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GET SMART! A STUDY GUIDE ON 'SMART CONSTRUCTION' CONCEPTS, TRENDS AND RISKS

Benton J. Barton
Moderator
HALL & EVANS, L.L.C.
Denver, Colorado
bartonb@hallevans.com

FEEL THE FORCE: THE ERA OF SMART CONSTRUCTION HAS ARRIVED

Smart construction — defined loosely as the development and use of technology in the construction industry — carries a host of benefits. Because building projects are necessarily long-running, complex, and fraught with unanticipated delays,[1] technology has a unique role to play in the construction industry. In the past, the industry has been criticized as fragmented and slow to adopt new technologies,[2] but this is no longer true.

One of the most important ways that technology can benefit the construction industry is by increasing safety. The industry is one of the most dangerous; indeed, the Occupational Safety and Health Administration (OSHA) has found that fatal accidents occur far more often in construction than they do in other professions.[3] This makes sense, given the presence of heavy machinery and the fact that workers often must perform tasks on elevated, unstable surfaces. OSHA ranks the following as the four most common reasons construction worksite injuries: (1) falls due to unprotected sides, holes, andunsteady working surfaces; (2) falling, swinging, or misplaced objects striking workers; (3) electrocutions; and (4) caught-ins orbetweens, referring to when workers are caught between moving or rotating equipment or within collapsing structures.[4]

A few statistics further illustrate why we should focus on improving safety industry-wide:

- One in five employee-related deaths in the U.S. is due to construction work.[5]
- Construction accidents result in workers' compensation claims costing an estimated $2.5 billion each year.[6]
- Approximately 130,000 construction workers missed at least a day of work due to an injury in 2020.[7]

Technology can help by allowing for better planning and oversight to prevent injuries from occurring. If an injury does happen, construction wearable technology can notify supervisors of the accident immediately, thereby enabling a faster response time and, hopefully, improving recovery prospects.

Although the list of benefits that smart construction can bring to projects is lengthy, downsides exist as well. This article provides an overview of various technologies the construction industry is now embracing and highlights benefits and drawbacks to each.

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[1] *E.g.*, unforeseen site conditions, inclement weather, supply chain shortages, budget conflicts.
[2] *See, e.g.*, Juan Delgado et al., *Robotics and automated systems in construction: Understanding industry-specific challenges for adoption*, Journal of Building Engineering (2019).
[3] www.osha.gov/data/commonstats.
[4] *Id.*
[5] *Census of Fatal Occupational Injuries Summary, 2020*, U.S. Bureau of Labor Statistics, www.bls.gov/news.release/cfoi.nr0.htm.
[6] https://constructionexec.com/article/the-hidden-cost-of-ladders-construction-injuries.
[7] *Labor Force Statistics from the Current Population Survey*, U.S. Bureau of Labor Statistics, www.bls.gov/cps/cpsaat47.htm.

A. Smart Construction Trends

a. Robots

Though critics questioned the credibility robots in live construction sites for a long time, real-world trials have proven robots' ability to perform well.[8] Robots are good at performing simple, repetitive tasks. Because they do not need to take breaks like humans, robots can be more efficient and productive than laborers. Robots can also: (1) help address the construction industry's labor shortage, a demand that is expected to grow significantly in the coming years;[9] (2) handle more dangerous tasks to decrease risk to humans; and (3) perform with increased accuracy.

Three types of robots are reshaping labor forces currently. First, there are factory robots, which perform simple manufacturing tasks. Second, there are collaborative robots, which can be used on a job to assist humans by, carrying tools or laying bricks, for example. Third, there are fully autonomous robots, which can perform complex tasks independently.[10]

The "Jaibot" by Hilti is a semi-autonomous robot that drills ceiling installations.[11] HITT Contracting used the Jaibot for construction on the Washington Metro Area Transit Authority headquarters in New Carrollton, Maryland.[12] Handling the task of marking and drilling ceiling holes, the Jaibot completed a project — which should have taken three workers ten days to complete — in just four days.[13]

The "FieldPrinter" by Dusty Robotics provides another example of a robot being used to improve job efficiency in construction.[14] This little machine takes BIM (building information modeling) data and uses it to autonomously print full-scale model layouts onto construction surfaces — completing the task ten times faster than humans could by using chalk.[15]

As is the case in other industries, one negative implication of robot use in construction is the possibility

[8] *9 Construction Tech Trends to Watch in 2019*, The B1M, www.youtube.com/watch?v=BkRsA_v5oY4.
[9] The Bureau of Labor Statistics projected construction employment growth to be 11% from 2016 through 2026.
[10] Liam Stannard, *Construction Technology to Watch in 2022*, BigRentz (Jan. 7, 2022), www.bigrentz.com/blog/construction-technology.
[11] www.hilti.com/content/hilti/W1/US/en/business/business/trends/jaibot.html.
[12] Jaclyn Randolph, *How robots are changing the construction industry – for the better,* WASHINGTON BUSINESS JOURNAL (Sept. 1, 2021).
[13] *Id.*
[14] Eugene Demaitre, *Dusty Robotics Raises $16.5M Series A for Construction Automation*, Robotics 24/7 (June 15, 2021), www.robotics247.com/article/dusty_robotics_raises_16.5m_series_a_construction_automation.
[15] www.dustyrobotics.com.

that the robots will put human workers out to pasture. Although only time will tell whether and to what extent this fear manifests, there are at least two arguments that this fear is unfounded in the context of construction work. First, humans are still needed to set up, monitor, sign off on, and otherwise work hand-in-hand with participating robots. Second, the current labor shortage[16] in the construction industry suggests that the addition of robots is welcome and will not displace human workers.

b. Construction Wearables

Construction wearables come in a variety of forms, but the term generally refers to technology embedded in work attire or otherwise worn by workers that tracks and stores data about its wearer.[17] Construction wearables are outfitted with location trackers, voltage detectors, and other sensors to monitor movements on site. Geofencing allows supervisors to label areas as restricted or hazardous; workers are then alerted through the wearables when they enter an area that is dangerous or off-limits.[18]

Some examples of specific "smart" wearables already in use on sites include:

- Watches that can detect falls and alert management when a fall occurs.[19]
- Boots that can track an employee's location with GPS or detect when a worker is at risk of collision with similarly sensor-equipped construction vehicles.[20]
- Hard hats that can monitor for fatigue by sensing brainwaves.[21]
- Sensors that clip onto a worker's arm to detect dangerous gasses.[22]
- Power gloves that provide the wearer with increased dexterity and strength, helping to combat injuries that result from muscle overuse.[23]

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[16] *See, e.g.*, Grace Dean and Heather Schlitz, *The construction industry needs a 'staggering' 2.2 million more workers to keep up with booming demand for houses amid the labor shortage*, BUSINESS INSIDER (Nov. 5, 2021), www.businessinsider.com/construction-industry-needs-staggering-22m-more-workers-2021-11.

[17] Jessica Courtway, *Legal Implications of Wearables in the Construction Industry*, AMERICAN BAR ASSOCIATION (March 16, 2020).
[18] Kendall Jones, *Construction technology is reshaping the industry*, CONSTRUCT CONNECT (April 16, 2020).
[19] Jessica Courtway, *Legal Implications of Wearables in the Construction Industry*, AMERICAN BAR ASSOCIATION (March 16, 2020).
[20] *Id.*
[21] Kendall Jones, *Construction technology is reshaping the industry*, CONSTRUCT CONNECT (April 16, 2020).
[22] Liam Stannard, *6 Innovative Construction Wearables Reshaping Safety*, BigRentz (Sept. 17, 2020), www.bigrentz.com/blog/construction-wearables.
[23] Liam Stannard, *Construction Technology to Watch in 2022*, BigRentz (Jan. 7, 2022), www.bigrentz.com/blog/construction-technology.

- Data collectors to monitor and measure the worker and their environment (such as heart rate and skin temperature) to help prevent an accident before it occurs.[24]

- Exoskeletons, which are mechanical suits, fitted with motorized muscles and joints to provide extra support and power during repetitive movements, worn by human workers,. These also protect workers from manual handling injuries and reduce fatigue, thereby increasing productivity.[25]

Though not unique to the construction industry, wearables are particularly useful on building sites because they can handle many activities that often take up management's time, for example, automatically recording when workers clock in and out, monitoring productivity levels, and tracking the whereabouts of personnel.[26]

In addition to on-site benefits, wearables have legal benefits, too. For example, they can provide reliable data to prove regulatory compliance.[27] Also, "a defendant in a workplace-injury lawsuit could use data from a wearable to tell a different story about an accident than the one contained in the plaintiff's complaint."[28] Using wearable technology may also help companies gain better insight into justification, or pretext, for an employee's termination for cause.[29]

Companies should be cognizant of the legal dilemmas that may arise with the use of construction wearables. For example, when machines cause fault, who (or what) should be liable? If a device fails to detect a hazard and an employee relying on that device is injured, should the employer, the device manufacturer, or someone else be responsible?[30] What if a worker is injured and there was a certain technology the employer *could have* adopted but chose not to adopt? Should an employer ever be held liable for failure to adopt, and should an employer require its employees to use a particular technology? Maybe no liability would result for failing to use the most advanced and expensive of technology, but what if the technology the employer chose not to adopt is widely used, inexpensive, and commonly known to reduce danger? Although the answers to these legal hypotheticals are unclear for now and would probably depend upon the jurisdiction and the particular facts of a case, they are nonetheless questions that companies should consider when debating whether to utilize the latest gadget.

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[24] Kendall Jones, *Construction technology is reshaping the industry*, CONSTRUCT CONNECT (April 16, 2020).
[25] *Id.*
[26] Jessica Courtway, *Legal Implications of Wearables in the Construction Industry*, AMERICAN BAR ASSOCIATION (March 16, 2020).
[27] *Id.*
[28] *Id.*
[29] ARTICLE: The New Decade of Construction Contracts: Technological and Climate Considerations for Owners, Designers, and Builders, 11 Seattle Journal of Environmental Law 171.
[30] Jessica Courtway, *Legal Implications of Wearables in the Construction Industry*, AMERICAN BAR ASSOCIATION (March 16, 2020).

As is often (if not always) the case when it comes to technology advances, the use of construction wearables in the industry may implicate privacy and data concerns.[31] In terms of the latter, data collected and left insecure could become the target of a cyberattack.[32] According to at least one author, the construction industry is particularly vulnerable to cyberattacks for two reasons: (1) the industry has largely avoided heavy regulations when it comes to data security; and, (2) the industry is a lucrative target.[33]

In terms of privacy concerns, certain laws — such as the Americans with Disabilities Act and the Genetic Information Nondiscrimination Act — prohibit employers from collecting certain information about employees.[34] Employers would need to be sure that requiring employees to wear technology that gathers personal information such as vital signs does not violate the law.[35]

c. Drones

Drones provide a bird's-eye view of a project area and may uncover potential hazards or other details that cannot be viewed from the ground.[36] Drones can be used for topographic mapping and land surveys; equipment tracking; remote monitoring and progress reports; security surveillance; personnel safety, for example, replacing a worker who must climb an unsteady platform to take measurements; and structure inspection and photography.[37]

Already in frequent use,[38] drone technology continues to advance and can perform duties beyond just providing visual data. For example, the "xFold DragonH" drone made by Kaizen Aerial Solutions can lift

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[31] *Id.*

[32] § 7:90. *Cyber risk in the design and construction*, 2A Bruner & O'Connor Construction Law.

[33] Jennifer A. Beckage and Daniel J. Parziale, ***Why the construction industry is being impacted by cyberattacks, and what to do about it***, The Associated General Contractors of American, 2021 Surety Bonding and Construction Risk Management Conference.

[34] Kevin J. Haskins, *Wearable Technology and Implications for the Americans with Disabilities Act, Genetic Information Nondiscrimination Act, and Health Privacy*, ABA Journal of Labor & Employment Law, 69 (2018).

[35] *Id.*

[36] "[I]t is important that construction lawyers become familiar with the use of drones, contracting and insurance considerations when drones are to be used on projects, and how data generated by drones can be used by counsel to prove or disprove construction claims." Jacqueline DeCamara and Daniel D. McMillan, *Use of Drones on Construction Projects: Legal and Contractual Considerations*, AMERICAN BAR ASSOCIATION (Dec. 9, 2019).

[37] Liam Stannard, *6 Ways Drones in Construction Are Changing the Industry*, BigRentz (Feb. 16, 2022), www.bigrentz.com/blog/drones-construction.

[38] A 2018 study found that the construction industry is the fastest-growing adopter of commercial drone activity, with a 239% increase in use over just one year. *The Rise of Drones in Construction*, DroneDeply (June 7, 2018), www.dronedeploy.com/blog/rise-drones-construction.

1,000 pounds.[39]

Critically, drone use is becoming heavily regulated, and the failure to comply with these regulations carries legal risk. The Federal Aviation Administration has implemented regulations for commercial use of drones that must be followed.[40] In addition to drone-specific laws and regulations, commercial use of drones implicates other legal doctrines such as privacy and trespass that employers must take into account.[41]

Special considerations are necessary with regard to insurance coverage when implementing the use of drones in construction projects. Many insurance companies offer specific drone insurance or coverage inclusions as part of commercial general liability insurance policies.[42] Without specifically negotiating coverage for drone use, companies may be exposed for liabilities arising out of drone use. For example, in *Philidelphia Indemnity Insurance v. Hollycal Products*, an insurer denied coverage for an accident arising out a drone collision with a bystander under an aircraft exclusion contained in the commercial liability insurance policy.[43] In upholding the insurance company's denial of coverage, the Court held that the drone fell within the plain and ordinary definition of aircraft.[44] Accordingly, the Court determined that the aircraft exclusion under the policy applied.[45]

d. Artificial Intelligence and Machine Learning

Artificial intelligence (AI) refers to the ability of technology to make decisions independent of human input. Machine learning, by contrast, refers to technology's ability to "learn" from past experiences, using algorithms and statistics to analyze massive amounts of data.[46] Because intelligent decision making is key to successful coordination of projects with thousands of moving pieces, both of these technologies have the potential to reshape the construction industry for the better. This is true regarding the building itself as well as the pre-build bidding process: Once the data is acquired and

[39] https://kaizen.aero/xfold-dragonh/.
[40] Jacqueline DeCamara and Daniel D. McMillan, *Use of Drones on Construction Projects: Legal and Contractual Considerations*, AMERICAN BAR ASSOCIATION (Dec. 9, 2019).
[41] *Id.*
[42] ARTICLE: The New Decade of Construction Contracts: Technological and Climate Considerations for Owners, Designers, and Builders, 11 Seattle Journal of Environmental Law 171.
[43] *Id. See also Philadelphia Indem. Ins. Co. v. Hollycal Prod., Inc.,* No. EDCV18768PASPX, 2018 WL 6520412, at *2 (C.D. Cal. Dec. 7, 2018).
[44] *Id.*
[45] *Id.*
[46] Liam Stannard, *Construction Technology to Watch in 2022*, BigRentz (Jan. 7, 2022), www.bigrentz.com/blog/construction-technology.

processed, the resulting insight can be used to predict future outcomes and thus gain competitive advantage when bidding and estimating costs.[47]

An AI system can analyze available data to recommend what materials are best for a contractor who wants to build a home in an unfamiliar area. As another example, consider the result if an employer installs sensors on all materials and equipment at a job site to track their movement. "Once enough data sets are collected, AI can analyze how workers move about and interact with the site to come up with solutions to reorganize the placement of tools and materials to make them more accessible to workers and reduce downtime."[48]

AI and machine learning have already proven to have the ability to transform the construction industry by:

- Improving safety — software using machine learning can analyze job site photos to identify risks and safety violations.
- Decreasing cost — by analyzing past projects, machine learning can identify inefficiencies and propose more effective timelines.
- Producing better designs — because machine learning software can "learn" over time, it can improve building designs by analyzing thousands of design variations.[49]

e. Augmented Reality

Conceptualizing a project with so many tiny, yet significant, details can be challenging. Augmented reality (AR) can help building planners conceptualize like never before.

Most of us are familiar with the concept of virtual reality (VR), which immerses users into a simulated environment that feels like real life. VR and AR are similar, but there are key distinctions. With AR, users can overlay computer-generated images onto the real world, usually through a smartphone, tablet, or special AR glasses. In this way, construction planners and clients alike are able to "step inside" a "finished" building before construction begins. This can show the client what the building will look like and allow them to make any design changes up front.[50] For the builder, AR can provide insight into less

[47] Kendall Jones, *Construction technology is reshaping the industry*, CONSTRUCT CONNECT (April 16, 2020).
[48] *Id.*
[49] Liam Stannard, *Construction Technology to Watch in 2022*, BigRentz (Jan. 7, 2022), www.bigrentz.com/blog/construction-technology.
[50] Grace Ellis, *The Power of Augmented Reality in Construction*, Digital Builder (Jan. 16, 2020), https://constructionblog.autodesk.com/augmented-reality-ar-construction/.

obvious details that otherwise might have been overlooked. There are even apps — such as "ARki"[51] — that provide AR services.

Many architects and engineers have long utilized BIM software. BIM is a holistic process for creating and managing project data and can be used in any phase of the construction process including plan, design, building, and operation.[52] BIM allows design teams to collaborate in a shared cloud-based environment by creating a 3D model with all the data associated with the project, capturing the physical and functional characteristics and relationships of buildings and infrastructure.[53] The benefits of BIM are endless and include increased collaboration among the design team, more flexibility in the design process, and better collaboration between design and construction. This results in reduced errors and re-work.[54]

Due to the degree of collaboration offered by design professionals' use of BIM software, the potential exists for blurred lines concerning the responsibility for design errors, versus construction defects, that consequently increases all participants' risk.[55] For example, in a lawsuit concerning a perceived design error, participants in the BIM process may look to one another to determine liability.[56] BIM complicates the ability to prove fault to a factfinder, leaving design professionals facing potentially increased exposure through arbitration or trial.[57]

Careful contract drafting can help mitigate these risks. Contracts should delineate ownership and obligations for protection of data and information.[58] Moreover, in the case of a BIM model provided to a general contractor, the parties should require the general contractor to sign an agreement requiring the contractor to rely on the stamped drawings as opposed to the BIM model.

f. Advanced Materials

Technology's continual progress also results in better materials. This article does not attempt to provide an exhaustive overview of the many materials that create stronger, more environmentally

[51] www.darfdesign.com/arki.html.
[52] https://www.autodesk.com/industry/aec/bim.
[53] *Id.*
[54] *Id.*
[55] ARTICLE: The New Decade of Construction Contracts: Technological and Climate Considerations for Owners, Designers, and Builders, 11 Seattle Journal of Environmental Law 171.
[56] *Id.*
[57] *Id.*
[58] *Id.*

friendly buildings, but consider a few ways the construction industry has taken advantage of smarter materials:

- Incorporation of hard-to-dispose-of plastic waste products into roadways.[59]
- Repurposing carbon dioxide: here, carbon dioxide is injected into the concrete mix used in the building structure; the carbon dioxide becomes trapped inside the structure as the concrete cures, a process which leads to chemical reactions that increase the overall compressive strength of the final material and disposes of the carbon dioxide.[60]
- Mixing self-healing concrete with calcite-precipitating bacteria: bacteria germinate when water enters cracks of the decaying concrete, thereby filling emerging air gaps.[61]
- Using kinetic paving, which harvests energy from pedestrians' footsteps to generate electricity.[62]
- 4D-printing structures that can reshape or self-assemble over time by virtue of how a structure's elements respond to different conditions.[63]
- Erecting smog-eating buildings. the Torre de Especialidades hospital in Mexico City features a giant wall made of Prosolve370e tile. This circular tile — which makes up the building's façade — is covered in titanium dioxide-based paint that neutralizes the chemicals which compose smog.[64]

g. Prefab and Modular Construction

Although the terms "modular" and "prefab" are somewhat synonymous, they are different in that prefab refers to a category of construction methods where the home — in all or in part — is manufactured off-site and then delivered and assembled on-site.[65] Modular, by contrast, is one type of prefab home, referring to a process where modules (for example, a room or a wall) are built off-site and then brought to the site for assembly.[66]

Off-site construction processes save time, money, and resources. Not only are projects built more quickly, there are also fewer costs relating to transportation of supplies as well as labor. Additional

[59] *9 Construction Tech Trends to Watch in 2019*, The B1M, www.youtube.com/watch?v=BkRsA_v5oY4.
[60] *Id.*
[61] *Id.*
[62] *Id.*
[63] *Id.*
[64] https://metamodernarchitect.com/project/torre-de-especialidades/.
[65] *The Difference Between Prefab and Modular Construction*, Acuity Insurance (Sept. 3, 2020), www.acuity.com/the-focus/contractor/the-difference-between-prefab-and-modular-construction.
[66] Liam Stannard, *Construction Technology to Watch in 2022*, BigRentz (Jan. 7, 2022), www.bigrentz.com/blog/construction-technology.

benefits include:

- Less construction waste: Since several buildings or building components are made in the same factory, excess materials from one project can easily be used on another project.
- No weather delays since work can be done indoors.
- Less pollution: Building inside a factory helps combat pollution and reduce noise levels associated with construction activities.[67]

B. Conclusion

These technologies are just some examples of the exciting, varied smart construction trends developers, designers and construction professionals are embracing. Employers looking to incorporate smart construction into their business models should also consider cloud-based management systems and 3D printing. Cloud technology has the ability to make every aspect of a build available to all parties, regardless of their location. This makes it easier to coordinate hundreds of moving parts — workers, engineers, equipment, off-site stakeholders, and the like. Although 3D printing does have one major drawback, cost, the process eliminates errors, provides design flexibility and makes more efficient use of materials.[68]

In sum, technology is affecting the construction industry like never before. With a host of benefits and relatively few serious downsides, the growth of smart construction will undoubtedly continue. For those industry professionals looking to adopt some of these new technologies, it is worth keeping in mind that process automation will require new skills.

[67] *Id.*
[68] *Id.*