THE VOICE AND ARCHITECTURE:
TRANSLATING THE FUNDAMENTALS OF VOCAL MECHANISM IN THE DESIGN OF A MUSIC PERFORMANCE HALL FACILITY

A DARCH PROJECT SUBMITTED TO THE GRADUATE DIVISION OF THE UNIVERSITY OF HAWAIʻI AT MĀNOA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF ARCHITECTURE

MAY 2018

By

Glenn C. Grande

DArch Committee:

Hyoung-June Park, Chairperson
Geoffrey Lewis
Marilyn Liu Kim
Takumah Itoh

Keyword: Vocal Mechanism, Architecture, Design, Music Performance Hall

ABSTRACT

The project is an exploration in converging the fundamentals of the vocal mechanism and architecture, especially the design of a music and performance hall facility. The research investigates the processes of vocal production, traces the fundamental components that govern the system, and translates these components into architectural form, function, and experiences.

The project proposes a methodological design approach that defines the essential elements of vocal generation into architectural variables. Design principles from various case studies pertaining to performance hall building typology assist in outlining the programmatic and schematic design of the project. The project intends to broaden the relationship between the human body and the built environment. The voice, which is the primary tool for human interaction, is explored in relation to building designs which serve as pieces of evidence in the continuance and invigoration of experiences within the built environment.

Finally, the project will provide a building design for the Music Department of the University of Hawaiʻi at Mānoa to evaluate the validity of the methodology. The design outcome aims to resonate the processes of vocal production and establish a facility that bridges the school to its community through music and the arts.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Project Inspiration

Creative musical experiences filled my childhood memories. I participated singing in choral groups both in church and school. I realized that singing was a passion and a powerful tool to convey what words alone cannot define. Since 2009, I invested myself in learning the techniques of classical singing. I learned how to use my voice not only to sing properly but use its beauty to touch the hearts of many. Through rigorous voice classes and weekly private lessons, I developed a technical understanding of the voice. I started as bass, the lowest vocal placement for the male voice and managed to broaden my range and became a tenor, reaching a range of about three octaves from low E to a high C relative to the middle C of a keyboard or piano. Learning the craft of singing is a lifetime journey. While the body and vocal engine ages through time, the techniques must adapt to its constant physiological changes. Singing is a learnable skill. Through dedication, passion, and hard work, the art of singing is more than just a talent, it can move the hearts and influence the minds of the listeners in an experience unlike any other.

The genesis of the project is a culmination of years of experience. I dedicate this research to unify my passion for singing and my interest in architectural design. Listening to a beautiful voice takes me to a world beyond existence. As Steven Holl, a noted American architect have mentioned in one of his interviews; music makes him

"emotional, and so does architecture."[1] Translating the mechanics of the voice into spatial experiences is my way to converge my hobby and future career into unique and valuable research. This project hopes to inspire students who aspire to pursue the field of design with motivation and excitement.

Project Theme

When we listen to a person singing, we unconsciously breathe and hold our breath. When we hear our favorite song, we cannot help but to tap our fingers and sing along on its tune and rhythm. We listen accordingly and sense the emotions being conveyed. The music may be jazzy and up bit or classical and sincere; we associate the innate response to a beautiful and ethereal experience. It is fascinating that we become one as we observe a performance and let a meaningful experience take us away to a world beyond imagination.

The study of the production of proper and beautiful vocal sound aims to converge the vocal engine as a conceptual driver for design along with the design of the built environment. The research expands its investigation through the various field of studies to develop a broad and complete analysis of the vocal mechanism. Studies in classical singing include vocal pedagogies that analyze the vocal tract as a musical instrument. The area of linguistics and phonetics help to examine the individual gears of the vocal engine and evaluate its roles within vocal creation.

[1] Holl, Steven. *Architectonics of Music. Documentary*. http://architectonicsofmusic.com/

The project focuses towards the proper production of beautiful tone. In the realm of classical singing, there are distinguishing criteria that constitute the creation of beautiful sound. The outcomes of the project aspire to use the concepts found in the vocal structure to create a fair and functioning music performance hall facility.

Project Intent

The hypothesis of the research is to use the concepts found in the vocal mechanism as guiding elements for a site and building design. Outlining a methodological approach that involves physiological research, architectural translations, and case studies help to orchestrate the design application in the latter part of the project. A definite correlation between the vocal mechanism and architecture assist in developing a design for a performance hall facility for the Music Department of the University of Hawaiʻi at Mānoa. The Music Department envisions a facility that supports music and performance production to assist the invigoration of culture within the community.

CHAPTER 2

INSIGHT: THE BODY AND ARCHITECTURE

Historical Inspirations: From Antiquity to Contemporary

The body has been a great inspiration in the realm of architecture and design. Many scholars see the body as a perfected model for its exemplary proportional scale, intricate operational systems, and structural components. These features of the body ignite the imagination of designers to produce beautiful and functional creations. As an observation by Rory Scott, a managing editor of an online architectural database, he mentioned in his article, "most architects agree that the primacy of the human is paramount to the creation of a successful design." He later added that architecture serves to shelter the human body and nurture the purpose of our existence.[2]

Architects are known for their ambitious and creative ideas. They use the human scale to visualize how their design relates to the human body. As examples, in Rory Scott's article, he gathered different human-scale figures used by renowned architects around the world to show the relationship between architectural design and the human body. Each of the figures has various characteristics that reflect on the designer's aesthetic and overall design concept.

[2] Scott, Rory. *These Architects' Drawings of Human Figures Offer an Insight Into Their Minds*. 2016 https://www.archdaily.com/784121/these-architects-drawings-of-human-figures-offer-an-insight-into-their-minds

Figure 1: Architects' Human Scale Figures

(Source: Roy Scott, These Architects' Drawing of Human Figures Offer an Insight into Their Minds, 2016, https://www.archdaily.com/784121/these-architects-drawings-of-human-figures-offer-an-insight-into-their-minds)

This clever observation shows the correlation between design and the human body. Architecture aims to design for the human body. Buildings and other structures prioritize to shelter the human body as it protects and provides comfort from the harsh outdoor climate. This research intends to use the body, specifically the vocal mechanism as the source of concept for designing a music performance hall building.

Museum of the Human Body: Concepts from the Human Body

Bjarke Ingles Group, one of the most innovative contemporary architecture and design firm proves that the human body can inspire design in an unprecedented approach. A winning idea from a design competition takes "nature and architecture" into an "artistic, scientific and societal" perspective of building design. The project design takes inspiration from the macrocosm of human interactions within the society to the microscopic human cellular structure. The purpose of the building intends to facilitate "cultural activities, interactive exhibitions, performances, and workshops." [3]

Figure 2: Project Rendering

(Source: Karissa Rosenfield)

Figure 3: Project Inspirations

(Source: Karissa Rosenfield, https://www.archdaily.com/450388/big-selected-to-design-human-body-museum-in-france)

[3] Rosenfield, Karissa. *BIG Selected to Design Human Body Museum in France*, 2013 https://www.archdaily.com/450388/big-selected-to-design-human-body-museum-in-france

The design of the facility conforms to the underlying concept of interconnectedness found in nature and the human body. The intertwining spaces create multiple spaces that appear "seemingly singular" because of the conscious integration of the "weave together" concept which is metaphorical to "individual fingers united together in a mutual grip."[4]

Figure 4: Project Process Diagrams

(Source: Karissa Rosenfield, https://www.archdaily.com/450388/big-selected-to-design-human-body-museum-in-france)

Bjarke Ingles Group produced an unprecedented building design that resonates to a concept that is found within nature and the human body. The design seamlessly bridges the function of the facility which celebrates the human body as an unceasing inspiration to our dynamic and ever-changing world.

[4] Rosenfield, Karissa. *BIG Selected to Design Human Body Museum in France*, 2013 https://www.archdaily.com/450388/big-selected-to-design-human-body-museum-in-france

Tesseracts of Time: Relationship between Architecture and Dance

"Writing about music is like dancing about architecture"[5] – Martin Mull, comedian

Architecture derives its form and function from the human body scale. Its static nature contrasts the dynamism of the human body. Steven Holl and Jessica Lang's *Terrasacts of Time* is a project that takes the concept of movement of the body as it dances to compose a progressive spatial design. "It's a dance for architecture. Where light and movements and the passage of another artist, the choreography moving through the architectonic becomes the total experience."[6] Although architecture is passive, the

Figure 5: Project Rendering

(Source: Patrick Lynch, https://www.archdaily.com/797079/steven-holl-and-jessica-langs-tesseracts-of-time-explores-the-relationship-between-architecture-and-dance)

[5] Lynch Patrick. Steven Holl and Jessica Lang's "Tesseracts of Time" Explores the Relationship Between Architecture and Dance. 2016. https://www.archdaily.com/797079/steven-holl-and-jessica-langs-tesseracts-of-time-explores-the-relationship-between-architecture-and-dance

[6] Lynch, Patrick. Steven Holl and Jessica Lang's "Tesseracts of Time" Explores the Relationship Between Architecture and Dance. 2016. https://www.archdaily.com/797079/steven-holl-and-jessica-langs-tesseracts-of-time-explores-the-relationship-between-architecture-and-dance

active motion of the body creates a dynamic interaction towards its surrounding. The coexistence of architecture and the body is likened to the nature of a performance or show where the audience watches the performer, and the performer performs to the audience. Their interaction creates an experience that divulges into mutual gratification. This project shows the mutual existence of architecture and the human body. As architecture continues to provide comfort and protection to the body, the body continues to evolve and innovate the design of the built environment.

Figure 6: Project Concept Sketches

(Source: Patrick Lynch, https://www.archdaily.com/797079/steven-holl-and-jessica-langs-tesseracts-of-time-explores-the-relationship-between-architecture-and-dance)

CHAPTER 3

RESEARCH: MECHANISM OF VOCAL PRODUCTION

Understanding the Human Voice

The human body consists of many systems. These systems execute the various functions of the body for life to exist. In Royal Stanton's third volume on Steps to Singing for Voice Classes, he uses the analogy of the human body to a car. He emphasizes that all the mechanical components in a vehicle, such as the engine, tires and other elements are essential for it to function correctly. Stanton explains that the body will only work accurately and efficiently through the holistic organizations of these mechanisms. He describes singing as a "single, unified action." The production of vocal sound while singing involves a sequential choreography of the vocal mechanism to produce the desired quality of the voice.[7]

One of the most significant mechanisms in the body is the ability to produce vocal sound for communication. It undergoes an intricate yet straightforward operation to conceive the voice. Five synchronized stages involve vocal production. These are contraction, respiration, phonation, resonation, and articulation. In every step, there are anatomical components that act like gears, to produce audible vocal sound.[8]

The process of breathing is a necessary voluntary action of the body. Breathing serves a dual purpose in the human anatomy. Inhalation of air is the primary source of

[7] Stanton, Royal. Steps to Singing for Voice Classes. Belmont, Calif.: Wadsworth Pub.Co. 1971. 24-25

[8] Shearer, William. Illustrated Speech Anatomy. Springfield, Illinois. Charles C Thomas Pub. 1979. 3-5

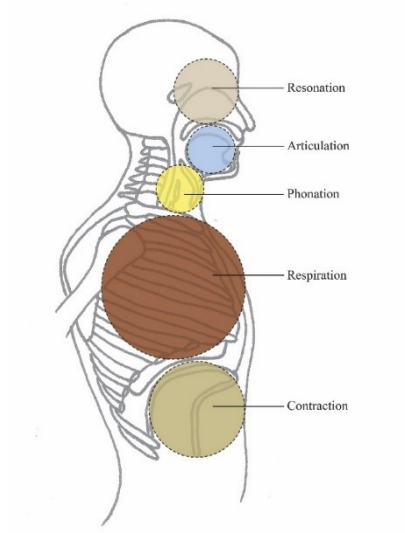


Figure 7: Stages of Vocal Mechanism

(Source: Illustrated by author, graphic adapted from Royal Stanton)

oxygen, while exhalation helps to flush carbon dioxide from the body and responsible for producing the voice through phonation and articulation. The inhalation and exhalation of air through the respiratory system involves various synchronized operations. Breathing is an occurrence when the body fills the lung cavity with air and releases air as it exhales. The body repeats this process as it tries to replenish the blood with oxygen.

As the body releases the excess air from the lungs through expiration, the air pressure expired from the lungs can be used to produce vocal sound. This outward movement of air from the lungs initiates vocal production through phonation. Phonation is the creation of inaudible vibrations. The oscillations of the vocal folds create vocal vibrations commonly heard from humming. This process occurs when air pressure passes through the partial opening of the vocal folds in the larynx. The vocal folds response with tension which produces vibrations that can be felt along the throat area when speaking. These vibrations are measured through frequencies and will be discussed accordingly later this chapter as it applies to the resonance of voice. The interpretation of these vibrations through resonation influences the tonal quality of the sound. The presence of the overtones shapes the quality of the voice. Overtones are the "spectrum of frequencies" from low to high.[9] The process of articulation is the ability to manipulate the vibrations to produce a

[9] Bunch, Meribeth. Dynamics of the Singing Voice. 2nd Edition. Springer-Verlag Wien New York. 1993. 93

comprehensible sound for communication. As we speak, there are various components in the mouth, such as the tongue and other articulators, that modifies the oral cavity to define the type of sound we intend to say. Unlike respiration and phonation, articulation engages many facial parts primarily seen when speaking and singing.[10] As mentioned, there are five stages of vocal production. Within the chapter, it will examine each of these stages to understand the fundamental operations that govern the process of vocal output. It will also identify the components that influence the production of beautiful tone in singing.

CONTRACTION AND RESPIRATION: Fuel for Sound

Respiration is a "reflex action" where the brain automatically sends a signal to the respiratory system to initiate the process of breathing. The openings from the nasal and oral cavities permit the intake of air to fuel the body system with oxygen.[11] Breathing is a mechanism that involves minimal work and energy. The inspiration of air engages the organs and muscles of the respiratory system to expand and contract.

Figure 8: Mechanics of Inhalation and Exhalation

(Source: William Shearer. Illustrated speech anatomy)

Richard Alderson, calls air as the "greatest human need." Most life forms on earth thrive from the presence of oxygen in the air to survive. Without air, life on earth goes extinct. Figure 8 illustrates the choreography of the respiratory system from

[10] Shearer, William. 73-79
[11] Bunch, Meribeth. 30

inspiration to the expiration of air. The downward contraction of the diaphragm allows the expansion of the lungs for air intake. Alderson discusses the importance of breath in singing. Mastering the art of breathing is the most fundamental elements when learning the proper way of singing.[12]

> "It is immediately apparent that gross alterations in the pattern of quiet breathing are necessary for phonation. During the greater portion of air flow, passes through the mouth rather than the nose: inspirations are brief and rapid; expirations are prolonged and slow, and airway pressures are more negative in inspiration and positive in expiration. These variances from ordinary breathing are more pronounced in singing than in speaking." [13]

Breathing is a repetitive action where a human being takes "about seventeen times per minutes in a healthy adult at rest, with an intake of approximately 500ml of air."[14] In a regular pattern of inspiration and expiration, without the intent of phonation, there is an equal distribution of air input and output. In the event of phonation, for example, in singing, the ratio of inspiration to expiration extends up to 10 times. In singing, inhalation becomes a rapid action while expiration lengthens the process of resonation and articulation.[15]

Throughout this chapter, it will examine the fundamental parts of the human body that contributes to the production of the voice. Each of these body parts plays an integral

[12] Alderson, Richard. *Complete Handbook of Voice Training*. West Nyack, N.Y. Parker Pub. Co. 1979. 28

[13] Alderson, Richard. 31

[14] Alderson, Richard. 31

[15] Brosnahan, L.F. *Introduction to Phonetics*. Cambridge W. Heffer and Sons Ltd. 1970. 30-31

role in the creation of voice. If one is not functioning properly, it compromises the ability to produce the desired effect or even yet, not function at all.

Nose and Mouth

There are two entrances of air to which respiration takes place, the nose and mouth. The nose is the primary mode of breathing in typical daily operation. On the other hand, when singing, the mouth proves to be more efficient for inhalation to maximize air intake needed for longer phrases of exhalation. The connection of the oral and nasal cavities with the pharynx to the trachea (the windpipe) allows air to pass through to the lungs. Tiny hair follicles in the nose filter dust and allergens from the internal of the body. When the nasal cavity is congested, breathing through the mouth is an efficient way to deliver air into the lungs. A vital characteristic of these passages is to keep them clear from any obstruction so that air can freely come in and out of the body.[16]

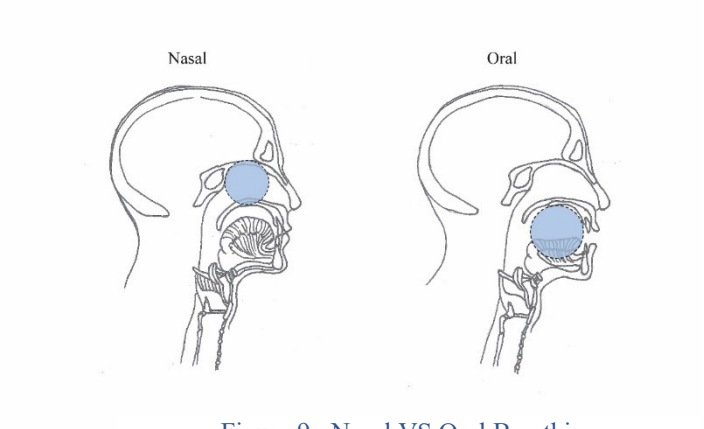


Figure 9: Nasal VS Oral Breathing

(Source: Illustrated by Author, graphic adapted from Royal Stanton)

Singing requires not just the skill of producing sound, but it takes a "mastery of the breath" to coordinate the vocal system properly and efficiently. Karen Tillotson Bauer wrote in her discussion of "The Essentials of Beautiful Singing" that "breath management" is critical to

[16] Meyer, George Hermann Von. *Organs of Speech and Their Application in the Formation of Articulate Sounds*. London Kegan Paul, Trench, Trubner and Co. Ltd. 1892. 6-9

approach proper singing. The ability to control the breath facilitates the body to be in equilibrium as it needs to inhale and exhale air accordingly while singing.[17]

Lungs and Diaphragm

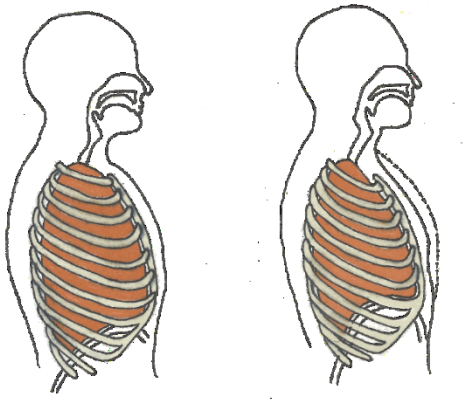


Figure 10: Lungs and Ribs Expansion / Diaphragm Contraction

(Source: Illustrated by Author)

The lungs are the gas tanks of the body. It divides into two chambers connected by the trachea. The trachea splits into the lungs and further branched into tinier tubes as it reaches to the bronchioles, alveoli, and pulmonary capillaries. The expansion of the lungs allows the thinning of walls and let the absorption of oxygen into the bloodstream. The lungs are like rubber balloons that expand as air pressure enter its cavities. This process of inhalation does not occur without the contraction of the diaphragm. The compression of the muscle membrane creates a thoracic vacuum to allow the lungs to expand.[18] The diaphragm is the "second-largest" and an essential muscular component in the process of respiration. It is connected underneath the ribs and separates the lungs from the viscera, which is the digestive system of the body. The diaphragm is responsible for initiating the process of respiration. As it constricts, tension changes its shape from its high convex form into a flatter surface. This movement creates a negative pressure right below the lungs to let the lungs expand for air intake. This action of the diaphragm pushes against the visceral parts which make the abdomen

[17] Bauer, Karen Tillotson. *The Essentials of Beautiful Singing*: A Three-Step Kinesthetic Approach. Landha, Md. Scarecrow Press. 2013. 17-19

[18] Doscher, Barbara M. *The Functional Unity of the Singing Voice.* Metuchen, N.J.: Metuchen, N.J. Scarecrow Press. 1994. 3-5

appear to be more prominent like if it is ballooning. The movement of the stomach when breathing is a sign of a proper inhalation.[19]

Breathing is an unconscious and involuntary action. "The baby has not had lessons in breathing and really knows nothing about it; it breathes instinctively to stay alive."[20] When a baby breathes, the abdomen area pushes out. It is a natural occurrence for it shows the most efficient way of inhalation. When the body releases the air through exhalation, the diaphragm goes back to its original relaxed position as a convex muscle following the contour of the base of the lungs.

The functions of the lungs and diaphragm is synergistic feedback where one's action responds to the other to facilitate breathing. The constriction of the diaphragm causes the expansion of the lungs. The relaxation of the diaphragm deflates the lungs as it pushes air out of the system.

Ribs and Intercostal Muscles

The ribcage is a skeletal structure that protects and holds the lungs and heart from collapsing and external damage. It is composed of two groups of 12 curved bones that connect from the spine to the sternum located at the back and front of the body, respectively. Cartilages link the

Figure 11: Mechanics of Exhalation and Inhalation

(Source: William Shearer. Illustrated speech anatomy)

[19] Doscher;, Barbara. 8-10
[20] Stanton, Royal. 28

ribs to the sternum, which allows flexibility and movement while breathing. On Figure 11**,** it shows the movement of the ribcage as it rises when inhaling. This lifting action allows the lungs to expand not only downward, but also from front and side to side.

The ribcage is made of primarily of bones and is incapable of moving. To facilitate the expansion of the ribs, cartilages bridging the ribs to the sternum allows the mobility of each rib. Intercostal muscles in between each bone have the elasticity to contract the ribcage back to its original position which is necessary for respiration.

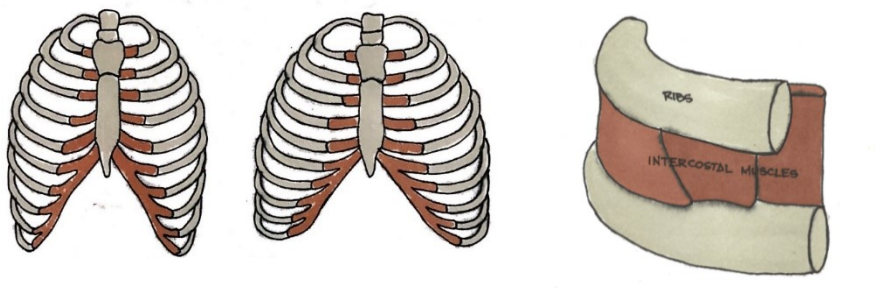


Figure 12: Ribs Expansion / Intercostal Muscles

(Source: Illustrated by Author)

PHONATION: Vocal Vibrations

The ability of the human body to produce vocal sound is due to the presence of the larynx. The larynx is responsible for the creation of vocal vibrations. The vibrations are the product of the oscillation of the vocal folds located inside the larynx as air pressure interacts with it. The buzzing sound along the throat area when humming is the manifestation of the air in contact with the vocal folds in tension. Connected under the larynx is the trachea or the windpipe. This component allows the passive of air to and from the lungs.

Trachea: The Windpipe

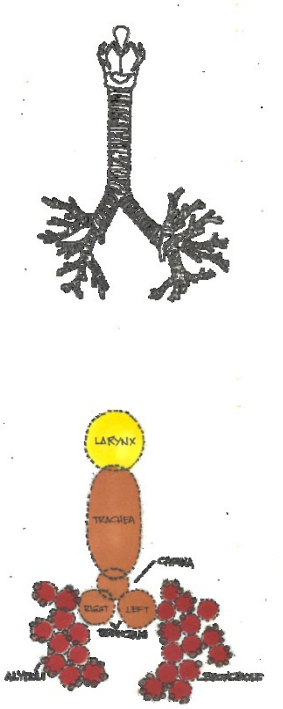


Figure 13: Larynx, Trachea, Bronchi, Bronchioles, and Alveoli

(Source: Illustrated by Author)

From inspiration to expiration, the trachea serves to be the primary passageway that delivers air to and from the lungs. It is composed of "incomplete cartilaginous rings" aligned under the larynx and is held and capped by ductile tissues. In Brosnahan's book, *Phonetics*, the trachea also produces resonance for its hallow tube-like cavity. The characteristics of the trachea influence the production of "lower frequencies" of the voice.[21]

Larynx: Vocal Folds

The larynx is responsible for creating vocal vibrations. As mentioned, air pressure allows the rapid and constant oscillation of the vocal folds to produces the vibrations. During inhalation, the vocal folds are open to let the influx of air unobstructed. In the event of phonation, the vocal folds are in some level of tension and narrow down its opening. This manipulation changes the passage of air through exhalation and produces the buzzing sound of the vocal vibrations. The opening of the vocal folds determines the pitch of the vocal sound. In Figure 15, it shows the different sizes of glottis (vocal fold slit opening) when taking a breath and when speaking or singing. Open vocal folds usually used for inhalation allows air to pass through.

[21] Brosnahan; pg. 31

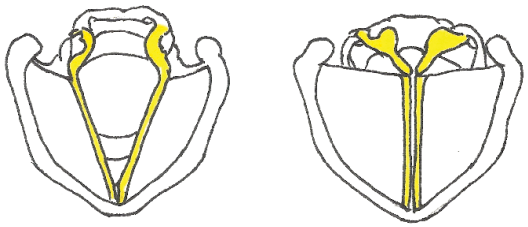


Figure 14: Vocal Folds: Opening and Closing

(Source: Illustrated by Author, graphic adapted from Royal Stanton)

There is no sound produced by this process because proper breathing should encompass still breathing. When trying to create sound, the variance of the glottis characterizes the quality of sound. A wider glottis allows more air to come out which makes the voice breathier and lower in pitch. A tighter glottis thins out the vocal folds which creates more vibrations and a higher tone. A man's vocal fold is essentially thicker compare to a woman's vocal folds. That this why there is a significant difference between the voices.[22]

Imagine a string instrument like a guitar. The strings are applied with tension by tightening. Like the strings, the vocal folds are stretched which narrows its opening. The interaction of air to the vocal folds is similar to the strumming of the string in a guitar. The amount of tension applied to the vocal folds determines the vibrations' wave frequency and pitch. The vibrations travel upwards directed by the open passages of the pharynx, oral and nasal cavities, and it is mediated to a more resonant tone quality for the ears to hear with clarity.

Figure 15: Vocal Folds Plan and Section

(Source: L. F. Brosnahan, *Introduction to Phonetics*)

[22] Brosnahan, L. F. 35

ARTICULATION: Modifying Sound

Articulation is the manipulation of the oral cavity to produce spoken sounds. The active and passive articulators are responsible for creating many formations to produce the vowels and consonants in any spoken language. The tongue along with the lips and other articulators projects the vibrations from phonation to form meaningful words and sounds. In singing, it is essential to articulate the lyrics of the song. Poor diction and clarity in words compromise the quality of singing. Beautiful singing encompasses not only the accuracy of pitch but also the deliverance of clear and comprehensible phrases.

Active Articulators

The tongue is a primary active articulator situated within the oral cavity and extends to the pharyngeal cavity with its root attached to the hyoid bone of the larynx. The tongue is the strongest in the body. Its malleable quality allows it to manipulate the oral cavity to form various spaces for every type of sound. The movement of the tongue constitutes the vowel sound a-e-i-o-u and also for consonants (d, l, t, etc.) According to Brosnahan, there are "three principle directions of tongue movement." These are the upward, downward, and forward. The upward motion touches the ceiling of the oral cavity while downwards presses to the floor of the mouth. The forward movement reaches out to the back of the upper set of teeth.[23] The tongue is classified as an interfering muscle when singing. To achieve a tall and resonant vowel "a" when singing, the tongue must lay flat on the base of the mouth. It permits constant air flow and characterizes an open throat technique.

[23] Brosnahan, L. F. 42

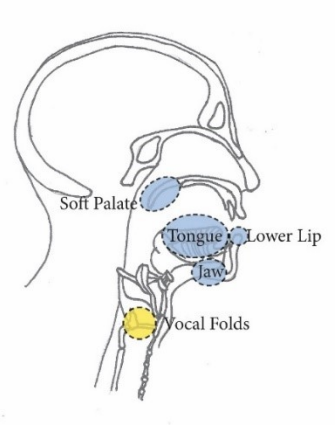


Figure 16: Active Articulators

(Source: Illustrated by Author, graphic adapted from Royal Stanton)

The soft palate is an active articulator. It is located on the "posterior end of the hard palate," which is the ceiling of the mouth.[24] The soft palate or the velum palati, is a "tissue organ" that can lift "to prevent reflux of air and liquids into the nasopharynx during speech and swallowing, respectively."[25] The soft palate influences the tonal quality of the singing voice. It is advised to lift the soft palate always to open up the throat allowing continues air flow. A high soft palate creates more oral spaces which make the sound more resonant. In contrast, a low soft palate dampens the sound making the voice dull and flat.

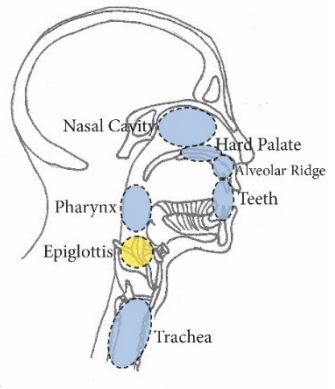


Figure 17: Passive Articulators

(Source: Illustrated by Author, graphics adapted from Royal Stanton)

Passive Articulators

The passive articulators are stationary elements within the oral cavity. The hard palate and teeth are integral components to produce the desired word and sound. Commonly, the passive articulators are more robust and hard. They assist in balancing the movements of the active articulators. The hard palate is on the roof of the mouth. It is a non-moving articulator to counterbalance the movement of the tongue and soft palate.

[24] Meyer, George Hermann Von. Organs of speech and their application in the formation of articulate sounds. The International Scientific Series. Vol. 47. London. Kegan Paul, Trench, Trubner and Co. Ltd. 1892. 42

[25] Morrison, William. Science Direct; http://www.sciencedirect.com/topics/medicine-and-dentistry/soft-palate

RESONATION: Vocal Chambers

"Most scholars agree that vocal resonance is produced by vibrating air within chambers.**"** The significance of resonance affects the clarity and balance of overtone in vocal production. As explained earlier in the chapter, overtones are the various frequencies found in the spectrum of harmonic sound. Alderson defines a resonant with four components which are, "depth, brilliance, projection, and spin."[26]

The Pharynx, Nasal, and Oral Cavities

The pharynx and the oral and nasal cavities serve as the primary resonant chambers for the voice. The vibrations produced by the vocal folds in the larynx travel towards these chambers to tune the "pitch and timbre" of the voice. That is why when these chambers are congestion due to cold and allergy, the sound dampens and become unnatural to the ear. The pharynx is the first space where the vibrations travel through when producing vocal sound. Its "tube-shaped channel" connects the other resonators such as the larynx, nasal cavity, and the oral cavity.[27] The pharynx comprises of three sections that link these resonators. These are the laryngopharynx, oropharynx, and nasopharynx. The pharynx as a whole is responsible for the undertones of the voice.[28] The intersection of these cavities is essential to the resonance of the voice for it directs the vibrations created by the larynx into an open wall space to amplify the vibrations of volume and clarity.

[26] Alderson, Richard. 99-104
[27] Brosnahan, L.F. 38
[28] Alderson, Richard. 101

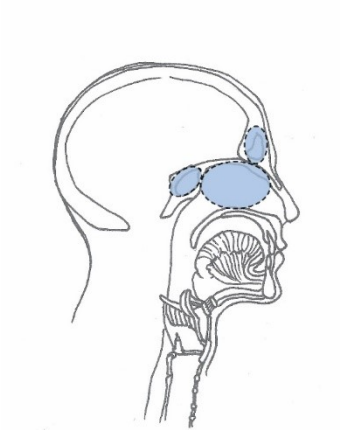


Figure 18 : Nasal Cavity and Sinuses

(Source: Illustrated by Author. graphic adapted from Royal Stanton)

The nasal cavities are primary passages for inhalation in normal operation. The cavities are essential pathways for vibrations to be amplified and resonated. Imagine a violin without its wooden case. It would only produce vibrations reminiscent of humming. Resonators are evident in all acoustic musical instruments. String instruments such as the violin and wind instruments like the flute rely on the open body casework of the instrument to transmit the vibrations into audible pitches and sound. Similar to the voice, the vocal mechanism is an instrument played by the air exhaled from the lungs.

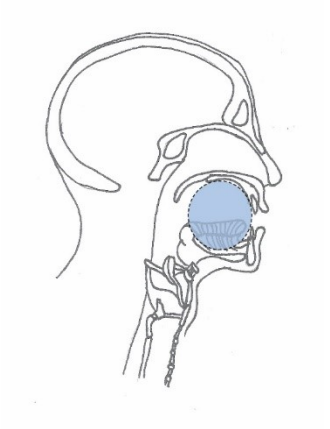


Figure 19: Oral Cavity

(Source: Illustrated by Author, graphics adapted from Royal Stanton)

The oral cavity is composed of active and passive articulator to manipulate the type of sound desired. Regardless of the kind of sound, the oral cavity acts like a cone-shaped megaphone. The combination of the amplified vibrations from the pharynx and nasal cavities with the shape of the oral cavity, it results in the sound we hear when someone speaks. Like a megaphone, the natural shape of the mouth amplifies the sound for audibility. In classical singing, the voice relies on the vocal chambers to bring its bright and apparent quality. A resonant vocal sound projects a healthy rounded voice. A well-trained singer does not need a microphone when singing because a resonant voice can project into a large hall and pierce through a full orchestra.

CHAPTER 4

MAPPING THE VOCAL MECHANISM

Mapping the Connections

The chapter explores the sequential processes of the vocal mechanism. Tracing and diagramming the overall operation of the vocal mechanism familiarizes the physiological space within the vocal tract. Formulating a methodological approach by illustrating the vocal system assists to outline the spatial qualities within the vocal scheme. The investigation aims to outline the design basis for a performance hall facility.

Producing vocal sound is a synchronized operation. A missing component which the mechanism prevents the whole system to function correctly. It all begins with the process of inhalation. The role of air is similar to gas or electricity in a vehicle. Without air, the vocal engine will not function nor produce vocal sound. Inhalation while singing starts through the oral cavity. The entrance of air through the mouth maximizes the air intake compare to inhaling from the nose. The sequence diagram shows the procession of air from inspiration to expiration.

The lungs are air reservoirs. It acts like the gas tank of the body. It absorbs oxygen through inhalation and releases air for exhalation. The expiration of air is responsible for producing vocal sound. The narrowing of the glottis (vocal fold opening) results in the oscillation of the vocal folds for the production of vocal vibrations. These vibrations go through resonation and articulation for audible and comprehensible sounds.

The physicality of proper singing demands a fully functioning mechanism to produce a desiring tonal quality of the voice. The anatomical movements of the vocal parts influence the spatial tract for air circulation. The dynamics of compression, release, tension, and relaxation of the muscles and organs establish an architectural design palate for building and site design application. It is essential to understand the scope of this methodology. The diagrammatic illustrations produced in this chapter does not finalize the aesthetics and form of the performance hall facility design. Instead, it helps to visualize physiological characteristics of the vocal mechanism translated into architectural forms.

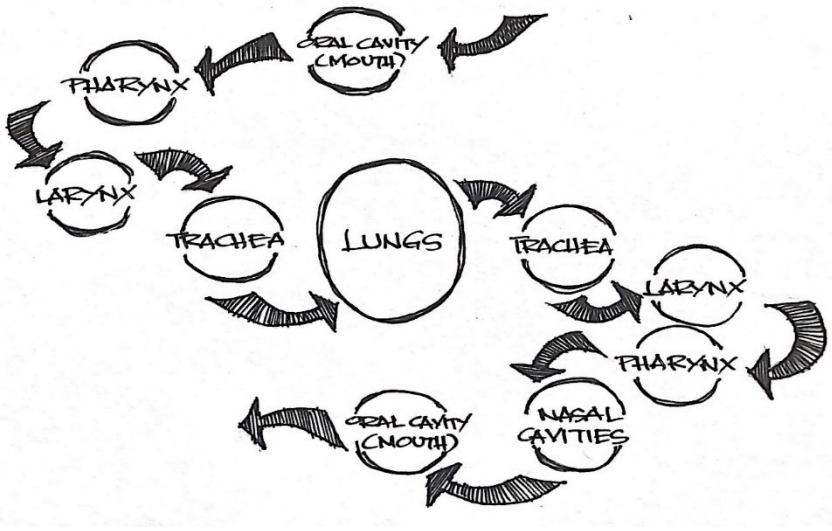


Figure 20: Sequence Diagram: Inspiration to Expiration

(Source: Author)

Inhalation

Diaphragm Contraction

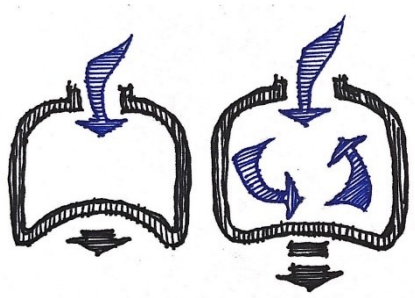


Figure 21: Diaphragm Movement during Inspiration Diagram

(Source: Author)

The contraction of the diaphragm initiates the process of inhalation. The outward pull of the diaphragm and expansion of the ribs create a thoracic vacuum for the lungs to fill with air. The negative pressure inside the lungs relative to the outside of the body let an influx of air.

Oral Cavity to Pharynx: Air Entrance

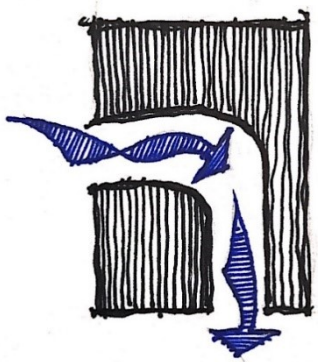


Figure 22: Entrance of Air from Oral Cavity Diagram

(Source: Author)

When singing, the oral cavity (mouth) is the most effective and efficient way of inhalation. It allows an unobstructed passageway for air into the lungs. Air travels from the mouth to the pharynx. The pharynx is at the back of the mouth. The pharynx expands and broadens the tract for continuous air flow.

Pharynx to Larynx

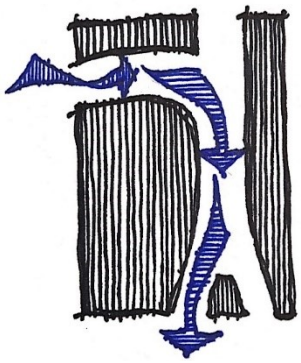


Figure 23: Air flow directed to Larynx Diagram

(Source: Author)

The pharynx divides into three connected parts. The nasopharynx links it with the nasal cavities. The oropharynx is behind the oral cavity, while the hypopharynx is under the tongue and above the larynx. The pharynx allows air as well as food to be delivered to its proper destination. The epiglottis allows air to the

lungs and closes to prevent food from going into the vocal tract.[29]

Larynx to Trachea

Figure 24: Air flow from Larynx to Trachea Diagram

(Source: Author)

Inhalation requires a fluid circulation of air. The larynx encases the vocal folds. As air travels from the mouth to the lungs, the glottis is wide open for air intake. The trachea is a tube-like cartilaginous tunnel that directs air to the lungs.

Trachea to the Lungs

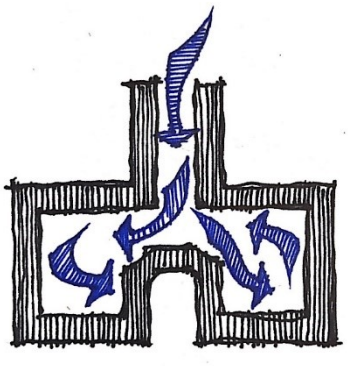


Figure 25: Air flow in the Lungs Diagram

(Source: Author)

The trachea divides into two segments to deliver air to the right and left lung. From a single tube, the trachea splits into two major branches, the bronchi. The bronchi further branch out into tinier twigs of bronchioles and alveoli inside lungs. The alveoli are groups of "secondary pulmonary lobules" that allows absorption of oxygen into the bloodstream. The hierarchy of spaces ensures the continuous flow of air within the respiratory system.[30]

[29] Meyer. George Hermann Von.72-75
[30] Get Body Smart. https://www.getbodysmart.com/ap/respiratorysystem/lungs/bronchioles/tutorial.html

Exhalation

Diaphragm Relaxation

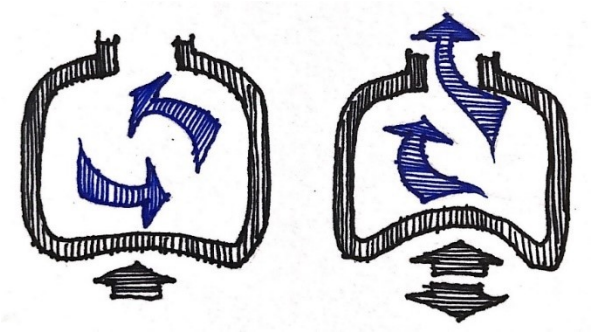


Figure 26: Diaphragm Movement during Expiration Diagram

(Source: Author)

The relaxation of the diaphragm initiates the process of exhalation. To produce a supported singing voice, the application of resistance in the abdominal muscles counteracts the relaxation of the diaphragm. It balances the core of the body to prevent the lungs and body posture from collapsing. It also assists the body in preparing for another cycle of respiration.

Lungs to Trachea to Larynx

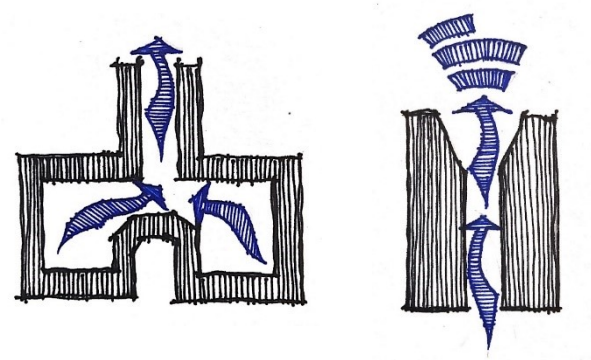


Figure 27: Air flows out from the Lungs / Vibration production Diagram

(Source: Author)

Air exits out from the lungs as the diaphragm relaxes into its usual convex shape form. Air travels through the trachea and larynx. With the intent of phonation, the glottis of the vocal folds in the larynx narrows due to the presence of tension. The thinning of the vocal folds and slimming of the glottis creates vocal vibrations as it interacts with the airflow from the lungs. These vibrations are essential in producing the voice. The more tension applied to the vocal folds, the higher the

frequency of the oscillations. The vibrations are later resonated and articulated for understandable sound.

Larynx to Nasal Cavities to Oral Cavity

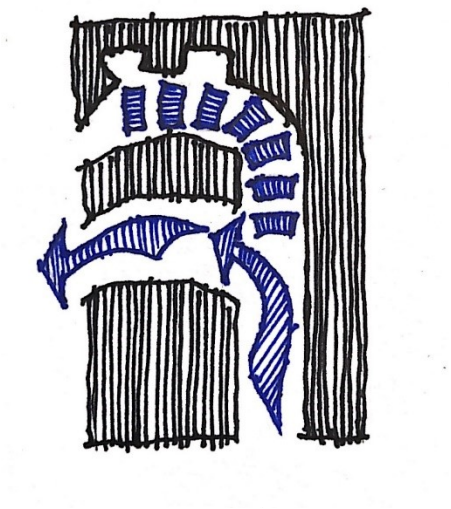


Figure 28: Air flow and vibration path

(Source: Author)

The resonation of the vibrations amplifies the sound and give brightness and clarity to the voice. Articulation allows the creation of various vowel and consonant sounds. The tongue and other articulators manipulate the oral cavity for different sound qualities. The production of sound requires a continuous expiration of air. It is essential that the nasal cavity to be open and clear of the any congestion and the oral cavity to be unobstructed to produce a beautiful and proper singing voice.

CHAPTER 5

METHODOLOGY: TRANSLATING VOCAL MECHANISM CONCEPTS INTO ARCHITECTURAL ELEMENTS

The methodology chapter is composed of two sections. The first section discusses the process of extrapolating the concepts learned from the research and rearticulate these ideas into architectural elements. These elements are ingredients that will help outline the building design application. Concepts come from the five stages of vocal production; contraction, respiration, phonation, resonation, and articulation. Each step of the mechanism is analyzed into two of the following categories:

(a.) *Spatial Experience* (SE) translate the concepts into physical and visual architectural elements.

(b.) *Spatial Function* (SF) convert the concepts into functional components that pertain to performance hall building typology.

The second section uses five building case studies to formulate the spatial and programmatic understanding of a performance hall building typology. The criteria produced from the first section will guide the case study to identify critical spaces to be tested in the design application portion of the research.

KEY CONCEPTS

The vocal mechanism compromises five operational stages. The table below sorts out the fundamental concepts learned from each stage and assigned the ideas to one or more categories.

Table 1.0 (*Key Concepts from Vocal Mechanism*)

KEY CONCEPTS				**SE**	**SF**
S T A G E S	**Contraction**				
		Diaphragm	Compression and Relaxation		x
	Respiration				
		Lungs	Expansion and Absorption	x	x
	Phonation				
		Vocal Folds	Tension and Air Flow		x
	Resonation				
		Nasal Cavities	Brightness and Clarity	x	x
	Articulation				
		Tongue	Formation and Position	x	x

The following table further explains the stages of the vocal process in correlation to its vocal operation, spatial experience, and spatial function. Some stages fulfill one category while others fit both criteria. It allows the translation and identification process more straightforward and consistent.

Translation Criteria

Table 2.0 (*Key Concept Translations to Architectural Experiences and Functions*)

Stages	**Vocal Operation**	**Spatial Experience**	**Spatial Function**
Contraction *Compression And Relaxation*	The diaphragm initiates the process of breathing. Its movement creates a thoracic vacuum. This vacuum changes the atmospheric pressure between the inside of the body and its surroundings. The act of inhalation is to balance the difference of pressure. The relaxation of the diaphragm to its original position allows the lungs to compress for exhalation.		Compression is a concept of spatial attraction that lures people to come into the site. If air enters the body through the dynamic action of compression, in architecture, people will be drawn into the site through an attraction (an interesting and exciting event/show/activity). Air and body are to people and site respectively in architecture.
Respiration *Expansion And Absorption*	In response to the contraction of the diaphragm, the lungs expand to accommodate the influx of air. The absorption of air carries oxygen that is into the body.	The expansion of the lungs creates a spacious cavity to accommodate a larger volume of air. In architecture, space must be proportionate to the number of people it can hold. It	An expansion is the concept of a space that accommodates people as they congregate for interaction. Space serves the people as a place for assembly,

	The lungs compress due to the relaxation of the diaphragm, and as a result, air is exhaled from the lungs and out of the body.	promotes comfort and safety issues. Ample area can contain a significant number of people while a smaller space limits only to a lesser capacity.	collaboration, and interaction. In a performance facility, the main concert hall is an example (but not limited to) of a type of space where the audience can congregate and utilize it to witness a performance.
Phonation *Tension And Air Flow*	This stage is the creation of vocal vibrations. Two elements that govern this operation. The constant flow of air from exhalation and the application of tension to the vocal folds. This synchronized combination allows the creation of vocal vibrations necessary for conceiving vocal sound or voice.		In a performance hall facility, the act of performance equates to the production of vocal vibrations. There are two elements in a performance. These are the performer and the audience. If airflow signifies the audience, the performer resembles the tension. A performer experiences pressure as they perform to an audience. There are various levels of performances. A formal setting can include a broader audience while a

			rehearsal room involves the performer(s) and the conductor as a sole audience. A solitary performance can occur in a practice room where the performer also becomes the audience.
Resonation *Brightness And Clarity*	Resonance relies on the open chambers of the nasal cavities. The openness of these chambers allows the vibrations to have a bright and clear quality.	In architecture, the element of light gives brightness and clarity to space. There are various ways to introduce light into a space. Natural light comes from the infiltration of sunlight into an enclosed area while artificial light depends on some form of electricity or energy.	Natural lighting helps to illuminate a space for a more natural ambiance. For instance, a light-well allows sunlight to penetrate an indoor space. Artificial lights are controllable to achieve different types of effects in an enclosed space.
Articulation *Formation And Position*	The active and passive articulators are elements within the oral cavity that defines the audibility of the voice. These articulators sculpt the oral cavity (mouth) to give the vocal sound the intended meaning and quality.	Elements such as ceiling and wall treatments along with stage and seating arrangements sculpt an enclosed space.	The arrangement of these components, such as acoustic panels identifies the ambiance of the space while the seating and stage arrangement can create an intimate interaction between performer and audience.

CHAPTER 6

CASE STUDY BUILDING PROFILES / SITE ANALYSIS

Case Studies Profiles

The chapter presents five concert hall buildings as case studies. The following buildings assist in identifying the spatial function and characteristics of a performance hall facility. The selected buildings represent the typology of contemporary concert performance halls and are engineered to ideal acoustical preference. These facilities range from a 700-seater recital hall to a grander 2265-seater concert hall. The facilities envision to strengthen the core of today's music and performance culture and enriches these components as vital ingredients for a healthy thriving society. The following are the building case studies:

- Bing Concert Hall
- Voxman Music Building
- New World Symphony
- China Philharmonic Hall
- Walt Disney Concert Hall

The following section briefly explains the concepts and visions behind these building. Each building displays innovative architectural elements as well as creative programmatic schemes. These examples will serve to identify the possible correlation between the concepts found in the vocal mechanism and the functions that facilitate a performance hall. It is essential to analyze these buildings to have a thorough understanding of the necessary programs and amenities for a performance hall facility.

Bing Concert Hall

Basic Information

Architects: Ennead Architects
Location: Stanford University
Area: 112365 sq. m.
Main Hall Seating Capacity: 842
Project Year: 2012
Acoustics: Nagata Acoustics America Inc.

The Bing Concert Hall, within the Stanford University complex, reflects a "seamless" vision of "architecture, acoustics, and technology." The Music Department and Stanford Live envisioned a contemporary facility that supports the programs of music and art performance. This multi-functioned amenity serves to inspire the academic and public community. The concert hall centers an "842-seat vineyard style" hall along with spaces that support music making and public leisure.[31]

Figure 29: Bing Concert Hall

(Source: ArchDaily / https://www.archdaily.com/335092/bing-concert-hall-ennead-architects)

[31] Bing Concert Hall. https://www.archdaily.com/335092/bing-concert-hall-ennead-architects

Voxman Music Building

Basic Information

Architects: LMN Architects
Location: Downtown, Iowa City
Area: 184000 sq. ft.
Main Hall Seating Capacity: 700
Recital Hall Seating Capacity: 200
Project Year: 2017

The Voxman Music Building is a building that houses the Music Department of the University of Iowa. This building consists not just a concert hall, but also amenities that support music and performance education. The concept of this building complex "celebrates musical performance at every turn, embracing a collaborative and exploratory student-driven model of education that treats every space as performance space."[32] The building is an excellent example of an ideal facility within the context of education. The engagement of students along with the community creates this facility more than just a concert hall, but rather a catalyst for music and art culture within its urban context.

Figure 30: Voxman Music Building

(Source: ArchDaily / https://www.archdaily.com/886640/voxman-music-building-lmn-architects/?ad_source=myarchdaily&ad_medium=bookmark-show&ad_content=current-user)

[32] Voxman Music Building. https://www.archdaily.com/335092/bing-concert-hall-ennead-architects

New World Symphony

Basic Information

Architects: Gehry Partners
Location: Miami Beach, Florida
Area: 100,641 sq. ft.
Main Hall Seating Capacity: 1200
Project Year: 2011

The New World Symphony is a masterpiece concert hall facility that serves as a center for the "professional development of outstanding instrumentalist."[33] This building in contrast to many of Frank Gehry's famous building designs has a unique spatial programmatic approach. The building not only encloses a concert hall, but it extends its performance stage outside the main hall through a wall projection. The facility pursues to enhance the academic world of music through outreach and search for promising talents within the community. This building case study presents innovative concepts designs for an ideal performance hall facility.

Figure 31: New World Symphony

(Source: ArchDaily / https://www.archdaily.com/107112/new-world-center-frank-gehry/?ad_source=myarchdaily&ad_medium=bookmark-show&ad_content=current-user)

[33] New World Syphony. *Statement of Purpose*. https://www.nws.edu/about/about-nws/

China Philharmonic Hall

Architects: MAD Architects
Location: Beijing, China
Area: 11600 sq. m.
Main Hall Seating Capacity: 1600
Project Year: 2019
Acoustics: Naga Acoustics

One of the world's renown orchestra resides in Beijing China, named the China Philharmonic Orchestra. This performance hall facility "will serve as the China Philharmonic Orchestra's first permanent residency while becoming a cultural exchange and China's new locus for classical music." The concept of the building is "to create a pure oasis in the midst of the bustling city." Inspired by the lotus flower, the interior and exterior of the hall exude a dramatic and ethereal atmosphere. According to Ma Yansong, the founder of MAD Architects, the building design prioritizes the spatial experience to which the "audiences will experience a transition from an urban setting to one of music and nature, preparing them for a journey of self-discovery."[34]

Figure 32: China Philharmonic Hall

(Source: ArchDaily / https://www.archdaily.com/797604/mad-architects-unveils-design-for-translucent-china-philharmonic-hall-in-beijing/?ad_source=myarchdaily&ad_medium=bookmark-show&ad_content=current-user)

[34] Lynch, Patrick. *MAD Architects Unveils Design for Translucent China Philharmonic Hall in Beijing.* https://www.archdaily.com/797604/mad-architects-unveils-design-for-translucent-china-philharmonic-hall-in-beijing. 2016

Walt Disney Concert Hall

Basic Information

Architects: Gehry Partners
Location: Los Angeles, California
Area: 200,000 sq. ft.
Main Hall Seating Capacity: 2265
Project Year: 2003
Acoustics: Naga Acoustics Inc. / Charles M. Salter Associates

The Walt Disney Concert Hall is a unique facility that takes the concept of music to create a dynamic aesthetic in the static nature of the built environment. The concert hall houses the LA Philharmonic orchestra, and the vision of this hall prioritizes the engagement between the performer and the audience. "The former director of the Los Angeles Philharmonic felt boxes and balconies implied social hierarchies within the audience, and spatial segregation was minimized in the design."[35]

Figure 33: Walt Disney Concert Hall

(Source: ArchDaily / https://www.archdaily.com/441358/ad-classics-walt-disney-concert-hall-frank-gehry)

[35] Walt Disney Concert Hall. https://www.archdaily.com/441358/ad-classics-walt-disney-concert-hall-frank-gehry. 2013

Site Analysis

The site analysis provides an inventory of existing conditions within the selected site. The site was a suggestion from the Music Department faculty. Its location distances about half a mile from the Music Department facility of the university. The lot area is approximately 74,682 square feet. It includes a circular six-story commercial building on the upper east side of the lot facing University Avenue. The rest of the site is a parking lot for the existing building along with other surrounding facilities.

Site History: Varsity Theater

The site held a cinema theatre facility, the Varsity Theater, from 1939 till 2008. The disrepair of the facility was due to the "absence of regular upkeep," which proposed the building to be unsafe and was "felt that the property was worth more without the historic building on it." Placing a new entertainment facility that focuses in art and music is a perfect opportunity to revitalize the property.[36]

Figure 34: Varsity Theater Before and After

(Source: http://cinematreasures.org/blog/2008/3/26/varsity-theater-demolished)

[36] Varisty Theater. Historic Hawai'i Foundation. https://historichawaii.org/2014/02/21/varsity-theater-demolished-2008/

Figure 35: Previous Site Map with Varsity Theater

(Source: Department of Planning and Permitting GIS)

Knowing that the site has a historical background of an entertainment facility, it reinforces the idea of using a performance hall facility to reinvigorate the site. Since the demolition of the Varsity Theatre in 2008, the site has not seen an attempt to diversify its function. The students and community can revive the place by making use of the educational and recreational purpose of the facility.

Site Inventory

A building must function beyond its shading and shelter capacity. Analyzing its surrounding context is essential. It allows taking advantage of the potential in designing the schematic program of the proposed site and building design. The site inventory considers three significant factors that influence the design of a building facility. These are zoning, circulation/access, and climate. The study of these categories gives a perspective of the characteristics of the site and later applied to the design of a performance hall facility.

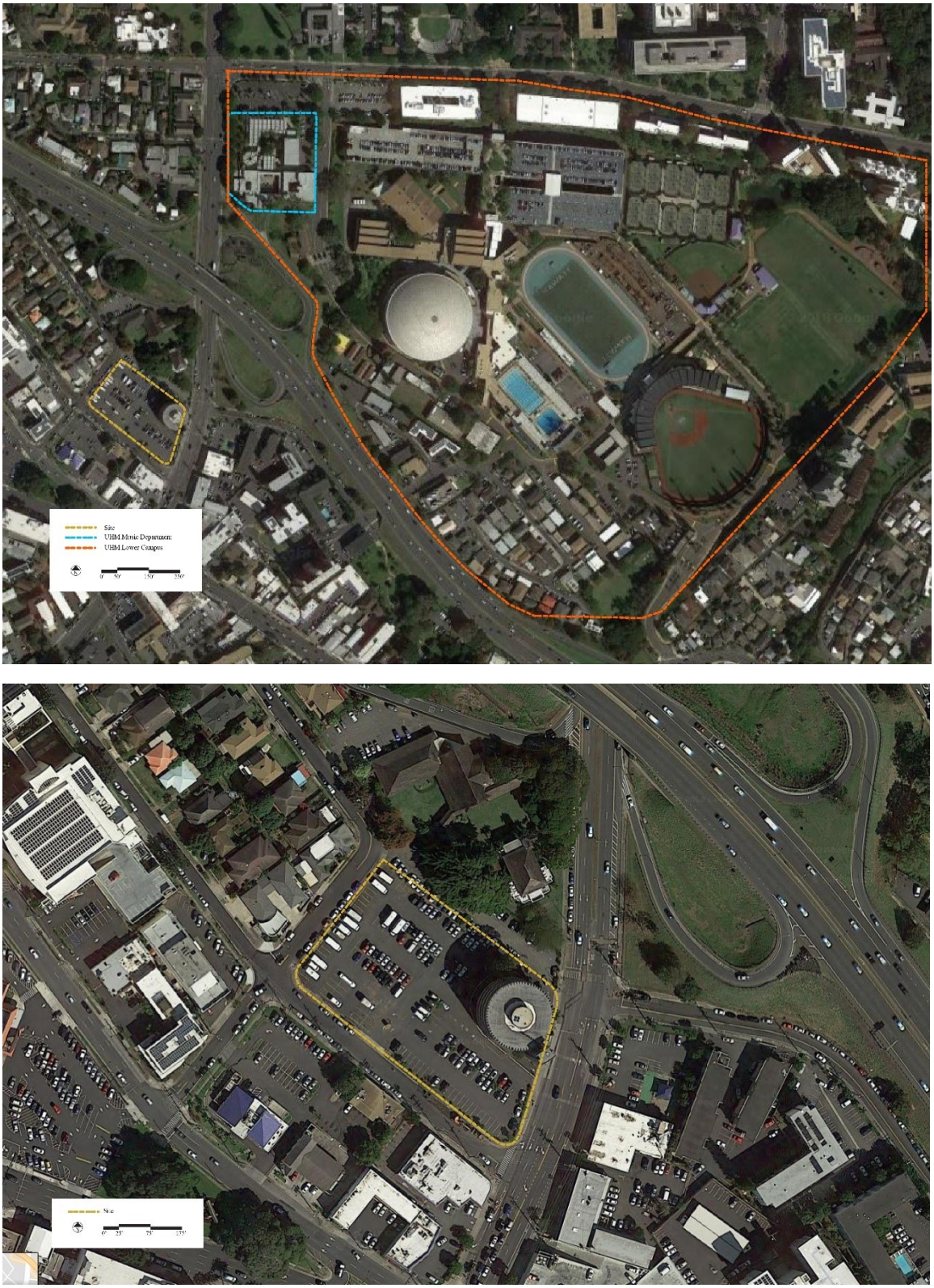


Figure 36: Site Relative to UHM Campus

(Source: Google Maps Adapted by Author)

Zoning

Zoning in city planning is defined as "to partition (a city, borough, or township) by ordinance into sections reserved for different purposes (such as residence or business)."[37] It is highly critical that a building's function abides by the zoning ordinances provided by the city planning organizations for full compliance.

Zoning also determines the character of a specific zone. In this case, three zoning categories surround the location of the site. Low to medium residential buildings and a church occupy the western and northern part of the site respectively. The eastern and southern areas are for commercial buildings including the location of the site. The northeastern area sets as an open space for a buffer between the populated areas and the freeway.

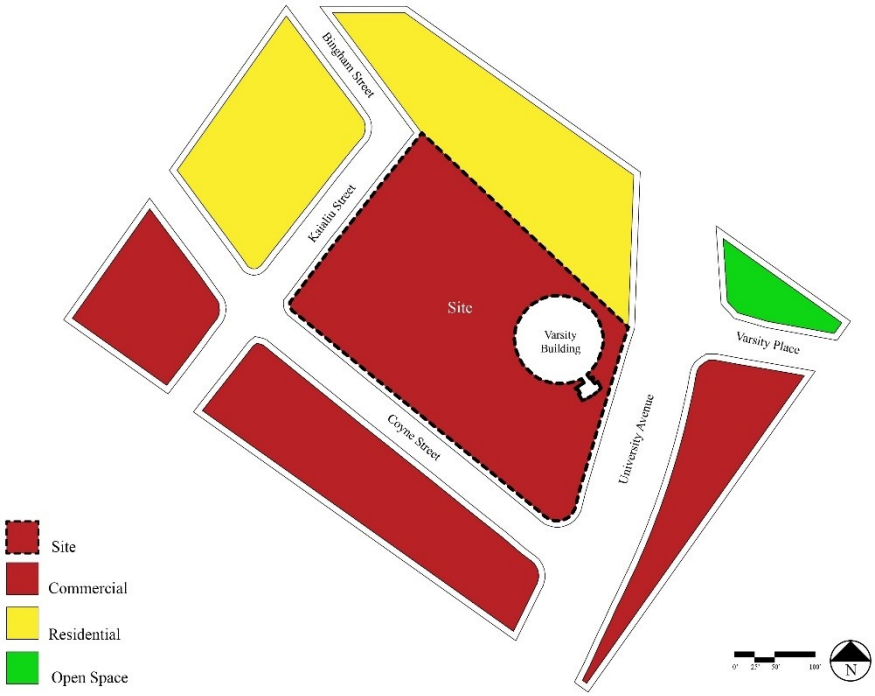


Figure 37: Site Zoning Diagram

(Source: Author)

[37] Merriam Webster Dictionary. https://www.merriam-webster.com/dictionary/zoning

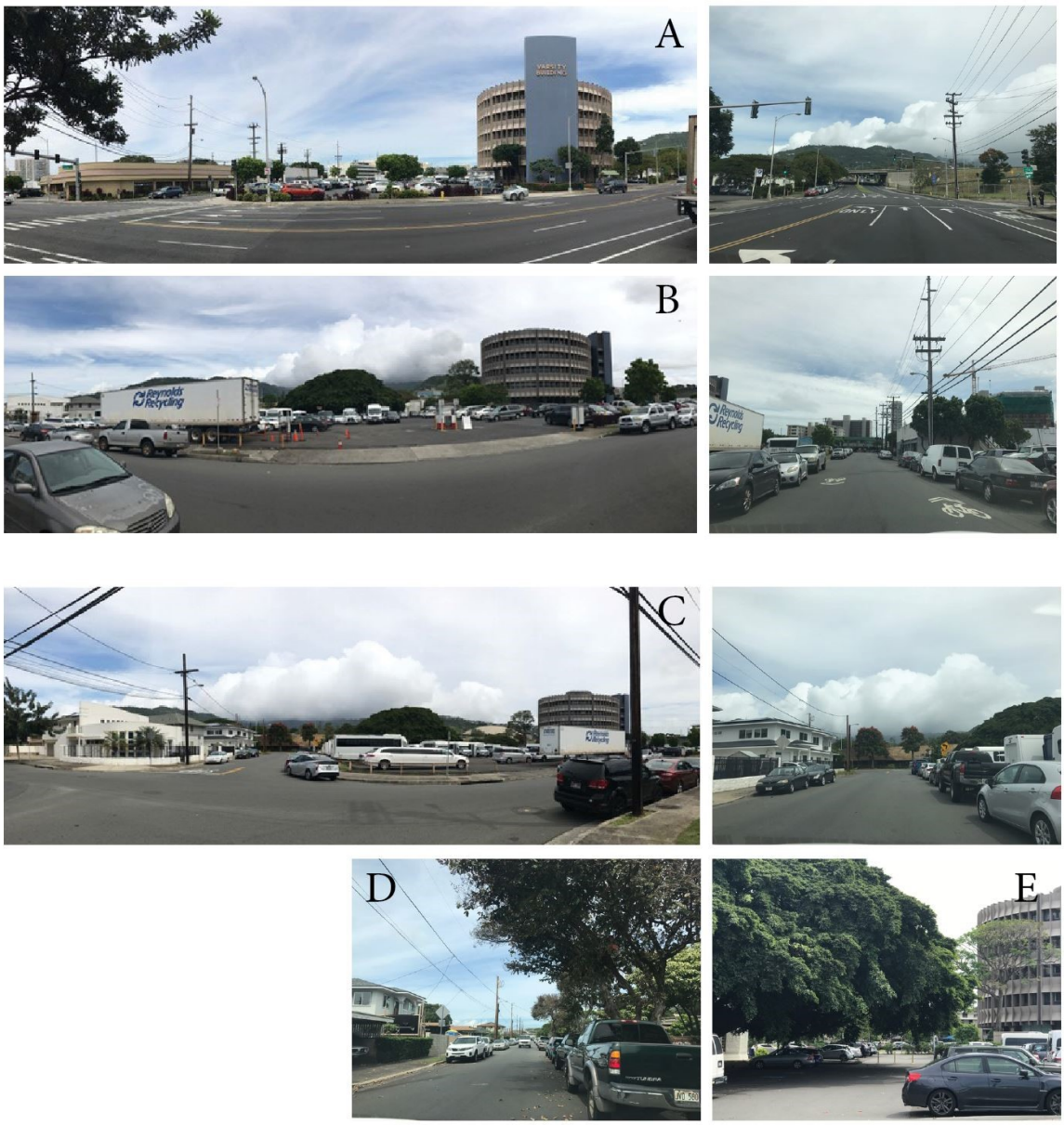


Figure 38: Site Images: (A) University Avenue (B) Coyne Street (C) Kaialiu Street (D) Bingham Street (E) Bingham Access

(Source: Author)

Circulation / Access

Knowing the site's current traffic circulation allows the design processes to consider the facility's accessibility. There are five ways to enter the site. Three entrances are located at the University Avenue which becomes the most practical access for the Music Department of the school. Back entry to a parking lot is on Bingham Street and Kaialiu Street which cater cars coming directly from H-1 freeway. The Coyne Street entrance serves as a connector for the commercial businesses that line the southern part of the site.

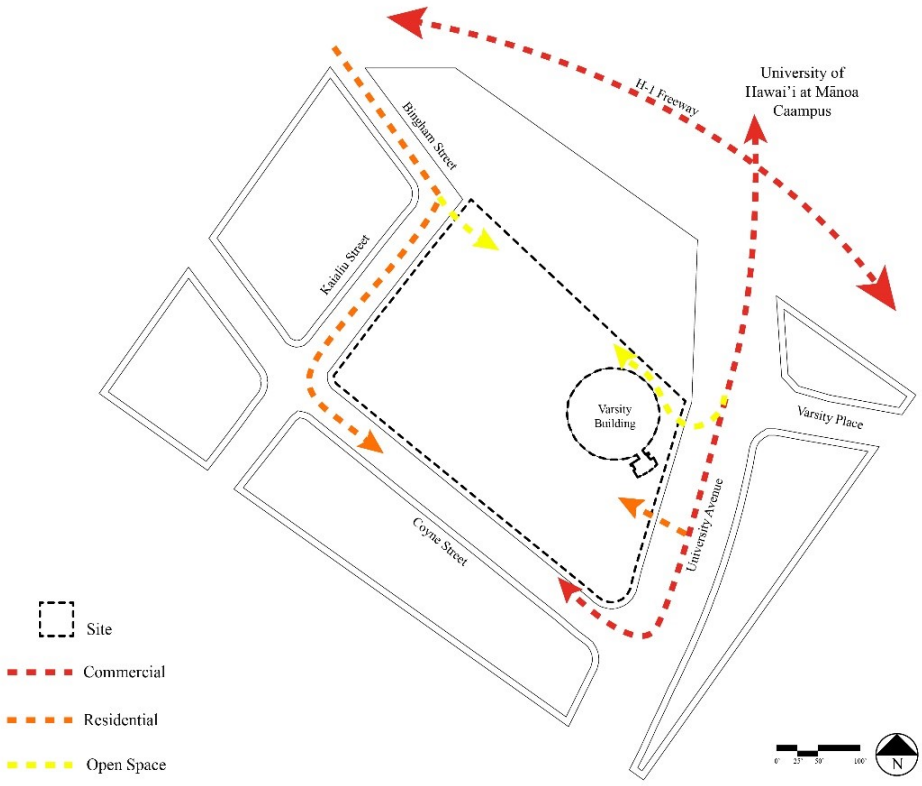


Figure 39: Circulation Access and Density Diagram

(Source: Author)

Climate

The hot and humid tropical climate of the site becomes an asset and nuisance to many people. Knowing the weather patterns of the site gives an advantage in providing a design that maximizes the comfort level the users. The sun pattern of the situates along the southern part of the site. The six-story Varsity Building sets as the tallest building along with a five-story midrise residential building located southwest of the site. The rest are one to two-story commercial and residential buildings. There are no prevailing shadows created by surrounding buildings. Having an open space penetrated by the intense sunlight during the peak hours can be discomforting to many people. Therefore, the building design must provide ample shading for outdoor activities. Trade winds mainly comes from the northeast. It is important to locate the direction of the wind to allow natural ventilation for outdoor and possibly some indoor spaces.

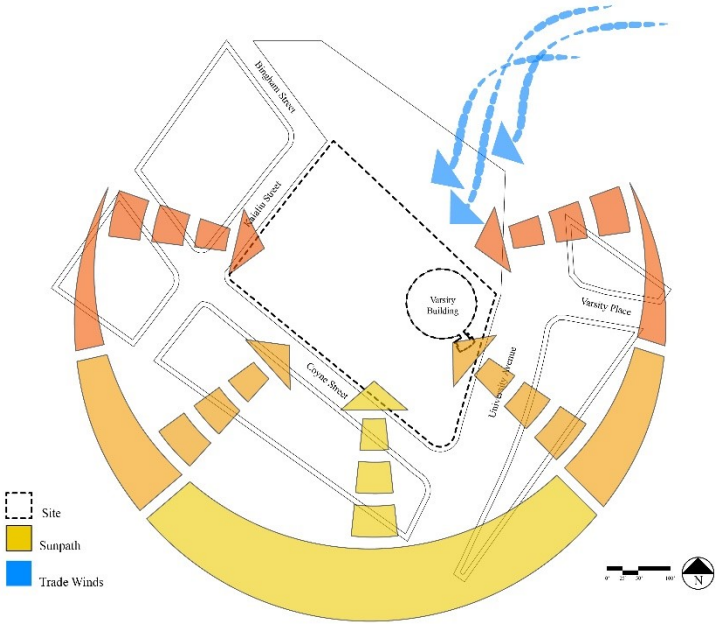


Figure 40: Sun and Wind Diagram

(Source: Author)

CHAPTER 7:

DESIGN APPLICATION

Building Design: Methodology Application

The project intends to produce a facility that celebrates music performance and architecture. The project's design scope is to deliver a schematic building design that caters to the vision of the Music Department of the University of Hawaiʻi at Mānoa. The facility will serve as a binding factor for the school and the community. The building includes programs that support the educational goals of the school, such as a state-of-the-art main concert hall, designated rooms for music and performance creation, and a facility that invigorates the communities that surround the site. The section aims to synthesize the formulated methodology and assess its validity for building design approach. The sequence of the design application will be the following:

Vocal Stages (Contraction, Respiration, Phonation, Resonation, and Articulation)

- Physiological Concepts
- Architectural Translations
- Case Studies
- Site Application

The sequential analyzation of each of the stages will provide a consistent flow of delivery. The physiological concepts and architectural translations with case study examples help to approach the design of the building and site. Examples from the building case studies will serve as design parameters to represent the concepts derived from previous studies.

Removing Varsity Building

The Varsity Building is a five-story, mid-century Modernist commercial building designed by a local firm, Wimberly and Cook, in 1963. The building was built to accommodate the First National Bank but currently supports office activities.[38] Removing the Varsity Building out of the site maximizes the full potential of the design approach application. This decision does not take into consideration the economical and historical value of the building because the project mainly focuses on the validity of design application onto the site. Since the Varsity Building is under a great interest for preservation, the building would become a critical influence on the development of the site. It is essential to understand the intent of removing the building for this project's purpose only to avoid misconceptions. For this reason, the removal of the Varsity Building helps the design application to concentrate on the objective of the project rather than other indirect factors.

The building sits on the northeastern part of the site which dominates its main street access. By removing the existing structure, the project can establish a performance hall facility that uses the site's prime location. The northern area of the site can be used as the primary private access for the school, while the eastern and southern areas can become the primary public access to the site. By taking out the Varsity Building and opening the site, it allows the project to connect with its surroundings and realize the possibility of a performance hall facility to revitalize the site and the community around it.

[38] Wagner, Kathryn D. *Varsity Building*. Hawaii Historic Foundation; https://historichawaii.org/2014/03/03/varsity-building-2012/

CONTRACTION: Spatial Attraction

The contraction of the diaphragm initiates the process of vocal production. Its dynamic constriction creates a negative space that allows the lungs and ribs to expand. The expansion allows the influx of air due to the difference of atmospheric pressure between the internal and external of the body. In singing, air primarily enters through the mouth for maximum inhalation. The physiological diagram below shows the pulling of breath by the contraction of the diaphragm allowing it to enter the body for respiration.

In architectural translation, the concept of contraction resembles spatial attraction. In the equation, the physical body translates to a site, while air resembles people circulating on the site. Attraction pertains to activities, shows, and other exciting events that lures the attention of the people to make use of the site. Programs that support daily activities of the people invigorate the community's culture. The site becomes an asset and a part of the daily lives of the people. In Figure 40, attractions are situated in strategic places to activate the perimeter of the site. Placing visible and accessible attractions enable the site at different times of the day.

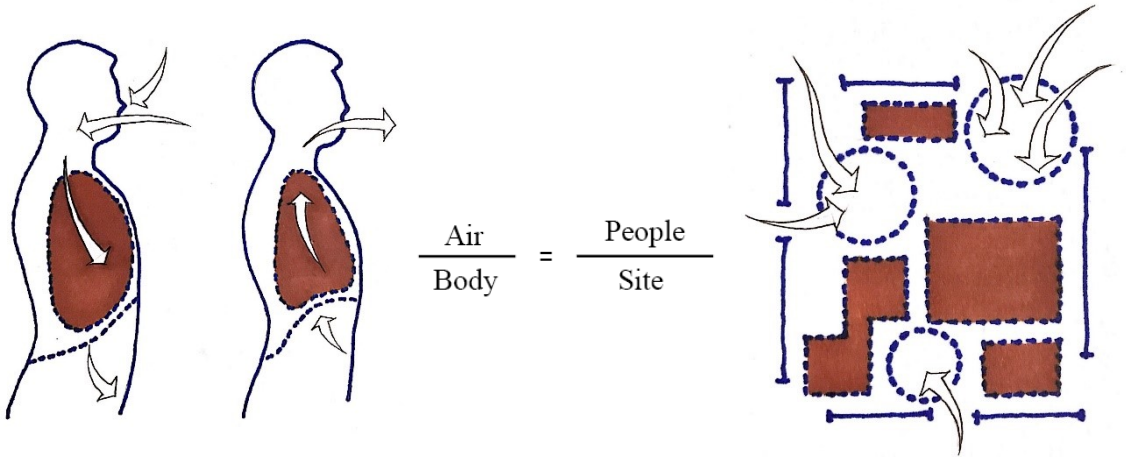


Figure 41: Contraction in Inspiration / Translation Equation / Concept Translation

(Source: Author)

Case Study Examples

Seating Areas

There are many types of activities that support the concept of attraction in a site. Seating areas is a common amenity that people uses for many potential functions and configurations. Along the perimeter of the main plaza in the Bing Concert Hall, seating areas are available for daily use. These seating places are accessible to the students any time of the day. Images show simple exterior furniture arrangements and shading devices promote an inviting atmosphere that serves the needs of students.

The concept of contraction in a site also serves as transition spaces. In a performance hall facility lobbies are usually the main social gathering spaces. Placing seating areas in lobbies and other social gathering spaces provides comfort while waiting for the main event. The Bing Concert Hall perfectly integrates seating areas set under tree canopies to support the social interactions.

Figure 42: Bing Concert Hall Seating Areas

(Source: ArchDaily / https://www.archdaily.com/335092/bing-concert-hall-ennead-architects)

Wallcast

In the New World Symphony, performance does not only take place inside the main concert hall. A "wallcast" innovatively invites people to outside the hall to watch the live telecast of the performance taking place inside the facility. The projection of the performance on the building's main façade along with speakers strategically places around the park creates an ambiance of excitement as if the people are inside the main hall of the facility.

The projection of a performance on a blank wall efficiently uses the building's surface area. It adds functional value for the community to enjoy. The facility's mission is to revitalize the community's music and performance culture. This creative design does not only expand the performances outside its walls, but it makes the facility to resonate to its people and community.

Figure 43: Wallcast from New World Symphony

(Source: ArchDaily / https://www.archdaily.com/107112/new-world-center-frank-gehry)

Plaza and Pre-Concert

In the Walt Disney Concert Hall, a plaza welcomes visitors as the main entrance of the facility. The strategic location of the plaza facing the intersection of two major streets gives the building a plan in a gridded urban landscape. The broad and elevated plaza invite pedestrians to venture the facility with natural and accessible wayfinding.

In this facility, a pre-concert room is a space provides accommodation for smaller gatherings such as recitals, convention assemblies, and other medium scale events. It includes a stage platform, a grand piano, and an array of chairs for the audience. The space situates within the lobby of the building. The concept of a preshow attracts people to gather and watch a show before the main event in the main hall. A designated area for this type of program helps ignite the excitement of people preparing to attend main show.

Figure 44: Preconcert and Plaza in Walt Disney Concert Hall

(Source: ArchDaily and http://www.lifeinafruitbasket.com /wp-content/uploads/2017/05/broad15.jpg)

Design Application: Contraction

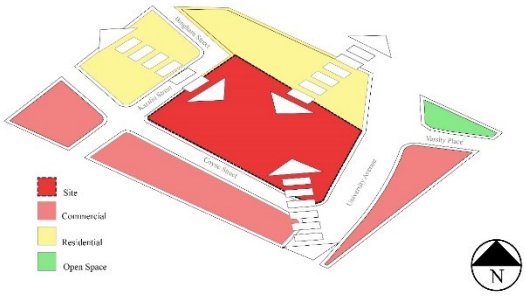


Figure 45: Site Zoning Entrance Consideration Diagram

(Source: Author)

Two zoning groups surround the site. The west and north part of the site includes single residential houses and a religious building. The east and south areas accommodate commercial facilities primarily food and dining establishments. It is vital to know the surrounding context of the site. Understanding the current conditions of the surroundings determine design decisions. It allows maximizing design integration for functionality and efficiency.

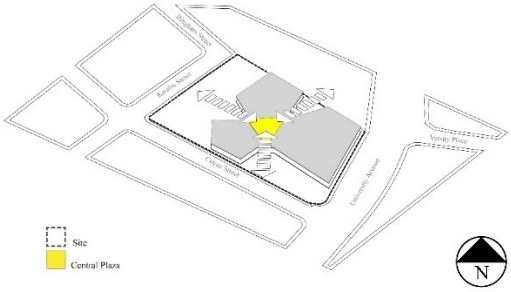


Figure 46: Central Plaza Diagram

(Source: Author)

The diaphragm situates in the core of the body. Locating a central plaza within the site resembles the location of contraction in the body. Typically, a plaza locates on the main façade of the site. Having a centralized plaza space helps to introduce multiple entrances for different types of users. Like the Walt Disney Concert Hall, the location of the main entrance on the southern corner of the site opens the facility for active commercial use. The north entrance provides private and backhouse access for the Music Department of the university. The west entrance, distanced by a buffer space, connects the facility with the residential area. The buffer space mitigates invasion of privacy of the residences and noise pollution from the facility.

RESPIRATION: Spatial Expansion and Absorption

> "So cleverly does he conceal the act of respiration that it is impossible to discover when the breath renews itself, inspiration and expiration being seemingly simultaneous, like lifting a cup with one hand while emptying it with the other. Thus, he can deliver the longest and most drawn-out phrases without any interruption of consonants."[39]

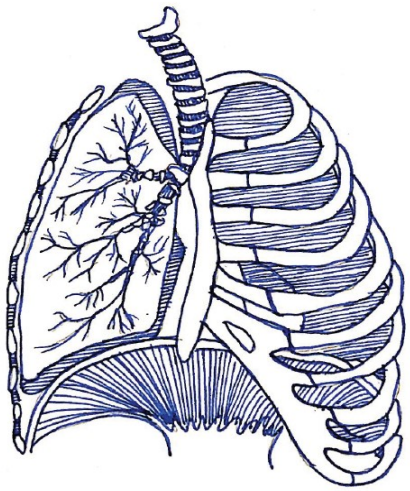


Figure 47: Lungs, Ribs, and Diaphragm

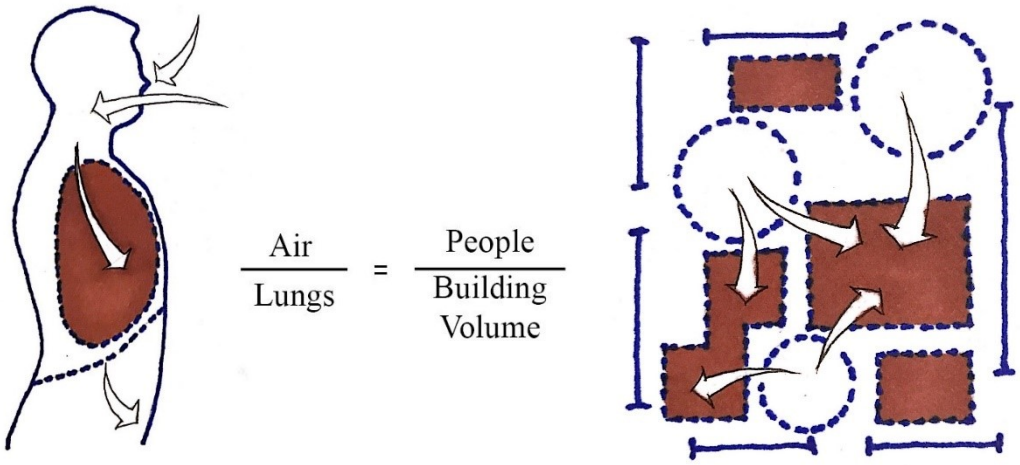
(Source: Author)

The art of singing begins with proper breathing. According to Dan H. Marek, a renown international singer, a teacher of voice in Mannes College of Music in New York City, and the author of a book published in 2013 titled Giovanni Battista Rubini and the Bel Canto Tenors, the "appoggio (from appoggiare – to lean)," is all about mastering the Italian technique of breathing. Marek described the mastery of breathing to "a great pitcher," Johan Santana, a baseball player. Santana masters his grip to the baseball by carrying the ball almost regularly. "Breathing is very much like that." If one is constantly thinking about how to breathe more efficiently and applies himself, it will become second nature."[40]

As mentioned, the expansion of the lungs is due to the contraction of the diaphragm. The synergistic action of these physical elements allows the influx of air to the lungs. In an architectural sense, the lungs become a volumetric space where oxygen

[39] Quoted from W. J. Henderson in Vocal Exercises, the Ultimate Collection: Giovanni Battista Rubini, Sheet Musci CD, 2005
[40] Marek; 257-258

is absorbed. Absorption is the primary function of the lungs. The lungs derive as building volumes to which absorption takes place. In a performance facility, absorption applies to witnessing a show or event. As the audience watch, they are absorbing the experience of the performance.



Case Study Examples

The main concert hall along with other enclosed volumes functions as spaces for performance. A performance hall facility prioritizes to provide a main gather space that accommodate large-scale performance. The Bing Concert Hall along with the other four building case studies provide a main hall in various scales. From the smallest to the largest, the Voxman Music Building has a 700-seating capacity hall while the Walt Disney Concert Hall can hold up to 2265 people in its audience.

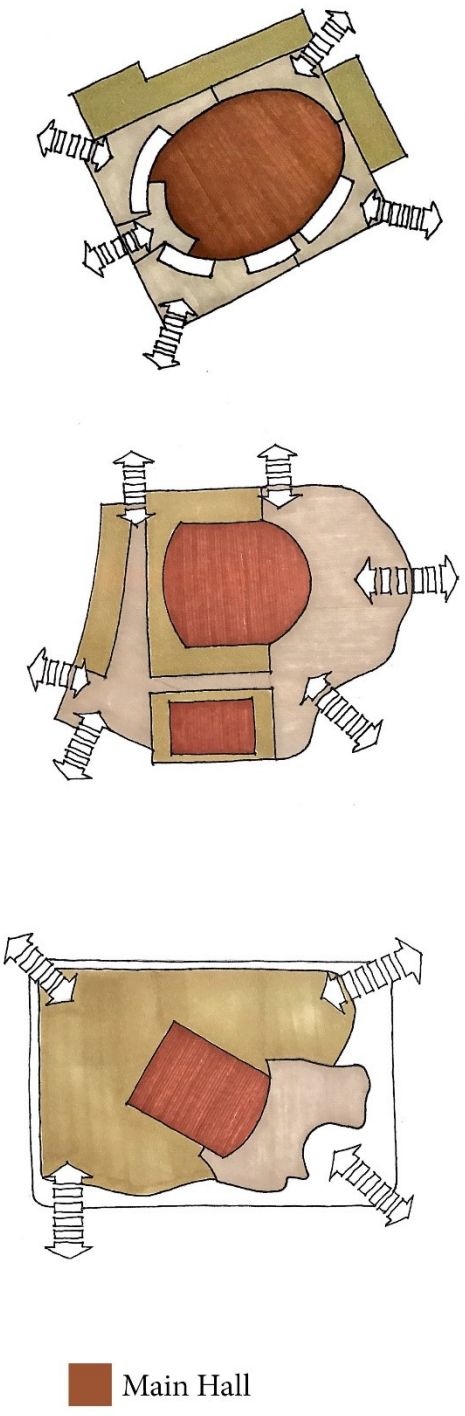


Figure 48: Enclosed Main Hall Diagram / Bing Concert Hall / China Philharmonic hall / Walt Disney Concert Hall

(Source: Graphics adapted by author / (https://www.archdaily.com/335092/bing-concert-hall-ennead-architects) / (https://www.archdaily.com/797604/mad-architects-unveils-design-for-translucent-china-philharmonic-hall-in-beijing) / (https://www.archdaily.com/441358/ad-classics-walt-disney-concert-hall-frank-gehry))

Design Application: Respiration

The facility includes three enclosed volumes to present the lungs of the site. These volumes will accommodate various scales of performances. The most significant volume located on the east façade of the site serves as the main hall of the facility. Placing the main hall in the commercial focused area allows the integration of retail spaces along the streets. The building scale of the main hall blends in with the taller commercial buildings along University Avenue in contrast to the shorter residential building along Kaialiu Street. It prevents the facility from blocking the views of the houses and respects the existing surrounding context of the site.

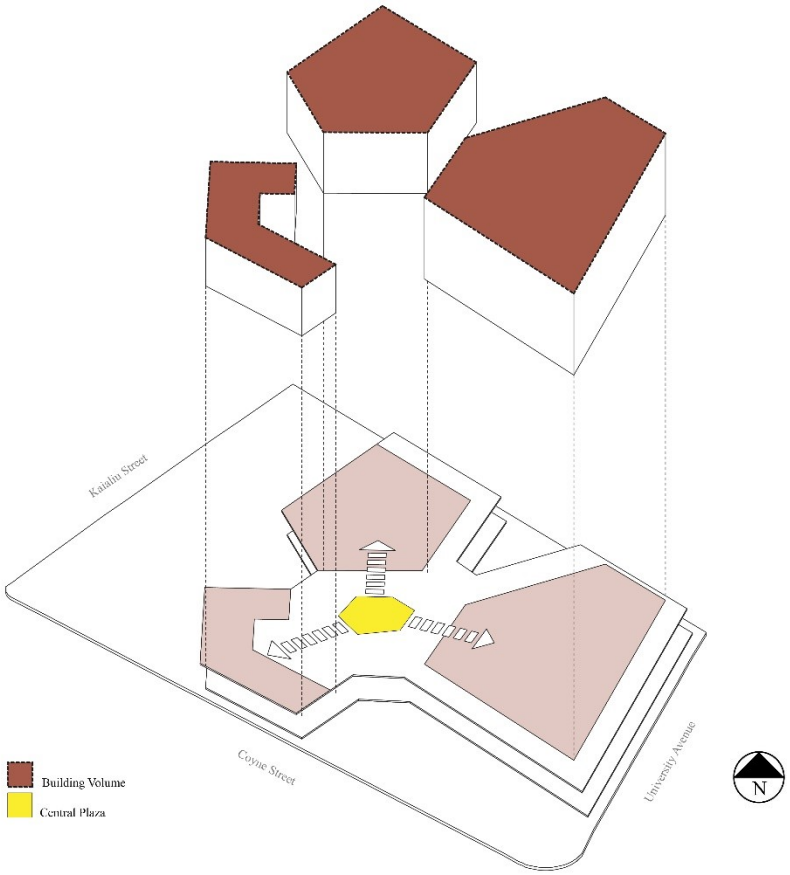


Figure 49: Building Volumes Diagram

(Source: Author)

PHONATION: Spatial Performance

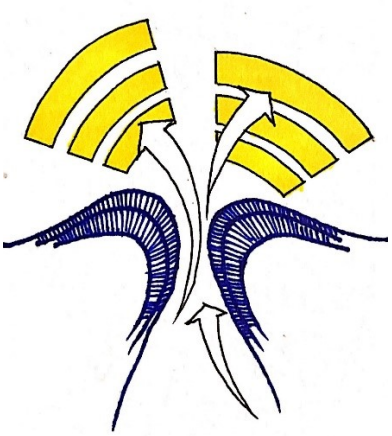


Figure 50: Vocal Fold Section during Phonation Diagram

(Source: Author)

Phonation is the production of vocal vibrations from the larynx. The vocal folds in the larynx undergo some level of tension to produce vibrations. Like the string in a guitar, the pulling of the strings determines the pitch and vibration frequency. In the vocal mechanism, two elements that must occur to produce the vibrations. Besides the presence of tension applied to the vocal folds, air pressure through expiration is essential. The interaction of air pressure with the larynx oscillates the vocal folds which become vibrations.

The act of performance is the primary function of a concert hall facility. The production of vocal vibrations in phonation resembles the creation of a performance. Like phonation, two elements compose a performance. These are the performers and the audience. The interaction between the performer and the audience ignites excitement and produces a meaningful experience.

Case Study Examples

There are three different types of performances. These performances vary from a large-scale event to an intimate practice. A production with a significant audience occurs in the main hall of the facility. Rehearsals that involve groups of performers and a wide-open space are informal performances. A solitary performance happens within a practice room to which the performer become its audience.

As mentioned in the stage of respiration, the main hall is the first amenity of a concert hall facility. Along with this space, rehearsal and practice rooms are essential space for performers to master their crafts. In the Bing Concert Hall, a large open room separated from the main hall allows the performers to rehearse before the main event. The rehearsal rooms in the Voxman Music Building facility replicates the stage the facility's main hall. The China Philharmonic Hall uses the rehearsal room as a recital performance space which often includes a small-scale presentation along with a small audience.

Figure 51: Bing Concert Hall / Voxman Music Building Hall / China Philharmonic Hall

(Source: ArchDaily / (https://www.archdaily.com/335092/bing-concert-hall-ennead-architects/51265a78b3fc4b32ca000072-bing-concert-hall-ennead-architects-photo) /

(https://www.archdaily.com/886640/voxman-music-building-lmn-architects/?ad_source=myarchdaily&ad_medium=bookmark-show&ad_content=current-user) /

(https://www.archdaily.com/797604/mad-architects-unveils-design-for-translucent-china-philharmonic-hall-in-beijing/580616ace58ece54c9000009-mad-architects-unveils-design-for-translucent-china-philharmonic-hall-in-beijing-image))

The Voxman Music Building is the school's main Music Department facility that center the education of music. The building provides individual practice rooms for both faculty and students to use. The practice rooms are equipped with keyboards and are soundproof to give privacy and mitigate sound pollution.

Figure 52: Voxman Music Building Rehearsal and Practice Room Plans

(Source: https://www.archdaily.com/886640/voxman-music-building-lmn-architects/5a4f2891f197cc8fba000193-voxman-music-building-lmn-architects-level-2-plan)

Design Application: Phonation

The three building volumes house the three levels of performances. The main hall accommodates larger events, while the rehearsal space located at the northern part of the site provides an open space for different scales of rehearsals. The main hall and the rehearsal room have backhouse access located at the north area of the site. The practice rooms are individual spaces for private performance preparations. These rooms are separated by different enclosed volumes that create a central plaza.

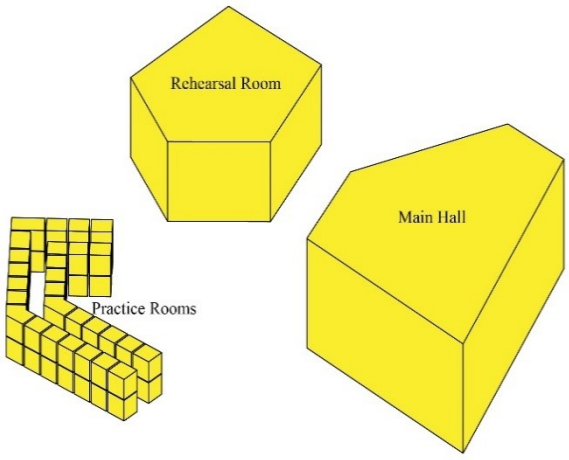


Figure 53: Types of Performance Spaces

(Source: Author)

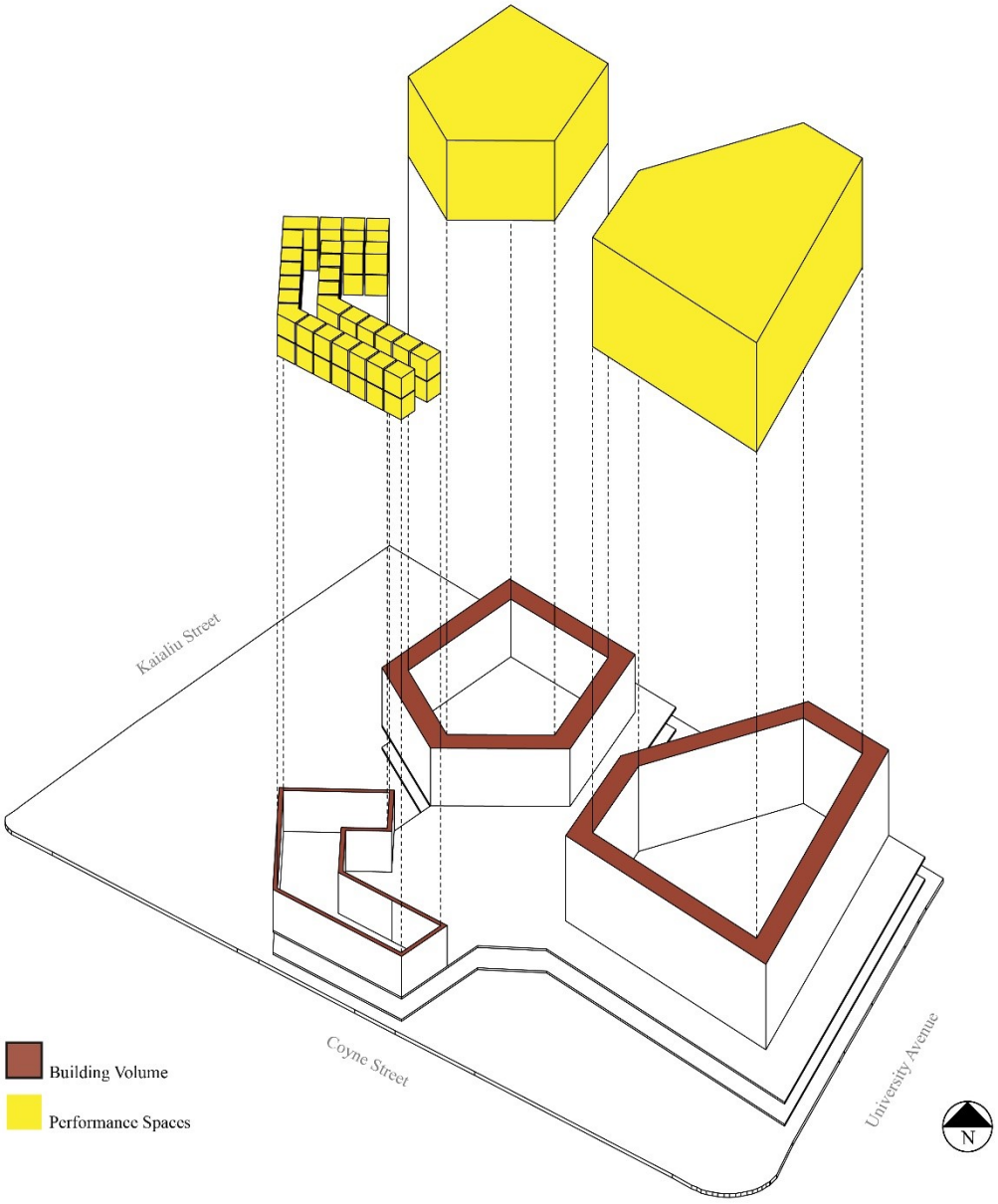


Figure 54: Performance spaces diagram on site

(Source: Author)

RESONATION: Spatial Clarity

Figure 55: Nasal Cavities

(Source: Author)

Imagine the sound of a violin without its ringing overtones. A resonant voice has a bright and clear sound quality even in the low pitch frequencies. Resonance amplifies the vibrations of the larynx like the wooden case of a string instrument. Without resonance, the sound of the voice becomes dull and unattractive. In singing, a resonant sound delivers the melody and words of a song with clarity and projection.

The production of resonance involves the nasal cavity including the sinuses. According to M. Barberuex-Parry, author of Vocal Resonance Its Source and Command and a voice teacher, explains that the ability to have mastered the control of breath has an indirect correlation with resonance. She points out that resonance and breath control are "entirely opposed to each other. Pure resonance is always nothing more or less than perfectly reflected sounds. In no way does breathing assist in that reflection." Resonance depends on the medium of waves rather than the circulation of air.

The concept of resonance is an essential stage to achieve proper and beautiful vocal sound. The open spaces of the nasal cavities become the soundboard for the amplification of the vibrations. Congested nasal cavities result in a reduced clarity of the

voice. The idea of a bright and clear sound resembles light and space. In architecture, the presence of light speaks resonance of a space.

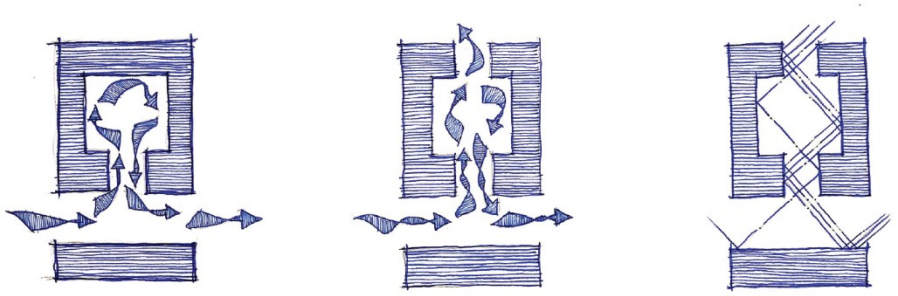


Figure 56: Light Well Concept Diagram

(Source: Author)

Case Study Examples

"Light is not so much something that reveals, as it is itself the revelation."[41]

James Turrell

Light reveals the essence of a space. Light in a space creates a subliminal experience. The absence of light defies the existence of architecture. The soul of architecture relies on light to expose the visual form of design. Of all different type of light sources, natural light from the sun provides the best kind of illumination. There are many ways to introduce natural light into a space. The Bing Concert Hall use light wells and transparent glazing materials to penetrate the building volume with natural light. The Walt Disney Concert Hall has a skylight feature that brightens the preconcert space for daylight solutions. The China Philharmonic Hall envelopes its entire building volume with a translucent material that filters direct sunlight into its interior spaces. These

[41] James Turrel; American artist

strategies are effective ways to brighten a space. Natural daylighting is free and cost efficient. It reduces the need for artificial lighting which saves the facility on electrical spending. These strategies resonate to the concept of vocal resonation into architectural translation.

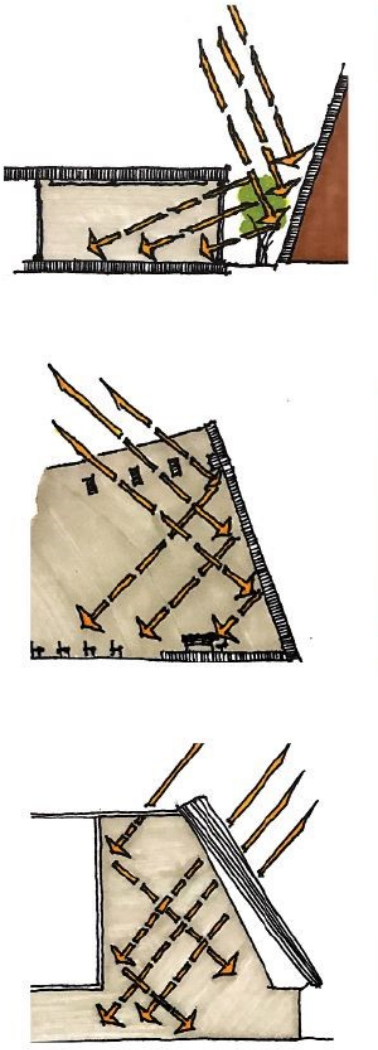


Figure 57: Daylighting Diagram

(Source: Graphics Adapted from (https://www.archdaily.com/335092/bing-concert-hall-ennead-architects) / (https://www.archdaily.com/441358/ad-classics-walt-disney-concert-hall-frank-gehry) / (https://www.archdaily.com/797604/mad-architects-unveils-design-for-translucent-china-philharmonic-hall-in-beijing/58061732e58ece54c900000e-mad-architects-unveils-design-for-translucent-china-philharmonic-hall-in-beijing-image))

Design Application: Articulation

Light Well / Atrium

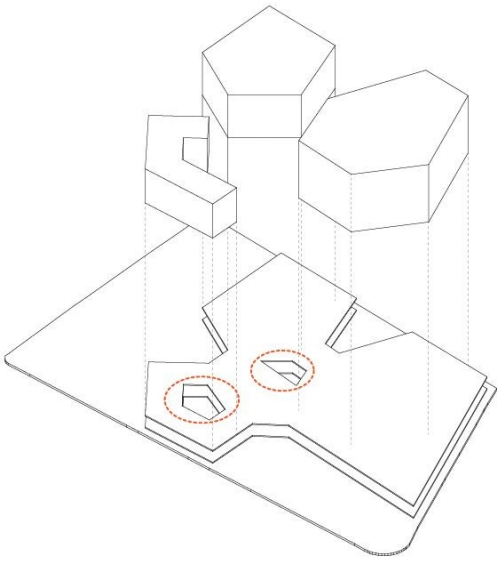


Figure 58: Light Well Atrium in central plaza Diagram

(Source: Author)

Introducing natural light into a room is an efficient strategy to illuminate enclosed spaces. Light wells are great ways to open up space. Atrium spaces open the ground floor of the facility. This strategy helps to lighten up the pathways on the first floor with natural daylighting. It also assists in air circulation for natural ventilation.

Skylights

Incorporating skylights in an enclosed space is an effective and practical strategy to illuminate an interior room while saving on the cost of electricity from artificial lightings. Using a skylight in the rehearsal space creates a bright atmosphere during practices. The acoustical panels filter and control the direct sunlight from overheating the interior space.

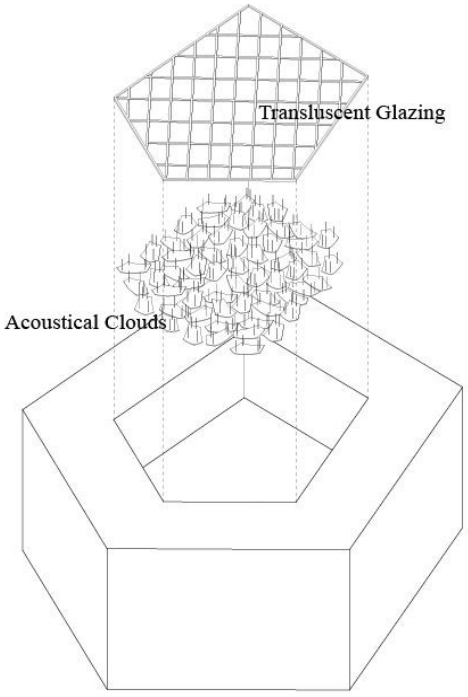


Figure 59: Skylight in Rehearsal Space

(Source: Author)

Translucent Building Envelope

The envelope design of the China Philharmonic Hall is a beautiful and innovative application of translucent glazing material to illuminate the lobby of the facility. Using translucent glazing material to wrap the perimeter of the main concert hall allows creating a bright and porous interior lobby. It connects the interior of the facility with the surrounding environment which helps visual continuity. Opening the building volume through glazing material not only helps in daylighting, but it also sparks visual interest from the perspective of the pedestrians and motorist on what occurs within the facility.

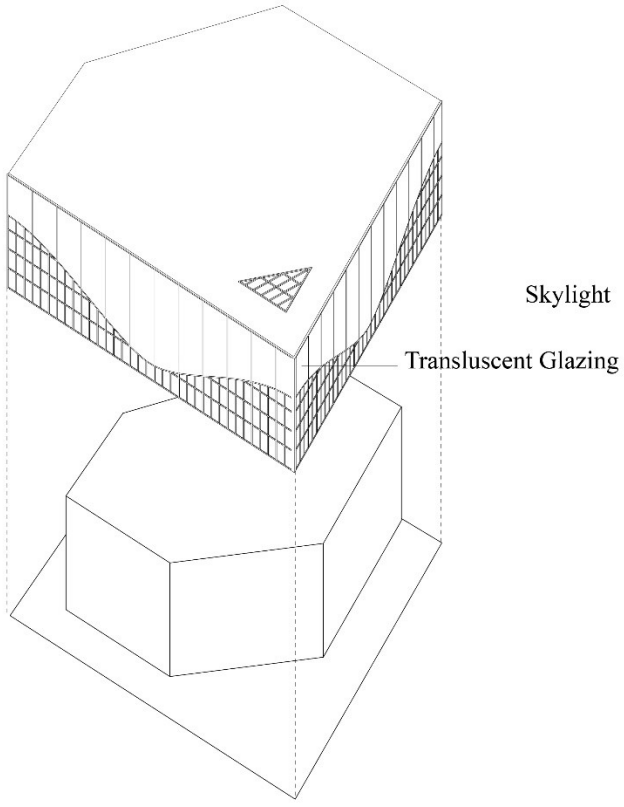


Figure 60: Skylight and Translucent Building Envelope on the Main Hall

(Source: Author)

ARTICULATION: Spatial Formation

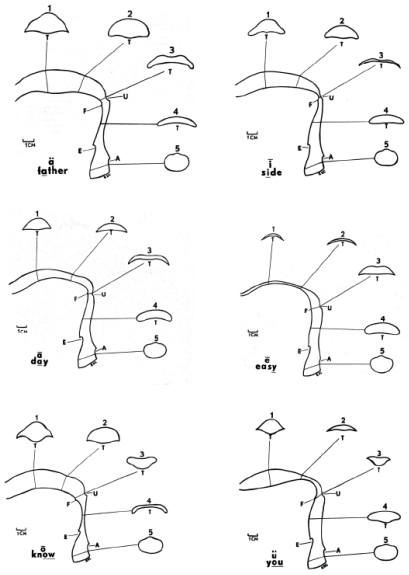


Figure 61: Oral Cavity Tongue Formation Section

(Source: Edmund Crelin. The Human Vocal Tract)

Beautiful singing must be clear, crisp, and easy to comprehend. Singing is an expressive way of communication. Enunciating the words is as important as singing the right pitch on the right note. Articulation is responsible for delivering the correct diction and pronunciation of the lyrics of a song. The tongue along with other active and passive articulators shape the oral cavity to create vowel and consonant sounds.

The tongue primarily influences the articulation of words. The positions of the tongue produce unique spatial quality within the oral cavity which result in the different vowel and consonant sounds. In the *Introduction to Phonetics* by L. F. Brosnahan and Bertil Malmberg, the positions of the tongue can be described in three divisions. These are the front, central, and back. Each vowel sound manipulates the position of the three part of the tongue. These are defined from low, middle, to high positions. [42]

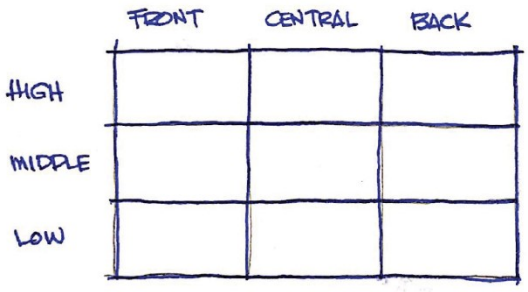


Figure 62: Tounge Position Reference Chart

(Source: Author from L.F. Brosnahan's Introduction to Phonetics. 1970)

[42] Brosnahan, L. F. 218

In architecture, it is important for a space that is beautiful and functional. The movement of the tongue forms the oral cavity to create the desired sound. In a performance hall, articulators such as the tongue resemble architectural elements, such as seating and stage arrangements, wall, and acoustical ceiling panels that define the overall function and ambiance of the space. These elements are integral components in a performance hall because it influences the interaction between the performer and its audience along with the acoustical atmosphere of the space.

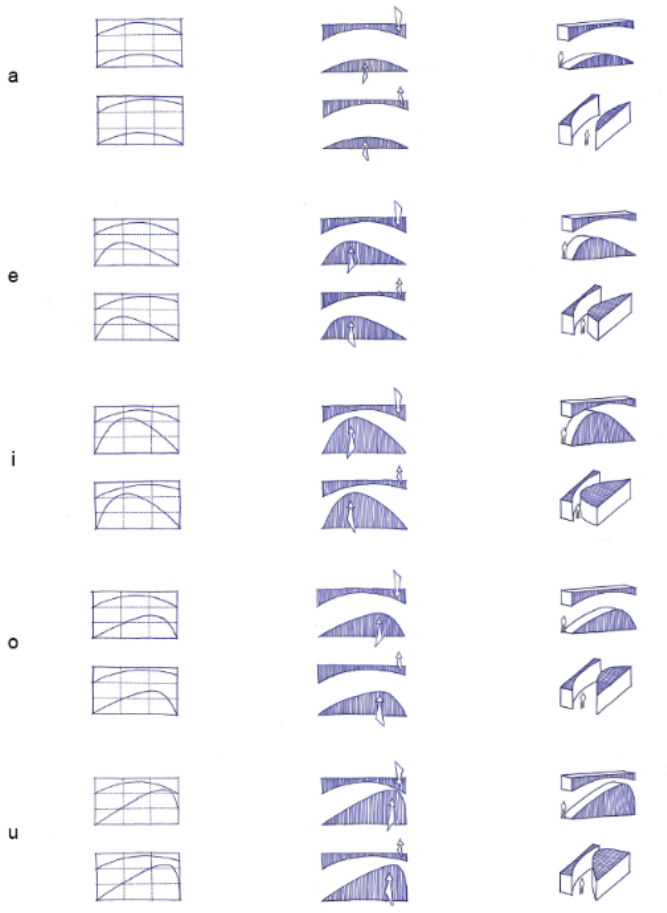


Figure 63: Vowel Tongue Formation Translation

(Source: Author)

Case Study Examples

Seating and Stage Arrangement

There are two types of seating arrangement (shoebox and vineyard concert halls). A shoebox hall is "a classic concert hall named after the rectangular shape and approximate proportions of a tennis-shoe box." A vineyard concert hall has a seating arrangement that "may completely or partially encircle the concert platform." [43] The seating arrangement along with the placement of the stage influences the ambiance of the room. The Voxman Music Building has a traditional shoebox hall, while the other four halls have a vineyard terraced seating arrangement.

The shoebox seating has a direct perspective between the performer and the audience. The stage is on one side of the room while the audience seating is on the

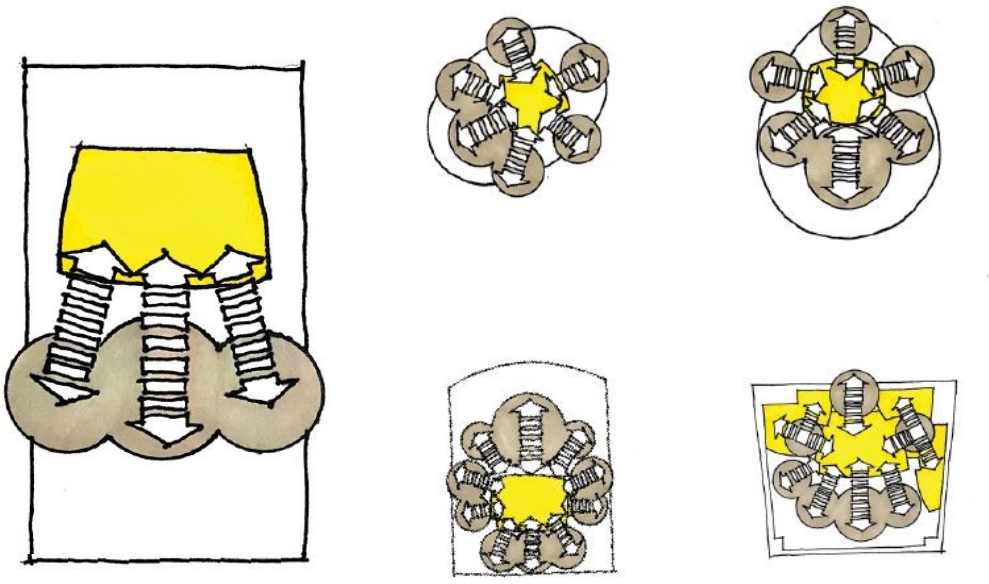


Figure 64: Shoebox and Vineyard Terraced Hall Seating and Stage Arrangement

(Source. Author)

[43] Theatre Projects Consultants. http://theatreprojects.com/files/pdf/Resources_IdeasInfo_typesandformsoftheatre.pdf. 9-10

opposite side. In vineyard terraced seating, the stage is in the center of the room, and the audience seating surrounds the stage.

Acoustical Panels

In a performance hall, acoustical panels are elements used to tune the acoustics of the space. The shape and material properties of the panels control sound reflection and absorption. Acoustical panels come in many shape and design. In all the case study halls, the convex design of the panels is effective in tuning the acoustics of the space. Acoustical treatments in a hall resemble the dynamic movements of the articulators within the oral cavity. The panels are the tongue where the room is the oral cavity. The design of the acoustical sails influences the shape and overall ambiance of the space. In

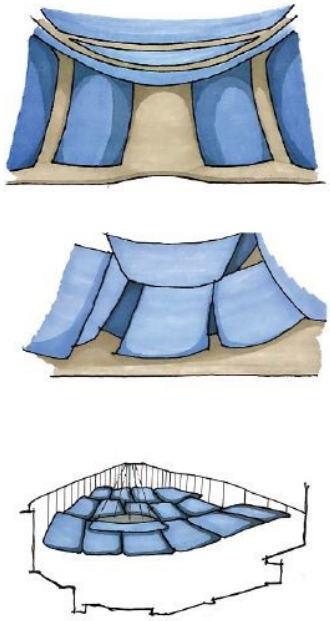


Figure 65: Acoustical Panel Designs

(Source: Author / (https://www.archdaily.com/335092/bing-concert-hall-ennead-architects/51265a77b3fc4b4959000071-bing-concert-hall-ennead-architects-photo) (https://www.archdaily.com/107112/new-world-center-frank-gehry/5007303e28ba0d41480014f4-new-world-center-frank-gehry-photo) (https://www.archdaily.com/797604/mad-architects-unveils-design-for-translucent-china-philharmonic-hall-in-beijing/5806169ae58ece9cf6000008-mad-architects-unveils-design-for-translucent-china-philharmonic-hall-in-beijing-image))

the Bing Concert Hall, the large panels have dominating presence surrounding the whole space. The panels in the China Philharmonic Hall and New World Symphony add dramatic flair to the room and are used for surface projection for visual presentations.

Design Application: Articulation

The main performance hall consists of a stage and seating areas for the audience. Placing the stage in the center of the hall with a vineyard terraced seating creates an intimate ambiance between the performer and the audience. This type of seating to stage arrangement allows every person in the audience to be closer to the performer. It prevents distant back row seats which often occurs in a shoebox seating arrangement. The main hall has a 500-seating capacity. The seat behind the stage can hold an audience as well as choral groups which are often involved in orchestral performances.

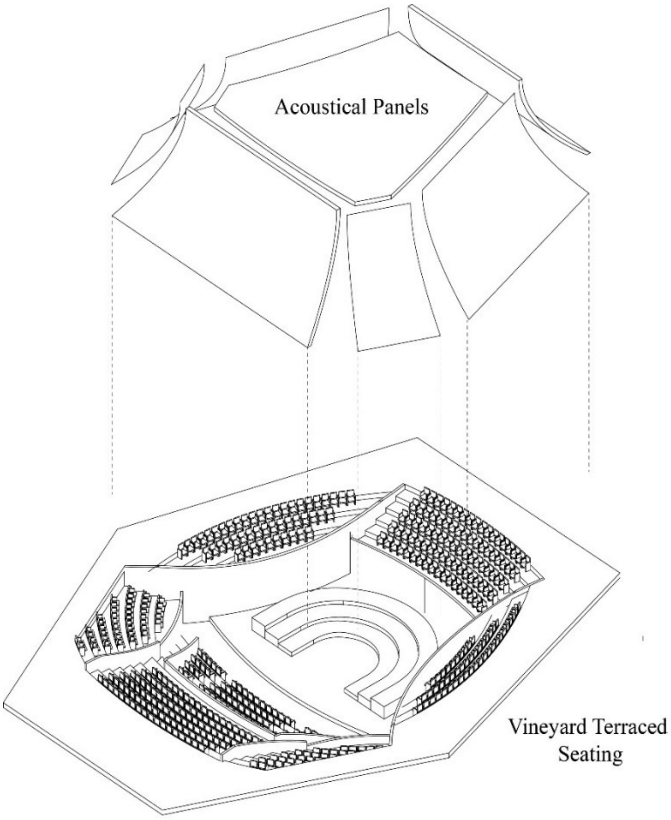


Figure 66: Main Hall Seating Arrangement and Acoustical Panels Design Diagram

(Source: Author)

The convex shape of the acoustical panels assists in fine-tuning the acoustics of the space. Although the project does not analyze quantitative acoustical properties, the

design of the panels architecturally fulfills the concept of articulation within a performance hall space.

The rehearsal room is an open space dedicated to large groups of people. The room can be used on various occasions. Orchestras and marching bands of the university can utilize the facility for practices. The space transforms for small to medium size convention gatherings. The room can also host a recital room which can hold up to 300 individuals in a single event. The presence of acoustical panels creates an experience similar to the main performance hall.

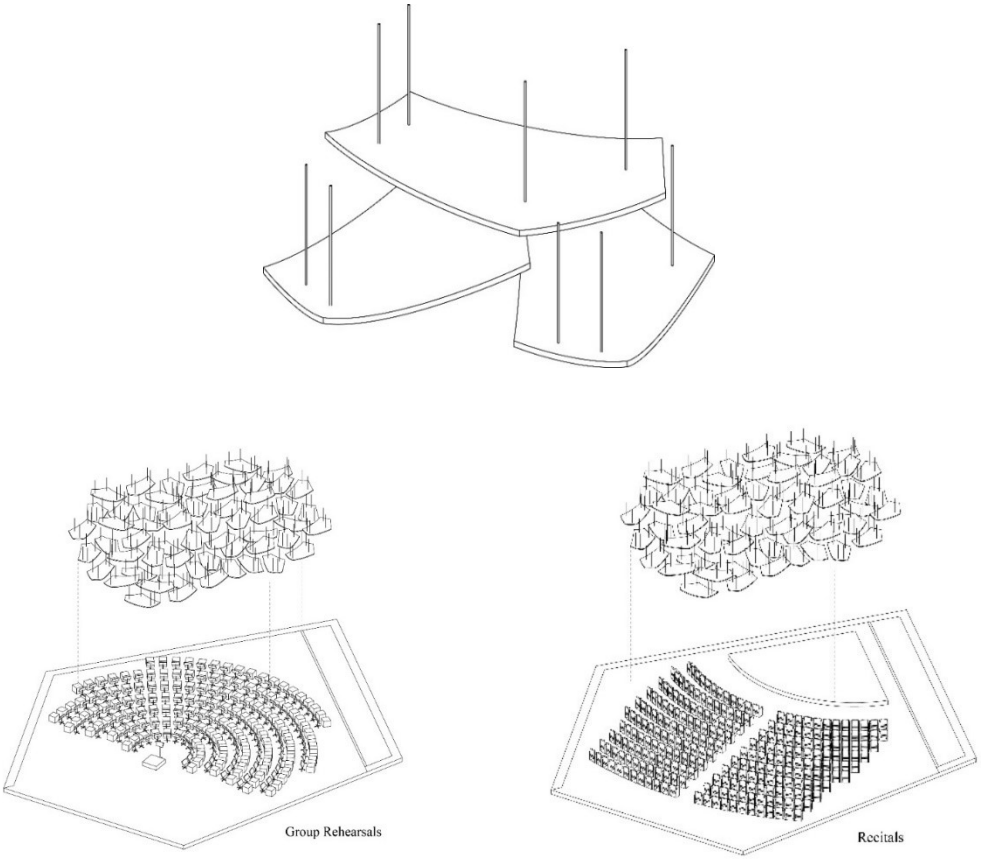
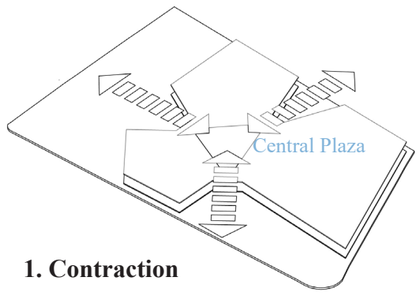


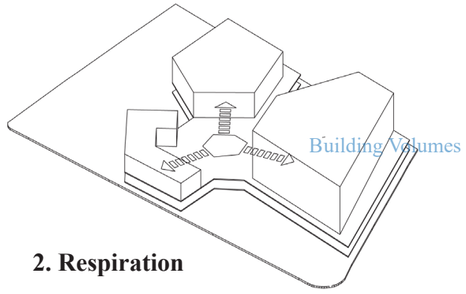
Figure 67: Rehearsal Acoustical Panels and Seating Arrangements

(Source: Author)

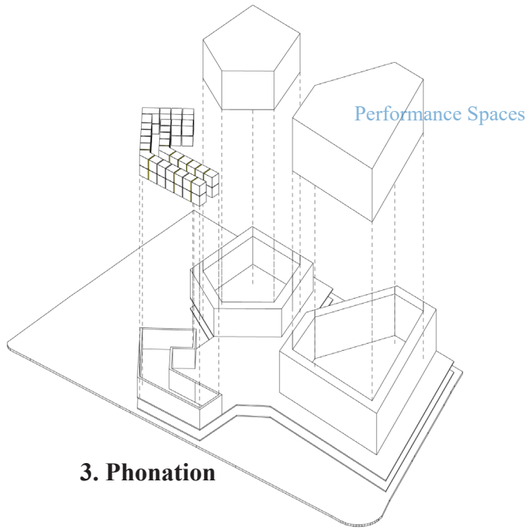
Design Summary



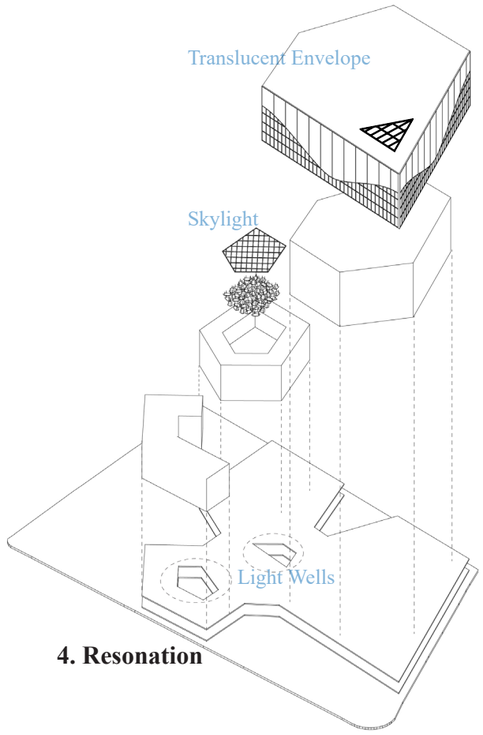
1. Contraction



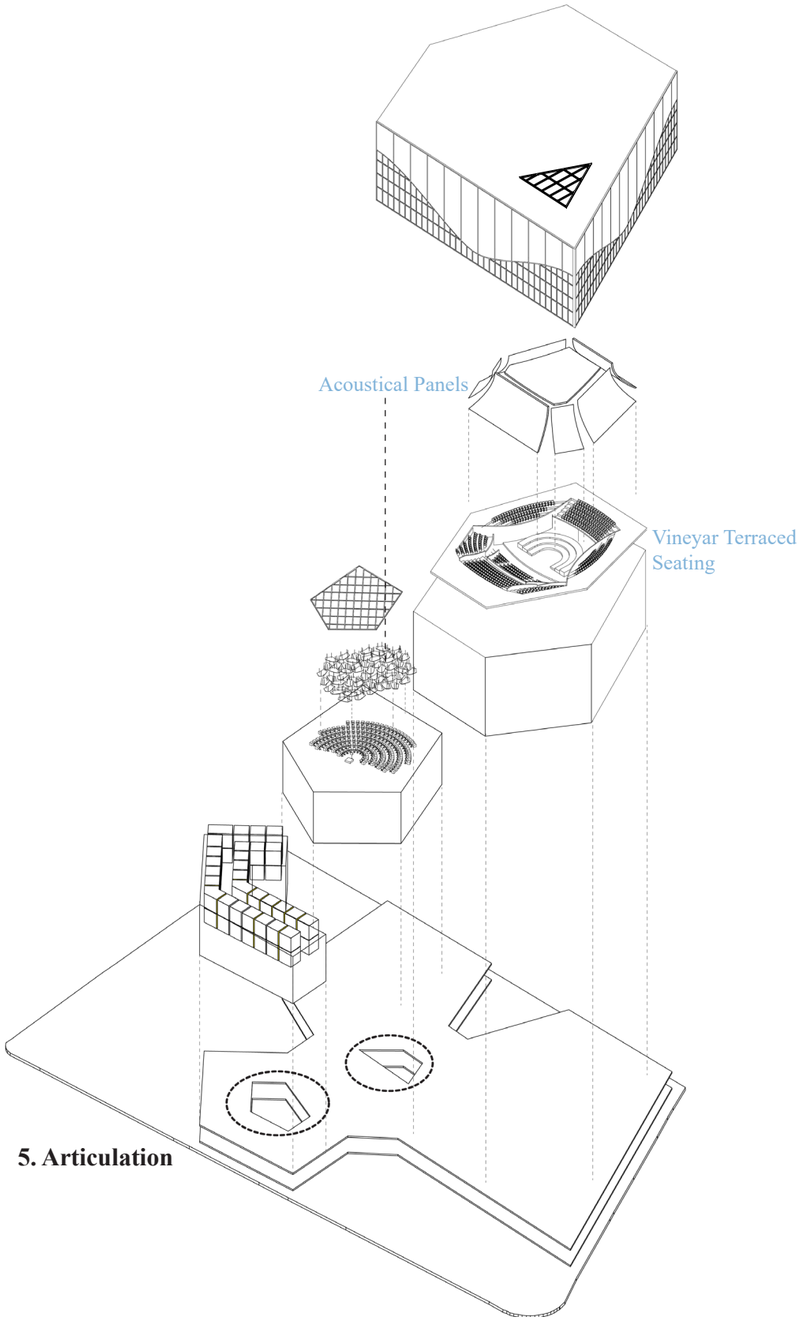
2. Respiration



3. Phonation



4. Resonation



5. Articulation

Figure 68: Design Summary
(Source: Author)

Site Plan

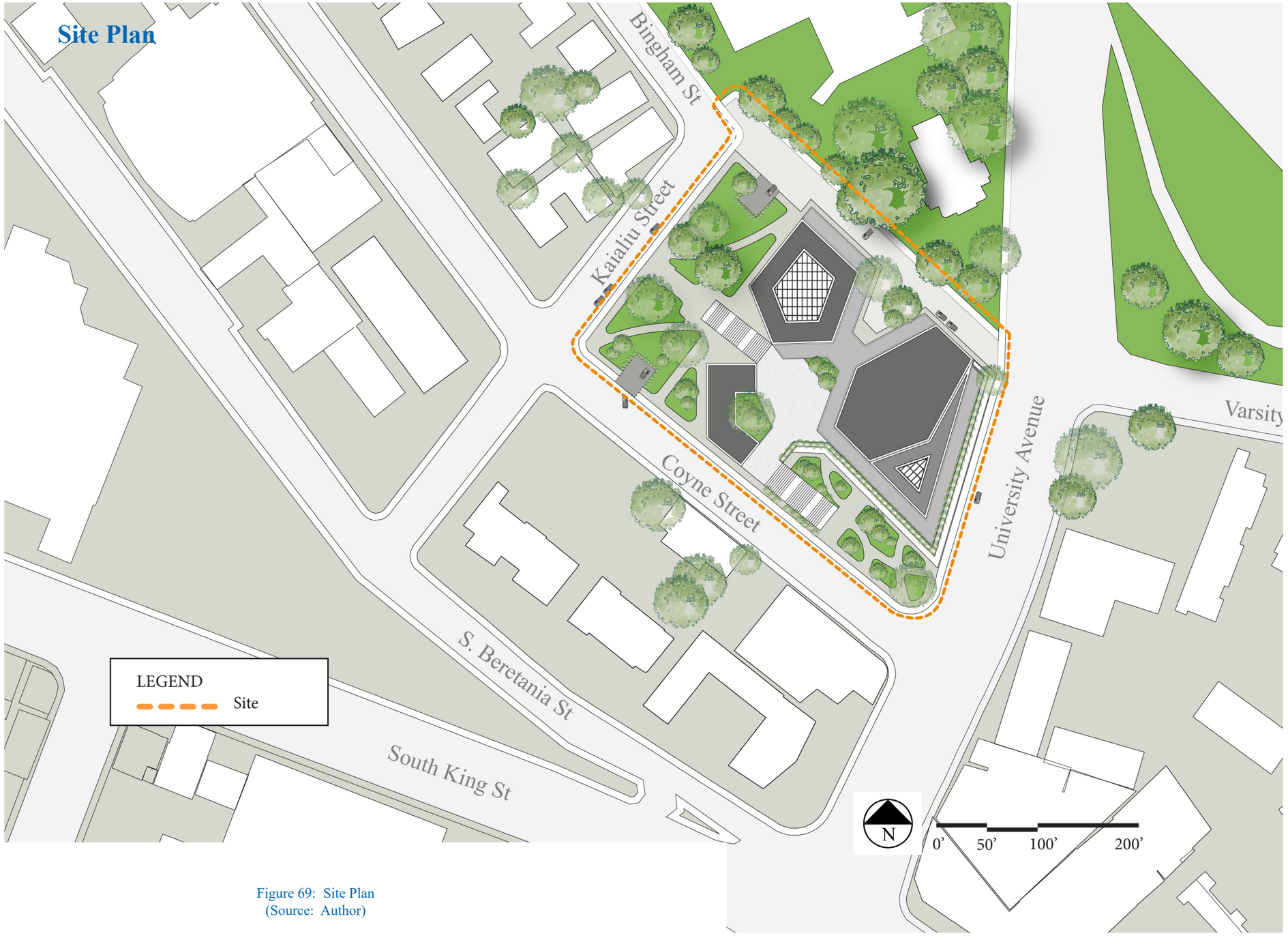
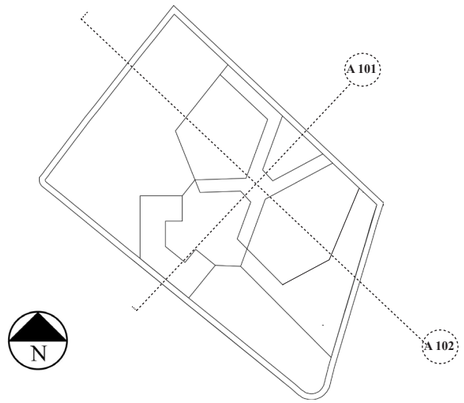


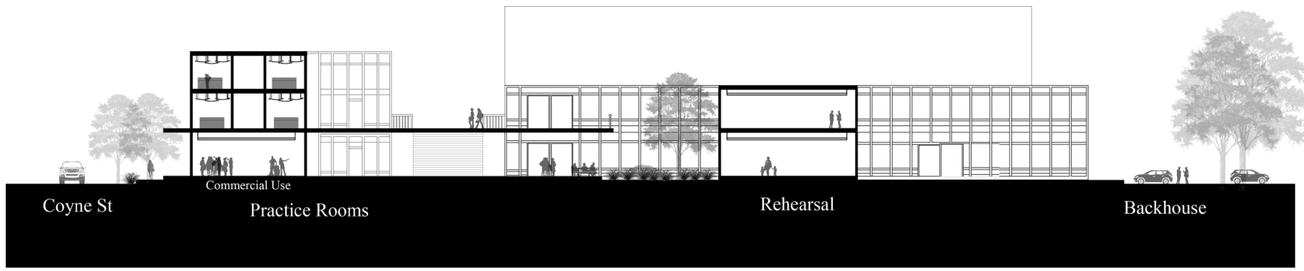
Figure 69: Site Plan
(Source: Author)

Building Plan

Figure 70: Building Plan
(Source: Author)

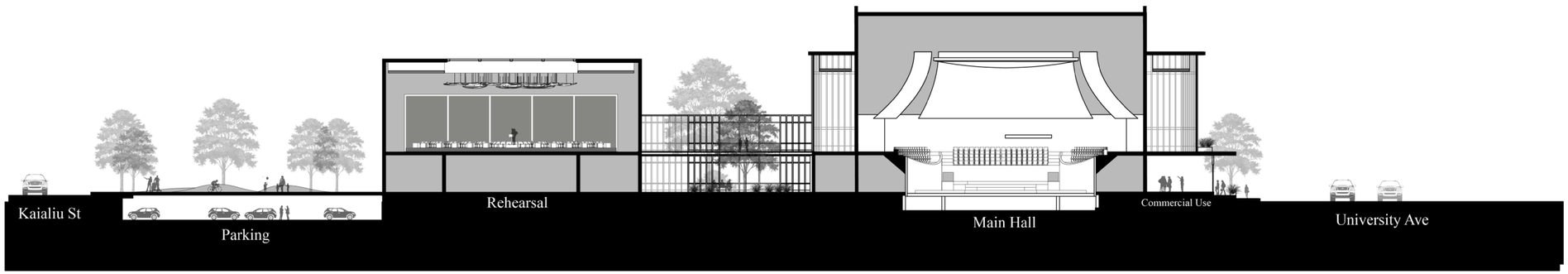
Site Sections





A101

0’ 25’ 50’ 100’



A102

0’ 25’ 50’ 100’

Figure 71: Site and Building Sections
(Source: Author)

Figure 72: Southeast Front Facade Entrance
(Source: Author)

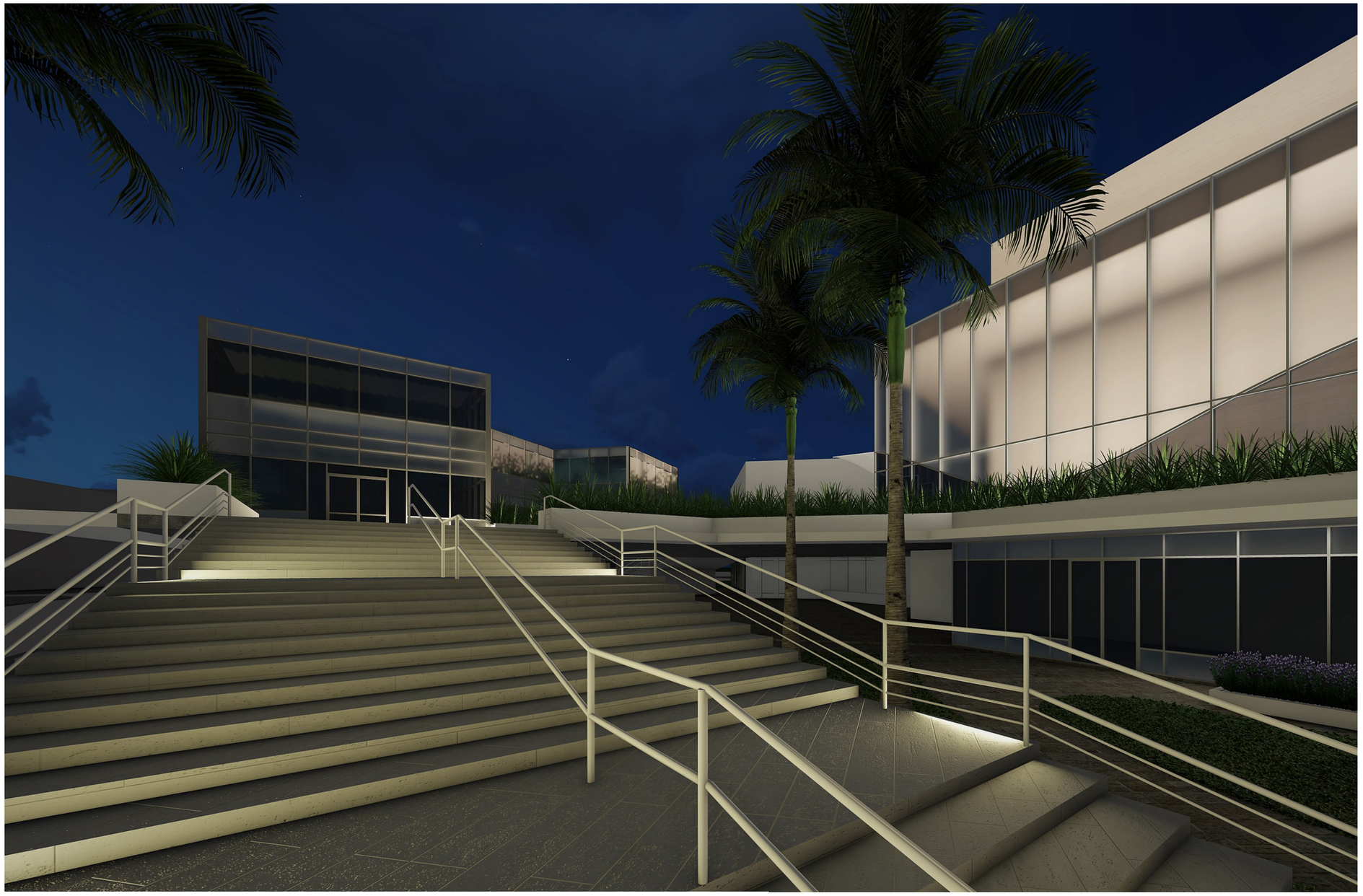


Figure 73: Stair PLaza
(Source: Author)

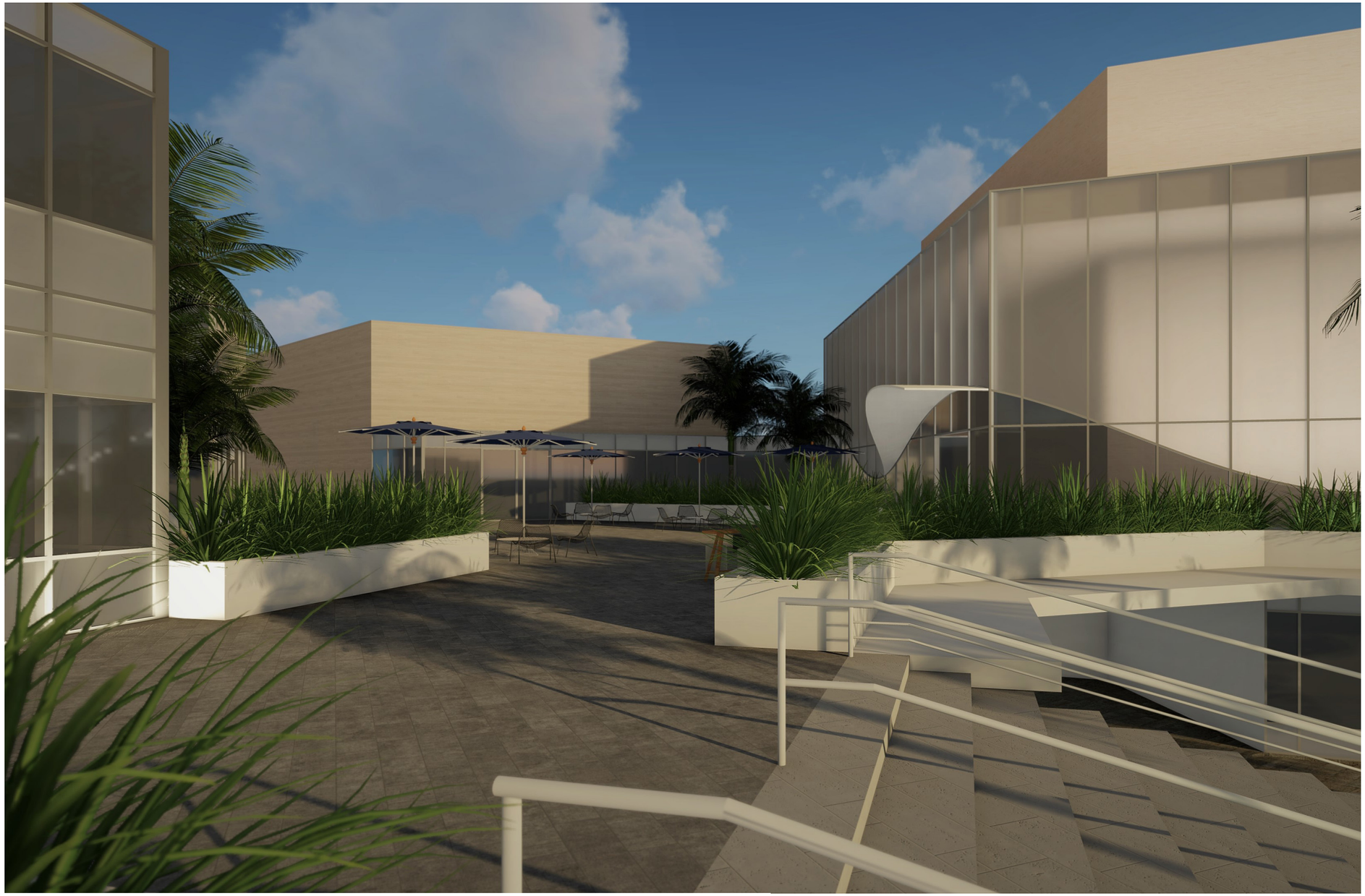


Figure 74: Central Plaza View
(Source: Author)

Figure 75: Pre Concert Space in Lobby
(Source: Author)

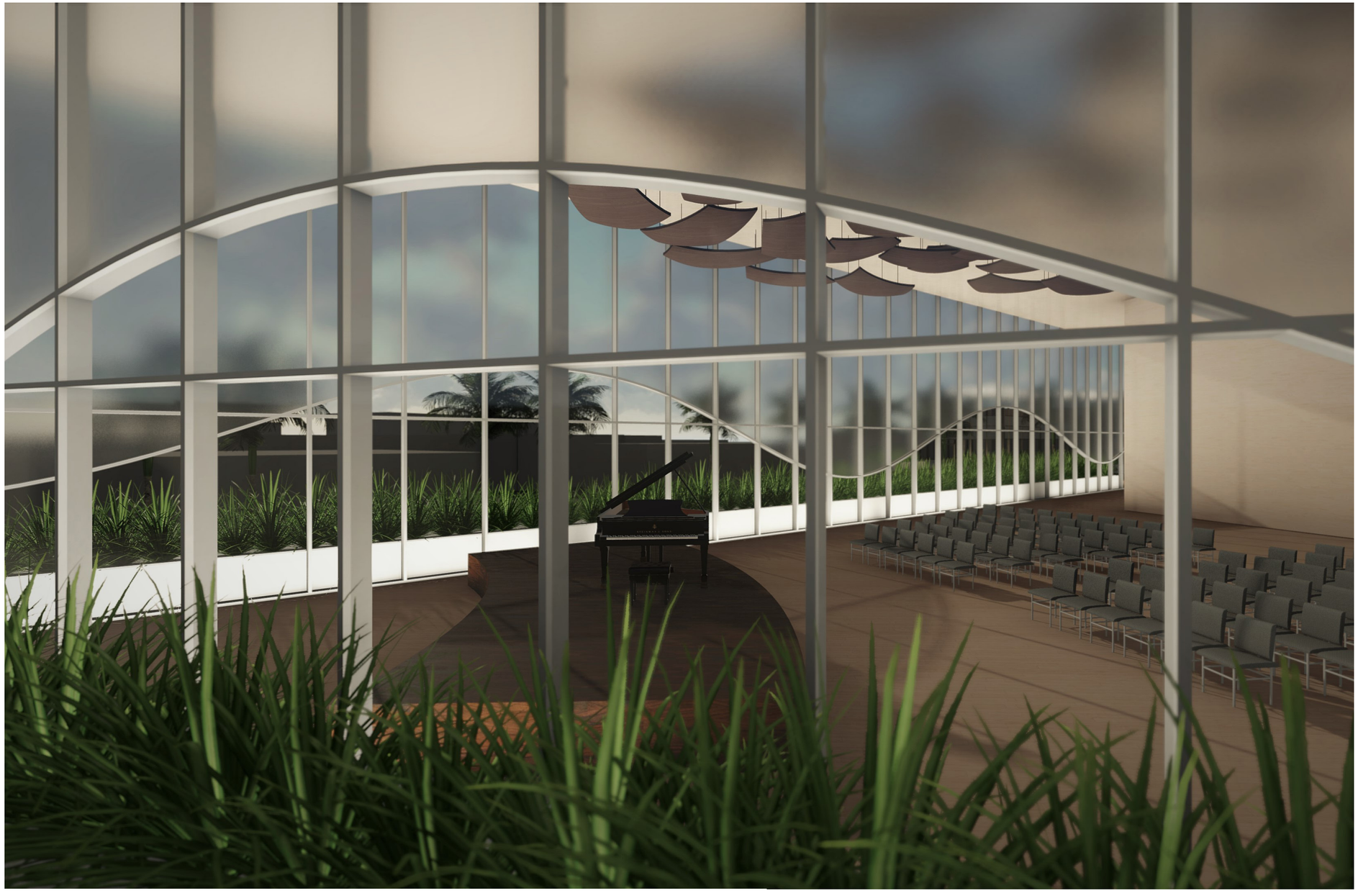


Figure 76: Pre-Concert Space
(Source: Author)

Figure 77: Main Concert Hall
(Source: Author)

Figure 78: Main Concert Hall Perspectives
(Source: Author)

Figure 79: Top: Rehearsal Space / Bottom: Practice Room and Hallway
(Source: Author)

CHAPTER 8:

CONCLUSION

Summary

The human voice is an essential tool that utilizes the oral language to define our surroundings and experiences. Architecture is an expression that conveys beauty and function. When words are incapable of describing what we see, hear, and feel, architecture reveals a unique sensory for visual and spatial experiences. The convergence of the human voice and architecture divulges into a research project with a comprehensive approach for building design.

In the design of a music performance hall facility, the synergistic dynamism of the vocal system provides a design guideline that integrates the spatial and functional principles of the oral voice production. The project investigation offers a methodology that describes the stages of the vocal processes. The stages of contraction, respiration, phonation, resonation, and articulation provide principle concepts that explain the dynamic mechanism of the vocal engine. Theses stage were described through diagrammatic illustrations to see the potential for architectural translation. The concepts translate into architectural elements that pertain to a performance hall typology.

Through five building case studies, the method of translation considers the functional and spatial aspect of a performance hall facility. From the concept of contraction to the articulation of vibrations for vocal sound, each of the stages present architectural elements that support the facility's primary objectives. In architecture, contraction resembles the ability of the facility to present interesting and exciting

amenities for the community into the site. Respiration provides building volumes that support social interactions and gatherings pertaining to a performance event. Phonation defines the act of performance where the performer and audience create a unique experience resembling the creation of vocal sound. Architectural resonation brings the element of light to give brightness and clarity to a space. Articulation organizes architectural features such as seating and stage arrangements and acoustical treatments the influence the ambiance and characteristics of a space.

The application of the methodology verifies that the concepts of vocal production are effective design approach for a concert hall facility. All of the principle concepts are geared to producing a performance hall facility that caters to the vision of the Music Department of the University of Hawaiʻi at Mānoa. The facility hopes to support the institutional and economical purpose of the site, but most importantly, it aims to invigorate the music and performance culture into the daily activities of the people for a thriving community.

BIBLIOGRAPHY

Alderson, Richard. 1979. Complete handbook of voice training. West Nyack, N.Y.: West Nyack, N.Y. : Parker Pub. Co.

Barbereux-Parry, M. 1979. Vocal resonance : its source and command. North Quincy, Mass.: North Quincy, Mass. Christopher Pub. House.

Bauer, Karen Tillotson. 2013. The essentials of beautiful singing : a three-step kinesthetic approach. Lanham, Md. Scarecrow Press.

Bing Concert Hall. Ennead Architects. Digital Images. Accessed December 26, 2017. https://www.archdaily.com/335092/bing-concert-hall-ennead-architects/?ad_source=myarchdaily&ad_medium=bookmark-show&ad_content=current-user

Brosnahan, L. F.. 1970. Introduction to Phonetics. Cambridge. W. Heffer and Sons Ltd

Crelin, Edmund S. 1987. The Human Vocal Tract: Anatomy, function, development, and evolution. New York. Vantage Press, Inc

Dayme, Meribeth Bunch. 1995. *Dynamics of the Singing Voice*. New York. Springer-Verlag Wien New York

Doscher, Barbara M. 1994. The functional unity of the singing voice. Metuchen, N.J.: Metuchen, N.J. : Scarecrow Press

Edgerton, Michael Edward. 2004. The 21st-century Voice : Contemporary and Traditional Extra-normal Voice. Lanham, MD. Scarecrow Press Inc.

Henderson, W. J.. 2005. Vocal Exercises, the Ultimate Collection: Giovanni Battista Rubini, Sheet Music CD

Holl, Steven. Architectonics of Music; Documentary. http://architectonics ofmusic.com/

Holl, Steven. 2003. Steven Holl. New York, NY. Rizzoli International Pub. Inc.

Get Body Smart. 2013. Respiratory System – Anatomy and Physiology https://www.getbodysmart.com/ap/respiratorysystem/lungs/bronchioles/tutorial.html

Jones, Rennie. AD Classics: Walt Disney Concert Hall. Digital Images. Accessed January 18, 2018. https://www.archdaily.com/441358/ad-classics-walt-disney-concert-hall-frank-gehry

Lynch, Patrick. MAD Architects Unveils Design for Translucent China Philharmonic Hall in Beijing. Digital Image. Accessed on January 19, 2018. https://www.archdaily.com/797604/mad-architects-unveils-design-for-

translucent-china-philharmonic-hall-in-beijing/?ad_source =myarch daily&ad_medium=bookmark-show&ad_content=current-user

Lynch, Patick. Steven Holl and Jessica Lang's "Tesseratcs of Time" Explores the Relationship Between Architecture and Dance. Accessed December 28, 2017. https://www.archdaily.com/797079/steven-holl-and-jessica-langs-tesseracts-of-time-explores-the-relationship-between-architecture-and-dance/?ad_ source =myarchdaily&ad_medium=bookmark-show&ad_content=current-user

Rory Scott. Digital Images. Accesssed November 26, 2018. These Architects' Drawings of Human Figure Offer and Insight Into Their Minds. https://www.archdaily.com /784121/these-architects-drawings-of-human-figures-offer-an-insight-into-their-minds

Rosenfield, Karissa. BIG Selected to Design Human Body Museum in France. Digital Images. Accessed December 21, 2017. https://www.archdaily.com/450388/big-selected-to-design-human-body-museum-in-france/?ad_source=myarchdaily &ad_medium=bookmark-show&ad_content=current-user

New World Center / Gehry Partners. Digital Image. Accessed January 18, 2018. https://www.archdaily.com/ 107112/new-world-center-frank gehry/?ad_source= myarchdaily &ad_medium=bookmark-show&ad_content=current-user

New World Symphony. WallCast: Concerts and Park Event. Digital Image. Accessed February 4, 2018. https://www.nws.edu/events-tickets/wallcast-concerts-and-park-events/

Marek, Dan. 2013. Giovanni Battista Rubini and the bel canto tenors: history and technique. Lanham, MD : Scarecrow Press

Meyer, George Hermann Von. 1892. Organs of speech and their application in the formation of articulate sounds. The International Scientific Series. Vol. 47. London. Kegan Paul, Trench, Trubner and Co. Ltd

Morrison, William.2012. Soft Palate. Science Direct. http://www.sciencedirect.

com/topics/medicine-and-dentistry/soft-palate

Seashore, Carl E. 1936. Psychology of the vibrato in voice and instrument. edited by Iowa University of. Iowa City, Ia.: Iowa City, Ia. : University Press.

Shearer, William. 1979. Illustrated speech anatomy. Springfield, Illinois. Charles C Thomas Pub.

Stanton, Royal. 1971. Steps to singing for voice classes. Belmont, Calif.: Belmont, Calif., Wadsworth Pub. Co.

Ulrich, Bernard. 1973. Concerning the Principals of Vocal Training during the A Capella Period and until the Beginning of Opera (1474-1640). Minneapolis, MN: Pro Music Press

Virtual Linguistics Campus. 2013. PHO103 – Speech Anatomy. https://www.youtube.com/ watch?v=-m-gudHhLxc

Voxman Music Building/ LMN Architects. Digital Image. Accessed January 16, 2018. https://www.archdaily.com/886640/voxman-music-building-lmn-architects /?ad_source=myarchdaily&ad_medium=bookmark-show&ad_content=current-user

Whitlock, Weldon. 1968. Bel canto for the twentieth century. Champaign, Ill.: Champaign, Ill. Pro Musica Press.