Amphitheater Design Challenge

Section 2, Team F

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**Introduction**

The audio engineering behind an amphitheater renovation is bound by several constraints. Due to the size of the building, the amphitheater cannot exceed the designated dimensions. Similarly, due to the Americans with Disabilities Act (ADA), several factors such as emergency exit, seat dimensions, maximum incline, and aisle width is important when designing the facility. Without this information many lives could be lost due to a natural disaster or emergency that could leave hundreds of Americans trapped in an enclosed space. The following report includes herein two designs for a renovated audio amphitheater that account for the size constraints and ADA requirements.

**Background**

For amphitheater design, several variables can be altered to both increase revenue, decrease overhead, and maintain the safety regulations provided by the ADA. One such factor is the noise level from the stage to the audience. According to the Center for Disease Control and Prevention (CDC), “REL for occupational noise exposures to be 85 decibels, A-weighted (dB[A]) as an 8-hour time-weighted average. Exposures at or above this level are considered hazardous” (Center for Disease Control and Prevention, 2016) This means that for a period of 8 hours, the maximum amount of noise a customer can experience must not exceed 85 decibels. Both amphitheater designs were needed to ensure that the audience could clearly hear any sound produced on the stage while also meeting safety requirements and ADA compliance to appeal to customers. As a result of these requirements, and similar constraints, there will be restrictions on how close the audience can be to the stage. Additionally, the employer has set a minimum noise level of 60 dB, which further limits the amount of space available for seating in the building. These constraints made by the ADA also required a certain number of ADA compliant seats, a maximum slope on the ramp, which needed to be a specific parameter, and a dispersion of ADA compliant seats. The average commercial facility has an incline of 5- 10 degrees.

**Methods**

Finding the optimal design was based upon 2 major calculations, the distance between the stage and the observer (, and the noise level at each location (). Given the X, Y, Z constraints of the space, a 3D array was constructed to simulate the space. Following this, several designs were brought forward with the final two being a proscenium style theatre with 3 columns and varying rows. Both designs were constructed within the constraints of the building (180 X 100 ft) and follow ADA compliance. The seats are 23” wide with a row separation of 42”. For wheelchair accessibility, 6 seats were equally distributed throughout the theatre and placed in easy to access locations. Similarly, their size was increased to 36” to accommodate the patron. Finally, the aisle sizes between the seats are 4 feet. These decisions are all in compliance with the ADA requirements for a theatre of this size. Finally, distinguishing between designs 1 and 2 is the vertical increase of the incline. In design 1, the incline is capped at 29.27 feet. This was done to increase the minimum decibel level for a better concert experience. Contrary to this, design 2 increases its vertical to 40ft from the base. This allowed for the creation of 3 extra rows and more revenue. Upon finalizing these values, the MATLAB simulation allowed for calculating a projected income and decibel locations at each location in 3D space.

**Test Results and Analysis**

Upon reviewing the simulation, design 2 was presented as the optimal layout for the renovation. This was determined by the difference in revenue produced and the difference in sound quality between the designs. Design 1’s revenue per show is estimated to be $63,926. With an average of 90 shows per year, and subtracting operating costs, the yearly revenue is projected to be $1,150,668. Contrary to this, Design 2’s revenue per show is estimated to be $70,527 with a yearly revenue of $1,269,487. Subtracting the two-yearly revenues, Design 2 increases profit by ~$120,000. This large increase in money demonstrates the optimized layout of design 2 without compromising seating or ADA compliance. When comparing the decibel units between the two designs, Design 1’s lowest value is 60.99 while design 2's lowest value is 60.24. With a difference of ~0.75 decibels, the quality loss between design 2 and design 1 is irrelevant compared to the increase in profit. Due to this evidence, design 2 has been recommended for development and purchasing.

**Conclusions**

Moving forward, design 2 has several challenges before this project can be completed. For example, a purchasing list must be created, and parts fabricated for the creation of the space. Utilizing several community sponsors, capital must be raised to purchase 1,380 seats with a size of 23”. Similarly, 6 36” seats must be purchased to accommodate wheelchaired patrons. For the work provided, the Gonzaga 2F Engineering Group is charging $17,808.75. A breakdown of the bill is provided in the Appendix of this report.

**Bibliography**

ADA Compliance. (n.d.). Assembly areas. ADA Compliance. <https://www.ada-compliance.com/ada-compliance/221-assembly-areas>

BraunAbility. (2023, March 3). Wheelchair Ramp Slope: ADA Compliance. BraunAbility. <https://www.braunability.com/us/en/blog/disability-rights/wheelchair-ramp-slope.html>.

ICC. (2018). 2018 International Building Code (IBC). Digital Codes. <https://codes.iccsafe.org/s/IBC2018/chapter-10-means-of-egress/IBC2018-Ch10-Sec1029.13.2>.

Centers for Disease Control and Prevention. (2016, September 6). Understanding Noise Exposure Limits: Occupational vs. General Environmental Noise. CDC NIOSH Science Blog. <https://blogs.cdc.gov/niosh-science-blog/2016/02/08/noise/>.

**Appendix**

**Team Leader and Group Manager:** Gabe DiMartino

* 8.5 Hours of Problem Scoping/Leadership (2 Real Hours)
* 6 Hours of Prototyping (1.5 Real Hours)
* 1 Hour of Programing (0.5 Real Hours)
* 4 Hours of Communication Preparation (2 Real Hours)

**Lead Programmer:** Noah Sabra

* 9 Hours of Programming (2.5 Real Hours)
* 6 Hours of Theatre Design (1.5 Real Hours)

**Junior Programmer and Budgeting Officer:** Alex McCulloch

* 4 Hours of Revenue Programing (1 Real Hour)
* 6 Hours of Internal Management and Budgeting (1.5 Real Hours)

**Communications Officer and Senior Researcher:** Payton Peters

* 9 Hours of Communication Preparation (2.5 Real Hour)
* 6 Hours of Researching and Data Collection (1.5 Real Hours)

**Problem Scoping/Leadership:** $130/hour

**Theatre Design:** $150/hour

**Prototyping:** $140/hour

**Senior Programming:** $150/hour

**Junior Programming:** $100/hour

**Communication Preparation:** $100/hour

**Other:** $80/hour