INCEPTION REPORT

Road/Highway/Bridge Project

Location: Sagar, Sagar district, Madhya Pradesh, India

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1.0 Executive Summary

Executive Summary: RFP Inception Report - Development of Economic and Inter-Corridors (Lot-1/Madhya Pradesh/Package-3)

This Executive Summary provides a high-level overview of the Inception Report 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 (Lot-1/Madhya Pradesh/Package-3)." Commissioned by the National Highways Authority of India (NHAI) and undertaken by M/s LEA Associates South Asia Pvt Ltd, this project is a strategic initiative under the Bharatmala Pariyojana, designed to significantly enhance logistics efficiency and regional connectivity within Madhya Pradesh.

The Inception Report, submitted in accordance with the Contract Agreement dated April 2017, details the consultant's comprehensive understanding of the project scope, outlines the detailed work plan for subsequent phases, and presents preliminary findings derived from desk studies and initial reconnaissance surveys.

1. Project Overview and Scope

The overarching objective of this consultancy is to prepare a Detailed Project Report (DPR) for the development and upgrading of critical road sections identified under Lot-1/Madhya Pradesh/Package-3. The project specifically focuses on improving the efficiency of freight movement, thereby fostering economic growth and facilitating better access to agricultural and industrial hubs.

The scope of the Inception Report encompasses:

* A thorough review of the Terms of Reference (ToR) and identification of any potential gaps or specific requirements.

* Verification of project stretches, including start and end coordinates, and initial assessment of alignment features.

* Establishment of the project organization, mobilization of key personnel, and setup of necessary resources.

* Preliminary assessment of existing site conditions, including pavement, structures, land use, and Right of Way (RoW).

* Initial environmental and social screening to identify potential sensitivities.

* Development of a comprehensive methodology and work plan for the Feasibility Study and subsequent DPR stages, adhering to national and international standards.

2. Key Corridors and Locations

The project encompasses two strategically important road sections within the state of Madhya Pradesh, aimed at bolstering economic and inter-corridor connectivity:

Project Lot / Package	Corridor Type	Section Name	National/State Highway	Start Point (Coordinates)	End Point (Coordinates)
Lot-1/Madhya Pradesh/Package-3	Economic Corridor	Sagar-Katni section	NH-934	Sagar (23.838805, 78.737807)	Katni (23.870014, 80.361474)
Lot-1/Madhya Pradesh/Package-3	Inter Corridor	Vidisha-Malthone section	SH-19, SH-14, SH-42A, SH-42	Vidisha (23.517449, 77.797208)	Malthone (24.3030959, 78.5255114)

These corridors are vital for enhancing logistics and trade, particularly serving the agricultural trade and industrial activities prevalent in regions like Sagar district, which connects major routes and serves as a significant economic center.

3. Approach and Methodology

The methodology adopted for the DPR preparation is meticulously structured to ensure technical robustness, economic viability, and environmental-social sustainability, in strict compliance with the guidelines and specifications of NHAI, Ministry of Road Transport and Highways (MoRTH), Indian Road Congress (IRC) codes, and Bureau of Indian Standards (BIS). The multi-stage approach includes:

• **Inception (Current Phase):** Detailed ToR review, project team mobilization, site verification, preliminary surveys, and work plan finalization.

• **Feasibility Study:** Comprehensive engineering surveys (topographic, traffic, hydrological, geotechnical, pavement condition), environmental and social impact assessments (EIA/SIA), identification of alternative alignments/bypasses, preliminary engineering designs, and initial economic & financial analysis.

• **Detailed Project Report (DPR):** Detailed engineering designs, land acquisition plans, utility shifting plans, cost estimates based on detailed rate analysis (MoRTH

Specifications), bid document preparation, and comprehensive environmental and social management plans.

Data collection will leverage advanced technologies, including GPS and Total Station for high-precision topographic surveys, automated traffic counters for volume and classification, Origin-Destination (OD) surveys, and Axle Load Surveys as per IRC:SP:19 and IRC:102-1988. Geotechnical investigations will involve boreholes, Dynamic Cone Penetration (DCP) tests, and laboratory analyses for pavement and structural foundation design. Pavement condition will be assessed using Benkelman Beam Deflection (BBD) tests and roughness surveys, analyzed through HDM-4 software. All designs will utilize industry-standard software such as Civil 3D/Softdesk for highway design and STAAD.Pro/RM for structural analysis.

4. Preliminary Findings and Recommendations

Initial reconnaissance and desk studies have yielded several key preliminary findings:

• **Existing Road Conditions:** Varying pavement conditions across both corridors suggest a blend of rehabilitation, strengthening, and widening interventions will be required. Existing lane configurations and pavement types (flexible/rigid/surfaced/unsurfaced) will be thoroughly documented during the Feasibility Study.

• **Right of Way (RoW):** Sections of the corridors exhibit limited RoW, necessitating detailed analysis to optimize widening proposals while minimizing land acquisition requirements.

• **Structures and Cross-Drainage:** An initial inventory of major and minor bridges, culverts, and other cross-drainage structures has been compiled. Many will require rehabilitation, widening, or new construction, subject to detailed structural assessment. Preliminary identification of level crossings has also been carried out.

• **Bypasses and Alignments:** In adherence to NHAI's directive, the identification of the most appropriate alignment options for bypasses, based on site conditions and techno-economic considerations, has commenced. This is a critical focus for minimizing congestion in urban/semi-urban areas (e.g., around Sagar) and optimizing freight movement.

• **Environmental & Social Aspects:** Initial screening indicates potential environmental sensitivities, including proximity to water bodies (e.g., Dhasan, Bewas rivers near Sagar), agricultural lands, and habitations. Concerns such as water scarcity and soil erosion, prevalent in the region, will be specifically addressed. Preliminary social assessments will focus on potential impacts on communities, land acquisition, and resettlement planning.

• **Project Team:** A dedicated and experienced multidisciplinary project team, including Senior Highway Engineers, Bridge Engineers, Traffic and Safety Experts, Pavement Engineers, Geotechnical Engineers, Quantity Surveyors, and CAD/Utility Experts, has been fully mobilized and is committed to the project's success.

5. Next Steps

Upon review and approval of this Inception Report by NHAI, M/s LEA Associates South Asia Pvt Ltd will promptly proceed to the **Feasibility Study** phase. This critical stage will involve:

* Mobilization of survey teams for detailed topographic, traffic, geotechnical, and pavement investigations.

* Conducting detailed environmental and social impact assessments.

* Developing and evaluating alternative alignment options, including detailed bypass proposals.

* Preparation of indicative design standards, preliminary designs, and cost estimates.

* Performing an initial economic and financial analysis to assess project viability.

M/s LEA Associates South Asia Pvt Ltd reaffirms its commitment to delivering a high-quality, technically sound, and implementable DPR that aligns with the vision of the Bharatmala Pariyojana and contributes significantly to the development of robust and efficient freight corridors in Madhya Pradesh.

2.0 Introduction

Inception Report

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)

Submitted to:

National Highways Authority of India

G-5 & 6, Sector-10, Dwarka, New Delhi 110 075

Submitted by:

M/s LEA Associates South Asia Pvt Ltd

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1. INTRODUCTION

1.1 Project Background

The National Highways Authority of India (NHAI), under the aegis of the Ministry of Road Transport & Highways (MoRTH), has embarked on the strategically significant Bharatmala Pariyojna. This nationwide program is fundamentally aimed at enhancing the efficiency of freight and passenger movement, thereby contributing to reduced logistics costs and accelerated economic growth. A core component of this initiative involves the systematic development of a robust network of Economic Corridors, Inter-Corridors, Feeder Routes, and Coastal Roads. In furtherance of this objective, NHAI has engaged M/s LEA Associates South Asia Pvt Ltd to provide consultancy services for the preparation of Detailed Project Reports (DPRs) for a vital package located within the State of Madhya Pradesh. The project corridors, notably initiating from Sagar in Madhya Pradesh, represent crucial arteries for regional and national freight movement, connecting areas of significant economic activity.

1.2 Project Identification

This Inception Report specifically addresses 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 (Lot-1/Madhya Pradesh/Package-3)." The Client for this assignment is the National Highways Authority of India (NHAI), and the Consultant engaged for these services is M/s LEA Associates South Asia Pvt Ltd.

1.3 Contractual Framework

The consultancy services are formally initiated and governed by the Contract Agreement executed on April 7, 2017, between the National Highways Authority of India and M/s LEA Associates South Asia Pvt Ltd. This foundational agreement integrates the General Conditions of Contract, Special Conditions of Contract, and a series of Appendices. Foremost among these is Appendix A: Terms of Reference (TOR), which delineates the comprehensive scope of services and stipulates all reporting requirements. As affirmed during the contract negotiations held on February 15 and 20, 2017, the Consultant is committed to delivering outputs that meet international standards of quality and adhere strictly to the agreed-upon time schedules, ensuring full alignment with the strategic objectives of the Bharatmala Pariyojna.

1.4 Project Location and Corridors

The project encompasses two strategically important road sections within the State of Madhya Pradesh, designed to bolster freight movement efficiency. The combined length of these stretches under Lot-1/Madhya Pradesh/Package-3 totals 335.1 km. A detailed breakdown of the proposed sections is provided below:

Table 1.4.1: Project Stretches for DPR Preparation (Lot-1/Madhya Pradesh/Package-3)

S.No.	Classification	Name of Route	Start Point (Coordinates)	End Point (Coordinates)	Length (km)
1	Sagar-Varanasi Economic Corridor	Sagar-Garhakota-Damoh-Raipur-Katni section of NH-934	Sagar (23.838805, 78.737807)	Katni (23.870014, 80.361474)	193.0

S.No.	Classification	Name of Route	Start Point (Coordinates)	End Point (Coordinates)	Length (km)
2	Vidisha-Malthone Inter Corridor	Vidisha-Saletara-Kurvai-Bina-Khimsala-Malthone section of SH-19, SH-14, SH-42 A and SH-42	Vidisha (23.517449, 77.797208)	Malthone (24.3030959, 78.5255114)	142.1
Total					335.1

The initial stretch commences in Sagar, a significant urban and educational center within the Sagar district of Madhya Pradesh, underscoring its role in facilitating regional connectivity and economic activities. The diverse topography of Madhya Pradesh, including undulating plains and sections influenced by the Vindhya Range, will necessitate tailored engineering solutions.

1.5 Objectives of the Consultancy

The overarching objective of this consultancy assignment is to thoroughly establish the technical, economical, and financial viability of the identified corridors and to meticulously prepare comprehensive Detailed Project Reports (DPRs). Key specific objectives include:

* **Technical, Economic, and Financial Viability:** To conduct rigorous assessments to ascertain the project's technical feasibility, economic benefits (including improved freight movement and reduced travel times), and financial sustainability.

* **Enhanced Freight Efficiency:** To formulate designs and propose interventions specifically targeted at improving the efficiency and seamlessness of freight movement. This includes identifying and addressing existing congestion points, developing long-term solutions, and designing strategic bypasses where necessary.

* **Infrastructure Augmentation:** To design the corridors for development to a minimum of a 4-lane access-controlled configuration, with provisions for 6-laning in specific sections based on detailed traffic analysis and future demand projections.

* **Integrated Engineering Design:** To deliver detailed highway designs, flexible and rigid pavement design options, designs for bridges, cross-drainage structures, grade-separated intersections, and comprehensive road safety features.

* **Quality and Safety Assurance:** To integrate value engineering principles, perform quality audits, and conduct multi-stage road safety audits as mandated by Supplement-III of the Terms of Reference.

* **Environmental and Social Responsibility:** To execute thorough Environmental Impact Assessment (EIA), Environmental Management Plan (EMP), and Rehabilitation and Resettlement (R&R) studies, adhering to national regulations and, where applicable, the safeguard policies of international lending agencies such as ADB/World Bank.

* **Tendering Readiness:** To prepare all requisite documentation, including detailed working drawings, Bill of Quantities (BoQ), comprehensive cost estimates, and bid documents suitable for tendering the project on a commercial basis (EPC/PPP models).

1.6 Scope of Services (Overview)

The scope of services, as articulated in Appendix A of the Contract Agreement, defines a holistic approach to project preparation. Key deliverables and activities include:

* **Comprehensive Surveys and Investigations:** Conducting all necessary field studies, including high-accuracy topographical surveys using advanced technologies such as LIDAR or equivalent, detailed traffic and axle load surveys, pavement condition assessments, and rigorous geotechnical investigations. The deployment of Ground Penetrating Radar (GPR) and equivalent technologies will be utilized for accurate mapping of underground utilities.

* **Detailed Engineering Design:** Developing conceptual and detailed engineering designs for all highway components, including geometric alignment, pavement structures, bridges, cross-drainage structures, and grade-separated interchanges. The design philosophy will prioritize optimization of the existing Right-of-Way (ROW) and minimize fresh land acquisition.

* **Bypass and Congestion Management:** Identifying, evaluating, and designing optimal bypass alignments, particularly for urban agglomerations and identified congestion points, to ensure smooth traffic flow and improved safety along the corridors.

* **Land Acquisition and Utility Shifting Management:** Preparing precise land acquisition details based on revenue records and drafting statutory notifications (3a, 3A, and 3D). Crucially, planning for utility shifting will commence simultaneously with the initial project phases to preempt delays in civil works.

* **Environmental and Social Safeguards:** Undertaking comprehensive EIA, EMP, and R&R studies, which include extensive stakeholder consultations, impact assessments on vulnerable populations, and the development of equitable entitlement matrices.

* **Costing and Financial Modeling:** Developing detailed item-wise cost estimates, a comprehensive Bill of Quantities (BoQ), and robust economic and financial viability analyses for the project.

* **Documentation and Reporting:** Preparing and submitting all required reports, including this Inception Report, the Feasibility Report, and the Final Detailed Project Reports. This also encompasses "Good for Construction" drawings and documentation necessary for EPC/PPP contract tendering.

* **Project Coordination and Monitoring:** Maintaining continuous interaction with assigned NHAI Project Directors and Regional Officers, facilitating necessary stakeholder consultations, and utilizing NHAI's Project Information Management System (PIMS) for transparent and timely progress monitoring. The Team Leader will ensure weekly updates to NHAI regarding project activities.

1.7 Applicable Standards and Guidelines

All engineering studies, designs, and reporting for this project will strictly adhere to the latest editions of the following national and international standards, codes, and guidelines:

* Indian Road Congress (IRC) Codes and Standards

* Ministry of Road Transport & Highways (MoRTH) Specifications for Road and Bridge Works

* Bureau of Indian Standards (BIS)

* National Highways Authority of India (NHAI) Manuals and Guidelines, specifically incorporating the uniform design standards being finalized for Bharatmala (Economic Corridors).

* Environmental and Social Safeguard Policies and Guidelines of multilateral financial institutions such as the Asian Development Bank (ADB) and the World Bank, where applicable to the project.

1.8 Structure of the Inception Report

This Inception Report is a foundational document that articulates the Consultant's comprehensive understanding of the project, proposed methodology, and initial strategic planning. Subsequent sections of this report will detail:

* **Project Appreciation:** An in-depth understanding of the project's strategic context, inherent challenges, and potential opportunities.

* **Detailed Methodology:** The proposed technical and operational methodologies for undertaking all defined activities, including scheduling of sub-activities, detailed approach for surveys, investigations, and data collection/collation.

* **Work Programme:** A comprehensive and phased work plan outlining timelines for key deliverables and milestones over the project duration.

* **Task Assignment and Manning Schedule:** The allocation of specific tasks and responsibilities to key personnel, along with the overall staffing and deployment plan.

* **Quality Assurance Plan (QAP):** The systematic procedures and protocols implemented to ensure the highest quality of all project deliverables, finalized in close consultation with NHAI.

* **Design Standards and Proposed Cross-Sections:** The preliminary design parameters and typical cross-sections proposed for the project corridors.

* **Key Plan and Linear Plan:** Graphical representations of the project alignment, key features, and corridor segmentation.

* **Proforma for Data Collection:** Standardized formats and templates for efficient and consistent field data acquisition.

* **Review of Development Plans:** An assessment of existing and planned development initiatives by local and state government bodies, and their potential impacts on the project.

* **Draft Design Standards:** Initial proposals for the specific design criteria and parameters to be adopted throughout the DPR preparation process.

* **Other Relevant Aspects:** Any additional pertinent information deemed necessary to establish a clear and actionable roadmap for the successful preparation of the Detailed Project Report.

3.0 Site Appreciation

1.0 Site Appreciation

This section provides a detailed professional appreciation of the project site for 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). The content is based on the comprehensive Terms of Reference (TOR) provided by the National Highways Authority of India (NHAI) and supplementary information regarding the project location.

1.1 Project Overview and Location

The project encompasses two significant road sections within the State of Madhya Pradesh:

1. **Sagar-Katni Section of NH-934:** This segment is part of the Sagar-Varanasi Economic Corridor, spanning approximately 193 km.

* **Start Point:** Sagar (23.838805 N, 78.737807 E)

* **End Point:** Katni (23.870014 N, 80.361474 E)

* **Route:** Sagar-Garhakota-Damoh-Raipur-Katni.

2. **Vidisha-Malthone Section:** This section comprises SH-19, SH-14, SH-42A, and SH-42, and forms the Vidisha-Malthone Inter Corridor, with a length of approximately 142.1 km.

* **Start Point:** Vidisha (23.517449 N, 77.797208 E)

* **End Point:** Malthone (24.3030959 N, 78.5255114 E)

* **Route:** Vidisha-Saletara-Kurvai-Bina-Khimsala-Malthone.

The total length of this package (Lot-1/Madhya Pradesh/Package-3) is 335.1 km. The project aligns with NHAI's mandate to enhance freight movement efficiency across India. The district of Sagar, a key location for one of the project stretches, is centrally located in Madhya Pradesh, situated between 23°10' and 24°27' North latitude and 78°4' and 79°21' East longitude.

1.2 Geographical and Topographical Context

The project corridors traverse regions characterized by varying topography typical of central India. Initial assessment of the coordinates suggests a transition across different geographical features along the considerable lengths of the corridors. Detailed topographic surveys, employing advanced technologies such as Mobile/Aerial LiDAR or equivalent, will be crucial to accurately capture ground features, inform geometric design, and identify critical areas for improvement or realignment. This includes assessment of existing alignment, embankment and cut slopes, and general ground profiles, particularly for proposed divided carriageways and potential bypasses in congested urban areas. The deliverables will include 360-degree panoramic images or ortho-images of the entire highway length and adjoining areas, providing comprehensive site visualization.

1.3 Climatic Conditions

The project area, particularly around Sagar district, experiences a pronounced monsoon climate. This implies significant annual and seasonal rainfall patterns, which must be carefully considered during all phases of the project, from design to construction.

Key climatic considerations include:

* **Rainfall Intensity and Duration:** Influencing drainage design, erosion control measures, and construction scheduling.

* **Temperature Variations:** Affecting material selection, pavement design, and construction techniques.

* **Wind Patterns:** Relevant for structural design and environmental impact assessments.

Detailed hydrological and hydraulic studies, in accordance with IRC Special Publication No. 13 and IRC:5, will be undertaken for all drainage structures to account for high flood levels (HFL), low water levels (LWL), and discharge velocities, mitigating risks associated with extreme weather events.

1.4 Existing Infrastructure and Traffic Profile

The project involves the development and improvement of existing National Highway (NH-934) and State Highways (SH-19, SH-14, SH-42A, SH-42). This necessitates a thorough inventory and condition assessment of the current road infrastructure, including:

* **Pavements:** Detailed pavement investigations, including roughness surveys (using Bump Integrator/similar) and structural strength surveys (using Falling Weight

Deflectometer as per IRC:115:2014 or IRC:117:2015), will be conducted to inform strengthening and overlay designs.

* **Structures:** An inventory and condition survey of existing bridges, culverts, cross-drainage structures, and river bank protection works will be carried out as per IRC:SP:35 and IRC:SP:40. Geotechnical investigations as per IRC:78 will inform foundation designs for new and rehabilitated structures.

* **Traffic:** Comprehensive traffic studies, including Classified Traffic Volume Counts (leveraging IHMCL data where available or using ATCC systems with specified accuracy), Origin-Destination surveys, Axle Load surveys (as per IRC:SP:19), and Speed-Delay Characteristics, will be performed. A 30-year traffic forecast, accounting for diverted and generated traffic, will form the basis for geometric and pavement design. The project's focus on freight movement efficiency implies a significant proportion of commercial vehicle traffic.

* **Utilities:** The corridors are expected to host a complex network of existing utility services, both overhead and underground (e.g., electric lines, telephone lines, optical fibre cables, water mains, sewers, oil/gas pipelines). A critical activity will be the detailed mapping and detection of sub-surface utilities using Ground Penetrating Radar (GPR) or Induction Locator technologies to a depth of 4m, enabling accurate relocation planning.

1.5 Land Use, Environment, and Social Aspects

The project stretches traverse a mix of land-use patterns, including agricultural areas, habitations, and potentially forest lands. Sagar district, for instance, has recorded areas of forest land, necessitating careful environmental planning.

Key considerations in this domain include:

* **Land Acquisition (LA):** The requirement for widening and new bypasses will entail land acquisition. Detailed land acquisition plans, prepared after digitization of cadastral maps, and drafting of 3(a), 3(A), and 3(D) notifications, will be a critical output.

* **Environmental Impact Assessment (EIA) & Management Plan (EMP):** Conducted to meet the requirements of lending agencies like ADB/World Bank/JICA, addressing air quality, noise, water resources, flora, and fauna. The mandatory use of fly-ash within 300 km from thermal power stations (as per MoRT&H circular dated 25.01.2016) for construction materials will be integrated into the EMP.

* **Social Analysis & Resettlement Action Plan (RAP):** Social analysis, in accordance with MoRT&H/World Bank/ADB Guidelines, will assess socio-economic profiles, identify project-affected people (PAPs), address poverty alleviation, gender, child labor, and develop comprehensive resettlement and rehabilitation strategies.

* **Arboriculture and Landscaping:** Plans for tree planting, horticulture, and floriculture on surplus land, with a focus on retaining existing trees and proposing transplantation where feasible, will contribute to aesthetic and environmental enhancement.

1.6 Geological and Material Resources

Sub-soil investigations, including boreholes (as per Form-V of the Financial Proposal, indicating tentative quantities of 2000m in soil and 300m in hard rock for projects over 110 km), will be conducted to determine sub-grade and sub-soil characteristics for road and embankment design, as well as foundation design for structures. MoRT&H empanelled geotechnical consultants will be engaged for these investigations.

Identification of local sources for construction materials (quarry sites, borrow areas), including field and laboratory testing, will ensure their suitability and optimize haulage through mass haul diagrams. The project will actively promote the use of "environment-friendly materials" and assess industrial byproducts, recyclable, and waste materials, where technically and economically feasible. Local availability of building material dealers in Sagar district suggests potential for local sourcing.

1.7 Key Site-Specific Considerations for Design and Implementation

The project's objective to improve freight movement efficiency necessitates specific design considerations:

* **Geometric Design:** Optimizing horizontal and vertical alignments, cross-sectional elements, and sight distances to support high-speed highway functionality and safety.

* **Intersections and Junctions:** Designing appropriate intersection types (at-grade, grade-separated, interchanges) and considering pedestrian/animal crossings (viaducts) in areas with high cross-traffic.

* **Bypasses:** Detailed evaluation and design of bypasses for congested urban locations to improve traffic flow and reduce environmental and social impacts on existing settlements.

* **Toll Plaza, Weighing Stations, Parking, and Rest Areas:** Strategic planning and design of these facilities, adhering to IRC:84 for toll plazas and ensuring user-oriented

amenities at approximately 50 km intervals.

* **Segregation of Local Traffic:** Provision of service roads and physical barriers, including fencing, where necessary to separate local and slow-moving traffic from the main carriageway, enhancing safety and efficiency.

* **Railway Crossings:** Meticulous coordination with Indian Railways authorities for the design and approval of General Arrangement Drawings (GADs) and detailed engineering drawings for any proposed Road Over Bridges (ROBs)/Road Under Bridges (RUBs).

* **Standards and Codes:** Strict adherence to IRC publications, MoRT&H circulars, Bureau of Indian Standards (BIS), and international best practices for all design, survey, and investigation activities.

1.8 Conclusion

The project site presents a dynamic and multi-faceted environment, offering both opportunities for significant infrastructure improvement and necessitating a rigorous, multidisciplinary approach to address various technical, environmental, and social complexities. A thorough understanding and appreciation of these site conditions, coupled with the application of advanced engineering methodologies and strict adherence to national and international standards, will be paramount to the successful preparation of a comprehensive and implementable DPR for this critical infrastructure development. Our approach is geared towards delivering an optimal design that is economically viable, environmentally sound, socially inclusive, and technically robust, meeting NHAI's objectives for enhanced freight movement efficiency.

4.0 Approach and Methodology

METHODOLOGY FOR DETAILED PROJECT REPORT PREPARATION

1.0 Introduction and Project Appreciation

This section outlines the comprehensive methodology adopted for the preparation of the Detailed Project Report (DPR) for road development projects within Sagar District, Madhya Pradesh, ensuring strict adherence to the Terms of Reference (TOR), National Highways Authority of India (NHAI) guidelines, and all relevant Indian Road Congress (IRC), Ministry of Road Transport and Highways (MoRTH), and Bureau of Indian Standards (BIS) specifications. Our approach integrates advanced engineering practices with a deep understanding of the local socio-economic and environmental context of Sagar, Madhya Pradesh, aiming to deliver a robust, implementable, and sustainable infrastructure solution.

The primary objective is to develop a project report that facilitates efficient freight movement and connectivity, considering the unique regional demands and challenges of Sagar. This involves meticulous planning, advanced surveying, rigorous analysis, and innovative design, all underpinned by a stringent Quality Assurance (QA) framework and continuous stakeholder engagement.

2.0 Overall Approach and Phased Execution

Our methodology is structured around a multi-disciplinary, phased approach to ensure systematic execution, timely deliverables, and comprehensive coverage of all TOR requirements. The project preparation activities are segmented into seven distinct stages, as outlined in the TOR, with an emphasis on parallel execution where feasible to optimize the overall timeline.

The Seven Stages of Project Preparation:

1. **Stage 1: Inception Report**

2. **Stage 2: Feasibility Report**

3. **Stage 3: Land Acquisition (LA) & Clearances I Report**

4. **Stage 4: Detailed Project Report (DPR)**

5. **Stage 5: Technical Schedules**

6. **Stage 6: Draft 3D Publication Report**

7. **Stage 7: Clearances II Report**

This phased approach facilitates iterative review and approval cycles with NHAI, allowing for flexibility and incorporation of feedback at critical junctures. Preliminary design work will commence without awaiting the full completion of the feasibility study, as specified, to streamline the process.

3.0 Key Guiding Principles

Our execution strategy for projects in Sagar District is governed by the following core principles:

• **Adherence to Standards:** Strict compliance with all national and international standards, including IRC codes, MoRTH specifications (Fifth Revision), BIS codes, and NHAI circulars/directives.

• **Integrated Multi-disciplinary Team:** A dedicated team of experts covering highways, bridges, geotechnical, traffic, environment, social, and quantity surveying will ensure holistic project development.

• **Quality Assurance (QA):** Implementation of a rigorous, NHAI-approved Quality Assurance Plan (QAP) across all field studies, investigations, design, and documentation activities.

• **Technology Integration:** Leveraging cutting-edge technologies like Mobile/Aerial LiDAR, Ground Penetrating Radar (GPR), Induction Locators, and Falling Weight Deflectometers (FWD) for enhanced accuracy and efficiency in data collection and analysis.

• **Stakeholder Consultation:** Proactive and continuous engagement with local communities, NGOs, utility agencies, and government departments in Sagar to address concerns and incorporate local insights.

• **Environmental and Social Safeguards:** Conducting detailed Environmental Impact Assessment (EIA) and Social Assessment (SA) in line with Government of India (GoI), World Bank, and Asian Development Bank (ADB) guidelines, ensuring robust mitigation and enhancement measures.

• **Value Engineering and Life Cycle Cost Analysis:** Exploring innovative design alternatives and construction materials to achieve optimal cost-effectiveness and long-term sustainability, particularly relevant for projects in Madhya Pradesh.

4.0 Detailed Methodology for Core Activities

4.1 Reconnaissance and Alignment Studies (Ref. TOR 4.11.1)

The initial phase involves a comprehensive desk study followed by detailed ground reconnaissance.

* **Desk Study:** Review of available topographic maps, satellite imagery, aerial photographs, geological maps, catchment area maps, contour plans, flood flow data, seismological data, and existing alignment information relevant to Sagar District. Emphasis will be placed on minimizing land acquisition.

* **Field Reconnaissance:** Experienced personnel will conduct thorough field visits to identify:

* Topographical features, land-use patterns (agricultural, commercial, forest, residential), and typical physical features along existing and proposed alignments.

* Possible alignment alternatives, including bypasses around congested urban areas within Sagar.

* Preliminary identification of improvement requirements, cross-road treatments, and traffic-homogenous links.

* Inventory of major aspects: land width, terrain, pavement type, structures, intersections, geologically sensitive areas (if any in Sagar), and environmental features.

* Critical areas requiring detailed supplementary investigations (e.g., problematic soil zones, areas with high utility density).

* **Documentation:** Data from reconnaissance will be documented in tabular and graphical forms, including major physical features and proposed widening schemes, to inform the Inception Report.

4.2 Traffic Surveys and Demand Forecasting (Ref. TOR 4.9, 4.10)

Traffic studies are critical for accurate demand estimates and pavement design.

* **Survey Stations:** The indicative number and locations of survey stations (as per TOR 4.9.1) will be finalized in consultation with NHAI based on reconnaissance findings and

local traffic patterns in Sagar.

* **Classified Traffic Volume Count (Ref. TOR 4.9.2):**

* Utilize data from Indian Highways Management Company Limited (IHMCL) ATCC systems where available.

* Conduct 7-day continuous, direction-wise classified traffic volume surveys using ATCC systems or equivalent technologies, meeting accuracy levels outlined in TOR.

* Vehicle classification will adhere to relevant IRC codes (e.g., IRC:SP:41-1994) and the generalized system provided in TOR (2-Wheeler, Passenger Car, LCV, Truck, Bus, Non-Motorised Traffic).

* Data analysis will derive hourly, daily, weekly average daily traffic (ADT), and annual average daily traffic (AADT) using seasonal factors specific to Madhya Pradesh.

* **Origin-Destination (O-D) and Commodity Movement Surveys (Ref. TOR 4.9.3):**

* 1-day (24-hour, both directions) O-D and commodity movement surveys at NHAI-approved locations, especially around congested towns in Sagar.

* Roadside interviews on a random sample basis for four-wheeled vehicles.

* Trip matrices for each vehicle type, commodity-wise weight tabulation, lead and load characteristics, and desire line diagrams will be developed to assess bypass requirements.

* **Turning Movement Surveys (Ref. TOR 4.9.4):** Conducted at major intersections for peak hour traffic estimation as per IRC:SP:41-1994, to identify grade-separated intersection requirements.

* **Axle Load Surveys (Ref. TOR 4.9.5):**

* 2-day (24-hour) axle load surveys using axle load pads or sophisticated instruments at suitable locations, primarily for trucks.

* Data collection axle configuration-wise to calculate Vehicle Damage Factor (VDF) for each truck type. National average VDF will be used if calculated VDF is below.

* Analysis will provide Gross Vehicle Weight (GVW) and Single Axle Load (SAL) distributions.

* **Speed-Delay Surveys (Ref. TOR 4.9.6):** Moving car survey to determine running and journey speeds, identifying congestion points and recommending mitigation measures for Sagar's specific traffic.

* **Pedestrian/Animal Cross Traffic Surveys (Ref. TOR 4.9.7):** To assess the necessity of pedestrian/animal viaducts for safety.

* **Traffic Demand Estimates (Ref. TOR 4.10):**

* Forecasts for a 30-year period from completion, considering optimistic, pessimistic, and most likely scenarios.

* Growth factors at five-yearly intervals, based on past trends, population, per capita growth, elasticity of transport demand, and regional development plans of Sagar.

* HDM-IV or internationally recognized life-cycle costing models will be used.

* Estimates for normal, generated, induced, and diverted traffic, including impact of toll charges.

4.3 Topographic Surveys (Ref. TOR 4.11.2)

High-accuracy topographic surveys are crucial for detailed design.

* **Technology:** Mobile/Aerial LiDAR or equivalent technology will be used to meet the specified accuracy levels (horizontal and vertical accuracy of 2 cm or better for land-based, 5 cm or better for aerial-based).

* For shadow areas (e.g., culvert inverts), traditional methods (Total Station/Auto Level) will supplement LiDAR data.

* 360-degree panoramic images or ortho-images will be submitted.

* **Deliverables:** Raw DGPS data, point cloud data, 1:1000 scale topographic maps, 50 cm contour maps, and cross-sections at every 1m (dwg format).

* **Field Activities:**

* Topographic surveys along existing Right of Way (ROW) and realignments, with referencing to permanent pillars (15cm x 15cm x 45cm RCC M15 with nail, embedded 30cm, 250m apart, as per TOR).

* Detailed surveys along proposed bridge locations and approach roads.

* Collection of details for all features: structures, utilities (O/H & U/G), buildings, trees (girth > 0.3m), oil/gas lines.

* **Survey Corridor Width:** Generally 30m beyond either side of the proposed divided carriageway centerline or land boundary, whichever is more. Widened appropriately for bypasses, grade-separated intersections, and areas with developments/encroachments.

* **Longitudinal and Cross-Sections (Ref. TOR 4.11.2.1):** Levels at 1m intervals along the centerline, curves, streams, and elevation changes. Cross-sections at 1m intervals (or 25m for hill roads, if applicable in parts of Sagar) covering sufficient spot levels.

4.4 Road and Pavement Investigations (Ref. TOR 4.11.3)

These investigations inform pavement design and rehabilitation.

* **Road Inventory Surveys (Ref. TOR 4.11.3.1):** Detailed collection of terrain, land-use, carriageway width, surfacing type, shoulder details, sub-grade soil type, horizontal/vertical curves, intersections, retaining structures, water bodies, embankment/cut height, ROW, culverts, bridges, roadside arboriculture, drainage, design speed. Data compiled in tabular/graphical form (e.g., MS Excel).

* **Pavement Composition (Ref. TOR 4.11.3.2):**

* Trial pits at specified intervals (e.g., every 500m or per homogenous segment) to ascertain material type and thickness of pavement layers.

* Subgrade type and condition (dry/wet).

* **Road and Pavement Condition Surveys:**

* Visual surveys supplemented by actual measurements to identify and quantify distresses (cracking, raveling, potholing, edge break, rut depth, shoulder/embankment condition, drainage condition) as per AASHTO, IRC, OECD, TRL, and World Bank publications.

* Road segments of similar performance will be identified using criteria in IRC:81-1997.

* **Pavement Roughness:**

* Surveys using Bump Integrator or similar instrument (or FWD-integrated roughness measurement).

* Results in terms of BI and IRI, presented tabularly and graphically, analyzed using cumulative difference approach to identify homogenous segments.

* **Pavement Structural Strength (Ref. TOR 4.11.3.3):**

* Surveys using **Falling Weight Deflectometer (FWD)** in accordance with **IRC 115:2014 or IRC 117:2015**, replacing Benkelman Beam Deflection (BBD) technique as per the amended TOR. This ensures modern, accurate assessment of pavement structural integrity.

* Project road sections will be divided into homogenous segments based on pavement condition, strength, and sub-grade characteristics using the cumulative difference approach (AASHTO, 1993).

* **Subgrade Characteristics and Strength:**

* In-situ density and moisture content at each test pit.

* Field CBR using Dynamic Cone Penetrometer (DCP) at each test pit.

* Characterization (grain size and Atterberg limits) and Laboratory moisture-density (modified AASHTO compaction).

* Laboratory CBR (unsoaked and 4-day soak, three energy levels) and swell.

* Rigorous testing for problematic soils (e.g., black cotton soil common in parts of MP), including permeability and consolidation characteristics, with frequency finalized in consultation with NHAI.

* Laboratory for testing material will be approved by NHAI.

4.5 Investigations for Bridges and Structures (Ref. TOR 4.11.4)

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

• **Hydraulic and Hydrological Investigations (Ref. TOR 4.11.4.2):**

• Conducted as per IRC SP:13 (“Guidelines for the Design of Small Bridges and Culverts”) and IRC:5 (“Standard Specifications & Code of Practice for Road Bridges, Section I—General Features of Design”).

• Desk study of topography, storm duration, rainfall statistics, soil, vegetation to assess catchment areas and hydraulic parameters.

• Collection of High Flood Level (HFL), Low Water Levels (LWL), High Tide Level (HTL), Low Tide Level (LTL), discharge velocity from records and local inquiries.

• **Condition Surveys (Ref. TOR 4.11.4.3):**

• Thorough inspection of existing structures with reports as per IRC-SP:35.

• Supplementary testing for distressed structures as per IRC:SP:35 and IRC:SP:40.

• Load carrying capacity assessment/rating as per IRC-SP:37, using analytical/correlation methods or load testing.

• Establish remaining service life with/without strengthening.

• **Geo-technical Investigations and Sub-Soil Exploration (Ref. TOR 4.11.4.4):**

• Carried out for proposed structures (bridges, ROBs, tunnels, viaducts, interchanges, high embankments, and road pavements).

• Explorations conducted through MORT&H empanelled Geotechnical Consultants.

• **Minimum scope for bridges and structures (as per TOR 4.11.4.4):**

• **Overall length = 6-30m:** One abutment location and at least one intermediate location between abutments for structures having more than one span.

• **Overall length = 30-60m:** One abutment location and at least one intermediate location between abutments for structures having more than one span.

• **Overall length > 60m:** Each abutment and each pier location.

• Geotechnical investigation and Sub-soil Exploration will be done as per **IRC:78**. Tunnels, if identified, will follow **IRC:SP:91**.

• Determination of nature and properties of strata, safe intensity of pressure, artesian conditions, seismic disturbance.

• For approach road pavements, boreholes at major changes in pavement condition or deflection readings (or 2 km intervals) to a depth of at least 2m.

4.6 Material Investigations (Ref. TOR 4.11.5)

• **Identification:** Sources of construction materials (quarry sites, borrow areas, including fly-ash/slag) will be identified within economic lead distances from the project site in Sagar.

• **Testing:** Field and laboratory testing to determine suitability for various work components.

• **Recommendation:** Techno-economic recommendations for material use.

• **Mass Haul Diagram:** Preparation of mass haul diagrams and quarry charts.

• **Environment-Friendly Materials:** Assessment of alternative pavement materials and technologies, including industrial byproducts, recyclable, and waste materials. **Use of fly ash within 300 km from Thermal Power station is mandatory** as per MoRT&H circular No. RW/NH-33044/53/2013-S&R(R) dated 20 November 2013, and subsequent amendments.

• **Rehabilitation:** Recommendations for rehabilitation of borrow and quarry areas post-exploitation.

• **Mix Design:** Preparation and testing of bituminous and concrete mixes conforming to latest MoRT&H specifications.

4.7 Sub-surface Utility Mapping (Ref. TOR 4.11.2.2)

• **Technology:** Ground Penetrating Radar (GPR), Induction Locator, or equivalent technologies will be employed to meet high accuracy levels for sub-surface utility detection.

• **Coverage:** Mapping of all sub-surface utilities within the project RoW, especially under additional carriageway width, up to a depth of 4m.

• **Differentiation:** Clear differentiation between utility types (e.g., live electric cables, metallic utilities, water mains, sewers, gas/oil pipes).

• **Deliverables:** Sub-surface utility radargrams processed into utility maps (PDF, JPEG, AutoCAD formats).

• **Coordination:** Separate strip plans for each utility service, prepared in consultation with concerned local authorities and utility agencies in Sagar.

4.8 Detailed Design (Ref. TOR 4.12)

Detailed designs and working drawings will be prepared for all components.

* **Design Standards (Ref. TOR 4.12.2):** Evolved primarily from IRC publications, MoRT&H Circulars, and relevant international standards (British, American if not covered by IRC/BIS), for approval by NHAI.

* **Geometric Design (Ref. TOR 4.12.3):**

* Horizontal and vertical alignment, cross-sectional elements (including refuge lanes), junctions, intersections, interchanges, bypasses, service roads.

* Verification for sight distances, appropriate markings and signs.

* Analysis of traffic flow and Level of Service (LoS) as per IRC.

* Identification of black spots from accident data and proposal of cost-effective remedial measures.

* Designs for grade-separated pedestrian/animal crossings where required.

* **Pavement Design (Ref. TOR 4.12.4):**

* Strengthening of existing road pavements and design of new pavements (rigid/flexible) based on IRC publications and latest practices.

* Life-cycle costing and techno-economic considerations for optimal design.

* Overlay thickness requirements for homogenous segments, including regulating and crack inhibiting layers.

* Consideration of geo-synthetics and cold/hot pavement recycling for economy.

* Paved shoulders designed as integral parts of the pavement.

* Maintenance and strengthening requirements, periodicity, and timing of treatments.

* **Embankment Design (Ref. TOR 4.12.5):**

* Maximum utilization of locally available materials, consistent with economy, including mandatory use of fly ash within 300 km from Thermal Power Stations.

* Detailed analysis and design for embankments > 6m height, including protection works and traffic safety features.

* **Design of Bridges and Structures (Ref. TOR 4.12.6):**

* Analysis of HFL, LWL, LBL, erodibility, design discharge, waterway, foundation depth, SBC, soil properties, seismic/wind loads.

* Preparation of General Arrangement Drawings (GAD) and Alignment Plans.

* Approval of GADs from NHAI, Indian Railways (for ROBs), and Irrigation/Waterway Authorities.

* Detailed design as per IRC codes/guidelines for all components, with working drawings.

* Rehabilitation/reconstruction measures as per IRC-SP:40 and IRC-SP:35.

* Design of underpasses, overpasses, interchanges, and protection works.

* RCC retaining walls or Reinforced Earth (RE) walls where land is inadequate.

* **Drainage System Design (Ref. TOR 4.12.7):** Roadside drainage system integrated with cross-drainage, special provisions for super-elevated sections, high embankments, cuts, and urban areas in Sagar. Turnouts and outfall structures fitting natural contours.

* **Traffic Safety Features, Road Furniture and Road Markings (Ref. TOR 4.12.8):** Design of traffic signals, signs, markings, overhead sign boards, crash barriers, delineators, etc., located in reports and drawings.

* **Arboriculture and Landscaping (Ref. TOR 4.12.9):** Plan for tree planting (specifying species), horticulture, floriculture for highway beautification, retaining/transplanting existing trees.

* **Toll Plaza (Ref. TOR 4.12.10):** Identification of optimal location(s) based on traffic studies and physical features, designed as per IRC:84.

* **Weighing Station, Parking Areas and Rest Areas (Ref. TOR 4.12.11):** Selection of suitable sites for these facilities (approx. 50 km interval), including common amenities like petrol pumps, first-aid, police, restaurants. Weighing stations near toll plazas for overloaded vehicles.

* **Miscellaneous Works (Ref. TOR 4.12.13):** Designs for rest areas, bus bays, vehicle parking, telecommunication facilities.

4.9 Environmental and Social Impact Assessment (Ref. TOR 4.13)

Conducted in accordance with GoI, MoRT&H/NHAI, World Bank, and ADB guidelines.

* **Environmental Impact Assessment (EIA) (Ref. TOR 4.13.1):**

* Preliminary environmental screening and baseline condition documentation (cultural properties, natural habitats, etc.) in Sagar district.

* Assessment of potential significant impacts and identification of mitigation measures.

* Analysis of alternatives (with/without project scenarios, modifications due to environmental considerations).

* Focus on environmental enhancement measures: cultural property, bus bays/shelters, landscape, water bodies, borrow area redevelopment.

* Preparation of Bill of Quantities (BOQ) and technical specifications for environmental works.

* Establishment of a monitoring network for air, water, noise pollution.

* Costing of mitigation measures, budgeting for environmental staffing/training.

* Preparation of application forms and liaison for forestry and environmental clearances from State Pollution Control Board (SPCB) and Ministry of Environment, Forest and Climate Change (MoEFCC).

* **Social Assessment (Ref. TOR 4.13.2):**

* Baseline socio-economic and census survey (25% socio-economic, 100% census) to assess impacts on people, properties, and livelihoods in project affected areas of Sagar.

* Identification of mechanisms to improve project designs to meet stakeholder needs.

* Preparation of Land Acquisition Plan (LAP) and assistance to NHAI in land acquisition processes (3a, 3A, 3D draft notifications as per NH Act, 1956).

* Preparation of Resettlement and Rehabilitation (R&R) Plan, assessing income restoration strategies and relocation site suitability.

* Developing entitlement matrix for Project Affected People (PAPs).

* Assessment of social issues: indigenous people, gender, HIV/AIDS, child labor.

* Implementation budgets, funding sources, schedules, responsibility matrix, institutional arrangements.

* Internal/external monitoring plans, key indicators, and grievance redress mechanism.

* **Reporting Requirements (Ref. TOR 4.13.3, 4.13.4):** Stand-alone EIA and R&R (RAP) reports, Executive Summary, Project Description, Environmental Setting, Impact Identification, Alternatives Analysis, Public Consultation, Policy Framework, EMP/RAP details, BOQ, monitoring plans.

4.10 Estimation of Quantities and Project Costs (Ref. TOR 6.0)

• **Detailed Estimates:** Prepared for the entire project (civil package-wise) based on detailed designs, MoRT&H Standard Data Book, and current market rates in Sagar District.

• **Unit Rate Analysis:** Detailed analysis of unit rates for all work items, considering inputs (manpower, machinery, materials), basic rates, and lead distances for mechanized construction.

• **Validation:** Project cost estimates checked against rates for similar ongoing NHAI/World Bank/ADB financed road projects in India.

4.11 Viability and Financing Options (Ref. TOR 6.1, 6.2)

• **Homogenous Links:** Project Road divided into traffic homogenous links and further into sections based on physical features, sub-grade, and drainage.

• **Economic Analysis (Ref. TOR 6.1):**

• Carried out for each section using HDM-IV or other recognized life-cycle costing models.

• Assessment of existing road capacity and VOC impacts.

• Quantification of economic benefits (reduced congestion, travel distance, maintenance savings, accident reduction).

• Estimation of Economic Internal Rate of Return (EIRR) over a 30-year period.

• Sensitivity analysis for various scenarios (Base Costs, Base Costs +/- 15%, Base Benefits +/- 15%).

• **Financial Analysis (Ref. TOR 6.2):**

• Prepared in a commercial format under different user fee scenarios and funding options.

• 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 project risks (construction delays, cost overruns, revenue shortfalls, etc.).

• Suggestions for enhancing project viability and different financial models (e.g., BOT format).

5.0 Quality Assurance Plan (QAP) (Ref. TOR 10.1)

A comprehensive QAP document will be submitted immediately upon award, covering all aspects of field studies, investigations, design, and economic/financial analysis.

* **Structure:** QAP will include separate sections for engineering surveys, traffic surveys, material/geo-technical/sub-soil investigations, road/pavement investigations, bridge/structure investigations/design, environment/R&R assessment, economic/financial analysis, drawings, and documentation.

* **Components:** Will detail manpower responsibility, equipment calibration and accuracy, applicable standards/codes (IRC, MoRTH, BIS), regulatory requirements, safety and environmental considerations, training, data verification, documentation, retrieval system, detailed work procedures, and standard proforma for data recording.

* **Approval:** Field and design activities will commence only after the QAP is approved by NHAI.

* **Data Formats:** Proposed data formats for field studies and investigations will be submitted within 14 days for NHAI approval.

6.0 Data Management and Reporting (Ref. TOR 9.0, 10.0)

Effective data management and timely reporting are central to project success.

* **Data Sources:** All data analysis and design proposals will be based on primary surveys and investigations, with complete details of data sources and model relationships referenced.

* **Digital Data:** All topographic data in (x, y, z) format for compatibility with standard highway design software (e.g., MX Road, Civil 3D). Drawing files in .dxf or .dwg format. Rate analysis data in MS Excel or importable utility packages.

* **Software Handover:** Any general software, including the financial model specifically developed for the project, will be handed over to NHAI on floppies/CDs, properly indexed and catalogued.

* **Soft Copies:** Editable soft copies of all final documents, including strip plans, plan & profile drawings, cross-sections, structure details, and cost workings, will be provided.

* **Reporting Schedule:** Reports, documents, and drawings will be submitted in bound volumes (and digital format) as per the schedule and number of copies outlined in Enclosure III of the TOR. Strict adherence to deadlines is paramount.

* **PIMS System:** Data will be submitted through the NHAI PIMS system for monitoring, with the Team Leader providing weekly updates on activities.

* **Checklists:** The NHAI-provided checklists for each stage (Inception Report, Feasibility Report, etc.) will be appended to the respective reports with proper references and page numbering, as a prerequisite for payment eligibility.

7.0 Team and Coordination

A multi-disciplinary team, with key personnel as per Enclosure I (Manning Schedule) and Enclosure II (Qualification and Experience) of the TOR, will be deployed.

* **Site Office:** A fully functional site office will be established in Sagar, staffed by senior personnel to ensure continuous oversight of surveys and investigations.

* **Coordination:** Regular interaction and consultation will be maintained with the assigned NHAI Project Director and Regional Officer at all stages of DPR preparation to seek inputs and ensure alignment. Stakeholder consultations will also be conducted at appropriate stages.

This detailed methodology ensures a systematic, technically sound, and compliant approach to DPR preparation for road projects in Sagar District, Madhya Pradesh, aligned

with NHAI's vision for efficient and sustainable infrastructure development.

5.0 Task Assignment and Manning Schedule

Task Assignment and Manning Schedule

1. Introduction

This section delineates the proposed team structure, individual task assignments, and the manning schedule for the successful execution of the Detailed Project Report (DPR) consultancy services for the Economic Corridor, Lot-1/Madhya Pradesh/Package-3, with a specific focus on the geographical context of Sagar district, Madhya Pradesh. The assignments are meticulously aligned with the Terms of Reference (ToR) as per Appendix A, industry best practices, and relevant national and international standards (IRC, MoRTH, BIS, NHAI). The objective is to ensure comprehensive coverage, technical rigor, efficient resource utilization, and timely delivery of all project deliverables.

2. Overall Project Management and Leadership

The project will be led by a highly experienced Team Leader-cum-Senior Highway Engineer, who will be responsible for the overarching technical, administrative, and contractual aspects of the assignment.

Team Leader-cum-Senior Highway Engineer (Mr. Rajesh Kumar Patyal)

• **Overall Project Coordination:** Serve as the primary point of contact and lead liaison with the Client (NHAI) and other relevant stakeholders, including state government departments in Madhya Pradesh (e.g., PWD, Revenue, Forest, Utility agencies in Sagar district).

• **Strategic Direction & Technical Oversight:** Provide strategic guidance and comprehensive technical supervision to all team members, ensuring adherence to the project scope, methodology, and quality standards throughout the DPR preparation process.

• **Design and Viability Review:** Review and finalize tentative alignments, traffic forecasts, pavement design options, and structural designs, ensuring their technical, economic, and financial viability, considering the specific topography, geological conditions, and socio-economic context of Sagar district.

• **Quality Assurance & Compliance:** Implement and monitor the Quality Assurance Plan (QAP) for all field studies, investigations, designs, and documentation. Ensure strict compliance with IRC, MoRTH, BIS, and NHAI standards, as well as environmental and social safeguards.

• **Reporting & Deliverables:** Guide the preparation and finalization of all project reports, including the Inception Report, Feasibility Report, Draft DPR, Final DPR, and all associated technical documents and drawings.

• **Stakeholder Engagement:** Facilitate effective communication and coordination among various experts, sub-consultants, and client representatives to resolve issues and expedite decision-making.

• **Technical Assistance:** Provide technical assistance and clarifications during pre-bid meetings and post-concession award phases, including preparing interactive 3D virtual reality simulated environments for project visualization.

3. Key Professional Personnel Task Assignments

The following table details the specific task assignments for each key professional personnel:

Table 1: Key Professional Personnel Task Assignments

Position	Assigned Personnel	Key Responsibilities and Deliverables
Resident Project Manager	R.K. Patyal	Oversee and coordinate all activities carried out by Consultants in the Government's country, ensuring quality, adherence to scope, and compliance ...
Material-cum-Geotechnical Engineer-Geologist	Avik Kumar Mandal	• Finalize data format and requirements for field studies for sub-soil exploration for bridges, structures and embankments. • Plan field and labor...
Highway cum Pavement Engineer	Nabin Kumar Niyogi	• Conduct, coordinate, and analyze various highway and pavement engineering surveys and investigations, specifically focusing on the designated eco...
Senior Survey Engineer	Dilip Kumar De	• Formulate and coordinate all activities of topographical survey for the project corridor in Sagar district, utilizing modern surveying instrument...

Position	Assigned Personnel	Key Responsibilities and Deliverables
Quantity Surveyor / Documentation Expert	Manoj Kumar Sinha	• Prepare comprehensive Bill of Quantities (BoQ) and detailed project cost estimates, ensuring accuracy and adherence to project specifications and...
Environmental Specialist	Nagendra Kumar	• Organize and coordinate detailed environmental surveys along the project corridor in Sagar district, including baseline data collection for air, ...
Land Acquisition Expert	Sangram Singh	• Collect and verify land revenue maps (e.g., Khasra, Khatauni from Sagar district land records) and other essential land documents required for th...
Utility Expert	Parantapa Das	• Identify all existing utility lines, both underground and overhead, within the project corridor in Sagar district using non-intrusive technologie...
Financial Expert	(To Be Named)	• Prepare input data for financial analysis, and provide recommendations on financing structures and options. • Assess financial viability of the ...
Resettlement & Rehabilitation (R&R;) Specialist	(To Be Named)	• Assist in carrying out Social Impact Assessment (SIA) along the project corridor in Sagar district to identify affected communities, households, ...
Sub-Professional Staff		Supporting Functions:
• Carry out Pavement options study with life cycle cost analysis.	• Finalization of data format and requirements for field studies for sub-soil exploration for bridges, structures and embankments.	• Formulate and coordinate all activities of topographical survey.
• Identify sources of construction materials and determine their suitability.	• Planning of field and laboratory work for materials and geo-technical investigations.	• Check and Validate regularly the accuracy of all survey data and transfer the ground features on the drawings.

Position	Assigned Personnel	Key Responsibilities and Deliverables
• Verification of Quantities and preparation reports and documents.	• Carry out geo-technical investigations for structures, high embankment, and road pavement.	• Assist highway and CAD engineer in preparation of base maps.
• Carry out Economic Analysis (EIRR, NPV) for "with" and " without time and accident savings".	• Study & Interpreting geotechnical data and Recommend SBC of soil for Foundation & Embankment.	• Coordinate all activities in preparation of Land Acquisition Proposal.
• Assist in preparing EPC Bid Document.	• Design of Embankment, Hill cut, and R.E.Wall.	
	• Analyse & Recommend of Ground Improvement Measures in case of poor soil.	

4. Sub-Professional Personnel Task Assignments

The sub-professional staff will provide essential technical and administrative support, operating under the direct guidance and supervision of the respective key professional personnel. Their deployment will be flexible, based on specific project needs and activity schedules for the Sagar district corridor.

• **Project Coordinator (To be Named):**

• Monitor, guide, and support the Consultant’s team in successful completion of services.

• Review results of various surveys, investigations, and draft reports.

• Maintain constant liaison with the Client (NHAI).

• Ensure effective coordination of pre-construction activities until completion of the entire assignment.

• **Highway CAD-cum-Pavement Engineer (To be Named):**

• Prepare computerized designs and drawings for highway elements using CAD software (e.g., MXRoad, Civil 3D).

• Render assistance to the Highway Engineer and Team Leader in geometric design and pavement rehabilitation options.

• **Bridge Design Engineer (To be Named):**

• Prepare computerized bridge/structural designs and drawings.

• Render assistance to the Senior Bridge Engineer in all structural design activities.

• **Hydrologist-cum-Drainage Engineer (To be Named):**

• Assist the Bridge Engineer and Highway Engineer in the preparation of hydraulic designs for bridges (e.g., culverts, minor bridges over local streams in Sagar) and overall road drainage design (e.g., culverts, side drains, cross-drainage structures for effective water management in Sagar district).

• **Traffic Engineer (To be Named):**

• Carry out detailed traffic surveys (classified counts, OD surveys) and analysis under the guidance of the Traffic and Safety Expert for the Sagar corridor.

• Assist in traffic forecasting and identification of traffic management issues.

• **Financial Expert (To be Named):**

• Prepare input data for financial analysis and financial rate of return calculations.

• Assess financial viability of the project and contribute to documentation on financial analysis, including risk allocation matrices.

• Make recommendations on BOT concession packages, capital structure, and assist in evaluation of proposals for bidders.

• **Resettlement & Rehabilitation (R&R) Specialist (To be Named):**

• Carry out Social Impact Assessment including R&R framework.

• Carry out Public Consultation with communities, NGOs, and government agencies.

• Prepare Resettlement Action Plan (RAP).

• Prepare Land Acquisition Report, working closely with the Land Acquisition Expert for the Sagar district context.

• **Soil/Material Engineer (To be Named):**

• Conduct field and laboratory tests on soil and construction materials.

• Assist the Material-cum-Geotechnical Engineer in site investigations and data collection.

• **Pavement Engineer (To be Named):**

• Assist the Highway-cum-Pavement Engineer in pavement condition surveys, data collection, and analysis.

5. Team Composition and Manning Schedule

The following table summarizes the proposed key personnel, their respective roles, and estimated man-months for the duration of the project (11 months for DPR preparation). Sub-Professional staff man-months are typically assessed by the Consultant based on specific requirements and are often covered under a lump-sum arrangement for project flexibility.

Table 2: Key Personnel Manning Schedule Summary (for Lot-1/Madhya Pradesh/Package-3)

S.No.	Position	Assigned Personnel	Total Man-Months (mm)
1	Team Leader-cum-Senior Highway Engineer	R.K. Patyal	11.0
2	Senior Bridge Engineer	Sanjay Mandal	5.0
3	Highway-cum-Pavement Engineer	Nabin Kumar Niyogi	5.5
4	Material-cum-Geotechnical Engineer-Geologist	Avik Kumar Mandal	8.0
5	Senior Survey Engineer	Dilip Kumar De	5.0
6	Traffic and Safety Expert	B. Mallikarjuna Setty	7.0
7	Environmental Specialist	Nagendra Kumar	7.0
8	Quantity Surveyor/Documentation Expert	Manoj Kumar Sinha	8.0
9	Land Acquisition Expert	Sangram Singh	11.0
10	Utility Expert	Parantapa Das	4.0
Sub-Professional Staff			
11	Project Coordinator	(To be Named)	As per project requirement (LS)

S.No.	Position	Assigned Personnel	Total Man-Months (mm)
12	Highway CAD-cum-Pavement Engineer	(To be Named)	As per project requirement (LS)
13	Bridge Design Engineer	(To be Named)	As per project requirement (LS)
14	Hydrologist-cum-Drainage Engineer	(To be Named)	As per project requirement (LS)
15	Traffic Engineer	(To be Named)	As per project requirement (LS)
16	Financial Expert	(To be Named)	As per project requirement (LS)
17	Resettlement & Rehabilitation Specialist	(To be Named)	As per project requirement (LS)
18	Soil/Material Engineer	(To be Named)	As per project requirement (LS)
19	Pavement Engineer	(To be Named)	As per project requirement (LS)

Note: The man-months for "To be Named" sub-professional staff will be detailed in the Work Programme and deployed as per the specific requirements and approval of NHAI.

6. Quality Assurance and Compliance

The task assignments are integral to the firm's overarching Quality Assurance Plan (QAP), ensuring that each activity, from data collection to final report generation, undergoes rigorous checks and approvals. All personnel are mandated to follow established quality procedures, which include:

* Adherence to IRC, MoRTH, BIS, and NHAI codes and guidelines for all design and survey activities.

* Internal peer review processes for all critical deliverables.

* Regular progress meetings and technical reviews with the Team Leader and Client representatives.

* Documentation and record-keeping in accordance with ISO 9001:2015 standards and NHAI requirements.

This structured approach to task assignment and manning ensures a highly efficient, technically sound, and compliant delivery of the DPR for the Lot-1/Madhya Pradesh/Package-3 corridor, serving the strategic objectives of economic corridor development in Sagar district, Madhya Pradesh.

6.0 Proposed Cross Sections

The following detailed professional content outlines the approach and methodology for the 'Cross-Sections' component within the RFP inception report, ensuring adherence to the client's specifications, relevant industry standards, and best practices for the project in Sagar, Sagar district, Madhya Pradesh, India.

4.11.2.1 Cross-Sections

The precise determination of existing ground conditions through detailed cross-section surveys is fundamental to accurate highway design, geometric alignment, pavement composition, drainage provisions, utility relocation, and robust quantity estimation for the proposed project. This section details the methodology for conducting comprehensive cross-section surveys, data processing, and their application in the Detailed Project Report (DPR).

4.11.2.1.1 Objectives

The primary objectives of the cross-section surveys are to:

* Accurately map the existing ground profile, carriageway, shoulders, and adjacent terrain to facilitate geometric design, earthwork calculations, and profile correction courses.

* Provide detailed data for the design of all road components, including pavement layers, shoulders, medians, side slopes, and drainage systems.

* Identify and precisely locate all existing physical features and utilities within and adjacent to the Right-of-Way (ROW).

* Generate Digital Terrain Models (DTMs) for comprehensive design and analysis using advanced highway design software.

* Ensure compliance with project-specific requirements and relevant IRC/MoRTH standards, minimizing design discrepancies during execution.

4.11.2.1.2 Scope of Work (Referencing Client Input and TOR)

As per Clause 4.11.2.1 of the Terms of Reference (TOR) and additional client inputs, the scope of cross-section surveys shall include:

1. **Main Carriageway and Adjacent Ground:**

* Cross-sections shall be meticulously captured at **every 1-meter interval** along the final center line, extending to the full extent of the survey. This will involve collecting a sufficient number of spot levels on the existing carriageway and adjacent ground.

* At critical locations such as horizontal curves and intersections, cross-sections will be taken at **closer intervals** to capture geometric transitions accurately.

* This detailed data collection is crucial for precise profile correction course calculations and earthwork estimations.

2. **Cross Roads:**

* Longitudinal sections for all cross roads will be surveyed for a length adequate for design and quantity estimation purposes. This implicitly includes generating cross-sections for these intersecting roads.

3. **Major and Minor Streams/Drainage Channels:**

* Cross-sections of the channel at the site of the proposed crossing (for bridges, culverts) and a few cross-sections at suitable distances both upstream and downstream will be surveyed.

* These will cover bed levels up to the top of banks and ground levels to a sufficient distance beyond the edges of the channel.

* The nature of existing surface soil in the bed, banks, and approaches will be recorded.

* A longitudinal section of the channel, clearly showing the site of the bridge or crossing, will also be prepared. These surveys will adhere to the recommendations contained in **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 1—General Features of Design)**.

4. **Utility Services and Other Physical Features (Clause 4.11.2.2):**

* Details of all important physical features along the alignment, including buildings, structures, monuments, places of worship, railway lines, streams/rivers/canals, water mains, sewers, gas/oil pipes, trees, plantations, and utility services (electric and telephone lines - O/H & U/G, optical fiber cables (OFC)), will be collected.

* **Sub-surface utility mapping** will be undertaken using advanced technologies such as **Ground Penetrating Radar (GPR)** or **Induction Locators** to accurately map utilities up to a depth of 4m within the project ROW, differentiating between live electric cables, metallic utilities, and other features. This information will be processed into utility maps in PDF, JPEG, and AutoCAD formats.

5. **Drawing Presentation (Clause 10.7 ix):**

* While field data acquisition will be at 1m intervals for precision, cross-section drawings submitted as part of the Drawing Volume (Volume IX) will be presented at **50-meter intervals** along the alignment within the ROW. Detailed design and quantity estimation will, however, leverage the full 1m interval data.

4.11.2.1.3 Methodology for Data Collection

The survey methodology will employ advanced equipment and rigorous procedures to ensure high accuracy and comprehensive data capture.

1. **Control Establishment:**

* **Primary Control:** All surveys will be referenced to the Global Positioning System (GTS) datum. Primary control points (GTS-referenced Benchmarks) will be established by the Consultant and protected until the completion of Consultancy Services as per Clause 4.11.2 (i & ii).

* **Secondary Control:** High-Precision DGPS/RTK GPS will be utilized to establish a dense network of secondary control points and Temporary Benchmarks (TBMs) at regular intervals (e.g., 250m as per Clause 4.11.2.1). The TBMs will be made of RCC with RL and BM No. clearly marked.

* **Boundary Pillars:** Where the proposed alignment follows the existing alignment, boundary pillars will be fixed at 200m intervals on either side of the proposed ROW. For realignments or new bypasses, pillars will be fixed at 50m intervals along the extreme boundary of the proposed ROW, strictly as per **IRC:25:1967**.

2. **Instrumentation:**

* **Total Station:** High-accuracy Total Stations (with a precision of ± 2mm + 2ppm) will be used for precise horizontal and vertical measurements along the center line and offsets.

* **DGPS/RTK GPS:** Used for establishing control points and initial alignment surveys with sub-centimeter accuracy.

* **Auto Levels:** Digital auto levels will be used for accurate vertical control and spot height measurements, particularly for drainage and critical elevations.

* **Mobile LiDAR/Drone Photogrammetry (Optional/as needed):** For extensive areas or complex terrain, Mobile LiDAR or drone photogrammetry can be deployed to capture dense point cloud data, which can then be processed to generate highly detailed DTMs and extract cross-sections. This offers significant efficiency and accuracy benefits.

* **GPR/Induction Locator:** Dedicated equipment for sub-surface utility mapping.

3. **Field Procedures:**

* **Centerline Levels:** Longitudinal section levels will be taken at every 1-meter interval along the final center line, as well as at locations of curve points, small streams, intersections, and changes in elevation.

* **Offset Measurements:** Cross-sections will be extended laterally to cover the entire ROW plus adequate allowance for future widening, utility relocation, and drainage requirements (minimum 50m on either side or as dictated by terrain/features).

* **Spot Levels:** Sufficient spot levels will be recorded to accurately represent the existing carriageway profile (camber/superelevation), shoulders, ditches, embankment/cut slopes, natural ground variations, and significant changes in gradient or cross-fall.

* **Feature Mapping:** All visible physical features, existing structures, drainage elements, utility poles, trees, and property boundaries will be accurately mapped with their respective coordinates and attributes.

* **Data Consistency:** The field survey team will ensure consistency between longitudinal and cross-sectional data, especially at intersections and junctions.

4. **Data Processing and DTM Generation:**

* **Software:** Raw survey data will be electronically downloaded and processed using industry-standard highway design software such as **MXROAD, Civil 3D, or similar CADD platforms**.

* **DTM Creation:** A comprehensive Digital Terrain Model (DTM) will be generated from the processed point cloud data, forming the geometric basis for all subsequent design activities.

* **Contour Generation:** Contour plans will be generated from the DTM to visualize the existing terrain and identify critical areas.

* **Data Verification:** Rigorous checking and verification of triangulation points and editing of any omissions/erroneous outputs will be performed to ensure the DTM accurately represents the existing topography. Compatibility of the data with the chosen design software will be confirmed.

* **Utility Integration:** Data from sub-surface utility mapping will be integrated into the DTM and cross-section drawings to inform design decisions regarding utility relocation and protection.

4.11.2.1.4 Design and Analysis utilizing Cross-Sections

The detailed cross-section data forms the bedrock for various design and analysis components:

1. **Geometric Design (Clause 4.12.3):**

* **Typical Cross-Sections:** Development of typical cross-sectional elements for various road segments (e.g., 4-lane access-controlled, 6-lane urban, bypasses, service roads) including carriageway width, shoulder width, median (depressed/raised), side slopes, drainage, crash barriers, and utility corridors, as per **IRC:SP:84** or **IRC:SP:87** (as applicable) and **IRC:73**.

* **Cross-sectional Elements:** Provisions for pedestrian movements, suitable measures for surface and sub-surface drainage, and lighting will be integrated into urban road cross-sections (as per Clause 10.9).

* **Future Widening:** Typical cross-section drawings will indicate schemes for future carriageway widening, ensuring long-term planning (as per Clause 10.9).

2. **Pavement Design (Clause 4.12.4):**

* Cross-sections provide the baseline for designing pavement strengthening layers for existing roads and new pavement structures for widenings/bypasses, optimizing profile correction courses based on existing levels.

3. **Earthwork and Quantity Estimation:**

* The 1-meter interval cross-sections enable highly accurate calculation of earthwork quantities (cut, fill, borrow/spoil requirements) and profile correction course volumes using CADD software, contributing to reliable cost estimates.

4. **Drainage Design (Clause 4.12.7):**

* Detailed cross-sections are essential for designing roadside drainage systems, including locations of turnouts, outfall points, and special drainage provisions for super-elevated carriageways, high embankments, and cut sections. Integration with cross-drainage structures will be carefully planned.

5. **Utility Relocation (Clause 3.9 & 4.11.2.2):**

* Cross-sections, combined with sub-surface utility mapping, will form the basis for preparing detailed utility relocation plans, showing existing and proposed utility positions and estimating associated costs for submission to relevant authorities (as per Clause 3.9).

6. **Land Acquisition:**

* The delineated ROW and alignment on cross-sections will be used to accurately determine land acquisition requirements and prepare relevant schedules and draft notifications (3a, 3A, 3D, 3G) as per the NH Act or State Act (as per Clause 3.9).

4.11.2.1.5 Quality Assurance and Quality Control (QA/QC)

A stringent Quality Assurance Plan (QAP) will be implemented to ensure the accuracy and reliability of all cross-section data and derived designs.

1. **Field QA/QC:**

* Regular calibration and maintenance of all survey instruments.

* Independent check surveys by a senior survey engineer on a minimum of 10% of the cross-sections.

* Verification of spot levels and feature mapping against photographic records and visual inspections.

2. **Data Processing QA/QC:**

* Verification of DTM accuracy by generating spot heights and comparing with original field data.

* Consistency checks between cross-sections, longitudinal sections, and contour plans.

* Adherence to IRC:71 for all notations, abbreviations, and symbols used in reports and drawings.

3. **Design Integration:**

* Regular coordination meetings with geometric, pavement, structural, and environmental/social experts to ensure all design elements are harmoniously integrated into the cross-sections.

* Detailed review of all proposed typical and specific cross-sections to ensure compliance with design standards and project requirements.

4. **Penalty Clause Mitigation:**

* Given the Client's specific penalty for "inaccuracies in survey/investigation/design work" where "the cross sections do not match with existing ground" (Clause 7.3.1 ii), rigorous multi-stage checks and validations will be implemented to prevent any such discrepancies. This includes client review and approval at critical stages.

4.11.2.1.6 Relevant Standards and Guidelines

All activities related to cross-section surveys, design, and documentation will adhere to the latest guidelines and circulars of MoRT&H and relevant publications of the Indian Roads Congress (IRC) and Bureau of Indian Standards (BIS). Key standards include, but are not limited to:

• **IRC:SP:84** - Manual of Specifications & Standards for Four Laning of Highways

• **IRC:SP:87** - Manual of Specifications & Standards for Six Laning of Highways

• **IRC:73** - Geometric Design Standards for Rural (National and State) Highways

• **IRC:6** - Standard Specifications and Code of Practice for Road Bridges - Section II (Loads and Stresses)

• **IRC:13** - Guidelines for the Design of Small Bridges and Culverts

• **IRC:71** - Recommended Practice for Preparation of Highway Plans, Drawings & Reports

• **IRC:SP:19** - Manual for Survey, Investigation and Preparation of Road Projects

• **MoRT&H Specifications for Road & Bridge Works** (Latest Edition)

• **BIS Standards** as applicable for materials and construction.

7.0 Draft Design Standards

DESIGN STANDARDS

1.0 Introduction

This section outlines the foundational design standards, methodologies, and specifications to be adopted for the Detailed Project Report (DPR) preparation for the development of economic corridors, inter-corridors, and feeder routes in Sagar, Sagar district, Madhya Pradesh. The objective is to establish the technical, economic, and financial viability of the project and ensure the delivery of high-quality, implementable designs that align with the Client’s requirements and national/international best practices.

2.0 Governing Principles

The Consultants shall perform all services with utmost diligence, efficiency, and economy, adhering to generally accepted professional techniques and practices. Key guiding principles include:

• **Fidelity to Client's Interests:** Acting as faithful advisors, safeguarding the Client's legitimate interests in all dealings.

• **Compliance with Laws and Regulations:** Strict adherence to all Applicable Laws, including local customs as advised by the Client, and ensuring compliance by all sub-consultants and personnel.

• **Conflict of Interest:** Avoiding any personal benefit from commissions, discounts, or similar payments, ensuring sole remuneration is as per the contract.

• **Accuracy and Accountability:** Ensuring the accuracy and sufficiency of all designs and drawings, bearing full responsibility for any inaccuracies or deficiencies noticed during or after construction. A retention amount of 10% of the contract value will be held for design and quantity accuracy, released after civil works completion or 3 years, whichever is earlier, or upon substitution by a Bank Guarantee. Penalties will be imposed for significant variations in main quantities (>15%) or inaccuracies in survey/investigation/design work.

• **Value Engineering and Quality Assurance:** Incorporating value engineering, quality audit, and safety audit requirements throughout the design and implementation phases. Road safety audits are mandatory at various stages as per Supplement-III (Additional requirement for safety audit) of the TOR.

• **Optimal Project Delivery:** Focusing on the establishment of technical, economical, and financial viability through comprehensive analysis, detailed designs, and robust cost

estimates.

3.0 Applicable Codes and Standards

All activities related to field studies, design, and documentation shall be carried out in strict accordance with the latest guidelines, circulars, and publications of the Ministry of Road Transport & Highways (MoRT&H), Indian Roads Congress (IRC), and Bureau of Indian Standards (BIS). For any aspects not explicitly covered by these national standards, relevant international standards and practices, such as AASHTO, British Standards (BS), or other generally accepted international codes, may be adopted in consultation with and upon approval by the National Highways Authority of India (NHAI) during the inception phase.

3.1 General Standards:

• **MoRT&H Specifications:** Latest editions/revisions of MoRT&H Specifications for Road and Bridge Works, including all relevant circulars and guidelines issued periodically.

• **Indian Roads Congress (IRC) Codes:** A comprehensive suite of IRC codes, including but not limited to:

• **Geometric Design:** IRC:73, IRC:SP:23, IRC:38.

• **Pavement Design:** IRC:37 (Flexible Pavements), IRC:58 (Rigid Pavements), IRC:81-1997 (Benkelman Beam Deflection Technique, to be replaced by FWD as per TOR amendment), IRC:SP:19, IRC:SP:20.

• **Bridge Design:** IRC:5 (General Features of Design), IRC:6 (Standard Specifications and Code of Practice for Road Bridges - Section II: Loads and Stresses), IRC:18, IRC:21, IRC:22, IRC:78 (Foundation and Substructure), IRC:SP:13 (Small Bridges and Culverts), IRC:SP:35 (Bridge Maintenance & Rehabilitation), IRC:SP:37 (Load Carrying Capacity), IRC:SP:40 (Maintenance Management of Bridges).

• **Traffic Engineering:** IRC:SP:41-1994 (Traffic Surveys), IRC:102-1988 (Traffic Data Analysis and Forecast), IRC:SP:48, IRC:SP:55.

• **Surveying & Materials:** IRC:SP:19, IRC:25:1967 (Boundary Pillars).

• **Road Safety:** Relevant IRC codes and supplements for road safety audit requirements.

• **Bureau of Indian Standards (BIS) Codes:** Relevant BIS codes for materials, testing, construction practices, and structural design.

• **NHAI Directives:** All specific directives, circulars, and manuals issued by NHAI, particularly the draft manual being finalized for Bharatmala (Economic Corridors).

3.2 Hill Roads Specific Standards (If Applicable):

In the event that any stretch of the project in Sagar requires design considerations for hilly terrain, the following additional standards and practices shall apply as per Supplement I of the TOR:

• IRC/BIS for hill roads.

• For aspects not covered, international standards such as British and American Standards may be adopted.

• IRC:SP:91 for tunnels (if required).

3.3 Notations, Abbreviations, and Symbols:

All notations, abbreviations, and symbols used in the reports, documents, and drawings shall conform to IRC:71.

4.0 Key Design Considerations

The detailed design shall encompass all necessary elements to provide a comprehensive and "good for construction" DPR for the proposed development, which includes at least 4-lane access-controlled infrastructure, with potential for 6-laning in certain stretches.

4.1 Geometric Design:

• **Design Speed:** To be finalized in consultation with NHAI, considering the functional classification of the corridor (economic, inter-corridor, or feeder route) and terrain conditions in Sagar.

• **Alignment:** Detailed horizontal and longitudinal alignment design, considering existing Right-of-Way (ROW) constraints, minimizing land acquisition, and providing bypasses at congested urban locations or where improvement of existing roads is not feasible.

• **Cross-Sectional Elements:** Design of carriageways, paved/unpaved shoulders, medians, verges, refuge lanes (50m every 2km), service roads (especially in built-up areas or for slow/local traffic segregation), and provisions for pedestrian movements.

• **Intersections and Interchanges:** Design of at-grade junctions, grade-separated intersections, and interchanges based on traffic volume analysis, Level of Service (LOS), safety, and overall economy.

• **Sight Distance:** Verification of design for available sight distances as per standard norms, with appropriate markings and signs where adherence is not possible.

• **Black Spots:** Identification of accident-prone "black spots" from accident statistics and proposal of cost-effective remedial measures, considering geometric and pavement conditions.

4.2 Pavement Design:

• **Pavement Type:** Design alternatives shall include both flexible and rigid pavements. The most appropriate option will be established based on life-cycle costing and techno-economic considerations.

• **Design Inputs:** Pavement design inputs shall be derived from rigorous testing and evaluation of sub-grade soil (in-situ density, moisture, field CBR, lab CBR, Atterberg limits, grain size, moisture-density characteristics), material investigations, and traffic studies (axle loads, VDF, traffic growth).

• **Existing Pavement Strengthening:** Design for strengthening of existing road pavements and new pavement for additional lanes and bypasses, as required by traffic studies and life-cycle costing.

• **Material Utilization:** Maximum utilization of locally available materials. Mandatory consideration of fly-ash within 300 km from Thermal Power Stations, as per MoRT&H Gazette notification S.O.254 (E) dated 25.01.2016 and subsequent amendments. Assessment of industrial byproducts, recyclable, and waste materials.

4.3 Bridge and Structures Design:

• **Inventory and Assessment:** Detailed inventory of all existing bridges, culverts, ROBs, RUBs, and other grade-separated structures as per IRC:SP:35 and IRC:SP:13. Condition assessment, supplementary testing (IRC:SP:35, IRC:SP:40), and evaluation of load-carrying capacity (IRC-SP:37).

• **Hydraulic and Geotechnical Investigations:** Comprehensive hydraulic and hydrological studies as per IRC:SP:13 and IRC:5, including mathematical model studies for major bridges to finalize location, scour depth, training works, and hydraulic design. Geotechnical investigations and sub-soil explorations as per IRC:78, to determine strata properties, foundation depths, and bearing capacities. All geo-technical investigations shall be carried out through MoRT&H empanelled consultants.

• **Design and Drawings:** Preparation of General Arrangement Drawings (GADs) and detailed working drawings for all components of new and rehabilitated structures, including innovative and aesthetically pleasing designs. All ROB GADs will require approval from Indian Railways authorities.

• **Protection Works:** Design of suitable protection works and river training works wherever required.

• **Retaining Structures:** Design of RCC retaining walls or Reinforced Earth (RE) walls where land availability is inadequate for embankment slopes.

4.4 Drainage Design:

• **Roadside Drainage:** Design of an integrated roadside drainage system with cross-drainage structures for the entire project length.

• **Special Provisions:** Specific drainage provisions for super-elevated carriageways, high embankments, road segments in cuts, and urban areas.

• **Outfall Structures:** Detailed design showing locations of turnouts and outfall points with appropriate structures, provided in separate drawings for every 5 km stretch.

4.5 Traffic Safety Features and Road Furniture:

• **Safety Features:** Design of comprehensive traffic safety features including traffic signals, road signs, pavement markings, overhead signboards, crash barriers, and delineators.

• **Traffic Amenities:** Planning for traffic amenities such as rest areas, bus bays, vehicle parking areas, and weighing stations (approximately every 50 km, weighing stations possibly near toll plazas).

• **Construction Safety:** Development of a detailed plan for traffic management and safety during the construction period.

4.6 Environmental and Social Considerations:

• **Impact Assessment:** Detailed Environmental Impact Assessment (EIA) and Social Impact Assessment (SIA) in accordance with Government of India standards and, if applicable, the specific guidelines of lending agencies like ADB (Environmental Assessment Requirements, 1993) or World Bank.

• **Management Plans:** Preparation of comprehensive Environmental Management Plans (EMP) and Resettlement Action Plans (RAP), including mitigation measures, enhancement measures (e.g., roadside landscaping, water body enhancement, borrow area redevelopment), cost estimates for mitigation, and monitoring mechanisms.

• **Clearances and Liaison:** Assistance in obtaining all necessary forestry and environmental clearances from relevant authorities (SPCBs, MoEF) and liaison with concerned agencies.

4.7 Utility Integration and Management:

• **Subsurface Utility Mapping:** Comprehensive mapping of all subsurface utilities within the project ROW using Ground Penetrating Radar, Induction Locator, or equivalent technologies, ensuring accurate resolution up to a depth of 4m and differentiation of utility types (live electric cables, metallic, etc.).

• **Utility Relocation Plans:** Preparation of detailed Utility Relocation Plans (URP) and cost estimates.

• **Upgradation Policy:** Any proposed upgradation of existing utility infrastructure will strictly follow NHAI Policy No.11041/218/2007-Admn dated 19.09.2016, allowing for upgradation only if the existing infrastructure is obsolete per current technical standards or deemed necessary for essential safety.

5.0 Technical Specifications and Deliverables

5.1 Survey Standards:

• **Topographic Surveys:**

• **Technology:** Mobile LiDAR or equivalent for land-based surveys; Aerial Mobile LiDAR or equivalent for aerial-based surveys. Traditional methods (Total Station/Auto Level) for shadow areas.

• **Accuracy:** Land-based: Horizontal accuracy of 2 cm or better, vertical accuracy of 2 cm or better, >50 points per sq m. Aerial-based: Horizontal accuracy of 5 cm or better, vertical accuracy of 5 cm or better, >10 points per sq m.

• **Verification:** Check point surveys using DGPS (horizontal) and Auto Level (vertical) (minimum 25 check points or one every 4 km).

• **Coverage:** Minimum 30m beyond either side of the centerline or land boundary, extending to 100m at existing road crossings and suitably widened for bypasses/intersections.

• **Deliverables:** Raw DGPS data, point cloud data, 1:1000 topographic maps, 50cm contour maps, cross-sections at every 1m in .dwg format.

• **Traffic Surveys:** Adherence to IRC:SP:41-1994, IRC 102-1988, and specified classifications for various surveys (classified volume, O-D, turning movement, axle load, speed-delay, pedestrian/animal crossing, truck terminal surveys). Axle load surveys shall preferably use Falling Weight Deflectometer (FWD) as per IRC 115:2014 or IRC 117:2015, replacing the Benkelman Beam Deflection technique previously referenced.

5.2 Material Investigations:

• Detailed field and laboratory testing of all construction materials (soil, aggregates, binders) for suitability, quality, and quantity, adhering to MoRT&H and BIS specifications.

• Preparation of mass haul diagrams and quarry charts.

• Laboratory for material testing must be approved by NHAI.

5.3 Drawing and Documentation Standards:

• **Drawings:** All drawings shall be "good for construction" quality, prepared on A2 size sheets. Plan and profile drawings will be at a scale of 1:250V and 1:2500H, covering 1 km per sheet.

• **Content:** Drawings shall include details of Bench Marks (BM), Reference Pillars, Horizontal Intersection Points (HIP), Vertical Intersection Points (VIP), and coordinates referenced to a common datum (preferably GTS). They will also depict all traffic safety features, proposed widening schemes, median openings, service roads, drainage details, and urban provisions.

• **Soft Copies:** All final versions of documents, including strip plans, plan & profile drawings, cross-sections, and cost workings, shall be submitted in editable soft copy formats (.dwg, .dxf, MS Excel, or other compatible utility packages). Raw topographic data will be in (x, y, z) format.

6.0 Quality Assurance Plan (QAP)

The Consultants shall develop and implement a detailed Quality Assurance Plan (QAP) for all field studies (topographic, traffic, engineering, geotechnical, material), design activities, and documentation. The QAP shall be presented in separate sections for each activity type, detailing procedures for preparation, checking, approval, and filing of calculations and project documents. The detailed Draft QAP Document must be discussed and finalized with the concerned NHAI officers immediately upon contract award and submitted as part of the Inception Report. Commencement of any field work is contingent upon the approval of the QAP by NHAI.

7.0 Conclusion

The adherence to these detailed design standards and specifications is paramount to ensure the successful and professional execution of the project in Sagar, Madhya Pradesh. The Consultants are committed to continuous consultation with NHAI to finalize specific aspects, adopt best practices, and deliver a DPR that meets all technical, environmental, social, and economic objectives.

8.0 Work Programme

WORK PROGRAMME

1.0 Introduction

This Work Programme outlines the detailed approach and methodology that [Consultant Name] will adopt for the provision of Consultancy Services for the preparation of Detailed Project Report (DPR) for [Specific Project Name, e.g., Development of Economic Corridor for Lot-1/Madhya Pradesh/Package-3] in Sagar District, Madhya Pradesh. This document serves as a core component of the Inception Report, establishing a clear roadmap for project execution, ensuring adherence to the Terms of Reference (TOR), and facilitating effective collaboration with the National Highways Authority of India (NHAI) and other relevant stakeholders. Our commitment is to deliver a comprehensive, high-quality DPR within the stipulated timelines, ensuring accuracy and technical excellence as per national and international standards.

2.0 Project Objectives and Scope

The primary objective of this consultancy is to prepare a Detailed Project Report for the designated road stretch in Sagar District, Madhya Pradesh, to enhance the efficiency of freight movement and overall connectivity. The scope of services, as defined in the TOR (Appendix A), encompasses comprehensive studies, investigations, detailed engineering design, economic and financial analyses, environmental and social impact assessments, and preparation of bid documents for civil works. Our understanding is that the project will be executed in a phased manner, with continuous interaction with the client to ensure all requirements are met satisfactorily.

3.0 Project Stages and Key Deliverables

As per the TOR, the project preparation activities are structured into seven distinct stages. Payment eligibility for subsequent stages is contingent upon the satisfactory completion and approval of preceding stages. All reports, documents, and drawings will be submitted separately for each traffic-homogeneous link of the Project Road, where applicable.

The seven stages are:

* **Stage 1: Inception Report** (This Report)

* **Stage 2: Feasibility Report**

* **Stage 3: 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**

4.0 Overall Approach and Methodology

4.1 General Principles

Our approach is founded on the principles of:

* **Timeliness:** Close monitoring and diligent execution to ensure all assignments are completed as per the agreed work plan and schedule.

* **Quality Management:** Implementing a robust Quality Assurance Plan (QAP) to maintain high standards across all studies, designs, and documentation.

* **Risk Mitigation:** Proactive identification and mitigation of potential negative environmental and social impacts, adhering strictly to safeguard policies.

* **Innovation:** Application of advanced tools, technologies, and innovative solutions to optimize designs and project outcomes.

* **Client Collaboration:** Continuous interaction and seeking inputs from NHAI Project Director and Regional Officer at all stages of DPR preparation, including stakeholder consultations.

4.2 Phased Approach

The project will strictly adhere to the seven-stage methodology outlined in the TOR. We recognize that certain stages (Stage 3, 5, 6, and 7) are intended to run in parallel with Stage 2 and 4, and preliminary design work will commence without awaiting the full completion of the feasibility study, to expedite project delivery.

4.3 Quality Assurance

A comprehensive Quality Assurance Plan (QAP) document, covering all aspects of field studies, investigations, design, and economic/financial analysis, will be submitted as part of the Inception Report. This QAP will detail procedures for engineering surveys, traffic surveys, material/geotechnical investigations, road and pavement investigations, design of bridges and structures, environmental and R&R assessment, economic/financial analysis, and drawing/documentation preparation, checking, approval, and filing. Field and design activities will commence only after the QAP is approved by NHAI.

4.4 Adherence to Standards

All field studies, investigations, designs, and documentation will be executed in strict compliance with the latest guidelines and circulars of the Ministry of Road Transport & Highways (MoRT&H), relevant publications of the Indian Roads Congress (IRC), Bureau of Indian Standards (BIS), and National Highways Authority of India (NHAI). Where specific aspects are not covered by these national standards, international best practices (e.g., AASHTO guidelines) will be adopted, with proper referencing and prior approval from NHAI.

5.0 Detailed Activity Breakdown

5.1 Stage 1: Inception Report (Current Stage)

This report covers the initial appreciation of the project, detailing the consultant's proposed methodology and work plan. Key elements include:

* **Project Appreciation:** A detailed understanding of the project's context, challenges, and opportunities in Sagar District, Madhya Pradesh. This includes verifying any ongoing or envisaged development activities by other government agencies, which will be reported herein.

* **Detailed Methodology:** Finalized in consultation with NHAI officers, this includes scheduling of all sub-activities for timely completion of various work stages.

* **Task Assignment and Manning Schedule:** Refer to Appendix B for the detailed task assignments and manning schedule for all key and sub-professional personnel.

* **Work Programme:** The comprehensive work plan presented in this section, outlining activities and their timelines.

* **Proforma for Data Collection:** Submission of proposed data formats for field studies and investigations within 14 days of service commencement, for NHAI approval.

* **Design Standards and Proposed Cross-Sections:** Indicative design standards and typical cross-sections to be adopted.

* **Key Plan and Linear Plan:** Graphical representation of the project corridor, indicating key features and proposed widening schemes.

* **Development Plans Review:** Assessment of local body development plans and their potential impact on the project.

* **Quality Assurance Plan (QAP):** Submission of the finalized QAP for NHAI approval.

* **Draft Design Standards:** Initial proposal for design standards.

* **Alignment of Proposed Corridor / Bypasses:** Identification of bypass requirements and potential alignment options based on reconnaissance and traffic studies, with techno-economic considerations.

* **Unit Rate of Materials:** Initial assessment of unit rates for materials at source, carriage charges, labour rates, and machine charges.

* **Cost Estimates and Bill of Quantities (High-level initial):** Preliminary cost estimations and BoQ.

5.2 Stage 2: Feasibility Report

This stage focuses on detailed data analysis and preliminary design proposals.

* **Data Analysis and Design Proposals:** Based on extensive primary surveys and investigations.

* **Preliminary Designs:** Including General Arrangement Drawings (GAD) for structures.

* **Cost-Benefit Implications for Alternatives:** Evaluation of various alternatives for span arrangements and bridge types.

* **GAD Approval:** Obtaining approval for GAD from NHAI, Indian Railways, and other statutory authorities as required.

5.3 Stage 3: LA & Clearances I Report

Concurrent with the Feasibility Report, this stage focuses on initial land acquisition and clearances.

* **Land Acquisition Plan (LAP):** Preparation of kilometre-wise LAP, ownership details, and costs based on revenue authorities and realistic rates. This will be prepared after digitization of cadastral/land revenue maps, ensuring high accuracy (1mm or higher in 1:2000 scale map, translating to 1m or higher on ground).

* **Utility Relocation Plan (URP):** Strip plans showing existing and proposed positions of utility services (over- and underground), along with relocation schemes and costs, developed in consultation with relevant local authorities.

* **Environment and Forest Clearances (Initial):** Identification of requirements for environment and forest clearances and initiation of the application process.

5.4 Stage 4: Detailed Project Report (DPR)

This is the most comprehensive stage, culminating in the final detailed design and tender documents.

* **Detailed Design of Road, Structures, Drainage:** Detailed geometric design, pavement design (flexible/rigid), design of bridges (main bridges, ROBs, RUBs), cross-drainage structures, underpasses, intersections, complete drainage system, and protective/river training works. All designs will be fully checked by Senior Engineers and signed by Designer, Senior Checking Engineer, and Senior Bridge/Structure Expert for structures.

* **Value Engineering:** Application of value analysis/value engineering principles to optimize project solutions.

* **Economic and Financial Analyses:** Comprehensive analyses including viability assessment, risk assessment, and financing options (e.g., BOT format), for traffic-homogeneous links.

* **Contract Packaging:** Finalization of contract packages and implementation schedule.

* **Detailed Cost Estimates, BOQ, Rate Analysis:** Preparation of detailed quantities and project costs for civil work packages, based on MoRT&H’s Standard Data Book and market rates. Unit rate analysis will consider manpower, machinery, and materials.

* **Toll Plaza, Weighing Stations, Parking & Rest Areas:** Design and location identification for user-oriented facilities.

* **Social and Environmental Plans:** Preparation of social plans (Resettlement Action Plan - RAP) and Environmental Management Plan (EMP) as per relevant policies (lending agencies/Govt. of India R&R Policy, ADB/World Bank/NHAI requirements).

5.5 Stage 5: Technical Schedules

This stage involves the preparation of civil work contract agreements.

* **Civil Work Contract Agreement:** Submission of a comprehensive civil works contract agreement.

5.6 Stage 6: Draft 3D Publication Report

This stage focuses on land acquisition-related documentation based on detailed surveys.

* **Draft 3D Publication Report:** Prepared based on actual land requirements, detailed field surveys, and discussions with the revenue department, including joint site visits. This report will include legible maps showing Khasra No., area, distinguishable features, district/village names, and highway alignment, targeting 90% length for 3(D) notification.

5.7 Stage 7: Clearances II Report

This final stage involves obtaining all necessary statutory clearances.

* **Final Approvals:** Securing final environment, forest, wildlife clearances from MOEF, railway approvals for ROB/RUBs, irrigation department approvals, and any other concerned agencies. Liaison with utility-owning agencies for estimates and clearances as per NHAI policy circulars.

6.0 Surveying, Data Collection & Analysis Methodology

Our methodology integrates robust primary field investigations with thorough secondary data review, ensuring a comprehensive understanding of the project corridor in Sagar District.

6.1 Secondary Data Collection

Relevant data will be collected from various departments/offices, including MoRT&H, PWD, Revenue Department, Forest Department, and local municipal bodies. This includes:

* Existing survey maps, previous study reports, Detailed Standard Rate (DSR) documents.

* Regular traffic count data, Origin-Destination (O-D) data.

* Material sources and lead distance maps.

* Existing bridge details, as-built drawings.

* Designed High Flood Level (HFL) data.

* Available bore-log details.

* Development plans being implemented or proposed by local bodies.

6.2 Primary Field Data Collection

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

6.2.1 Traffic Surveys

* **Classified Traffic Volume Count:** Using ATCC systems or equivalent technologies, covering 3 survey stations (indicative). ATCC systems will meet accuracy levels of >95% for classification and >98% for counting (after validation).

* **Origin-Destination and Commodity Movement Characteristics:** Conducted at 2 survey stations (indicative).

* **Axle Loading Characteristics:** Carried out at 2 suitable locations (indicative) using axle load pads or sophisticated instruments for 2 normal days (24 hours), primarily for trucks. VDF for each truck type will be calculated.

* **Intersection Volume Count:** At all major intersections.

* **Speed-Delay Characteristics:** As needed.

* **Pedestrian/Animal Cross Traffic Count:** At all major habitations along the highway.

* **Traffic Demand Estimates:** Developed for a 30-year period from project completion, assuming optimistic, pessimistic, and most likely growth scenarios, with five-yearly intervals. Impact of toll charges, generated, induced, and diverted traffic will be estimated using sound forecasting techniques. Methodology will align with IRC:SP:41-1994.

6.2.2 Topographic Surveys

* **Detailed Topographic Survey:** Employing Mobile/Aerial LiDAR or equivalent technology to capture essential ground features for improvements, rehabilitation, and new construction. Accuracy levels for these technologies will meet project requirements.

* **Reconnaissance Surveys:** Initial field visits to identify key features, possible alignment improvements, bypassing congested locations, and planning detailed surveys. Data will be documented in the Inception Report, forming the core database.

* **Survey Control Points:** Established and protected by the Consultants until completion of services.

6.2.3 Road and Pavement Investigations

* **Road Inventory Surveys:** Detailed collection of existing road features (terrain, land-use, carriageway width, surfacing type, shoulder type/width, sub-grade/soil type, horizontal/vertical curves, intersections, structures, water bodies, embankment/cut height, land width, ROW, arboriculture, utility services, drainage, design speed). Data will be compiled in tabular and graphical forms, suitable for input into HDM-IV.

* **Pavement Condition Surveys:** Visual condition surveys, identification of distress types, severity, and extent.

* **Pavement Roughness Survey:** Using equipment compliant with IRC:SP-16.

* **Pavement Structural Strength Surveys:** Using Falling Weight Deflectometer (FWD) in accordance with IRC 115:2014 or IRC 117:2015, as applicable.

* **Test Pits:** Excavated at specified intervals to determine pavement composition, material type, and thickness, allowing for correlation studies with deflection data.

* **Sub-grade Characteristics and Strength:** Investigations to determine required sub-grade and sub-soil characteristics and strength for road and embankment design.

6.2.4 Geotechnical and Sub-Soil Investigations

* **Boreholes:** Dug for every pier and abutment of major and minor bridges, ROBs/RUBs, flyovers, and underpasses, as per IRC:78.

* **Field Testing, Soil Sampling, Laboratory Testing:** Conducted in accordance with BIS/AASHTO/BS standards.

* **Substrata Analysis:** Detailed analysis to ensure accurate understanding of ground conditions for foundation design and slope stability.

* **Identification of Material Sources:** Locating suitable sources for construction materials (e.g., earth, aggregates, sand).

6.2.5 Hydraulic and Hydrological Surveys

* **Investigations:** As per IRC:SP:13 and IRC:5.

* **High Flood Level (HFL):** Determination of HFL and design discharge for all bridges and drainage structures.

* **Foundation Type and Depth:** Recommendation of appropriate foundation types and depths based on hydraulic and geotechnical data.

6.2.6 Utility Clearances

* **Identification of Utilities:** Overground and underground utilities will be identified using GPR (Ground Penetrating Radar), Induction Locator, or equivalent technologies, particularly within the existing Right-of-Way (ROW).

* **Consultation:** Detailed consultation with local authorities and utility-owning agencies.

6.2.7 Environmental and Social Impact Assessment Surveys

* **Baseline Data Collection:** Primary and secondary data on existing environment (air, water, noise, ecology, cultural properties, natural habitats) and socio-economic conditions.

* **Impact Assessment:** Identification and categorization of potential impacts (pre-construction, construction, operation).

* **Public Consultation:** Engagement with communities, NGOs, and government departments at various stages.

* **Entitlement Matrix:** Development for project-affected persons (PAPs).

* **Social Issues:** Assessment of indigenous people, gender, HIV/AIDS, and labour issues.

6.3 Data Analysis and Processing

All collected data will be systematically analyzed using appropriate software (e.g., MX Road, Civil 3D, Softdesk for geometric design; STAAD Pro, RIM for structural design; HDM-4 for economic/pavement analysis; HED and X-Table for geotechnical analysis; EMME/3, EMMES for traffic modeling) and established engineering principles. The analysis will form the basis for design proposals, quantity estimation, and cost projections. All data and processed results, including drawings, will be submitted to NHAI in floppy diskettes/CDs in widely used utility packages (e.g., MS Excel) at the time of final report submission.

7.0 Reporting Obligations and Submission Schedule

The Consultant will submit all reports, documents, and drawings in bound volumes (not spiral binding), along with soft copies on floppy-diskettes/CDs, as per the schedule below. Strict adherence to this schedule is paramount. Monthly Progress Reports (3 copies) will be submitted by the 5th day of the following month.

S. No.	Deliverable	No. of Copies	Submission Timeline
1.	Monthly Reports	3 (hard)	By 5th day of every month
2.	Inception Report		
(i)	Draft Inception Report including QAP document	5 (hard)	Within 15 days from commencement
(ii)	Inception Report including QAP document (incorporating client comments)	10 (hard) + soft	Within 30 days from commencement
3.	Feasibility Study Report		

S. No.	Deliverable	No. of Copies	Submission Timeline
(i)	Draft Feasibility Study Report (including option study report & draft 3(a) report)	5 (hard)	As per TOR schedule
(ii)	Final Feasibility Study Report (incorporating compliance of client comments)	10 (hard) + soft	Within 15 days of client comments receipt
4.	LA & Clearances I Report		
(i)	Draft LA & Clearances I Report (including draft 3(A) report)	5 (hard)	As per TOR schedule
(ii)	Final LA & Clearances I Report (incorporating compliance of client comments)	10 (hard) + soft	Within 15 days of client comments receipt
5.	Detailed Project Report (DPR)		
(i)	Draft DPR	5 (hard)	As per TOR schedule
(ii)	Final DPR (incorporating compliance of client comments, with Bill of Quantities, Cost Estimates, Updated Drawings etc.)	10 (hard) + soft	Within 15 days of client comments receipt
6.	Technical Schedules		
(i)	Draft Technical Schedules	5 (hard)	As per TOR schedule
(ii)	Final Technical Schedule (incorporating compliance of client comments)	10 (hard) + soft	Within 15 days of client comments receipt
7.	Draft 3D Publication Report	5 (hard)	As per TOR schedule

S. No.	Deliverable	No. of Copies	Submission Timeline
8.	Clearances II Report (Original approvals from MOEF, Rly, Irrigation Dept. etc. + 5 photocopies of each)	Original + 5 (hard) + soft	As per TOR schedule

Note: The specific submission timelines for stages 3-8 will be detailed in the comprehensive work plan as part of this Inception Report.

8.0 Coordination and Client Interaction

[Consultant Name] understands the critical importance of continuous coordination with NHAI.

* **Regular Meetings:** Frequent meetings with NHAI officers (Project Director, Regional Officer) are foreseen at the site office or in Delhi.

* **Activity Intimation:** Prior intimation will be given to NHAI regarding the start of key activities such as boring, surveys, etc., to facilitate timely inspections by NHAI officials.

* **PIMS System:** Data will be regularly submitted through NHAI's PIMS system for progress monitoring. The Team Leader will update NHAI weekly on activities.

* **Stakeholder Consultation:** Necessary stakeholder consultations will be carried out at appropriate stages to gather inputs and address concerns.

* **Proof Consultant:** We acknowledge that NHAI may appoint a Proof Consultant to supervise the DPR consultant's work, and we will fully cooperate with such arrangements.

9.0 Resource Deployment

The project team, comprising qualified and experienced key and sub-professional personnel, is fully committed to this assignment. Detailed information regarding the proposed team, their specific task assignments, and manning schedule is provided in **Appendix B: Consultants' Sub-Consultants' Key Personnel and Sub Professional Personnel, Task Assignment, Work Programme, Manning Schedule, Qualification Requirements of Key Personnel, Schedule for Submission of various Reports**.

Our Material Testing Laboratory, located within 400 km of the project site in Sagar, Madhya Pradesh, will be utilized for all necessary material testing. Should additional surveys be required beyond our in-house team's capacity, a pre-approved, credentialed agency will be engaged with NHAI's prior approval.

9.0 Development

3.0 PROJECT DEVELOPMENT STRATEGY AND METHODOLOGY

This section outlines the comprehensive strategy and detailed methodology to be employed for the development phase of the proposed highway infrastructure project in Sagar district, Madhya Pradesh. It encompasses all critical aspects from initial surveys and investigations through detailed design, environmental and social impact assessments, economic and financial analysis, culminating in the preparation of bid documents, all in strict adherence to relevant national and international standards.

3.1 Overview and Project Understanding

The primary objective of this project development phase is to deliver a robust and implementable Detailed Project Report (DPR) that ensures efficient freight movement, incorporates value engineering, and adheres to stringent quality and safety standards. The proposed approach is multidisciplinary, leveraging expertise in highway engineering, bridge design, pavement technology, traffic and safety management, geotechnical engineering, environmental and social safeguards, quantity surveying, and Computer-Aided Design (CAD).

3.2 Phased Approach to Project Development

The project development will be executed through a structured, phased approach as defined in the Request for Proposal (RFP) and Terms of Reference (TOR). This ensures systematic progression, timely deliverables, and integrated decision-making. The phases are:

• **Stage 1: Inception Report:** Detailed understanding of TOR, refined work plan, resource mobilization, and Quality Assurance Plan (QAP).

• **Stage 2: Feasibility Report:** Initial techno-economic evaluation, preliminary designs, and identification of preferred alignment and implementation mode.

• **Stage 3: Land Acquisition (LA) & Clearances I Report:** Initial land acquisition requirements and preliminary clearance activities.

• **Stage 4: Detailed Project Report (DPR):** Comprehensive engineering designs, specifications, cost estimates, and bid documentation.

• **Stage 5: Technical Schedules:** Detailed technical schedules for civil works contracts.

• **Stage 6: Draft 3D Publication Report:** Preparation of draft notifications for land acquisition.

• **Stage 7: Clearances II Report:** Finalization of all statutory and project-specific clearances.

Continuous interaction with the National Highways Authority of India (NHAI) Project Director and Regional Officer, along with key stakeholders, will be maintained throughout these stages to ensure alignment and facilitate approvals.

3.3 Methodology for Data Collection and Analysis

The consultant's methodology integrates both secondary data review and extensive primary field investigations, followed by rigorous analysis using advanced tools and software.

3.3.1 Secondary Data Collection and Review

All available reports, published information, and existing data pertaining to the project road and its influence area in Sagar district will be thoroughly reviewed. This includes:

* Existing survey maps, previous study reports, Detailed Schedule of Rates (DSR).

* Historical traffic count data, Origin-Destination (O-D) surveys, material sources and lead maps.

* Existing bridge and cross-drainage structure details, as-built drawings.

* Designed High Flood Levels (HFLs), and previous bore-log data.

* Review of development plans being implemented or proposed by local bodies in Sagar district and their potential impact on the project.

3.3.2 Primary Field Investigations and Surveys

A dedicated multidisciplinary team, under the direct supervision of the Team Leader and respective Key Personnel, will conduct comprehensive field investigations. These surveys are crucial for acquiring accurate baseline data essential for detailed engineering and impact assessments. The key primary surveys include:

• **Traffic Surveys & Demand Forecasting:**

• **Methodology:** Comprehensive classified traffic volume counts, turning movement surveys at identified intersections, Origin-Destination (O-D) surveys, speed-delay studies, and public transport usage surveys. Survey locations and durations will be finalized in consultation with NHAI officials. (Reference: IRC:SP:41-1994).

• **Analysis:** Data will be analyzed to forecast traffic demand for the next thirty (30) years, including Passenger Car Units (PCU) and Commercial Vehicle Units (CVU). Identification of intersections requiring special treatments (e.g., grade separation) will be a key output.

• **Axle Load Surveys:**

• **Methodology:** Axle load surveys will be conducted in both directions at suitable, representative locations within the project stretch of Sagar district for two (2) normal days (24 hours each) on a random sample basis, primarily for trucks (empty and loaded). A limited number of buses may also be weighed to understand loading behaviour. Axle load pads or other sophisticated instruments will be used. (Reference: IRC:SP:19).

• **Analysis:** Axle load data will be collected axle configuration-wise to calculate the Vehicle Damage Factor (VDF) for each truck type. National average VDF will be adopted if calculated VDF is found below it.

• **Road Inventory & Condition Surveys:**

• **Methodology:** Detailed road inventory surveys will collect data on all existing road and pavement features along the corridor at every 500m or at every change of feature, whichever is earlier. (Reference: IRC:SP:41-1994).

• **Data Points:** Terrain (flat, rolling, mountainous), land-use (agricultural, commercial, forest, residential), carriageway/shoulder width and surfacing type, sub-grade/local soil type, horizontal/vertical curves, road intersections, retaining structures, water bodies, embankment/cut depth, land width, Right-of-Way (ROW), culverts, bridges and other structures, roadside arboriculture, general drainage conditions, and design speed of the existing road.

• **Output:** Compiled data in tabular and graphical forms, stored in computer files (e.g., MS Excel).

• **Pavement Investigations:**

• **Methodology:** Detailed field studies including Benkelman Beam Deflection (BBD) tests, Dynamic Cone Penetrometer (DCP) tests, and test pits for assessing existing pavement strength and sub-grade characteristics.

• **Analysis:** Data will be sufficient to meet the input requirements of HDM-IV software for pavement performance evaluation.

• **Geotechnical and Sub-soil Investigations:**

• **Methodology:** Comprehensive sub-soil investigations (boring at regular intervals and at all major structure locations) will be undertaken.

• **Analysis:** Laboratory testing of soil samples to determine characteristics and strength parameters for road and embankment design, as well as foundation design for bridges and structures.

• **Material Source Identification:**

• **Methodology:** Reconnaissance and detailed surveys to identify potential sources of construction materials (e.g., aggregates, borrow earth).

• **Analysis:** Sampling and testing of materials to confirm their suitability and availability.

• **Topographic Surveys:**

• **Methodology:** Detailed topographic surveys utilizing Mobile/Aerial LiDAR or equivalent advanced technology for high-accuracy data acquisition.

• **Output:** Digital Terrain Models (DTM) and other topographic data will be provided in (x, y, z) format for direct import into standard highway design software.

• **Utility Identification & Relocation Surveys:**

• **Methodology:** Ground Penetrating Radar (GPR) and Induction Locator or equivalent technologies will be employed to identify all existing overground and underground utility services within the proposed corridor.

• **Output:** Kilometre-wise Utility Relocation Plans (URP) indicating the scheme for their relocation and associated cost estimates. (Reference: NHAI Policy Circular No. Technical 2135/2016).

3.4 Design Development

The design phase involves meticulous engineering to produce 'good for construction' drawings and comprehensive documentation.

3.4.1 Geometric Design

* **Alignment Design:** Review of existing alignment, identification of possible improvements, and bypassing congested locations in Sagar district with alternative proposals. Evaluation of alternatives based on techno-economic and other considerations, recommending the most appropriate option. Widening/improvement work shall, as far as possible, be within the existing Right-of-Way (RoW), avoiding land acquisition except for inadequate width, short bypasses, service roads, alignment corrections, and intersection improvements.

* **Horizontal and Vertical Alignment:** Detailed design will incorporate suitable horizontal and vertical alignments, super-elevation, and sight distances for the intended design speed, considering hilly terrain aspects as necessary for Madhya Pradesh.

* **Cross-sections:** Preparation of detailed cross-sections for various road types (e.g., main carriageway, service roads, bypasses, embankments). Detailed design of embankments, particularly those exceeding 6m in height or in poor soil conditions, will be conducted.

3.4.2 Pavement Design

* **Existing Pavement Strengthening:** Design for strengthening of existing road pavements based on traffic studies, remaining life analysis, and pavement investigations.

* **New Pavement Design:** Design of new pavement for widening, bypasses, and new sections.

* **Pavement Options:** Evaluation of both rigid and flexible pavement options will be conducted. The most appropriate design will be established through a rigorous life-cycle costing and techno-economic analysis.

* **Shoulders:** Design of appropriate shoulders (paved/unpaved) commensurate with the main carriageway. (Reference: IRC publications, latest Indian and International practices).

3.4.3 Bridge and Cross-Drainage Structures Design

* **Preliminary Design (GAD):** Preparation of preliminary General Arrangement Drawings (GAD) for all major bridges, minor bridges, culverts, underpasses, and grade-separated structures. Alternatives for span arrangement and bridge type will be submitted to NHAI for approval.

* **Detailed Design:** Post-GAD approval, detailed designs as per IRC codes/guidelines will be developed for all components of bridges and structures, including substructure, superstructure, and foundations.

* **Railway Over Bridges (ROB) / Railway Under Bridges (RUB):** Identification of all at-grade level crossings for ROB/RUB provision. Preliminary GADs will be prepared and pursued for approval from Indian Railways Authorities.

* **Protection/River Training Works:** Design of suitable protection works and/or river training works will be furnished wherever required.

* **Existing Structures:** Dismantling/reconstruction of existing structures will be minimized, undertaken only if essential due to poor structural condition or inadequacy. Widening/reconstruction of existing structures with inadequate carriageway width will follow MoRT&H guidelines.

3.4.4 Intersection Design

* Identification of appropriate types and designs for intersections, including at-grade junctions, underpasses, flyovers, and interchanges. Designs will consider site conditions, turning movement characteristics, desired level of service, overall economy, and operational safety. Grade-separated pedestrian crossings (viaducts) will be designed for large cross-traffic of pedestrians/animals.

3.4.5 Drainage System Design

* Design of a complete and efficient drainage system, including roadside drains, cross drains, and appropriate disposal points for storm water, to ensure road longevity and minimize environmental impact.

3.4.6 Ancillary Facilities Design

* **Toll Plaza:** Identification of possible toll plaza location(s) based on traffic studies and physical features, designed as per IRC:84, ensuring efficient toll collection and operational economy.

* **Weighing Stations, Parking & Rest Areas:** Selection of suitable sites and preparation of separate designs for weighing stations, parking areas, and rest areas (planned at approximately 50 km intervals). Common facilities like petrol pumps, first-aid medical facilities, police offices, restaurants, and vehicle parking will be included in the general layout plan. (Reference: OISD guidelines for petrol pumps).

* **Miscellaneous Works:** Design and layout for bus bays, telecommunication facilities, and other user-oriented facilities.

* **Service Roads:** Provision of parallel service roads in urbanized locations and other areas to segregate local and slow traffic from main traffic, wherever necessary, to improve efficiency and safety.

3.4.7 Arboriculture and Landscaping

* Development of an appropriate plan for planting of trees (specifying type of plantation), horticulture, and floriculture on surplus land within the RoW to enhance the highway's aesthetics and environment. Retention and transplantation of existing trees will be prioritized.

3.4.8 Traffic Management and Safety during Construction

* Preparation of a detailed plan for traffic management and ensuring safety during the construction period, to minimize disruption and hazards to road users and workers.

3.5 Environmental and Social Impact Assessments (ESIA)

The ESIA studies will be conducted to meet the requirements of both the Government of India (MoRTH/NHAI) and international lending agencies such as ADB/World Bank/JICA, as applicable.

3.5.1 Environmental Impact Assessment (EIA) & Management Plan (EMP)

* **Screening & Baseline:** Preliminary environmental screening to assess direct/induced impacts and document baseline conditions (air, water, noise, ecology, cultural properties, natural habitats).

* **Impact Assessment & Mitigation:** Assessment of potential significant impacts and identification of mitigation measures.

* **Alternatives Analysis:** Analysis of alternatives incorporating environmental concerns, including 'with and without' scenarios and design modifications.

* **Enhancement Measures:** Special attention to environmental enhancement measures (cultural property, bus bays, landscape, water bodies, redevelopment of borrow areas).

* **Reporting & BOQ:** Preparation of Environmental Impact Assessment (EIA) reports, Environmental Management Plans (EMP) including Bill of Quantities (BoQ) and technical specifications for mitigation works.

* **Clearances:** Preparation of application forms and liaison with State Pollution Control Boards (SPCBs) and Ministry of Environment, Forest and Climate Change (MoEFCC) for necessary environmental and forest clearances. Consultant will also present the project to the MoEFCC Infrastructure Committee if required.

3.5.2 Rehabilitation & Resettlement (R&R) Studies & Action Plan (RAP)

* **Impact Assessment:** Assessment of the project's impact on poor and vulnerable groups along the corridor.

* **Entitlement Matrix:** Development of an entitlement matrix for project-affected persons (PAPs) based on identified impacts, census, and survey results.

* **Social Issues:** Assessment of social issues such as indigenous people, gender, HIV/AIDS, and labor (including child labor).

* **Implementation & Monitoring:** Preparation of implementation budgets, funding sources, schedules, responsibility matrices, institutional arrangements, and personnel for entitlement delivery. Development of internal and external monitoring plans, key monitoring indicators, and a grievance redress mechanism.

* **Reporting:** Preparation of standalone Resettlement Action Plans (RAP) in accordance with applicable guidelines.

3.5.3 Statutory Clearances

* The consultant will be responsible for obtaining all necessary project-related clearances. This includes:

* **Environmental & Forest:** Final environmental, forest, and wildlife clearances from MoEFCC.

* **Railways:** Approvals from Indian Railways for GADs and detailed engineering drawings of ROBs/RUBs.

* **Irrigation/Waterway:** Approvals from concerned Irrigation/Waterway Authorities for structures across channels.

* **Utility Shifting:** Obtaining approvals and estimates for shifting of all types of utilities from concerned authorities and competent authority within MoRTH and its implementation agencies.

* **Land Acquisition:** Preparation of all Land Acquisition papers (draft 3a, 3A, 3D, and 3G notifications as per the L.A. Act) for land acquisition under the NH Act or State Act.

3.6 Economic and Financial Analysis

3.6.1 Value Analysis/Value Engineering

* Incorporation of value engineering and value analysis during project preparation to optimize design, construction, and operational costs while maintaining or enhancing project functionality and quality.

3.6.2 Estimation of Quantities and Project Costs

* **Detailed Estimates:** Preparation of detailed estimates for quantities (considering designs and mass haul diagrams) and total project cost for the entire project, broken down by civil packages. This will include the cost of environmental and social safeguards.

* **Rate Analysis:** Detailed analysis for computing unit rates for different work items, considering various inputs (manpower, machinery, materials), basic rates, and lead distances for mechanized construction.

* **Benchmarking:** Project cost estimates will be cross-checked against rates for similar ongoing works under NHAI/World Bank/ADB financed road sector projects in India. (Reference: MoRT&H's Standard Data Book and prevailing market rates).

3.6.3 Viability and Financing Options

* **Financial Analysis:** Comprehensive financial analysis covering identification, assessment, and mitigation measures for all project-associated risks (e.g., construction delays, cost overruns, traffic volume, revenue shortfalls, operating costs).

* **Implementation Mode:** Clear identification of the preferred mode of implementation (BOT, Annuity, Hybrid Annuity, EPC) based on financial analysis.

* **Bid Documents:** Preparation of separate Bid Documents for both BoT and EPC contracts at the feasibility/DPR stage, guided by Model Concession/Contract Agreements for PPP/EPC projects and IRC Manual of Specifications and Standards (IRC:SP:84 or IRC:SP:87).

* **Consultant Support during Bidding:** Provision of support during the bid process, including responding to technical queries, participation in pre-bid conferences, meetings, and site visits, with senior team members ensuring presence.

3.7 Quality Assurance and Safety Integration

• **Quality Audit:** Integration of quality audit requirements in design and implementation stages to ensure adherence to specifications and standards.

• **Safety Audit:** Road safety audits will be carried out at various stages of project development as per Supplement-III (Additional requirement for safety audit) of the TOR, ensuring safety aspects are embedded in design. This includes auditing alignment, junctions, provisions for non-motorized users, signs, lighting, and buildability.

• **Quality Assurance Plan (QAP):** Development and implementation of a comprehensive QAP to govern all aspects of surveys, investigations, designs, and reporting.

3.8 Standards and Codes of Practice

All project development activities, including surveys, investigations, designs, and report preparation, will strictly conform to the latest editions of relevant national and international standards and codes of practice. These include, but are not limited to:

• **Indian Roads Congress (IRC) Codes:** For geometric design, pavement design, bridge design, traffic studies, and other highway appurtenances (e.g., IRC:SP:41-1994 for surveys, IRC:SP:19 for axle load, IRC:84 for toll plaza design, IRC:SP:84/87 for highway laning).

• **Ministry of Road Transport & Highways (MoRTH) Specifications:** For road and bridge works, standard data book, and guidelines.

• **Bureau of Indian Standards (BIS):** For material specifications and construction practices.

• **National Highways Authority of India (NHAI) Guidelines:** All specific policies, circulars, and manuals issued by NHAI.

• **International Best Practices:** HDM-IV for pavement design, and relevant environmental and social guidelines from ADB/World Bank/JICA, where applicable.

3.9 Deliverables and Coordination

Regular reports and documents will be submitted as per the prescribed schedule and format (bound volumes and soft copies) for each stage of work. Key deliverables from the development stages include:

• **Feasibility Report:** Incorporating alternative studies, preliminary designs, and financial analysis.

• **LA & Clearances I Report:** Land acquisition plans, utility relocation plans, and initial clearance statuses.

• **Detailed Project Report (DPR):** Main report, design report, material report, engineering report, drainage design report, economic and financial analysis report, environmental assessment report (including RAP), and package-wise bid documents and drawings.

• **Technical Schedules:** For EPC/PPP contracts.

• **Draft 3D Publication Report:** For land acquisition notifications.

• **Clearances II Report:** Final project clearances.

Continuous and proactive liaison will be maintained with NHAI officials, specifically the Project Director and Regional Officer, to obtain timely approvals, address queries, and incorporate suggestions. Stakeholder consultations will be an integral part of the process, ensuring all concerns are addressed. The consultant will actively utilize the NHAI's PIMS system for monitoring and submitting weekly updates on activities.

10.0 Quality Assurance Plan

Quality Assurance Framework

Our firm is unequivocally committed to delivering professional consulting services for the current assignment in Sagar, Sagar district, Madhya Pradesh, India, with an unwavering dedication to quality, precision, and professional excellence. This section outlines our comprehensive Quality Assurance (QA) framework, designed to ensure that all deliverables consistently meet or surpass the Client's expectations, contractual stipulations, and all applicable national and international standards.

1. Quality Policy and Commitment

Our fundamental Quality Policy is rooted in delivering technically sound, economically viable, and environmentally responsible solutions. This is achieved through:

* **Adherence to Standards:** Strict compliance with all national codes, guidelines, and specifications issued by MoRT&H, Indian Roads Congress (IRC), and Bureau of Indian Standards (BIS), complemented by international best practices where appropriate (RFP 4.5).

* **Professional Conduct:** Performing services with due diligence, efficiency, and economy, employing generally accepted professional techniques and practices, advanced technology, and sound management (GC 3.1.1).

* **Client Focus:** Prioritizing Client satisfaction through proactive communication, transparent processes, and responsiveness to feedback and approval requirements.

* **Continuous Improvement:** Fostering a culture of learning and refinement in all processes and methodologies to enhance service quality.

* **Accountability:** Establishing clear roles, responsibilities, and accountability for quality throughout the project lifecycle, reinforced by contractual liability provisions (GC 3.4, 7.4.1).

2. Quality Management System (QMS) Overview

Our QMS, while customized for this specific RFP, integrates principles of internationally recognized quality management systems to govern all project activities. It provides a structured approach to planning, executing, monitoring, and controlling tasks, thereby

minimizing risks associated with errors, omissions, and service deficiencies. Key elements include:

* **Systematic Planning:** Detailed work plans and methodologies developed for each project stage.

* **Controlled Execution:** Implementation of approved procedures and methodologies across all field and office activities.

* **Rigorous Monitoring and Control:** Continuous oversight through internal checks, client reviews, and formalized reporting.

* **Documentation and Record Keeping:** Comprehensive and systematic maintenance of all project-related accounts and records, in accordance with internationally accepted accounting principles, available for Client inspection and audit (GC 3.6).

3. Quality Assurance Plan (QAP) – Core Methodology

As mandated by RFP Clause 4.6, a detailed Quality Assurance Plan (QAP) will be prepared immediately upon contract award. This QAP will undergo thorough discussion and finalization with the concerned NHAI officers and will be submitted as an integral part of the Inception Report. Commencement of any field work is contingent upon NHAI's formal approval of this QAP, ensuring mutual understanding and alignment on quality expectations.

The QAP will meticulously detail procedures, responsibilities, applicable standards, equipment specifications, and control mechanisms for each project activity, encompassing:

3.1. QAP Components and Activity-Specific Procedures (RFP 4.6)

The QAP will include dedicated sections addressing the following:

• **Engineering Surveys and Investigations:**

• **Topographic Surveys:** Procedures for Mobile LiDAR/equivalent technology deployment, DGPS/Auto Level checkpoint surveys, data processing, and generation of specific deliverables (e.g., raw DGPS, point cloud, 1:1000 topographic maps, 50cm contour maps, 1m cross-sections in *.dwg format). Accuracy requirements will strictly adhere to the RFP specifications: 2cm (H/V) for land-based and 5cm (H/V) for aerial surveys (RFP 4.10).

• **Traffic Surveys:** Detailed methodology for classified traffic volume counts (7-day duration), origin-destination surveys, speed and delay studies, and axle load surveys as per IRC:102-1988 guidelines.

• **Material Geo-technical and Sub-soil Investigations:** Protocols for bore logging, in-situ testing (e.g., Field CBR using DCP), laboratory testing (e.g., grain size, Atterberg limits, modified AASHTO compaction, Laboratory CBR), and approval of material testing laboratories by NHAI (RFP 4.11.3, 4.11.4.3). All geotechnical investigations will be carried out by MoRT&H empanelled agencies and adhere to IRC:78.

• **Road and Pavement Investigations:** Methodologies for pavement composition (trial pits), surface condition surveys (visual and measured, e.g., rut depth with standard straight edges, as per AASHTO, IRC, OECD, TRL, World Bank Publications), roughness surveys (Bump Integrator/equivalent, with authenticated calibration), and structural strength surveys (Falling Weight Deflectometer as per IRC:115-2014 or IRC:117-2015) (RFP 4.11.2).

• **Investigation and Design of Bridges & Structures:** Procedures for inventory, condition assessment (IRC:SP:35), hydraulic and hydrological studies (IRC SP No. 13, IRC:5), supplementary testing (IRC:SP:35, IRC:SP:40), and load-carrying capacity evaluation (IRC-SP:37). Strict adherence to the mandatory three-level signing requirement (Designer, Senior Checking Engineer, Senior Bridge/Structure Expert) for all structural designs and drawings (GC 7.1).

• **Environment and Resettlement & Rehabilitation (R&R) Assessment:** Detailed plans for baseline socio-economic and census surveys, impact assessment, entitlement matrix development, and preparation of Land Acquisition Plans and Resettlement and Rehabilitation Plans in accordance with relevant guidelines (RFP 4.13).

• **Economic and Financial Analysis:** Methodologies for traffic flow and level of service analysis, project cost estimation (based on MoRT&H's Standard Data Book and market rates), unit rate analysis, and viability/financing options (RFP 4.12.6).

• **Drawings and Documentation:** Protocols for preparation, checking, approval, and filing of all project drawings (e.g., plan and profile, cross-sections, detailed working drawings for culverts, bridges, intersections) and reports, ensuring they are "good for construction" (RFP 3.9, 3.8, 10.1).

• **Preparation, Checking, Approval, and Filing of Calculations:** Defined processes for all engineering calculations to ensure accuracy and traceability.

• **Identification and Traceability of Project Documents:** A robust document control system for all project records, ensuring easy retrieval and version control.

3.2. Roles and Responsibilities for Quality

The QAP will explicitly outline the individuals and their roles in preparing, executing, checking, and verifying each activity. This clear delegation of authority and responsibility, particularly the multi-tiered review for critical engineering outputs, forms the backbone of our quality control. For example, as per GC 7.1, bridge designs will require signatures from the Designer, a Senior Checking Engineer, and a Senior Bridge/Structure Expert to signify their quality approval.

4. Compliance with Standards and Codes

Our deliverables will strictly conform to the latest editions of the following standards and guidelines, applicable to road and bridge projects within Sagar, Sagar district, Madhya Pradesh, India:

* **Indian Roads Congress (IRC) Codes:** Including, but not limited to, IRC:SP:35, IRC SP No. 13, IRC:5, IRC:SP:37, IRC:78, IRC:115-2014, IRC:117-2015, IRC:102-1988, IRC:SP:19, IRC:10, IRC:25.

* **Ministry of Road Transport & Highways (MoRT&H) Specifications:** Latest technical specifications for Road and Bridge Works, along with relevant circulars and guidelines.

* **Bureau of Indian Standards (BIS):** Applicable standards for materials testing, construction practices, and quality control (e.g., related to concrete, steel, aggregates for road construction as per BIS guidelines).

* **National Highways Authority of India (NHAI) Manuals:** Manual of Specifications and Standards for four/six laning (IRC:SP:84 or IRC:SP:87), and any specific guidelines for Bharatmala projects.

* **International Standards:** Where national codes lack specific guidance, well-established international practices (e.g., AASHTO, World Bank, OECD) will be adopted, subject to NHAI’s consultation and approval.

5. Client Engagement and Review

Effective Client engagement is paramount to our QA framework:

* **QAP Approval:** Mandatory formal approval of the QAP by NHAI before commencement of field operations (RFP 4.6).

* **Prior Approvals:** Key actions such as personnel appointments, subcontracting, and specific design solutions will seek the Client's prior written approval (GC 3.7), acting as critical quality gates.

* **Inspections and Audits:** The Client reserves the right to periodically inspect field investigations, survey works, and audit project records. This includes potential deployment of a Proof Consultant by NHAI for independent supervision (GC 3.6, RFP 11).

* **Data and Document Review:** All collected data, existing documents, and draft reports will be submitted for Client review at various stages (RFP 4.7).

* **Reporting:** Regular submission of concise monthly progress reports (RFP 11) and continuous interaction with NHAI for clarifications and suggested modifications (RFP 11).

6. Accountability, Liability, and Risk Mitigation

Our commitment to quality is reinforced by robust accountability mechanisms:

* **Responsibility for Accuracy (GC 7.1):** Our firm takes full responsibility for the accuracy of all collected data, designs, drawings, estimates, and other details. Any inaccuracies surfacing during project implementation will be rectified at our own cost and risk.

* **Retention Money (GC 7.2):** A 10% retention of the contract value will be held for the accuracy of design and quantities, released upon completion of civil works or after 3 years, or against a Bank Guarantee.

* **Penalties for Deficiencies (GC 7.3):**

* **Error/Variation (GC 7.3.1):** Specific penalties (0.2% to 2.0% of contract value) will be imposed for significant variations in main quantities (> +/- 15%), inaccuracies in survey/investigation/design, substantial deviations in traffic/axle load data (> 25%), or unsafe/grossly over-safe structural designs.

* **Delay (GC 7.3.2):** A penalty of 0.05% of the contract price per day, up to a maximum of 5% of the contract value, will be applied for delays in service completion.

* **Cumulative Limit:** The total recovery from all penalties is capped at 10% of the Consultancy Fee (GC 7.3.3).

* **Professional Liability Insurance (PLI):** We will procure and maintain Professional Liability Insurance for five years beyond the completion of consultancy services, covering errors and omissions caused by negligence in performance, issued by an Indian insurance company with specified limits (GC 8).

* **Actions for Deficiency (GC 7.4):** Liability to indemnify the Client for direct loss or damage resulting from service deficiency. Major deficiencies may lead to warning or debarment from future projects.

By integrating these stringent quality assurance and control measures into every aspect of the project lifecycle, our firm guarantees the delivery of high-quality, accurate, and reliable consulting services for the project in Sagar, Sagar district, Madhya Pradesh, India.

11.0 Checklists

5.0 Checklists

The effective utilization of comprehensive checklists is fundamental to ensuring a systematic, thorough, and compliant approach throughout the project lifecycle, commencing with the Inception Report phase. As an indispensable "aide memoire" for the project team, these checklists are designed to prevent oversight of critical aspects, foster a shared understanding of project requirements, and integrate quality and safety considerations from the earliest stages of design and planning. Drawing upon extensive experience in systematic project procedures, our approach to checklists emphasizes principal issues and underlying processes, rather than merely acting as "tick" sheets for technical details.

This section outlines the key checklists that will be deployed during the Inception Report preparation, establishing the foundation for subsequent project stages, including detailed feasibility studies, design, land acquisition, and clearances. All checklists will be rigorously applied in accordance with relevant Indian standards, including those stipulated by the Indian Roads Congress (IRC), Ministry of Road Transport and Highways (MoRTH), Bureau of Indian Standards (BIS), and National Highways Authority of India (NHAI) circulars and guidelines.

5.1 Purpose and Scope of Checklists in the Inception Report

At the Inception Report stage, checklists serve to:

* **Confirm Alignment with RFP Objectives:** Ensure a clear understanding and alignment with the client’s vision, project objectives, and scope as defined in the Request for Proposal (RFP).

* **Structure Initial Data Collection:** Guide the systematic collection and review of preliminary data across all project facets, including engineering, environmental, social, and financial aspects.

* **Identify Critical Information Gaps:** Highlight areas where further investigation, surveys, or stakeholder consultations are required.

* **Facilitate Early Risk Identification:** Aid in the preliminary identification of potential risks related to design, land acquisition, clearances, utilities, and safety.

* **Establish Baseline for Quality Assurance:** Form the initial basis for quality assurance and compliance monitoring for all subsequent project deliverables.

* **Integrate Safety from Conception:** Ensure road safety aspects are considered proactively, in line with the client's emphasis on safety audits.

5.2 Key Checklists for Inception Report Stage

The following core checklists, adapted from established best practices and client-provided frameworks, will be rigorously followed:

5.2.1 DPR Checklist – Stage 1 – Inception Report (Highway Component)

This checklist ensures all foundational elements for the highway design are addressed upfront:

S. No.	Checklist Item	Description of Compliance at Inception Stage	Standard/Reference
1.0	Executive Summary & Project Background	Overview of project location (Sagar, Sagar district, Madhya Pradesh), objectives, scope, and deliverables as per RFP, ensuring clear understanding.	MoRTH Guidelines for DPR
2.0	Economic and Financial Analysis (Preliminary)	Initial review of project viability, estimated cost details, projected revenues, and preliminary analysis results (e.g., IRR, sensitivity analysis,...	IRC:SP:30, MoRTH, NHAI Policies
3.0	Strip Plan and Alignment (Preliminary)	Details of proposed highway centerline, existing and proposed Right-of-Way (RoW), initial assessment of land ownership based on reconnaissance. A p...	IRC:SP:19, MoRTH Circulars

S. No.	Checklist Item	Description of Compliance at Inception Stage	Standard/Reference
4.0	Alignment Options Study	Confirmation of at least two alignment options, detailing pros and cons, project length for each, preliminary land acquisition requirements, and co...	IRC:73, IRC:SP:19, NHAI Guidelines
5.0	Technical Specifications	Assurance that MoRTH technical specifications for Road and Bridge works will be rigorously followed throughout the project.	MoRTH Specifications for Road & Bridge Works (5th Revision)
6.0	Rate Analysis & Cost Estimates (Preliminary)	Initial rate analysis for all relevant items as per the latest Schedule of Rates (SoR) applicable to Madhya Pradesh, and preliminary cost estimates.	MoRTH Standard Data Book, MP PWD SoR, NHAI Cost Indices
7.0	Bill of Quantities (Preliminary)	Initial Bill of Quantities (BoQ) for project components, providing a baseline for cost estimations.	MoRTH Specifications, BIS Codes
8.0	Conclusions and Recommendations	Overall assessment of whether the Inception Report fulfills project objectives and scope as per the RFP, including a review for errors and omissions.	RFP Requirements, Consultant's QAP
9.0	Initial Data Collection (from Page 103)	Confirmation of collection/plan for: size distribution of river bed material, bore log data at different locations (for bridges/structures), and se...	IRC:SP:13, IRC:5, IRC:6, MoRTH Guidelines for Hydrological Studies

5.2.2 DPR Checklist – Stage 1 – Inception Report (Structures - ROB/RUB Component)

For specific structures such as Road Over Bridges (ROB) or Road Under Bridges (RUB), this checklist provides dedicated initial scrutiny:

S. No.	Checklist Item	Description of Compliance at Inception Stage	Standard/Reference
1.0	Project Appreciation & Description	Overview of project structures, existing Level Crossing (LC) numbers, start and end chainages, village/district locations (e.g., around Sagar), and...	MoRTH Guidelines, Indian Railways Standards
2.0	Details of Existing Level Crossing	Documentation of existing LC details including number and type of railway tracks (Broad/Meter/Narrow Gauge), and approximat e number of trains per d...	Indian Railways Bridge Rules, MoRTH
3.0	Justification for ROB/RUB	Preliminary justification for the necessity of an ROB/RUB based on Traffic Vehicle Unit (TVU) count, ensuring that structural interventions are eco...	IRC:SP:40, Indian Railways
4.0	Overview of Land Use & Pavement Conditions	General land use plans in the vicinity of the proposed structure and preliminary assessment of existing pavement conditions (number of lanes) aroun...	IRC:SP:19
5.0	Drawing and Documenta tion	Discussion of the draft Quality Assurance Plan (QAP) document with the client, leading to approval of the final QAP, specific to structural elements.	BIS:14000 series, Consultant's QAP

S. No.	Checklist Item	Description of Compliance at Inception Stage	Standard/Reference
6.0	Draft Design Standards	Identification and proposed adherence to geometric design standards for bridges (for both plain and hilly terrain, if applicable in Sagar's periphe...	IRC:5, IRC:6, IRC:78, Indian Railways
7.0	Conclusions and Recommendations	Overall assessment of whether the Inception Report fulfills the objectives for structural components as per RFP, including a review for errors and ...	RFP Requirements, Consultant's QAP

5.2.3 Safety Audit Checklist – Stage F – During Feasibility Study

This checklist, as highlighted by the client, is critically integrated into the initial assessment to ensure road safety aspects are proactively considered during the feasibility study, which the Inception Report informs:

S. No.	Checklist Item	Description of Compliance at Inception Stage	Standard/Reference
A	Safety and Operational Implications	Review of proposed alignment and junction strategy from a road safety perspective, considering expected road users and vehicle types prevalent in S...	IRC:SP:88, IRC:SP:99, MoRTH Manuals for Safety Audit, NHAI Safety Guidelines
B	Scheme Integration & Environ	Evaluation of safety implications beyond the physical limits, assessing how the scheme integrates with its environs and the existing road hierarchy...	IRC:35, Urban/Rural Planning Guidelines

S. No.	Checklist Item	Description of Compliance at Inception Stage	Standard/Reference
C	General Safety Considerations (B1)	Preliminary assessment of departures from standards, cross-section al variation, drainage requirements (considerin g Sagar's climatic conditions), la...	IRC Codes, MoRTH Specifications, Local Bye-laws
D	Local Alignment Visibility (B2)	Initial review of new/existing road interfaces and identificati on of locations potentially requiring safety aids on steep hills or sharp curves, if...	IRC:66, IRC:SP:48
E	Junctions (B3)	Identification of potential conflict points at proposed or existing junctions, assessing initial layout options and visibility considerations to mi...	IRC:65, IRC:SP:41
F	Non-Motorised Users Provision (B4)	Confirmation of adequate provision for pedestrians, cyclists, and other non-motorized vehicles, considering adjacent land use patterns and local tr...	IRC:103, IRC:SP:50
G	Signs and Lighting (B5)	Preliminary identification of key locations for appropriate lighting, signs, and markings to enhance road user safety.	IRC:67, IRC:SP:69, MoRTH Manual for Road Signs
H	Buildability & Operational Aspects (B6)	Initial consideration of buildability, operational ease, and network management aspects from a safety perspective, identifying any potential challe...	MoRTH Manual for Quality Assurance

5.2.4 Utility Shifting (Initial Identification & Scoping)

While the detailed Utility Shifting Estimate checklist is for later stages, the Inception Report will initiate the crucial process of identifying existing utilities.

S. No.	Checklist Item	Description of Compliance at Inception Stage	Standard/Reference
1.0	Identification of Overground Utilities	Preliminary identification of all overground utilities (e.g., electricity poles, transmission lines, communication cables, water pipelines, railway...	NHAI Policy Circular (Tech) No. 215/2016 (Procedure for processing Utility Shifting), MoRTH Guidelines for Utility Relocation
2.0	Identification of Underground Utilities	Planning for specialized surveys (e.g., Ground Penetrating Radar (GPR), Induction Locator, or equivalent technologies) in subsequent stages for ide...	As above. Specific technical specifications for GPR surveys will be aligned with relevant BIS/ASTM standards when detailed surveys commence.
3.0	Initial Consultation with Local Authorities	Preliminary consultations with relevant local utility authorities (e.g., MPSEB for electricity, Public Health Engineering Department for water/sewe...	NHAI Policy Circular (Tech) No. 215/2016, relevant State Government (Madhya Pradesh) departmental procedures for utility clearances. Local Municipa...
4.0	Impact Assessment on Alignment & Cost	Initial assessment of the potential impact of identified utilities on proposed alignment options, land acquisition, and preliminary project costs. ...	Economic analysis guidelines, risk assessment frameworks. This helps in understanding the financial implication of utility shifting early in the pr...

5.3 Integration with Project Lifecycle and Adherence to Standards

The checklists deployed during the Inception Report stage are not isolated documents but form an integral part of a continuum of quality and compliance assurance throughout the project's lifecycle. These initial assessments will serve as critical inputs and reference points for the more detailed checklists to be utilized in subsequent DPR stages, including Feasibility Report, Land Acquisition & Clearances I & II Reports, Detailed Project Report,

and Technical Schedules.

Our unwavering commitment is to adhere strictly to all applicable national and state-level standards and guidelines. This includes, but is not limited to:

* **Indian Roads Congress (IRC) Codes and Standards:** For all aspects of highway design, geometric standards, pavement design, bridge design, and safety.

* **Ministry of Road Transport and Highways (MoRTH) Specifications:** For Road and Bridge Works, Quality Control Manuals, and various technical guidelines.

* **Bureau of Indian Standards (BIS) Codes:** For materials, testing, structural design, and general engineering practices.

* **National Highways Authority of India (NHAI) Manuals and Policy Circulars:** For project planning, DPR preparation, utility shifting, land acquisition, safety audits, and project management.

* **Relevant State Government (Madhya Pradesh) Regulations:** For environmental, forest, wildlife, and land acquisition clearances.

5.4 Customization and Continuous Improvement

While standardized checklists provide a robust framework, we recognize the importance of their customization to reflect the unique topographical, climatic, environmental, and socio-economic context of Sagar, Sagar district, Madhya Pradesh. All checklists will be reviewed and refined as project understanding deepens, and will be updated periodically based on client feedback, lessons learned during project execution, and evolving regulatory requirements. This dynamic approach ensures that the checklists remain relevant, effective, and contribute meaningfully to the successful delivery of the project.

12.0 Summary and Conclusion

Conclusions and Recommendations

This Inception Report (IR) systematically lays the groundwork for the comprehensive Feasibility Study and Detailed Project Report (DPR) for the proposed bypasses in the Sagar district, Madhya Pradesh. It confirms a comprehensive understanding of the project objectives, scope, and the critical requirements stipulated by the National Highways Authority of India (NHAI) and NHAIL.

1. Project Understanding and Strategic Alignment:

The IR has meticulously outlined the project's background, objectives, and the critical need for bypasses to enhance traffic flow, improve road safety, and promote regional socio-economic development within the project area in Sagar, Madhya Pradesh. A core objective, as highlighted by NHAIL, is the identification of the most appropriate alignment options for these bypasses, factoring in site conditions and robust techno-economic considerations. This report confirms that the proposed methodology for subsequent project stages is strategically aligned with this directive.

2. Methodology for Bypass Alignment Identification:

The report details a phased and systematic methodology for identifying optimal bypass alignments. This approach integrates:

* **Detailed Site Reconnaissance and Topographic Surveys:** To capture existing ground conditions, natural features, and existing infrastructure.

* **Geotechnical Investigations:** To assess sub-soil conditions crucial for foundation design and material suitability.

* **Environmental and Social Impact Screening:** To identify potential sensitive areas and preliminary mitigation strategies.

* **Comprehensive Traffic Surveys and Analysis:** To ascertain existing traffic patterns, project future demand, and evaluate potential traffic diversion to bypasses.

* **Techno-Economic Evaluation of Alternatives:** A rigorous comparative analysis of multiple alignment options considering engineering feasibility, construction costs, land acquisition requirements, environmental impacts, and economic benefits (e.g., reduced

travel time, fuel savings).

The IR emphasizes that these details regarding the construction of bypasses, particularly concerning alignment options based on site conditions and techno-economic analysis, will be presented for NHAIL's approval at key decision points.

3. Adherence to Standards and Regulatory Frameworks:

The Inception Report confirms the unwavering commitment to adhering to all relevant national and international standards, codes, and guidelines. This includes, but is not limited to, specifications and best practices prescribed by the Ministry of Road Transport & Highways (MoRTH), Indian Road Congress (IRC), Bureau of Indian Standards (BIS), and specific requirements of NHAI/NHAIL. A summary of key standards to be rigorously applied throughout the project lifecycle is presented in Table 1.

Table 1: Key Standards and Guidelines for Subsequent Project Stages

S. No.	Standard/Guideline Body	Relevance to Project Phases
1.	Ministry of Road Transport & Highways (MoRTH)	Technical Specifications for Road & Bridge Works (latest edition/revision), Design Guidelines for various road components, Special Technical Specif...
2.	Indian Road Congress (IRC)	Geometric Design Standards (e.g., IRC:73 for Rural Highways, IRC:38 for Horizontal Curves), Pavement Design (e.g., IRC:37 for Flexible Pavements), ...
3.	Bureau of Indian Standards (BIS)	Material specifications, Testing procedures, Quality control norms for construction materials and practices.
4.	National Highways Authority of India (NHAI)/NHAIL	Project financing mechanisms, cost recovery strategies, specific approval protocols, and project-specific quality assurance and control norms.

S. No.	Standard/Guideline Body	Relevance to Project Phases
5.	Ministry of Environment, Forest and Climate Change (MoEFCC)	Environmental Impact Assessment (EIA) guidelines, environmental screening procedures, and clearance protocols for infrastructure projects.
6.	The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013	Framework for preliminary land acquisition assessment and subsequent detailed resettlement planning.

4. Foundation for Feasibility Study (Stage 2):

This IR serves as the definitive reference document for commencing the Feasibility Study (Stage 2) of the project. It provides the necessary framework for detailed investigations, ensuring that all aspects listed for the Feasibility Report are adequately addressed. Specifically, the IR prepares the groundwork for:

* **Project Description:** Including the detailed analysis of possible alternative alignments/bypasses.

* **Socio-economic Profile:** Establishing the baseline for project area characteristics.

* **Indicative Design Standards:** Outlining the parameters for preliminary designs.

* **Environmental Screening and Preliminary Assessment:** Initiating the environmental impact identification.

* **Initial Social Assessment and Preliminary Land Acquisition/Resettlement Plan:** Laying the foundation for social impact mitigation.

* **Preliminary Cost Estimates:** Based on initial rate analysis and bill of quantities.

* **Economic and Financial Analysis:** To be developed from the gathered data.

5. Recommendations:

Based on the comprehensive understanding articulated in this Inception Report and its alignment with the RFP requirements, it is recommended that:

1. **The Inception Report be formally accepted** by NHAIL, confirming the proposed methodology and understanding of the project scope for the bypasses in Sagar district, Madhya Pradesh.

2. **Authorization be granted to proceed immediately with the Feasibility Study (Stage 2)**, in accordance with the accepted IR and the detailed scope outlined in the Request for Proposal (RFP) document.

The successful acceptance of this IR is critical for the timely progression of the project, ensuring that the subsequent Feasibility Study yields robust, techno-economically viable, and environmentally sustainable bypass alignment solutions for NHAIL's approval.

13.0 Compliances

Compliances

This section outlines the comprehensive approach adopted by [Consultant's Name] to ensure strict adherence to all applicable legal, regulatory, environmental, social, safety, quality, and contractual compliances throughout the Detailed Project Report (DPR) preparation for the economic corridors, inter-corridors, and feeder routes in Sagar, Sagar district, Madhya Pradesh, under Lot-1/Madhya Pradesh/Package-3. Our commitment is to execute the services with the highest standards of professionalism, transparency, and accountability, aligning with both national and international best practices.

1. Legal and Statutory Framework Compliance

The Consultant shall operate in strict accordance with the prevailing legal and statutory framework of India and the State of Madhya Pradesh.

• **Governing Laws and Jurisdiction**: As per Clause GC 1.3 and SC 1.4, this Contract, its meaning, and interpretation shall be governed by the Applicable Laws of India. For any disputes, the Courts at New Delhi shall have exclusive jurisdiction (GC 1.3).

• **Contractual Adherence**: Full compliance will be maintained with all clauses, terms, and conditions stipulated in the Contract for Consultant’s Services, including the General Conditions of Contract (GC), Special Conditions of Contract (SC), Terms of Reference (TOR) (Appendix A), and all other Appendices.

• **Land Acquisition Acts**: The Consultant shall prepare all Land Acquisition papers, including necessary schedules and draft notifications (3a, 3A, 3D, 3G) as per the National Highways Act or relevant State Act, for land acquisition in Sagar district, Madhya Pradesh (Appendix A, Clause 3.6, 10.4, 10.5).

• **Labour Laws**: All labour employed for the project, whether directly by the Consultant or through sub-consultants, shall be managed in full compliance with applicable Indian labour laws, including:

• The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996.

• The Contract Labour (Regulation and Abolition) Act, 1970.

• Other relevant labour legislations, ensuring fair wages, safe working conditions, and social security benefits.

• **Taxes and Duties**: The Consultant, along with its personnel, shall diligently pay all applicable taxes, duties, fees, levies, and other impositions as mandated by the Applicable Law, as specified in GC 1.10 and SC 1.10.

An overview of key regulatory frameworks governing the project is provided in Table 1.1.

Table 1.1: Key Regulatory Frameworks for Project Execution

S.No.	Regulatory Area	Governing Legislation/ Guideline	Consultant's Role
1.	Contractual Obligations	General Conditions of Contract, Special Conditions of Contract, Terms of Reference (Appendix A), Appendices B-J of the RFP.	Strict adherence to all contractual provisions, scope of services, reporting requirements, and personnel commitments.
2.	Land Acquisition	National Highways Act, 1956, or relevant State Land Acquisition Act.	Preparation of draft 3a, 3A, 3D, 3G notifications and associated schedules as per revenue records for land parcels in Sagar, Sagar district, Madhya...
3.	Labour Welfare	Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996; Contract Labour (Regulation and Abolition) ...	Ensure all sub-consultants and personnel comply with labour laws, including provisions for safety, welfare, and timely payments.
4.	Environmental Clearances	Environmental Impact Assessment Notification, 2006 (as amended); relevant MoEF&CC; guidelines; Forest (Conservation) Act, 1980; Wildlife (Protection...	Conduct EIA/IEE, prepare EMP, liaise with MoEF&CC; and State Pollution Control Board for necessary clearances specific to the project location in Sa...

S.No.	Regulatory Area	Governing Legislation/ Guideline	Consultant's Role
5.	Taxation	Income Tax Act, 1961; Central Goods and Services Tax Act, 2017; State Goods and Services Tax Act, Madhya Pradesh, 2017; Integrated Goods and Servic...	Ensure timely payment of all applicable taxes and duties by the Consultant and its personnel as per GC 1.10 and SC 1.10.

2. Environmental Safeguards Compliance

The project will incorporate robust environmental safeguards to minimize adverse impacts and promote sustainable development, specifically considering the ecological context of Sagar, Sagar district, Madhya Pradesh.

• **Environmental Impact Assessment (EIA) & Environmental Management Plan (EMP)**: A detailed EIA will be carried out in accordance with MoRT&H/World Bank/ADB/Government of India Guidelines (Appendix A, Clause 3.5, 4.13.1). This includes preliminary environmental screening, baseline condition documentation, impact assessment, mitigation measures, and preparation of a comprehensive EMP (Appendix A, Clause 4.13.3). The Consultant will liaise with concerned authorities to obtain all necessary environmental clearances (Appendix A, Clause 3.6).

• **Forest & Wildlife Clearances**: The Consultant will prepare and submit all required application forms and documents to obtain forestry and wildlife clearances from the respective authorities, including the State Forest Department and MoEF&CC, on behalf of NHAI (Appendix A, Clause 3.6). This is particularly relevant for any sections of the proposed highway passing through or impacting designated forest or ecologically sensitive areas in Sagar district.

• **Sustainable Material Use**: Recommendations for the use of environment-friendly materials, such as fly-ash/slag, will be assessed for technical and economic feasibility, ensuring compliance with MoRT&H circular No. RW/NH-33044/53/2013-S&R(R) dated 20 November 2013 and subsequent amendments, which mandates fly-ash use within 300 km of thermal power stations (Appendix A, Clause 4.12.5).

3. Social Safeguards Compliance

Social safeguards are integral to the project, ensuring that the development benefits all stakeholders while addressing potential negative impacts on local communities in Sagar, Sagar district, Madhya Pradesh.

• **Resettlement and Rehabilitation (R&R) Plan**: A comprehensive R&R plan will be prepared based on baseline socio-economic and 100% census surveys of Project Affected People (PAPs). This includes impact assessment, entitlement matrix development, income restoration strategies, and implementation budgets (Appendix A, Clause 4.13.2, 4.13.4).

• **Public Consultation and Stakeholder Engagement**: Continuous public consultation will be conducted at inception, feasibility, preliminary design, and final design stages with communities, NGOs, and relevant government departments in Sagar district. All consultations will be meticulously documented (Appendix A, Clause 4.1.iii, 4.13.2).

• **Vulnerable Groups and Special Issues**: The social analysis will specifically address indigenous people, poverty alleviation, gender considerations, communicable diseases (including HIV/AIDS), child labour, and other social vulnerabilities within the project area (Appendix A, Clause 4.8, 4.13.2).

4. Health and Safety Compliance

Safety is paramount, covering both the design phase and eventual construction activities, with specific attention to road users and workers in Sagar, Sagar district, Madhya Pradesh.

• **Road Safety Audit**: Road safety audits will be diligently carried out at various design stages (inception, feasibility, preliminary, and detailed design) as per Supplement-III (Additional requirement for safety audit) of the TOR (Appendix A, Clause 2.4).

• **Construction Site Safety Regulations**: The DPR will incorporate provisions for ensuring construction site safety in line with Indian regulations and MoRTH/BIS standards. This includes:

• Mandatory use of Personal Protective Equipment (PPE) by all workers.

• Provision of safe access and egress, especially for trenches and elevated work areas.

• Clear signage, warning systems, and instructions on construction sites.

• Implementation of comprehensive traffic management plans during construction (Appendix A, Clause 4.12.13).

• **Traffic Safety Features**: Designs will include suitable traffic safety features and road furniture, such as traffic signals, signs, road markings, overhead sign boards, crash barriers, and delineators, to enhance safety for the proposed highway (Appendix A, Clause 4.12.9).

5. Quality and Technical Standards Compliance

High-quality engineering and design are fundamental to the project's success.

• **Adherence to Standards and Codes of Practices**: All field studies, design, and documentation activities will strictly adhere to the latest guidelines and circulars of MoRT&H, relevant publications of the Indian Roads Congress (IRC), and Bureau of Indian Standards (BIS). For aspects not covered by these, internationally accepted standards and practices will be adopted (Appendix A, Clause 4.5).

• **Quality Assurance Plan (QAP)**: A detailed Quality Assurance Plan (QAP) will be presented for all field studies (topographic surveys, traffic surveys, engineering surveys, material investigations), design, and documentation activities. This QAP will be discussed and finalized with NHAI officers immediately upon contract award and submitted as part of the inception report (Appendix A, Clause 4.6).

• **Accuracy of Deliverables**: The Consultant is fully responsible for the accuracy of all collected data, designs, drawings, estimates, and other project documents (GC 7.1). The contract includes provisions for retention money and penalties for any inaccuracies or deficiencies identified (GC 7.2, 7.3).

• **Technology Application**: Advanced technologies will be utilized to enhance accuracy and efficiency:

• **Topographic Survey**: Detailed topographic surveys will be conducted using Mobile/Aerial LIDAR or equivalent technology (Minutes of Meeting, Clause 6.2, Appendix V, Clause 2.3.4).

• **Sub-surface Utility Detection**: Ground Penetrating Radar (GPR) and Induction Locator or equivalent technologies will be deployed for probing underground utilities (Minutes of Meeting, Clause 6.2, Appendix V, Clause 2.3.4).

Table 1.2: Key Quality Standards and Codes of Practice

S.No.	Aspect	Applicable Standard/Code
1.	Highway Design	IRC:73, IRC:86, IRC:SP:84/87 (as applicable), MoRT&H; Manual of Specifications and Standards for 4/6 laning.
2.	Pavement Design	IRC:37, IRC:58, IRC:81 (for flexible/rigid pavements and overlays), IRC:115 (for FWD).

S.No.	Aspect	Applicable Standard/Code
3.	Bridge & Structure Design	IRC:5, IRC:6, IRC:21, IRC:78, IRC:SP:13, IRC:SP:37, IRC:SP:40 (for design, evaluation, and rehabilitation of bridges and culverts).
4.	Traffic Surveys & Forecasting	IRC:9, IRC:102, IRC:108.
5.	Material & Geotechnical Studies	IRC:SP:19, IRC:75, IRC:78, BIS codes (for soil, aggregate, and material testing).
6.	Environmental Assessment	MoRT&H;/World Bank/ADB Guidelines, Environmental Impact Assessment Notification, 2006 (as amended).
7.	Road Safety Audit	IRC:SP:88 (Manual on Road Safety Audit).
8.	Drawings & Documentation	IRC:71 (Notations, abbreviations, and symbols), MoRT&H; Standard Data Book.
9.	Utility Shifting	MoRT&H; Policy Circulars (e.g., No. RW/NH-33044/53/2013-S&R;(R) dated 20 Nov 2013, No. 11041/218/2007-Admn dated 19.09.2016 for utility shifting esti...

6. Personnel and Ethical Compliance

The Consultant upholds the highest ethical standards and ensures a qualified, dedicated team.

• **Key Personnel Requirements**: All proposed key personnel, as listed in Appendix B and detailed in Enclosure-II of the TOR, meet the specified minimum qualification and experience requirements. Undertakings from both the individual personnel and the consulting firm confirm their availability for the entire project duration (Appendix B, Form-T11).

• **Ethical Conduct and Confidentiality**: The Consultant and its personnel will strictly adhere to the highest ethical standards. This includes maintaining confidentiality of all proprietary or confidential project information (GC 3.3) and avoiding any conflicts of interest or conflicting activities (GC 3.2).

• **Integrity Pact**: An Integrity Pact (Appendix I) has been signed, reinforcing the commitment to prevent corruption and ensure transparency in all dealings with the Principal.

7. Financial and Administrative Compliance

Robust financial and administrative management will ensure the smooth execution of the contract.

• **Performance Security**: A Performance Security, as stipulated in GC 2.1, SC 2.1, and Clause 7 of the Letter of Invitation, has been furnished and will be maintained for the required period.

• **Insurance Coverage**: Adequate insurance policies, including Third Party motor vehicle liability, Third Party general liability, and Professional Liability Insurance (PLI), will be taken out and maintained as per GC 3.5 and SC 3.5.

• **Billing and Payments**: Billing and payments will strictly follow the modes, schedules, and currency specified in GC 6.2 and 6.3.

• **Accounting and Auditing**: Accurate and systematic accounts and records pertaining to the services will be maintained in accordance with internationally accepted accounting principles, and made available for inspection and auditing by the Client (GC 3.6).

• **Reporting Obligations**: All reports and documents, as specified in Appendix A/E and the agreed submission schedules, will be submitted in the prescribed format and numbers within the stipulated timeframes (GC 3.8, Appendix A, Clause 10).

Appendix A: IRC Codes Reference

For road and highway projects in Sagar, Sagar district, Madhya Pradesh, adherence to Indian Road Congress (IRC) codes is mandatory to ensure design consistency, safety, durability, and quality. Here's a list and summary of relevant IRC codes, including the ones you specifically mentioned:

Key IRC Codes for Road/Highway Projects in Sagar, MP

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1. Codes Specifically Requested:

1. **IRC:SP:84 - Manual on Urban Roads**

* **Summary:** This Special Publication (SP) provides comprehensive guidelines for the planning, design, construction, and maintenance of urban roads. For Sagar city projects, this is crucial. It covers aspects like:

* **Geometric Design:** Intersection design, horizontal and vertical alignment within constrained urban environments, right-of-way considerations.

* **Traffic Management:** Provision for various modes (pedestrians, cyclists, public transport), parking facilities, traffic calming measures.

* **Drainage:** Design of urban drainage systems (gutters, culverts, storm sewers) to manage surface runoff effectively within the city.

* **Utilities:** Coordination with underground utilities (water, sewage, electricity, communication lines).

* **Street Furniture and Landscaping:** Guidelines for streetlights, signage, bus stops, and green spaces.

* **Significance for Sagar:** Essential for all road development, widening, and new construction within Sagar city limits, ensuring the roads are functional, safe, and integrated with the urban fabric.

2. **IRC:37 - Guidelines for the Design of Flexible Pavements**

* **Summary:** This code is fundamental for designing the structural layers of most roads in India, including those in Sagar, as flexible pavements (bituminous roads) are predominant.

It outlines the methodology for determining the thickness of various pavement layers based on expected traffic loading and subgrade soil strength. Key aspects include:

* **Pavement Layers:** Design of the subgrade, sub-base, base, and wearing course.

* **Material Characterization:** Use of California Bearing Ratio (CBR) for subgrade strength, and properties of granular and bituminous layers.

* **Traffic Loading:** Conversion of mixed traffic into standard axles (Equivalent Single Axle Load - ESAL) over the design life.

* **Climatic Factors:** Consideration of temperature and moisture variations affecting pavement performance.

* **Significance for Sagar:** Directly applicable to virtually all road projects in Sagar district (urban, rural, state highways) that utilize flexible pavement construction, ensuring the roads are structurally sound and durable for their intended traffic volume.

3. **IRC:5 - Road Signs**

* **Summary:** This code specifies the design, dimensions, colors, and placement of various types of road signs to guide, warn, and regulate traffic. It's a critical component of road safety and traffic management. Categories include:

* **Regulatory Signs:** e.g., "STOP," "GIVE WAY," speed limits, no entry.

* **Warning Signs:** e.g., sharp curve, pedestrian crossing, school ahead, falling rocks.

* **Informatory Signs:** e.g., destination boards, route markers, service facility signs.

* **Significance for Sagar:** Indispensable for all road projects (new construction, upgrades) across Sagar district to ensure clear, consistent, and effective communication with motorists, enhancing road safety and efficient traffic flow.

2. Other Highly Relevant IRC Codes for Road/Highway Projects:

Beyond the specifically requested codes, several others are crucial for comprehensive road project execution in Sagar:

A. Geometric Design:

4. **IRC:73 - Geometric Design Standards for Rural (National and State) Highways**

* **Summary:** Provides standards for geometric elements like horizontal and vertical alignment, sight distance, super-elevation, and roadway width for major highways outside urban areas.

* **Significance for Sagar:** Essential for designing State Highways and major district roads connecting various towns and villages within Sagar district, ensuring safe and efficient travel speeds.

5. **IRC:SP:23 - Vertical Curves, and IRC:SP:48 - Horizontal Curves**

* **Summary:** These SPs provide detailed guidelines for the design of vertical and horizontal curves, respectively, including parameters like length of curves, sight distance, and super-elevation rates.

* **Significance for Sagar:** Used in conjunction with IRC:73 and IRC:SP:84 to ensure precise and safe curve design on all types of roads.

B. Pavement Design & Materials (in addition to IRC:37):

6. **IRC:15 - Guidelines for the Design of Rigid Pavements (Concrete Roads)**

* **Summary:** For projects where concrete roads are chosen (e.g., high traffic industrial areas, specific urban sections, or where material availability makes it viable), this code governs the design of cement concrete pavements, including slab thickness, joint spacing, and reinforcement.

* **Significance for Sagar:** Applicable if any section of road is proposed to be rigid pavement, ensuring its long-term performance.

7. **IRC:SP:20 - Rural Roads Manual**

* **Summary:** This manual offers comprehensive guidance for the planning, design, construction, and maintenance of rural roads, often with lower traffic volumes and specific material considerations.

* **Significance for Sagar:** Highly relevant for the vast network of rural and village roads within Sagar district, focusing on cost-effective and appropriate solutions for local conditions.

C. Construction & Quality Control:

8. **MoRTH Specifications for Road and Bridge Works (5th Revision or latest)**

Summary: *While not an IRC code, the Ministry of Road Transport and Highways (MoRTH) Specifications are the* bible* for execution. They detail the quality requirements, material specifications, construction procedures, and measurement criteria for almost every item of work in road and bridge construction.

* **Significance for Sagar:** Absolutely indispensable. Every project drawing and contract document will refer to these specifications for materials, workmanship, and quality assurance/quality control (QA/QC) for all road projects.

D. Drainage:

9. **IRC:SP:42 - Guidelines on Road Drainage**

* **Summary:** Focuses on the importance of proper drainage, design of cross-drainage structures (culverts, bridges), and surface drainage systems to prevent water accumulation on roads and damage to pavement structure.

* **Significance for Sagar:** Crucial given Madhya Pradesh's monsoon season. Effective drainage design is vital to prevent road degradation, erosion, and ensure longevity of roads.

E. Traffic Management & Safety (in addition to IRC:5):

10. **IRC:35 - Code of Practice for Road Markings**

* **Summary:** Specifies the types, dimensions, color, and placement of various road markings (e.g., centerlines, edge lines, pedestrian crossings, hazard markings) on the pavement surface.

* **Significance for Sagar:** Complements IRC:5 to provide complete visual guidance and safety features for motorists and pedestrians across all road types.

11. **IRC:SP:55 - Guidelines for Traffic Management in Work Zones**

* **Summary:** Provides guidelines for setting up safe and efficient traffic diversions, signage, and controls during road construction or maintenance activities.

* **Significance for Sagar:** Essential for ensuring the safety of both workers and the public during the construction phase of any road project in the district.

12. **IRC:SP:99 - Manual on Road Safety Audit**

* **Summary:** Provides a systematic process for evaluating the safety performance of road designs at various stages (feasibility, detailed design, pre-opening) to identify potential hazards and recommend remedial measures.

* **Significance for Sagar:** Promoting proactive safety measures for all new and upgraded road projects in the region.

F. Surveys & Investigations:

13. **IRC:SP:19 - Manual for Survey, Investigation, and Preparation of Road Projects**

* **Summary:** Provides guidelines for conducting topographic surveys, soil investigations, traffic surveys, and preparing project reports and drawings.

* **Significance for Sagar:** The foundational code for the initial stages of any road project, ensuring comprehensive data collection and accurate planning.

Conclusion:

For any road or highway project in Sagar, engineers and planners must refer to the latest editions of these IRC codes. The specific requirements will vary based on the type of road (urban, rural, highway), traffic volume, terrain, and local climatic conditions, but the codes listed above form the essential regulatory framework for robust and safe infrastructure development. The MoRTH Specifications act as the overarching technical guide for all construction and quality aspects.

Appendix B: Monsoon Calendar

Sagar, located in the heart of Madhya Pradesh, experiences a typical Central Indian monsoon, characterized by hot, dry summers, a distinct rainy season, and mild, dry winters. Understanding this calendar is crucial for agriculture, construction, and daily life.

Here's a detailed monsoon calendar for Sagar, Sagar district, Madhya Pradesh:

Monsoon Calendar for Sagar, Madhya Pradesh

Key: Construction Suitability Rating

* **Excellent:** Ideal conditions, minimal weather hindrance.

* **Good:** Favorable, minor considerations (heat, occasional showers).

* **Challenging:** Significant weather factors, requires careful planning/mitigation.

* **Poor:** Highly restrictive, often halts outdoor activities.

* **Impossible:** Active work generally stops.

Pre-Monsoon & Build-up Phase

1. March: The Warming Up

* **Typical Rainfall:** Very low (0-10 mm). Rare, isolated showers possible towards the end of the month.

* **Weather Considerations:**

* Clear, sunny skies dominate.

* Temperatures begin to rise steadily. Daytime highs range from 28°C to 35°C.

* Nights are pleasant and cool.

* Humidity is low, air is generally dry.

* **Construction Suitability: Excellent**

* **Pros:** Dry ground, stable soil, clear skies, moderate temperatures. Ideal for earthwork, foundation laying, structural work, concrete pouring, and masonry.

* **Cons:** None significant, perfect working conditions.

2. April: Peak Summer Heat

* **Typical Rainfall:** Low (5-20 mm). Occasional, localized pre-monsoon thundershowers (known as "mango showers") might occur, but they are brief.

* **Weather Considerations:**

* Intensely hot and dry. Daytime temperatures regularly exceed 38°C and can touch 42°C-44°C.

* Heatwaves are common.

* Humidity remains low, but can briefly spike during thundershowers.

* Dust storms are possible, especially before showers.

* **Construction Suitability: Good**

* **Pros:** Ground remains mostly dry and stable. Good for most structural and finishing work.

* **Cons:** Extreme heat requires worker management (hydration, shaded breaks, early morning/late evening shifts). Concrete curing needs careful attention to prevent rapid drying. Sudden thundershowers can briefly disrupt outdoor work.

3. May: Scorching & Pre-Monsoon Rains Intensify

* **Typical Rainfall:** Moderate (20-50 mm). Pre-monsoon thundershowers become more frequent and sometimes more intense, offering temporary relief from heat.

* **Weather Considerations:**

* The hottest month. Daytime temperatures consistently above 40°C, often reaching 45°C.

* Humidity gradually increases towards the end of the month as monsoon approaches.

* Dust storms are common.

* The atmosphere feels "heavy" and muggy before a downpour.

* **Construction Suitability: Good (but challenging due to heat)**

* **Pros:** Still possible to carry out extensive work, especially structural and interior.

* **Cons:** Intense heat and increasing humidity make outdoor work difficult. Risk of sudden, heavy thundershowers means sensitive materials (cement bags, fresh concrete) need protection. Site access can become muddy for a short period after heavy rain.

Active Monsoon Phase

4. June: Monsoon Onset

* **Typical Rainfall:** High (100-200 mm). The monsoon typically arrives in Sagar by mid-June (around 15-20th), bringing a significant and sustained increase in rainfall.

* **Weather Considerations:**

* Temperatures drop noticeably from May, settling around 30-35°C.

* Humidity becomes very high.

* Skies are often overcast or partly cloudy.

* Initial showers can be heavy and widespread.

* **Construction Suitability: Challenging to Poor**

* **Pros:** Some indoor work, sheltered activities (e.g., roofing under existing structure, plumbing, electrical).

* **Cons:** Ground becomes saturated quickly, making earthwork, excavation, and foundation work very difficult/risky. Concrete pouring is risky due to rain. Site access can become muddy. Material storage needs proper waterproofing. Outdoor masonry and plastering are affected.

5. July: Peak Monsoon Intensity

* **Typical Rainfall:** Very High (250-400 mm). This is usually the wettest month, with frequent and often continuous heavy rainfall.

* **Weather Considerations:**

* Temperatures stabilize around 28-32°C.

* Humidity remains extremely high.

* Days are often overcast, with long periods of rain.

* Waterlogging in low-lying areas is common.

* **Construction Suitability: Poor to Impossible**

* **Pros:** Almost exclusively interior finishing work, electrical, plumbing, painting (if humidity can be managed), or work under completely enclosed structures.

* **Cons:** Heavy, sustained rain halts most outdoor activities. Earthwork is impossible. Foundation work is out of the question. Concrete work is extremely challenging. Material degradation (e.g., rust, moisture damage) is a concern. Worker safety due to slippery conditions.

6. August: Continued Heavy Rains

* **Typical Rainfall:** High (200-350 mm). Continues to be a very wet month, though rainfall might slightly decrease towards the end compared to July's peak.

* **Weather Considerations:**

* Similar to July: stable temperatures (28-32°C), very high humidity, often overcast.

* Lingering waterlogging.

* **Construction Suitability: Poor to Impossible**

* **Pros:** Same as July – interior work only.

* **Cons:** Same challenges as July. This is the heart of the monsoon period where major outdoor construction activities are generally paused.

7. September: Monsoon Withdrawal Begins

* **Typical Rainfall:** Moderate to High (100-200 mm). Rainfall intensity and frequency start to decrease, especially towards the latter half of the month. More sunny breaks appear.

* **Weather Considerations:**

* Humidity remains high, but slightly less intense than July/August.

* Temperatures remain around 28-33°C.

* Days become a mix of sunny periods and intermittent showers.

* The ground slowly begins to dry out, though still damp.

* **Construction Suitability: Challenging, improving towards end**

* **Pros:** Outdoor work can slowly resume during longer dry spells. Roofing, exterior plastering, and some masonry might be possible.

* **Cons:** Ground is still too damp for major earthwork or foundation laying without significant precautions. Sudden, heavy showers are still possible. Risk of unseasonal rain for concrete work. Site still muddy in parts.

Post-Monsoon & Dry Season

8. October: Post-Monsoon Cleansing

* **Typical Rainfall:** Low (20-50 mm). The monsoon officially withdraws from Sagar by mid-October. Occasional light, retreating monsoon showers might occur, but most days are dry.

* **Weather Considerations:**

* Pleasant weather returns. Humidity drops significantly.

* Clear, blue skies become prevalent.

* Temperatures are very comfortable, ranging from 25°C to 30°C.

* Nights become cooler.

* **Construction Suitability: Excellent**

* **Pros:** Ideal working conditions. Ground is drying out and stabilizing. Perfect for all types of outdoor work, including foundations, earthwork, structural, and finishing.

* **Cons:** None significant. One of the best months for construction.

9. November: Mild Winter Onset

* **Typical Rainfall:** Very Low (0-10 mm). Virtually no rainfall.

* **Weather Considerations:**

* Dry, clear, and cool weather.

* Daytime temperatures are very pleasant (20-28°C).

* Nights are cool, sometimes chilly.

* Humidity is low.

* **Construction Suitability: Excellent**

* **Pros:** Perfect weather for all construction activities. Stable ground, no heat stress, no rain disruption. Peak construction season.

* **Cons:** None.

10. December: Peak Winter

* **Typical Rainfall:** Very Low (0-5 mm). Negligible, very rare light showers from Western Disturbances (uncommon for Sagar).

* **Weather Considerations:**

* Coldest month. Daytime temperatures around 18-25°C.

* Nights can be quite cold (5-10°C), sometimes with fog.

* Dry air, clear skies.

* **Construction Suitability: Excellent**

* **Pros:** Excellent for all types of construction. Stable, dry ground.

* **Cons:** Cold mornings might slow down initial work, but overall conditions are highly favorable.

11. January: Continuing Cold & Dry

* **Typical Rainfall:** Very Low (0-5 mm). Similar to December, extremely dry.

* **Weather Considerations:**

* Continues to be cold, especially mornings and nights. Daytime temperatures 18-25°C.

* Foggy mornings are common.

* Clear, sunny days.

* Very low humidity.

* **Construction Suitability: Excellent**

* **Pros:** Ideal for construction, similar to December.

* **Cons:** Morning cold.

12. February: Warming Up Slowly

* **Typical Rainfall:** Very Low (0-5 mm). Negligible.

* **Weather Considerations:**

* Temperatures gradually start to rise towards the end of the month (22-30°C).

* Nights remain cool.

* Clear skies, dry air.

* **Construction Suitability: Excellent**

* **Pros:** Excellent construction conditions, with warming temperatures.

* **Cons:** None.

General Considerations for Construction in Sagar:

• **Monsoon Preparedness:** Always plan to complete major outdoor, ground-level, or exposed structural work *before* mid-June. Ensure proper drainage on-site. Protect materials from moisture.

• **Material Storage:** During monsoon, cement, rebar, wood, and other moisture-sensitive materials must be stored in completely dry, elevated, and well-covered areas.

• **Worker Safety:** Prioritize worker safety during extreme heat (hydration, breaks) and monsoon (slippery surfaces, electrical hazards, lightning).

• **Foundation Work:** Best undertaken in the dry months (October to May) when soil stability is optimal.

• **Concrete Curing:** During summer, ensure proper and extended curing to prevent premature drying and cracking. During monsoon, protect fresh concrete from direct rain.

• **Unseasonal Rain:** While the calendar gives typical patterns, climate change can lead to unpredictable weather. Always monitor local forecasts.

• **Road Access:** Unpaved roads or site access can become severely muddy and unusable during peak monsoon. Plan for alternative routes or pre-monsoon road improvements.

By understanding this detailed calendar, project managers and residents in Sagar can effectively plan their activities to align with the region's distinct weather patterns.

Appendix C: Equipment Catalog

This catalog outlines a comprehensive range of equipment essential for road construction projects in Sagar, Sagar district, Madhya Pradesh, India. Given Sagar's location in the Bundelkhand region, the projects often involve varying soil types (including black cotton soil in some areas), potential rocky outcrops, and a climate that necessitates robust equipment for both hot summers and monsoon challenges.

The catalog is structured by the typical phases of road construction.

Comprehensive Equipment Catalog for Road Construction in Sagar, Madhya Pradesh

Project Context: Construction and maintenance of National Highways (NH), State Highways (SH), Major District Roads (MDR), and Rural Roads (PMGSY).

Phase 1: Survey, Site Preparation & Clearing

These machines are used for initial site assessment, clearing vegetation, and preparing the ground for further work.

1. **Total Station / DGPS (Differential Global Positioning System)**

* **Specifications:**

* **Accuracy:** Angle 2-5 arc seconds, Distance ±(2mm + 2ppm).

* **Range:** Reflectorless up to 500m, with prism up to 5,000m.

* **Features:** Data logging, Bluetooth/USB connectivity, integrated software.

* **Capacity:** High precision data collection for up to 1-2 km/day for detailed surveys.

* **Usage:** Topographical surveys, precise setting out of alignment, cross-sections, calculating cut/fill volumes, monitoring settlement.

Sagar Context:* Essential for accurate alignment in varying terrain, critical for large NH/SH projects.

2. **Auto Level / Digital Level**

* **Specifications:**

* **Magnification:** 24x - 32x.

* **Accuracy:** ±1.0 mm/km double-run leveling.

* **Range:** Up to 100m.

* **Capacity:** Daily leveling over 500-1000m.

* **Usage:** Establishing vertical control, checking grade, setting out levels for various layers, drainage slopes.

3. **Brush Cutter / Earth Auger**

* **Specifications:**

* **Engine:** 2-stroke, 25-50 cc (Brush Cutter); 2-stroke, 50-70 cc (Earth Auger).

* **Blade/Bit Diameter:** 250-300mm (Brush Cutter); 150-300mm (Earth Auger).

* **Capacity:** Clearing dense vegetation over 500-1000 sq m/day (Brush Cutter); Drilling 50-100 holes/day (Earth Auger).

* **Usage:** Clearing shrubs, small trees, and grass; drilling holes for fencing, signposts, or soil sampling.

Phase 2: Earthwork & Subgrade Construction

This phase involves excavation, filling, shaping, and compacting the ground to form the road's foundation.

1. **Hydraulic Excavator (Backhoe Excavator)**

* **Specifications:**

* **Operating Weight:** 10-30 tons (e.g., JCB JS205, Tata Hitachi EX200, Volvo EC210D).

* **Engine Power:** 120-200 HP.

* **Bucket Capacity:** 0.8 - 1.5 m^3.

* **Max Digging Depth:** 5.5 - 7.0m.

* **Capacity:** Excavating 150-300 m^3/hour.

* **Usage:** Excavation of earth, loading dumpers, trenching for drains, rock breaking (with hydraulic hammer attachment).

Sagar Context:* Critical for both soil excavation and potential rocky areas.

2. **Bulldozer (Crawler Dozer)**

* **Specifications:**

* **Operating Weight:** 15-25 tons (e.g., CAT D6, L&T Komatsu D85).

* **Engine Power:** 150-250 HP.

* **Blade Capacity:** 3.5 - 6.0 m^3.

* **Capacity:** Spreading 200-400 m^3/hour, pushing material over short distances.

* **Usage:** Clearing, leveling, pushing earth, ripping hard soil/soft rock (with ripper attachment), backfilling.

3. **Motor Grader**

* **Specifications:**

* **Operating Weight:** 12-18 tons (e.g., CAT 140K, Volvo G930, JCB 455).

* **Engine Power:** 140-190 HP.

* **Blade Length:** 3.7 - 4.3m.

* **Blade Reach:** Up to 2.5m beyond tires.

* **Capacity:** Grading 1000-2000 sq m/hour per pass.

* **Usage:** Fine grading of subgrade, sub-base, and base course, achieving desired cross-slope and super-elevation, mixing aggregates.

Sagar Context:* Essential for achieving precise road profiles and drainage in all road types.

4. **Soil Compactor (Smooth Drum Vibratory Roller)**

* **Specifications:**

* **Operating Weight:** 8-12 tons (single drum), 10-16 tons (double drum) (e.g., Hamm 3410, Dynapac CA250D, JCB VMT860).

* **Engine Power:** 80-120 HP.

* **Drum Width:** 1.7 - 2.1m.

* **Centrifugal Force:** 150-300 kN.

* **Capacity:** Compacting 800-1500 sq m/hour (depending on layer thickness and passes).

* **Usage:** Compaction of earthwork, subgrade, granular sub-base (GSB).

5. **Padfoot Compactor (Sheepfoot Roller)**

* **Specifications:**

* **Operating Weight:** 10-15 tons (often interchangeable drum with smooth drum).

* **Drum Width:** 1.7 - 2.1m.

* **Pad Height:** 100-150mm.

* **Capacity:** Similar to smooth drum, but more effective on cohesive soils.

* **Usage:** Compaction of cohesive and semi-cohesive soils (e.g., black cotton soil if present).

Sagar Context:* Highly recommended if black cotton soil is encountered, as it provides better deep compaction.

6. **Dump Truck (Tipper Truck)**

* **Specifications:**

* **Capacity:** 10-25 m^3 (15-35 tons) (e.g., Tata Signa, Ashok Leyland Haulage, BharatBenz).

* **Engine Power:** 200-350 HP.

* **Wheel Configuration:** 6x4, 8x4.

* **Capacity:** Transporting 15-30 tons per trip.

* **Usage:** Hauling excavated material, aggregates, hot mix asphalt, and other construction materials.

Sagar Context:* Backbone of material logistics, essential for both short and long hauls.

7. **Water Tanker**

* **Specifications:**

* **Capacity:** 8,000 - 16,000 liters.

* **Mounted on:** Truck chassis.

* **Features:** Sprinkler bar, pump.

* **Capacity:** Watering 5,000-10,000 sq m/hour (for dust control/compaction aid).

* **Usage:** Dust suppression on site, providing water for compaction of earthwork and aggregate layers, curing concrete.

Phase 3: Sub-base & Base Course Construction

This phase involves laying and compacting granular layers above the subgrade.

1. **Wheel Loader**

* **Specifications:**

* **Operating Weight:** 10-20 tons (e.g., JCB 432ZX, L&T Komatsu PC200, Volvo L120).

* **Engine Power:** 100-200 HP.

* **Bucket Capacity:** 1.5 - 3.5 m^3.

* **Capacity:** Loading 150-300 m^3/hour.

* **Usage:** Loading aggregates into dumpers, feeding crushers, stockpiling material, general material handling.

2. **Crushing Plant (Optional - If on-site aggregate production)**

* **Specifications:**

* **Type:** Jaw Crusher (Primary), Cone/Impact Crusher (Secondary/Tertiary).

* **Capacity:** 100-300 TPH (Tons Per Hour).

* **Output Size:** Customizable to client requirements (e.g., 65mm, 40mm, 20mm, 10mm aggregates).

* **Capacity:** Producing 800-2400 tons of aggregates per 8-hour shift.

* **Usage:** Crushing stones/boulders into required aggregate sizes for GSB, WMM, DBM, BC.

Sagar Context:* Can reduce transportation costs if a suitable quarry is nearby and project volume justifies it.

3. **Wet Mix Macadam (WMM) Plant**

* **Specifications:**

* **Capacity:** 100-200 TPH (e.g., Apollo, Wirtgen, Linnhoff).

* **Features:** Pugmill mixer, aggregate feeders, water injection system.

* **Capacity:** Producing 800-1600 tons of WMM per 8-hour shift.

* **Usage:** Producing a homogenous mixture of aggregates and water for WMM layer as per MORTH specifications.

4. **Pneumatic Tire Roller (PTR)**

* **Specifications:**

* **Operating Weight:** 15-25 tons (ballasted) (e.g., Hamm GRW15, Dynapac CP275, Ammann AP240).

* **Tires:** 7-9 tires, smooth tread.

* **Engine Power:** 70-120 HP.

* **Capacity:** Compacting 600-1000 sq m/hour.

* **Usage:** Compaction of WMM, DBM, BC layers; provides kneading action, sealing the surface.

Phase 4: Pavement Course (Bituminous / Concrete) Construction

This is the final structural layer of the road, typically asphalt or concrete.

For Bituminous Pavements:

1. **Asphalt Mixing Plant (Hot Mix Plant)**

* **Specifications:**

* **Type:**

* **Drum Mix Plant:** Continuous production, 60-160 TPH (e.g., Apollo, Ammann, Nilang).

* **Batch Mix Plant:** Batch production, higher quality control, 80-200 TPH (e.g., Wirtgen, Lintec, Marini).

* **Features:** Cold aggregate feeders, drying drum, bitumen tank, filler unit, control cabin.

* **Capacity:** Producing 480-1280 tons (Drum Mix) / 640-1600 tons (Batch Mix) per 8-hour shift.

* **Usage:** Producing hot mix asphalt (DBM, BC, SDBC, etc.) by heating and mixing aggregates with bitumen and filler.

Sagar Context:* Batch mix plants are preferred for high-quality NH/SH projects, while drum mix are common for MDR/rural roads due to cost-effectiveness.

2. **Bitumen Sprayer / Distributor**

* **Specifications:**

* **Tank Capacity:** 6,000 - 10,000 liters.

* **Spray Width:** 2.4 - 4.5m (extendable).

* **Heating System:** Direct flame or thermic fluid.

* **Capacity:** Spraying 5,000-10,000 sq m/hour (prime coat/tack coat).

* **Usage:** Applying uniform coats of bitumen emulsion or hot bitumen for prime coat, tack coat, and surface dressing.

3. **Asphalt Paver Finisher**

* **Specifications:**

* **Type:** Tracked or Wheeled (e.g., Vogele, Wirtgen, Dynapac, Ammann, Apollo).

* **Paving Width:** 3.0 - 7.5m (extendable screed).

* **Paving Thickness:** 20 - 300mm.

* **Engine Power:** 100-200 HP.

* **Features:** Automatic grade and slope control (sensor pavers).

* **Capacity:** Paving 100-250 tons/hour, covering 150-400 sq m/hour (depending on thickness).

* **Usage:** Laying hot mix asphalt evenly and accurately to specified thickness and crown.

Sagar Context:* Sensor pavers are mandatory for NH/SH for achieving ride quality.

4. **Tandem Vibratory Roller**

* **Specifications:**

* **Operating Weight:** 8-12 tons (e.g., Hamm HD90, Dynapac CC4200, Volvo DD100).

* **Drum Width:** 1.5 - 2.1m.

* **Frequency/Amplitude:** High frequency, low amplitude for asphalt.

* **Capacity:** Compacting 600-1000 sq m/hour.

* **Usage:** Primary compaction of bituminous layers (DBM, BC).

5. **Static Roller / Smooth Wheel Roller**

* **Specifications:**

* **Operating Weight:** 8-10 tons (3-wheel type).

* **Engine Power:** 60-80 HP.

* **Capacity:** Finishing compaction of bituminous layers.

* **Usage:** Final compaction and finishing of bituminous layers, achieving high density and smooth surface.

For Concrete Pavements (PQC/DLC - if applicable):

1. **Concrete Batching Plant**

* **Specifications:**

* **Type:** Wet Mix or Dry Mix.

* **Capacity:** 30-120 m^3/hour.

* **Features:** Aggregate bins, cement silo, water tank, admixture dispensers, twin-shaft mixer (for wet mix).

* **Capacity:** Producing 240-960 m^3 of concrete per 8-hour shift.

* **Usage:** Producing designed concrete mixes (DLC, PQC) for rigid pavements.

2. **Slipform Paver**

* **Specifications:**

* **Paving Width:** 3.0 - 12.0m.

* **Paving Thickness:** 150 - 450mm.

* **Features:** Auto grade/slope control, dowel/tie bar inserters.

* **Capacity:** Paving 500-1500 sq m/hour (depending on thickness and width).

* **Usage:** Laying and forming concrete pavements (PQC, DLC, kerbs, barriers) in a continuous operation.

3. **Concrete Transporters / Transit Mixers**

* **Specifications:**

* **Drum Capacity:** 6 - 9 m^3.

* **Mounted on:** Truck chassis.

* **Capacity:** Transporting 6-9 m^3 of fresh concrete per trip.

* **Usage:** Transporting mixed concrete from batching plant to the paving site while agitating to prevent segregation.

4. **Curing Compound Sprayer**

* **Specifications:**

* **Capacity:** 100-200 liter tank.

* **Spray System:** Manual or automatic.

* **Usage:** Applying curing compounds on fresh concrete pavements to prevent rapid moisture loss.

Phase 5: Finishing, Drainage & Ancillary Works

Equipment for completing the road, ensuring drainage, and adding safety features.

1. **Road Marking Machine**

* **Specifications:**

* **Type:** Thermoplastic or Cold Paint.

* **Application:** Manual push-type or ride-on.

* **Tank Capacity:** 100-250 kg (thermoplastic), 50-100 liters (cold paint).

* **Usage:** Applying road markings (lane lines, edge lines, arrows, symbols) for traffic safety.

2. **Concrete Cutter / Road Saw**

* **Specifications:**

* **Engine:** Petrol/Diesel, 10-25 HP.

* **Blade Diameter:** 350-600mm.

* **Cutting Depth:** Up to 200mm.

* **Usage:** Cutting expansion/contraction joints in concrete pavements, utility cuts, removal of damaged pavement sections.

3. **Plate Compactor / Rammer**

* **Specifications:**

* **Engine:** Petrol, 5-10 HP.

* **Plate Size:** 400x500mm to 700x800mm.

* **Compacting Force:** 15-30 kN.

* **Usage:** Compacting soil in confined areas (trenches, around structures, shoulders).

4. **Concrete Mixer (Mini/Site Mixers)**

* **Specifications:**

* **Drum Capacity:** 0.2 - 0.5 m^3 (1 bag to 3 bags).

* **Engine:** Diesel or Electric.

* **Usage:** Mixing concrete for culverts, drains, kerbs, side walls, and other small structures.

5. **Concrete Vibrator**

* **Specifications:**

* **Type:** Needle (flexi-shaft) or screed vibrator.

* **Needle Diameter:** 25-60mm.

* **Frequency:** 12,000-15,000 VPM.

* **Usage:** Consolidating freshly poured concrete to remove air voids and ensure uniform compaction.

Phase 6: Quality Control & Laboratory Equipment

Essential for ensuring materials and finished products meet MORTH (Ministry of Road Transport and Highways) specifications.

1. **Soil Testing Equipment:**

* Liquid Limit Apparatus, Plastic Limit Apparatus, Shrinkage Limit Apparatus.

* Proctor Compaction Apparatus (Standard & Modified).

* California Bearing Ratio (CBR) Test Apparatus.

* Field Density Test (Sand Replacement Method) Apparatus.

2. **Aggregate Testing Equipment:**

* Sieve Shaker & Sieves (various sizes).

* Aggregate Crushing Value (ACV) Apparatus.

* Los Angeles Abrasion Value Apparatus.

* Flakiness & Elongation Index Gauge.

* Specific Gravity & Water Absorption Test Setup.

3. **Bitumen Testing Equipment:**

* Penetration Test Apparatus.

* Ductility Test Apparatus.

* Softening Point Apparatus.

* Viscometer.

* Centrifuge Extractor (for bitumen content).

* Marshall Stability Test Apparatus.

4. **Concrete Testing Equipment:**

* Cube Moulds (150mm x 150mm x 150mm).

* Compression Testing Machine (CTM) - 2000 kN.

* Slump Cone Apparatus.

* Core Cutting Machine (for pavement samples).

* Schmidt Rebound Hammer (non-destructive testing).

5. **Field Testing Equipment:**

* Nuclear Density Gauge (NDG) / Sand Cone Density Apparatus.

* Falling Weight Deflectometer (FWD) / Benkelman Beam Deflection Apparatus (for pavement deflection).

* Roughometer / Bump Integrator (for ride quality).

* Digital Thermometers (for asphalt temperature).

* Measuring Tapes, Rulers, Spirit Levels.

Phase 7: Support, Maintenance & Safety Equipment

General site support, vehicle maintenance, and safety essentials.

1. **Fuel Bowser / Mobile Fuel Station:**

* **Capacity:** 5,000 - 10,000 liters.

* **Usage:** On-site refueling of machinery.

2. **Mobile Workshop / Service Van:**

* **Equipped with:** Tools, welding machine, air compressor, spare parts, lubrication systems.

* **Usage:** On-site repair and maintenance of equipment.

3. **Generator Sets:**

* **Power Output:** 10 KVA to 125 KVA.

* **Usage:** Providing power for site offices, lighting towers, and various electrical tools.

4. **Lighting Towers:**

* **Mast Height:** 6-9 meters.

* **Light Type:** LED or Metal Halide, 4x1000W or 6x200W.

* **Usage:** Illuminating work areas for night operations.

5. **Traffic Management & Safety Equipment:**

* Traffic Cones, Barricades, Warning Lights.

* Road Signs (temporary and permanent).

* High-Visibility Vests, Helmets, Safety Shoes.

* First Aid Kits and trained personnel.

* Fire Extinguishers.

6. **Pickup Trucks / Utility Vehicles:**

* **Usage:** Supervision, carrying small tools, personnel transport.

Key Considerations for Road Construction in Sagar, MP:

• **Local Availability:** Many brands like JCB, Tata Hitachi, Apollo, L&T, Volvo, CAT, Wirtgen, Hamm have strong presence and service networks in India, including Madhya Pradesh. Rental options are also widely available.

• **Maintenance & Spares:** Ensure ready availability of spare parts and skilled mechanics, as downtime can be very costly.

• **Environmental Compliance:** Adherence to dust control measures, noise pollution limits, and waste management protocols.

• **Weather Conditions:** Equipment should be robust enough to handle the hot and dry summers and the wet monsoon seasons typical of Sagar.

• **Skilled Manpower:** Availability of trained operators and technical staff is crucial for efficient and safe operation of advanced machinery.

• **Technology Integration:** GPS-enabled equipment for precise grading, telematics for fleet management, and digital project management tools can significantly improve efficiency and quality.

This comprehensive catalog provides a robust foundation for planning and executing various road construction projects in the Sagar region, ensuring efficiency, quality, and adherence to modern construction standards.

Appendix D: Testing Protocols

Material testing protocols for road projects in Sagar, Sagar district, Madhya Pradesh, India, strictly adhere to the **Ministry of Road Transport & Highways (MoRTH) "Specifications for Road and Bridge Works" (latest edition, typically the 6th edition)**. These specifications are comprehensive and cover all aspects from material sourcing to final layer compaction.

The primary objective of these protocols is to ensure that all materials used and the workmanship employed meet the design requirements, leading to a durable, safe, and cost-effective road infrastructure.

Here's a breakdown of the material testing protocols:

General Principles of MoRTH Testing Protocols:

1. **Reference Document:** The MoRTH "Specifications for Road and Bridge Works" (current edition) is the ultimate guide for all material and construction quality control. All tests are conducted as per relevant **Indian Standards (IS codes)**.

2. **Field Laboratory:** A well-equipped field laboratory, conforming to MoRTH Clause 100, is mandatory at the project site. It must be staffed by qualified and experienced engineers and laboratory technicians.

3. **Frequency of Testing:** MoRTH specifies minimum frequencies for various tests (often detailed in Appendix-1 of the specifications), which must be strictly followed. The Engineer-in-Charge may demand higher frequencies based on site conditions or quality concerns.

4. **Sampling:** Samples must be representative of the material Lot, drawn in a manner specified by relevant IS codes.

5. **Calibration:** All testing equipment must be regularly calibrated by NABL accredited laboratories or other approved agencies.

6. **Documentation:** All test results, observations, and corrective actions must be meticulously recorded, signed by the testing personnel and verified by the Engineer-in-Charge. Control charts (e.g., for compaction, gradation) are often maintained.

7. **Quality Assurance (QA) & Quality Control (QC):** QC is performed by the contractor to ensure conformity, while QA is typically performed by an independent agency (client's consultant) to verify the effectiveness of the QC system.

I. Soil Testing Protocols (Embankment, Subgrade, Blanketing/Capping Layer):

Soil testing is crucial for ensuring the stability and load-bearing capacity of the road foundation.

A. Pre-Construction (Borrow Area Identification & Subgrade Assessment):

1. **Identification & Classification:**

* **Sieve Analysis (IS:2720 Part 4):** To determine particle size distribution.

* **Atterberg Limits (Liquid Limit, Plastic Limit, Plasticity Index - IS:2720 Part 5):** To classify fine-grained soils and assess their plasticity and workability.

* **Specific Gravity (IS:2720 Part 3):** For various calculations related to soil properties.

* **Moisture Content (IS:2720 Part 2):** Natural moisture content of the soil.

* **Purpose:** To ascertain the suitability of borrow materials for embankment/subgrade and classify existing subgrade soil.

2. **Strength & Compaction Characteristics:**

* **Proctor Compaction Test (Standard & Modified - IS:2720 Part 7/8):** To determine Optimum Moisture Content (OMC) and Maximum Dry Density (MDD). These are target values for field compaction.

* **California Bearing Ratio (CBR) Test (IS:2720 Part 16, typically soaked for 4 days):** Crucial for pavement design, it measures the resistance of a soil to penetration.

* **Purpose:** To provide design parameters (CBR) and compaction targets (OMC/MDD) for the road layers.

B. During Construction (Embankment & Subgrade Laying):

1. **Field Density Test:**

* **Sand Replacement Method (IS:2720 Part 28) / Core Cutter Method (IS:2720 Part 29):** To check the achieved dry density of compacted layers against the specified MDD (e.g., 97% for subgrade, 95% for embankment).

* **Frequency:** Minimum 1 test per 1000 sqm for embankment, 1 test per 500 sqm for subgrade, or as per MoRTH Appendix-I.

2. **Field Moisture Content:**

* **Rapid Moisture Meter / Oven Drying (IS:2720 Part 2):** To ensure that compaction is carried out at or near the OMC.

* **Frequency:** To be performed along with field density tests.

3. **Layer Thickness & Level Check:**

* **Chain & Level Survey:** To ensure the laid layer meets the design thickness and profile.

4. **Proof Rolling:** For critical layers like subgrade, heavy pneumatic-tyred rollers may be used to identify any localized weak spots.

II. Aggregate Testing Protocols (GSB, WMM, Bituminous Mixes, Concrete):

Aggregates form the bulk of pavement layers and their quality is paramount.

A. Source Approval & Initial Testing (Quarry/Crusher):

1. **Gradation / Sieve Analysis (IS:2386 Part 1):** To ensure the aggregates meet the specified grading limits for different layers (e.g., GSB, WMM, DBM, BC).

2. **Specific Gravity & Water Absorption (IS:2386 Part 3):** Important for mix design and assessing aggregate quality (porosity).

3. **Flakiness Index & Elongation Index (IS:2386 Part 1):** To check the shape characteristics of aggregates; high values can lead to poor interlock and workability.

4. **Aggregate Crushing Value (ACV) (IS:2386 Part 4):** Resistance to crushing under compressive load.

5. **Los Angeles Abrasion Value (LAAV) (IS:2386 Part 4):** Resistance to wear and abrasion, crucial for wearing courses.

6. **Aggregate Impact Value (AIV) (IS:2386 Part 4):** Resistance to sudden shock or impact.

7. **Soundness Test (Sodium Sulphate/Magnesium Sulphate - IS:2386 Part 5):** To assess resistance to weathering and disintegration.

8. **Stripping Value (for bituminous mixes, IS:6241):** Adhesion between aggregate and bitumen in the presence of water.

9. **Polished Stone Value (PSV) (for wearing courses, IRC:37/BS 812 Part 114):** Resistance to polishing under traffic, essential for skid resistance.

* **Purpose:** To approve aggregate sources and ensure the aggregates possess the necessary strength, durability, and shape properties for their intended use.

B. During Construction (Material at Site/Production Stage):

1. **Gradation (Sieve Analysis):**

* **Frequency:** Very frequent (e.g., 1 test per 200 cum for GSB/WMM, 1 test per 80-100 tonnes for bituminous mixes from hot bins) to ensure consistency of received material or plant output.

2. **Flakiness & Elongation Index:** Less frequent than gradation, but periodically checked to monitor crusher output.

3. **Binder Content (for Bituminous Mixes):**

* **Extraction Test (Reflux/Centrifuge Method - IS:2386 Part 8):** To determine the actual bitumen content in the mixed material from the plant.

* **Frequency:** As per MoRTH Appendix-I (e.g., 1 test per 100 tonnes of mix).

4. **Field Density of Compacted Layers (GSB, WMM, DBM, BC):**

* **Sand Replacement / Core Cutter Method (for unbound layers like GSB, WMM):** To verify target compaction.

* **Core Cutter Method (IS:73) / Nuclear Density Gauge (for bituminous layers):** To determine the density of compacted bituminous layers. Target density is usually a percentage of laboratory-determined maximum theoretical density or specific gravity.

* **Frequency:** MoRTH Appendix-I (e.g., 1 test per 500 sqm for GSB/WMM, 1 test per 700 sqm or 100 tonnes for bituminous layers).

III. Bituminous Binder & Mix Testing Protocols:

Essential for bituminous pavement layers.

A. Bituminous Binder (Bitumen - VG/PMB/CRMB grades):

1. **Penetration Test (IS:1203):** Consistency.

2. **Softening Point (Ring & Ball) (IS:1205):** Temperature susceptibility.

3. **Ductility Test (IS:1208):** Elasticity and adhesive properties.

4. **Specific Gravity (IS:1202).**

5. **Viscosity (Absolute/Kinematic - for VG grades, IS:1206 Part 2/3):** Flow characteristics.

6. **Flash & Fire Point (IS:1209):** Safety during handling and heating.

7. **Elastic Recovery (for modified bitumen - IS:15462).**

8. **Storage Stability (for modified bitumen - IS:15462).**

* **Purpose:** To ensure the binder meets the specified grade requirements and will perform adequately in the mix.

B. Bituminous Mix Design (Marshall Method - MoRTH Clause 500, MS-2):

1. **Optimum Binder Content (OBC) Determination:** Through a series of laboratory tests varying binder content.

2. **Marshall Stability & Flow (ASTM D6927):** Measures the mix's resistance to deformation and its flexibility.

3. **Volumetric Properties:**

* **Percent Air Voids (Vv).**

* **Voids in Mineral Aggregate (VMA).**

* **Voids Filled with Bitumen (VFB).**

* **Purpose:** To achieve a durable, stable, and workable mix design that meets MoRTH specified volumetric and strength criteria.

C. During Bituminous Mix Production & Laying:

1. **Aggregate Gradation (Hot Bins):** Sieve analysis of aggregates from hot bins before mixing.

2. **Binder Content (Extraction Test):** As mentioned under Aggregate Testing.

3. **Mix Temperature:** Checked at plant, paver, and roller to ensure proper compaction.

4. **Field Density (Core Cutter/NDG):** As mentioned under Aggregate Testing.

5. **Layer Thickness:** Measured by depth gauge or after coring.

6. **Surface Evenness (MoRTH Clause 900):**

* **3-meter Straight Edge:** For localized irregularities.

* **Rolling Straight Edge / Automatic Road Analyzer:** For overall ride quality (IRC:SP:73).

* **Purpose:** To confirm the hot mix asphalt (HMA) plant is producing the designed mix, it's being laid at correct temperatures, and achieving the required compaction and surface profile.

IV. Water Testing:

1. **Tests (IS:456 for concrete, similar standards for road works):** pH value, presence of chlorides, sulphates, organic matter, and total dissolved solids.

* **Purpose:** To ensure water used for mixing, curing, or compaction is free from deleterious materials that could affect the quality of the road layers.

V. Quality Control (QC) & Quality Assurance (QA) Measures:

1. **Sampling and Testing Frequencies:** As per MoRTH Appendix-I (mandatory minimums). Higher frequencies may be adopted based on site requirements.

2. **Test Record Keeping:** Detailed registers and reports for every test performed, including date, time, sample location, test method, results, and acceptance criteria.

3. **Control Charts:** For key parameters (e.g., compaction density, aggregate gradation, bitumen content) to monitor trends and identify potential issues early.

4. **Non-Conformity Management:** Clear procedures for identifying non-conforming materials or work, taking corrective actions (rejection, removal, reprocessing, re-compaction), and documenting them.

5. **Personnel Qualification:** All testing personnel must be adequately qualified and experienced.

6. **Regular Audits:** QA agencies periodically audit the contractor's QC laboratory and procedures to ensure compliance with MoRTH specifications.

7. **Documentation of Construction Activities:** Records of material receipts, plant calibration, daily work progress, weather conditions, etc., are maintained.

By rigorously following these MoRTH material testing protocols, road projects in Sagar (and across India) aim to achieve the highest standards of quality, ensuring the longevity and performance of the infrastructure. The local context of Sagar, such as the specific geological formations providing aggregates or prevalent soil types (e.g., black cotton soil requiring specific treatment if encountered), would be addressed within the framework of MoRTH's general and specific clauses.

Appendix E: Compliance Matrix

This compliance matrix outlines adherence to key Indian standards (IRC, MoRTH, BIS, NHAI) for infrastructure projects, specifically in Sagar, Sagar district, Madhya Pradesh. While the standards themselves are national, their application and enforcement are critical for any project undertaken in the specified location.

Key Abbreviations:

* **IRC:** Indian Road Congress

* **MoRTH:** Ministry of Road Transport and Highways (primarily refers to the "Specifications for Road and Bridge Works")

* **BIS:** Bureau of Indian Standards (primarily refers to various IS codes)

* **NHAI:** National Highways Authority of India (often adopts/mandates IRC, MoRTH, BIS, and may have its own supplementary guidelines/manuals)

* **QA/QC:** Quality Assurance / Quality Control

* **DPR:** Detailed Project Report

* **ITP:** Inspection & Test Plan

Compliance Matrix for Projects in Sagar, Madhya Pradesh

Project Type (General): Road/Bridge/Infrastructure Project

Location: Sagar, Sagar District, Madhya Pradesh, India

S. No.	Project Activity/ Component	Specific Requirement/Aspect	Applicable Standard/Code (IRC/ MoRTH/ BIS/NHAI)	Key Clauses/Sections	Method of Compliance/ Evidence	Responsible Party	Frequency/Stage of Check	Remarks
1.	Project Planning & Design							
1.1	Feasibility Study & DPR	Project viability, alignment, environmental/social impact, preliminary design.	NHAI Manuals for DPR Preparation, IRC SP Series, MoRTH Guidelines	Relevant sections on planning, surveys, traffic studies, economic analysis, environmental assessment.	DPR documents, Feasibility Reports, Environmental Impact Assessment (EIA), Social Impact Assessment (SIA).	Consultant/Client	Pre-construction (Planning)	NHAI often provides specific templates for DPRs to ensure comprehensive coverage.
1.2	Geotechnical Investigation	Soil classification, bearing capacity, settlement, foundation design parameters.	IRC:75, IS:1892, IS:6403, IS:2911, IS:1904, MoRTH Section 200	Relevant IS codes for field/lab tests. MoRTH requirements for sub-grade and foundation.	Geotechnical Investigation Report (GIR), Bore log data, Lab test reports.	Geotechnical Engineer	Pre-construction (Design)	Critical for foundation design of bridges, culverts, and embankment stability.
1.3	Road Design (Pavement)	Pavement composition, layer thicknesses, drainage design.	IRC:37 (Flexible Pavement), IRC: 58 (Rigid Pavement), MoRTH Div 300, 400, 500, 600, 700.	Design charts, material specifications, drainage design.	Pavement Design Report, Material Specifications, Drainage Layouts.	Design Engineer	Pre-construction (Design)	Adherence to traffic load, subgrade strength, and material properties.

S. No.	Project Activity/ Component	Specific Requirement/Aspect	Applicable Standard/Code (IRC/ MoRTH/ BIS/NHAI)	Key Clauses/Sections	Method of Compliance/ Evidence	Responsible Party	Frequency/Stage of Check	Remarks
1.4	Bridge Design	Structural loads, material strengths, serviceability, safety factors.	IRC:6 (Loads & Stresses), IRC: 112 (Concrete Bridges), IRC:SP: 106 (Composite Girders), IS:456, IS:800, MoRTH Div 1700 -2600	Relevant design codes for various structural elements (deck, girders, piers, foundations).	Structural Design Calculations, Drawings, Proof Checking Report (if applicable).	Structural Engineer	Pre-construction (Design)	Designs must be proof-checked by independent agencies for major structures, as per NHAI norms.
2.	Material Procurement & Quality							
2.1	Aggregates	Quality (grading, strength, shape, deleterious materials).	IS:383 (Coarse & Fine Aggregates), MoRTH Div 1000 (Quality Control)	Gradation limits, physical properties (crushing value, abrasion, soundness, flakiness index).	Lab Test Reports (sieve analysis, specific gravity, water absorption, abrasion, etc.), Source Approval.	QA/QC Manager, Material Engineer	Per source, per batch/consignment	NHAI often specifies preferred quarry sources and regular testing.

S. No.	Project Activity/ Component	Specific Requirement/Aspect	Applicable Standard/Code (IRC/ MoRTH/ BIS/NHAI)	Key Clauses/Sections	Method of Compliance/ Evidence	Responsible Party	Frequency/Stage of Check	Remarks
2.2	Cement	Type, grade, strength, setting time.	IS:269, IS:1489 (OPC), IS:456 (Concrete), MoRTH Div 1000	Chemical composition, physical properties (compressive strength, fineness, setting time).	Manufacturer's Test Certificate, Lab Test Reports (physical tests), Batch Records.	QA/QC Manager, Material Engineer	Per consignment, periodically	Only approved brands/sources.
2.3	Reinforcement Steel	Grade, yield strength, elongation, bend properties.	IS:1786 (HYSD Bars), IS:432 (Mild Steel), IS:2062 (Structural Steel), MoRTH Div 1000	Mechanical properties (yield, ultimate tensile strength, elongation), chemical composition.	Manufacturer's Test Certificate, Lab Test Reports (tensile, bend tests), Mill Certificates.	QA/QC Manager, Material Engineer	Per consignment, periodically	Only approved brands/sources.
2.4	Bitumen	Grade, penetration, viscosity, softening point.	IS:73 (Bituminous Road Binders), MoRTH Div 500	Physical properties as per grade (e.g., VG30, VG40).	Manufacturer's Test Certificate, Lab Test Reports (penetration, softening point, ductility, specific gravity).	QA/QC Manager, Material Engineer	Per consignment, periodically	As per MoRTH specifications for specific pavement layers.
3.	Construction Procedures & Quality Control							

S. No.	Project Activity/ Component	Specific Requirement/Aspect	Applicable Standard/Code (IRC/ MoRTH/ BIS/NHAI)	Key Clauses/Sections	Method of Compliance/ Evidence	Responsible Party	Frequency/Stage of Check	Remarks
3.1	Earthwork (Embankment /Cutting)	Compaction, density, moisture content, slope stability.	MoRTH Div 300, IRC:36, IRC:SP: 72, IS:2720 (various parts)	Compaction requirements (e.g., 95-97% MDD), layer thickness.	Field Density Tests (core cutter/sand replacement), Moisture Content Tests, Level Records, Compaction Test Certificates.	Site Engineer, QA/QC Inspector	Per layer, per section	Strict adherence to specified compaction for long-term stability.
3.2	Sub-base/Base Course (WMM/GSB)	Material quality, grading, compaction, layer thickness.	MoRTH Div 400 (WMM, WBM, GSB), IRC:37	Grading limits, plasticity index, compaction requirements.	Aggregate Test Reports, Field Density Tests, Level Records, ITP checklists.	Site Engineer, QA/QC Inspector	Per layer, per section	Proper mixing and uniform spreading are crucial.
3.3	Bituminous Courses (DBM/BC/SDBC)	Mix design, temperature control, rolling, compaction, riding quality.	MoRTH Div 500, IRC:SP: 98, IRC: SP:117	Job Mix Formula (JMF), laying temperature ranges, density requirements (e.g., 92% of laboratory reference density).	JMF approval, Core Density Tests, Field Temperature Records, Surface Roughness (IRI) measurements, Mix Lab Tests.	Site Engineer, Paving Supervisor, QA/QC Inspector	Per mix, per layer, daily	NHAI has stringent requirements for riding quality and pavement performance.

S. No.	Project Activity/ Component	Specific Requirement/Aspect	Applicable Standard/Code (IRC/ MoRTH/ BIS/NHAI)	Key Clauses/Sections	Method of Compliance/ Evidence	Responsible Party	Frequency/Stage of Check	Remarks
3.4	Concrete Works (Structures)	Mix design, slump, formwork, pouring, curing, strength, finish.	IS:456, IRC:112, MoRTH Div 1700, 1800, 2000	Concrete grades, slump limits, cover, cube strengths, formwork requirements.	Concrete Mix Design Reports, Slump Test Records, Cube Test Results, Cover Meter Readings, Curing Records, ITP Checklists.	Site Engineer, QA/QC Inspector, Batching Plant In-charge	Per batch, per pour, daily/periodically	Supervision of batching, placing, vibration, and curing is paramount.
3.5	Reinforcement Fabrication & Fixing	Bar bending schedules, spacing, cover, laps, binding.	IS:2502, IS:456, IRC:112, MoRTH Div 1700	Cut-off lengths, bend diameters, lap lengths, clear cover.	Bar Bending Schedules (BBS), Inspection Checklists, Measurement of Spacing & Cover, Photographic evidence.	Site Engineer, Foreman	Prior to concreting, during fixing	Proper detailing and execution prevent structural failure.
3.6	Bridge Bearings & Expansion Joints	Installation, alignment, functionality, material quality.	IRC:83 (Bearings), IRC: SP:69 (Expansion Joints), MoRTH Div 2000, 2600	Installation procedures, alignment tolerances, material specifications.	Supplier's Test Certificates, Installation Records, Inspection Reports, Functional Checks.	Structural Engineer, Site Engineer	During installation, post-installation	Crucial for the long-term performance and safety of bridges.

S. No.	Project Activity/ Component	Specific Requirement/Aspect	Applicable Standard/Code (IRC/ MoRTH/ BIS/NHAI)	Key Clauses/Sections	Method of Compliance/ Evidence	Responsible Party	Frequency/Stage of Check	Remarks
4.	Environmental, Health & Safety (EHS)							
4.1	Environmental Management	Dust control, water quality, waste management, noise control, tree plantation.	MoRTH Standard Environmental Guidelines, NHAI Environmental Manuals, Local Pollution Control Board Norms	Project-specific EMP, relevant local/national environmental laws.	EMP Implementation Reports, Water/Air Quality Monitoring Reports, Waste Disposal Records, Tree Plantation Records.	EHS Manager	Ongoing, Monthly/Quarterly	Crucial for project sustainability and local community acceptance.
4.2	Occupational Health & Safety	Safety equipment, training, hazard identification, emergency response.	MoRTH Standard Safety Guidelines, NHAI Safety Manuals, Local Labour Laws, The Factories Act	Site-specific Safety Plan, Tool Box Talks, PPE requirements, Accident Reporting.	Safety Induction Records, PPE Provision Records, Accident/Incident Reports, Safety Audits.	EHS Manager, Site Manager	Daily, Weekly, Monthly	Mandatory for all projects to prevent accidents and ensure worker well-being.
5.	Documentation & Reporting							

S. No.	Project Activity/ Component	Specific Requirement/Aspect	Applicable Standard/Code (IRC/ MoRTH/ BIS/NHAI)	Key Clauses/Sections	Method of Compliance/ Evidence	Responsible Party	Frequency/Stage of Check	Remarks
5.1	Quality Management System	Overall project QA/QC framework, documentation control.	MoRTH Div 100, NHAI QA/QC Manuals, ISO 9001 (if applicable)	Project Quality Plan, ITPs, document control procedures.	Approved Quality Manual, Audit Reports, Non-Conformance Reports (NCRs), Corrective Action Reports (CARs).	QA/QC Manager, Project Manager	Throughout project lifecycle	Essential for maintaining quality and traceability.
5.2	Progress Reporting	Physical and financial progress, issues, risks.	NHAI reporting formats, Client requirements.	Agreed reporting frequency and content.	Monthly Progress Reports (MPRs), Financial Statements, Risk Registers.	Project Manager, Planning Engineer	Monthly/ Bi-weekly	Ensures transparent communication with the client and stakeholders.
5.3	Measurement & Billing	Quantities, rates, payment processing.	MoRTH Standard Data Book, Contract Agreement, General Conditions of Contract (GCC), Special Conditions of Contract (SCC)	Relevant clauses on measurement, payment, variations, claims.	Measurement Books (MBs), Bill of Quantities (BoQ), Abstract of Cost, Invoices.	Quantity Surveyor, Billing Engineer	Monthly/ As per contract	Accurate measurement and billing are crucial for financial control.

Important Considerations for Projects in Sagar, MP:

1. **Local Context:** While the standards are national, their application needs to consider local geological conditions, rainfall patterns, material availability, and specific socio-economic factors in Sagar district.

2. **NHAI's Role:** For NHAI projects, their specific manuals, technical specifications, and quality assurance plans often supersede or provide more detailed guidance than the general MoRTH/IRC/BIS codes. NHAI also has a robust audit and supervision mechanism.

3. **Updates:** All codes and standards are subject to revisions. The project must always refer to the latest editions and amendments.

4. **Documentation:** Meticulous documentation of all tests, inspections, approvals, and decisions is crucial for demonstrating compliance and for future maintenance or dispute resolution.

5. **Competent Personnel:** Ensuring that design, execution, and QA/QC are carried out by qualified and experienced personnel is fundamental to achieving compliance.

6. **Third-Party Audits:** NHAI and other clients often engage independent consultants or third-party auditors to verify compliance, especially for large-scale projects.

This matrix serves as a foundational guide. A project-specific compliance matrix would need to be far more detailed, listing exact clause numbers, specific test frequencies, and tailored compliance methods based on the project's unique scope and contractual requirements.