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Tall, Gray, and Green: Reinforced Concrete Construction in the Pacific Northwest

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Biography

Martin Maingot, P.E. has been a Project Manager with Cary Kopczynski & Company (CKC) since 2005 and was recently promoted to Associate. CKC is a Bellevue, WA based structural engineering firm specializing in the design of building structures that include hi-rise towers, mixed use projects, hotels, offices, and parking structures. His experience includes residential and mixed-use towers, integrated and stand alone parking structures, office buildings, and hospitals. Current projects include Rollin Street, a mid-rise, 400,000 square foot residential loft project, Avalon Towers Bellevue, twin tower high-rise 704,000 square foot luxury apartment complex, and 1915 2nd Avenue, a 318,000 square foot luxury condominium tower. Mr. Maingot received his Bachelor and Master of Science degrees from Texas A&M University, and has since been involved in the conceptual layout, design, and construction phases of many building structures throughout the United States. He is also a registered Professional Engineer in Washington State, Missouri, and Texas.

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Abstract

The Pacific Northwest region of the United States stands alone in sustainable design – Washington State and Oregon enjoy the largest number of LEED® (Leadership in Energy and Environmental Design) certified buildings per capita by a margin of 2.5 to 1 over almost any other "green" state.

As the center for sustainable design, Pacific Northwest property owners and developers expect their design teams to incorporate sustainable practices into their projects. High seismic considerations add to the challenge of meeting this expectation; large demands on material needs, amplified by recent cost increases in transportation, labor, and materials, require creative thinking to eliminate inefficiencies and help keep projects within budget.

This paper presents four case studies of how structural engineers at Cary Kopczynski & Company (CKC) have contributed to green building design in the Pacific Northwest. Savings in materials, cost, and labor on award winning CKC projects will be highlighted. These savings are attributable, but not limited to, the use of post-tensioned flat plate floor slabs, high strength concrete, and high strength reinforcing steel among many others. Reductions in environmental impact during and after construction are discussed. In addition, owner and architect thoughts and opinions are addressed.

Keywords: Green building, Pacific Northwest, Structural Engineering, Cost Savings, Material Reductions.

Introduction

Building construction and operation have a profound effect on people's lives and the health of the environment. They are a major source of pollutants that cause urban air and water quality problems, and also contribute to global climate change (USGBC, 2003). According to a 2004 estimate by the United States Department of Energy (USDOE), carbon dioxide (CO_2) emissions represent 38% of the total building CO_2 emissions nationwide*. This figure is expected to increase by an average of 1.2% per year as more buildings are constructed and domestic population increases (USDOE, 2006). On a larger scale, CO_2 emissions for US buildings represent approximately 9.8% of the world total, greater than that of Japan, France, and the United Kingdom combined (USDOE, 2006). With respect to water quality, construction activities account for more water pollution incidents that any other industry, with sources varying from diesel, oil, paint, and solvents to construction debris and dirt (SustainableBuild, 2007). Cleared land causes soil erosion which leads to silt-bearing run-off and sediment pollution. Once absorbed by natural waterways, these substances poison water life and any animals that drink from them, including humans. Regarding energy consumption, 2004 USDOE estimates show that residential and commercial buildings consume 39% of the total energy needs of the country, with 71% of that energy in the form of electricity (USDOE, 2006). Lastly, typical building construction projects in North America produce up to 2.5 pounds of solid waste per square foot of floor space (USGBC, 2006).

These facts make it clear that there is a pressing need for environmentally sensitive buildings. Green buildings offer substantial reductions in materials, water, and energy consumption in addition to significantly limiting the development of the land they occupy. Green buildings also provide advantages that go far beyond the environment: reductions in operating costs, enhanced marketability, as well as increases in occupant comfort and productivity to help create a healthier, more sustainable community.

In short, the essence of green building is to design, construct, and operate buildings to maximize their environmental and economic performance, both inside and out. While a significant part of this is achieved through efficient operation and maintenance, it is creative

∗ Excludes emissions of buildings-related energy consumption in the industrial sector. Emissions assume complete combustion from energy consumption and exclude energy production activities such as gas flaring, coal mining, and cement production.

layout and design that ultimately take full advantage of building green.

Many tangible examples of the green building advantage abound; for example, the Denver Dry Goods building was able to reduce their operating costs by $75,000 per year by implementing energy efficiency measures. Waste management costs were reduced by 56% and 48 tons of waste was recycled during the construction of a supermarket in Spokane, WA (USGBC, 2003). Hence, green building has economic, environmental, and social aspects that benefit all those involved, and to a greater extent, those who are not.

The following four case studies will present how CKC structural engineers have contributed to green building design in the Pacific Northwest. The projects will show how one or a combination of selected methods produced substantial savings for the owner and/or contractor in addition to contributing to the greening of their building.

Case Study 1: Metropolitan Tower, Seattle, WA

Metropolitan Tower is an award winning 560,000ft^2 (52,025m^2) facility located in downtown Seattle that includes a 300,000ft^2 (27,870m^2) 24 level residential tower over a 386-stall 7 story parking structure with 23,500ft^2 (2180m^2) of ground level retail space. The building features an outdoor recreation area, indoor swimming pool, spa, exercise room, party room, library, and private theater. Long cantilevered decks surrounding the perimeter provide an unhindered view of the Seattle skyline. The Washington Aggregates and Concrete Association awarded the project first place in its annual competition for excellence in design, engineering, and construction in May 2002.

Figure 1: Metropolitan Tower, Seattle, WA (source: courtesy of CKC)

The floor system consists of 7.5in (190mm) thick post-tensioned flat plates with an average span of 28ft (8.5m). Lateral resistance is provided by a combination of 24in (610mm) thick shear walls located around the elevator/stair cores and a series of special seismic resisting frames along the ends of the building and parallel to the corridor. Typical columns are 24in (610mm) square with typical floor to floor heights of 9ft 1in (2.75m). Relatively shallow frame beams of 22in (560mm) depth were used to maximize clear height and remain as unobtrusive as possible.

Foundation Efficiency and Reinforcing Reduction

The building is supported on a floating foundation mat of varying thickness tied to perimeter basement walls. In collaboration with the soils engineer, a soil/structure interaction analysis was performed that helped minimize settlements and significantly lower construction costs by eliminating the need for a deep foundation system (i.e. driven piles). An additional 20% reduction in reinforcing steel was realized for the foundation mat by specifying 75ksi (520Mpa) steel in lieu of standard 60ksi (420Mpa) steel. The top of the mat also serves as the wearing surface for the lowest parking level, thereby eliminating the need for an added topping slab.

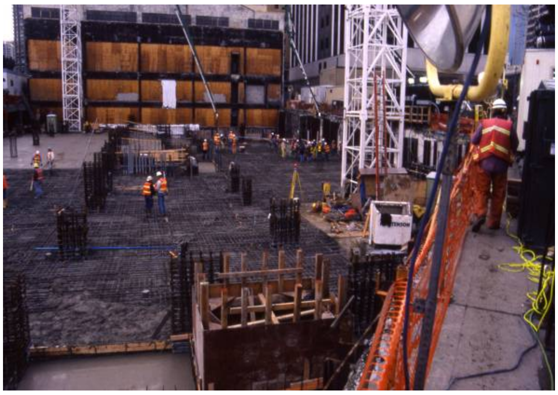

Figure 2: Metropolitan Tower foundation pour, Seattle, WA (source: courtesy of CKC)

Reductions in Reinforcing Tonnage

Maintaining constant column and wall dimensions throughout the height of the building helped increase constructability and reduce the overall construction schedule which far outweighed the added concrete in terms of labor and time. An additional 10% reduction in total steel reinforcing was achieved by using actual yield strength versus specified yield strength in the design calculations; this allowed to take advantage of the overshoot that is common to steel production without experiencing any increase in material cost. However, close coordination with the rebar supplier was required for greater quality control over the rebar delivered to the project site. High strength concrete was used to minimize column and shear wall dimensions, with 10,000psi (70MPa) specified at 90 days to further reduce cost and allow for more curing time. At the suspended slabs and footings, fly ash was added to assist in long-term strength gain and replaced approximately 20% of the total cement content.

Concrete vs. Steel Advantage

Cast-in-place concrete was the only logical choice for the structural frame. Reduced floor to floor heights offered a significant advantage over a structural steel option where large savings in vertical building components, such as HVAC, electrical, plumbing, stair and elevator runs, and exterior cladding systems were realized, with lower building volume adding to reductions in energy demands. In addition, the underside of the flat slabs was used as the finished product which precluded the need for an architectural ceiling. Furthermore, the inherent fire resistance offered by concrete provided the required fire rating without the need for additional fireproofing. An added bonus was the sound dampening quality of concrete and reduced floor vibrations that enhance overall occupant comfort.

Figure 3: Metropolitan Tower structural frame construction, Seattle, WA (source: courtesy of CKC)

Architect and Engineer Collaboration

The unique shape of the building, coupled with the need for unobstructed views from balconies and window bays, required that the architect and structural engineer work together to determine how to achieve the desired exterior expression without compromising structural integrity. Mike Scott, principal with Seattle based Callison Architecture and project architect, explains "any engineer will tell you the consequence of shape on structure is logarithmic when it comes to designing towers. That is why the relationship between an engineer and architect needs to be highly collaborative" (PCA Supplement, 2001).

Case Study 2: Escala, Seattle, WA

Escala is an 830,000ft^2 (77,110m^2) glass tower that is expected to be the largest residential building in Seattle upon its completion in 2009. While not the tallest condominium tower in town, the imposing 20,000ft^2 (1,858m^2) residential floors will break all previous records for total area. With 31 stories above grade and 8 subgrade parking levels, it already holds the record for the city's deepest excavation in recent time with a bottom elevation of approximately 90ft (27.5m) below street level.

Figure 4: Escala, Seattle, WA (source: courtesy of MG2)

Residential unit sizes will vary between 950ft^2 (88m^2) to more than 3,000ft^2 (279m^2), and will top out at 16,000ft^2 (1,486m^2) at the penthouse level. Balconies range up to 1,000ft^2 (93m^2) and will provide an exciting extension of the living space, connecting residents with the outdoors. Street level retail, landscaped areas at two elevated levels, semi-private elevator vestibules, and a 25,000ft^2 (2,322m^2) private city club await future residents. The city club will showcase a fitness area with pool, theater, wine cave with storage, conference center, bar and lounge fronting a large south facing terrace with a dramatic water feature (Thoryk, 2006). The structure consists of a cast in place concrete frame with 8.5in (216mm) thick post-tensioned flat plate floor slabs. Lateral loads are resisted by 30in (762mm) thick shear core walls and ductile moment frames.

Typical moment frame beams measure 30in (762mm) wide by 24in (610mm) deep with 30in (762mm) wide by 40in (1,016mm) deep typical columns. Deflections at cantilevered balconies are controlled using 24in (610mm) wide by 24in (610mm) deep by 4ft (1,219mm) long concrete outriggers supported off the columns for spans reaching out as much as 15ft (4,572mm).

Figure 5: Escala foundation mat, Seattle, WA (source: courtesy of JE Dunn)

Forming System Efficiency

Cost saving options were considered during conceptual design. CKC was hired directly by the land developer, Lexas Companies LLC, to discuss several forming system options to reduce materials and labor, but more importantly, shorten the construction schedule. CKC worked with the developer and contractor prior to getting an architect on board to ensure that the chosen system could work. A column-hung forming system was finally selected as it was viewed as the best option to speed up construction. In order to take full advantage of the forming systems efficiency, column faces were aligned so that the forming tables could slide in on either side (Bacon, 2007). With this system, slight column offsets are allowed up to 1ft (305mm), which allow a little more flexibility in column layout. Collaboration between the engineer and the contractor is clear evidence that time saving construction methods may not be possible if the engineer does have a clear understanding of the contractor's schedule and construction preferences and/or techniques. It was estimated that the system saved the project two days per floor (Bacon, 2007).

High Strength Reinforcing Steel

Constructability was further improved by the recent project specific approval by the City of Seattle to allow the use of high strength reinforcing steel for seismic confinement of high strength concrete. The high strength 100ksi (690Mpa) steel offers a 40% reduction in column and shear wall confinement reinforcement as compared to 60ksi (420Mpa) steel, which is the highest grade of reinforcing allowed by the current building code.

Long a major frustration for both contractors and ironworkers, reinforcement congestion decreases quality and slows construction, with confinement reinforcement as one of the most time consuming pieces to install. The change will take at least another two years to be written into the next building code cycle, but CKC saw the opportunity to take advantage of a pending code-change proposal written by the American Concrete Institute's (ACI) seismic subcommittee approving its use.

Figure 6: Column-hung forming system (source: courtesy of CKC)

The approval process was not without its challenges; the city rejected CKC's requests for a code alternate several times. Extensive documentation from leading experts, American Society for Testing and Materials (ASTM) approvals, conversations with building code officials, meetings with Seattle Department of Planning and Development personnel, and a personal letter from CKC president, Cary Kopczynski, certifying the suitability of the material for its intended use, were required.

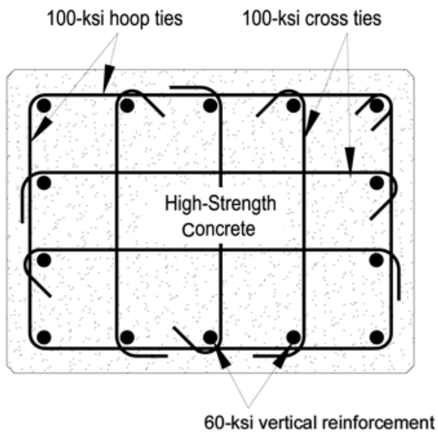

Figure 7: Seismic Column with 100ksi Confinement Reinforcement (source: courtesy of CKC)

Approval was finally granted in July 2007, and marks the very first use of 100ksi (690MPa) confinement steel in North America. The use of 100ksi (690MPa) confinement steel not only reduces rebar tonnage, but improves construction speed, reduces labor, and in many cases reduces vertical reinforcing further simplifying installation without compromising seismic performance. It was estimated that the use of 100ksi (690MPa) saved the project 230 tons (208,650 kg) in seismic confinement steel alone.

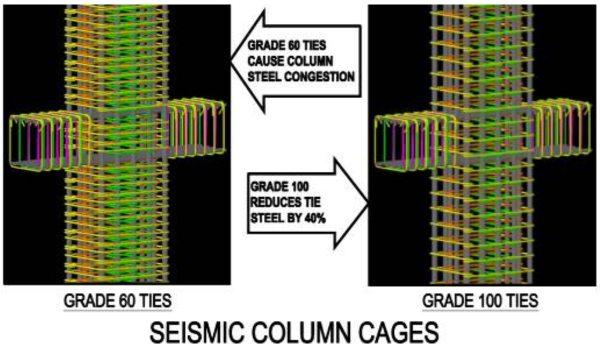

Figure 8: Seismic column cage comparison (source: courtesy of CKC)

Additionally, the code required quantity of confinement steel, or seismic ties, is directly proportional to concrete strength; Cary Kopczynski comments "the quantity of seismic ties increases linearly with concrete strength, which on Escala is 14,000psi (97MPa). This requires more cross-ties, called J-bars. Each J-bar has to hook around vertical bars. That often results in additional vertical bars, for no other reason that to satisfy the requirement" (Post, 2007). With 100ksi (690MPa) seismic ties, the column vertical bar tonnage was reduced by between 6 and 7%. John Plaggmeier, Escala's superintendent for the local general contractor, JE Dunn-NW, states that the 100ksi (690MPa) rebar "improves the fit of horizontal and vertical structural elements, requires fewer hours of labor, and puts less demand on hoisting equipment because of reduced weight" (Post, 2007).

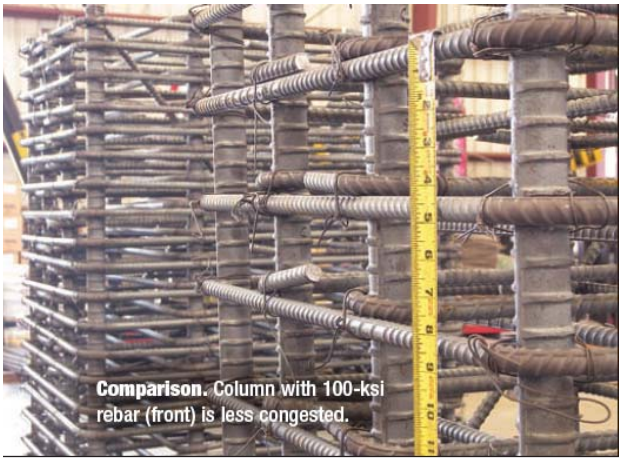

Figure 9: Physical column congestion comparison (source: courtesy of Harris Rebar)

The potential disadvantage of the 100ksi (690MPa) steel is that the unit cost is about 30% higher than standard 60ksi (420MPa) steel. Nevertheless, test column results were very positive, suggesting that the approach will be embraced in the near future by the owners, contractors, iron workers, placers, and design engineers alike.

Architect Reflections

Paul Thoryk, design architect for Escala and president of Thoryk Architecture, comments "when I design, I try to incorporate the beauty of the outdoors. So often, architecture focuses on the outer façade or the interiors. I believe that a design is not complete without the inclusion of natural elements. At Escala, I incorporated a large mezzanine that includes an open courtyard with a variety of plants and flowers". (Thoryk, 2006).

Case Study 3: The Cosmopolitan, Seattle, WA

The Cosmopolitan is a 315,000ft^2 (29,265m^2) tower located in downtown Seattle that includes 25 residential levels over a 270-stall, 8 story parking structure, with residential units starting at the 10th floor. Amenities include a fitness center with spa and sauna, swimming pool, manicured rooftop terrace, business and conference center, owner's lounge, guest suite, and street level retail. The Washington Aggregates and Concrete Association awarded the project first place in its annual competition for excellence in concrete construction.

Figure 10: The Cosmopolitan, Seattle, WA (source: courtesy of CKC)

State of the Art Structural System

Seismic loads are resisted by a code unclassified cast-in-place concrete shear wall core that was designed using displacement based analytical methods. This provided more accurate lateral design loads and a better description of the behavior of the building during a seismic event. In addition, long span post-tensioned slabs of variable thickness were introduced to serve two purposes: concentrate a large portion of the vertical gravity load on the shear core and allow for column free floor space. The added gravity load "preloaded" the shear core and improved efficiency by reducing lateral overturning forces and tension steel demands by approximately 15%. The long span post-tensioned slab was achieved by thickening the slab around the central core of the building from a typical 8in (203mm) slab up to 18in (457mm) deep, taking full advantage of reduced height requirements at the corridor about the central core. The thickened slab or "drop head" design created a support condition that allowed the slab to span much greater distances than with a conventional flat plate system. The drop head allowed to boost slab span capacity from 30ft (9.1m) to close to 40ft (12.2m) and push all building columns toward the perimeter. The exterior building columns and walls were then used as part of the fascia, which eliminated the need for exterior column and wall cladding, reduced building weight, and saved on fascia costs (DJC, 2007).

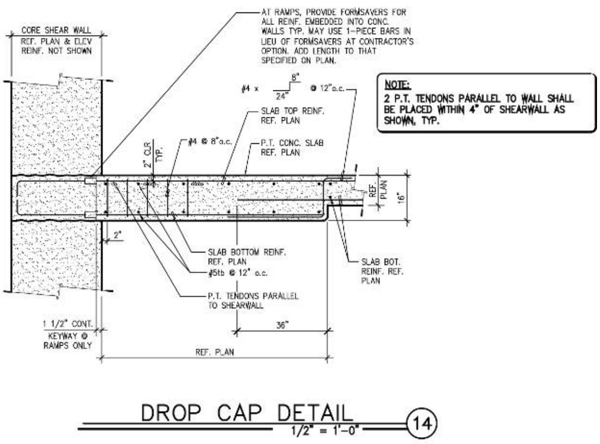

Figure 11: Drop cap detail (source: courtesy of CKC)

On the other hand, drop head designs do not come without potential disadvantages; post-tensioned quantities increase by about 0.25 lbs/ft^2 (1.22kg/m^2) beyond what is required for a conventional flat plate system. Depending on the building type, the suitability of a drop head design needs to be thoroughly investigated to determine the added benefit of removing interior columns against increases in reinforcing. Cary Kopczynski comments "it is important that the engineer bring the possibility of this type of design to the table early so implementation is possible. Minor shifts made before drawings are well underway can mean the difference between living units with restrictive columns and those with floor plans that offer enhanced possibilities" (Bacon, 2006).

No Interior Columns

Eliminating interior columns had a positive effect throughout the building. The relatively small footprint would have required costly and potentially intrusive transfer beams to eliminate columns at the parking and lobby levels.

Figure 12: Drop head at slab soffit (source: courtesy of CKC)

In addition, the column free floor space allowed for complete architectural freedom in living units by releasing all interior column restrictions and precluded the added effort to coordinate column locations with the parking levels below. "In residential towers, eliminating columns can often significantly raise the value and aesthetics of the project" (Bacon, 2006).

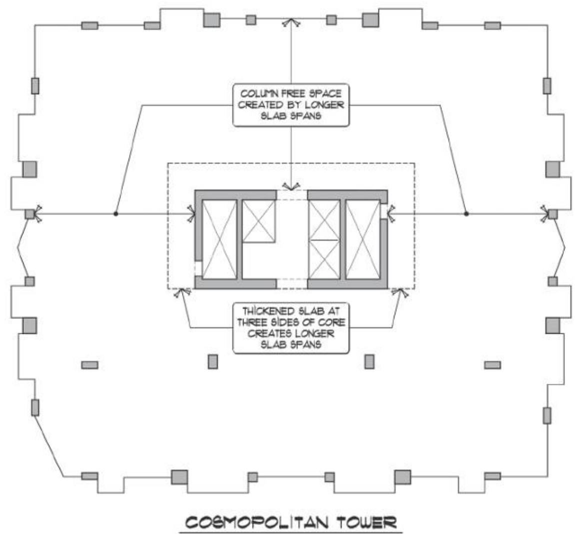

Figure 13: Typical structural floor plan with drop head (source: courtesy of CKC)

Owner Comments

"We went beyond the traditional rooftop terrace of potted plants and created a real green space atop the building," says Claudio Guincher, president of Continental Properties Inc., an affiliate of the Cosmopolitan's developer, 9th and Virginia, LLP. "The garden has bushes, flowers and Japanese maples planted into lush green patches of lawn. Homeowners can toast the sunset over the Sound or gather with friends for an outdoor barbecue at one of our two professional-grade gas grills." (NWHomes, 2007).

Case Study 4: Mosler Lofts, Seattle, WA

Mosler lofts is a 234,000ft^2 (21,740m^2) mid-rise residential loft building located in downtown Seattle that includes 12 residential levels over 3 subgrade parking decks and ground level retail. The first two floors include townhouse condominiums, with the remaining 10 floors consisting of studio, one bedroom, one bedroom plus den, and penthouse units. Mosler is scheduled to be the first BuiltGreen™ and LEED® Silver certified residential condominium building in Seattle*. Features and amenities include a landscaped rooftop garden, controlled access parking garage, fitness center, guest suite, library and reading room, café and coffee shop at ground level. Green features include high efficiency appliances, high efficiency elevators, use of certified wood products, hybrid flex car availability, storm water management, CO_2 monitoring, low VOC paints, low-flow plumbing fixtures, 30% potable water savings over a code compliant building, high performance windows, and natural day lighting and dual flush toilets (EGB, 2007). A green roof is intended to insulate the building, filter rainwater, and provide outdoor space for residents (DJC, 2007).

Figure 14: Mosler Lofts, Seattle, WA (source: courtesy of The Schuster Group, Inc.)

The structure consists of a cast in place concrete frame with 7.5in (190mm) thick post-tensioned flat plate typical slabs. Seismic loads are resisted by 24in (610mm) thick shear walls located about the elevator core. Typical columns are 18" (460mm) by 24in (610mm).

Material Reductions and Layout Considerations

The slab thickness at the parking levels was reduced from 7.5in to 7in (190mm to 178mm) to account for reduced gravity design loads, saving the project 225,000lbs (102,000kg) of concrete. Bolt-on decks were used in lieu of cantilevered concrete balconies to provide a thermal break which significantly improved energy efficiency calculations. Concrete shear walls were limited to the interior core of the building to provide more open space. Deep transfer beams were eliminated at the third floor by lengthening the columns between the first and third floors to capture the horizontal offset between them. The extended columns were then used as an architectural feature and demising wall between townhouse units on the ground floor. Roof drain locations were carefully coordinated to minimize concrete thickness without compromising roof slab capacity. Concrete strength and reinforcing quantities were reduced as allowed by lateral and vertical load demands. Shear walls, columns, and slab soffits were left exposed to view to reduce finish materials and give a more natural look. Foundation mat and spread footing reinforcing were reduced 20% by specifying 75ksi (520MPa) reinforcing in lieu of standard 60ksi (420MPa) reinforcing.

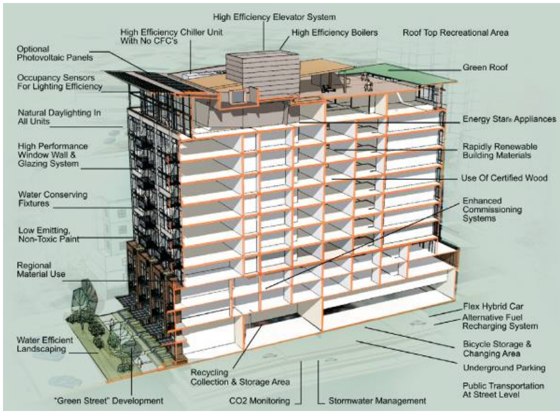

Figure 15: Green features at Mosler Lofts, Seattle, WA (source: courtesy of The Schuster Group, Inc.)

Green Developer

Mark R. Schuster, Founder and CEO of The Schuster Group, Inc. and Mosler Lofts real estate developer, states "as inhabitants of this earth, we are visitors here. We have a moral obligation to leave it, through sustainable efforts and practices, as a better place than we found it. We pledge ourselves as a company and as individuals to be exemplary stewards of our environment and resources" (Schuster, 2007).

Conclusions

While the solution to significant CO_2 emission reductions, energy efficiency, and energy independence are still years beyond our reach in terms of technology and/or government policy, certain measures to reduce the environmental impact of our buildings are available to us now. From a structural engineering standpoint, a reduction in material demand, selection of methods geared toward shortening construction schedules, and reducing building volume without compromising architectural expression are all proven measures that contribute to happy clients and end users.

* Certification pending with LEED® (Leadership in Environmental and Energy Design) a national organization, and BuiltGreen™, a King and Snohomish County entity.

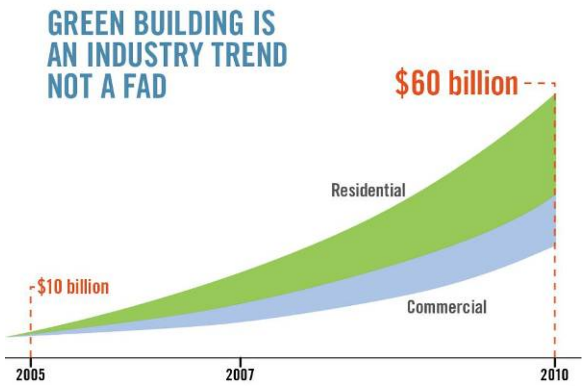

Figure 16: Green Building Trend (source www.usgbc.org)

Close collaboration between all design team members is also key in creating green buildings. Both structural engineer and architect play a vital role in striking a balance between layout efficiency and aesthetics. As such, structural engineers will need to become much more involved in the early conceptualization of any proposed building to ensure that this balance is met. Ruben Aya-Welland, project engineer for Hellmuth, Obata + Kassabaum (HOK), summarizes "sustainable design integration has led project teams towards the emergence of innovative ideas that cross disciplinary boundaries. If we are to move forward toward a truly holistic design philosophy, structural engineers must adapt to different ways of thinking about how their structures are conceived and built" (Aya-Welland, 2007).

References

US GREEN BUILDING COUNCIL, 2006. ***LEED Reference Guide for New Construction & Major Renovations*** (LEED-NC), Version 2.2. USGBC, Washington, D.C.

US GREEN BUILDING COUNCIL, 2003. ***LEED Reference Guide for New Construction & Major Renovations*** (LEED-NC), Version 2.1. USGBC, Washington, D.C.

US DEPARTMENT OF ENERGY, 2006. ***Buildings Energy Data Book: 1.1 Buildings Sector Energy Consumption.*** US DOE, Washington, D.C.

US DEPARTMENT OF ENERGY, 2006. ***Buildings Energy Data Book: 3.1 Carbon Emissions.*** US DOE, Washington, D.C.

AYA-WELLAND, RUBEN, 2007. ***Sustainable Design Integration for Structural Engineers***. Structural Engineer, September 2007.

POST, NADINE, M. 2007. ***High-Strength Rebar Called Revolutionary***. Engineering News-Record, August 27-Sepctember 3, 2007. New York, NY.

BACON, SHEILA, 2007. ***Escala: Post-tensioning is obvious choice for Seattle's Largest Condominium Tower***. PTI Journal, July 2007.

THORYK, PAUL, 2006. ***Designers bet Urban Dwellers Want More***. Seattle Daily Journal of Commerce, October 26, 2006. Seattle, WA.

PCA SUPPLEMENT. 2001. ***Downtown Living***. Building Design & Construction, Sept. 2001. Oak Brook, IL.

BACON, SHEILA, 2006. ***Taking in the View: New Core Design Allows for Longer PT Slabs and Column-Free Space in Residential Applications***. PTI Journal, December 2007.

NWHOMES, 2007. ***The Cosmopolitan (Seattle); Downtown Community Celebrates Completion of Penthouse Homes***. The Seattle Times Company representing the Seattle Post Intelligencer, May 8, 2007.

SCHUSTER, MARK R., 2007. ***Building Green***. The Schuster Group Inc. 2007 (www.theschustergroup.com).

SEATTLE DAILY JOURNAL OF COMMERCE (DJC), 2007. ***2007 Washington Aggregates and Concrete Association Cast-in-Place Structures Cosmopolitan Tower***. May 4, 2007

SEATTLE DAILY JOURNAL OF COMMERCE (DJC), 2007, ***.Mosler Lofts to Open in October***. July 7, 2007

EQUITY GREEN BLOG (EGB), 2007. ***Mosler Lofts in Seattle Deliver Green Urban Lifestyle***, June 16, 2007. http://equitygreen.typepad.com/blog/2007/06/mosler_lofts-in.html

US GREEN BUILDING COUNCIL, 2007. ***Introductory Power Point Presentation***. www.usgbc.org

US ENVIRONMENTAL PROTECTION AGENCY, 2002. ***The National Water Quality Inventory: Report to Congress***. 2002 Reporting Cycle. USEPA Office of Water, EPA 841-R-07-001, October 2007.

SUSTAINABLEBUILD, 2007. ***Pollution From Construction,*** www.SustainableBuild.co.uk/PollutionFromConstruction.html