GRAPHICAL SIMULATION FOR LEARNERS TO UNDERSTAND THE CONSTRUCTION OF JAMAICA’S PARAMOUNT TREASURE: ”THE DEVON HOUSE”

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Introduction

Despite the near ubiquity of 3-D modeling and building information management (BIM) software packages in the architecture, construction, and restoration industries, potential employers have continuously expressed concern that graduating students are not adequately prepared to operate some of these BIM software packages (Harris, 2014). Exposing students to construction methods via software used in the field may help to soften the transition from the classroom to the industry. Consequently, the authors proposed the use of fully-developed 3-D models, based on accurate data, as an instructional tool which may simultaneously achieve three goals: (1) Improve the facility with which the students use common software tools; (2) develop knowledge of construction processes and techniques, both historical and contemporary; and (3) expand students’ knowledge of architectural and engineering history.

In this paper, the researchers explore the potential for a 3-D model created in Revit Architecture to be used as an instructional tool for college aged students. The paper is organized into four sections and begins by describing the problems and the potential solutions. Section One discusses the motivations, methodology, software used, survey instruments, means and methods of conducting the presentation; Section Two is the background and significance; Section Three discusses the construction process of Devon House in detail; and Section Four entails the student survey, educational potential, participation population and the conclusion.

Section One is described for future utilization because the current scale of the research is relatively small with twenty – five participants. Based on the findings, other researchers may replicate or tailor the research presented to suit their own circumstances. Section two allows readers to connect with the importance of the building. Much of the section relies heavily on historical elements because the construction practices informed contemporary methods. It is crucial that participants and readers understand historical information so that they may have context for when, how and why Devon House was created. It provides the answer to the question of why this building was chosen out of hundreds or possibly thousands available throughout the Caribbean region.

Section Three, as previously stated, discusses the construction process. While the paper focuses in part on the 3-D model and its applications, it is important for the readers and participants to understand how the different parts of the building come together. Information is borrowed heavily from this section to inform the creation of the 3-D model. This section also provides information that the participants will interact with during the presentation and survey. Finally, Section Four reviews the student survey, educational potential, participation population and conclusions. This section facilitates the process of collecting quantitative results to answer the questions about the merits of the focus of the research. In addition is the opportunity to discuss the quality of findings, constraints encountered and the applicability or utility of such findings.

Methodology

Prior to assessment of the strengths and weaknesses of the methodology, it is necessary to determine what it entails. Assessing the educational strength of this model is paramount to determining its utility in the classroom, as well as improvements that can be made upon the
model to provide a more realistic experience in future implementations. This study will employ a simple pre-test, intervention, post-test process to explore and expand student knowledge of the construction process and how it can be clarified using a 3-D model. In addition to providing basic demographic details, participants will be asked to answer a few preliminary questions about construction methods in general and Devon house. Subsequently, the research team will offer a brief slide presentation which will discuss the relevant history of Devon House, its construction methods, and other related information. Upon the conclusion of the presentation, participants will be given a chance to explore a 3-D model of the Devon house created by the research team. After addressing any participant questions, the researchers will administer a brief survey designed to probe what knowledge has been gained though the presentation and model use. Brief demographic information will provide the researchers a baseline for later comparison. Researchers will be able to determine which groups better grasped the information, what parts of the information were the easiest to understand and what was the most difficult. Thereafter, the researcher will be able to determine what parts of the research need to be tailored for future use.

Survey Instrument

The survey instrument was chosen by identifying the relevant research problems and the desired solution. A key issue introduced was the inadequacy of student preparation for industry particularly as it relates to the use of software. It was determined that the accompanying solution was to introduce students to the software by using it as an instructional tool. A questionnaire was selected for data collection because it provided relatively quick feedback and could be administered immediately following the presentation so that the memory of the participants could be fresh. The questions provided, facilitated objectivity based on the standardized method of giving the survey. Finally, the survey provides a chance to gather quantitative results so that assumptions can be made across the two groups. Thirty minutes were allotted for the survey; however, it could comfortably be completed in less than ten minutes because there were only eleven questions. The additional twenty minutes were provided to facilitate conversation and open the floor to questions about the use of the model.

Questions were then developed to represent each section of the paper and determine how well the participants understood the material. The first few questions requested background information on the students to determine whether understanding of the material related to age, academic standing or work experience. In addition, questions sought to determine whether the graduate level participants performed better than the undergraduate counterparts. Questions 1 – 9 focused on the construction process and pulled data from all four sections to determine understanding. Consequently, questions 10 – 11 focused on the 3-D model. Such questions required users to express comfortability of using the model and interacting with the model’s interface. These users were also required to judge the realism of the model in comparison to images provided as well as perceptions on the usefulness of the model.

Software

Each software package used in this project is presented to provide deeper understanding of the educational module developed. Choosing the appropriate software for 3-D representation was
one of the key factors that aided in the development of the paper. Whereas most 3-D modelling software programs have the capacity to represent the model, not all of them will represent the true characteristics of the material or the building’s structural components. The software selected for completing the drawings were AutoCAD and Revit.

**AutoCAD/ Revit Architecture**

AutoCAD was used to produce 2-D representations of the floor plans, also known as top views, as well as elevations or front and end views and construction details. These construction details, or working drawings, were included because they typically show how the parts of the buildings can be built. The plans and elevations were imported into Revit Architecture and then used to create an outline to generate the general layout of the building as it would have been placed *in situ*. These plans specifically provided the thickness of walls, location and width of doors as well as windows. Alternately, the elevations facilitated the placement of external and detailed elements as well as the location of floors at their appropriate heights, which led to the completion of the roofs and remaining facades. Conversely, Autodesk Revit was selected because it is a software program connected to the entire Autodesk suite, and offers the opportunity to work in tandem with its sister software and their respective platforms. This program affords modelling efficiency so that the potential exists to produce more finalized material in a shorter space of time. For example, working in the plan view simultaneously generates sections, the 3-D model of the structure, and elevations.

Modeling in the Revit’s platforms affords a great deal of precision, as each component can be modelled and analyzed individually without changing the nature of the remainder of the materials. When combined with an in-depth understanding of the structure, the creation process becomes more precise. Furthermore, this program is currently the industry standard, much like AutoCAD was when it arose in the 1980’s; it has become the design standard and a larger part of the Building Information Modeling (BIM) movement within the construction industry and so if any adjustments had to be made to the actual building, multiple firms could use the files to inform the changes. This also allows for the opportunity to test certain conditions, such as any changes to be made and determine their impacts within the software prior to construction. Finally, Revit architecture was chosen because it requires the creator of the 3-D model to have a firm grasp on the construction process and the dimensions of materials, to properly construct a model that is convincing to a wider audience.

**Presentation**

The researcher proposes that one of the best methods to test the applicability of the model would be through an in-class presentation. With the purpose of providing instruction on the construction process of Devon House. The first stage of the process was to create the model and complete the research on the construction process and then issue a presentation followed by a survey. It was hosted at a large Midwestern Public University. This location was chosen because it is a central one to most students in the engineering discipline. The presentation was designed to highlight the relevant goals of the topic by putting forth the technical information that arose from the research. It employed the use of a power point to highlight the construction process of Devon House using
rendered photographs of the 3-D model. The entire session will last for one hour: approximately 20 minutes for the presentation, which will also allow for the explanation of what the research is about and allows any questions on the waiver; 20 minutes for questions, which will be allowed throughout the presentation if the participants are unclear of anything being taught; and 30 minutes for the completion of the survey, in turn divided into 10 minutes for the survey, 10 minutes for the tutorial about the model and 10 minutes for any additional discussion. There is no long-term review intended of any of the participants, so the presentation is intended to supplement all the information and provide an opportunity for the collection of the statistical data.

**Background and Significance:**

Devon House is one of the most notable remnants of colonial history, being particularly noteworthy because of two factors. Firstly, its construction was conscripted by a black millionaire and it was fitted with all the trimmings possible with the Georgian architectural style, and then infused with new life because of vernacular responses. The property known as Devon Pen was originally glebe lands which were purchased in 1879 from the Anglican church by George Stiebel, the main house was completed in 1881. Devon House was built 70 years after the end of the Georgian Period, but was constructed using many of the features that characterized the Georgian style.

As such, it has been referred to as The Jamaican – Georgian, so named because of the combination of the vernacular interpretation and influence on the classic style of architecture. Georgian architecture became popular in Jamaica in and around 1712, following a great

Figure 1: Digitally modified map of the original plat for Devon Pen.
rebuilding effort which was necessary following a hurricane in the same year (Green, 1988:31). The style was provided by the island engineers from Britain, who were responsible for the designs of public buildings and is characterized by formal and symmetrical lines. Predominantly, two stories’ high, with the primary façade being given prominence by the presence of a portico, under which you can find the main entrance centered exactly on the south elevation. Figure 3 Shows the ground floor which is the principal floor and is elevated approximately 1.5 m above street level. The stairs lead to a large central hall with stairs located to the left in the main entrance. In Figure 4, the continuation of the central stairs can be identified as well as the windows on this floor, located directly above those on the ground floor and appear with more frequency to emphasize the importance of rooms. Traditionally, these houses would adhere closer to the style of the Palladian Villa, with wings extended from the main house: glazed windows, double hung sash (Green, 1988:75).

Devon House utilized the features highlighted above but made amendments based on climatic consideration by adding verandahs on the east, west and north of the house, fretwork and detailed bargeboards. Shutters and jalousie louvers that spanned the entire length of the front façade shielded its large windows, highlighted in Figure. 2. In 1923, Devon House was sold following the death of Theresa Stiebel-Jackson. For £5000, Reggie Melhado purchase the property and it was majority subdivided, leaving 11 acres (Shields, 1991:66). The property changed hands again in 1928 by Cecil Lindo, however since it was only 11 acres, the new owners renamed it Devon (named for Agnes Irene Lindo). The house was in great disrepair and Cecil Lindo contracted George Hart to make the repairs, which came to approximately £5000 (Shields, 1991:84). Much of the layout remained the same, though no detailed account of the repairs was found. The only difference it appears is how the rooms were used by the Lindo
family. Twenty years after the commissioned repairs, the government of Jamaica purchased the house in 1967.

Consequently, the house stood empty over the twenty-year period and fell into a state of disrepair. The reconstruction process saw the old buildings on the eastern side of the site which once stood as the maid’s quarters and kitchen converted into craft shops. On the western side, the former coach house which had housed the chauffeurs and gardener’s quarters was so dilapidated that the roofs were gone. Repairs were completed in part by Ray McIntyre under the supervision of Tom Concannon, who oversaw the entire remodeling process. The coach house was enlarged for use as an English styled tavern; the old kitchen was fully restored for use to service the tavern. Staff quarters located behind, were restored for local craft display, this work was completed in 1968 (Shields, 1991:101).

![Figure 3: Ground Floor Plan – to plotted at 1/16" = 1'-0"

It was used as a museum and a national showpiece until 1974, at the behest of his mother Edna Manley, the Prime Minister at the time, Michael Manley, and his government determined that Devon House would become the site of the national gallery. In the late 1980’s the property became a museum with a series of shops which featured the work of local artisans. When Devon...
Pen was purchased by George Stiebel, it already had the rectory house onsite that had once housed Reverend Alexander Campbell and previous clergymen for over a hundred years. It is widely believed by historians in Jamaica that Devon House was constructed on the remnants of the house's foundation. However, before any construction processes can begin, the Architect/Engineer must first determine whether the materials can be stored onsite or in some alternate location. Planning and mobilization details the preparations that were made for the selection of the site and the drafting of plans, resources, materials and their sources, methods of transportation, equipment types, and the location of said equipment.

![First Floor Plan](image)

Figure 4: First Floor Plan to plotted at 1/16" = 1'-0"

In Figure 5, the site map of the Devon House site as it exists in modern times features a large open area on the southern section of the property. This area, while littered with trees, is the main entrance to the site and is a perfect location to store materials. In recent interviews with Ray McIntyre, it was revealed that no known drawings of Devon House were ever retrieved, and this was in fact such a common practice in the past that George may have come upon the design of the house in a catalog or on one of his numerous trips overseas. Additionally, other factors such as the site selection, water table, soil type, and water use as well as planning and mobilization will
be addressed. Together, these factors are expected to paint a clearer picture of the construction process of the Devon House.

Figure 5: Site Map of Devon House

Construction Process

Devon House sits at an elevation of 29.261 m (96 ft.), located in a valley at the foot of the Blue Mountains. This natural slope, covered in vegetation, aids in the prevention of surface erosion and provides soil stability. As the slope progresses, however, the vegetation decreases, so the Devon House property is covered in numerous tree and plant species to compensate. The existence of onsite vegetation aids in providing additional soil stability to counteract water run-off. In tandem with the onsite vegetation, location and site characteristics, it provides a natural slope that allows water run-off to occur with ease, thus improving drainage and limiting the potential for water retention around the foundation of Devon House.

Figure 6: Google Earth image of natural slope from The Blue Mountains beyond Devon House

The substructure is defined as the structure or framework of the building, which lies beneath the floorboards and often the ground level. The review of the substructure will entail the analysis of the soil type, foundation type with its components, the floor joists and primary beams. Selection of the appropriate materials and the step-by-step construction process is integral to determining a foundation type. Soil types inform how the positioning of the structure on site and how the
foundation may provide support. Lithographical data collected from a series of wells on Devon Houses site revealed a wealth of information. From a depth of 0 - 12.192 m (0 – 40 ft.), at ground level, the soil type is gravel but at its deepest level of 83 m (272.310 ft.), it transitioned from gravelly material to fine grained sand, resulting in the classification of coarse-grained to clayey sand.

Table 1: Lithographic Data from Well #2 at Devon House

<table>
<thead>
<tr>
<th>Strata in meters (ft.)</th>
<th>Depth from meters (ft.)</th>
<th>Depth to meters (ft.)</th>
<th>Thickness meters (ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dark brown friable alluvium, moderate well rounded, gravel with quartz fragments.</td>
<td>0</td>
<td>12.192 (40)</td>
<td>12.192 (40)</td>
</tr>
<tr>
<td>Slightly coarser than above, more rounded</td>
<td>12.192 (40)</td>
<td>30.48 (100)</td>
<td>18.288 (60)</td>
</tr>
<tr>
<td>As for 0- 12.192 m (0 – 40) but 33.528 - 36.576 (110 – 120) more angular.</td>
<td>30.48 (100)</td>
<td>36.576 (120)</td>
<td>6.096 (20)</td>
</tr>
<tr>
<td>Coarser than above diameter up to 0.635 m (2.083) Moderate sorting.</td>
<td>57.912 (190)</td>
<td>64.008 (210)</td>
<td>6.096 (20)</td>
</tr>
<tr>
<td></td>
<td>64.008 (210)</td>
<td>67.056 (220)</td>
<td>3.048 (10)</td>
</tr>
<tr>
<td>As for 36.576 - 45.72 m (120 – 150)</td>
<td>67.056 (220)</td>
<td>77.724 (255)</td>
<td>10.668 (35)</td>
</tr>
<tr>
<td>Fine grained-less sorted than above.</td>
<td>77.724 (255)</td>
<td>89.916 (295)</td>
<td>12.192 (40)</td>
</tr>
<tr>
<td>As for 36.576 - 45.72 m (120 – 150)</td>
<td>89.916 (295)</td>
<td>92.964 (305)</td>
<td>3.048 (10)</td>
</tr>
<tr>
<td>Fine medium-grained sand. More quartz moderate well sorted.</td>
<td>92.964 (305)</td>
<td>97.536 (320)</td>
<td>4.572 (15)</td>
</tr>
<tr>
<td>Medium-grained coarser than 77.724 - 89.916 m (255 - 295)</td>
<td>97.536 (320)</td>
<td>109.728 (360)</td>
<td>12.192 (40)</td>
</tr>
<tr>
<td>As for 77.724 - 89.916 m (255 - 295)</td>
<td>109.728 (360)</td>
<td>121.92 (400)</td>
<td>12.192 (40)</td>
</tr>
<tr>
<td>Fine-grained sand, poor</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The foundation type depicted in Figure 7 is a strip foundation, which is commonly used to support current infrastructure in Jamaica. As such, the author has deduced that the main foundation used in Devon Houses construction is a strip foundation. Firstly, the soil type identified in Table 1 as coarse-grained to clayey sand is known for its ability to provide foundational support and drainage; the choice of a strip foundation would be suitable under the conditions. To further corroborate the stance, the researcher conducted several site visits and observed foundations of structures constructed during times contemporary with Devon Houses construction. Strip foundations are also beneficial when minimal excavation is needed, especially in cases where the height of the water table does not significantly affect the choice of the foundation. Lithographic data captured from wells on site show that over time, the water levels fluctuated consistently, but even at its highest point, the water table was still not high enough to pose a problem to a shallow foundation. In addition, strip foundations are also suitable in instances where budgetary constraints are a considerable factor. While construction in the time of George Stiebel had no monetary constraints, the original construction done by the Anglican Church had budgetary limits and so the strip foundation was an obvious choice. Finally, the strip foundation is excellent for minimal impact on neighboring properties and since the quantity of land purchased was 291374 m² (72 acres) (Shields, 1991: 26) and was covered with vegetation, so impact on neighboring properties would be minimal.

Figure 7: Hybrid strip foundation detail, based on Devon House foundation and a modern strip foundation found in Jamaica
The construction detail in Figure 7 shows that one of the first steps would entail having the footer formed from Portland cement and 12 mm (15/32 in.) rebar, which would then be used to attach 150 mm (529/32 in.) concrete blocks to create the vertical section of the footing. Directly alongside the vertical section of the footer is compacted soil, which provides the base for the concrete slab. The footing works in tandem with the vertical portion of the footer as the support in the formation of the main floor structure. Therefore, the researchers have generated a detail based on historical practices and dimensions, using the modern strip foundation. Given the similarities between the modern strip foundation, shown in Figure 8 and hybrid foundation in

![Figure 8: Modern strip foundation detail found in Jamaica](image)

Figure 7, Devon House would likely have utilized a similar process. This process would begin with the excavation of surface soil down to a soil layer stable enough to bear the weight of the structure. Following this is the pouring of the footing, used to distribute the weight of the structure evenly along the grounds surface area. While Portland cement would have been invented earlier in 1824, there is no known confirmation of its use prior to 1944. In its stead, a local material known as lime mortar was provided (Anderson, 2010) as binding material in the creation of a stepped-out wall base to make it wider, using brick or stone. The completion of the footer means that the plumbing lines can then be installed. Unlike in modern times, the waste
water pipes would have been created from clay or iron (Davis, 1884). The main means of waste removal however, was done through use of a septic tank, which was built on the property. As a means of modernization, PVC pipes were later installed and a connection made to the city of Kingston and St. Andrews’ main waste water pipes to remove waste from the property. The final step was the installation of the main walls borne directly on the foundation.

The final sections of the foundation reviewed were the floor joists and the primary beams highlighted in Figure 9 below. They were reviewed together because they were both constructed in a similar manner. The primary beams would have been constructed first from bullet wood (*Manilkara bidentate*). This wood was chosen for its hardness but also because of its natural ability to repel insect attacks. The main section of the primary beam was constructed by placing the bullet wood beams atop the exposed foundation wall. In some sections, it could be observed that the beam was built to fit into a notch created in the adjoining wall to house the joist. Site dimensions reveal that the primary beams were 0.305 m x 0.203 m (1 ft. x 8 in.) and spaced in 2.134 m - 2.286 m (7 ft. – 7 ft. 6 in.) in some instances.

![Diagram of Devon House basement Detail](https://example.com/diagram.png)

**Figure 9: Devon House basement Detail**

Floor joists were often made of wood during the construction process. However, specific wood types were favored for different characteristics. In modern times, cedar remains one of the most popular choice for floor joists because the material is affordable and is abundant on the island of Jamaica. Despite the swelling of the cedar joists when exposed to water, it is quite durable and was often used in areas that were expected to get wet. Other woods such as mahogany, greenheart, breadnut, and blood heart (Gosse, 1851: 156 – 7) were selected for not only their comparative durability but their hardness as well. 0.076 m x .133 m (3 in. x 5 ¼ in.) hand cut and hand planed joists were connected to primary beams by nails or slots created in the beams. In the latter case, gravity and the weight of objects kept the members in place. For accurate dispersal of loads and the provision of stability, the joists were placed along the primary beam 0.784 m (2 ft. 7 in.) apart. The method of securing the joists differs between the two floors, something that could have occurred because the ground floor was older than the first floor. In addition, readings of construction practices during the period of construction discussed this method as being geared towards added aesthetic appeal for guests who would be able to see the
open beams from below. The ground floor sees the joists placed flush atop the sill plate and the beam. On the other hand, the first-floor features notches on the joists, which allows their ends to sit securely in the slots of the beam, and the undersides of both joists and beams to be flush with each other. Floorboards were then installed atop the joists, and are typically characterized by nominal dimensions of 0.025 m x 0.152 - 0.203 m (1 in. x 6 in. – 8 in.)

The superstructure is defined as the part of the structure above the floorboards, typically characterized by nominal dimensions of 0.025 m x 0.152 m - 0.203 m (1 in. x 6 in. – 8 in.). It is inclusive of the walls, windows and columns. Based on several site visits, it was determined that Devon House has three wall types. Pure brick wall, with bricks exposed, using the Flemish bond layout and to a lesser extent, the English bond, brick walls with stucco finish, and framed wooden stud walls covered by gypsum board and plaster finished. Brick is one of the most dominant materials, used predominantly on the ground floor and partially on the first floor, except for the louvered wall located on the southern façade, which extends to the first floor and onward to the roof to provide added support. Measured surveys on site revealed that all walls were between 0.457 m - 0.61 m (1 ft. 6 in. – 2 ft.) thick. The walls on the ground floor of the main house were typically 0.61 m (2 ft.) with small deviations and were made of brick with stucco finish. Conversely, the walls throughout the rest of the property were exposed red brick and ranged between 0.457 m – 0.508 m (1 ft. 6 in. – 1 ft. 8 in.). The ground floor walls provided the dominant structural support with accompanying support from the first floor to stabilize the roof. The known brick standard was the American standard, corroborated by onsite dimensions of 0.21 m x 0.095 m x 0.064 m (8\(\frac{1}{4}\) in. x 3\(\frac{3}{4}\) in. x 2\(\frac{1}{2}\) in.). Figure 10 below shows the building integrated into its landscape, showing the overall character of the walls. Further perusal of the interior structure of the walls will provide a more complete understanding of the construction process of the brick walls.
The first step needed to construct a brick wall is to determine how much brick was needed for the specified wall size; a calculation, which also included the mortar measurement. Considering the foundation discussed above, the brick laying process will be described to account for this process. However, it should be noted that guide posts would be placed in the foundation trench and soil compacted around it. The top of the trench was leveled, smoothed and then left to dry for 2 to 3 days. Levelling posts were then driven into the soil 0.61 m - 1.219 m (2 ft. – 4 ft.) apart depending on wall length to guide the placement of the of the bricks and their courses. A gauging rod was then used to identify the bricks courses and a level used to ensure that the courses would be lined up correctly. The first row was then tested by laying them without the placement of the mortar. Afterwards a string was used to create a guideline based on the first test row, ensuring that the guide was held taut for the maintenance of the level state of the wall. The first required inches of mortar were then laid atop the foundation wall and the brick applied by pushing it down slowly, using the trowel to press it below the centerline the remainder of the way. The process was continued as the mortar is laid for the next two or three bricks. The last of the neighboring bricks was then “buttered” with mortar and pressed in place, scraping away the excess mortar as the process continued. Bricks were continually added and each complete course checked for levelness until the wall was finished.
The brick wall with stucco finish would have been constructed as the pure brick wall discussed above. The difference was that the wall would have been allowed to sit for a few days, giving the mortar enough time to set and achieve strength. Thereafter, the stucco finish would be applied where required until the entire wall was covered and the appropriate finish was achieved. The first floor, while constructed with some brick, was completed predominantly with wood, likely pine which was favored for its lightness, ease of workability and availability. Internal images of damaged sections of the first floor reveal that there were girts in place, made from using solid, heavy beams. Connections were made using mortise (hole) and tenon (protrusion) joints, held together with wooden pins. Since the walls were so heavy, they were first cut by hand saw and laid out on the ground, then a large labor source would converge on the scene and raise the walls in place. In some places, brick was packed into the walls between the common studs. This wall was then covered with lath, creating a slat wall. The slat wall is then covered with plaster and finished as desired. The exterior section on Figure 11 provide an idea of the construction process. Of note is that the interior section were the conditions found onsite, the exterior construct is the actual traditional representation of the walls details.

Continually, the wall construction method was continued excepting in cases where windows were needed and in the construction of the southern wall, which was, timber framed wall filled with a series of windows, louvered and sash. When windows were added headers, trimmers and sills were added to facilitate them. The final components of the superstructure were the columns liberally scattered throughout the house. They prominently sat on every façade in the location of the verandahs and again as ornamentation on the faces of the building. The on-site dimensions were determined to be 4.801 m (15 ft. 9 in.) tall and a circumference of 0.794 m (2 ft. 7 ¼ in.); the base of the column tapers upward to a slightly smaller circumference of 0.762 m (2 ft. 6 in.). Bullet wood and Lignum Vitae\(^1\) were used as the choice of material for the columns because they were extremely durable and naturally resilient to insect attack (Pawson & Buisseret,

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\(^1\) Species of hard wood found in abundance in the surrounding areas on the island of Jamaica. Its color can range from pale yellowish olive, to a deeper forest green or dark brown to almost black.
The construction was completed by turning the shaft on a hand lathe, whereas details on the capital, shaft and base were hand carved. To complete the process, the wood was treated and finished with whitewash.

Devon House is comprised of four hip roofs capped by cedar shingles, used to cover different sections of the structure. The detail provided in Figure 12, identifies how the components of the roof are comprised. Construction of the roof had a similarly process utilized in the completing the walls. Mortise and tenon joints were used to connect the roof to its components. There are opposing rafters of typical dimensions 0.025 m x 0.102 m (2 in. x 4 in.), which are joined by a spacing of 0.61 m (2 ft.) max, center to centers and were connected to form a triangle the peak with pins. The lath based on site dimensions found at Devon House was 0.019 m x 0.051 m - 0.064 m (¾ in. x 2 in. – 2 ½ in.) and positioned in a horizontal fashion, supported by rafters.

Student Survey

With the completion of the digital model, the final step will be to demonstrate it to a learning audience and gauge how effective it can be as an educational tool. This model has the advantage of being based on an existing structure that has preserved much of its architectural details, so students can explore as close a representation to the actual structure as possible. Although no formal survey has yet been conducted as of the time of writing, plans for one are currently
ongoing and the investigation of the impact of this simulation upon a learning audience will be the subject of a future paper.

Participant Population

A mix of undergraduate and graduate students of the College of Engineering (COE) at Ohio State University will be recruited using college-wide email advertising and active solicitation of participants from among student groups to which the research team has ready access. All participants will be full-time students of the COE over the age of 18; no further exclusionary criteria will be applied to participant enrollment. Table 2 documents the expected number of participants, 10 undergraduate students and 15 graduate students.

Table 2: Interview Groups

<table>
<thead>
<tr>
<th>Prospective Interviewees</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Undergraduate Students</td>
<td>10</td>
</tr>
<tr>
<td>Graduates Students</td>
<td>15</td>
</tr>
</tbody>
</table>

Using graduate students will make it possible to provide a comparison between the ability of undergrads to graduate students. More importantly, the comparison will provide assessment over a greater cross section of the university by including students at different levels of their educational journey.

Educational Potential

Based on feedback from graduate students that this model has been shown to, the model has considerable potential as an educational tool due to the amount of data that has been worked into it and that can be presented thusly. The consensus is that the methodologies demonstrated by the model, which primarily entail taking the raw data and representing it in a graphical format, are useful for simulating both the architectural information of the completed model and the construction processes that were employed to create the actual structure. A bonus to this is that students do not have to take multiple trips to the actual structure and can investigate the architecture and engineering more frequently. The simulated option also helps conserve the structure itself, as repeated physical visits could risk gradually damaging some of its more frequently contacted components over time.

One of the main educational uses of the model is to allow students to review any feature or combination of features from the house by creating sectional views. The provided examples show more detailed sections of the house that are difficult to visualize without a great deal of
text. The first showing the central core of the house, with the exterior walls removed to highlight aspects of that interior relationship (Figure 14).

Figure 14: Sectional detail of interior walls

Figure 15 creates a clean cut through the substructure section portion of the house (Figure 15), and highlights the relationship of the basement to the overlying floor. Figure 16 identifies a portion of the exterior façade and provides the opportunity for visual comparison between the interior and the exterior.

Figure 15: Detail of overlying subfloor support in relation to the basement

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A user who may not yet be comfortable with sections may look at a section in tandem with the detailed view to achieve better comprehension of navigating the building. Furthermore, the ability to explore internal elements in a non-destructive manner, allows students to study and appreciate the inter-relationships between function and design. This can become an effective and interactive portion of classroom instruction. Simulating digital investigation when physical visits are not permissible.

![Figure 16: Relationship between the interior and the exterior](image)

In addition, the digital model presents the architectural information about the structure in a comprehensible manner, which is important in engineering education as well as architecture. The flexibility of this model can also be applicable to other fields of study aside from civil engineering along with other structures and construction methods aside from the Devon House. Digital modeling in this way can thus be used in a variety of educational circumstances in the architectural field, and may be a critical process for helping architecture curriculums move forward. Indeed, this practice is an important part of professional education in architecture and civil engineering, and bringing it into the classroom so students can also learn about buildings and digital modeling would be a relatively small but pivotal step forward.

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Conclusion

With the completion of the 3-D model and the power point presentation, it draws significant attention to the fact that are a series of future facing issues that need to take place to provide complete assessment of the 3-D model as an instructional tool. Following this paper, the researchers intend to conduct on the building site instructional sessions to test the 3-D models use as an instructional tool. Statistical results withstanding, the creating of a 3-D model for Devon House is a significant contribution to preservation methods for the property. Besides being used as an instructional tool, Revit may be combined with other programs to: simulate possible environmental contingencies for the houses damage over time; calculate damages and money required for repair or additions to the site; and, extrapolate data of the house in relation to its environment. Such a demonstration is provided below in Figure 17, wherein the model was integrated into a site context using photoshop and the Revit model.

A key feature to understanding the construction process are the vernacular responses used in Jamaica during the 19th century that took advantage of the local climate and indigenous materials. Even with the use of primary historical texts, it is often difficult to determine the rationale behind specific design and construction decisions. Unfortunately, the research processes most likely to be fruitful are both invasive to the structure of the house and require the
use of expensive equipment. Nevertheless, this study has the potential to produce highly accurate 3-D models of complex structures like the Devon House. The open distribution of this model to other researchers in the field may provide a single launching point for other research on this and other properties in the Caribbean as well as other educational programs seeking to leverage the power of 3-D models for engineering and construction training.

Acknowledgements

We would like to thank the reviewers of this paper and the distributors of the survey. In addition, we would like to thank the graduate and undergraduate students who helped comment on this paper, along with those who took the time to participate in the presentations and take the surveys. Many thanks to Eli Balkin who provided invaluable knowledge on completing the IRB process and in finding students to complete the survey; Dwayne Brown for his countless hours assisting with the design of details both historical and modern; David Cuthbert for his feedback and provision of details; Dr. David Delaine for his timely and extremely useful feedback on the intricacies of creating a paper based on engineering education; Stephen Ellis for too many hours to count troubleshooting the Revit model; Kevaughn Harding of Falmouth Heritage Renewal for facilitating on site tours and discourse to determine historical accuracy of the description and dimensions used in Devon House; Ray McIntyre and Wayon Quest of APEC Consultants Limited, Jamaica for providing the autoCAD drawings of Devon House and numerous interviews about repairs on the property; Maya St. Juste for acting as an onsite liaison in the data gathering process; Tiffany Sealy for her assistance in sourcing much needed components to complete the model and Marsha Gaye Wright for providing feedback on the quality of the drawings, renderings and assistance with relearning the skills needed to operate Adobe Photoshop. Special thanks to The Caribbean School of Architecture and the Water Recourse Agency of Jamaica for their expertise and special contributions. Finally, we would like to thank the cohort of the Construction Laboratory for Automation and System Simulation (CLASS), Shilun Hao, Melissa Hrivnak, Adrian Tan, Fei Yang, Jin Yang and others unnamed who have provided valuable feedback to the paper.
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