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Terrestrial Laser Scanning, GPR, and CAD Stabilization Survey, of the Dummett Mill Ruins, Florida (8VO241)

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This report documents the use of terrestrial laser scanning (TLS), ground penetrating radar (GPR), and Computer-aided design (CAD) drawings derived from the 3D survey documentation conducted for use in the planning of stabilization measures to be undertaken at the Dummett Mill Ruins (8VO241). This summary report overviews the methods used in the project, the results derived from data obtained, and provides a discussion of some recommendations for work at the site. AutoCAD files produced from the TLS surveys, along with 3D models and other pertinent materials are provided on a DVD as an appendix to this report.

**Data Collection**

Historic sugar mill ruins and structures associated with the early Florida sugar industry are made primarily from coquina, limestone, or brick. Along with these stone-types, the mortars used in the constructions also face issues of deterioration from weathering of their exposed surfaces and from moisture intrusion. Previous restoration efforts at mill ruin sites used materials like Portland cement to repair coquina and limestone structures, methods now known to cause structural concerns, such as cracking and fissuring of surface features (Ferro, et al. 2000). Development of new methods for the examination, documentation, and analysis of structural composition and integrity, and identification of areas for restoration and conservation is a statewide and national need for heritage management.

Researchers at the University of South Florida’s Alliance for Integrated Spatial Technologies (AIST) are using new laser scan survey and mapping techniques to more completely document these structures in three dimensions. They are working with restoration specialists, heritage preservation architects, and land resource agency managers to develop improved ways of protecting these heritage sites. The ability for managers and restoration specialists to more completely visualize and study these mill ruins, remote from the site, will enhance conservation strategies and lead to better and more effective restoration.

AIST began a spatial documentation survey at the Dummett Sugar Mill Ruins (8VO241) in Volusia County in April 2009 (Collins and Doering 2009) (Figure 1). At that time, the mill ruins and the adjacent land within the fenced-in site area were digitally recorded using TLS survey techniques. From these data, a 3D model of the site and registered laser scan data was archived with the idea that these data would stand as a snap shot of current conditions at the site and could prove useful to conservators, engineers, and architects at a later date.

Figure 1. The Dummett Sugar Mill Ruins (8VO241) in April 2009. The spherical white objects in the photo are targets used for spatial orientation and scan registration.
This report deals with a subsequent, second survey to document the Dummett ruins following a structural collapse of a portion of the southern face of the north wall. Emergency salvage measures were taken by conservators to stabilize the feature until further analysis and planning measures for restoration could be undertaken (Figure 2). In November of 2009, AIST performed the follow-up 3D TLS survey. The data from this survey were used to produce accurate CAD 2D drawings of the ruins. Further, AIST researchers examined portions of the ground sub-surface using non-destructive GPR. The purpose of this segment of the survey was to establish the presence or absence of structural connectivity, footers, or foundations in the area adjoining the north elevation of the north wall and in and around the two extant chimney features.

Figure 2. Dummett Sugar Mill Ruins (8VO241) photographs show pre (left) and post (right) collapse of southern face of North wall.

The TLS survey was conducted using a FARO LS880 mid-range laser scanner with color option. The acquired data consist of millions of x, y, and z point coordinates that are accurate to +/-3mm and, collectively, form what is called a point cloud. These data, taken post-collapse, focused on the southern face of the north wall area where the collapse had occurred (Figure 3). The TLS survey was performed concurrently with an on-site reconnaissance by participating structural and architectural engineers and state officials who had assembled to discuss possible plans of action for stabilization. AIST researchers and technicians returned to the site in December 2009 to use dual-frequency GPR equipment to collect data in the sub-surface areas targeted by the stabilization team.
Figure 3. Color point cloud from the Dummett Sugar Mill Ruins (8VO241) TLS survey conducted in November 2009 following a collapse of a portion of the standing wall.

Post-Processing Point Clouds in AutoCAD

The data collected during the November 2009 3D TLS survey at the Dummett Mill was processed, registered, filtered, and cleaned. The processed data were then prepared and activated for its use in Kubit PointCloud® software. This software interface allows for the registered 3D scan point clouds to be utilized within the AutoCAD environment to produce 2D drawings (Figure 4). This interface proved useful in allowing AIST partner architects to receive and prepare data for analysis in 2D construction formats and allowed for a seamless processing and analysis tool for modeling.

The resulting 3D models and 2D drawings were then analyzed in an effort to better understand the nature of the historic ruin's construction and to inspect areas of structural concern. This analysis includes an on-going forensic assessment of natural and anthropogenic changes to the structure, observation and study of previous restoration efforts, identification of areas that may be at risk for further damage or collapse. The results are also designed to be used in the development of appropriate stabilization techniques. These data are also useful not only for their as-built information, but for developing models of what the site may have looked like historically, based on extant remains that are now digitally documented. These formats have useful function for interpretive development and long-term management planning for the site (Collins and Doering 2009).
Figure 4. Scan point cloud data of the north wall face elevation (top) and a portion of the south wall face (bottom) containing areas of structural are shown. The red and green lines were made using Kubit PointCloud® software in AutoCAD and are an example of the process of creating 2D line drawing directly from the 3D point clouds.
Existing Features

The Dummett Sugar Mill Ruins (8VO241) are associated with the circa 1825 sugar factory with rum distillery belonging to Thomas Dummett. The mill ruins are part of what is thought to be the first steam-operated mill in the area (Daniel et al. 1980) that used a boiler Dummett imported from Barbados for his operation (Payne 1999; Stanton 1949). The ruins today consist of the foundation of the structure, standing portions of the northern wall, two chimneys, remains of the kettle train, the steam boiler pit, and water supply features.

The structure was made from coquina and brick. Special refractory bricks or fire bricks were used to line portions of the chimneys (Figure 5). This specific type of brick was known to have been commercially produced in Pensacola, Florida in 1827 (Ries and Leighton 1909:39). The north wall contains masonry arches as an architectural support mechanism for stress-relief on the structure (Payne 1999:111).

Today, the extant northern wall measures 24.6 ft (7.5 m) at its widest point and the height of the southern face of the wall ranges from 8.5 to 9 ft (2.59 to 2.74 m) from present ground levels. The thickness of the wall is approximately 15-16 inches (0.39 m) (Figure 6). The lower portion of the wall is comprised of smaller cut coquina blocks (±1 ft width) assembled with thick mortar joints. An arch is present in the western portion of the existing wall and the coquina blocks occurring above this arch are significantly larger (±2 ft width). Previous surveys have indicated that these walls were originally plastered with tabby (Wayne 2001:76). Indications of the original plaster material can be observed in crevices in and around beam sockets and areas where wooden members previously existed (Figure 7). The east chimney measures 27.7 ft (8.45 m) high from the north elevation grade, and the West chimney measures 27.9 ft (8.49 m) from the north elevation grade surface.
Figure 6. CAD line drawing produced from scan data illustrates the south elevation of the Dummett Mill Ruins and includes the post-collapse coquina support.

Figure 7. Detail of the southern face of the North wall show remains of plaster where wooden beams and lintel features were mortared in place.
The TLS survey captured the extant structural ruin features, inclusive of the site footprint and visible below-surface features (wells) (Figures 8-10). These data were processed as point clouds viewable through the Kubit and AutoCAD interface, that allowed architectural site plans, elevations, and feature details to be reproduced in 2D line drawings (Figures 11-13). The recently collapsed portion of the wall was targeted for comparative examination using pre- and post-collapse scan data (Figures 14 and 15).

One area of structural instability noted in the scan data involved the west chimney (Figure 16), which appears to have moved away from the north wall more than the east chimney (Figure 17). This movement may be a result of differences in the grade of the land surface. The east chimney may have less of a northerly tilt due to its attachment to the wall by a metal connector and brick flue that are located on the north face of the wall (Figure 18). The east chimney, however, does lean to the east which may also be a result of the connective devices mentioned above. It is possible that if the wall is sinking downward, the chimney is being pulled in the same direction causing the deformational angle.

Figure 8. Static screen image of a 3D Point cloud, consisting of millions of x, y, and z location points, that comprise the west elevation of the Dummett Mill Ruins.

Figure 9. Landscape terrain features including visible below-ground features were captured in the survey for site plan drawings and modeling features.
Figure 10. Post-collapse color TLS survey data of the mill structure and surrounding landscape.

Figure 11. Example of CAD 2D line work derived from point data collected during the TLS survey showing the site plan for the Dummett Mill Ruins.
Figure 12. Example of CAD 2D line work derived from point cloud data collected in the TLS survey.

Figure 13. CAD 2D line work derived from point cloud data collected in the TLS survey showing areas of structural modification and concern for current stabilization project.
Figure 14. Scan data (top) showing the area on the southern face of the north wall affected by collapse that would require immediate stabilization, and pre-collapse measurement (bottom).
Figure 15. Color scan images showing the same area as seen in Figure 14 after collapse and following initial stabilization treatment. On-screen measurements of features are demonstrated in the bottom scan image.
Figure 16. Point cloud data was used to slice sections and create profiles of the west (right) and east (left) chimneys for further analysis in CAD and 3D software.
Figure 17. Point cloud data shown in clear, or see through mode, allows the chimney profiles to be viewed in relation to each other and the wall and for measurements to be made and CAD sections to be drawn.

Figure 18. Detail of flue area on north face elevation showing exposed brick and metal work below that tie into the eastern chimney.
**Historic Elements**

Significant changes are noted in the structural elements at the Dummett Mill since the first record of the site was made more than 74 years ago. Two photographs, now in the Florida Photographic Archives on-line, were taken of the site in 1935 and show that an estimated 30 percent of the north wall has fallen since those photographs were taken. A comparison of the structure in 1935 and today is illustrated in Figure 19, and a second arch feature is evident in the photograph.

![Figure 19. Photo of the north wall face taken in 1935 (credit Florida Photographic Archives) is overlain with present-day CAD line drawing demonstrating the structural loss that has occurred over the past 75 years. Note the arch feature to west of the chimneys.](image)

These changes are also noted from the south wall face elevation perspective. The west arch feature and beam inserts, similar to those in the extant east wall, can be observed (Figure 20). The photo in Figure 20 also appears to show what maybe a third chimney to the west or left of the image. Trees and foliage, however, make this photo difficult to interpret securely.
Additional suggestions about the historic configuration of the site are made in a 1934 reconnaissance report by Forester Felix Benton (1934), who reported on several ruin sites in the Volusia coastal hammock area. Benton includes a sketch of the site, then known as the Old Anacape or Tissimi Mission, and drew a planview and elevation of a portion of the then existing wall and chimneys (Benton 1934) (Figure 21). Compared to the 1935 photographs and later recorded information, his sketches of the mill appear to be more fanciful than factual. His spatial inaccuracies are understandable, but he depicts three arches and three chimneys in areas where they are not present in photos taken in the same time period. Nevertheless, when his drawings are considered in relation to present day conditions and alignments, there are some areas of congruency in the site plan (Figure 22).
Figure 21. Benton’s (1934) sketch of a portion of the north wall elevation and a planview drawing of the footprint of the mill, which was at that time thought to be an old mission site.

Figure 22. Benton 1934 drawing showing sketch of the north elevation with present day CAD overlay.
The presence of a third chimney has been an item of discrepancy between historic documents and field sketches made at the site. The sugar works were built by Rueben Loring of St. Augustine, who was commissioned by Dummett in 1825. Loring would later file a lawsuit against Dummett for non-payment and claims that inferior materials were used. The Loring case documents indicate that there were two chimneys and associated abutments and three arches (Wayne et al. 2001:70).

Benton’s 1934 drawing (Figures 21 and 22) indicates a third chimney was present at the westernmost end of the structure, although this area has been considered today as a likely wall support. John Griffin hypothesized a different location for a third chimney following a visit in 1952. He reported finding a chimney base at the north side of the structure approximately a meter west of the extant western chimney (Wayne et al. 2001:72) (Figure 24). Drawings based on Griffin’s 1952 recording of the mill include elements to the west of today’s standing structure, however, the surface grade and spatial scale are depicted inaccurately.

Payne, who conducted work at several plantation sites in the Tomoka basin including the Bunch/Dummett parcel area in 1996, 1997, and 1998 (Payne 1999) (Figure 23), did not find evidence to indicate a third chimney in the location suggested by Griffin (Wayne et al. 2001:73) (Figure 24). Because the area on the north and west sides are today covered with rubble, confirmation of the actual number and location of an additional chimney, as well as the exact configuration of the site structure will require additional archaeological excavation and testing.

Figure 23. Payne’s (1999) site plan on the left, compared to the current TLS-derived plan on the right.
The Ground Penetrating Radar Survey

AIST also performed a limited scope Ground Penetrating Radar Survey (GPR) survey at the Dummett mill that concentrated on an area of interest that was identified on-site by the structural engineering and architectural stabilization team in November 2009. GPR data were collected with an 800 MHz antenna using a ProEx system from Mala Geoscience Inc (Figure 25). Sub-surface profiles were collected beginning immediately adjacent to the north wall face, from the east edge of the wall to the west chimney. East-to-west passes were made at 5 cm intervals in a northerly direction. The small alcove, or recess between the two chimneys, was surveyed at the same intervals but in a south-to-north direction. Data sampling was taken every 0.23 cm along each pass (Figure 26).
Data were processed using the ReflexW software. Processing steps include filtering, static shifts, background removal, uniform application of linear and exponential gains, and 3D migration. The resulting images show considerable scatter energy, indicative of pebbles, blocks, or other point-like objects. There were three notable zones of reflected energy that are indicative of larger features that are within the sub-surface of the northern wall and chimney area. These data suggest that foundational stones may extend some 15 cm north of the north wall (Figures 27 and 28), and that it extends fully under the open area between the chimneys, at approximately 30 to 40 cm depth (Figures 29-31).

Figure 26. GPR survey location grid is shown in color relative to TLS surveyed area (top) and the derived CAD 2D line work (bottom).
Figure 27. This planview image map shows energy returned from a depth of approximately 30 cm from the surface. A bright spot, within the red outline, extends some 15 cm north of the north wall between 1.5 and 3 m west of the east end of the wall. At greater depth this feature appears wider. The north side of the wall runs parallel to the bottom edge of the image.

Figure 28. The planview image map (top) shows a view of energy returned from about 40 cm depth from the ground surface at the north edge of the wall (outlined in red). The figure below shows this same feature in a cross profile view. The anomaly is located at 2.0 m y-distance on the figure above (outlined in red), and 10 cm north of the wall. The north side of the wall runs parallel to the bottom edge of the image.
Figure 29. The planview image map (top) shows a view of energy returned from about 30 cm depth from the ground surface at the north edge of the wall in the area between the east and west chimneys (outlined in red). The figure below shows this same feature in a cross profile view. The north side of the wall runs parallel to the bottom edge of the image. The upward-curving arcs are an artifact of data processing of a set grid with gaps, which are the chimneys on either side of the alcove.

Figure 30. The planview image map (top) shows a view of energy returned from about 30 cm depth from the ground surface at 60 cm north of the wall, at $y = 1.5$ m on the grid. A faint NW-SE linear feature in the central part of the survey area outlined in red) is an anomaly suggestive of additional sub-surface stone material.
Recommendations

The TLS surveys conducted by the USF Alliance for Integrated Spatial Technologies in April and again in November of 2009, serve as an archival reference of present-day conditions at the Dummett Mill Ruins (8VO241). These data have been processed and used to produce accurate CAD drawings, and serve as a foundational reference for future archaeological, stabilization, conservation, and interpretive efforts at the site. Taken in combination with other forms of non-invasive remote sensing methods, such as GPR, these data offer potential for the continued monitoring and targeted exploration of these ruins. The current scan-derived CAD work portion of the project (Appendix 1,) is useful for the analysis of present site conditions and can be compared to other 2D renderings and early photographs of the site to examine changes through time and to pursue appropriate methods for stabilization and restoration of this historic site.

The following are further recommendations based on AIST involvement in these surveys for future work at the Dummett Mill Ruins:

1) Verification of subsurface anomalies from the GPR survey could prove valuable in understanding the foundation features and assist further in the stabilization, interpretation, and understanding of the site.

2) A more complete understanding of the Dummett Mill Ruins could be garnered by targeted excavations, particularly in securing site details and layout. Taken in combination with the three-dimensional data collected, a model of the site in its historically-accurate configuration can be produced and made available both virtually.
(on-line) and in display and interpretive development. Scan data from the TLS survey, combined with CAD, can render models that can be scaled and 3D printed. These 3D visualization techniques can prove useful for future interpretive and public archaeology at the site or in an off-site locale.

3) Tree roots, from trees that have been removed, now appear to be contributing to structural integrity problems as the subsurface spaces once taken up by the roots are now collapsing and causing shifting in above ground features. Most notably impacted is an area near the firebox opening and first kettle. Subsurface stabilization, such as petrification of the remaining roots in situ, could be investigated.

4) Reinforcement between the chimneys and the north wall is needed, as is separate stabilization measures for reinforcing the western end of the wall nearest the west chimney.

5) Existing and displaced stones from recent collapse episodes should be cataloged and sorted in an effort to retain historic understanding of this site. Currently, there are numerous stones from recent collapse episodes that scatter the surface of the west end of the north wall and into the row of kettles and purging area.

6) Continued removal of intrusive vegetation and biological growth on the stone surfaces using best management techniques is recommended.

7) Protection strategy for reducing moisture intrusion, such as roofing over the extant ruins is put forward as a possible area of exploration, assisting with the redirection of water and moisture accumulation on the coquina surfaces.

8) Structural voids in the north wall should be filled, preferably without adding mortar mixes that would be non-reversible or would affect the original fabric and mortars. Replacement of lintels and other non-stone structural supports that historically existed is also recommended.

9) Develop a database of past and on-going restoration and stabilization treatments at the site, including all associated documents, drawings, and datasets. This database could be added to as part of on-going management planning and documentation. Included in this database can be interviews with engineers, archaeologists, architects, managers, and conservators who have or are conducting work at the site. This database can function as an historic Building Information Management (BIM) system.

10) Continued monitoring of the site with TLS survey and color panoramic photography should occur both at defined intervals (such as annually), and at prescribed times such as during pre and post stabilization and restoration procedures, and in the event of any collapse or if any structural integrity problem arises.
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