The University of Iowa | Office of Outreach and Engagement

FINAL DELIVERABLE

Title	Essex Gym Redesign
Completed By	Drew Kissamis, Gary Gifford, and Jacob Molden
Date Completed	May 2019
UI Department	Civil and Environmental Engineering
Course Name	Senior Design - CEE:3084:0001
Instructor	Paul Hanley
Community Partners	City of Essex, M.E.G.A.

This project was supported by the Provost's Office of Outreach and Engagement at the University of Iowa. The Office of Outreach and Engagement partners with rural and urban communities across the state to develop projects that university students and faculty complete through research and coursework. Through supporting these projects, the Office of Outreach and Engagement pursues a dual mission of enhancing quality of life in Iowa while transforming teaching and learning at the University of Iowa.

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UNIVERSITY OF IOWA

DEPARTMENT OF CIVIL & ENVIRONMENTAL ENGINEERING

Project Design & Management

(CEE:3084:0001)

Final Design Report

Gymnasium Redesign

KGM Engineering

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<u>Section I:</u> Executive Summary

The following document is a final design report, from a group of senior civil engineering students from the University of Iowa named KGM Engineering, for the redesign of an old high school gymnasium submitted by the town of Essex, Iowa. KGM engineering focuses on sight development, structural design and architectural design. KGM engineering is comprised of three senior engineering students Drew Kissamis, Gary Gifford, and Jacob Molden. Jacob Molden is a general civil engineer with experience in structural engineering, transportation engineering, and site development. The project manager, Gary Gifford, is knowledgeable about structural engineering and water resource engineering. Drew Kissamis also has experience in structural engineering.

To help strengthen the town, the old Essex high school gym has been redesigned to provide a multipurpose community center to the town. To determine the best options for the old gymnasium, KGM Engineering, has provided alternatives for multiple upgrades. These designs and redesigns include fitness area, a storm shelter, refurbished bathrooms, parking lot designs, ADA (Americans with Disabilities Act) accessible features, and a community area design. The alternatives have been evaluated using feasibility studies and engineering calculations. KGM Engineering remained in close contact with the client to ensure a product that successfully improves functionality of the old gymnasium for the town of Essex, Iowa. All design solutions comply with building codes and relevant specifications.

To ensure fitness necessities, the existing bleacher on the first floor, west side, will be removed and a floor will be design in this area. The floor will be supported with the help of C channels, metal bearing plates, and the current interior walls of the area. Fitness equipment, like treadmills, ellipticals, stationary bikes, free weights, and cable machines will be installed to meet these needs.

The storm shelter will take place of the existing girls locker room and the middle room of the east basement. To ensure that standards are meet for the storm shelter, the doors and the windows will be replaced with storm rated windows. Calculations were also completed to check the structural stability of the area, and it was concluded that it indeed was and would not require any new material.

The locker rooms on the west side basement will be updated with new lockers, toilets, and shower heads to ensure quality changing area.

The bathrooms will be designed inside of the storm shelter to allow ADA accessibility in-case of an emergency. A single toilet will be placed in each bathroom ensuring plenty of space for people with ADA necessities as well as a shower head for people unable to use the updated locker rooms on the westside of the building. Interior walls built from standard CMU blocks will surround the bathrooms.

A community area will be designed in the existing cafeteria. This will be located in the southeast room in the basement. A fully functioning kitchen will be installed for use during events or town meetings. Tables and chairs will also be added to provide seating.

The parking lot will be updated with a 4” lift of pea gravel. 4” is chosen because it will allow Essex to save money for future design alternatives by recompacting the gravel as a subbase (the load-bearing layer of pavement) for concrete or asphalt.

The cost estimate for the project comes to a total of **$231,500**. This estimate includes: materials, installation, overhead, profit and a 10% contingency. RSMeans rounding standards were applied to the total estimated cost for each design component as well as the total project cost.

KGM Engineering thanks Essex, Iowa for the opportunity to work on this project. We look forward to broadening our experience and providing our services to your community both now and in the future.

<u>Section II:</u> Organization Qualifications and Experience

1. Overview of the Organization and Name

Our design team, KGM Engineering, received a proposed project that involved the restoration of an old high school redesigned into a public community center. Each member of our design team has extensive experience in structural, transportation, and water resource engineering. Discussing the educational background, each member has experience with several parts of this project including transportation design, site design, structural design, and storm water analysis. Members of the design team have had experience with consulting firms, government services, and design projects within their engineering focus area.

2. Organization Location:

KGM Engineering
University of Iowa College of Engineering
3100 Seamans Center
Iowa City, IA 52242

Gary Gifford (PM) - Email - gary-gifford@uiowa.edu
Phone - 630-740-6208

All design work except for a preliminary site visit and final project presentation has been completed at the College of Engineering in Iowa City. The site is located in Essex, Iowa and the final project presentation location is in Iowa City.

3. Organization and Design Team Description:

KGM Engineering is a team of students from the college of engineering at the University of Iowa in the capstone design class. Everyone on the team is well qualified to handle the project because of the past experiences. They all can give to the team, whether it is from classes and clubs at the university or outside work experience through internships and jobs. A list of the team members and what their roles are on the team are provided below. Resumes from each member are also included in the appendix.

Drew Kissamis: Currently a senior studying to be a civil engineer, specializing in the structures sub-track. He plans on graduating in May of 2019.

Gary Gifford: A senior at the University of Iowa, studying Civil/Environmental Engineering with a focus area on Civil/Environmental Practice. He is currently a Student

Operator at the University of Iowa's Water Treatment Plant. and will take the role of project manager. Gary also has experience with the Village of Carol Stream, as an Engineering Intern. At the Village of Carol Stream, Gary assisted the Storm water Administrator with surveying and flood mitigation projects.

Jake Molden: Senior Civil/Environmental Engineering student, focusing on the general practice of Civil Engineering. He is currently a teaching assistant for Principles of Transportation Engineering. Jake has experience working for The Department of Transportation as a highway technician and worked as an engineering technician at Beck Engineering designing utility lines, a parking lot, and a cul-de-sac.

4. Description of Experience with Similar Projects:

Design of Wood Structures*:* Framing layout and analysis of wood frame structures for loads and designing structural members for bending, axial load, and shear, including joists, beams, columns, engineered lumber, bearing walls, shear walls, and diaphragms were the main focus of this class.

Foundations of Structures: Techniques to analyze soil and how the different forces from buildings can affect the soil beneath it were the main subjects that were studied in this class. Important topics that can apply to most buildings included analyzing and design footings and piles.

Design of Steel Structures: Concepts and procedures in steel design; LRFD (load and resistance factor design) methodology for beams/columns; analysis and design of indeterminate structures. The class also provides an introduction to Autodesk ROBOT, a structural analysis software.

Design of Bridge Engineering: Bridge engineering and design; history of the bridge; factors that affect bridge design; bridges according to use (e.g., road, rail, pedestrian and bicycle) and type (e.g., suspension, cable stay, truss); how sustainability concepts may impact bridge design; substantial design exercise.

Design of Concrete Structures: Fundamental analysis and design of reinforced concrete members and structures, flexure, shear, bond, continuity, beams, one-way slab system; columns.

Design of Transportation Systems: Overview of different modes within transportation systems; concepts of sustainability and livability in transportation system design; derivation of standards for geometric design of highways; roundabout design; cross-sectional and longitudinal geometric design of highways.

Previous Work:

Gary's experience with the Village of Carol Stream's Storm Water Administrator gave him knowledge of runoff calculations and flood mitigation. This will be useful for the design of the parking lot. Jacob's experience with the Iowa DOT as a highway technician allowed him to oversee the construction site by checking standards and completing tests on the materials used. At Beck Engineering he was able to see the design side included: utility design, cul-de-sac design, and a parking lot design, which will be useful when designing the parking lot.

Section III: Proposed Services

1. Project Scope

The purpose of this project was to provide a multipurpose community center for Essex, Iowa by redesigning an old high school gymnasium. The services provided include: the design of a parking lot, addition of fitness equipment, a storm shelter, ADA accessible features, and bathroom remodels. To determine the exact needs of the community, KGM Engineering remained in close contact with the client. In addition, to determine the best way to purpose the facility, feasibility studies were completed. The feasibility studies complimented engineering calculations and helped the design engineers provide the best solution for the new community center. When designing the storm shelter a structural analysis was necessary to make sure it is structurally sound and able to comply with building and storm shelter codes. The designed upgrades have been incorporated into separate phases that reduce the economic strain the project has on the community of Essex, IA. The gymnasium is located on 111 Forbes Street north of St. John's Lutheran Church.

2. Work Plan

A work plan can be found in Figure 1. The work plan has been split into eight categories throughout the entire design process. The eight categories are: pre-design, parking lot design, fitness area design, bathroom design, storm shelter design, community area design, ADA accessibility design, and post-design. The pre-design includes tasks that were finished within the first two weeks. Within these two weeks, tasks were split between group members and research began on standards that must be met.

The second category was the design of the parking lot. Currently the parking lot is to be designed as a gravel parking lot, but an asphalt parking lot and permeable pavement parking lot have also been designed for future consideration. As for the design of the gravel parking lot, the thickness of the layer has been determined to be 4 inches. While the parking lot is being designed, a structural analysis was completed on the building to proceed with the design of the storm shelter.

The third category was the design of the fitness area. A structural analysis was completed for the flooring that will replace the bleachers on the west end of the building. Following the analysis, a floor was designed to meet the necessary loads of the fitness area. The floor addition will safely carry the loads of the fitness equipment and people using the equipment. A factor of safety was also included within the design. A cost estimate for the construction of the floor and fitness equipment required is given in the engineer's cost estimate.

The fourth category was to remodel/design the bathrooms and walls within the storm shelter. Bathrooms will be designed in the building to be ADA accessible. For convenience and to meet necessary storm shelter codes, the bathrooms have been designed to be in the storm shelter which is located in the northeast corner of the basement. The interior walls designed were made from the same material as the rest of the interior walls, CMU brick. Both designs comply with the International Building Codes.

The fifth category was to design the storm shelter. The shelter was designed based on the 2014 ICC/NSSA Standard for the Design and Construction of Storm Shelters. The storm shelter was designed to replace the girl's locker rooms, which is found in the northeast corner of the basement.

The sixth category was the community area design. A fully functional kitchen will be added into the existing cafeteria area. Water lines and gas lines are available to connect. Curtain walls will be added and designed based on the International Building Codes.

The seventh category was ensuring ADA accessibility to the storm shelter and community area via wheelchair lift. The client has the choice of two ADA compliant lifts. The first is the Ascension Clarity Model and other is the Genesis Enclosure Model Vertical Platform Lift from Garaventa Lift. Details and specifications of the lifts can be found in Appendix B. Both lifts are ADA compliant.

The eighth category was the post-design. This comprised of the completion of the project presentation, project report and finalizing cost estimates. Table 1 shown below is an outline of our work plan.

Table 1: Gantt chart with a legend

<u>Section IV:</u> Constraints, Challenges, and Impacts

1. Constraints

As with any design project, there are constraints that must be considered when the alternatives are presented to the designers. Some of the constraints will not have a huge impact on the project while some others will have a lasting impact. Each part of the design process will have their own constraints to handle.

The first set of constraints pertain to the overall design of the project, and the two most prevalent are cost and space. The town of Essex is very small which translates to a finite amount of money and space. Alternatives will be added at different expenses depending on the client’s necessities, allowing for some elements of the design to be separated into phases to implement as more money becomes available. Along with money, the space to design within was severely limited because it is in a small, pre-built gym.

The second set of constraints pertain to the parking lot design. The money spent on the asphalt plays a huge factor. The goal was to use asphalt that can handle the stress of the types of vehicles that will be driving over on it, while trying to find the type and amount of material that was within the budget of the town. The space allotted to make the parking lot was also a constraint because the available space includes the area that originally was the rest of the school, meaning a design was made that can maximize the area for the most parking spaces.

The next constraint involved redesigning the bathrooms within the gym. The design needed to contain ADA access points. It was important that there are ADA accessible entrances to the bathrooms. This implies that wherever our team decided to place the bathrooms, there must be enough space to allow an ADA accessible path, which was determined by the small space and limited amount of money.

Another set of constraints deals with the storm shelter and new floor addition. Because the building is pre-existing and not built to conform to the storm shelter codes, extra care was taken when redesigning the area of the basement to make sure all the requirements were met. We also had to take into consideration how materials will go in and out of the gym with the construction that would take place inside it. Whatever materials and equipment that is needed to help construct the new windows, doors, and floors must be able to fit inside the building. The front entrance doors and hallways have enough clearance for people to carry the storm shelter rated windows and doors, along with any tools needed along with them. In the back of the gym thee is an entrance to the stage that seemed like it was used for truck to back into and unload supplies for the school. That entrance can be used to transport the Vulcraft prefabricated floors into the building because the floor parts are only three feet wide. A much more complicated situation with this constraint involves the lift to be implemented in the building. For the successful completion of the lift, its parts will also need to fit within the front doors or the back-stage entrance.

2. Challenges

This project has unique challenges because it was a redesign rather than the design of a new building. The small community already depends on the gym to host events and activities for people of all ages. To ensure the community does not go without these for too long, the construction process must be completed in a timely manner. In addition, it was desired for the basement of the building to be renovated into a storm shelter. The storm shelter was required to be designed to meet the 2014 ICC 500/NSSA Standard for the Design and Construction of Storm Shelters without changing the building's load bearing or exterior walls. It was also important to ensure the storm water runoff, from the parking lot, does not create flooding problems on the property or adjacent properties. Another smaller challenge we came across involves removing the boiler from the basement because it was designed before the gym was completely constructed. We have the choice to either hide it in the room or try to remove it. Hiding it behind curtain walls leaves the room with less space while removing it would take more time and may require knocking down some walls.

3. Societal Impact within the Community and/or State of Iowa

Even though redesigning the gym might not seem like a huge project, a new and improved gym will have huge impacts for the town. These impacts include, but are not limited to, the community, economy, and environment.

To begin, the community will benefit from a newly designed gym. The gym will serve as a community meet up area, where kids, adults, and senior citizens alike can socialize and interact with each other, building a stronger community bond. For the children, the building could host after school activities such as the boy and girl scout troop programs, where they would socialize with their friends and learn how to be an upstanding member of the community. A daycare could also be implemented, giving them a safe place to stay while their parents work. The adults could use the facility to stay active and healthy in cardio and yoga classes or take recreational classes where they can stay up to date on current events. The senior citizens could also join their own physical activity clubs or social clubs to improve their mental health and still feel a productive member of society.

The redesigned gym could also stimulate the economy. If the facility becomes popular enough people could start buying memberships, which opens up possibilities for hiring people to manage and maintain the building. The gym could also be rented out for parties, sports tournaments, or neighborhood gatherings where not only can money be generated to boost the economy, but again provide a place for the community to grow closer together. With more interaction within the community, the word about small businesses will spread, giving people the incentive to go visit and support those businesses.

The environment, on the other hand, will not be impacted as greatly. With a new parking lot and reinvigorated facility that could be the center of the community, the vehicle traffic will increase, leading to a slight rise in air pollution. The increase in human traffic could also lead to more littering if not handled well enough.

Section V: Alternative Design Options

Since the redesign of the gymnasium is a general repurposing, there is no one design that several alternatives will be stated for. Rather, individual upgrades have their own alternatives.

Exercise Options: The original design was for a track to be designed for the people of Essex to use for exercise. The track was to be elevated to maximize the space within the gym, otherwise more space would have been necessary to safely avoid the track. However, we determined that it was infeasible to add a track due to lack of space and budget. Instead we decided that fitness equipment would be capable of serving the same function as a walking track. The equipment implanted will be treadmills, ellipticals, and stationary bicycles. Having an exercise area is important for a small community like Essex, because there are no other buildings in the town that can serve the community like this gymnasium. Therefore, a fitness area will provide additional value to the renovated gymnasium and could lead to additional revenue being generated for the town. To make room for a fitness area, the bleachers on the west side of the building are to be removed. In addition, a new floor was designed to replace the bleachers on the west end and accommodate the loads of the fitness equipment and people. See the plan details P.02 and P.04 for the current layout of the bleachers and the proposed exercise area, respectively.

Parking Lot Options: Regarding the parking lot, gravel is to be used on the existing lot. Alternatives for the parking lot are asphalt and permeable pavement. These will be a more expensive, but asphalt could potentially save money in the long run. Asphalt will not shift or move like gravel will, which will decrease the chance of improper drainage. The second alternative is to use concrete. Using concrete will cost the most but will last longer than asphalt. There could be a potential chance of cracking occurring, but products have been developed to easily fix cracking problems. The third alternative is permeable pavement. This design will allow for rain water to infiltrate the subbase, which would then drain into the storm sewer system. This alternative is an inexpensive way to control flow in heavy periods of rain. The water would also flow into neighboring soil that will benefit the environmental life around the parking lot.

ADA Accessibility Options: Some of the other design elements, such as the storm shelter design, did not have alternative design options investigated due to project scope constraints. However, the ADA accessibility options to enter the basement level of the gym needed to be considered. We first decided on building a ramp to the basement, but quickly came to the conclusion that design would be infeasible because every one inch of elevation needs the ramp to be one foot long, meaning there would not be enough space in the gym to implement the design. The outside of the gym was out of our project scope, also denying us the possibility of designing a ramp that led to the basement from the outside. Instead, we decided on a lift that can transport people between the basement and first floor, allowing ADA accessibility to the storm shelter. Because it was also infeasible to add a ramp to the bathrooms in the locker rooms in the basement on the west side because of the ramp constraints, we designed new bathrooms in the storm shelter to be ADA accessible and include showers to make up for the inaccessibility. See the plan details P.01 and P.01 for the old and new bathroom location, respectively, and see detail U.03 for the bathroom layout.

Section VI: Final Design Details

Parking Lot Design: A 4” lift will be added on-top of the existing parking lot. A 4” lift was chosen based on the subbase layer from the Iowa Design Manual. The subbase layer is the load-bearing layer of pavement. This implementation will reduce the cost for future design phases. 38 vehicles will be able to fit in the parking lot. This was found based on the ITE Guideline for parking facility location and design. See Appendix D for more details.

Gym Equipment: Three options for each exercise equipment are listed for a pricing range.

Treadmill: Model - C700 NordicTrack - $799, Sole Fitness SOLE F63 - $999, ProForm Performance 600i $899

Stationary Bike: Model - Commercial VR 21 Nordic Track - $663, Horizon Comfort R Recumbent Bike Johnson Fitness $999, Schwinn 270 Recumbent Bike $549

Elliptical Machine: Model Sole E25 Elliptical $999, Horizon EX-59 Elliptical $499, NordicTrack C 7.5 Elliptical $799

Free Weights: Promaxima Dumbbell Rack $1444, Troy 10 Pair Dumbbells Set $1149, 3 Tier Hex Dumbbell Rack $1054

Cable Machine: XMark Fitness Functional Trainer Cable Machine XM-7626.1 $2069, Body-Solid gym Multi Station Modular Gym System $2875, Body Solid Deluxe Cable Crossover pulley Machine $2075

Floor Design: After the bleacher are removed, a floor was added to give people a space to exercise. See plan sheet P.04 on the west side of the drawing for a visualization of the new exercise area. The design will be a prefabricated floor from the Vulcraft Catalog. The floor was selected by determining the loads applied to the floor, and the lengths the floor would need to span. The loads were determined using the ASCE 7 guidelines. We decided on a 1.5VL22 composite design, meaning there is a 2.5” lightweight concrete slab covering a 1.5” metal deck. The floor joists will run perpendicular to the east and west walls. The rest of the dimensions can be found in the drawing detail U.01. When the bleachers are removed, additional concrete may need to be added to flush the new floor with the existing. The parts of the floor connecting the outer wall of the building will need support from C channels that will be bolted to the side of the wall to hold up the floor and balance the load. Using the line load calculations that can be found in Appendix E and a span of five feet between bolts, the 14th Edition of the Steel Construction Manual recommended to choose the C channel size of C6x8.2. See detail drawing U.01 for more design information. The floor laying on top of the interior walls need metal bearing plates in between them to help distribute the force from the floor, lowering the applied stress. The design we chose is a 0.5” thick and 8” wide A36 hot-rolled steel, which came from the ASTM Compass for A36 Steel Standards. Detail drawing U.01 shows more information on the plates. See Appendix A for more information on both the C channel and bearing plate. Because we did not want to fill in the windows that would now be at knee level in the exercise area, we replaced them with frosted tempered windows from Lowes to insure natural light can still enter the room. See detail U.01 and appendix A for more information on the windows.

Wall Design: 4”x8”x8” ground faced CMU blocks will be used in the design of new walls built throughout the building, including the new bathroom area and kitchen area. The design is based on the International Building Codes. The walls will be doweled into the existing floor for support with 6” rebar that is 0.75”. The rebar will be placed into each opening of the first row of CMU, and then filled in with cement for extra stability. The rest of the blocks will be placed together using mortar. All the walls will be interior so they will not have any load bearing responsibilities. More information on the walls can be found in detail U.02 and Appendix C.

Bathroom Design: We designed two identical bathrooms within the storm shelter area following ADA accessibility guidelines. Each bathroom is for single use so labels for the bathrooms are not required. A bathroom will contain a toilet, sink, baby changing station, and a shower head. The shower head was included because the showers in the locker room on the other side of the gym are not ADA accessible, leading us to make an area for a shower if necessary. A drain is also located in the center of each bathroom to drain the water from the shower. The ADA compliances that were met can be found in Appendix C, and the measurements can be seen in detail U.03.

Storm Shelter: The final design for the storm shelter involves removing the showers in the girl's locker as well as the curtain walls. The current doors and windows in the shelter did not meet the storm shelter guidelines and will be replaced. The windows are 3.85'x 3.85' SD-TH600 FEMA tornado windows from StormDefend. The new windows will be the same size as the current ones, so no extra wall will need to be added/filled. The single door sizes are 3.25'x7'and are replaced with Tornado 320 Doors from Securall. The doors have three dead bolts attached to the side of the door with the handle, one placed at the top, middle, and bottom of the door. These bolts then lock into the frame of the door, giving the door extra support from the forces of a tornado. They were both designed to meet the ICC-500 requirements. The storm shelter meets requirements, meaning the structure itself will not have to change or need extra materials to support itself. The minimum and maximum occupancy for the shelter is 31 and 62, respectively, and was calculated using the guidelines in the ICC-500. All design calculations for the loads applied to the shelter and occupancy space can be found in Appendix E. More information on the shelter and the design standards from the 2014 ICC 500/NSSA Standards for the Design and Construction of Storm Shelters can be found in Appendix C. Details C show more information on the windows and doors, which are from the StormDefend and Securall website. Plans S.01-S.05 show in detail the load takedown of the system that was used to determine if the storm shelter was structurally sound.

ADA Accessible Lift: The client has the choice of two vertical platform lifts that are ADA compliant. The first is the Ascension Clarity Model and other is the Genesis Enclosure Model Vertical Platform Lift from Garaventa Lift. Both lifts can be customized to meet the needs of the project. Details and specifications of the lifts can be found in Appendix B. Both lifts are ADA compliant.

The vertical platform lift is to be placed near the southern stairwell of the building, see Figure 1 below. This area was chosen so the small hallway in the basement and to the right of the basement stairs can act as a discrete but convenient way to access the vertical lift. The vertical lift will then be accessible, from the first floor, near the top of the basement stairs. For installation of the lift to take place in this location it will be necessary to remove the 3.5' elevated concrete slab near the top of the basement stairs and replace it with another concrete slab, of the same size, that is flush with the ground floor.

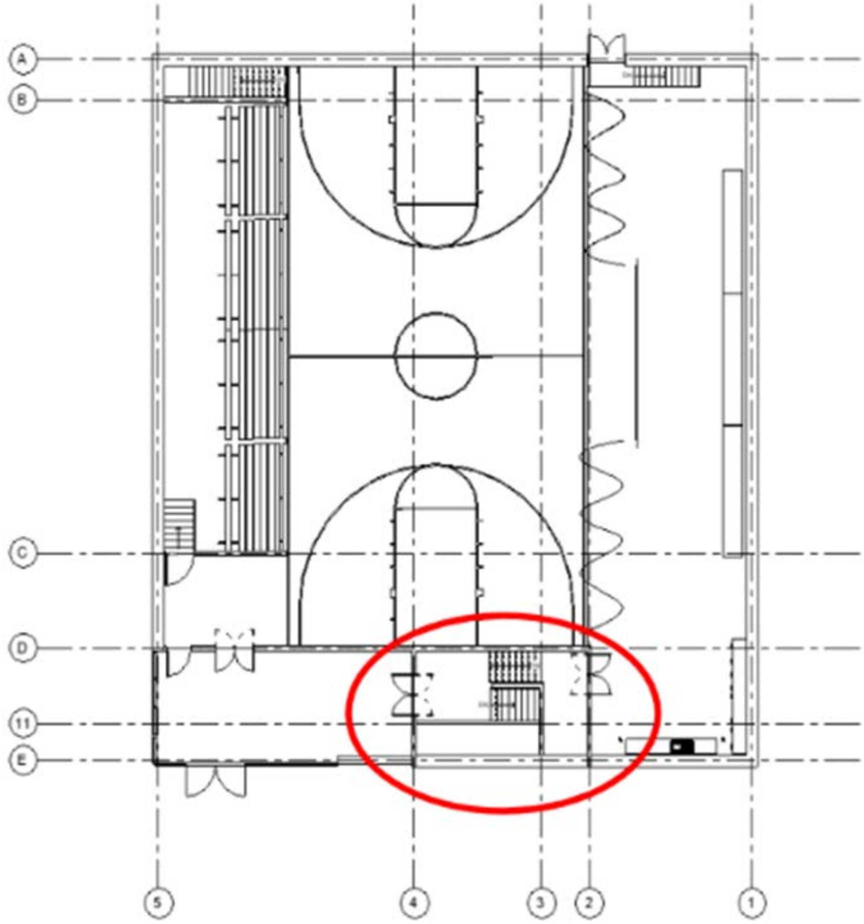


Figure 1: Vertical Lift Location

Community Center: The final design of the community center shall include a fully functional kitchen area. A curtain walls will be designed with 8” CMU blocks and the same design as the bathroom walls. See detail U.02 for more details on the wall. A countertop of the clients choosing will be installed for a bar use with the kitchen. A fridge, stove, and oven will be installed along with a sink and countertop space. Foldable tables will be placed in the community center for events and town meetings. Pricing can be found in Section VII.

Locker Room Redesign: Renovations on the existing west basement locker room will include updated lockers and updates to the existing showers and toilets. The existing boiler will also be demolished and removed. Floor plan P.01 on the west side of the drawing shows the layout of the locker room. The room can be split into two rooms if necessary, one for women and one for men.

Section VII: Cost Estimate

Cost estimates include materials, installation as well has overhead and profit. To help ensure the cost is not underestimated a 10% contingency was applied to the total cost of each design component. For simplicity and providing a conservative estimate, RSMeans rounding standards were applied to the total cost of each design component.

It is also important to note that the storm shelter includes the demolition of the East basement locker room (girls), the construction of the new ADA accessible bathrooms, and the tornado proofing of the designated storm shelter area. Additionally, several cost estimates were given for parking lot upgrades. This was provided in case the parking lot experiences a significant increase in vehicle traffic (asphalt, concrete) or a flooding problem arises due to storm runoff from the parking lot (pervious brick). For now, it is recommended to keep the gravel parking lot and improve its condition. Table 2 shown directly below summarizes the final designs implemented and their costs. Tables 3-10 explain all the costs taken into consideration for the project.

Table 2: Summarized total costs of all the design elements implemented

Total Estimated Project Cost	
Design Component	Estimated Cost
Storm Shelter	$68,000.00
Fitness Area	$34,600.00
Kitchen Renovation	$13,100.00
West Locker Room Renovation	$33,300.00
Update to Gravel Parking Lot	$7,950.00
Vertical Lift	$74,500.00
Total	**$231,500.00**

Tables 3-10: Costs for each design element and what they pertain

ADA Accesible Bathrooms		
Item	Estimation Source	Estimated Cost
Partition Walls	Table C1010 102 from 2018 Assemblies Costs with RSMeans Data	$5,937.75
Handicap Toilets (2)	Table D2010 110 from 2018 Assemblies Costs with RSMeans Data	$3,540.00
Handicap Shower (2)	Table D2010 710 from 2018 Assemblies Costs with RSMeans Data	$16,600.00
Handicap Sink (2)	Table D2010 310 from 2018 Assemblies Costs with RSMeans Data	$5,050.00
Door (2)	Table D2010 210 from 2018 Assemblies Costs with RSMeans Data	$1,342.00
Baby Changing Station (2)	WebstaurantStore.com	$280.00
ADA Grab Bar (2)	WebstaurantStore.com	$60.00
Toilet Paper Dispenser (2)	Uline.com	$80.00
Total cost for Materials and Installation (includes 10% contingency)		**$32,889.75**

Tornado Proofing of Storm Shelter		
Item	Estimation Source	Estimated Cost
Tornado Proof Windows (5)	StormDefend FEMA Tornado Windows	$20,751.50
Tornado Proof Door Panels (3)	Securall Steel Doors	$10,275.00
Total cost for Materials and Installation (includes 10% contingency)		**$34,129.15**

Fitness Area		
Item	Estimation Source	Estimated Cost
Composite Deck	Vulcraft Catalog	$3,300.00
C Channel	MetalsDepot.com	$358.00
Deck Installation	Table B1010 258 from 2018 Assemblies Costs with RSMeans Data	$3,069.00
Bike (4)	Average of online prices	$2,948.00
Treadmill (3)	Average of online prices	$2,697.00
Elliptical (3)	Average of online prices	$2,298.00
Freeweights Rack (1)	Average of online prices	$1,216.00
Cable Machine (1)	Average of online prices	$2,340.00
Netting Divider	usnetting.com	$4,857.27
Partition Wall	Table C1010 101 from 2018 Assemblies Costs with RSMeans Data	$1,651.81
Tempered Glass Windows	Table 08 51 13.20 from 2018 Facilities Construction Costs with RSMeans Data	$2,675.00
Bleacher Demolition	Table 02 42 10.10from 2018 Facilities Construction Costs with RSMeans Data	$3,988.20
Total cost for Materials and Installation (includes 10% contingency)		**$34,538.11**

Kitchen Renovation		
Item	Estimation Source	Estimated Cost
Unit Kitchen (1): combination range, sink, refrigerator, microwave, ice maker	Table 11 32 13.10 from 2018 Commercial Renovation Costs with RSMeans Data	$7,175.00
Counter Tops	Table 12 36 19.10 from 2018 Commercial Renovation Costs with RSMeans Data	$2,100.00
Partition Walls	Table C1010 101 from 2018 Assemblies Costs with RSMeans Data	$2,608.20
Total cost for Materials and Installation (includes 10% contingency)		**$13,071.52**

West Locker Room Renovation		
Item	Estimation Source	Estimated Cost
Toilet Demolition (2)	Table 02 42 10.20 from 2018 Facilities Construction Costs with RSMeans Data	$129.00
Sink Demolition (2)	Table 02 42 10.20 from 2018 Facilities Construction Costs with RSMeans Data	$129.00
Group Shower Demolition (2)	Table 02 42 10.20 from 2018 Facilities Construction Costs with RSMeans Data	$296.00
Lockers Demolition	Table 02 42 10.20 from 2018 Facilities Construction Costs with RSMeans Data	$1,188.00
Toilet (2)	Table C2010 110 from 2018 Assemblies Costs with RSMeans Data	$4,240.00
Sink (2)	Table C2010 110 from 2018 Assemblies Costs with RSMeans Data	$3,570.00
Shower (6 heads)	Table C2010 110 from 2018 Assemblies Costs with RSMeans Data	$13,600.00
Lockers	Table C2010 110 from 2018 Assemblies Costs with RSMeans Data	$7,056.00
Total cost for Materials and Installation (includes 10% contingency)		**$33,228.80**

East Locker Room Demoliton		
Item	Estimation Source	Estimated Cost
Toilet Demolition (2)	Table 02 42 10.20 from 2018 Facilities Construction Costs with RSMeans Data	$129.00
Sink Demolition (2)	Table 02 42 10.20 from 2018 Facilities Construction Costs with RSMeans Data	$129.00
Group Shower Demolition (1)	Table 02 42 10.20 from 2018 Facilities Construction Costs with RSMeans Data	$148.00
Partition Wall Demolition	Table 02 41 16.17 from 2018 Facilities Construction Costs with RSMeans Data	$257.53
Total cost for Materials and Installation (includes 10% contingency)		**$729.88**

Parking Lot Upgrades		
Item	Estimation Source	Estimated Cost
Gravel	Table 32 06 10.10 from 2018 Commercial Renovation Costs with RSMeans Data	**$7,931.35**
Concrete	Table 32 06 10.10 from 2018 Commercial Renovation Costs with RSMeans Data	$83,400.00
Asphalt	Table 32 12 16.13 from 2018 Facilities Construction Costs with RSMeans Data	$54,239.77
Pervious Brick	Table 32 14 16.10 from 2018 Commercial Renovation Costs with RSMeans Data	$175,200.00

Vertical Lift		
Item	Estimation Source	Estimated Cost
Vertical Platform Lift	Table 14 42 16.10 from 2018 Facilities Construction Costs with RSMeans Data	$67,025.00
Demolition	Table 02 42 10.20 from 2018 Facilities Construction Costs with RSMeans Data	$297.96
Construction	Table 03 35 29.30 from 2018 Facilities Construction Costs with RSMeans Data	$135.78
Total cost for Materials and Installation (includes 10% contingency)		**$74,204.61**

Section VIII: Appendices

Appendix A: Fitness Area

Calculations: Calculations for the C channel can be found in Appendix E.

Assumptions:

C Channels: The diameter of the bolts is standard for a C channel. The type of bolt used will be the standard type. The load the C channel can resist is 22.3 kips (LFRD).

Floors: The clearance for laying a floor on a surface is 1.5", which is met. The floor on the wall has a clearance of 4" and 1.92" for the C channel. The floor will just be used for exercising so the live load of the floor will be 100 psf. According to ASCE 7, the load for the partition walls in the exercising area is ignored if the minimum live loads is more than 80 psf. The load was determined form ASCE 7, under the live load section. The Load and Resistance Factor Design (LRFD) method was also used. The floor parts can be carried into the building without any major concerns. Mechanical, electrical, and plumbing can be applied to the floor where they are necessary. Because the load applied on the interior walls from the floor is less than the load applied to the interior walls in the storm shelter, and that the both interior walls are made from the same material, it can be assumed that the bearing walls under the fitness floor can also handle the loads. This assumption is based off using the calculations of the load takedown from the storm shelter and treating them like the worst-case scenario.

Metal Bearing Plates: The compressive strength of the steel is the same as the yield point, 250 MPa, which is enough to handle the stress from the Vulcraft floors.

Frosted Windows: The tempered and frosted glass used for the windows in the area can withstand the forces from the people who might accidentally come in contact with them.

Exercise Equipment: The equipment is spaced out enough to use each machine safely.

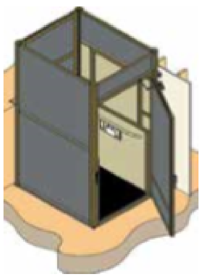
Resources: Vulcraft Steel Decking Catalog, ASCE 7, the 14th Edition Steel Construction Manual, the ASTM Compass for A36 Steel Standards, Engineers Edge, Lowes

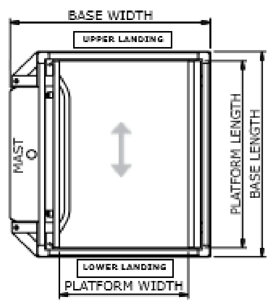
Appendix B: ADA Accessible Lifts

Genesis Enclosure Model Vertical Platform Lift Specifications

Dimensions

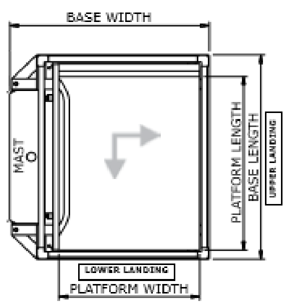
Genesis Enclosure Model - Includes a factory enclosure and integrated doors or gates.





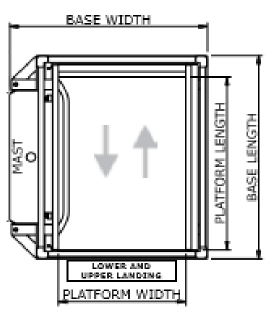
Enclosure Straight Through

Platform Size	Base Width	Base Length	Platform Width	Platform Length
Standard	1399mm [55 1/8"]	1505mm [59 1/4"]	947mm [37 1/4"]	1370mm [53 7/8"]
Mid-Size	1399mm [55 1/8"]	1656mm [65 1/8"]	947mm [37 1/4"]	1520mm [59 7/8"]
Large	1551mm [61 1/8"]	1656mm [65 1/8"]	1099mm [43 1/4"]	1520mm [59 7/8"]



Enclosure 90° Entry / Exit

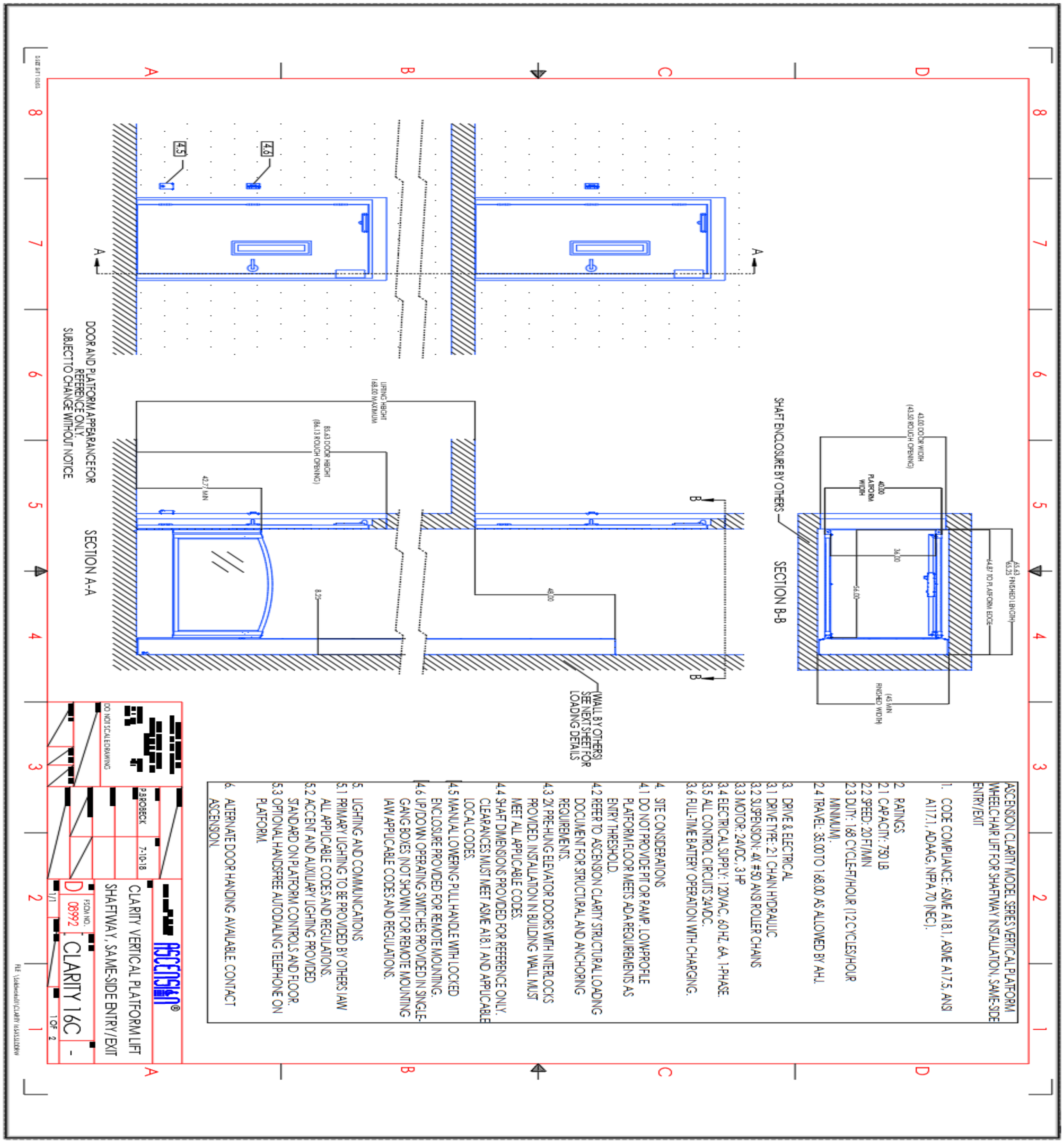
Platform Size	Base Width	Base Length	Platform Width	Platform Length
Standard	1399mm [55 1/8"]	1505mm [59 1/4"]	1017mm [40"]	1295mm [51"]
Mid-Size	1399mm [55 1/8"]	1656mm [65 1/8"]	1017mm [40"]	1446mm [56 7/8"]
Large	1551mm [61 1/8"]	1656mm [65 1/8"]	1168mm [46"]	1446mm [56 7/8"]



Enclosure On/Off Same Side

Platform Size	Base Width	Base Length	Platform Width	Platform Length
Standard	1399mm [55 1/8"]	1505mm [59 1/4"]	947mm [37 1/4"]	1295mm [51"]
Mid-Size	1399mm [55 1/8"]	1656mm [65 1/8"]	947mm [37 1/4"]	1446mm [56 7/8"]
Large	1551mm [61 1/8"]	1656mm [65 1/8"]	1099mm [43 1/4"]	1446mm [56 7/8"]

Ascension CLARITY 16E/S Model Series Vertical Wheelchair Lift Product Specifications



Appendix C: Storm Shelter

Calculations: Calculations for the types of loads and what they pertain to, as well as the load takedown of the gravity and wind loads for the storm shelter can be found in Appendix E. Occupancy calculations can also be found there.

Assumptions:

Bathrooms: Some of the ADA guidelines that were followed in the making of the design of the bathrooms include: all grab bars are 34” off the ground and are 1.5” in diameter, the toilet seat height is 18” from the ground, the sink height is 27” from the ground, 48” of space between the toilet and the wall it is facing, and a clear circle of at least 60” of space in the center of the room for wheelchair access. The rest of the guidelines can be found in the ADA Compliant Restroom website.

CMU Walls: The walls are not load bearing, so no calculations are needed to be performed to confirm their structural soundness. Standard concrete is used to fill the holes of the first row of CMU blocks. The same design was also used in the and exercise area, where walls are placed. See plan sheets P.03 and P.04, respectively, for the locations of the walls.

Storm Shelter: The minimum occupancy for the shelter is 31 people, while the max is 62. The minimum design is based off the space needed for wheelchair bound people, while the maximum design was based from the space a standing person needs. The standards for occupancy can found in the 2014 ICC 500/NSSA Standard for the Design and Construction of Storm Shelters. The shelter also can be used a recreational area. The CMU walls and concrete have compressive strengths of 158400 psf and 432000 psf, respectively, exceeding the resistance required for tornadoes, meaning no new building materials were required to reinforce the shelter.

Requirements for a Storm Shelter: The main requirements from the ICC 500 for a safe storm shelter are met and will be summarized. Load, strength, and factor design (LFRD) came from ASCE 7. The gym is not on a floodplain so flooding and rain loads did not need to be considered. The roof live load is at least 100 psf. The tornado wind speeds for the area came from the Figure 2 below:

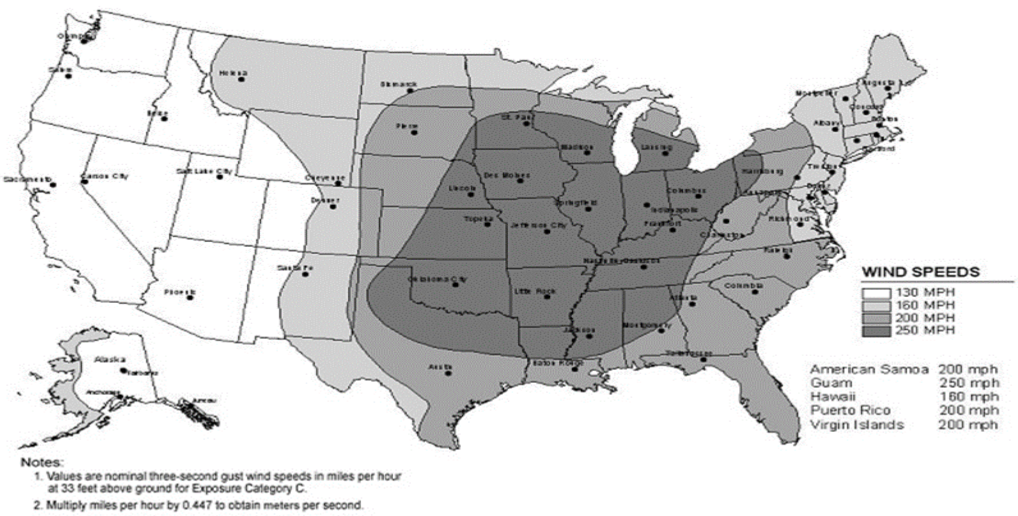


Figure 2: Tornado wind speeds based on the location in America

Shelter design according to wind speed and environment can be found in Appendix F and followed the guidelines given. The debris hazard forces coming from tornadoes is designed from 15 lb, 2x4 sawn lumber, and is 68 psf. Below shows the information in Table 10:

Table 11: Summary of debris criteria based on the code used

Tornado and Hurricane Windborne Debris Criteria

Guidance, Code, or Standard Criteria for the Design Missile	Debris Test Speed (mph)	Large Missile Specimen	Momentum at Impact (lb, s)
Tornado Missile Testing Requirements			
FEMA 320 / FEMA 361	100	15# 2x4	68
International Code Council (ICC) Shelter Standard	100 (maximum) 80 (minimum)	15# 2x4 15# 2x4	68 55
Hurricane Missile Testing Requirements			
FEMA 320 / FEMA 361	100	15# 2x4	68
ICC Shelter Standard	102 (maximum) 64 (minimum)	9# 2x4 9# 2x4	42 26
Florida State Emergency Shelter Program (SESP) Criteria	50 (recommended) 34 (EHPA minimum)	15# 2x4 9# 2x4	34 14
IBC/IRC 2006, ASCE 7-05, Florida Building Code, ASTM E 1886 / E 1996	55 34	9# 2x4 9# 2x4	21 14

It can be assumed the foundation slabs of the shelter meet the standards because the dead load of the slab is not required to resist overturning. The shelter can be below ground level because it is not in the area of a flood plain. Occupant density is determined by Table 11 below:

Table 12: Standard areas based on the status of the person

TABLE 501.1.1
OCCUPANT DENSITY – COMMUNITY SHELTERS

TYPE OF SHELTER	MINIMUM REQUIRED USABLE SHELTER FLOOR AREA[a] IN SQUARE FEET PER OCCUPANT
Tornado	
Standing or seated	5
Wheelchair	10
Bedridden	30

The useable floor area involves reducing the gross floor area by 35% because it is assumed the shelter has unconcentrated furnishings and not fixed seating. The shelter has a minimum of one wheelchair space for every 200 occupants. Because there are two doors for escape in the shelter, no other escape openings are needed. All fire safety requirements are met. The shelter includes four bathrooms and the standard hand-washing facilities. It can be assumed the requirements out of our project scope and expertise in the guidelines, such as ventilation, intake openings, lighting and sanitation systems, are also met.

StormDefend Windows and Securall Doors: All the ICC 500 standards were already met when the manufacturer built the product, so we did not need to do any testing. Installation of the doors and windows can be performed by whomever is hired to replace them.

Resources: ASCE 7, 2014 ICC 500/NSSA Standard for the Design and Construction of Storm Shelters, Strength of Masonry Walls Under Compressive and Transverse Loads from the National Bureau of Standards, ACI 318, StormDefend, Securall, FEMA Storm Shelter: Selecting Design Criteria, the International Building Codes, and an ADA compliant bathrooms guide.

Appendix D: Parking Lot

Assumptions:

Material: Condensing the pea gravel into a subbase helps spread the load from vehicles evenly throughout the parking lot, prolonging the usefulness of the road. With a quality subbase, the surface layer can then be scraped off and replaced with the other design options previously mentioned without having to replace the whole parking lot.

Stalls: The stalls for the vehicles are standard size for cars and trucks.

Resources: Iowa DOT Design Manual, ITE Guidelines

Appendix E: Engineering Calculations

Essex Calculations

LFRD

(Calculations made come from information from the ICC 500 Standard for the Design and Construction of Storm Shelters)

Occupancy Calculation

Available floor space in the storm shelter

$A := 889.575\ ft^2$

Available floor space in the storm shelter that can be used

(Assuming the area has unconcentrated furnishings and no fixed seating reduces the useable floor area by 35%)

$newA := 0.35 \cdot A = 311.351\ ft^2$

Occupancy: Assume wheelchair bound as lowest occupancy and standing as highest occupancy

(From Table 501.1.1)

$W := 10\ ft^2 \qquad S := 5\ ft^2$

$People1 := \dfrac{newA}{W} = 31.135 \qquad People2 := \dfrac{newA}{S} = 62.27$

C Channel Calculation

Span between bolts: $Span := 5\ ft$

Floor load: $L := 100\ psf$

Floor line load: $w := 500\ plf$

Force floor creates: $F := w \cdot Span = 2.5\ kip$

Find c channel that can at least withstand 2.5 kip from Steel Manual

Wind Calculations (Calculations used come from ASCE 7)

Variables

$Bns := 22.5\ ft$ $Lns := 55.33\ ft$

$Bew := 55.33\ ft$ $Lew := 22.5\ ft$

Importance Factor: Category II $Is := 1$

Wind Speed $v := 250\ mph$

Kd $kd := 1$

Exposure Category: C

Kzt $kzt := 1$

Ke $Zground := 991\ ft$

$$ke := \exp\left(-0.0000362 \cdot \frac{Zground}{ft}\right) = 0.965$$

Find Natural Frequency

Because building is less than 60 ft tall, it is classified as rigid

Gust Factor $G := 0.85$

Enclosure Classification

enclosed

$GCpi := 0.18$

Find the kzs

$a := 9.5$ $zg := 900\ ft$

$Z1 := 15\ ft$ Typical measurement

$Z2 := 28.75\ ft$ To flat roof of the gym

$$k1 := \left(\frac{Z1}{zg}\right)^{\left(\frac{2}{a}\right)} \cdot 2.01 = 0.849$$

$$k2 := \left(\frac{Z2}{zg}\right)^{\left(\frac{2}{a}\right)} \cdot 2.01 = 0.973$$

Find the qzs

$$q1 := \left(\frac{0.00256\ psf}{mph^2}\right) \cdot k1 \cdot kzt \cdot kd \cdot ke \cdot v^2 = 131.035\ psf$$

$$q2 := \left(\frac{0.00256\ \textbf{psf}}{\textbf{mph}^2}\right) \cdot k2 \cdot kzt \cdot kd \cdot ke \cdot v^2 = 150.27\ \textbf{psf}$$

Pressure Coefficients

$$\frac{Bns}{Lns} = 0.407$$

$$\frac{Lns}{Bns} = 2.459$$

Windward	$Cw := 0.8$
Sidewall	$Csw := -0.7$
Leeward NS	$Cns := -0.25$
Leeward EW	$Cew := -0.5$

North/South

Positive Internal Pressure

Windward/Leeward

$$p1 := q1 \cdot G \cdot Cw - q2 \cdot GCpi = 62.055\ \textbf{psf}$$

$$p2 := q2 \cdot G \cdot Cw - q2 \cdot GCpi = 75.135\ \textbf{psf}$$

Leeward NS

$$Plee := q2 \cdot G \cdot Cns - q2 \cdot GCpi = -58.981\ \textbf{psf}$$

Net Pressure

$$p1net := p1 + -Plee = 121.036\ \boldsymbol{psf}$$

$$p2net := p2 + -Plee = 134.116\ \boldsymbol{psf}$$

North/South

Negative Internal Pressure

Windward/Leeward

$$p1 := q1 \cdot G \cdot Cw - q2 \cdot -GCpi = 116.153\ \boldsymbol{psf}$$

$$p2 := q2 \cdot G \cdot Cw - q2 \cdot -GCpi = 129.232\ \boldsymbol{psf}$$

Leeward NS

$$Plee := q2 \cdot G \cdot Cns - q2 \cdot -GCpi = -4.884\ \boldsymbol{psf}$$

Net Pressure

$$p1net := p1 + Plee = 111.269\ \boldsymbol{psf}$$

$$p2net := p2 + Plee = 124.348\ \boldsymbol{psf}$$

East/West

Positive internal pressure

Windward/Leeward

$$p1 := q1 \cdot G \cdot Cw - q2 \cdot GCpi = 62.055\ \boldsymbol{psf}$$

$p2 := q2 \cdot G \cdot Cw - q2 \cdot GCpi = 75.135\ \mathbf{psf}$

Leeward EW

$Plee := q2 \cdot G \cdot Cew - q2 \cdot GCpi = -90.913\ \mathbf{psf}$

Net Pressure

$p1net := p1 + -Plee = 152.969\ \mathbf{psf}$

$p2net := p2 + -Plee = 166.048\ \mathbf{psf}$

East/West

Negative Internal Pressure

Windward/Leeward

$p1 := q1 \cdot G \cdot Cw - q2 \cdot -GCpi = 116.153\ \mathbf{psf}$

$p2 := q2 \cdot G \cdot Cw - q2 \cdot -GCpi = 129.232\ \mathbf{psf}$

Leeward EW

$Plee := q2 \cdot G \cdot Cew - q2 \cdot -GCpi = -36.816\ \mathbf{psf}$

Net pressure

$p1net := p1 + Plee = 79.336\ \mathbf{psf}$

$p2net := p2 + Plee = 92.416\ \mathbf{psf}$

Dead Loads

CMU Stage (4 in normal concrete slab) $CS := 4\ in \cdot 150\ pcf = 50\ psf$

Electrical $E := 1\ psf$

Plumbing $P := 1\ psf$

Mechanical $M := 4\ psf$

Welded, Rectangular Bar, GW-75, 19-W-4 Spacing, Galvanized, Hot Dipped, 3/4" x 3/16" Rectangular Bar (assumed) $SS := 5.7\ psf$

Insulation $I := 1.5\ psf$

Total $DL := E + M + SS + I + CS + P = 63.2\ psf$

Live Load

Ceiling (stage) $LL := 100\ psf$

No rain loads

Snow Loads: Flat roof

Balanced

Importance factor (Storm shelter) $Is := 1.2$

Exposure factor (fully exposed, surface C) $Ce := 0.9$

Thermal factor $Ct := 1$

Ground Load $Pg := 20\ psf$

$Pf := 0.7 \cdot Pg \cdot Is \cdot Ce \cdot Ct = 15.12\ psf$ Pf<Pm

$Pm := 20\ psf \cdot Is = 24\ psf$ Use this

Take Down

Tributary Areas

East Wall

$$EastWallArea := \frac{55.33\ ft \cdot 22.5\ ft}{2} = 622.463\ ft^2$$

West Wall

$$WestWallArea := \frac{55.33\ ft \cdot 22.5\ ft}{2} = 622.463\ ft^2$$

Forces at the Footings

Dead Loads

$DL = 63.2\ psf$ $DL := \frac{63.2}{2}\ psf = 31.6\ psf$ The shear walls on the east and west side split the load equally

East Wall Footing

$P1 := DL \cdot EastWallArea = 19.67\ kip$

West Wall Footing

$P2 := DL \cdot WestWallArea = 19.67\ kip$

Live Loads

$LL = 100\ psf$ $\quad LL := \frac{100}{2}\ psf = 50\ psf$ The shear walls on the east and west side split the load equally

East Wall Footing

$P1 := LL \cdot EastWallArea = 31.123\ kip$

West Wall Footing

$P2 := LL \cdot WestWallArea = 31.123\ kip$

Snow Loads

$Pm = 24\ psf$ $\quad Pm := \frac{24}{2}\ psf = 12\ psf$ The shear walls on the east and west side split the load equally

East Wall Footing

$P1 := Pm \cdot EastWallArea = 7.47\ kip$

West Wall Footing

$P2 := Pm \cdot WestWallArea = 7.47\ kip$

Wind Loads

Standard height for calculations is 15 ft

N/S Net Pressure

$P1 := 121\ psf$

E/W Net Pressure

$P2 := 153\ psf$

North/South Direction

Diaphragm Load

$w := P1 \cdot \frac{15}{2}\ ft = 907.5\ plf$

Diaphragm Reaction Forces

$L := 55.33\ ft \qquad B := 22.5\ ft$

$R1 := \frac{w \cdot B}{2} = 10.209\ kip$

Shear

$V1 := R1 = 10.209\ kip$

Exterior Column Shear Forces

$V1ext := \frac{V1}{8} = 1.276\ kip$

Horizontal Exterior Column reaction Forces

$R1ext := V1ext = 1.276\ kip$

Horizontal Exterior Column reaction Moments

$M1ext := V1ext \cdot \frac{15}{2}\ ft = 9.571\ kip \cdot ft$

Vertical Exterior Column reaction Moments

$R1y\_ext := \frac{2}{L} \cdot \left(\frac{V1ext \cdot 15\ ft}{2}\right) = 0.346\ kip$

East/West Direction

Diaphragm Load

$$w := P2 \cdot \frac{15}{2}\ ft = \left(1.148 \cdot 10^{3}\right)\ plf$$

Diaphragm Reaction Forces

$L := 22.5\ ft$ $B := 55.33\ ft$

$$R2 := \frac{w \cdot B}{2} = 31.746\ kip$$

Shear

$$V2 := R2 = 31.746\ kip$$

Exterior Column Shear Forces

$$V2ext := \frac{V2}{8} = 3.968\ kip$$

Horizontal Exterior Column reaction Forces

$$R2ext := V2ext = 3.968\ kip$$

Horizontal Exterior Column reaction Moments

$$M2ext := V2ext \cdot \frac{15}{2}\ ft = 29.761\ kip \cdot ft$$

Vertical Exterior Column reaction Moments

$$R2y\_ext := \frac{2}{L} \cdot \left(\frac{V2ext \cdot 15\ ft}{2}\right) = 2.645\ kip$$

LFRD Load Combinations

$DL := 19.67\ psf$ $LL := 31.12\ psf$ $SL := 7.47\ psf$ $WL1 := 0.35\ psf$ $WL2 := 2.65\ psf$

KGM Engineering

(1) $Combo1 := 1.4 \cdot DL = 27.538\ psf$

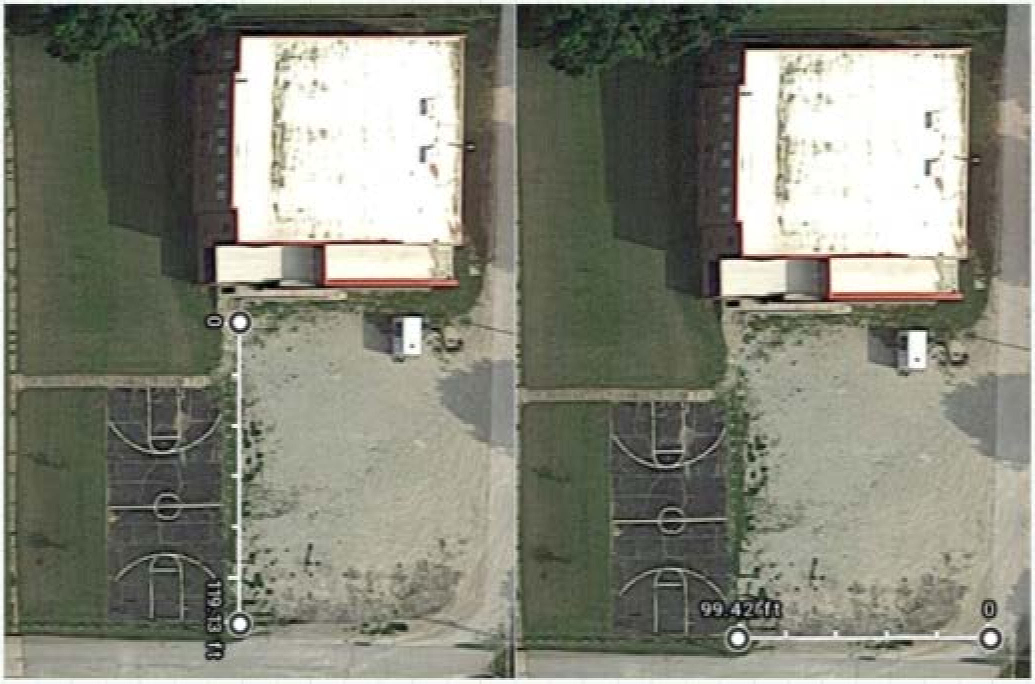
(2) $Combo2 := 1.2 \cdot DL + 1.6 \cdot LL + 0.5 \cdot SL = 77.131\ psf$ **Max LFRD Load Combination**

(3) $Combo3 := 1.2 \cdot DL + 1.6 \cdot SL + LL = 66.676\ psf$

(4) $Combo4 := 1.2 \cdot DL + WL2 + LL + 0.5 \cdot SL = 61.109\ psf$

(5) $Combo5 := 0.9 \cdot DL + WL2 = 20.353\ psf$

Parking Lot Hydrological Assessment



Calculate parking lot runoff using rational method:

$L := 120\ ft \qquad W := 100\ ft \qquad A := L \cdot W = 12000\ ft^2$

$A = 0.275\ acre$

Rainfall intensity values (in/hr) recieved from NOAA's Hydrometeorological Design Studies Center, Percipitation Frequency Data Server

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.378 (0.305-0.469)	0.450 (0.363-0.560)	0.572 (0.459-0.712)	0.676 (0.540-0.845)	0.825 (0.640-1.06)	0.944 (0.715-1.22)	1.07 (0.782-1.41)	1.20 (0.841-1.61)	1.37 (0.929-1.88)	1.51 (0.995-2.08)
10-min	0.553 (0.446-0.687)	0.659 (0.531-0.819)	0.837 (0.672-1.04)	0.990 (0.791-1.24)	1.21 (0.937-1.55)	1.38 (1.05-1.79)	1.56 (1.15-2.06)	1.75 (1.23-2.35)	2.01 (1.36-2.75)	2.21 (1.46-3.06)
15-min	0.675 (0.544-0.838)	0.804 (0.647-0.999)	1.02 (0.820-1.27)	1.21 (0.964-1.51)	1.47 (1.14-1.89)	1.69 (1.28-2.19)	1.91 (1.40-2.51)	2.13 (1.50-2.87)	2.45 (1.66-3.36)	2.69 (1.78-3.73)
30-min	0.969 (0.781-1.20)	1.16 (0.936-1.44)	1.49 (1.19-1.85)	1.76 (1.41-2.20)	2.16 (1.67-2.77)	2.47 (1.87-3.20)	2.79 (2.04-3.67)	3.12 (2.19-4.19)	3.57 (2.42-4.90)	3.93 (2.50-5.43)
60-min	1.27 (1.03-1.58)	1.53 (1.23-1.90)	1.97 (1.58-2.46)	2.37 (1.89-2.96)	2.96 (2.31-3.84)	3.45 (2.62-4.50)	3.97 (2.92-5.28)	4.53 (3.10-6.11)	5.31 (3.60-7.31)	5.93 (3.82-8.21)

$I_{10} := 2.37\ \frac{in}{hr} \qquad I_{100} := 3.97\ \frac{in}{hr}$

Runoff coefficient values obtained from Iowa DOT and "Experimental Resulsts on Permeable Pavements in Urban Areas: A Synthetic Review" - M. Marchioni & G. Becciiu

Table 1: Runoff coefficients for the Rational Method.

description of area	runoff coefficient (C)***			
	5 year	10 year	50 year	100 year
Paved Surfaces/Buildings	0.94	0.95	0.98	0.98
Gravel Surfaces, Compacted	0.45	0.50	0.55	0.60
Gravel Surfaces, Loose Graded or Not Compacted	0.35	0.40	0.45	0.50
Industrial Light, 60% Impervious	0.64	0.69	0.79	0.83
Industrial Heavy, 75% Impervious	0.76	0.79	0.86	0.89
Commercial/Business Areas, 85% Impervious	0.81	0.85	0.91	0.92
Residential Row houses/town houses, 65% Impervious	0.66	0.67	0.74	0.76
Residential 1/4 Acre lots, 40% Impervious*	0.48	0.49	0.58	0.62
Residential 1/2 Acre lots, 25% Impervious*	0.36	0.39	0.49	0.54
Residential 1 Acre lots, 20% Impervious*	0.32	0.34	0.46	0.51
Lawn, 0 to 2% slope (flat) **	0.22	0.22	0.30	0.36
Lawn, 2 to 7% slope (average) **	0.24	0.25	0.35	0.40
Lawn, 7% or greater (steep) **	0.26	0.30	0.38	0.45
Parks/Golf Courses/Cemeteries, 8% Impervious	0.21	0.21	0.28	0.34

* Based on Type B soils. Some regions in Iowa have predominant C and D type soils which require larger 'C' values. Appropriate experience is required in selecting appropriate 'C' values. Contact Office of Design Soils Section for further guidance.

** Based on heavy soils and lawn in fair condition. For situations involving sandy soils, contact the Methods Section

*** For higher percent of imperviousness than in the "description of area", developing land with no cover to poor cover, compacted soils, locations of high water table, and/or soils having a slow infiltration rate when thoroughly wetted, these values may be too low. Consult HEC-22, AASHTO Drainage Design Guidelines, or the Methods Section.

$C_{P10} := 0.95$ $C_{P100} := 0.98$ $C_{G10} := 0.50$ $C_{G100} := 0.60$

Table 2: Runoff coefficient on permeable pavement full-scale tests.

Reference	Types of pavement	Runoff coefficient range
[9]	Grid	0.00–0.35
[12]	PICP	0.37–0.45
[22]	Grid, PICP	0.00–0.03
[24]	Grid	0.00–0.10
[27]	Grid	0.00–0.26

PICP: permeable interlocking concrete pavement.

$C_{grid} := 0.35$

Rational Equation : Q=CIA
where,
A= area (acres)
C= runoff coefficient
I= rainfall intensity (in/hr)
Q=runoff (cubic feet per second)

Gravel Parking Lot

10 year storm:

$$Q := C_{G10} \cdot I_{10} \cdot A = 0.329\ \frac{ft^3}{s}$$

100 year storm:

$$Q := C_{G100} \cdot I_{100} \cdot A = 0.662\ \frac{ft^3}{s}$$

Paved Parking Lot

10 year storm:

$$Q := C_{P10} \cdot I_{10} \cdot A = 0.625\ \frac{ft^3}{s}$$

100 year storm:

$$Q := C_{P100} \cdot I_{100} \cdot A = 1.081\ \frac{ft^3}{s}$$

Grid Parking Lot

10 year storm:

$$Q := C_{grid} \cdot I_{10} \cdot A = 0.23\ \frac{ft^3}{s}$$

100 year storm:

$$Q := C_{grid} \cdot I_{100} \cdot A = 0.386\ \frac{ft^3}{s}$$

Appendix F: Bibliography

ACI 318 Building Code Portal. (2019). Retrieved May 1, 2019, from https://www.concrete.org/tools/318buildingcodeportal.aspx

ASCE 7 & SEI Standards. (n.d.). Retrieved May 1, 2019, from https://www.asce.org/structural-engineering/asce-7-and-sei-standards/

ASTM A36 Steel Standards. (n.d.). Retrieved May 1, 2019, from https://compass.astm.org/EDIT/html_annot.cgi?A36 14

Body-Solid. (2019). Retrieved May 1, 2019, from https://www.bodysolid.com/

Cybex. (n.d.). Three Tier Hex Dumbbell Rack. Retrieved May 1, 2019, from https://www.cybexintl.com/free-weights-three-tier-hex-dumbell-rack.aspx

Exercise and Home Fitness Equipment. (n.d.). Retrieved May 1, 2019, from https://www.proform.com/

FEMA. (n.d.). *FEMA Storm Shelter: Selecting Design Criteria*[PDF]. FEMA.

Home and Exercise Equipment by NordicTrack - Treadmills and Ellipticals Online. (2019). Retrieved May 1, 2019, from https://www.nordictrack.com/

Home Gym Products. (2019). Retrieved May 1, 2019, from https://www.xmarkfitness.com/

ICC. (n.d.). 2014 - ICC 500/NSSA Standard for the Design and Construction of Storm Shelters. Retrieved May 1, 2019, from https://codes.iccsafe.org/content/ICC5002014?site_type=public

I. (n.d.). Ite: A Community of Transportation Professionals. Retrieved May 1, 2019, from https://www.ite.org/

Iowa DOT Design Manual. (n.d.). Retrieved May 1, 2019, from https://iowadot.gov/design/design-manual

Lowe’s Frosted Windows. (2019). Retrieved May 1, 2019, from https://www.lowes.com/b/jeld-wen.html

ProMAXima. (n.d.). Retrieved May 1, 2019, from https://www.promaxima.com/

Reinforced Steel Doors. (2018). Retrieved May 1, 2019, from http://www.securalldoors.com/

Schwinn 270 Recumbent Bike. (n.d.). Retrieved May 1, 2019, from https://www.schwinnfitness.com/270/100515.html?adID=SDOSG2SSL2&gclid=EAIaIQobChMIwfbWson74QIVUrnACh2PqA2lEAAYASABEgJntvD_BwE&gclsrc=aw.ds&psearch=1

Sole Fitness: Treadmills, Ellipticals & Exercise Bikes. (n.d.). Retrieved May 1, 2019, from https://www.soletreadmills.com/

Standard for the Design and Construction of Storm Shelters, Strength of Masonry Walls Under Compressive and Transverse Loads[PDF]. (n.d.). National Bureau of Standards.

Steel Construction Manual 14th Edition. (2017). Chicago, IL: American Institute of Steel Construction.

StormDefend™ FEMA Tornado Windows. (2013). Retrieved May 1, 2019, from http://protectivestructures.com/product/stormdefend-fema-shelter-windows/

Structural A36 Steel Channel Section Properties Table Chart -Engineers Edge. (2019). Retrieved May 1, 2019, from https://www.engineersedge.com/standard_material/Steel_channel_properties.htm

The ADA-Compliant Restroom. (2019). Retrieved May 1, 2019, from https://www.buildings.com/article-details/articleid/9242/title/the-ada-compliant-restroom

The International Building Code. (2019, February 19). Retrieved May 1, 2019, from https://www.iccsafe.org/products-and-services/i-codes/2018-i-codes/ibc/

THE WORLD'S SMARTEST TREADMILLS. (n.d.). Retrieved May 1, 2019, from https://www.horizonfitness.com/

Troy Barbell and Fitness. (n.d.). Retrieved May 1, 2019, from http://troybarbell.com/

Vulcraft Steel Decking Catalog. (2019). Retrieved May 1, 2019, from https://www.vulcraft.com/catalogs/#Decks Catalog

NOAA. (n.d.). Precipitation frequency estimates. Retrieved from https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html

Iowa DOT. (n.d.). Using the rational method to determine peak flow. In *Design manual chapter 4 drainage*.

Marchioni, Mariana & Becciu, Gianfranco. (2015). Experimental results on permeable pavements in Urban areas: A synthetic review. International Journal of Sustainable Development and Planning. 10. 806-817. 10.2495/SDP-V10-N6-806-817.

A36 structural steel channel. (n.d.). Retrieved from https://www.metalsdepot.com/steel-products/steel-channel