# Embodied Carbon Action Plan

2025

BASE

# About Us

Formed in 1995 as a full-service structural engineering firm, we pride ourselves on our problem-solving acumen and in the constructability of our designs, even if they might sometimes seem unconventional from an engineering standpoint. We enjoy engineering problems of every stripe, turning creative solutions into practical designs.

At BASE, we start with an understanding that every project is unique. That's why we are so passionate about collaborating with owners and architects, design teams and builders. We believe that through communication— drawing on each other's experiences and knowledge— we can assist the team in lowering the risk of undesirable project outcomes.

BASE embraced a carbon reduction strategy long before carbon reduction was a thing. This included presentations, papers, and obtaining LEED Innovation in Design points for carbon reduction some 20 years ago. The firm continues to integrate sustainable practices and prioritizing low-carbon design solutions throughout its operations. This commitment is communicated internally to all employees, as well as externally to clients, partners, and stakeholders.



Ko'ula | Honolulu, HI | 2022
LEED Gold building in Ward Village, a LEED Platinum neighborhood

Arthur | Boise, ID | 2024



# Efficiency in Design

*"If you can't (don't) measure it, you can't improve it." - Peter Drucker*

Sustainable design is not something we focus on because it's new or trendy. Our standard since BASE was founded in 1995 has been to focus on designing efficient, cost-effective structural systems to achieve one of the core tenets of sustainable design: the efficient use of materials and resources.

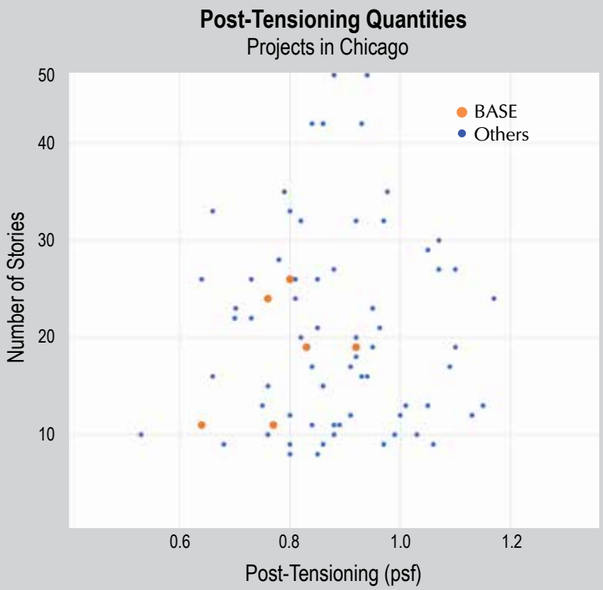
BASE routinely seeks ways to improve overall structural efficiency of buildings. A lot of times, it comes from challenging ourselves and seeing if we can do better. The key is not to approach a project with any preconceived notions, but to develop a structural system suited to the project's unique needs.

While architects and mechanical and electrical engineers have many tools to work with, structural engineers have often limited themselves to only maximizing recycled content of steel or using fly ash or slag to reduce the cement content of concrete in designing green. Sustainable design, however, is also about the efficient use of materials.
- Steven M. Baldridge

# Reduction Strategy

We adopt a design optimization approach to reduce embodied carbon and actively promote the use of less materials in our designs. We also pursue the use of low-carbon materials and establish guidelines for material selection, favoring options with lower embodied carbon content. This includes investigating materials with recycled content, sourcing locally to reduce transportation emissions, and considering renewable alternatives where applicable. We also collaborate with suppliers and manufacturers to encourage the development and availability of low-carbon material options.

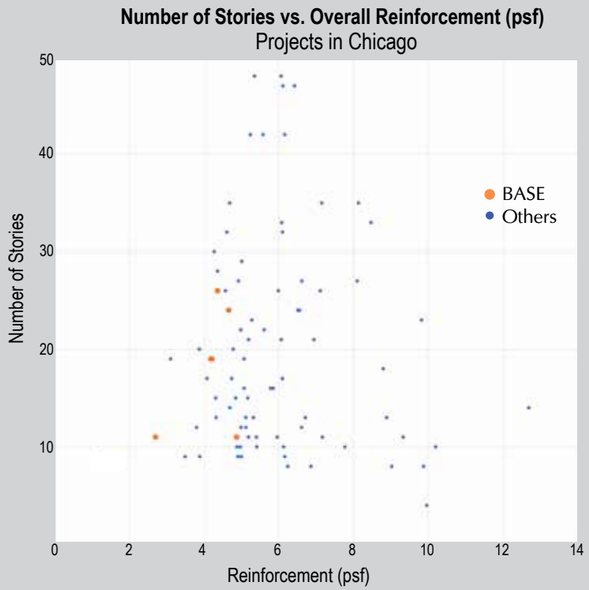
We track project metrics during the entire life cycle and are able to provide valuable pricing and material data at a relatively early stage based on preliminary analyses, in conjunction with metrics collected in-house. A comparison of quantities for post-tensioning and reinforcement on our projects in comparison with our peers is shown for reference.

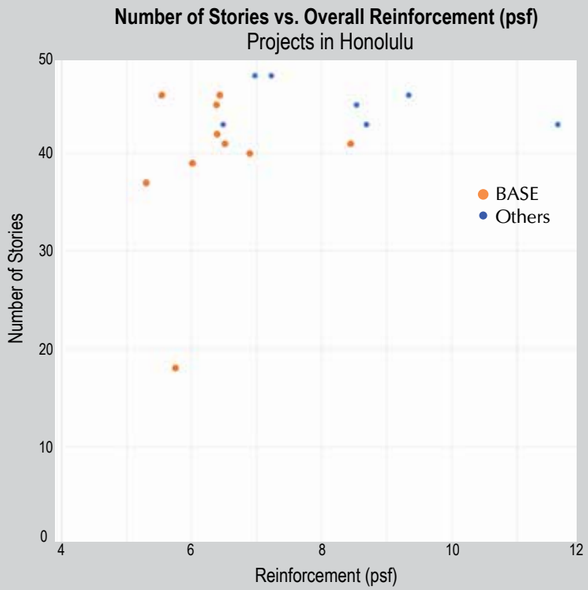


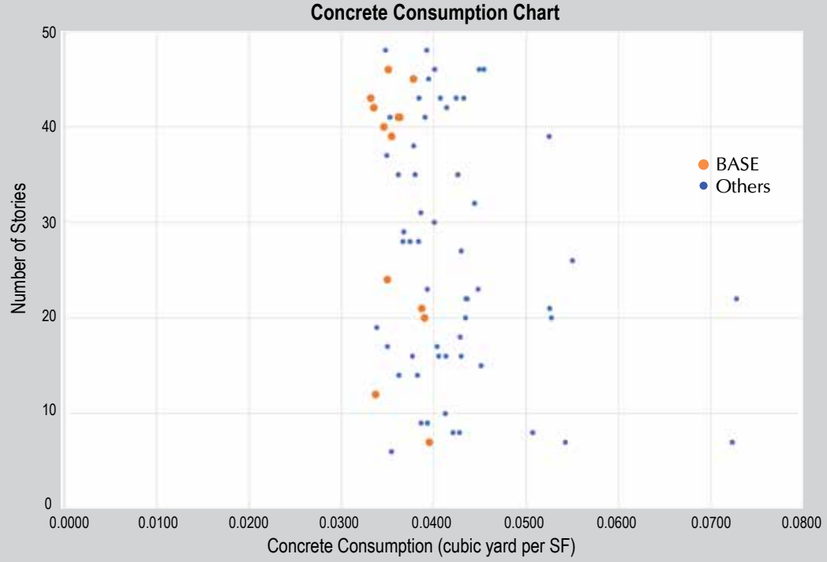


Avenir | Chicago, IL | 2020


PALMtower | Phoenix, AZ | 2025



Ae'o | Honolulu, HI | 2018
LEED Silver building in Ward Village, a LEED Platinum neighborhood



# Reporting Plan

Throughout the years, BASE has kept a library of projects along with material quantities for benchmarking purposes. The many innovative projects we design on an regular basis add to the extensive archive. Having a vast array of past projects allows new engineers, and project managers alike, to understand what has worked previously. From that knowledge, we can improve designs even more so, becoming more efficient in terms of materials, design, and overall time spent on a project. Ultimately, reducing embodied carbon content with the additional benefit of saving money for the client in a multitude of ways.

# Case Study

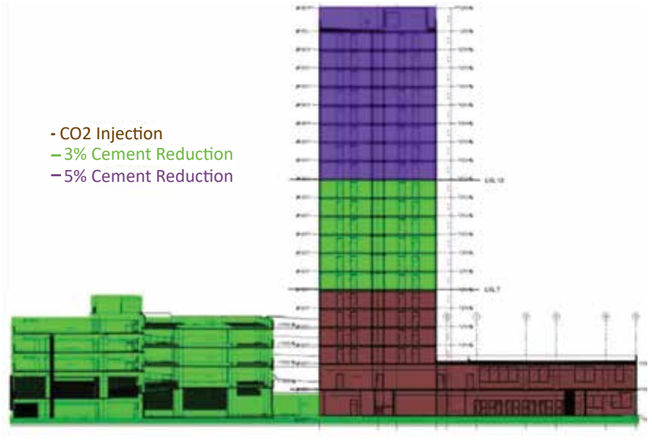
## Hale Kalele

**Location:** Honolulu, HI
**Material:** Concrete tunnel-form
**Size:** 299,758 SF
**Completion:** 2022

- Hale Kalele is a public-private partnership to transform a State-owned, underutilized urban parcel into a mixed-use development featuring a 20-story affordable rental tower, two-story Juvenile Center, and six-level parking structure. To support the project's long-term needs durability of the tower and its units was of utmost consideration, so an all-reinforced concrete system utilizing tunnel-form construction was selected.

- Sustainability was a critical component of the project's design and the team expended extra time and energy to be mindful of the project's carbon footprint. Everyone collaborated closely to develop a strategy to further reduce the embodied carbon of the project. This started with a comparison of tunnel-form construction versus post-tensioned concrete to validate that excess concrete wouldn't be added using tunnel-form.

CONCRETE MIX OPTIMIZATION PLAN




- The project was taken a step further by incorporating CarbonCure into the vertical construction which consists of trapping carbon dioxide and injecting it into the concrete mix. CarbonCure uses clean technology to create concrete with less cement, resulting in a reduced carbon footprint without comprising strength. This required commitment from all stakeholders including the concrete supplier HC&D to identify and address their concerns with the use of this relatively new technology.

- One of those concerns was achieving the required concrete strengths. When the project started construction there was minimal test data available for CarbonCure in higher strength concrete that was needed for the apartment tower. Since this would be the tallest building to date utilizing CarbonCure, the project team along with the concrete supplier implemented a stepped process in its incorporation in the concrete mixes. This included progressively increasing the amount of CO2 injection while decreasing the amount of cement in the mixes as the tower went vertical. Additional concrete testing was conducted by BASE and concrete supplier HC&D to help track the progress and allow for further reduction of cement content. By the time the typical tower floors were reached, there was enough data to justify the proposed final mix and the project was able to achieve a 5% reduction in the cement requirements.

- Other sustainability features are EV chargers, a car share program, and e-scooters onsite to help residents use less gas, walk more, and use e-vehicles. The project includes a significant PV installation, covering the entire parking structure, for renewable energy that supplies 60% of the electrical consumption of the total project.

- At the time of construction, Hale Kalele was the tallest high-rise to ever use CarbonCure and the first tunnel-form structure in their history. With CarbonCure, 68 tons of CO2 were saved, which is equivalent to 76 acres absorbing CO2 for a year. The success of Hale Kalele has now become a model for other concrete buildings, small and tall, to reduce their embodied carbon.

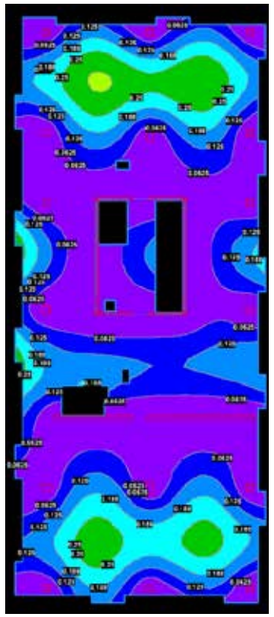
# Case Study

**Location:** Chicago, IL
**Material:** Concrete shear wall and PT flat plate
**Size:** 366,834 SF | 35 stories
**Completion:** 2017

- The project site was home to a parking garage that was demolished to make way for the new 265-unit residential tower. The building features three floors of parking, two floors of amenities, including a fitness center, pool, spa, outdoor terraces, cafe, social room, and conference rooms.

- BASE performed value engineering services on the post-tensioned slabs and vertical elements. Typical parking and residential levels were studied in detail using 3D finite element analysis to optimize the layout of the post-tensioned cables and mild steel reinforcement, while maintaining or improving slab performance. Stud rails were eliminated at a majority of columns.

- A vertical load take-down analysis was conducted, which resulted in an average 2000 psi reduction in column concrete grade throughout the building, and a net savings of around $35,000.



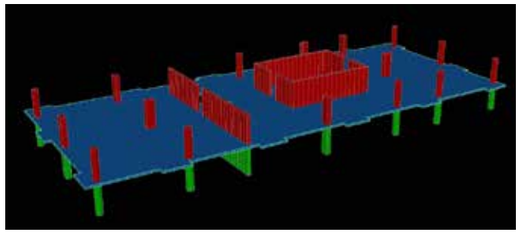
Deflection plot from finite element analysis model.

Without impacting the design concept or space usage, a total proposed savings of $535,000 was achieved.

Material Savings

| **Savings** | Rebar (Ton) | Post-Tensioning (Lbs) | Concrete* |
|---|---|---|---|
| Priced | 607.14 | 289,000 | $377,781.25 |
| Proposed | 433.42 | 243,802 | $343,471.60 |
| **Reduction** | **173.72** | **45,198** | **$34,309.65** |

* Optimization of concrete grade for columns and shear walls.



3D perspective of finite element analysis model.



# Case Study

## Frear Hall

**Location:** Honolulu, HI
**Material:** Concrete shear wall and PT flat plate
**Size:** 197,000 SF | 12 stories
**Completion:** 2008

- This 810-bed dormitory is located on the University of Hawaii campus replaces the old Frear Hall, which was built in 1952 and was closed in 1997 after the development of severe plumbing and electrical problems.

- Through value engineering, BASE achieved a 31% reduction in concrete material and 18% reduction in reinforced material for the project by using a post-tensioned structural system instead of the conventionally-reinforced system typically used on campus.

- Frear Hall was the first UH facility to receive LEED Silver certification with the U.S. Green Building Council and the project received an Innovation in Design point toward LEED certification because of this significant reduction in use of materials (see below).

1 | 0 **Innovation in Design** Credit 1.3-Version 2.2

**Construction Application** 10/31/2008

The project team seeks an innovation credit for the reduction in structural materials. A narrative provided explains that the use of a post-tensioned system over a conventionally-reinforced system was evaluated as a strategy to approach in the design of the project to reduce the amount of materials needed for the building structure. A detailed analysis, including sketches have been provided demonstrating that a comprehensive process was employed for establishing the use of a more efficient post-tensioning structural system, further indicating that a 31% reduction in concrete material and 18% reduction in reinforcing material were achieved when compared to the project's original conventional system. This documentation warrants achievement of an innovation point via a comprehensive approach that quantifies significant materials use reductions relative to a benchmark.

The most effective contribution a structural engineer can make as a part of the design team's sustainable design effort is to use Innovations in Design and use as little material as possible to provide a safe, durable structure. - Steven M. Baldridge

# Case Study

**Location:** Chicago, IL
**Material:** Concrete shear wall and PT flat plate
**Size:** 320,000 SF | 26 stories
**Completion:** 2018

- This 26-story, 320,000 SF residential tower is on a 19,568 SF parcel in the South Loop of Chicago. The mixed-use development features 320 apartments, 141 parking spaces, and about 10,000 SF of ground level retail space.

- Comparative analysis of the typical parking and residential floors resulted in significant material savings by reducing the number of full length tendons, providing only the demand driven additional tendons, improving tendon profiles and efficiencies at cantilever slabs etc. This resulted in 20% reduction of post-tensioning and a potential savings of $250,000

## Pacifica

**Location:** Honolulu, HI
**Material:** Concrete shear wall and PT flat plate
**Size:** 878,000 SF | 46 stories
**Completion:** 2011

- The structural design of Pacifica features 41 floors of residential units over five floors of parking. Quantity takeoffs on high-rise construction in Honolulu at the time demonstrated that this is likely the most efficient tower designed to current building codes. When compared to other high-rises in Honolulu at the time of construction, the savings in reinforcing steel alone range are equivalent to $1 to $2.6 million.



# Case Study

## 909 Kapiolani

**Location:** Honolulu, Hawaii
**Material:** Concrete shear wall and PT flat plate
**Size:** 254,000 SF | 36 Stories
**Completion:** 2007

- An alternate framing scheme was modeled to validate the overall design concept. BASE built a BIM model and provided material quantities to the contractor for rapid estimating. The review also included optimizing the foundation, wall and slab design to achieve a potential $2.1 million in savings. Additional benefits were achieved by eliminating dropped slabs in the tower allowing for more efficient and reduced cycle times for the forming systems.

- Additional benefits were achieved by eliminating dropped slabs in the tower allowing for more efficient and reduced cycle times for the forming systems.

**Location:** Chicago, IL
**Material:** Concrete shear wall and PT flat plate
**Size:** 746,600 SF | 45 stories
**Completion:** 2019

- This 45-story mixed-use tower in the West Loop neighborhood of Chicago consists of a 492-unit tower atop a 7-story podium.

- BASE studied the unique geometry of the oval flat-plate and provided realistic tendon grouping to achieve a practical and economical layout. Other VE options were presented such as reducing the temperature and shrinkage reinforcement in one-way post-tensioned slabs, reduced lap splice lengths, reduced wall horizontal reinforcement in the upper half of the building, using perimeter concrete crash wall as an upturned beam, etc. which resulted in potential savings of $380,000

- Material quantities were also estimated for slabs, beams, columns, and shear walls, with comparisons to the existing designs, and a detailed summary of cost savings.

# Green Infrastructure

At BASE, sustainability has become a core part of how we design and innovate. In recent years, we've designed a series of green projects that rethink how space is used, turning overlooked or underutilized areas into high-impact opportunities for clean energy. By designing smart, functional photovoltaic structures that integrate seamlessly into spaces like rooftops and over-top irrigation canals, we're helping our clients unlock new value while supporting a more sustainable future. By reimagining these spaces, we're not only generating clean energy but also maximizing the efficiency of the built environment.

# Case Study

## Airport Industrial Park PV Canopy

**Location:** Honolulu, HI
**Material:** Structural steel and cold-formed metal framing
**Size:** 57,500 SF
**Completion:** 2023

- In addition to design work on standard commercial and residential buildings, BASE also partners directly with specialty renewable energy designers and builders to provide efficient designs to large-scale installations. Designed and constructed in two phases from 2020 through 2023, the PV Canopy addition to the Airport Industrial Park in Honolulu added roughly 60,000 square feet of PV panels to double the Industrial Park's total solar capacity to 1.45 Megawatts. With this increase, the Industrial Park regularly generates significantly more power than it uses.

- The structural system for the canopy consists of efficient structural steel long-span trusses that were located and designed to apply load to the building near columns below to limit the amount of strengthening required to accommodate the new structure. The steel trusses support pods framed by cold-formed metal framing that directly support the solar panels. The entire canopy was designed for hurricane-force winds and was galvanized to withstand the humid, tropical conditions present year-round in Honolulu.

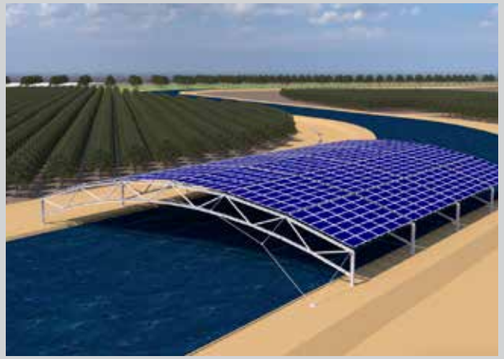
# Case Study

## Project Nexus

**Location:** Turlock, CA
**Material:** Structural steel and steel tension cables
**Size:** Originally 229,000 SF
**Completion:** 2025

- BASE served as the original structural engineer of record for Project Nexus, an innovative pilot project to erect PV panel canopies over irrigation canals in California. In addition to solar generation, the over-canal canopies provided shade to reduce evaporation of the water in the canals and also limit the sunlight available for photosynthesis of weeds and algae, improving water quality and decrease canal maintenance requirements. Unfortunately, the project faced stiff budget limitations and had to be scaled down to a significantly smaller pre-engineered canopy for its final construction.

- The original design consisted of two different canopy types, a narrow canopy over canals a maximum of roughly 22 feet wide, and a wider canopy over canals up to 100 feet in width. The original design of the narrow canopies consisted of steel moment frames over the canals with steel tension cables running along the length of the canal to carry the rail-supported PV. The tension cables were anchored at the ends of the canopies at heavier tension trusses with ground anchors resisting overturning. The original design for the wide canopy consisted of structural steel trusses again supporting tension cables running along the length of the canal to carry the rail-supported PV with guy wires to carry the cable tension down to ground anchors. Both canopies utilized helical pile foundations.



Bachelors Enlisted Quarters P-469| Naval Base Guam | 2011
Guam's first LEED Gold building.



# Education Plan

While efficient design is the key to BASE's embodied carbon reduction strategy, we have also strived to invest in employee awareness and education in reducing embodied carbon. Numerous seminars are regularly provided for employees to attend on varying topics. From emerging technologies to updates on best practices, there is no shortage of education opportunities for both newer and established engineers. BASE has also presented seminars to audiences around the world, focused on reducing embodied carbon.

## Sustainability Team

**Christian Jones**
Senior Structural Designer &
Embodied Carbon Champion,
SEAOH Sustainability Design
Committee Member

**Fernando Frontera**
SE, LEED AP
Principal

**Anantha Chittur**
PE, SE
Principal

# Knowledge Sharing

BASE actively engages with clients, architects, contractors, and other stakeholders to promote the importance of embodied carbon reduction. We advocate for sustainable design principles and collaborate with project teams to identify and implement low-carbon strategies.

Employees also participate in industry conferences, seminars, and initiatives to share knowledge and best practices.

**Presentations**

- Structural Engineering Society of Mexico, “Carbon Reduction Strategy That Provides Seismic Benefits,” February 2025
- 4th R.N. Raikar International Memorial Conference (India), “Carbon Reduction Strategy That Provides Seismic Benefits,” December 2024
- PTI Convention, “High-Rise with Height Restrictions: Feeling the Squeeze,” Seattle, WA, May 2019
- CTBUH Conference, “Tall Structural Sustainability in an Island Context: The Hawaii Experience,” Dubai, March 2008

**Articles & Papers**

- “That Green Thing: Thin Post-Tensioned Concrete Slabs,” PTI Journal, December 2019. Won the Kenneth B. Bondy Award for Most Meritorious Technical Paper in 2020 from the Post-Tensioning Institute.
- “Ko‘ula: Inspired by Nature,” STRUCTURE, April 2023
- “400 feet, 53 stories,” Structural Engineer, July 2012
- “Structural System Optimization: A Sustainable Design Strategy,” CTBUH, 2005



Pearl Harbor Visitor Center | Honolulu, HI | 2010
LEED Gold

# Lessons Learned

Over the 30 year history of BASE, there have been a multitude of lessons learned from the wide variety of projects that have been completed.

Collaboration with architects is crucial. Floor plates make up 60-80% of a buildings concrete volume compared to the vertical elements such as columns and walls. Optimized spans lead to efficient floor plates which entails less consumption of materials. Sometimes a single conversation with the architect is all it takes to end up saving material and ultimately being more environmentally conscious.

BASE is committed to working with clients to deliver the most efficient designs while also exploring new technologies and advancements in materials. There is, and always will be, an effort on BASE's part to identify these emerging developments and ways to implement them into our design. BASE has been at the forefront of the transition to the lower carbon type 1L Cement in Hawaii including meetings with suppliers and clients to discuss the change and through our Concrete Testing Laboratory monitoring the changes in concrete strength gain with the new mixes.

BASE also provides special inspections in addition to structural design work. BASE is committed to reducing its fossil use by 69% over the next 7 years, replacing our Testing and Inspection trucks with more fuel efficient Ford Maverick Hybrid Trucks.

Fulton East | Chicago, IL | 2020

**B A S E**

HONOLULU ■ CHICAGO ■ FLORIDA ■ GUAM ■ INDIA

www.baseengr.com ■ info@baseengr.com


**HONOLULU**

1164 Bishop Street, Suite 1600
Honolulu, Hawaii 96813
Tel 808.534.1300

**CHICAGO**

8623 W Bryn Mawr Avenue, Suite 509
Chicago, Illinois 60631
Tel 312.739.3701