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PRESERVING THE HISTORY OF AFRICAN AMERICAN EDUCATION: DIGITAL DOCUMENTATION OF ROSENWALD SCHOOLS - A CASE STUDY ON THE TANKERSLEY SCHOOL IN HOPE HULL, ALABAMA, USA

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ABSTRACT:

Established across the American South between 1917 and 1932, Rosenwald Schools were crucial for providing education to African American children during segregation. Now, many of these structures are abandoned and deteriorating, in urgent need of digital documentation and preservation. This paper introduces an innovative approach for using Matterport technology to capture immersive virtual tours and enhance Heritage Building Information Modeling (HBIM) with high-resolution imagery. The Tankersley Rosenwald School in Hope Hull, Alabama serves as the case study. Additionally, this paper features traditional Reality Capture techniques, such as Terrestrial Laser Scanning and aerial photogrammetry, in combination with Matterport technology to create a detailed HBIM model of the historic school. This model enables architectural and structural analysis, informing suitable stabilization, conservation, and restoration strategies. It also acts as a powerful visualization tool, allowing stakeholders to safely examine the school's architectural, structural, and historical aspects. The virtual tour produced through Matterport provides valuable data for developing an accurate HBIM model in Revit, leading to more effective conservation approaches. The integration of these technologies showcases the potential for digital preservation of built heritage and emphasizes the importance of innovative methods in cultural heritage documentation. By digitally preserving these historically significant schools, this research supports the conservation and restoration of a vital aspect of African American educational history and raises awareness of their cultural importance.

1. INTRODUCTION

Between 1914 and 1932, more than 5,000 Rosenwald Schools were built across the rural South of the United States of America, and over 400 of these were in the state of Alabama. Responding to decades of racial segregation and rampant underfunding of public education for African Americans, Rosenwald Schools afforded necessary educational opportunities. The success of the Rosenwald Fund came in part from a matching-grant program, which put responsibility and ownership into the hands of the community. The Rosenwald Fund, created through the leadership of Booker T. Washington and Julius Rosenwald, provided seed money to fund a portion, communities raised a portion of funding, and white school boards funded the remainder. By 1928, the height of the matching-grant program, at least one in every five rural schools for Black students in the South was a Rosenwald School. Forty percent of Black children in the South attended a Rosenwald School at the height of the program's popularity (Bean, 2007). These schools represented the education of a new generation of African American thinkers and are considered by economists to have created the African American middle class. The Rosenwald Schools laid the groundwork for the Civil Rights movement, with notable alumni such as poet Maya Angelou and the late Civil Rights leader and US Congressman John Lewis.

The design of the Rosenwald Schools was innovative and efficient for its time, incorporating passive systems such as natural daylighting, deep overhangs for shading, elevated foundations for natural ventilation, and movable partitions for flexible classroom instruction. According to the plans, "the building should always be set with the points of the compass, and the plan so designed that every classroom will receive east or west light" (Julius Rosenwald Fund, 1931). Schools varied, with one, two, and three-teacher school types so that each community could decide which type best met their needs. Figure 1 shows the original design of a one-teacher school.

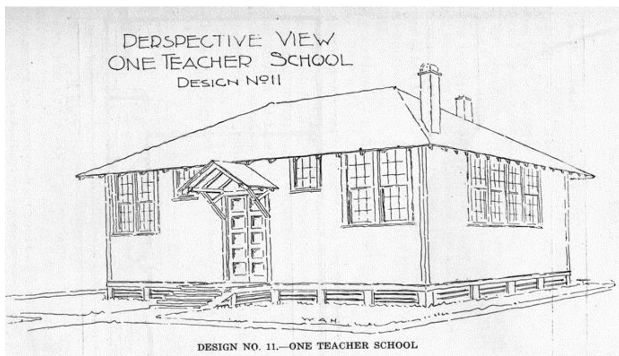

Figure 1. Design of one-teacher Rosenwald school. (Ncurrie, 2020)

Many Rosenwald Schools were abandoned in the 1960s when Black students were integrated into the previously all-white public schools. In 2002, the National Trust for Historic Preservation added the Rosenwald Schools to its list of historic places in peril ("America's Most Endangered Historic Places Listings by Year | National Trust for Historic Preservation," n.d.). The exact number of remaining Rosenwald Schools is unknown;

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however, the National Trust estimates that between ten to twelve percent remain across the South (Hoffschwelle, 2006). Today, preservation efforts of the Rosenwald Schools have been primarily reactive, rather than proactively seeking out sites across the South. Given the age of the buildings and the materials for construction, many of the remaining schools are at significant risk of substantial structural deterioration and the need to document these buildings is extremely urgent (as shown in Figure 2 for the current conditions of the two school buildings). Taking into account the historical significance of these schools, there is an urgent need for digital documentation and preservation (Conti et al., 2022; Liu and Willkens, 2021).

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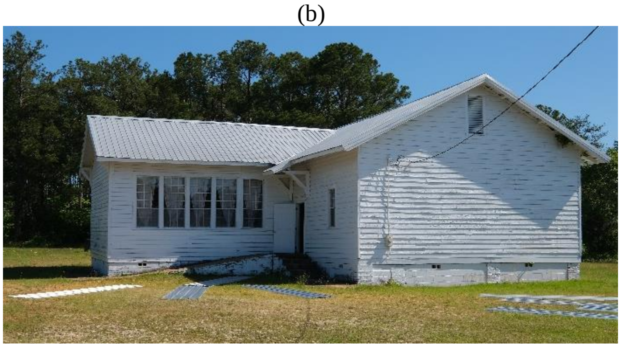
(b)



(c)

Figure 2. Photos shows the current conditions of several Rosenwald School building in Alabama. (author’s photo)

The research objective of this study is to develop a framework for digitally preserving Rosenwald Schools using various Reality Capture (RC) technologies and Heritage Building Information Modeling (HBIM), focusing on the case study of the Tankersley School in Hope Hull, Alabama. The RC techniques utilized include Terrestrial Laser Scanning (TLS), immersive 360-degree photography, and aerial photogrammetry assisted by Unmanned Aerial Vehicle (UAV). To digitally reconstruct the school buildings for future restoration, HBIM was also adopted by the research team (Banfi et al., 2019; Liu et al., 2022).

2. LITERATURE REVIEW

The preservation of cultural heritage sites has been an ongoing concern for professionals in the fields of architecture, archaeology, and conservation. The application of digital technologies in heritage preservation has gained significant momentum in recent years (Historic England, 2020; Ioannides et al., 2020). Among these digital technologies, Reality Capture (RC) techniques and Heritage Building Information Modeling (HBIM) have emerged as promising tools for the documentation, analysis, and preservation of historic structures (Andrea Adami et al., 2018; Angulo-Fornos and Castellano-Roman, 2020; Banfi et al., 2019; Garcia-Gago et al., 2022; Liu et al., 2023)

Reality Capture techniques, such as Terrestrial Laser Scanning (TLS), photogrammetry, and Unmanned Aerial Vehicles (UAVs), have been used to create accurate and detailed representations of heritage sites (Carvajal-Ramirez et al., 2019; Martinez-Carricondo et al., 2020; Youn et al., 2021). These methods enable the generation of high-resolution data, which is crucial for understanding the current condition of historic buildings and informing preservation efforts (A Adami et al., 2018). Heritage Building Information Modeling (HBIM) is an extension of Building Information Modeling (BIM) that has been specifically developed for the documentation and management of historic structures (Liu et al., 2023). HBIM integrates geometric, spatial, and semantic information into a single digital model, providing a comprehensive and accessible platform for the analysis, management, and preservation of heritage sites (Bagnolo et al., 2019). Various studies have demonstrated the potential of these technologies in different contexts.

For instance, Oreni et al. (2014) explored the integration of RC and HBIM in the restoration of a historical building in Milan. They highlighted the importance of accurate documentation for restoration projects and how these technologies can facilitate better decision-making and planning. Fai et al. (2011) discussed the role of HBIM in the conservation and management of historic sites, focusing on a case study of the Parliament Buildings in Ottawa. The authors stressed the importance of a collaborative approach in managing complex heritage sites and demonstrated how HBIM can be a valuable tool for coordination and communication among stakeholders. Moreover, Remondino et al. (2012) examined the use of RC techniques, such as laser scanning and photogrammetry, for the 3D modeling of archaeological and architectural heritage. Mukupa et al. (2017) investigated the use of RC for monitoring and assessing the degradation of cultural heritage sites by developing a methodology for comparing 3D models obtained at different times to detect and analyse changes in the physical state of the sites, demonstrating how RC can be employed as a valuable tool for monitoring and maintaining cultural heritage assets.

In addition to the studies mentioned earlier, Murphy et al. (2013) demonstrated the benefits of combining laser scanning and image-based techniques with HBIM for generating accurate and detailed 3D models of European classical architecture. The authors emphasized the value of these models in facilitating the conservation and understanding of complex historical buildings. Moreover, in their article, Del Giudice and Osello (2018) presented a case study to explore how the integration of different data sources, such as CAD, GIS, and BIM, can help create a comprehensive and efficient information management system for heritage sites.

These studies illustrate the versatility and potential of RC and HBIM in various aspects of cultural heritage preservation. By combining advanced technologies with traditional conservation methods, professionals in the field can achieve more effective and sustainable preservation strategies, ultimately safeguarding our shared cultural heritage for future generations. In conclusion, the growing body of literature on RC and HBIM in cultural heritage preservation showcases the potential of these technologies in various applications, ranging from documentation and restoration to monitoring and management. As these technologies continue to advance, their importance in the field of cultural heritage preservation is expected to increase, offering more effective and efficient solutions for preserving the invaluable heritage assets of our past.

Furthermore, recent developments in digital technology introduced new tools for capturing and documenting cultural heritage sites, such as Matterport technology (Matterport, 2022). This innovative approach creates immersive virtual tours, capturing high-resolution imagery and spatial data of heritage buildings (Foreman and Liu, 2022; Heesom et al., 2021; Liu et al., 2023, 2022; Liu and Willkens, 2021). The use of Matterport technology in combination with other RC techniques and HBIM has not been extensively explored, presenting an opportunity for further investigation and innovation in the field of heritage documentation.

The proposed framework in this study seeks to build upon the existing research by applying a combination of RC techniques and HBIM, with the integration of immersive virtual tours powered by Matterport technology, to the digital documentation and preservation of Rosenwald Schools, which are an essential part of African American educational history.

3. METHODOLOGY AND RESULTS

The research team developed a comprehensive framework for digitally preserving Rosenwald Schools using various RC technologies and HBIM, focusing on the case study of the Tankersley School in Hope Hull, Alabama. The methodology involved the following steps: 1) site selection and preliminary investigation; 2) RC data acquisition; 3) data processing and integration; and 4) HBIM model development. Figure 3 is an illustration of the HBIM implementation program utilized for the case study.

3.1 Site Selection and Preliminary Investigation

The Tankersley Rosenwald School in Hope Hull, Alabama, was selected as the case study for this research due to its typical architectural representation of Rosenwald Schools and its status as a building at risk. Studying this school provides valuable insights into Rosenwald Schools' historical context and emphasizes the need for immediate preservation strategies. Tankersley school was built in 1922 following the plans provided by the Julius Rosenwald Fund (1931). The building is a single-story wooden structure with a gable roof, featuring three classrooms and a small teacher's room. The exterior is clad with horizontal wood siding, and the interior walls are covered with beadboard panelling (shown in Figure 4). Preliminary investigations were conducted in late 2021 to gather historical data, architectural drawings, and other relevant information about the building.

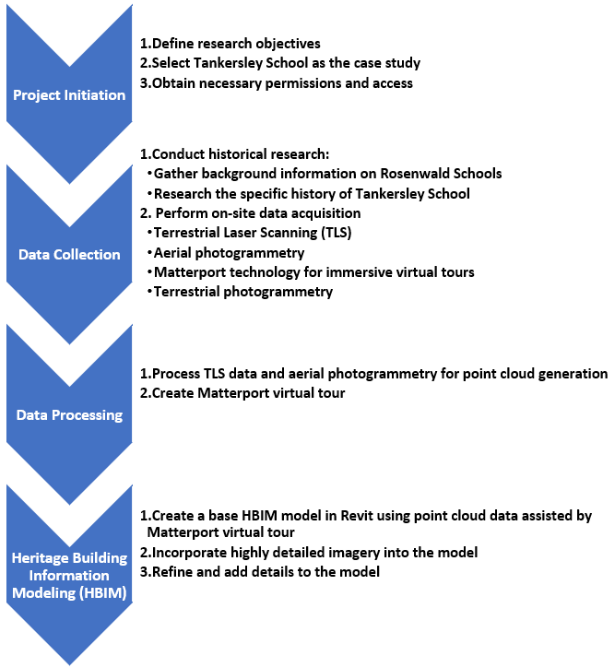


Figure 3. HBIM program of the Tankersley Rosenwald School building.

Figure 4. Tankersley Rosenwald School, Hope Hull, Alabama. (authors' photo)

3.2 Reality Capture Data Acquisition

The research team conducted a comprehensive RC survey using multiple techniques for the Tankersley Rosenwald School in early 2022. The following technologies and methodologies were employed:

3.2.1 Terrestrial Laser Scanning (TLS): A FARO Focus S-350 scanner was used to capture high-resolution TLS scans of the interior, exterior, and crawlspace of the Tankersley Rosenwald School. The TLS scanning took approximately 6 hours to capture a total of 51 scans (Figure 5). Scanning was performed using a medium resolution setting (12 million–28 million points captured by each scan) with a field of view of 360° horizontally and 270° vertically. Panoramic photographs were also captured for colorizing the points. Each scan lasted about eight minutes on average, including setting up scan station, scanning, and capturing panoramic photographs. Field notes were taken to track scan locations for post-processing. The TLS survey provided detailed, accurate, and comprehensive point cloud data, which formed the basis for the HBIM model (Murphy et al., 2013). This data captured the architectural and structural features of the building, including walls, windows, doors, and roof structure, as well as the building's relationship to its surrounding context.

Figure 5. TLS scan of the interior of Tankersley Rosenwald School building using a FARO Focus S-350 scanner. (authors' photo)

3.2.2 Immersive 360-degree Photography: A Matterport Pro2 3D camera was utilized to create immersive virtual tours of the Tankersley Rosenwald School. This process was completed in approximately an hour with 39 total setups (as shown in Figure 6). This method allowed for the efficient capture of high-resolution imagery and the creation of a detailed, navigable 3D environment. The virtual tour served as a valuable resource for documenting the existing conditions of the school and informing the development of the HBIM model (Liu et al., 2023).

Figure 6. Capture a 3D immersive virtual tour of Tankersley Rosenwald School using a Matterport Pro2 camera. (authors' photo)

3.2.3 Aerial Photogrammetry: A DJI Mavic Pro-2 Enterprise drone (as shown in Figure 6a) was utilized for aerial photogrammetry to capture high-resolution images of the Tankersley Rosenwald School and its surrounding area (as shown in Figure 6b). With the help of a mobile app called DJI Pilot, five pre-programmed flight routes were set to fly over the survey area at an altitude of 100 feet (30.5 m). The drone captured a total of 355 photographs, with individual image file sizes ranging between 10.7MB and 15.5MB. Among these, 121 photos were taken from a 90° bird's-eye view, while 234 photos were obtained at a 60° oblique angle. This aerial imagery offered valuable insights into the building's roof condition, site topography, and landscape features. By integrating this data into the HBIM model, a comprehensive understanding of the roof surface and site context was ensured (Carvajal-Ramirez et al., 2019).

(a)

(b)

Figure 7. A DJI Mavic Pro-2 Enterprise drone was used to capture aerial photos of the roof and site of Tankersley Rosenwald School: a) A DJI Mavic Pro-2 Enterprise in action; 2) An aerial photo pf Tankersley Rosenwald school taken by the DJI Mavic Pro-2. (authors' photo)

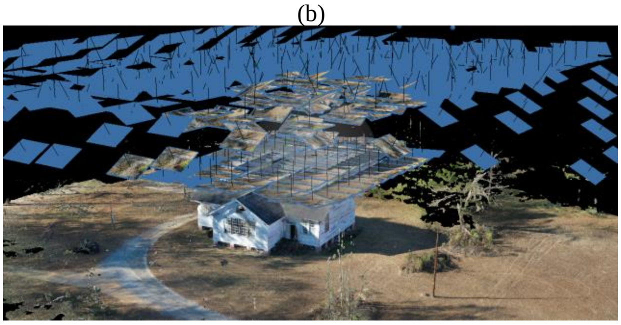
3.2.4 Terrestrial Photogrammetry: Terrestrial photogrammetry was conducted to document the details of the building's facade and architectural features. High-resolution photographs were taken from various angles and distances using a digital camera, Fuji X-T30, , and these images were later processed using Agisoft Metashape software to generate a 3D model of the building's exterior (Alshawabkeh et al., 2021).

3.3 Data Processing and Integration

The captured data from the various RC techniques were processed using specialized software programs. Agisoft Metashape was employed for processing aerial and terrestrial photogrammetry data, while FARO SCENE software was utilized for processing TLS data. The 51 TLS scans captured a total of over 840 million points. The mean registration error is less than 1/6 of an inch (3.9mm), which is sufficient for HBIM development in this case (Barrile and Fotia, 2022). The immersive virtual tour captured by Matterport provided an additional source of high-resolution imagery, enhancing the accuracy and detail of RC data of the building. By incorporating the Matterport data with TLS and photogrammetry data, a comprehensive and detailed representation of the Tankersley Rosenwald School was achieved. Figure 8 illustrate the results of the processed RC data.

(a)

(b)



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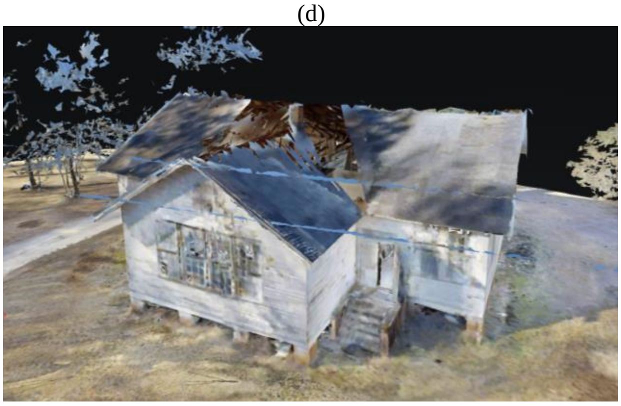

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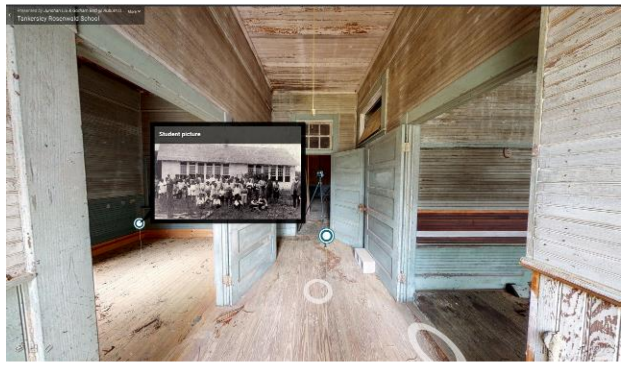

(f)

(g)

Figure 8. Resultant processed data from the RC survey of Tankersley Rosenwald School: a & b) TLS point cloud; c & d) aerial photogrammetric point cloud; e & f) immersive virtual tour; g) photomosaic of the east elevation. (author's photos)

3.4 Development of HBIM Model

Using Autodesk Revit, the research team developed an HBIM model based on the captured RC datasets (Figure 9). The model incorporated geometric, spatial, and semantic information about the Tankersley Rosenwald School, enabling a detailed and comprehensive representation of the building and its features. The HBIM model replicate the building's structural and architectural features, as well as serving as a visualization tool for the interpretation of the building.

The TLS and photogrammetric (both aerial and terrestrial) point clouds serve as the primary data source for developing the Revit HBIM model, while the immersive virtual tour captured by Matterport technology is utilized as a secondary source to enhance the process with highly detailed imagery. The point cloud datasets provide an accurate and comprehensive representation of the heritage site's architectural elements and overall spatial configuration. Meanwhile, the Matterport virtual tour offers high-resolution imagery, enabling precise identification and visualization of building components. This combination of data sources facilitates the creation of a detailed and accurate HBIM model.

The user-friendly visualization provided by the Matterport virtual tour also allows stakeholders and team members to easily explore the building and assess its condition. This enhanced visualization improves communication among team members, ensuring that everyone involved in the project has a clear understanding of the building's current state and preservation requirements.

Furthermore, the immersive virtual tour has the potential to be integrated into the HBIM model as a visual reference, complementing the point cloud data. This integration streamlines the process of model validation and offers a comprehensive understanding of the site. As a result, the HBIM model becomes a more powerful tool for conservation planning, structural analysis, and stakeholder engagement.

In summary, the combination of the point cloud data and Matterport technology's immersive virtual tour in the development of the Revit HBIM model enables a more accurate representation of the heritage site, improved communication among team members, and an enhanced overall understanding of the building's condition and preservation needs.

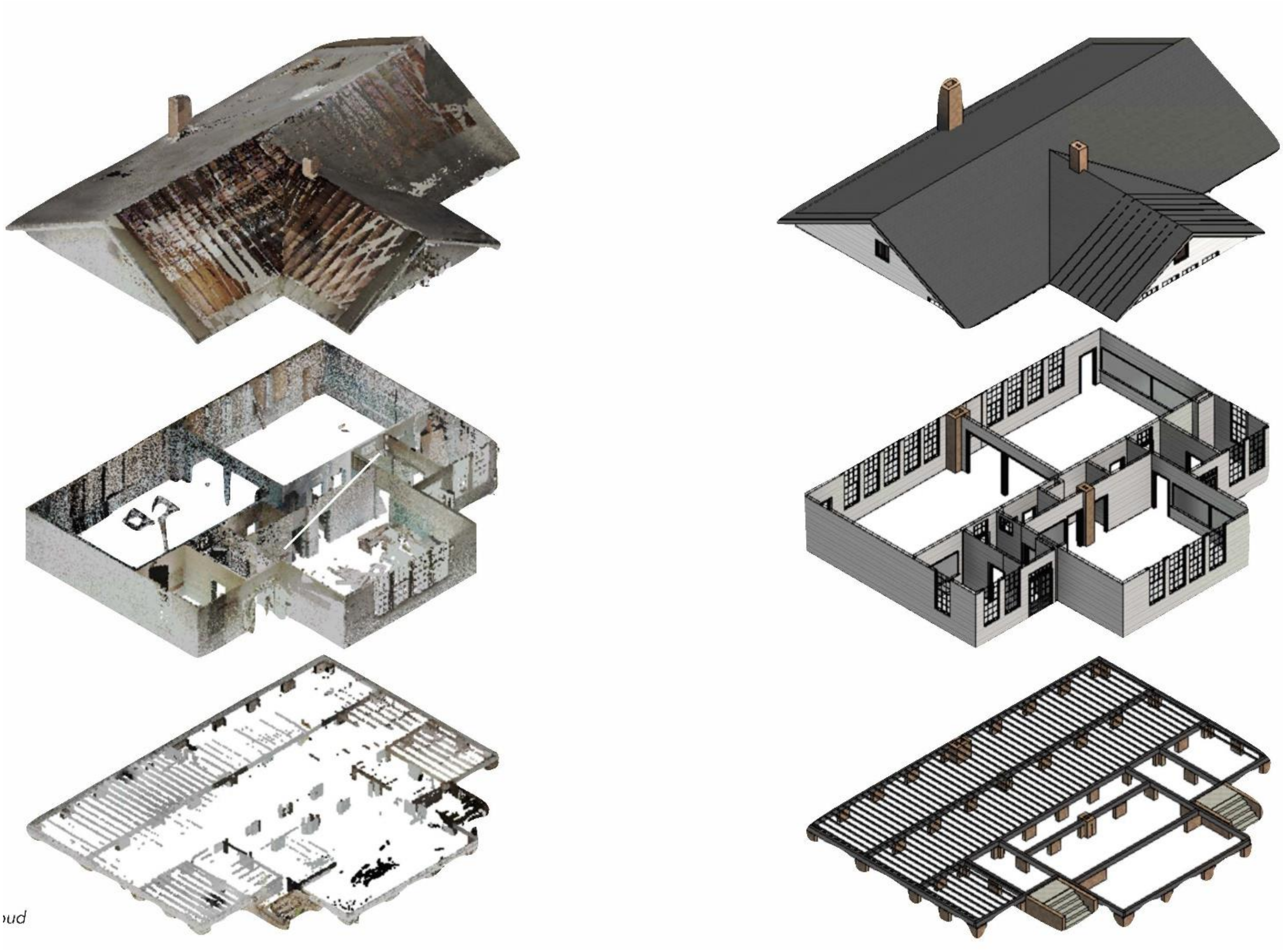

Figure 9. HBIM model development from the point clouds.

3.4.1 Geometric Modeling: The research team utilized the point cloud data as a reference for modeling the building's geometry in Autodesk Revit. The walls, windows, doors, floors, and roof structure were accurately modelled, respecting the original dimensions and proportions of the Tankersley Rosenwald School. The geometric model was essential for understanding the spatial relationships between the building's elements and providing a solid foundation for further analysis and intervention.

3.4.2 Semantic Enrichment: The HBIM model was enriched with semantic information by adding metadata about the building's materials, construction techniques, and historic significance. This information was gathered from archival research and field investigations. The semantic enrichment allowed for a more comprehensive understanding of the building's history, construction, and cultural significance, which is essential for informed conservation and restoration decisions.

3.4.3 Visualization and Dissemination: The HBIM model served as a powerful visualization tool, enabling stakeholders to explore and understand the Tankersley Rosenwald School's architectural, structural, and historical aspects. The model was used to create interactive virtual tours, 3D renderings, 3D prints, and augmented reality experiences that facilitated stakeholder engagement and communication. The dissemination of the HBIM model and associated visualizations play a vital role in raising awareness of the cultural significance of Rosenwald Schools and advocating for their preservation.

4. CONCLUSION

In conclusion, Rosenwald Schools hold a significant place in the history of African American education in the United States, serving as a catalyst for educational opportunities and social progress during the early 20th century. These schools played a crucial role in fostering educational growth and community development for African American students in the rural South, providing them with resources and facilities that were otherwise scarce. Therefore, it is vital to preserve and honour the legacy of these historical institutions.

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The framework presented in this research offers a valuable approach to digitally preserving Rosenwald Schools by utilizing a combination of reality capture and HBIM technologies, as well as the innovative integration of Matterport's immersive virtual tours. By generating accurate, detailed, and information-rich 3D models, the framework not only ensures the preservation of the schools' architectural characteristics but also creates a platform to showcase and share the cultural significance of these sites with a wider audience.

This research has broader implications for the preservation of other cultural heritage projects across the nation. By demonstrating the applicability and effectiveness of this framework, the study opens new avenues for using advanced technologies, like Matterport, in conjunction with traditional preservation methods. It provides a roadmap for professionals and stakeholders involved in the conservation and management of various heritage sites, emphasizing the need to preserve not only the physical structures but also the intangible history and cultural value associated with them.

Ultimately, this research contributes to the ongoing endeavors to protect and celebrate the diverse cultural heritage of the United States, ensuring that future generations can appreciate and learn from the past. By integrating innovative technologies and methods, it promotes a more comprehensive and engaging approach to the digital documentation and preservation of shared history.

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