

White Paper: The Future of Civil Engineering: Key Trends

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THE FUTURE OF CIVIL ENGINEERING: KEY TRENDS



Challenges of population growth and inadequate or deteriorating infrastructure are best tackled with new tools and technologies.

The future of the planet with its growing population is linked closely to the continued advances in the field of civil engineering. Government agencies and private developers spanning the globe have set ambitious targets to rebuild aging infrastructure, tackle climate change, provide clean water to developing nations, improve energy efficiency and resiliency, and grow the supply of quality housing. To accomplish these ambitious goals, the world will be looking to civil engineers to design and bring to fruition the projects to fuel the sustained growth and prosperity of humanity.

Over the next decade, civil engineering is expected to experience continued strong job growth, with an expectation that nearly 25,000 new jobs will be created each year just in the United States. In addition to the sheer number of new engineers needed to handle the high workload, new and emerging technologies will play an integral role in allowing the engineering community to successfully deliver the transformative projects world leaders envision. Civil engineers across the world are gearing up for an exciting future.

Here are the biggest trends to watch out for, with key technologies and strategies to help address them.

A GROWING POPULATION WITH A SHRINKING RESOURCE POOL

During the height of the coronavirus pandemic, the world experienced the effects of the global supply chain being turned upside down. The shocks to the system came quickly – remember making special trips to multiple stores in search of toilet paper and cleaning products – but lasted longer than economists could have predicted. Prices and availability of many basic goods have yet to recover to pre-pandemic levels. Though the pandemic was clearly a painful, black swan event, it should serve as a stark warning that the world must be better prepared to ward off dramatic shocks to global commerce.

Civil engineers play a role here. They can be involved in creating a more resilient global supply chain, developing alternative energy sources—specifically renewable and nuclear power sources—working to avoid food and housing shortages and building roads, bridges, and other infrastructure in developing nations.



Colorado River
Sign at Hite
Crossing in Utah,
U.S. (Stock photo.)

Trends in population growth will shape the future of civil engineering in the United States and abroad. In the United States, population centers in the southern half of the country continue to experience rapid growth, while growth slows in northern cities. The U.S. Southwest is one region where population growth continues to sprint past the region's ability to support it. As the Colorado River continues to recede, this region will need an alternative water source. In Florida and Texas, where major cities lie in the path of hurricanes, infrastructure must be made to withstand the effects of climate change.

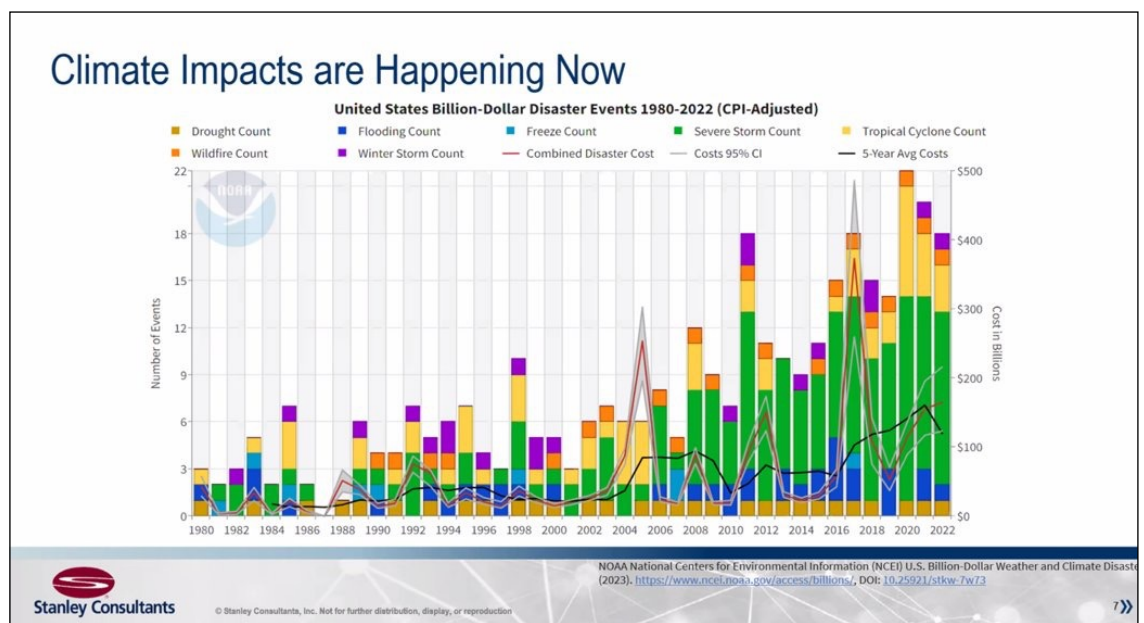
Globally, fertility rates in North America and Europe continue to decline, with the highest rates of population growth occurring in Africa, India, Southeast Asia and parts of South and Central America. India is projected to surpass

China as the world's most populous nation by the end of 2023. As population growth slows in the developed world, engineering focus should shift to rapidly modernizing the developing worlds' infrastructure. These regions still suffer from a staggering lack of clean water, energy and agriculture. Investment in large-scale projects in these parts of the world will offer two-fold rewards: supercharged economic growth and improved quality of life.

Shifts in population in developed countries and population growth in already populated areas of the world will lead to challenges with allocating resources and raw materials. Over the next 30 years, the world population is expected to grow by over two billion people, with most of that growth skewed toward cities in developing economies. Population growth will strain infrastructure and require careful and intentional development as populations become more concentrated and resource demand intensifies.

Civil engineers can lead the effort to develop infrastructure and natural resources effectively and sustainably in growing regions of the world. Managing water supply, waste disposal and housing for 50 million people in the world's megacities will be one of the biggest challenges civil engineers face. Long-term growth and prosperity depend on the ability of nations to develop their limited natural resources using modern technologies, leapfrogging the old ways of building systems with an eye on the 22nd century.

MITIGATING THE EFFECTS OF CLIMATE CHANGE



(Picture from presentation by Dennis Truax.)

Countering the impact of climate change is arguably the most critical challenge civil engineers face over the coming decades. Their role in combatting climate change is multifaceted; helping develop clean energy sources capable of replacing fossil fuels and contributing to climate-proofing existing infrastructure.

The Bipartisan Infrastructure Investment and Jobs Act (IIJA) commits \$79 billion to upgrade the power grid and \$47 billion to improving the resiliency of the nation's infrastructure through flood mitigation and drought and wildfire protection. These disasters cost the country hundreds of billions of dollars annually and impact lives and livelihoods.

While the impacts of climate change can be mitigated and reversed, it will take decades, not years, to reverse the trend—and this assumes that every measure of sustainability and green energy in the pipeline is implemented immediately. In reality, this is far from the case. Instead, the transition to clean energy and sustainable infrastructure will be gradual. Civil engineers can be a key part of transitioning to clean energy sources and working around the effects of climate change, including flooding, drought, and wildfires that are expected to continue. Engineers must also lead the development of sustainable construction methods and materials that reduce greenhouse gas emissions and allow buildings to work more efficiently.

Outside the United States and Europe, the focus should be on building new infrastructure systems with sustainability in mind. In large parts of the world, infrastructure systems are either nonexistent or outdated.

CIVIL ENGINEERS DOING MORE WITH LESS

As mentioned, job growth for civil engineers in the United States will continue to be dramatic, with an exceedingly high number of opportunities for young engineers and promising future prospects. However, this comes at a time when the building and construction industry, which includes civil engineers, faces a deficit in the workforce.

With fewer engineers entering the workforce, the building and construction industry must incorporate new and innovative technologies to compensate for staffing shortages. Technologies such as drones, artificial intelligence, virtual/augmented reality, digital twins, BIM (building information modeling), surveying solutions, and water and wastewater software help engineers work smarter, not harder.

As these technologies evolve and are adopted, civil engineering can be touted to students as an appealing alternative to Silicon Valley—which attracts a higher percentage of talented STEM majors. Civil engineering has a reputation for being risk-averse and conservative. However, this perception can begin to shift by embracing innovative technologies, as well as a readiness to take greater strategic risk, improved leadership, and a stronger public voice around policy, all of which are extremely valuable in ensuring that plans are developed on a strong foundation.

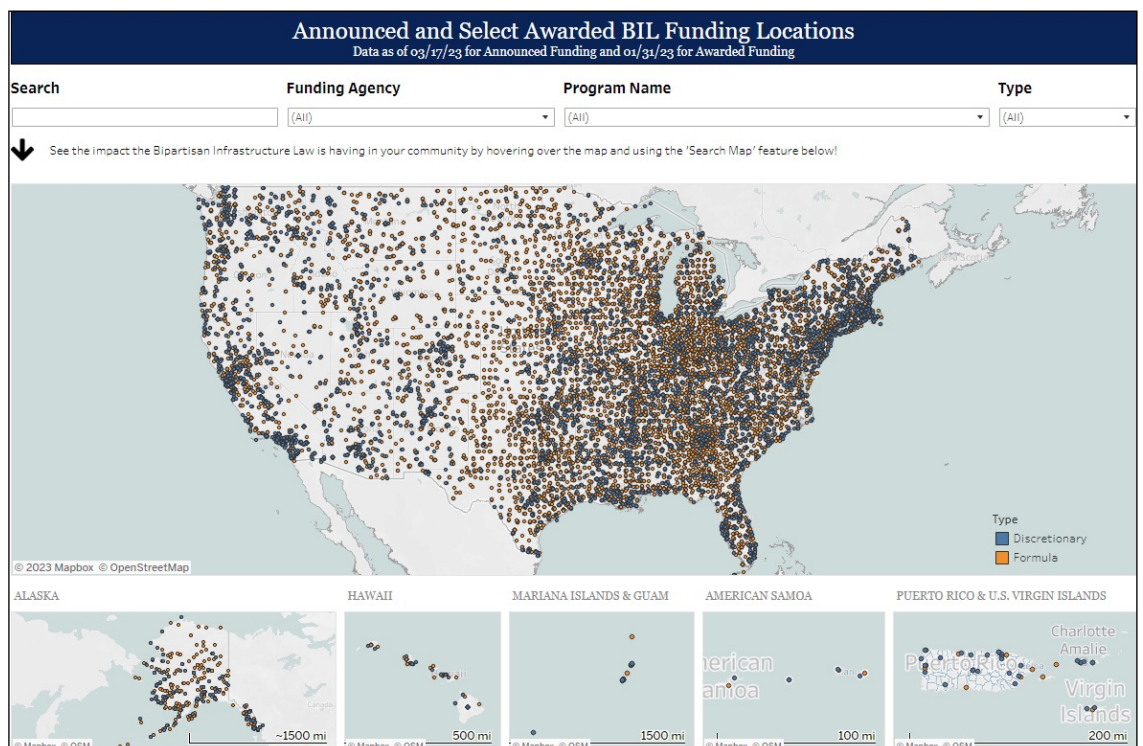
“The young people that are coming into this profession want to be impactful,” said ASCE 2022 President Dennis Truax. “People are in this profession because they want to make change. Civil engineering is all about doing great things that have positive benefits for others.”

HISTORIC INFRASTRUCTURE INVESTMENTS

The IIJA provides a monumental funding package encompassing virtually every infrastructure category at a critical time for the country. The 2021 ASCE Report Card painted a bleak picture of the state of the nation's infrastructure. Though the overall grade ticked up from a D+ to a C-, many crucial infrastructure categories, including roads, dams, transit, schools, wastewater and stormwater management, and aviation, were still graded D+ or worse.

Highlights of the IIJA include:

- \$55 billion to address the 10 million American households and 400,000 schools and childcare centers that lack access to safe drinking water.
- \$65 billion to build out the nation's broadband internet as access to high-speed internet becomes a necessity for education, workforce participation and healthcare.
- \$110 billion to rebuild bridges and highways.
- \$39 billion to modernize public transportation, especially in underserved communities, with an additional \$66 billion for passenger rail.
- \$25 billion to modernize America's substandard airports and \$17 billion for port infrastructure.
- \$65 billion for clean energy transmission and upgrades to the grid with an additional \$7.5 billion for electric vehicle charging stations.
- \$50 billion towards climate resiliency.
- \$21 billion directed at Superfund cleanup sites.



Bipartisan Infrastructure Law (BIL) Maps Dashboard.
(Picture courtesy of GSA.com.)

Since its passage, the IIJA has injected desperately needed funding, which is being swiftly used. An interactive dashboard to track the thousands of projects nationwide that have already been funded can [be used here](#). The more than \$1 trillion earmarked by the government through IIJA will be distributed over a decade, creating a long runway of growth and demand for civil engineering services and new and innovative technology and project delivery methods.

This federal-level investment in infrastructure was long awaited and will help reverse the effects of decades of underinvestment and deterioration.

TECHNOLOGY WILL LEAD THE WAY

As civil engineers have already discovered, innovative technology has a lot to offer civil engineering. Technology adoption is accelerating due to a generational shift in leadership at the highest ranks of the profession. The desire to innovate and the willingness to experiment with new technologies such as drones, digital twins, augmented and virtual reality, artificial intelligence, generative design, and automation—all of these emerging technologies are transforming the way engineering projects are executed.

VR/AR AND DIGITAL TWINS



Digital twin of building.

(Picture courtesy of Autodesk.)

Until recently, engineering drawings, plans and models existed primarily in their own space, separate from the piece of infrastructure they represented. Strides have been made with 3D modeling, BIM and BrIM (bridge information modeling), but these models still lack a connection to the physical world. That will change as virtual and augmented reality and digital twins become the norm in the civil engineering industry.

This technology allows engineers to create immersive spaces to fully interact with and experience their work before or after its construction. Unlike a CAD model, a digital twin is not a model. Instead, it is a 1:1 recreation of a bridge, power plant, highway or wind turbine that can be experienced as a holographic projection or seen with a virtual reality headset. The applications of more immersive representations of infrastructure are boundless. For example, digital twins are being used to accelerate bridge inspection and maintenance projects, with the ability to predict the behavior of the structure under different conditions. Water treatment plants and power plants can also be managed more effectively using digital twins, as other inputs into the systems and equipment upgrades can be modeled to accurately predict how the system reacts to variables.

Digital twins go hand in hand with augmented reality, another technology with game-changing potential for civil engineers, especially those in the construction industry. Superimposing plans and models onto the job site makes it possible to visualize work and monitor progress. Virtual reality works similarly and opens new avenues for communication and collaboration between all stakeholders in a project before it gets off the ground. This technology helps engineers understand their projects and clients' needs faster, as well as resolves conflicts quicker.

RISE OF THE MACHINES

Many trends emerge from the fast-paced world of tech. In 2020, events conspired to make ecommerce and remote working critical to our life and work. As things began returning to normal, we heard about blockchain and the metaverse. Now, it's AI's turn in the spotlight as ChatGPT makes waves and venture capitalists bicker over how much power to give the machines.

Artificial intelligence will be far more valuable for civil engineers than getting playful answers from a chatbot online. For example, AI is being used combined with drones to detect bridge cracks quickly. This keeps the bridge inspector out of harm's way and avoids costly lane closures. Feeding more bridge inspection data into machine learning algorithms also opens the door for smarter management of assets through predictive modeling based on trends in deterioration.

The ability of ChatGPT and its kin to respond creatively to a prompt, answer a question or draw a picture gives them a more "human" feel than algorithms that crunch numbers and forecast trends based on statistical models. In civil engineering, there is a similar application in the form of generative design.

Generative design is a new method based on a series of inputs and constraints to quickly generate alternatives, relying on data-driven decision-making. This will accelerate the design process and improve performance where time is money. Other options can also be compared based on modifying constraints within the model. For example, designers can explore how different features, such as windows and roof pitches, impact the sustainability of their building. This leads to a better-finished product, automating many routine and tedious processes that create bottlenecks, while using human engineering capital more wisely.

ENGINEERS NO LONGER WORK ALONE



Using AR on a site.

(Picture courtesy of Autodesk.)

Technological growth will require the expansion of the civil engineering family to encompass scientists and experts in other fields. Autodesk, for example, has worked closely with video game developers to improve the quality of their AR/VR offerings. Artificial intelligence and machine learning do not fall within the expertise of most civil engineers, requiring assistance from data scientists, computer programmers and statisticians. This is a healthy development for the industry, as collaboration among experts in different fields leads to innovation and new viewpoints being embraced and accepted. Civil engineering should look beyond its own ranks to continue advancing the industry.

GO TECH

In a world of growing populations, limited resources, substandard infrastructure and climate change, the civil engineering industry is up to the challenge – as it always has been, proven by its impressive legacy. But more is needed – and quickly – for the industry to realize its vision of attracting the best and brightest to the profession, fully adopting the most innovative technology, embracing sustainability, and playing a more active role in public policy for sound engineering plans.

A quick win for the industry lies in the use and adoption of existing technology, whether in the form of BIM, digital twins, cloud-based software, drones, or on-the-ground surveying methods. These technologies enable civil engineers to work smarter (not harder), increase collaboration, digitalize, upskill, reduce menial and laborious tasks, and save project time and costs. Adoption and mastery of technology provides a significant advantage to organizations in the civil engineering industry and ensures the organization's advancement and success.

For more insight into civil engineering key trends, watch the [2023 Key Trends Shaping the Future of Civil Engineering](#) webinar.

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