Gateway Arch National Park's Engineering Competition

Old St. Louis Courthouse
12th November 2022

EXECUTIVE SUMMARY

PREPARED BY:

PREPARED FOR:

Old Courthouse shot from the Top of the Gateway Arch
NPS/Sue Ford

OVERVIEW

The historic Old Court House in St. Louis is an important part of the Gateway Arch National Historic Site. The Old Courthouse has been closed for several years undergoing major renovations. Before closing for restorations, this popular attraction was visited by around 300,000 visitors per year.[i] Despite the historical significance of the building and considerable interest in viewing it, the second floor of the building is inaccessible to those unable to use the stairs. The following executive summary outlines a practical solution to establish an ADA-compliant elevator to access the second floor of the building. This renovation will allow all visitors to be able to experience the historic treasures in the same way.

EXISTING CONDITIONS

The Old Courthouse Construction dates to 1839. The building is considered a contributing structure in a historic district, thus special considerations will need to be made for any alteration of the building. Any construction must satisfy the requirements of the ABAAS (Architectural Barriers Act Architectural Standards)[ii] and section 106 of the National Historic Preservation Act (NHPA)[iii] by preserving the historic architecture of the building as much as possible. The National Parks Service (NPS) indicated the goal will be to design an ADA-compliant elevator located in the current first-floor Conference Room that will allow people unable to travel up the stairs to access the second floor. The elevator must be able to be operated by an individual who is visiting alone and be constructible within the space restrictions of the building. Another challenge is that there is a thick layer of concrete beneath each level serving as structural support. Due to the age and unknown structural condition of the building, structural improvements will need to be made to accommodate the proposed openings in the existing building.

OUR SOLUTION

Ultimately, an elegant solution was developed to address all the project needs cost-effectively. We are proposing a readily available specialized elevator package with an estimated cost of $240,000. We would also like to recommend a project budget of around $311,000 (See Budget Section) and an anticipated construction schedule of about 10 weeks with a lead time on equipment of about 28 weeks.[iv]

Numerous factors were considered in our decision-making, with the following deemed critical issues in defining our solution:

- Space Allocation / Preservation of Historic Building

We quickly determined that the industry standard for two-floor elevators, the hydraulic elevator, is not the best fit for this situation. Installing a standard hydraulic elevator would

force us to dig out a significant amount of the building's foundation to make room for a long descending piston and would require a separate room to be occupied as a machine control room. With the basement directly underneath the desired installation location being almost entirely unexcavated, maintenance of a hydraulic elevator would bring further challenges. Additionally, if a machine room was constructed, it would infringe on valuable space within a place of historical significance, possibly violating section 106 of the NHPA (National Historic Preservation Act).[v] Based on the very stringent conditions, we concluded that the best solution is a traction-driven Machine Room-Less (MRL) elevator. An MRL elevator's mechanism is located completely within the shaft, eliminating the need for a machine room by design. Plus, this solution will not require nearly as much excavation below the base of the building, or any construction on the first two floors of the building and will not involve any drilling through the thick concrete beams above the current second-floor Law Enforcement Office.

- Constructability

The best course of action is to use the commercially proven Schindler 3100 elevator system that is already being produced by Schindler Elevator Corporation. Utilizing a commercialized solution will reduce the development and construction time of the project. Schindler's products allow for customization options including weight capacities, heights, and safety features. Figure 1 displays the dimensions alongside a basic blueprint of the Schindler 3100 model elevator customized for use inside the Old Saint Louis Courthouse. In most low to mid-rise buildings, the elevator shaft is capable of providing enough support to the building on its own, but due to the lack of solid understanding as to how an elevator may affect the structural integrity of this historically constructed building, extra caution should be taken. Steel columns and a concrete shaft, made of mainly concrete masonry units will be added around the elevator to alleviate any stress the floors may have after drilling through the concrete support structure (See Figure 2). These steel columns will run from the top of the shaft to the bottom of the pit, and we opted for only two of these steel beams as they will be tied into the support structure of the building.

- Cost

The focus on a commercially-proven solution greatly reduces the overall cost of the project. MRL-traction systems are also one of the most energy-efficient varieties of elevators. Our solution, the Schindler 3100 model elevator is up to 60% more energy efficient when compared to a traditional hydraulic solution.[vi]

Overall, this solution is the most well-proven, efficient, feasible, and historically conscious solution to the issue.

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SAFETY

An important consideration of our design was maintaining a high level of safety not only amongst those using the elevator but for the structural integrity of the historic building with the addition of an elevator. Thanks to our commercial approach, we know that our elevator will meet all ADA requirements as the Schindler 3100 model elevator was specifically designed with these regulations in mind.[vii] Examples of some of the ADA-required features met by the Schindler 3100 are displayed in Figure 4. This elevator design also exhibits braille to allow the visually impaired to safely access the elevator. According to the ADA, the elevator doors must be 36 inches wide to account for wheelchairs and possibly allow multiple people to exit at the same time. The elevator car must be 51 inches deep and at least 68 inches wide. Our elevator design not only meets but exceeds these requirements and is 52-7/8" deep and 81-5/16" wide. This extra leeway leaves some extra space for comfort during travel. Additionally, necessary controls will be placed at a height that is easily accessible by those in a wheelchair (See Figure 5). Since this elevator will help the building to be more accessible to everyone, the project will help to satisfy the building's compliance with the ABAAS.[viii]

The reliability of our elevator system is another important consideration when it comes to the safety of passengers. We specified our elevator to have a weight capacity of 2500lbs, offering more than enough lifting capacity for the flow of people through the building. Our solution also avoids the dangerous risk of mechanical failure brought forth by a standard hydraulic elevator. The hydraulic jack of such an elevator could develop an oil leak which would likely require further digging into the unexcavated foundation to remedy and could create a risk of groundwater contamination.[ix] The complete mechanism of an MRL traction-based elevator can be accessed from the top of the shaft from within the elevator car when maintenance is required. Plus, Schindler has a location less than twenty-five minutes outside of downtown St. Louis, allowing for shorter response times for service and maintenance needs. In case of emergency, the nearest fire station is only about .7 of a mile away from the courthouse.

Finally, our elevator shaft will be mostly free-standing so there will be limited contact with the exterior wall of the building. This will ensure that the façade of the building and outer wall integrity remain undamaged by the vibrations caused by the elevator's motion. With these considerations in mind, we are confident that our design offers the safest possible experience both in terms of structure and visitor experience.

MATERIALS AND IMPLEMENTATION

Materials required for the construction of this project include:

- Schindler 3100 Model Machine Room-less Elevator (Figure 2 provides the exact materials used in the elevator car

- CMU (Concrete Masonry Units) to construct the elevator shaft
- Two steel columns to support the floors above and the weight of the elevator itself.

Digging will be one of the first steps in the construction of the elevator. The pit depth required for our design is five feet below the first floor. The space between the slab and the first floor is 4-½".[x] This means we must excavate 4'7-½" deeper. The pit is 8'6" wide and 5'9" long. So, the total amount of ground that will need to be excavated is 226 cubic feet. All excavation must be performed by hand because we cannot take out any windows or walls to comply with historic building codes.

The construction of the elevator shaft will begin with wooden framing. As the framing works its way up from the first floor, the beams and ceilings will be removed and replaced with wood and temporary support structures. Steel columns will be added separately from the wood temporary support and will be a permanent support structure. The steel columns will be placed in line and connected to the structural support beams that are completely cut through to account for the weight being held by the original beam. After the shaft is framed, Concrete Masonry Units (CMUs) will start to be placed around the frames. While possibly more expensive, CMUs are easier to install than pouring concrete as it is potentially less time-consuming especially in the winter when pouring concrete is not optimal, and it is also easier given our confined space. Another option is Cross-Laminated Timber (CLT) elevator shafts, however, these are nearly impossible to implement without opening the roof of the building, as they require a crane. After the CMUs are installed on the top of the shaft, electrical wiring and machines will be inserted and the elevator mechanism and car will be installed.

BUDGET

The cost of our solution can be broken down as follows (See Figure 3 for more detail):

Item	*Price*
Excavation	$2,167
Shaft	$22,095
Removing Ceiling Support Structure	$125,000
Schindler 3100 Materials	$45,000
Elevator Installation	$45,000
*Contingency (239,262*30%)*	$71,779
Total	$311,000

Much of our cost information comes directly from Schindler Group, the producer and installer of the Schindler 3100 elevator. We were able to contact a St. Louis-based sales representative with the company, supplying us with a total bid amount for their elevator based on our specifications of $90,000.[xi] Half of this cost was allocated to installation in

> Schindler's estimate, and the other half was attributed to materials. This bid does not include the cost of elevator shaft construction or excavation, which we estimated using online tools to be around $22,095. This same sales representative also conferred with a General Contractor (GC) colleague to discuss the cost of removing the thick concrete ceiling support structure present beneath each floor. The GCs best estimate was about $9,000 per floor for solely the removal, and they noted that the price could quickly skyrocket up to nearly $150,000 if there were any structural, electrical, or plumbing problems revealed during floor and ceiling demolition. After consulting with an engineer on the issue, we decided $125,000 was a good estimate for this aspect of the project when considering the high likelihood of difficulties associated with the historic building. Schindler group further included a list of potential expenses due to construction complications that can be found in Figure 3 amongst further detail on cost breakdown. Finally, we once again conferred with an engineer about the total cost of the elevator. They suggested that we add about a 30% contingency to the overall cost of the elevator system and installation to account for any further problems arising from the historic nature of the building, and for potentially inaccurate excavation and shaft costs. Therefore, we suggest a total budget of $311,000 to be allocated to the elevator project in its entirety.

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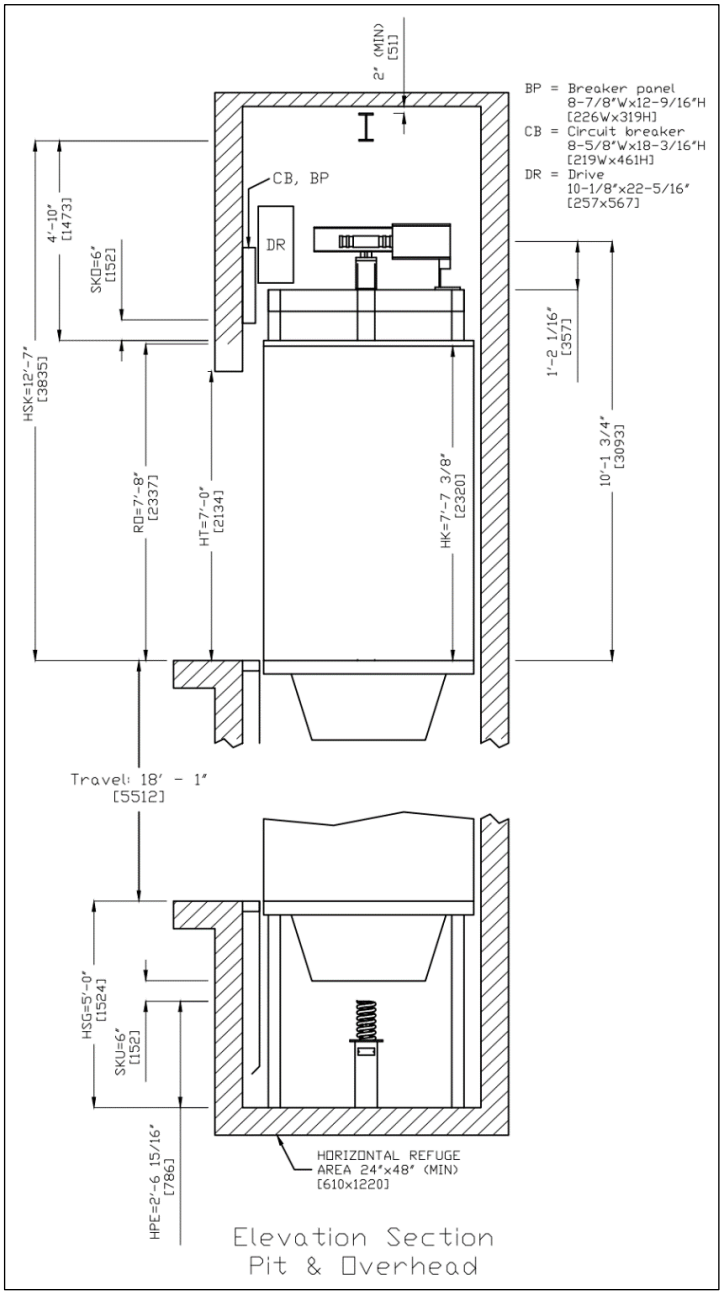
DIAGRAMS:

Figure 1: Elevator Overview

Customized Specifications for Schindler 3100[xii]

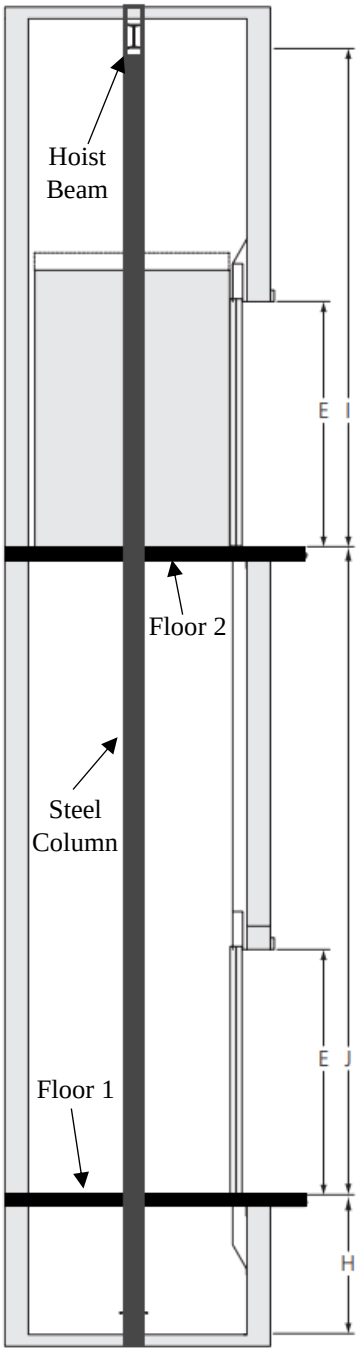
In Seismic Zone?	Yes
Capacity	2500 lbs
Speed	100ft/min
Door Type	Single Side Opening (Front Only)
Cab Height	7’9”
Landings	2
Hoistway Entrance Dimensions	3’6” Wide * 7’10” High
Travel Limit	18’1”



Blueprint of customized Schindler 3100 MRL traction-based elevator.

*Diagram not drawn fully to scale

Figure 2: Elevator Shaft



Individual Hoistway Dimensions

Dimension	*Configured Elevator*	*Maximum Available*
Hoistway Width	8’6”	12’5.75”
Hoistway Depth	5’9”	9’11.25”
Pit Depth	5’0”	N/A
Overhead	12’8”	13'1.25"

Dimensions and Materials of Elevator Car[xiii]

Cab Height	7’9”
Cab Width	6’9-5/16”
Car Depth	4’4-7/8”
Base, Frieze, and Reveals	Aluminum
Cab Ceiling	Stainless Steel with LED lighting
Cab Return and Transom	Stainless Steel
Cab Doors	Stainless Steel
Cab Threshold	Aluminum
Threshold Finishes	Aluminum

Diagram of the proposed steel elevator support columns running from the top hoist beam on either side down to the bottom of the pit.

*Diagram not drawn to scale

Estimated Cost of Materials for Shaft[xiv]

Item	**Specification**	**Amount**	**Price**
Steel Universal column	36ft UC 305 x 305 x 195	2*	$10010
Concrete Masonry Unit	12 x 8 x 16in	21.375 ft^2 x 36	$2890
CMU Labor	1 job	21.375 ft^2 x 36	$9195
Total			$22095

*Two UCs (Universal Column) will be used instead of four because only one of the original beams should need to be cut entirely. Thus, the columns will be placed and connected in such a way that they are at the open ends of the cut beam and take its load.

Figure 3: Cost Details

Estimated Cost to Excavate Pit[xv]

Item	Amount	Price (Low – High)	
Land Excavation Labor, Basic	12.9 h	$382	$1610
Land Excavation Equipment Allowance	1 job	$149	$224
Land Excavation Debris Disposal	9 yd^3	$293	$333
Total*		$824	$2167

*These numbers are based on the assumption that there is only dirt under the concrete floor. If there is limestone less than 5' under the floor then these costs would be increased due to increased labor and complications of moving material.

Estimated Cost of Removing Ceiling Support Structure (Labor Included)[xvi]

Item	Amount	Price (Low – High)	
Concrete Beam and floor removal*	8'6 x 5'9" x 5'1-¼"	$16000	$20000

*There is the potential for added cost due to structural, electrical, or plumbing complications and the price could quickly rise to $150,000

Energy Cost[xvii]

Item	Volts	Watts per hour	Energy cost
Electricity (60 amp)	480	28800	15.42 cents per kWh
Daily cost			$44.40
Monthly Cost			$1351.70
Yearly Cost			$16220.60

Permits (Cost already included in previous totals)[xviii]

Permits	Price (Low-High)
Demolition	$100-500
General Building Permit	$1000-2000
Inspections	$300-400
Total	$1400-$2900

Potential Additional Costs of Installation (May not be applicable)[xix]

Description	Additional Fees
Hourly cost per man	$250.00 per man hour, straight time $432.00 per man hour, overtime $500.00 per man hour, double time
Operator time	$2,000.00 per day (8 straight time hours) for one man
Storage	$1900.00 per elevator per month for the first month, $1,200.00/month per unit (no prorate)
Remobilization	$2500.00 per occurrence
Pre-Test Requested by Others	$3500.00 per occurrence and scheduled a minimum of three (3) weeks before the date of request

Figure 4:

Additional features allow for ease of use and ADA compliance.[xx]

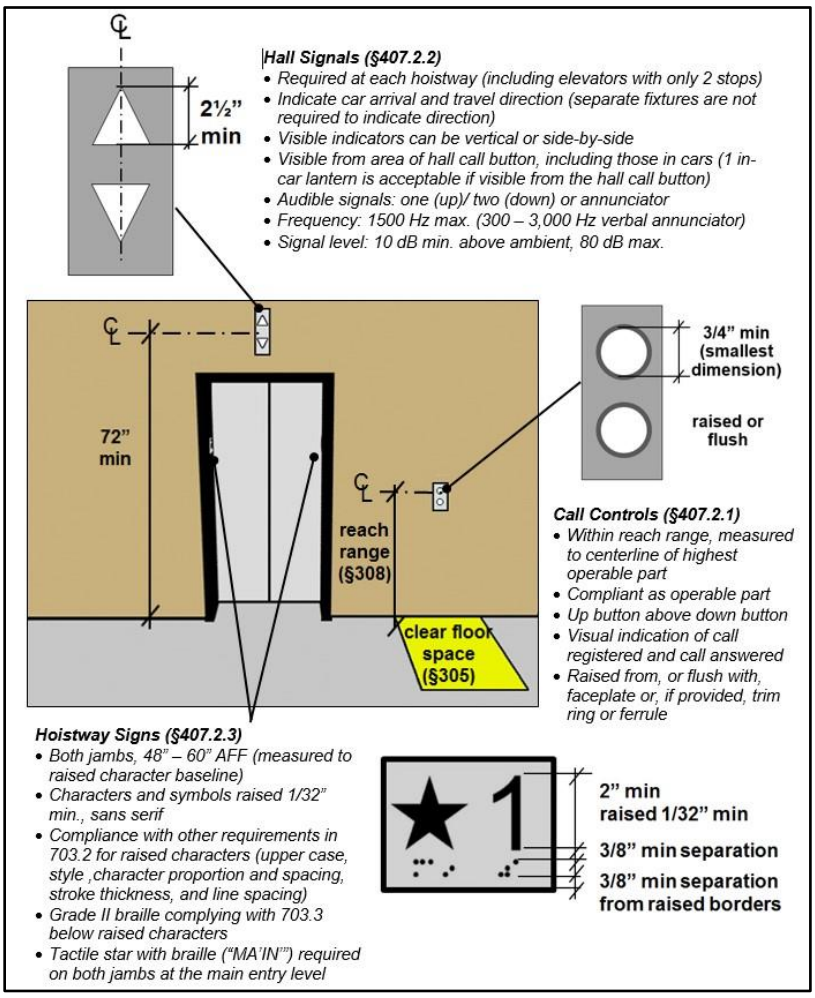
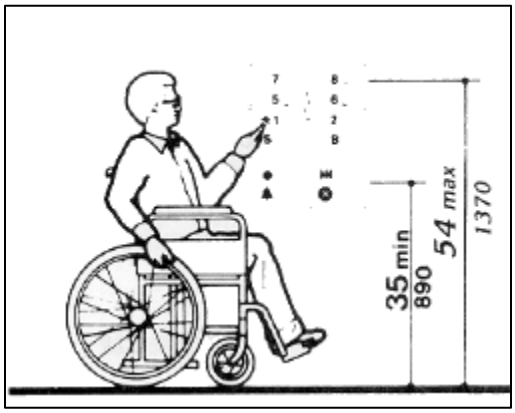


Figure 5:



The Standard Schindler control panel is ADA-compliant. Note how the emergency controls are placed only 35" from the ground, and the highest button necessary for our operation will only be 48". The max high a person sitting in a wheelchair can reach is around 54'' so our max height fits well within the range. Also, note that braille is under each button for those with vision impairment.[xxi]

(Resources Located on Next Page)

RESOURCES:

[i] Officer Gilpin's Rough Estimate

[ii] https://www.access-board.gov/aba/

[iii] https://www.gsa.gov/real-estate/historic-preservation/historic-preservation-policy-tools/legislation-policy-and-reports/section-106-national-historic-preservation-act-of-1966

[iv] Leida Pickett, Sales Representative of Schindler Group St. Louis

[v] https://www.rd.usda.gov/programs-services/all-programs/water-environmental-programs/section-106-review-basics#:~:text=Section%20106%20of%20the%20National,a%20reasonable%20opportunity%20to%20comment.

[vi] https://us.schindler.com/content/dam/website/us/docs/elevators/schindler-3100/schindler-3100-mrl-elevator-brochure.pdf/_jcr_content/renditions/original./schindler-3100-mrl-elevator-brochure.pdf

[vii] https://schindlerplan.com

[viii] https://www.gsa.gov/cdnstatic/ABAAS_Leasing_Checklist_FINAL_R2C15-e_0Z5RDZ-i34K-pR.pdf

[ix] https://mac-hyd.com/blog/dangers-hydraulic-leaks/

[x] Based on Blueprints Provided by NPS

[xi] Leida Pickett, Sales Representative of Schindler Group St. Louis

[xii] https://schindlerplan.com

[xiii] https://schindlerplan.com

[xiv] https://eurocodeapplied.com/design/en1993/steel-design-properties; https://eurocodeapplied.com/design/en1993/ipe-hea-heb-hem-design-properties; https://shop.buyabeam.com/suppliers/prestige-structural/beams/universal-column/products/305-x-305-x-198-UC

[xv] https://www.homewyse.com/services/cost_to_excavate_land.html

[xvi] Leida Pickett, Sales Representative of Schindler Group St. Louis

[xvii] Leida Pickett, Sales Representative of Schindler Group St. Louis; https://www.rapidtables.com/calc/electric/electricity-calculator.html

[xviii] https://www.angi.com/articles/how-much-does-building-permit-cost.htm; https://tradingeconomics.com/united-states/building-permits#:~:text=Building%20Permits%20refer%20to%20the%20approvals%20given%20by,the%20United%20States%20require%20a%20permit%20for%20construction.

[xix] Leida Pickett, Sales Representative of Schindler Group St. Louis

[xx] https://www.archives.gov/research/americans-with-disabilities/transcriptions/naid-6037490-fact-sheet-americans-with-disabilities-act-of-1990.html.html

[xxi] https://us.schindler.com/content/dam/website/us/docs/elevators/schindler-3300-3100-elevator-fixtures.pdf/_jcr_content/renditions/original./schindler-3300-3100-elevator-fixtures.pdf