Documentation and Preservation of Historical Monuments in Nepal using 3D Laser Scanning Technology - Pancha Deval Temple

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Abstract

Nepal is a country known for its rich cultural heritage and architectural legacy. The Architecture is recognized worldwide from the myriad of anonymous street temples, large and small, to the inimitable marvels of Newari culture and the three Durbar Squares situated in the Kathmandu Valley. Nepal has one of the highest concentrations of World Heritage architecture and sites, some dating from the 13th to 17th centuries. Nepal's unique architectural and cultural is part of the living fabric of Nepali life, past, present, and future.

It is, therefore, an inspiring to embrace the mission and participate in the ongoing preservation efforts in Nepal due to the frequency of earthquakes at these sites. Many of these sites are in perpetual danger of collapse and are in a constant need of maintenance and repair while a number require extensive rehabilitation or total reconstruction. It is rare for any structure to have a complete set of archival or record drawings.

Recently, Prairie View A&M University, School of Architecture (PVAMU-SoA) in collaboration with UNESCO-Nepal, conducted a comprehensive 3D laser scan of the historic Pancha Deval Temple complex (five temples) located in Kathmandu, Nepal. PVAMU-SoA has long recognized the importance of preservation and creating digital and analog records of historic sites for record as a component of their CURES center. At PVAMU-SoA, we contribute to the professional record and maintenance of existing, damaged or destroyed structures for the benefit of preservation and historical heritage record.

In this paper, we will demonstrate the exceptional capability and long term potential of the 3D laser scanning technology for standard use in preservation projects and as a new learning tool for students in the architectural education curricula. The 3D laser scanner has become a requisite technology, capable of merging the varied digital, and analog systems within the discipline of architecture, landscape architecture, city and regional planning and preservation. And finally, we will expound on its potential as a complete and specialized technology with a broad range of solutions to the task of preserving treasured sites and foster collaborations.

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Overview

1. **Link this paper to the 2015 earthquake as the seminar is dedicated to the Lessons Learnt or rehabilitation after the 2015 Gorkha earthquake.**

Nepal lies on top of two colliding plates, the Indian and Eurasian and is extremely prone to earthquakes, landslides, and avalanches. In 2015 the Gorka earthquake devastated the entire nation of Nepal, killing nearly 9,000 people and many thousands more were injured. There was also damage to more than half a million homes and other buildings. It was the worst natural disaster to strike Nepal since the 1934 Nepal–Bihar earthquake.

The Total Collapse of Kathmandu's 188-year-old Dharahara Tower is an example of the devastation of a living architectural monument and UNESCO recognized site. The Dharahara Tower is a perfect model for collaborative reconstruction efforts that will focus on best methods of reconstruction and an insight into future preservation methodologies. Nepalese Architecture is a unique archetype among its neighbors and the architectural tradition forms an authentic cultural legacy that has remained unchanged over the centuries, preserving the use of its buildings for their express purposes even now.

Fig 1: 3 D Model Assembly

Nepali houses, shrines, buildings, and architecture form a living museum in real time. With limited funding ability, it is wise to involve the expertise of everyone and involve the boundless energy of our young students, artists, archeologists, preservations, and architectural historians in the best methods of restoration and reconstructing for their long-term survival and durability.

With the creation and development of sophisticated 3D laser scanning devices, there is a new awareness and excitement for historic preservation from the architectural and engineering disciplines that were traditionally slow to adopt this new technology. This new 3D laser technology is being utilized by students and academic programs in Architecture, Historic Preservation, and Community Planning Departments.

PVAMU-SoA faculty and students use 3D laser scanning technology to engage in historic preservation projects that increase awareness of the educational, scientific and cultural fabric of societies as well as their historic value, building practices, and to provide information for their ongoing digital documentation, maintenance, and reconstruction projects.

More significantly, our program offers, especially students, the opportunity to acquire sophisticated work experience and learn an advanced skill that will be useful in their future. It is essential that students in architecture and allied preservation professions acquire these new tools during their studies and it is our intent to promote collaboration with other parties and like disciplines across the globe at every opportunity.

Fig 2: 3D model Pancha Deval Temple

We believe in sharing our knowledge and expertise and are willing to work in tandem and in partnership to train and establish connections to other schools of architecture, planning and engineering departments especially in Nepal where there is such a strong desire among the Nepali government and people to preserve their heritage and architecture. It is, therefore, our honor and privilege to establish these partnerships and participate in the growing global awareness of historic preservation, archival drawing, and professional documentation that embodies the timeless memory, history, and continuity of culture, people and place.

Laser Technology

3. Provide a summary of the methodology and outcome in the Abstract. Please also suggest in the Abstract what paper intends to deliver.

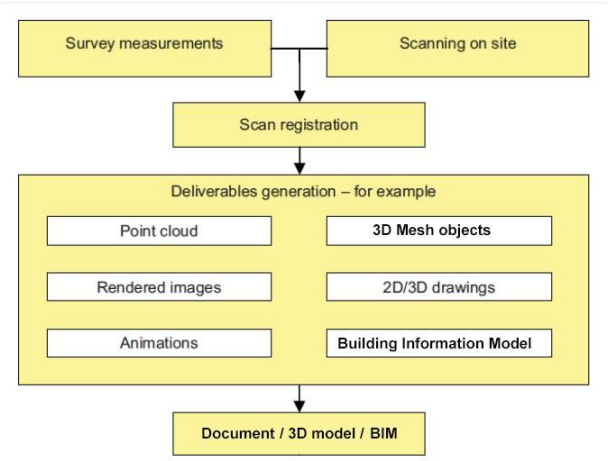
Historical buildings with many blended elements are often difficult to measure with conventional surveying material. By scanning buildings, facades and interiors using a 3D laser point cloud one can easily generate and define data through safe, non-contact means. The 3D laser scanning technology captures large and small scale projects with precision and accuracy and enables the study of details with spectacular accuracy delivering the highest quality 3D data and High Definition Resolution (HDR) imaging at an extremely fast accurate scan rate and range of 270m radius horizontally and vertically, at the rate of one million points per second.

A synopsis of this process is as follows:

1. Survey, measure, and set up: The process includes how to plan and set up a 3D laser scanner and targets at the site and configure the basic set up for the scanner.

2. 3D laser scanning on site: The process requires conducting an actual 3D laser scan of the building and site by using Leica ScanStation P40 scanner and targets.

3. Scan registration of the database using Cyclone: In this process, import raw data to the project database to be used for registration by using Cyclone software. The project database generates point clouds



3D laser scanning work flow

scanned from each position of the site and 'stitches' them together as an entire 3D point cloud of the targeted building.

4. Deliverable Reconstruction drawings from AutoCAD: This point cloud can be imported to an AutoCAD drawing in 3D space by using CloudWorx software. The AutoCAD floor plan, elevation and section drawings can be generated from the point cloud information.

5. Creating a reconstructed 3D model from AutoCAD drawings: By converting the point-cloud to a mesh model, a 3D digital model can be created and a 3D physical model can be fabricated using a 3D printer.

The PVAMU-SoA Fabrication Center has the capacity to fabricate large architectural models as well as small details. Recently PVAMU-SoAFC fabricated a scaled model of one of the historic Pancha Deval Temples from the complex of five at Kathmandu. The fabrication process starts with drawing the three dimensional model using one of several software programs such as; AutoCAD 3D, Revit, SketchUp, and Rhino. For the Pancha Deval Temple, we used our F370 3D printer, which has one of the best quality and speeds on the Stratasys 3D printer line. We divided the model into three separate pieces and started printing at 1/1000 of an inch per slice height. Our printer is a FDM (Fused Deposition Modeling) 3D printer.

2. Inclusion of limitations of the proposed method and how these could be recovered would make paper comprehensive.

One of the limitations of the laser scanner is that it is not accessible to all building areas. The added use of a drone enables the laser scanning technology the ability to scan in places that are inaccessible or dangerous. The drone gives an added sense of safety sand saves valuable time by accurately measuring blind views and building roof areas from a bird's eye view.

After the laser scanning work is a complete part of our objective is to assist in determining the best means of reconstruction to prevent failure and or future collapse of existing and new structures. Some of the traditional methodologies may have to be enhanced, changed, or improved in order that long term viability of the historical artifact can be best preserved.

Conclusion

PVAMU-SoA CURES Center has engaged in ongoing projects nationally and internationally, with partners in their efforts to preserve and document numerous historical sites. In doing so, our faculty, staff and students gain valuable experience and work in tandem with others and strive toward a high level of success and achievement that will provide the groundwork for lifelong future collaboration while fostering intercultural understanding, and supporting the preservation vision of World Heritage sites that strengthen the bonds between nations, societies and people.

Fig 4: PVAMU students at UNESCO-Nepal

Most recently, PVAMU-SOA CURES Center faculty and students traveled to Katmandu, Nepal, to present to UNESCO reconstruction as-built drawings of the Pancha Deval Temple complex in Kathmandu. Our exciting project and work with UNESCO-Nepal was a catalyst for our present and future efforts in working with historic preservation. An additional outcome of this effort will be to engage students at other Universities in Nepal in local preservation efforts and train students in the use of 3D laser scanning technology and digital documentation so they become partners and stakeholders themselves.

The laser scanning is but a first step, the data it produces is the second. The decisions and best practices are third and most important. The preservation effort must be propelled by prevailing technology. The use of non-traditional building materials must follow a pragmatic path where practical. The use of prevailing and sensible technology must be paramount. It is essential that these issues be decided now for future preservation efforts to be successful while still maintaining the wondrous and timeless cultural heritage and architecture of Nepal.

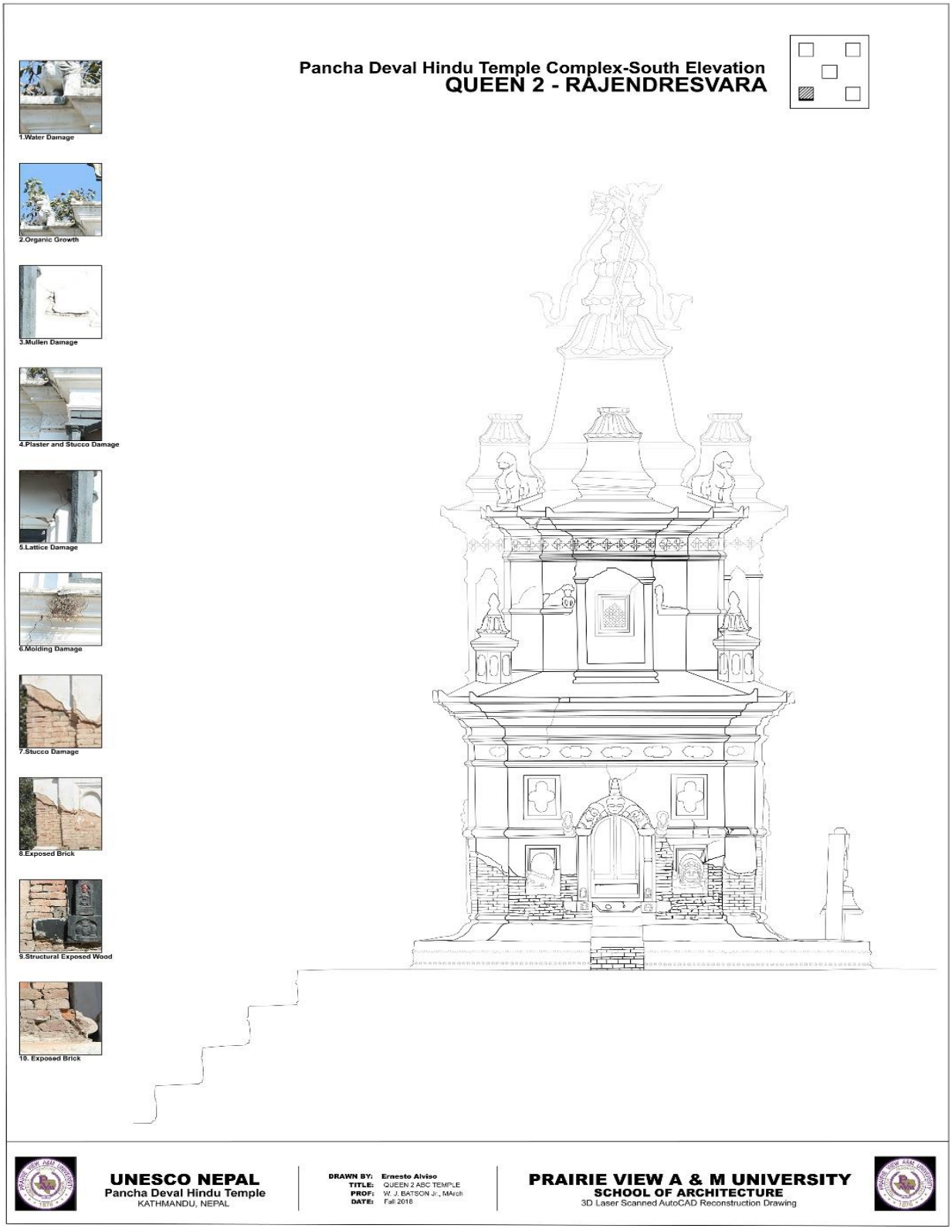


Fig 5: Drawing of Pancha Deval Temple Complex-South Elevation

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Stephen Y. Song: Has a Master's degree in Architecture and studied Ph.D program in Architecture. His research is focused on digital documentation of built environment and digital fabrication. He has numerous publications for the research area. He is currently the Director of Fabrication Center, where he is teaching advanced digital fabrication technology to students and he is also involved in historic preservation and rehabilitation projects with CURES Center.

Abel T. Simie: Holds Master's in Architecture and taught Auto-CAD and Revit for several years. Currently, he manages the Fabrication Center at the School of Architecture, Prairie View A&M University. He gives trainings and assists on variety of projects involving students, staff and Faculties with different discipline. His expertise is focused on 3D Printing, 3D Scanning, CNC Cut, and Laser Cut Machine. He enjoys being involved in projects such as Historic Preservations that make a huge impact in capturing humanities historical buildings.

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