CRITICAL ISSUES OF LAYERED STONE CONSTRUCTIONS AND APPLICATION OF ARCHIVES IN INVESTIGATION – THE CASE OF VITTHALA TEMPLE, HAMPI WORLD HERITAGE SITE

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ABSTRACT

Structural analysis of traditional constructions, irrespective of its scale, nature or importance, is complex and an interdisciplinary process, often challenging interventions. Such structures are faced by the lack of information on building materials, architectural and construction system, history of interventions and workmanship, limiting structural assessment. Moreover, trained in modern construction methods, conservators find it difficult to comprehend historic constructions and either require intrusive tests or involve specialists.

This paper discusses the approach adopted to analyze and communicate causes of structural failure of the inscribed properties of Hampi, which are essentially of stone or composite in nature and are evidences of evolution in architecture, construction system and material application. Built over time, the Vitthala Temple marks the culmination of this experiment. Abandoned over two centuries, the Temple was ‘repaired’ by introduction of buttresses and new members, removal of ‘deteriorated’ members and application of concrete. The impact of these interventions coupled with other factors, today manifest through non-designed movement and inclination of structural members, instability and in some cases – collapse. Today, conservation of these structures and selecting the appropriate course of intervention pose a challenge for decision-makers.

Keywords: Stone and Composite Structure, Analysis, Communication of technical information

1. INTRODUCTION

Authentic information forms the backbone to comprehend, analyse and thereby undertake conservation of historic constructions. Generation of building information, considering all possible sources, is the crucial first-step, but receives very little priority and the resultant implementation, remains largely debatable. Moreover gap in technical know-how of the traditional construction together with little information on the life-cycle of the structure, remains a challenge for conservators to take informed decisions. The impact of ill-informed and non-recorded intervention over a length of time, in many cases as seen in India, has led to irreversible alteration of the original traditional construction system. This paper, though the example of an inscribed property – the Vitthala Temple of Hampi (World Heritage Site), Karnataka, Southern part of India, demonstrates the approach developed to enable relevant agencies to take informed action.

2. THE GAP IN COMPREHENSION – WHAT AFFECTS COMPREHENSION OF HISTORIC CONSTRUCTIONS IN INDIA

The principles governing modern constructions have evolved through experimentation. In cases of modern constructions, the built envelop is the result of known theories, principles and material. Any innovation or altered techniques remain within an accessible domain and can be made available in

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case of defects or failures. Identification of the causes of failure is often rectified before construction or within a short span of time or it becomes a topic of pedagogical interest. The time-lag and the gap in knowledge between identification of defects and research for a solution are reduced as exhaustive information pertaining to the building is accessible and available.

For historic buildings, the nature of source and availability of information and the paucity of knowledge of the method of construction in combination challenges accurate comprehension and analysis. Today, the understanding of historic structure in India depends solely on secondary or generated information i.e. either classical literature, texts, tenets, chronicles or eulogies of kings, that shed some light on its establishment, alterations and events during its lifecycles, but carry little information that enable understanding the architecture and construction system. Also, the quantity and quality of information contained in the records remains affected by the prevalent contemporary socio-political situation and perceptions of decision-makers. Altogether, in the absence of supporting data and knowledge among related professionals, comprehension of historic structures becomes subjective. Decision-makers and working professionals often resort to methods that often have irreversible negative impact on the resource.

This paper, through the example of Vitthala Temple in the World Heritage Site of Hampi, (Karnataka, South of India), tries to demonstrate that comprehension of historic constructions and foreseeing impacts of interventions are essential to conserve such structures for posterity. It must be noted that this paper explains the condition of the structure and has been written with the sole purpose of aiding decision-makers who may not possess technical know-how to assess the long and short-term impacts of sanctioned interventions. In a way, it stresses the need to bridge the gap between the technical requirement and administrative limitations that has affected many historic constructions of the Sub-continent. Although a condition appraisal, material testing and recording of movements in structural members is indispensable to validate this paper, the resources available could not support the same. The paper is based on secondary sources and visual surveys.

3. DEVELOPING AN APPROACH

Sources, irrespective of form, date or origin, add to building information when processed. The Site of Hampi has been in the records by many over a length of time. Ranging from chronicles and courtly literatures, to departmental (ASI) archives to research, the offsite sources of data can be classified in many ways. However, as the application of information for decision-making is a process seldom followed, its maintenance, updating as well as access for application remains challenged.

In the case of Hampi, it has been noted that several decisions pertaining to conservation works were independent of available information. The continuation of this practice has in some cases affected the structural integrity to an extent where the original construction system remains permanently altered. The approach developed for the paper started with the search for secondary information to better comprehend the structure and condition of the Vitthala Temple. To generate information on the architectonics and lifecycle of the structure and to develop a method for site observation, the potential of all sources present were considered. From previous research and official endeavours certain number of publications and official records were acquired that enabled understanding of the history of constructions, develop a general chronology and identify changes of the Vitthala Temple Complex. Thereon, off-site information was correlated with site observations to analyse the condition and state of the structures.

3.1. About the Site

The Hampi World Heritage Site is the remnants of a Medieval Capital City of the Vijaynagara Empire (14th-16th Cent CE) of a metropolitan scale. The Site is located in southern India, in the state of Karnataka, on the western ghats, on either banks of the river Tungabhadra. It is known for the excellence achieved in art, architecture, socio-cultural and economic dimension, administration and military organisation evident from remains unearthed, the extent monumental ruins and archival records. The Vitthala Temple Complex established between late 15th cent to mid 16th Cent was one of the most elaborate constructions of the era, marking the zenith of development of Vijayanagara Architecture [1].

Research or data on constructions prior to the 19th century is scanty. As a result, much of the information is correlative, from sources which provide little information that help conserve the structure and its material. Hampi, as opposed to many other sites in India, has some research
conducted by the team steering the Vijaynagara Research Project, whose focus was documentation. The three decade long Project that spanned between 1970’s to 2000 AD, help in developing a deeper understanding of the historic structures extant in the Site. The book – ‘Hampi-Vijayanagar, The Temple of Vithala’ by Vasundhara Filloozat, a historian, is probably the only comprehensive study conducted on the Vithala Temple [2]. Apart from information from the aforementioned project, extracts from the epigraphs, site inspection notes and site observations, help develop the chronology of construction, understand the life of the structure and hence comprehend the condition of the structural system. It must be noted that to reach the conclusion mentioned in this paper, tests could not be conducted as it was beyond the scope of the project, affecting definitive analysis. Broadly, the establishment and completion of the Temple Complex can be dated from late 15th cent A.D. to 1554 A.D., in use simultaneously. In 1556 AD, the principle shrine and the Gopuras were destroyed partially by mechanical injury and arson when the Vijaynagara rulers were defeated in the Battle of Talikota and post which the site depopulated and the structures fell from use. Till late 19th Century when the British administrators commenced surveys, the area was described to be ‘covered by dense vegetation and in ruins’. Works that have been defined as ‘emergency’, ‘civil’, ‘special repairs’ and ‘gardening’ undertaken since 1880’s and with slight modification of technique and technology, continues till date by the Archaeological Survey of India. In 1986, the Vithala was inscribed in the World Heritage List as a part of ‘the Group of (56) Monuments, Hampi’.

![Fig. 1 Site (Left) and view of Vithala Temple Complex (Right)](image)

### 3.2. Processing information from Off-site sources

Off-site sources of information for the Vithala temple include courtly chronicles, epigraphs, research documents, translation of epigraphs, architectural and survey drawings, photographs, site-inspection notes, estimates and quantifications, logs of implemented works, correspondence concerning site observations, published and unpublished texts and oral information from resource persons.

![Fig. 2 Samples of Site Inspection Notes (A), Survey Drawing (B) and Epigraph (C)](image)

#### 3.2.1. Extracting from Epigraphs [3]

The epigraphs, court chronicles and traveller’s notes are perhaps the oldest form of data available for the Vithala Temple, as well as for Hampi. Though these accounts are often overlooked as ‘non-technical’ and or secondary, their application largely lies in corroborating chronology, dispel ambiguity in identification and provide an idea of building defects, apart from forming a supporting narrative for the Site. It is also interesting to note that the identification of phases of construction of individual structures can be made possible from the inscriptions. Also, the primary purpose of epigraphs was to eulogise grants made by patrons, so for most cases, the contents need to be corroborated with other sources. It must however be understood that the total number of inscription dedicated to a temple cannot be known as many has been destroyed or still are unknown. Within the Vithala Temple complex, there are over 76 inscriptions in 3 different languages have been found. Most of the epigraphs include information on the number of grants that were made for the maintenance and functioning of the temple complex by kings, nobles and others. Three epigraphs have
been found to provide information on the chronology of construction. First, the establishment of the Noorkal Mandapa or the Hundred Pillared mandapa within the Prakara (Enclosure Wall) can be dated to 1516 A.D. As per another epigraph, the construction of the pinnacle and installation of the Kalasha of the northern Gopura (Gateway) completed in 1538 A.D.. Later in 1559, addition was made to the pinnacle, nature of which remains unknown. The extracts from the epigraphs corroborates the layering in construction i.e., the different components extant in the site today, have been constructed over a period of time.

3.2.2. Extracting from Published and Unpublished sources [4, 5]
Most of the published sources of information for Hampi has been drawn from the Vijayanagara Research Project, which, continuing over three 3 decades explores different aspects of the Site. The book ‘Hampi-Vijayanagar, The Temple of Vithala’, which is an output of the aforementioned project, provides information on the history, architecture and phases of construction of the Vithala Temple. The publication also provides a set of documentation of the temple complex and its features, forming the base for further understanding. Official archives, both published and unpublished is the most critical source that helps assess the condition of the structure and understand the impacts of interventions that altered much of the construction system. Since its establishment, the Archaeological Survey of India under the British administrators began the system of recording condition of protected monuments prior to execution of civil and other works. These records were in the form of Site Inspection notes and schedule of estimates supported by survey drawings and later photographs that best justified intended interventions. Later, the Annual Reports or the Indian Archaeology – A Review, retained excerpts from the Site inspection notes, demonstrating works undertaken during the financial year. Till as late as 1970’s there are traces of recording made in Site Inspection Notes, which provide an elaborate description of the sites and its condition as well as impact of interventions. Between 1880 to 1928 as many as 29 interventions and 42 between 1958 to 2000 A.D. were recorded by the Archaeological survey of India. These records show that over the century, ranging from partial demolition, replacement of ‘cracked’ or ‘broken’ member, re-plastering, construction of accretionary or masonry pillars supporting wall sections, laying of cement concrete and bitumen as water-proofing layers, cementing of joints, complete and partial reconstruction of parts of structures, re-alignment of floor slabs and other members, excavation, landscaping and road laying. The Temple Complex today embodies the aforementioned types of interventions that were undertaken at a point of time when the technology was limited and there was very little understanding of the construction system. The focus being on the physical form, interventions stopped with maintaining stability. This left little scope to develop an understanding of the architectonics prior to intervention. The introduction of accretionary pillars and masonry props, sealing of interlocked joints with concrete to maintain alignment as well as application of layers of bitumen to water-proof the roofs have affected the structural system by introducing a new pattern of non-designed load.

4. FINDING FROM OFF-SITE SOURCES ABOUT THE VITTHALA TEMPLE COMPLEX

4.1. Chronology of the Temple Complex
Broadly, the establishment and completion of the Temple Complex can be dated from late 15th cent A.D. to 1554 A.D. In 1556 AD, the principle shrine and the Gopuras were destroyed partially by mechanical injury and arson when the Vijaynagara rulers were defeated in the Battle of Talikota and post which the structures fell from use. Till late 19th Century when the British administrators commenced surveys, the area was described to be ‘covered by dense vegetation and in ruins’. Works that have been defined as ‘emergency’, ‘civil’, ‘special repairs’ and ‘gardening’ undertaken since 1880’s and with slight modification of technique and technology, continues till date by the Archaeological Survey of India. In 1986, the Vithala was inscribed in the World Heritage List as a part of ‘the Group of (56) Monuments, Hampi’.

Stone (Quartzo-Feldspathic Granite-Schist for structural members and green-chlorite schist for decorative members) and bricks with lime mortar respectively, were the primary and secondary material for construction. Since most of the structures were dry, interlocked stone construction, very little of the composition and origin of bricks and lime is known.
Stone sections that are processed and used as building material are extracted from the ‘boulder-hills’ that are a part of the Western Ghat in Deccan Plateau region. Over millions of years of physical and chemical processes, the hills have disintegrated and eroded to form ‘piles of boulder’-hills that are characteristic to the landscape. The extraction of building material from the surrounding landscape follows the same process of its disintegration as observed from the traditional quarries, evident till date. The high change in the diurnal range of temperature, caused extreme heating and cooling in a short span of time repeatedly, causing the deepening of the fissures of the boulder. As a result, the boulder split easily along the cracks, especially where there was a concentration or pattern formed by embedded minerals. The process of splitting is often expedited by addition of moisture, when minerals dissolve, lowering resistance to splitting along cracks. The method of extraction applied by the traditional craftsmen involved selection of an area in close proximity to the site of construction. Thereon, small sections of wooden pegs were strategically wedged within cracks and wetted, being kept overnight. The wooden pegs absorbing water increased in volume, inducing stress that caused the boulder to disintegrate along the crack. Sections were then sized and transported to the site for construction.

Fig. 3 Part of the quarry demonstrating method of extraction of stone sections

4.3. About the Architecture, Structure and Construction System [7, 8]
The Vitthala Temple marks a high point of architecture and construction practice of the Vijaynagara Dynasty and is the focal point for Vitthalapura – an expance dedicated to Lord Vitthala (an incarnation of Lord Vishnu). This Temple Complex is located in the Tungabhadra River valley, a low lying area, surrounded by scanty vegetation and granite boulder-hills. Owing to the proximity to a perennial river and being traversed by fresh water streams carrying overflow of rain water from surrounding highland, the valley is subjected to annual flooding, leading to erosion of top soil. Considered as one of the most artistic and elaborate temple in Hampi, Vitthala Temple is the testimony of the most elaborate form of Vijaynagara Architecture. Unlike other temple complexes in the site, it is the most elaborate in scale having a Prakara (enclosure wall) that encloses a principle and subsidiary shrines, associated mandapas (hypostyle pillared pavillions), of which the Kalyana mandapa (ceremonial hall) is the most elaborate. Within the enclosure, axially aligned with the principle shrine is a Garuda shrine in stone, fashioned as a chariot, which is a significant development of the Vijayanagara period, a testimony to religious rituals. The Enclosure Wall is punctured on the 3 sides (east, south and north) with Rayagopura (entrance ways). The Raya Gopura, introduced first in the Vijayanagara temples and attributed to Raja Krishna Deva Raya, is a landmark all over South India. Dedicated Bazaar streets were an integral part of Temple Complexes as elaborate as the Vitthala. The Bazaar Street of the Vitthala Temple Complex was the largest of the 7 known in Hampi with a width of 16.3 meters in width and 122 meters length. To support the Vitthala temple complex an elaborate water system was dedicated in the form of a large Pushakarani (Stepped temple tank) with a Vasantotsava mandapa (ceremonial pavilion in the centre of the tank), wells and conduits or water channels. To maintain and manage the temple and its functions, grants of resources were allocated enabling performance of daily, weekly and monthly rituals. The synchronization of the Temple Complex with the surrounding natural landscape and construction of the built forms spanned over 50 years.

4.4. The System of Construction
Information on the architecture and construction is acquired through site observation in combination with few older official photo-archives (early 20th Cent) and survey drawings that were used by appointed conservation assistant to communicate with the superintending archaeologist at circle head offices.
There are 4 elements of the structure and its stability was maintained by placing larger or heavier sections over comparatively smaller sections and together with interlocked joints, retained members in position. The synchronised interlocked joints together with the systematic distribution of the over-head load enabled the traditional craftsmen of the Vijayanagara empire experiment with the span, scale and use of stone against wood. The main shrine of the Vitthala Temple is an example of this experiment, achieving largest of spans and monumental scale in the site.

The first layer that is, the foundation or substructure extends to the plinth, the latter being carved on the exposed surface. A trench or cavity was excavated where larger sections of stones were used to consolidate the base. Layers of rammed earth reinforced by broken stones, bricks and rubbles were used to fill the pit. Later, the same was levelled and topped by stone flooring.

On the evened flooring of the plinth, columns of a predetermined number, were placed in regular interval. In some cases, the gap between peripheral columns is filled with stone slabs, stacked from floor to ceiling, giving a sense of enclosure to the space. Where a of a circumambulatory pathway is added, the excavation for its foundation would be undertaken later. However, this remains an exception with the Vitthala Temple, which was constructed together with the Sanctum.

The column base and shaft are monolithic, sometime carved and is topped by a capital having a larger section. Over the columns, which act as vertical separators between the flooring and the ceiling, lay a network of inter-locked beams that support roof slabs. Along the periphery of the beams, a comparatively smaller section of stone slabs are placed to support overhangs from the roof, dispelling rainwater from the structure.

The roof over hypostyle pillared halls or mandapas is flat, with the exception of the tapering shikhara or pinnacle, constructed of bricks and lime mortar, finished with stucco and is placed over the sanctum. The Prakara wall followed a different system of construction from that of the other built envelopes. These were double-leafed with an infill of random masonry. Even sections of stones lined the exposed surfaces and at regular intervals, spacer strips were used to resist buckling.

![Fig. 4 Active Deterioration processes in the natural landscape](image)

5. **LEARNING FORM THE SITE [8]**

Site observation followed by tests, which in this case could not be performed, is possibly the most effective method to identify issues affecting the structure and the long term impact of the interventions made earlier. Today, the site presents a highly altered form of the architecture and construction system and material utilization pattern. Much of the understanding and conclusions are acquired through
a correlative process, piecing together site observation and other related information. Understanding of the behaviour of building materials in its environment, followed by its condition on the building and lastly assessing the impact of interventions together help understand condition of the structure, stability and likeliness of failure.

5.1. Understanding the building materials and its performance
Understanding of the basic material – stone and its behaviour in its natural setting was the first step undertaken. Granite on MoHs (Measure of Hardness) scale measures as 4th hardest and is the principle building material. The landscape of Hampi is located in a granite basis, where the boulder hills extant today are formed by disintegration of larger ‘piles’ through physical and chemical weathering action. Over a length of time, due to great change in diurnal range of temperature, the rocks expand and contracts. This manifests in formation of cracks and fissure, especially along mineral striations. Repetition of this process over a length of time, aided by moisture, larger rock surfaces disintegrate to form smaller section. Over time the shape of these sections become rounded by erosion and thus has formed a landscape which can be described as a monumental pile of boulders. Vegetation growth, animal action and moisture plays a vital role in expediting this process by weakening of rock sections by dissolving minerals and exerting pressure on condensing within cracks. Traditionally, extraction of requisite sections for construction also used the same principle that is facilitating splitting of the stone along a weakened crack. From this, it can be concluded that first, the material is susceptible to disintegration naturally. Secondly, the stone sections and surface exposed to moisture and sunlight is gradually weakened by dissolution of matrix as well as simultaneously aiding the natural process of physical disintegration. Moreover, the natural landscape, till date shows evidence of disintegration of rock sheets through the aforementioned process. The breaking of the Sister Stones along the existing fissure validates this hypothesis.

Under the given circumstances, the question remains on length of time for which the structural members retain their natural and design core strength to perform as intended in a building. This is because; the stone sections in the structure have been extracted from the immediate setting. Hence, there is a possibility that the natural processes of disintegration are active in the stone sections too. It also indicates the need to study to identify if the stone sections are affected by the active natural processes and if so, strategise a viable solution to develop alternate support systems, given that this is an inscribed property.

5.2. Understanding the impact of previous interventions
Much of the interventions undertaken by the Archaeological Survey of India prior to and post independence have been based on a different understanding of the cultural resource and its properties as well as under circumstances of limited access to technology. Moreover, the impacts of sanctioned works under the definition of ‘conservation action’ was also little known. This has manifested in altering the original construction system and distribution of load from the superstructure. Based on the impact on the structure, three major types of interventions can be identified from the history of conservation works official record. First is introduction of buttresses or accretionary pillars or masonry props. As mentioned earlier, the structural members were aligned in such a manner that the load from the superstructure i.e. the roof slabs and beams maintained the columns in erect position. The columns on the other hand acted as vertical separators between the ceiling and flowing members. The load of the superstructure was distributed as point load to the flooring, through these columns. The larger the absolute width of the structure, the greater was the length of columns and lower was the span between each. Initially the masonry props or buttresses were introduced to withstand a horizontal movement with a tendency of collapse. However, the ad-hoc addition of the same has resulted in
disturbing the vertical channelisation of the point load from the superstructure. Ultimately, the newly introduced buttress becomes a more integral part of the core structural system, as the load from the superstructure now is dispersed through it to the ground, reducing the role of the columns. In the absence of the designed load from the superstructure, these columns show tendency of movement. As the introduction of the new members were non-designed for the entire structure and were local corrections, the movement of the columns adds to the possibility of collapse in those sections of the structure where it retains the role of structural members.

Today, it is considered that reversibility is an essential principle of any conservation intervention. Although present in spirit, the removal of masonry props introduced in late 19th to mid 20th century remains a cause for concern for the Vitthala Temple. Although in many sections the masonry props have detached from the original plane, but in the absence of structured information on the behaviour of the structural members, it is extremely difficult to remove the additions.

Secondly, as mentioned earlier, the columns began to show movement, because of the absence of the overload that ensured its alignment. To resolve this issue, the dry masonry joints were with cement concrete in many sections. In some of the columns, the capital was sealed to the shaft and the beam running above it. While in some cases, the base of the column was sealed to the floor. In some columns, the capital and base were both sealed to adjacent members. This intervention had two impacts. First it induced a movement in the towards the direction in which the structure as a whole was tilted. Second, a stress was introduced in those columns, whose bases were sealed to the floor as the application of cement concrete countered its movement towards the general inclination of the building. A third type of movement was observed in columns which were not sealed at the junction of base-floor and capital-beam. Many of these were out plumb, with the vertical centre-line running through the column and capital were un-aligned. This differential movement together with other factors have lead to many of the structures being rendered unstable or collapsed.

It also must be said that the location of construction in a low-lying, flood prone zone, adds to the instability of the structure. At several location evidence of non-uniform settlement of soil inducing outward movement of the foundation and plinth has been found. The repeated landscaping activity, laying of road as well as introduction of electrical services has also added to the disturbance of soil particles. The diminishing retaining capacity of the soil together with an already destabilised monumental construction is a cause of concern for the Site.

Another critical alteration has been the significant increase of dead-load over the designed load by addition of multiple layers of cement concrete and bitumen on the roof. As mentioned earlier, traditional construction was devoid of mortars. Hence, during heavy monsoon, water was noticed to seep between roof-slabs to which, was decided that a layer of water-proofing would be necessary. Thereon, since late 19th century, repeated layers of bitumen and cement concrete have been added as a solution. The impact of this addition had aggravated the unplanned or un-designed movement of structural members, hence increasing the tendency of collapse. Also, the bitumen component in presence of moisture has also been found to corrode the roof slabs, an impact yet to be tested.
Apart from the aforementioned interventions, poor workmanship and a general lack of understanding of the impacts of work executed has added to the deteriorating condition of the traditional construction. Over and above these, human action, landscape, beautification, general rise in the pollution level and works undertaken under the bracket of maintenance often further aggravate the situation. More-so, the lack of consistent context and resource specific research, coupled with a bureaucratic stand on technical issues hinder development of new approach and perhaps generate an understanding that can improve the quality and effectively of conservation works as a whole.

6. WHAT THE FUTURE HOLDS

Today, technology provides answers to many of the issues that impact historic constructions. Many of the modern methods, for example the Finite Element Method, are being applied innovatively to provide possible answers to professionals and decision-makers. However, it must be mentioned that the interest to develop such methods and application of the same to improve the quality of intervention is still a new idea in India and is often met with much scepticism. More often than not, such research or focused studies are limited to academic exercises or forms an exclusive part of a research, not accessible to other disciplines or professionals. In many cases, due to lack of information, other resources and support from the relevant authorities, most field exercises, such as that of the Vitthala Temple, are aborted in a conceptual stage. It is also noted, that in many cases, technically viable solution remains at cross-purposes with the general accepted principles of conservation, especially where reversibility of structural interventions are concerned. Over and above is the general lack of importance adhered to interdisciplinary processes, such as research in the field of historic constructions as a crucial support to decision-making. Under such circumstances, together with loss of information from the structure and lack of pedagogical support, the future of historic constructions as a source of knowledge and a teaching tool for future professionals, may become a lost opportunity.

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