

Civil Capstone Design Projects - 2015

Project Title:

Modular Construction Unit

Design Team Members:

Sylvia Green, Mahdi Rafatpanah, Talal Antar, Ahmad Javaheri

Technical Advisor:

Dr. Adel Al-Mayah

Abstract:

MTE (modular tech engineering) is a modular building design and consulting company. In modular construction, rooms are prefabricated in a controlled setting on the ground (instead of on-site construction, such as in traditional building techniques), and then integrated to the building structure. Modular construction techniques contain many advantages that overcome the most common construction obstacles; they are more efficient, environmentally friendly, and more economical than traditional building techniques, making them worth considering when building large and repetitive structures, such as condominiums. The current project being undertaken is the design of a customizable bathroom unit for a condominium, including four different pre-customized options to suit the different customer needs; the green unit, the tech unit, the luxury unit, and the basic unit. These options demonstrate how modular units can suit a wide range of tastes and applications. The full process of construction is analysed for this project, this includes the design of the units, their fabrication, and installation on site.



Project Title:

East Campus Skywalk Design

Design Team Members:

Raymond Wong, Muhammad Usman, Brett Cyr

Technical Advisor:

Prof. Robert Gracie

Abstract:

Epsilon Consultants Inc. designed a Skywalk pedestrian bridge connecting the recently constructed Engineering 5 and Engineering 6 buildings at the University of Waterloo. Epsilon Consultants believe that the best engineering design is the one with the most predictable future performance. For this reason the project team chose to design a composite steel and concrete structure. Skywalk pier and slab will use reinforced concrete while, the structure and framing will use steel beams and columns. The focus of the design team is to make the design simple in order to reduce the cost of construction. We believe that the safety of the public is paramount. The challenge is to achieve the project goals while maintaining the simplicity of structural components.



Project Title:

Hamilton Soccer Stadium Removable Grandstand Design

Design Team Members:

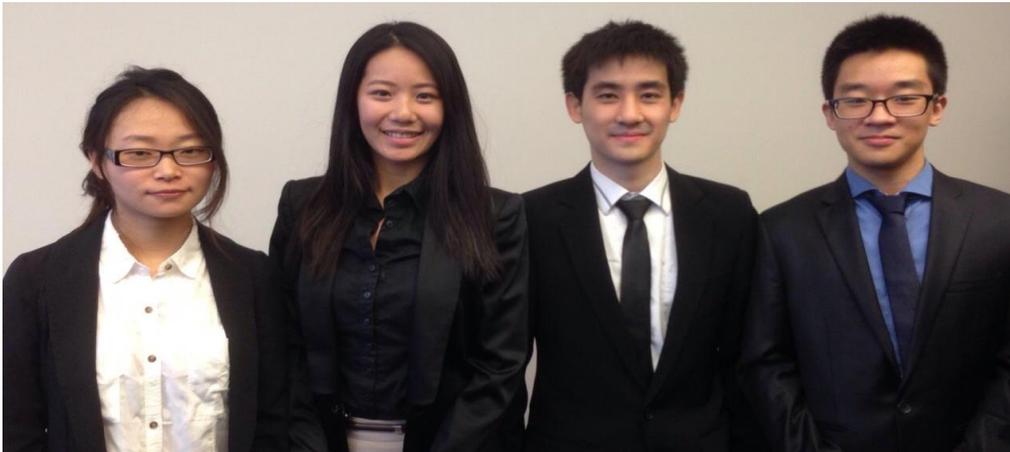
Shi Hui Guo, Jin Deuk Ko, Natapong Rojvanich, Ying Yu

Technical Advisor:

Dr. Lei Xu

Abstract:

To host the upcoming Pan-Am Games where over 7,000 athletes from all over the Americas are expected to participate, a newly designed Hamilton Stadium is needed to accommodate 40,000 spectators for this one-time event. Stadium Optimum Solution (SOS) is tasked to design a sustainable stadium which meets the standards of the Fédération Internationale de Football Association (FIFA) and National Building Code of Canada (NBC). Post Pan-Am Games, relatively less spectator attendance are expected for small scale events, including the local Hamilton Tiger Cats Football Team. To maximize the usage of the stadium, the final design of the Hamilton Stadium features a temporary steel framed grandstand in addition to the permanent concrete grandstand. The steel framed structure is designed with a removable feature without compromising the structural integrity in terms of performance and serviceability due to human-induced vibration.



Project Title:

A Community Centre for Pokhara, Nepal

Design Team Members:

Andrew Chong, David Stanton, John Adamek, Rushin Khakharia

Technical Advisor:

Dr. David Brush

Abstract:

Pokhara, Nepal is home to numerous hardworking families who have moved from rural settings in search of work and a better life in the city. Due to financial necessities, they have been subjugated to living in the slums of Nepal where access to adequate drinking water, sanitation and durable housing is of grave concern. To foster a sense of community, DRJD Designs is proposing to design a community center for the slum dwellers of Pokhara. Aside from providing a space for the community to meet, grow and prosper, the centre could act as an emergency shelter in difficult times. The team has also proposed to design a rainwater harvesting system that would treat the collected rainwater through a slow sand filter to provide adequate drinking water. Providing proper sanitation facilities was investigated, however, it was decided that it would be more effective if it were provided at the municipal level.



Project Title:

Residential Shipping Container Design for Affordable Housing

Design Team Members:

Emily Peat, Sam DesRoches, Steve Pauls, Yasiman Alizadeh

Technical Advisor:

Dr. Mahesh Pandey

Abstract:

While affordable housing is defined as total housing expenses that consume 30% or less of a family's annual income, thousands of families in the Waterloo region are spending much more than that on rent alone. YES Solutions presents an innovative multi-unit residential building design for use in affordable housing applications. The three-storey building, constructed from recycled shipping containers, comprises six two-bedroom units. The team has undertaken the design of the superstructure, enclosure, fabric, and systems and services for a complete building solution. The novel design approach is intended to decrease construction costs such that a typical landlord could rent the building profitably within affordable rental ranges and without government subsidies. The modular design lends itself to several exciting secondary applications including temporary housing for remote work sites and housing for disaster relief situations.



[Design Team from left-to-right: Yasi Alizadeh, Sam DesRoches, Emily Peat, Steve Pauls]

Project Title:

Integrated Geothermal Modular Deck Panel

Design Team Members:

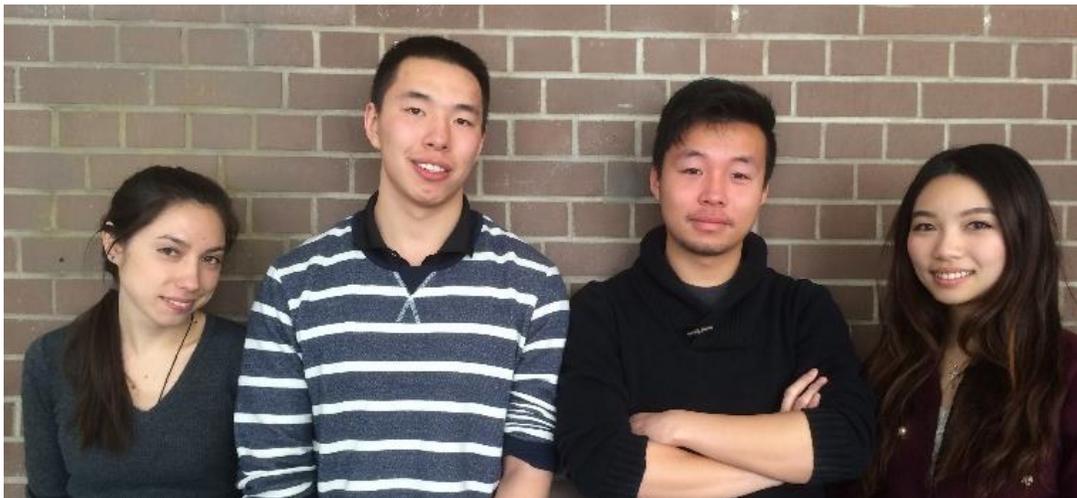
Phil Fan, Jessica Deslippe, Stan Fong, Eleanor Mak

Technical Advisor:

Dr. S. Narasimhan

Abstract:

Integrated Geothermal Deck Panelling (IGDP) is an easy-to-install decking addition meant to prolong the service life of existing bridge structures. The lightweight panels form a low-temperature hydronic heating system which provides a sustainable and cost-effective alternative to traditional pedestrian bridge de-icing methods through the distribution of geothermal energy to the walking surface. The prevalent method of spreading road salts leads to accelerated corrosion in concrete bridge decks and the pollution of the local environment through the introduction of excess chlorides. In comparison, geothermal energy in Canada is a plentiful, accessible, and untapped source of clean and sustainable energy with minimal environmental impact. In addition to providing automated de-icing, the IGDP system itself includes a waterproof membrane which further protects the existing bridge deck below from chloride ingress.



Project Title:

Upgrade of Riverside Dam in Cambridge, Ontario

Design Team Members:

Michael Hu, Jamie Huang, Brian Kester, Relja Lukic

Technical Advisor:

Dr. Don Burn

Abstract:

Riverside Dam is a structurally unsound concrete weir in Cambridge, Ontario. Condition assessments performed by the City of Cambridge identified the need for immediate decommissioning of the weir. Maintaining the existing recreational reservoir is highly desirable for local communities. As such DTConsulting proposes to remove the existing dam and to reconstruct a new overflow concrete weir to alleviate safety concerns as well as to reduce frequent flooding at Riverside Park. Fish migration is a major concern in the Speed River and therefore a denil fishway has been incorporated in the design. The fishway is a key feature in providing adequate fish passage and consequently promoting local tourism and land value. The new design will adhere to standards outlined in the Lakes & Rivers Improvement Act (LRIA).



[Design Team from left-to-right: Relja Lukic, Jamie Huang, Brian Kester, Michael Hu]

Project Title:

Expansion of Single-Family Detached Homes

Design Team Members:

Victor Chan, Robert Culbert, Jacky Lau, Renee Yip

Technical Advisor:

Dr. John Straube

Abstract:

Granny flat is an independent secondary dwelling adjacent to the primary housing unit. The purpose of a granny flat is to provide a living space for the elderly who are often closely related to the residents of the primary unit without forsaking the privacy of the existing living space. Granny flats provide the basic necessity of a living space including a kitchen, bedroom(s), living room, bathroom(s) and utility room. Innovative construction techniques such as panelized construction will be utilized to adhere to spatial constraints. The design will be flexible to provide various alternatives to meet the client's desires. Currently, construction of secondary independent units is not allowed in the majority of municipalities in North America. Therefore, the goal of this project is to demonstrate the advantages of constructing granny flats in these areas.



[Design Team from left-to-right: Victor Chan, Jacky Lau, Robert Culbert, Renee Yip]

Project Title:

Unionville GO Station Expansion

Design Team Members:

Garry Anggawinata, Kyle Saulnier, Edward Lau, Sujeepan Kalanadan

Technical Advisor:

Dr. Hassan Baaj

Abstract:

Unionville GO station will be experiencing a rapid increase in commuters due to the addition of new rail lines and a growing demand in the City of Markham due to immense population growth. TransporTech Engineers have proposed a modification of the existing station layout to accommodate for the increase in travel demand at this transit hub. A transportation impact study (TIS) has been performed using Synchro traffic analysis software to determine the most feasible alternative design for the site. Research pertaining to SMART parking technology was conducted to maximize efficiency in traffic circulation within the station. After selecting the ideal option, a detailed roundabout geometric design at the station entrance was performed as this was determined to be the most effective based on the results of the TIS. In addition, a detailed pavement material design using sustainable features has been explored.



Project Title:

Net-Zero Energy Students Residential Housing

Design Team Members:

Axel Taganda, Chathurika Gamage, Lara Chahrour, Sonny Sahun Yoon

Technical Advisor:

Dr. John Straube

Abstract:

The University of Waterloo is planning on constructing more residential buildings on campus. It is preferable that these buildings have lower net energy characteristics than the existing residences to save utility costs, contribute to the environment, and stimulate residents to think green.

Net-Zero Energy Building (NZEB) is a building with zero net energy consumption. The total amount of energy required by the building on an annual basis is equal to the amount supplied by renewable energy on site. This is done through aggressively reducing the energy demand and increasing the energy efficiency of a building.

There are different types of NZEBs such as net-zero site energy, net-zero source energy, net-zero energy costs, and net-zero carbon emissions. In this project, the building is to achieve a net-zero site energy. Various aspects such as space heating, cooling, hot water, lighting and appliances are taken account. Building enclosure is the major focus of this project in reducing the energy demand with general look over on energy efficient technologies. Lastly, solar panels are utilized as the on-site energy production, and their annual capacity was used as the energy target.





Project Title:

St David Street Bridge Replacement

Design Team Members:

Riley McMillan, Kyle Balkos, Brandon Torry, Aaron Roeper

Technical Advisor:

Dr. Scott Walbridge

Abstract:

Aluminum bridge superstructures provide opportunities for accelerated bridge replacement on minor highways and local roads. Preliminary analysis suggested that an aluminum structure could compete with traditional cast-in-place concrete, precast concrete and corrugated steel culvert structures in terms of cost and performance while significantly reducing construction time.

Detailed design of an aluminum superstructure for the St David Street Bridge in Fergus, Ontario was undertaken as a case study. Major design tasks included designing aluminum plate girders, checking an available aluminum bridge deck product for code compliance, designing barrier walls such that vehicle impacts would not damage the aluminum deck or girders, and analyzing the superstructure for vibration. Additional design tasks included construction scheduling, cost estimation and designing the transition from the road to the aluminum deck.

The final product is an aluminum superstructure that is competitively priced with traditional construction and allows a bridge superstructure replacement on an accelerated schedule.

Project Title:

Standardized Public Housing in Nunavut: Prototype Design

Design Team Members:

Kim Cruz, Camilo Mendoza, Ishan Prabhu, Anne Wright

Technical Advisor:

Dr. Jeffrey Casello

Abstract:

The hostile climatic conditions and remoteness of Canada’s arctic regions have rendered the current state of publicly funded housing infrastructure inadequate in comparison to the rest of the country. The conditions in Nunavut provide a unique challenge in generating a durable, energy efficient housing alternative that is economically viable. KCIA Impact group designed a prototype 6-plex single storey home that can be easily reproduced to provide much-needed housing throughout the territory. The prototype home incorporates experimental building and energy technologies—such as adjustable foundations and small-scale wind turbines. Innovative construction techniques were also incorporated into the design process to facilitate fast paced construction and accommodate the limited construction season. The prototype’s design is simplistic to allow occupants to contribute to the building process and long-term operation of the units. The implementation of this structure across Canada’s North will provide the backbone for the rebuilding of the arctic communities.



Project Title:

UM House Detailed Design

Design Team Members:

Travis Huang, Brian Tian, Janice Tian, Eric Zou

Technical Advisor:

Dr. Jeffrey S. West

Abstract:

UM House is an innovative upgradable modular residential solution offered by UFV. It is designed to revolutionize the single-family residential building industry by utilizing in-factory construction to minimize on-site construction, achieve superior build quality and promote sustainability. Modular structures and connectors are designed to incorporate convenient upgrade for the home owners. Sustainability is embedded in the design to elevate building performance, optimize material usage and escalate production efficiency. The upgradeable features, construction procedures and transportation methods are explained in detail to demonstrate the constructability of UM House. UM House will be showcased through BIM technology to provide comprehensive understanding of the system. The superiorities of UM House enable it to become one of the most promising residential building systems for the future.



Project Title:

Kwartha Lakes Forcemain Crossing of the Scugog River

Design Team Members:

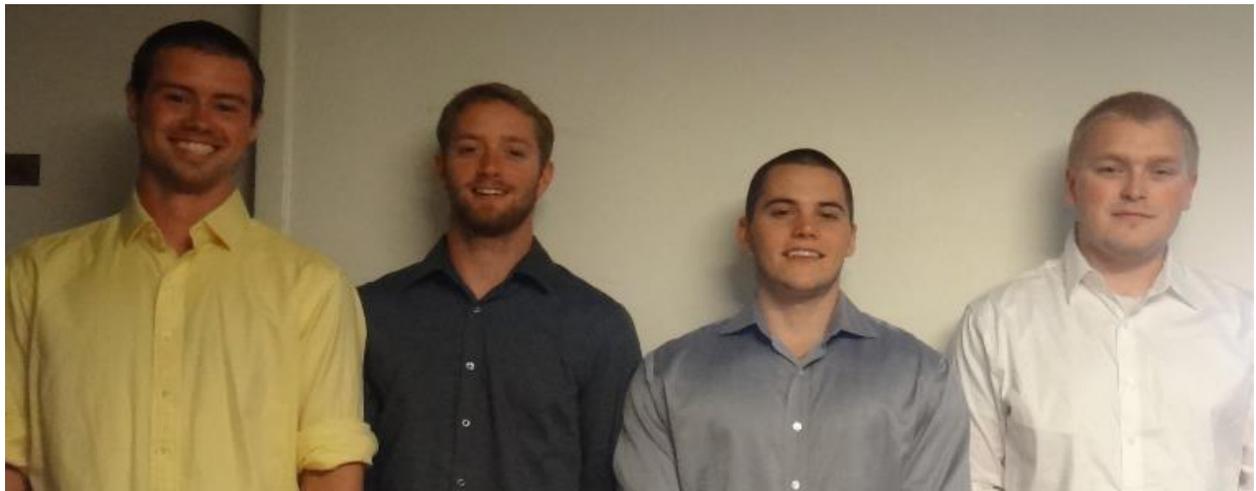
Patrick McLellan, Adam Wood, Dustin Van Heck, Zach Richards

Technical Advisor:

Professor Mark Knight, P.Eng

Abstract:

The Kwartha Lakes Forcemain Crossing, designed by Complete Engineering, is the selection and design of a trenchless technology method to be utilized in the construction of twin 500 mm sanitary forcemains crossing below the Scugog River. The goal of the project is to service the expanding community of Lindsay. The project tackles many challenges. The riverbed is contaminated with PCB's due to earlier manufacturing upstream. Any disruption of the sediment will lead to pollution of the river downstream. As well the required exit location of the tunnel is located near an abandoned landfill. During construction, if the clay landfill liner is punctured, then seepage of various pollutants into both the soil and the river are possible. To complete the crossing, horizontal directional drilling (HDD) will be used to bore two twin tunnels for the installation of the forcemains. HDD provides the most accurate, environmentally safe, and economical option available.



Project Title:

Retractable Tensegrity Framed Roof

Design Team Members:

Sean Reinsma, Kyle Sutton, Al Borgers, Brad Souter

Technical Advisor:

Dr. Adil Al-Mayah

Abstract:

The team developed a detailed retractable roof design, following a feasibility study that compared the effectiveness of various moveable building elements. In the previous study, a roof was found to be the one of the most effective moveable elements. The design roof, with plan dimensions of 42 meters by 72 meters, was developed using post-tensioned cables and compression struts, while adhering to the practices of tensegrity framing. An elliptical confining perimeter truss and two space trusses were required to maintain the feasibility of the design. Special consideration was given to the fabric cladding, structural connections, and roof operability. A total of approximately 60% of the roof area is retractable. The use of an ETFE membrane as cladding allows for more light into the enclosure, while providing adequate enclosure control. In comparison to conventional framing methods the design roof is lighter, but less stiff.



Project Title:

Structural Design of a Model Luxury House in Markham

Design Team Members:

Maru Abantao, Ian De Vera, Jae Kang, Amin Shojaei

Technical Advisor:

Dr. John Straube

Abstract:

The Markham Luxury Model House Project integrates a green roof assembly based on evaluated environmental, social, and economical criteria defined by MAJI Group to meet and exceed current industry standards. The integrated green roof assembly in the model house introduces an edge over existing luxury homes in the market by providing more efficient energy consumption, maintenance cost, and a longer life cycle. MAJI Group has utilized a unique and luxurious architectural design for the house that makes it more structurally challenging to design. Moreover, the architectural design encompasses a traffic bearing dome on the roof with a glass curtain wall, promoting the luxurious feel for the guests and owners of the house. In terms of building envelope, MAJI Group has used the most suitable wall assembly from the technologies currently available in the industry to ensure energy efficiency and integrate building science knowledge in the design. MAJI Group is currently undergoing the design of the superstructure of the house.



Project Title:

High-Capacity Telecommunications Tower

Design Team Members:

Nancy Hui, Mikhail Laguta, Monica Wahba, Daniel Wai

Technical Advisor:

Dr. Lei Xu

Abstract:

In order to encourage antenna colocation and minimize inefficient tower placement by cell carriers in the City of Mississauga, a high-capacity telecommunications tower was designed to house as broad a range of antennas as possible, while being aesthetically integrated into Mississauga's urban landscape. An inventory of the heights and dimensions of antennas pre-existing in Mississauga was constructed to determine the most appropriate types of towers for design refinement. Thus based on the results of this investigation, along with the criteria of cost, sustainability, aesthetic appeal, and constructability, a tripole tower was selected as the basis for the design of the high-capacity telecommunications tower. An optimized, cost-efficient tripole tower is presented which provides innovations to design practices currently implemented throughout the City of Mississauga.



Project Title:

Princess Street Tall Wood Building

Design Team Members:

Kevin Doherty, Jordan Schneider, Matt Vanderzee

Technical Advisor:

Dr. Lei Xu

Abstract:

VD&S Partnership Limited is designing a 10-storey wood framed building in uptown Waterloo. The concept of a 10-storey wood framed building was selected as optimal from eight alternatives of varying heights and structural composition. The analysis between alternatives focused on economics, environmental impacts, architectural appeal, and presumed difficulty of the design process. The scope of the tower's detailed design is limited to the structural system and fire-rated enclosures. The result will be a Building Information Model (BIM) using Autodesk Revit.

The novelty of this project stems from the use of wood as the primary structural component. As the Ontario Building Code currently only permits wood-framed structures up to six storeys, this project pushes the limits of what is both feasible and permitted. As structural wood is rarely used on such a grand scale, information regarding member sizes, fire-resistance methods, and cost could be very informative to developers and designers alike.



[Design Team from left-to-right: Kevin Doherty (Project Manager & Fire-enclosure Designer), Jordan Schneider (Lead Structural Designer & Building Modeler), Matt Vanderzee (Lead Building Modeler & Structural Designer)]

Project Title:

Brossard Bridge Research Project

Design Team Members:

Chris Rausch, Juan Silvera, Andrew Easton, Eric Otten

Technical Advisor:

Dr. Scott Walbridge

Abstract:

In May 2014, CJAE Consultants were awarded a research contract with the City of Brossard to conduct a comprehensive assessment of an existing aluminum pedestrian bridge located within their township. The purpose of this assessment is two-fold: (1) to investigate the adequacy of the constructed aluminum bridge with respect to more conventional pedestrian bridge design alternatives, and (2) to prepare a detailed bridge design utilizing aluminum and other innovative construction aspects. The objective of this assessment is to facilitate with a continuous improvement initiative set-out by the Province of Quebec, which seeks to address current life-cycle impacts of public infrastructure, by utilizing more sustainable construction and more innovative design systems. Resulting from this comprehensive assessment, CJAE Consultants developed several innovative bridge design aspects consisting of an efficient aluminum structure, glass decking and a modular construction design approach.



Project Title:

Post-Disaster Shelter Design from Humatia

Design Team Members:

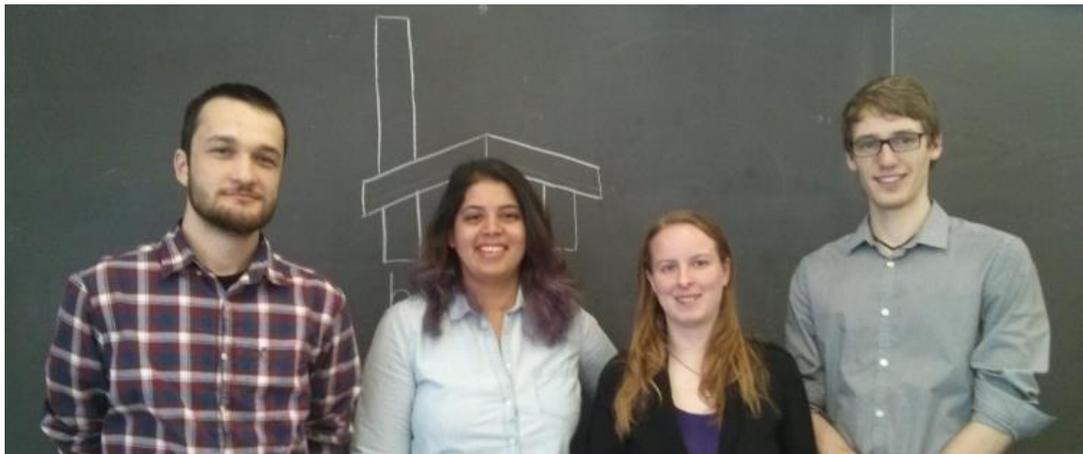
Kyle Gowanlock, Nouha Javed, Penelope Osterman, Daryl Sobanski

Technical Advisor:

Dr. Carl Haas

Abstract:

Humatia has developed a rapidly deployable, durable shelter intended for use in post disaster responses. The shelter is to be used as a replacement for conventional temporary housing utilized by aid groups and governments, such as tents or trailers. A collapsible design and simple setup will allow for easy transportation and erection. An integral part of the design is the emphasis on a tool free setup that requires no technical skills or knowledge. With simple, image only instructions, even the victims can assemble their shelters. The durable aluminium design can withstand years in the field and can be collapsed, stored, and reused with minimal maintenance. On top of superior lifecycle duration, the shelter will also be able to provide inhabitants with electricity, from solar cells in the roof, and provisions for capturing rainwater. The shelter exists as a design ready for fabrication and field-testing.



Project Title:

Revitalization of King Edward Avenue

Design Team Members:

Gregory Lue, Kelsey Waugh, Tiffany Chan, Brian (Hyungjun Jo)

Technical Advisor:

Dr. Liping Fu and Doubra Ambaiowei

Abstract:

King Edward Avenue is a residential street in Ottawa, Ontario that is currently experiencing issues with high truck volumes, excessive speeding, and frequent collisions. Residents in the area have expressed concerns for increased noise, frequent collisions, pollution and greenhouse gas emissions and would like King Edward Avenue to become more liveable and sustainable. Street Synergy has analyzed existing traffic conditions, evaluated and selected a sustainable street layout to accommodate the needs and objectives of the City of Ottawa. The new street design will accommodate drivers, pedestrians and cyclists and create a more attractive area for all. Using innovative materials and improved construction methods, the King Edward Avenue corridor will become a model for complete street design for years to come.



Gregory Lue
Project Manager



Tiffany Chan
Technical Analyst



Brian Jo
Technical Analyst



Kelsey Waugh
Technical Analyst

Project Title:

SusTec: Design for a 10-storey timber apartment structure

Design Team Members:

Noah Wolfe, Steve Jeon, Adam Morrison, Emily Wartman

Technical Advisor:

Dr. Jeff West

Abstract:

SusTec has designed a 10-storey timber structure in order to address the increasing concern of the rising greenhouse gas emissions associated with the construction industry. Currently, steel and concrete production account for approximately 8% of global greenhouse gas emissions. By using timber as a primary building material for mid-rise apartment structures, SusTec intends to reduce the environmental impact of the construction industry. Current building codes in Canada restrict the height of timber structures to 6-storeys, primarily due to fire safety and lack of experience. However, by utilizing CLT (cross-laminated timber) technology, SusTec is able to produce a building design that meets all structural and fire safety requirements. CLT has already been introduced as a structural material in Europe and Australia, and now SusTec intends to popularize it in Canada as well. With the implementation of CLT into Canada's construction industry, SusTec hopes to provide a sustainable solution to the ever increasing demand for housing.



Project Title:

STANCE Engineering: Hurricane Resistant Homes

Design Team Members:

Justin Johnson, Eduard Mandru, Neneph Oshana, Glenn Hartman

Technical Advisor:

Dr. John Straube & Dr. Maria Anna Polak

Abstract:

STANCE Engineering is a designer specializing in hurricane resistant homes. STANCE’s current project aims at designing a home capable of withstanding the impacts of a Category 3 hurricane in Myrtle Beach including wind speeds up to 208 km/h, and flood water levels of 2.5m. STANCE’s innovative approach of a raised octagonal home will be fastened to an elevator shaft that extends through the centre of the home to provide structural reinforcement. By incorporating such a unique design that utilizes symmetry, STANCE has been able to simplify the design of a typically complicated structure. In addition, STANCE’s design allows for many various state-of-the-art hurricane tie down measures. By connecting all of the different systems together and through the use of a sound concrete shaft, all of the hazardous forces will be directed into the ground. As our home stands above the others, disaster struck home owners will be rushing to STANCE.



Project Title:

Inroads to Affordable Sustainable Housing

Design Team Members:

Scott Klinger, Ted Paul, Matthew Benson, Jared Murphy

Technical Advisor:

Dr. Jeff Casello

Abstract:

Construction accounts for \$118 billion (7%) of Canada's GDP. Just over one third of that is residential construction, making residential construction one of the biggest industries in the country. Despite this massive market, typical homes are still designed with green technologies as an afterthought. Attaining green building metrics such as LEED Canada for Homes is often seen as expensive extras to residential construction costs. This project, *Inroads to Affordable Sustainable Housing*, challenges that disposition by designing a LEED Platinum home while increasing the home construction cost by less than 10%. Various design approaches were considered and the upfront construction cost of each was weighed against other green alternatives. The selected approach underwent an architectural design, structural engineering, and building enclosure design. Together, these aspects created a model housing development that is better for the environment and operationally cheaper for the home owner.



Project Title:

UW Parking Garage: A solution to the university's growing parking problem

Design Team Members:

Amr Farag, Daniel Ou Yang, Nader Sleiman, Ryan Thibeault

Technical Advisor:

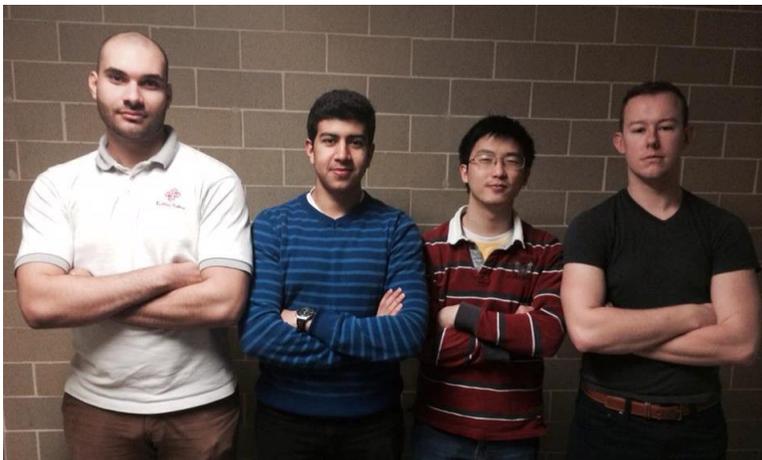
Dr. Polak

Abstract:

The growing student and staff population at the University of Waterloo suggests a higher future demand for parking. To date, the university's strategy for addressing parking needs was to build on-grade parking lots. Upon conducting an analysis of different parking strategies, upgrading an existing on-grade parking lot to a multi-level parking garage was found to be the most suitable solution.

To select a location we compared a wide variety of metrics including sustainability, capital cost, pedestrian connectivity, embodied energy, traffic impact, and safety. Accordingly we selected the existing on-grade parking lot north of the E5 building as our ideal project site.

This past term we completed a detailed design for this new parking garage. This included several sub-designs: a full structural design incorporating one way cast-in-place slabs, a detailed layout maximizing parking and accounting for building code requirements, and a site civil design connecting to existing servicing and grading.



Project Title:

Sustainable Foundation Design

Design Team Members:

Hussain Abbas, Zain Anjum, Muhammad Chaudhary, Mostafa El-Sadek

Technical Advisor:

Dr. Dipanjan Basu

Abstract (max of 150 words):

Hallbar Foundations is designing a concrete driven pile foundation for the Engineering-5 building located on the University of Waterloo campus. In the first phase of the project, a detailed sustainability analysis was conducted for the foundation. Tools such as the Life Cycle Analysis and Cost benefit Analysis were used to determine the most economically, socially and environmentally sustainable foundation. The concrete driven pile foundation was determined to be the most sustainable and in the second phase of the project a detailed design of the driven concrete has been designed. The design includes the complete structural design incorporating a sustainability factor to the foundation.

