CORE studio is Thornton Tomasetti’s firm-wide, virtual incubator of ideas. Its name denotes the union of computational modeling and research and development, which are at the core of our firm’s mission. Our team is a diverse collection of specialists. Each member brings expert knowledge and an inquiring mind to projects of every size and scope. We work with all of Thornton Tomasetti’s practices and disciplines, experience that provides us with an insightful perspective.

We aim to act as a collaborative interface between design and construction teams. We develop new workflows and processes that promote collaboration and information exchange to enhance building design. By analyzing current practices, we envision the optimized workflows of tomorrow.

All CORE studio services are offered within Thornton Tomasetti, as well as to external clients.
**Parametric modeling** expedites the exploration of iterations for geometrically complex designs. CORE studio applies advanced parametric modeling tools to realize design intent, manage drawing production and facilitate fabrication.

**Geometric rationalization** for building envelope surfaces at various scales is critical to efficient structural, environmental and fabrication/construction performance. Our team implements 3D modeling and advanced form-finding techniques to optimize complex surface geometry for design intent and constructability.

**Custom software development** begins where commercially available software leaves off. The scale and complexity of the projects we work on often demands more specific functionality than software providers can justifiably build. CORE studio has developed plug-ins and extensions for a variety of applications and tools, including Revit, Tekla, CATIA/Digital Project, AutoCAD, Rhinoceros, Grasshopper, Dynamo, SAP2000, ETABS, RAM Structural System, SolidWorks, Inventor, EnergyPlus, Radiance, Daysim and many others. We are familiar with a range of web APIs and database frameworks and are currently involved in the development of numerous cloud-based solutions.

**Interoperability** tools are developed when collaboration across design, engineering and construction teams requires the coordination of many 3D models and software packages. We specialize in managing BIM and analysis data to streamline the design, analysis and documentation processes. CORE studio offers custom software interoperability and BIM workflow solutions.

**Integrated building analysis** involves integrating our analysis model directly into a client’s design model, beginning in the early stages and continuing throughout the project. We work closely with our sustainability and structural engineering staff, along with software developers, to find ever-better ways to analyze and adjust designs and prioritize solutions.

**Fabrication modeling** allows us to clearly communicate design intent and facilitate producing deliverables to fabricate and assemble systems. CORE studio employs a variety of software tools to provide a seamless interface between design, fabrication and construction teams.

**Physical prototyping** is an important part of our work at CORE studio – the ability to bring our ideas from the digital world into reality allows us to explore another facet of the projects we work on. From scale models to full-size prototypes, we are able to use our in-house 3D printer to experiment with a wide range of ideas. These almost-instant models also allow us to present to, and interact with, our clients in new and exciting ways.

**Research and development** regularly fuel new projects at CORE studio. Whether it’s inventing a new kind of building damping and vibration mitigation system, exploring the application of performance-based design principles to wind engineering or calculating the embodied carbon in the structures we design, Thornton Tomasetti staff has been busy with several R&D projects this year. Our R&D approach nurtures innovation across the firm and cultivates collaboration with clients and other partners in the AEC industry, including government research organizations, academia, and others. We seek ideas from our people – in all locations, roles and levels of experience – and help promising projects get off the ground and flourish.

**Education** is crucial to our mission. Teaching workflows is just as important as developing new tools and processes. Therefore, we make education a priority: we have taught dozens of workshops, seminars, and classes to our colleagues and external clients since founding CORE studio in 2011.

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Roger’s Place Arena  
Edmonton, Alberta

Thornton Tomasetti practices: Structural Engineering, Façade Engineering  
Client: HOK

The swooping, curvilinear form of Rogers Place, in Alberta, Canada, provided a compelling challenge for our computational design team, which was hired by HOK to assist with the arena’s facade modeling and rationalization. The CORE studio team developed a novel facade rationalization workflow that utilized Kangaroo – a Grasshopper plug-in developed for form finding and physics simulation – to significantly speed up the development of the complex facade and roof geometries. Kangaroo allowed the values of the design and engineering team – target panel sizes, acceptable panel curvature, architectural relationships, et cetera. – to be encoded as physical forces that are brought into equilibrium during a Kangaroo form-finding simulation. Whereas traditional top-down approaches to facade rationalization demand significant amounts of time to optimize any single design iteration (minutes or hours), our bottom-up, physics-based approach produced suitable results in seconds. This rapid engineering feedback loop allowed the design team to explore a vast number of options earlier in the design process and to identify entire ranges of buildable design iterations to consider.

Hazza Bin Zayed Stadium  
Al Ain, Abu Dhabi, United Arab Emirates

Thornton Tomasetti Practices: Structural Engineering, Façade Engineering  
Client: Pattern Design Limited

Thornton Tomasetti provided structural and façade engineering services for the 25,000-seat stadium. Most of the structural and facade modeling was done in Rhino and Grasshopper. During the schematic design phase, the rain screen, then designed in GFRC, featured 480 unique panels, which would need to be created from individual molds. CORE studio helped the façade engineering team rationalize the panels, reducing the 480 unique panel shapes down to a manageable 50 individual mold shapes by grouping similar panels. We wrote a custom mold-search algorithm that helped the design team to control the quantity of molds needed to panelize the facade, while modifying driving parameters that describe the panel geometries. The tool automatically grouped, color coded and laid out the panels, and helped the team understand cost implications of the various design iterations.
Culture Shed
New York, New York
Thornton Tomasetti practices: Sustainability, Structural Engineering, Façade Engineering
Client: Diller Scofidio + Renfro, Rockwell Group

The Culture Shed will be an indoor-outdoor/assembly/performance space. It is composed of two parts: a fixed building that is a gallery space and a kinetic structure that can move outward to cover the adjacent plaza, creating a dynamic event space. The Shed’s walls will be clad in cushions of pressurized ETFE, a material we proposed based on its minimal weight and high strength. The ETFE will be coated with frit patterns that vary depending on each individual element’s orientation. These patterns control daylight while minimizing glare and direct radiation into the event space. For our analysis, we integrated the parametric capabilities of Grasshopper to generate the pattern, assign materials, and control the final analysis in Radiance, a validated, physically accurate light engine. Our skin studies provided an accurate simulation for both the technical performance and the aesthetic qualities of this landmark project.

Carbon Calculator
Thornton Tomasetti Practices: Sustainability

CORE studio has developed many tools to automate the schematic-level design of structures. Known as the “Generative Structures Suite,” these tools output material sizes, types and quantities for the derived structures. Our custom carbon calculator takes these metrics as inputs to calculate the total embodied energy and carbon of any design configuration early in the design phase. We referenced the Inventory of Carbon and Energy, or ICE, database to create an array of Grasshopper components that calculate and visualize embodied carbon in real time with the design process. We also developed plug-ins for Tekla and Revit that let us take down and track embodied carbon in our detailed BIMs. Over time, these tools are allowing us to establish baseline typical-embodied-carbon values for buildings of different types and in various climates. These data are reported to the AIA as part of Thornton Tomasetti’s commitment to the 2030 Challenge.
Commonground
Indianapolis, Indiana

Thornton Tomasetti Practices: Structural Engineering, Façade Engineering
Client: Eskenazi Health, Diller Scofidio + Renfro, The Land Collective

To promote a wellness-focused model of care, Eskenazi Hospital developed a sweeping outdoor space at the hospital’s entrance called The Commonground. Working closely with our design clients, Thornton Tomasetti achieved the architectural goal of a trellis that uses horticulture as a structural facade. The trellis promotes wellness with the impression of weightlessness – verdant, plant-covered and column-free spaces span 70 feet long and soar 32 feet high.

At 13,000 square feet, the project presented large-scale structural challenges. The trellis structure was intended to support native vines, and needed to be designed with rods and cables thin enough to facilitate climbing plant growth. By architectural design, the mast columns were intended to be the only evidence of the structural system. With thin structural elements as a primary component, lateral and vertical stability had to be addressed through the rigorous evaluation of possible forms and sizes. Although it was a relatively small project totaling $2 million, Thornton Tomasetti brought in a big team to tackle these issues, comprising structural engineers, façade engineers, and CORE studio. Our firm provided structural design and advanced computational modeling services through construction administration for the trellis canopy. We also provided full construction drawings, a complete 3D digital BIM and fabrication centerline models.

Basrah Sports City Stadium
Basrah, Iraq

Thornton Tomasetti Practices: Structural Engineering, Façade Engineering
Client: HOK

Thornton Tomasetti provided structural design and façade engineering services for Basrah Sports City, a multi-use complex. The design-build, fast-track project is the largest of its kind in Iraq. The original façade concept called for 100-foot-long GFRP panels in 10 different configurations; however, the project’s tight schedule necessitated a more efficient design. CORE studio developed a parametric CATIA model to derive and analyze different panel shapes and worked closely with project architects and panel fabricators to decrease the number of molds to five, cutting the fabrication time in half. CORE studio also designed highly adjustable brackets that connect the panels to the ladder columns and accommodate the varying panel sizes and positions. To save time and guarantee model accuracy, we developed a custom BIM translator that transferred the ladder columns and parametric connection brackets from CATIA into a Tekla model, which we provided to the fabricator for shop drawing production.
Geometrid Pavilion
Temporary Installation, Amsterdam, Netherlands

Collaborators: Mia Tsiamis of TU Delft

Collaborating with Mia Tsiamis of TU Delft, CORE studio designed, engineered, fabricated and installed a temporary pavilion for the 2015 International Association for Shell and Spatial Structures (IASS) Symposium. Entitled Geometrid, after a type of moth that originates as an inchworm, the pavilion is an eight-meter-long kinetic structure that "pulses" through a programmed sequence, radically changing in diameter through the expansion and contraction of eight scissor rings spaced along its central truss.

Symposium rules limited the pavilion to a maximum installed weight of 192 kilograms and required that it be delivered to the site in no more than six boxes of 1 meter by 0.75 meters by 0.6 meters. We met the shipping restrictions by basing the design around one-meter-long modules. The primary structural materials – aluminum pipes and waterjet-cut expanded PVC boards – provided a rigid yet lightweight structure that could support the pavilion's kinetic components while meeting the weight requirements.

The kinetic assembly consisted of stepper motors, precision steel rods, ACME threaded rods, and an array of custom 3D-printed and CNC-cut parts, which actuate each of the scissor rings. A tensile skin of coated fiberglass mesh provided lateral stability between rings while accentuating the transformation of the pavilion's overall form. The designers used Grasshopper to study geometric proportions and relationships, Digital Project for fabrication modeling, clash detection and assembly logic, and Processing, Arduino and Gcode for motion programming and control.

San Francisco Kinetic Sculpture
San Francisco, California

CORE studio designed, engineered, programmed, fabricated and installed a kinetic sculpture in the lobby of Thornton Tomasetti’s San Francisco office space. The sculpture, which is suspended from the ceiling, features 48 servos with lightweight carbon-fiber rods that cantilever outward. Movement is controlled via Arduinos and sensors that cause the sculpture to respond to people walking through the space below. The servo motors communicate wirelessly among one another to sync their movements, creating an array of possible shapes.
**Constructed Aurora**

*Temporary Installation, New York, New York*

*Client: FXFOWLE*

CORE studio provided structural design consultation and analysis for FXFOWLE’s “Constructed Aurora” sculpture at the National Academy’s Monograph exhibit. The hanging sculpture was based on a Möbius strip, and the challenge was to understand and account for non-linear force flows in the project. Cable placement and self-deflections in the pre-chosen materials drove the structure, where the effects of changing a single support location would ripple through the project to change the forces and design at all other points.

To achieve balance with as few cables as possible was the goal, and only four cables were used in the final design. Each cable met a thin compression member, which supported both edges of the strip, while other compression supports spanned the strip as needed – the longest of these additionally presented a buckling challenge. The strip edges were wooden, off-the-shelf handrail parts; care was taken to keep the splices between pieces away from the bent sections. We performed analysis of multiple conditions and options in Strand7.

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**Long-Span Roof Sculpture**

*Thornton Tomasetti Practices: Structural Engineering*

CORE studio helped a structural engineering team in our Newark office to develop a long-span, doubly curving roof truss design. The truss system, composed of over 60,000 structural steel members, demanded a parametric approach to allow for a rapid design iteration/analysis feedback loop. CORE studio members were embedded in the engineering team for the entire design and documentation process. They developed and applied novel computational solutions, and provided a comprehensive, project-specific BIM/analysis workflow.

In order to evaluate many design iterations, CORE studio developed a workflow that allowed the engineering team to parametrically create a structural analysis model from Grasshopper, while automatically generating unique IDs for all framing members. Clash detection was run after every analysis to compare the analysis model – deflected under self-weight — with the architect’s boundary surface. Finally, we developed a DWG export tool for Grasshopper, as well as “view drawing” production tools for Revit, which automatically created all necessary views to describe the structure and produce a complete drawing set in Revit.
TT Toolbox for Grasshopper

Thornton Tomasetti Practices: Structural Engineering, Façade Engineering, Sustainability

The Grasshopper community is one of a kind in our industry. We learn from the resources that are generously shared among Grasshopper users every day. Many of the processes developed within the CORE studio include the use of Grasshopper. Moreover, we constantly leverage Grasshopper’s Software Developer Kit (SDK) to extend the platform to suit our needs. CORE studio has developed entire suites of tools to support Grasshopper users within Thornton Tomasetti, and provides a subset of these tools to support the global Grasshopper community.

Tekla Tools

Thornton Tomasetti Practices: Structural Engineering, Façade Engineering, Construction Engineering

Our Construction Engineering practice relies on Tekla for steel and concrete detailing and to collaborate with fabricators. CORE studio is developing a series of Tekla plug-ins to support this work and has been working with the Construction Engineering team to identify problem domains where computational solutions could prove suitable. We are actively prototyping a revolutionary set of steel connection design tools that will enable automated connection detailing directly from forces calculated in structural analysis programs.

Revit Tools

Thornton Tomasetti Practices: Structural Engineering

Revit has become the industry standard BIM authoring platform, and CORE studio has developed a suite of Revit extensions to support the needs of our in-house modelers and engineers. Revit’s Software Developer Kit (SDK) is leveraged by CORE studio’s development team to enable interoperability, automation, custom analysis and visualization applications, among others. Tools include a parameter explorer, a suite of automated drawing production tools, as well as programs that check and improve the accuracy and quality of REVIT models.
DynamoSAP

Thornton Tomasetti Practices: Structural Engineering

DynamoSAP is a parametric interface for SAP2000, built on top of DynamoBIM. The project enables designers and engineers to generatively author and analyze structural systems in SAP using Dynamo to drive the SAP model. The projects prescribes a few common workflows, and provides a wide range of opportunities for automating typical tasks in SAP.

Energy Analysis for Dynamo

Thornton Tomasetti Practices: Structural Engineering, Sustainability

Energy Analysis For Dynamo is a parametric interface for Autodesk Green Building Studio, built on top of DynamoBIM and Revit. The project will enable parametric energy modeling and whole-building energy analysis workflows in Dynamo 0.8 and Revit.

Dynamo for Rebar

Thornton Tomasetti Practices: Structural Engineering, Construction Engineering

Dynamo for Rebar is an Open-Source project available on github and Dynamo's package manager. It enables iterative, parametric rebar design inside of Dynamo 0.8.2 and Revit 2016. The library contains a set of nodes that help create bars and containers in Revit. It also provides a set of nodes for creating the base curvature of single bars or entire rebar containers. It includes a parametric interface for Revit's 2016 Rebar API, which allows for the creation of single reinforcing bar elements and rebar container elements in Revit.
Remote Solving

Thornton Tomasetti Practices: Structural Engineering, Façade Engineering

Remote Solving is a workflow designed to create more efficient communication between multidisciplinary project teams design by digitally connecting design and engineering analysis models. The workflow and custom software plug-ins that make this process possible connect an architectural design model to remotely hosted, bespoke engineering analysis engines created by CORE studio. As the design model is updated, changes are automatically pushed to the analysis engine, quickly generating engineering feedback that is returned to the design team in near real time. As the project progresses, the analysis engines and type of feedback can quickly be adjusted to provide the right feedback at the right time. Compared to the traditional process, remote solving workflows eliminate days – or even weeks – from the time it takes to communicate information across a design team.

Platypus

Thornton Tomasetti Practices: Structural Engineering, Façade Engineering

CORE studio developed Platypus, a tool that allows Grasshopper authors to stream geometry to the web in real time. It works like a chat room for parametric geometry and allows for on-the-fly 3D model mashups in a web browser. Multiple Grasshopper authors can stream geometry into a Platypus Session – a shared 3D environment on the web – and multiple viewers can join the session to interact with the model. Platypus can be used to present parametric 3D models to a remote audience, to quickly collaborate with other Grasshopper users, or both!

Generative Structure Tools

Thornton Tomasetti Practices: Structural Engineering

Our ambition is to create a flexible framework that allows all structural engineers at Thornton Tomasetti to seamlessly design and document building structures. Since 2011, CORE studio has developed a suite of structural sizing tools for Grasshopper that we call Generative Structure Tools. These include a number of tools that let engineers and modelers calculate tributary areas of floor slabs and use them for preliminary structural calculations. For example, our beam and girder layout and beam sizing tools help engineers understand stresses acting upon beam connections by taking direct outputs from our facade loading tools in order to design a full framing system of a building structure. Coupled with our automated column-, foundation-, and slab sizing tools, we can generate full structural building information models in near real-time. These tools can then inform the Carbon Calculator or be translated through TTX to generate drawings and fabrication models.
TTX Interoperability Platform

Thornton Tomasetti Practices: Structural Engineering

The proliferation of design and analysis platforms has made the use of one-to-one translators an increasingly unmanageable way to collaborate. Industry standard file formats like IFC are a step in the right direction, but are still lacking in some important ways. To respond to these shortcomings, CORE studio has developed TTX, a platform that can “talk” directly to multiple programs, translating data across modeling, analysis and documentation applications. TTX allows project teams to focus on their specialties in the platform of their choice and then update the corresponding models in all other platforms.

In addition to model updates and translations, users can leverage project information on a higher level using TTX. Using BIM metadata stored in the TTX database, team members can review project revision history by date, time, user or analysis program; can “roll-back” all models to review an earlier version of the project; can manage the merging of disparate models into one another; and can easily run queries and reports on a wide variety of elements and parameters.

TTX is used on an increasing number of Thornton Tomasetti projects, including some of the most complex projects on our firm’s drawing boards. In addition to in-house use, we offer TTX as part of a consulting service to our clients.

TTX In Action

Thornton Tomasetti Practices: Structural Engineering

Large, complex digital models are a part of everyday life at Thornton Tomasetti, as is the increasing need for effective collaboration with design partners. CORE studio explored ways to help the engineering team working one of the largest private development projects in the U.S. to more effectively manage and integrate a range of BIM data. We developed a variety of processes and workflows that not only increased our staff’s ability to review, edit and approve critical project data sourced from a variety of models in various software (for both analysis and documentation), but also ensured that our project partners could always access and integrate the latest models and data with ease.
AEC Technology Symposium & Hackathon

Each year, Thornton Tomasetti hosts New York City’s AEC Technology Symposium and Hackathon. The event began in 2013 as a two-day conference with workshop presentations that brought together technology leaders from the architecture, engineering and construction industry.

In 2015, our third annual AEC Technology Symposium and Hackathon was a four-day event that explored topics such as data-driven city planning, machine learning for building design, the benefits of open source and state of the art development in AEC research.

Workshops

Education is crucial to our mission. Teaching workflows is just as important as developing new tools and processes. Therefore, we make education a priority: we have taught dozens of workshops, seminars, and classes to our colleagues and external clients since founding CORE studio in 2011. We offer four- to six-hour workshops tailored to the needs of our clients on the following topics:

- Interoperability
- Parametric environmental design
- Introduction to Dynamo
- Grasshopper introductory and advanced courses on data-driven design
- Grasshopper and Dynamo custom plugin development in Python or C#
- Physical computing with Arduinos
- AIA Seminar: Data-Driven Design & Engineering

We are also able to develop courses on other topics on request. Please contact us for more information on custom workshops.
Send us an email if you would like to collaborate or learn more about our services. We would love to stop by your office to present our latest work or lead a training session. We want to hear from you!

Our director, Jonatan Schumacher, can be reached at JSchumacher@ThorntonTomasetti.com.