Cognitive Infrastructure for an Uncertain World: How AI and Data Can Reinvent the World's Largest Industry

This report explores how AI and structured data can unlock transformative potential in the infrastructure and construction sector. It outlines how embedding intelligence into early planning and decision-making processes can help organizations navigate rising complexity, mitigate risks, and build more adaptive, resilient systems.

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The World's Largest Industry, Trapped in the Analog Age

The construction and infrastructure industry—spanning everything from highways and airports to data centers and water systems, is the largest industry on the planet. Every year, it represents over $12 trillion in spending, or roughly 12% of global GDP and employs more than 7% of the global workforce. Yet despite its scale, it remains one of the last industries to digitally transform. Operating margins remain slim, rarely exceeding 5%, despite rising complexity and capital flows. Meanwhile, the sector struggles to evolve its data infrastructure and decision systems, operating in an analog manner within an increasingly digital world.

As shown in Figure 1, publicly traded construction firms (about 120) significantly underperform compared to other industries, both in profitability and efficiency. The world's oldest industry is one of the last to adopt new technologies to reinvent its business workflows.

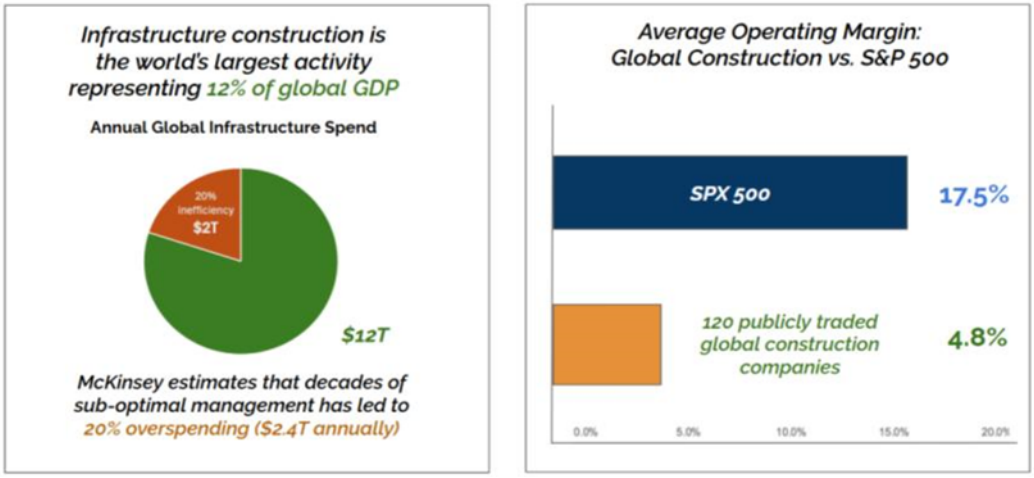

Figure 1. Chronic Underperformance in the World's Largest Industry

Source: Taiyo.AI, May 2025.

Despite $12 trillion in annual spending, the infrastructure and AEC sector wastes an estimated 20% due to inefficiencies. Operating margins for global construction firms lag significantly behind the S&P 500, highlighting the sector's persistent challenges in productivity and digital transformation.

AI Is Getting Cheaper and Faster — But Data Is the Bottleneck

In recent years, artificial intelligence has crossed a major threshold: the cost of building powerful models has collapsed. As shown in Figure 2, training advanced AI systems used to require more than $100 million in compute power and engineering. Today, thanks to more efficient architectures and open models, training costs have dropped to as low as $450. The number of participants able to build and fine-tune advanced systems is growing, spanning universities, governments, startups, and emerging economies.

The pace of AI adoption is unprecedented. ChatGPT reached one million users in just five days—faster than any consumer technology in history (see Figure 3). By contrast, the iPhone took 74 days, and Netflix required 3.5 years to hit the same milestone. What once took the telephone 75 years is now happening in days. Figure 3 further highlights this rapid diffusion: ChatGPT soared to 800 million users in just 17 months, while Netflix took a decade to reach 100 million.

This revolution in cost structure and speed of adoption has profound implications for legacy sectors like construction. For the first time, AI can be applied affordably at scale—not just by tech giants, but by contractors, ministries, and infrastructure operators around the world.

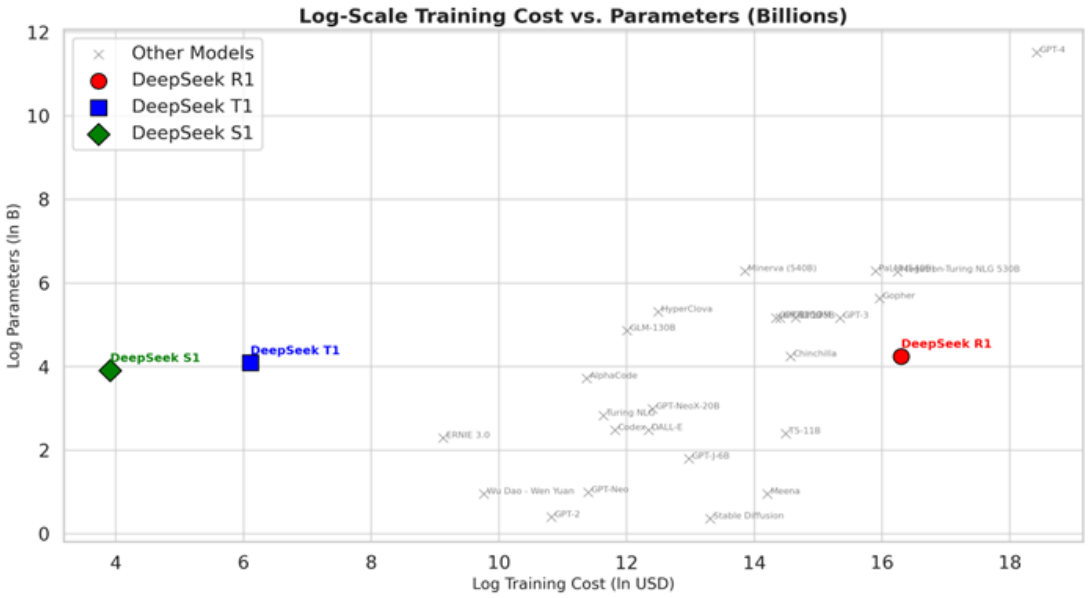

Figure 2. Small Is the New Big: Democratizing AI Development

Source: authors' calculations, May 2025.

However, there's a catch. AI cannot function without clean, structured, and contextual data. And that's where the infrastructure and AEC industry falls dangerously behind. While AI is more accessible than ever, legacy industries still struggle with the data foundation needed to take advantage of it. Without interoperable systems, historic records, or consistent standards, AI systems remain disconnected from the workflows they are meant to improve.

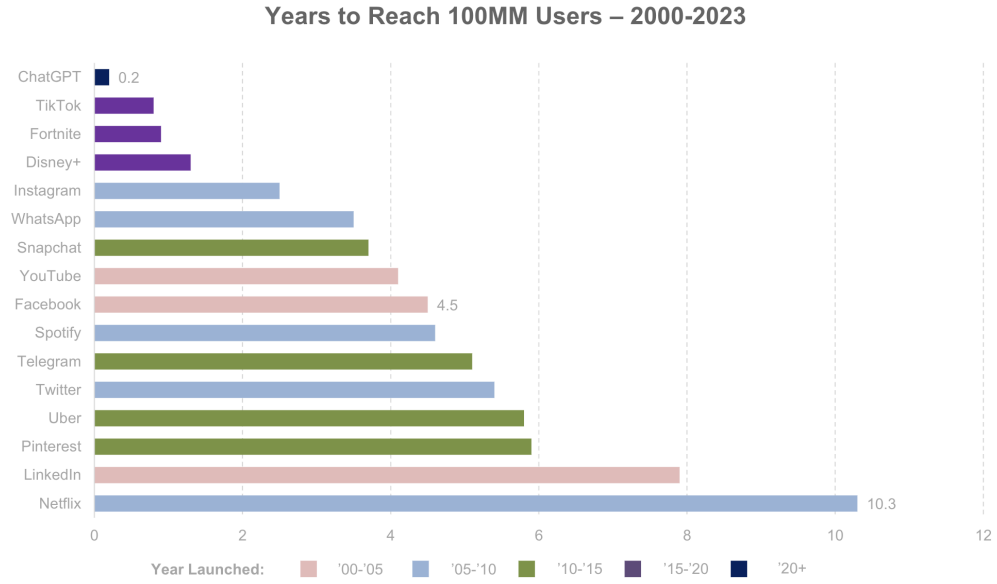

Figure 3. Duration to reach 100 M Users – Acceleration of Technology Adoption from Years to Days

Source: BOND, 'AI & Universities' (2024) via company filings, press
Note: Netflix represents streaming business. AI User Adoption (ChatGPT used as Proxy) materially faster vs. internet comparable.

Mass adoption is happening faster than ever. While it took Facebook 4.5 years and the iPhone 74 days to reach 1 million users, ChatGPT did it in just 5 days, reflecting the unprecedented diffusion speed of modern AI technologies.

The Industry's Data Deficit

Infrastructure is a sector of enormous scale and complexity transcends jurisdictions and sectors, and like the industry itself is deeply fragmented when it comes to data. Projects span energy, transport, digital, water, buildings, and defense, all governed by different authorities and standards. There is no universal format for project records, contracts, or procurement histories. Critical information is often buried in PDFs, government websites, or offline archives. No global body oversees or enforces consistent data practices across the sector.

The result? Infrastructure executives are forced to make high-stakes decisions—about billions in spending—with limited visibility into the pipeline of projects, judgement about stakeholders, risks, outcomes, or comparative insights about learning from past success and failures. This isn't a minor inconvenience. It's a major strategic liability that hinders:

- Plan projects intelligently, informing selectivity,
- Manage risks and costs,
- Learn from past mistakes, including choosing the right partners and clients,
- Build resilience against climate, labor, and geopolitical shocks.

The irony is clear: the sector building the future is stuck in the past. In a volatile and interconnected world, adaptability must become a foundational principle of infrastructure strategy. This means designing not only assets, but also organizations and systems, that can evolve with changing demands and technologies. AI-enabled planning doesn't just make infrastructure smarter; it makes it more adaptive. By continuously learning from new data, these systems can recalibrate priorities, reassess risks, and optimize performance over time. In essence, adaptability becomes the bridge between static capital investment and dynamic global needs. Just as physical infrastructure must withstand climate and time, decision infrastructure must adapt to uncertainty and complexity. This fragmented data environment is visualized in Figure 4, illustrating the depth of the infrastructure sector's data deficit.

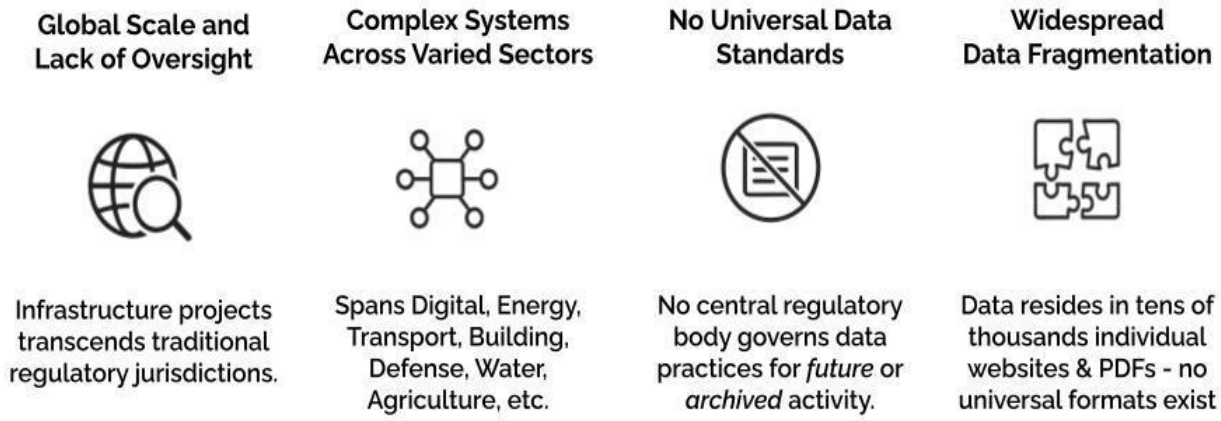

Figure 4. The Data Deficit – The Industry's Unsolved Challenge

Source: Taiyo.AI, May 2025.

Building the Data Foundation for the AEC Industry

Recognizing this gap, new models are emerging to bridge the divide between AI capability and infrastructure practice. At the core of these efforts is the concept of a "data mesh"—a structured, interoperable system that integrates fragmented infrastructure data across sectors, regions, and timeframes.

These systems do more than digitize legacy records—they convert raw procurement and project data into AI-ready, insight-rich ecosystems capable of supporting early-stage decision-making and long-term planning.
In the absence of universal data standards or coordinated governance, much of this progress has come from cross-sector collaborations—combining technical innovation with infrastructure domain expertise to begin constructing this missing layer of cognitive infrastructure.

One such effort has integrated over 65 years of procurement and infrastructure project history, sourced from more than 10,000 government and public data channels worldwide. The resulting system applies generative AI to:

- **See everything** – enable real-time visibility into global project opportunities and trends,
- **Choose better** – inform smarter partner, client, and market selection through structured intelligence,
- **Improve outcomes** – help reduce planning errors, avoid risks, and optimize capital deployment before construction begins.

This represents more than digitization, it is a paradigm shift in how infrastructure decisions are made. By embedding intelligence into upstream workflows, infrastructure actors can move from reactive risk management to proactive opportunity design and portfolio shaping.

Early Planning Is Where the Value Is Won—or Lost

Much of today's construction technology focuses on what happens on the site—robotic bricklayers, sensor-embedded helmets, drones for surveying. These tools are important, but they intervene too late in the project lifecycle to influence systemic outcomes.

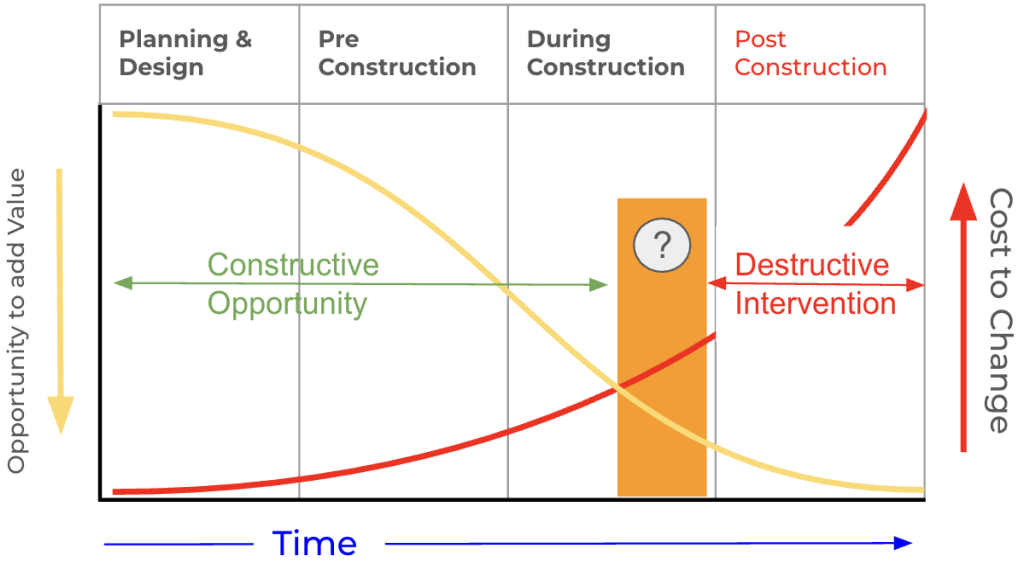

Figure 5. Too Late to Apologize – Value Capture Across the Project

Source: authors' adaptation based on Laufler, 1997.

As shown in the classic curve above, the opportunity to add value is highest during planning and pre-construction—and declines rapidly once execution begins. At the same time, the cost of making changes increases exponentially as the project progresses. In fact, by the time a project enters the construction phase, over 80% of its future costs and risks have already been determined.

That's why the real frontier of construction intelligence isn't automation at the job site—it's augmentation in the boardroom. Firms that invest in AI-powered planning tools can improve commercial selectivity, reduce risk exposure, and optimize capital allocation before ground is broken.

Strategic Urgency in a Multi-Hazard, Multi-Trillion Dollar Moment

Infrastructure is no longer just about steel, cement, and engineering—it's about geopolitics, climate resilience, economic strategy, and national security. Around the world, governments are injecting unprecedented capital into infrastructure development, and without data and AI it's impossible for human organizations to get visibility into this dynamic environment. For example, the Middle East is channeling over $1.3 trillion into giga-projects for post-oil futures; India, China, and Southeast Asia are scaling digital, urban, and transport infrastructure to match explosive urban growth; Europe is investing billions into defense, green energy, and resilient supply chains under threat from war and trade volatility; The U.S. is deploying over $1.2 trillion.

These spending surges arrive at a time of acute challenges:

- Climate risks disrupting timelines and reshaping investment priorities.
- Economic uncertainty, where material costs like steel or solar can spike 30–40% in weeks with tariff surges.
- Labor shortages, especially in the U.S., where up to 41% of the construction workforce may retire by 2030, and a large share of the current workforce is undocumented.

A senior official from India's central infrastructure body recently posed a vital question:

We're investing billions—but how do we ensure we're selecting the right projects, based on local needs and future demand?" The answer lies in early intelligence, robust data, and AI-powered planning—not just more concrete.

Call to Action: Building the Future with Intelligence

To transform the world's largest—and most analog—industry, we must rethink how infrastructure is planned, managed, and led. As summarized in Figure 6, six pillars define the path to becoming an AI-driven infrastructure organization. The path forward begins with treating clean, standardized infrastructure data as a shared public good within an organization and across the industry. Without it, AI cannot function, and without AI, organizations will struggle to adapt to the complexity of modern development.

Next, we must embed AI into the earliest stages of planning, where its ability to support project selection, partner due diligence, and strategic risk assessment can deliver the greatest value. This is where decisions shape outcomes for decades—and where traditional systems have failed to keep up.

Transformation also requires a cultural shift. Infrastructure organizations must evolve into adaptive, learning institutions—ones that preserve institutional memory, upskill their workforce, and use feedback loops to continuously improve. This kind of adaptive intelligence is essential in an age of climate volatility, labor disruption, and global uncertainty.

Critically, these shifts must be led from the top. C-suite and board leadership must treat AI not as a technical tool but as a strategic lever—one that can reshape portfolios, unlock new channels, and guide the next era of global development.

To enable all of this, we must invest in cognitive infrastructure: the intelligence layer that connects data, people, tacit domain knowledge, and systems across the value chain. Cognitive infrastructure is what allows us to see more, choose better, and adapt faster—embedding intelligence directly into the workflows that will define the next century of building.

The construction industry faces not only a digital transformation gap but also a branding crisis. With an aging workforce and a declining pipeline of new talent—many opting for tech and other sectors instead—there is an urgent need to reimagine the industry's future. AI offers a path to do more with less—not just by driving efficiency and productivity, but by accelerating learning, improving decision quality, and embedding institutional memory. By leveraging data to learn from history and prepare for generational transition, organizations can transform into adaptive institutions. But this requires cultural change—greater openness, faster iteration, and a proactive embrace of intelligence-driven workflows. Now is the time to modernize not only the tools but the identity of the infrastructure industry itself.

This framework connects data, decision-making, and adaptability across the infrastructure value chain—from foundational standards to leadership-driven strategy. In a world of cascading risks and fast-moving opportunities, intelligence is the most resilient building material we have.

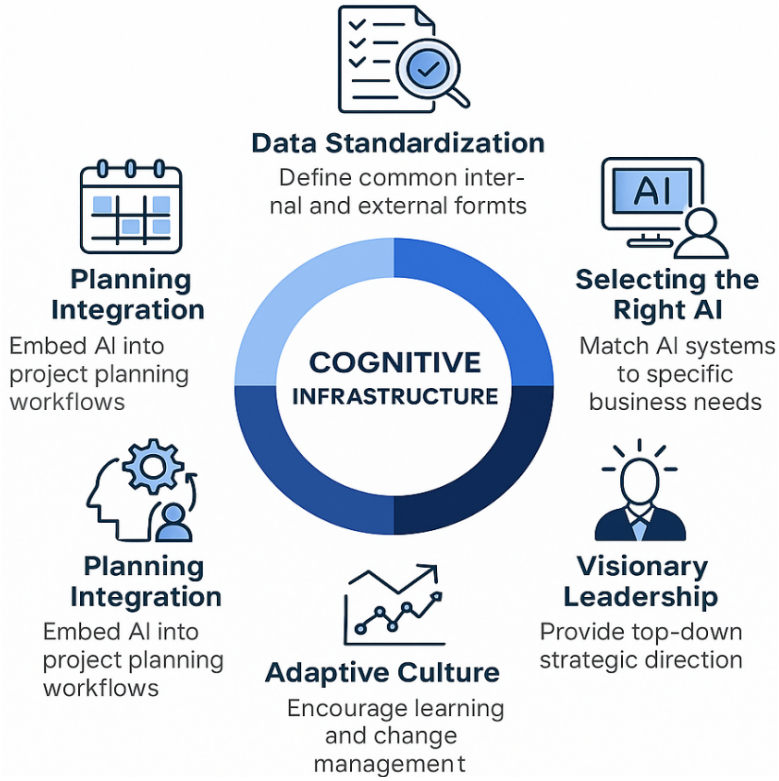

Figure 6. Building an AI-Driven Infrastructure Organization: Six Pillars of Cognitive Transformation

About Taiyō.AI

Taiyō.AI is the first general-purpose AI platform built specifically for the global infrastructure and construction ecosystem. With a foundation of over 65 years of standardized procurement, project records, scholarly publication, activities and risk data covering tens of thousands of companies and 50 million infrastructure records, Taiyō.AI provides an unprecedented layer of standardized, interoperable intelligence across the entire Architecture, Engineering, and Construction (AEC) value chain.

Founded by leading experts at the intersection of artificial intelligence and infrastructure strategy, Taiyō.AI is designed to accelerate knowledge and decision-making across the entire infrastructure ecosystem. From government agencies and engineering firms to suppliers, developers, and capital partners, Taiyō empowers stakeholders to conduct real-time due diligence on partners and markets, uncover emerging opportunities early, and enhance project planning and risk management through grounded industry data and AI-powered insights. By embedding intelligence into upstream workflows, it also strengthens stakeholder engagement and supports long-term strategic positioning in an increasingly complex global environment.

To learn more, visit taiyo.ai or explore the platform directly at infra.taiyo.ai/signup.

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About GLCM

The Global Leaders in Construction Management (GLCM) is a strategic research and leadership initiative established in 2011 at Columbia University by Professor Ibrahim S. Odeh. Operated within the Department of Civil Engineering and Engineering Mechanics, GLCM focuses on advancing thought leadership at the intersection of strategic management, digital transformation, and industry innovation in the Engineering and Construction (E&C) sectors.

GLCM is structured around four core components: Global and National Industry Immersion, Strategic Industry Collaborations, Research and Thought Leadership, Leadership Development.

Since its founding, GLCM has expanded its global reach through study tours and partnerships in countries including Turkey, the United Arab Emirates, Saudi Arabia, Qatar, Jordan, China, Malaysia, Thailand, France, India, Japan, UK, and Greece, establishing itself as one of the leading global academic-industry bridging between theory and practices in the E&C industry.