Living Wall

Information Workflow and Collaboration

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Beyond the benefits of standard documentation agreement and project management coordination, many architects and other design professionals express concern over the limitation of Building Information Modelling (BIM) process may have on the design process, or better yet social responsibility or ecological benefit. For Living Wall facade exploration, this research suggests BIM is arguably an effective tool to support innovation in the design process, as well as promote collaboration between ecology and architecture disciplines. Ecological measures and data collection evidence further validates BIM procedural clarity and recognizes building facade exploration both technologically and environmentally.

Keywords: Living Wall, BIM, data collection

Since the early 2000s, Building Information Modelling (BIM) has become a necessary part of major building construction. Beyond the benefits of standard documentation agreement and project management coordination, many architects and other design professionals express concern over the limitation this modeling process may have on the design process, or better yet social responsibility or ecological benefit. This research suggests BIM is arguably an effective tool to support innovation in the design process, as well as promote collaboration between ecology and architecture disciplines. Ecological measures and evidence further validates BIM procedural clarity and recognizes building facade exploration both technologically and environmentally.

Facade greenery, or more specifically a living wall-a vertical plant system rooted in growing media attached to a wall-is suggestive of an alternative landscape approach in service to ecological enhancement. Such views of landscape move away from those traditionally ascribed by the human contrived Anthropocene era: cultivation, reflection, utilitarian. Instead, living walls offer opportunities for the architecture discipline to serve as a connected, interdependent whole (Anderson, 2017). In this manner, BIM technology assists in the appropriation of ecological benefits and furthermore, allows a post-construction actuality to negotiate a relationship between the built and natural world.

In May of 2016, a Living Wall pilot project was installed along the west façade of Goldsmith Hall, the primary building for the University of Texas at Austin’s School of Architecture (UTSOA). Investigating the role of ecology in architecture, the structure is comprised of a patent-pending honeycomb design, patent-pending soil media, SkySystem(TM) and
native flora specially selected to attract local fauna. Five years in the making, the project tests the limits of what is possible with living walls in central Texas through ongoing research, data collection and analysis. This paper documents multi-disciplinary living wall research and its installation in the hot and dry climate of Austin, Texas.

The project location (30°11’N. 97°52’W, elevation 247 m average annual precipitation 34.25 inch) is just blocks away from the State Capitol of Texas and is within a dense urban campus condition. According to U.S. Climate Data the sub humid, subtropical Austin climate experiences a bimodal rainfall pattern that often peaks in spring (May-June) and fall (September-October). In the summer months, the average high temperatures range between 87°F in May and 97°F in August. Additionally, nighttime temperatures tend to remain high in the summer months (>75°F) especially in the urban core. Central Texas also is prone to sporadic rainfall patterns and temperatures especially during periods of drought, where temperatures range even higher, precipitation levels fall, and the time between precipitation events increases. Warmer climates, such as Austin’s pose a number of problems for living wall designs due to high ambient air and soil temperatures, varied rainfall patterns and high evapotranspiration rates. For this reason, the pilot project investigation contributes to knowledge in urban heat mitigation using advanced applied BIM technique.

The primary goals of the project include: observing and testing living wall technology at the University to evaluate future use, providing a living laboratory to facilitate educational opportunity with students, faculty and staff, and contributing to the ongoing research on living wall systems around the world. The research conveys a multi-stakeholder workflow where BIM supports the design, fabrication, construction and metric of a customized, plant and eco-habitat façade. As a co-operative and academically funded project, the installation addresses the specific challenges of its regional climate from the perspectives of architecture, ecology and landscape departments. The design, installation and maintenance of the Living Wall is a collaborative effort between the School of Architecture and the Lady Bird Johnson Wildflower Center (Wildflower Center). Facilities Services and Landscape Services at the University oversees the irrigation system design and maintenance. The Jha Lab at the University of Texas at Austin’s Department of Integrative Biology performs invertebrate sampling and analysis.

Although many commercial living wall products exist, none found were suitable for sustainability in an extremely hot and dry climate. Many successful applications are often in mild or temperate climates; interior climate controlled conditions or focused solely on plant graphics or aesthetics (Van Uffelen 2015). Other academic research precedents have noted the importance of factors such as material efficiency, energy demands and waste production for an
Figure 2
Wall assembly showing final plant selection and distribution, bottom figure shows material differentiation for uniform versus eccentric geometric cells

- Little Bluestem
- Sideats Grama
- Mexican Feathergrass-Prairie Verbena
- Red Yucca
- Nolina (Bear Grass-Devil’s Shoestring)
- False Aloe
- Cross Vine
- Virginia Creeper
- Cork, pine, and cedar

**Acrylonitrile butadiene styrene (ABS)**
a common thermoplastic polymer: an economical, general purpose material that is easily machined to close tolerances. It is tough, dimensionally stable, and may also be thermformed. ABS has good chemical and stress cracking resistance.

Typical applications for ABS sheet include formed tub/shower enclosures, boat accessories, automotive trim parts, and computer housings.

**Kunin Eco-fi Classicfelt**
Made in America from Eco-K, a high-quality, fade-resistant fiber made from 100% post-consumer recycled and BPA-free plastic bottles.
environmental perspective in construction. Innovative processes and technologies recognize the importance of sustainable or environmentally driven design and overcome the inefficiency and lack of interoperability present in the sector. (Agusti-Juan and Habert 2016). Live BIM processes, for design, education and post-installation evaluation, are becoming an integral part of modern product development (Al-Qattan et al. 2016). Furthermore, walls modelled by computational design and constructed to reduce thermal gain on façades have improved thermal performance of the façade (Andreani and Bechthold, 2014).

The key ecological innovation of this pilot project (relative to a standard living wall) derives from the optimization of soil volume, the incorporation of biohabitats for beneficial fauna and post-construction analysis features. As a freestanding wall, its west-facing orientation challenges the maximum heat gain in this climate. The pilot project stands 10’ x 20’ x 18” Deep in scale. Each of the 104 hexagonal CNC extruded cells are gravity supported in a steel, water-jet milled frame in order to support the load of flora and fauna integration. Larger soil volume per plant is necessary to reduce thermal load of plant root networks. Each standard size cell holds approximately 4 liters, 0.14 cubic feet of soil media, about the same size as a standard 1gallon pot. The cell size and capacity also accommodates the eco-habit requirements and data capturing technologies. Ecological design specificity (embedded in several cells) targets the particular needs of pollinators (for hummingbirds and butterflies), songbirds and raptors (like owls or hawks), and arachnids and herbivores. One cell, for example, holds the birdhouse for the Carolina wren species. This bird is one of many from the Central Bird Flyway, a migration path stretches along the entire length of the Americas and that use this location as a stopping point along this long journey. Parameters such as the habitat dimensional constraints (simple BIM tasks) constrain placement of this habitat at 3-6 feet above ground. An intensive looping pattern to determine location and plant placement were created using Grasshopper for Rhino and L-loop scripting. The box dimensions of 5” x 6.5” an opening diameter of 1 1/8” deters non-native species such as starlings and house sparrows from entering. These plant and habitat combinations offer an inevitable natural and effective air purifying system, removing particulate matter (O3, VOC and CO2) as it passes through or across the wall. The potential ecological networks afforded by these plant to plant placements and plant to habitat combinations hold an expectation to increase biodiversity and ecological rejuvenation (Cantrell and Justine Holzman 2015).

BIM in this design scenario is the decisive authority for the synthesis of all other programs. BIM Material Editor Properties initially incorporated the ecologist’s plant list and habitat characteristics into BIM.
Later advanced use of material take-off for scheduling plants’ and species’ characteristics and requirements develops plant patterning through Dynamo visual programming and allows for quantification of plants to ecologist and landscape maintenance team in charge of intelligent water system and monitoring. This information is color coded for visual clarity and pattern update acknowledgments. Likewise, specific plant parameters embedded within each BIM type properties menu can then be a scheduled as a material take-off quantity but understood as a plant performance and façade performance measure, as if it were a sum of building material, from each generated pattern.

The post-installation BIM workflow identifies ways in which the project could be expanded to further the goal of monitoring the biological species living in the wall and transforming it into an interactive experience. Multiple, 3D printed custom sensors are placed within the living wall and used to track data. This data records in real time using Arduino Photo Transistor, temperature-humidity sensor, Sound Detector and IR distance sensor. Grasshopper for Rhino and the Firefly plugin translate the temperature, light, sound and proximity data into real units (degrees Fahrenheit, lux, decibels, and inches, respectively). These quantifiable values written into Excel sheets save at specified intervals, allowing the data to track over time for the past year. Monitors also track water usage for each plant cell through individually fed lines. The spreadsheet then imports the data back to the BIM model with an Import/Export Excel plug-in and the schedule updates the plant combination and water to soil performance. This then gives a ranking of which plants are using the most or least water in comparison to longevity. Analysis proves low water usage relative to other similarly scaled areas on campus. Overall, these data measurements are evaluating whether this green wall is cooling the west facade surface where it sits. Whether living wall reduces ambient air temperature around the building and ultimately helping to mitigate the urban heat-island effect are still under analysis.

Post-construction analysis of granular interactions between the living wall’s surface, fauna habitats and specific plants, with reference to user proximity, daily water distribution and local temperature values give relevance to a live, interactive BIM platform. A highly coordinated water and data feed system is integral to the digitally fabricated cells. A digital dashboard co-exists with Arduino technology data sampling to fine-tune the BIM and analytical relationship and then disseminate metrics for educational purposes. The results establish the benefits and disadvantages to a holistic BIM for surface-plant-air interactions, ultimately to assess the effects of green architecture visions. The work concludes as potential to associating architecture and landscape through technological methodologies for future work and its ability to analyze human impact on biodiversity.

CONCLUSION
The need to move towards the development of collaborative and holistic BIM processes requires facades to inform continuously post installation. The nature of this research truly requires a wide range of disciplines and coordination in order to understand and monitor the conditions affecting the range of bi-
ological species growing in or visiting the living wall and explore the possibilities of what this system offers to its environment. Indeed, the discipline needs a new type of construction process, one that utilizes technology to organize it (Chien et al 2016). A BIM framework and workflow promotes the organization and innovation of this collaboration.

Such application (if aggregated across a city) holds the ultimate pervasive potential to leave a lasting, “human induced” improvement to the planet. The intended application of the research addresses a university owned parking structure, but its scalability warrants the foundation for a more industrialized approach than this pilot or single typology. In this regard, technologists can turn their call for radical austerity into a renewed push for ecological incubation (Yang 2017). The architecture discipline now charged to be geological in scope, climatically motivated and furthermore driven by an advanced computational substrate gives relevance to BIM as a collaborative mainframe in the industry and in architecture.

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