Structural Engineers Reach for the Cloud

Boost productivity, performance and predictability

A Bentley White Paper

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Introduction

Engineers have always embraced new technology to improve the performance, safety, and cost of the structures that they put their stamp behind. With the digital revolution, structural engineers were some of the first to utilize mainframe computing to understand complex structural behavior. The personal computing and internet evolution democratized computation and delivered a paradigm shift in how engineers collaborate and communicate. Engineering firms have made radical increases in productivity by adopting digital workflows that encompass all aspects of their technical business, including analysis, design, documentation, and even downstream activities like detailing and fabrication.

We now stand at the precipice of the next major advancement in the technology revolution – cloud services. Cloud services promise three fundamental dimensions of value to the engineering profession: virtually endless compute power, improved collaboration, and performance-improving insight through learning from your firm's collective digital experiences. It is an exciting new era that structural engineers must embrace if they want to meet the increasing demand for efficient, sustainable, and resilient infrastructure that our society expects.

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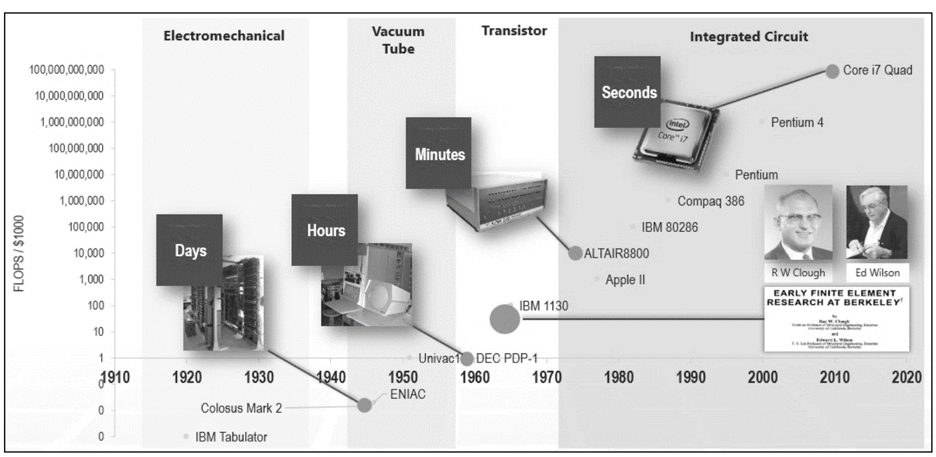
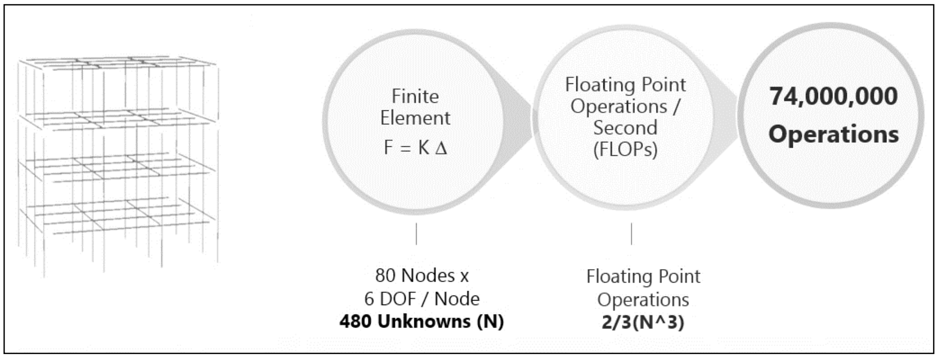


Graphic adapted from "Singularity is Near," Ray Kurzweil, Google

Plug into the Power

We have moved from an era of large mainframes—where engineers spent a day entering punch cards and another day waiting to learn if they made a mistake and have to start again—to analyzing skyscrapers on a desktop in half the time. Our structures are getting bigger and more complex while our cities grow more congested, demanding growth onto more challenging geotechnical surfaces. In addition, we must meet increasing environmental hazards and community resilience demands. The need to efficiently design under these conditions, and remain productive and profitable, demands new power not likely achieved through conventional desktop computing.

To put compute demand into perspective, look at this small frame structure and the number of floating point operations required to solve the elastic finite element analysis for a single, static load case.



Fifty years ago, processing this analysis would have taken a day with a huge computing power cost. Now, with multiple cores on a single processor, the same analysis takes seconds.

Consider a more realistic structure with walls, floors, and thousands-to-millions degrees of freedom; nonlinear material requiring continuous recalculation of stiffness matrices; and subject to dynamic seismic or hurricane events in multiple directions. To achieve productive design in these instances, engineers typically make conservative simplifications to their idealization of the structure, soil, material, and loads. Yet, they still require hours of compute time and produce gigabytes of data to be post-processed. To productively perform these kinds of simulations and explore the design space for the most efficient solution, requires a revolutionary leap in compute power. Unfortunately, the doubling of compute power every couple of years, as promised by Moore's law, cannot keep up with the physics of size. This situation has prompted *The Economist* to state that, "The main unit of analysis is no longer the processor, or the number of transistors that can be squeezed on a chip, but the number of servers in a rack or data center size itself."[1]

Cloud services, including Bentley's Scenario Services that leverages Microsoft's secure Azure platform, enable engineers to perform complex tasks (such as wind turbine analysis for many wind and wave loading conditions) in parallel, reducing what used to be a multi-day process to a few hours. For instance, innovative post-tension slab design software (RAM Concept) uses genetic algorithms to optimize the geometry of tendon layout with cloud services, saving engineers days on a typical flat slab design. Using structural analysis and design software such as STAAD, engineers can analyze their structures in the cloud as well as consider multiple design scenarios in parallel. They can also perform tradeoff analysis between the designs and their performance with all stakeholders through the web visualization interface.

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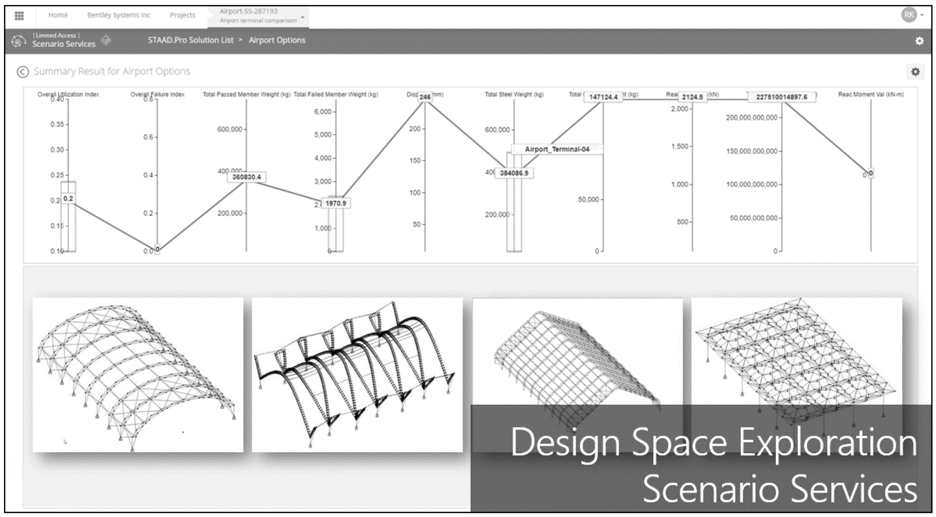


It Takes a Village

Design projects involve a multitude of different disciplines, stakeholders, and distributed organizations working together. Every decision made on a project has implications, if not to another discipline than to the project cost, schedule, and risk. If change is a constant of projects, we want to make the most informed decisions relative to project objectives, requiring systems and applications that can help us coordinate, collaborate, and manage that change efficiently. Cloud services are the ideal technology to help deliver these needs. We must synchronize work from various project members, using any number of desktop products from a multitude of software providers. To move from a world of files and documents held in disconnected digital silos to one that is secure, scalable, and reusable, we need to address the three A's in a common service:

Alignment

Data from disparate products and vendors need to be "aligned" in a single source to produce consistent structure, units, and semantics to enable interoperability and intelligent analytics.

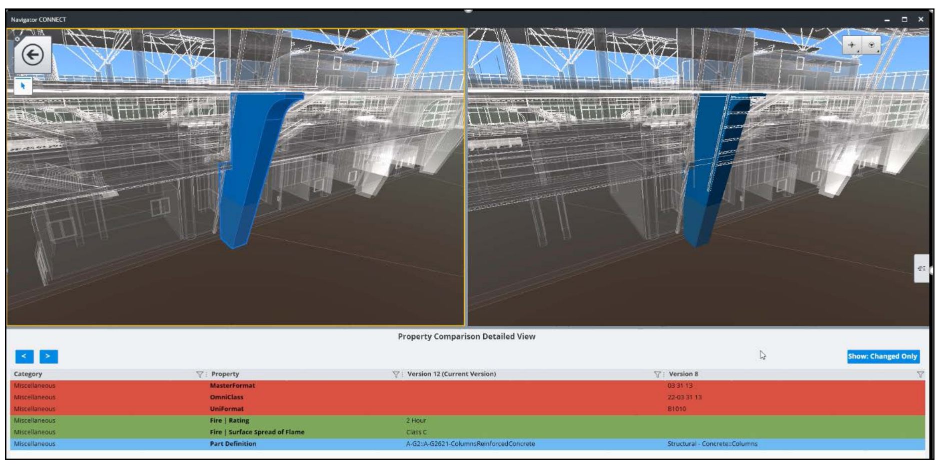
Accountability

Change is constant and needs to be a fundamental construct to ensure that we know who changed what and when. Change must be a first-order concept, not simply an added feature.

Accessibility

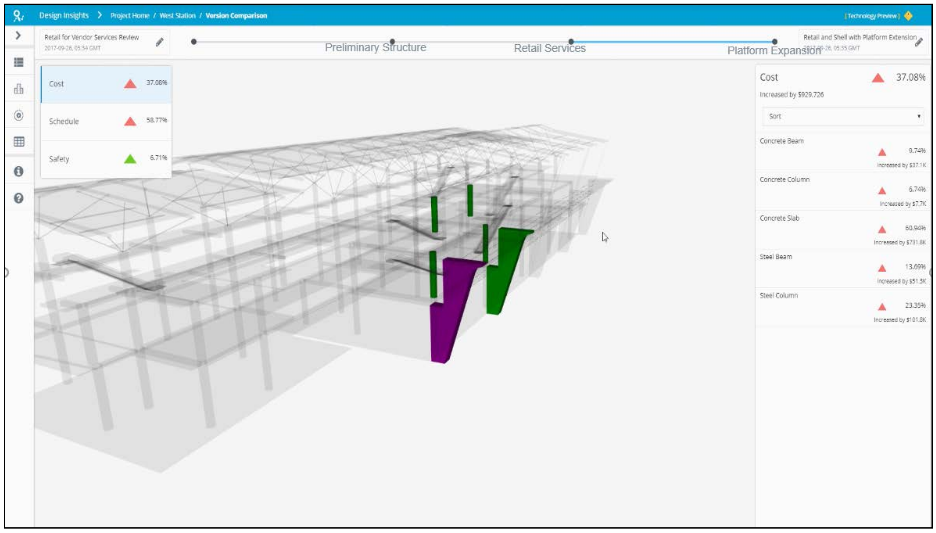
With multiple contributors and stakeholders, a collaborative service must provide a secure way for users to access, add to, and interrogate the information without impacting others working on the same project and data.

Bentley's iModelHub is a cloud technology platform that addresses the three A's. Housed in Microsoft's secure Azure cloud service, iModelHub is built from the ground up with change and scale as fundamental constructs. Authorized project members can use their existing desktop products from multiple vendors and send change sets to the iModelHub, where data is aggregated, aligned, and shared in a web interface. Stakeholders can visually understand changes made from all project contributors.



Visualize change during project progression using iModelHub and Navigator on the web.

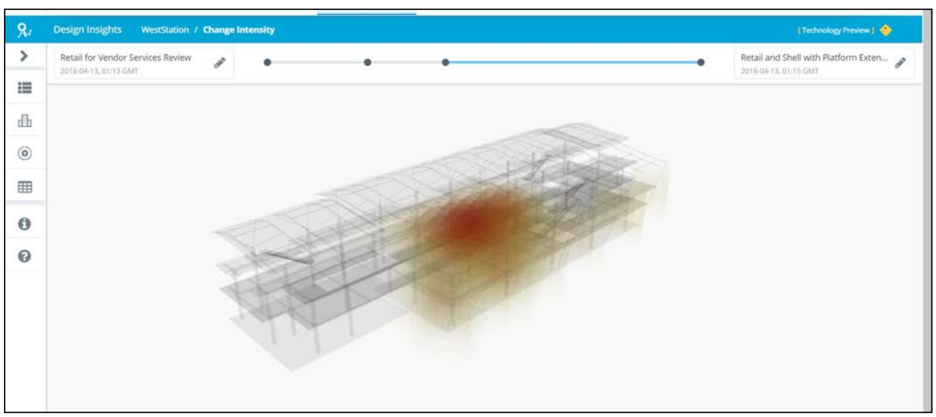
With data aligned across all source products, engineers can develop analytics to expose the impact of change. Design Insights on iModelHub shows the impact of change on key project performance indicators like relative cost, schedule, and volume. The ramifications of design changes are now understood by all stakeholders when decisions are being made, rather than afterward.



Design Insights shows the impact of change on key project performance indicators.

The world's most valuable resource is no longer oil, but data.[2]

As iModelHub brings accountability and alignment to the data, various cloud services built on top of the platform compare the current state of the project with any past snapshot in time. For example, data gathered from multiple sources can be visualized to highlight the intensity and location of changes between any two phases of the project.

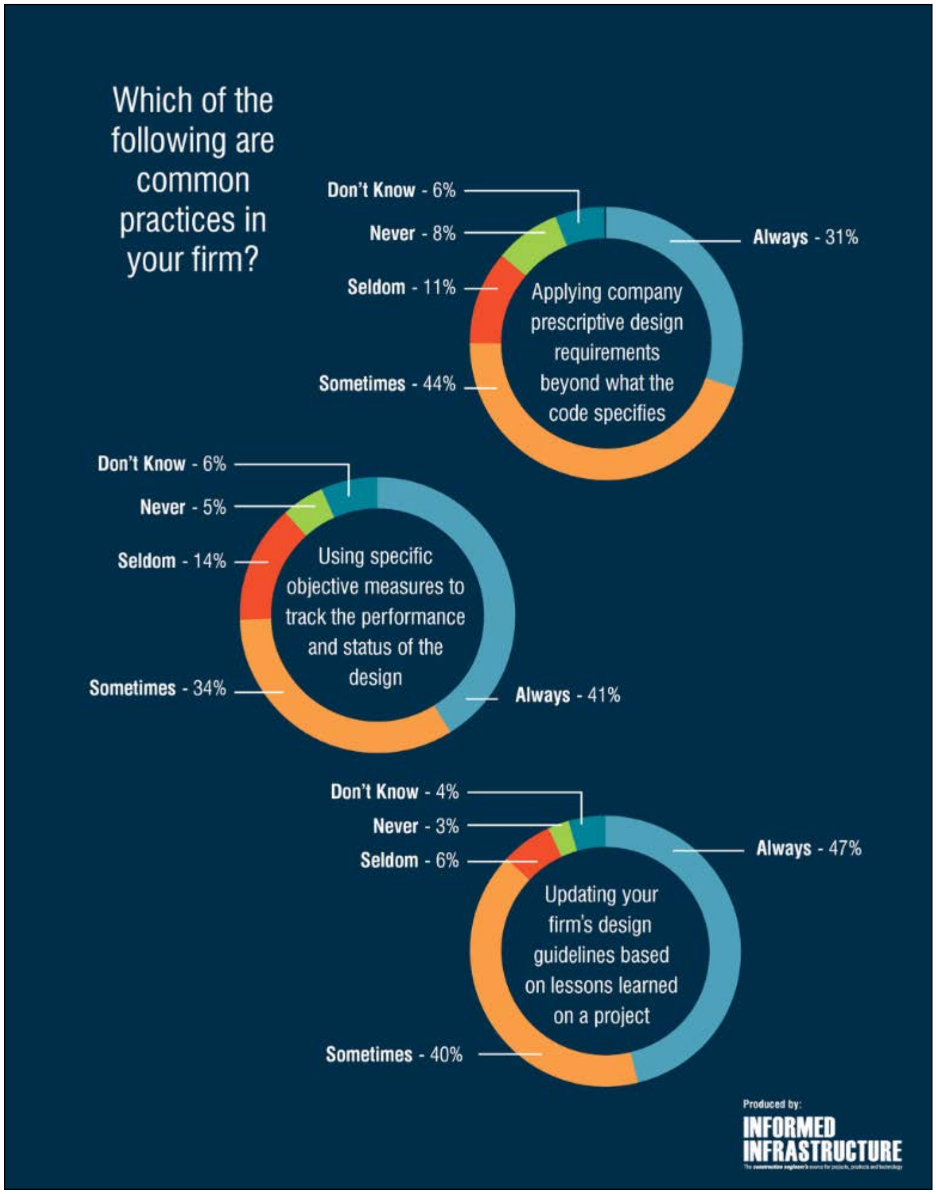


Heatmap highlights intensity of change between versions of design.

With data aligned and aggregated in one platform with open analytics, the stakeholders can make better informed decisions for better project outcomes.

Take off the Training Wheels

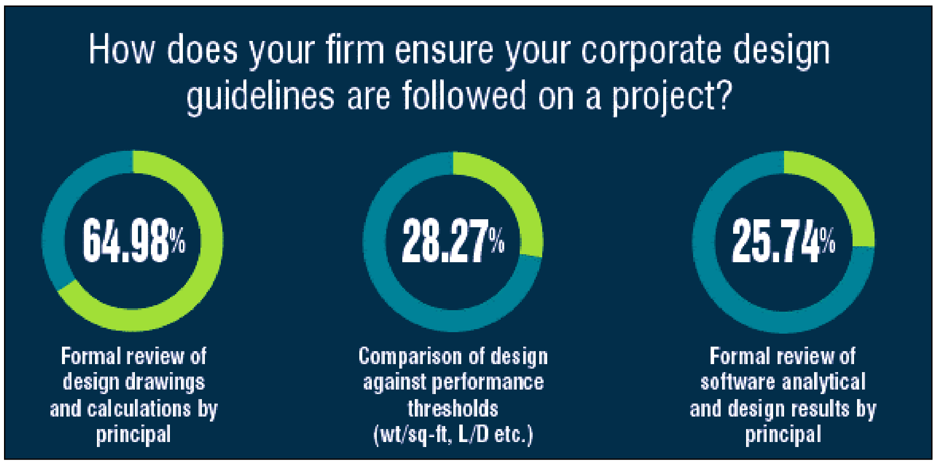
Seventy-five percent of engineering firms report applying their own performance requirements beyond what the code mandates. How does your firm ensure that lessons learned on every project in your organization are captured and institutionalized, not to be repeated?



Firms practice many kinds of risk management to avoid common issues with internal design reviews.[3]

In the next decade, the fastest growing segment of the US labor force will be those individuals nearing retirement at 60 years and older. The collective experience of a firm is captured in all the project data, the performed calculations, the completed designs, and the built structures. Gaining insight and using this knowledge to educate and inform engineering decisions is both the challenge and potential of machine learning.

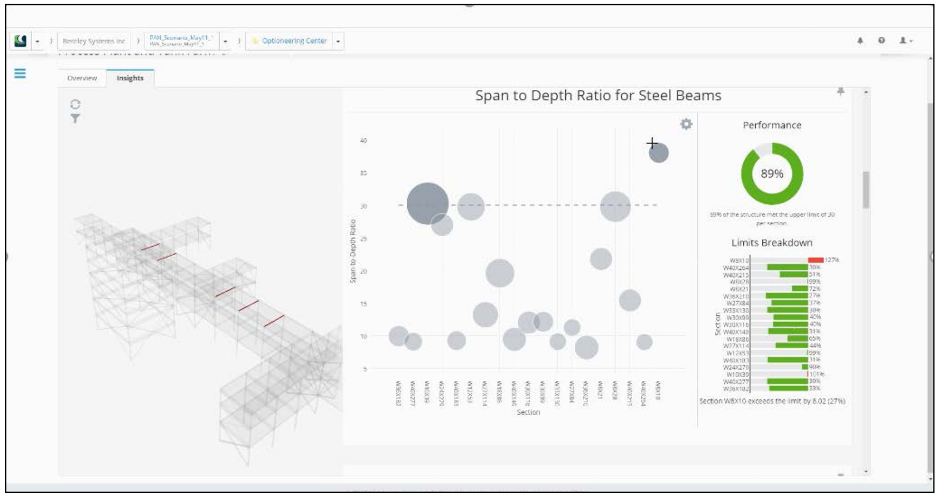
Expert systems can be deployed to try and capture a firm's collective experience. Lessons learned are captured in knowledge management systems, and best practices are developed and enforced through quality assurance and quality control manual review processes.



According to Informed Infrastructure's survey on risk management, most firms use a formal review of the design drawings and calculations to ensure compliance of corporate design guidelines.[4]

Some cloud services, such as Bentley Systems' Analytical Insights, allow firms to automate the process of institutionalizing and enforcing best practice rules. Designers can perform code compliance checks using structural design software and further enhance the design quality by checking their model against best practice guidelines of an engineering firm. The design's constructability, efficiency, and performance are evaluated relative to specified outcomes and priorities using a cloud service. Results of the evaluation help designers identify the most critical areas to improve the design performance, and allow stakeholders instant access to the progress through a cloud service. Managers can review design progress without needing to run a complex desktop finite element solution or reviewing a set of drawings.

Engineers have a choice: sticking with the status quo and potentially risk obsolescence, or adapting new applications and services...



Bentley's Analytical Insights highlights areas of potential for improved design performance.

Expert systems are only as good as the processes used to capture experience, establish standards, and enforce compliance. Each step is a potential weak link in the process. But what if a machine could learn from all the designs, drawings, and project results that your firm previously performed, identifying what characteristics resulted in the most successful projects? That day is here and so is the promise of machine learning and new deep learning software algorithms.

Services like Bentley's Analytical Insights and iModelHub provide that immediate value while allowing firms to develop a portfolio of designs, enabling machine learning in the future.

CONCLUSION

There is tremendous pressure on structural engineers to produce safer, more economic structures in less time and with a tighter budget. Engineers have a choice: sticking with the status quo and potentially risk obsolescence, or adapting new applications and services, like Bentley's RAM Concept for concrete design, SACS Wind Turbine, and STAAD.Pro and RAM Structural System for structural analysis, to better differentiate their services and outcomes. Cloud services offer one important way for firms to achieve these desired results. Cloud services can make a difference to your performance and profitability, whether by optimizing analyses and designs in less time, reducing schedule and risk with a collaborative cloud platform, or taking advantage of new software intelligence to extract important insights.

Visit www.bentley.com to learn more about:

SACS Cloud Services | RAM Cloud Services | STAAD Cloud Services

References

1. & 2. The Economist, May 6, 2017.

3. Organizational Risk Management Practices Survey, Informed Infrastructure, 2014, page 2.

4. Organizational Risk Management Practices Survey, Informed Infrastructure, 2014, page 4.