffic Management in Work Zones

\* **Summary:** Deals with the planning, design, and implementation of temporary traffic management schemes at road construction and maintenance sites. Its goal is to ensure the safety of both workers and road users during project execution.

\* **Relevance to Bhopal:** Highly critical for any road project in a busy city like Bhopal, minimizing disruptions, preventing accidents, and ensuring smooth passage of traffic during construction.

#### 10. IRC:SP:44: Guidelines for Road Safety Audit

\* **Summary:** Provides a framework for conducting systematic and independent road safety audits at different stages of a project (feasibility, preliminary design, detailed design, pre-opening, and existing roads) to identify and mitigate potential safety hazards.

\* **Relevance to Bhopal:** Essential for proactive safety management, ensuring that all new road designs and existing road improvements in Bhopal incorporate high safety standards from conception to completion.

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### IV. Other Important Codes

#### 11. IRC:SP:42: Guidelines on Road Drainage

\* **Summary:** Provides guidance on the design of effective road drainage systems, including surface drainage (culverts, side drains, camber) and subsurface drainage



(sub-surface drains, filter layers) to protect the road structure from water damage.

\* **Relevance to Bhopal:** Given Bhopal's varied topography and monsoon season, proper drainage design is vital to prevent waterlogging, pavement damage, and ensure road longevity.

## 12. MORTH Specifications for Road and Bridge Works (Latest Revision)

**Summary:** *While not an IRC code, these are the Standard Specifications for Road and Bridge Works\** published by the Ministry of Road Transport & Highways (MORTH). They detail the quality requirements, materials, construction methods, and measurement procedures for various items of work.

**Relevance to Bhopal:** *These specifications are the bedrock for how\** roads and bridges are built. They are indispensable for contractors, supervisors, and quality control personnel on any road project in Bhopal, ensuring adherence to quality standards.

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### Conclusion:

For any road/highway project in Bhopal, a comprehensive understanding and application of these IRC codes, along with MORTH specifications, are paramount. Project managers and engineers must ensure they are using the latest revisions of these documents. Additionally, specific local regulations from the Bhopal Municipal Corporation (BMC) or Madhya Pradesh Public Works Department (MPPWD) may also need to be consulted, though they generally align with IRC standards.

## Appendix B: Monsoon Calendar

This detailed monsoon calendar for Bhopal, Madhya Pradesh, provides a month-by-month breakdown of typical weather patterns, rainfall, and suitability for construction activities.

### Bhopal Monsoon Calendar: A Detailed Guide

Bhopal experiences a humid subtropical climate (Köppen Cwa), characterized by hot, dry summers, a distinct monsoon season, and mild, dry winters. The monsoon is a critical period for the region, bringing the vast majority of its annual rainfall.

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#### Annual Rainfall Overview for Bhopal:

\* **Average Annual Rainfall:** Approximately 1100-1200 mm (43-47 inches).

\* **Monsoon Contribution:** Over 90% of this rainfall occurs during the monsoon months (June-September).

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#### Month-by-Month Breakdown:

##### 1. January (Winter - Dry & Cool)

\* **Weather:** Typically the coolest month. Clear skies, pleasant sunny days, chilly nights. Occasional fog in the mornings. Very low humidity.

\* **Rainfall Patterns:** Extremely low to nil. Rains are rare, usually associated with western disturbances, if any.

Average Rainfall:\* < 5-10 mm

\* **Construction Suitability: Excellent.** Ideal conditions for all types of outdoor construction, civil work, and finishing. Low humidity aids in drying times for concrete and paint.

\* **Weather Considerations:** Requires warm clothing, especially in mornings and evenings. Days are comfortable for outdoor work.

## 2. February (Winter to Pre-Summer Transition - Dry & Warming)

\* **Weather:** Begins to warm up. Days are sunny and pleasant, nights are cooler. Humidity remains low.

\* **Rainfall Patterns:** Very low to nil. Similar to January, sporadic and minimal.

Average Rainfall:\* < 5-10 mm

\* **Construction Suitability: Excellent.** Continues to be ideal for all construction activities.

\* **Weather Considerations:** Pleasant conditions, comfortable for work.

## 3. March (Early Summer - Hot & Dry)

\* **Weather:** Temperatures rise significantly. Days are hot and sunny. Nights are warm. Humidity remains low.

\* **Rainfall Patterns:** Very low to nil. No significant rainfall expected.

Average Rainfall:\* < 5 mm

\* **Construction Suitability: Good.** While hot, the dry weather is still favorable. Concrete curing needs attention due to faster evaporation. Ample water for curing is essential.

\* **Weather Considerations:** Hydration is important. Work in direct sunlight can be tiring.

#### 4. April (Peak Summer - Very Hot & Dry, Pre-Monsoon Scorch)

\* **Weather:** Intense heat. Scorching days, warm nights. Humidity is still low but can sometimes see a slight increase with pre-monsoon atmospheric instability.

\* **Rainfall Patterns:** Minimal to low. Isolated, brief pre-monsoon thundershowers are possible towards the end of the month, often accompanied by strong winds or dust storms.

Average Rainfall:\* 5-15 mm

\* **Construction Suitability: Challenging.** Work can proceed, but heat stress on workers is a major concern. Concrete work requires careful planning for pouring and curing in high temperatures. Outdoor work during peak afternoon hours should be avoided.

\* **Weather Considerations:** Extreme heat requires frequent breaks, shade, and constant hydration. Risk of heatstroke.

#### 5. May (Late Summer - Extreme Heat, Pre-Monsoon Build-up)

\* **Weather:** Often the hottest month. Temperatures can soar, leading to heatwaves. High discomfort. Pre-monsoon activity (thunderstorms, squalls) becomes more frequent towards the end of the month, providing temporary relief but also posing risks.

\* **Rainfall Patterns:** Low to moderate. Pre-monsoon showers increase in frequency and intensity, often short-lived but heavy, accompanied by strong winds and lightning. These are localized.

Average Rainfall:\* 15-30 mm

\* **Construction Suitability: Poor to Avoid.** The combination of extreme heat and unpredictable, often violent, pre-monsoon storms makes major outdoor construction risky and inefficient. Material handling can be difficult.

\* **Weather Considerations:** Extreme heat and potential for sudden, severe weather events (dust storms, strong winds, rain). Safety protocols for lightning and wind are crucial.

## 6. June (Monsoon Onset - Humid & Wet)

\* **Weather:** The monsoon typically arrives in Bhopal by mid-June (around June 15th-20th), bringing a dramatic change. Temperatures drop, but humidity soars. Cloudy skies dominate.

\* **Rainfall Patterns: Significant increase.** Initial heavy showers mark the onset. Rain becomes consistent, though not constant. The first half of the month might still see pre-monsoon heat and isolated showers, while the second half is distinctly monsoonal.

Average Rainfall:\* 150-250 mm

\* **Construction Suitability: Unsuitable for most outdoor work.** Ground starts to get saturated. Concrete pouring is risky due to rain washing away cement. Earthwork becomes impossible. Finishing work (painting, plastering) is severely affected by high humidity. Covered work can proceed with caution.

\* **Weather Considerations:** High humidity causes discomfort. Constant rain requires protective gear. Risk of waterlogging and ground instability.

## 7. July (Peak Monsoon - Heaviest Rainfall)

\* **Weather:** Peak monsoon activity. Skies are mostly overcast. High humidity persists. Temperatures are moderate and pleasant after the initial heat, but the constant dampness can be irritating.

\* **Rainfall Patterns: Highest rainfall month.** Frequent, widespread, and often heavy to very heavy rainfall. Continuous spells of rain are common.

Average Rainfall:\* 350-450 mm

\* **Construction Suitability: Highly Unsuitable.** All major outdoor construction activities should cease. Waterlogging, erosion, material damage, and safety risks are extremely high. Focus shifts to maintenance, planning, or indoor activities that are impervious to moisture.

\* **Weather Considerations:** Risk of localized flooding, disruption to transport. Humidity promotes mold growth. Ground is completely saturated.

### 8. August (Active Monsoon - Heavy Rainfall Continues)

\* **Weather:** Monsoon remains active. Similar to July, with frequent rain, high humidity, and overcast skies. Intensity might slightly reduce towards the end of the month.

\* **Rainfall Patterns: Second highest rainfall month.** Continues to receive heavy to moderate rainfall. Spells can still be prolonged.

Average Rainfall:\* 300-400 mm

\* **Construction Suitability: Highly Unsuitable.** Similar to July, conditions are not conducive for construction.

\* **Weather Considerations:** Continued risk of waterlogging and ground instability. Mosquito breeding increases.

### 9. September (Monsoon Withdrawal - Decreasing Rain, High Humidity)

\* **Weather:** Monsoon withdrawal typically begins by mid-September. Rainfall decreases in frequency and intensity, but occasional heavy showers can still occur, especially in the first half. Humidity remains high. Skies start clearing towards the end of the month.

\* **Rainfall Patterns:** Decreasing but still substantial. Rain becomes more intermittent. Retreating monsoon showers can be heavy.

Average Rainfall:\* 150-250 mm

\* **Construction Suitability: Poor to Challenging.** While rain lessens, the ground is still saturated and drying out slowly. Limited, protected work might be attempted late in the month, but caution is advised for any earthwork or foundation activities due to soft ground.

\* **Weather Considerations:** High humidity persists. Potential for unexpected heavy downpours.

#### 10. October (Post-Monsoon - Pleasant & Drying)

\* **Weather:** "Sharad Ritu" - one of the most pleasant months. Clear skies return, temperatures are comfortable, and humidity gradually decreases. The air feels fresh and clean.

\* **Rainfall Patterns:** Very low to nil. Occasional, light retreating monsoon showers are possible early in the month, but generally dry.

Average Rainfall:\* 15-30 mm

\* **Construction Suitability: Excellent.** Ideal conditions for all types of construction. The ground starts to firm up. Low humidity aids in drying.

\* **Weather Considerations:** Perfect weather for outdoor activities and work.

#### 11. November (Autumn/Early Winter - Cool & Dry)

\* **Weather:** Cool and dry. Clear, sunny days and increasingly chilly nights. Humidity is low.

\* **Rainfall Patterns:** Extremely low to nil. Essentially dry.

Average Rainfall:\* < 5 mm

\* **Construction Suitability: Excellent.** Continues to be ideal for all construction activities.



\* **Weather Considerations:** Pleasant weather, comfortable for work.

## 12. December (Winter - Cool & Dry)

\* **Weather:** Cool, dry, and pleasant. Similar to November but slightly cooler. Clear skies, crisp air.

\* **Rainfall Patterns:** Extremely low to nil. Dry.

Average Rainfall:\* < 5 mm

\* **Construction Suitability: Excellent.** Ideal conditions persist.

\* **Weather Considerations:** Coolest month alongside January. Requires moderate warm clothing.

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## Summary for Construction Planning:

### • Best Months for Construction (Dry & Stable):

• **January, February, October, November, December:** Optimal for all types of construction, earthwork, foundations, concrete, finishing, and painting.

### • Good/Manageable Months (Requires Heat Management):

• **March:** Generally good, but manage heat and ensure proper concrete curing.

### • Challenging Months (Heat & Pre-Monsoon Showers):

• **April:** Very hot, occasional pre-monsoon storms. Difficult for outdoor work.

### • Poor/Avoid Months (Extreme Heat & Monsoon Onset):

• **May, June (first half):** Extreme heat, increasing pre-monsoon storm activity. Monsoon onset in late June.

- **Unsuitable Months (Peak Monsoon - Heavy Rain & Ground Saturation):**

- **June (second half), July, August:** Absolutely not recommended for major outdoor construction due to heavy, continuous rainfall, waterlogging, and ground instability.

- **Challenging Months (Monsoon Withdrawal - Wet Ground):**

- **September:** Rain decreases, but ground still saturated. Limited work with extreme caution.

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### **General Monsoon Precautions for Bhopal:**

1. **Drainage:** Ensure proper drainage around construction sites and properties to prevent waterlogging and foundation damage.
2. **Material Protection:** Store construction materials (cement, steel, wood) in waterproof and elevated conditions to prevent spoilage and rust.
3. **Site Security:** Secure loose objects and structures against strong winds that can accompany monsoon showers.
4. **Worker Safety:** Provide appropriate rain gear and ensure safe working conditions on slippery surfaces. Avoid work during lightning and heavy downpours.
5. **Pest Control:** Increased humidity and stagnant water lead to higher mosquito populations; implement preventive measures.
6. **Inspection:** Regularly inspect roofs, walls, and drainage systems for leaks and blockages before and during the monsoon.
7. **Roads & Access:** Be prepared for potential road disruptions and waterlogged access routes during heavy rain.

This detailed calendar should aid in planning activities, especially construction, around Bhopal's distinct weather patterns. Remember that climate change can bring variations, so always refer to local forecasts for the most current information.



## Appendix C: Equipment Catalog

This catalog provides a comprehensive list of equipment typically used in road construction projects in Bhopal, Madhya Pradesh, India, detailing their specifications, capacity, and usage. The selection will vary based on the project size, type (e.g., national highway, state road, urban road, rural road), and specific terrain.

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Comprehensive Equipment Catalog for Road Construction Projects in Bhopal, Madhya Pradesh, India

### Introduction:

Road construction projects in Bhopal, like anywhere else, require a diverse fleet of heavy machinery to handle various tasks from earthmoving and material production to paving and compaction. This catalog aims to provide a detailed overview of essential equipment, including key specifications, operational capacities, and primary usage. The emphasis is on modern, efficient machinery suitable for constructing durable and high-quality road infrastructure.

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### I. Earthmoving & Site Preparation Equipment

These machines are crucial for initial site clearing, excavation, and shaping the roadbed.

#### 1. Hydraulic Excavator (Crawler/Wheel Mounted)

\* **Usage:** Digging, trenching, loading dump trucks, demolition, breaking rocks (with attachment), precise grading, and clearing vegetation. Essential for cut-and-fill operations.

\* **Specifications:**

\* **Engine Power:** 100 HP (75 kW) to 350 HP (260 kW)

- \* **Operating Weight:** 15 tonnes to 45 tonnes
- \* **Bucket Capacity:** 0.8 m<sup>3</sup> to 2.5 m<sup>3</sup> (various types: GP, heavy-duty, rock)
- \* **Max Digging Depth:** 5m to 8m
- \* **Max Reach:** 8m to 12m
- \* **Capacity:** Can excavate and load 100-300 cubic meters per hour depending on material and bucket size.
- \* **Common Manufacturers:** JCB, Caterpillar, Komatsu, Volvo, L&T, Tata Hitachi.

## 2. Motor Grader

- \* **Usage:** Fine grading, leveling, spreading base materials (granular sub-base, base course), shaping shoulders, mixing soil stabilization agents, and scarifying. Critical for achieving precise levels.
- \* **Specifications:**
- \* **Engine Power:** 140 HP (105 kW) to 220 HP (165 kW)
- \* **Operating Weight:** 12 tonnes to 18 tonnes
- \* **Blade Length:** 3.7m (12 ft) to 4.3m (14 ft)
- \* **Blade Rotation:** 360 degrees
- \* **Capacity:** Can grade 0.5-2 km of road per hour, depending on the required precision and material.
- \* **Common Manufacturers:** Caterpillar, John Deere, Volvo, Mahindra, L&T.

## 3. Bulldozer (Crawler Dozer)

- \* **Usage:** Pushing large quantities of earth, clearing land, spreading soil, preliminary grading, ripping hard soil/rock (with ripper attachment), and assisting scrapers.
- \* **Specifications:**
- \* **Engine Power:** 150 HP (112 kW) to 350 HP (260 kW)
- \* **Operating Weight:** 15 tonnes to 40 tonnes

- \* **Blade Type:** Straight (S), Angle (A), Universal (U), Semi-U (SU)
- \* **Blade Capacity:** 3 m<sup>3</sup> to 10 m<sup>3</sup>
- \* **Capacity:** Can move 150-500 cubic meters of material per hour over short distances.
- \* **Common Manufacturers:** Caterpillar, Komatsu, Shantui, BEML.

#### 4. Wheel Loader / Front End Loader

- \* **Usage:** Loading aggregate materials (sand, gravel, crushed stone) into dump trucks, feeding asphalt plants or crushers, stockpiling, and general material handling.
- \* **Specifications:**
  - \* **Engine Power:** 100 HP (75 kW) to 250 HP (185 kW)
  - \* **Operating Weight:** 10 tonnes to 25 tonnes
  - \* **Bucket Capacity:** 1.5 m<sup>3</sup> to 5 m<sup>3</sup> (GP or rock bucket)
  - \* **Capacity:** Can load 150-400 cubic meters of material per hour.
  - \* **Common Manufacturers:** Caterpillar, Komatsu, Volvo, JCB, L&T.

#### 5. Backhoe Loader

- \* **Usage:** Versatile machine for smaller earthmoving tasks, trenching, digging, loading, and backfilling. Ideal for urban areas or projects with limited space.
- \* **Specifications:**
  - \* **Engine Power:** 75 HP (56 kW) to 100 HP (75 kW)
  - \* **Operating Weight:** 7 tonnes to 9 tonnes
  - \* **Loader Bucket Capacity:** 0.8 m<sup>3</sup> to 1.2 m<sup>3</sup>
  - \* **Backhoe Digging Depth:** 4m to 6m
  - \* **Capacity:** Digging/loading capacity around 50-80 cubic meters per hour.
  - \* **Common Manufacturers:** JCB, Caterpillar, Mahindra, Case.

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## II. Aggregate Production & Material Handling

Equipment for crushing, screening, and processing raw materials into usable aggregates.

### 1. Crushing Plant (Primary, Secondary, Tertiary)

\* **Usage:** Processing quarried rock into various sizes of aggregates (Gravel, WMM, DBM, BC aggregates) required for sub-base, base, and asphalt layers.

\* **Types:** Jaw Crusher (primary), Cone Crusher (secondary/tertiary), Vertical Shaft Impactor (VSI - for cubical aggregates).

\* **Specifications:**

\* **Capacity:** 100 TPH (tonnes per hour) to 400 TPH (total plant capacity).

\* **Feed Size:** Up to 1000 mm (jaw crusher).

\* **Product Size:** Configurable based on screen mesh (e.g., 6mm, 10mm, 20mm, 40mm).

\* **Power:** Electric motors for various components.

\* **Capacity:** Produces aggregates at the specified TPH rate.

\* **Common Manufacturers:** Metso, Sandvik, Puzzolana, Propel, Crushing Equipment.

### 2. Screening Plant / Vibrating Screens

\* **Usage:** Separating crushed aggregates into different size fractions as per project specifications. Can be standalone or integrated into a crushing plant.

\* **Specifications:**

\* **Capacity:** 50 TPH to 300 TPH.

\* **Number of Decks:** 2 to 4 decks for various output sizes.

\* **Screen Mesh:** Customizable.

\* **Capacity:** Processes aggregates at the specified TPH rate.



- \* **Common Manufacturers:** Same as crushing plants, plus local fabricators.

### 3. Wet Mix Macadam (WMM) Plant / Soil Stabilization Plant

- \* **Usage:** Uniformly mixing aggregates with water (and sometimes binding agents like cement/lime) to produce WMM or other stabilized base materials.
- \* **Specifications:**
- \* **Capacity:** 100 TPH to 250 TPH.
- \* **Mixer Type:** Pugmill mixer (twin shaft).
- \* **Components:** Aggregate feeders, conveyor belt, pugmill, water pump, control panel.
- \* **Capacity:** Produces WMM at the specified TPH rate.
- \* **Common Manufacturers:** Apollo, Linhoff, Atlas, Kaushik.

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## III. Bituminous Paving & Compaction Equipment (Flexible Pavements)

These are used for constructing asphalt roads, the most common type in India.

### 1. Asphalt Batch Mix Plant / Drum Mix Plant

- \* **Usage:** Producing hot mix asphalt (HMA) at specified temperatures and mix designs (Dense Bituminous Macadam (DBM), Bituminous Concrete (BC)). Batch plants offer higher quality control, drum mix plants offer continuous production.
- \* **Specifications:**
- \* **Type:**
- \* **Batch Mix:** Cold feed bins, dryer drum, hot elevator, vibrating screen, hot bins, weigh hoppers (aggregate, bitumen, filler), pugmill mixer, control cabin.
- \* **Drum Mix:** Cold feed bins, drum (drying & mixing), bitumen tank, control cabin.
- \* **Capacity:** 60 TPH to 200 TPH for drum mix, 80 TPH to 260 TPH for batch mix.

- \* **Burner Type:** Diesel, Furnace Oil, LPG/Natural Gas options.
- \* **Bitumen Tank Capacity:** 20 to 50 tonnes.
- \* **Capacity:** Produces hot mix asphalt at the specified TPH rate.
- \* **Common Manufacturers:** Apollo, Linhoff, Wirtgen (for higher end), Atlas, Kaushik.

## 2. Asphalt Paver Finisher

- \* **Usage:** Laying the hot mix asphalt material uniformly on the prepared base layer at a specified thickness, width, and crown/camber.
- \* **Types:** Wheel-mounted (more mobile) or Crawler-mounted (better traction and stability for thick layers).
- \* **Specifications:**
  - \* **Engine Power:** 100 HP (75 kW) to 200 HP (150 kW).
  - \* **Paving Width:** 2.5m (min) to 9m (max), extendable using hydraulic screed extensions.
  - \* **Paving Thickness:** 10mm to 300mm.
  - \* **Hopper Capacity:** 8 tonnes to 15 tonnes.
  - \* **Screed:** Fixed or hydraulically extendable, with tamper bar and vibrators for initial compaction.
  - \* **Sensor:** Automatic Grade and Slope Control (e.g., MOBA, Vögele Niveltronic) for precision.
  - \* **Capacity:** Can lay 100-300 TPH of asphalt mix, paving 300-1000 linear meters per day depending on width and thickness.
  - \* **Common Manufacturers:** Vögele, Dynapac, Roadtec, Wirtgen, Apollo, ABG, Schwing Stetter.

## 3. Vibratory Soil Compactor (Single Drum Roller)

- \* **Usage:** Compacting sub-grade, granular sub-base (GSB), and wet mix macadam (WMM) layers.

\* **Specifications:**

- \* **Operating Weight:** 9 tonnes to 15 tonnes (smooth drum).
- \* **Drum Width:** 1.7m to 2.2m.
- \* **Vibration Frequency:** 28 Hz to 35 Hz.
- \* **Amplitude:** Dual amplitude settings.
- \* **Centrifugal Force:** 200 kN to 300 kN.
- \* **Capacity:** Can compact layers up to 300mm thick over an area of 800-1500 m<sup>2</sup> per hour.
- \* **Common Manufacturers:** Dynapac, Hamm, Bomag, Ammann, JCB.

#### 4. Vibratory Tandem Roller (Double Drum Roller)

\* **Usage:** Compacting bituminous layers (DBM, BC, SMA) for smooth finish and density. Can also be used for granular layers.

\* **Specifications:**

- \* **Operating Weight:** 3 tonnes to 12 tonnes.
- \* **Drum Width:** 1.2m to 2m.
- \* **Vibration Frequency:** 40 Hz to 60 Hz.
- \* **Amplitude:** Dual amplitude.
- \* **Capacity:** Efficiently compacts asphalt layers, achieving density over 500-1000 m<sup>2</sup> per hour.
- \* **Common Manufacturers:** Dynapac, Hamm, Bomag, Ammann, Wirtgen.

#### 5. Pneumatic Tire Roller (PTR)

\* **Usage:** Final compaction and sealing of bituminous layers, kneading action for better interlock, and achieving high density without crushing aggregates. Also used for some soil compaction.

\* **Specifications:**

- \* **Operating Weight:** 15 tonnes to 25 tonnes (ballasted).
- \* **Number of Wheels:** 7 to 9 tires.
- \* **Tire Pressure:** Adjustable (important for different layers).
- \* **Capacity:** Provides finishing compaction and sealing for asphalt layers.
- \* **Common Manufacturers:** Hamm, Bomag, Dynapac, Ammann, Volvo.

#### 6. Bitumen Sprayer / Distributor

- \* **Usage:** Applying a uniform layer of hot bitumen emulsion (tack coat) or prime coat on the prepared surface before laying the next asphalt layer.
- \* **Specifications:**
  - \* **Tank Capacity:** 4000 liters to 10,000 liters.
  - \* **Spray Width:** 2.4m to 4.5m, adjustable.
  - \* **Heating System:** Diesel burner.
  - \* **Spray Bar:** Fully insulated, full circulation.
  - \* **Capacity:** Can spray 500-1000 m<sup>2</sup> per hour depending on spray width and site conditions.
  - \* **Common Manufacturers:** Apollo, Atlas, Kaushik, local fabricators.

#### 7. Cold Milling Machine / Road Planer

- \* **Usage:** Removing existing asphalt layers (scarifying) to a specified depth for rehabilitation, resurfacing, or recycling. Essential for road widening or repair projects.
- \* **Specifications:**
  - \* **Engine Power:** 200 HP (150 kW) to 700 HP (520 kW).
  - \* **Milling Width:** 0.5m (for small repairs) to 2.2m (for full lane width).
  - \* **Milling Depth:** 0mm to 300mm.
  - \* **Drum Type:** Standard or fine milling.

- \* **Capacity:** Can mill 500-2000 m<sup>2</sup> per hour depending on width and depth.

- \* **Common Manufacturers:** Wirtgen, Roadtec, Caterpillar.

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IV. Concrete Paving Equipment (Rigid Pavements - Less common for all roads, more for highways/specific stretches)

### 1. Concrete Batching Plant

- \* **Usage:** Producing ready-mix concrete for rigid pavements, culverts, drains, and structures.

- \* **Specifications:**

- \* **Type:** Stationary or Mobile.

- \* **Capacity:** 30 m<sup>3</sup>/hr to 120 m<sup>3</sup>/hr (cubic meters per hour).

- \* **Components:** Aggregate bins, cement silo, water tank, admixture tanks, weigh batchers, mixer (twin-shaft or planetary).

- \* **Capacity:** Produces concrete at the specified m<sup>3</sup>/hr rate.

- \* **Common Manufacturers:** Schwing Stetter, Putzmeister, Apollo, Speedcraft.

### 2. Slipform Concrete Paver

- \* **Usage:** Laying concrete pavements, barriers, and channels with high precision and speed.

- \* **Specifications:**

- \* **Engine Power:** 150 HP (112 kW) to 300 HP (225 kW).

- \* **Paving Width:** 3m to 12m.

- \* **Paving Thickness:** 150mm to 450mm.

- \* **Automation:** Automatic grade and steering control (e.g., GOMACO, Wirtgen).

- \* **Capacity:** Can pave 100-300 linear meters of concrete road per day.

- \* **Common Manufacturers:** GOMACO, Wirtgen, Power Curbers.

### 3. Concrete Transit Mixers

- \* **Usage:** Transporting ready-mix concrete from the batching plant to the paving site while maintaining its consistency.

- \* **Specifications:**

- \* **Drum Capacity:** 6 m<sup>3</sup> to 12 m<sup>3</sup>.

- \* **Mounted on:** Heavy-duty truck chassis.

- \* **Capacity:** Delivers fresh concrete to the site.

- \* **Common Manufacturers:** Schwing Stetter, Putzmeister, ACE, BharathBenz.

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## V. Material Transport

### 1. Dump Trucks / Tippers

- \* **Usage:** Transporting aggregates, excavated earth, asphalt mix, and other bulk materials.

- \* **Specifications:**

- \* **Payload Capacity:** 10 tonnes (6 m<sup>3</sup>) to 30 tonnes (20 m<sup>3</sup>).

- \* **Engine Power:** 200 HP to 400 HP.

- \* **Axle Configuration:** 6x4, 8x4.

- \* **Capacity:** Crucial for continuous material supply, variable based on distance and load.

- \* **Common Manufacturers:** Tata Motors, Ashok Leyland, Eicher, BharathBenz, Volvo.

### 2. Low Bed Trailer

\* **Usage:** Transporting heavy machinery (excavators, dozers, rollers, pavers) between sites or to and from the project location.

\* **Specifications:**

\* **Payload Capacity:** 40 tonnes to 100 tonnes.

\* **Axle Lines:** 2 to 5.

\* **Capacity:** Transports heavy equipment.

\* **Common Manufacturers:** Schmitz Cargobull, Mahindra, local fabricators.

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## VI. Ancillary & Support Equipment

### 1. Water Tanker / Water Bowser

\* **Usage:** Dust suppression on haul roads, compaction of granular layers (GSB, WMM), curing concrete, and general site water supply.

\* **Specifications:**

\* **Tank Capacity:** 8,000 liters to 20,000 liters.

\* **Pump:** High-pressure pump for spraying.

\* **Capacity:** Provides essential water supply and dust control.

\* **Common Manufacturers:** Tata Motors, Ashok Leyland (chassis), local fabricators.

### 2. Diesel Bowser / Fuel Tanker

\* **Usage:** On-site refueling of all machinery to minimize downtime and avoid trips to fuel stations.

\* **Specifications:**

\* **Tank Capacity:** 5,000 liters to 15,000 liters.

\* **Pump:** Dispensing unit with meter.



- \* **Capacity:** Ensures continuous operation of machinery.
- \* **Common Manufacturers:** Local fabricators on commercial chassis.

### 3. Service Van / Mobile Workshop

- \* **Usage:** On-site maintenance, repair, and lubrication of equipment, carrying tools and spare parts.
- \* **Specifications:**
- \* **Vehicle:** Light/medium commercial vehicle.
- \* **Equipment:** Compressor, welding machine, tools, oil dispensing units.
- \* **Capacity:** Reduces downtime by providing quick repairs.
- \* **Common Manufacturers:** Local modifications on commercial vans.

### 4. Generator Sets (Gensets)

- \* **Usage:** Providing electrical power for site offices, workshops, lighting towers, and small electrical tools where grid power is unavailable.
- \* **Specifications:**
- \* **Power Output:** 15 kVA to 250 kVA.
- \* **Fuel:** Diesel.
- \* **Capacity:** Provides reliable power supply.
- \* **Common Manufacturers:** Kirloskar, Cummins, Mahindra Powerol.

### 5. Lighting Towers

- \* **Usage:** Illuminating the construction site for night work, ensuring safety and productivity during low-light conditions.
- \* **Specifications:**
- \* **Light Type:** LED or Metal Halide.

- \* **Mast Height:** 5m to 9m.
- \* **Power:** Integrated generator.
- \* **Capacity:** Enables 24/7 operations.
- \* **Common Manufacturers:** Wacker Neuson, Atlas Copco, local fabricators.

## 6. Road Sweeper

- \* **Usage:** Cleaning the finished road surface or existing roads before applying new layers or for maintenance.
- \* **Specifications:**
  - \* **Sweeping Width:** 2m to 3.5m.
  - \* **Water Tank:** For dust suppression.
  - \* **Hopper Capacity:** 1 m<sup>3</sup> to 5 m<sup>3</sup>.
  - \* **Capacity:** Keeps roads clean and ready for subsequent layers.
- \* **Common Manufacturers:** Schwing Stetter, Dulevo.

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## VII. Surveying & Quality Control Equipment

These are crucial for ensuring the road is built to exact specifications and quality standards.

### 1. Total Station / Robotic Total Station

- \* **Usage:** Highly accurate surveying for setting out alignment, levels, cross-sections, and quantity measurement.
- \* **Specifications:**
  - \* **Accuracy:** 1 to 5 arc seconds.
  - \* **Range:** Up to 5000m (with prism).

- \* **Features:** Data logging, auto-tracking (robotic).
- \* **Capacity:** Precision measurement and setting out for all road elements.
- \* **Common Manufacturers:** Leica, Trimble, Topcon.

## 2. GPS (Global Positioning System) / GNSS Receiver

- \* **Usage:** For precise positioning, large-scale mapping, and machine control integration (e.g., with graders, pavers).
- \* **Specifications:**
  - \* **Accuracy:** Centimeter level (RTK/PPK).
  - \* **Channels:** Multi-constellation (GPS, GLONASS, Galileo, BeiDou).
  - \* **Capacity:** High-accuracy location data.
- \* **Common Manufacturers:** Trimble, Leica, Topcon.

## 3. Automatic Level & Staff

- \* **Usage:** Basic leveling, checking grades, and setting out for less critical elements or cross-checking.
- \* **Specifications:**
  - \* **Magnification:** 20x to 32x.
  - \* **Accuracy:** +/- 1.5mm per km double run.
  - \* **Capacity:** Essential for everyday leveling tasks.
- \* **Common Manufacturers:** Leica, Trimble, Topcon, Bosch.

## 4. Density Gauges (Nuclear/Non-Nuclear)

- \* **Usage:** Measuring the compaction density of soil, granular, and asphalt layers on-site.
- \* **Specifications:**
  - \* **Nuclear:** Uses radioactive source (Cs-137, Am-241/Be).

- \* **Non-Nuclear:** Electrical impedance-based (e.g., Pavement Quality Indicator - PQI).
- \* **Capacity:** Rapid on-site density testing for quality control.
- \* **Common Manufacturers:** Troxler, InstroTek, TransTech.

#### 5. Laboratory Equipment (for on-site or central lab)

- \* **Usage:** Testing material properties (aggregate gradation, plasticity, CBR, bitumen penetration, softening point, ductility, Marshall stability for asphalt, concrete compressive strength, etc.).
- \* **Key Equipment:** Sieves, ovens, balances, CBR testing machine, Marshal Stability apparatus, Core cutting machine, Compression Testing Machine (CTM).
- \* **Capacity:** Ensures all materials and final products meet specified quality standards.

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#### Conclusion:

This comprehensive catalog outlines the primary equipment required for modern road construction projects in Bhopal, Madhya Pradesh. The actual fleet for any specific project will be tailored based on the project's scale, design, budget, timeline, and local conditions. Investing in well-maintained, technologically advanced machinery, coupled with skilled operators and robust quality control, is paramount for delivering high-quality and durable road infrastructure. Safety equipment, personal protective equipment (PPE), and proper waste management tools are also integral to any successful project.

## Appendix D: Testing Protocols

Material testing protocols for road projects in Bhopal, Madhya Pradesh, India, strictly adhere to the **Ministry of Road Transport & Highways (MoRTH) Specifications for Road and Bridge Works (latest revision, e.g., 5th Revision)**. These specifications are the national standard and are rigorously followed to ensure the quality, durability, and safety of road infrastructure.

The protocols involve a combination of field and laboratory tests at various stages of the project, from initial material sourcing to final layer placement.

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### Overarching Principles of MoRTH Testing Protocols:

- 1. Reference Standards:** All tests must be conducted as per relevant Bureau of Indian Standards (BIS) codes (e.g., IS 2720 series for soil, IS 2386 series for aggregates) or other specific ASTM/AASHTO standards adopted by MoRTH.
- 2. Accredited Laboratories:** Projects typically require dedicated field laboratories and often depend on NABL-accredited (National Accreditation Board for Testing and Calibration Laboratories) central laboratories for specialized or dispute resolution testing.
- 3. Qualified Personnel:** Testing must be carried out by trained and qualified laboratory engineers and technicians.
- 4. Sampling Frequency:** MoRTH specifies minimum testing frequencies for each material and layer, which must be strictly adhered to. The Engineer-in-Charge has the authority to demand more frequent testing if quality concerns arise.
- 5. Acceptance Criteria:** Each test has specified acceptance limits provided in relevant MoRTH clauses, which materials must meet.
- 6. Documentation:** Comprehensive records of all tests, including dates, locations, results, equipment used, and passing/failing remarks, must be maintained.

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## **I. Soil Testing Protocols (for Embankment, Sub-grade, and Borrow Areas):**

Soil is a fundamental component for embankment and sub-grade layers. Testing ensures its suitability and proper compaction.

### **A. Initial Investigation & Source Approval (Borrow Areas & Alignment):**

1. **Visual Classification:** Initial assessment of soil type (clay, silt, sand, gravel).

2. **Sieve Analysis (Gradation):** (IS 2720 Part 4)

\* **Purpose:** Determine particle size distribution.

\* **Frequency:** 1 test per 2500 cubic meters or change in soil type.

\* **Acceptance:** To classify soil as per IRC:36 (Recommended Practice for Construction of Earth Embankments and Sub-grades for Road Works) and MoRTH Table 300-1 for sub-grade and shoulder.

3. **Atterberg Limits (Liquid Limit, Plastic Limit, Plasticity Index):** (IS 2720 Part 5)

\* **Purpose:** Determine consistency limits and plasticity characteristics, important for cohesive soils.

\* **Frequency:** 1 test per 2500 cubic meters or change in soil type.

\* **Acceptance:** Plasticity Index (PI) typically should not exceed 6-9 for granular sub-base materials (as fines), and for subgrade, specific limits are given based on soil classification (e.g.,  $PI < 25$  for general subgrade).

4. **Standard Proctor Compaction Test (Optimum Moisture Content - OMC & Maximum Dry Density - MDD):** (IS 2720 Part 7)

\* **Purpose:** Determine the moisture content at which maximum compaction can be achieved in the lab, serving as a reference for field compaction.

\* **Frequency:** 1 test per 2500 cubic meters or change in soil type or source.

\* **Acceptance:** Provides reference values for field compaction.

#### 5. California Bearing Ratio (CBR) Test (Unsoaked & Soaked): (IS 2720 Part 16)

\* **Purpose:** Determine the strength and load-bearing capacity of the soil, crucial for pavement design.

\* **Frequency:** 1 test per 5000 cubic meters or change in soil type.

\* **Acceptance:** Minimum CBR values are specified for different layers (e.g., 8% for sub-grade under flexible pavement, 10% for the top 500mm of subgrade).

#### B. During Construction (Compacted Layers):

##### 1. Field Density Test (Sand Replacement Method or Core Cutter Method): (IS 2720 Part 28)

\* **Purpose:** Verify the achieved degree of compaction in the field.

\* **Frequency:** As per MoRTH Table 300-1 (e.g., 1 test per 1000 square meters or 500 cubic meters, whichever is more stringent, and at least 1 per day per layer).

\* **Acceptance:** Degree of compaction must be 97-100% of MDD for sub-grade and embankment (as per MoRTH Section 300).

##### 2. Field Moisture Content: (Rapid Moisture Meter or Oven Dry Method)

\* **Purpose:** Ensure compaction is carried out at or near OMC.

\* **Frequency:** Along with field density tests.

\* **Acceptance:** Within  $\pm 2\%$  of OMC.

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#### II. Aggregate Testing Protocols (for Granular Sub-Base (GSB), Wet Mix Macadam (WMM), Dense Bituminous Macadam (DBM), Bituminous Concrete (BC), etc.):

Aggregates form the bulk of pavement layers. Their quality significantly impacts pavement strength, stability, and durability.

##### A. Source Approval & Initial Testing:



1. **Visual Inspection:** Assess rock type, presence of deleterious materials, and general quality.

2. **Specific Gravity & Water Absorption:** (IS 2386 Part 3)

\* **Purpose:** Specific gravity for volumetric calculations, water absorption for durability and binder demand.

\* **Frequency:** 1 test per 200 cubic meters or change in source.

\* **Acceptance:** Water absorption typically < 2% (varies by layer).

3. **Los Angeles (LA) Abrasion Value:** (IS 2386 Part 4)

\* **Purpose:** Measure resistance to wear and abrasion, critical for durability.

\* **Frequency:** 1 test per 500 cubic meters or change in source.

\* **Acceptance:** Varies by layer (e.g., GSB < 50%, WMM < 40%, DBM/BC < 30-35%).

4. **Aggregate Crushing Value (ACV):** (IS 2386 Part 4)

\* **Purpose:** Measure resistance to crushing under compressive load.

\* **Frequency:** 1 test per 500 cubic meters or change in source.

\* **Acceptance:** Varies by layer (e.g., GSB < 40%, WMM < 30%, DBM/BC < 25-30%).

5. **Flakiness Index & Elongation Index:** (IS 2386 Part 1)

\* **Purpose:** Measure particle shape, which affects interlocking and workability.

\* **Frequency:** 1 test per 200 cubic meters or change in source.

\* **Acceptance:** Combined Flakiness + Elongation usually < 30-35% for wearing courses.

6. **Soundness Test (Sodium/Magnesium Sulphate):** (IS 2386 Part 5)

\* **Purpose:** Assess resistance to weathering and disintegration from freeze-thaw cycles or chemical attacks.

\* **Frequency:** 1 test per 500 cubic meters or change in source.

\* **Acceptance:** Loss by weight typically < 12% (sodium) or < 18% (magnesium).

#### 7. Polished Stone Value (PSV): (IS 2386 Part 6 / BS 812)

- \* **Purpose:** Measure resistance to polishing, crucial for skid resistance in wearing courses, especially for high-volume roads.
- \* **Frequency:** As required, especially for surface course aggregates.
- \* **Acceptance:** Minimum 55-60 for high-traffic roads.

#### 8. Stripping Value (for Bituminous Mixes): (IS 6241)

- \* **Purpose:** Assess adhesion between aggregate and bitumen in the presence of water.
- \* **Frequency:** Initial mix design and as required.
- \* **Acceptance:** Minimum 95% coating retained.

### B. During Production & Placement:

#### 1. Gradation/Sieve Analysis: (IS 2386 Part 1)

- \* **Purpose:** Ensure correct particle size distribution for each layer's mix design.
- \* **Frequency:** MoRTH Table 400-1 (e.g., GSB: 1 per 200 cum; WMM: 1 per 100 cum; DBM/BC: 1 per 50 cum of mix).
- \* **Acceptance:** Must fall within specified grading limits for each layer.

#### 2. Field Density & Compaction Tests (for GSB, WMM):

- \* **Purpose:** Verify achieved compaction in the field.
- \* **Frequency:** MoRTH Table 400-1 (e.g., 1 test per 500 square meters or 100 cubic meters, whichever is more stringent, and at least 1 per day per layer).
- \* **Acceptance:** Minimum 98-100% of MDD for GSB/WMM.

#### 3. Binder Content & Mix Properties (for DBM, BC):

- \* **Purpose:** Confirm correct bitumen content and volumetric properties of the mix.
- \* **Frequency:** MoRTH Table 500-1 (e.g., 1 test per 100 tonnes of mix).

\* **Tests:** Binder content (extraction), gradation, Marshall Stability & Flow (for design and control), core density.

\* **Acceptance:** Binder content within  $\pm 0.3\%$  of design; Marshall Stability, Flow, Voids in Mineral Aggregate (VMA), Voids Filled with Bitumen (VFB), Air Voids within specified limits.

#### 4. Coring & Density (for Bituminous Layers):

\* **Purpose:** Measure in-place density of compacted bituminous layers.

\* **Frequency:** MoRTH Table 500-1 (e.g., minimum 3 cores per 7000 sq.m or 1 core per 200m length of lane).

\* **Acceptance:** Minimum 92-97% of theoretical maximum specific gravity (or 95% of laboratory Marshall Density).

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### III. Quality Control (QC) and Quality Assurance (QA) Measures:

These are integral to the successful implementation of MoRTH specifications.

1. **Quality Control Plan:** The contractor is required to submit a detailed QC Plan, outlining their testing procedures, frequencies, personnel, and reporting mechanisms, which must be approved by the Engineer.

2. **Dedicated Field Laboratory:** A well-equipped and regularly calibrated field laboratory must be established at the project site by the contractor.

3. **Qualified Personnel:** All testing is carried out by qualified and experienced laboratory engineers and technicians.

4. **Sampling:** Samples are collected randomly and representatively from the materials being used or the layers being constructed. Proper labeling, sealing, and transport of samples are essential.

5. **Calibration:** All testing equipment (weighing balances, sieves, compaction moulds, CBR machines, ovens, Marshall apparatus, density gauges, etc.) must be regularly

calibrated by NABL-accredited agencies.

#### **6. Documentation & Reporting:**

- \* Daily, weekly, and monthly reports of all test results are submitted to the Engineer.
- \* Test results are recorded in a standardized format, including location, chainage, layer, date, time, personnel, and pass/fail remarks.
- \* Material Approval Registers and Test Result Registers are meticulously maintained.

#### **7. Non-Conformance & Corrective Actions:**

- \* A clear procedure exists for dealing with failed tests. This may include re-testing, investigation into the cause of failure, removal and replacement of substandard material/work, or imposition of penalties.
- \* No material or work is accepted without successful testing.

**8. Trial Mixes and Pavement Stretches:** For critical layers like WMM, DBM, and BC, trial mixes and trial stretches are laid and tested to finalize job mix formulas and compaction parameters before full-scale production.

**9. Independent Quality Assurance (IQA)/Third-Party Audits:** Often, an independent quality assurance agency is appointed by the client (e.g., NHAI, State PWD) to conduct surveillance, witness testing, and carry out check tests to ensure the contractor's QC is effective.

**10. Engineer's Supervision:** The Resident Engineer and his team rigorously supervise all testing activities, review results, and approve/reject materials and work based on MoRTH specifications.

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By adhering to these stringent MoRTH testing protocols and quality control measures, road projects in Bhopal aim to achieve high standards of construction, ensuring long-lasting, safe, and robust road infrastructure.

## Appendix E: Compliance Matrix

A compliance matrix is a critical tool for any infrastructure project, especially in India, where multiple national and state-level standards apply. For projects in Bhopal, Madhya Pradesh, adherence to IRC, MoRTH, BIS, and NHAI standards is paramount, alongside any specific directives from the Madhya Pradesh Public Works Department (MP PWD), Bhopal Municipal Corporation (BMC), or other local urban bodies.

This matrix outlines key project aspects and their corresponding compliance requirements from the specified standards.

### Compliance Matrix for Infrastructure Projects in Bhopal, Madhya Pradesh

**Project Location:** Bhopal, Madhya Pradesh, India

**Applicable Standards:** IRC, MoRTH, BIS, NHAI

S.No.	Project Aspect/Component	Relevant Standard(s) (Primary)	Specific Reference (Example Documents /Codes)	Compliance Requirement/Action	Evidence of Compliance	Remarks/Bhopal Specific Considerations
1.	Planning & Design	IRC, MoRTH, NHAI	IRC:37 (Flexible Pavements), IRC:58 (Rigid Pavements), IRC:6 (Bridge Code), IRC:112 (Concrete Bridges), IRC:SP-73 (Urban Roads), MoRTH Standard Spe...	Adherence to geometry, structural design, pavement design, drainage design, traffic forecasting, and safety audit recommendations.	Detailed Design Reports, Drawings, Design Basis Report, Road Safety Audit Reports, Hydrological Reports, Geotechnical Investigation Reports, Approv...	NHAI projects often require third-party design vetting. Urban projects (BMC, MP PWD) may follow IRC:SP-73.

S.No.	Project Aspect/Component	Relevant Standard(s) (Primary)	Specific Reference (Example Documents /Codes)	Compliance Requirement/Action	Evidence of Compliance	Remarks/Bhopal Specific Considerations
2.	Material Procurement & Testing	BIS, MoRTH, IRC	BIS (IS) codes for Cement (IS 269, 455, 1489, 12269), Steel (IS 1786, 2062), Aggregates (IS 383, 2386), Bitumen (IS 73, IS 1201-1208), Water (IS 45...	Sourcing materials from approved vendors, conducting prescribed laboratory and field tests to confirm quality, quantity, and properties meet specifications...	Material Test Certificates from NABL accredited labs, Supplier Test Reports, Inspection Reports, QA/QC Plan.	Local availability of specified materials may vary; proper mix designs are crucial for Bhopal's climate.
3.	Earthwork & Subgrade	MoRTH, IRC	MoRTH Section 300 (Earthwork, Embankment, Subgrade), IRC:36 (Recommended Practice for Construction of Earth Embankments and Sub-grades for Roads).	Proper survey & setting out, stripping topsoil, achieving specified compaction (Proctor Density) & CBR values for embankment & subgrade, ensuring proper drainage...	Field Density Test Reports, CBR Test Reports, Level Surveys, Joint Measurement Records, Inspection Reports.	Black cotton soil is prevalent in parts of MP; special treatment (lime/cement stabilization) might be required as per MoRTH/IRC.

S.No.	Project Aspect/Component	Relevant Standard(s) (Primary)	Specific Reference (Example Documents /Codes)	Compliance Requirement/Action	Evidence of Compliance	Remarks/Bhopal Specific Considerations
4.	Sub-base & Base Courses (GSB, WMM, DBM, BC)	MoRTH, IRC	MoRTH Sections 400 (Granular Sub-base), 500 (Wet Mix Macadam), 600 (Bituminous Bound Macadam, Dense Bituminous Macadam, Bituminous Concrete), IRC:S...	Adherence to mix design, gradation, thickness, binder content, compaction, and layer temperatures during laying.	Mix Design Reports, Laboratory Test Reports (gradation, PI, ACV, binder content), Field Density Test Reports, Core Cutting Reports (thickness, dens...	Ensuring proper aggregate quality (crushing value, soundness) is vital.
5.	Pavement (Flexible/Rigid)	IRC, MoRTH	IRC:37 (Flexible), IRC:58 (Rigid), MoRTH Section 500 (Bituminous Courses), Section 800 (Cement Concrete Pavement).	Proper mix design, laying, compaction, curing (for concrete), achieving specified surface regularity (IRI), and skid resistance.	Marshall Stability (for asphalt), Slump/Compressive Strength (for concrete), Core Cutting Reports, IRI (International Roughness Index) Reports, Ben...	Bhopal experiences significant temperature variations, influencing asphalt performance and concrete expansion/contraction.



S.No.	Project Aspect/Component	Relevant Standard(s) (Primary)	Specific Reference (Example Documents /Codes)	Compliance Requirement/Action	Evidence of Compliance	Remarks/Bhopal Specific Considerations
6.	Road Structures (Bridges, Culverts, Retaining Walls)	IRC, BIS, MoRTH	IRC:5 (General Features of Bridge Design), IRC:6 (Loading Standards), IRC:112 (Concrete Bridges), IRC:78 (Foundation and Substructure), IS 456 (Plac...	Adherence to structural design, material quality, reinforcement detailing, casting/erection procedures, and quality of protective coatings.	Structural Design Reports, Material Test Reports (cement, steel, aggregates), Concrete Mix Design, Cube Strength Results, Welding Test Reports, NDT...	Proper scour protection for structures crossing rivers/drains.
7.	Drainage System	IRC, MoRTH	IRC:SP-42 (Road Drainage), MoRTH Section 1400 (Drainage, Cross Drainage and Protective Works).	Design and construction of efficient surface and subsurface drainage systems, culverts, and bridges to prevent water accumulation and erosion.	Hydrological Design Reports, Drainage Layout Plans, Design of Culverts/Bridges, As-Built Drawings, Inspection Reports.	Monsoon intensity in Bhopal requires robust drainage design to prevent flooding, especially in low-lying urban areas.

S.No.	Project Aspect/Component	Relevant Standard(s) (Primary)	Specific Reference (Example Documents /Codes)	Compliance Requirement/Action	Evidence of Compliance	Remarks/Bhopal Specific Considerations
8.	Road Safety & Traffic Management	IRC, MoRTH, NHAI	IRC:SP-55 (Guidelines for Traffic Management), IRC:SP-44 (Road Signs), MoRTH Standard Plans for Traffic Safety Devices, NHAI Road Safety Audit Guid...	Provision of adequate road signs, markings, crash barriers, delineators, street lighting, pedestrian facilities, and implementation of traffic management.	Road Safety Audit Reports, Traffic Management Plans, Signage & Marking Plans, Material Test Reports for reflective sheeting, Inspection Reports.	Coordination with Bhopal Traffic Police for implementation of traffic management plans.
9.	Environmental & Social Safeguards	MoRTH, NHAI, Local Environmental Laws	MoRTH/NHAI Environmental Guidelines, EIA/EMP Reports (if applicable), Forest Clearance Act, Water (Prevention & Control of Pollution) Act, Air (Pre...	Obtaining necessary environmental clearances, implementing mitigation measures (dust control, noise control, waste management, tree plantation), an...	Environmental Impact Assessment (EIA) Reports, Environmental Management Plans (EMP), Forest Clearance Certificates, NOCs from MP Pollution Control ...	Compliance with MP Pollution Control Board (MPPCB) norms is mandatory for all projects.

S.No.	Project Aspect/Component	Relevant Standard(s) (Primary)	Specific Reference (Example Documents /Codes)	Compliance Requirement/Action	Evidence of Compliance	Remarks/Bhopal Specific Considerations
10.	Quality Control & Assurance (QC/QA)	MoRTH, IRC, NHAI	MoRTH Section 900 (Quality Control for Road Works), IRC:SP-47 (Quality Control on Road Construction), NHAI Quality Assurance Manual.	Establishment of a comprehensive QC/QA system, independent quality checks, third-party quality audits, and adherence to specified inspection & test...	Project Specific QA/QC Manual, Site Quality Plans, Internal and External Audit Reports, Records of Non-Conformities & Corrective Actions, Lab Accreditation...	Ensure qualified QA/QC personnel are deployed, and regular reporting to the Project Authority (NHAI/MP PWD/BMC).
11.	Maintenance	IRC, MoRTH, NHAI	IRC:SP-76 (Maintenance Management System), MoRTH Long Term Maintenance Manual, NHAI O&M; Guidelines.	Implementation of routine, periodic, and special maintenance activities, timely repairs, and ensuring serviceability throughout the design life.	Maintenance Manuals, Inspection & Condition Reports, Repair Records, Feedback from Road Users (if applicable).	Specific maintenance contracts may be in place for NHAI/MP PWD projects.

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## Key Considerations for Projects in Bhopal, Madhya Pradesh:

### 1. Local Bodies:

- \* **Madhya Pradesh Public Works Department (MP PWD):** For State Highways and major district roads.
- \* **Bhopal Municipal Corporation (BMC):** For urban roads and infrastructure within city limits.
- \* **Madhya Pradesh Urban Development & Housing Department:** For urban infrastructure schemes.
- \* **Madhya Pradesh Pollution Control Board (MPPCB):** For environmental clearances and compliance.
- \* **Local Geology:** Parts of Bhopal are prone to black cotton soil, requiring specific subgrade treatment (e.g., lime stabilization) as per IRC/MoRTH guidelines.
- \* **Monsoon Impact:** Heavy monsoon rains necessitate robust drainage design and considerations for erosion control.
- \* **Traffic Congestion:** Urban projects in Bhopal require detailed traffic management plans to minimize disruption.

2. **Latest Revisions:** Always ensure the latest revisions/amendments of all IRC, MoRTH, BIS, and NHAI codes/manuals are being followed.

3. **Project Specifics:** This matrix is a general guide. Specific project requirements, client demands, funding agency guidelines (e.g., World Bank, ADB), and contractual agreements will also dictate compliance.

4. **Documentation:** Meticulous documentation of all tests, inspections, approvals, and actions taken is crucial for demonstrating compliance and for audit purposes.

This comprehensive compliance matrix serves as a foundational document for project teams, ensuring systematic adherence to the prescribed standards for infrastructure projects in Bhopal.