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Waste to Opportunity

Reusing an Abandoned Storage Building in Puerto Rico

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Abstract

In Puerto Rico, the intersection of environmental vulnerability and decaying historic infrastructure presents an urgent opportunity for adaptive reuse. This design research focuses on the transformation of an abandoned food-storage warehouse located within San Juan's former "Sanitary City", an early 20th century historic complex originally comprising hospitals and penitentiaries. One of them being the Río Piedras State Prison, known as "Oso Blanco"—one of the first reinforced concrete buildings on the island, demolished in 2015. The site is now part of the proposed Science City masterplan, a government-led initiative focused on converting the former penitentiary site into a campus centered on laboratories and scientific innovation. The derelict warehouse structure is reimagined with the intent of being a part of the Science City's larger urban initiative responding to Puerto Rico's ongoing waste crisis, where 17 of the 28 existing landfills are noncompliant with U.S. EPA standards. The project explores the potential of upcycled single-use plastics as a viable construction material. By leveraging algorithmic modeling and digital fabrication methods such as additive manufacturing, the proposal generates modular architectural components—including green wall panels, partitions, and breeze blocks—tailored to be integrated to the existing building's structural frame. The repurposed warehouse is envisioned as a hybrid space: a digital fabrication lab and a plastic recycling hub that not only aligns with Science City's goals but also engages the surrounding community in sustainable practices. This case study offers a replicable model for transforming underutilized structures through the convergence of material innovation, environmental responsibility, and advanced design technologies. By acknowledging the site's symbolic complexity and layered past, the project reflects on how adaptive reuse can navigate the tension between preservation and progress, demonstrating how digital tools can bridge an abandoned building revitalization with inclusive, future-oriented urban regeneration.

Keywords: Digital Fabrication, Plastic Recycling, Prototyping

Introduction

The concept of adaptive reuse can be an effective tool to deal with environmental mitigation. Repurposing existing buildings contributes to social, cultural, economic, and sustainability benefits (Aigwi, Duberia, and Nwadike 2023). In Puerto Rico, the urgency of this emerging discourse becomes particularly acute. The island faces infrastructure deterioration challenges, due to a prolonged economic recession that has been more evident since 2014, after budget cuts and lack of proper maintenance of vital structures (Anagnostakos et al., 2023). Decades of irregular planning and lack of investment have left Puerto Rico's infrastructure in a vulnerable state. Furthermore, the decay was exacerbated by multi-factorial natural events like hurricanes and earthquakes that have proven to be destructive to buildings in various parts of the island (Hain et al., 2023). These circumstances provide the conditions to attend the topic of adaptive reuse in certain strategic sites in parts of Puerto Rico, where the opportunity arises to repurpose structures that would otherwise become an environmental or health risk.

This study examines the viability of rescuing an abandoned warehouse building that was previously in use as a food storage facility in the historic Sanitary City found in San Juan, Puerto Rico. The design considers transforming the derelict building into a hybrid center that houses fabrication laboratories and a recycling collection center. The proposal makes use of upcycled plastics as raw material and integrates digital design, fabrication, and additive manufacturing for the elaboration of modular architectural components to adapt the salvaged structure to its new uses. The intervention aims to align the proposed building with the Puerto Rico Law 214, 18 Aug. 2004[1], focusing on promoting the use of science, technology, and innovation as tools for economic development inside the lands that previously hosted the Sanitary City. The history of the original site, along with its relationship to the ideas of control, confinement, and rehabilitation, provides an adequate context for a project that reimagines obsolescence as opportunity.

Context: from Sanitary City to Science City

The Sanitary City was a historic institutional complex built early in the twentieth century in the Río Piedras neighborhood of San Juan, Puerto Rico. The master plan was comprised primarily of a mental hospital, a tuberculosis treatment center, and a prison, which was considered the main carceral and rehabilitation institution in Puerto Rico in mid-twentieth century. The Insular Penitentiary at Río Piedras, commonly known as Oso Blanco, was designed by Bennet, Parsons, and Frost in 1925 at their Chicago offices. Their blueprint for the penitentiary building, inaugurated in 1926, was one of the first reinforced concrete structures built on the island (Díaz 2020). As shown in figure 1, Oso Blanco was demolished in 2015 despite its historic relevancy, leaving an important urban space to be reconsidered for the Science City masterplan. The masterplan was a governmental initiative that aimed to develop science, research, and innovation laboratories in the campus that previously housed the Sanitary complex.

Fig. 1. Satellite Images of Sanitary City in 1995 vs. Science City Current Structures in 2025, magnifying the Abandoned Building (Perez and Vargas, 2025)

The Puerto Rico Law 214, 18 Aug. 2004, lists as part of its strategic plans, the execution of the development of the Science City master plan that includes design and construction improvements inside the former Sanitary City's 69.9-acre district. According to the law, the conception of this new science hub intends to make Puerto Rico competitive in science and technology, as well as fostering the potential of students, researchers, and academics.
Even though the original institutional initiative was formulated in the early two thousand's, it remains to an extent without materializing completely. While the masterplan is still unfinished, the Puerto Rico Science, Technology, and Research Trust have situated its headquarters and Innovation Center in the complex. This retrofitted building houses dry laboratories, coworking spaces, and offices. More recently, the Puerto Rico Environmental Research Laboratory and the Forward Center Building were built from the ground up in the complex, adding research, business, and manufacturing components to the Science City. The facilities follow global standards and provide high-tech installations for research and development purposes[2]. Hence, the interest in exploring other opportunities inside the district is to keep expanding the capabilities and scope of the Science City initiative with new typologies of science experimentation spaces.

Repurposed Building: the ReFab Proposal

The study took advantage of an available existing building of approximately twenty thousand square feet. The structure offered the architectural potential for the ideation of the reFab project, a novel digital fabrication laboratory. This laboratory considers spaces that house emerging additive manufacturing and prototyping equipment, alongside recycling technology that could help reuse plastic waste and turn it into functional materials inside a makerspace environment.
The intention was to incorporate the food storage warehouse of the former penitentiary center as a case study. Therefore, reimagining it as a building where architecture complies with a space that provides an environment of innovation, collaboration, and learning; typical of a Fab Lab (Soomro, Casakin, and Georgiev 2022). Additionally, the project also focused on circularity and waste material reuse for the local community. The reFab building's new design proposal serves not only as a science laboratory but also as a hub to educate and raise awareness concerning the island's waste management challenges. Puerto Rico has serious issues and challenges with waste, such as the limited capacity of the island's landfills to hold the demand of the waste disposal. The island has twenty-eight operating landfills; seventeen of them don't comply with EPA regulations. Most of them have been filled to full capacity, and the rest are expected to get full in the next few years (Brinton et al. 2023).
To achieve this, the initial phase of the study documented the existing conditions of the neglected hangar-like building through site visits, as-built drawings, and spatial analysis. From the observations, it was determined that the existing building possesses several positive qualities. These include a salvageable steel frame structure, open spaces, high ceilings, retaining walls, block walls, and a gabled metal roof with skylights, as shown in figure 2. The nature of the structural grid organization and open floor plan of the warehouse facilitated the accommodation of its original program as a large-scale food storage and distribution facility. Additionally, the adjacent loading docks connect to the service roads of the complex.

Fig. 2. Existing Conditions of Abandoned Structure (Perez and Vargas, 2021)

Another distinct architectural quality is that the building has existing walls that divide the central span into three separate spaces. It was determined to preserve the skeleton steel structure and multiple existing walls. Subsequently, a demolition plan was created to mark the components to be removed and replaced. This typology allows for a simpler construction intervention with new indoor partitions and building envelopes without modifying load bearing components of the structure. Also, the building's existing typology has the proper accommodation for new equipment installation and open spaces that can serve the community. These conditions call for an all-purpose and resourceful transformation for adaptive reuse, especially for the proposed fabrication laboratory program.

Design Intervention

The reFab's program intention is to function both as a digital fabrication laboratory and as a space that incorporates plastic material recycling processes. Accordingly, the Fab Foundation[3] and Precious Plastics[4] guidelines were considered for the decision making of the spatial design. The spatial distribution was organized into three major components: production, education, and exhibition. While other programmatic spaces consisted of administrative, service, and miscellaneous areas.

The existing walls that divide the structure into three open spaces were used as axes to segment the space accordingly to the principal program zones. The first zone, the exhibition space, was designed with a reception area, public restrooms, and a double-height multipurpose exhibition area. This space was intended to display the possibilities of repurposing single-use plastics as well as to promote the circular economy through a shop open to the community. This zone also incorporates an administrative area on the mezzanine level.

The second zone, the educational space, was intended to include conference rooms, learning classrooms, and a meeting room. Its double-height area opens to a multifunctional auditorium space for conferences, lectures, and seminars. The idea was for this area to be a clean workspace for the fabrication laboratory, dedicated to research and prototyping using digital additive manufacturing and recycled materials.

The production area was strategically placed at the end of the programmatical sequence to responsibly manage the fabrication laboratory spaces with equipment such as laser cutters, CNC cutters, 3d printers, and manual tools. This area also provided a double-height space dedicated to plastic recycling methods with machines that shred, extrude, and mold discarded plastics. Another purposeful design decision was to locate the plastic collection and distribution area in the service entrance of the repurposed building. This specific component of the program was designed to organize received plastics by type and initiate the recycling process. The resulting fabricated product ultimately returns to the first zone, the exhibition area.

Following the schematic spatial configuration, algorithmic design methods were implemented to avail parametrizing dimension aspects of the existing steel structure. This process led to the development of modular architectural elements—including solid partitions, green wall modules, and ornamental perforated modules that fit the existing building. The modular elements were proposed to be fabricated using recycled plastics as their main material. These components were thought of as part of the building's skin design catalog. Detailed drawings and renderings, illustrated in figure 3, were created to demonstrate how these elements integrate with the existing structure of the building. This process allowed the creation of bespoke modular architectural components that improve the material use as well as spatial quality and integrity of the repurposed facility. In addition, these components introduce new environmental enhancing and esthetic appeal properties. The architecture itself becomes part of the intention of the program by its use but also by the material choice of the added components in the adaptation of the new purpose of the building.

Fig. 3. Exterior Renderings of reFabs's Main Entrance and Service Entrance (Perez and Vargas, 2021)

Experimental Prototyping and Plastic Reuse

The use of disposed waste plastics as a construction material helps approach design from a sustainable perspective offering a long-term solution for the management of these materials. When accumulated in copious quantities in landfills, such materials pose a significant risk of environmental contamination (Awoyera and Adesina 2020). Benefitting from the reFab building's proposed use, the spatial design informed the development of physical prototypes. These prototypes were intended to explore the constructability, replicability, and assembly of modular architectural components made of recycled plastics. The physical exploration focused on making use of single-use PET plastic, or polyethylene terephthalate, the material used typically for water plastic bottles. It is estimated that polyethylene terephthalate represents fifty-five percent of the total recycling polymers globally (Vidakis et al. 2021). Given the widespread use of this material, disposed PET materials were collected in this phase of the project and used as additive prototyping material to create real-scale, physical models of the modules.

For this, similar machinery to the ones proposed to be installed in the reFab facilities was acquired. Equipment such as plastic granulators were utilized, as they help reduce the plastic materials into smaller particles that can be processed efficiently in the next steps of the material recycling process (Ravindran et al. 2019). This process is illustrated in figure 4. After the plastic shredding, the granulated material was fed to a filament extruder where it was melted in a heated barrel. The extruder then expelled the newly formed fabrication material to the specific diameter needed to use the filament in a 3d printer (Harimalairajan, Sadhananthan, and Murugan 2016). Raise 3d brand printers were selected because they provided sufficient print bed dimensions to fabricate the architectural scale elements. The ornamental module type was chosen for real-scale physical prototype printing, as seen in figure 5. The components work as breeze blocks in the exterior part of the building and as space dividers in the interior. In both cases, the individual modules add up to create a skin that is deployable and intended to be assembled on to the building's existing structure. This step of the study concluded with the testing of interlocking joinery and their tolerances to ensure proper assembly between each module. Further investigations inspired by the physical prototypes include improving the module's fire and UV resistance.

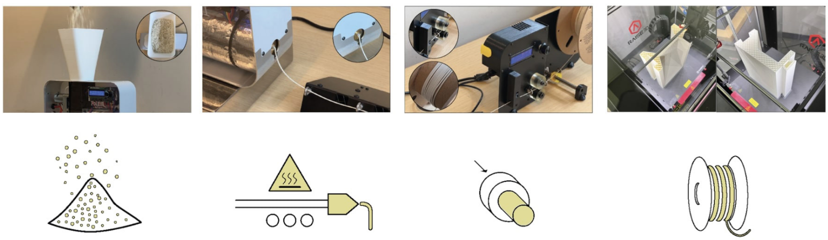

Fig. 4. Plastic Recycling and Prototype Printing Equipment and Process (Perez and Vargas 2021)

Fig. 5. Ornamental Breeze Block Design and Prototype (Perez and Vargas 2021)

Conclusions

The adaptive reuse of the Sanitary City's former storage warehouse is proposed as an architectural regeneration model reasoned as a multi-scalar project. The design demonstrates that the retrofitting of a building in Puerto Rico can coincide with sustainable practices in waste material management. It also supports the preservation of cultural memory, reimagined through innovative spaces for the local community.

The project operates across different scales understanding the urban implications of the Science City masterplan, the architectural articulations of the existing building, and the material implications of rescuing previously disposed plastic waste to create architectural components. Preserving the structural shell of the building while incorporating a recycled plastic modular skin becomes a technical yet symbolic gesture: a dialog between the permanent and the transitory. The architecture resulting from the intervention is not intended as a deletion of the past, but as a reactivation exemplary of a sustainable future.

From a methodological standpoint, the work contributes to the emerging discourse of circularity in architecture. The reusable and recycled material selection during renovations promotes a gradual paradigm change in design towards circularity in the built environment (Stijn et al. 2020). The newly proposed PET plastic components are subsequently recyclable at the end of the life cycle of the structure.

The study includes a prototyping phase that validates the use of post-consumer waste as a building skin and modular component. The experiments demonstrate the use and implementation of plastic recycling technologies and additive manufacturing strategies to print physical models that adapt to the dimensions and scale of the structure.

The project reaffirms that adaptive reuse in Puerto Rico can transcend the mere preservation of a building. It includes a multilayered approach of programmatic design, space redistribution, and material prototyping that opens the possibility of further testing the material properties and physical attributes of using recycled materials to rescue other buildings in the island.

Notes

1. This law establishes the mandate, governance structure, and funding mechanisms for the creation of the Puerto Rico Science, Technology, and Research Trust. The law also defines the initial details of the Science City masterplan development project.

2. The Puerto Rico Science, Technology, and Research Trust posts updates on the Science City development and general information on its buildings on the Science City webpage.

3. Fab Foundation is an organization that imparts guidelines for the design and implementations of fabrication laboratories, including recommendations related to equipment, human resources, and education.

4. Precious Plastics organization provides open-source information on equipment and plastic recycling processes at a local level.

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