American Journal of Civil Engineering and Constructions (AJCEC)

ISSN: 3070-0884 (ONLINE)

VOLUME 2 ISSUE 1 (2026)

PUBLISHED BY
E-PALLI PUBLISHERS, DELAWARE, USA

American Journal of Civil Engineering and Constructions (AJCEC)

Volume 2 Issue 1, Year 2026
ISSN: 3070-0884 (Online)
DOI: https://doi.org/10.54536/ajcec.v2i1.7036
https://journals.e-palli.com/home/index.php/ajcec

When Verification Lacks Authority: Structural Failure of Quality and Risk Governance in Public Road Projects

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Article Information

Received: December 20, 2025

Accepted: February 12, 2026

Published: June 22, 2026

Keywords

Contractor-Executed Quality Control, Evidence-Chain Integrity, Independent Assurance (IA), Institutional Role Convergence, Public-Sector Road Projects, Quality Verification Governance, Risk Governance (Decision Authority)

ABSTRACT

Public-sector road projects, including associated infrastructure and maintenance works, are delivered within highly regulated environments characterized by dense specifications, unified contracts, and standardized project management frameworks. In principle, such institutional density should ensure controlled quality, effective risk management, and predictable delivery outcomes. In practice, however, recurring failures persist at the execution stage, particularly in quality control (QC) and risk governance. The analysis is intentionally weighted toward the governance of quality verification (evidence generation, independence, and acceptance authority), with risk treated as a governance extension of the same institutional logic. This paper argues that these failures are not uniform and cannot be explained solely by deficiencies in specifications, contractor capability, or individual engineering performance. Instead, they arise from structurally different governance breakdowns associated with two distinct institutional configurations commonly observed in public-sector projects. The first configuration involves projects delivered without an independent third-party consultant, where the role of "the Engineer" defined in the unified contract is assigned to a single employee of the owner's organization. In this model, supervision, quality verification, risk management, decision-making, and coordination functions are concentrated within one individual. The absence of institutional role separation results in a complete governance collapse, whereby the engineer effectively becomes the system itself. The second configuration examines projects delivered under the unified contract with an independent consulting firm acting as a third party. While this arrangement introduces multi-disciplinary teams, resident engineers, and formal acceptance and rejection authority, quality control remains contractor-executed. The consultant's role is primarily limited to reviewing quality control outputs rather than independently governing the verification process. Consequently, governance failure manifests not through role concentration, but through structural hollowing, where verification lacks independence and quality assurance becomes dependent on contractor-generated evidence. By distinguishing between these two configurations, the study demonstrates that improving public-sector road project outcomes requires institutional redesign - rather than procedural reinforcement- that reallocates authority over quality verification and risk acceptance away from delivery-driven structures.

INTRODUCTION

Public Road and Infrastructure Projects in Government Contexts

This study focuses specifically on public-sector road, infrastructure, and maintenance projects delivered under government ownership and control. These projects operate within institutional environments characterized by standardized design manuals, detailed technical specifications, unified contractual frameworks, and formalized project management procedures. Such environments are commonly perceived as highly governed, procedurally mature, and technically safeguarded.

The scope of this paper is deliberately limited to traditional public delivery models, including government-funded road construction, infrastructure development, and maintenance works. Delivery configurations such as public–private partnerships (PPP), turnkey EPC arrangements with independent assurance structures, and fully privatized infrastructure systems are excluded from the analysis, as they operate under fundamentally different governance and risk allocation mechanisms.

Accordingly, the findings of this study are not intended to be generalized beyond government-administered delivery systems, where institutional authority, quality oversight, and risk management are formally centralized within public entities.

By narrowing the scope to government-administered delivery systems, the paper addresses contexts where institutional authority, quality oversight, and risk management are formally centralized within public entities, making governance design - not contractual abundance - the primary determinant of project outcomes.

Roads as High-Risk, Publicly Exposed Systems

Unlike enclosed building projects, road and infrastructure works function as open, linear, and continuously exposed

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systems. Construction activities frequently take place under live traffic conditions, evolving site constraints, and direct public interaction. Decisions related to sequencing, materials, workmanship, and temporary arrangements have immediate safety, serviceability, and socio-economic implications.

These characteristics amplify the importance of effective quality control and risk governance. Failures in road projects rarely remain localized; they propagate rapidly through network performance, safety outcomes, and long-term maintenance liabilities. Consequently, governance deficiencies in road projects tend to manifest not as isolated technical defects, but as systemic operational failures with cumulative public impact.

Despite this elevated risk profile, road projects are often managed through governance structures that prioritize procedural compliance and documentation over institutional separation of roles, independent verification, and enforceable risk authority. This mismatch between operational exposure and governance design forms a critical backdrop for the failures examined in this study.

While the governance deficiencies examined in this study are not unique to road projects and can be observed across various public-sector construction domains, the open, linear, and operationally exposed nature of roadworks makes such failures more observable, recurrent, and systemically consequential when compared to other civil works.

Problem Statement

It is important to note that the manifestation of governance failure in public-sector projects is not uniform across all institutional contexts. Even within similar legislative and contractual frameworks, outcomes vary significantly depending on the maturity of the owner organization, the professionalism of its project management practices, and the clarity with which quality and risk governance are institutionally articulated and enforced.

Recurring failures in public-sector road and infrastructure projects are frequently attributed to inadequate specifications, contractor performance, or individual engineering judgment. While such factors may contribute at the surface level, they fail to explain why similar deficiencies persist across projects governed by dense regulatory frameworks, certified contractors, standardized design manuals, and mature project management procedures.

From a documentary and procedural perspective, road projects operate within highly controlled environments. Design standards, technical specifications, contractual provisions, quality procedures, and risk registers are widely available and formally enforced. In theory, this accumulation of standards and controls should ensure predictable delivery, controlled risk, and stable operational outcomes. In practice, however, a persistent gap exists between what is prescribed institutionally and what is enacted during execution. This gap cannot be adequately explained as a procedural deficiency or a failure of compliance. Rather, it reflects a structural weakness in how governance is designed and operationalized at the project level (OECD, 2015; Power, 2004).

The core of this weakness lies in the absence of a clearly engineered institutional framework that separates execution, verification, and decision authority. Although quality management, risk management, project management, and contractual governance are presented as distinct systems in formal frameworks, these boundaries frequently collapse at the point of execution.

Responsibilities related to supervision, quality verification, risk handling, safety decisions, and institutional coordination converge into a limited set of operational roles. As a result, governance does not function as an integrated institutional system, but is informally substituted by individual judgment under delivery pressure. Within this configuration, quality management is often reduced to inspection records, laboratory tests, and material approvals conducted within the same operational layer responsible for construction. Quality assurance does not function as an independent preventive mechanism capable of separating production from verification. Similarly, risk management is formally documented but weakly embedded in day-to-day decision-making. Risks are recorded, discussed, and acknowledged, yet rarely possess the authority to govern sequencing, methodology, or execution choices. The conditions under which quality and risk governance collapse in practice are therefore not primarily professional, behavioral, or ethical in nature. They are systematically associated with methodological deviations at the institutional level-namely policy choices, organizational structuring, and the design of governance architectures that shape how authority, verification, and decision-making are distributed.

This study contends that such conditions do not represent isolated implementation failures, but predictable outcomes of governance design. Rather than asking why engineers fail to comply with standards, the more fundamental question is why institutional systems fail to protect compliance during execution. By reframing quality and risk deficiencies as institutional failures rather than individual shortcomings, this paper establishes the basis for a differentiated analysis of how governance collapses under two dominant public-sector delivery configurations.

While this study addresses both quality verification and risk governance, it is primarily centered on quality governance specifically the institutional authority over verification and the integrity of the evidence chain. Risk is examined as a governance extension of the same authority independence logic, rather than as a parallel technical domain. Accordingly, this study addresses the following research question: Why do quality and risk failures persist in public-sector road projects despite dense procedural and contractual frameworks?

LITERATURE REVIEW

Conceptual Foundations and Definitions

Role Differentiation: Engineer, Quality Engineer, and Risk Governance Functions

The governance of public-sector road projects involves multiple technical and managerial roles that are conceptually distinct in the literature but frequently conflated in practice. International engineering and management standards consistently differentiate between execution, quality control, quality assurance, and risk governance; however, empirical studies show that these distinctions often collapse at the point of project delivery. The site or roads engineer is primarily responsible for supervising construction activities, coordinating execution, and ensuring compliance with approved drawings, specifications, and construction methodologies. This role is inherently operational and production-oriented, focusing on translating design intent into constructed works under dynamic site conditions (Zhang *et al.,* 2019).

Quality Control (QC), by contrast, is defined as the operational techniques and activities used to fulfill quality requirements, including inspection, sampling, testing, and documentation (ISO, 2015). QC is inherently linked to production and is typically executed by or on behalf of the contractor as part of the construction process. As such, QC activities are subject to schedule pressure, cost constraints, and sequencing demands (ISO, 2015; Juran & Godfrey, 1999; Oakland, 2014).

Quality Assurance (QA) operates at a fundamentally different level. ISO 9001 defines QA as a system of planned and systematic activities implemented to provide confidence that quality requirements will be fulfilled (ISO, 2015). The literature emphasizes that QA is preventive rather than detective, focusing on process capability, organizational discipline, and system reliability rather than on post-production inspection (Juran & Godfrey, 1999).

Effective QA requires structural independence from execution teams to prevent production pressures from undermining its preventive function (Hoonakker *et al.,* 2010). Risk governance functions extend beyond hazard identification or documentation. ISO 31000 frames risk management as coordinated activities to direct and control an organization with regard to risk, explicitly linking risk processes to decision-making authority (ISO, 2018; PMI, 2021; Aven, 2016). Similarly, the Project Management Institute positions risk management as an integrative decision-support function embedded across all project processes rather than as a parallel administrative activity (PMI, 2021).

The literature therefore establishes a clear conceptual boundary: execution engineers deliver the work, QC verifies conformity of outputs, while QA and risk governance are system-level functions intended to influence decisions, constrain execution pathways, and govern exposure. Governance failure emerges when these roles are merged, subordinated to delivery imperatives, or treated as interchangeable managerial tasks rather than as distinct institutional authorities.

Quality Control, Verification, and Independent Assurance

Construction quality literature consistently distinguishes between quality control, verification, and independent assurance, although these distinctions are frequently blurred in practice. Quality control refers to the execution-linked activities undertaken to ensure that materials and workmanship conform to specified requirements. These activities include sampling, laboratory testing, inspection, and record keeping and are typically embedded within the contractor's production process (Love *et al.,* 2016). Verification represents a higher-level function concerned with confirming the validity, reliability, and representativeness of QC outputs. Verification assesses whether sampling methods are appropriate, testing procedures comply with standards, and results accurately reflect constructed conditions. In many delivery models, verification responsibilities are assigned to supervising engineers or consultants; however, this verification often occurs after QC activities have been completed, limiting its ability to govern the process itself (Abdul-Rahman *et al.,* 2006).

Independent Assurance (IA) introduces institutional separation between those who generate quality evidence and those who evaluate the integrity of the quality system. Independent assurance assesses not only test results, but also laboratory accreditation, sampling governance, personnel competence, data traceability, and systemic reliability (ISO/IEC 17025, 2017). Unlike QC and routine verification, IA is designed to be structurally insulated from project delivery pressures.

The absence of independent assurance does not necessarily invalidate individual test results; however, it creates systemic vulnerability by allowing self-validation loops to emerge. In such configurations, contractors generate quality evidence that is subsequently reviewed - but not independently governed - by supervising entities. This condition has been identified as a key contributor to rework, latent defects, and specification dilution in infrastructure projects (Zou *et al.,* 2007; Love *et al.,* 2016; Hoonakker *et al.,* 2010). The literature thus recognizes that quality failure is rarely the result of inadequate testing alone, but rather of governance structures that fail to separate production, verification, and assurance as independent institutional functions.

The Engineer in the Unified Contract: Theory versus Practice

The Normative Role of the Engineer in Unified Contract Models

Unified contract forms, including those derived from FIDIC-based models, define "the Engineer" as an impartial entity responsible for administering the contract, supervising execution, certifying payments, and ensuring compliance with contractual obligations.

In normative terms, the Engineer is conceived not as an individual, but as an institutional role supported by organizational neutrality, multidisciplinary expertise, and procedural independence (Too & Weaver, 2014; Flyvbjerg, 2014). The literature emphasizes that this role is central to contractual governance. The Engineer is expected to act fairly between parties, base decisions on technical and contractual merit, and balance delivery objectives with compliance requirements (FIDIC, 2017). Importantly, the Engineer's authority is administrative and supervisory rather than productive; the Engineer governs the process but does not execute the works.

This conceptualization presumes the existence of an organizational structure capable of supporting role separation, internal checks, and decision-making independence. Governance effectiveness under unified contracts therefore depends not only on contractual wording, but on the institutional capacity through which the Engineer's role is operationalized.

Local Implementation Deviation and Institutional Drift

Empirical studies and professional practice literature indicate that the normative role of the Engineer is frequently altered in public-sector applications. In some government-delivered projects, the Engineer's role is assigned to a single employee within the owner's organization rather than to an independent consulting entity.

This deviation produces a fundamental institutional shift. When the Engineer becomes an internal representative of the owner, contractual administration, supervision, quality verification, and risk-related decisions are absorbed into a single operational role. The organizational safeguards implied in the unified contract - such as neutrality, internal separation, and institutional checks - are effectively removed (OECD, 2015; World Bank, 2017).

Governance literature consistently identifies role concentration as a primary driver of institutional failure. The OECD emphasizes that effective infrastructure governance requires clear role separation, accountability, and functional independence to prevent conflicts of interest and decision distortion (OECD, 2015). World Bank studies similarly demonstrate that blurred institutional responsibilities are a recurring cause of performance failure in public infrastructure projects (World Bank, 2017).

When governance functions are absorbed into operational roles, oversight becomes personalized, escalation pathways weaken, and accountability shifts from institutions to individuals. Rather than functioning as an impartial administrator, the Engineer becomes embedded within the delivery hierarchy and subject to organizational pressures, programmatic priorities, and internal accountability constraints. As a result, governance failure emerges not from the absence of procedures, but from the absence of institutional separation between execution, verification, and decision authority.

MATERIALS AND METHODS

Research Design

This study adopts a qualitative analytical research design grounded in institutional and governance-based analysis. Rather than seeking to quantify performance outcomes or measure compliance rates, the research focuses on examining how quality control and risk governance are structurally configured within public-sector road, infrastructure, and maintenance projects.

The analysis is conceptual and comparative in nature, drawing on internationally recognized normative frameworks, including ISO 9001 for quality management, ISO 31000 and PMI/PMBOK for risk governance, and OECD and World Bank principles for public infrastructure governance. These frameworks are used as analytical reference points rather than prescriptive checklists, enabling structured comparison between formal governance intent and operational practice.

This approach is particularly suited to investigating systemic failures that persist despite the presence of formal procedures, certifications, and technical standards. By framing governance as an institutional design problem rather than a behavioral or technical deficiency, the study avoids attributing failure to individual performance and instead evaluates the structural conditions under which decision-making, verification, and accountability operate (ISO, 2015; ISO, 2018; PMI, 2021; OECD, 2015).

The methodological perspective is further informed by systems-thinking literature, which conceptualizes road projects as dynamic socio-technical systems. Within such systems, governance effectiveness depends on the alignment between institutional structures and continuously evolving operational conditions, particularly under live traffic, public exposure, and sequencing uncertainty.

Case Selection Logic

The study examines two institutional configurations commonly observed in public-sector road, infrastructure, and maintenance projects:

Case A

Projects delivered without an independent third-party consultant, where the role of "the Engineer" defined in the unified contract is assigned to a representative from within the owner's organization.

Case B

Projects delivered under the unified contract with an independent consulting firm acting as a third party responsible for supervision, contract administration, and acceptance functions.

These configurations were selected due to their prevalence in government-administered projects and their repeated association with execution-stage quality and risk issues documented in both professional practice and governance literature. Rather than representing isolated or exceptional cases, they reflect standard delivery arrangements applied across multiple jurisdictions and project scales. The comparative focus on these two configurations enables the study to isolate governance effects arising from institutional role allocation and authority distribution, independent of project complexity, contractor capability, or specification adequacy.

Analytical Framework

The analytical framework employed in this study evaluates governance performance through four interrelated dimensions:

Role Distribution

Examination of how responsibilities for execution, quality control, verification, risk management, and decision-making are allocated among project actors, and whether institutional role separation is structurally maintained.

Decision Flow

Analysis of how technical findings, nonconformities, and risk signals translate - or fail to translate - into enforceable project decisions, including approval, rejection, or modification of execution pathways.

Quality Control Pathway

Assessment of who executes quality control activities, who verifies their outputs, and whether verification is structurally independent of production pressures, consistent with ISO 9001 distinctions between QC, QA, and system assurance.

Risk Governance Positioning

Evaluation of whether risk management functions possess formal decision authority or remain confined to advisory, reporting, or documentation roles, as conceptualized in ISO 31000 and PMI frameworks.

These analytical dimensions are derived directly from established governance and management frameworks. Role distribution and authority separation draw on OECD and World Bank infrastructure governance principles, the quality control pathway reflects ISO 9001's preventive-versus-detective logic, and risk governance positioning is informed by ISO 31000 and PMI's emphasis on integration with decision-making.

The study applies role-mapping and structural comparison techniques to trace how decision authority, execution, verification, and oversight converge or separate under each institutional configuration. Importantly, the framework does not presuppose failure in either case. Findings and interpretations are reserved for the Results and Discussion section, where observed patterns and structural implications are examined in detail.

Methodological Clarification

This study deliberately refrains from labeling either institutional configuration as successful or failed within the methodology section. The purpose of the methodological framework is to establish a transparent and systematic basis for comparison, not to advance evaluative conclusions. Interpretations regarding governance effectiveness, structural failure modes, and institutional consequences are developed exclusively in the Results and Discussion section. Accordingly, the findings of this study are analytical in nature, grounded in institutional logic and governance theory, and are not intended to provide empirical measurement or statistical generalization.

RESULTS AND DISCUSSION

Case A: Projects Without Independent Consultant (Owner-Representative Model)

Institutional Configuration

This case reflects public-sector road, infrastructure, and maintenance projects delivered without an independent third-party consultant. In this configuration, the contractual role of "the Engineer" - normatively intended as an impartial contract administrator - becomes operationally assigned to an internal employee of the owner's organization, a condition whose broader contractual and policy implications for decision independence are examined later in Section 1.11. As a result, institutional safeguards that typically rely on role separation and independent authority are structurally weakened at the point of execution.

Rather than functioning as distinct governance layers, supervision, verification, acceptance, coordination, and risk-related decision-making converge within a limited operational layer. Governance does not disappear; it migrates downward and becomes absorbed by the actor most continuously present in the field. This produces a structural condition in which the owner-representative engineer is compelled to act simultaneously as executor, verifier, decision gatekeeper, and liability sink; often without the institutional authority, resourcing, or independence required to govern each domain effectively. Accordingly, the analysis in this section is not organized around symptoms (e.g., defects, disputes, or incidents), but around structural pathways through which institutional authority is redistributed in Case A, progressively collapsing the separation between decision-making, execution, verification, and accountability.

Quality Governance Collapse Under Role Absorption (QA/QC and Testing Systems)

In contemporary quality governance, quality is not conceived as a collection of technical checks, laboratory results, or inspection routines. It is designed as an institutional system. ISO 9001 distinguishes Quality Assurance (QA) as an organizational-level, preventive function responsible for ensuring that processes are capable and controlled, while Quality Control (QC) represents operational inspection and testing activities used to confirm conformity of outputs (ISO, 2015). This architecture presupposes independence from production pressure and separation between execution, verification, and acceptance.

In Case A, that separation is structurally absent. Contractors execute the work and conduct material testing- often through laboratories engaged by them - while the owner-representative engineer is expected to review results and manage nonconformities without institutional control over core integrity mechanisms such as sampling representativeness, chain-of-custody, laboratory governance, technician competence, equipment calibration, method validation, or data traceability. Where QA units exist at organizational level, they are frequently centralized, detached from site realities, and structurally incapable of intervening in real-time acceptance decisions. Independent Assurance (IA), which constitutes a cornerstone of mature quality governance, is commonly absent as an operational authority.

This configuration collapses the governance principle of independence by enabling self-validation: the producer generates compliance evidence, while accountability for acceptance migrates to an individual engineer who lacks authority over the evidence-generation system itself. From a governance standpoint, this is not a procedural weakness; it is an institutional design failure.

International practice explicitly treats the testing system as a governed object. The U.S. Federal Highway Administration defines Independent Assurance as an unbiased evaluation of sampling and testing procedures used in acceptance programs, emphasizing that IA evaluates the reliability of the testing system rather than the acceptability of individual materials (FHWA, 2016).

Similarly, ISO/IEC 17025 institutionalizes laboratory competence through requirements for method validation, calibration, personnel qualification, and traceability - reflecting a core principle: a test result has limited meaning independent of the system that produced it (ISO/IEC, 2017). In the owner-representative model, the engineer becomes the final filter between deviation and acceptance. In practice, the engineer is expected to interpret specifications, supervise execution, assess the adequacy of testing, review results, resolve nonconformities, and justify deviations - often simultaneously. This convergence contradicts the preventive logic of quality systems and reframes quality from institutional enforcement to individual improvisation under schedule and traffic pressure.

Empirical studies align with this diagnosis. Hoonakker *et al.* (2010) show that construction quality systems fail when quality roles lack authority or are organizationally embedded within production layers. Love *et al.* (2016) similarly report that non-compliance and rework correlate strongly with weak quality governance rather than technical complexity, reinforcing foundational quality theory that defects are predominantly systemic rather than individual (Juran & Godfrey, 1999).

As institutional enforcement weakens, compliance becomes negotiable and deviation normalized. This produces what Power (2004) describes as ritualistic compliance: procedures and records remain visible, while substantive governance capacity erodes. Once quality governance is hollowed in Case A, specifications lose their institutional anchor and increasingly operate through negotiation rather than binding authority. This structural collapse is not incidental but systemic. The divergence between the theoretical architecture of quality governance and its operational reality in Case A - particularly the loss of independence, the self-validation of testing, and the convergence of acceptance authority - is summarized in Table 1.

Table 1: Structural Comparison of Quality Governance (QA/QC and Testing): Theory vs. Case A Operational Reality

Dimension	Theoretical Framework (ISO 9001, ISO/IEC 17025, FHWA)	Case A Operational Reality	Structural Implication
QA authority	Organizational, independent, preventive	Subordinate to execution or absent on site	Loss of governance
QC function	Verification linked to controlled processes	Contractor testing + engineer review	Self-validation loop
Testing governance	Governed system with IA	Ungoverned technical activity	Systemic integrity risk
Decision power	Authority to reject/stop work	Minimal or non-existent	Quality overridden
Role of engineer	Oversight/admin, not system substitute	De facto QA/QC/verifier	Role convergence
System behavior	Preventive and structured	Reactive and negotiated	Normalized deviation

Risk Governance Collapse and Total Absorption

Risk management is designed as a decision-support governance system, not a compliance appendix. ISO 31000 defines risk management as coordinated activities to direct and control an organization with regard to risk, emphasizing integration with decision-making across processes (ISO, 2018). PMI similarly positions risk management as a continuous, embedded function intended to shape scope, sequencing, procurement, and execution decisions (PMI, 2021). In Case A, risk governance is structurally localized at the operational layer.

Even where risk registers exist, they are frequently detached from binding decision authority. Risk becomes "managed" insofar as it is recorded, reviewed, and archived, rather than insofar as it modifies methodology, sequencing, traffic arrangements, or acceptance thresholds. This reflects organizational decoupling consistent with Power's (2004) notion of ritualistic risk management: the form of control remains, while its operational effect is hollowed out.

This hollowing is amplified in road projects because execution occurs under live traffic and continuous public exposure. Decisions regarding temporary traffic management, closures, work-zone configurations, access arrangements, and sequencing are inherently risk-bearing.

In mature governance systems, such decisions are governed acts - subject to independent scrutiny and authorized risk acceptance. In Case A, they are frequently resolved under schedule pressure at site level, with limited institutional risk authority to veto, delay, or enforce escalation.

The structural consequence is role convergence: the same layer that creates exposure assesses it, accepts it implicitly, and later absorbs liability when it materializes. Chapman and Ward (2003) highlight that risk evaluation should be separated from risk ownership to reduce bias and institutional blindness. Aven (2016) similarly argues that risk frameworks often fail because they are decoupled from power structures. Under Case A conditions, risk acceptance becomes an operational default rather than an institutional decision, and exposure becomes individualized rather than organizationally governed. This decoupling between formal risk frameworks and actual decision authority produces a predictable governance pattern. The structural contrast between risk management as a decision-support system in theory and its documentation-oriented implementation in Case A is illustrated in Table 2.

Table 2: Structural Comparison of Risk Management: Theory vs. Case A Operational Reality

Dimension	Theoretical Framework (ISO 31000, PMI)	Case A Operational Reality	Structural Implication
Primary function	Decision support under uncertainty	Documentation/ compliance	Loss of function
Integration	Embedded into execution decisions	Detached from daily decisions	Organizational decoupling
Authority	Power to influence/stop decisions	Advisory or absent	Risk without control
Risk register	Living, continuously updated	Static, archived	Ritual compliance
Role of engineer	Input provider within governed system	De facto risk owner	Role convergence
System behavior	Proactive, preventive	Reactive, normalized	Risk internalization

When quality governance and risk governance collapse simultaneously, the result is not merely weakened oversight but structural role convergence. Decision-making, execution, risk assessment, and risk acceptance migrate toward the same operational layer. To clarify this convergence, Table 3 maps the theoretical allocation of authority against its operational concentration in Case A.

Table 3: Risk Role Convergence Matrix: Case A Mapping of Decision, Execution, Risk, and Liability

Function	Theoretical Allocation	Case A Operational Reality	Resulting Condition
Decision-making	Authorized governance body	Site/owner-representative layer	Decision localized
Execution	Contractor operations	Same operational layer drives methods/sequence	No separation
Risk assessment	Independent risk function	Same operational layer	Self-assessment
Risk acceptance	Organizational authority	Implicit by engineer	Unauthorized exposure
Liability	Institution/contracting entity	Personalized to engineer	Institutional displacement

Outcome: Total Role Convergence ("The Engineer Becomes the System")

In Case A, the phrase "the engineer becomes the system" is not rhetorical. It is a structural diagnosis. Governance functions do not disappear when institutional layers are absent; they migrate downward and converge into the owner-representative engineer's operational role. Decision-making, execution oversight, verification, risk handling, coordination, and acceptance are compressed into one locus; often without corresponding independent authority or institutional protection.

This configuration collapses a core governance principle: separation between decision, execution, and oversight. OECD governance principles emphasize that role clarity and separation of functions are structural safeguards against conflict of interest and accountability distortion (OECD, 2015). In Case A, those safeguards are structurally missing, producing predictable outcomes: negotiated quality, normalized deviation, localized risk acceptance, defensive documentation behavior, and post-event personalization of systemic failure. Under these conditions, failure becomes personalized while institutional architecture remains unchallenged. The engineer functions as an institutional buffer, absorbing contradictions between static procedures and dynamic exposure, between production pressure and public risk, and between formal compliance artifacts and operational reality. This is not resilience. It is institutional under-design masked as professional burden.

Case B: Projects WITH Independent Consultant (Unified Contract – Third Party)

Institutional Configuration

Under the unified contract model with an independent third-party consultant, public-sector road and infrastructure projects are delivered through a formally differentiated institutional arrangement. The role of "the Engineer" is assigned to an external consulting entity rather than to an internal representative of the owner. This entity typically operates as an organizational body comprising multidisciplinary expertise, including resident engineers, discipline specialists, quantity surveyors, and quality and safety personnel.

This configuration partially satisfies the governance assumptions embedded in unified contracts: role differentiation, procedural independence from the contractor, and a structurally separate supervision channel. Decision-making, verification, and certification are no longer concentrated within a single individual embedded in the owner's hierarchy. Accordingly, governance does not collapse through total role absorption, and the engineer does not fully "become the system" in the same manner observed in Case A. However, the presence of an independent consultant does not, by itself, guarantee independent quality governance. The critical question in Case B is not whether a third party exists, but whether the third party controls the integrity of the evidence-generation system that underpins acceptance decisions.

Partial Independence: Verification Exists, but Evidence Production Remains Contractor-Controlled

Despite the formal institutional differentiation introduced by the consultant-supervised delivery model, quality governance in Case B remains structurally constrained by the way quality control is organized and executed. While the presence of an independent consultant separates supervision and certification from the owner's internal hierarchy, it does not, by itself, reconfigure control over how compliance evidence is produced.

In most public-sector road projects delivered under unified contracts, quality control activities- including inspection, sampling, testing, and documentation - remain contractually assigned to the contractor. The contractor develops and implements the QC plan, determines sampling locations and timing, engages laboratories and technicians, and generates the test results submitted as evidence of compliance. These activities are embedded within the contractor's production system and are inherently influenced by delivery pressures related to schedule, cost, sequencing, and traffic management.

Within this structure, the consultant's role is typically limited to reviewing QC outputs after they have been produced. Consultants may witness selected tests, audit documentation, or request clarifications, but these actions function primarily as post-production verification rather than as procedural control over the evidence-generation process itself. Verification, in this context, evaluates results against specifications but rarely governs the conditions under which samples are taken, tests are scheduled, or results are generated. This creates a fundamental structural asymmetry: the same party responsible for executing the works also controls the primary evidence used to demonstrate conformity. The consultant evaluates compliance outcomes but does not institutionally govern the upstream processes that determine representativeness, timing, chain-of-custody, or continuity of verification. As a result, acceptance decisions rely on contractor-generated data that is reviewed, but not independently governed, by the supervising authority.

This condition does not imply falsification or malpractice. Rather, it represents a structural vulnerability. Even when laboratories are accredited and test methods comply with applicable standards, the governance of "when, where, how, and under what operational conditions" samples are taken and tests are conducted remains embedded within production incentives. Sampling regimes, test frequency, and submission timing are typically aligned with construction progress rather than with independent governance logic. Consequently, Case B reduces the intensity of total role absorption observed in Case A, but does not eliminate the potential for self-validation loops to persist at the evidence level.

The academic literature on quality assurance programs consistently emphasizes that effective quality governance depends not only on the technical validity of tests, but on institutional separation between evidence generation and evidence evaluation. When quality control remains execution-embedded, verification - even when performed by an independent consultant - operates within constrained boundaries. The presence of review authority does not equate to control over the integrity of the evidence-generation system itself.

Accordingly, in consultant-supervised projects, quality governance exists in a partial and conditional form. Formal supervision and acceptance mechanisms are present, but they stop short of governing the full evidence pathway. The result is a structurally exposed configuration in which compliance is demonstrated through reviewed outputs rather than through independently governed processes. This condition forms the foundation for the distinct failure mode observed in Case B: governance hollowing rather than total role absorption.

Independent Assurance as the Boundary between Review and Governance

In mature highway quality systems, the testing program is not treated as a neutral technical activity. It is treated as a governed system whose integrity is fundamental to the credibility of acceptance decisions. A central safeguard within such systems is Independent Assurance (IA), which functions as the institutional boundary between post-production review and actual governance of the evidence-generation process. Independent Assurance is conceptually and operationally distinct from routine quality control and consultant verification.

While quality control focuses on executing inspections and tests, and consultant verification focuses on reviewing results against specifications, IA targets the reliability of the system that produces those results. Its purpose is not to judge whether individual materials or layers are acceptable, but to evaluate whether sampling regimes, testing procedures, personnel competence, equipment calibration, laboratory practices, and data traceability collectively form a trustworthy acceptance system.

Highway quality frameworks explicitly recognize this distinction. Materials quality programs developed by highway agencies treat IA as an unbiased and independent evaluation of the sampling and testing procedures used within acceptance programs, with the explicit objective of validating the integrity of the evidence-generation system rather than the acceptability of isolated test outcomes. In this architecture, IA does not duplicate consultant review; it governs the conditions under which review can be relied upon.

In Case B, however, Independent Assurance is frequently absent as an institutionalized operational authority. Where the consultant's contractual scope is limited to reviewing contractor-generated test results, witnessing selected activities, and auditing documentation, governance authority stops at the boundary of post-production review. The consultant evaluates outcomes, but does not control how those outcomes are produced. As a result, the acceptance system remains structurally dependent on contractor-controlled evidence pathways.

This boundary problem is often obscured by reliance on laboratory accreditation and quality management certification. Accreditation frameworks such as ISO/IEC 17025 establish requirements for laboratory competence, including method validation, equipment calibration, personnel qualification, and traceability. Similarly, ISO 9001 certification indicates that an organization has implemented a documented quality management system with defined procedures. However, competence and procedural consistency do not equate to independence of governance.

Laboratory accreditation confirms that tests are performed correctly; it does not govern who selects samples, when sampling occurs, how representativeness is ensured, or whether evidence production is insulated from production incentives. Likewise, ISO-certified quality systems support internal consistency and documentation discipline, but they do not, by themselves, establish structural separation between evidence generation and acceptance authority. Treating certification as a substitute for independent governance creates a false sense of assurance while leaving the evidence chain operationally exposed.

Without Independent Assurance, consultant verification remains inherently reactive. Review activities occur after tests have been completed and results submitted, limiting their ability to influence sampling strategy, test timing, custody controls, or process stability. Even when nonconformities are detected, intervention is typically corrective rather than preventive, addressing outputs rather than governing upstream processes.

The absence of IA therefore produces a distinct governance condition in Case B. The system appears complete: procedures are defined, laboratories are accredited, consultants review documentation, and acceptance decisions are formally issued. Yet the core governance function - independent control over the integrity of the evidence-generation system - is missing. Verification exists, but it is bounded by the limits of post-production review. This condition constitutes the defining boundary between review and governance. Where Independent Assurance is present, verification operates within a governed system whose reliability is continuously validated. Where IA is absent, verification becomes an evaluative overlay on contractor-controlled processes. In Case B, this boundary remains uncrossed, resulting in a structurally hollowed governance architecture in which quality compliance is demonstrated, but not institutionally governed (Zou *et al.,* 2007; Love *et al.,* 2016).

As a result, the absence of Independent Assurance enables self-validation loops to emerge within consultant-supervised delivery systems. Compliance evidence is generated, reviewed, and accepted within a closed institutional circuit that lacks an external governance boundary. Although roles appear differentiated and procedures formally complete, the same production system ultimately governs its own reliability. This configuration does not eliminate oversight; it internalizes it.

Governance functions persist in form but lose their preventive and decision-shaping capacity, giving rise to a condition in which quality is verified but not governed. This mechanism distinguishes Case B from the total role absorption observed in Case A and defines the specific failure mode of governance hollowing.

Structural Failure Mode in Case B: Governance Hollowing Rather than Role Absorption

The governance failure observed in Case B differs fundamentally from the total role absorption identified in Case A. In consultant-supervised projects, governance does not collapse through concentration of authority within a single operational role. Instead, it fails through structural hollowing, whereby institutional roles, procedures, and oversight mechanisms remain formally present but lack effective control over the processes and decisions they are intended to govern.

Under Case B conditions, supervision, verification, and certification functions are institutionally differentiated and distributed across multiple actors. The consultant operates as an external entity, documentation flows are maintained, laboratories are accredited, and acceptance decisions are formally issued. From an organizational perspective, the system appears complete and compliant. However, this formal completeness masks a critical structural boundary problem: governance authority stops at review, while evidence production and exposure remain embedded within contractor-controlled and operationally pressured systems.

This hollowing effect arises because verification authority is decoupled from procedural control. Acceptance decisions rely on evidence that is generated within the same production environment responsible for delivering the works. Although the consultant evaluates results and documentation, it does not institutionally govern the conditions under which compliance evidence is produced. As a result, the integrity of the evidence chain is assumed rather than continuously governed. Governance exists as an evaluative overlay rather than as an active constraint on production behavior.

A similar boundary problem characterizes risk governance in Case B. While risk registers, method statements, and safety documentation are prepared, reviewed, and formally approved, decision authority over sequencing, temporary traffic arrangements, work-zone configurations, and exposure acceptance remains operationally constrained. Risk management functions primarily as an advisory and reporting mechanism rather than as an independent governance authority capable of altering execution pathways. Consequently, risk considerations influence documentation more than they constrain behavior.

The defining characteristic of governance hollowing is therefore not the absence of institutions, but the misalignment between authority and control. Institutional roles exist, but their reach is limited to post hoc review rather than proactive governance of evidence generation and risk-bearing decisions. The system evaluates itself through internally generated information while maintaining the appearance of independent oversight.

This failure mode stands in contrast to Case A, where governance functions are absorbed into a single operational role and institutional separation collapses entirely. In Case B, separation exists formally but is operationally incomplete. Authority is distributed, yet insufficiently empowered to govern the most critical aspects of execution. The result is a self-referential system in which compliance is demonstrated, decisions are documented, and responsibilities are allocated, but preventive governance capacity is structurally weakened.

Accordingly, Case B does not represent a resolved or mature governance configuration relative to Case A. It represents a different failure topology. Governance does not disappear; it becomes hollow. Quality and risk are formally managed but substantively under-governed, leaving public-sector road projects vulnerable to systemic failure despite the presence of consultants, certifications, and procedural compliance.

Risk Governance Collapse Across Both Cases: Distinct Structural Mechanisms

Risk management is a core component of project governance in public-sector infrastructure delivery. International standards and project management frameworks consistently emphasize that risk management is not merely a technical exercise of identifying hazards, but a governance function that must possess decision authority, escalation power, and institutional independence. However, evidence from public-sector road projects indicates that risk governance collapses under both institutional configurations examined in this study; albeit through different structural mechanisms. This section distinguishes between risk absorption in projects without an independent consultant (Case A) and risk governance hollowing in consultant-supervised projects (Case B), demonstrating that the presence of formal risk tools does not equate to effective risk governance.

Case A: Total Absorption of Risk Governance

In projects delivered without an independent third-party consultant, risk governance is fully absorbed into the operational role of the engineer representing the owner. Although risk management artifacts - such as risk registers, mitigation logs, and meeting records - may exist, they do not function as governance instruments. Instead, risk identification, evaluation, and response are localized within a single operational role.

According to ISO 31000, effective risk management requires integration with organizational decision-making and the ability to influence strategic and operational choices. In the owner-representative model, this requirement is structurally unmet. The same individual responsible for supervising works, coordinating stakeholders, and maintaining delivery progress is also expected to evaluate and respond to risk exposure. Risk therefore never attains institutional separation from execution pressures (ISO, 2018). Under this configuration, escalation pathways are informal and discretionary. Risks are managed through personal judgment rather than institutional mandate, and preventive intervention is frequently deferred in favor of short-term delivery continuity. The literature describes this condition as risk localization, where exposure is transferred from the organization to the individual, undermining systemic resilience (OECD, 2014).

As a result, risk governance collapses not because risks are unrecognized, but because they lack an independent seat in the decision hierarchy. Risk becomes an operational concern rather than a governing constraint, and accountability is individualized rather than institutionally distributed.

Case B: Hollowing of Risk Governance under Consultant Supervision

In consultant-supervised projects, risk governance does not collapse through absorption, but through structural hollowing. Formal risk management structures are typically present: risk registers are maintained, periodic reviews are conducted, and mitigation measures are documented. However, these mechanisms lack enforceable authority over project decisions.

Project management frameworks such as PMBOK distinguish between risk identification and risk response authority, emphasizing that effective risk management requires the ability to alter scope, sequencing, resources, or execution strategy when risk thresholds are exceeded (PMI, 2021). In Case B, risk discussions occur within governance forums, but decision authority remains embedded within operational delivery structures.

Consultants may advise on risk exposure and recommend mitigation actions, but they rarely possess unilateral authority to halt works, re-sequence activities, or impose systemic corrective measures based on risk considerations alone. Consequently, risk registers function as communication tools rather than governance instruments. Risk is acknowledged but not empowered. This condition aligns with what governance literature identifies as decoupling between formal control systems and actual decision-making. Risk management exists procedurally but is structurally disconnected from authority, resulting in a hollow governance framework where compliance is demonstrated without corresponding control (Aven, 2016; Chapman & Ward, 2003; PMI, 2021).

Comparative Governance Implications

The contrast between Case A and Case B highlights a critical insight: the effectiveness of risk governance is determined less by the presence of tools and more by the institutional location of authority.

- In Case A, risk governance is fully absorbed into individual judgment, leading to personalization of exposure and complete institutional failure.
- In Case B, risk governance exists formally but lacks decisional force, resulting in procedural compliance without substantive control.

In both cases, the absence of an independent risk authority capable of influencing project execution decisions undermines the preventive function of risk management. Risks are documented, discussed, and reviewed, yet remain operationally subordinate to schedule and delivery imperatives.

Structural Consequences for Public-Sector Road Projects

Road and infrastructure projects amplify the consequences of weak risk governance due to their open-system nature, public exposure, and continuous interaction with live traffic and environmental conditions. When risk governance lacks institutional authority, deviations propagate rapidly into safety, performance, and long-term maintenance outcomes. In public road projects, this governance failure has direct public safety implications, as risks related to material conformity, temporary traffic management, and construction staging may be acknowledged but not institutionally constrained, allowing unsafe conditions to persist under delivery-driven pressure.

The FHWA and other highway agencies emphasize that effective risk management in road projects requires early identification, independent review, and enforceable response mechanisms integrated into decision-making processes. Where such mechanisms are absent or weakened, risk management devolves into retrospective justification rather than proactive governance (FHWA, 2016).

Synthesis

Across both institutional configurations, risk governance failure is systemic rather than incidental. The distinction lies not in whether risk management exists, but in how governance authority is structurally allocated. Without an independent institutional seat for risk- capable of influencing or constraining delivery decisions - risk management remains symbolic, regardless of the sophistication of tools or the experience of practitioners.

Comparative Structural Synthesis: Governance Failure Across Two Institutional Configurations

The preceding sections demonstrate that quality control and risk governance failures persist in public-sector road projects under both institutional configurations examined in this study. However, the nature of failure differs fundamentally depending on how governance authority, verification independence, and decision power are structurally allocated. This section synthesizes the findings from Case A and Case B through a comparative institutional lens. Rather than restating descriptive analysis, it identifies structural patterns, failure mechanisms, and governance implications that emerge consistently across both configurations.

Comparative Governance Architecture

The two delivery configurations differ significantly in their formal institutional arrangements. In Case A, governance functions are concentrated within a single individual representing the owner. In Case B, governance functions are formally distributed across multiple entities, with an independent consultant introduced as a third party. Despite this formal differentiation, both configurations exhibit systemic weaknesses arising from the absence of independent verification authority and enforceable risk governance. To consolidate these findings, the comparative structural characteristics of governance, verification independence, and decision authority across both institutional configurations are synthesized in Table 4.

Table 4: Structural Comparison of Governance Configurations

Dimension	Case A: No Independent Consultant	Case B: With Independent Consultant
Execution of Works	Contractor	Contractor
Quality Control (QC) Execution	Contractor	Contractor
QC Verification	Same owner's engineer	Consultant
Verification Independence	None	Partial
Independent Assurance (IA)	Absent	Absent
Risk Authority	Not established	Advisory only
Decision Power	Individualized	Operationally constrained
Dominant Failure Mode	Total governance absorption	Structural governance hollowing

Divergent Failure Mechanisms

Although both configurations result in governance failure, the mechanisms through which failure occurs are structurally distinct.

In Case A, failure arises through total absorption. Governance functions related to quality, risk, coordination, and decision-making are consolidated within a single operational role. Risk and quality do not possess institutional standing; instead, they are managed through individual judgment under delivery pressure. This results in personalization of exposure, normalization of deviation, and complete erosion of institutional checks.

In Case B, failure arises through structural hollowing. Governance mechanisms formally exist - procedures are defined, roles are distributed, and documentation flows - but core governance functions lack independent operational control. Verification relies on contractor-generated evidence, and risk management lacks decisional authority. Governance is present in form but weakened in effect.

This distinction is critical: Case B does not represent an improved version of Case A, but a different failure topology.

Quality Governance Implications

Across both configurations, quality governance is constrained by a common structural condition: the absence of independent control over evidence production.

- In Case A, quality verification is fully internalized within the owner's operational role.
- In Case B, quality verification is externalized but remains dependent on contractor-controlled QC processes.

In neither case does quality governance achieve full independence from production pressures. The absence of independent assurance mechanisms allows self-validation loops to persist, undermining evidence integrity regardless of consultant involvement or ISO certification status.

Risk Governance Implications

A similar pattern emerges in risk governance. While tools such as risk registers and mitigation plans are present in both configurations, they lack enforceable authority.

- In Case A, risk governance is fully localized within the engineer's role, resulting in absorption and individual liability.
- In Case B, risk governance is procedurally maintained but decoupled from decision-making authority, resulting in hollow governance structures.

In both cases, risk management functions as a documentation and communication mechanism rather than as a governing constraint on execution.

Structural Insight

The comparative synthesis reveals a central insight of this study:

Governance failure in public-sector road projects is not determined by the presence or absence of a consultant, but by whether verification and risk functions possess independent institutional authority capable of influencing project decisions. Both institutional configurations fail for different reasons, but neither satisfies the governance conditions required to ensure robust quality control and proactive risk management in high-exposure road projects (OECD, 2015; World Bank, 2017). This finding challenges the prevailing assumption that introducing an independent consultant is, by itself, sufficient to resolve governance deficiencies. Instead, effective governance requires explicit institutional separation between execution, evidence generation, verification, and decision authority. This comparative synthesis provides the analytical bridge between diagnosis and reform. The following section translates these structural findings into policy and contractual implications, identifying targeted interventions required to address governance failure under each configuration.

Policy and Contractual Implications

The comparative analysis developed in this study demonstrates that governance failure in public-sector road projects is not uniform, but fundamentally configuration-dependent. Although quality control and risk management deficiencies appear across projects delivered with and without independent consultants, the structural mechanisms through which failure emerges differ significantly. As a result, policy and contractual reforms cannot be generic or uniformly applied. In practice, weaknesses in risk governance are most frequently expressed through execution-level quality failures rather than isolated risk events. Interventions designed to address governance collapse in owner-representative delivery models are insufficient to resolve the structural vulnerabilities observed in consultant-supervised projects, and vice versa. Effective reform therefore requires differentiated institutional responses aligned with the specific governance failure mode present in each configuration. While the owner-representative delivery model (Case A) is often perceived as a contractual deviation, it is important to clarify that the Unified Contract does not explicitly require the Engineer to be an external third-party consultant (Ministry of Transport, Communications and Information Technology, 2019).

The contract defines the Engineer as an Employer-appointed role, thereby permitting the Employer to assign internal personnel to perform this function. However, the contract architecture implicitly assumes that this role is supported by adequate institutional capacity, including delegated authority, functional separation, technical support staff, and access to independent inspection and testing mechanisms. More critically, it presumes a degree of decision independence that allows the Engineer to exercise acceptance, rejection, and risk-related judgments without direct managerial interference from the same authority responsible for delivery priorities.

When the Engineer is embedded within the owner's organizational hierarchy and subject to operational directives from the same management structure driving schedule, cost, and program pressures, this implicit independence collapses. Under such conditions, quality assurance and risk governance are structurally prevented from functioning as independent control mechanisms, regardless of the formal presence of specifications, procedures, or supervisory roles.

In such configurations, governance does not formally violate the contract, but fails functionally. The outcome is not contractual non-compliance, but institutional under-design; where the Engineer becomes a substitute for absent governance structures rather than an administrator operating within a protected decision framework.

Rather than presenting prescriptive recommendations in narrative form, this section consolidates the analytical findings into a structured policy synthesis. The objective is to translate diagnostic insights into clear institutional and contractual levers that can be operationalized by public-sector owners, regulators, and contract drafters. To this end, Table 5 presents a comparative policy framework that aligns observed failure modes with targeted governance interventions for each institutional configuration.

Table 5: Differentiated Policy and Contractual Interventions by Institutional Configuration

Policy Dimension	**Case A: No Independent Consultant (Owner-Representative Model)**	**Case B: Independent Consultant (Unified Contract – Third Party)**
Dominant Governance Failure Mode	Total absorption of governance functions into a single operational role	Structural hollowing of governance despite formal role differentiation
Root Structural Cause	Concentration of supervision, verification, risk management, and decision authority	Limited independence of verification and absence of enforceable risk authority
Primary Policy Objective	Prevent institutional role convergence	Restore effective governance reach and decisional force
Required Institutional Intervention	Mandatory separation of supervision, quality verification, and risk governance into distinct organizational roles	Institutionalization of independent verification and assurance beyond outcome review
Quality Governance Reform Lever	Establish owner-side governance units operating outside the delivery chain	Separate contractor-executed QC from independently governed verification and evidence pathways
Independent Assurance (IA)	Not present unless explicit internal IA capacity is established	Mandatory integration of IA as a distinct governance function independent of both contractor and consultant
Risk Governance Reform Lever	Remove risk acceptance from individual engineers and relocate it within institutional decision structures	Elevate risk management from advisory status to a function with authority to influence sequencing and execution
Contractual Implication	Prohibit assigning the role of "the Engineer" to a single internal position without institutional separation	Expand consultant authority from review of outputs to governance of evidence and risk decisions
Accountability Structure	Shift accountability from individuals to institutional entities	Rebalance accountability by aligning authority with responsibility
Expected Systemic Effect	Elimination of personalized governance failure and normalization of deviation	Transformation of formal compliance into substantive governance control

Table 5 illustrates that governance reform in public-sector road projects is not a matter of adding procedures, documentation, or additional supervisory layers. Instead, reform hinges on institutional architecture: who controls evidence, who holds decision authority, and how independence from delivery pressure is structurally protected.

In Case A, effective reform requires dismantling role concentration and preventing engineers from becoming de facto substitutes for absent institutions. In Case B, reform requires deepening governance capacity by extending authority beyond formal supervision into independent verification, assurance, and risk decision-making.

Although the failure modes differ - absorption versus hollowing - both configurations converge on a common insight: governance fails when authority is misaligned with responsibility. These differentiated policy and contractual implications reinforce the central argument of this study: persistent quality and risk failures in public-sector road projects are not technical deficiencies, but the predictable outcome of institutional design choices. The concluding section situates these findings within the broader context of engineering governance and public infrastructure delivery. While Table 5 defines what must change at the policy and contract level (institutional architecture), implementation still fails at the operational edge where materials, processes, evidence, and acceptance decisions are produced. In roadworks, the highest-risk failures are rarely "paper failures"; they occur at specific execution moments where quality evidence is generated under production pressure (source selection, sampling, hauling, placement, compaction, and test reporting). It is important to distinguish independent quality assurance from project management functions. While project management offices may coordinate quality processes and reporting, effective quality governance at execution level requires a function that is institutionally independent from delivery coordination, schedule control, and acceptance pressures. Accordingly, Table 6 translates the institutional diagnosis into an execution-level map of where governance typically collapses across the roadwork lifecycle - earthworks, granular layers, and asphalt works - and why this collapse persists in both configurations: Case A through role absorption, and Case B through evidence-chain hollowing. The table also identifies practical, execution-time controls that can be implemented by the owner or an independent assurance function to close the gap between specification intent and field reality.

Table 6: (QC & Source-Control Stages – From Specification Compliance to Execution-Time Governance)

NO.	**QC / Source-Control Stage (what is normally done)**	**What the Specifications explicitly require (baseline)**	**Case A – No independent consultant: where the governance gap appears**	**Case B – With consultant: why the gap still appears**	**Why Owner QA / Third-Party QA is needed (execution-time governance)**
1	Material source identification and formal pre-approval (RFI / Submittal)	Sources must be approved prior to procurement or processing. Contractor submits statement of origin, location, and composition before crushing or screening operations commence.	Approval becomes document-centric and concentrated within the owner-representative engineer's limited capacity. The system approves the proposed source on paper, without a standing mechanism to verify what is actually extracted and transported on a day-to-day basis.	Consultant reviews submittals and clarifications, but compliance is still framed as "approved source + passing tests," not as a continuously governed source-to-site evidence chain.	Owner QA / IA introduces continuous field verification of source conformity, auditing the integrity of the origin statement as an operational control rather than a one-time administrative approval.
2	Permissions and legality of quarry/ borrow operations	Contractor must obtain written permissions before starting quarry or borrow operations. Required approvals may include haul routes and related arrangements.	Permissions may exist formally, but there is no independent QA mechanism to monitor how extraction is actually executed in the field (where, when, how), or whether active extraction matches the approved source and method.	Consultant may check permits at initiation and during audits, but typically does not operate an execution-level system that treats extraction as a quality-controlled process on a daily basis.	Owner QA / IA adds structured field verification: spot checks at extraction points, cross-checking delivery tickets and custody chains, and confirming that physical extraction aligns with approved permissions and plans.
3	Source sampling and approval testing prior to use	Source samples taken by contractor in the presence of the Engineer using approved procedures. Approval testing under Engineer supervision or approved independent lab. No use before approval; retesting required if conformity changes.	The requirement for Engineer presence becomes fragile due to role overload. Sampling may satisfy formal presence requirements without constituting a robust system for representativeness, custody, and continuity of verification.	Consultant presence improves witnessing but remains selective. Sampling timing and locations are still largely controlled by the production system, creating representativeness risk despite compliant results.	Owner QA / IA establishes a governed sampling regime: randomization rules, custody controls, and periodic unannounced sampling so representativeness is enforced rather than negotiated.

4	Contractor QC testing program and Engineer’s right to reject it	Contractor performs QC tests before submission and submits QC program details. Engineer may declare the QC program unacceptable if rejection patterns indicate failure.	QC exists, but its governance is not independent. The engineer is expected to judge QC adequacy while under delivery pressure and without an institutional QA function to audit QC system reliability.	Consultant reviews QC programs with greater capacity, but unless empowered contractually, the process remains plan review and result checking rather than governance of QC execution quality.	Owner QA / IA shifts focus from “existence of a QC plan” to “reliability of the QC system in practice,” through field audits of equipment, calibration, procedures, and sampling behavior.
5	Control tests and joint sampling under Engineer supervision	Control samples taken jointly by Engineer and Contractor. Tests under supervision in site lab or in situ. Engineer may order retesting, rejection, removal, and additional testing to define extent.	Practical constraints (time, manpower, traffic pressure) can reduce joint sampling to a procedural formality. Acceptance may drift toward paperwork rather than governed field verification.	Consultant presence increases joint sampling frequency, but acceptance may still default to pass/fail test sheets rather than control of delivery, segregation, and stockpile behavior.	Owner QA / IA provides systematic verification coverage: governed sampling frequencies, stockpile controls, segregation checks, and escalation rules when trends indicate drift.
6	Check tests and independent cross-checking	Engineer may order check tests by persons not normally responsible. Samples may be sent to Employer’s central lab or approved independent lab to verify accuracy of control testing and equipment.	Although permitted by specifications, check testing depends on individual initiative and available institutional capacity. Without a formal QA unit, it becomes irregular and reactive.	Consultant may perform check tests, but without a mandated IA role, they may function as troubleshooting rather than as an independent system reliability audit.	Owner QA / IA institutionalizes check testing as Independent Assurance: planned, risk-based, and enforceable audits of system reliability, not occasional dispute resolution.

Table 7: Subgrade & Geosynthetics – Governance-Accurate, Execution-Focused

#	Work stage / item	Typical failure or “collapse moment”	Why it slips in Case A (no consultant)	Why it slips in Case B (with consultant)	Practical control that makes it non-negotiable (Owner / IA)
7	Laboratory independence & sample governance	Testing is carried out by formally accredited laboratories, but sample selection, handling, and submission remain operationally linked to the contractor, limiting governance over evidence integrity despite compliant results.	The owner-representative engineer lacks institutional authority to control sampling personnel, custody procedures, or the full sample-to-test pathway, relying on submitted reports.	The consultant relies on laboratory accreditation and compliant reports, assuming accreditation ensures independence, without governing sampling and custody processes.	Independent sampling authority for critical layers, split samples, chain-of-custody audits, and periodic third-party laboratory governance reviews beyond accreditation status.

8	Subgrade preparation & proof-rolling	Proof-rolling and subgrade acceptance are performed procedurally, while localized weak zones remain undetected due to time pressure and limited independent verification.	The engineer balances supervision, coordination, and acceptance roles, reducing the ability to treat subgrade readiness as a governed decision rather than a routine step.	Proof-rolling is observed based on contractor notification; it becomes an activity check rather than a controlled acceptance gate.	Formal hold-points preventing progression to the next layer without documented proof-rolling records and independent sign-off on subgrade readiness.
9	Subgrade moisture conditioning	Moisture conditioning is uneven or skipped in localized areas, yet acceptance proceeds based on limited density test results.	Continuous field moisture verification is not feasible without dedicated QA resources, leading to reliance on end-result testing.	Verification focuses on laboratory density outcomes rather than real-time moisture conditioning across the full working width.	Field moisture verification logs tied to stationing, random spot checks, and mandatory rejection of pumping or unstable zones regardless of density results.
10	Subgrade compaction	Numerical density requirements are met at test points, while spatial variability leaves untreated weak zones within the layer.	The engineer cannot continuously monitor roller patterns, coverage, and sequencing across the full working area.	Compliance is verified through minimum test frequencies that may not capture between-point variability.	Increased random testing density, targeted re-testing of suspect areas, and governance of compaction methodology rather than reliance on minimum test counts.
11	Subgrade material consistency	Approved subgrade material is locally substituted with visually similar but mechanically inferior material without triggering re-approval or rejection.	Material verification relies on intermittent presence and document review, limiting real-time control over localized substitutions.	Periodic inspections may miss material variation between visits unless laboratory results fail retrospectively.	Material delivery traceability, visual inspection protocols, and random excavation checks to confirm in-situ material consistency with approved sources.
12	Geotextile / geogrid installation	Incorrect type, overlap, anchoring, or damage occurs during placement and is concealed once covered by subsequent layers.	Short installation windows coincide with the engineer's absence, limiting verification before cover.	Consultant presence does not always coincide with placement; verification relies on contractor notification and documentation.	Mandatory pre-cover photographic evidence, installation checklists, and independent spot checks before authorizing placement of overlying layers.

Table 8: Subbase & ABC – Material Governance and Execution Control

#	Work stage / item	Typical failure or "collapse moment"	Why it slips in Case A (no consultant)	Why it slips in Case B (with consultant)	Practical control that makes it non-negotiable (Owner / IA)
13	Subbase source compliance	Subbase is priced and approved as crusher material but supplied partially or entirely from wadi sources, while laboratory test results remain within specification limits.	The engineer approves RFIs and test results but lacks field-level traceability over actual extraction, hauling routes, and active supply points.	The consultant verifies compliance through test reports and documentation, but does not govern physical source traceability once approval is granted.	Source traceability system linking haul tickets, delivery logs, approved source coordinates, and random field verification of active extraction locations.
14	Subbase gradation stability	Gradation gradually drifts between testing intervals due to changes in source face, screening conditions, or material handling, without triggering corrective action.	The engineer relies on periodic laboratory results and cannot continuously monitor production variability at the source or stockpile.	The consultant reviews results at contractual frequencies but lacks authority to impose process control adjustments at the source.	Increased testing frequency tied to production volume, change-of-source triggers, and basic process control charts to monitor gradation trends.
15	Subbase thickness control	Localized under-thickness is masked by grading and surface tolerance, passing visual inspection and limited spot checks.	Time and coverage constraints prevent systematic level checks across full stationing, increasing reliance on contractor-reported quantities.	Consultant thickness checks are limited to selected locations, which may not capture full-width and longitudinal variability.	Mandatory level checks by station and offset, supported by random pits or cores prior to acceptance of subsequent layers.
16	Subbase segregation during placement	Segregation occurs during dumping, spreading, or grading, resulting in non-uniform layer properties despite compliant average test results.	The engineer is frequently diverted to coordination and approvals, limiting continuous oversight during placement operations.	Consultant presence is intermittent; segregation develops between visits and is often corrected cosmetically rather than structurally.	Strict enforcement of approved method statements prohibiting end-dumping, supported by visual acceptance criteria and photo or video audit records.
17	Subbase moisture control window	Watering is uneven or mistimed, creating pumping zones or dry pockets that are compacted and accepted without remediation.	The engineer cannot continuously verify moisture conditioning across the working area and relies on final density results.	Consultant inspections focus on surface condition and density outcomes rather than moisture uniformity during conditioning.	Moisture conditioning logs, spot moisture tests prior to compaction, and mandatory rejection of pumping or unstable zones regardless of density compliance.
18	ABC / base course source integrity	ABC material required to originate from a controlled crusher is partially substituted with visually similar material from less controlled sources.	Source approval is treated as a one-time administrative action, with limited enforcement during ongoing supply.	Consultant verifies laboratory results and documentation, but physical source switching may occur without immediate detection.	Source tagging and haul ticket verification, random quarry audits, and mandatory re-approval and testing upon any source change.

Table 9: ABC Layer, Prime/Tack, Asphalt Plant & Mix Governance

#	Work stage / item	Typical failure or "collapse moment"	Why it slips in Case A (no consultant)	Why it slips in Case B (with consultant)	Practical control that makes it non-negotiable (Owner / IA)
19	ABC compaction	Roller type, passes, or sequence not optimized, producing variable density despite acceptable average test results	Engineer lacks capacity to approve and enforce rolling patterns continuously	Consultant approves method statement once; execution drifts in practice	Mandatory rolling trials, documented rolling pattern approval, and enforcement through daily compaction logs
20	ABC surface tolerance	Poor shaping or uneven surface transferred to asphalt layer, affecting long-term performance	Engineer prioritizes progress and coordination over geometric tolerances	Consultant checks intermittently; minor deviations tolerated	Straightedge and level checks on granular layers with corrective grading hold-points
21	Prime coat application	Incorrect application rate or insufficient curing time before asphalt	Engineer cannot continuously police distributor calibration and timing	Consultant relies on visual inspection and contractor logs	Calibrated distributor verification, tray tests, application logs, and minimum curing hold-point
22	Tack coat application	Tack coat skipped, uneven, or contaminated, leading to debonding between layers	Engineer overstretched across operations	Consultant often arrives after application has dried	Mandatory before-and-after photo evidence, rate verification, and paving hold-point
23	Asphalt mix design (JMF)	Informal adjustments to JMF during production without formal approval	Engineer lacks continuous plant presence	Consultant reviews submissions but not ongoing production changes	Owner / IA plant audits, "no-change without approval" rule, and extraction monitoring
24	Hot bin aggregate control	Gradation drift or segregation in hot bins goes undetected	Engineer absent from plant operations	Consultant not continuously present at plant	Process control charts, frequent bin sampling per specification, and alarm thresholds
25	Binder content control	Binder content drifts, causing bleeding or raveling while passing periodic tests	No QA system to detect early deviations	Consultant reviews periodic extraction results only	Increased extraction frequency, trigger limits, and stop-production authority
26	Marshall stability and flow	Sampling timing is controlled by the production schedule, limiting the representativeness of test results across full production cycles.	Engineer cannot witness sampling	Consultant relies on laboratory reports	Split samples, independent replicate testing, and randomized sampling windows
27	Plant calibration	Scales, feeders, or temperature sensors out of calibration, affecting mix consistency	Engineer not focused on plant governance	Consultant not mandated to audit calibration periodically	Independent assurance calibration audits, certificates verification, and surprise checks

Table 10: Hauling, Paving, Compaction, Coring & Thickness Control

#	Work stage / item	Typical failure or "collapse moment"	Why it slips in Case A (no consultant)	Why it slips in Case B (with consultant)	Practical control that makes it non-negotiable (Owner / IA)
28	Haul temperature	Asphalt mix arrives at site below specified temperature, compromising compaction	Engineer cannot track trucks or monitor temperature continuously	Consultant focuses on site operations, not hauling conditions	Infrared temperature checks at arrival, temperature logs per truck, reject-below-threshold policy
29	Paving temperature	Rolling starts below minimum allowable temperature due to delays	Engineer overstretched across paving fronts	Consultant may arrive after paving has started	Mandatory temperature recording at laydown and rolling start; no-rolling-below-limit rule
30	Roller equipment	Incorrect roller types, weights, or tire pressures used	No QA authority to enforce equipment compliance	Consultant allows informal "equivalents"	Pre-approval of rollers, tire pressure charts, and daily equipment compliance checks
31	Rolling pattern execution	Approved rolling pattern not followed consistently, causing density variability	Engineer cannot supervise continuously	Resident engineer may miss segments	Rolling pattern trials, documented passes, GPS roller tracking where available
32	Density targets	Density below specification accepted under schedule pressure	Engineer absorbs risk to keep progress	Consultant pressured by program constraints	Enforce density acceptance criteria with clear rejection rules and rework thresholds
33	Coring locations	Cores taken from visually "good" areas only	Engineer not present during coring	Presence becomes procedural rather than controlling	Engineer/IA-designated randomized coring locations with stationing records
34	Coring frequency	Insufficient number of cores to represent actual variability	Engineer overloaded with multiple activities	Consultant accepts minimum contractual frequency	Enforce minimum statistical frequency per lane/set/day regardless of progress
35	Core drilling quality	Damaged or shattered cores distort thickness and density results	Engineer not supervising drilling quality	Sampling rushed to meet reporting deadlines	Approved drilling equipment, witnessed coring, rejection of damaged cores
36	Thickness compliance	Under-thickness masked by surface smoothness	Engineer cannot verify full coverage	Consultant checks limited points only	Thickness verification tied to stationing, independent measurements, corrective action mandate

Table 11: Surface Acceptance, Joints, Night Works, Traffic & Interfaces

#	Work stage / item	Typical failure or "collapse moment"	Why it slips in Case A (no consultant)	Why it slips in Case B (with consultant)	Practical control that makes it non-negotiable (Owner / IA)
37	Surface tolerances (straightedge/ IRI proxy)	Straightedge failures tolerated or patched cosmetically	Engineer under pressure to open road	Consultant accepts localized patching to maintain progress	Enforce straightedge tolerances with remove-and-replace rule; documented checks by chainage
38	Surface segregation	Visual segregation not treated as a defect	Engineer overload; focus on tests	Consultant prioritizes lab results over visual cues	Visual acceptance criteria + segregation log + immediate corrective action

39	Joint construction (transverse)	Cold joints, poor compaction at joints	Engineer absent at joint moments	Consultant not present at every joint	Joint-specific QA: temperature checks, compaction method, joint density testing
40	Longitudinal joints	Inadequate overlap/ compaction leading to early cracking	Engineer absorbs acceptance risk	Consultant observes later, not at formation	Approved joint method statement + infrared checks + joint coring
41	Night works	Reduced oversight leads to shortcuts	Engineer cannot cover nights	Consultant coverage limited or rotated	Night QA coverage plan + IA surprise audits + enhanced documentation
42	Traffic management during works	Unsafe staging accepted to keep flow	Engineer personalizes risk decisions	Consultant advisory only, lacks stop authority	Independent risk authority with stop-work power for unsafe staging
43	Temporary diversions	Weak geometry/ compaction causes failures	No QA focus on temporary works	Consultant checks general condition only	Diversion acceptance checklist + independent compaction tests
44	Drainage interfaces	Poor tie-in causes water ingress and early damage	Engineer stretched across fronts	Consultant role fragmented between disciplines	Hold-point at drainage tie-ins + photo evidence + as-built verification
45	Utility reinstatement	Poor backfill leads to settlement and surface defects	Engineer overwhelmed post-utility	Consultant relies on contractor reports	Reinstatement QA protocol: layer-by-layer density + independent sign-off

Table 12: Documentation Integrity, NCRs, Acceptance, Payment & Institutional Learning

#	**Work stage / item**	**Typical failure or “collapse moment”**	**Why it slips in Case A (no consultant)**	**Why it slips in Case B (with consultant)**	**Practical control that makes it non-negotiable (Owner / IA)**
46	Documentation integrity	RFIs, tests, and reports become a “paper shield” detached from reality	Engineer uses paperwork defensively	Consultant inherits and validates documents	IA audits evidence integrity: timestamps, custody chain, duplicates, anomalies
47	Nonconformance handling (NCRs)	NCRs closed administratively without real correction	Engineer pressured to close issues	Consultant compromises to maintain progress	NCR closure only after verification test + independent re-check
48	Acceptance bias	Schedule dominates acceptance decisions	Engineer absorbs institutional pressure	Consultant operationally constrained	Separate acceptance authority from delivery pressure (Owner QA / IA gate)
49	Change of source/material	Midstream source change not re-approved	Engineer misses change in field	Consultant discovers change late	Mandatory re-approval trigger + immediate sampling before use
50	Material traceability	No linkage between delivered lots and test results	Engineer overloaded	Consultant reviews results detached from lots	Lot-based tracking system: ticket–sample–result linkage
51	Sampling governance	Sampling staff hired/controlled by contractor	Engineer lacks leverage	Consultant not managing samplers	Independent sampler (Owner/IA) for critical layers

52	"ISO-certified" myth	Certification treated as substitute for governance	Engineer cannot challenge assumption	Consultant comforted by ISO badge	Explicit clarification: ISO ≠ independence; IA oversight and custody audits
53	Payment linkage	Payments released without verified compliance	Engineer limited authority	Consultant certificates rely on reported compliance	Link payments to completion of independent verification milestones
54	Skills coverage	No dedicated QA governance role on project	Engineer becomes de facto QA	Resident team focused on supervision	Contractual requirement: dedicated QA/IA interface role
55	System learning	Lessons learned not captured institutionally	Knowledge remains personal	Consultant report archived	Institutional "failure library" + mandatory policy feedback loops

Table 6 demonstrates that execution-level quality failure in road projects is not primarily a consequence of contractor behavior, consultant competence, or specification adequacy. Rather, it is the predictable outcome of how quality authority and decision power are institutionally allocated within the delivery system.

Under both institutional configurations examined in this study, quality control activities are executed by the contractor, while acceptance decisions rely on evidence generated within the same production environment. In Case A, this arrangement results in total role absorption, whereby the owner-representative engineer informally substitutes for absent governance structures. In Case B, the introduction of a consultant redistributes roles formally, but does not eliminate the core structural vulnerability: the absence of an independent Quality Assurance authority with control over material sources, sampling regimes, evidence integrity, and acceptance thresholds.

Consultant supervision, as currently structured under unified contracts, operates predominantly within an acceptance-based logic. It validates outcomes after the fact, rather than governing the processes through which compliance evidence is produced. Consequently, quality assurance remains reactive and documentation-driven, rather than preventive and decision-oriented. The evidence synthesized in Table 6 therefore supports a central conclusion of this study: effective quality in public-sector road projects cannot be achieved through supervision alone. It requires an institutional QA function - whether owner-based or independently appointed - with explicit authority over source governance, process control, evidence generation, and risk-informed acceptance decisions. Where such authority is absent, quality failure persists regardless of consultant presence, specification density, or contractor qualification.

CONCLUSIONS

This study examined persistent quality control and risk governance failures in public-sector road, infrastructure, and maintenance projects, despite the presence of unified contracts, detailed specifications, certified contractors, and formal oversight structures. The analysis demonstrates that these failures are not technical in nature, nor are they the result of individual engineering shortcomings. Rather, they are the outcome of structurally deficient governance architectures. By differentiating between two dominant institutional configurations, the study shows that governance collapse occurs through distinct mechanisms. In projects delivered without an independent third-party consultant, governance fails through total absorption. Oversight, quality verification, risk management, and decision authority are concentrated within a single owner-representative role, eliminating institutional separation and causing governance to disappear as a distinct system. In projects delivered under unified contracts with an independent consultant, governance failure takes a different form. Although roles are formally distributed and supervision is institutionalized, quality control remains contractor-executed, verification lacks full procedural independence, and risk management functions remain advisory. In this configuration, governance is not absent but structurally hollowed: authority exists formally but lacks effective control over evidence production and execution decisions. Across both configurations, the central structural weakness is the absence of an independent institutional authority capable of governing verification processes and exercising enforceable risk decision power. The findings challenge the assumption that contractual density, certification, or procedural compliance alone can ensure effective governance. The study concludes that improving quality and risk outcomes in public-sector road projects requires institutional redesign rather than incremental procedural refinement. Explicit separation between execution, verification, and decision authority - supported by independent assurance and empowered risk governance - is essential to prevent systemic failure during project execution.

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