Heritage Information Modelling: A Conceptual Framework for Enhancing Cultural Resilience of Indian Tangible and Intangible Heritage

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Abstract

Now a day, preservation of Indian heritage buildings and monuments is a major challenge. Without proper understanding of the heritage sites, historical structures, specifications of materials and construction methods, the preservation of heritage structures becomes difficult and challenging. All relevant tangible and intangible information about heritage structures should be available and considered before their repairing. Due to non-availability of basic information such as complete and full drawings of heritage buildings, specifications and sources of used materials, construction methodology, etc., the retrofitting and preservation work of heritage structures gets delay and becomes difficult to manage them. All required tangible and intangible information about heritage structures in form of the digital and user-friendly format can be helpful to solve the above issues. This paper presents the concept of Heritage Information Modeling (HIM) and its application by developing a framework. The framework of HIM integrates all tangible and intangible information for heritage such as photographs, images, virtual tours, laser scanned model, plans, elevations, sections, construction related information, material information, assets register, detailed history, cultural importance, history of repair and retrofitting, travel and tourism data, development policy, maintenance and repair plans. The framework will also help to improve resilience of heritage structures and be part of smart and sustainable development. It will be beneficial to various stakeholders such as historians, archaeologists, architects, engineers, contractors, and different government bodies involved in conservation of heritage.

Keywords: Heritage Information Modeling; Conservation; Resilience; Sustainable; Database

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Introduction

India is enriched with the richest and diversity of cultural and architectural heritage. India has many heritage structures and sites. In which the protected 36 monuments are declared as World Heritage Monuments by UNESCO, and about 3,650 monuments in the custody of Archaeological Survey of India (ASI) are declared as monuments of national importance. Many heritage buildings are in the custody of religious trusts, Archaeology Departments of state governments and private owners (Menon 2014). Conservation of heritage is not limited to only tangible heritage, but intangible heritage is also preserved. The tangible heritage consists of monuments, structures, sites, artefacts and physical objects while intangible heritage includes culture, tradition, festivals and arts. The preservation of such enriched cultural heritage is also the major challenge in India. Conservation and preservation of heritage is delayed due to non-availability of full information about intangible and tangible heritage at one place. In this connection, it needs to have a common platform of tangible and intangible information of heritage in digital form so they can easily be accessed by users.

Challenges and limitation of current practice

Documentation of heritage buildings is mainly in form of 2D plans, elevations and sections. Hard copies of drawings are not preserved for long time and shared easily with other stakeholders. Now, these drawings are developed and stored in the digital format by computer aided drafting. However, 2D drawings fail to provide the information on third dimension, depth or height of the objects. This leads the scope for enhancing the process, by introducing a digital model. A 3D digital model can provide a more realistic visualization for all stakeholders, so they efficiently and accurately understand the unique characteristics of a heritage building and the site. This practice will lead to the development of a more sustainable and resilient design for heritage conservation work.

Objectives

The prime objective of this paper is to develop a framework to retrieve, compile and store the intangible and tangible information of heritage by Heritage Information Modelling (HIM).

The paper first introduces the term Building Information Modelling and its application. Then understanding the concept of HIM and its application are described. Last section describes the conceptual framework of HIM and necessary details about it followed by concluding remarks of the paper.

Literature review

Building Information Modelling (BIM) was primarily being used by Phil Bernstein from Autodesk. Charles Eastman frequently used this term in his books in late 1970. Then, this term was used by German Jerry Laiserin to present the manufacturing process and to give the exchange of information in digital format. The first implementation of BIM was under the Virtual Building concept in 1987 by the company Graphisoft with platform ArchiCAD (Logothetis et al. 2015). BIM is the *n* dimensional digital presentation of construction site, a structure or a building along with its desired properties and information. BIM is the intelligent parametric components and information of built environment which includes data and parameter for each component (Hergunsel 2011). As per National BIM Standard, BIM is "*a digital representation of physical and functional characteristics of a facility and a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition*" (Saeed 2013). BIM model becomes extensively useful from all individual key players who participate in the construction for sharing information (Brumana et al. 2013). The systems which are using BIM are different then the 3D CAD because BIM models are the smart

virtual model that consists of the detailed information about whole construction project such as 2D drawings, plans, elevations, sections, 3D views, structural drawings and details, methodology of construction, material specification and related information, Mechanical, Electrical, Plumbing (MEP) system plans and information, cost and financial related data, time and scheduling data (Eastman et al. 2011). BIM represents the whole project in n Dimensions, while six dimensions are popularly known. 3D represents the all three spatial dimensions of the project. 4D represents the dimension of Time. 5D represents the dimension of cost and 6D represents the dimension of sustainability. BIM is now a day most popular platform for project delivery all across the globe.

From BIM to Heritage Information Modelling (HIM)

The key benefits of BIM are efficient stakeholder collaboration, structured information sharing, and integration of facilities management requirements in the early stages of project. Generally, there is a myth that BIM has shown exclusive benefits in new building construction and infrastructure sector only. However, heritage sector projects such as conservation, repair and maintenance, refurbishment, reuse etc. could have extensive benefit from the incorporation of BIM and collaborative work practice, which leads to improvement in efficiency, cost reduction, better planning and less reworks for heritage buildings and sites (Historic England 2017).

Heritage Information Modelling (HIM)

Many researchers have been trying to how to apply BIM in conservation of heritage, its documentation and for other many purposes. The application of BIM in heritage is known as H-BIM (Heritage Building Information Modelling). The HIM adopts and integrates the concept of BIM for the heritage science point of view. Figure 1 shows the conceptual representation of HIM.

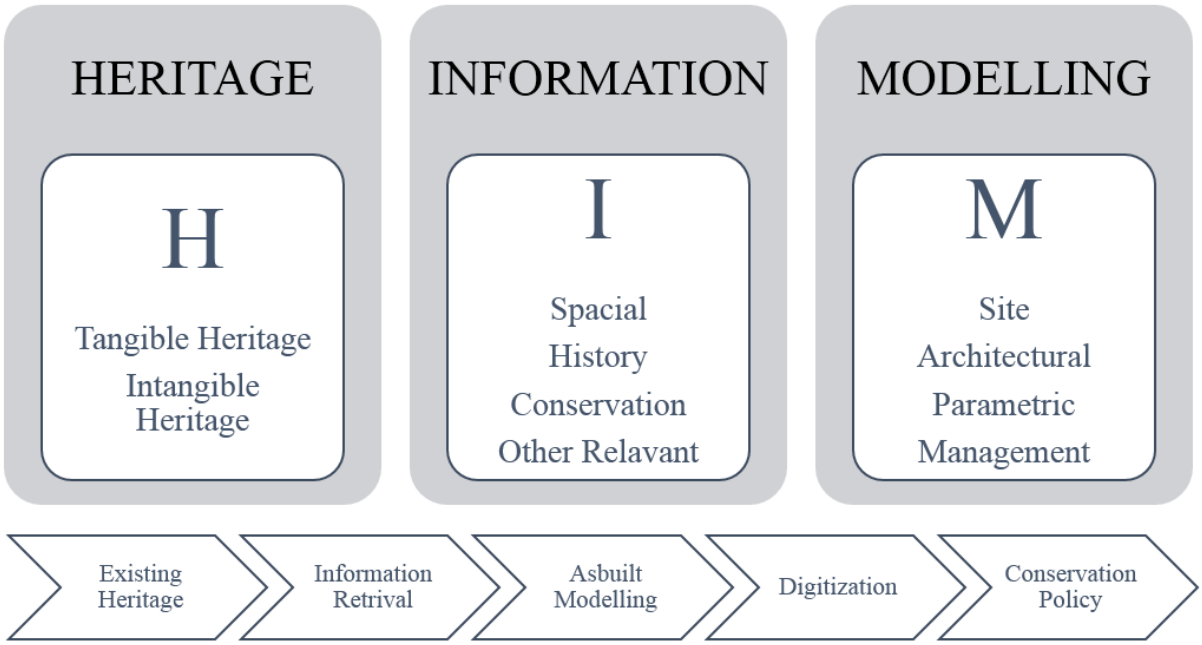

Figure 1 Conceptual Representation of HIM

Heritage

The term Heritage refers to all kind of heritage such as the tangible and intangible cultural heritage. Also the heritage refers as the existing building or structure or monument which is having the high cultural importance. Tangible cultural heritage consists of moveable and immovable heritage, the moveable heritage consists of paintings, sculptures, furniture and artefacts etc., while the immovable heritage include historic buildings, monuments and archaeological sites. Intangible cultural heritage refers as cultural traditions, oral traditions, science and habits related to world and traditional skills.

Information

HIM has the main aim of providing the common platform of information. Information refers to all relevant information associated with heritage such as special information, which refers to all existing plans, elevations, sectional data, photographic documents etc. Another important information is the History. In HIM, the history is the primary information which

consists of the history in all aspects such as philosophical history, timeline, cultural history, repair and maintenance history, conservation history, practice codes, guidelines, rules and regulations, etc. The information is essential for understanding the structure, materials, construction methods and other character defining elements of historic sites. The information is being retrieved from all the relevant sources and stored in the digital format.

Modelling

The term Modelling represents the digital 3D virtual model of the heritage site which is being prepared by various as-built modelling techniques such as laser scanning, photogrammetric and virtual tours. The modelling is also refers to the linkage of information with the virtual model or the digitization of the information. All the relevant information are collected and linked to appropriate place of the model.

HIM Framework

Successful heritage conservation project depends on complete, accurate and reliable information. HIM is the collaborative working platform offer a framework for managing exchanging of information and maintaining its integrity throughout the project stages among all the stakeholders. The newly prepared conceptual framework of HIM represents the comprehensive workflow and integration of information which provides clear picture of Heritage Information Modelling in all the aspects. Figure 2 shows the conceptual representation of HIM framework. The Information is mainly divided into three main categories: (1) Spatial information (Tangible data), (2) Temporal information (intangible data), and (3) Other linked information. These three databases make the model enriched with the required information. Depending on the type and size of the heritage site, the amount of information and level of detail will be varying. For example, small heritage site may not need

high level of details while the heritage site of national importance or world heritage sites require more details

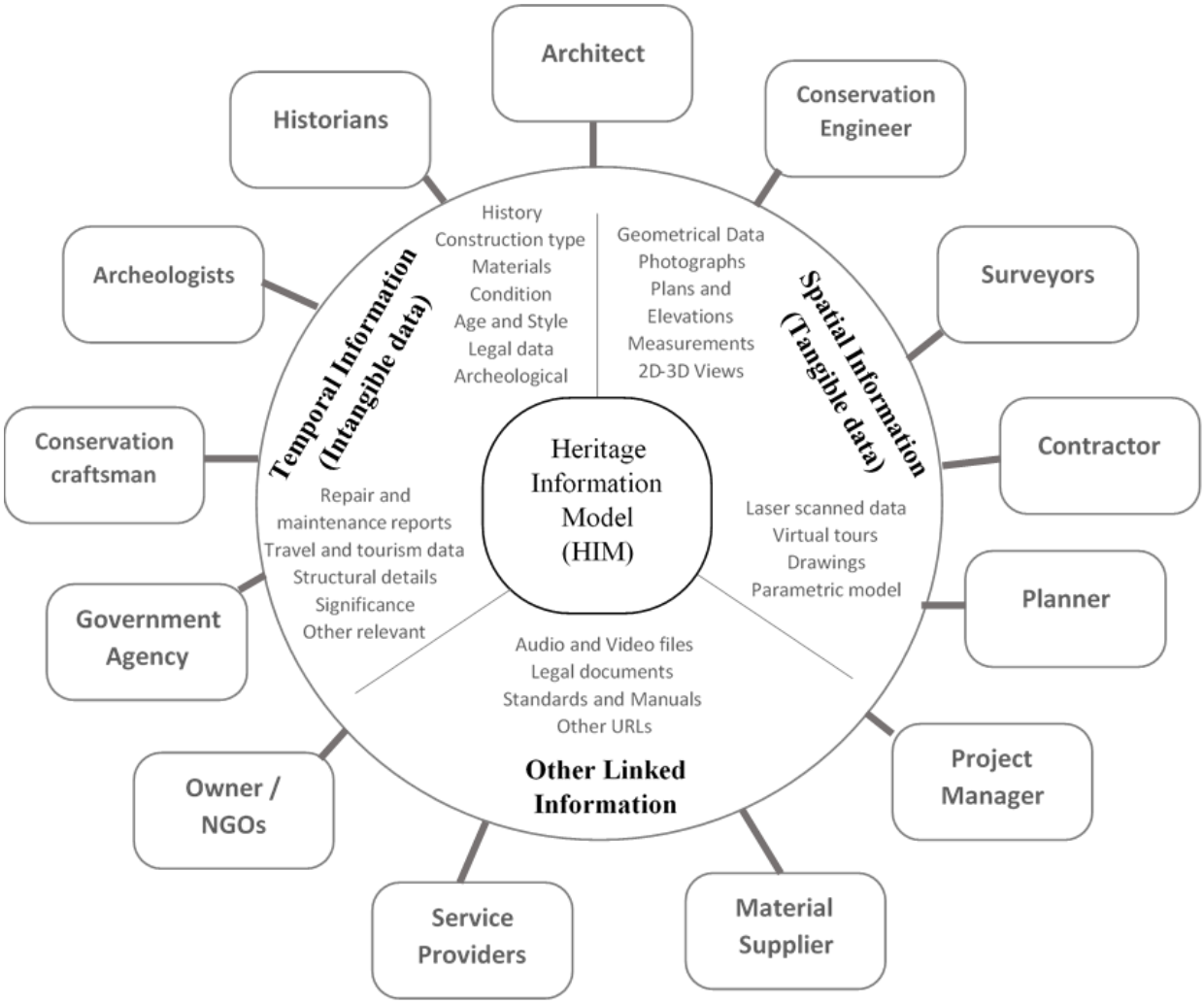

Figure 2 HIM Framework

Spatial Information (Tangible data)

In the first category, spatial information consists of all existing tangible data as listed in Figure 2. Documentation of existing condition of heritage sites is a main important aspect of the heritage conservation and this is the base of Heritage Information Modelling. As built modelling techniques are accurate and fast for obtaining 3D data, and being used to prepare the document of heritage buildings and sites (Garagnani and Manferdini 2013). As-built modelling techniques such as laser scanning, closer range scanning, photogrammetric,

LIDAR, mobile mapping or a combination of desired techniques can be used to produce 3D as built model (Brumana et al. 2013, Santagati 2005, M. Galizia 2011, Soler et al. 2016, Maxwell 2016). Outcomes of built modelling in point clouds are supported by most BIM software. 3D surveys, 2D drawings and virtual tours (Napolitano et al. 2017) can be used as to collect spatial data for modelling of relatively small or low budget sites.

Temporal Information (Intangible data)

The temporal information are the intangible dataset which consists of history in all aspects, construction type, materials, condition, age and style legal data, archeological data, repair and maintenance data, travel and tourism data, structural details, historical, local or religious significance etc. HIM provides the facility of organizing all information such as drawings, historic photos, prints, written materials, recordings or any of digital file into a spatial hierarchy. This information is being linked to model components and that makes the intelligent 3D model of the heritage.

Other linked Information

Other information from surveys and site investigations can also be embedded into the model as external attachments. Other than embedded data, any kind of external file can be attached with the model and can be linked to components. These may include archived data, operation and maintenance guidelines, reports, condition surveys, audio and video files, inspection reports and any other type of file. The external file format is not concern of software because it can be linked by uniform resource locator (URL) and can be opened in operable applications.

Stakeholder Coordination

As shown in Figure 2, the key feature of HIM is that, it will bring all stakeholders on a single platform. In the heritage conservation project, many stakeholders are working together so it

needs to have proper communication to avoid scope creep, dispute, and unnecessary delay. Thus HIM provides a single digital model which can be used by all stakeholders to communicate and disseminate information among themselves in smoother way which leads to higher efficacy of the work. Different stakeholders can use the digital tools which are appropriate to their task regardless of the software choices of other members of the team. Most popular BIM software are Allplan (Nemetschek), ARCHICAD (Nemetschek/Graphisoft), Revit® (Autodesk®), Navisworks (Autodesk®), Digital Project (Gehry Technologies), Solibri (Nemetschek), Vectorworks® (Nemetschek), MicroStation (Bentley®) and AECOsim (Bentley®). These software can be used for HIM as per requirements. The software systems are commonly referred as digital ecologies or digital software ecologies (Abanda et al. 2015). These software mainly depend on interoperability, the seamless flow of information across different software platforms. Interoperability is facilitated through open-data exchange formats, which are developed at an international level and applied across all sectors of the architecture engineering and construction industry.

Application of HIM

The applications of HIM are as below;

Visualization: the 3D virtual model provides better visual understanding of heritage site or structure in all aspects.

Drawings: it becomes easy to generate any kind of drawing from the model as and when required for any purpose.

Cost Estimation: the available software tools are able to estimate quantity and to take off options which are useful for cost estimation of any maintenance, repair or rehabilitation work.

Inspection and Diagnosis: HIM is as-built model, so that it is very easy for inspection and diagnosis, as whole model can be inspected accurately on computer software.

Simulation: the model can be used to visualize and simulate various conditions such as earthquakes, floods, water leakage checking, energy generation, thermal expansion, and other site specific simulations.

Facility management: the model can be used for different facility planning such as repair and maintenance, tourism planning, and all other kind of facilities management.

Concluding Remarks

Requirement of information (data) is quite essential for research. The major challenges of conservation of Indian cultural heritage are the non-availability or lack of the information as and when required. Traditional practice mainly relay on 2D drawings and non-collaborative working environment which leads to inappropriate or delayed conservation work. The HIM can be the best way to store, maintain and disseminate the information as and when required throughout the life cycle of heritage. HIM is not just a 3D model or software, but it is a technology which provides multi-disciplinary stakeholders collaboration for better information sharing management in heritage conservation projects. Proposed framework comprehensively provides a repository or database for information related to all three aspects of heritage assets, which will be used efficiently and effectively for future research, investigation, conservation and management. The modeling seems costly in initial stage but due to its seamless advantages, it can be economical for conservation and preservation of Indian cultural heritage. The HIM model will be useful for further research such as condition assessment surveys, structural health monitoring and other many kind of analysis.

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