ADVANCED TECHNOLOGIES DRIVING ARCHITECTURAL DESIGN

PART 1: CONCEPTUAL DESIGN

Image courtesy of Kohn Pedersen Fox

INTRODUCTION

Concept design for architecture is changing dramatically. Hand sketches and physical models are being augmented by advanced digital workflows that put data-driven design, visualization, simulation, and virtual reality up front in the design process.

As the construction industry strives to conform to increasingly stringent regulations and hit net zero energy targets, building performance will need to be considered from the very early stages of design. It should not be left for specialists in building services to resolve at the end of the process.

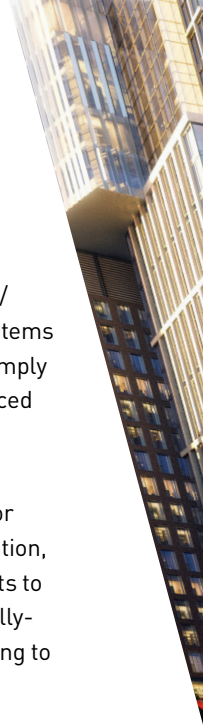
Architects are not expected to become experts in heating and ventilation or pedestrian wind comfort. But by focusing on these tasks at the formative stages, they can make better informed decisions and move the design forward with confidence. Making sure the design is in the right ballpark early on means less chance of major concept rework and fewer late-stage changes in the detailed design phase, which can be incredibly costly.

Architectural designs also need to be placed in their real-world context from the very beginning, so architects can explore how they interact with their surrounding environment. Advanced visualization using NVIDIA RTX technology to accurately simulate the way light behaves in the real world, can be used to assess the impact of early design decisions, considering shadows, daylighting, luminance and glare.

The Architecture, Engineering, Construction, and Operations (AECO) industry continues to face a huge challenge in terms of interoperability and collaboration. Design teams typically use many different software tools at the concept stage. Applications like Trimble SketchUp excel in the generation of simple massing models, while others like McNeel Rhino offer standout capabilities for freeform modeling.

The challenge for the modern architectural practice is how to get these applications to work together in harmony, so teams can collaborate effectively, often across great distances. Staged file-based import/export workflows between poorly compatible systems have been the standard way of working. This is simply not practical and often a hindrance in the fast-paced formative phase.

NVIDIA Omniverse, a new virtual platform built for real-time collaboration and photorealistic simulation, addresses these challenges by enabling architects to simultaneously collaborate in real time in a visually-rich common shared environment, while continuing to model, edit and tweak geometry in their familiar design environments.



SKETCHING

For the rapid exploration of ideas, the sketch has been the lifeblood of architectural design for thousands of years. It's perfect for the early stages of a project to convey concepts, spark conversations and inspire new ideas while the design is still fluid.

Pencil and paper have evolved into powerful digital tools that allow architects to draw naturally, using infinite variations of brushes and pens that combine precision control with creative freedom.

Layer upon layer of digital data can be captured and combined using pressure sensitive pens with Wacom tablets/interactive displays, in applications like Adobe Photoshop, Adobe Illustrator and SketchBook.

Sketching can even be a collaborative process. With the whiteboard in Microsoft Teams, for example, meeting participants can draw together on a shared digital canvas.

It also doesn't have to be restricted to two dimensions. With Mental Canvas, architects can get inside a drawing and express their ideas with spatial strokes in a 3D space for complete freedom.

Pen-based input devices come in many different forms. Tablets and interactive pen displays can be tethered to desktop workstations with powerful NVIDIA® RTX™ professional GPUs, so architects can move seamlessly between sketch and early-stage 3D concept models without changing hardware.

Sketching can also be done away from the desk, wherever inspiration might strike. Handheld tablets and convertible 2-in-1 mobile workstations with NVIDIA RTX professional GPUs can be transformed from tablet mode to a traditional laptop in seconds with the flex of a hinge.

Sketching is not limited to personal workstations. With NVIDIA RTX Virtual Workstation software (RTX vWS) architects can use Wacom tablets with just about any local device without having to worry about latency or pressure sensitivity.

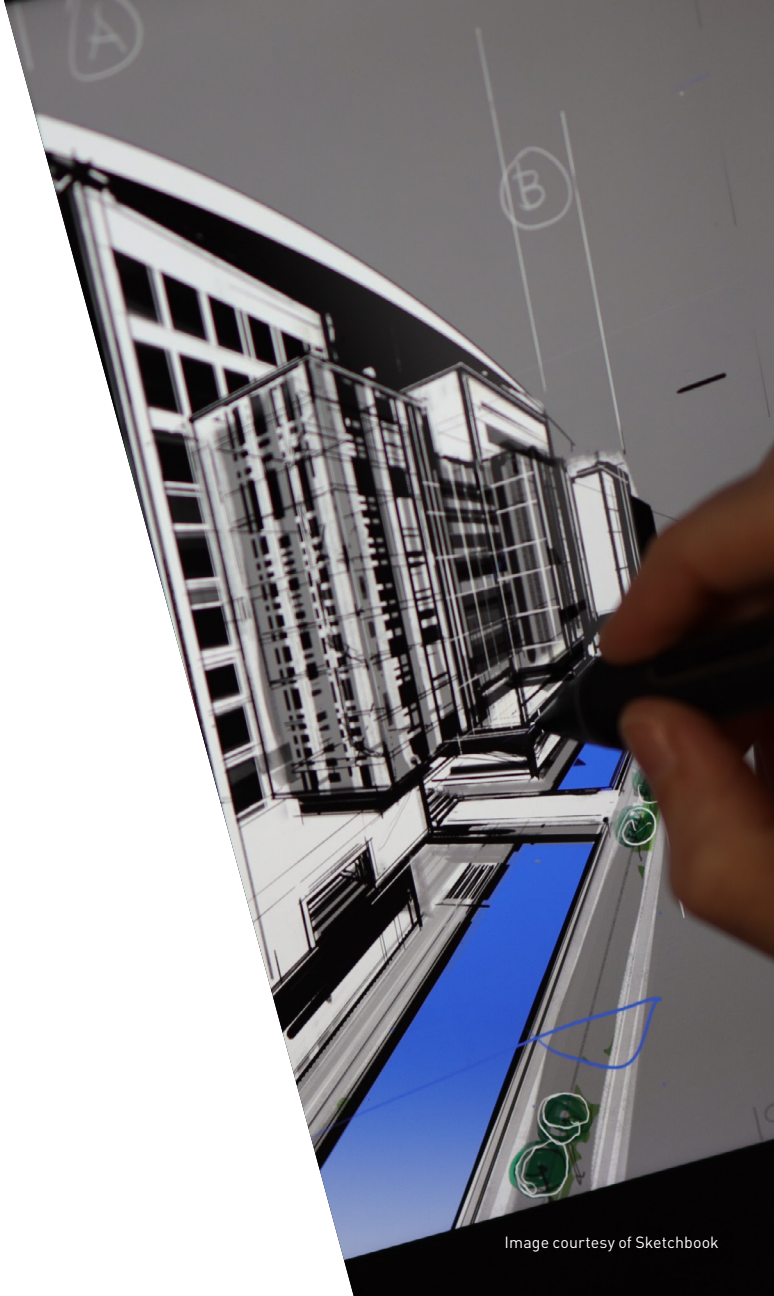


Image courtesy of Sketchbook

CONCEPT MODEL

Digital 3D concept models play a very important role in architectural design and have replaced the traditional physical model in many practices, especially with the wide adoption of BIM (Building Information Modeling). They give architects the opportunity to expand their ideas beyond initial 2D sketches, to experiment with form, volume and express specific features of a design.

The process often starts with a massing model then evolves as more details are added, such as doors, windows, structures and facades. This can be done inside dedicated concept design tools like Trimble SketchUp, McNeel Rhino, Autodesk FormIT and BricsCAD Shape or more advanced BIM authoring applications like Autodesk Revit, BricsCAD BIM and Graphisoft Archicad.

NVIDIA Omniverse Enterprise helps teams involved in conceptual design collaborate more effectively by uniting project members using various software tools on a single platform. Geographically dispersed architects, engineers, and designers working on a concept model can create and quickly iterate in real time on initial ideas for building designs. Teams can explore design options swiftly to drive innovation, with the ability to create compelling photorealistic renders faster, to meet deadlines and win new projects.

Importantly, the 3D concept model can form the foundation for many downstream workflows including visualization, simulation, virtual reality (VR) and augmented reality (AR).

Image courtesy of Kohn Pedersen Fox

REAL-TIME VISUALIZATION

Visualization plays a very important role at the concept modeling stage. As an aid to design development, it can help validate ideas, identify errors, and enable architects to communicate clearly with project teams and clients, especially those with an untrained eye.

Real-time visualization tools like Enscape, Lumion and Twinmotion, are tightly integrated with SketchUp, Revit and other modeling tools, so concepts can be visualized throughout all development phases. NVIDIA Omniverse™ Enterprise also delivers advanced visualization capabilities to these desktop applications in a truly collaborative environment.

Using visualization in tandem with 3D modeling can have a huge positive impact on workflow, especially when using dual displays powered by a desktop or mobile workstation with an NVIDIA RTX professional GPU.

Here, an architect can model on one display and instantly visualize the impact of design decisions on a second display, without having to 'Alt-Tab' between applications.

Workstations with NVIDIA RTX GPUs can help maximize performance to deliver ultra-smooth walkthroughs at very high resolutions. This isn't just about harnessing the huge processing power of the CUDA Cores in NVIDIA RTX GPUs. With NVIDIA Deep Learning Super Sampling (DLSS) the rendering calculations are also getting smarter.

In Enscape, for example, DLSS technology allows scenes to be rendered at a lower resolution, while the

Image courtesy of Enscape

dedicated Tensor Cores in the NVIDIA RTX GPU ‘upscale’ the image using AI and Machine Learning techniques. To the end user, there is no noticeable loss in image quality, but frame rates can rise dramatically, removing any sign of ‘ghosting’ as the user navigates around the virtual building.

To truly bring designs to life, NVIDIA RTX real-time ray tracing simulates how light behaves in the real world. Along with physically based materials, detailed models of trees, vegetation, people and general entourage help architects achieve the most realistic results in applications like Enscape, Omniverse Enterprise and Chaos V-Ray.

By getting photorealistic feedback in real time, architects can make better informed decisions much earlier in the process. For example, higher fidelity feedback can help architects maximize the quality of light within a building or explore which colors and surface finishes work best on an interior. Above all, visualization of this quality encourages experimentation in a digital environment.

The use of photorealism at the early phases of design is incredibly powerful, but sometimes it can be preferable to visualize a concept model in its most elemental sculptural form.

Clay, polystyrene or white rendering styles remove the distraction of materials, helping architects focus solely on form, volume and where shadows are cast at different times of the day. The ease with which geometry can be edited inside a tool like SketchUp, gives architects a means to quickly explore different options for site orientation and glazing to help maximize natural light within the building.

Here, it is important to ensure the model is correctly geolocated, so the position of the sun is correct at all times of the year. Surrounding buildings also need to be modeled accurately and associated data imported from third parties. This helps ensure that their impact is properly assessed, and that the proposed building does not interfere with their rights to light.

Bridging the gap between hand sketches and geometry, 3D models can also be rendered with artistic styles that mimic a pencil sketch or watercolor painting. This can be particularly useful at the very early stages of design, before key details are filled in.

Renderings don’t always have to directly represent an architect’s vision. Light view rendering styles, for example, where the intensity of light is displayed as a heat map, can give an idea of how much light will hit the surface in different parts of the design. Subsequently, this can be explored more accurately in dedicated lighting and solar gain analysis tools.

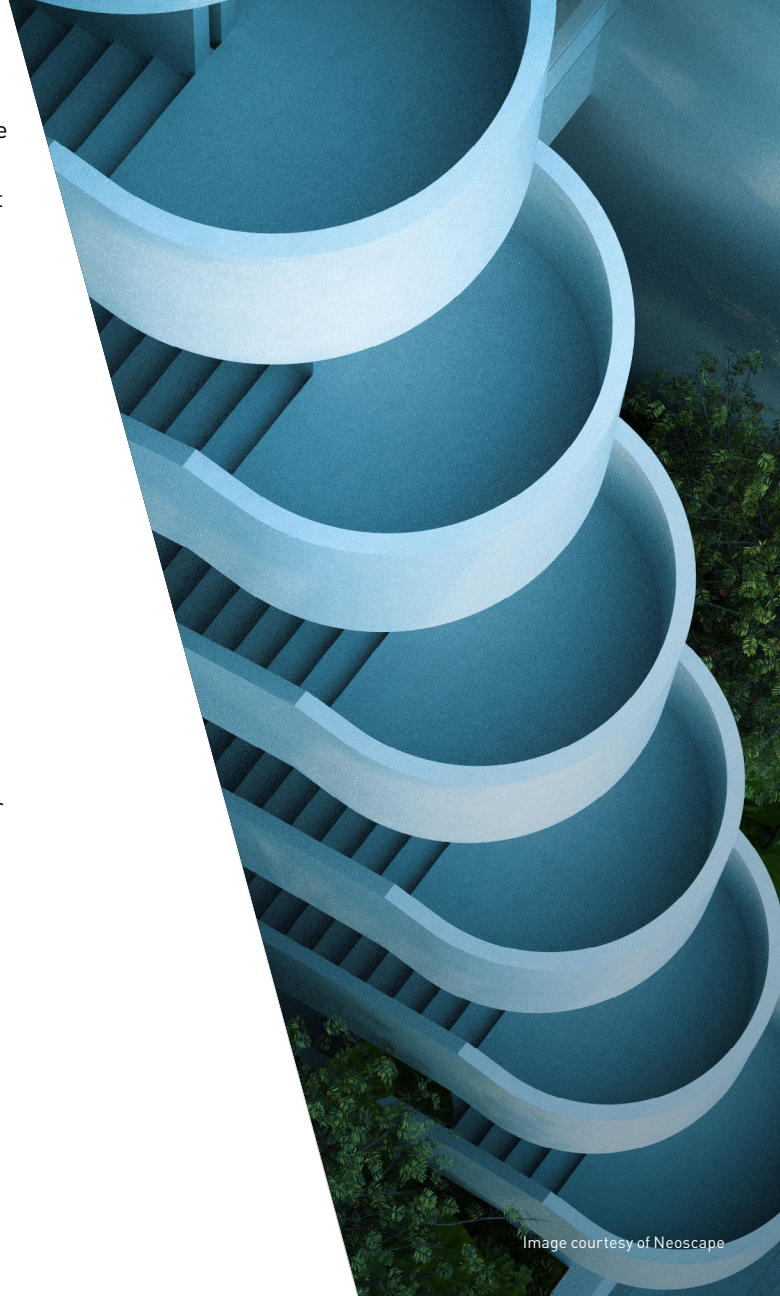


Image courtesy of Neoscape

EXTENDED REALITY (XR)

Virtual reality (VR) is often considered a technology for precisely mimicking the real world. While new generation VR headsets, accelerated by powerful NVIDIA RTX GPUs, can deliver exceptional detail with incredibly realistic environments, there is still great value in using fully immersive VR with simple models at the very early stages of design.

VR can be an incredibly effective tool for exploring design ideas. Rather than having to imagine what a space might feel like once built, it allows an architect to 'exist' inside their building and get a true sense of proportion and scale. With a tool like Enscape, an architect can move from concept model to VR at the click of a button. Any edits made to the concept model in the desktop application are instantly reflected in VR.

Model preparation doesn't have to be done on the desktop. New generation tools like Arkio allow architects to generate simple massing studies directly inside VR. Direct modeling tools, similar to those found in SketchUp, allow the creation of physical

volumes that automatically snap, glue and carve into each other. Boolean operations allow architects to easily create windows, doors and other openings.

Designing in Arkio doesn't have to be a solo experience. The software also supports collaborative design where multiple distributed users can share ideas together in real-time. The simplicity of the tool means non-technical users, including clients, can also be invited to participate.

VR isn't the only Extended Reality (XR) technology that can be used for concept design. Augmented Reality (AR) also has an important role to play. Architects or clients can open a window into a design or collaborate around a virtual building, with others who may or may not be in the same room. All different types of devices can be used, including the Apple iPad, Microsoft HoloLens, and all types of VR headsets.

Many XR devices have built-in computers, but graphics processing doesn't have to be done locally. With NVIDIA CloudXR, advanced streaming technology can deliver high-fidelity AR and VR across 5G and Wi-Fi networks. And because CloudXR harnesses the power of NVIDIA RTX GPUs models can be larger, more detailed, and more visually rich.

ADVANCED ARCHITECTURE

For more organic forms, the powerful freeform modeling tool, McNeel Rhino, can be used to explore concepts for complex architectural forms beyond mere rectilinear.

The software also excels when it comes to modeling with scripts, where computational design harnesses the power of the computer so an architect can explore new architectural vocabularies that simply would not be possible when modeling manually.

Grasshopper for Rhino, for example, can be used to parametrically define the form of a building, roof or façade. The architect can then play with different ideas, perhaps adjusting the building envelope or number of floors. Because the model has built-in parametric relationships and dependencies, the design will automatically regenerate, ensuring codified rules are obeyed.

STREAMLINED COLLABORATION

Throughout the concept design process, architects often work in teams, using a variety of different tools, each of which might excel at a specific task. Interoperability between these applications is a continual challenge, with a heavy reliance on file-based data exchange via neutral formats.

Such import/export workflows are not only time consuming but can be prone to errors, especially when it comes to ensuring all designers are working on the latest revisions. This is a particular challenge at the concept phase when the design is still incredibly fluid, and many different options are being explored.

The NVIDIA Omniverse™ Enterprise platform solves this challenge by uniting teams, assets, and software tools in a shared virtual space, so diverse workgroups can simultaneously collaborate on a single project file. It's incredibly useful at the concept design phase where architects and designers can create and quickly iterate on initial ideas for building designs.

The beauty of Omniverse Enterprise is that it allows teams to work directly in their architectural modeling application of choice. There are plug-ins for Rhino, SketchUp, Revit, Archicad, 3ds max and others. Built around Pixar's USD open-source format, data can be streamed from each application into a shared Omniverse scene that serves as one source of truth.

Once the initial CAD/BIM models have been synced, only geometry edits need to be pushed to the scene. This means all team members can view changes in real time through an interactive viewport, as they work together and exchange feedback.

Omniverse Enterprise places a big emphasis on visualization and teams can use the real-time ray-traced and path-traced renderer, Omniverse RTX Renderer to visualize the scene with photorealistic quality. Designers and engineers can import or assign physically accurate materials and add environments.

The platform has proved invaluable at specialist architectural visualization studio OutdoorLiving3D. With its designers working remotely during the pandemic it needed a solution that could keep up with their graphics needs and help them collaborate more efficiently. "Our workflows can now go from conceptual design all the way to renderings and real-time presentations, explains owner and CEO, Chris Scott." We can show clients the projects and interact with the scene: where we can drag and drop objects, move things around, or even hide things."

Omniverse Enterprise also comes with several tools designed specifically for architectural workflows. A Sun Study feature provides an accurate way to review a model with sunlight using latitude and longitude. With the ability to accurately simulate light, designers can make informed decisions on materials, light fixtures, and their placement.

Omniverse is incredibly scalable and is suitable for firms of all sizes. Workgroups in a local area network (LAN) can deploy Omniverse on any NVIDIA-Certified Workstation or professional laptop powered by an NVIDIA RTX GPU. For larger enterprises, teams also have the option to work entirely virtualized from a cloud or on-premise data center using NVIDIA RTX Virtual Workstation software (RTX vWS). NVIDIA RTX vWS is different to most other Virtual Desktop Infrastructure (VDI) technologies as it is specifically designed to handle graphics-intensive 3D workflows.

The use of virtual workstations has additional workflow benefits. First, by centralizing data, globally distributed teams can work together more effectively. Second, all types of users can be given access to powerful workstation hardware on-demand, and not just those that use CAD, BIM or viz applications daily. This could include design principals or even clients.

DATA-DRIVEN DESIGN

Architecture is a continual balance of aesthetics, performance and cost. A building not only needs to look good and function effectively, but conform to increasingly tough regulations, hit sustainability goals and, of course, deliver economic value.

By addressing some of these competing constraints early in the design process, architects can make more informed decisions about which direction a design should take. This not only leads to better buildings but can help avoid costly late changes.

A growing number of tools offer instant feedback from the very early stages of design. As an architect pushes, pulls, edits and tweaks geometry, they can directly see the impact of their actions through real time feedback on a variety of metrics. For a multi-story apartment block, for example, this could be gross floor area (GFA), number of floors, number of units, daylight potential, shadows, or even how many apartments will have a premium view.

Architects don't have to manually generate the geometry. The computer can also do the heavy lifting to help augment the design process.

With generative design, an architect can define all the key criteria and constraints, while advanced algorithms generate hundreds or thousands of design configurations, all of which can comply with building codes.

The results can then be explored through dashboards where data can be filtered and prioritized to help identify which options have the greatest potential from which to start the design. Through a process of iteration, an architect can then explore more solutions, more finely balance the constraints, and ultimately make better decisions before the design moves into the next phase.

Image courtesy of Autodesk

SIMULATION

From energy, lighting and solar, to structural, wind and pedestrian, simulation is playing an increasingly important role in the building design process.

In many cases, however, it's still the preserve of specialists and is often used only for purposes of validation. This means it's typically applied much later in the design process. However, at that stage, if any major issues are discovered, they usually require more design rework and are much more expensive to resolve.

There are huge benefits to bringing simulation up front in the design process, but design-discipline expert tools can be difficult to learn and the results hard to interpret.

To make simulation more accessible, there are a growing number of tools designed specifically for conceptual design. They are not only simple to use, but the results are presented in a way that makes them easy for non-experts to understand. In some cases, it may be as simple as 'green is good, red is bad', but giving them

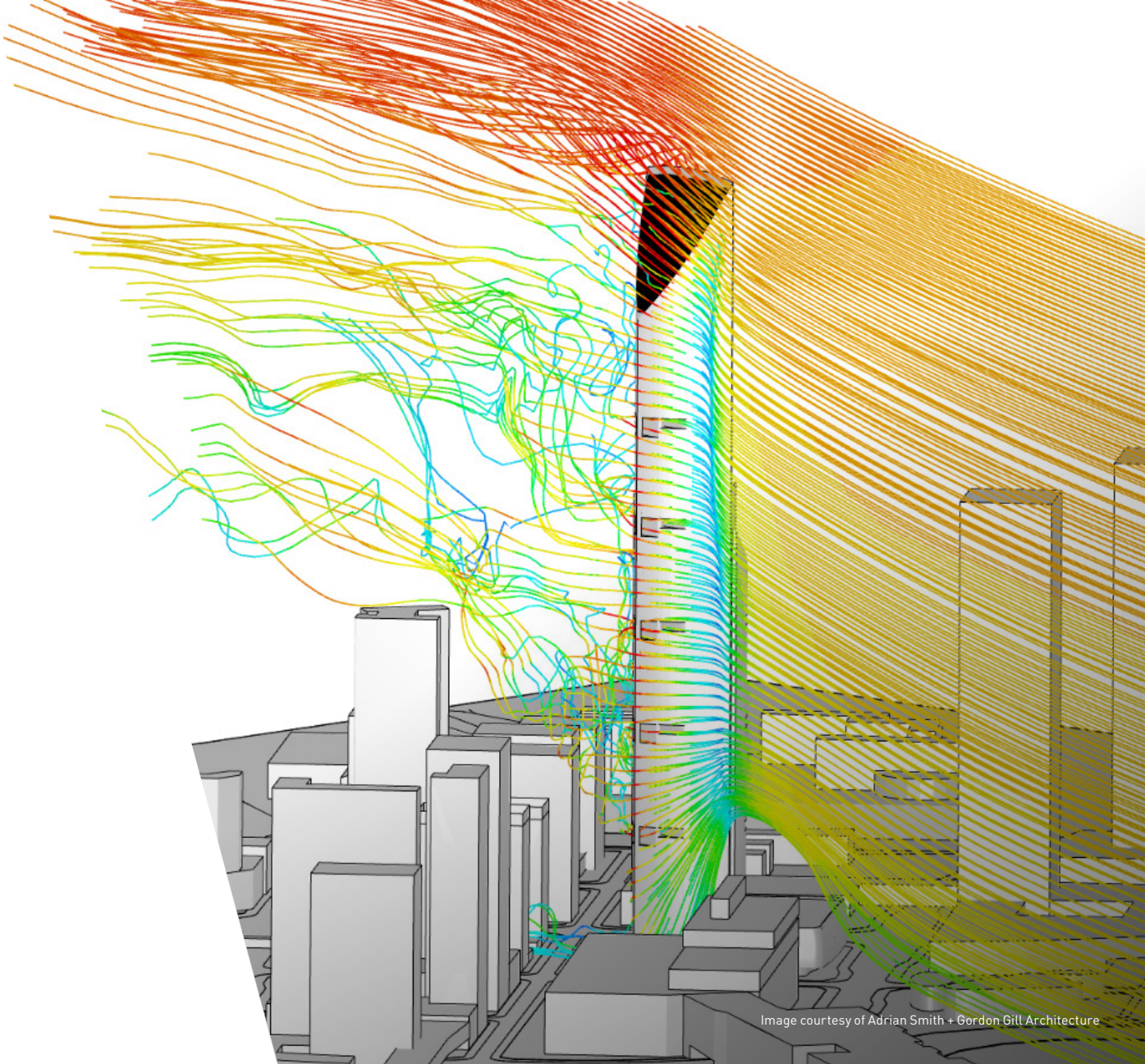


Image courtesy of Adrian Smith + Gordon Gill Architecture

access to this information early on can help non-experts make informed decisions and put projects on the right path from the very beginning.

A wide range of analyses can be carried out on early-stage concept models to help estimate building performance. Studies into daylighting, for example, can help architects optimize the orientation of buildings on site and develop strategies for glazing to deliver generous levels of natural light into a building. This can enhance the spatial quality of the building, increase the comfort and wellbeing of occupants, and have a positive sustainable impact by reducing the need for artificial light throughout the day.

To help the industry hit net zero energy goals, the need for conceptual thermal analysis tools that can optimize buildings for energy efficiency has never been more important. Tools like LadyBug for Grasshopper can be used to explore energy use, carbon emissions and thermal comfort at the conceptual stage.

Computational Fluid Dynamics (CFD) can also be used for virtual wind tunnel testing of buildings. SimScale, for example, can harness the power of NVIDIA GPUs in the cloud to conduct microclimate analyses and help inform the optimal shape, orientation, and site features for a project. The software can also be used to quickly evaluate pedestrian wind comfort in and around the building.

Visualization can also play a very important role in simulation. For example, by combining diagrammatic data from CFD simulations with massing models inside NVIDIA Omniverse Enterprise, architectural teams can immediately understand unwanted wind effects around a building and adjust the design accordingly.

Image courtesy of Kohn Pedersen Fox

TODAY'S CONCEPTUAL DESIGN WORKFLOW

Conceptual design has become far more than simply scoping out the aesthetic and functional aspects of an architectural design. For a building to truly satisfy the needs of clients, governments, and the very people that will use the facility, architects are adopting advanced digital workflows to properly address the increasingly complex requirements much earlier on in design.

NVIDIA is perfectly placed to support the progressive architectural practice throughout this process. The NVIDIA Omniverse Enterprise platform allows teams to simultaneously collaborate in real-time while using the best tools for the jobs at hand. Through a single shared 'scene', Omniverse Enterprise provides AECO teams with a visually rich, physically-accurate environment to accelerate creative workflows and enhance communication, putting all project participants on the same page.

Workstations with powerful NVIDIA RTX professional GPUs help further compress design cycles, by delivering instant results for all types of visualization, from rendering 'clay' models to advanced real time ray-tracing. This can be desktop or mobile, or virtual via the cloud or on-premise datacenter. NVIDIA RTX Virtual Workstation software also has the power to connect global teams and those working from home, putting firms in a strong position to formalize their IT strategies and support flexible working well into the future.

Learn more about how NVIDIA technologies are transforming AECO from concept to construction

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