Quarantine Center MQP

Major Qualifying Project
Submitted to the Faculty of
Worcester Polytechnic Institute
in partial fulfillment of the requirements for the Degree of Bachelor of Science.
This report represents work of WPI undergraduate students submitted to the faculty as evidence of a degree requirement.

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Abstract

The main objective of this major qualifying project was to develop the architectural, structural and mechanical design for a temporary quarantine facility to aid in the fight against pandemics such as COVID-19. The design is situated in New York City (NYC) and aims to solve the problems of overwhelmed hospital systems by creating a quick-build facility utilizing modular prefabrication and systems with quick installation techniques. This project includes components that promote physical and mental health, can be easily deployed, removed and reused once the pandemic has subsided and the building is no longer required.

MQP Design Statement

This Major Qualifying Project (MQP) demonstrates the use of the design process for a new modular building that incorporates different building systems and criteria to create a quarantine pandemic center. AutoCAD, Revit, DesignBuilder, Climate Consultant and RISA 2D Educational, were utilized to apply the different codes and regulations required of the architectural, MEP, and structural designs.

For the architectural design, a concept was developed and the site was analyzed. Additionally, a form and program were established and daylighting strategies were considered. The floor plan was developed in Revit and the site was imported and massed. The floor plan followed the 2018 International Building Code and Americans With Disabilities Act regulations to properly design the different building aspects. The Heating Ventilation and Air Conditioning system and structural components were also incorporated in the Revit model to determine aspects such as furniture placements and ceiling heights.

The considerations for MEP included the heating, ventilation, and air conditioning systems throughout the building. Initially, the building envelope design was established to minimize heat transfer and to control air flow throughout the building. By utilizing the components of the envelope, the heating and cooling loads were calculated. Additionally, the ventilation requirements were established, and the design of the system was created in AutoCAD. These calculations used the 1980 *ASHRAE Cooling and Heating Load Calculation Manual,* the ASHRAE Standard 170, and the 2014 NYC Mechanical Code.

The structural design component included choosing a construction type, analyzing the structural members and determining their sizes using RISA 2D Educational. Once the member sizes were determined, the frame was examined for lateral stability and selected structural members were checked for buckling and yielding. The calculations were performed in accordance with the 2014 NYC Building Code, the ASCE 7-10, the North American Specification for the Design of Cold-Formed Steel Structural Members, and the AISI Cold Formed Steel Design standard. Finally, a conceptual design of the connection detail was created in AutoCAD for the connection between the modules and their supports.

Furthermore, several variations of building orientation, glazing, system types, and material usage were analyzed in order to develop a structure acknowledging and maximizing building performance and sustainability.

Professional Licensure Statement

The National Council of Examiners for Engineering and Surveying considers obtaining a Professional Engineer (PE) license necessary. Obtaining a PE protects the public health, safety, and welfare from engineering malpractice. Many professional practices also require engineers to have or work towards obtaining a Professional Engineer (PE) license. The first step of acquiring a PE license is to obtain a degree from an Accreditation Board for Engineering & Technology (ABET) accredited school. An ABET accredited school, such as Worcester Polytechnic Institute, ensures that all its graduates meet the educational requirements necessary to enter their respective profession. One of the ways Worcester Polytechnic Institute does this is by having all its students submit a Major Qualifying Project, such as this one. Every project has students apply their course knowledge to solve real world problems, in turn, preparing them for challenges they might encounter in the workforce.

After earning a degree from an ABET-accredited school, a student then must take a Fundamentals of Engineering Exam (FE) in their field. After passing the FE, the individual then becomes an Engineer in Training (EIT). Once becoming an EIT, the person must gain four years of experience working under a PE, or three years of experience with a master's degree. Then, they become a PE after the successful completion of the PE licensure exam. Upon becoming a PE, the individual can sign and stamp their own work.

Executive Summary

The outbreak of the novel coronavirus left the healthcare system in a difficult situation. With the number of infections increasing daily during the peak of the 2020 pandemic, hospitals were overwhelmed, and the escalation of the situation resulted in a world-wide lockdown. One of the key takeaways from this experience is that the world needs to be better prepared for the next inevitable pandemic. Although the spread of a contagious virus such as COVID-19 that could transmit via air is not likely to be eradicated without a vaccine, other preventative measures such as field hospitals and quarantine centers can play a significant role in the fight against infectious diseases.

As observed from past pandemics and the different approaches utilized to try to underwhelm the healthcare system, prefabrication and modular construction have been employed in order to facilitate and speed up the construction of temporary hospitals. Despite their success in proving a well-functioning facility in record-breaking time, oftentimes the overall mental state and wellbeing of the building's occupants were not considered in the design. Hence, the purpose of this project was to develop the architectural, structural and mechanical design for a temporary, quick-build quarantine facility which is not only meant to aid in the fight against pandemics such as COVID-19, but which also takes patient and health workers wellness into consideration.

Design & Function

The architectural design of the facility was derived from several key concepts that were meant to help promote health, such as closeness to nature and natural elements, adequate separation between patients, and exposure to sunlight. From these concepts, along with the flexibility of modular design, a floor plan for the building was developed and placed within the chosen site for the project: Central Park, New York City (NYC), NY. The overall floor plan for this quarantine facility consists of a central hallway space with other functioning spaces perpendicularly attached to it and separated accordingly. The programming incorporates patient rooms, medical stations, staff bathrooms, storage spaces, a kitchen, lounge areas, mechanical and electrical rooms, radiology rooms, as well as laundry spaces and labs. Code compliance and feedback from medical staff were considered in the development of the architectural design. In addition, interior and exterior features were implemented with the goal of enhancing the wellness of its occupants.

The HVAC system design is crucial when regulating airborne transmission. Besides compensating for heat transfer, the ventilation of the facility during the pandemic can control and contains the spread of infected air particles from one space to another. The HVAC system in the facility provided higher ventilation rates than the requirements given by New York in order to promote occupant safety in the building.

The structural system was designed to be built quickly and effectively. The foundation system utilized adjustable screw jacks, which removed the need for excavation and therefore decreased construction time. Prefabrication is an effective means to dramatically decrease assembly time, while cold formed steel members can provide a strong skeleton for the modular design of the facility.

Concluding Remarks and Recommendations

The final design of the building aims to offer an appropriate response to a pandemic due to its architectural layout, interior design, effective mechanical system design, and quick constructability. As a result of the main focus being on these factors and the time restrictions, other aspects within this specific project can be further developed. A few recommendations that could improve the design include:

- Developing preventative measures that can be taken within the facility
- Designing proper plumbing, electrical, and fire protections systems for this specific type of scenario
- Further improvements in the design of the structural connections
- Implement other sustainable design features such as solar panels

Authorship

The design, calculations, and report for this project were prepared by Yllara Maia, Kimberly Ramos and Samantha Wile. Altogether, the team created the architectural design of the Quarantine Pandemic Center. Yllara Maia focused on the building envelope, Kimberly Ramos focused on the structural design, and Samantha Wile focused on the building mechanical systems. Each separate system and written section were reviewed and edited by the other members of the team. As a whole, the team also developed recommendations to improve the project for further analysis and sustainability measures.

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Figures, Tables and Equations

Abbreviations

Abbreviation	Phrase
ABET	Accreditation Board for Engineering & Technology
AISI	American Iron and Steel Institute
ASCE	American Society of Civil Engineers
ASD	Allowable Strength Design Method
ASHRAE	The American Society of Heating, Refrigerating and Air-Conditioning Engineers
CDC	Center for Disease Control
CLTD	Cooling Load Temperature Difference
EIT	Engineer in Training
EUI	Energy Use Intensity
FE	Fundamentals of Engineering Exam
HVAC	Heating, Ventilation, and Air Conditioning
IBC	International Building Code
IFC	International Fire Code
LWS	Lightweight Steel Construction
MEP	Mechanical, Electrical, and Plumbing
MQP	Major Qualifying Project
MWFRS	Main Wind Force Resisting System
NYC	New York City
NYCBC	New York City Building Code
O.C.	On Center
PE	Professional Engineer
PPE	Personal Protective Equipment

SARS	Severe Acute Respiratory Syndrome
UVB	Ultraviolet B
WHO	World Health Organization

1.0 Introduction

In late 2019, there was an outbreak of a novel coronavirus, a severe acute respiratory syndrome identified as SARS-CoV-2. The outbreak is believed to have originated in Wuhan, China and was designated as COVID-19 by the World Health Organization (WHO) in February 2020 (McIntosh, 2020). As several other countries began to report confirmed cases of the new virus, a public state of emergency was declared by the WHO in January 2020. By March 11th, COVID-19 had spread to the rest of the world and the WHO declared the coronavirus outbreak a global pandemic (Kantis, Kiernan, & Socrates Bardi, 2020).

On March 13th, President Donald Trump declared a state of National Emergency under the Stafford Act in the United States. Due to the influx of infected individuals, many hospitals reached capacity. In order to provide more beds for infected patients, emergency field hospitals were built around the country. However, due to a lack of planning and coordination of projects, many of these field hospitals went unused. Nevertheless, the ones that were occupied served as a powerful tool in patient care. The Javits Center field hospital in NYC, for instance, was implemented as NYC became an epicenter during the early stages of COVID-19 (Rose, 2020). Prior to converting the Javits Center, NYC hospitals had to make quick decisions on patients' level of infection and whether to admit them. This led to several patients not receiving the care they needed and amplified the spread of the virus from patients that were sent back home to their families (Salcedo, 2020).

Although the spread of an infectious disease such as COVID-19 cannot be entirely eradicated without a vaccine, preventative measures can be imposed to flatten the infection-rate curve. As observed from past pandemics, field hospitals or quarantine centers can play a significant role in accomplishing this goal. Oftentimes however, such projects take too much time to complete in a scenario where time is a matter of utmost importance. In order to reduce the overcrowding of hospitals during times like these, the design and construction process for emergency healthcare facilities must be altered to meet the needs of exponential contamination. If the world is to better prepare for its next pandemic, science and engineering must come together to provide a quick and flexible solution.

2.0 Background

2.1 Pandemics

Pandemics have occurred since the start of human civilization. From the bubonic plague, to tuberculosis and the most recent, COVID-19, communicable diseases have been continuously changing science and technology throughout the years.

2.1.1. COVID-19

Coronavirus (COVID-19) is an infectious disease caused by a newly discovered coronavirus (WHO, n.d.). Shortly after the WHO declared a public state of emergency due to COVID-19, several nations began to put some precautions in place. Initially, the virus was presumed to have originated from the consumption of exotic animals in Wuhan, China; China therefore placed a ban on the trade of wild animals and enforced travel restrictions in different cities. Additionally, flights were suspended to China, and some countries even closed their borders to highly infected nations. As each country was exposed to the virus, different reactions occurred, some more severe than others. Taiwan quickly closed its borders and banned the exports of surgical masks (Bemmer, 2020). Similarly, Singapore had an aggressive approach; they scanned ID's at supermarkets and implemented widespread testing (Bemmer, 2020). Iceland, on the other hand, decided to protect only the compromised while allowing the disease to run its course. The United States, like many other nations, decided to undergo a lockdown in an attempt to prevent the spread of the virus. The timeline of COVID-19 in the United States and its infection rate was different for each state. Therefore, states regulated their own lockdown procedures. Most defined essential workers and enforced stay at home guidelines for individuals not deemed essential (Kaiser Family Foundation, 2020).

After several months of battling the novel coronavirus under lockdown, research revealed more information about its transmissibility. It is now known that COVID-19 is an infectious disease that mainly spreads from person to person through respiratory droplets when they sneeze, cough, talk, or sing. These droplets can land in another person's eyes, mouth, or nose and be inhaled into the lungs, which is why the disease is most likely to spread when people are within 6 ft of each other (CDC, 2020b). The virus can also be transmitted by touching a contaminated surface, and then touching your nose, mouth, or eyes. In addition, airborne transmission of COVID-19 can occur under special circumstances including closed spaces, prolonged exposure to respiratory particles, and inadequate ventilation of ai handling that allows a build-up of suspended respiratory droplets and particles (CDC, 2020f). Given its rapid transmission, COVID-19 has been classified as highly contagious, and it has impacted the lives of many throughout the world.

Individuals with COVID-19 are more infectious in the early days of being exposed and are unlikely to spread the virus 7-10 days after being infected. Signs of infection can include, but are not limited to, fever, cough, shortness of breath/difficulty breathing, fatigue, muscle or body aches, loss of taste or smell, sore throat, congestion or runny nose, and nausea or vomiting (CDC, 2020e). It can take between 1-14 days for an infected person to develop any symptoms (CDC, 2020c). However, an infected individual may also experience some or none of these symptoms.

This novel coronavirus is threatening due to its asymptomatic victims, who can easily transmit the disease unknowingly. In addition, the lack of knowledge on the infection means that immunity is uncertain (UCI Health, 2020). SARS-CoV-2 (COVID-19) is similar to SARS-CoV-1, a flu-like animal virus identified in 2003 (WHO, 2020), but it can cling to cells more firmly and quickly. The virus attacks the lower respiratory tract, and it can lead to pneumonia. This causes the body to develop an inflammatory response, where it attempts to fight off the foreign cells. However, this immune response can lead to a cyclical overreaction of the body's immune system called a cytokine storm. A cytokine storm is considered a normal immune response when the response peaks early. However, about 15% of COVID-19 patients' immune response lasts longer than usual. This can cause severe lung, kidney and heart damage. So far, this overreaction has shown to cause severe illness or death (UCI Health, 2020). Despite these strange symptoms, not everybody is at risk. There is a higher fatality rate in people with compromised immune systems and adults over 70, while children and young adults are less likely to develop severe reactions.

The Center for Disease Control and Prevention (CDC) has developed a list of precautions to advise individuals on how to prevent the spread of this disease. These precautions include cleaning and disinfecting frequently touched objects and surfaces, washing hands often with soap and water, and utilizing hand sanitizer with 60% alcohol. People are also asked to avoid close contact with those that are sick and wear a mask in public settings (CDC, 2020d). These provisions have been proven beneficial in the larger scale, and it can highly decrease the spread from one stranger to the other. Other proven methods to control the spread of disease can be seen implemented for Tuberculosis outbreaks before the time of modern medicine.

2.1.2. Tuberculosis

As the COVID-19 outbreak became more prominent in the country during March of 2020, state governments began issuing stay-at-home orders. Imposed quarantine also occurred during Tuberculosis outbreaks. Tuberculosis (TB) is an infectious disease usually caused by mycobacterium tuberculosis bacteria (MTB). Isolation facilities known as sanatoriums (see Figure 1) were built in order to provide infected individuals with a place to quarantine. The first sanatorium was built 1875 and by 1904 there were 115 with the capacity for 8,000 patients (CDC, 2019b). These sanatoriums were established to mainly isolate contagious patients from their community, while allowing them to recover peacefully (Neklason, 2020). At the time, there were no vaccines, or any advanced medication used to treat Tuberculosis. Doctors instead recommended patients have plenty of access to pure air and get sufficient exposure to sunlight as a form of treatment. Patients were encouraged to avoid strenuous activity and to rest as much as they could (Hurt, 2004).

In order to categorize the level of risk and contagion of its patients, several Tuberculosis sanatoriums in the 1940's organized its patients into three categories, which were based on the progression of their disease (Grahn, 2015). Those who experienced more severe symptoms were placed in "hospital" wards and were advised to remain in bed. "Semi-ambulant" patients, or those with mild symptoms, were housed in separate wards that allowed them to be slightly more active. Lastly, those who were close to being cured, the "ambulant" patients, were placed in open air cottages away from the main hospital buildings. Separate wings were also constructed for dining, medical offices, and for housing sanitarium staff (Grahn, 2015). Although devised several years ago, the concept of separation and quarantine still applies to disease outbreaks today. The implementation of sanatoriums allowed for contagious patients to isolate themselves in order to prevent the spread of the disease to their community. Although fresh-air and sunlight alone may not cure a disease, studies have shown that natural light does have an impact in the well-being of the patient (Razzaque, 2018). Well-lit structures were erected during the Tuberculosis outbreak for this reason. However, given the knowledge and technology at the time, it was time consuming to build them. After the world's recent experience with COVID-19, it is clear that in the case of an outbreak, time is crucial. If the intention is to utilize quarantine centers to help combat such pandemics, these facilities must be assembled quickly.

Figure 1:Tuberculosis Sanatorium (Caminero, J.A., Matteelli, A., & Loddenkemper, R., 2013)

2.1.3. 1918 H1N1 Virus

The 1918 H1N1 virus, also known as the influenza virus, spread globally during the years of 1918-1919 (CDC, 2019). Today, it is considered to be the most devastating pandemic in recent history, killing more people than World War I (Billings, 1997). Although it is unclear as to where it originated, the H1N1 virus reached United States military camps in the spring of 1918. Within a week, the number of flu cases in the country quintupled. By the time it reached its peak, about one third of the world's population became infected with the virus and at least 50 million people died.

The severity of the 1918 H1N1 virus puzzled scientists for years. Unlike any past influenza viruses, which mainly affected infants and the elderly, H1N1 caused deaths in individuals of all ages. Overall, nearly half of the deaths caused by the 1918 flu were in young adults ranging from 20-40 years of age (Taubenberger & Morens, 2006). Those who were fortunate enough to avoid infection, however, were still required to follow the public health laws imposed to restrain the spread of the disease. In the United States, the public health department distributed gauze masks to be worn out in public (Billings, 1997). Additionally, some towns required a signed certificate of good health to enter. In some cities like Chicago, several businesses were closed, and public gatherings were prohibited (Jordan, Tumpey, & Jester). As three waves of the H1N1 virus swept throughout the country all within one year, a drastic alteration of lifestyle was called for.

Despite its extremity and unusual infection range, the consequences that were issued by the 1918 H1N1 pandemic did resemble those of previous and more recent outbreaks. For instance, the exponential spread of the virus resulted in overcrowded hospitals and a shortage of healthcare workers (CDC, 2019). Similar to COVID-19, medical supplies became scarce and priority treatment was given to higher risk patients. Additionally, burials were delayed due to a shortage of coffins and morticians (Billings, 1997). Although this was not a major issue within the United States during the peak of the 2020 pandemic, it did occur in other countries such as Brazil (Associated Press, 2020). Correspondingly, shutdowns and quarantine had to be implemented to suppress the further spread of disease. Overall, both in 1918 and in 2020, society was not prepared for the wave of infections that overwhelmed the healthcare system. Other preventative strategies, such as supplemental healthcare facilities, could have aided in the fight against these infectious diseases.

2.2 Quick Build Hospitals

Supplemental temporary health care facilities have shown to be a key factor in combating the issues that come with worldwide pandemics. The Xiaotangshan and Huoshenshan Hospitals are two examples of how prefabrication and modular construction was utilized in order to erect fully functioning hospitals in less than two weeks.

2.2.1. Xiaotangshan Hospital

In 2002, a coronavirus caused an outbreak of severe acute respiratory syndrome (SARS) in Asia. SARS and COVID-19 are similar in nature because they both attack the respiratory system. During the outbreak of SARS, the Xiaotangshan Hospital (Figure 2) was designed and constructed to assist with the care of patients infected with the virus in Beijing, China. The hospital was designed by Dr. Huang Xiqiu and constructed in 7 days (Da, 2003). In order to be built quickly, the construction utilized prefabricated panels; only the foundation was built on site. Dr. Xiqiu recommended that distance be increased, and sewage be considered early in design in any future projects, as those aspects were not fully developed during the Xiaotangshan Hospital design. He also recommended having a model in order to decrease construction time (Guoxiu, 2020). The main aspects of the Xiaotangshan Hospital to use in future quick build hospitals are prefabrication and early planning in order to quickly create a well-functioning hospital.

Figure 2: Xiaotangshan Hospital (Mingmei, 2020)

2.2.2. Huoshenshan Hospital

In late December of 2019, Wuhan, China was faced with a difficult situation. As the original epicenter of the COVID-19 pandemic, the city's healthcare system became overwhelmed as the number of cases rose to an all-time high (Luo, Liu, Li, Chen, & Zhang, 2020). In order to resolve this problem, the people of Wuhan turned to technology and prefabricated units to build an emergency specialty field hospital in just 10 days. The Huoshenshan Hospital (Figure 3) of Wuhan was modeled after the Xiaotangshan Hospital in Beijing (Holland & Lin, 2020). As thousands of workers operated through the night, modular units were lifted and laid on top of pillars to keep them off the ground. The assembly of the entire facility was made easier through the use of prefabricated units, which allowed for faster construction.

After its completion on February 2, 2020, the facility could accommodate one thousand patient beds and it contained 30 intensive care units, medical equipment rooms, and quarantine wards (Wang, Zhu, & Umlauf, 2020). Like in the Tuberculosis Sanatoriums, patients within Huoshenshan Hospital were categorized into groups based on the level of risk they posed (Holland & Lin, 2020). The form of the building, which consists of long rectangular wards branching out from a central axis, aided in this isolation from one another in order to prevent cross-infection. The center, which contains two separate channels, serves as a passageway for medical staff. In addition to its layout, each ward in the hospital has a negative pressure system, and the exhaust air is discharged outside after being disinfected (Holland & Lin, 2020). To maximize air cleanliness, an advanced ventilation system, several air purifiers and central oxygen supply systems were installed within the facility. All these technologies combined were a crucial tool in taking away some pressure from the overwhelmed healthcare system. The quick construction period saved precious time in providing high quality treatment to thousands of patients, and it was a key strategy in fighting the COVID-19 outbreak in Wuhan.

Figure 3: Huoshenshan Hospital (Mo, 2020)

2.2.3. Modular Construction and Prefabrication

The demand for quicker construction time, such as in the case of a pandemic, has caused engineers and builders to resort to prefabricated parts and modular units. Ultimately, the numerous advantages of modular construction have allowed for reduced construction time, since it occurs simultaneously with site work (Modular Building Institute, n.d.). In this case, weather delays are diminished, and projects can be completed in substantially less time. In addition to this, it can also be a greener and safer construction option. Since a factory-controlled process usually occurs in a closed environment, there is less material waste by recycling and managing inventory (Modular Building Institute, n.d.). Moreover, indoor construction also allows for reduced risk of accidents and liability for workers.

There are different types of prefab, including modular and panel built. Panel built prefabrication includes constructing the floor and lowering the different wall sections in place one at a time. Generally, commercial prefab buildings are constructed in this way because it allows for larger open spaces and higher ceilings (Vanguard Modular Building Systems, 2017). In modular construction there are permanent and relocatable buildings. Modular construction utilizes separate box modules which are transported from the offsite facility where they were constructed and are then pieced together on site. For permanent structures, they can be integrated into a site or can stand alone; this is generally used for multi-story buildings. Relocatable buildings are an option for temporary space. It is designed to be reused or repurposed multiple times (Modular Building Institute, n.d.). This quarantine center will be a relocatable building. The entire concept of the pandemic quarantine center is that it be built quickly and be able to be taken down when it is no longer in use and have its components be reused on another site or recycled.

In terms of the structural benefits of modular construction, building off site ensures better construction quality management. Since the modular parts need to be made to withstand transportation and craning onto foundations, they are also generally stronger than site-built construction. However, maximized strength is not the only structural benefit of modular construction. Given that buildings are usually assembled with prefabricated parts in modular technology, they can also be disassembled for relocation or reuse. This allows for greater flexibility within the design of the building and its purpose. In this case, it allows for limitless design possibilities. Currently, there are two different types of modular construction: permanent and relocatable buildings. With permanent modular construction, techniques such as offsite and lean manufacturing are used to create multi-story or single-story buildings. In this case, modules can be integrated into site-built projects or stand alone, and they can also be delivered with built-in MEP, fixtures, and interior finishes. Relocatable buildings, on the other hand, are fully or partially assembled. They are constructed in a building manufacturing facility and can then be transported to several different building sites (Modular Building Institute, n.d.). By utilizing a modular construction process, they are designed and built to be reused or repurposed several times. Relocatable buildings can be utilized for several types of facilities such as schools, medical clinics, and in any application where temporary use is needed. In cases where speed, temporary space, and relocation are crucial, this type of modular construction serves a great purpose.

2.3 The Built Environment’s Effect on Patient Recovery

Although quick-build hospitals can provide a fast and effective solution for treating patients affected by a pathogenic disease, they are often not designed with the patient’s mental and emotional health in mind. In the case of a pandemic, it must be considered how sunlight, ventilation, and other environmental factors can impact the overall well-being of a patient that is being asked to quarantine outside of their own homes for an extended period of time.

2.3.1. Sunlight

For many years, society has been aware of several beneficial impacts that natural light can have on human health. In actuality, human beings need exposure to sunlight for many reasons. One of these reasons is to acquire vitamin D, which about 80% of the required dosage needed in humans is generated by ultraviolet B (UVB) light (Razzaque, 2018). Not only does vitamin D tend to improve overall mood in humans, but it is also responsible for decreasing blood pressure and helping to regulate the immune system (Razzaque, 2018). In fact, a lack of vitamin D can result in several other health complications such as cancer, heart disease, diabetes, and asthma (Holick, 2010). The benefits of sunlight therapy were tested by a study done on patients with post-stroke depression, who were exposed to sunlight for at least 30 minutes per day for four weeks. Consequently, the study showed that sunlight therapy improved the mood of these patients and helped enhance daily activities and facilitate their recovery (Wang & Chen, 2020). In respect to COVID-19, another study conducted in Indonesia concluded that higher duration of sunlight exposure highly correlated to the recovery from the virus amongst patients (Asyary & Veruswati, 2020).

Although sunlight exposure has shown to have a significant impact on the health and recovery of patients, it can also play a role in the inactivation of viruses. Studies have shown that UVB levels, representative of natural sunlight, rapidly inactivates SARS-Cov-2 on surfaces (Ratnesar-Shumate et al., 2020). Although, having access to sunlight through ordinary windows is not sufficient, because generally UVB light does not pass-through windows. It is necessary for large openings to be present in-patient rooms so they can have direct access to this beneficial UVB light. The study also found that the rate of inactivation was highly dependent on the intensity of sunlight exposure and in addition to COVID-19, similar deactivation results were witnessed when exposing the influenza virus to natural sunlight (Shuit et al., 2019). The outcome of these specific studies has only emphasized the importance of natural light exposure when combating a pandemic. In this case, ample access to sunlight should be available to infected patients to improve their overall wellbeing and aid in their recovery.

2.3.2. Ventilation & Air Quality

In the midst of a pandemic caused by an airborne virus, the circulation of air throughout a building, especially a hospital, is an essential factor. Ventilation plays a crucial role in the transmission of infectious agents (Li et al., 2007). In fact, studies have shown that "ensuring even minimum levels of outdoor air ventilation reduced the transmission of the flu by as much as having 50-60% of the people in the building vaccinated" (International Well Building Institute, 2020). Although not enough studies have been conducted to determine exactly how much ventilation would be considered "minimum" amounts, several cases have outlined the impact of poor ventilation on the spread of disease. In fact, a study by Hoge et al (1994) has shown that higher rates of disease in an epidemic of pneumococcal illness were found in jail cells with crowding and poor ventilation. In addition to quantity when it comes to ventilation in a building, the pathway of air flow is also crucial. Based on research conducted by engineers through the past years, there is plenty of evidence of the transportation of pollutants in buildings by airflows (Li et al., 2007). Therefore, the amounts of ventilation and direction of airflow should be strictly controlled between rooms within a hospital facility.

In addition to ventilation, the quality of air within a built environment can also impact disease transmission. In fact, adequate air filtration and UV air treatment, along with humidity control within an enclosed space can play a role in the survival of viruses. In terms of humidity, high relative humidity has shown to be effective in decreasing infection rate (Li et al., 2007). The reason for this may be that cilia lining the body do not function as well in dry conditions, impairing their ability to repel viruses as they normally would (Sandoiu, 2020). As a matter of fact, a study done on mice infected with influenza has shown that the rodents kept in environments with 10-20% relative humidity were overcome by the virus more rapidly than those kept in an environment with 50% relative humidity (Sandoiu, 2020). For this reason, in the case of a healthcare facility, advanced mechanical systems and new technologies must be incorporated to promote patient health and prevent cross-infection.

2.3.3. Other Environmental Factors

Through the years, studies have shown that an individual's surrounding has a strong impact on that person's well-being. Several components of an interior environment can play a part in altering the way a person feels. Colors, for instance, have shown to influence the emotional state of the observer (Wilms & Oberfeld, 2017). In fact, arousal rates appear to increase with brightness, with red and green being the most arousing colors. Achromatic colors, on the other hand, have shown to have the opposite effect. Restful and non-irritating color schemes can play a role in decelerating heart rate (Color in hospitals.1949). Lighter shades of green and blue, for instance, rank best among patients and hospital staff (Dalke et al., 2006). The use of these colors has also shown to promote relaxation as well as better sleep. Color, however, is not the only visual component that can be implemented in hospitals to improve the mental state of patients. Visual images, especially of nature, can serve therapeutic purposes (Nanda, Eisen, Zadeh, & Owen, 2011). Based on former patient responses from an extensive survey discussed by (Nanda et al., 2011), access to nature views was identified as one of the most important factors of the hospital environment. Whether it is through real or synthetic plants, paintings and natural views, or electronic displays, access to nature has proven to have a positive impact on the emotional soundness of individuals.

In the case of a national emergency, like a pandemic, the question of why emotional health should be prioritized within health care facilities can be a controversial topic. In this case, experts may argue that the sole purpose of a temporary hospital facility is to treat the select disease, such as COVID-19. However, both positive and negative emotions have been distinctly associated with health and disease outcomes (Trudel-Fitzgerald, Qureshi, Appleton, &

Kubzansky, 2017). To illustrate, previous research has proven that anxiety and depressive symptoms correlate with increased risk of developing diabetes, coronary heart disease, stroke and obesity among initially healthy adults. Additionally, numerous studies have also linked dysregulated emotion to higher inflammation levels (Trudel-Fitzgerald et al., 2017). Given this, a patient's emotions must be managed carefully in order to ensure physical well-being, which in turn promotes a quick and effective recovery.

2.3.4. Designing for the Wellbeing of Patients

Recognizing that the interior environment can have a significant impact on the health of patients is a key step in adopting design strategies for their wellbeing. According to the WELL Building standard (version 1), there are several steps that can be taken to support the fight against disease outbreaks, such as COVID-19. A few of these strategies include supporting movement and comfort, strengthening immune systems, and fostering mental resilience (International Well Building Institute, 2020). In terms of providing comfort and strengthening immune systems, several strategies that were previously mentioned, such natural and artificial ventilation along with sunlight exposure can trigger positive emotions in people. Exposure to more natural light has several health benefits, such as boosting vitamin D, warding off seasonal depression, and improving sleep (Garone, 2020). For areas within a building where natural sunlight is not sufficient, even artificial lighting strategies can be implemented to promote the health of its occupants. Hence, circadian light design can provide appropriate exposure to light for maintaining circadian health and aligning the circadian rhythm with the day-night cycle. Correspondingly, scientists have discovered that long-term exposure to specific wavelengths of blue light can have a negative impact on the production of melatonin (Knoerzer, n.d.). By manipulating the intensity and color of the artificial lighting within a building throughout the day, the natural lighting cycle can be mimicked indoors to improve the happiness and comfort of the occupants. Along with light exposure, other effective design tactics can be carried out in order to promote the wellness of the inhabitants. As previously mentioned, a connection with nature or natural features, such as plants, can be implemented to improve overall mood and reduce stress. Natural colors and materials, such as wooden furniture or finishes, can also play a role in achieving this result. Therefore, implementing such strategies while keeping the importance of ventilation, sunlight, and other environmental factors into consideration can have a positive impact in the mental state and recovery of patients.

2.4 Project Significance

The occurrence of another global pandemic is inevitable. As seen throughout history, there have been several cases where a disease has been prevalent over the majority of the world. Time and time again, the world has been unprepared to handle the influx of patients needing to be hospitalized. One aspect that has remained the same in all these instances is the need for more locations where the mildly sick can recover without risking the lives of those close to them.

In any emergency, time is of the essence. In the case where a disease is rapidly spreading throughout the world, it is imperative that everything that is being done to minimize the impact is completed promptly. The use of modular prefabrication will allow for the quickest and most efficient build. The preparation of the site and the construction of the modules will be able to occur simultaneously. Modular prefabrication will be the most time efficient choice for a quarantine pandemic center. Taking away the complexity of a traditional building but incorporating operational and health considerations will be required in the extreme case of a pandemic.

The purpose of this report is to propose a design of a center where those exposed to the current pandemic can be monitored for the duration of their exposure. This quarantine center would also cater to the patients in terms of mental health. It would incorporate design aspects that would fit the general requirements of maintaining safety in the event of a global pandemic, as well as feature components that would promote wellness of the patients. Aspects such as color, nature, and exposure to sunlight and fresh air are all essential to a quick recovery. Similarly, the quarantine center will circulate clean air, practice social distancing in its communal spaces, and have a thorough cleaning and disinfection plan. A quarantine pandemic center will fill the current void for temporary centers for the moderately ill to seek refuge and care while minimizing the spread of infection.

3.0 Methodology

Designed a Flexible & Modular Pandemic Facility

The goal of this project was to work towards a flexible and effective design solution for a facility meant to be utilized in times of a pandemic. To achieve the overarching goal, the following objectives were completed, also shown in Figure 4 below:

1. Conducted research and acquired information on relevant topics, such as past pandemics and current hospital design, which aided in better understanding the specifications for designing such a facility.

2. Gathered feedback from hospital employees and former COVID-19 patients in order to better understand their experience and their judgement of the hospital environment in which they work/stayed in. Feedback was acquired through WPI Qualtrics surveys in order for participants to remain anonymous.

3. Developed a final design for a modular facility based on the research and gathered feedback.

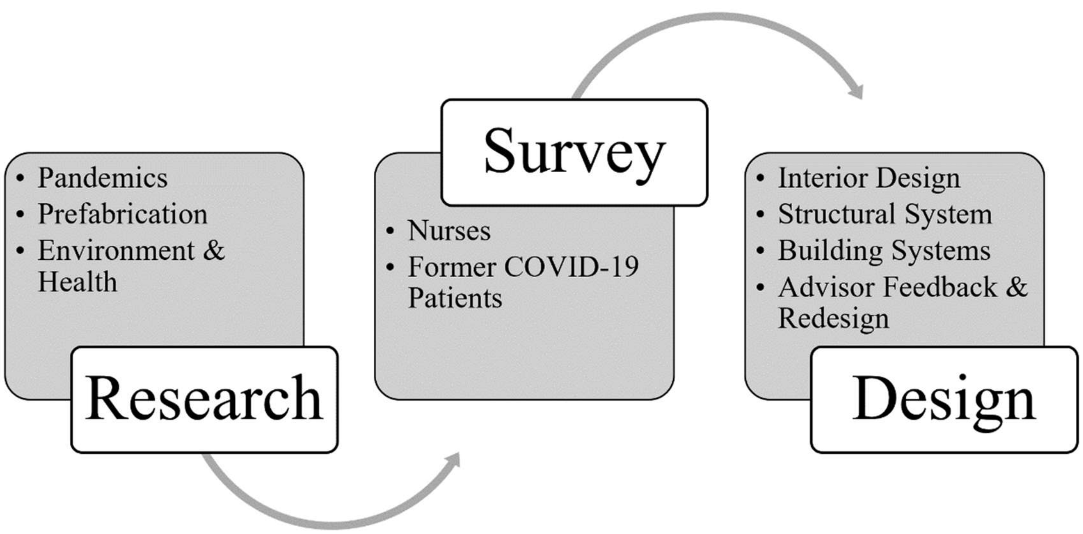


Figure 4: Methodology Steps

Conducted Research on Relevant Topics

The first step that was taken was to gather adequate information on topics of interest to facilitate the design process. This research was meant to enhance the overall understanding on pandemics and how quick-build facilities behave in accordance with the outbreaks. The following topics were reviewed and analyzed accordingly:

- Past pandemics
- Prefabricated structures
- Examples of quick-build hospitals
- Effective MEP systems
- The impact of the environment on health
- Innovative building materials
- Possible sites for the project and their respective zoning laws

Gathered Feedback from Hospital Employees and Former COVID-19 Patients

The second step which was taken to achieve the project goal was to consult with roughly 50 hospital employees and former COVID-19 patients, in order to obtain a greater insight on their experience. To better understand hospital conditions during a pandemic, it was important for outsiders to gather feedback from those who have encountered such a case. This feedback aided in making critical design choices later in the process, since the aim was to create a space that will not only address a worldwide problem but will also cater to those who are inhabiting the facility.

In order to complete this objective, an anonymous Qualtrics survey, as seen in Appendix A, was sent out to individuals within the community through email or social media. Depending on whether the participant identified as a hospital worker or former COVID-19 patient, they were taken to different sections of the survey. An announcement was made on several Facebook pages/accounts with a link to the surveys asking people to participate in the study. The survey addressed living and working conditions within the space, along with any emotions associated with the situation. The results from the surveys were then analyzed and discussed. This feedback was considered during the design process for the facility. The final survey results are discussed in Chapter 4.

Developed a Final Modular Facility Design

The third step was to develop a design for the modular facility. Once the site was established and the construction type determined, the chosen concept was referenced to generate different forms for the facility. Although the purpose of this project was to provide flexibility in design, a specific form was chosen to provide a more accurate and detailed final project. A program was then established, which helped to determine a final form. Once the form was chosen, a solar study was performed and a preliminary floor plan for the facility was drafted. The primary drafter coordinated with other teammates in order to design in accordance with the 2018 International Building Code. Once the floor plan was established, specialized structural and MEP systems were established for the facility. Lastly, the interior design of the space was carefully pieced together with the intention of creating a natural-feeling and welcoming space.

Overall, the intention was to design a modular pandemic facility that could be easily constructed, reduced, or expanded as necessary. Providing a flexible and effective design is crucial in order to help underwhelm hospitals that have reached maximum capacity and to provide that critical separation between infected patients and other individuals. Lastly, the design also aimed to provide a more pleasant experience to those inhabiting the space, despite the difficulty of the scenario. The efficacy of the pandemic facility was analyzed by the team and the advisors based on these factors.

4.0 Survey Analysis

In order to gain more insight on what was important to include in the proposed design, a survey was administered to both hospital workers and former COVID-19 patients. The responses from hospital workers were to gain a better understanding of common precautions taken in different hospitals. The answers would also be helpful in determining what healthcare workers felt was needed for them to do their job safely and efficiently. The information would make it possible to implement strategies that work and improve the proposed design. Similarly, the input of former COVID-19 patients was sought in order to learn from their experiences in hospitals during their stay. Since one of the aims of the project is to ensure that patients are comfortable, the questions presented to them were to better understand what was ineffective in the facility that they stayed at and what they felt would have improved their experience.

The distributed survey acquired seven usable responses. In total there were thirty responses, however, many participants submitted the survey without any of the questions filled out. These empty responses were removed from the exported results report; the full list of responses can be found in Appendix B.

All the useful survey results came from hospital workers. The questions which were directed towards them were to determine protocols in place at their place of work that could be implemented in our design. In addition, they also provided more ideas on how to design a facility that would cater to a patient's mental health.

Q1: What new precautions has your hospital taken?

The responses to this question generally included always wearing masks and eye protection, as well as having access to hand sanitizer. One response also mentioned the modification of waiting rooms to adhere to social distancing. In one hospital, gowns were provided to COVID-19 precaution patients, visitors were limited, and COVID-19 testing was made available to patients and staff.

Q2: Do you feel safe with these precautions in place?

For this question, 71.43% of hospital workers answered that they did feel safe with these new precautions in place. Those who answered no attributed it to the uncertainty of knowing if someone had COVID-19 and was asymptomatic. They would also have preferred that the hospital they worked at used face shields and N95 masks instead of surgical masks.

Q3: What new procedures have to be followed?

The new procedures set in place were using N95 masks with any aerosolizing procedures, such as intubations or nebulizer treatments. In general, extra personal protective equipment (PPE) was to be used when necessary and extra cleaning/disinfecting protocols were implemented.

Q4: Do you feel there has been an impact on a patient's mental wellbeing with the new precautions in place? If so, how?

Most who took the survey agreed that the mental wellbeing of patients have been impacted because of the new precautions. Several hospital workers responded that they feel that one of the big issues facing patients is the inability to interact with them in the same way. The strong limits on the visitor's policy and the reduced interactions with hospital staff has left patients frustrated. One hospital worker reported that patients are visibly uneasy seeing the medical team in full PPE and that one-on-one interactions are necessary because they provide the patient and family support and reassurance.

Q5: Do you feel like there is enough space for you to work while maintaining socially distant? (i.e., is there enough room for multiple people to go down a hallway?)

Four out of the seven responses for this question indicated that there was not enough space for hospital workers to maintain socially distant. One person answered that there is no way to be six feet away in the nurses' station and they are "crammed together like always." Another hospital worker described that the physician areas had up to fourteen people in a 5' x 30' workspace. They also mentioned that equipment often crowds the hallways. In addition, teams doing "standing rounds," which is when they discuss their plan for the day outside of a patient's room, also crowded hallway spaces.

Q6: Can the layout of your workspace be improved to better the safety of both workers and patients? If so, how?

In about half of the responses, the staff answered that they did not feel their workspace could be improved. One respondent attributed this to the lack of available square footage in the hospital that they work at. The remaining responses said their workspace could be improved by having more space in any of their work areas.

Q7: Aside from medical treatment, what else do you feel a patient needs to have an efficient recovery? (i.e., sunlight, space, nature, visitors, etc.)

There was almost a consensus among the responses that natural light is needed for an efficient recovery. Another response indicated that if a patient were to share a room, that it should be large enough to allow space for both beds. Most of them also felt it was important that the rooms be well ventilated and that patients are able to socialize to keep their mind off their diagnosis.

Overall, what was taken away from the survey results is the need for space, sunlight, socialization, ventilation, and sanitization within healthcare facilities. In the architectural design chapter, the specifications for the single person rooms and the ample opportunity for sunlight were outlined. The room also features a balcony where patients can have access to fresh air and potentially socialize with other patients surrounding them at a safe distance away. The rooms also feature sanitation stations for when hospital personnel have to interact with patients; these stations can also be found in other locations all around the hospital. For the workers, the design incorporates large hallways and one-way traffic to minimize crowding. Nurses stations were also increased in size to allow for social distancing. This factor also extended to break rooms and other workspaces. Overall, the survey helped to ensure that the architectural design incorporated the needs of the personnel that would ultimately be utilizing the facility.

5.0 Architectural Design

The overall architectural goal of this project was to utilize modular technology and prefabrication techniques to develop a flexible design for a quarantine facility that could be assembled quickly on a variety of different sites. By utilizing COVID-19 as a reference, the plan for a temporary quarantine center was designed, with the intention of housing patients with mild symptoms. The facility was hypothetically placed in NYC, since it initially was a COVID epicenter in the USA. The design process evolved from several different conceptual ideas.

5.1 Concept

Necessary aspects to implement in the design of the project were brainstormed in the early stages of design. Based on the research conducted about the temporary quick-build hospitals in China, it was determined that flexibility in design was a crucial concept to include. In the case of a medical emergency, the quick construction of a healthcare facility is necessary to help combat the disease in a timely fashion. To facilitate this, the use of prefabricated modules was chosen as a key design strategy. Modular construction allows for the completion of a project in a shorter time frame. In addition, it also allows for easier separation between different sections of the facility. Patient areas can be separated from more general employee areas and the flow of traffic within the building can be easily controlled.

Although modular construction facilitates several technical aspects, it reduces the possibility of a more creative design. Nature, colors, and sunlight were key aspects that could be included in the design to improve the overall health and recovery of the occupants. Based on the WELL standards for health and safety within a building, exposure to nature and sunlight has a significant influence on the wellness of humans (International Well Building Institute, 2020). Given this, it was believed to be in the best interest of the occupants for the building to be positioned in an area surrounded by nature and with access to ample natural light. Considering these aspects, the concept of building blocks was deemed to be a promising solution for this project. The thought process behind this outcome can be summarized in Figure 5.

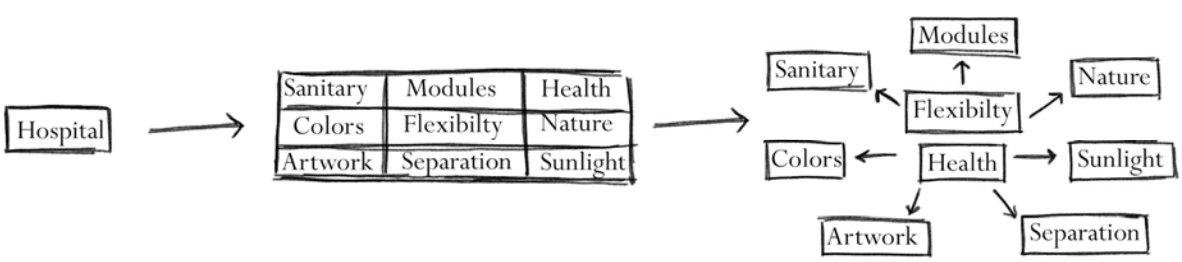


Figure 5: Concept Thought Process

As shown in Figure 5, the process began by determining what factors were crucial for the design of a conventional hospital facility. In normal conditions, health and sanitation are two of the most important elements. For the purpose of this project, other components were incorporated into the concept in order to reach the desired objective, as previously mentioned. In this case, modular construction accounted for flexibility in design and separation of patients from staff. In addition, color, artwork, nature and sunlight promote the well-being of the occupants in the building. The final concept of these individual factors being modeled together to form a structure can be summarized in Figure 6 below.

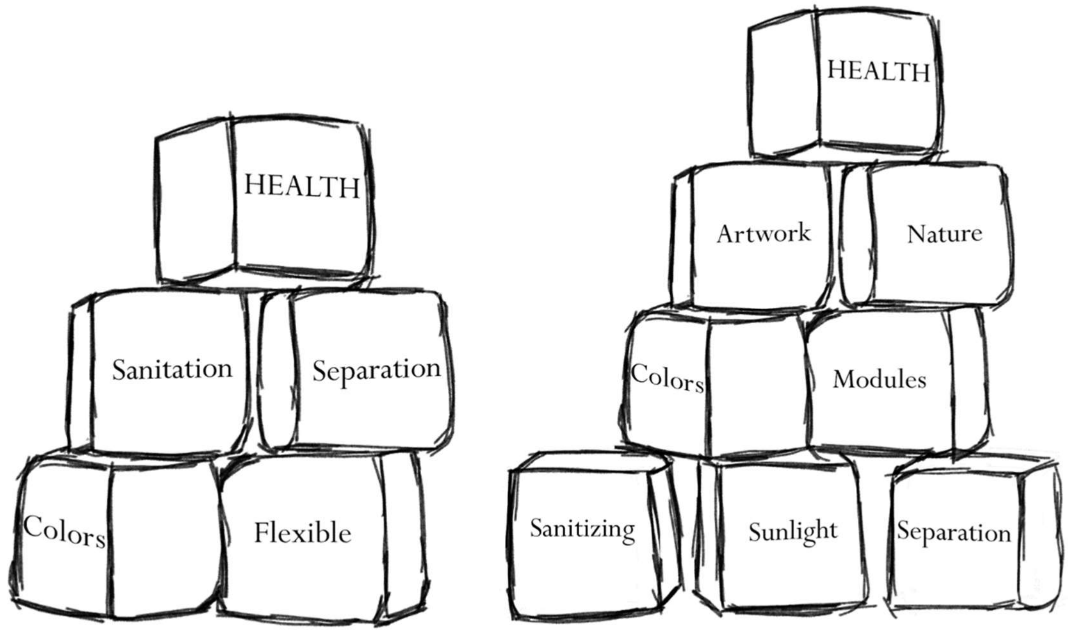


Figure 6: Building Blocks Concept for Staff (left) and Patients (right)

The concept of building blocks can also be applied to the assembly of the facility. The individual modules will be assembled offsite and outfitted with all the major components, such as the structural framing, building envelope, and the electrical system already installed before arriving. Once completed, the modules will be transported to the site and set down in place. Afterwards, exterior elements such as ramps and railings will be installed at all exits/entrances for accessibility requirements, then the remaining building systems installed. Finally, after all these systems are in place, all the associated furniture will be brought into the building. At this time, the building would be ready for use. Depending on the urgency of the center, the building can be occupied before the installation of the facade and other less critical components.

5.2 Site

When the COVID-19 outbreak hit the United States, several large cities became hotspots for the virus. Amongst those epicenters was NYC, due to its highly dense population and great deal of tourism. Within highly developed cities like New York, however, there is usually a lack of empty space to place a large temporary facility. Given this, Central Park was chosen as the site for this project. Placing a temporary facility within a city park serves several benefits, such as the desired exposure to nature and natural light. In the case of New York, Central Park is one of the few areas that is not entirely shaded by skyscrapers and it contains various locations composed of open grass space. Amongst its expansive grounds, East Meadow, located in the upper-east side of the park, was found to be a more desirable location. Containing 106 acres of mostly flat landscape surrounded by a few bushes and trees, East Meadow is also situated directly in front of Mount Sinai Hospital (see Figure 7). In the event that a patient requires more extensive medical care, said patient can be quickly transported to the hospital for adequate care. In addition, East Meadow is easily accessible from 5th avenue, which is beneficial during construction. Construction machines are more easily able to access the location from the street or pedestrian walkway that surround the site.

Figure 7: Map of Chosen Site (MIF, n.d.)

A site analysis was conducted in order to determine the site-specific components. NYC lies in a Humid Subtropical climate zone, meaning that its summers are warm and humid, and its winters are cold and windy. Average temperatures in the area are 33°F in the winter and 76°F in the summer. Despite the variation of temperature during those seasons, temperatures rarely fall below 15°F or exceed 92°F. Additionally, Central Park lies within a metropolitan area and wind speeds average from 6 to 10 mph. Hence, a design for a facility within this site would have to consider these high and low temperatures, a considerable amount of precipitation, and snow and wind loads acting upon the building.

In terms of soil composition, most of the areas within the chosen site is composed of sandy loam, which consists of a mix of sand, silt and clay (National Cooperative Soil Survey, 2017). Despite its more level-sloped landscape, the soil is well drained and easy to work with. Regardless of the soil's workability, it became apparent that utilizing a raised foundation, which is further discussed in the Structural Design section, would be less intrusive to the chosen site.

5.3 Form and Program

After selecting a site, the development of a form and program for the building was initiated. Abiding by the concept of modular construction, it was decided that this quarantine facility would be composed of 12' by 27.5' rectangular modules, each of which would be twelve feet high. In this case, separate singular modules would make up the patient rooms, employee bathrooms etc., while larger spaces would be composed of two or more modules assembled. This approach would allow for each module to be prefabricated in a factory while the foundation and site preparations are being developed. Consequently, this would enable simpler and faster assembly. With each rectangular module acting as a building block, there were several layouts the facility could take. Despite the many possibilities and flexible design options offered by the modular approach, the Huoshenshan Hospital in Wuhan, China was referenced. Since the design of this hospital focused on separation and the controlled flow of air and people, it made sense to adopt a similar form. The final form consists of a large rectangular center with smaller modules perpendicularly branching out from the main hallway space.

The program was established in accordance with the building form. Given each team member's inexperience in the medical field, current hospital employees were consulted in order to acquire a better idea of what is typically included in a healthcare space and how the staff collaborate. An approximated number of occupants per floor was then estimated given their survey responses and conducted research. Based on the idea that each patient in quarantine would have their own designated room, a total of 38 patients per floor was estimated. According to National Nurses United's proposed 1:5 nurse to patient safe staffing ratio, 8 nurses per floor were approximated, along with other hospital staff such as doctors, food service and janitorial staff, receptionists, technicians, pharmacists and IT. The specific number for the personnel were determined based on the total number of patients per floor. Given this, a total of 68 occupants per floor were estimated. Based upon the number of occupants and their specialized spatial needs, an initial program was laid out consisting of patient rooms with built-in bathrooms and balconies, offices, nurses' stations, break rooms, kitchens, storage space and other specialized areas. The detailed program with exact square footage can be found in Figure 8 below.

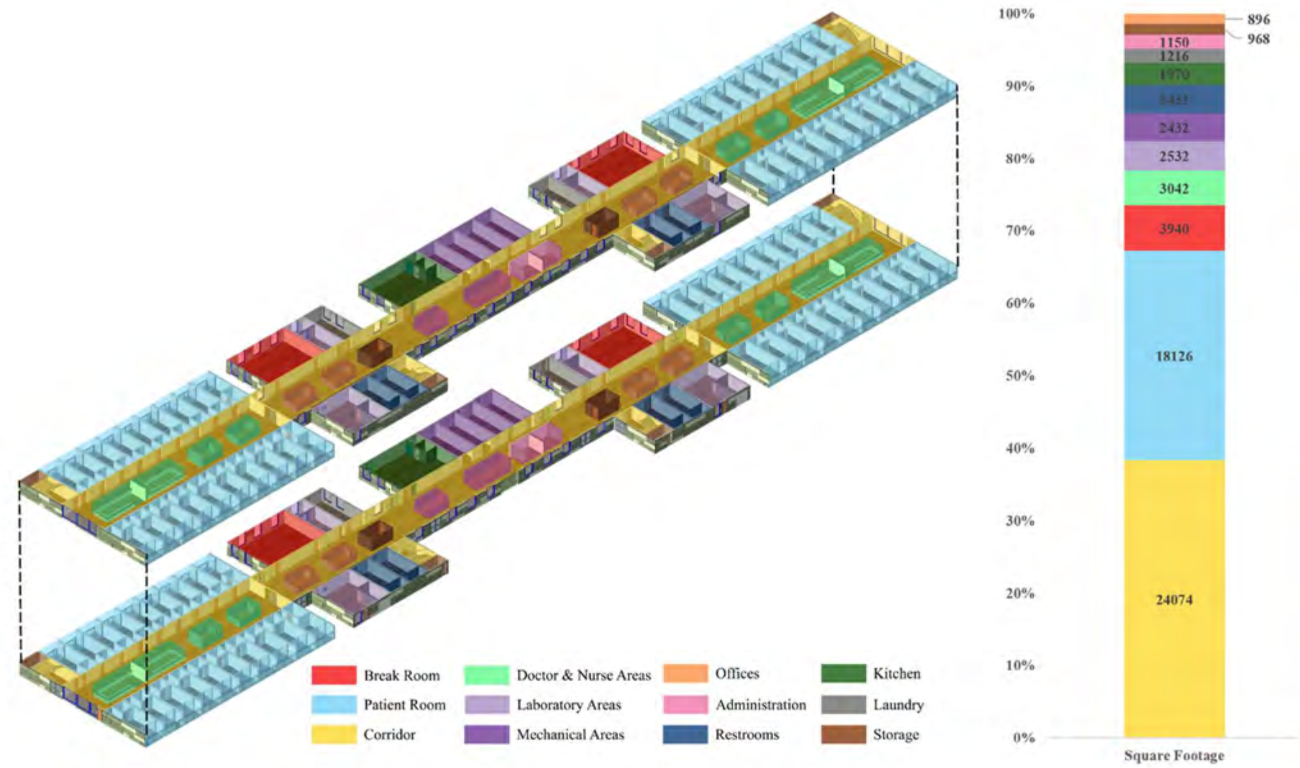


Figure 8: Program Graphic

5.4 Solar Study and Daylighting

After finalizing the building form, a 3D model was established in Revit. Revit is a 3D building information modeling software; it allows for designing building components, visualizing design intent, and collaboration between project contributors. One of the features on Revit allows for the analysis of sun position and solar effects. Using this component, a solar study was undertaken to determine if the facility received enough natural light and if any drastic changes needed to be made to the form. An initial floor plan was drafted in Revit based on the program. The form of the building was then placed in its exact geographical location and orientation within East Meadow in Central Park, New York. The sun and shadow commands available in the Revit software were used to model the path of the sun throughout the day, in the winter and summer. This solar study revealed which sides of the building received the most direct sunlight, as shown in Figure 9, and allowed for investigation of the orientation in which the facility would receive optimal amounts of natural light.

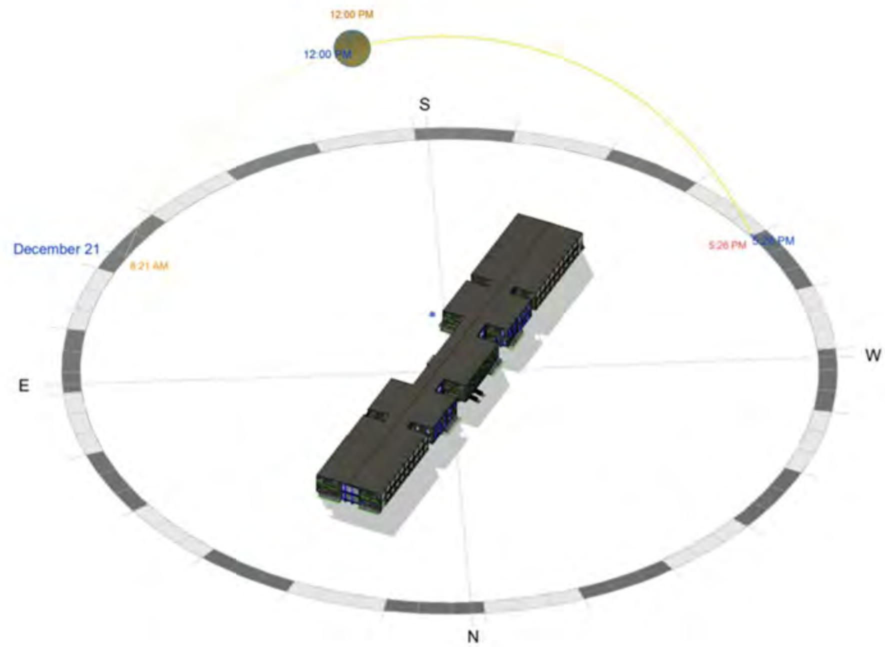


Figure 9: Sun Path Diagram – Winter Solstice

Along with determining an appropriate orientation, the solar study also aided in the placement of windows and other glazing throughout the facility. Large windows were placed in spaces that were meant to be more frequently occupied. Within the main hallway, a series of double-pane windows were implemented to allow for natural light to enter the space. More windows were also placed within the spaces where multiple modules came together and along the lateral side of specific rooms such as the labs, lounge areas, and offices. After placing the fenestration, it was evident that the medical wings on each side containing the nurses' stations received much less natural daylight. Other strategies were then implemented in order to improve the inadequate lighting situation in the east and west medical wings. For example, the height of the windows was increased to allow for more light penetration into the hallway. In addition, lighting shelves were incorporated to reflect light deeper into the hallway, as seen in Figure 10.

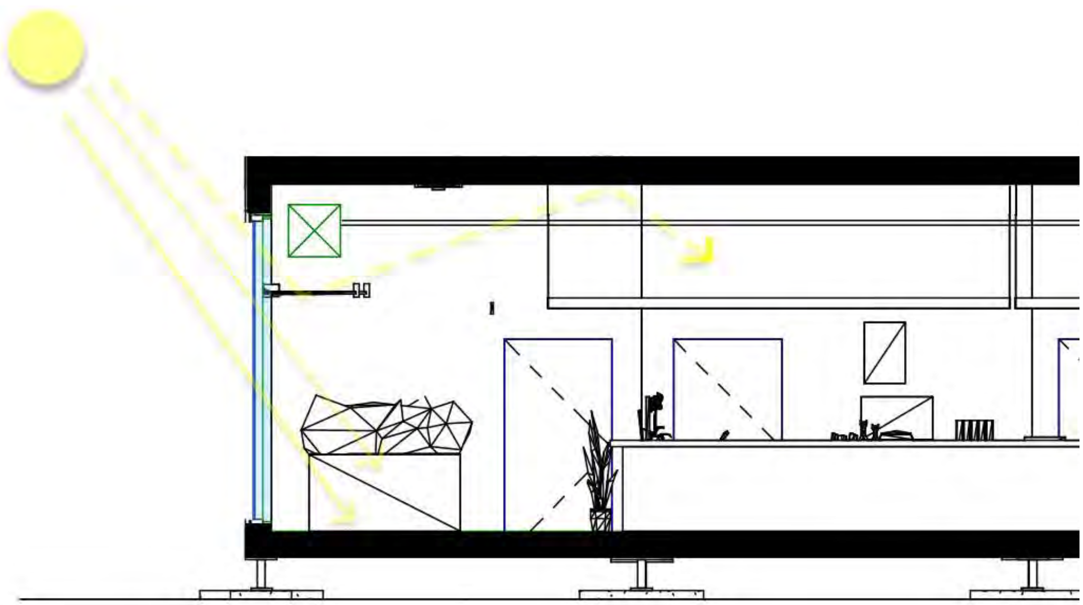


Figure 10: Light Shelf in the Hallway

Within the patient rooms, a large sliding glass door allows for an abundance of light to enter each module as shown in Figure 11. Using the Climate Consultant software, the effect of shading in the patient rooms was analyzed. Climate Consultant is a computer program that translates raw weather data from thousands of weather stations into graphics. Figure 12 shows the sun shading from December 21 to June 21, the shortest and longest days of the year. The image depicts the shortest day of the year having the lowest bearing and altitude angles throughout the entire day. According to the legend, the graph also shows that during this time until about March, the temperature will be cool/cold. After March, the temperature varies from cool in the early morning to comfortable in the day and back to cool at night. This pattern is similar until the graph gets closer to June. During the longest day of the year, the graph depicts the highest bearing and altitude angles of the sun which coincides with the temperature being warm/hot for most of the day. From this graph, it was determined that a shading mechanism would be imperative in the design of the rooms and hallways. In the winter, the occupants would benefit from the large glass sliding door that would let in as much sunlight as possible. In the summer, the occupants can implement the shading mechanism to escape from the heat.

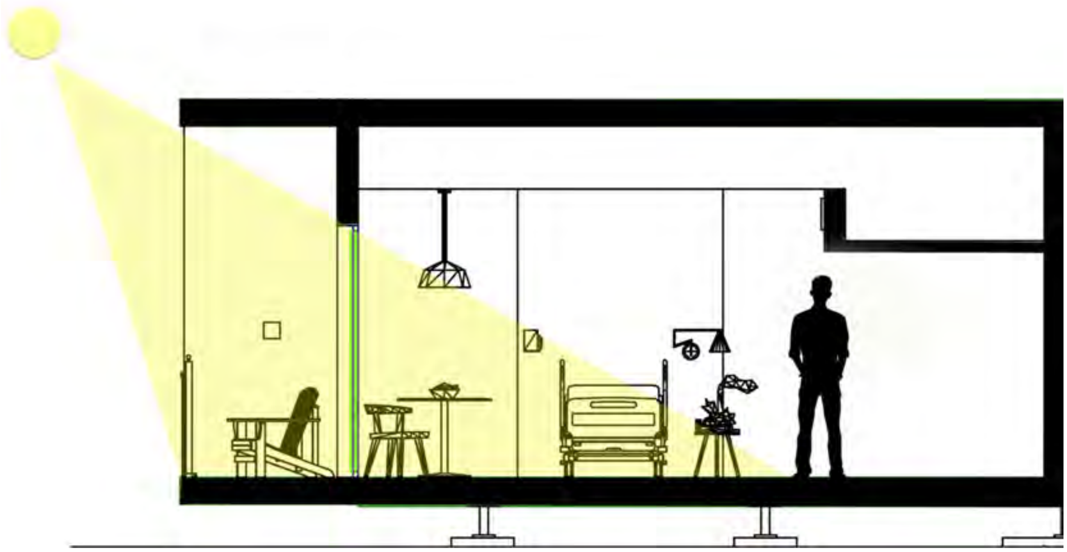


Figure 11: Lighting in the Patient Room

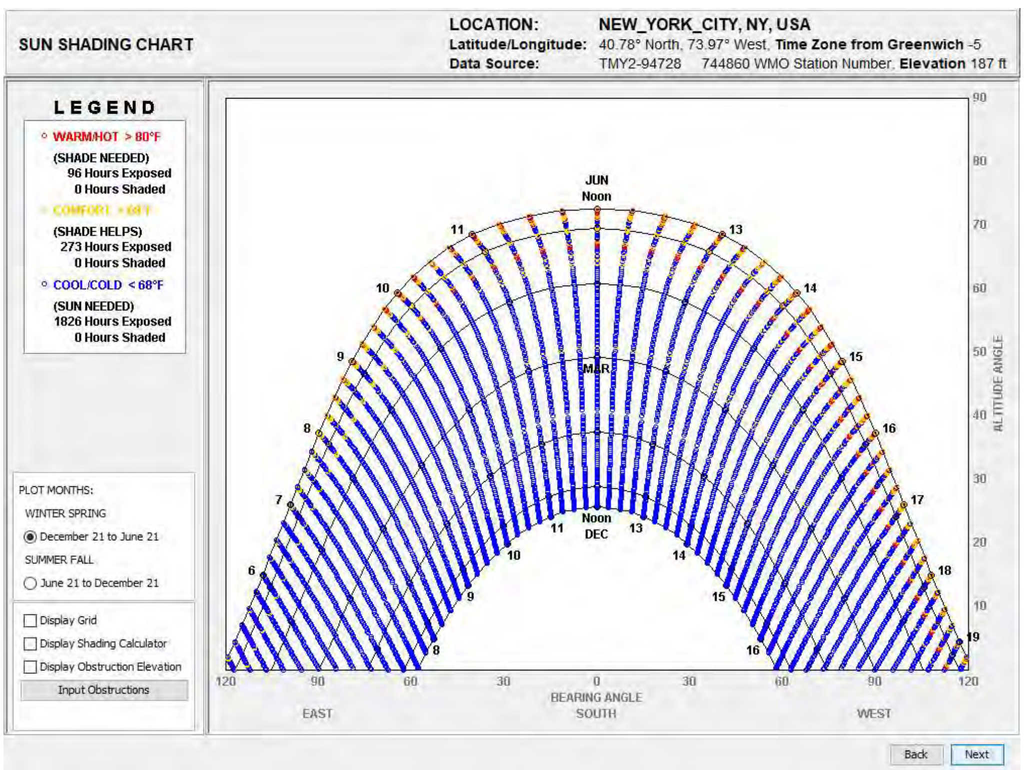


Figure 12: Sun Shading Chart

5.4.1. DesignBuilder

DesignBuilder is a software that calculates and simulates building energy consumption using analytical methods. This software provides a user-interface for EnergyPlus, developed by the US Department of Energy. This program was also used to conduct a daylighting analysis to ensure sufficient lighting in the patient rooms. To complete the analysis, the building form had to be recreated in DesignBuilder. Material properties such as reflectance and transmission were taken from the project's design materials and/or average design values.

In addition to analyzing the quantity of light in the patient rooms, the impact of the orientation of the building was also evaluated. Three different orientation angles were investigated. These included (i) having the building parallel to 5th Avenue (300 degrees), (ii) rotated ten degrees clockwise relative to 5th Avenue (290 degrees), and (iii) ten degrees counterclockwise relative to 5th Avenue (310 degrees). The daylighting simulation was run on DesignBuilder for the three rotations at 12:00 PM on the Winter Solstice (December 21st). As expected, there was little to no variation in the quantity of daylight due to the small changes in building rotation (See Figure 13). Due to the slight variations, it was decided to keep the building parallel to 5th Avenue in order to minimize disruptions to the site and follow NYC's grid lines. After determining the rotation of the building, the quantity of daylighting was analyzed in more depth.

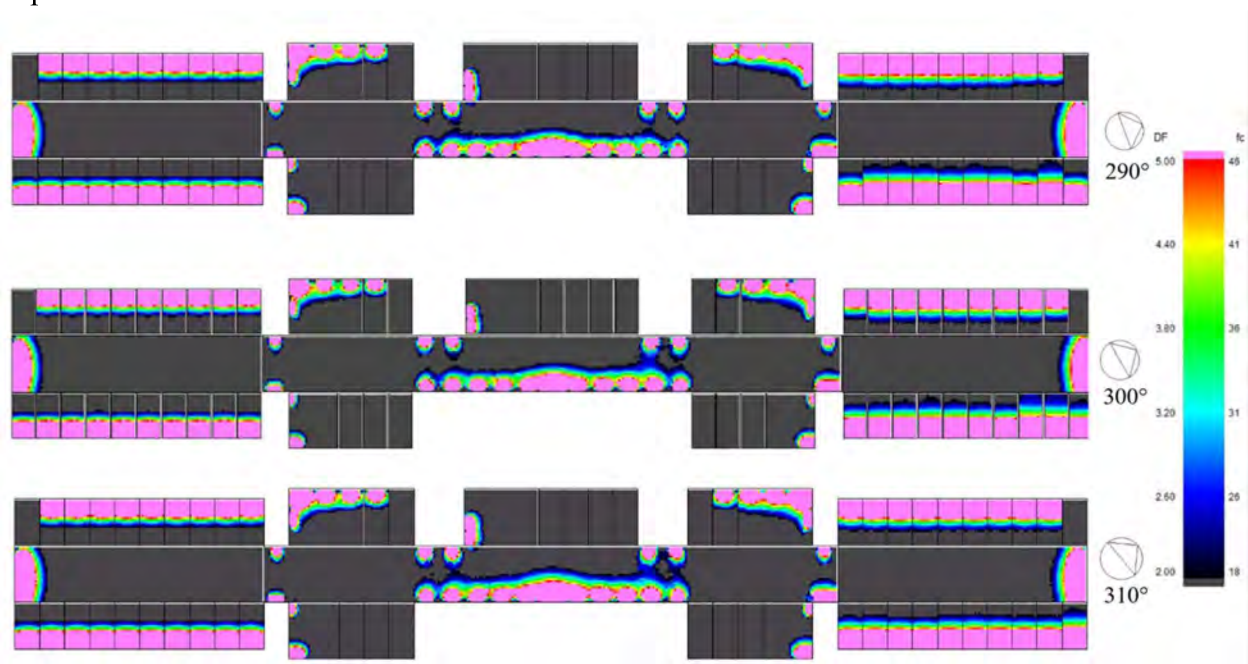


Figure 13: Design Builder Analysis

By overlaying the DesignBuilder calculation map with the floor plan of a patient room, it is shown that on either side of the building a sufficient amount of daylight (around 20 foot-candles) reaches the patient beds (See Figure 14). The design of the patient rooms encourages occupants to spend most of their time within the space between the bed and the sliding glass door. Therefore, it was determined that there was sufficient daylighting in the patient rooms.

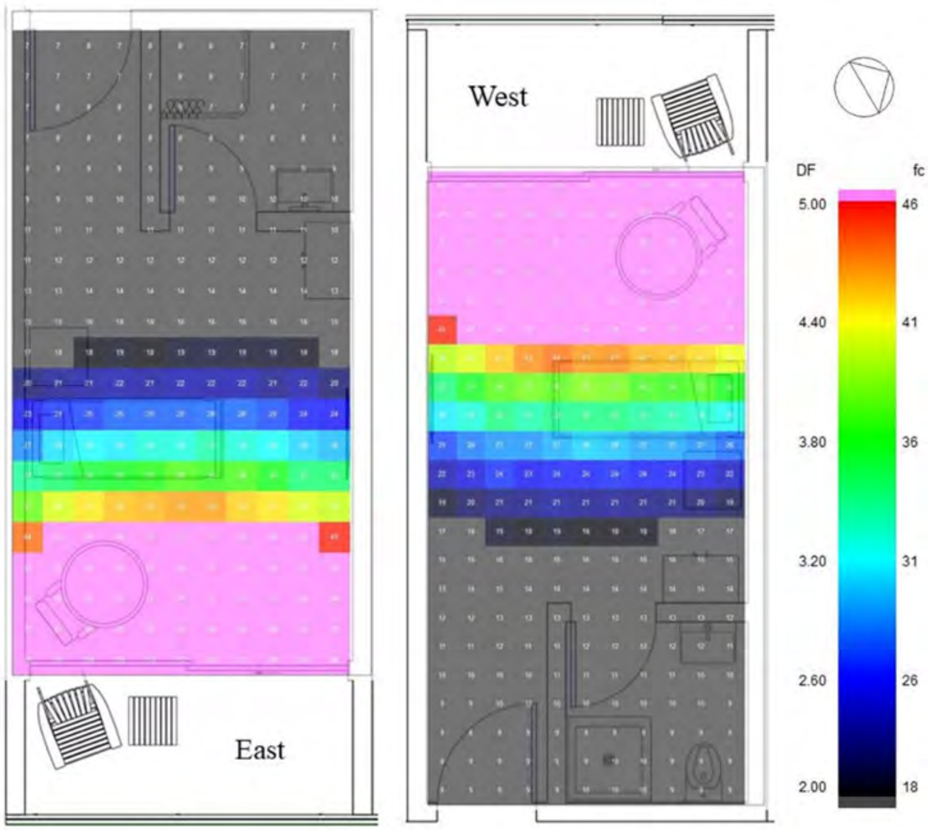


Figure 14: Daylight Analysis Overlapping Room Module

5.5 Floor Plan

From the early stages of the design process, the floor plan for this project evolved in a fashion that would make it easier to integrate other building systems, site factors, comply with the relevant codes. Initially, the preliminary floor plan consisted of a long continuous horizontal hallway with smaller hallways perpendicularly branching out from it. Early on, it was decided to keep all the angles within the facility perpendicular to facilitate the design of the mechanical system and to better control the flow of people in the building. The patient room modules and other necessary spaces were connected to these smaller hallways. The nurses' stations and office partitions were placed within the main hallway space. The floor plan during initial stages of design can be found in Figure 15.

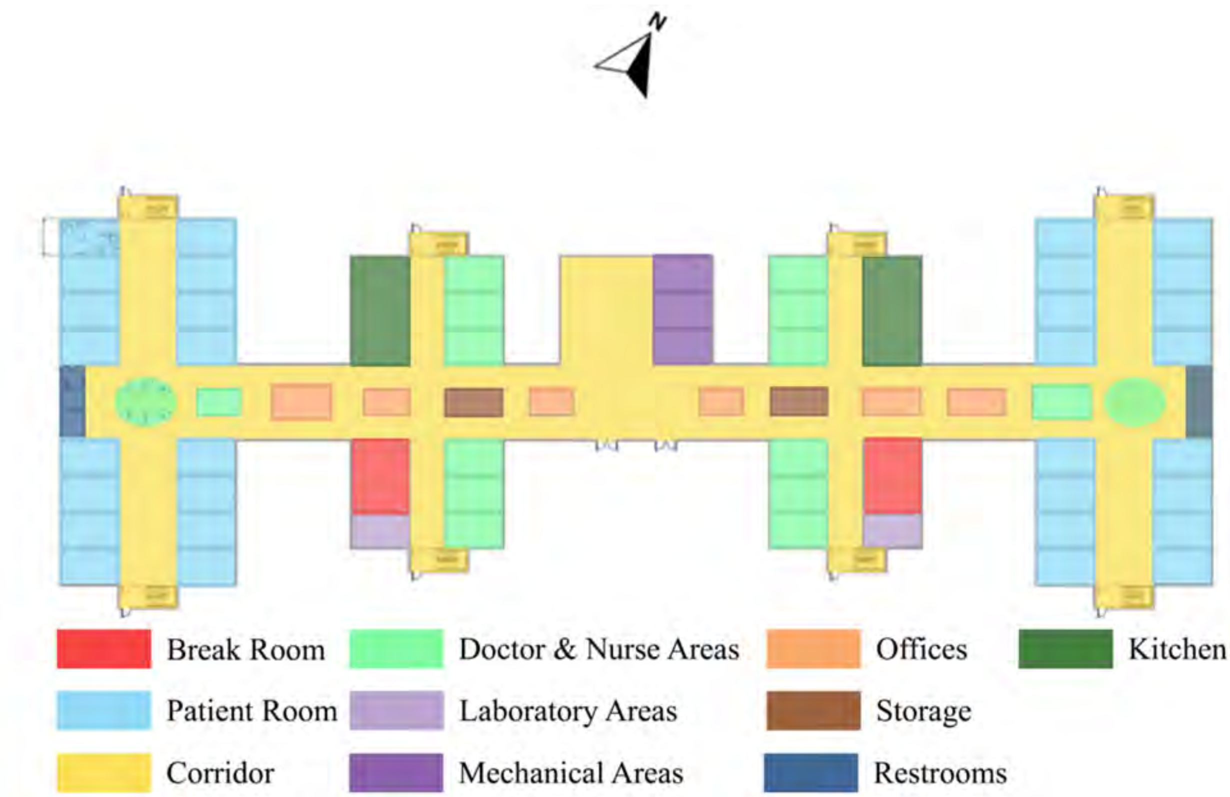


Figure 15: Floor Plan Draft One

Figure 16: Initial Floor Plan on Site (Google Maps, n.d.)

It was evident that the initial floor plan would disrupt the site due to its large size (Figure 16) and major components needed to be reconfigured. The idea of a long central hallway continued to the next stage of design, as seen in Figure 17. Rooms were then attached directly to the north and south side of the central hallway to remove the need for any additional passageways, which reduced the overall footprint of the building. The majority of the modules were multiples of the same size, 12’ x 20’ with the hallway being 27.5’ wide. The orientation of the modules differed; for example, central stairwells and restrooms were oriented differently than patient rooms and mechanical rooms.

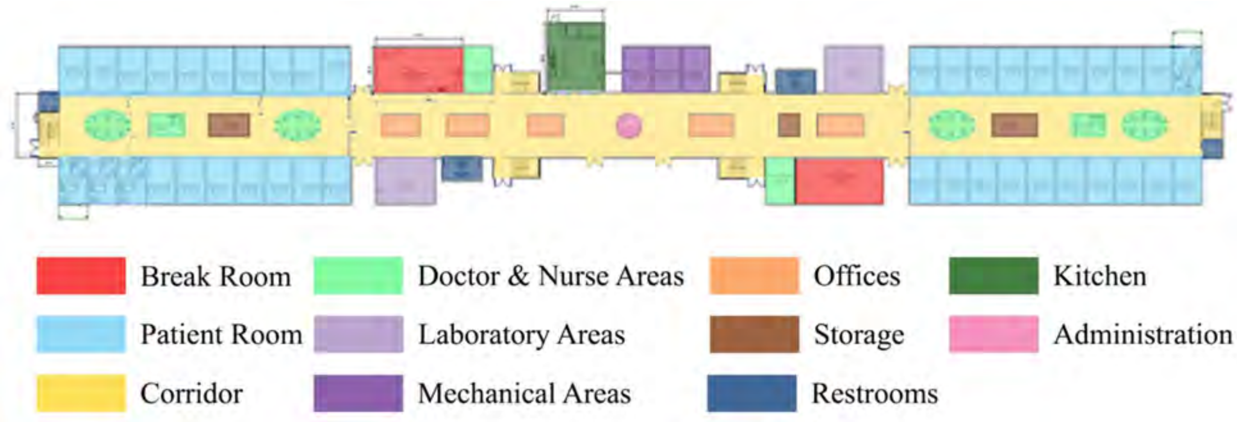


Figure 17: Floor Plan Draft Two

The final iteration of the pandemic quarantine facility floor plan consists of a long center hallway with modules branching out on the north and south sides. As seen in Figure 18, each module is of equal dimension and oriented the same way, while multiple modules were joined in order to create larger spaces. For instance, the lounge areas and the kitchen consist of three 12’ x 27.5’ modules which creates a 36’ x 27.5’ space. A major component in this design is the speed in which the building can be constructed; with modules of the same size, both the prefabrication process and construction process will be more efficient. As the modules are delivered to the site, workers will not have to spend time sorting and determining which frames are needed. For a more detailed view of the floor plan, refer to sheets A102-A105 in Appendix J.

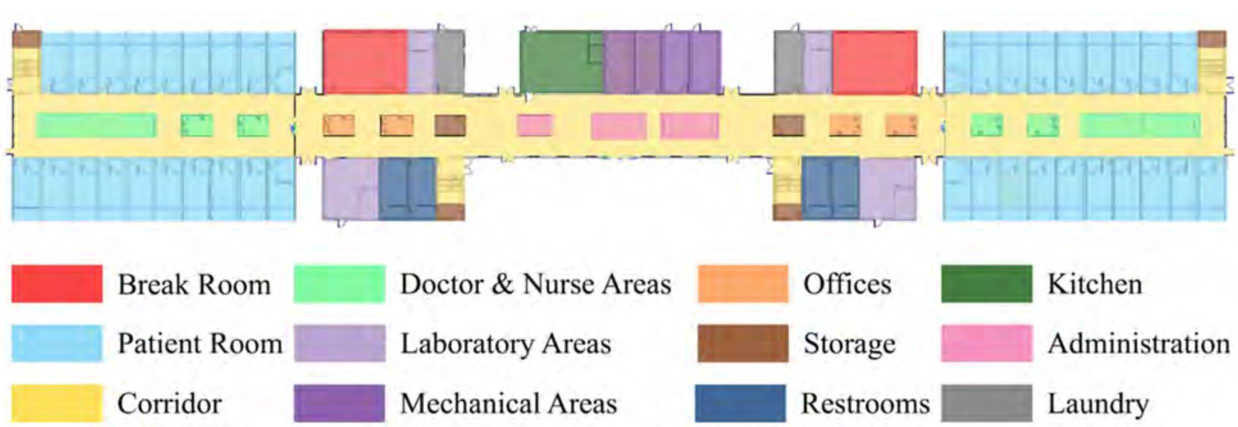


Figure 18: Final Floor Plan

The main entrance, which lies directly in the center of the facility, opens to a reception area. Within the large hallway, a copy/print space and a seating area lie on either side of the reception. The remaining space within the limits of the center hallway is reserved for partitioned offices and minor storage areas. Directly behind the reception area, multiple modules were combined to create a commercial kitchen with adequate produce and dry storage areas. To the right of the kitchen, four more modules were included to house accessible elevators, a mechanical room, and an electrical room, respectively. Further down the main hallway on both the northern and southern sides of the facility, a laundry service area, radiology room, and a lounge area were placed adjacent to each other. Directly in front, two conjoined modules form a lab/pharmacy area, which is neighbored by two staff bathrooms and a stairway module connecting to the second floor. All staff bathrooms contain three stalls, including an accessible stall, and a janitorial closet.

Two patient bedroom wings are located on the east and west sides of the center of the facility. Each wing is separated by a partition for safety and ventilation control. Within the patient wings, nurses' stations and doctor's offices were placed inside the hallway. 19 patient room modules and a stairway module then surround the medical staff region on the south and north sides. Each patient room, including the ADA compliant rooms, contain a private bathroom and balcony area.

The floor plan promotes a socially distant traffic flow, as seen in Figure 19. The 9' hallways allow for plenty of space for occupants to navigate the building. However, to better control the movement within the facility, the floor plan allows for one-way routes to be taken within each wing. The connections between partitions throughout the middle of the hallway allow for individuals to change directions in multiple areas throughout the floor plan.

Figure 19: Flow of Traffic

5.6 Relevant Codes and Standards

After the preliminary floor plan was established, it was reevaluated to determine what was required for code compliance. First, research was conducted on the codes currently utilized by NYC. In this case, it was found that any construction within NYC must abide by a few codes including the 2014 NYC General Admissions Provision and the NYC Zoning Resolution. In addition, as of 2020, New York State and NYC adopted the 2018 family of codes for residential and commercial construction, including the 2018 International Building Code (IBC). Based on the NYC Zoning Resolution, it was discovered that Central Park does not lie within any specific zone. However, it is important to consider that the chosen site lies across a special purpose district zone.

5.6.1. Design Constraints

To determine the design constraints for placing a temporary building in Central Park, the occupancy and construction type of this facility was established. Based on Section 308 of the 2018 IBC, this quarantine facility can be classified as an Institutional Group I-2 occupancy. Group I-2 consists of buildings and structures used for medical care on a 24-hour basis, such as hospitals, nursing homes, and several other types of healthcare facilities. Within this occupancy group, the most common construction type is I-A. According to Chapter 6 of the 2018 IBC, Types I and II construction are those types in which the building elements listed in Table 601 are of noncombustible materials (International Code Council, 2017)). The difference between Type I-A and Type I-B is based on fire-resistance rating requirements.

Upon determining the occupancy and construction type for this building, design constraints were identified. Based on the IBC, a facility within this occupancy group must be fully sprinklered by Section 903.2.6 and International Fire Code (IFC) 1103.5. As a result of including a fully sprinklered system, the allowable height, number of stories, and allowable area factor for this building are unlimited according to the code. In addition, the fire resistance rating of the exterior walls must be 1 hour. Also, since this building was designed for temporary use, the Temporary Building Restrictions section in the IBC was also considered. As attested by this section, any facility with a surface area greater than 120 square feet needs a permit to be built. All other aspects must comply with the same sections of the building code as a permanent facility.

5.6.2. Means of Egress

After the design constraints were determined, alterations were made to the preliminary floor plan in order to ensure that an acceptable means of egress was included in the design. Although an estimated number of occupants was previously established to aid with the programming, an accurate occupancy load needed to be calculated in accordance with Section 1004 of the IBC. By determining the exact area of each space and utilizing the occupant load factors from Table 1004.5 in the IBC, the maximum number of occupants in each space within the building was calculated. The designated number of occupants per space provided can be found in Table 1 below.

Table 1: Occupant Load

Room Type	Quantity	Area (ft^2)	Load Factor	Load/Room	Load/Floor
Patient Room	38	270	120	2	76
Break Room	2	984	150	6	12
Lab	2	528	100	5	10

Lab Storage	2	107	300	0	0
Storage & Mechanical	6	304	300	1	6
Radiology	1	304	240	1	2
Kitchen	1	1027	200	5	5
Fixed seating	26	-	-	-	26
				Load/Floor:	*137*
				Total Load:	*274*

As determined from these calculations, the total number of occupants per floor is 137 people. Utilizing this number, the following restrictions were established according to Chapter 10 of the IBC, as shown in Table 2.

Table 2: IBC Egress Restrictions

Requirement Type	Requirement	Citation
Travel Distance	• Maximum of 75 feet from exit doorway	Table 1006.2.1
Exits and Exit Doorways	• Minimum of 2 exits • Minimum door width of 41.6 inches • Height of door must not be less than 80 inches • Doors must swing in direction of egress	Table 1006.3.2 Section 1010.1.1 Section 1010.1.2.1
Corridors	• Minimum width of 8 feet where beds must be moved • A fire resistance rating of 0	Table 1020.1 Table 1020.2
Stairways	• Minimum width of 44 inches • Landing depth of 4 feet with the width the same as the stairway • Must have handrails • Required to be enclosed in I-2 occupancy	Section 1011.2 Section 1019.3 Section 1011.11 Section 1011.6
Handrails	• Height must be between 34 and 38	Section 1014.1

	inches	

Alterations to the floor plan were then conducted in order to comply with these code requirements. A total of ten exits are accessible on the first floor, including the ones available from the enclosed stairways. From the second floor, four exit stairways are available at an equal distance from each other. Therefore, the longest travel distance from any room or space within the facility to a nearby exit does not exceed 65 feet. In addition, exits doors, stairways, and corridors were sized accordingly and with the idea that hospital beds must be able to be transported throughout all parts of the facility if necessary.

5.6.3. Accessibility

After redesigning for egress requirements, adjustments for accessibility were considered. Since ten percent of sleeping units within the facility are required to be accessible, four accessible patient rooms were included within each floor. The ADA compliant module can be seen in Figure 20. In this module the bathroom was made larger to allow for a 2’-6” turning radius. The bathroom also features an accessible roll-in shower equipped with grab bars and a seat. The centerline of the toilet is 20 inches from the side wall, 17 inches off the floor, and has a pull-down grab bar beside it located 33 inches from the floor. Additionally, to meet ADA guidelines, the sink is mounted 34 inches from the floor. Within the rest of the room, there is also a turning radius of 2’-6” and the doors have a clear width of 32 inches. The clear width of the hallways is 9’ and accessible for all wheelchairs. The staff bathrooms also feature an accessible stall that comply with the ADA guidelines (*2010 ADA standards for accessible design,* 2010).

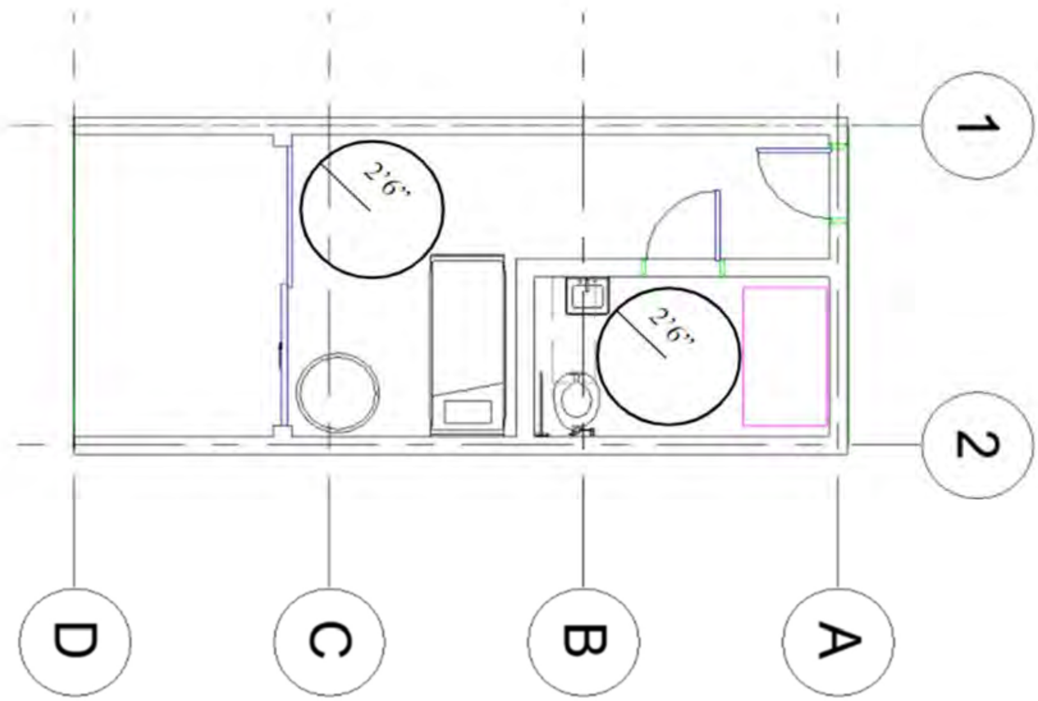


Figure 20: ADA Compliant Module

As discussed in Chapter 6, the building will be elevated for structural reasons. Therefore, there will be a ramp at all exits and entrances with a maximum allowable slope of 1:12. The ramps will have a clear width of 36 inches with railings on both sides and include level landings at both ends that are 60 inches long.

5.7 Interior and Exterior Appearance

5.7.1. Furniture and Finishes

Once the final floor plan was established, furnishings, along with the interior design, were completed. The patient rooms, nurses' stations, and staff lounges were the main areas of focus. The objective was to implement neutral colors and wooden finishes. Given that the use of achromatic colors, such as lighter shades of blue and green, have shown to promote relaxation in patients, a light shade of blue was chosen for the interior walls (Dalke et al., 2006). In addition, vinyl tiles with the appearance of hardwood flooring were placed on the floors of the main hallway space, the patient rooms, and the lounge area. Along with the walls and the flooring, lighter colors and natural finishes were also incorporated in most of the selected furniture. The objective for the patient rooms (Figure 21) was to create a more comfortable environment by including textures, finishes and accents that resembled something one would find in their own home. A connection with nature was also a key concept to emphasize in the design of the facility since an access to nature or nature-like features has shown to improve overall mood and reduce stress. Despite each patient room having a view of Central Park through their sliding-glass door, the addition of decorative plants and wall-art of landscapes and vegetation were included. Overall, the aim was to create a more comfortable and aesthetically pleasing interior space for the patients and the staff, which would promote wellbeing and relaxation despite the difficult circumstances.

Figure 21: Patient Room Rendering

5.7.2. Interior Lighting

Artificial lighting was another aspect of the interior design that was investigated. A lighting plan was developed by focusing first on general or ambient lighting, which is mainly used to make an interior space visible. The adequate number of bulbs and fixtures was determined by utilizing the area of the space in square feet and the number of lumens in a 20-watt LED bulb with 1600 lumens, which was chosen for this project. The specific number of bulbs was calculated by multiplying the area by the specific number of foot candles for each designated space. The number of foot candles or lumens per square foot for each space was chosen based on recommended light levels (ArchToolbox, 2020). For the patient room modules, the room area of the entire module was 330 ft^2 and the recommended lighting level for this specific area was 10-20 lumens per square feet. Based on these factors, the number of bulbs required for the patient rooms were calculated using Equation 1.

$$\text{Number of bulbs} = \frac{area * lumens/ft^2}{lumens/bulb}$$

Equation 1: Number of Bulbs

$$= \frac{330\ ft^2 * 15\ lumens/\ ft^2}{1600\ lumens/bulb}$$

= 4 bulbs

Based on the calculations, it was recommended that each patient room had at least 4 bulbs to provide for adequate general lighting. By utilizing this equation and the same LED bulbs, the desired number of bulbs for the other separate spaces within the facility was calculated. The results of these calculations can be found in Table 3.

Table 3: Number of Bulbs and Lighting Fixtures

Space	Area (ft^2)	Recommended Foot Candles (lumens/ft^2)	Minimum Number of Bulbs
Patient Room	330	15	4
Nurse’s Stations	3,465	20	43
Main Corridor	7,957	20	99
Bathroom	330	10	3
Kitchen	990	75	48
Labs	660	50	21
Lounge Areas	990	10	10
Radiology	330	50	10
Laundry	330	25	6
Storage	78	5	1

Once the number of bulbs for each room was calculated, the corresponding lighting fixtures were selected. In the patient rooms, for example, six ceiling mounted recessed lights (each with one 20-watt bulb) provided adequate amounts of ambient lighting within the space. In the patient wings, suspended luminaires with 4 bulbs in each fixture were utilized to implement a more flexible and creative lighting design. In other areas, such as stairways, labs, and the kitchen, more commercially common troffer fixtures were used. A full lighting plan for the entire facility can be found in the project drawing set (Appendix J). Following the completion of the general lighting within the interior spaces, task lighting was placed to give more details to objects and to provide more direct lighting to work areas. The pendant light located directly above the table in the patient room and the series of suspended fixtures placed above the reception desk are examples of task lighting utilized in the project. In addition, accent lighting such as wall mounted spotlights were placed above wall art and other decorative features throughout the facility.

Overall, the interior lighting system was designed to provide acceptable ambient lighting conditions to all areas of the facility, to work correspondingly with the interior design features, and to emphasize certain decorative characteristics within the space. The concept of circadian lighting design was also considered for the purpose of this project. As it was briefly mentioned in the background, circadian lighting is designed to have a positive biological impact on the human circadian system (Bios Lighting, 2020). As a result, a healthy circadian rhythm is associated with improved long-term health and promoting better sleep at night. In this case, the goal of implementing circadian lighting is to transmit information to the “master-clock” in the brain which tells the body when it is daytime or nighttime, and when to perform the functions it needs to during the day (Bios Lighting, 2020). This is mainly achieved by altering the color temperatures and lighting intensity emitted by each lighting fixture throughout the day (Rossi, 2019). Incorporating this concept as a part of the lighting design supplements the goal of promoting patient health.

5.7.3. Exterior Finishes

For the exterior design, the main factors considered are the facade of the facility, exterior lighting, and other site components such as accessways to and from the building. For the facade, the objective was to choose an effective material that would shield the envelope from harsh weather conditions and also serve as an aesthetic addition to the design. It was concluded that the use of rain screens would be an effective approach with a flexible choice of finishes. In accordance with the concept of building blocks, three different shades of green were chosen to create the look of stacked rectangular blocks as it can be seen in Figure 22. The color green was selected mainly to blend in with the color scheme of Central Park and to cause as little disruption to its natural appearance as possible. This facade would be assembled on site once the modules have been placed. In addition to the facade, the ADA compliant ramps, which were briefly mentioned in previous sections, are also an important exterior component to be included since the building was elevated above grade level. All exit doorways included a ramp which extend all the way to ground level. All ramps would have to be placed directly after positioning the modules on site to allow access into the facility. Lastly, despite the fact that civil and landscape design were not items of focus in this project, it was concluded that it would be beneficial to determine access ways to and from the facility around Central Park. Currently in the site, there is one continuously paved sidewalk surrounding East Meadow on all sides. These walkways are accessible through 5th Avenue and East Drive. However, since the building was placed within a grass-area and the plan was to leave the site mostly undisturbed, temporary walkways must be placed to allow for easier vehicle and pedestrian access to and from the building. In this case, 16 ft wide temporary walkways made of recycled plastic were placed around the perimeter of the building for easier access. In addition, these walkways were extended from the front and back of the building to connect to the existing paved walkways surrounding East Meadow.

Figure 22: Exterior Rendering

5.7.4. Exterior Lighting

Unlike the interior lighting, no specific calculations were done for the exterior lighting of this project. Instead, the objective was to provide sufficient lighting surrounding the building to make it clearly visible and easy to navigate around at night. In addition, another objective was to showcase the details of the facade. Double-emission sconce lighting fixtures were placed throughout the exterior perimeter of the facility at an elevation of 12'-6" from the bottom of the structure. The fixtures were evenly spaced and provided enough lighting surrounding the building. Additionally, smaller sconces were placed at an elevation of 6 feet on either side of each exit doorway to better illuminate the means of egress as shown in Figure 23. Altogether, these exterior fixtures warmly illuminated the facade of the building and provided a safer and more visible exit pathway.

Figure 23: Exterior Lighting Rendering

6.0 Structural Design

The main purpose for the structural design is to have a stable and safe structure. Additionally, since the building is meant to be temporary, the desire was to cause minimal disruption to the site. After the pandemic is over, the aim is for the site to return to its normal use. Other considerations were made regarding ease of construction and the potential of the material to be reused or recycled. The structural frame of each module (see Figure 24) would be assembled in an offsite facility. As previously mentioned, each module would be 27.5' x 12' x 12' and after construction it would be transported via flatbed trucks to the site. Afterwards, the individual modules would be lifted by cranes and placed on top of its respective support. The modules would come preassembled with the wall system, including doors, windows, and other required openings. After the module has been set in place it will be secured through its connection system, at which point, the module will be prepared for furnishing, the roof insulation, and the building's HVAC system.

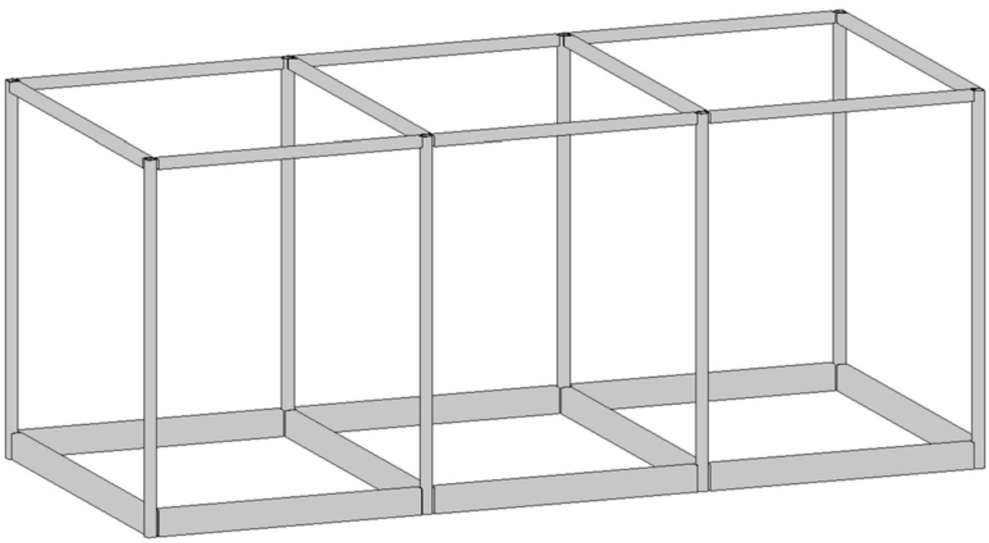


Figure 24: Module Structural System

6.1 Foundation

To minimize disruptions to the site, an adjustable footing system was utilized. Adjustable footing systems allow for differential settlement on the site, which is to be expected because the building will be erected on the existing topography without typical excavations. The design utilized translating screw jacks to support the building, as seen in Figure 25. The screw jacks will be supported on 2' x 2' concrete piers. The footing size was determined using the bearing capacities found in Table 1804.1 in the New York City Building Code (NYCBC). The bearing capacities assume that the footings will be placed underground. Therefore, to be cautious and ensure the footing would support the structure, the smallest bearing capacity was considered (see full calculation in Appendix D). The jacks would be placed under the necessary columns and be adjusted as needed to maintain the building level and account for any settlement (JAES Company, 2019).

Figure 25: Translating Screw Jack (JAES Company, 2019)

6.2 Lightweight Steel Construction (LWS)

A lightweight steel (LWS) construction type was selected for the building's structural system. LWS construction was ideal for this project since it would provide the strength the structure needed without the weight of hot rolled steel members.

Load bearing LWS is required to have the strength of at least 50 ksi and be the specific thickness, gauge, and protection as shown in Figure 26 (Allen & Iano, 2012). LWS is also in accordance with the construction type since it is noncombustible. Due to the temporary nature and quick construction time of the building, the LWS construction combined with the modular approach will allow the structure to be easily changed or modified at any point in its lifespan as well as quickly taken down and recycled when it is no longer needed.

Thickness	18 mil	27 mil	30 mil	33 mil	43 mil	54 mil	68 mil	97 mil
Gauge and color mark	25	22	20 DW	20 STR White	18 Yellow	16 Green	14 Orange	12 Red
Strength	33 ksi		33 ksi and 50 ksi			50 ksi		
Protection	G40		G40 and G60			G60		
	Used for interior drywall framing		Used for interior drywall framing, exterior non-load-bearing walls and low-rise, load-bearing applications			Commonly used in mid-rise, load-bearing applications		

Figure 26: LWS Properties Table (Allen & Iano, 2012)

6.3 Member Design and Analysis

The Allowable Strength Design (ASD) method was used to design the structural members of the modules. With ASD, the largest load group was used for analysis and design. The working loads were summed up for the various combinations and the largest of those values were then used to calculate the forces acting upon the members. This total axial force cannot exceed the available axial strength.

To determine the necessary member sizes and analyze the acting forces, RISA 2D was utilized. A truss was designed so that it could be used repeatedly throughout the structure. The loads were applied to the top and bottom chord of the truss and were modeled in two ways: to simulate the module being lifted and when the module was in place.

6.3.1. Loads

Loads are the forces acting on the building that the structural members must endure. The loads that were considered based on location and occupancy were dead loads, live loads, wind loads, and snow loads. New York is not in a seismically active zone. For this location, the more critical load that would be acting on this building is the wind load. All the load combinations in the ASD methods were analyzed and the governing load was the sum of the dead load, 75% of the wind load, 75% of the live load, and 75% of the snow load.

The dead loads for this project include the structural columns and beams, walls, floors, and ceilings. The live loads were found in Table 1607.1 of the NYCBC for patient rooms, balconies, hospital corridors, etc.

The location of the building is in Risk Category III and Exposure Category C according to Table 1604.5 and Figure 1609.3.3(1) respectively in the NYCBC. To calculate the snow load, Equation 2 was used from the ASCE 7-10 (American Society of Civil Engineers (ASCE) Staff, 2013). The associated variables can be seen in Table 4. The snow load was found to be 17.325 psf. The full calculation can be found in Appendix E.

$$p_f = 0.7 C_e\ C_t\ I_s\ P_g$$

Equation 2: Snow Load for Flat Roof

Table 4: Snow Load Variables

Variable	Value	Citation (NYCBC)
C_e (Snow Exposure Factor)	0.9	1608.3.1
C_t (Thermal Factor)	1.0	1608.3.2
I_s (Snow Load Importance Factor)	1.10	1604.5.2
p_g (Ground Snow Load)	25	1608.2

The wind load and earthquake loads were also calculated. The wind load was calculated using the Main Wind Force Resisting System (MWFRS) method for enclosed and partially enclosed buildings of all heights. This calculation can be found in Appendix F. The seismic load was calculated using the equivalent lateral force procedure for regular multi-level buildings/structural systems. The full calculation can be found in Appendix G.

6.3.2. RISA 2D Model

The design utilized a vierendeel truss. A vierendeel truss is a structure that does not employ triangulated members and both the horizontal and vertical members are connected with moment connections. This truss was determined to be the best option because the members form rectangular openings which are capable of transferring and resisting bending moments. This allows for components such as doors or windows to be more easily placed on any wall. Different trusses with diagonal members would have inhibited the placement of such elements and multiple trusses would have had to be utilized in order to fulfill the needs of the building. Since the same truss was repurposed for the entire building, the manufacturing time would be decreased.

6.3.2.1. Determining the Truss

Several iterations of the truss were examined. Each module is composed of 2 trusses, that form the modules side walls, each truss being 27.5’ long and 12’ tall. In the first iteration the columns were spaced 5.5’ apart as seen in Figure 27. While this truss configuration worked well for the room modules, there were too many columns obstructing usable space in the hallway and lounge areas.

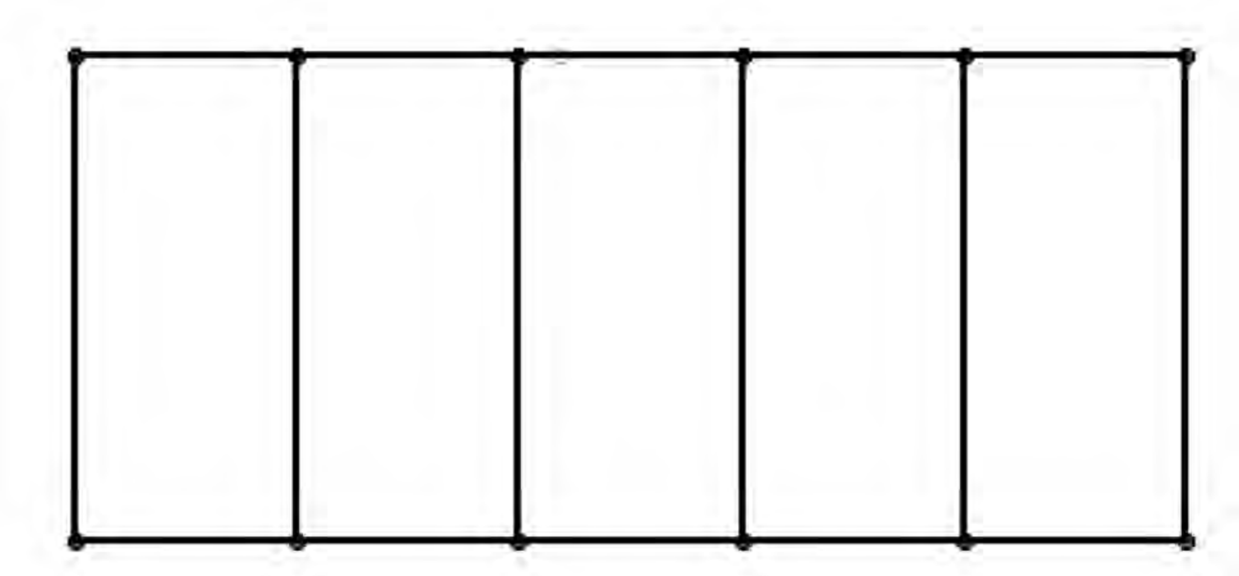


Figure 27: Truss One

The second iteration of the truss, as show in Figure 28, removed the middle two columns and only had four columns which were spaced 5.5’ apart from the end columns. In this version, there was a space created in the center of the truss which would work in the breakroom or lab, but for the hallways the columns did not leave adequate space.

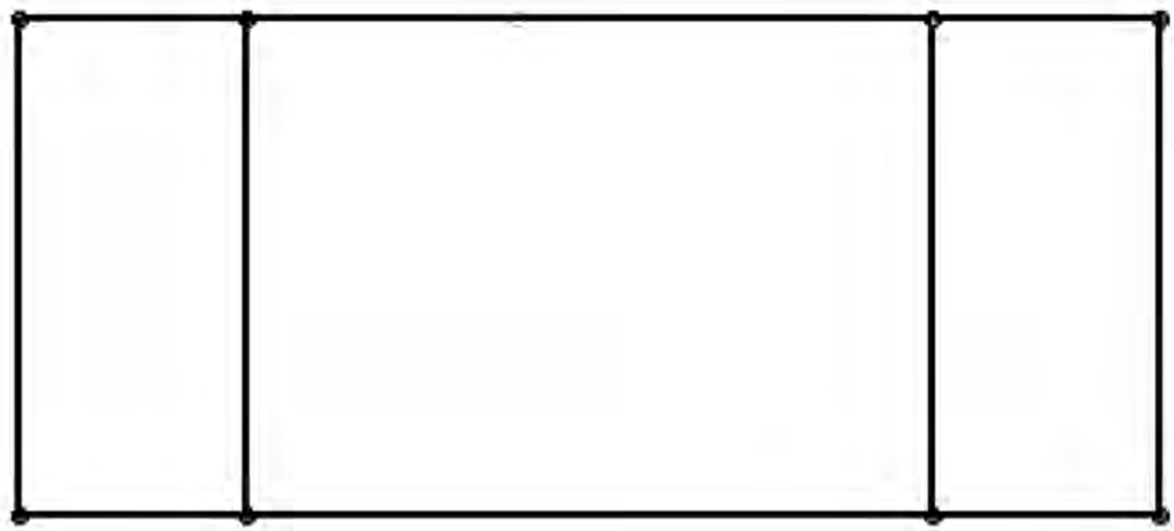


Figure 28: Truss Two

The final version of the truss is shown in Figure 29. Again, most of the original columns were removed and each column was spaced about 9.2’ apart from each other. This spacing was better suited as it allowed for 9’ hallways going through both sides of the truss while also leaving space in the center for the nurses’ stations and other offices. It was also practical in the break rooms because furniture would be able to be placed in between the openings of the truss.

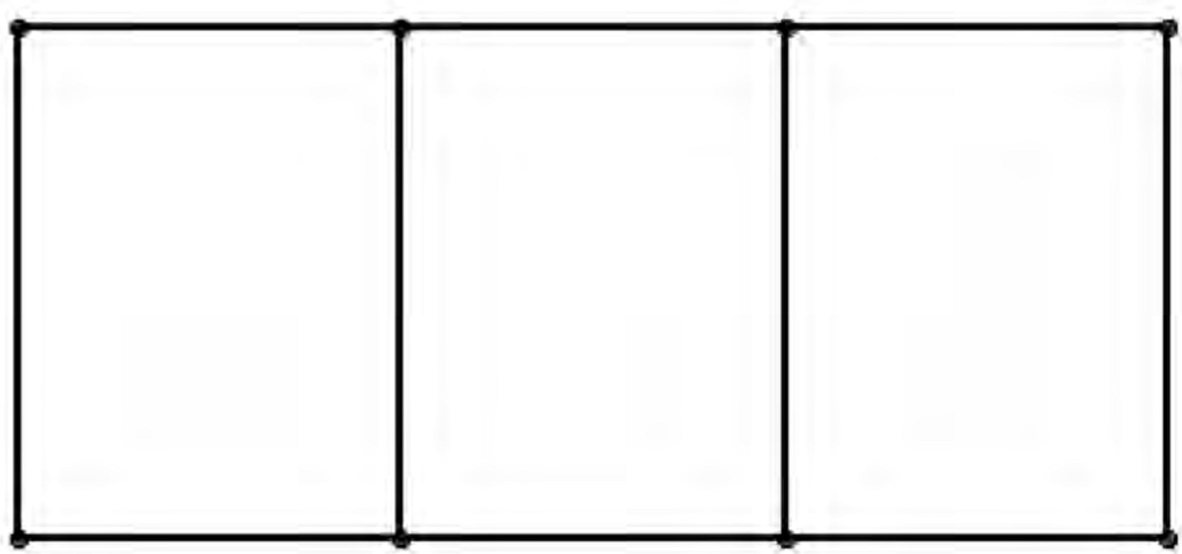


Figure 29: Truss Three

After the truss configuration was chosen, the truss was analyzed. The member deflections were then compared to the allowable deflections given by Table 1604.3 of the NYCBC. One of the challenges was to determine how the truss would be supported. In the first scenario, when the module is being lifted, pin supports were placed at both ends of the truss, under both center nodes and under each column. This simulated the different ways the truss could be lifted. When the pin supports were placed under each column, the results indicated that the actual deflections did not exceed the allowable deflection (Figure 30).

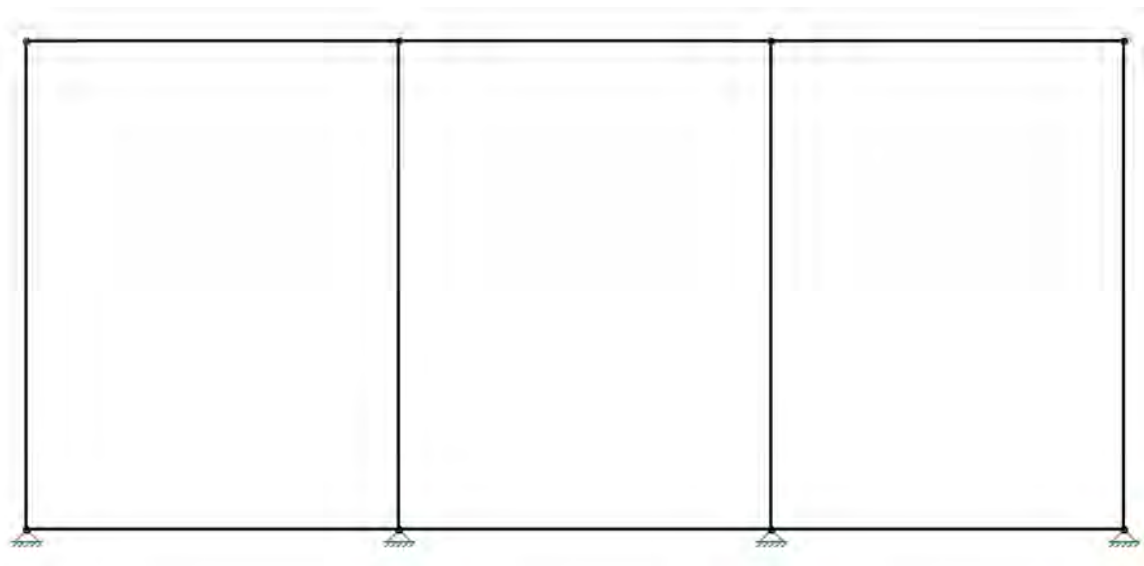


Figure 30: Truss Being Lifted

In the second scenario, the truss was simulated as a section of the entire building, as shown in Figure 31. This section represents a cut through the patient wing. The truss was found to be best supported when the supports were under the middle two nodes. However, due to the loads acting on the corridor, it was determined that it would be best if the corridor module had a support under each column. Once the wind loads were applied, (see Section 6.5: Lateral Stability) it was determined that a support would be needed under each column so none of the members would exceed the allowable deflection.

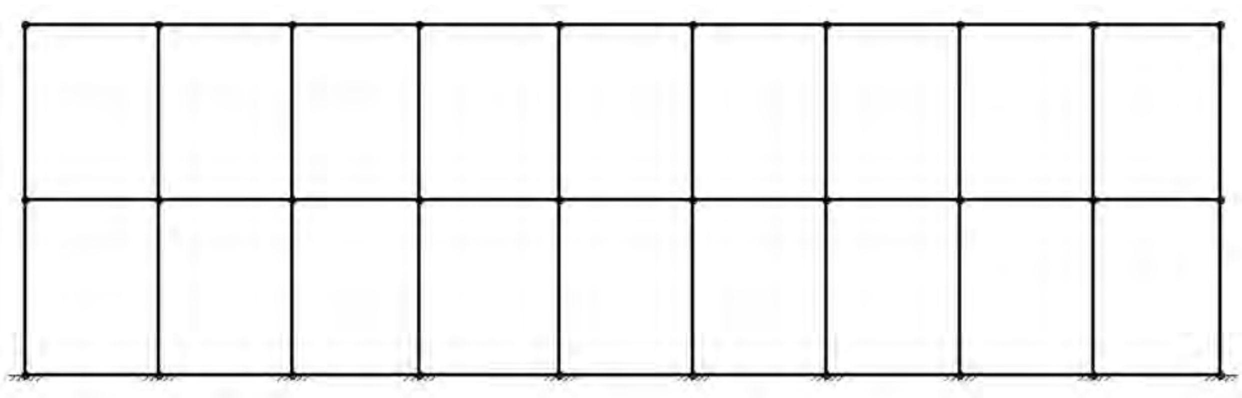


Figure 31: Vertical Section of Patient Area

In both scenarios, the maximum deflection for a beam or column was not exceeded.

Table 5: Maximum Allowable Deflection

Top Chord	Bottom Chord	Columns
0.46 in (Y)	0.46 in (Y)	1.2 in (X)

Table 6: Member Deflections

Scenario	Maximum Deflection (X)	Maximum Deflection (Y)
Lifted	0 in	0.056 in
In Place	0.379 in	0.082 in

The columns and beams were analyzed as cold formed steel tubes created by welding together two C channels. To determine the member sizes, tubes were inputted into RISA 2D using the American Iron & Steel Institute (AISI) Cold Formed Steel Design (AISI, 2002). Different sized tubes were selected until the maximum deflection, in both cases, were within the allowable limits. The member sizes are as seen in Table 7 below.

Table 7: Member Sizes

Column	Bottom Chord	Top Chord
4.25" x 4"	10.161x3	3.875x4
400T200-68	1000T150-43	362T200-68

6.4 Allowable Stress and Column Buckling

Using RISA 2D, the member displacements and axial forces acting on the truss members were obtained. It was then verified if member stresses remained below the yield stress with a sufficient margin of safety.

The North American Specification for the Design of Cold-Formed Steel Structural Members was used for these calculations (AISI, 2016). Chapter E of this manual was used to determine the available axial strength of the columns, while Chapter F was used to determine the available flexural strength of the beams. Chapter E addresses members in compression. The nominal axial strength for yielding and global buckling was determined using Equation 3 below. Then, the available axial strength was determined from that value using Equation 4. The available axial strength was then compared to the axial force in each of the members in the simulated section of the entire building. These values can be seen in Table 8. The actual axial stress of the member must be less than the critical stress divided by the factor of safety. The available axial strength is not exceeded; therefore, the members do not buckle. The full calculation can be seen in Appendix H.

$$P_{ne} = A_g F_n$$ *Equation 3: Nominal Axial Strength*

$\frac{P_{ne}}{\Omega_c}$ = Available axial strength *Equation 4: Available Axial Strength*

Table 8: Axial Strength

Available Axial Strength	Maximum Axial Force
25.613 k	5.768 k

Chapter F addresses members in flexure. In the case of the floor, the decking is secured to the bottom beams; this is the same for the top beams that support the roof. The L_u, according to Equation 5, was found to be greater than the unbraced length of the member. Therefore, global buckling does not need to be considered. Each beam size was analyzed for its available flexural strength, as seen in Table 9. The maximum flexural strength did not exceed what was available; the member does not fail due to yielding. The full calculation can be found in Appendix H.

$$L_u = \frac{0.36 C_b \pi}{F_y S_f} \sqrt{EGJI_y}$$ *Equation 5: Calculation of L_u*

Table 9: Flexural Strength

Beam Type	Available Flexural Strength	Maximum Flexural Strength

362T200-68	1.46 k-in	103.02 lb-in
1000T150-43	6.07 k-in	560.71 lb-in

6.5 Lateral Stability

To determine the lateral stability, wind loads were applied to a horizontal section of the patient module as well as a vertical section using RISA 2D. The wind loads were applied to the section on the windward and leeward walls. The lateral displacements were evaluated to ensure they stay under the allowable deflection as seen in Table 10. The allowable lateral displacement was given by Table 1604.3 of the NYCBC. The frame deflection can be seen in Figures 32 & 33. If the lateral displacement was exceeded, then the truss would require bracing and/or the members would need to be resized. In the case of this building, the frame sway, in both sections, did not exceed the allowable displacement, and therefore extra bracing was not required.

Table 10: Lateral Displacement

Allowable Displacement	**1.2 in (X)**
Section	**Displacement (X)**
Horizontal	0.427 in
Vertical	0.39 in

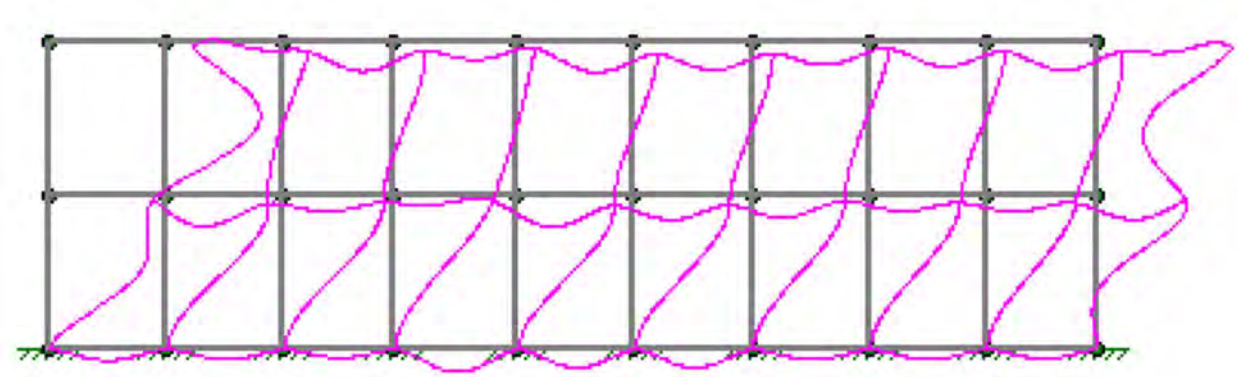


Figure 32: Horizontal Section Displacement Diagram

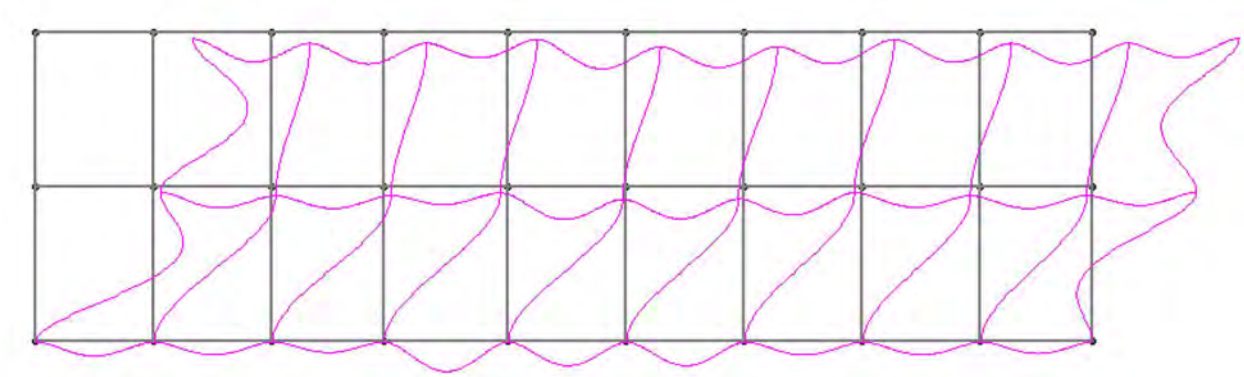


Figure 33: Vertical Section Displacement Diagram

6.6 Conceptual Connections Detail

A conceptual design was developed to connect modules into a larger building that effectively transfer loads from individual modules towards the foundation support, while also providing lateral stability for the building overall. The modules will be connected via metal plates that are welded onto the top and bottom chords of the horizontal members of the vierendeel trusses. There will be a 1-inch space between the bottom and top of each module in order to isolate the deflection of each module relative to its adjacent modules. The connector plates lie in the small gap between each module. This plate will include a protruding tapered guiding rod to aid in the initial connection and alignment of the modules during placement. The second-floor module will be placed over the protrusion and will be mated to another connector plate located in the same location on the adjoining module. After this initial "loose" placement, a structural bolted connection will pull module members tightly together – to be fastened from the inside of the module below it. The plate will be accessed through removable access ports provided in the truss members. The flooring in each corner can be lifted and will provide enough space for a worker to reach in and tighten the bolt with a wrench. The access port opening can then be capped while the building is in use. When it is time for the takedown of the building, it can easily be deconstructed again via the same access ports. Similarly, the screw jacks supporting the building are placed onto their concrete footings and a similar metal plate connects the screw jack to the module – and also ties modules together laterally. In the corners of the module, there are similar protrusions that the module will be placed upon before being bolted onto the plate through similar access ports. In the span of the module, the screw jack can be connected by two bolts, which can be accessed from the crawl space below the building (see Figures 34, 35, 36, 37 & 38).

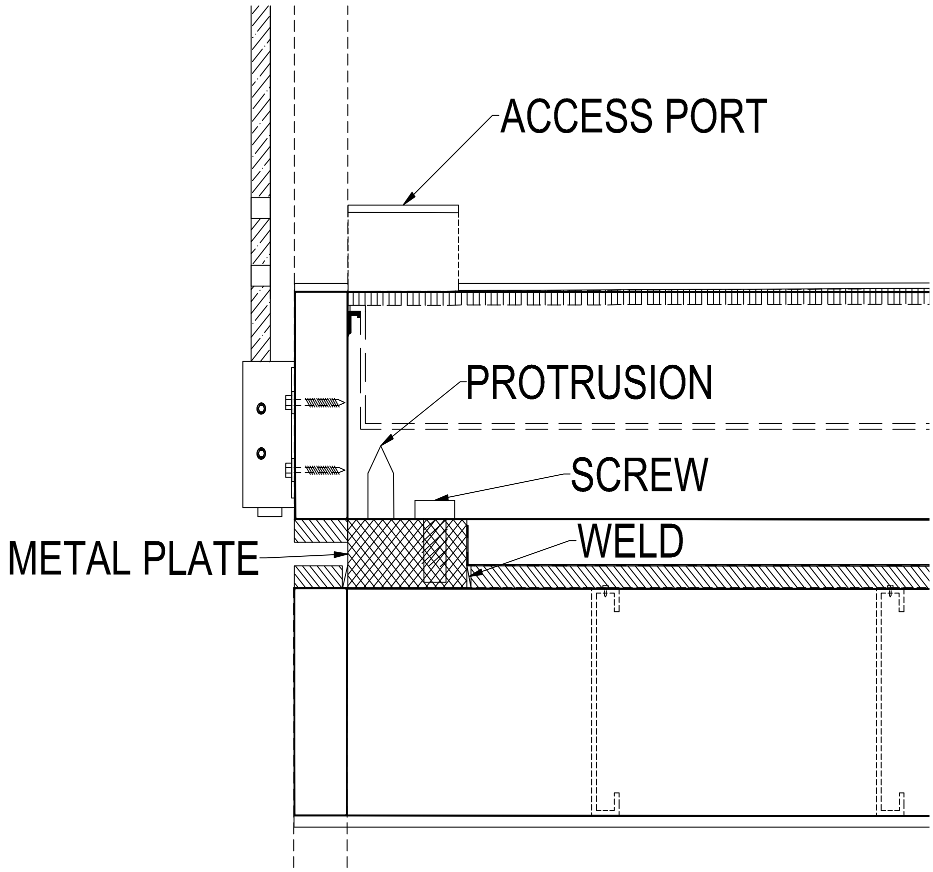


Figure 34: Connection Between Two Modules Stacked

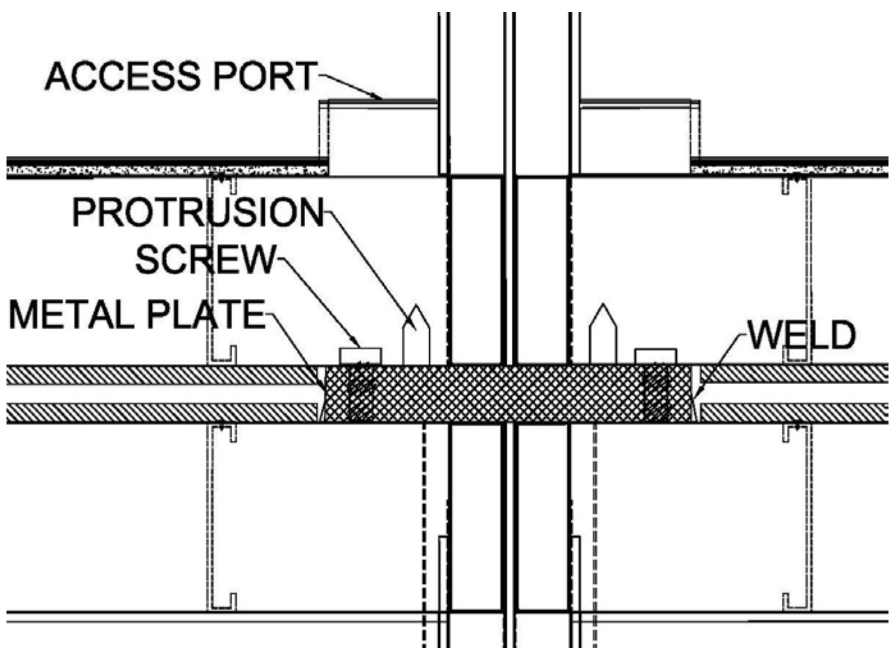


Figure 35: Connection Between Adjacent Modules

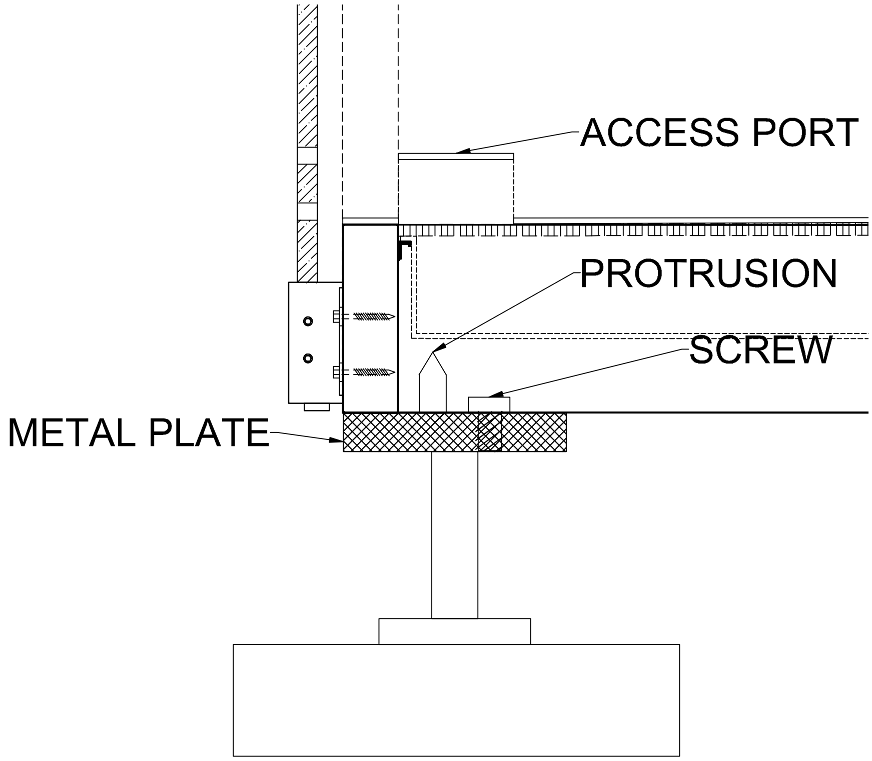


Figure 36: Support Connection at Module Corner

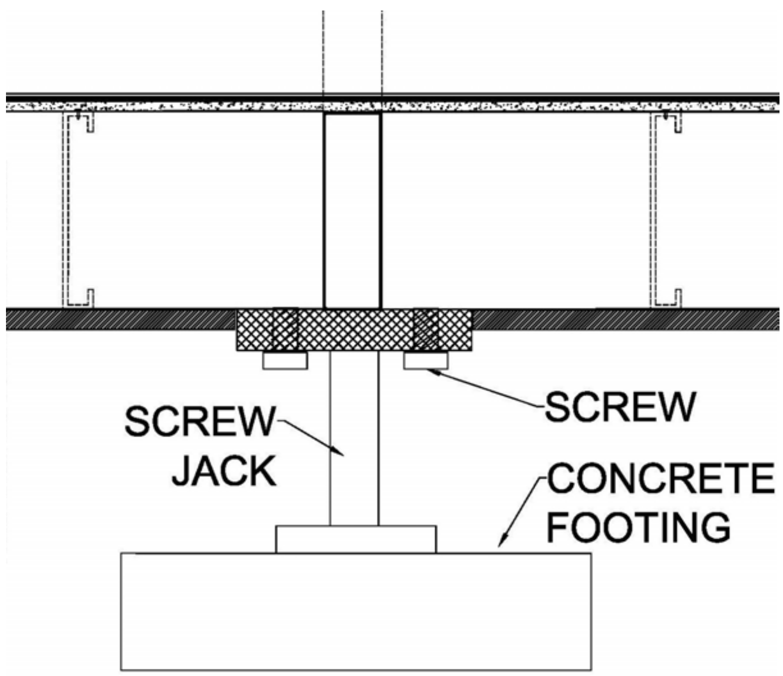


Figure 37: Support Connection at Span of Module

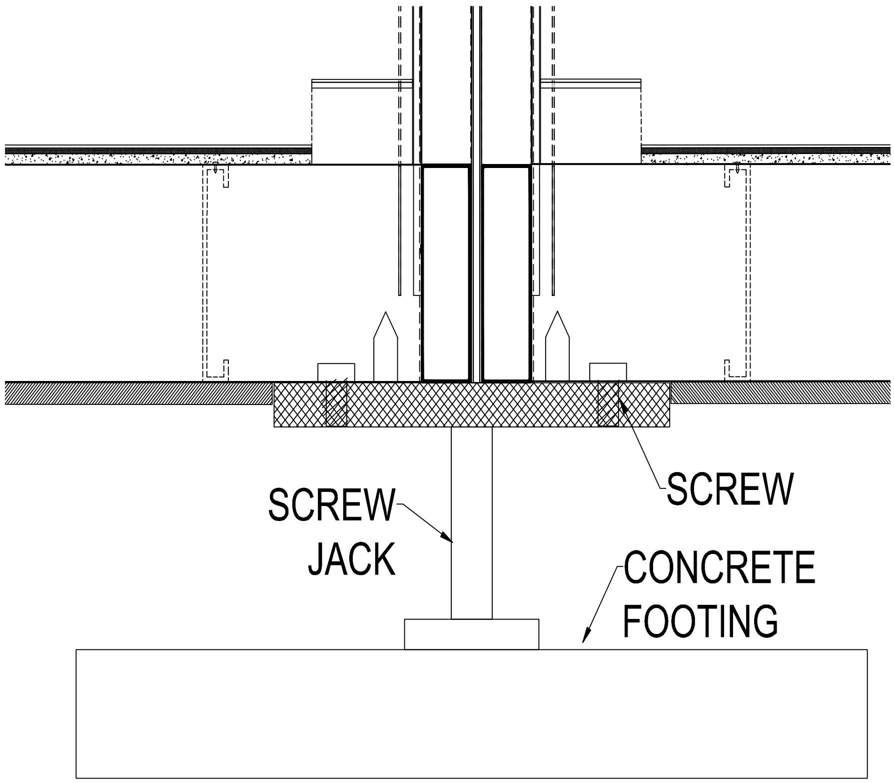


Figure 38: Support Connection Between Adjacent Modules

At the beginning of construction, all the first-floor modules are placed and connected in their specified locations atop their foundation supports. After they are fastened to each of the supports, they become interconnected and the next set of modules can be placed on top. There will be three types of metal plates used (see Figures 39, 40, and 41). In the case where two modules come together, Plate-Type A will be used. Where three modules connect, Plate-Type B will be used and finally, when there are four modules connecting, Plate-Type C will be utilized.

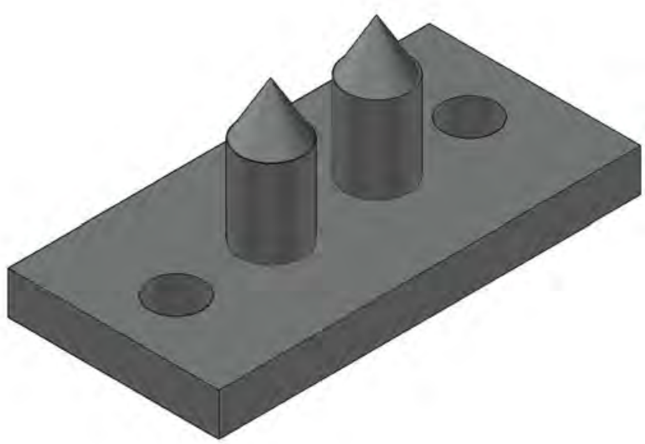


Figure 39: Plate-Type A

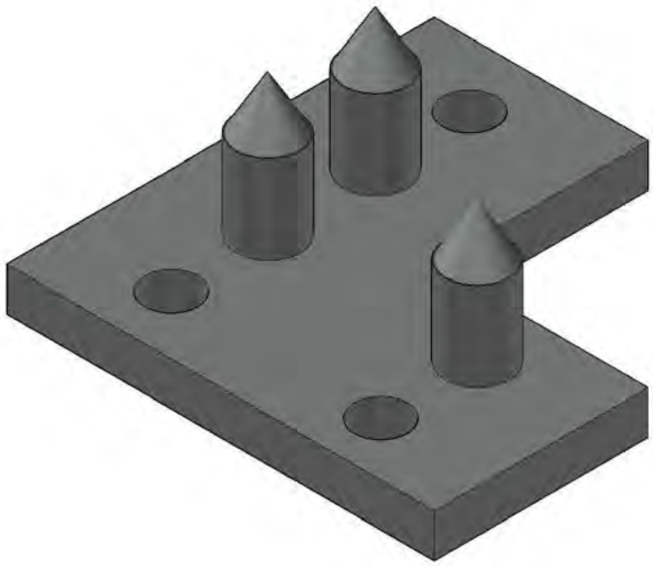


Figure 40: Plate-Type B

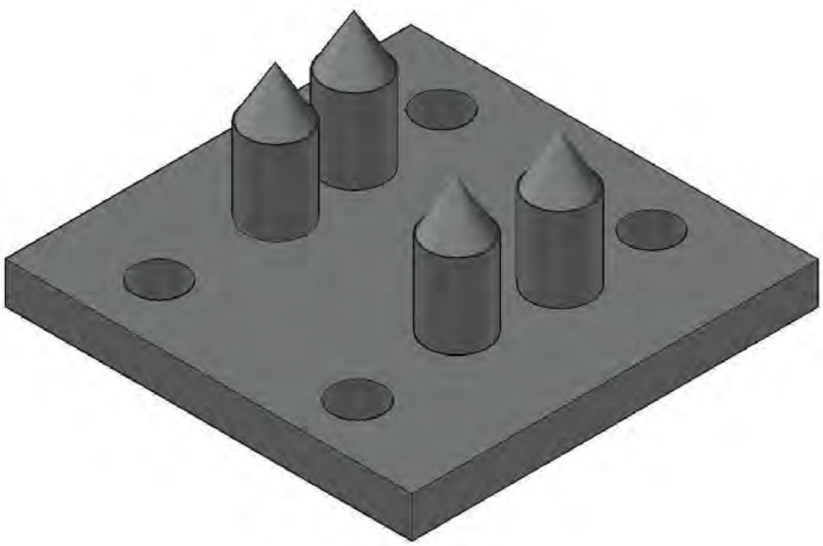


Figure 41: Plate-Type C

7.0 Building Systems & Sustainable Design

7.1 Conceptual Building Envelope

Once the structural system was established, the challenge of how to best enclose the building with a high-performance envelope had to be determined. A building envelope is the physical barrier between the interior and exterior of a building. Its main purpose is to control or prevent the flow of air, vapor, water, and heat between the indoor and outdoor environment. There is no one ideal design for the enclosure of a building, and depending on the climate of the site, several configurations can be considered. With the chosen site being in a humid subtropical climate, various factors such as high and low temperatures, along with lots of rain and wind had to be accounted for. In addition, the concept of modular prefabricated construction presented several challenges regarding the assembly of the system. In this case, the decision was made to have the majority of the envelope prefabricated in an enclosed factory along with the structural framing. The facade would be applied once the modules have been placed on the site, along with the roof, which would then be covered with a waterproofing membrane.

7.1.1. Purpose of the Envelope and Main Objectives

The main objective for the envelope design was to establish an effective system that fits into the concept. The envelope had to serve very specific purposes in addition to the standard performance criteria. In terms of air movement, a hospital environment requires a more rigorous control of ventilation. Given the circumstances of a pandemic caused by a virus that could have airborne transmission, the aim was to limit the natural flow of air in most areas of the facility and rely on a more advanced HVAC system to circulate air. Although the airflow through most of the building would need to be tightly controlled, some natural ventilation can also be incorporated within the patient rooms because of the health benefits of fresh air.

Moisture control within this medical facility was also a priority when designing the envelope. As previously mentioned, studies have shown that air humidity can affect the spread of airborne diseases. Since many airborne viruses have shown to be responsive to different levels of ambient humidity, it is crucial to maintain desired levels of relative humidity indoors when the outdoor temperature changes. Considering that moisture tends to travel from areas of higher to lower temperatures and moisture content, designing for a better control of the flow of moisture through the envelope was another key aim. In order to maintain a comfortable indoor environment during any season, insulation materials had to be carefully chosen based on specific R-values as required by code. In addition, these materials had to comply with the construction Type I-A and be composed of non-combustible or fire-treated materials. Lastly, flashing and other methods of water-proofing were incorporated with the aim of keeping water from entering the building and causing any damage to the enclosure.

7.1.2. Envelope Design & Materials

Centered on the previous objectives, possible material assemblies and configurations for the building envelope were investigated. Separate systems had to be established for the wall, floor, and roof of the module based on the American Society of Heating, Refrigeration & Air-Conditioning Engineers (ASHRAE) Standard 90.1 requirements for climate Zone 4. Figure 42 below shows a section drawing of a conceptual roof to wall connection of the patient room modules.

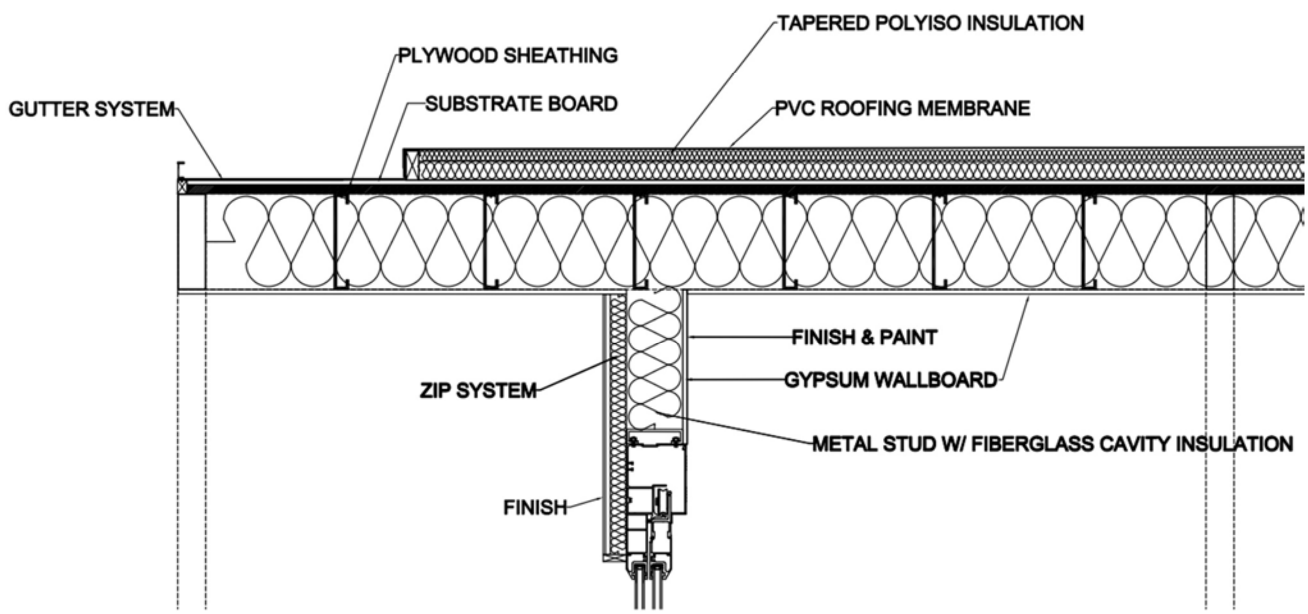


Figure 42: Section of Roof and Wall Composition

According to Table 5.5-4 of the ASHRAE Standard 90.1, the minimum R-value for the insulation of a wall assembly in a steel framed building is R-13 + R-7.5 continuous insulation. Given these restrictions, it was decided that utilizing a composite system such as ZIP R-Sheathing would aid in quick assembly. ZIP system R-sheathing is an all-in-one structural panel with built in exterior insulation along with integrated moisture and air protection. It is usually attached to wall joists on the exterior of the building and it is available with several different R-values. Utilizing an R-12 ZIP Sheathing system along with corresponding ZIP tape and seam sealants would not only comply with code and facilitate the prefabricated assembly process, but it would also provide structural support and protection from water when transporting the modules. A self-adhering (peel and stick) air and moisture barrier could also be installed as a precautionary measure to fully envelop the structural modules to ensure airtightness, and to serve as a vapor barrier inboard of the continuous insulation boards (wrapping walls, roof, and flooring). Once placed on site, a rain screen will be attached to the ZIP system as a form of cladding. Following the ZIP system on the interior, fiberglass cavity insulation was chosen to fill between the metal wall studs. Fiberglass insulation was found to be the best solution for steel-framed buildings because of its effective insulating properties and non-combustible nature. Therefore, fiberglass was also placed within the joists in the floor and roof assemblies. Combining the insulation in the ZIP system and the fiberglass cavity insulation resulted in a total effective R-value of 29.09 ft^2•°F/BTUH, which exceeds the minimum amount as required by code. As for the interior wall, the cavity insulation is followed by fire-rated gypsum wallboard, finish, and paint, respectively. The detailed composition of the wall assembly along with the chosen materials, their thickness, and R-values can be found in Table 11.

Table 11: Wall Composition (Interior to Exterior)

Material	Thickness	R-value (ft^2•°F/BTUH)
Plaster & Paint	N/A	N/A
Gypsum Wallboard	½”	0.45
Metal stud w/ Neima 202-96 Fiberglass insulation R-30 16” OC	4.75”	32.5
Zip System sheathing	2-½”	12.6
Air Space	1”	1
Rain Screen	N/A	N/A

The composition of the roof, according to ASHRAE Standard 90.1 was required to have a minimum R-value of R-25 + R-8 or R-19 + R-11 for a non-residential metal-framed building. The final composition of the roof consisted of gypsum wallboard followed by fiberglass insulation in between the ceiling joists, which are then topped by plywood sheathing, self-adhering (peel and stick) air and moisture barrier, tapered polyiso insulation, and a PVC roofing membrane. The effective R-value of the roof assembly is 33.77 ft^2•°F/BTUH. A detailed section drawing of the roof composition can be found in Figure 43 below.

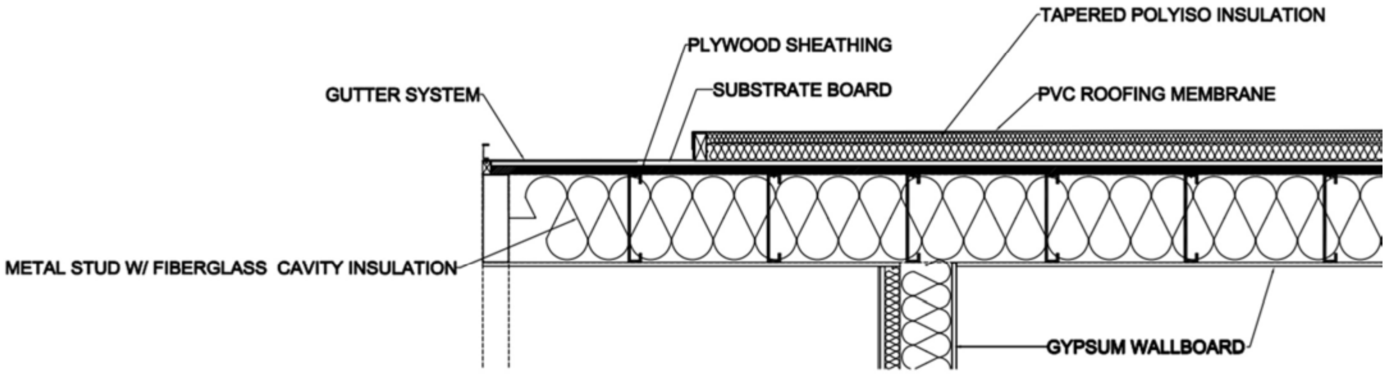


Figure 43: Section of Roof Composition

At first, the plan was to utilize the ZIP system to enclose the entire module, given its structural, insulating, and waterproofing benefits. Eventually, the concern of water management with a flat roof in a humid climate zone led to more research on other compositions for the roof of this building. Although the thick fiberglass insulation within the cavity of the ceiling accounted for much of the R-value requirements, an exterior insulating system had to be included. The exterior insulation also mitigates the risk of condensation within the cavity when used in combination with a vapor and air barrier. In this case, a tapered polyiso insulation system was incorporated into the roof assembly to account for the remaining R-value requirements and to provide a slight slope of 0.7 degrees to the roof. The purpose of this was to direct rainwater away from the center of the building and towards a gutter system installed along the north and south perimeters of the roof. Proper flashing techniques, which can be schematically seen in Figure 44, need to be further developed to seal the connection between the gutter system and the roof and to protect the underlying envelope against water infiltration. A PVC roofing membrane was placed on top of the insulation material and spans the entire length of the roof serving as the primary waterproofing system. The schematic composition of the roof assembly along with the chosen materials, their thickness, and R-values can be found in Table 12.

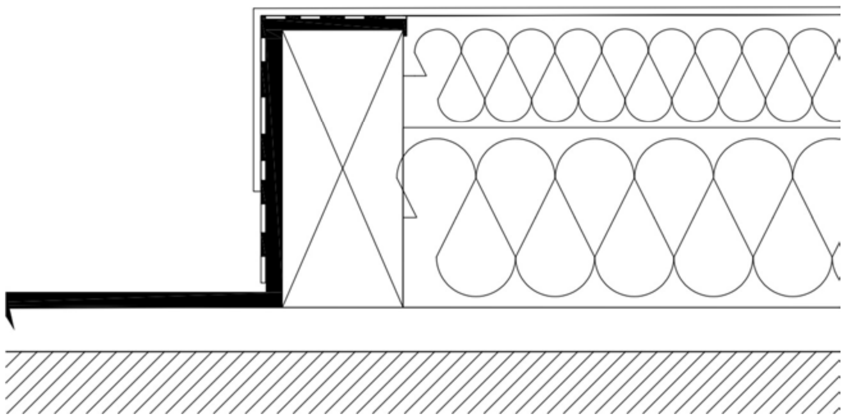


Figure 44: Flashing Technique in Roof

Table 12: Roof Composition (Interior to Exterior)

Material	Thickness	R-value (ft^2•°F/BTUH)
Gypsum Board	½”	0.45
Metal Joist w/ Neima 202-96 Fiberglass insulation R-11	3.875” 362T200-68	11.9
Plywood Sheathing	¼”	1.25
Substrate Board	½”	1.3
Tapered Polyiso Insulation	Differs	12.4/ 2 inch
Top Covering PVC Membrane	1/16”	0.24

The floor composition of the patient modules was the most challenging to design given the balcony on the exterior and the risk of thermal bridging due to protruding structural members. For the interior flooring, a minimum total R-value of 30 was included to comply with ASHRAE standards. As it can be seen in Figure 45, the interior floor composition consists of plywood sheathing, R-30 fiberglass insulation between the floor joists, an MGO subfloor, backerboard, and vinyl tiling, respectively. The effective R-value of the floor assembly is 32.76 ft^2•°F/BTUH. The subfloor and other layers following are supported by the joists which are spaced 16” on center. To keep the insulation continuous, additional insulation was included in between the floor joist and the tube supporting the sliding glass door. The ceiling and floor of joining modules are thus both thermally insulated which results in some insulation redundancies that can otherwise serve as an enhanced acoustical barrier between modules. By providing insulation in the ceiling, only one module type is required. The detailed composition of the interior floor assembly along with the chosen materials, their thickness, and R-values can be found in Table 13.

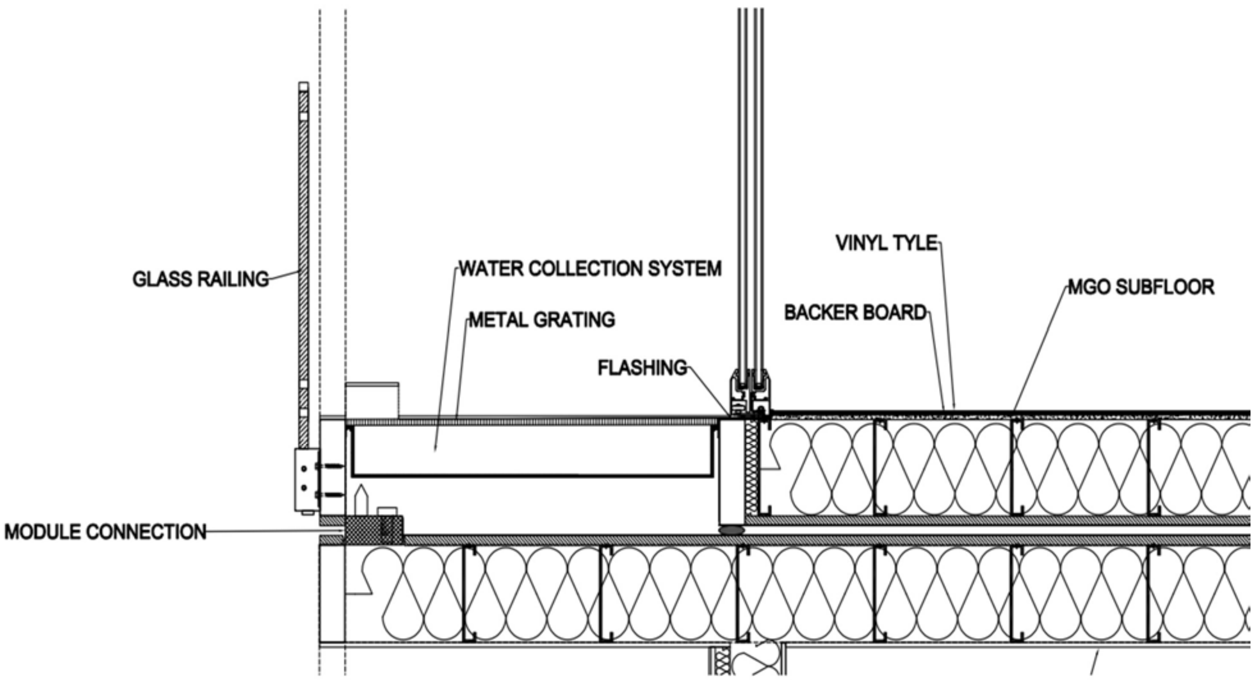


Figure 45: Section of Floor Composition

Table 13: Floor Composition (Interior to Exterior)

Material	Thickness	R-value
Vinyl Tile (different finishes)	⅛”	0.2
Backerboard	1/4”	0
MGO Flooring/ Fire Rated Subfloor	½”	1.2
Metal Joist w/ Neima 202-96 Fiberglass insulation R-30	10.161” 1000T150-43	32.5

Plywood Sheathing	1/4”	1.25
SILCOR seamless waterproofing membrane (Flashing)	1/16”	N/A

As for the balcony flooring, one of the primary challenges was waterproofing the sliding door connection and developing a way to redirect rainwater away from the envelope of the building as well as the modules underneath. Although the balcony is mostly covered by the roof overhang, there is no guarantee that rainwater will not reach the balcony floor. With this in mind, outdoor panels that would allow for water to drain through the spacing between them were chosen for the balcony flooring. To prevent water damage to the plywood sheathing within the modules, a water collection system was implemented within the cavity of the balcony floor. The water collection system is supported by a ledge welded to the tubes running perpendicular to the balcony. Due to the water collection system, the floor joists that were originally placed to support the flooring were removed. The balcony flooring is supported by a metal grate that lies on top of the welded ledges on the steel tubes.

To further waterproof the building, proper flashing is needed between the balcony floor and the sliding door connection. The purpose of utilizing waterproofing membranes within this area was to prevent water from seeping through the connection spaces and into the interior of the building. A detailed image of how this was implemented can be found in Figure 46.

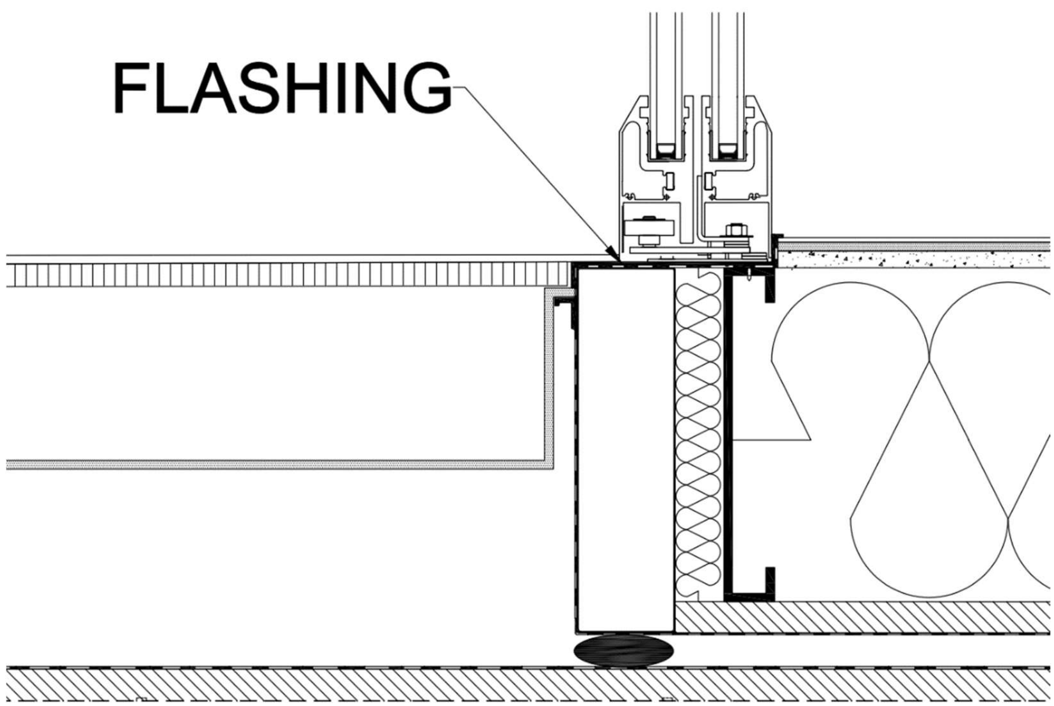


Figure 46: Flashing Implementation

The thermal performance of the envelope is demonstrated throughout Sections 7.2 and 7.3, where the building heating, cooling, and overall energy usage loads are calculated. The connections of other fenestration and doorway systems to the walls, including their waterproofing factors, were not designed for the purpose of this project. The main focus of this conceptual envelope design was to showcase how the patient module would be enclosed.

7.2 Heating, Ventilation, and Air Conditioning (HVAC) System

The design of an HVAC system in a quarantine center has many requirements. Providing clean air and a comfortable setting for occupants is imperative, especially during a pandemic. Besides the New York City Mechanical Code, there are standards produced by ASHRAE that provide more stringent design requirements for hospital settings. For the purpose of this project, only the HVAC system for the West Patient Wing was designed. The HVAC system would be one of the last systems to be installed in facility. While the structural framing and part of the building envelope would be preassembled off site, openings for the HVAC ductwork would be added to provide a quicker installation on site.

7.2.1. System Determination

The first step of determining the type of HVAC system to use in the quarantine center was researching the overall requirements of the system. One of the main design aspects of hospital HVAC systems is the necessity of airflow control. One of the ways in which airflow is controlled is the difference in air pressure. Typically, rooms containing infectious patients should have a negative air pressure in order to reduce the spread of a disease out of the room (CDC, 2003). Air flows from positive to negative pressure and clean air is also achieved by the air intake and exhaust.

Both centralized and split unit HVAC systems were considered. Initially, it was thought that a split unit system would be best in the event of a pandemic so each patient room could be controlled individually. Additionally, the separation of the systems seemed to be the most sanitized. However, due to the floor plan, the air intakes and exhausts for each room would be within 12 feet of each other. It was determined that this distance was not acceptable in the event of a pandemic. The focus then shifted to a centralized HVAC system. Monitoring pressure differentials could be done much easier in a centralized HVAC system than a split unit system. Furthermore, the system could be designed as three separate centralized systems - one for each patient wing and one for the center wing. By separating the patient wings into different systems, there is an added layer of sanitation. For these reasons, a centralized variable air volume (VAV) with reheater system was chosen (see Figure 47).

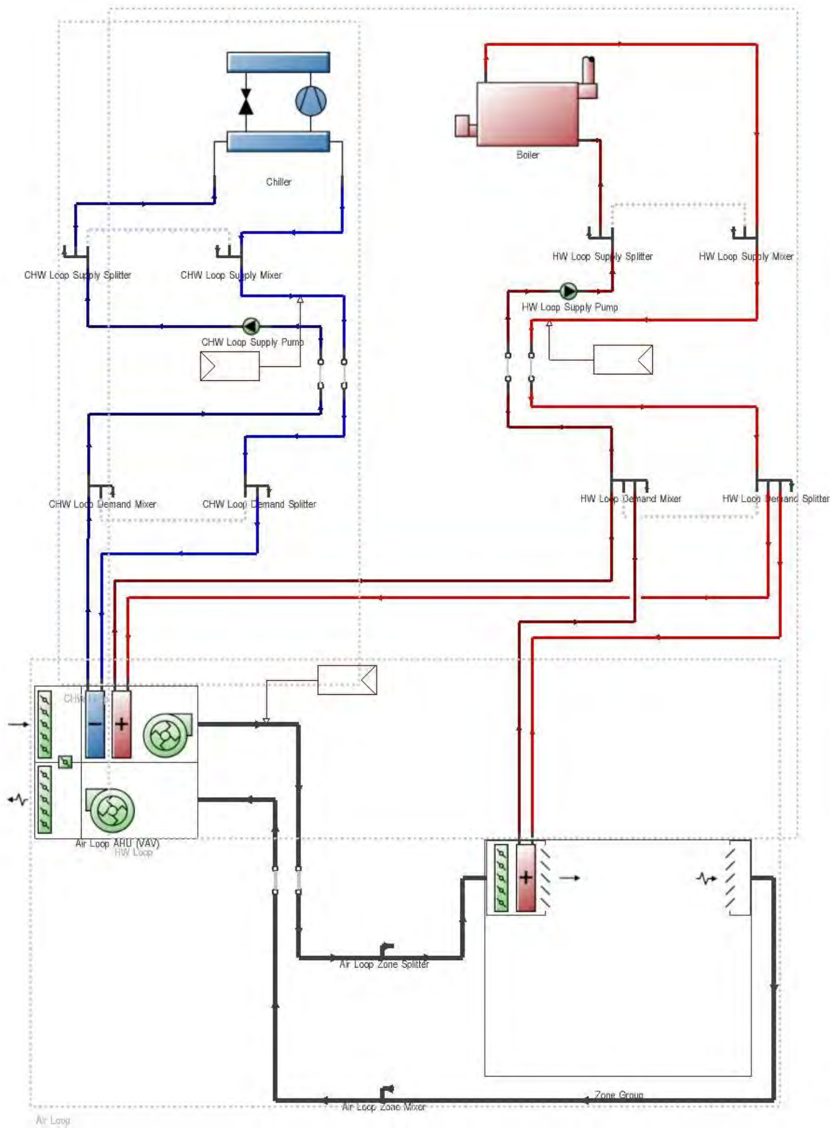


Figure 47: HVAC System Schematic

7.2.2. HVAC System Loads

7.2.2.1. Heating and Cooling

In order to determine the heating and cooling loads for the South Patient Wing, the CLTD Method from the *ASHRAE Cooling and Heating Load Calculation Manual* was used (ASHRAE, 1980)

The overall equations for heating and cooling loads are shown below.

$Q_{BTUH} = U * A * \Delta T$ *Equation 6: Heating Load*

$Q_{CFM} = A_L\sqrt{C_s|\Delta T| + C_w V^2}$ *Equation 7: Heating Load Infiltration*

$Q_{BTUH} = U * A * CLTD$ *Equation 8: Cooling Load for Walls, Floors, & Doors*

$Q_{BTUH} = A * CLF$ *Equation 9: Fenestration Cooling Load*

where:
U: Overall heat transfer coefficient
A: Area of heat transfer
ΔT: Temperature difference
A_L: Leakage area
C_S: Stack coefficient
C_W: Wind coefficient
V: Average wind speed
CLTD: Cooling load temperature difference
CLF: Cooling load factor

The overall heat transfer coefficient is the reciprocal of the effective thermal resistance (R-value) of each assembly. The R-value of each material in the assembly (described in Section 7.1 Building Envelope) was found in the *ASHRAE Cooling and Heating Load Calculation Manual* or from other product specification sheets. Due to the joists in the walls and floors, there were two parallel heat transfer assemblies: between and at the joists. The heat transfer coefficient was found for both assemblies and combined using percent area (see Table 14 below).

Table 14: Floor Heat Transfer Coefficient

Floors		
Material	R Value between joist (ft²•°F/BTUH)	R value at joist (ft²•°F/BTUH)
Outside Air	0.17	0.17
SILCOR Waterproofing Membrane	0	0
1/4" Plywood Sheathing	0.31	0.31
9.25" Metal Joist &R-30 Insulation	32.5	16.0
MGO Flooring/Fire Rated Subfloor	1.1	1.1
1/4" Backerboard	0.13	0.13
1/8" Vinyl Tile	0.2	0.2
Inside Air	0.92	0.92
R total	35.29	18.82
U	0.028	0.053
Effective U	0.031	
Effective R	32.76	

The outdoor winter and summer design temperatures for Central Park is 15°F and 89°F, respectively, per Table 2.1A of the *ASHRAE Cooling and Heating Load Calculation Manual*. The interior design temperature of the building is 72°F. In addition, the typical U-value of a window (0.30 BTUH/ft^2•°F) was used in the calculations.

During the winter, the total transmission heat loss in the first floor West Patient wing was calculated to be 54,563 BTUH. During the infiltration calculations, a typical leakage area of 0.12in^2/ft was used. The total air flow from infiltration is 256 CFM, or 16,072 BTUH in heat loss. In total, the heating load is 70,635 BTUH, which requires an airflow rate of 1,147 CFM (See Appendix I for calculations). The conversion between BTUH and CFM is shown in Equation 10 below:

$$Q_{BTUH} = 1.1 * Q_{CFM} * \Delta T$$ *Equation 10: BTUH to CFM Conversion*

The total cooling load is a combination of transmission heat gain and internal heat gain. In order to calculate the transmission heat gain, the CLTD for the wall and floor must be calculated. The CLTD considers latitude, direction, and the average outdoor temperature with factors given from Chapter 3 of the *ASHRAE Cooling and Heating Load Calculation Manual*. The CLF for the windows is given from Table 7.6, using double pane glass at 90°F. The total transmission heat gain is 111,062 BTUH. The internal heat gain is caused by people, lights, and appliances. The number of people was based on the occupant load for the wing, with the heat gain per person given in the Table 4.5 of the *ASHRAE Cooling and Heating Load Calculation Manual*. Heat gains for persons seated with light work and standing with light work were considered. The wattage of the lights and appliances was converted into BTUH. The total internal heat gain is 30,561 BTUH. The total cooling load is 141,623 BTUH, which requires an airflow rate of 8,583 CFM. The system will be designed for the cooling load as it is larger than the heating load.

7.2.2.2. Ventilation

Ventilation is extremely important in a pandemic quarantine center. Minimum requirements for the ventilation of the building are given in the NYC Mechanical Code Chapter 4. The NYC Mechanical Code gives the requirements in airflow per person or airflow per square foot, depending on the space. The requirements in ASHRAE Standard 170: Ventilation of Health Care Facilities were also analyzed. The ASHRAE standard gives the requirements in air changes per hour (ACH). ACH was converted to an airflow rate by multiplying by the room volume and converting hours to minutes. The requirements for both the NYC Mechanical Code and ASHRAE Standard 170 are shown below in Table 15. It was decided to use the ASHRAE Standard 170 requirements, the more stringent of the two, to properly design for a pandemic situation.

Table 15: Ventilation Requirements

Room Name	NYC Supply Requirement	NYC Return Requirement	ASHRAE 170 Supply Requirement	ASHRAE 170 Return Requirement
Patient Room	50 CFM	50 CFM	65 CFM	65 CFM
Patient	N/A	50 CFM	N/A	70 CFM

Bathroom				
Patient Corridor	202 CFM	202 CFM	1336 CFM	1336 CFM

The ASHRAE 170 Standard requires a total air supply rate of 2,578 CFM for ventilation and a total return rate of 3,915 CFM. The ventilation required comprises 23% of the total air requirement. Considering both the cooling load and the ventilation load, the building has a total load of 22 BTUH/ ft^2.

7.2.3. System Design

After determining the HVAC system loads in the patient area, the duct system was designed based on industry standards. There is one air loop for supply air and three air loops for return air throughout the patient wing. The additional return air loops in the wing are for the bathroom exhaust systems, which typically run in a separate loop. The supply air main runs down the middle of the corridor and branches off in order to run above the bathroom's drop ceiling, ending in a 24" x 24" sidewall diffuser that feeds air into the patient room. Throughout the supply main in the corridor, there are five 12" x 12" diffusers attached directly to the duct for the airflow required in the corridor. The diffusers were sized in terms of required air flow, noise control, and throw length. The required air flow per room was a combination of the room's cooling load and ventilation requirements. For hospital design, a typical noise control level is between 25 and 30 N.C. (Engineering Toolbox, 2004). A Price Industries Square Plate diffuser was chosen to be installed and manufacturer data was used to determine the proper size (Price Industries, n.d.). By using a 24" x 24" Size 10 diffuser, the noise control level is 26, below the recommended hospital value of 30, and the throw is 12 feet, slightly under the length of the patient rooms. Similarly, a 12" x 12" Size 8 diffuser has a noise control level of 26 and a throw length of 13 feet, which meets the requirements needed for the hallway.

The return duct system for the patient bathrooms runs directly in a straight line from the ADA patient bathroom to the exterior of the building. The ductwork is hidden above the dropped ceiling in the patient bathrooms and rooms; it is only exposed when in the stairwell before it exits the building. The return duct system for the air in the patient rooms consists of 12" x 10" louvered return grilles on the edge of the patient room soffits that connect to a main directly outside the room, through a branch line that runs straight through the soffit. There are two return air mains in the patient wing corridor that connect in the southwest corner of the hallway before exiting the building to be filtered and reused in the supply air system. Similar to the diffusers, the grilles were sized based on required air flow and the noise control level. A 12" x 10" Price Industries Louvered Grille Return with 0° deflection provides a noise control level under 30 for the required air flow for the patient rooms, while an 8" x 6" grille provides the necessary airflow with a noise control under 15 for the patient bathrooms (Price Industries, n.d.).

Typically, ducts are designed with a friction loss of 0.08-0.1 ft/100 ft of duct. This friction loss also ensures that noise coming from the ducts will be minimal. A Trane ductulator was then used to determine the size of duct needed to obtain this pressure loss for the required airflow. There were times during the design that the given duct size was not feasible; for example, transitioning from a 12” x 12” duct to a 16” x 10” duct. In these cases, a lower friction loss was used to obtain duct transitions that were practical. The duct sizes given by the ductulator were adjusted to ensure the sizing was entirely even numbers, as done in industry practice. The outdoor unit that supplies the system is a 20-ton Carrier heat pump which includes a safety factor of 20%. To see the full duct layout with routing ad sizing, see sheet M101 in the building plans (Appendix J).

After designing the HVAC system, the indoor air quality was examined by calculating the carbon dioxide levels in the patient rooms and the patient wing corridor. The guidelines given by Appendix D of the ASHRAE Standard 62.1 were used in the calculation process. The indoor carbon dioxide level is equal to the sum of the outdoor carbon dioxide level and the carbon dioxide generation rate per person divided by the ventilation rate of the area per person. The outdoor carbon dioxide level in NYC is typically 400 ppm or less (Hsueh, Griffin, & McGillis, 2010). The ASHRAE guidelines provide breathing levels and carbon dioxide generation rates for different activity levels, shown in Figure 48 below.

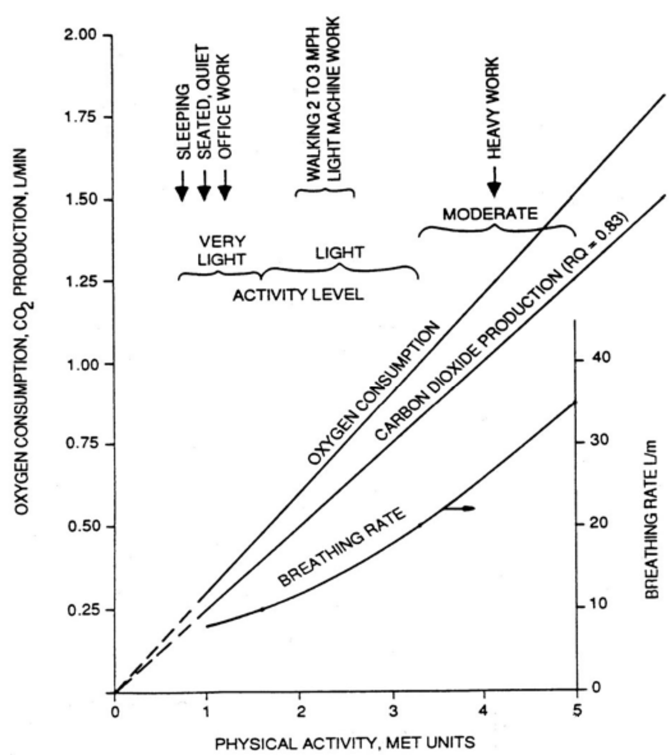


Figure 48: Metabolic Data from ASHRAE Standard 62.1

A physical activity of 1.5 met units, which is between a light and very light activity level, was used for the patient rooms. For the corridor in the patient wing, physical activity would be slightly higher, so 2.0 met units was used. Utilizing the graph in Figure 48, the carbon dioxide generation rate per person for 1.5 met units and 2.0 met units is 0.375 L/min and 0.50 L/min, respectively. Table 16 below shows the ventilation rates per person for each area and the corresponding carbon dioxide levels. As depicted in the same table, the carbon dioxide levels for each of the rooms is under the industry standard of 1000 ppm by at least 19.2%. For this reason, it was determined that the air quality in the building was acceptable.

Table 16: Carbon Dioxide Levels

Room	Activity Level (met units)	Carbon Dioxide Generation Rate (L/min)	Ventilation Rate per Room (L/min)	Occupant Load	Ventilation Rate per Person (L/min)	Indoor Carbon Dioxide Level (ppm)
Patient Room	1.5	0.375	1,840	2	920	808
Corridor	2.0	0.50	37,809	8	4,726	506

While it was determined that certain criteria were imperative in the HVAC system, the design of these aspects was not developed due to time constraints. As previously mentioned, pressure differentials are important in hospital design to ensure that infected air does not flow out of patient rooms. The patient rooms need to be kept at a negative pressure while the common areas (such as the corridors) should be kept at a positive pressure. Sensors should be installed throughout the system to monitor the pressure of key areas and trigger a response when pressures rise and/or drop. Additionally, the utilization of heat recovery ventilation systems would significantly decrease the energy demand and assist with humidity control (Zhang, 2008). Finally, the air filters that would purify and sanitize the air throughout the HVAC system are not specified. These filters are important to ensure that none of the airborne virus particles travel from space to space through the HVAC system.

7.3 Sustainability Measures

Throughout the design of the quarantine center, one of the objectives was to attempt to make the design sustainable. However, designing for a pandemic situation was the main goal of the project, therefore, sustainable measures needed to be compromised in some areas. For example, based on the needed construction time alone, items such as geothermal heat pumps were not able to be implemented into this project. In addition, natural ventilation could not be used throughout most areas of the building due to difficulties to control indoor airflow across different rooms. While some sustainability measures were not an option, an effort was made to reduce the energy loads and incorporate materials that would be easily reused or recycled.

As previously mentioned in Chapter 6, the structural system of the building will utilize lightweight steel construction. LWS was chosen for several reasons, one of the major ones being its ability to be recycled. Due to the nature of this building, it will ultimately be deconstructed once the pandemic subsides. Therefore, to reduce raw materials, energy, and waste, LWS can be shredded, melted down and made into sheets that are then sold to manufacturers. This process can save nearly 74% of the energy used to produce steel from raw materials (Keep America Beautiful, n.d.). Steel is also one of the only resources that be recycled indefinitely without losing its material properties (Steel Recycling Institute, n.d.). Often times, the cost of the project can be offset by selling the recyclable steel scraps.

The envelope design provided the building with a high heat resistance which therefore decreased the load of the HVAC system. The cooling and ventilation load of the building that was manually calculated was 22 BTUH/ft^2. The typical hospital load is about 27 BTUH/ft^2 (US Energy Information Administration, 2012). Therefore, by designing an efficient envelope, the typical hospital load was minimized by 5 BTUH/ft^2. Due to the decreased load given by the envelope, increasing the ventilation rates given by the ASHRAE 170 standard by 50% and 100% was considered. With these increases, the HVAC system load would be 25 BTUH/ft^2 and 28 BTUH/ft^2, respectively. While increasing the ventilation rate by 50% would result in a total load less than the average, it was decided not to increase the load for maximum energy savings.

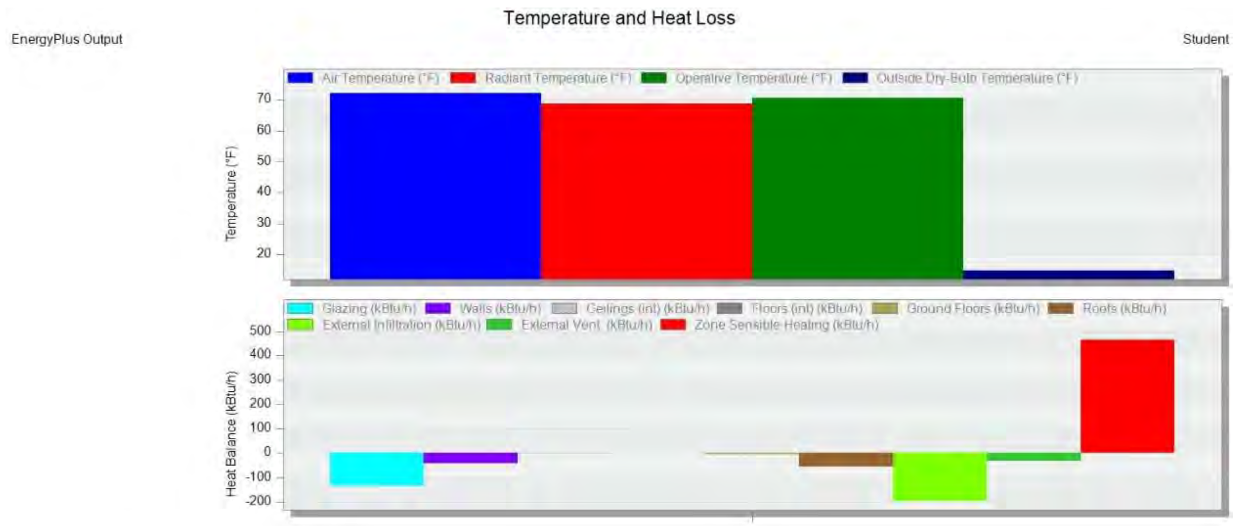
7.3.1. DesignBuilder

DesignBuilder was utilized to verify the calculated system loads and determine the building's total energy per square foot of area. The building had already been recreated in DesignBuilder as a part of the daylighting analysis. Additional properties such as building schedule, occupancy type, and envelope materials were then added to the program. DesignBuilder uses the Zone Heat Balance Model calculation method whereas the manual calculations used the CLTD calculation method. In addition, only the heating and cooling loads for the western patient wing on the first floor were calculated. The manually calculated loads were extrapolated to the rest of the building. Due to these discrepancies, it was assumed that there would be around a 20% difference in the calculated values. The comparison of the manual calculations and the values given by DesignBuilder can be found in Table 17 below.

Table 17: Comparison of Manual and DesignBuilder Calculations

	Heating Load	Cooling Load
Manual Calculation	382 kBTUH	1584 kBTUH
DesignBuilder	465.8 kBTUH	2062 kBTUH
Percent Difference	-18.0%	-23.2%

As shown in Table 17, both the heating load and the cooling load were around the 20% difference that was expected. The DesignBuilder outputs for the heating and cooling loads can be seen in Figures 49 and 50. This confirmed that the parameters used in DesignBuilder were sufficiently accurate and would produce reliable results about the building's total energy usage. The majority of both the heating and cooling loads were caused by infiltration and heat transfer through the windows. Reducing the glazing percentage of the building would reduce the HVAC system loads. However, the effect of sunlight on patient recovery was a crucial component to this project, therefore, the surface area of the windows was maximized.



Air Temperature (°F)	72.00
Radiant Temperature (°F)	68.86
Operative Temperature (°F)	70.43
Outside Dry-Bulb Temperature (°F)	15.00
Glazing (kBtu/h)	-134.64
Walls (kBtu/h)	-41.89
Ceilings (int) (kBtu/h)	-1.03
Floors (int) (kBtu/h)	1.03
Ground Floors (kBtu/h)	-4.98
Roofs (kBtu/h)	-53.90
External Infiltration (kBtu/h)	-198.59
External Vent. (kBtu/h)	-32.08
Zone Sensible Heating (kBtu/h)	465.82

Figure 49: DesignBuilder Heating Loads

EnergyPlus Output

Temperature and Heat Gains - QCMQP, Building 1
15 Jul, Sub-hourly

Time	2:00	4:00	6:00	8:00	10:00	12:00	14:00	16:00	18:00	20:00	22:00
Air Temperature (°F)	72.00	72.00	72.00	72.00	72.00	72.00	72.00	72.00	72.00	72.00	72.00
Radiant Temperature (°F)	73.79	73.52	76.24	81.31	81.23	79.41	79.17	80.53	80.45	77.32	76.10
Operative Temperature (°F)	72.89	72.76	74.12	76.65	76.61	75.71	75.58	76.27	76.22	74.66	74.05
Outside Dry-Bulb Temperature (°F)	87.16	87.04	87.04	87.52	88.24	88.74	89.00	88.88	88.52	88.00	87.64
Glazing (kBtu/h)	19.53	19.78	38.74	48.53	44.14	34.63	41.61	45.23	32.02	16.44	18.26
Walls (kBtu/h)	10.44	8.28	-17.61	-13.34	20.38	28.25	14.97	14.75	25.37	26.87	17.23
Ceilings (int) (kBtu/h)	0.55	0.26	-5.53	-1.85	3.52	3.95	-0.01	1.52	3.96	2.23	0.97
Floors (int) (kBtu/h)	0.32	0.13	-8.36	-6.12	-0.38	2.27	-3.77	-4.56	0.23	2.12	1.04
Ground Floors (kBtu/h)	-8.34	-8.29	-18.45	-20.52	-15.57	-10.75	-15.73	-17.69	-14.40	-10.23	-10.06
Partitions (int) (kBtu/h)	29.12	13.55	-192.26	-208.27	8.76	89.09	-20.35	-68.91	34.02	128.33	64.18
Roofs (kBtu/h)	1.84	-1.20	-46.20	-19.48	58.31	85.17	62.69	45.85	43.26	25.00	7.83
External Infiltration (kBtu/h)	45.91	45.56	45.56	46.97	49.09	50.55	51.32	50.96	49.91	48.38	47.32
External Vent. (kBtu/h)	217.41	215.83	215.81	222.10	232.35	239.55	243.31	241.57	236.38	228.94	223.85
General Lighting (kBtu/h)	0.00	0.00	0.00	324.28	0.00	0.00	0.00	0.00	162.14	324.28	243.21
Computer + Equip (kBtu/h)	5.03	5.03	5.03	71.90	5.03	5.03	5.03	5.03	38.47	71.90	55.18
Occupancy (kBtu/h)	165.11	165.11	165.11	165.11	165.11	165.11	165.11	165.11	165.11	165.11	165.11
Solar Gains Exterior Windows (kBtu/h)	0.00	0.00	565.94	1005.18	876.56	444.41	549.33	893.75	689.62	0.00	0.00
Zone Sensible Cooling (kBtu/h)	-269.32	-247.43	-509.15	-1368.62	-1211.60	-902.44	-839.55	-1119.08	-1228.53	-799.64	-607.22
Sensible Cooling (kBtu/h)	-489.32	-465.50	-727.30	-1594.43	-1447.84	-1145.84	-1086.65	-1364.48	-1468.79	-1032.40	-834.72
Total Cooling (kBtu/h)	-802.99	-759.56	-1151.82	-2061.63	-1865.78	-1558.37	-1509.94	-1787.35	-1896.86	-1451.17	-1235.49
Relative Humidity (%)	64.97	66.82	64.18	56.64	57.24	57.71	58.00	57.75	57.08	57.34	58.35
Mech Vent + Nat Vent + Infiltration (ac/h)	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39

Figure 50: DesignBuilder Cooling Loads

The building's energy use intensity (EUI) is 231 kBTUH/ft^2, slightly under the median hospital energy usage of 234 kBTUH/ft^2 (Energy Star, n.d.). This shows that the efforts to reduce the building energy consumption worked minimally. The EUI by category for the facility is shown in Figure 51. The heating and distribution of domestic water requires the most energy in the building. This is believed to be the predominant load because the design of this system was not included as a part of this project. The plumbing system should be designed with sustainable measures in order to decrease this load. As mentioned in the Recommendations Chapter, the plumbing system needs to be designed and sustainability aspects require further development for this project.

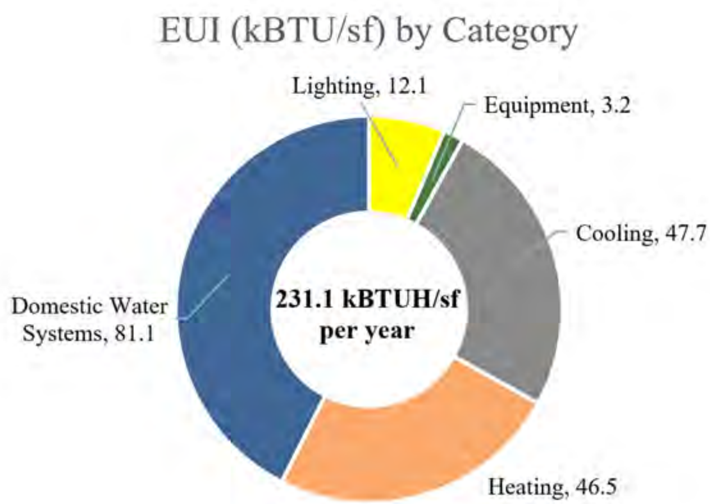


Figure 51: Energy Use Intensity by Category

8.0 Concluding Remarks & Recommendations

After the coronavirus pandemic revealed a need for temporary facilities to house mildly sick patients in order to assist the overloaded healthcare system, the issue was approached by utilizing innovative design. Collectively, the team worked to develop a quick-build quarantine center through modular construction and prefabrication that focused on occupant mental and physical health. Overall, the final design is appropriate in the event of a pandemic for numerous reasons. First, the layout of the architectural floor plan aids in separating infected individuals from the rest of the hospital staff. The composition of spaces also allows for better control of human traffic patterns throughout the facility. Additionally, the interior design features aim to improve the wellness of the patients and the staff and promote quicker recovery. In terms of air quality and control, the HVAC system was designed to provide ample ventilation throughout the separate spaces in the building. Lastly, the use of prefabricated modules allows for the possibility of quick construction and assembly in the event of a pandemic. Although the main focus of the design was on the architectural, structural and HVAC designs, there are several other aspects that can be considered to further develop this project. A list of possible advancements and recommendations can be found in the following sections.

8.1 Further Developments

Due to the time restriction and priority given to specific building systems, there were several components that were not able to be fully developed but would be essential to the complete design of the building. The following sections outline further developments that can be made to improve the deliverables of this project.

8.1.1 Preventative Measures

It is imperative that this facility develop a cleaning and disinfection plan to be implemented daily and potentially after every use of an item. In accordance with the CDC, frequently touched surfaces should be cleaned with soap, water, then disinfectant while using disposable gloves. The use of self-cleaning adhesives on frequently touched surfaces, such as doorknobs, light switches, faucets etc., would minimize the risk of transmission in between cleanings. Wipeable covers should be considered on electronics and wiped down with alcohol-based wipes/sprays after each use. Additionally, clothing and linens should be laundered with the warmest water appropriate while wearing disposable gloves (CDC, 2020a). Outlining a cleaning strategy is imperative for this high-risk situation to keep all workers as safe as possible and reduce the chance of re-exposing any patients.

8.1.2 Plumbing & Electrical Systems

Although plumbing and electrical systems were not designed as part of this project, the facility allows for easy installation. The building will have a crawl space due to the nature of how it is being supported. This will allow for plumbing to run underneath the building. As mentioned in Section 7.3.1, the domestic water system accounts for about 35% of the building's energy usage. The plumbing system needs to be designed to be energy efficient in order to reduce the facility EUI. In terms of the electrical system, it would be best if the module came prewired with all the necessary components. The wiring can run through the raised floors into the building. This preassembly will facilitate the construction and allow for all the furnishings to be quickly put in for the building to be ready for use.

8.1.3 Fire Protection

As a part of the building's life safety, the quarantine center will need to be equipped with fire protection systems. Per the NYCBC, this quarantine center will need to be equipped with an automatic sprinkler system and a fire alarm system (2018 IBC §407.7 and §407.8). Both systems should be designed in accordance with the proper National Fire Protection Association Standards and the associated NYC amendments. The automatic sprinkler system must connect to the city's municipal water supply, while the fire alarm system will be supplied by the building's electrical system. The fire protection system is crucial to the safety of the building occupants.

8.1.4 Connections Detail

The connections detail provided in this report demonstrates a conceptual example of how this structure could be connected. In order to fully develop this design, the calculations from chapter J in the North American Specification for the Design of Cold-Formed Steel Structural Members would have to be implemented. The available strength of the weld would have to be calculated and compared to the amount of force being applied to ensure it does not exceed what is available. Knowing this information will determine the precise size the metal plate must be. Similarly, to determine the appropriate screw size the nominal shear strength per screw must be calculated to establish what the available strength is. This applied force, again, must not exceed the available strength in the screw (AISI, 2016). Once these calculations are performed the connections detail can be made more specific and dictate the exact materials necessary for the construction of the building.

8.1.5 Solar Panels

The use of solar panels can greatly decrease the building's net energy usage. Roof mounted photovoltaic panels are not an option in this design, as the roof was not designed to support them. Instead, a field array of solar panels could be assembled in the park area behind the building. Utilizing a field array also helps decrease the time until the building is occupiable. The solar panels could be installed after the Quarantine Center opens. The use of energy collection from 3’x5’ solar panels was analyzed in DesignBuilder. In New York, solar panels collect the most energy when they face South and are angled at 41° (Marsh, 2018). A set of 10 panels oriented in the optimal position gather 13,866 kBTUH

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Appendices

Appendix A: Survey

Worcester Polytechnic Institute
Pandemic Quarantine Center MQP Project Survey

Intro: A team of 3 college students are designing a quarantine center for patients in a future pandemic scenario. The project design focuses on health, comfort, affordability, and energy efficiency. You are being asked to participate in a survey to gather opinions on hospitals during the time of the pandemic.

What you will be asked to do: Based on your experience, give your opinions on the hospital environment during COVID-19. Answer the following questions as completely and honestly as you can. The survey should take 10-15 minutes to complete.

Risk to participants: A WPI Institutional Review Board (Ethics Board) has reviewed and approved this study considering ethical considerations, the protection of human participants, and minimizing risks to participants. They have determined there is *minimal to no risk* to participants.

Confidentiality: The information you give will be anonymous. You will not be asked to write your name on any form. Your responses will only be used in the project to make design decisions.

Voluntary participation: Your participation in this survey is completely voluntary. There is no penalty if you decide not to participate. There is no compensation for completing this survey.

Right to withdraw: You have the right to withdraw from the study at any time. To withdraw from the survey, simply close out of the browser.

For questions or concerns please contact:
Our Email: gr-qcmqp@wpi.edu Attn: Yllara Maia, Kimberly Ramos, Samantha Wile
Advisor: Shichao Liu via sliu8@wpi.edu
WPI IRB Email: irb@wpi.edu

I agree to the terms & conditions as stated above and am voluntarily consenting to answering the survey questions hereafter.

a. I consent
b. I do not consent

Are you a:

a. Hospital Worker
b. Former COVID-19 patient

*Depending on the answer to the previous question, they will be taken to either section 1 or 2 of the survey. Hospital workers will go to section 1, former COVID-19 patients will go to section 2.

SECTION 1:

In order for us to understand how your work environment has changed since the beginning of the pandemic, please answer the following questions.

1. What new precautions has your hospital taken?
2. Do you feel safe with these precautions in place?
    a. If no, why not?
3. What new procedures have to be followed?
4. Do you feel there has been an impact on a patient's mental wellbeing with the new precautions in place?
    a. If so, how?
5. Do you feel like there is enough space for you to work while maintaining socially distant? (i.e., is there enough room for multiple people to go down a hallway?)
6. Can the layout of your workspace be improved to better the safety of both workers and patients?
    a. If so, how?
7. Aside from medical treatment, what else do you feel a patient needs to have an efficient recovery? (i.e., sunlight, space, nature, visitors etc.)

SECTION 2:

Former Patients:
In order for us to understand your experience being hospitalized during a pandemic, please answer the following questions.

1. What was the severity of your condition during your hospital stay?
2. Did you feel safe during your hospitalization?
3. Did you have a private room? If not, how many others were in your room?
    a. If you did not have a private room, would you have preferred one? Why or why not?

4. What was included in your room? (Check all that apply)
    a. Window
    b. TV
    c. Plants
    d. Artwork
    e. Bedside table
    f. Comfortable chairs and/or couches
    g. Other: ______________
5. If your room had a window, what was it facing?
6. What were you able to do to pass the time? (i.e., TV, reading, games etc.)
7. Do you feel like your room accommodations impacted your recovery?
8. Were you able to communicate with your family during your hospital stay? If yes, how so?
9. Do you feel as if hospital staff was able to respond to your needs in a timely manner?
10. Is there anything you wish you could have had that would have aided in your recovery?

Worcester Polytechnic Institute

100 Institute Road, Worcester MA 01609 USA

Institutional Review Board

FWA #00015024 - HHS #00007374

Notification of IRB Approval

Date:	08-Sep-2020
PI:	Liu, Shichao
Protocol Number:	IRB-21-0010
Protocol Title:	Pandemic Quarantine Center
Approved Study Personnel:	Ramos, Kimberly~Maia, Yllara~Wile, Samantha~Liu, Shichao~Van Dessel, Steven~
Effective Date:	08-Sep-2020
Exemption Category:	2
Sponsor*:	

The WPI Institutional Review Board (IRB) has reviewed the materials submitted with regard to the above-mentioned protocol.We have determined that this research is exempt from further IRB review under 45 CFR § 46.104 (d). For a detailed description of the categories of exempt research, please refer to the IRB website.

The study is approved indefinitely unless terminated sooner (in writing) by yourself or the WPI IRB. Amendments or changes to the research that might alter this specific approval must be submitted to the WPI IRB for review and may require a full IRB application in order for the research to continue. You are also required to report any adverse events with regard to your study subjects or their data.

Changes to the research which might affect its exempt status must be submitted to the WPI IRB for review and approval before such changes are put into practice. A full IRB application may be required in order for the research to continue.

Please contact the IRB at irb@wpi.edu if you have any questions.

Appendix B: Survey Responses Report

Hospital Worker Feedback

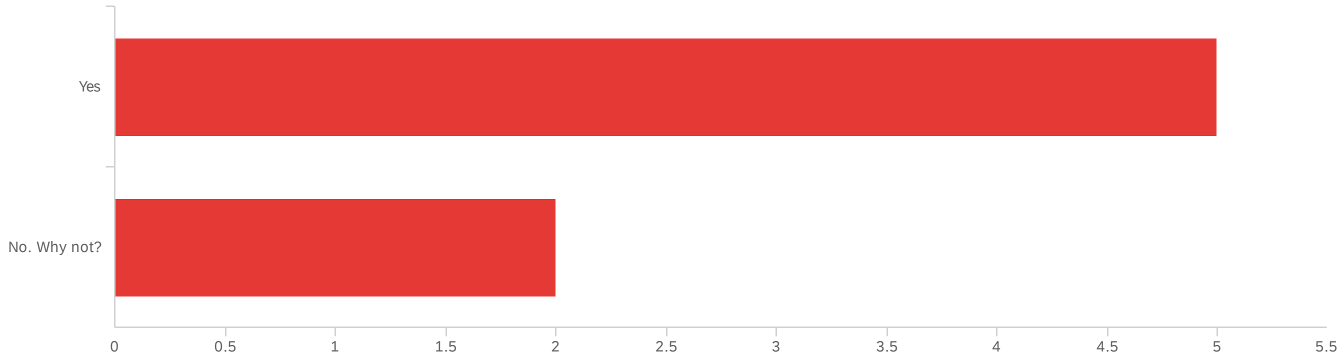
Pandemic Quarantine Center

November 24, 2020 12:54 AM EST

Q1 - What new precautions has your hospital taken?

What new precautions has your hospital taken?
- Masks required for all employees and visitors - Eye protection required for all employees - N95, gowns for COVID-19 precaution patients + symptoms (patients with a COVID test pending and symptoms) - Medical students are not allowed to see patients COVID-19 pending - Medical students may recieve a weekly COVID test free of charge - COVID-19 test for all patients with symptoms that could be COVID - COVID-19 test prior to all surgeries and procedures - Currently visitors are allowed, maximum 3 visitors per day, one visitor at a time exceptions for children, family goals of care meetings - Patients cannot wander the floors; I believe initially they were not allowed to leave their rooms, now they can stay on the same floor - Cleaning equipment with wet wipes that can kill viruses - Cleaning stethoscopes between patients with alcohol wipes
All staff, patients and visitors must wear masks at all times. Hand sanitizer is available at each entrance and at numerous locations. Cleaning/desinfecting of areas are done with more frequency than usual. Modification of waiting rooms and lobbies for a 6-feet a part distance
Mask station, more handsanatizer stations, day work pass (questionaire if you are feeling well/sick/fever) less foot traffic in hospital
Screening at the door including a survey and temperature checks and limiting visitors
Mask + goggles for every patient, regardless of COVID status
All the ones recommended by CDC. Contact and droplet precaution on all Covid positive or suspected. Surgical mask and eye protection all day
Masks

Q2 - Do you feel safe with these precautions in place?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Do you feel safe with these precautions in place? - Selected Choice	1.00	2.00	1.29	0.45	0.20	7

#	Field	Choice Count	
1	Yes	71.43%	5
2	No. Why not?	28.57%	2
			7

Showing rows 1 - 3 of 3

Q35_2_TEXT - No. Why not?

No. Why not?
because someone might have covid19 and be asymptomatic
I would prefer face shields and n95 instead of surgical

Q3 - What new procedures have to be followed?

What new procedures have to be followed?
All of them. Protective eye wear is difficult for some as it fogs up and is difficult to see the patient.
Masks are required at all times, extra PPE when necessary, extra cleaning/desinfecting protocol, staff/visitors(visitors policies changed) wellness screening at the entrance, rigorous measures in place at triage assessing patients for COVID-19 symptoms upon arrival
all new procedures from above
Limit visitors to one visitor per 24 hours
N95 use with any aerosolizing procedures (intubations, nebulizing treatments, etc)
Many, it is hard to list them all. Wear a mask everyday, when do test once twice or more a patient with Covid, what trigger covid suspect, n95 for any aerosolizing procedure, visitor reduction policy. In reality every week things change, door of rooms closed, additional ventilation
Differences I'm calling patients back and who can come into the room with the pt

Q4 - Do you feel there has been an impact on a patient's mental wellbeing with the new precautions in place? If so, how?

Do you feel there has been an impact on a patient's mental wellbeing with t...
Yes. I think the biggest issue is visitors being able to see patients, though this rule has been relaxed compared to before.
Yes. I do feel that during this difficult time hospitals had to put strong limits on visitors policy and that definitely had an impact not only on patient's mental wellbeing but also their families. In-person visits provide support and reassurance for patients and families alike.
Yes because there is limited visits allowed and because they can't interact with us the same way due to our mask and muffled voices
Uneasiness due to medical team needing to be in PPE at all times
For sure, they are alone in a small space with decreased interaction with nursing
They've been frustrated more

Q5 - Do you feel like there is enough space for you to work while maintaining socially distant? (i.e. is there enough room for multiple people to go down a hallway?)

Do you feel like there is enough space for you to work while maintaining so...
Sometimes. The physician workspaces in many of the hospital floors at UMass University hospital are cramped. The workspace is probably 4-5 feet wide and 20-30 feet long with 2 teams working in the space. Each team is composed of an attending physician, senior resident, 2 intern residents, and 1-3 medical students. Hallways can be cramped with equipment and rolling computer stations. Though, I would say for the most part people can walk in the hallways with enough space. Sometimes teams will do "standing rounds" which are where we talk about the patient outside of their room with the team to discuss the plan for today and this can cause some cramping of the hallways.
Yes.
In most cases
No
Not always
No, we are all crammed together like always at the nurse station, there is no way to provide care 6ft away.
No

Q6 - Can the layout of your workspace be improved to better the safety of both workers and patients? If so, how?

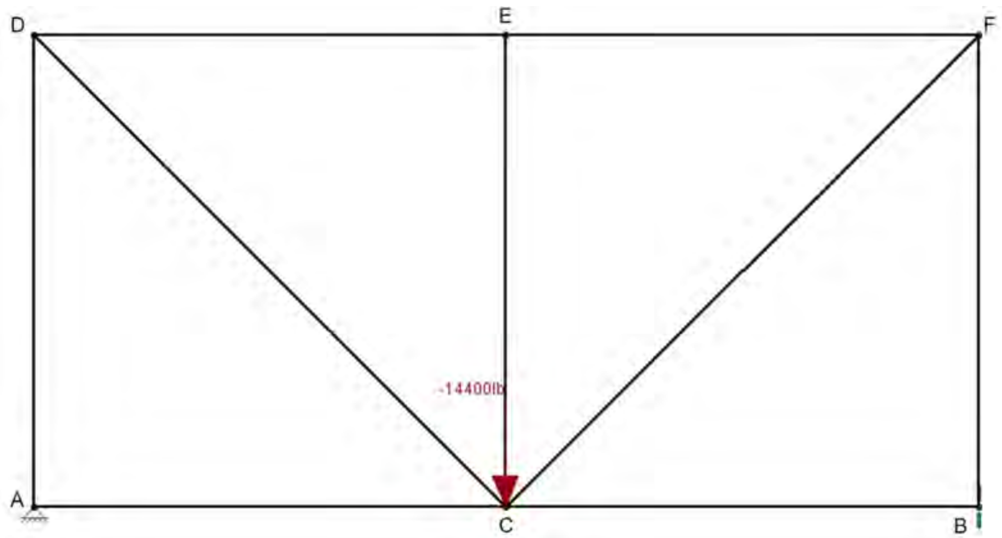
Can the layout of your workspace be improved to better the safety of both w...
- More space in physician work
I believe that the department I work at is following the guidance and best practices to keep all the personnels and patients safe
Yes, telephone rooms are fully staffed with people sitting next to eachother
Yes so sort of makeshift break room/ area could have been created to allow workers to spread out during breaks
No
No there is no Sq ft available to spare.
No

Q7 - Aside from medical treatment, what else do you feel a patient needs to have an efficient recovery? (i.e. sunlight, space, nature, visitors, etc.)

Aside from medical treatment, what else do you feel a patient needs to have...
- Natural light - Windows - Large rooms, if shared double patient rooms, enough space for both beds - Visitors
I feel that even though the implementation of new strict visitors policy is for the best interest in protecting patients and everyone else, it’s importante for them to feel loved and cared in the presence of family members
stace, nature, visitors, sunlight
Visitors and sunlight
Socialization, sunlight, visitors
There is a holistic approach involved in healing, medical treatment alone does not do it. They need more human interaction, family at bedside better ventilation, lighting, things to keep their mind of their diagnosis

End of Report

Appendix C: Sample Truss Calculation



$$\curvearrowright \Sigma M_A = 0 = C_y(12) - B_y(24)$$
$$\curvearrowright \Sigma M_A = 0 = 14{,}400(12) - B_y(24)$$
$$B_y = 7{,}200lbf$$

$$\Sigma F_y = 0 = A_y - 14{,}000 + 7{,}200$$
$$A_y = 7{,}200lbf$$

$$\curvearrowright \Sigma M_D = 0 = -A_x(12) - C_y(12) - B_y(24)$$
$$\curvearrowright \Sigma M_D = 0 = -A_x(12) - 14{,}400(12) - 7{,}200(24)$$
$$A_x = 0$$

MEMBER FORCES

Joint A

$$\Sigma F_y = 0 = F_{AD} + A_y$$
$$\Sigma F_y = 0 = F_{AD} + 7{,}200$$
$$F_{AD} = -7{,}200lb\ (c)$$

$$\Sigma F_x = 0 = F_{AC} \rightarrow F_{AC} = 0$$

Joint D

$$\Sigma F_y = 0 = F_{AD} - \left(\frac{12}{\sqrt{288}}\right) F_{DC}$$

$$\Sigma F_y = 0 = -7{,}200 - \left(\frac{12}{\sqrt{288}}\right) F_{DC}$$
$$F_{DC} = 10{,}182.338 lb$$

$$\Sigma F_x = 0 = F_{DE} + \left(\frac{12}{\sqrt{288}}\right) F_{DC}$$
$$\Sigma F_x = 0 = F_{DE} + \left(\frac{12}{\sqrt{288}}\right) F_{DC}$$
$$F_{DE} = -7{,}200.02 lb\ (c)$$

<u>Joint E</u>

$$\Sigma F_x = 0 = F_{DE} - F_{EF}$$
$$\Sigma F_x = 0 = -7{,}200.02 - F_{EF}$$
$$F_{EF} = -7200.02 lb\ (c)$$
$$\Sigma F_y = 0 = F_{EC}$$

<u>Joint F</u>

$$\Sigma F_x = 0 = -F_{EF} - \left(\frac{12}{\sqrt{288}}\right) F_{FC}$$
$$\Sigma F_x = 0 = -7200.02 + \left(\frac{12}{\sqrt{288}}\right) F_{FC}$$
$$F_{FC} = -10{,}182.338 lb$$

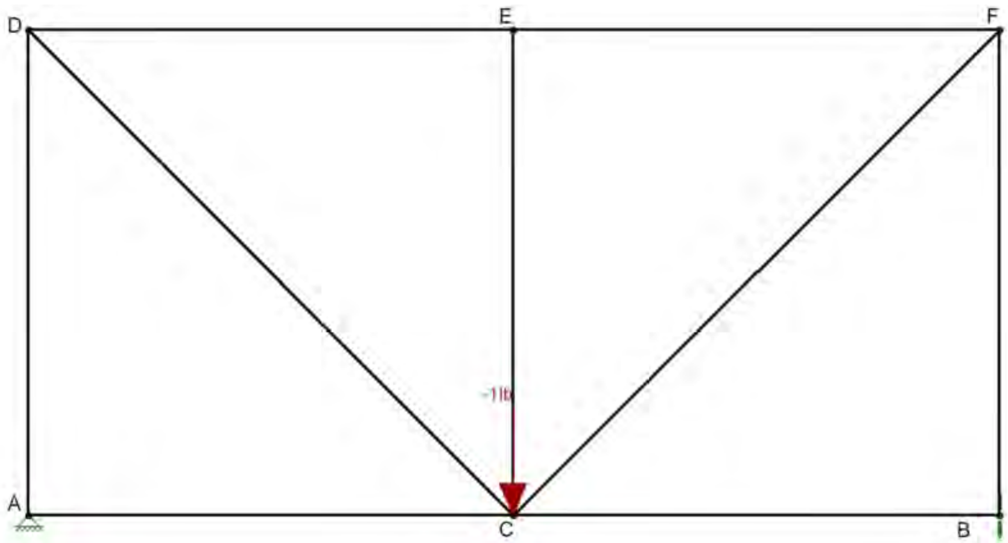
$$\Sigma F_y = 0 = -F_{FB} - \left(\frac{12}{\sqrt{288}}\right) F_{FC}$$
$$\Sigma F_y = 0 = -F_{FB} - \left(\frac{12}{\sqrt{288}}\right)(-10{,}182.338)$$
$$F_{FB} = -7200.02\ (c)$$

<u>Joint B</u>

$$\Sigma F_x = 0 = F_{BC}$$

$$\Sigma F_y = 0 = F_{BF} + B_y$$
$$\Sigma F_y = 0 = F_{BF} + 7200$$
$$F_{BF} = -7{,}200\ (c)$$

<u>DEFLECTION – Virtual Work</u>



S162 Structural Stud

$$A = 0.670in^2$$
$$E = 29{,}500ksi$$

$$\curvearrowright \Sigma M_A = 0 = C_y(12) - B_y(24)$$
$$\curvearrowright \Sigma M_A = 0 = 1(12) - B_y(24)$$
$$B_y = 0.5$$

$$\Sigma F_y = 0 = A_y + B_y - 1$$
$$\Sigma F_y = 0 = A_y + 0.5 - 1$$
$$A_y = 0.5$$

$F_{AD} = -0.5$ $F_{FE} = -0.5$ $F_{DC} = 0.707$

$F_{DE} = -0.5$ $F_{FB} = -0.5$ $F_{FC} = 0.707$

Member	f	F	L (ft)	lb^2ft
AD	-0.5	-7,200	12	43,200
AC	0	0	12	0
DC	0.707	10,182.338	16.97	122,165.553
DE	-0.5	-7,200	12	43,200
EC	0	0	12	0
EF	-0.5	-7,200	12	43,200
FC	0.707	10,182.338	16.97	122,165.553
FB	-0.5	-7,200	12	43,200
BC	0	0	12	0
			Total:	373,931.106

$$\frac{37393.106 lb^2 ft * (\frac{12in}{ft})}{0.00694 ft^2 * 29{,}500{,}000 psi} = 1lb \cdot \Delta$$

$$\Delta = 0.18$$

STRESS

$$\sigma = \frac{F}{A}$$

Member	Force	T/C	A (in^2)	Stress (psi)
AD	7,200	C	0.67	10,746.27
AC	0	-	0.67	0
DC	10,182.338	T	0.67	15,197.52
DE	7,200	C	0.67	10,746.27
EC	0	-	0.67	0
EF	7,200	C	0.67	15,197.52
FC	10,182.338	T	0.67	15,197.52
FB	7,200	C	0.67	10,746.27
BC	0	-	0.67	0

BUCKLING

$$E = \frac{\pi^2 EI}{l^2}$$

$$I = \frac{side^4}{12}$$

Appendix D: Footing Calculation

NYC Building Code

Size of column: 4.25" × 4"

Soil bearing capacity: 3 kip/ft^2 (From Table 1804.1)

Load on column: 6.637 kip

Increase 10% above load: $6.637 * 1.10 = 7.3007 kip$

Area of footing:

$$\frac{Load}{SBC} = \frac{7.3007}{3} = 2.43 sf$$

Side of Footing:

$$\sqrt{2.43 sf} = 1.56 ft \approx 2 ft$$

Appendix E: Snow Load Calculation

Risk Category: III → Flat Roof
Exposure: C
Ground snow load: 25 (from 1608.2)
Table 1608.3.1: $C_e = 0.9$
Table 1608.3.2: $C_t = 1.0$
Table 1604.5.2: $I_s = 1.10$

$$P_f = 0.7C_eC_tI_sP_g$$
$$P_f = 0.7(0.9)(1.0)(1.10)(25) = 17.325psf$$
$$17.325psf(6ft) = 103.95lbs/ft$$

Appendix F: Wind Load Calculation

FLSMIDTH	**MWFRS Wind Loads** *ASCE 7-10* *Enclosed & Partially Enclosed Buildings of All Heights*	Job No: Designer: Checker:
	Notes: Grinding Building (+/- Z Direction)	Date: 10/28/2020

Basic Parameters

Risk Category	III	Table 1.5-1
Basic Wind Speed, V	140 mph	Figure 26.5-1A
Wind Directionality Factor, K_d	0.85	Table 26.6-1
Exposure Category	C	Section 26.7
Topographic Factor, K_{zt}	1.00	Section 26.8
Gust Effect Factor, G or G_f	0.850	Section 26.9
Enclosure Classification	Partially Enclosed	Section 26.10
Internal Pressure Coefficient, GC_{pi}	+/- 0.55	Table 26.11-1
Terrain Exposure Constant, α	9.5	Table 26.9-1
Terrain Exposure Constant, z_g	900 ft	Table 26.9-1

Wall Pressure Coefficients

Windward Wall Width, B	28 ft	
Side Wall Width, L	12 ft	
L/B Ratio	0.44	
Windward Wall Coefficient, C_p	0.80	Figure 27.4-1
Leeward Wall Coefficient, C_p	-0.50	Figure 27.4-1
Side Wall Coefficient, C_p	-0.70	Figure 27.4-1

Roof Pressure Coefficients

Roof Slope, θ	4.8°	
Median Roof Height, h	12 ft	
Velocity Pressure Exposure Coef., K_h	0.85	Table 27.3-1
Velocity Pressure, q_h	36.2 psf	Equation 27.3-1
h/L Ratio	1.00	
Windward Roof Area	0 ft²	
Roof Area Within 6 ft of WW Edge	0 ft²	

Location	*Min/Max*	*Horiz Distance From Windward Edge*			
		0 ft	*6 ft*	*12 ft*	*24 ft*
Windward Roof Coefficient Normal to Ridge, C_p	Min	-1.30	-1.30	-0.70	-0.70
	Max	-0.18	-0.18	-0.18	-0.18
Leeward Roof Coefficient Normal to Ridge, C_p	Min	-1.30	-1.30	-0.70	-0.70
	Max	-0.18	-0.18	-0.18	-0.18
Roof Coefficient Parallel to Ridge, C_p	Min	-1.30	-1.30	-0.70	-0.70
	Max	-0.18	-0.18	-0.18	-0.18

Figure 27.4-1

Structure Pressure Summary (Add Internal Pressure q_zGC_{pi} or q_hGC_{pi} as Necessary)

Height, z	K_z	q_z	*Walls*				*Roof*			Internal	
							Normal to Ridge		*Parallel to Ridge*		
			WW	*LW*	*WW + LW*	*Side*	*WW*	*LW*		Positive	Negative
0 ft	0.85	36.2 psf	24.6 psf		40.0 psf					19.9 psf	
1 ft	0.85	36.2 psf	24.6 psf		40.0 psf		Min:	Min:	Min:	19.9 psf	
2 ft	0.85	36.2 psf	24.6 psf		40.0 psf		-40.0 psf	-40.0 psf	-40.0 psf	19.9 psf	
4 ft	0.85	36.2 psf	24.6 psf		40.0 psf					19.9 psf	
5 ft	0.85	36.2 psf	24.6 psf		40.0 psf					19.9 psf	
6 ft	0.85	36.2 psf	24.6 psf	-15.4 psf	40.0 psf	-21.5 psf				19.9 psf	-19.9 psf
7 ft	0.85	36.2 psf	24.6 psf		40.0 psf					19.9 psf	
8 ft	0.85	36.2 psf	24.6 psf		40.0 psf		Max:	Max:	Max:	19.9 psf	
10 ft	0.85	36.2 psf	24.6 psf		40.0 psf		-5.5 psf	-5.5 psf	-5.5 psf	19.9 psf	
11 ft	0.85	36.2 psf	24.6 psf		40.0 psf					19.9 psf	
12 ft	0.85	36.2 psf	24.6 psf		40.0 psf					19.9 psf	

Page 1 of 1

Appendix G: Seismic Load Calculation

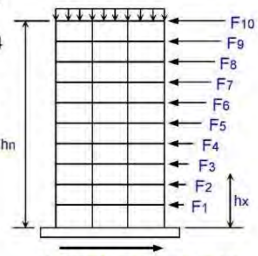
"ASCE710E.xls" Program
Version 2.1

SEISMIC BASE SHEAR AND VERTICAL SHEAR DISTRIBUTION
Per IBC 2012 and ASCE 7-10 Specifications
Using Equivalent Lateral Force Procedure for Regular Multi-Level Building/Structural Systems

Job Name:		Subject:			
Job Number:		Originator:		Checker:	

Input Data:

Risk Category =	III	IBC 2012, Table 1604.5, page 336
Importance Factor, I =	1.25	ASCE 7-10 Table 1.5-2, page 5
Soil Site Class =	D	ASCE 7-10 Table 20.3-1, page 204
Location Zip Code =	98520	
Spectral Accel., S_S =	0.250	ASCE 7-10 Figures 22-1 to 22-11
Spectral Accel., S_1 =	0.073	ASCE 7-10 Figures 22-1 to 22-11
Long. Trans. Period, T_L =	6.000	sec. ASCE 7 Fig's. 22-12 to 22-18
Structure Height, h_n =	25.000	ft.
Actual Calc. Period, T_c =	0.000	sec. from independent analysis
Seismic Resist. System =	C4	Steel ordinary moment frames (ASCE 7-10 Table 12.2-1)



V = Cs*W = Σ(Fi) = 0.49 kips
Seismic Base Shear
(Regular Bldg. Configurations Only)

Structure Weight Distribution:

No. of Seismic Levels = 2

Seismic Level x	Height, hx (ft.)	Weight, Wx (kips)
2	12.000	2.57
1	12.000	2.57

Total Weight, W = ΣW_x = 5.13 kips (ASCE 7-10 Section 12.7.2)

Results:

Site Coefficients:

F_a =	1.600	ASCE 7-10 Table 11.4-1, page 66
F_v =	2.400	ASCE Table 11.4-2, page 66

Maximum Spectral Response Accelerations for Short and 1-Second Periods:

S_{MS} =	0.400	$S_{MS} = F_a*S_s$, ASCE Eqn. 11.4-1, page 65
S_{M1} =	0.175	$S_{M1} = F_v*S_1$, ASCE Eqn. 11.4-2, page 65

Design Spectral Response Accelerations for Short and 1-Second Periods :

S_{DS} =	0.267	$S_{DS} = 2*S_{MS}/3$, ASCE 7-10 Eqn. 11.4-3, page 65
S_{D1} =	0.117	$S_{D1} = 2*S_{M1}/3$, ASCE Eqn. 11.4-4, page 65

(continued:)

Seismic Design Category:

Category(for S_{DS}) =	B	ASCE 7-10 Table 11.6-1, page 67
Category(for S_{D1}) =	B	ASCE 7-10 Table 11.6-2, page 67
Use Category =	B	Most critical of either category case above controls

Fundamental Period:

Period Coefficient, C_T =	0.028	ASCE 7-10 Table 12.8-2, page 90
Period Exponent, x =	0.8	ASCE 7-10 Table 12.8-2, page 90
Approx. Period, T_a =	0.368	sec., $T_a = C_T*h_n\text{^}(x)$, ASCE 7-10 Section 12.8.2.1, Eqn. 12.8-7
Upper Limit Coef., C_u =	1.666	ASCE 7-10 Table 12.8-1, page 90
Period max., $T_{(max)}$ =	0.613	sec., $T_{(max)} = C_u*T_a$, ASCE 7-10 Section 12.8.2, page 90
Fundamental Period, T =	0.368	sec., T = Ta <= Cu*Ta, ASCE 7-10 Section 12.8.2, page 90

Seismic Design Coefficients and Factors:

Response Mod. Coef., R =	3.5	ASCE 7-10 Table 12.2-1, pages 73-75
Overstrength Factor, Ω_o =	3	ASCE 7-10 Table 12.2-1, pages 73-75
Defl. Amplif. Factor, C_d =	3	ASCE 7-10 Table 12.2-1, pages 73-75
C_S =	0.095	$C_S = S_{DS}/(R/I)$, ASCE 7-10 Section 12.8.1.1, Eqn. 12.8-2
$C_{S(max)}$ =	0.113	For T<=TL, CS(max) = SD1/(T*(R/I)), ASCE 7-10 Eqn. 12.8-3
$C_{S(min)}$ =	0.015	CS(min) = 0.044*SDS*I >= 0.01, ASCE 7-10 Eqn. 12.8-5
Use: C_S =	0.095	$C_{S(min)} <= C_S <= C_{S(max)}$

Seismic Base Shear:

V = 0.49 kips, V = Cs*W, ASCE 7-10 Section 12.8.1, Eqn. 12.8-1

Seismic Shear Vertical Distribution:

Distribution Exponent, k = 1.00 k = 1 for T<=0.5 sec., k = 2 for T>=2.5 sec.
k = (2-1)*(T-0.5)/(2.5-0.5)+1, for 0.5 sec. < T < 2.5 sec.

Lateral Force at Any Level: $F_x = C_{vx}*V$, ASCE 7-10 Section 12.8.3, Eqn. 12.8-11, page 91

Vertical Distribution Factor: $C_{vx} = W_x*h_x\text{^}k/(\Sigma W_i*h_i\text{^}k)$, ASCE 7-10 Eqn. 12.8-12, page 91

Seismic Level x	Weight, Wx (kips)	hx^k (ft.)	Wx*h^k (ft-kips)	Cvx (%)	Shear, Fx (kips)	Σ Story Shears
2	2.57	12.000	30.8	0.500	0.24	0.24
1	2.57	12.000	30.8	0.500	0.24	0.49
Σ =	5.13		61.6	1.000	0.49	

Comments:

Appendix H: Member Buckling Calculation

AISI Standard, Chapter E – Columns, ASD Method
$\Omega_c = 1.8$
$\mu = 0.287$ (steel, cold rolled)
$P_{nc} = A_g F_n$ (Eq. E2-1)
(E2.1.1) closed-box sections:

$$L_o = \pi r \sqrt{\frac{E}{F_{crl}}} \qquad \text{(Eq. E2.1.1-1)}$$

$$F_{crl} = k * \frac{\pi^2 E}{12(1-\mu^2)}\left(\frac{t}{w}\right)^2 \qquad \text{(Eq. 1.1-4)}$$

$$F_{crl} = 4 * \frac{\pi^2(29500)}{12(1-0.287^2)}\left(\frac{0.0713}{4.23}\right)^2 = 29.767$$

$$L_o = \pi(1.69)\sqrt{\frac{29500}{29.767}} = 167.3959$$

$$KL < 1.1L_o$$
$$KL = (0.5)(12' * 12') = 72$$
$$1.1L_o = 1.1(167.3959) = 184.13549$$
$$KL < 1.1L_o$$

$$R_r = 0.65 + \frac{0.35(KL)}{1.1L_o}$$

$$R_r = 0.65 + \frac{0.35(72)}{1.1(167.3959)} = 0.787$$

$$r = 0.787(1.69) = 1.33$$

$$F_{cre} = \frac{\pi^2 E}{\left(\frac{KL}{2}\right)^2}$$

$$F_{cre} = \frac{\pi^2(29500)}{(72/1.33)^2} = 99.35$$

$$\lambda_c = \sqrt{\frac{F_y}{F_{cre}}}$$

$$\lambda_c = \sqrt{\frac{50}{9935}} = 0.709 \leq 1.5$$

$$F_n = 0.685^{\lambda_c{}^2} F_y$$
$$F_n = 0.685^{.709^2}(50) = 40.513$$

$$P_{ne} = (0.569 * 2)(F_n)$$
$$P_{ne} = (0.569 * 2)(40.513) = 46.104 \rightarrow \text{nominal axial strength}$$
$$\frac{P_{ne}}{\Omega_c} = \frac{46.104}{1.8} = 25.613 kips \rightarrow \text{available axial strength}$$

AISI Standard, Chapter F – Beams, ASD Method
1000T150-43
$C_b = 1$
$F_y = 33$ ksi
E = 29500 ksi
G = 11408.668 ksi
J = 0.000397 in^2
$I_y = 0.0804$ in^2
$r_o = 3.56$ in
A = 1.172 in^2
$C_w = 1.61$ in^6

$$M_{ne} = S_f F_n \leq M_y \text{ (Eq. F2.1-1)}$$
$$L_u = \frac{0.36 C_b \pi}{F_y S_f} \sqrt{EGJI_y} \text{ (Eq. F2.1.4)}$$

$$I = \frac{(4)(10.161)^3 - (3.9098)(10.0708)^3}{12} = 16.9078$$
$$S_f = \frac{2I}{h} = \frac{(2)(16.9078)}{110.004} = 0.307 in^3$$
$$L_u = \frac{0.36 C_b \pi}{F_y S_f} \sqrt{EGJI_y}$$
$$L_u = \frac{0.36(1)(\pi)}{(33)(.307)} \sqrt{(29500)(11408.668)(.000397)(0.0804)} = 85.74 in > 16"OC$$

$$M_y = S_{fy} F_y$$
$$F_n = F_y \quad if \quad F_{cre} \geq 2.78 F_y \qquad \text{(F2.1-3)}$$
$$F_{cre} = \frac{C_b r_o A}{S_f} \sqrt{\sigma_{ey} \sigma_t}$$

$$\sigma_{ey} = \frac{\pi^2 E}{(k_y L_y / r_y)^2} = \frac{\pi^2 (29500)}{((1*16)/0.539)^2} = 330.41\ ksi$$

$$\sigma_t = \frac{1}{A r_o^2}\left[GJ + \frac{\pi^2 E C_w}{(k_t L_t)^2}\right]$$

$$\sigma_t = \frac{1}{(1.172)(3.56)^2}\left[(11408.668)(.000397) + \frac{\pi^2(29500)(1.61)}{(1*16)^2}\right] = 123.58136 ksi$$

$$F_{cre} = \frac{C_b r_o A}{S_f}\sqrt{\sigma_{ey}\sigma_t} = \frac{(1)(3.56)(1.172)}{0.307}\sqrt{(330.411)(123.58136)} = 24914.62$$

$$F_{cre} \geq 2.78(33) = 91.74$$

$$F_n = F_y = 33 ksi$$

$$M_y = S_{fy} F_y = .307(33) = 10.131\ k \cdot in$$

$$M_{ne} = (.307)(33) \leq M_y$$

$$M_{ne} = 10.131 k \cdot in$$

$$\frac{M_{ne}}{\Omega_o} = \frac{10.131}{1.67} = 6.07 k \cdot in$$

362T200-68

J = 0.00919 in^2

I_y = 0.221 in^4

r_y = 0.638 in

A = 1.086 in^2

r_o = 2.09 in^2

C_w = 0.564 in^6

$$L_u = \frac{0.36 C_b \pi}{F_y S_f}\sqrt{EGJI_y}$$

$$I = \frac{(4)(3.875)^3 - (3.8574)(3.7324)^3}{12} = 2.68$$

$$S_f = \frac{2I}{h} = \frac{(2)(2.68)}{110.004} = 0.0487 in^3$$

$$L_u = \frac{0.36(1)(\pi)}{(50)(0.0487)}\sqrt{(29500)(11408.668)(0.000919)(0.221)} = 121.43 in \geq 16"OC$$

$$\sigma_{ey} = \frac{\pi^2 E}{(k_y L_y / r_y)^2} = \frac{\pi^2 (29500)}{((1*16)/0.638)^2} = 462.938\ ksi$$

$$\sigma_t = \frac{1}{Ar_o^2}\left[GJ + \frac{\pi^2 EC_w}{(k_t L_t)^2}\right]$$

$$\sigma_t = \frac{1}{(1.086)(2.09)^2}\left[(11408.668)(0.00919) + \frac{\pi^2(29500)(0.564)}{((1)(16))^2}\right] = 137.42942$$

$$F_{cre} = \frac{C_b r_o A}{S_f}\sqrt{\sigma_{ey}\sigma_t}$$

$$F_{cre} = \frac{(1)(2.09)(1.086)}{0.0487}\sqrt{(462.958)(137.429)} = 11755.698 \geq 2.78(50) = 139$$

$$F_n = F_y = 50ksi$$

$$M_y = S_{fy}F_y = 0.0487(50) = 2.435k \cdot in$$

$$M_{ne} = (0.0487)(50) = 2.435 \leq M_y$$

$$\frac{M_{ne}}{\Omega_o} = \frac{2.435}{1.67} = 1.46k \cdot in$$

Appendix I: HVAC Calculations

Walls		
Material	R Value b/w stud	R Value at stud
Outside Air	0.17	0.17
Rainscreen	0	0
1" Airspace	1.97	1.97
2.5" Zip System Sheathing	12.6	12.6
SILCOR seamless waterproofing membrane	-	-
n/a	-	-
Metal Stud w/ Fiberglass insulation	14	7.37
1/2" Gypsum Wallboard	0.45	0.45
Paint	0	0
Inside Air	0.68	0.68
R total	29.87	23.23666667
U	0.033	0.043
Effective U	**0.034**	
Effective R	29.09	

Floors		
Material	R Value b/w stud	R Value at stud
Outside Air	0.17	0.17
SILCOR Waterproofing membrane	0	0
1/4" Plywood Sheathing	0.31	0.31
9.25" Metal Joist w/ R-30 insulation	32.5	16.0
Mgo Flooring/ Fire Rated Subfloor	1.2	1.2
1/4" Backerboard	0.13	0.13
1/8" vinyl tile	0.2	0.2
Inside Air	0.92	0.92
R total	35.43	18.96
U	0.028	0.053
Effective U	**0.031**	
Effective R	32.76	

Roof		
Material	R Value b/w stud	R Value at stud
Outside Air	0.17	0.17
PVC Membrane		
1/4" Substrate Board	1.3	1.3
Tapered Polyiso Insulation	18.6	18.6
1/4" Substrate Board	1.3	1.3
-	-	-
6" Metal Joist w/ R-19 insulation	11.9	6.7
Gypsum Board	0.45	0.45
Inside Air	0.61	0.61
R total	34.33	29.15
U	0.029	0.034
Effective U	**0.030**	
Effective R	33.77	

Date:				Summer	Winter				Q=U*A*CLTD		walls/doors/roofs	
10/13/2020			Outdoors	90	0				Q=A*CLF		glass	
			Indoors	72	70	roof cltd	29					
SOUTH WING			Daily Range	18		door cltd	18.6					
LEVEL 1			Wall Height	12								

TOTAL COOLING LOAD		CFM REQUIRED	
141588.2	BTUH	8581.1	CFM

Room	Level	Oreint-ation	Wall Length ft	Gross Wall A sf	Glass Area sf	Door Area sf	Net Wall A sf	Room Area sf	Floor Area sf	Wall U	Wall CLTD	Glass CLF	Door U	Floor U	Wall BTUH	Glass BTUH	Door BTUH	Floor BTUH
Room 56/stairwell	1	SW	27.5	330	0	49	281	330	330	0.034	33.54	48	0.64	0.031	324.0	0.0	583.3	292.1
Storage Room 56	1	NW	12	144	0	0	144	0	0	0.034	29.39	48	0.64	0.031	145.5	0.0	0.0	0.0
Patient 1	1	NW	12	144	88	0	56	270	270	0.034	29.39	48	0.64	0.031	56.6	4224.0	0.0	239.0
Patient 2	1	NW	12	144	88	0	56	270	270	0.034	29.39	48	0.64	0.031	56.6	4224.0	0.0	239.0
Patient 3	1	NW	12	144	88	0	56	270	270	0.034	29.39	48	0.64	0.031	56.6	4224.0	0.0	239.0
Patient 4	1	NW	12	144	88	0	56	270	270	0.034	29.39	48	0.64	0.031	56.6	4224.0	0.0	239.0
Patient 5	1	NW	12	144	88	0	56	270	270	0.034	29.39	48	0.64	0.031	56.6	4224.0	0.0	239.0
Patient 6	1	NW	12	144	88	0	56	270	270	0.034	29.39	48	0.64	0.031	56.6	4224.0	0.0	239.0
Patient 7	1	NW	12	144	88	0	56	270	270	0.034	29.39	48	0.64	0.031	56.6	4224.0	0.0	239.0
Patient 8	1	NW	12	144	88	0	56	270	270	0.034	29.39	48	0.64	0.031	56.6	4224.0	0.0	239.0
ADA Patient 9	1	NW	12	144	88	0	56	270	270	0.034	29.39	48	0.64	0.031	56.6	4224.0	0.0	239.0
ADA Patient 9	1	NE	22.5	270	0	0	270	0	0	0.034	23.58	61	0.64	0.031	218.8	0.0	0.0	0.0
ADA Patient 46	1	NE	22.5	270	0	0	270	0	0	0.034	23.58	61	0.64	0.031	218.8	0.0	0.0	0.0
ADA Patient 46	1	SE	12	144	88	0	56	270	270	0.034	28.56	61	0.64	0.031	55.0	5368.0	0.0	239.0
Patient 47	1	SE	12	144	88	0	56	270	270	0.034	28.56	61	0.64	0.031	55.0	5368.0	0.0	239.0
Patient 48	1	SE	12	144	88	0	56	270	270	0.034	28.56	61	0.64	0.031	55.0	5368.0	0.0	239.0
Patient 49	1	SE	12	144	88	0	56	270	270	0.034	28.56	61	0.64	0.031	55.0	5368.0	0.0	239.0
Patient 50	1	SE	12	144	88	0	56	270	270	0.034	28.56	61	0.64	0.031	55.0	5368.0	0.0	239.0
Patient 51	1	SE	12	144	88	0	56	270	270	0.034	28.56	61	0.64	0.031	55.0	5368.0	0.0	239.0
Patient 52	1	SE	12	144	88	0	56	270	270	0.034	28.56	61	0.64	0.031	55.0	5368.0	0.0	239.0
Patient 53	1	SE	12	144	88	0	56	270	270	0.034	28.56	61	0.64	0.031	55.0	5368.0	0.0	239.0
Patient 54	1	SE	12	144	88	0	56	270	270	0.034	28.56	61	0.64	0.031	55.0	5368.0	0.0	239.0
Patient 55	1	SE	12	144	88	0	56	270	270	0.034	28.56	61	0.64	0.031	55.0	5368.0	0.0	239.0
Patient 56	1	SW	22.5	270	0	0	270	0	0	0.034	33.54	48	0.64	0.031	311.3	0.0	0.0	0.0
Hallway	1	SE	27.5	330	135	21	174	3363	3363	0.034	29.39	61	0.64	0.031	175.8	8235.0	250.0	2976.8
																		Total Transm:

Internals	Rooms	People/room	People	People(/room)	Lights/room	Lights/room	Appliances/room	Appliances/room	Total Internal/rm
Room	Amt	Amt	BTUH/p	BTUH	W	BTUH	W	BTUH	BTUH
Patient Room	19	2	255	510	48	163.8	81	276.5	950.3
Stairwell	1	4	255	1020	44	149.7	0	0.0	1169.7
Hallway	1	9	315	2835	941	3211.0	1550	5290.2	11336.1
									Total Interal:

Date:			
10/13/2020			
SOUTH WING			
LEVEL 1			
	Transm	Internal Load	Air Required/Room
Room	**BTUH**	BTUH	CFM
Room 56/stairwell	**1199.4**	1169.7	143.6
Storage Room 56	**145.5**	0	8.8
Patient 1	**4519.6**	950.3	331.5
Patient 2	**4519.6**	950.3	331.5
Patient 3	**4519.6**	950.3	331.5
Patient 4	**4519.6**	950.3	331.5
Patient 5	**4519.6**	950.3	331.5
Patient 6	**4519.6**	950.3	331.5
Patient 7	**4519.6**	950.3	331.5
Patient 8	**4519.6**	950.3	331.5
ADA Patient 9	**4519.6**	950.3	344.8
ADA Patient 9	**218.8**		
ADA Patient 46	**218.8**		
ADA Patient 46	**5662.0**	950.3	414.0
Patient 47	**5662.0**	950.3	400.7
Patient 48	**5662.0**	950.3	400.7
Patient 49	**5662.0**	950.3	400.7
Patient 50	**5662.0**	950.3	400.7
Patient 51	**5662.0**	950.3	400.7
Patient 52	**5662.0**	950.3	400.7
Patient 53	**5662.0**	950.3	400.7
Patient 54	**5662.0**	950.3	400.7
Patient 55	**5662.0**	950.3	419.6
Patient 56	**311.3**		
Hallway	**11637.5**	11336.1	1392.3
	111027.1		
	Total Internal		
	BTUH		
	18055.3		
	1169.7		
	11336.1		
	30561.1		

Date:				Summer	Winter					Q=U*A*CLTD	walls/doors/roofs							
10/13/2020			Outdoors	90	15					Q=A*CLF	glass							
			Indoors	72	72		Delta T	57										
SOUTH WING			Daily Range	18			Cs	0.0299		**TOTAL HEATING LOAD**		70.56654254	**CFM REQUIRED**					
LEVEL 1			Wall Height	12			Cw	0.0051		**70566.5**	**BTUH**		**1146.3**	**CFM**				
		Oreint-	Wall Length	Gross Wall A	Glass Area	Door Area	Net Wall A	Room Area	Floor Area	Wall	Glass	Door	Floor	Wall	Glass	Door	Floor	**Transm**
Room	Level	ation	ft	sf	sf	sf	sf	sf	sf	U	U	U	U	BTUH	BTUH	BTUH	BTUH	**BTUH**
Room 56/stairwell	1	SW	27.5	330	0	49	281	330	330	0.034	0.3	0.64	0.031	550.6	0.0	1787.5	574.1	**2912.2**
Storage Room 56	1	NW	12	144	0	24.5	119.5	0	0	0.034	0.3	0.64	0.031	234.1	0.0	893.8	0.0	**1127.9**
Patient 1	1	NW	12	144	88	0	56	270	270	0.034	0.3	0.64	0.031	109.7	1504.8	0.0	469.7	**2084.3**
Patient 2	1	NW	12	144	88	0	56	270	270	0.034	0.3	0.64	0.031	109.7	1504.8	0.0	469.7	**2084.3**
Patient 3	1	NW	12	144	88	0	56	270	270	0.034	0.3	0.64	0.031	109.7	1504.8	0.0	469.7	**2084.3**
Patient 4	1	NW	12	144	88	0	56	270	270	0.034	0.3	0.64	0.031	109.7	1504.8	0.0	469.7	**2084.3**
Patient 5	1	NW	12	144	88	0	56	270	270	0.034	0.3	0.64	0.031	109.7	1504.8	0.0	469.7	**2084.3**
Patient 6	1	NW	12	144	88	0	56	270	270	0.034	0.3	0.64	0.031	109.7	1504.8	0.0	469.7	**2084.3**
Patient 7	1	NW	12	144	88	0	56	270	270	0.034	0.3	0.64	0.031	109.7	1504.8	0.0	469.7	**2084.3**
Patient 8	1	NW	12	144	88	0	56	270	270	0.034	0.3	0.64	0.031	109.7	1504.8	0.0	469.7	**2084.3**
ADA Patient 9	1	NW	12	144	88	0	56	270	270	0.034	0.3	0.64	0.031	109.7	1504.8	0.0	469.7	**2084.3**
ADA Patient 9	1	NE	22.5	270	0	0	270	0	0	0.034	0.3	0.64	0.031	529.0	0.0	0.0	0.0	**529.0**
ADA Patient 46	1	NE	22.5	270	0	0	270	0	0	0.034	0.3	0.64	0.031	529.0	0.0	0.0	0.0	**529.0**
ADA Patient 46	1	SE	12	144	88	0	56	270	270	0.034	0.3	0.64	0.031	109.7	1504.8	0.0	469.7	**2084.3**
Patient 47	1	SE	12	144	88	0	56	270	270	0.034	0.3	0.64	0.031	109.7	1504.8	0.0	469.7	**2084.3**
Patient 48	1	SE	12	144	88	0	56	270	270	0.034	0.3	0.64	0.031	109.7	1504.8	0.0	469.7	**2084.3**
Patient 49	1	SE	12	144	88	0	56	270	270	0.034	0.3	0.64	0.031	109.7	1504.8	0.0	469.7	**2084.3**
Patient 50	1	SE	12	144	88	0	56	270	270	0.034	0.3	0.64	0.031	109.7	1504.8	0.0	469.7	**2084.3**
Patient 51	1	SE	12	144	88	0	56	270	270	0.034	0.3	0.64	0.031	109.7	1504.8	0.0	469.7	**2084.3**
Patient 52	1	SE	12	144	88	0	56	270	270	0.034	0.3	0.64	0.031	109.7	1504.8	0.0	469.7	**2084.3**
Patient 53	1	SE	12	144	88	0	56	270	270	0.034	0.3	0.64	0.031	109.7	1504.8	0.0	469.7	**2084.3**
Patient 54	1	SE	12	144	88	0	56	270	270	0.034	0.3	0.64	0.031	109.7	1504.8	0.0	469.7	**2084.3**
Patient 55	1	SE	12	144	88	0	56	270	270	0.034	0.3	0.64	0.031	109.7	1504.8	0.0	469.7	**2084.3**
Patient 56	1	SW	22.5	270	0	0	270	0	0	0.034	0.3	0.64	0.031	529.0	0.0	0.0	0.0	**529.0**
Hallway	1	SE	27.5	330	135	21	174	3363	3363	0.034	0.3	0.64	0.031	340.9	2308.5	766.1	5850.9	**9266.4**
																	Total Transm:	**54494.5**

Date:
10/13/2020

SOUTH WING
LEVEL 1

	Glass Leakage	Glass Leakage	Glass Infil	Glass Infil	Floor Leakage	Floor Leakage	Floor Infil	Floor Infil	Door Leakage	Door Leakage	Door Infil	Door Infil	Infiltration	infilt
Room	ft	in^2	CFM	BTUH	ft	in^2	CFM	BTUH	ft	in^2	CFM	BTUH	BTUH	cfm
Room 56/stairwell	0	0	0.0	0.0	27.5	3.3	4.9	307.9	28	3.36	5.0	313.5	621.4	9.9
Storage Room 56	0	0	0.0	0.0	12	1.44	2.1	134.4	21	2.52	3.7	235.1	369.5	5.9
Patient 1	46	5.52	8.2	515.0	12	1.44	2.1	134.4	0	0	0.0	0.0	649.4	10.4
Patient 2	46	5.52	8.2	515.0	12	1.44	2.1	134.4	0	0	0.0	0.0	649.4	10.4
Patient 3	46	5.52	8.2	515.0	12	1.44	2.1	134.4	0	0	0.0	0.0	649.4	10.4
Patient 4	46	5.52	8.2	515.0	12	1.44	2.1	134.4	0	0	0.0	0.0	649.4	10.4
Patient 5	46	5.52	8.2	515.0	12	1.44	2.1	134.4	0	0	0.0	0.0	649.4	10.4
Patient 6	46	5.52	8.2	515.0	12	1.44	2.1	134.4	0	0	0.0	0.0	649.4	10.4
Patient 7	46	5.52	8.2	515.0	12	1.44	2.1	134.4	0	0	0.0	0.0	649.4	10.4
Patient 8	46	5.52	8.2	515.0	12	1.44	2.1	134.4	0	0	0.0	0.0	649.4	10.4
ADA Patient 9	46	5.52	8.2	515.0	12	1.44	2.1	134.4	0	0	0.0	0.0	649.4	10.4
ADA Patient 9	0	0	0.0	0.0	22.5	2.7	4.0	251.9	0	0	0.0	0.0	251.9	4.0
ADA Patient 46	0	0	0.0	0.0	22.5	2.7	4.0	251.9	0	0	0.0	0.0	251.9	4.0
ADA Patient 46	46	5.52	8.2	515.0	12	1.44	2.1	134.4	0	0	0.0	0.0	649.4	10.4
Patient 47	46	5.52	8.2	515.0	12	1.44	2.1	134.4	0	0	0.0	0.0	649.4	10.4
Patient 48	46	5.52	8.2	515.0	12	1.44	2.1	134.4	0	0	0.0	0.0	649.4	10.4
Patient 49	46	5.52	8.2	515.0	12	1.44	2.1	134.4	0	0	0.0	0.0	649.4	10.4
Patient 50	46	5.52	8.2	515.0	12	1.44	2.1	134.4	0	0	0.0	0.0	649.4	10.4
Patient 51	46	5.52	8.2	515.0	12	1.44	2.1	134.4	0	0	0.0	0.0	649.4	10.4
Patient 52	46	5.52	8.2	515.0	12	1.44	2.1	134.4	0	0	0.0	0.0	649.4	10.4
Patient 53	46	5.52	8.2	515.0	12	1.44	2.1	134.4	0	0	0.0	0.0	649.4	10.4
Patient 54	46	5.52	8.2	515.0	12	1.44	2.1	134.4	0	0	0.0	0.0	649.4	10.4
Patient 55	46	5.52	8.2	515.0	12	1.44	2.1	134.4	0	0	0.0	0.0	649.4	10.4
Patient 56	46	5.52	8.2	515.0	22.5	2.7	4.0	251.9	0	0	0.0	0.0	766.9	12.2
Hallway	84	10.08	15.0	940.5	27.5	3.3	4.9	307.9	20	2.4	3.6	223.9	1472.3	23.5
												Total Infil:	**16072.0**	256.3

Ventilation					CFM=ACH*Vol/60		
Room	Room Volume	NYC Intake	NYC Outake	170 Air Changes	**170 Air Flow**	**150%**	**200%**
Name	cf	CFM	CFM	ACH	**CFM**	**CFM**	**CFM**
Patient Room	1961	50	0	2	**65**	**98**	**131**
Patient Bathroom	422.2	0	50	10	**70**	**106**	**141**
Patient Corridor	40077	201.78	0	2	**1336**	**2004**	**2672**
				Total (CFM)	**3915**	**5872**	**7830**
				Total (BTUH)	**77514**	**116271**	**155027**

Appendix J: Project Plans

Pandemic Quarantine Center
East Meadow, Central Park, New York

Yllara Maia, Kimberly Ramos, and Samantha Wile

Sheet List

Sheet Number	Sheet Title	Sheet Number	Sheet Title
G101	Title Sheet	A111	Building Elevations
A101	Architecctural Floor Plan	A112	Building Sections
A102	Architectural Floor Plan Patient Wing - West	A113	Conceptual Building Envelope Sections
A103	Architectural Floor Plan Middle Section - West	M101	HVAC Plans Patient Wing - West
A104	Architectural Floor Plan Middle Section - East	M102	HVAC Sections
A105	Architectural Floor Plan Patient Wing - East	S101	Beam & Column Placement Patient Wing - West
A106	Reflected Ceiling Plan Patient Wing - West	S102	Beam & Column Placement Middle Section - West
A107	Reflected Ceiling Plan Middle Section - West	S103	Beam & Column Placement Middle Section - East
A108	Reflected Ceiling Plan Middle Section - East	S104	Beam & Column Placement Patient Wing - East
A109	Reflected Ceiling Plan Patient Wing - East	S105	Connections Detail Stacked & Adjacent Modules
A110	Site Plan	S106	Connections Detail Support Connection

No.	Description	Date

Pandemic Quarantine Center
East Meadow, NY

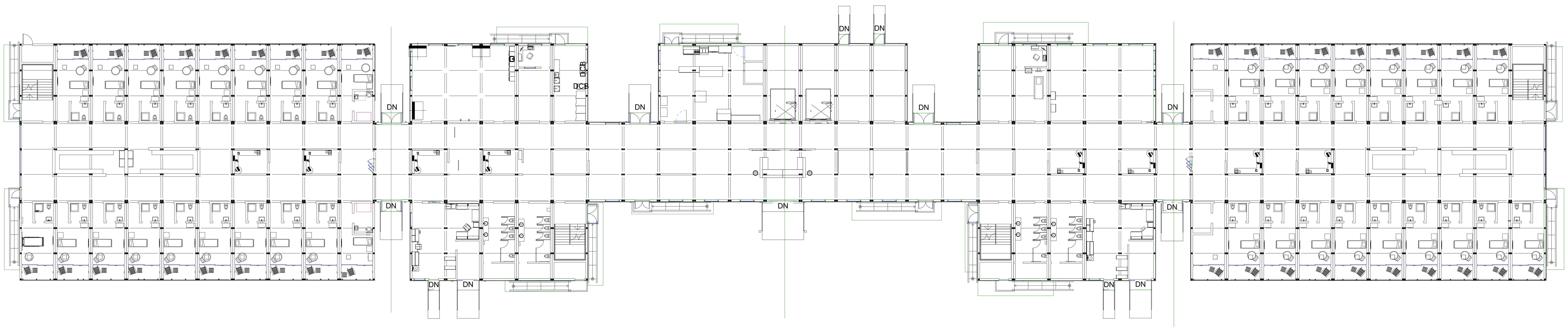
Title Sheet

Project number	
Date	
Drawn by	Author
Checked by	Checker

G101

Scale 12" = 1'-0"

12/8/2020 2:42:05 PM



No.	Description	Date

Pandemic Quarantine Center
East Meadow, NY

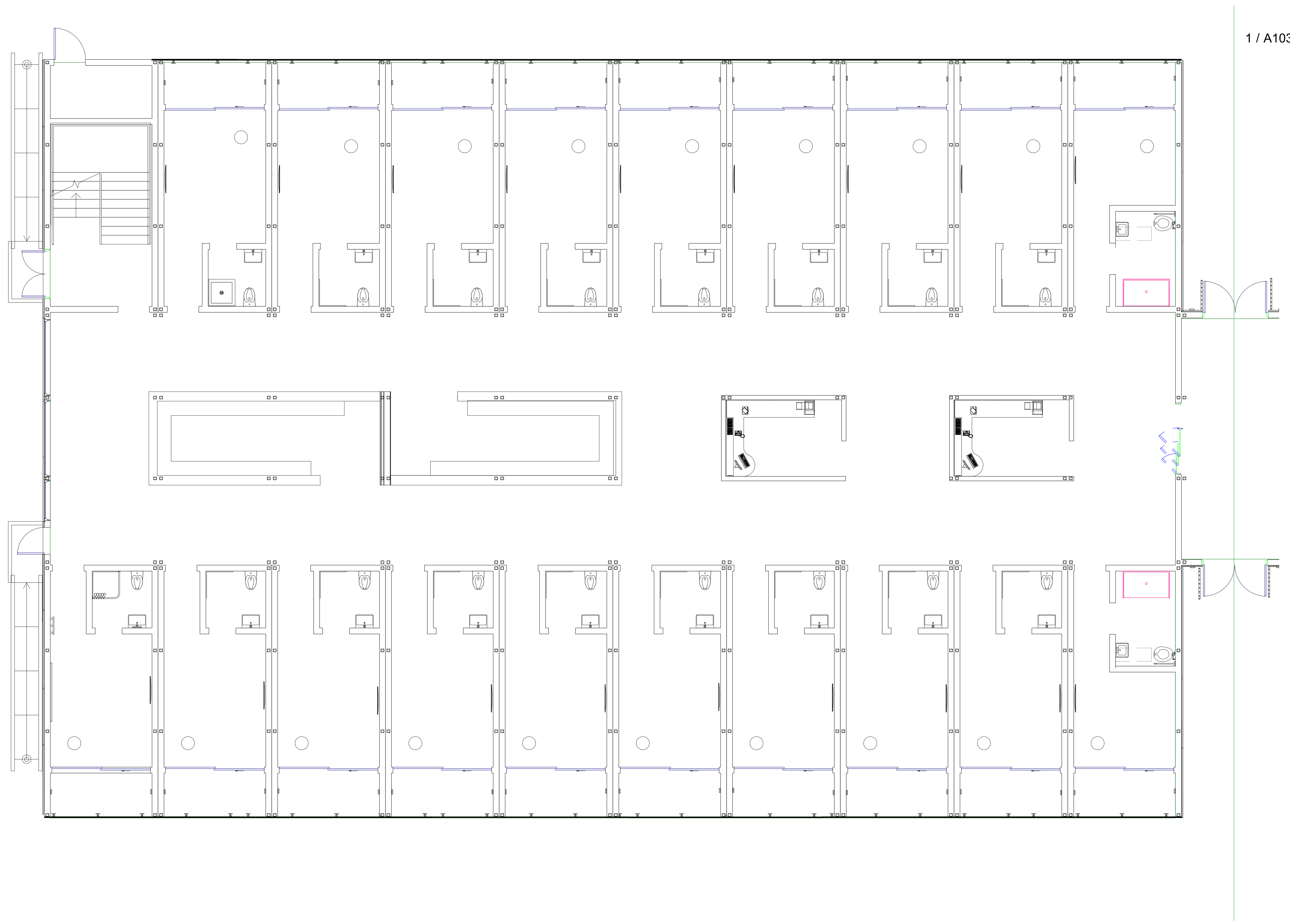
Architectural Floor Plan

Project number	
Date	
Drawn by	Author
Checked by	Checker

A101

Scale	1" = 20'-0"

11/24/2020 1:38:34 PM



No.	Description	Date

Pandemic Quarantine Center
East Meadow, NY

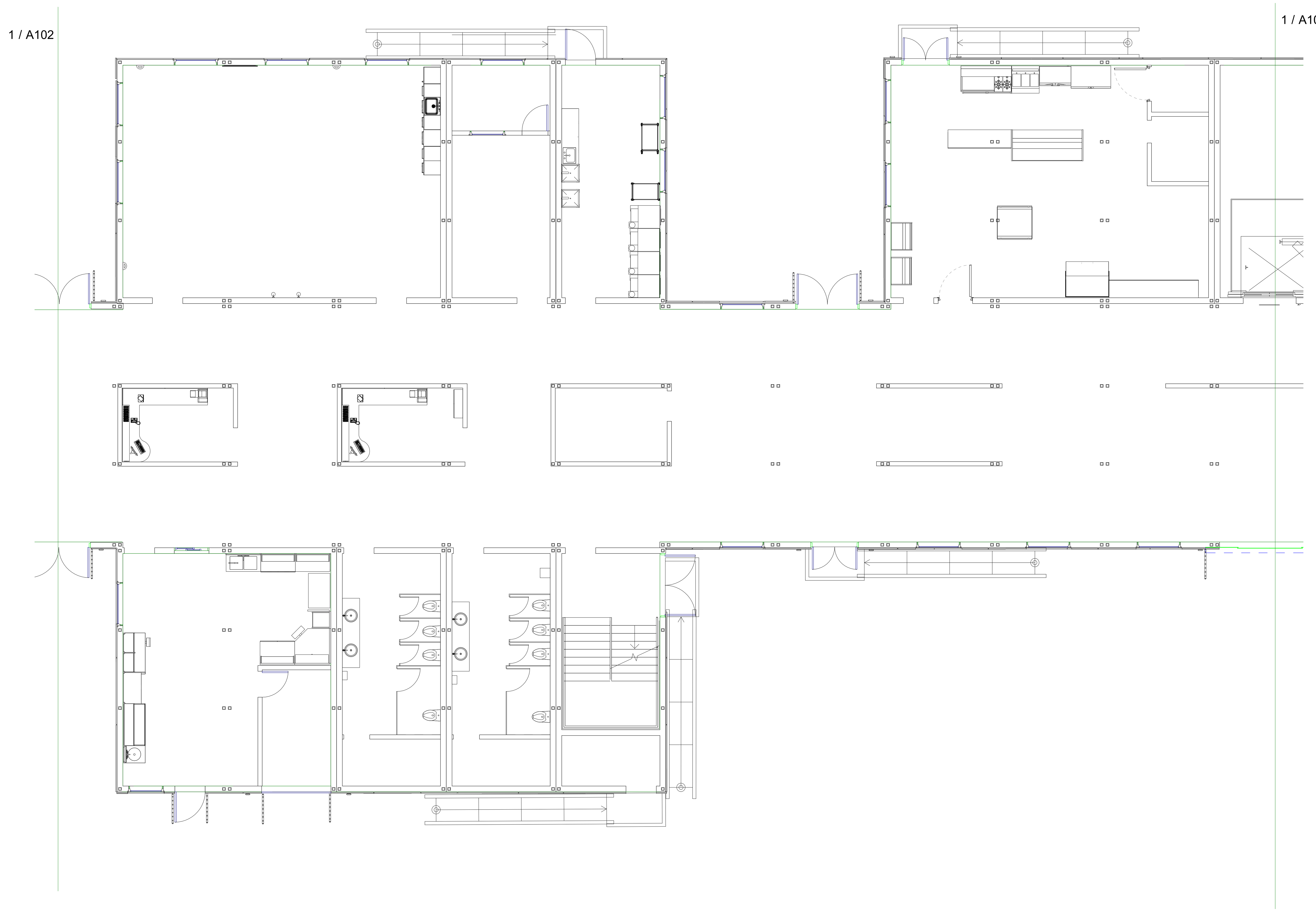
Architectural Floor Plan
Patient Wing - West

Project number	
Date	
Drawn by	Author
Checked by	Checker

A102

Scale	1/8" = 1'-0"

12/8/2020 11:05:25 PM



No.	Description	Date

Pandemic Quarantine Center
East Meadow, NY

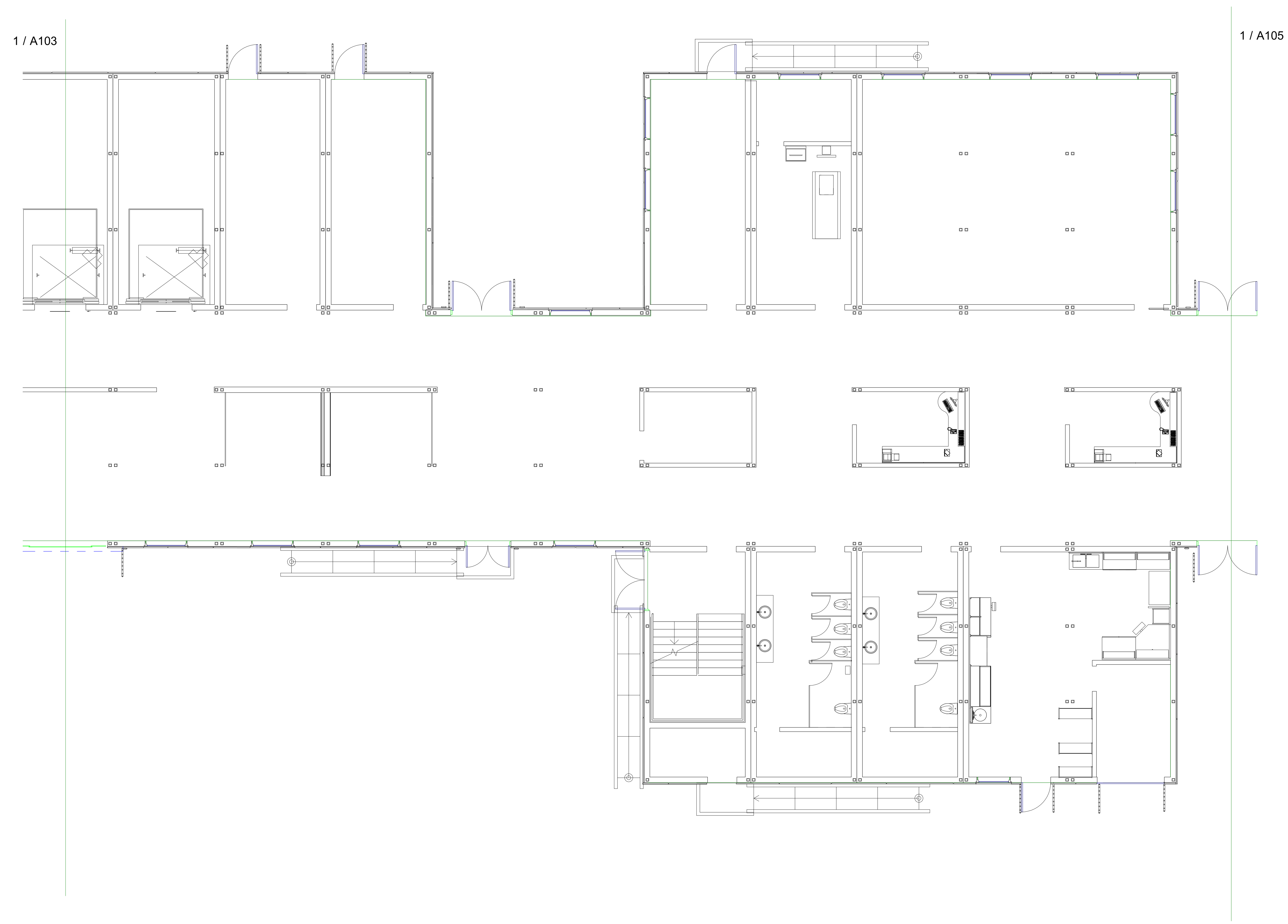
Architectural Floor Plan
Middle Section - West

Project number	
Date	
Drawn by	Author
Checked by	Checker

A103

Scale 1/8" = 1'-0"

12/8/2020 11:05:47 PM



No.	Description	Date

Pandemic Quarantine Center
East Meadow, NY

Architectural Floor Plan
Middle Section - East

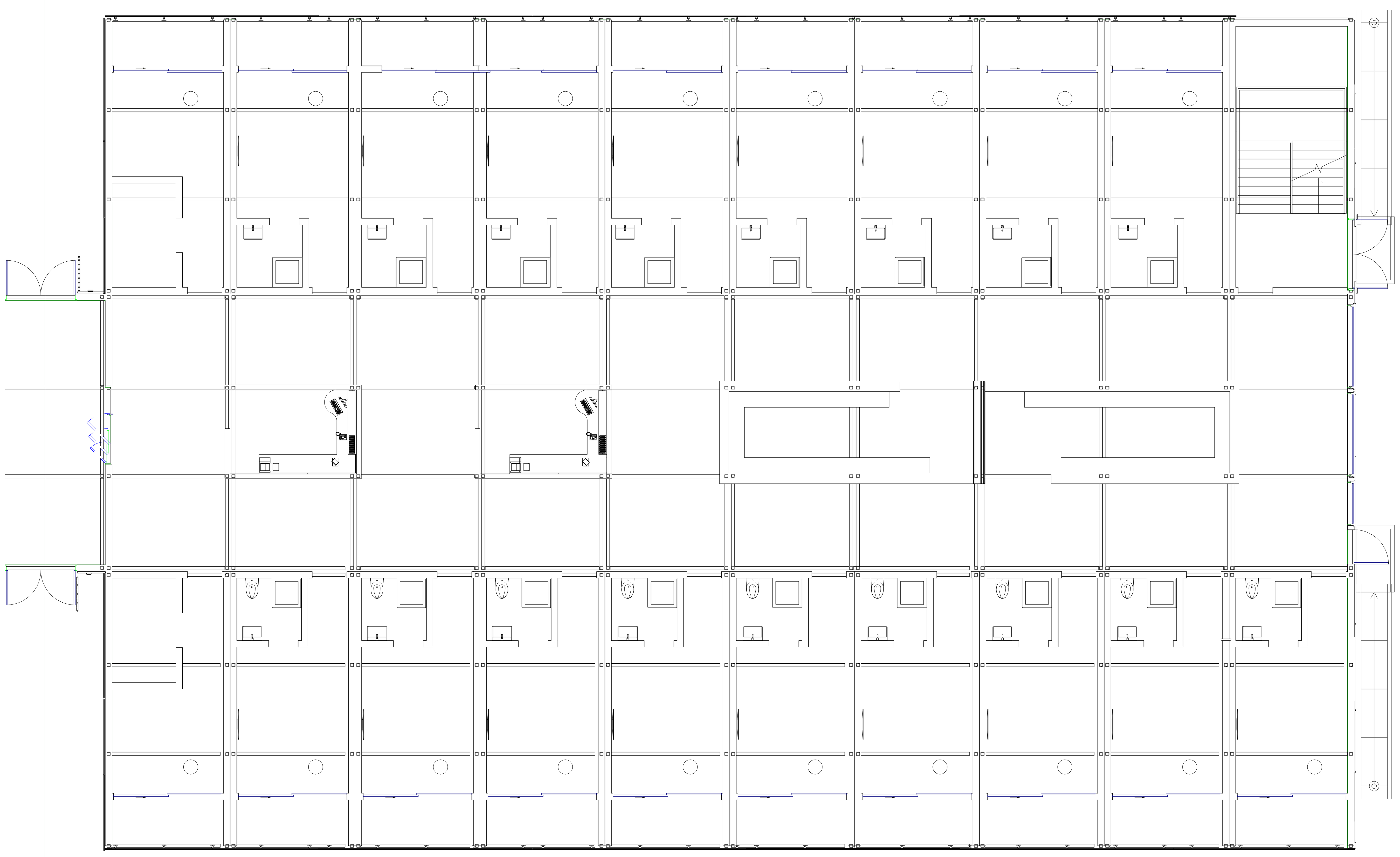
Project number	
Date	
Drawn by	Author
Checked by	Checker

A104

Scale	1/8" = 1'-0"

12/8/2020 11:06:11 PM

1 / A104



No.	Description	Date

Pandemic Quarantine Center
East Meadow, NY

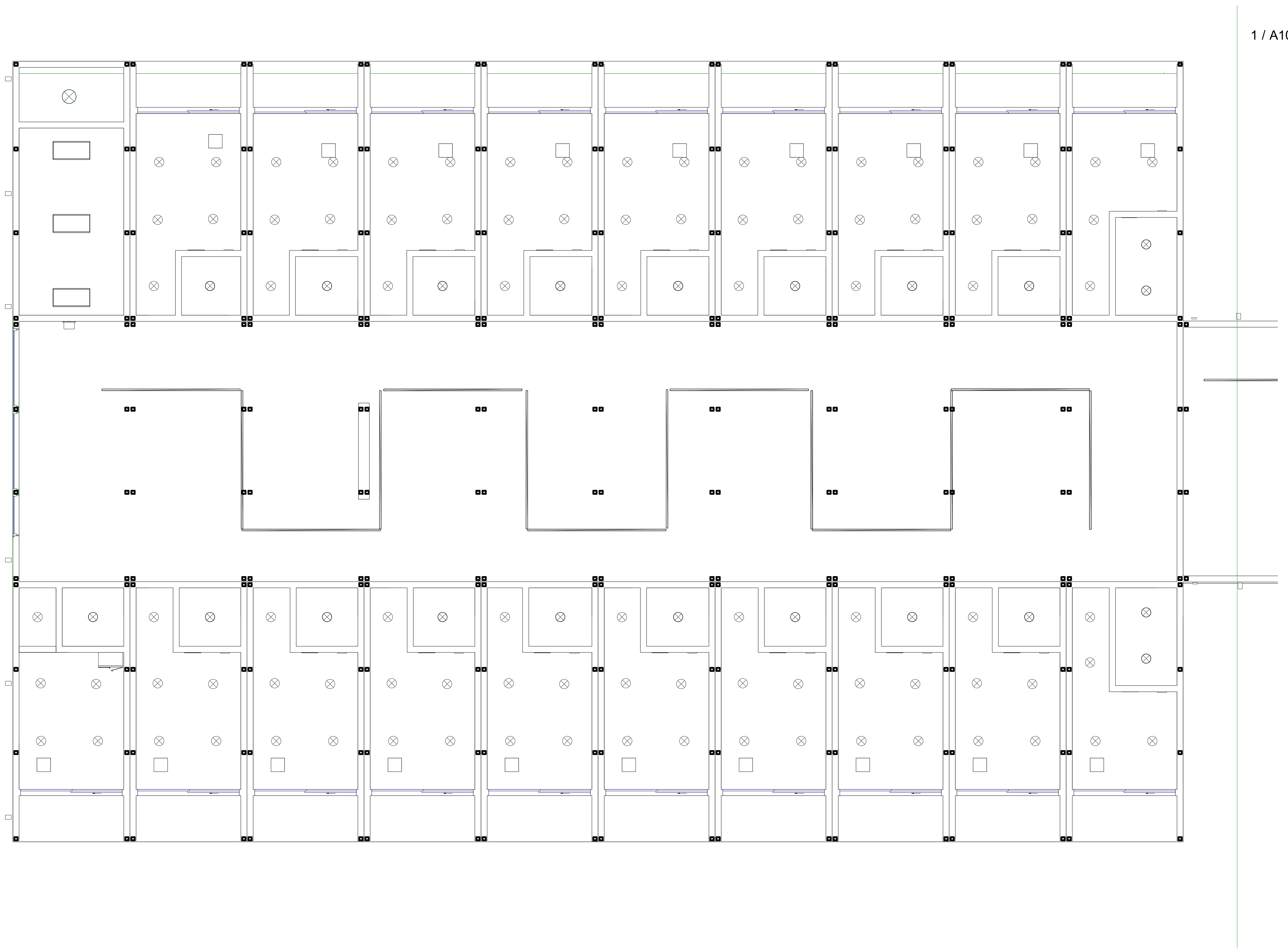
Architectural Floor Plan
Patient Wing - East

Project number
Date
Drawn by Author
Checked by Checker

A105

Scale 1/8" = 1'-0"

11/24/2020 1:38:44 PM



No.	Description	Date

Pandemic Quarantine Center
East Meadow, NY

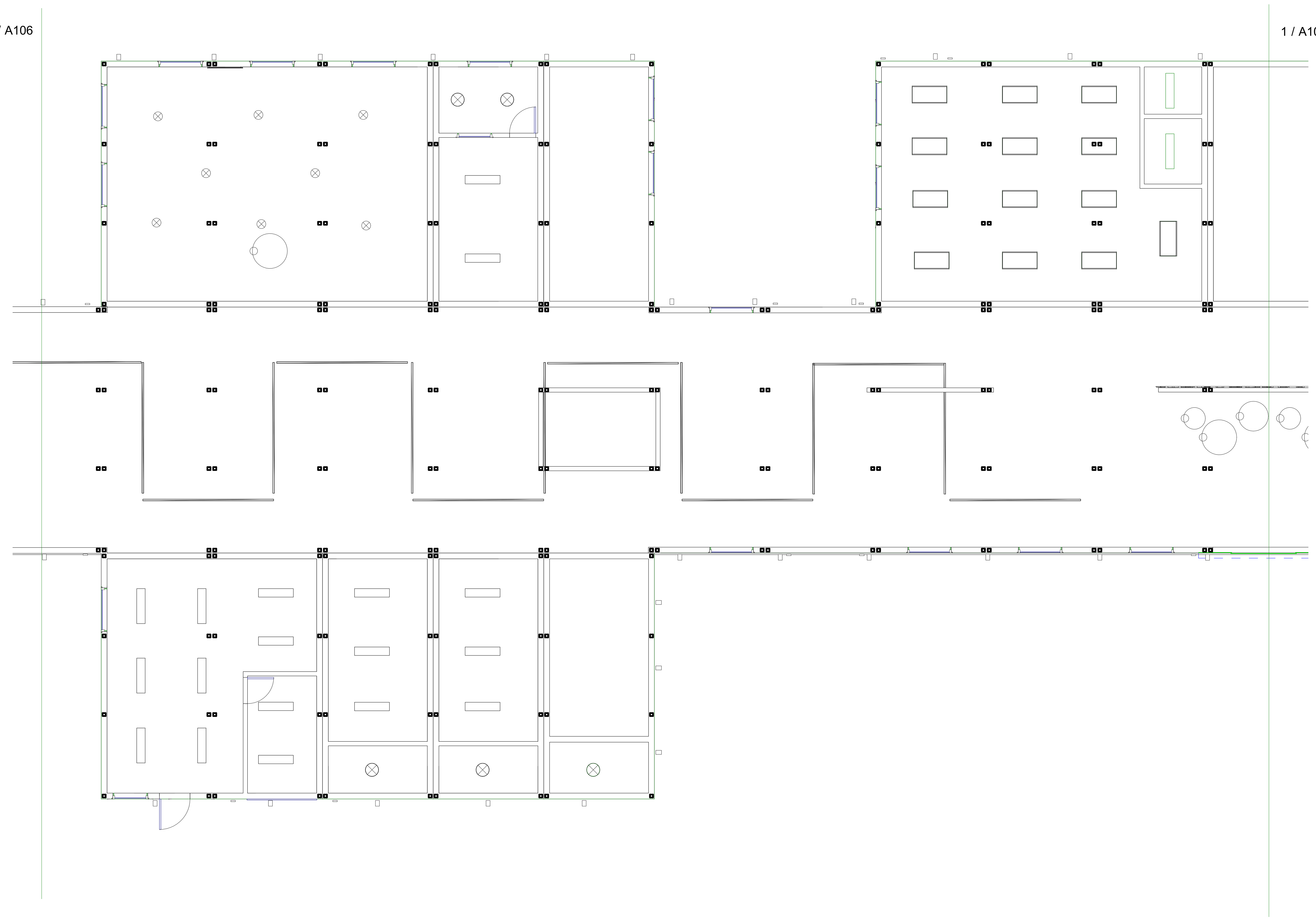
Reflected Ceiling Plan
Patient Wing - West

Project number	
Date	
Drawn by	Author
Checked by	Checker

A106

Scale	1/8" = 1'-0"

12/8/2020 11:06:34 PM



No.	Description	Date

Pandemic Quarantine Center
East Meadow, NY

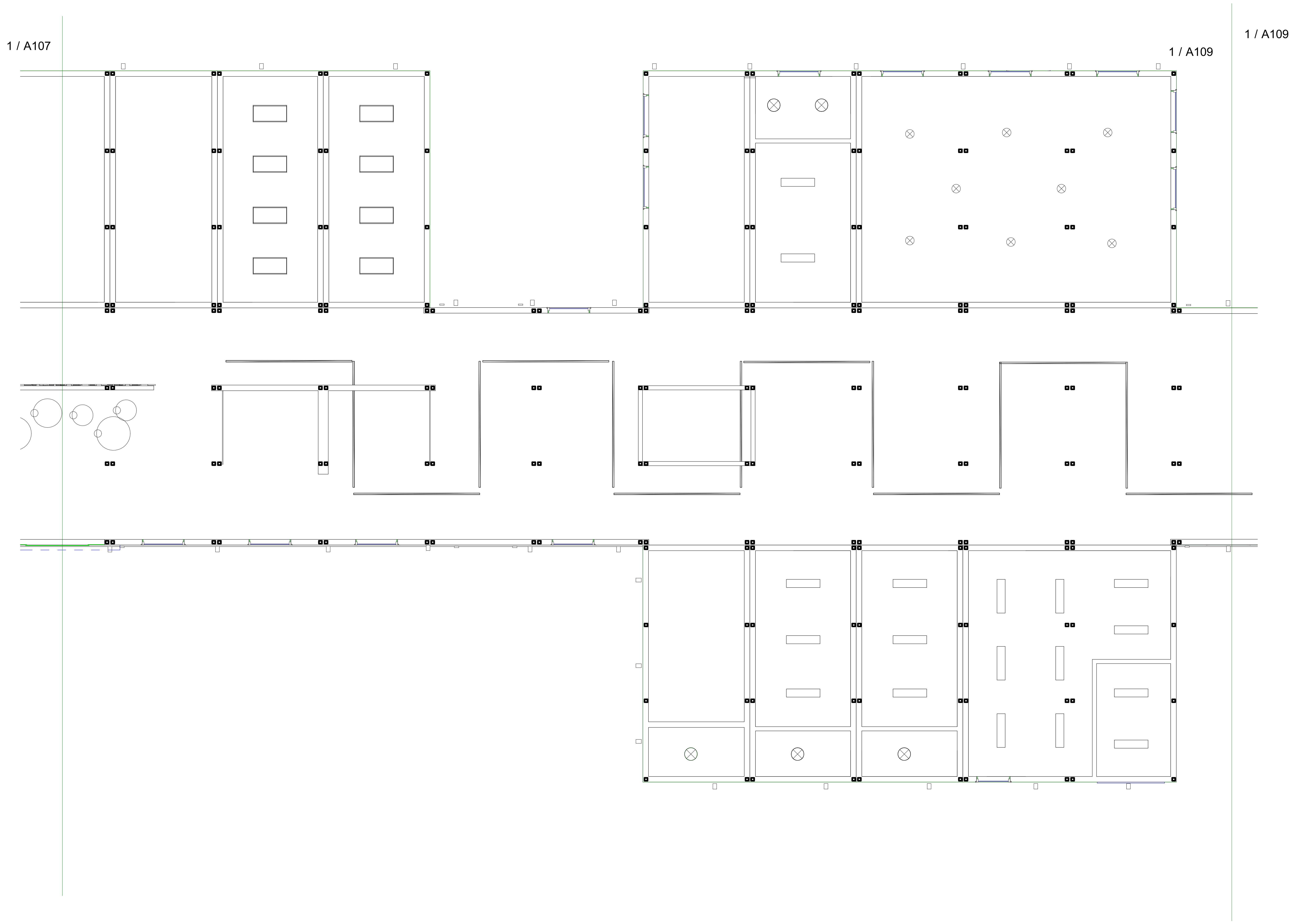
Reflected Ceiling Plan
Middle Section - West

Project number	
Date	
Drawn by	Author
Checked by	Checker

A107

Scale	1/8" = 1'-0"

12/8/2020 11:10:02 PM



No.	Description	Date

Pandemic Quarantine Center
East Meadow, NY

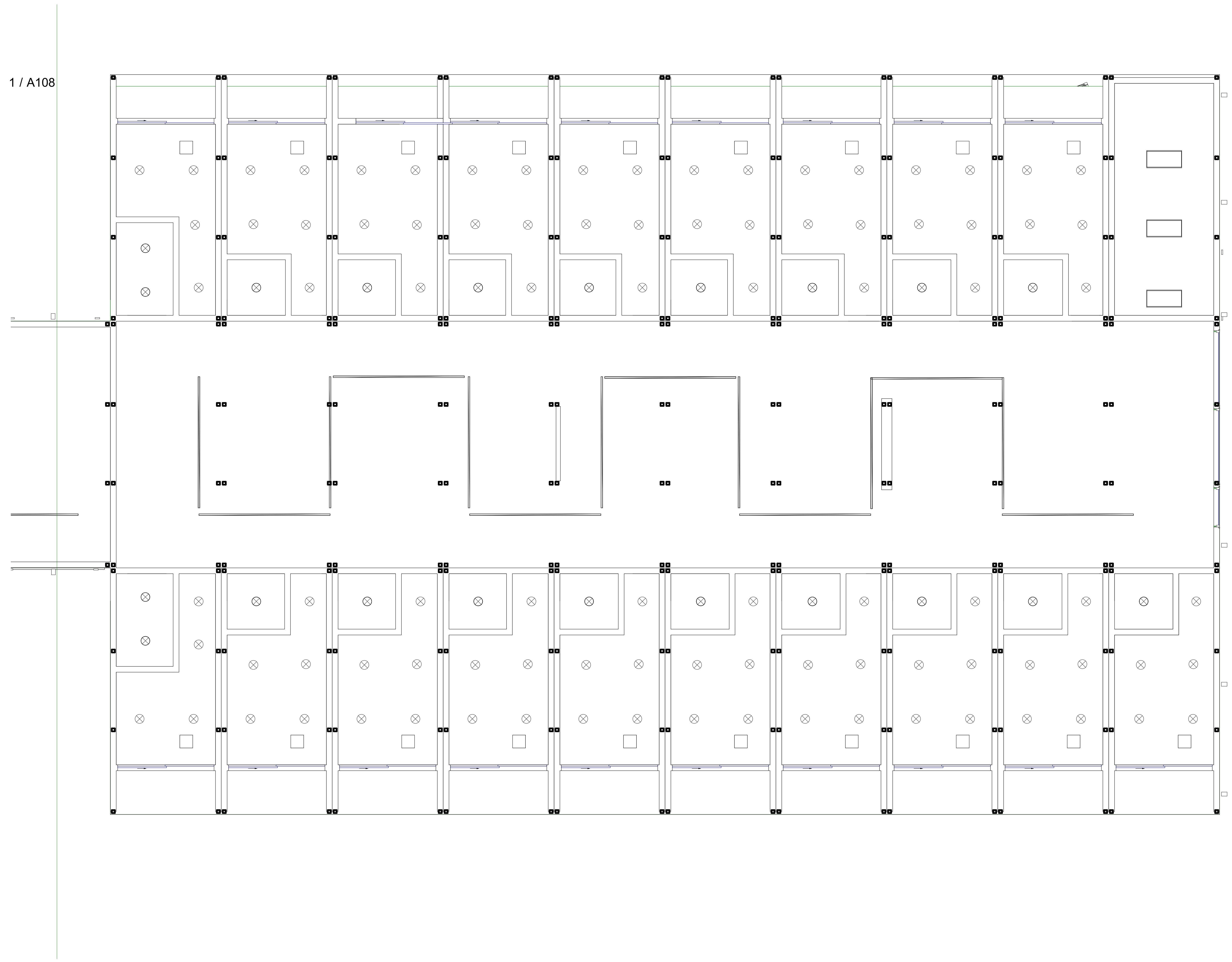
Reflected Ceiling Plan
Middle Section - East

Project number
Date
Drawn by Author
Checked by Checker

A108

Scale 1/8" = 1'-0"

12/8/2020 11:10:21 PM



No.	Description	Date

Pandemic Quarantine Center
East Meadow, NY

Reflected Ceiling Plan
Patient Wing - East

Project number
Date
Drawn by Author
Checked by Checker

A109

Scale 1/8" = 1'-0"

12/8/2020 11:10:45 PM

No.	Description	Date

Pandemic Quarantine Center
East Meadow, NY

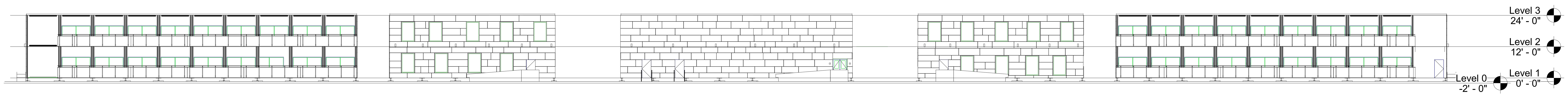
Site Plan

Project number	
Date	
Drawn by	Author
Checked by	Checker

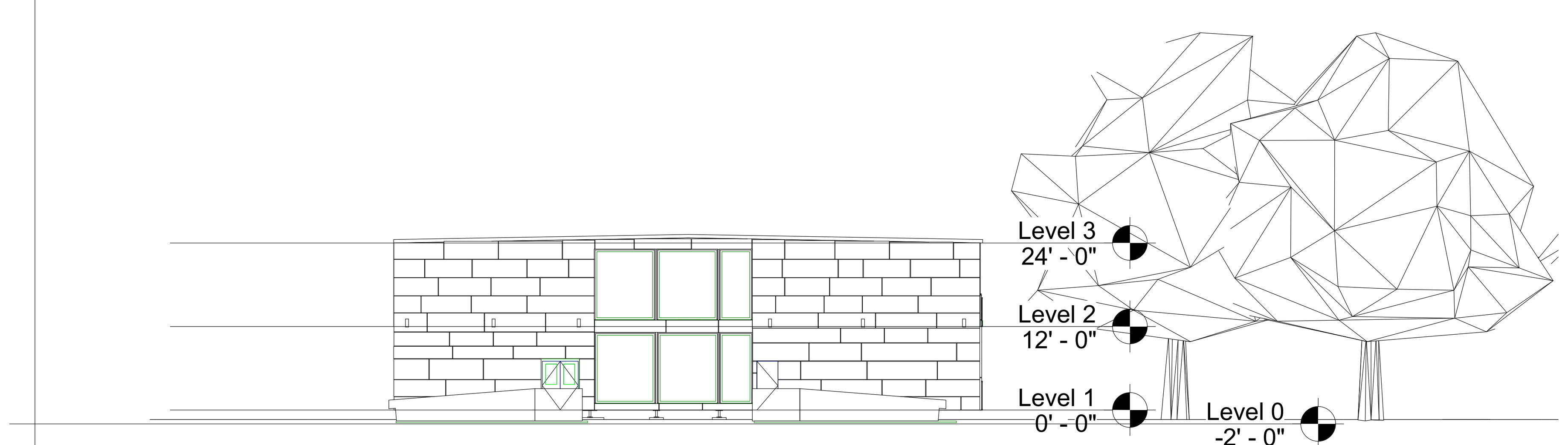
A110

Scale	1" = 60'-0"

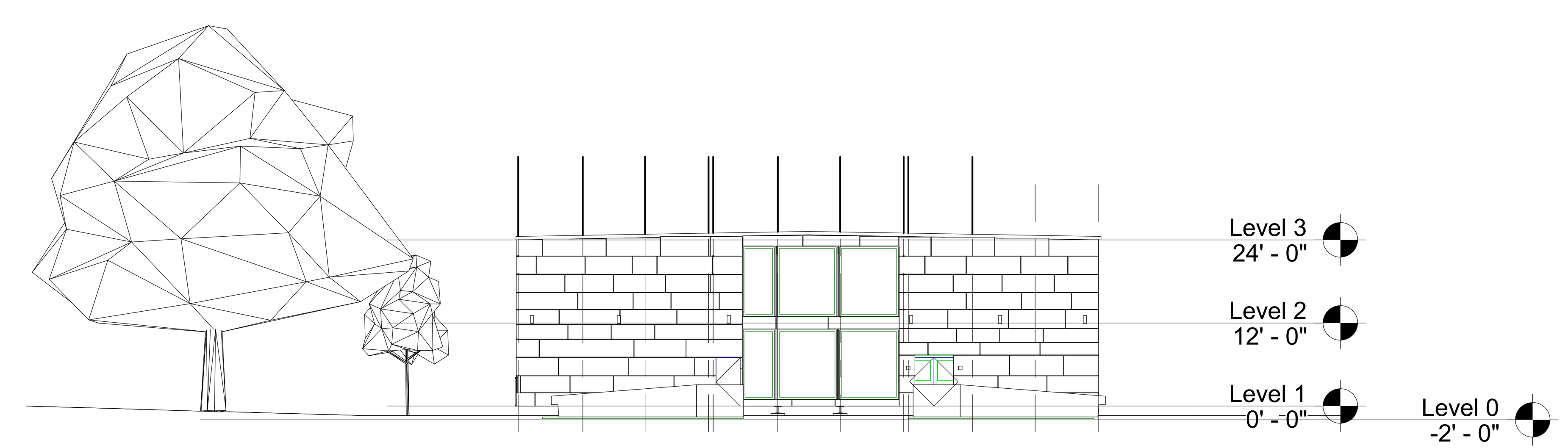
11/24/2020 1:38:57 PM



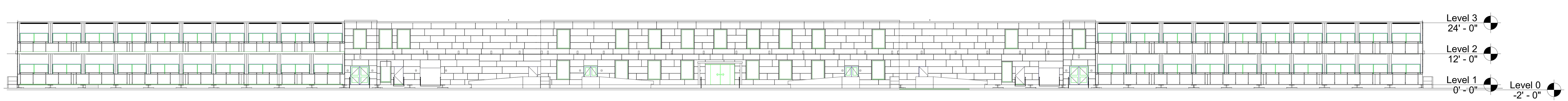
1 North Elevation
3/64" = 1'-0"



2 West Elevation
1" = 20'-0"



3 East Elevation
1" = 20'-0"



4 South Elevation
3/64" = 1'-0"

No.	Description	Date

Pandemic Quarantine Center
East Meadow, NY

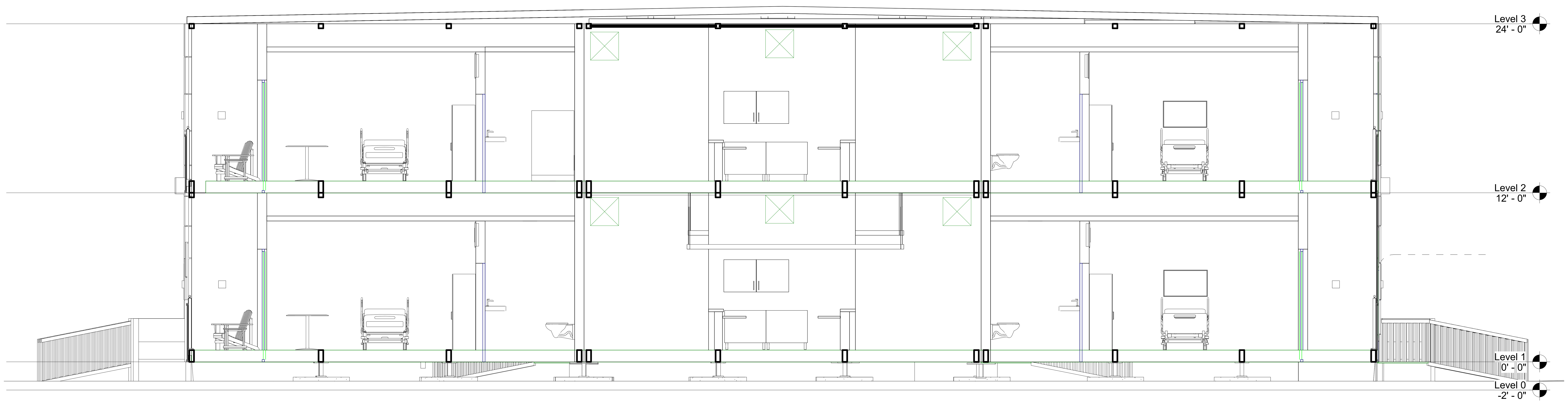
Building Elevations

Project number	
Date	
Drawn by	Author
Checked by	Checker

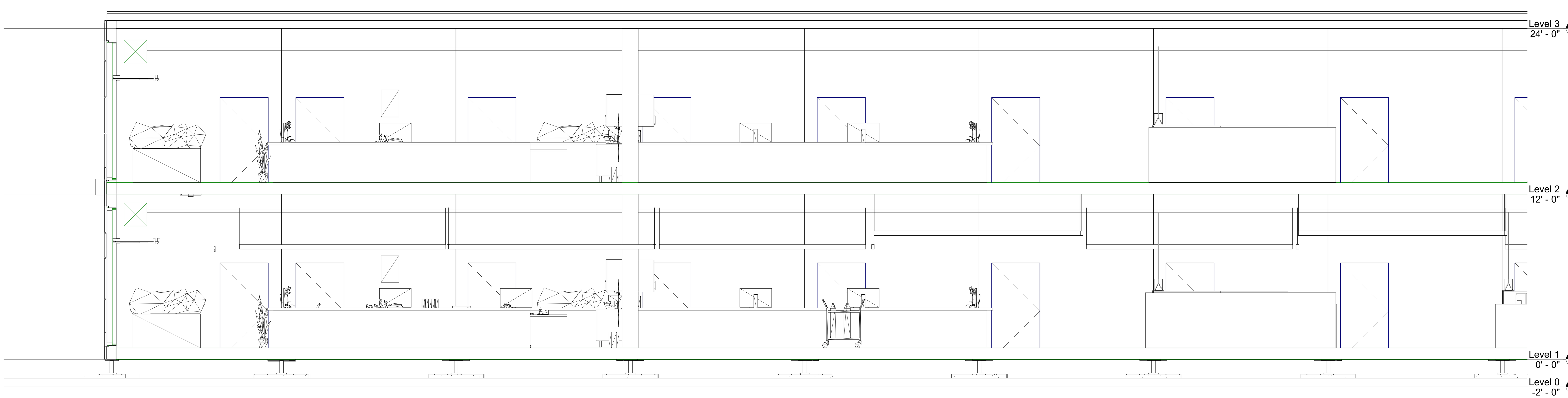
A111

Scale	As indicated

11/24/2020 1:38:59 PM



1 Section 1
1/4" = 1'-0"



2 Section 2
1/4" = 1'-0"

No.	Description	Date

Pandemic Quarantine Center
East Meadow, NY

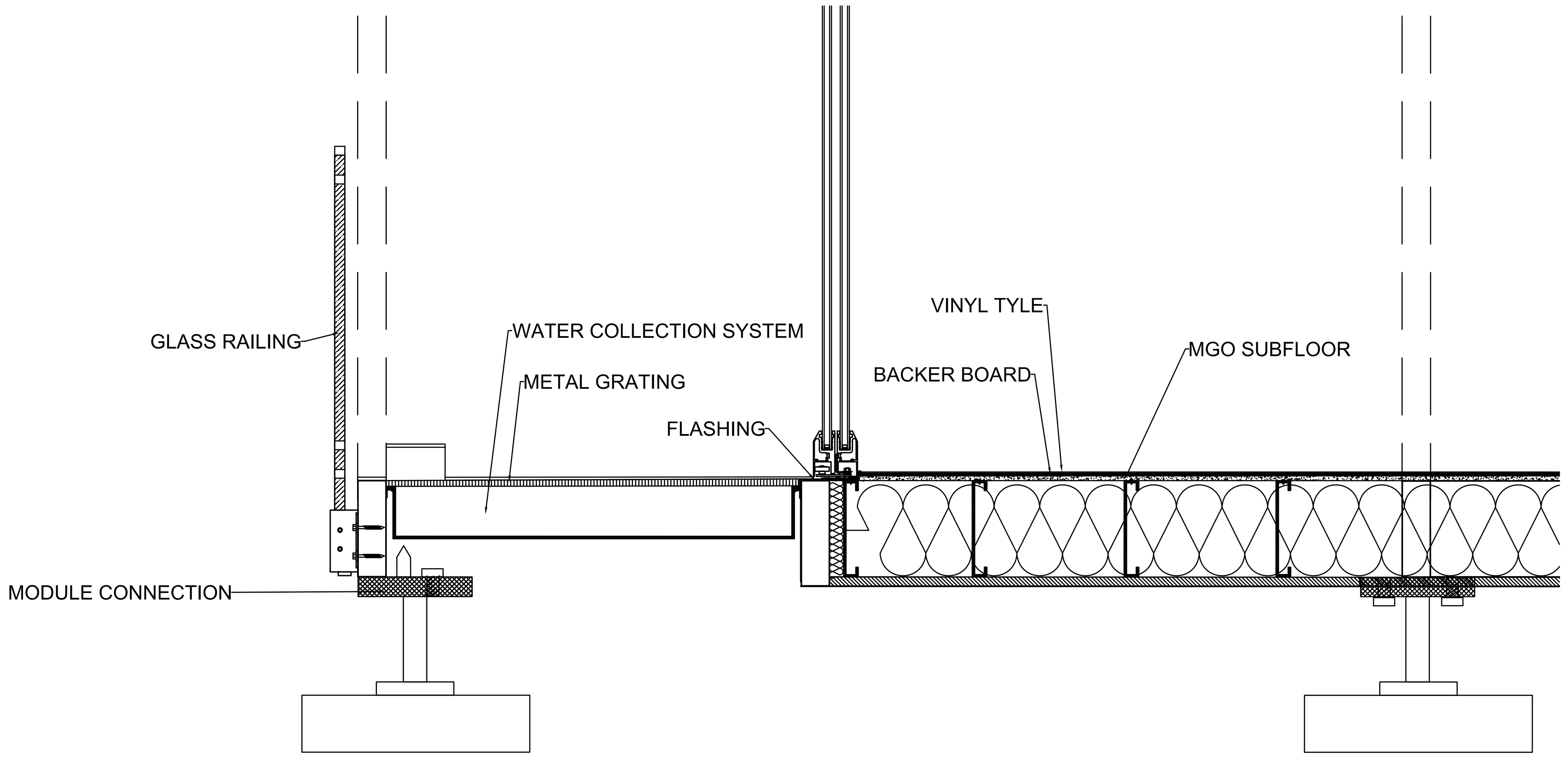
Building Sections

Project number	
Date	
Drawn by	Author
Checked by	Checker

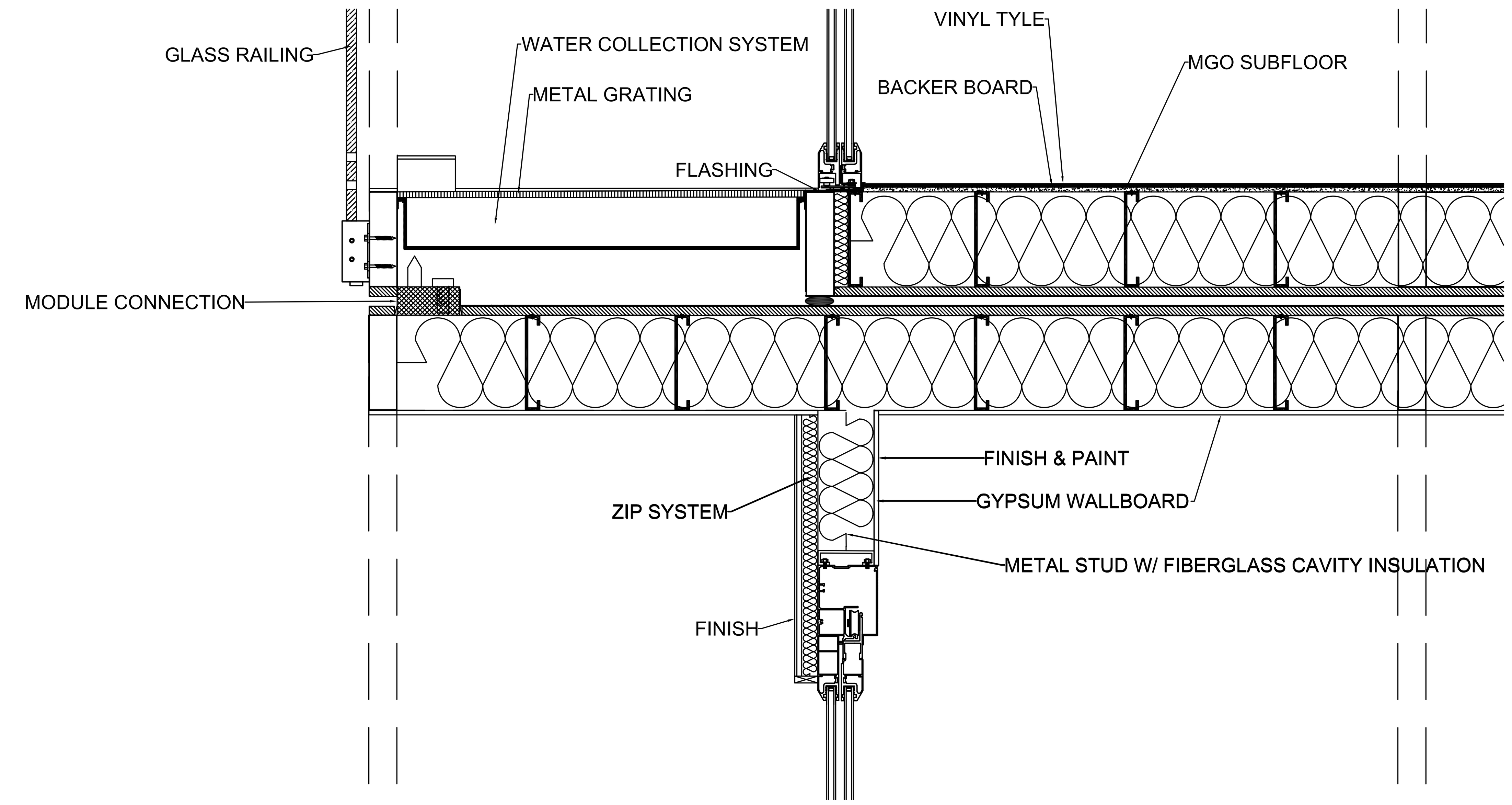
A112

Scale	1/4" = 1'-0"

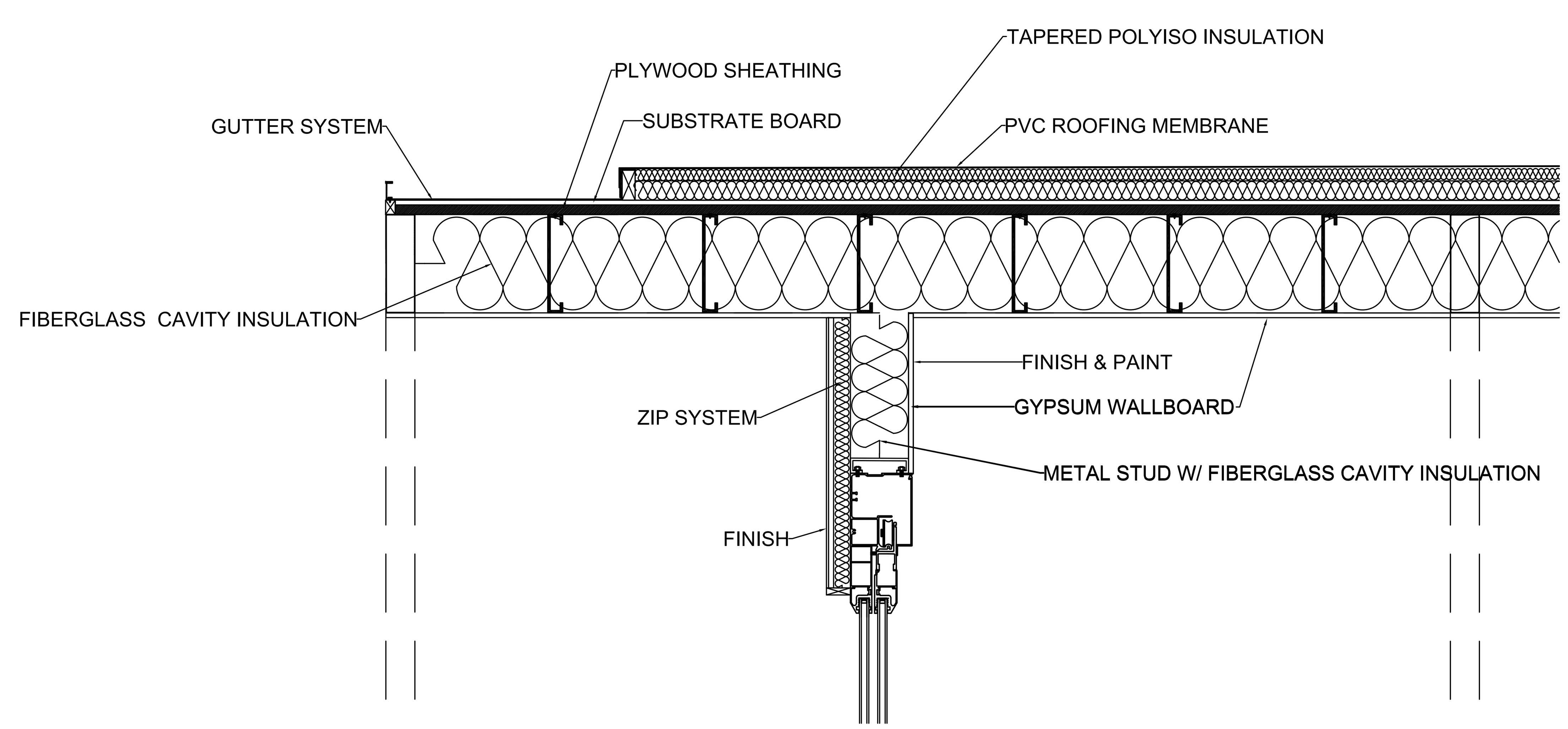
12/8/2020 11:11:04 PM



1 Conceptual Floor Detail - First Floor to Foundation
1" = 1'-0"



2 Conceptual Connection Detail
1" = 1'-0"



3 Conceptual Roof Detail
1" = 1'-0"

No.	Description	Date

Pandemic Quarantine Center
East Meadow, NY

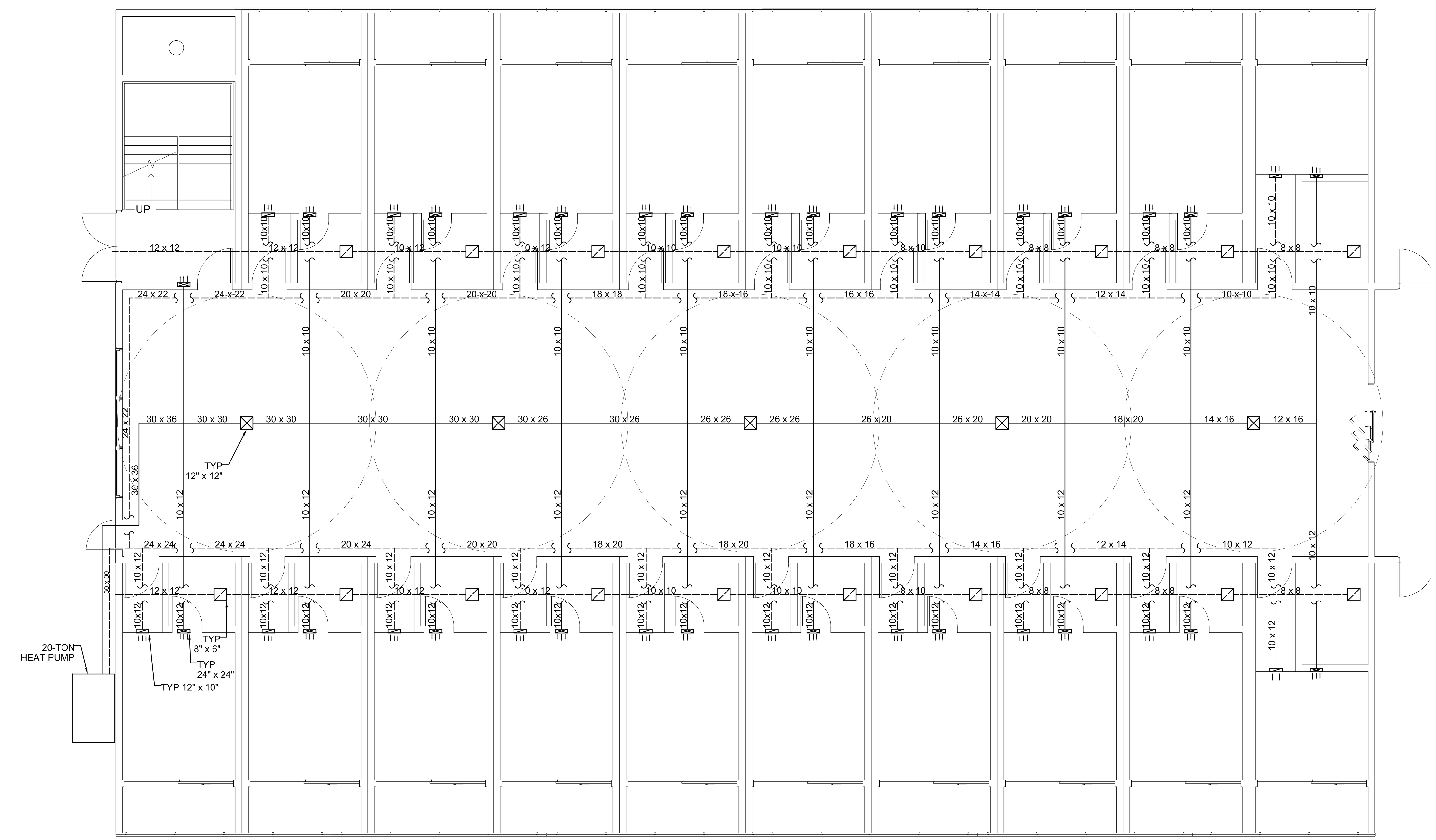
Conceptual Building Envelope Sections

Project number	
Date	
Drawn by	Author
Checked by	Checker

A113

Scale	1" = 1'-0"

11/22/2020 11:40:32 AM



- CEILING MOUNTED SUPPLY DIFFUSER
- CEILING MOUNTED RETURN GRILLE
- SIDEWALL SUPPLY DIFFUSER
- SIDEWALL RETURN GRILLE
- DIFFUSER THROW LENGTH
- SUPPLY DUCT
- RETURN DUCT
- DUCT CONTINUATION

TYP - TYPICAL

No.	Description	Date

Pandemic Quarantine Center
East Meadow, NY

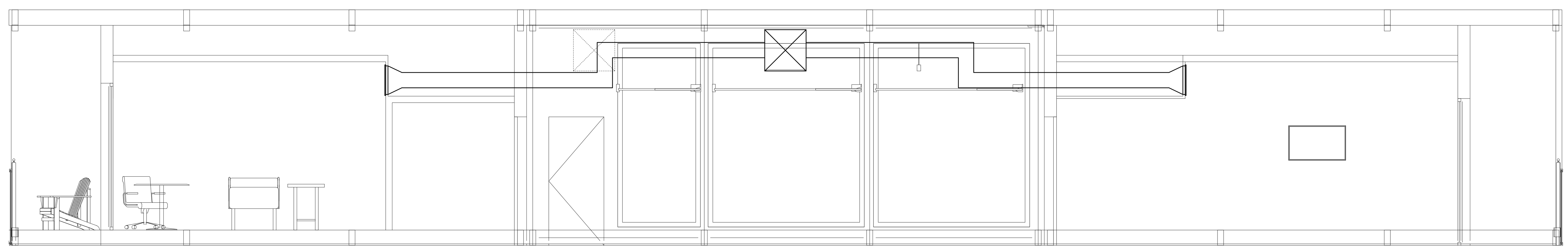
HVAC Plans
Patient Wing - West

Project number	
Date	
Drawn by	Author
Checked by	Checker

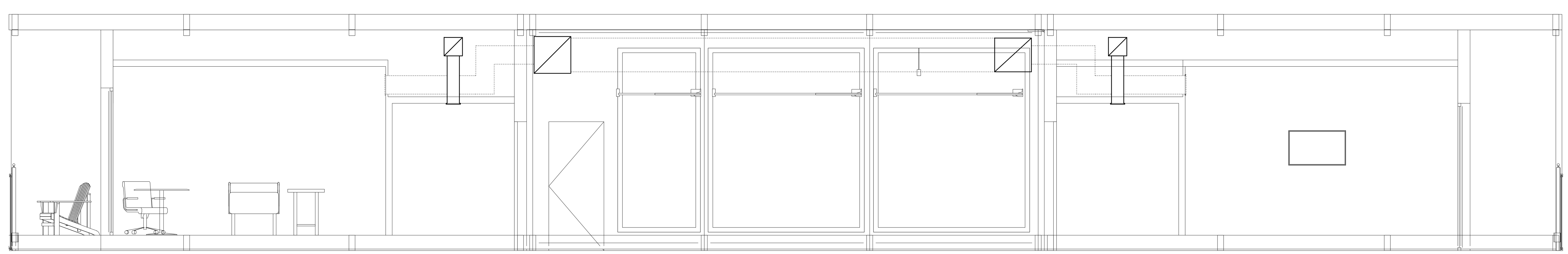
M101

Scale	1/8" = 1'-0"

11/22/2020 11:40:32 AM



1 Supply Duct Routing
1/4" = 1'-0"



2 Return Duct Routing
1/4" = 1'-0"

No.	Description	Date

Pandemic Quarantine Center
East Meadow, NY

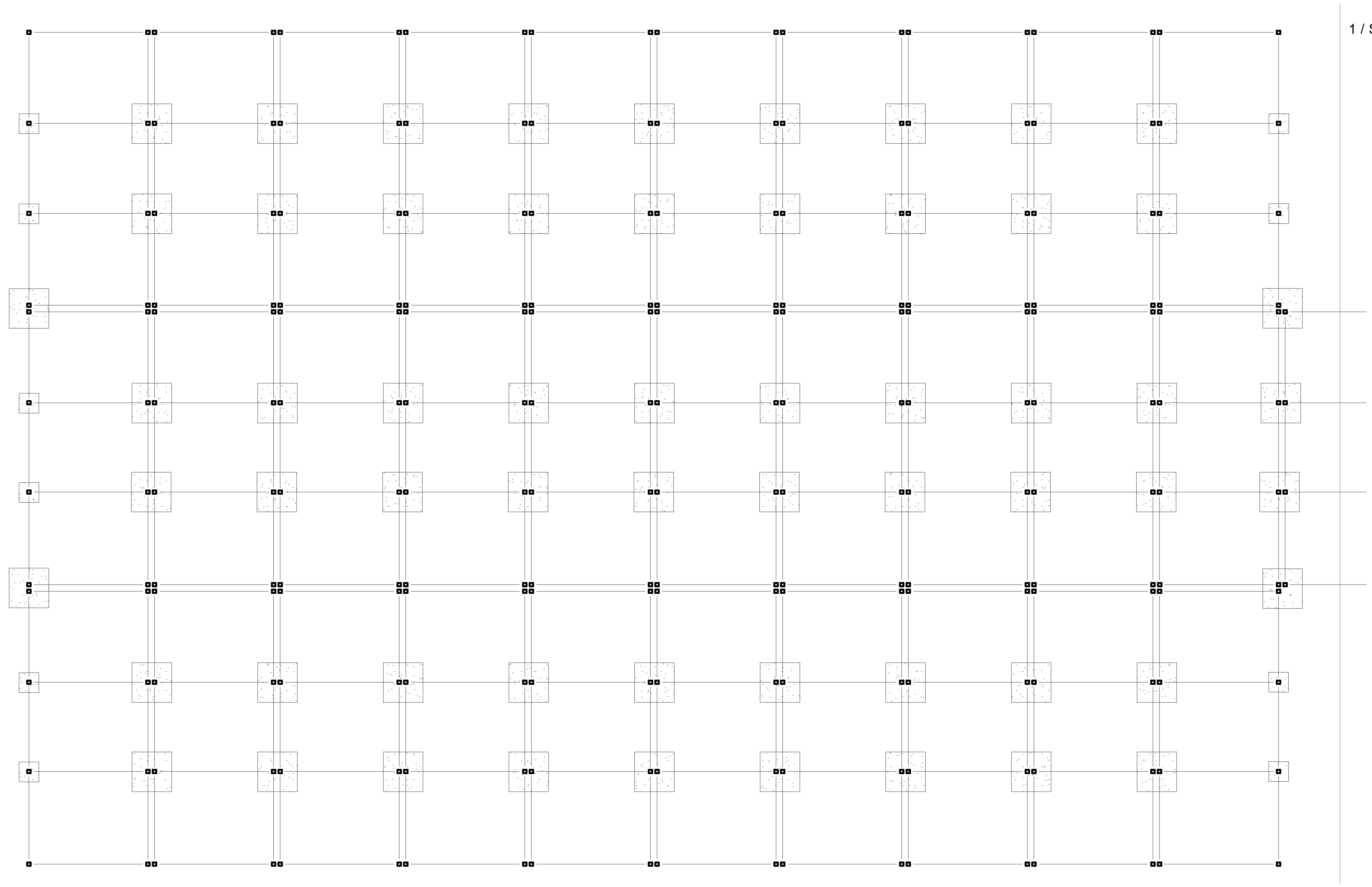
HVAC Sections

Project number
Date
Drawn by Author
Checked by Checker

M102

Scale 1/4" = 1'-0"

11/22/2020 11:40:32 AM



Bottom Chord: 1000T150-43 x 2
Top Chord: 362T200-68 x 2
Columns: 400T200-68 x 2

No.	Description	Date

Pandemic Quarantine Center
East Meadow, NY

Beam & Column Placement
Patient Wing - West

Project number

Date

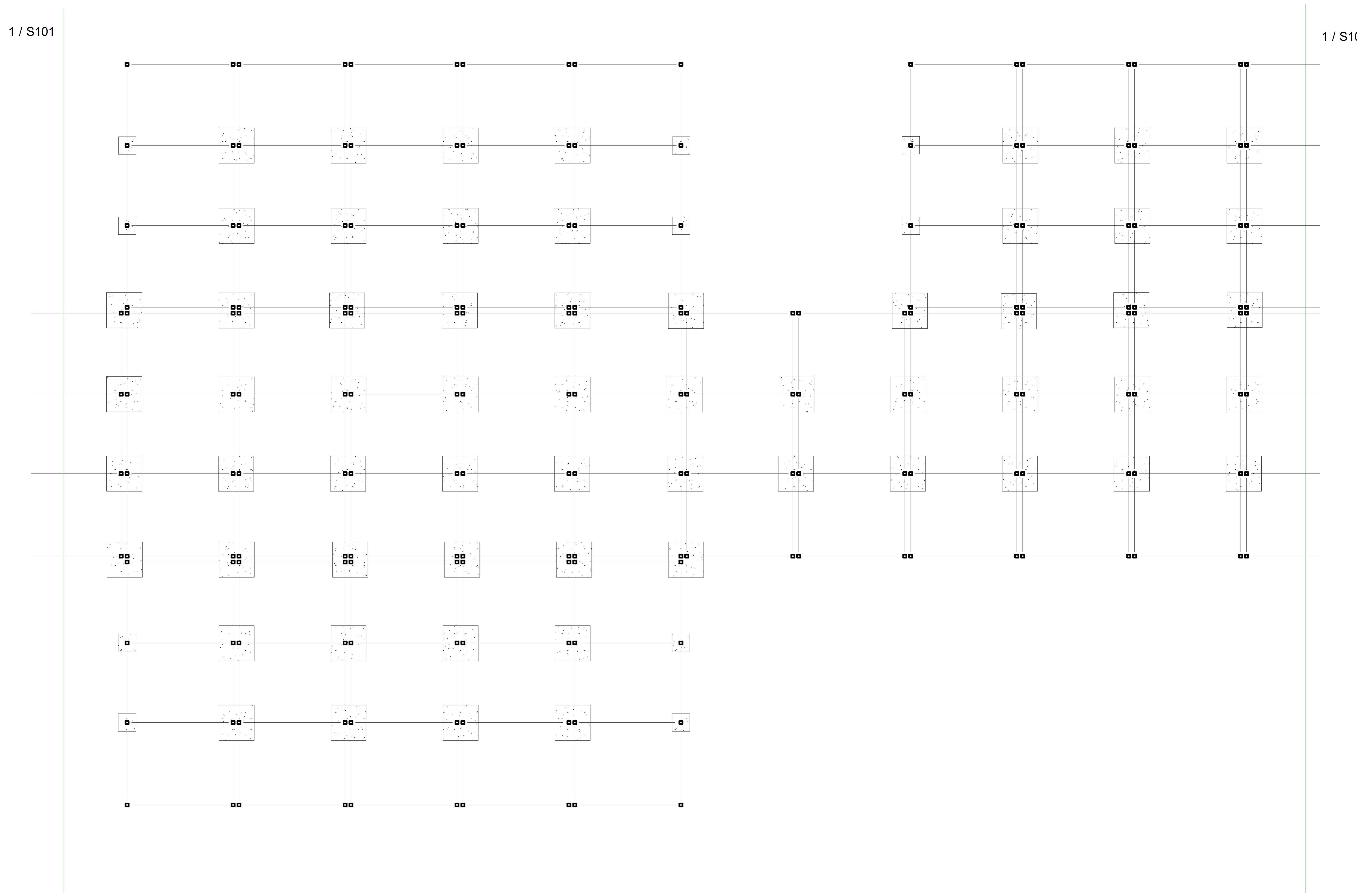
Drawn by Author

Checked by Checker

S101

Scale 1/8" = 1'-0"

12/8/2020 11:13:37 PM



Bottom Chord: 1000T150-43 x 2
Top Chord: 362T200-68 x 2
Columns: 400T200-68 x 2

No.	Description	Date

Pandemic Quarantine Center
East Meadow, NY

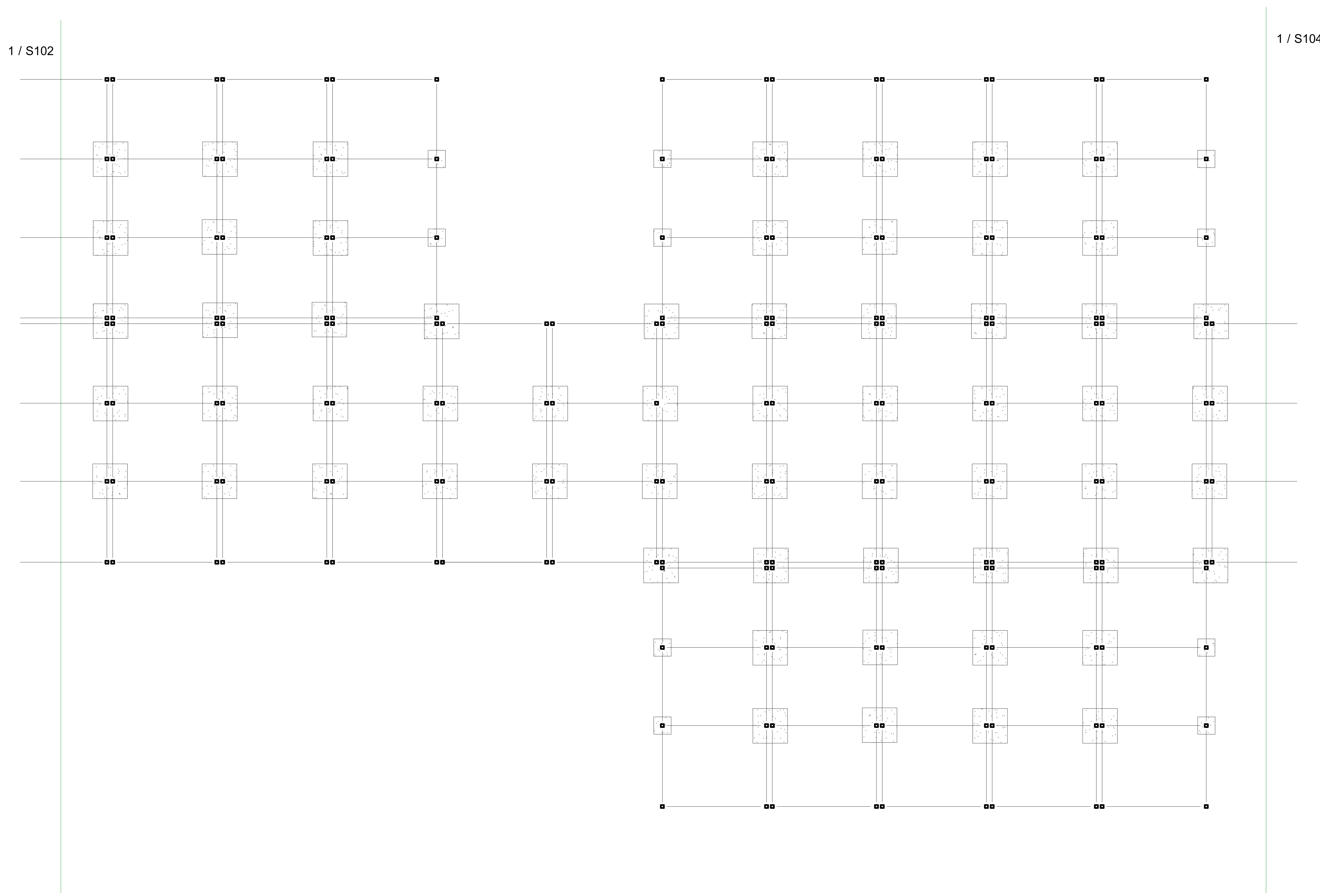
Beam & Column Placement
Middle Section - West

Project number	
Date	
Drawn by	Author
Checked by	Checker

S102

Scale	1/8" = 1'-0"

12/8/2020 11:16:35 PM



Bottom Chord: 1000T150-43 x 2
Top Chord: 362T200-68 x 2
Columns: 400T200-68 x 2

No.	Description	Date

Pandemic Quarantine Center
East Meadow, NY

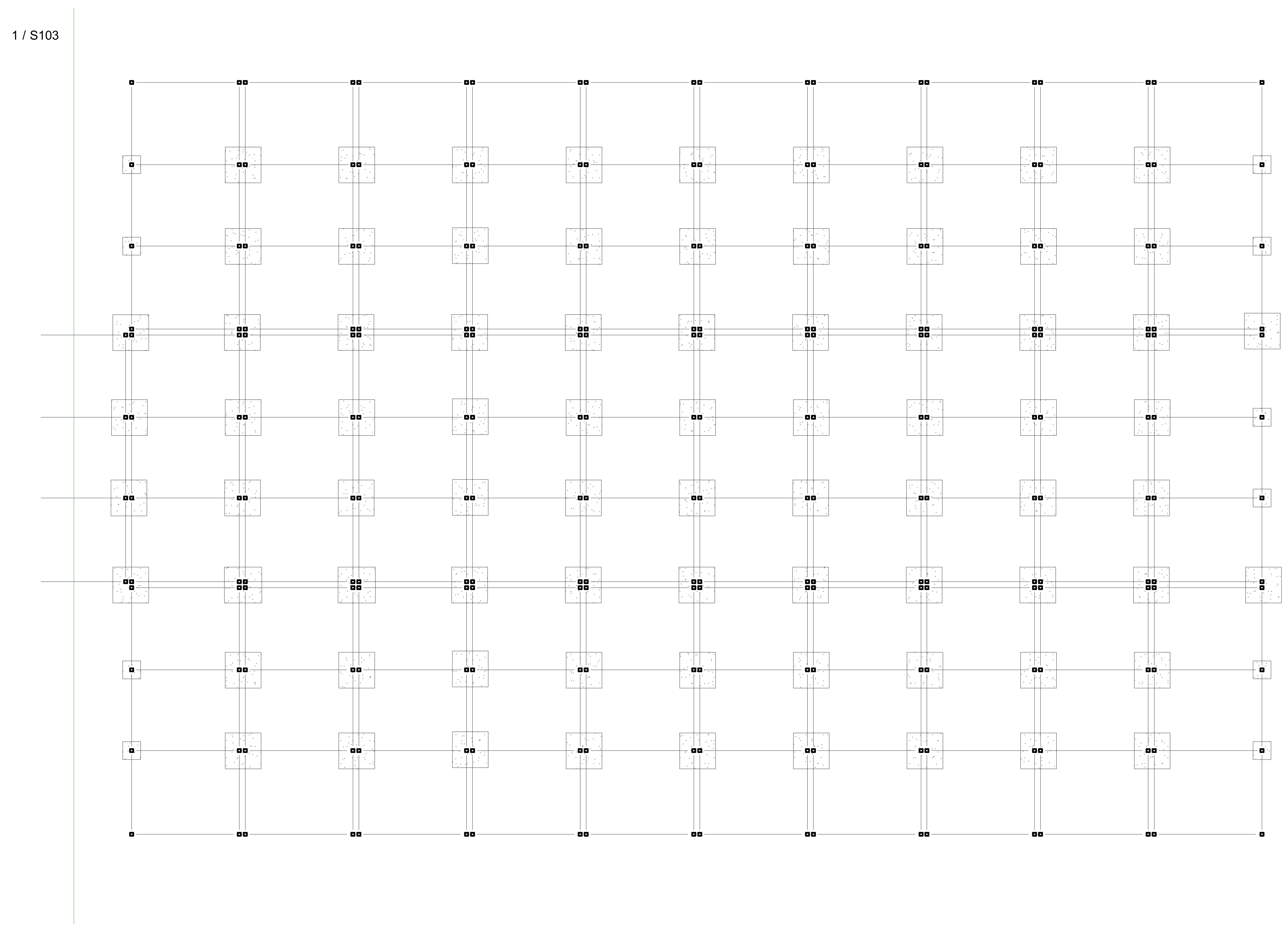
Beam & Column Placement
Middle Section - East

Project number	
Date	
Drawn by	Author
Checked by	Checker

S103

Scale	1/8" = 1'-0"

12/8/2020 11:21:12 PM



Bottom Chord: 1000T150-43 x 2
Top Chord: 362T200-68 x 2
Columns: 400T200-68 x 2

No.	Description	Date

Pandemic Quarantine Center
East Meadow, NY

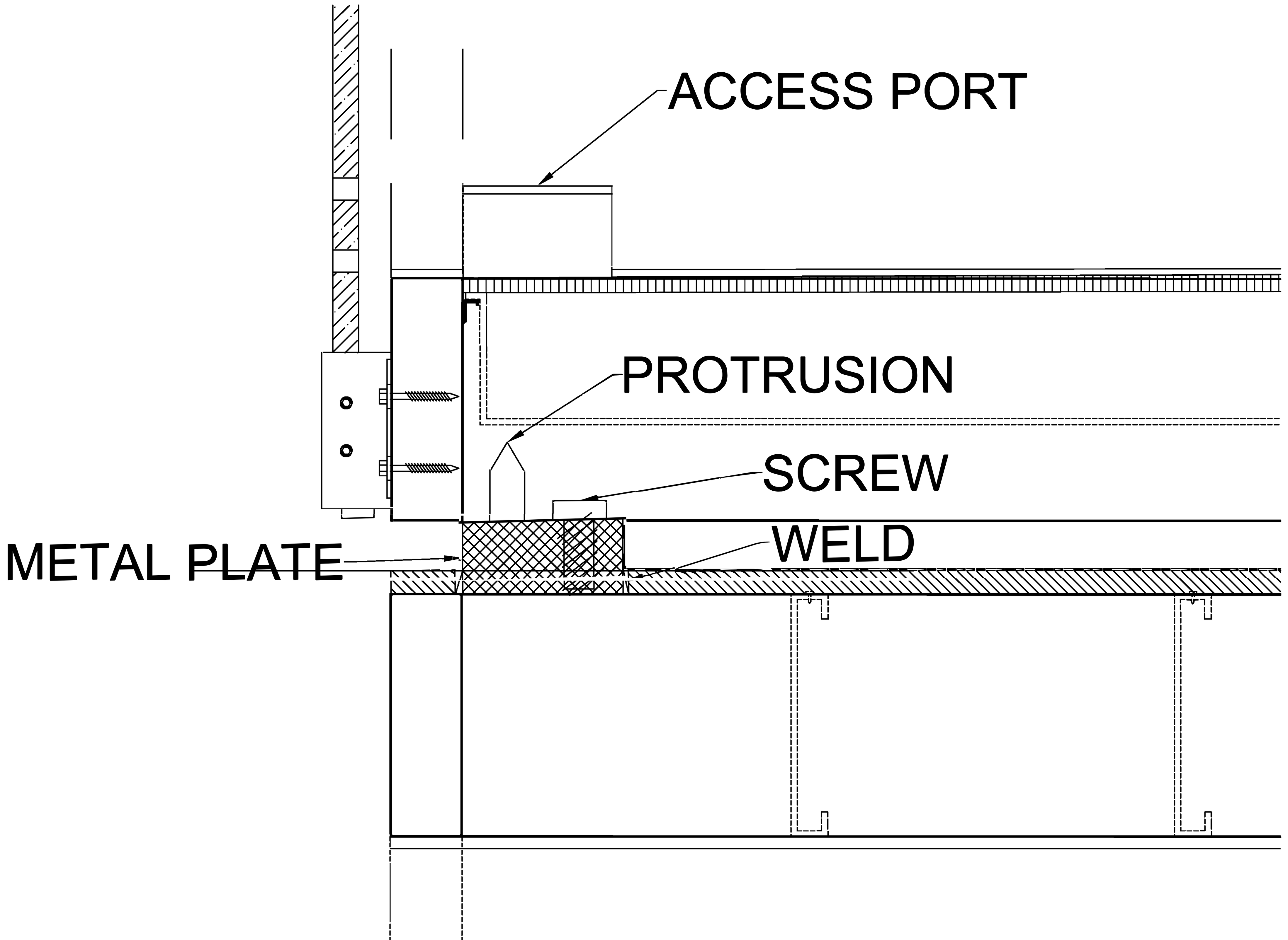
Beam & Column Placement
Patient Wing - East

Project number	
Date	
Drawn by	Author
Checked by	Checker

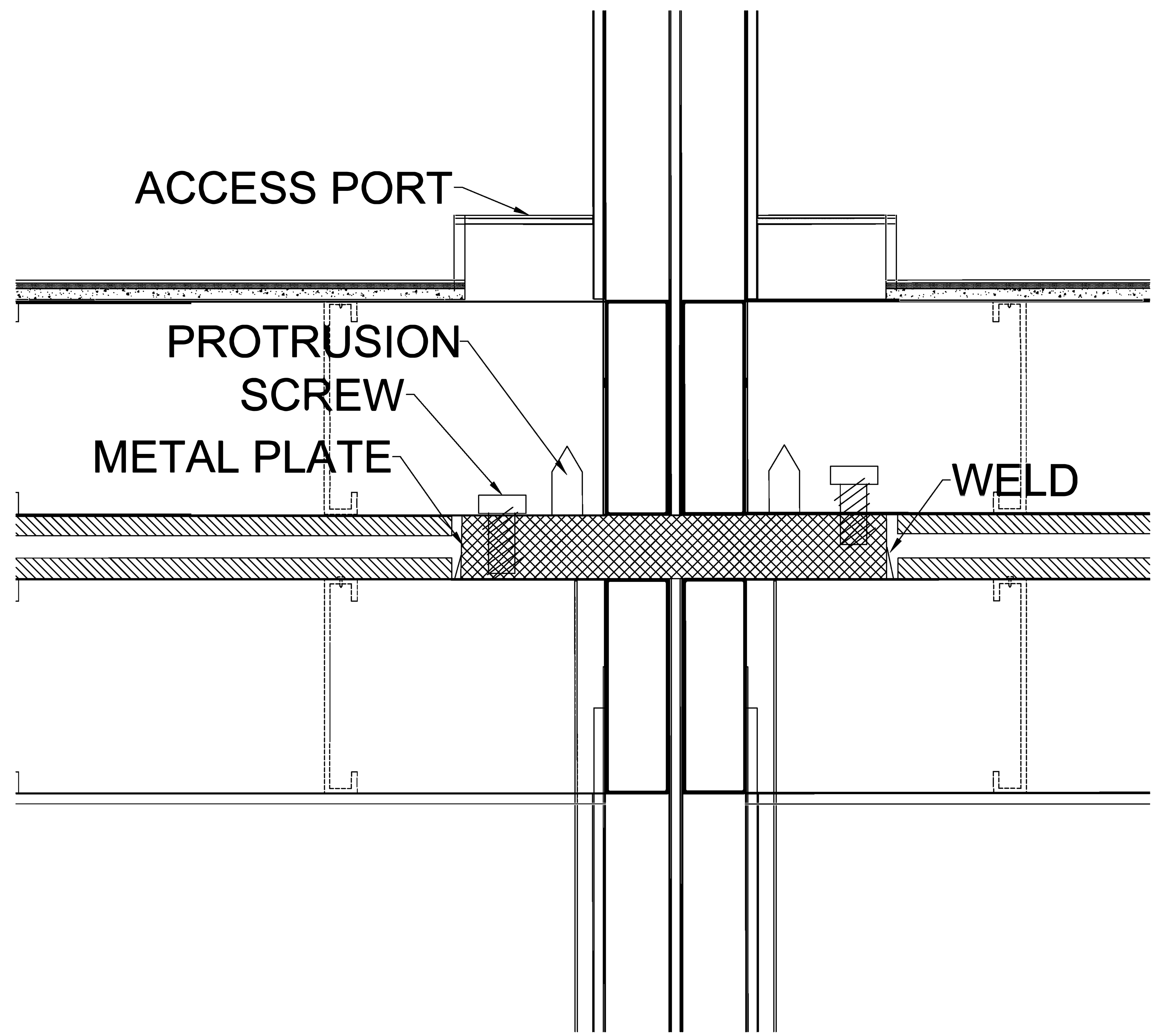
S104

Scale 1/8" = 1'-0"

12/8/2020 11:23:25 PM



1 Connection Between Two Modules Stacked
1/4" = 1'-0"



2 Connection Between Adjacent Modules
1/4" = 1'-0"

No.	Description	Date

Pandemic Quarantine Center
East Meadow, NY

Connections Detail
Stacked & Adjacent Modules

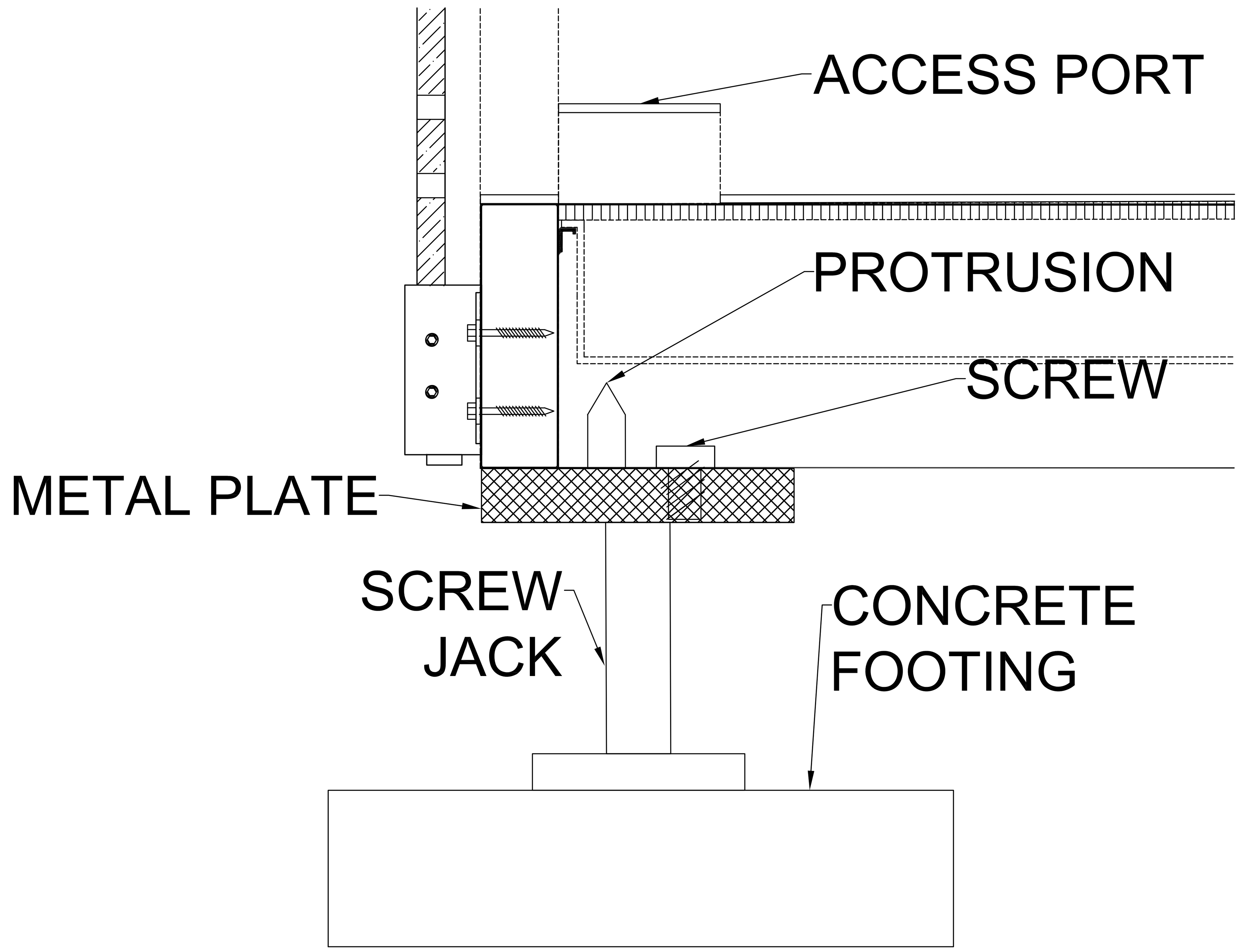
Project number	
Date	
Drawn by	Author
Checked by	Checker

S105

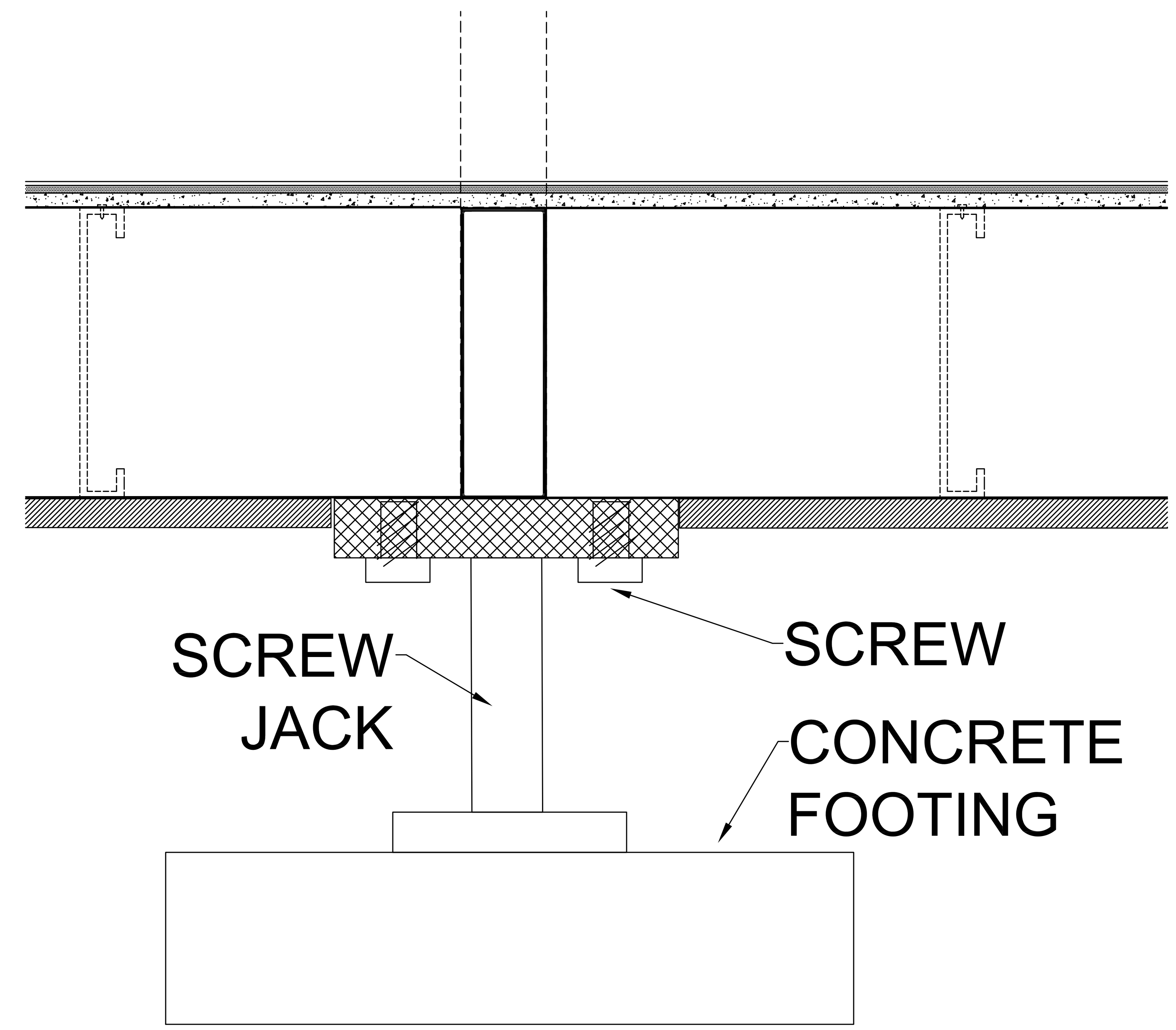
Scale	1" = 4"

11/22/2020 11:40:32 AM

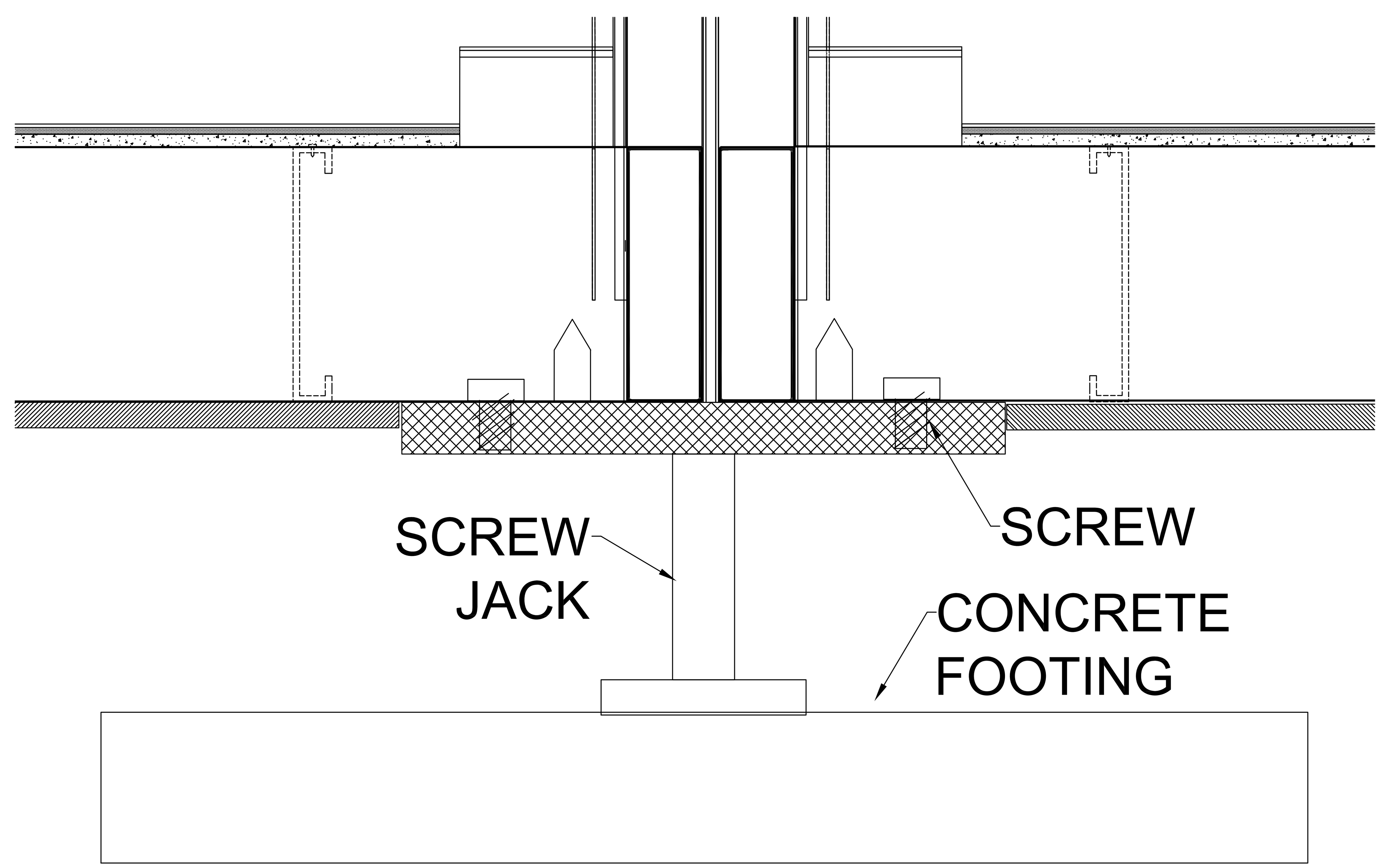
PRODUCED BY AN AUTODESK STUDENT VERSION
PRODUCED BY AN AUTODESK STUDENT VERSION
PRODUCED BY AN AUTODESK STUDENT VERSION



1 Support Connection at Module Corner
1/4" = 1'-0"



2 Support Connection Between at Span of Module
1/4" = 1'-0"



3 Support Connection Between Adjacent Modules
1/4" = 1'-0"

No.	Description	Date

Pandemic Quarantine Center
East Meadow, NY

Connections Detail
Support Connection

Project number	
Date	
Drawn by	Author
Checked by	Checker

S106

Scale	1" = 4'

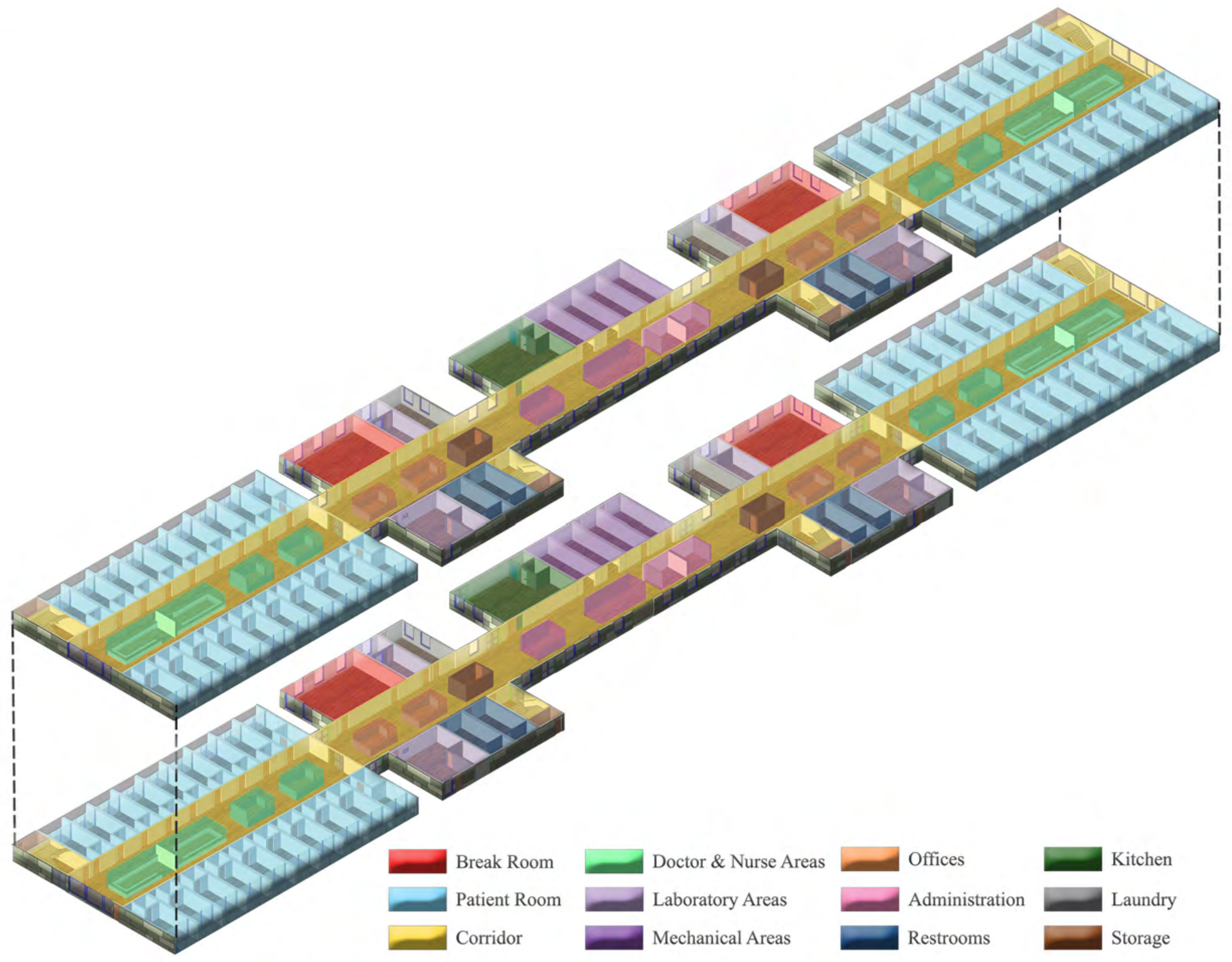
11/22/2020 11:40:32 AM

Appendix K: Design Board

Pandemic Quarantine Center

By Yllara Maia, Kimberly Ramos, & Samantha Wile

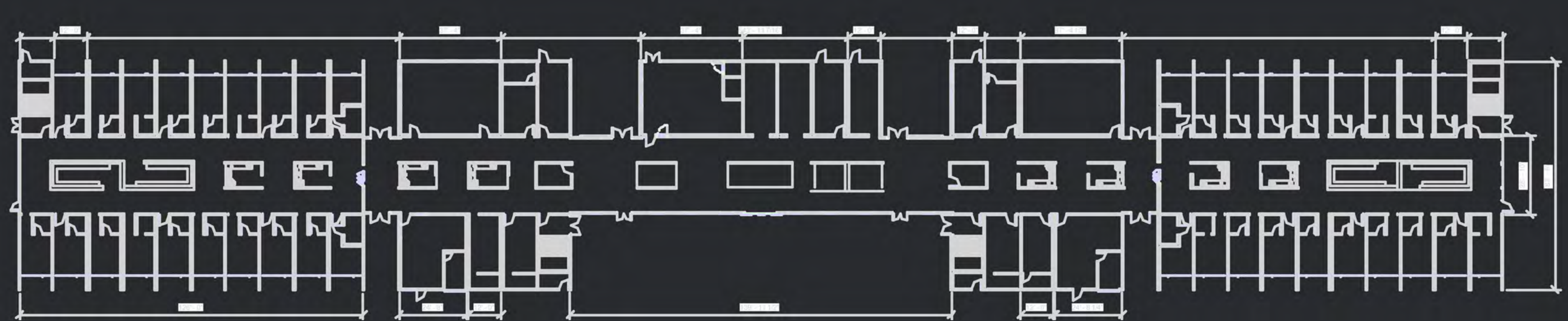
Innovation meets healthcare design with this modular facility which is intended to help underwhelm the hospital system during a pandemic. Using the concept of building blocks, the building is composed of modular units of the same size that can be pieced together in alsmost any unoccupied area in a short period of time.



Site & Program

Hypothetically placing the facility in New York City's Central Park allowed for a possible scenario to be analyzed. Its systematic location, being near a hospital and within natural surroundings, enabled the incoorporation of key concepts into the design. By placing the facility in an open and exhisting site, such as East Meadow within the park,no extrenuous sitework needs to be done to prepare for construction. In addition, the building is not entirely shaded by skyscrapers and itsoccupants are surounded by views of trees and nature.

Programming for this specific project was established based on the needs of hospital staff and patients. Staff areas were placed nearby windows and patient rooms surround the nurses' areas on both sides of the building. Each patient room includes a private bathroom and a balcony to allow them a to have view of the park and some fresh air.



Designing for the Well-Being of Patients

One of the overarching goals for this facility was to incorporate design strategies that would help promote the wellness of its occupants.
In addition to effective mechanical systems, the interior design of the facility was carefully planned out for this purpose. One of the main areas of focus was the patient roms, where individulas would be spending an ample amount of time in. Neutral colors, natural finishes, and access to plants and other foliage were key aspects that were placed in order to reduce stress and encourage rapid recovery.