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Connecting the Built and External Environments Through Architectural Compositions

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Connecting the Built and External Environments Through Architectural Compositions

A study regarding architectures' potential to address the separation of humanity and nature.

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Honors Project

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How can I create an architectural form which addresses the stark delineation between the external environment and the built environment? Can this form promote a positive relationship between the built environment and the external environment, while also promoting positive growth? What benefits can this form have on its surroundings? This project aims to answer these questions through the generation of an architectural composition as a method for studying the interaction between the built environment and external environment. The composition responds to the issue of water collection through generating a visually interesting way of guiding water into a collection area by taking influence from the temple tank water collection system. Constructed at a small scale, the composition has the ability to respond to the immediate environment and show that the built environment can have a positive impact on the external environment. This also will help in defining architectures roll in addressing the separation of humanity and nature by synthesizing the creative approach that architecture fosters, and the analytical, research-based approach which is promoted within the realm of climatology.

The environment is constantly changing. While most changes are natural, others are unnatural and have the potential to cause disturbances. These changes cause the ecosystem to be transformed from its natural condition resulting in a disturbed site, which lacks the characteristics of its natural state[1]. Once the factor causing these ecological changes ceases to affect the ecosystem, succession may begin to occur. This process is recognized by the

[1] *Disturbed Ecosystems* 2014.

sequential shift of the variety of species within an ecosystem. There are two types of succession: primary and secondary. Primary succession occurs when the ecosystem has been severely changed, while secondary succession occurs when there is a high level of soil development and nutrients to promote new ecological growth[2]. The previously cultivated farmland of the project area is highly susceptible to secondary succession, as regeneration of the land can occur quickly due to the highly developed soils present in the cultivated farmland. Succession can occur at different paces, and creates a spectrum of succession, ranging from annual weeds and shrubbery, to early and late successional tree growth[3]. An increased awareness of ecological succession has brought water into the conversation by using it as a medium to understand the environment.

Architecture began as an attempt to achieve a balance between the external environment and the built environment, reinforcing the idea that the idea of sustainability in architecture is not a new concept. An example of this is the practice of vernacular architecture, which highlights the holistic interaction between a societies' culture and interactions with nature[4]. Vernacular architecture is a part of a larger architectural idea: phenomenology. Phenomenology is centered around the experience of the human being, and in an architectural sense translates into an experience of the senses. Phenomenology is a useful tool in designing the experience of a space and serves as a tool to elicit a bodily response through sight, touch,

[2] Walker, Lawrence R. "*Ecological Succession*." In *Encyclopedia of Environmental Change*, edited by John A. Matthews, 324. Thousand Oaks,, CA: SAGE Publications, Ltd., 2014.

[3] Meatyard, Barry. 2007. *Ecology – from Individuals to Ecosystems, 4th Ed., Michael Begon, Colin R. Townsend, John L. Harper, Blackwell Publishing, Oxford, 2005, 738 Pages, Price £37.50 (Paperback) ISBN: 1405111178*. Vol. 135 Elsevier Ltd.

[4] Kırbaş, Berrak and Neslinur Hızlı. 2016. "Learning from Vernacular Architecture: Ecological Solutions in Traditional Erzurum Houses." *Procedia - Social and Behavioral Sciences* 216: 788-799.

and sound. We are constantly surrounded by architecture, and thus are constantly surrounded by new sensory experiences. Since we are constantly surrounded by new sensory experiences, the experiential quality is expressed through the human body as the medium for experience. The result of this experience is a deeper understanding of what the realm of architecture is, and an understanding of architectural significance[5]. Water is the medium in which one would experience the final design of this project.

Water is a part of our everyday life, and we interact with water in one way or another on a daily basis. Water is volatile, fragile, devastating, nourishing, and ultimately spatial. This dynamic allows for a unique application of water in an architectural sense[6] (Lorback). Water is an element that can be used as a tool to promote a phenomenological experience due to its ability to influence ones' emotions. Temple tanks act as a medium for this, as they are a water collection system with both social and ecological benefits.

Systems which capture water for later use propose a unique design challenge. Throughout human civilization, there have been many design solutions proposed, most with one thing in common: they all collect water in one way or another. The temple tanks and step wells of India stand out due to the unique social environment generated by their installation[7]. Temple tanks are a culmination of the cultural sensitivity to water in Hindu philosophy, as they generate a community space. They are typically either square or rectangular in shape and are

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[5] Rush, Fred Leland. 2009. *On Architecture*. First ed. New York: Routledge.

[6] *Phenomenology Online » Lorback, Colin. Water Experience*. Www.Phenomenologyonline.com/Sources/Textorium/Lorback-Colin-Water-Experience/.

truncated and trapezoidal in section, staggering from top to bottom. At the bottom of the tank there is a well which links the aquifer and tank. This link allows for natural discharge of the retained water to occur. This is ideal to water harvesting, water storage, and the recharging and refilling of the aquifer. These factors make this a sustainable solution for controlling the microclimate of the site. The storage of the water allows for an area in which water can be drawn from during periods of low rainfall. The temple tanks help to prevent soil erosion and wasting excess runoff water during periods of heavy rainfall and begin to form their own miniature ecosystems[8].

A case in which this phenomena is found is the Kaliadeh Palace temple tank outside of Ujjain, India. This system consists of 52 ponds of varying sizes and depth which originated as storage tanks that doubled as reservoirs (Appendix A). Water enters this system through small water channels at the entrance and moves from one pond to another through connecting channels. Water exits the system via a waterfall which allows the water to flow into a nearby river. As seen in Appendix A, the accessibility of site features is limited and restricted following times of heavy rainfall. This design facilitates a large amount of public interaction while being functional[9].

There are many architectural designs inspired by nature, and Las Palmas Water Theater is no exception (Appendix B). Designed by British architecture Nicholas Grimshaw, this project is located in the port city of Les Palmas in the Canary Islands. The theater's design was inspired by

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[8] M.Alaguraj1, C. Divyapriya2 & S. Lalitha3. 2017. "Temple Tanks-the Ancient Water Harvesting Systems and their Multifarious Roles.".

[9] Pandey, Dr Anjali. 2018. "Water Management System of Kaliyadeh Mahal.".

the water collection properties of the Namibian desert beetle that collects water through fog. The scheme considers the surrounding wind and sun properties, relying on the wind to bring seawater into the evaporators in the design. There are numerous solar thermal panels on this design that heat the moisture from the wind blowing through. The solar panels act as trays that are used to collect the condensed water. In addition to collecting water, this design also works as a desalination plant. The design houses a public venue for the performing arts as well as collecting water in a visually interesting way[10]. This design emphasizes the idea that architecture is forward thinking, always looking to address the next problem.

Architecture is always based on future projection, and the future projections for Northwest Ohio predict that dry and very dry growing seasons will double in the years 2041-2070 as compared to the years 1984-2013. Systems which capture water for later usage have potential to help alleviate this issue, while being sustainable and cost effective[11]. Considering that, this project will aim to address a potential issue targeting Northwest Ohio in the future. Identifying a location of study provides contextual issues that can be studied through small-scale compositions.

Data was gathered from the National Centers for Environmental Information, otherwise known as NCEI. The NCEI is a division of the National Oceanic and Atmospheric Admistration, otherwise known the NOAA. The NCEI provides access to a large database of oceanic,

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[10] Brown-Toganivalu, Sarah. “Bio-Mimicry: Water Collection or Treatment Systems of Water Using Systems Research.” spatialdesign, March 18, 2009.

[11] Baule, William, Barry Allred, Jane Frankenberger, Debra Gamble, Jeff Andresen, Kpoti M. Gunn, and Larry Brown. 2017. "Northwest Ohio Crop Yield Benefits of Water Capture and Subirrigation Based on Future Climate Change Projections." *Agricultural Water Management* 189 (C): 87-97.

atmospheric, and geophysical data from across the earth. The NCEI collects data regarding rainfall amounts, temperature, atmospheric pressure, and many other data points. For this study, rainfall amounts were collected for Putnam County in Northwest Ohio, as this was chosen as the site for study. As the Putnam County Airport does not collect rainfall amounts, data from the Findlay Airport was used. The Findlay Airport is approximately 35 miles from the area of study. This was the nearest data collection point with reliable data[12].

A major component of architecture that interacts with the environment is the consideration of the local context. This approach is realized through experimental small-scale projects that are less subjected to the constraints of globalized architecture, as these projects are designed and constructed within local contexts. Working at a small-scale is preferred to working at medium and large-scales as they are frequently driven by considerations that are prohibitive to experimentation. Small-scale projects tend to offer a broader scope of possibilities that are enhanced if they are understood as experimental and developed within research-oriented environments[13]. Studying the interactions of the building envelope provides a method at which small-scale projects can be studied.

The building envelope plays a crucial role in the interaction between the built environment and the external environment, as the building envelope is the interface between the built environment and the external environment. In technical terms a surface is defined as a plane separating two different media, and the interface of a surface has a possibility to produce

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[12] "Products." National Climatic Data Center.
[13] Hensel, Michael, and Jeffrey P Turko. *Grounds and Envelopes: Reshaping Architecture and the Built Environment*. London: Routledge, Taylor & Francis Group, 215.

climatic effects. The active boundary is oftentimes defined as the plane at which climatic activity is occurring in a system. It is at this layer where precipitation is intercepted[14]. These strategies are useful in bridging the disconnect between the two environments as the spaces adjacent to existing architectures have the possibility to impact the environment. Furthermore, this decreases the amount of completely new construction that would need to occur. Often times these strategies are executed using membrane systems as they can replicate foliage and vegetation systems and their interactions with the environment. These auxiliary systems become mechanisms that aid in understanding the impact the built environment has on the immediate external environment. For architectural design, the initial focus should be on the scale of a singular external environment, with opportunities to be scaled up to a larger focus after the process is understood. The initial focus on the immediate external environment has the possibility to gain a better understanding of the interaction of the built environment with the external environment. Grounds and envelopes are the points at which introduced modifications have an impact on the external environment. Studying these points questions how the built environment positively interacts with the external environment. This is done on a larger scale through policies which usually do not consider the nuances of each small scale environment. By understanding the way in which grounds and envelopes interact, the completed design considers the needs of the specific environment, mediating the interaction

[14] Oke, T. R. *Boundary Layer Climates. 2nd Ed.* London: Methuen (reprinted by Routledge), 1987.

between the built and external environments[15].By understanding the construction method, one can understand how the built piece interacts with the environment.

An important part of the architectural process is the craft of the construction: whether it's the joinery used, or the technique used to develop the final product. From the numerous different techniques for bending sheet materials, kerf bending was chosen for its simplicity and flexibility. Kerf bending is a method of cutting sheet materials typically used in woodworking applications. Originally, a kerf was defined by the amount of material removed by a saw, due to the width of the saw blade. With technological advancements such as the laser cutter, a kerf is not commonly referred to as the width of the material removed by the cutting process[16]. This fabrication technique is executed using a series of cuts within close proximity of each other called kerfs. Kerfing increases the flexibility through the subtraction of material, which modifies the resistance of the material. Utilizing the kerf bending technique provides a simple, yet effective way to create a three-dimensional form out of a two-dimensional planar surface. This technique was used as it is a cost-efficient design-to-fabrication approach, due to not needing the use of a mold, which is a time-consuming portion of the fabrication process[17].

Kerf bending creates a folded architectural composition rethought in a new, creative way. The two-dimensional surface generates a three-dimensional spatial condition that provides a geometric relationship between the surface and the volumetric configuration of the

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[15] Hensel, Michael, and Jeffrey P Turko. *Grounds and Envelopes: Reshaping Architecture and the Built Environment*. London: Routledge, Taylor & Francis Group, 215.

[16] Capone, Mara and Emanuela Lanzara. 2019. "Parametric Kerf Bending: Manufacturing Double Curvature Surfaces for Wooden Furniture Design." *Digital Wood Design*: 415-439. doi:10.1007/978-3-030-03676-8_15.

[17] Mitov, Dejan, Bojan Tepavčević, Vesna Stojaković, and Ivana Bajšanski. 2019. "Kerf Bending Strategy for Thick Planar Sheet Materials." *Nexus Network Journal* 21 (1) (/04/01): 149-160. doi:10.1007/s00004-018-0415-7.

composition. The expression of these configurations displays a competency in controlling production methods while also exploring the spatial development of the physical product. This design process reveals aspects of scale and construction which inform the final composition. Additionally, folded compositions establish a strong connection between the conceptual design and the physical fabrication process used. The potential of folded compositions within architecture have been explored by contemporary architects who claim to have used folding design processes in the conceptual stages of their projects, developing new spatial and material configurations. As the transformation of a physical form, folded compositions have the opportunity to act as a mechanism to formulate a design, while also providing a manufacturing solution. This production method is a clear example of a form-finding process of evolution, with the final solution transforming its spatial conditions while also expressing its creative potential[18]. The practice of kerf bending is focused on the removal of material to make a rigid material flexible.

There are three different kerf cut techniques to remove material, and they are: cutting on one side of the material, cutting on both sides, and cutting through the entire thickness of the material. Performing cuts on one side of the rigid material allows for the material to bend in one direction, and is often used in the fabrication of furniture. Cutting the material on both sides allows the material to be bent and twisted and can eventually result in three-dimensional shapes. Cutting through the entire thickness is the most efficient method to creating a surface which can be bent in two directions, and proved to be the most useful cutting technique as the

[18] Chiarella, Mauro and Rodrigo García Alvarado. 2015. "Folded Compositions in Architecture: Spatial Properties and Materials." *Nexus Network Journal* 17 (2) (/07/01): 623-639. doi:10.1007/s00004-014-0226-4.

areas in which material was removed allows for water to soak through. By subtracting material, its resistance is modified, allowing for the surface to be bent in two directions. Pattern distribution on the surface is also useful in increasing the flexibility of the panel, as well as creating a design that is aesthetically pleasing[19].

Architecture is fundamentally a material practice, using the design process to experiment with different materials. Conventional materials are continually put to unexpected uses and used in untraditional ways, bringing into focus the long-established conceptions of materials within architecture. Materials such as fiberglass, polymers and foams that are not widely used in the building industry are becoming more commonplace within the building industry. These materials are lightweight, high strength, and can easily be transformed into various forms, proving their place as a material for structural skins. These materials require curvilinear geometries to enable them to act structurally. However, these materials often can transform over time, which is why they were overlooked in the past. This quality has recently become attractive to the field of architecture, as designers are looking towards nature to discover new materials and new material behaviors so that building enclosures can respond dynamically to environmental conditions. Material effects are performative, and we understand the material by sensing how they work. Their performance is evaluated by their physical and perceptual qualities: the appearance of the material matters as much as how the material interacts with the environment. Materials and their properties make architecture a multi-sensory experience, as one can interact with the materials. By understanding the properties of

[19] Capone, Mara and Emanuela Lanzara. 2019. "Parametric Kerf Bending: Manufacturing Double Curvature Surfaces for Wooden Furniture Design." *Digital Wood Design*: 415-439. doi:10.1007/978-3-030-03676-8_15.

a material, designers can push the limits of the material, while still considering their aesthetic and phenomenological aspects[20]. (manufacturing material effects).

A series of 21 prototypes were made using a laser cutter. Mylar, a thin plastic material, and plexiglass were used to produce these prototypes. All of the prototypes were made with cuts through the entire thickness of the material. This allowed one to understand how the cuts made the material move in different ways. The series of prototypes were produced in groups, in which a few prototypes were generated, and then tweaked based on how their cuts affected the material. The tweaks involved changing the distance between cuts and the lengths of the cuts, as well as testing different orientations of cuts. A few prototypes were made using plexiglass, however, they did not allow the plexiglass to bend, and broke during the process of trying to bend them. Through this evaluation, mylar was chosen as the final material, as its thickness allowed for the greatest movement of material.

Following the execution of the cuts, their performance with water was evaluated. Their performance was evaluated by considering how the water interacted with the prototype and how effective the prototype was in collecting water. The prototypes were tested using the highest rainfall amount from 2019: three inches. This was done as it allowed for the prototype to perform under a large rainfall event. A container with holes in the bottom was used to simulate the rainfall. The water was placed in this container, and held over the prototypes, with water collection devices at the end of the system to collect the water that made it through the system. After the container was empty, the amount of water collected was measured and

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[20] Kolarevic, Branko, 1963 and Kevin R. Klinger. 2008. *Manufacturing Material Effects: Rethinking Design and Making in Architecture* Routledge.

recorded as an evaluation of the effectiveness of the prototype. All of the prototypes were tested, however, only two were studied in depth due to their flexibility and permeability. Each prototype was tested three times in order to verify the results.

The two protypes tested were 'Prototype 9' and 'Prototype 18' (See Appendix C). These two were chosen as their cuts allowed the material to be manipulated to increase the largest amount of permeability. Each prototype was tested independently from one another. 'Prototype 9' produced an unmeasurable amount of water each time the test was run. 'Prototype 18' produced 1/8" of water each time the test was run. After running these tests, it was determined that these prototypes were too permeable and were unable to direct water along their surfaces. A flat piece of mylar was placed underneath the prototypes at a depth of 1/8" as an impermeable layer. The tests were then rerun. 'Modified Prototype 9' was then tested three times, with the average of the water collected being 2-1/8" of water. 'Modified Prototype 18' was tested for three times, with the average water collected being 2-1/4" of water.

While collecting water is a large part of this project, the experience of the system is also a component of its effectiveness. Each prototype was evaluated based on how water moved throughout the system. 'Prototype 9' produced a visually interesting condition when water was introduced. Instead of collecting on the top of the prototype, the water hung from the bottom of the prototype, through cohesion. It is unknown why this prototype produced this effect. 'Prototype 18' did not produce a visually interesting condition when water was introduced. The material did not allow for water to collect on it, and the water just passed through. This did not perform in a visually interesting way. 'Modified Prototype 9' produced a visually interesting condition when water was introduced. However, it was lessened by the flat mylar sheet placed beneath the top layer. The water which collected underneath the top layer still existed, just could not be seen easily seen. 'Modified Prototype 18' produced a visually interesting condition when water was introduced. The water passed through the top layer and collected on the bottom layer. The force of the water hitting the top layer was enough to push it into the bottom layer, and through cohesion, was stuck together. When new water was not introduced on the prototype, the top layer began to slowly separate from the bottom layer. With each separation, a little bit more water was released, until the two layers were completely separate from each other.

The results of these tests support the conclusion that 'Modified Prototype 18' is the most effective prototype system for water collection that was tested. 'Modified Prototype 18' was objectively concluded to be most effect prototype in producing a visually interesting experience. Considering both situations, it is concluded that 'Modified Prototype 18' is the most successful prototype is both water collection and producing a visually interesting experience. From the prototypes suggested, using 'Modified Prototype 18' would be the best solution to design problem.

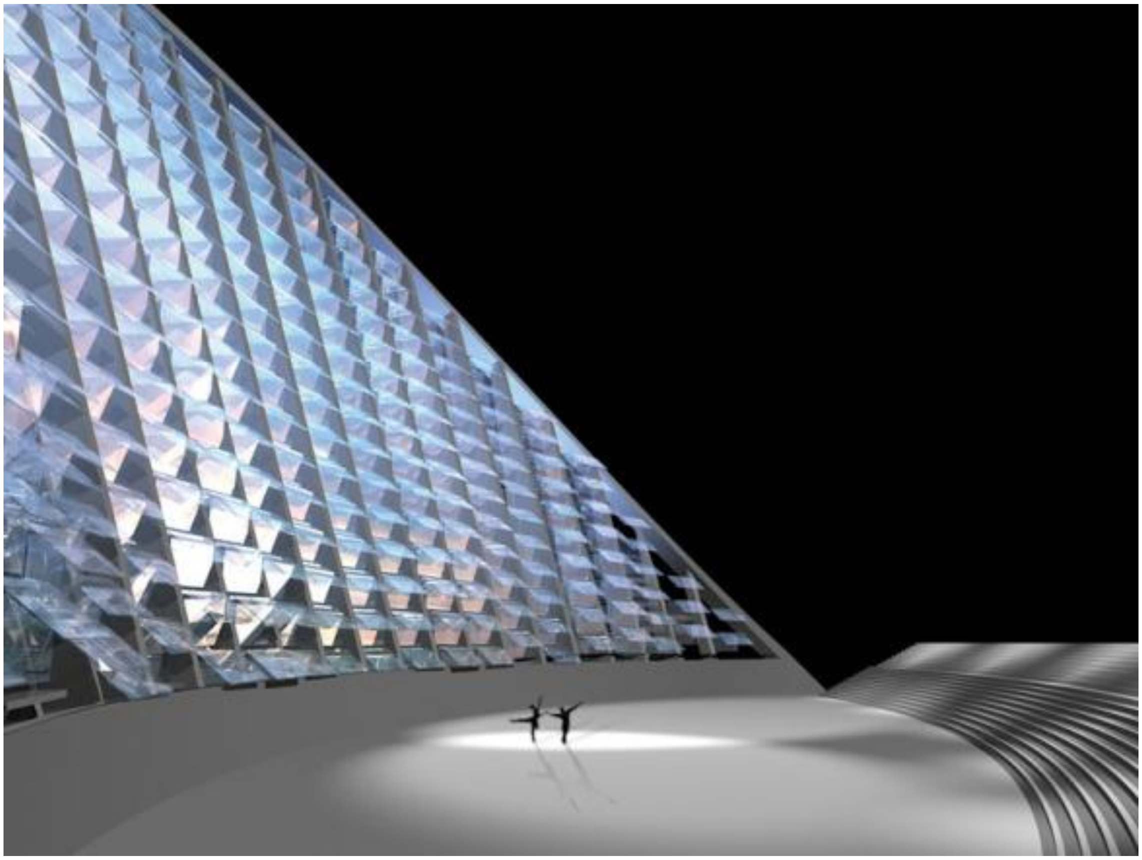
A limitation of this study was the availability of fabrication tools. The only fabrication tool available was a laser cutter, which greatly limited the study to planar limitation. This led to the kerf cutting technique being chosen, as it one of the only methods available to give a two-dimensional object a three-dimensional quality. Having access to other fabrication tools would have allowed for a wider range of possible solutions to be developed. Additionally, accuracy could be increased by having a more precise way of simulating rainfall. While a container with holes in the bottom of it does allow the correct amount of water to be introduced on each prototype, the intensity and water distribution may be slightly unrealistic.

In conclusion, this project addresses the delineation between the external environment and the built environment by creating an architectural form within the built environment which interacts with the external environment. The architectural form takes on the form of prototypes which act as a water collection system within the external environment, while also belonging to the built environment. The prototypes are used as a medium of understanding a natural process. This form promotes a positive relationship by addressing a future design issue: water collection. The resulting system collects water, while also doing so in a visually interesting way. The positive relationship is realized through the interaction between the prototype and the introduction of the water. This project has the possibility of benefiting its surroundings by providing a visually interesting way to experience water collection. This can become a learning tool to explain how water collection can work, as well as being a viable method for collecting water.

The research suggests that ‘Modified Prototype 18’ is the most successful tested method of collecting water while doing it in a visually interesting way. As there is a possibility of water becoming more scarce, this solution has the potential to be a useful solution to this issue. Ultimately, this solution uses an architectural approach to an ecological issue. By using the design process, the solution reacts to the issue of water collection by proposing a system that collects water.

Appendix A

Appendix B



Appendix C

Prototype 9

Prototype 18

Modified Prototype 9

Modified Prototype 18

Bibliography

Brown-Toganivalu, Sarah. “Bio-Mimicry: Water Collection or Treatment Systems of Water Using Systems Research.” spatialdesign, March 18, 2009. http://www.spatialdesign.info/blog/ wp- content/uploads/2009/03/302_09_biomimetics_small3.pdf.

Baule, William, Barry Allred, Jane Frankenberger, Debra Gamble, Jeff Andresen, Kpoti M. Gunn, and Larry Brown. 2017. "Northwest Ohio Crop Yield Benefits of Water Capture and Subirrigation Based on Future Climate Change Projections." *Agricultural Water Management* 189 (C): 87-97.

Capone, Mara and Emanuela Lanzara. 2019. "Parametric Kerf Bending: Manufacturing Double Curvature Surfaces for Wooden Furniture Design." *Digital Wood Design*: 415-439. doi:10.1007/978-3-030-03676-8_15. https://link-springer-com.ezproxy.bgsu.edu/chapter/10.1007/978-3-030-03676-8_15.

Chiarella, Mauro and Rodrigo García Alvarado. 2015. "Folded Compositions in Architecture: Spatial Properties and Materials." *Nexus Network Journal* 17 (2) (/07/01): 623-639. doi:10.1007/s00004-014-0226-4. https://link-springer-com.ezproxy.bgsu.edu/article/10.1007/s00004-014-0226-4.

Hensel, Michael, and Jeffrey P Turko. *Grounds and Envelopes: Reshaping Architecture and the Built Environment*. London: Routledge, Taylor & Francis Group, 2015.

Kırbaş, Berrak and Neslinur Hızlı. 2016. "Learning from Vernacular Architecture: Ecological Solutions in Traditional Erzurum Houses." *Procedia - Social and Behavioral Sciences* 216: 788-799.

Kolarevic, Branko, 1963 and Kevin R. Klinger. 2008. *Manufacturing Material Effects: Rethinking Design and Making in Architecture* Routledge. http://bgsu.summon.serialssolutions.com/2.0.0/link/0/eLvHCXMwdV07T8MwED7xWCo68GgFlET5A0Xh_EpGVLViYYI9cuzzmAlWfjt-pHVTwXg6ydJZJ5_v832fARg-1-uTM0GiIftilTa-HPYSta98SKi5dHVtSEwf0w-qOVNpHZuRC2x95yabnw_frZ9zxtOfDRlciToramSgKyUU50eGwCy9E53N1A68v6yYnUrN7houAv3gBs5ouIWr1yOc_w7Kdz18BypC5BZW_rIZ86cahzIWUOy2n5u3dVi0G4GZbh8F4hLmOgy0D1-R-GbvoTJaOmFJtcQY59S3yldbpnkjpVWC3AMs_17s8T_HCmZp2CHgB09w6Xx-U5ECLeP-_QKrn3IW.

M.Alaguraj1, C. Divyapriya2 & S. Lalitha3. 2017. "Temple Tanks-the Ancient Water Harvesting Systems and their Multifarious Roles.".

Meatyard, Barry. 2007. *Ecology – from Individuals to Ecosystems, 4th Ed., Michael Begon, Colin R. Townsend, John L. Harper, Blackwell Publishing, Oxford, 2005, 738 Pages, Price £37.50 (Paperback) ISBN: 1405111178*. Vol. 135 Elsevier Ltd.

Mitov, Dejan, Bojan Tepavčević, Vesna Stojaković, and Ivana Bajšanski. 2019. "Kerf Bending Strategy for Thick Planar Sheet Materials." *Nexus Network Journal* 21 (1) (/04/01): 149-160.

doi:10.1007/s00004-018-0415-7. https://link-springer-com.ezproxy.bgsu.edu/article/10.1007/s00004-018-0415-7.

O'Hare, Gregory. "*Disturbed Ecosystems*." In *Encyclopedia of Environmental Change*, edited by John A. Matthews, 288. Thousand Oaks,, CA: SAGE Publications, Ltd., 2014. doi: 10.4135/9781446247501.n1094.

Oke, T. R. *Boundary Layer Climates. 2nd Ed.* London: Methuen (reprinted by Routledge), 1987.

Pandey, Dr Anjali. 2018. "Water Management System of Kaliyadeh Mahal.".

Phenomenology Online » Lorback, Colin. Water Experience. Www.Phenomenologyonline.Com/Sources/Textorium/Lorback-Colin-Water-Experience/. http://www.phenomenologyonline.com/sources/textorium/lorback-colin-water-experience/.

"Products." National Climatic Data Center. Accessed February 21, 2020. https://www.ncdc.noaa.gov/isd/products.

Rush, Fred Leland. 2009. *On Architecture*. First ed. New York: Routledge.

Walker, Lawrence R. "*Ecological Succession*." In *Encyclopedia of Environmental Change*, edited by John A. Matthews, 324. Thousand Oaks, CA: SAGE Publications, Ltd., 2014. doi: 10.4135/9781446247501.n1199.