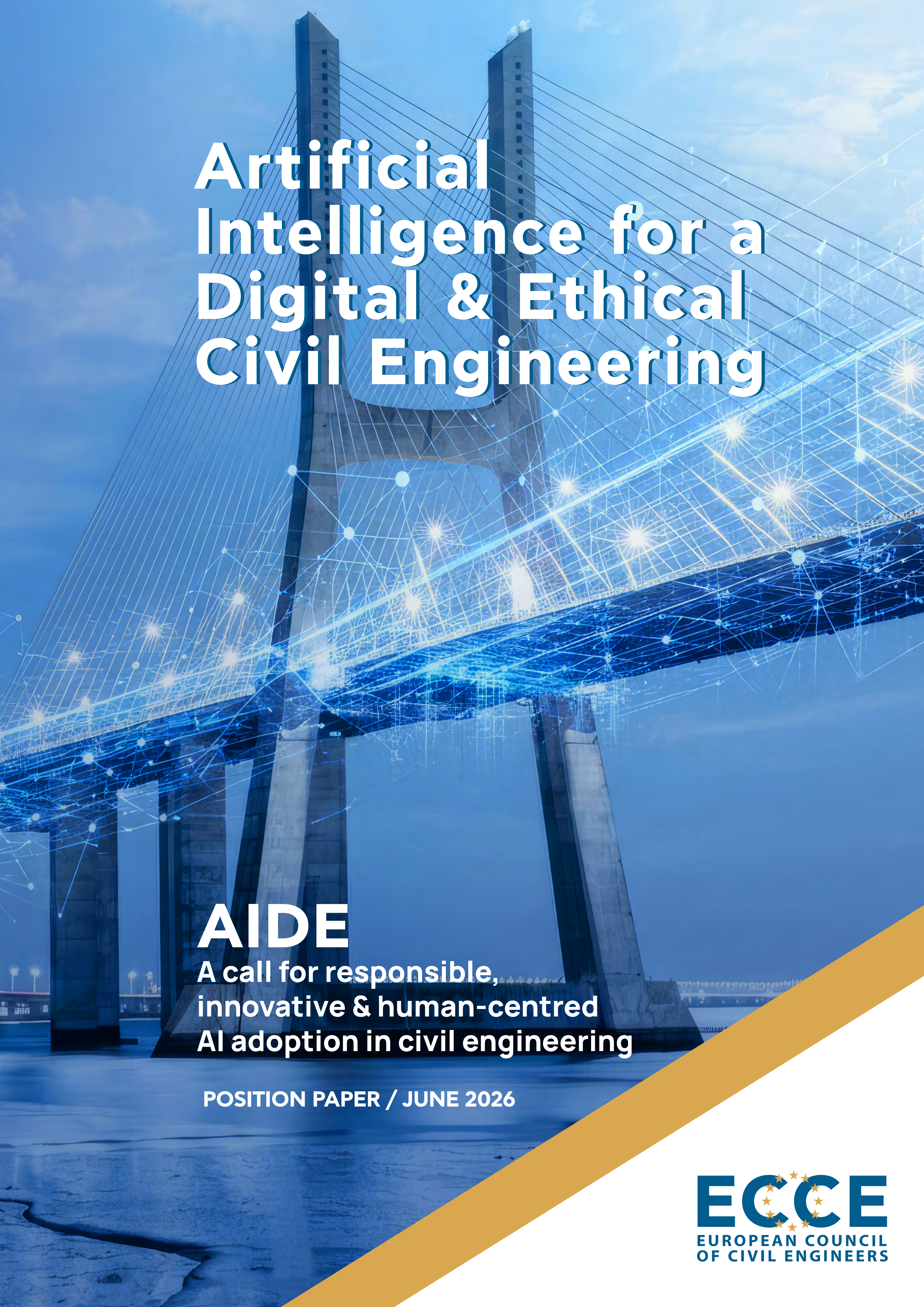

Artificial Intelligence for a Digital & Ethical Civil Engineering

AIDE

A call for responsible, innovative & human-centred AI adoption in civil engineering

POSITION PAPER / JUNE 2026

ECCE
EUROPEAN COUNCIL
OF CIVIL ENGINEERS

“AI is already embedded within civil engineering practice.

The defining challenge is ensuring its integration remains aligned with professional responsibility.”

Introduction and Context

The European construction sector is entering a decisive moment in its evolution. Artificial intelligence is no longer experimental; it is increasingly embedded within the tools, processes, and decision-making environments that define civil engineering practice. From design optimisation in Building Information Modelling to predictive analytics in project management and maintenance, AI is influencing not only how engineers work, but how engineering judgement itself is formed. What is now at stake is not adoption, but governance: ensuring that AI is integrated in a way that preserves safety, accountability, and public trust.

This transformation is advancing faster than the development of the professional, ethical, and regulatory structures that govern the sector. Unlike other industries, construction is undergoing a compressed transition, encountering advanced forms of AI without fully consolidating earlier stages of digitalisation. Civil engineering is therefore not simply adopting new tools, but adapting to a fundamental shift in how information is generated, interpreted, and applied.

Given the long-term and often irreversible nature of engineering decisions, this shift carries direct implications for safety, sustainability, and societal well-being. The question is no longer whether AI will be adopted, but whether its integration can remain aligned with the profession's responsibility to ensure safe, reliable, and trusted outcomes.

Across Europe, this transformation is unfolding within a complex policy landscape, alongside persistent sector challenges such as labour shortages, environmental demands, and low productivity. While AI is frequently positioned as a response to these pressures, its adoption risks becoming fragmented and inconsistent in the absence of clear, sector-specific guidance.

In response, the European Council of Civil Engineers has developed AIDE, a structured approach to responsible AI adoption based on four core principles:

Accountability — clear responsibility and oversight
Innovation— enhancing processes while retaining engineering judgement
Data Integrity — ensuring reliable and transparent data
Ethics — embedding professional values in AI use

This position paper builds on these principles to bridge the gap between regulatory frameworks and engineering practice, proposing a pathway for aligned, sector-specific AI governance. It reflects the collective effort of a multidisciplinary working group across Europe, ensuring that the recommendations are both technically grounded and aligned with the broader societal responsibilities of the profession.

Acknowledgements

This position paper reflects the collective insight of the European civil engineering community. The European Council of Civil Engineers gratefully acknowledges the members who contributed through workshops, a structured questionnaire, and strategic working groups, as well as the Working Group:
Dr Jeanette M Muñoz Abela – Malta (Chair)
Prof Humberto Varum – Portugal
Mr Panagiotis-Paris Charlaftis – Greece
Mr Paul Coughlan – United Kingdom
Ms Helēna Endriksone – Latvia
Dipl.ing.građ. Nina Dražin Lovrec – Croatia
Ms Maria Karanasiou – ECCE Secretary General

The Current State: AI as an Emerging Condition in Civil Engineering

The integration of artificial intelligence within the European construction industry is characterised by growing momentum, yet uneven implementation. While the potential of AI is widely recognised, its adoption remains fragmented across countries, organisations, and project scales. The current state is best understood not as a mature transformation, but as an emerging shift shaped by clear drivers, selective applications, and persistent structural barriers.

Drivers of AI Adoption

The growing focus on artificial intelligence in civil engineering is driven by structural challenges rather than technological curiosity. Key pressures include labour shortages, increasing project complexity, and persistently low productivity. AI offers opportunities to augment capacity, optimise workflows, and improve coordination through data-driven decision-making.

Sustainability requirements further reinforce this need, with European policies demanding improved energy performance, resource efficiency, and carbon reduction—areas where AI can support modelling and lifecycle optimisation. As illustrated in Figure 1, these combined drivers position AI not as an optional enhancement, but as a structural response to systemic pressures, making structured and responsible integration essential for safe and reliable outcomes.

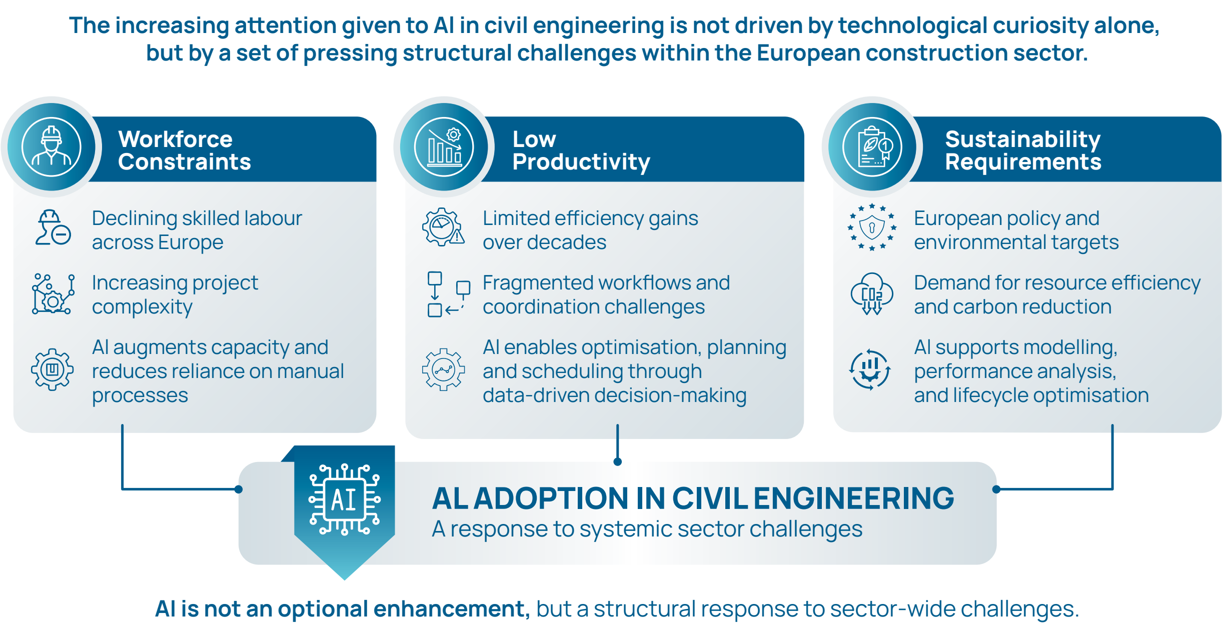

Figure 1: Systemic Drivers Positioning AI as a Necessity in Civil Engineering

Emerging Applications

Although adoption remains limited, key applications are shaping how AI is integrated into civil engineering. AI-enhanced Building Information Modelling (BIM) enables automated clash detection, design optimisation, and improved coordination. Predictive analytics supports project management and asset maintenance by forecasting risks, delays, and defects, enabling earlier intervention.

Robotics and automation are emerging in repetitive and hazardous tasks, improving efficiency and site safety. In parallel, AI-driven safety monitoring systems use computer vision and sensors to detect unsafe behaviours and ensure compliance in real time.

Together, these applications demonstrate that AI is already influencing multiple stages of the construction lifecycle, even if its use remains selective and context-dependent.

Structural Barriers to Adoption

Despite its potential, AI adoption in the European construction sector is constrained by interconnected barriers. The industry's fragmented structure, dominated by small and medium-sized enterprises, limits investment capacity and creates uneven uptake. Data challenges further restrict progress, as information is often siloed, inconsistently formatted, and lacking interoperability.

A shortage of digital skills and AI expertise widens the gap between technological capability and professional competence. At the same time, concerns around reliability, ethics, accountability, and liability affect trust and cultural acceptance. As illustrated in Figure 2, these barriers are systemic and interdependent, requiring a harmonised approach to enable consistent and reliable integration across the profession.

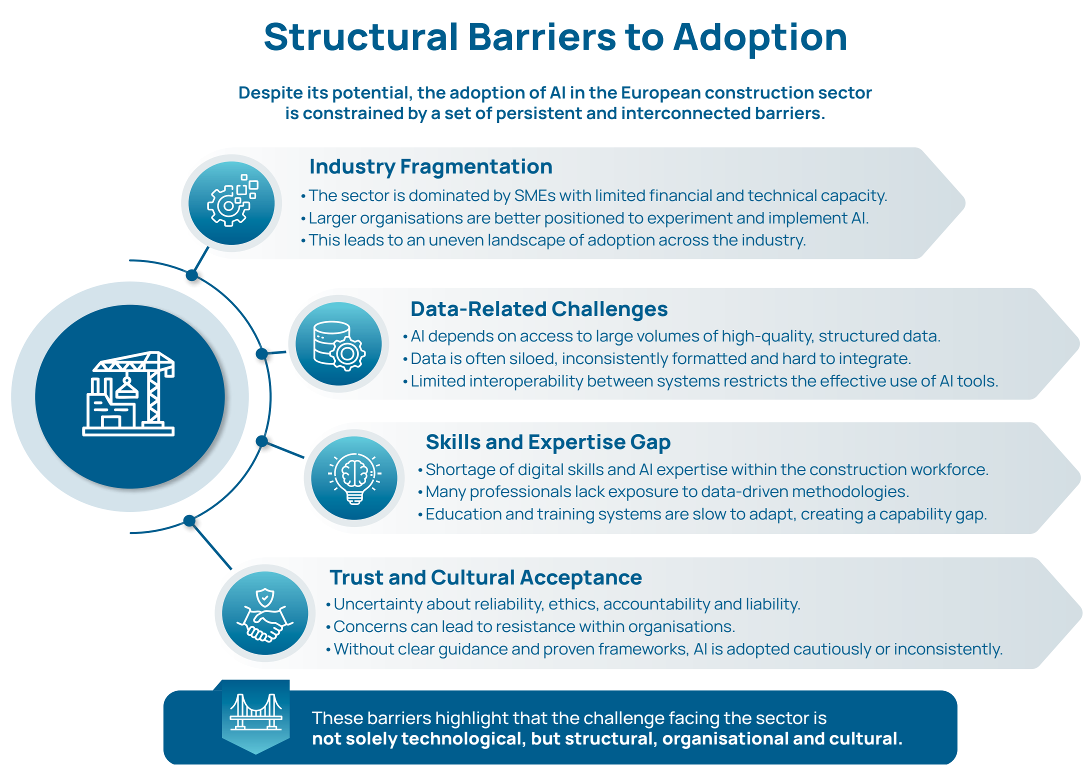

Figure 2: AI Adoption Constrained by Structural, Organisational, and Cultural Barriers in Civil Engineering

The Hierarchy of AI Adoption Barriers

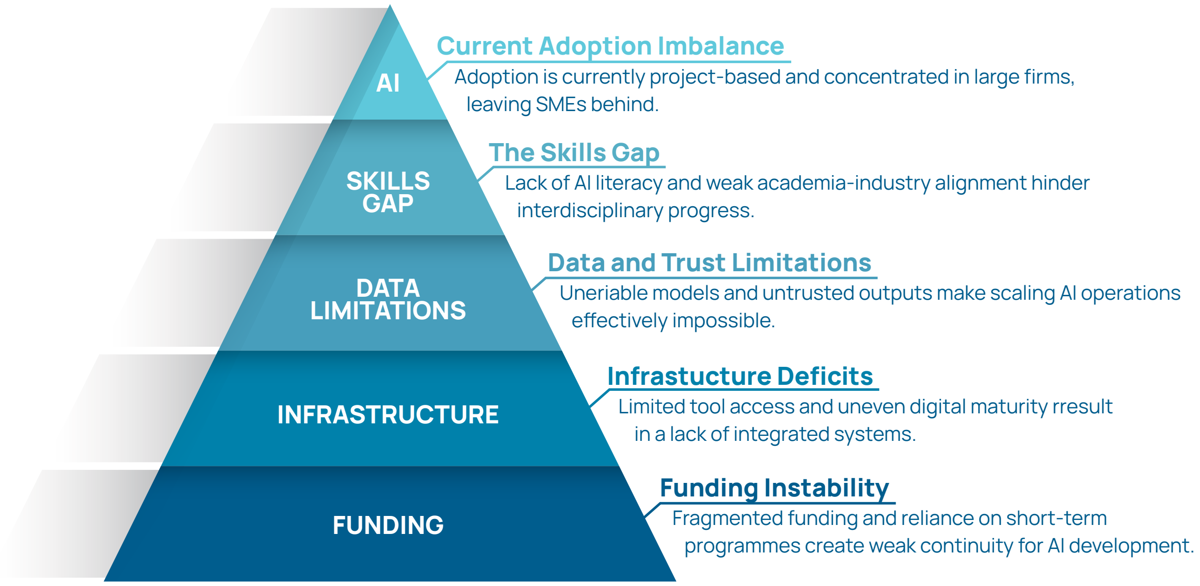

Figure 3: AI Adoption as a Function of Structural Preconditions

The adoption of artificial intelligence is contingent upon a hierarchy of structural preconditions, from infrastructure and data to skills and funding is shown in Figure 3. The absence of any of these layers disrupts coherence, leading to uneven adoption patterns that challenge the consistency expected of engineering practice.

Taken together, these conditions reveal a critical shift: the challenge facing the sector is no longer whether artificial intelligence can be adopted, but whether its adoption can be made coordinated. In the absence of such coherence, the increasing presence of AI within engineering workflows introduces variability that cannot be reconciled with the profession's obligation to ensure safety, reliability, and consistency.

The Need for Responsible AI Implementation

The integration of artificial intelligence in civil engineering signals a shift not only in tools and processes, but in professional responsibility. As AI increasingly informs design, risk, and operational decisions, the focus is no longer on whether it is used, but on how it is governed to uphold the profession's core values.

A Shift in Responsibility

AI systems increasingly shape the inputs informing engineering decisions, from design optimisation to predictive analysis. However, responsibility remains with the engineer. Civil engineering is grounded in accountability, requiring decisions to meet regulatory and societal expectations. AI may support decision-making but does not replace professional judgement. Responsibility cannot be delegated to non-accountable systems; therefore, AI outputs require verification, validation, and oversight. Rather than shifting responsibility, AI intensifies the need for demonstrable and accountable engineering judgement.

Key Risks in AI Integration

The integration of AI introduces significant risks in civil engineering. Bias in data and algorithms can lead to flawed or inequitable outcomes, particularly when based on incomplete datasets. The opacity of many AI systems limits transparency, making it difficult to verify outputs or justify decisions, thereby affecting accountability and trust.

Data quality, availability, and integrity directly influence reliability, introducing vulnerabilities into engineering workflows. Generative AI raises further concerns around authorship, originality, and intellectual property.

These risks are not theoretical; they directly impact the safety, reliability, and legitimacy of engineering outcomes.

Regulatory Convergence and Fragmentation

A range of frameworks, including the European Union's Artificial Intelligence Act, ISO/IEC 42001, and risk management approaches by National Institute of Standards and Technology (NIST) and Institute of Electrical and Electronics Engineers (IEEE), address the ethical and operational challenges of AI. However, these operate largely at a general level and do not fully reflect the specific realities of civil engineering practice, creating a disconnect between regulatory intent and execution.

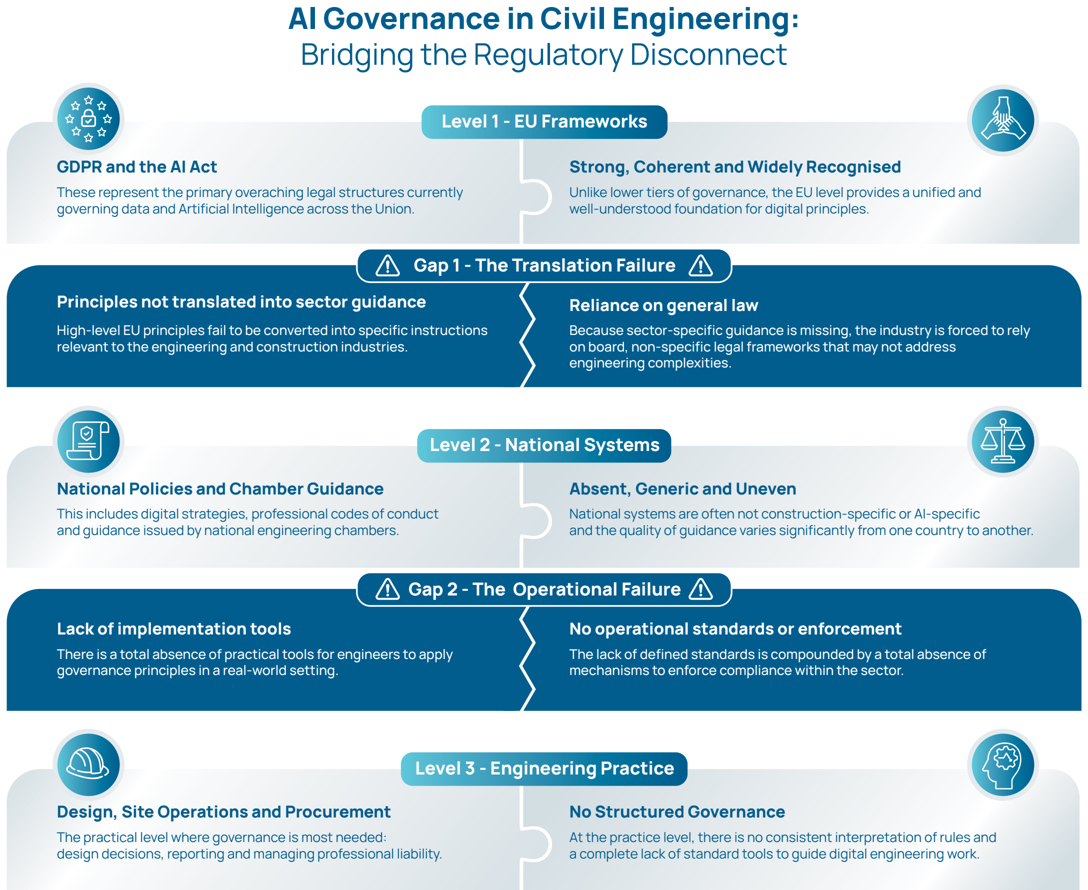

Figure 4: The Principles-Practice gap in AI governance for civil engineering

This results in a fragmented landscape where frameworks lack translation into day-to-day decisions. As illustrated in Figure 4, this gap risks creating a false sense of assurance, where compliance exists in principle, but safe and consistent practice is not guaranteed.

This fragmentation does not arise from a lack of frameworks, but from their limited capacity to inform engineering action. The issue is therefore not the existence of principles, but their translation. It is at this point—between intention and execution—that coherence is either established or lost.

From Principles to Practice

The central challenge is therefore not the absence of principles, but the absence of their translation into engineering practice. Civil engineers are not operating in a regulatory vacuum. Ethical guidelines, professional codes, and emerging AI frameworks already exist. However, these are often too abstract to inform specific engineering decisions, such as how to validate AI-generated design outputs, how to assign liability, or how to integrate AI into site operations.

What is required is a structured approach that bridges this gap, translating high-level principles into actionable guidance that can be applied within design processes, construction activities, and asset management.

It is within this context that the AIDE position paper is valuable: not as an additional layer of principles, but as a means of operationalising them within the realities of civil engineering practice. Translation is not a supporting function; it is the missing infrastructure of AI governance. Figure 5 presents this translation as a structured system, linking principles, practices, adaptation, and professional capability. It is within this system that coherence is established, ensuring that artificial intelligence can be integrated in a manner consistent with engineering responsibility.

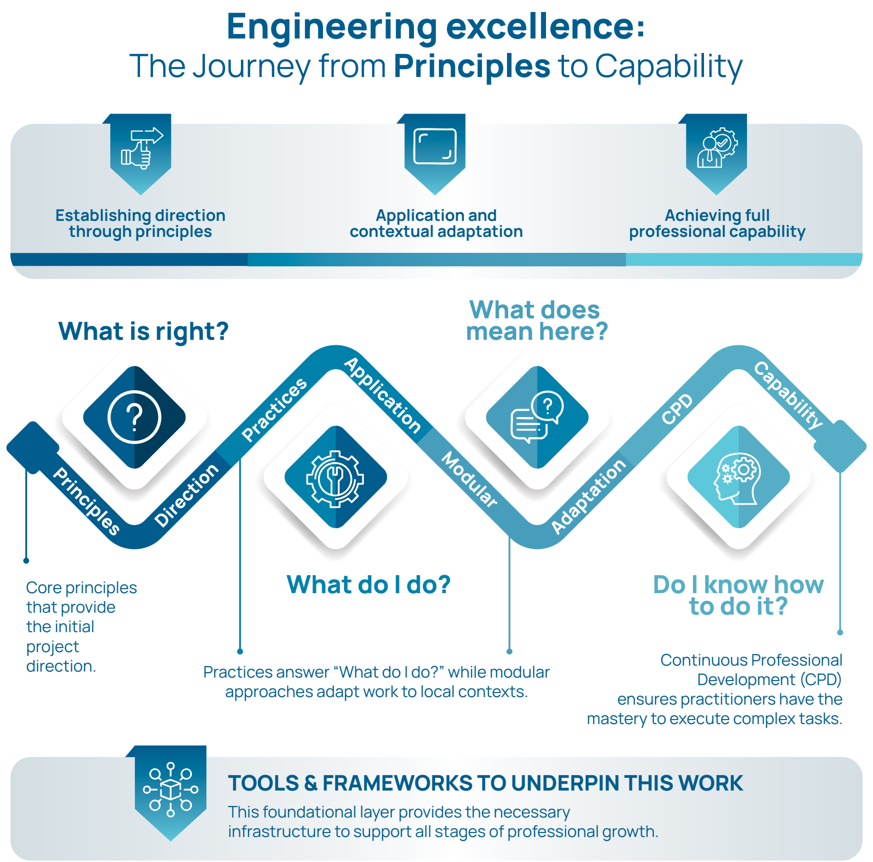

Figure 5: A System of Ethical AI Guidance: From Principles to Practice, Adaptation, and Capability

Perspectives from Across the Profession

A System in Transition

The findings presented are informed by a series of engagements with ECCE members, including dedicated workshops and a structured questionnaire designed to capture perspectives on the role of AI within the profession. In parallel, the topic has been examined across ECCE's strategic working groups—namely Education, Research and Knowledge Transfer; Societal Factors and Impact; and Industry and Enterprise Impact. Together, these inputs provide a consolidated view of the opportunities and challenges identified by the profession, reflecting both practical experience and strategic insight.

At first glance, the responses suggest a broad and perhaps unfocused demand, as if stakeholders are expressing breadth without structure. However, a closer reading reveals something far more structured. Rather than a diffuse set of expectations, the responses reflect a structured need: high-level principles provide direction, industry-specific practices translate these into application, modular guidance allows adaptation across different national contexts, and continuing professional development builds the necessary capability. Taken together, this is not a fragmented set of requests, but an implicit reconstruction of a missing framework.

The findings therefore point to a profession in transition. Artificial intelligence is no longer perceived as a distant or optional innovation, but as an emerging component of engineering practice. At the same time, its integration remains uneven, partial, and often informal. Across all responses, there is a shared recognition of both the opportunity presented by AI and the absence of a structured approach to its implementation. This tension defines the current state: AI is present, but not yet systematised; understood in parts, but not as a whole; applied in practice, but without a common framework guiding its use.

Education, Research and Knowledge Transfer

Across the surveyed countries, the integration of artificial intelligence within civil engineering education, research, and knowledge transfer remains present but structurally uncoordinated. AI is entering the profession through multiple pathways, yet without a systematic framework to ensure consistency in how it is taught, developed, and applied.

In many cases, AI is absorbed into broader processes of digitalisation. Tools such as Building Information Modelling, simulation, and data analysis are frequently cited as indicators of progress. While these provide an essential foundation, they do not reflect a deliberate engagement with AI as a distinct discipline. Consequently, AI is often treated as an extension of existing digital practices rather than as a methodological shift requiring new forms of understanding and application.

This fragmentation is reinforced by structural constraints. Institutions report limited academic expertise in AI and data-driven approaches, alongside insufficient infrastructure, including access to advanced software, computational capacity, and high-quality datasets. At the same time, curriculum inertia constrains rapid adaptation, as programmes must integrate emerging content without compromising core engineering fundamentals. The result is a gradual and uneven integration, characterised by isolated initiatives rather than systematic implementation.

A similar pattern is observed in research. Activity tends to be concentrated within well-resourced institutions, while other contexts rely on fragmented or externally driven efforts. AI is frequently positioned within broader agendas—such as sustainability or digital transformation—rather than being developed as a central research domain in its own right. Ethics, although widely acknowledged, remains marginal in practice. It is typically addressed indirectly through legal or professional frameworks, rather than embedded within technical education and research. Without deliberate integration, there is a growing risk of producing engineers who apply AI tools without fully understanding their implications.

Insights on AI in Education, Research and Knowledge Transfer

The findings suggest that the challenge is not the absence of AI within education and research, but its fragmented and peripheral integration. Without a more coordinated approach, there is a risk of developing uneven competencies across Europe, leading to inconsistencies in how future engineers understand and apply artificial intelligence in practice

Societal Factors and Impact

The responses relating to societal factors reveal a clear awareness that the integration of artificial intelligence in civil engineering extends beyond technical considerations. AI is recognised as having direct implications for public safety, trust, equity, and the overall quality of the built environment.

A central theme is the question of public trust. While AI offers opportunities to enhance safety, efficiency, and sustainability, its use introduces concerns regarding transparency and accountability. The “black box” nature of many AI systems challenges the ability of engineers, regulators, and the public to fully understand how decisions are made. This lack of explainability can undermine confidence, particularly in a sector where safety and reliability are paramount.

Workforce transformation is another key consideration. AI is expected to reshape professional roles, automating certain tasks while augmenting others. Across responses, there is a consistent emphasis on the need for reskilling and upskilling, ensuring that engineers are equipped to work alongside AI systems rather than being displaced by them. The future is not framed as a replacement of human expertise, but as a reconfiguration of it. As illustrated in Figure 6, the evolution of professional roles reflects a transition from traditional practice to AI-integrated workflows. Ensuring coherence across this transition is essential to maintain continuity in responsibility, competence, and trust within the profession.

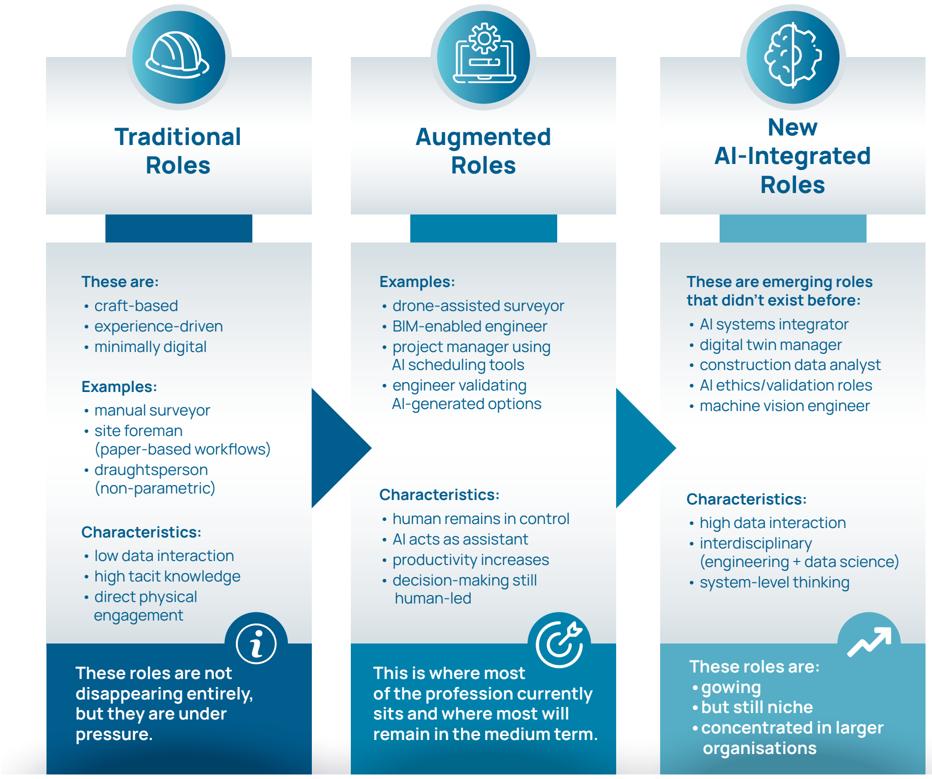

Figure 6: The Workforce Transition Spectrum: Evolving Roles in AI-Enabled Civil Engineering

Ethical concerns, particularly related to bias and fairness, are also prominent. Respondents highlight the risk that AI systems, if trained on incomplete or unrepresentative data, may produce outputs that reinforce existing inequalities or lead to inappropriate design decisions. In civil engineering, where projects directly affect communities, such risks carry significant societal implications.
At the same time, AI is recognised as a potential enabler of sustainability and resilience. Its capacity to optimise resource use, improve energy performance, and support climate adaptation strategies is widely acknowledged. However, these benefits are not automatic; they depend on how AI is applied and the values embedded within its use.

Insights on AI in Societal Factors and Impact

The findings indicate that AI in civil engineering cannot be treated solely as a technical innovation. Its Integration carries a public dimension, influencing trust, safety, and equity. Responsible implementation is therefore essential not only for professional integrity, but for maintaining the confidence of society in the engineering profession. Trust is not a by-product of AI adoption; it is a precondition for its acceptance.

Enterprise and Industry Impact

The responses relating to enterprise and industry highlight both the potential of AI to transform the construction sector and the structural challenges that currently limit its adoption. AI is widely perceived as a tool capable of improving productivity, enhancing decision-making, and enabling new forms of innovation. Applications such as predictive analytics, automated reporting, safety monitoring, and design optimisation are already demonstrating value in specific contexts. For larger organisations, AI represents an opportunity to streamline operations, reduce costs, and gain a competitive advantage.
However, the benefits of AI are not evenly distributed. A clear divide emerges between large organisations and small and medium-sized enterprises. Larger firms are better positioned to invest in technology, develop in-house expertise, and experiment with new tools. In contrast, smaller organisations often face significant barriers, including high initial costs, limited access to data, and a lack of specialised knowledge.

Uncertainty regarding return on investment further complicates adoption. For many organisations, particularly smaller ones, the benefits of AI are not yet sufficiently clear to justify the required investment. This is compounded by challenges related to integration with existing systems and workflows.
Questions of liability and responsibility also remain unresolved. The use of AI in design, analysis, and decision-making raises complex issues regarding accountability, particularly when outputs are generated or influenced by external tools. Without clear guidance, organisations may be hesitant to fully integrate AI into critical processes.

Insights on AI in Enterprise and Industry Impact

The findings suggest that while AI has the potential to transform the construction industry, its adoption risks becoming fragmented and unequal. Without structured guidance and support, the integration of AI may reinforce existing disparities within the sector rather than addressing them. Without intervention, AI risks becoming a capability of scale rather than a capability of the profession. Such a trajectory would not only reinforce existing disparities within the sector, but also fragment professional standards, leading to divergent levels of reliability, accountability, and performance across projects and jurisdictions.
Across these perspectives, a consistent pattern emerges. The challenges identified—whether related to skills, trust, investment, or implementation—are not independent issues, but symptoms of a broader absence of structure. What appears as fragmentation at the surface reflects a deeper lack of coherence in how artificial intelligence is integrated into professional practice.

Demand to Framework: What Engineers Are Asking For

Taken together, the findings across all three pillars point to a consistent and underlying message. Engineers are not asking for more abstract principles; they are asking for the translation of those principles into real practice. This demand can be understood as a structured system composed of four interrelated components:

- **Principles**— ethical direction
- **Industry-specific practices** — application in engineering decisions
- **Modular guidance** — adaptable frameworks
- **Professional development** — building capability

In practical terms, this requires clarity on how AI informs design validation, responsibility, and integration into workflows. The gap is not conceptual but operational—less about more guidance, and more about usable guidance. As shown in Figure 7, weak links across education, industry, policy, and society hinder coherence, requiring stronger alignment for effective AI integration.

The articulation of this need marks a transition from observation to responsibility. If the challenge is one of coherence, then the question is no longer what is required, but who is positioned to enable it.

Implications for ECCE: Enabling Coherent Integration Across the Profession

These concerns define a clear role for ECCE within the evolving AI landscape. The task is not to establish principles in isolation, but to operationalise them within civil engineering practice. This requires translating existing frameworks into actionable guidance, supporting capacity building, and promoting consistent adoption across Europe.

By bridging the gap between principle and practice, ECCE can lead and provide the structure needed for responsible and effective integration. The findings therefore move beyond describing the current state, outlining the conditions for future development and positioning ECCE not only as a contributor, but as a structuring agent within the profession.

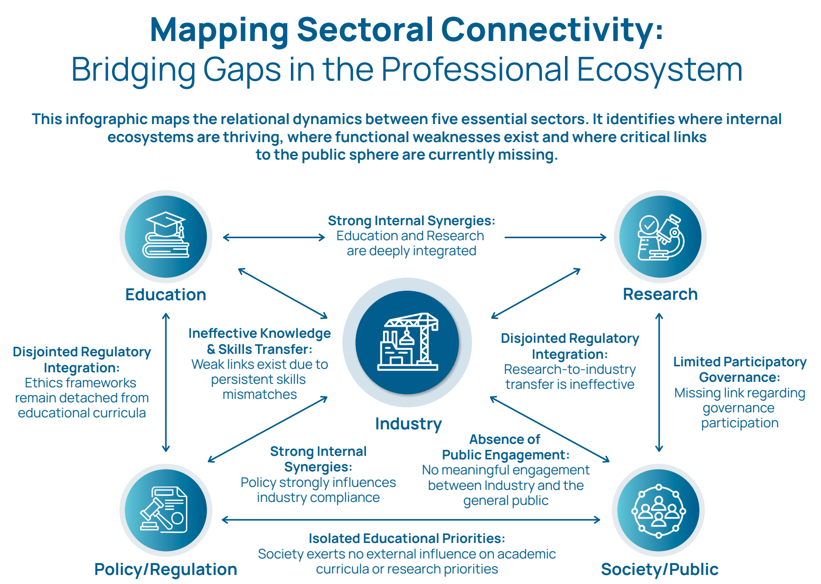

Figure 7: A system transition: Uneven linkages in the adoption of AI in civil engineering

Conclusion

Artificial intelligence is no longer a prospective development within civil engineering; it is already embedded in the way decisions are informed, analysed, and executed across the lifecycle of projects. Its influence is not defined by a single moment of disruption, but by a gradual and cumulative integration into professional practice.

What emerges from this is not a question of adoption, but of coherence. Without a structured approach, the integration of artificial intelligence risks introducing fragmentation into engineering processes, leading to inconsistencies that are incompatible with the profession's obligation to ensure safety, reliability, and long-term performance. In such a context, the absence of coherence is not a neutral condition, but a source of risk. The role of AIDE is therefore not to introduce new principles, but to ensure that existing ones can be safely applied in practice. By translating accountability, innovation, data integrity, and ethics into actionable structures, it provides the conditions under which artificial intelligence can be integrated without undermining professional responsibility.

The future of civil engineering will not be defined by the presence of artificial intelligence, but by the clarity and coherence with which its use is governed. What is at stake is not the adoption of technology, but the profession's ability to maintain safety, accountability and public trust in an environment where decisions are increasingly shaped by it.

ECCE is uniquely positioned to lead this transition by translating principles into practice, supporting capacity building, and promoting coherence in AI adoption across Europe.

ECCE calls on European institutions, national authorities, industry stakeholders, and academia to:

- **Develop sector-specific guidance to support the practical application of AI in civil engineering**
- **Align engineering practice with EU regulatory frameworks, ensuring that policy translates into actionable standards**
- **Invest in skills and continuing professional development, enabling engineers to engage with AI responsibly**
- **Support small and medium-sized enterprises, ensuring equitable access to AI capabilities across the sector**
- **Establish pilot frameworks and demonstration projects to test and refine AI integration in practice**
- **Clarify responsibility and validation processes for AI-assisted engineering decisions**

ECCE will act to promote a clear, accountable, and aligned integration of AI in civil engineering, consistent with the profession's responsibility to society.

Read the
Position Paper
Executive Summary

EUROPEAN COUNCIL
OF CIVIL ENGINEERS

ECCE Secretariat
P.O. Box 136 41
NTUA Patission Str. Complex
28th October & Stournari St.
10682, Athens, Greece
secretariat@ecceengineers.eu

Registered Office
1 Great George Street, Westminster
London SW1P 3AA, United Kingdom

www.ecceengineers.eu