

RESEARCH AND DEVELOPMENT IN CONSTRUCTION INDUSTRY

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Abstract: Research and development (R&D) is increasingly recognized as a strategic necessity in the construction sector, despite historically low investment levels compared to high-tech industries. This paper explores the evolving role of R&D in construction, beginning with a conceptual overview and typology of R&D models, then examining how these models translate into real-world practices among contractors, design firms, and equipment manufacturers. The analysis outlines how R&D spending is measured, what innovation areas receive funding, and offers international examples from leading companies such as CSCEC, Bouygues, Vinci, and Caterpillar. While these global actors demonstrate structured and impactful R&D strategies, the paper also highlights the underdeveloped state of R&D reporting in Serbia, where data is scarce and no major construction firms have reported intangible investments in development. This gap emphasizes the need for improved policy frameworks, financial transparency, and national innovation incentives. The study concludes by advocating for a more integrated and accountable approach to R&D in construction as a pathway toward sustainable growth, competitiveness, and technological resilience in both global and national contexts.

Keywords: Research and Development (R&D), Construction Industry, OEM Industry, Innovation Strategies, Global Benchmarking, Sustainable Construction

1. INTRODUCTION

Research and development (R&D) is a vital component of economic growth and technological progress. While traditionally emphasized in high-tech industries, its relevance in the construction sector has grown significantly in light of rising demands for innovation, efficiency, and sustainability (Gutterman, 2023).

The construction industry contributes significantly to global GDP but faces persistent challenges such as low productivity, high fragmentation, and limited adoption of digital technologies (Hampson i dr., 2014). These structural issues limit the industry's ability to innovate, making targeted R&D investment increasingly critical for competitiveness and resilience.

This paper explores the role of R&D in the construction sector by first defining the concept and types of R&D. It then examines how R&D manifests across various stakeholders in the construction industry, how R&D spending is measured, what areas receive investment, and presents real-world examples from leading global firms. A final section will later address the current status of R&D in Serbia. The goal is to highlight how structured R&D practices can help transition construction from a reactive, project-driven model toward a more innovative, knowledge-based industry.

2. WHAT IS R&D

R&D refers to systematic activities aimed at developing new knowledge and translating it into practical applications. These efforts typically involve a mix of scientific research, engineering development, and innovation management (Gutterman, 2023).

There are several recognized types of R&D. Fundamental R&D (basic research) seeks to advance general scientific understanding. Applied R&D aims at solving specific problems or developing new products. Incremental R&D improves existing solutions, while radical R&D targets transformative innovations. Additional categories include compliance-based activities for regulatory approval and support-related tasks like troubleshooting and post-launch modifications (Gutterman, 2023).

Historically, R&D followed a linear model: science leads to technology, which leads to product development. This “technology-push” view dominated mid-20th century thinking. Later models emphasized feedback loops between market needs and R&D efforts, treating innovation as a more dynamic and interconnected process. Today's best practices, often termed fifth-generation R&D, emphasize cross-functional teams, system integration, external collaboration, and strategic portfolio management (Gutterman, 2023).

Modern R&D also plays a strategic role in aligning innovation with business goals. It supports long-term competitiveness, intellectual property creation, and adaptability in fast-changing environments. In sectors like construction, where innovation is often fragmented, integrating R&D into core strategy is essential (Abdul Hamid i dr., 2016). This theoretical understanding sets the stage for evaluating how R&D functions specifically within the construction sector.

Gross domestic expenditure on R&D by sector, 2023

(%, relative to GDP, ordered by the expenditure in the business enterprise sector)

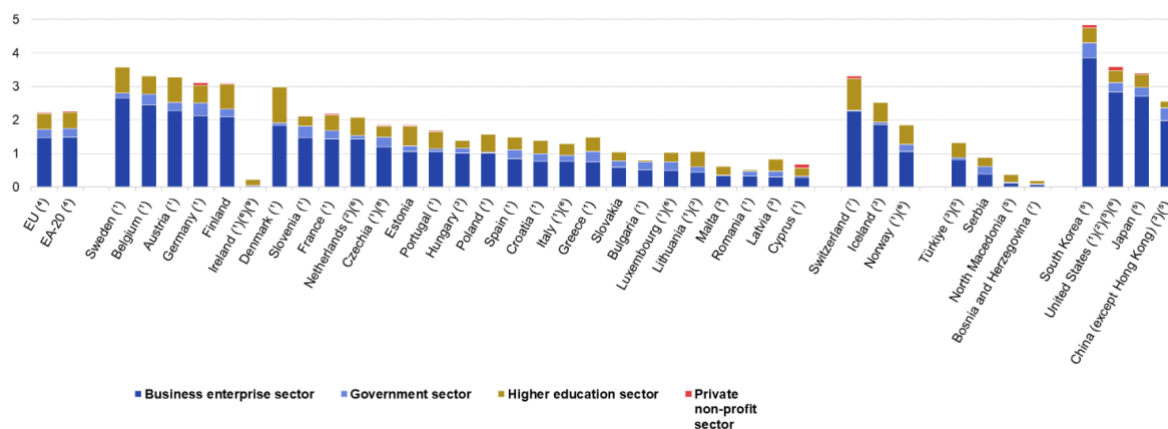


Figure 1 How much is spent on R&D in different counties (Eurostat 2023)

3. R&D IN THE CONSTRUCTION SECTOR

While R&D is a well-established concept in many sectors, its integration into the construction industry has been historically limited. Construction has long been classified as a low-R&D intensity sector due to its project-based nature, short-term focus, and fragmented value chains (Hampson i dr., 2014). This has hindered systematic innovation and made it difficult for companies to justify long-term research investments.

Several core characteristics distinguish R&D in construction from that in manufacturing or pharmaceuticals. First, most construction firms operate on narrow margins and customized projects, leaving little room for standardized innovation or product development cycles (Abdul Hamid i dr., 2016). Second, the supply chain is decentralized, often involving designers, general contractors, subcontractors, consultants, and equipment manufacturers, each with different roles and incentives regarding innovation. Consequently, R&D responsibilities are often scattered and uncoordinated (Hampson i dr., 2014).

Despite these limitations, the need for R&D in construction has become more pressing. Industry challenges such as labor shortages, environmental regulations, digital transformation, and rising cost pressures are pushing firms to adopt new technologies, materials, and processes. Areas such as prefabrication, building information modeling (BIM), AI-assisted design, and green construction materials have emerged as key domains of R&D focus (Construction Briefing, 2024), (Abdul Hamid i dr., 2016).

Different stakeholders in the construction ecosystem contribute to R&D in specific ways. Design firms may invest in advanced modeling and simulation tools, while contractors focus on process optimization, automation, and lean construction methods. Construction equipment manufacturers (OEMs) typically engage in product innovation, such as smart machinery and fuel-efficient systems (Hampson i dr., 2014). However, most of these efforts remain siloed and lack integration at the project or industry level.

Institutional and national reports repeatedly identify this fragmentation as a barrier to systemic innovation. For instance, despite decades of academic research into construction management and technology, many findings fail to influence real-world projects due to poor knowledge transfer and weak collaboration between academia and industry (Alhamadi i dr., 2016). In countries with higher R&D coordination, such as Germany or Finland, public-private partnerships and innovation platforms have helped consolidate efforts across firms and sectors (Hampson i dr., 2014).

Ultimately, to make R&D more effective in construction, companies must move beyond ad-hoc experimentation and begin treating R&D as a strategic business function. This includes aligning innovation with long-term goals, allocating dedicated resources, forming alliances with external researchers, and creating mechanisms for learning from projects. As global competition intensifies and sustainability pressures mount, firms that integrate R&D into their core operations will likely emerge as leaders in the next generation of construction.

4. HOW ARE INVESTMENTS IN R&D PRESENTED

R&D investment is commonly evaluated through financial metrics that compare R&D spending to a company's overall financial performance. The most widely used indicator is R&D intensity, typically expressed as a percentage of either total revenue or net profit. This metric allows companies and analysts to benchmark innovation efforts across industries and time periods (NetSuite, 2024).

In high-tech industries, R&D intensity often ranges from 5% to 20% of annual revenue. In contrast, construction companies traditionally report much lower figures, typically well below 1% (Construction Briefing, 2024). This difference reflects not only the lower prioritization of R&D in the sector but also structural barriers such as low margins, fragmented workflows, and limited standardization.

For accounting purposes, qualifying R&D expenditures may include costs for salaries of technical staff, prototype development, design testing, engineering work, and regulatory compliance efforts. These are often captured under general overhead but can be isolated with proper financial tracking systems. Some companies also capitalize R&D costs as assets if they are expected to generate future economic benefits, while others expense them immediately, depending on jurisdiction and accounting standards (NetSuite, 2024).

In the construction sector, comparing R&D investment as a share of profit rather than revenue can offer a more realistic view of the effort involved. For example, a company that allocates 2% of its net profit to developing sustainable materials or AI-driven planning tools is making a meaningful investment in innovation, even if the percentage of revenue appears small. Once R&D is measured, the next consideration is where firms direct these investments.

5. WHAT ARE R&D FUNDS SPENT ON

In the construction industry, R&D funds are increasingly directed toward technologies and methods that improve efficiency, sustainability, and competitiveness. These investments cover a broad spectrum of innovation areas, tailored to the specific focus of the company — whether design, construction, or manufacturing (Construction Briefing, 2024), (Global Construction Guide, 2024).

For design firms, R&D often focuses on enhancing digital capabilities. Investments are made into Building Information Modeling (BIM), generative design software, and simulation tools that allow for more accurate planning and scenario modeling. These tools help reduce errors, improve energy efficiency, and enable collaboration across disciplines (Abdul Hamid i dr., 2016).

Construction contractors tend to invest in process innovation. This includes R&D into modular and prefabricated construction, robotics, drones for site monitoring, and lean construction methodologies. Some companies also fund research on low-carbon building techniques, construction waste reduction, and energy-efficient building materials (Construction Briefing, 2024), (Alhammadi i dr., 2016).

Equipment manufacturers (OEMs) allocate R&D budgets toward product development. For example, smart construction machinery, autonomous systems, and telematics for real-time equipment monitoring. These investments often aim to reduce fuel consumption, enhance safety, and optimize lifecycle costs of equipment (Global Construction Guide, 2024).

Increasingly, construction companies are also investing in AI and predictive analytics to forecast project risks, manage labor, and optimize logistics. These shifts reflect a growing understanding that R&D is not a luxury, but a necessity for long-term survival and leadership in a rapidly changing environment.

6. EXAMPLES OF INVESTMENTS IN R&D FROM COMPANIES

R&D investment in the construction industry varies widely depending on firm size, strategic orientation, and regional context. A comparative look at major companies reveals distinct patterns in how R&D is approached, from state-driven megaprojects in Asia to digitally focused innovation platforms in Europe and smart machinery development by OEMs.

Among the most significant investors is China State Construction Engineering Corporation (CSCEC), which spent over CNY 49.7 billion (US\$6.8 billion) on R&D in 2022 alone. This figure represents a substantial 24.3% year-on-year increase, aligned with national-level research agendas under China's Five-Year Plan. CSCEC's R&D covers a wide scope including supertall buildings, construction automation, and integrated land development systems (Global Construction Guide, 2024).

China Railway Construction Corporation (CRCC) and China Communications Construction (CCCC) also report multi-billion-dollar annual R&D budgets. Their work includes research into deep-underground infrastructure, smart transportation systems, and satellite-based construction monitoring, indicating a strong emphasis on mega-infrastructure and system-level innovations (Global Construction Guide, 2024).

In Europe, Vinci invests approximately €50 million annually in R&D through its innovation hub *Leonard*, which explores AI, predictive maintenance, and future mobility solutions. Meanwhile, Bouygues focuses on eco-construction and digital twins. The company has participated in the BIO4EEB project, funded by Horizon Europe, to develop bio-sourced building materials (Global Construction Guide, 2024).

From the equipment manufacturing side, Caterpillar has committed up to US\$2.5 billion in annual R&D spending. Their focus includes smart construction machines, autonomous vehicle platforms, and predictive analytics aimed at minimizing lifecycle costs and environmental impact (Global Construction Guide, 2024), (Construction Briefing, 2024).

ACS Group (Spain), Shanghai Construction Group, and Metallurgical Corporation of China also exemplify targeted investments. These range from climate-resilient infrastructure and smart water systems to advanced concrete technologies for high-rise and tunnel projects (Global Construction Guide, 2024).

On an institutional level, initiatives like those reported by the Canadian Construction Association illustrate the role of national innovation platforms. These initiatives emphasize collaboration between academia, government, and industry, aiming to reduce duplication and accelerate adoption of proven technologies (Canadian Construction Association, 2022).

Collectively, these examples show that while the scale and focus of R&D vary, leading firms increasingly view innovation as a core competency rather than an auxiliary function. The strategic integration of R&D is not only boosting operational efficiency but also shaping the construction industry's capacity to respond to environmental, technological, and market challenges.

Table 1. Overview of Revenues and R&D spendings by Construction companies

Company name	Revenue [mil. \$]	R&D Spendings [mil. \$]	Percentage of Revenue spent on R&D
<i>China State Construction (CSCEC)</i>	282,600	6,800	2.4%
<i>China Railway Group</i>	173,700	4,100	2.4%
<i>China Railway Construction Corporation (CRCC)</i>	156,500	3,700	2.4%
<i>China Communications Construction (CCCC)</i>	106,600	3,800	3.6%
<i>Metallurgical Corporation of China (MCC)</i>	89,403	2,700	3.0%
<i>Vinci Construction</i>	31,500	54	0.2%
<i>Bouygues Construction</i>	9,800	77	0.8%
<i>ACS Group</i>	35,740	28	0.1%

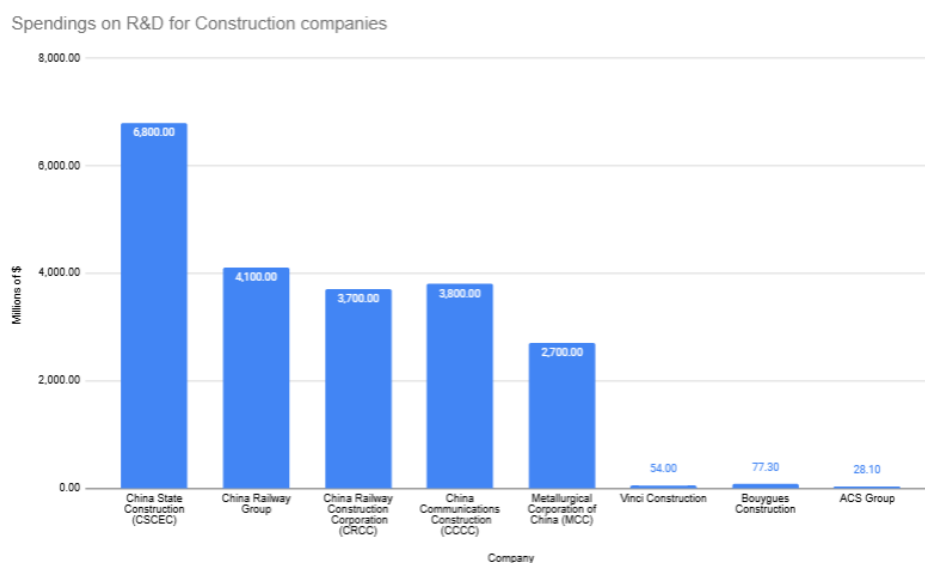


Figure 2 How much Construction companies spend on R&D

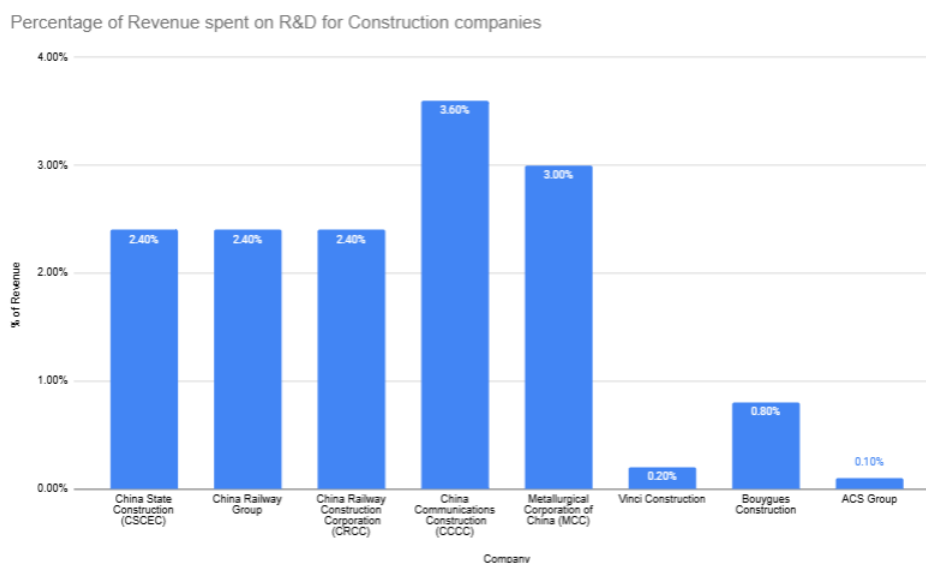


Figure 3 How much of their Revenue do Construction companies invest in R&D

Table 2. Overview of Revenues and R&D spendings by OEM companies

Company name	Revenue [mil. \$]	R&D Spendings [mil. \$]	Percentage of Revenue spent on R&D
<i>Caterpillar</i>	67,741.9	2,100.0	3.1%
<i>Komatsu</i>	23,269.2	605.0	2.6%
<i>XCMG</i>	14,545.5	800.0	5.5%
<i>Deer & Co</i>	56,410.3	2,200.0	3.9%
<i>Sany</i>	11,900.0	700.0	5.9%
<i>Volvo Group</i>	52,000.0	2,600.0	5.0%
<i>Liebherr</i>	15,200.0	688.0	4.5%
<i>Hitachi Construction Machinery</i>	8,570.0	162.9	1.9%
<i>Sandvik</i>	12,370.0	470.0	3.8%
<i>JCB</i>	8,710.0	261.3	3.0%

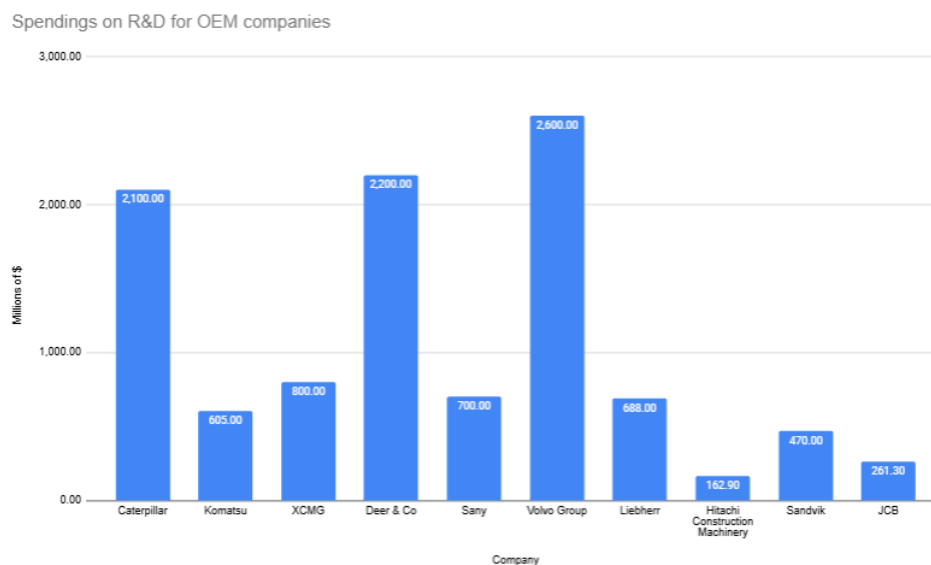


Figure 4 How much Construction companies spend on R&D

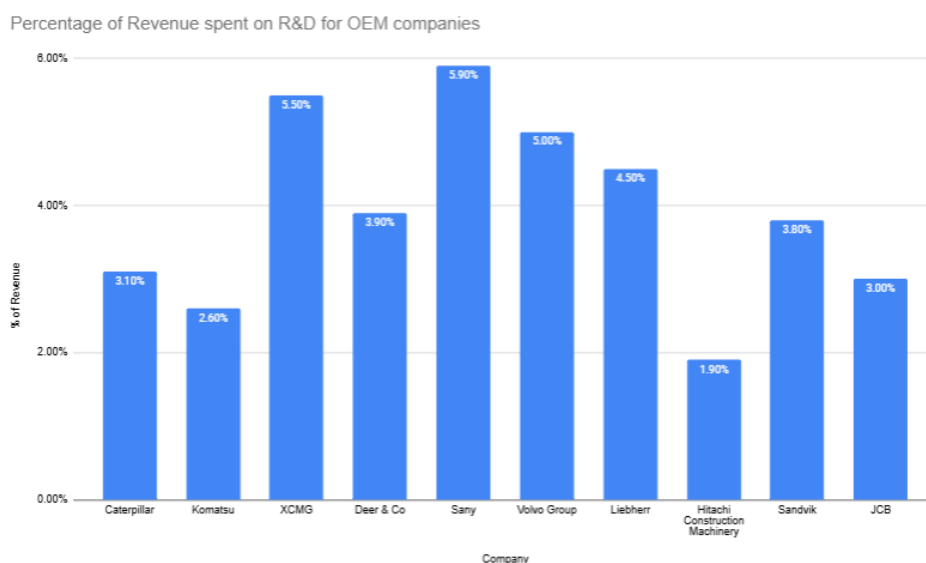


Figure 5 How much of their Revenue do Construction companies invest in R&D

7. R&D IN SERBIAN CONSTRUCTION SECTOR

Publicly accessible data on R&D expenditures by domestic construction companies in Serbia is scarce. Mandatory financial disclosures do not isolate research and development costs as a separate category. In financial statements, material development costs are grouped within the “Operating Expenses” section, under the subcategory “Cost of Goods Sold,” which also

includes expenses for materials, fuel, energy, and wages. As a result, it is not possible to identify or estimate development-related costs from this grouping alone.

A second relevant indicator appears under “Intangible Investments” in the balance sheet, which includes potential R&D investments under the subheading “Development Expenditures.” However, according to Serbian accounting standards, a distinction is made between the research phase and the development phase of R&D activities. Expenses incurred during the research phase are treated as period costs and are not capitalized. Only development phase costs that meet strict recognition criteria, including technical feasibility, commercial viability, and reliable measurability, can be reported as intangible assets.

An analysis of the top 10 construction companies in Serbia by revenue reveals that none disclosed any intangible R&D investments over the past four years (Petronijević i dr., 2024). As previously mentioned, material R&D costs are not explicitly reported either. Therefore, it is currently not possible to determine the full scale of R&D investments among Serbian construction firms. This significant data gap underscores the need for future research into innovation financing and reporting practices in the domestic construction sector.

8. CONCLUSION

This paper has outlined the growing importance of research and development (R&D) in the construction industry, a sector traditionally marked by low innovation intensity and high fragmentation. As environmental pressures, technological disruptions, and global competition accelerate, R&D is becoming not only a tool for improvement but a precondition for long-term survival.

International leaders such as CSCEC, Bouygues, Vinci, and Caterpillar have demonstrated that consistent, high-volume investment in R&D, spanning smart construction systems, green technologies, and AI-driven workflows, is achievable even in a capital-intensive and risk-sensitive sector (Construction Briefing, 2024), (Global Construction Guide, 2024). Their efforts show that strategic alignment between innovation and core business goals yields measurable gains in productivity, sustainability, and competitiveness.

In contrast, Serbia’s construction sector reflects systemic challenges. With no centralized data on R&D spending and no significant disclosures from top-performing companies (Petronijević i dr., 2024), innovation remains largely undocumented and possibly underdeveloped. This silence in financial reporting and strategic communication underscores the need for targeted policy reforms, clearer R&D accounting standards, and national programs that actively incentivize innovation in the built environment.

Moving forward, construction companies, both globally and in Serbia, must reframe R&D as an embedded, measurable, and collaborative function. Governments and industry associations should support this shift through tax incentives, public-private partnerships, and transparent

reporting frameworks. Only through deliberate action and structural support can the sector unlock the full value of R&D and meet the demands of a rapidly changing world.

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