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Water management system, photogrammetric 3D documentation, and modelling of selected monuments in the medieval fort of Naldurgh

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Abstract--The Naldurgh Fort is one of the strongest forts of Deccan. The fort is said to have been originally built by a Hindu king who was a vassal of the Chalukya kings of Kalyani. It was later included in the domain of the Bahamas and later taken over by the Adil Shahi kings of Bijapur, from whom it passed into the hands of the Mughals in 1686 AD. Naldurgh is about 35 km from the Tuljabhawani temple of Osmanabad and 45 km away from Solapur town and is accessible through the Pune-Hyderabad highway. Southeast of Osmanaba, district of Marathwada region of Maharashtra. The fort, which is an interesting site, surrounds the surface of a mound or basaltic rock plain extending into the valley of the Bori River. Fortifications ran on three sides along the rest of the rock. The fortified ramparts are lined with basalt and are large enough to carry heavy weapons. The entire circumference is about one and a half miles. The inside is covered with crumbling walls and a half, the inside is covered with crumbling walls and a glazed driveway that climbs up to the center. The fort has many ramparts including Upli Buruj. The most interesting building connecting the fort and the battlefield is the dam on the Bori River, the dam, and the Pani Mahal, which are built below and in the middle of the dam. During the reign of Ibrahim Adil Shah II. This research paper is focused on the study of the relations between digital embodiment, close range sensing and three-dimensional information in archaeology. The relations between digital recording and simulation

environments generate new research questions and design a new epistemology in digital archaeology. These new and unconventional field documentation strategies bring new possibilities and dimensions to the method of accessing materials and inevitably give archaeologists the opportunity to create new research questions. This dissertation will discuss how the development and use of such new simulation systems is influencing the way archaeologists restore and analyse materials found in this area to support more accurate archaeological interpretations.

Keywords---Deccan Sultanate, Adil Shahi, Nizam Shahi, Naldurgh, fort, water works, hydraulic system, digital technologies.

Introduction

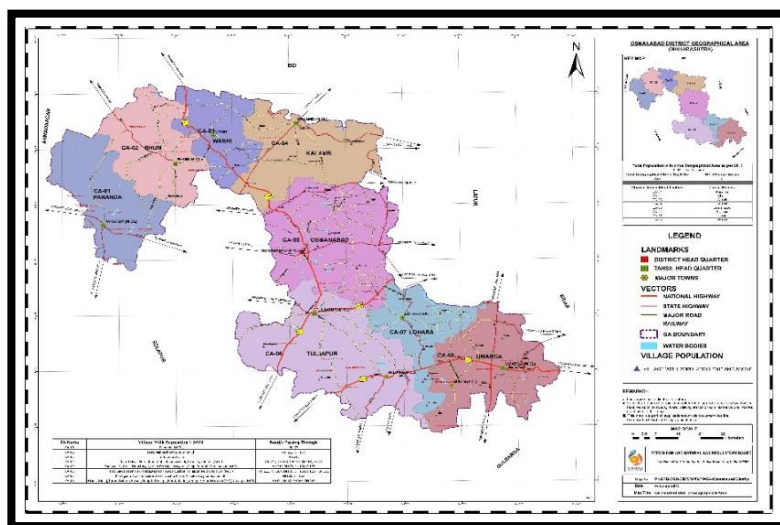
Naldurgh fort is located at an altitude of 670 meters above sea level. It is built on a hill on the banks of the river Bori. The fort is not visible from a distance as the hill is surrounded by hills. The total area of Ranmandal Bandhara fort is 104 acres. Of these, Ranmandal has 26 acres and Naldurg has 77 acres. Naldurg fort is known as an ancient fort. This original fort is believed to have been built during the Chalukya period of Kalyani. During the Chalukya period, this fort was made of mud only. This fort was of great importance during the reign of the Chalukyas. Because the fort was close to Kalyani, the capital of the Chalukyas. After the Chalukyas, Bahamani power was established in this area. The Bahamani sultans recognized the importance of Naldurg. And in his time this earthen fort was transformed into a stone building. During the Bahamani period, the fort was rebuilt between 1351 and 1480 AD. The soil was replaced by stone. And Naldurgh fort became very strong. Adjacent to this fort is an old old fort. It is called Ranmandal. Naldurg fort was conquered by Adilshah of Bijapur in 1481 AD. During the Adilshahi period, in 1558 AD, a strong fortification of stone chisels was built in this fort. During the reign of Ibrahim Adilshah II, a dam was built on the river Bori in the year 1613 AD. Due to this, Ranmandal fort was connected to Naldurgh fort. Therefore, it came to be known as *Jodh Killa*. The new water palace is a great example of contemporary architecture and engineering. During the reign of Ibrahim Adilshah II, Mir Imam Din built a wonderful water palace on the river Bori. In this place, there is an article in Persian in 1613 AD. During the Mughal period, when Aurangzeb came to the south, his attention was drawn to this fort, which he conquered in 1666 AD. During the reign of Aurangzeb, the fort became a part of the Mughal Empire. Naldurgh came under the control of Nizam after Mir Kamaruddin alias Nizamulmuluk As Wajah separated from the Mughals and established an independent power in the south in 1724. The fort was conquered by the Peshwas in Sindkhed in 858 AD. It remained under the control of Marathas for some time. But then again the Nizam established his dominance over it.

Naldurgh fort is built in different periods. Similarly, the fort appears to have been rebuilt between 1351 and 1480 AD. Ranmandal is an old fort and is also known as Ramdurg. Two double ramparts are later seen around the Ranmandal fort. A protective wall has been built in front of the elephant gate here. This is called

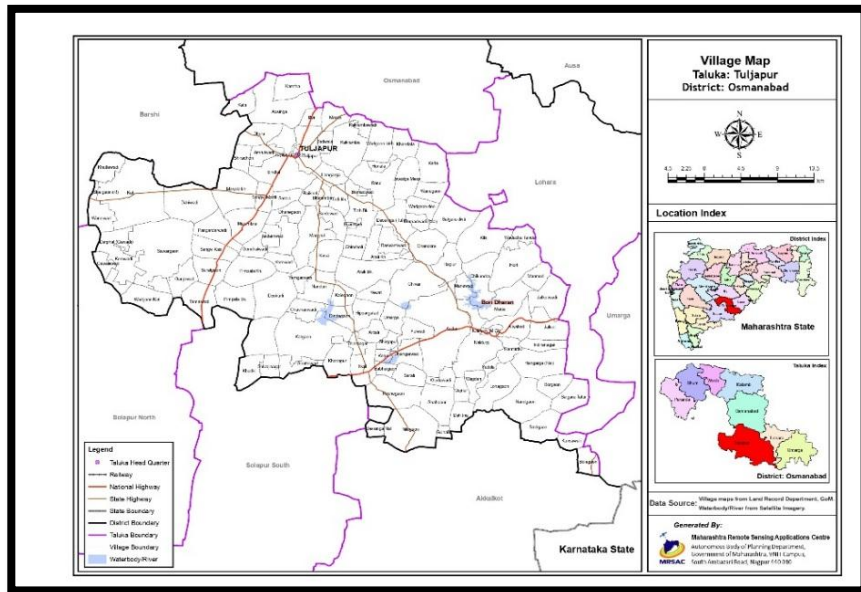
Jibhi in fortifications. Naldurgh fort dates back to the time of Allauddin Bahamani II. Samsuddin Mohammed III was the Sultan of the Bahamani Kingdom from 1463 to 1482 AD. At this time, Mohammad Gawhan was appointed as the Wazir by the Sultan. Gawhan and many forts in the south were conquered. Among them was Naldurg fort. At that time he built a rampart at Naldurgh and handed over the fort to Dastur Dinar. (Kunte, 2014).

It is mentioned that Abul Muzaffar Ali Adilshah visited Naldurg fort in 1558 AD. The Persian inscription on the Jama Masjid at Naldurgh mentions that the mosque and fort were built during the reign of Ali Adilshah in the (968 *Hijari* year) 1560 AD under the supervision of Khwaja Niyat Ullah. In the document, the name of Naldurgh is *Shahdurgh* but this name could not be established. Adilshahi ruled over this fort which was on the border of Adilshah and Nizamshah. Additional constructions were made in the fort to answer the frequent battles. After the establishment of an independent state, Adilshah made Bijapur his capital. For the protection of this capital, he built forts at Solapur, Naldurgh, etc., and obstructed the enemy army. It was certain that it would have been rebuilt from time to time.

In summary, the Naldurgh fort is an excellent example of fort architecture. The present fort was built during the reign of Adilshah. On three sides of the fort, there is a natural shield of the Bori River and on one side a moat has been dug to protect the fort. The fort is surrounded by fortifications and 114 strong bastions. It has main towers like Paranda, Upali, Sangram, and nine towers. Upali Buruj is the highest point in the fort. Some of these bastions still have cannons. The main entrance to the fort is the *Hululmukh* Main Gate. Characteristic structures can be seen in this fort. These include *Panimahal*, *Nau Buruj*, *Upali Buruj*, *Jama Masjid*, *Baradari*, *Amberkhana*, *Rang Mahal*, *Hamamkhana*, *Hatti Talao*, *Machli Tat*, and *Ranmandal*



Osmanabad District



Tuljapur Tehsil, Osmanabad.

Aims

- Preliminary research on the hydraulic system of the Adilshahi Sultanate in Naldurgh for the renovation of hydraulic works and a model study in Naldurgh fort with emphasis on the future performance of other hydraulic structures. To do GPS & GIS documentation and mapping of selected monuments in the Naldurgh fort. To do photogrammetric 3D documentation and modeling of selected monuments in the Naldurgh fort.

Objective

- To discuss the historical outline of the Naldurgh fort.
- To do GPS & GIS documentation and mapping of selected monuments in the Naldurgh fort
- To do photogrammetric 3D documentation and modeling of selected monuments in the Naldurgh fort.
- To have a detailed outlook on the water management system of the Naldurgh Fort.

Material and Methods

For this research work we used the field archaeological exploration method and documentation method. We concentrated on the Naldurg Fort. For the Proper documentation we used the GPS & GIS, observation, photography, Photogrammetric 3D Documentation and Modelling and oral sources on the basis of this data we describe the whole art and architectural legacy of Adilshahi and its impact on Naldurg Fort. Through the secondary data we collected the religious,

cultural places information and explored the legacy of monuments as cultural activity centre.

Geoarchaeology

The district is part of the Deccan Plateau, known locally as the Balaghat Plateau, sloping to the southwest and south and has a varied topography consisting of hills, plains and rolling topography near the shores of the River. The district is part of the Godavari Basin. The Balaghat Plateau includes low hills that form a watershed. Many tributaries of the Godavari River come from the Balaghat plateau. The Manjra River is the main river flowing through the district. Much of the area is occupied by rocks of the Deccan Trap Formation, which lie in nearly horizontal lava flows of basaltic composition, believed to have been placed by fissures in the late Mesozoic Era in the tertiary area. Osmanabad district (formerly known as Dharasiva) is located in the southern part of the state of Maharashtra. The district headquarters is located in Osmanabad. Geographically, Osmanabad district borders Beed district to the north, Latur district to the east, Solapur district in the west, Ahmednagar district in the northwest and Bidar and Gulbarga districts of Karnataka state in the south. Most of the district is located in the mountainous areas of the Balaghat range.

In general, the rivers of Osmanabad district flow from northwest to southeast and from north to south. The drainage of the study area is of the ordinary dendritic pattern as the rivers and streams have developed a branching system. Balaghat is a branch chain of Sahyadri and forms a major water divider between the Krishna River and Godawari in the Indian peninsula. The Bori is another tributary of the Bhima River. It rises west of Dharur and flows southeast from the Tuljapur Range to Naldurgh. It flows southwest and south and eventually joins the Bhima River. Naldurgh is another historic place in Osmanabad with a historic Naldurgh fort. The fort contains two artificial waterfalls known as Nar-Madi *Dhabdhaba* or waterfalls.

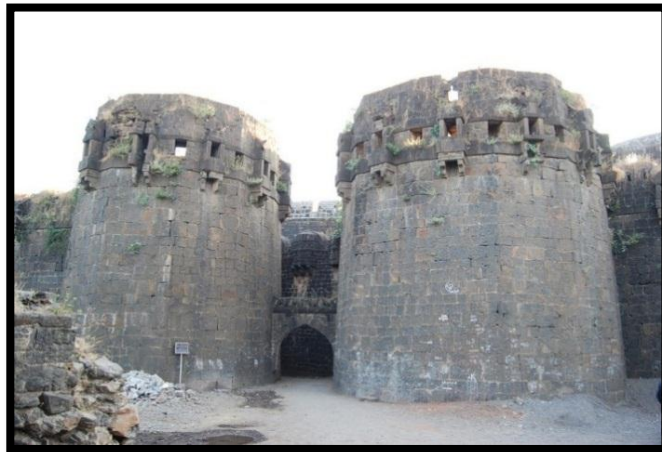
Historical background

The Naldurgh Fort is one of the strongest forts of Deccan. (fig.01). Naldurgh does not figure in the Deccan campaign of Muhammad bin Tughluq, and so probably came into Bahman's possession after the Imperial forces had withdrawn, in the late 14th century; its stone fortifications, which appear to be of Bahman work although elaborated later under the Adil Shah of Bijapur, may have replaced an earlier Hindu (Chlukya) mud fort. Thereafter, Naldurgh incurs frequent mention in the dynastic squabbles of the Deccan, lying as it does on the border of the Adil Shah and Nizam Shah territories of Bijapur and Ahmadnagar respectively, having later even attracted the attention of the Qutub Shah of Golkonda. Thus Muhammad Khan, the brother of Al al-Din Amad II Bahman, in rebellion in 840/1436, is reported to have occupied Naldurgh as well as Mudgal, Raichur, and Sholapur; after the fragmentation of the old Bahman kingdom, when Naldurgh became a bone of contention between the rival sultanates, there was a war between Qasim Barid and Yusuf Adil Khan in 897/1492, when Qasim was humiliated; in 914/1508 Amad Nizam Shah unsuccessfully demanded Naldurgh

from Yusuf as his price for neutrality against the rival claims of Muhammad Shah Bahman and Al Barid. In 938/1531 Amir Barid had entered into an alliance with Burhan Nizam Shah against Ismail Adil Shah and marched on Naldurg, but was defeated by Ismail; Vijayanagara entered the contest when in 970/1562–3 the lands of Husayn Nizam Shah of Ahmadnagar were invaded by Ram Raj of Vijayanagara, now allied to Ali Adil Shah of Bijapur; but Ram Raj withdrew after his camp was flooded in the rains, whereupon Ali Adil Shah withdrew to Naldurgh and carried out some rebuilding, including a dam across the river Bori, to improve the water supply to the garrison. In 989/1581, after the death of Ali Adil Shah, Murtaza Nizam Shah attempted to recover Sholapur and Naldurgh, now with the help of Ibrahim Qutub Shah of Golkonda; but the allied forces, on seeing Naldurgh's great strength, moved rather to Bijapur itself; the siege of Naldurgh, however, was prolonged under the next Qutub Shahi sultan, Muhammad Quli Qutub Shah, the following year.

In 1003/1595 Ibrahim Adil Shah of Bijapur invaded the Nizam Shah kingdom; in an ensuing battle at Naldurgh Ibrahim Nizam Shah was killed. But there was now a greater danger on the horizon, and the Adil Shah and Qutub Shah, forces were allied at Naldurg against the Mughals. During the Mughals' Deccan campaign the Nizam Shah Sultanate was in 1046/1636 invaded by Shahjahn's general Shaista Khan, who after his success turned his attention to the Adil Shah kingdom, conquered Naldurg and occupied the region between Sholapur and Bidar, although the Mughal success was then short-lived; in 1087/1676 the Mughal general Bahdur Khn failed in a further siege against Naldurg, although Naldurg fell to the Mughals the following year; this was, of course, an important possession for the Mughals in view of the growth of the hostile Maratha power. There seems to be no record of when Naldurg finally came into the possession of the Marthas. (Khare, 2001).

The fort is an imposing building but now disfigured with mean squatters' buildings. An interesting addition to its fortifications is a multiplied circular bastion on the south wall, similar to but smaller than the one at Golconda fort. The water palace and other palace buildings, and the mosque, have not been adequately described or published, but an inscription in the water palace *Pani Mahall* refers to the erection of a dam in 1022/1613. There are illustrations of the *Pani Mahall* and the multi-lobed bastion. Besides those within the fort, there are several mosque buildings in the vicinity of Naldurgh which appear to be of the late Adil Shah Style and period.



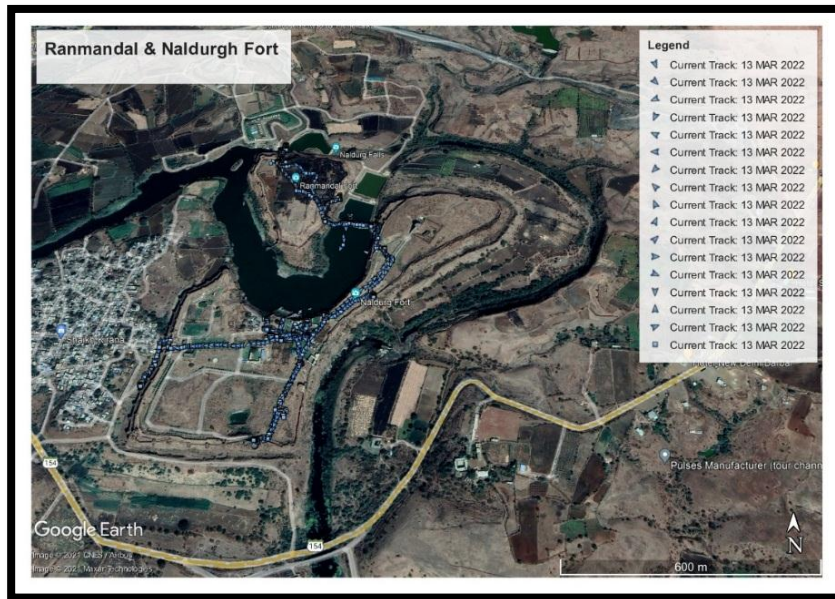
(fig.01)

GPS & GIS Mapping

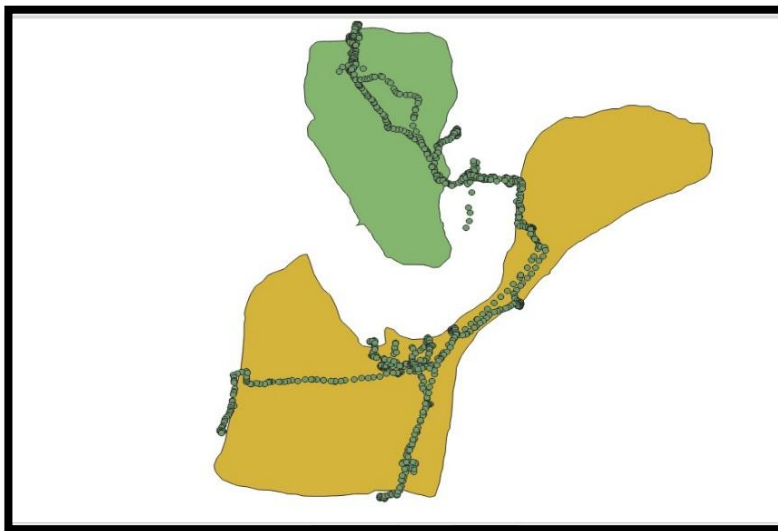
GPS stands for Global Positioning Systems and is now used all over the world. A GPS device is actually a receiver that collects signals from satellites. The satellites of the Global Positioning System transmit signals to GPS receivers on the ground. The receivers require a clear view of the sky, so they are only used outdoors and do not work well in woods or near tall buildings. Each GPS satellite has an atomic clock and sends a signal indicating its location and exact time. All GPS satellites transmit at the same time. The signals travel at the speed of light and arrive at a GPS receiver at slightly different times because some satellites are further away than others. The distance to GPS satellites can be calculated by estimating the time it takes for their signals to reach the receiver. When the receiver estimates the distance to at least four GPS satellites, it can calculate your position in latitude, longitude and height. Garmin's Montana 650 device is used for GPS. GPS method has been used in surveying Naldurgh fort. We have been pointed out using GPS to visit important water points in the fort. (fig.02). Based on this available information, we can design the map in different ways.

Maps have come a long way since people started drawing to show where they were. Modern maps are created using special software that combines many types of information. This modern cartographic system is called GIS - Geographic Information Systems. GIS is used by organizations, such as municipalities, that need access to data and need to be able to combine different data sets. GIS provides members of these organizations with graphical representations of data that allow them to operate. A geographic information system (GIS) is a system that creates, manages, analyzes and maps all types of data. GIS connects data to a map, integrating location data (where things are) with all kinds of descriptive information (how things are). This provides a foundation for mapping and analysis used in science and in almost every industry. GIS helps users understand patterns, relationships, and geographic context. Benefits include better communication and efficiency, as well as better management and decision making. Geographic information systems are currently recognized as one of the most effective tools for managing and analyzing archaeological data and are

considered the standard for archaeological documentation in many countries. The importance and feasibility of using GIS are discussed in detail. (fig.03).



(fig.02).



(fig.03).

Art and Architecture of Ranmandal Fort

Ranmandal is an old fort at Naldurgh. It is called Ramdurg. It is triangular in shape with an area of 32 acres and 22 towers. Ranmandal fort is also built on a small hill. The river Bori flows on all four sides. The waterfall here is called

Balance Falls. To the west of the fort is a double rampart with a gate between two high bastions. This is the first gate of this fort (fig.04). To enter through this gate one has to cross the river Bori. In the side walls of this door is a sculpture of *Gandabherund*. (fig.05). The sculpture depicts an eagle holding an elephant in both beaks and legs. *Gandabherund* is a fictional animal and *Gandabherund* is considered to be an incarnation of Shiva. During the reign of the Kalyani Chalukyas, Mahamandleshwar established the *Gandabherund* Ache temple at *Gadag*. It can be seen even today. The *Gandabherunds* appear to have been carved on the Chalukyas' gold coins. To the left of this door is a sculpture with six fish on the bastion. (fig.06). On the bastion in front of this bastion, there is a sculpture of a lion and six fishes in a circle. After entering through this door, there are guard gates on both sides. There is a stone wall in front. This is called *Jibhi* in fort architecture. (fig07).

The purpose of building it here is to prevent the back door from being identified and to protect it from being hit. *Sihankruti* sculptures can be seen on the back wall of this wall. This is where the elephant door is in the ramparts on the right. Naldurgh fort and Ranmandal fort are connected by water palace. Also, if you want to go to Ranmandal from Naldurgh fort, you have to go through *Pani Mahal*. The battlefield can be reached through a door after the water descends a few steps of the palace. There are no remains of a building in Ranmandal fort. In recent times, canals have been constructed for the convenience of water. There are trees on it. If you stop in the middle of it, you can see the surrounding ramparts. But the main elephant door is not visible. The open space in the fort would have been considered. In the eastern ramparts of the fort, that is, on the side of *Pani Mahal*, there is a secret door. This door is also known as hanging door. This fort should have been here before the construction of Naldurgh fort. This is evident from the style of sculpture and architecture here. Some of the eastern ramparts have collapsed due to heavy rains.



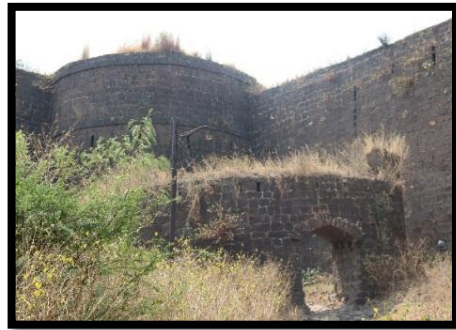
(fig.04).



(fig.05).



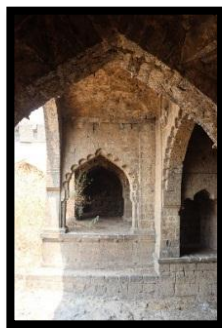
(fig.06)



(fig.07)

Elephant door

The most important structure of Ranmandal fort is the Elephant Gate. The name of this door is derived from the yard sculpture on it. The main entrance has three arches one after the other and the inner temples have a stone roof to prevent water from entering. But at present its horizontal stones remain. The rocks on the roof above are falling down. This elephant door is really worth seeing. It has arched porches with shaped carvings on both sides from the main entrance. (fig.08). It is carved with carvings of elephants and lions. (fig.09, 10). The guards' porches are also decorated here. This elephant door is very beautifully carved and has a Persian inscription on it. (fig.11). It mentions that she was in charge of the district from this fort.



(fig.08)



(fig.09)



(fig.10)



(fig.11)

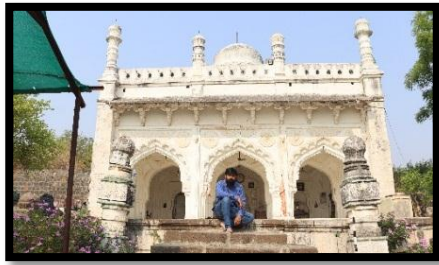
Art and architecture of Adilshahi period

Adil Shahi rulers were great builders and patrons of all aspects of fine arts. The capital city with its citadel enclosed by a fortification was embellished with many magnificent tombs, mosques, and palaces, gorgeously painted pleasure resorts and elaborate hydraulic systems. The remnants of these still stand as sentinels to the marvelous architectural innovations. The monumental heritage of the Adil Shahi illustrates the Deccan style developed into a mature style both in regards to methods and conception as well as in the field of ornament and decoration. This highly developed style is marked on the one hand by the monumentality and grandeur of conception that is characteristic of the Deccan style, while on the other hand, it developed a few features of its own. The bulbous, proportionate, and shapely dome with its drum concealed within a band of conventional petals. The use of attractive pendentives, projecting and richly ornamented *chajjas* and tall slender minarets, and finials, and frequent use of masonry piers of considerable size instead of pillars, the treatment of the pointed arch and the graceful curve of its outlines is some of the salient features of the Adil Shahi style. These edifices are remarkable for the treatment of ceilings, built without any apparent support. Equally typical is the richness and variety of its ornamentation, all executed with great artistic skill in stone carving, cut-plaster, and painting. Another aspect is the intrusion and assertion of Hindu elements in building techniques and methods as well as in the decoration. The edifices of the period Ibrahim Adil Shah - I, especially the Shahi Jama Masjid, present a harmonious and judicious blending of the two stylistic features. Thus, these architectural splendors with distinct and unique features present masterpieces of human creative genius (Campbell, 1884 and Cousens, 1889).

Selected monuments for the engineering and architectural style of Naldurg fort

Shahi Jama masjid

The largest mosque in the fort in front of the *Munsif* Court. The mosque is built on a large stone square. (fig.12). There are four minarets in the front area. There are carved arches of leaves, flowers, etc. The carvings are similar to the carvings on the round dome of Bijapur. This mosque has a dome with lotus petals. (fig.13). There are currently four minarets, four smaller on the side and four larger on the corners, and two of the four on the front and rear walls are currently missing. In all, we get to see ten minarets. There are two ornately carved pillars in the courtyard of the mosque. It is inscribed in Persian. (fig.14). It is not recognizable by coloring it. The architectural style of this mosque is similar to the masjid architecture of Bijapur. This Masjid was built in 1560 during the reign of Ibrahim Adilshah I. Its main hall is 42 * 46 * 30. (fig.15). The size of the front yard is 42 feet * 13 feet. (fig.16). The protective wall and door of the mosque were later built. To the left of this mosque, about twenty families still live. He says his ancestors have lived here since the construction of the mosque. There is a small door to enter this mosque. (fig.17). The south-north length of the mosque is 72 feet and the east-west length is 52 feet. There is a 20 * 20 *haud* in the front yard of the majjid. This *haud* must have been used for *Wajukhan*. It is 26 feet long, 22 feet wide, and 5 feet deep. Majjid has many tombs.



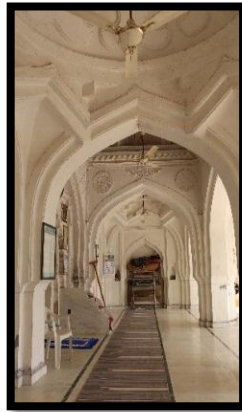
(fig.12)



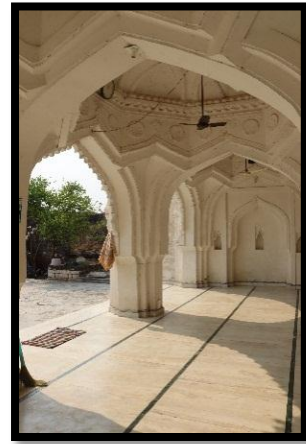
(fig.13)



(fig.14)



(fig.15)



(fig.16)



(fig.17)

Baradari

Baradari is one of the most important buildings in Naldurg fort to experience cool air. (FIG.18). The building, to the left of the main Shahi Jama Masjid, was formerly a two-story building. Now the upper floor of this building is completely destroyed. Baradari is a building with a total of twelve doors on the first floor, three on each

side and three on both sides. The baradari had four main doors opening in front and in the balcony. Now the following two are left. That is, the name comes from the door and we can call it Baradari. Such a building is close to a stream of water. Attempts are made to provide garden, fountain, evergreen tree, natural cooling in this place.

There is a square fountain in front of the main gate of this Baradari in Naldurg fort. It should have two main purposes. One as a *vajukhana* and the other as a fountain. (fig.19). When you go to Baradari. Then there are separate gardens on the right and left. These stones are carved in stone. This is called the Stone Garden. It can be seen from the roof of Baradari. The cannon of the longest range of the fort is placed near the main gate. It is 22 feet long. Upon entering Baradari, there is a veranda which is 10 feet wide and 40 feet long. Next to it is the space of the main baradari 30 * 20 feet high fifteen feet. The palace is 30 feet long from south to north and 18 feet wide from east to west. The bricks used in the construction of this palace are 21 cm long, 12 cm wide and 5 cm high. Stone, clay, wood etc. are used in the construction of the palace. The palace has four parts in total. The first part is the front pavilion. The palace is the second part of the palace and is 33 feet long from north to north and 18 feet wide from east to west and 15 feet high. The third side of the palace on the west side is circular. The length of this palace is 17 feet eight inches. The mahala on the east side is the fourth part. It is round, 17 feet long and 8 inches high. The palace has a joint gallery on the east, west and south sides. It is 42 feet long and eight feet wide.

There are stairs from the ground floor to the second floor. If you go up the stairs to the side of the Durbar Hall, there is a toilet on the right side. Sitting in this palace, the flow of cool air is definitely worth experiencing. From the back balcony of Baradari you can see the dam, Ranmandal fort, Bori river basin as well as male and female waterfalls in the river. There is a door in the side rampart to enter the river basin. This is called fish shore. The rooms appear to be arranged in a row on the right side of the baradari.



(fig.18)



(fig.19)

Photogrammetric 3D documentation and modelling

Over the past decade, digital technologies (databases, GIS, 3D surveys, GPS mapping) have had a significant impact on archaeological research and documentation. Today, 3D modeling is one of the most discussed topics in computer applications in various fields of archeology (research, documentation, conservation, visualization and animation of objects or archaeological references). Despite the high quality and accuracy of 3D models based on reconstructed reality, programs that use the third dimension as a new analysis tool are rarely used in archeology for various reasons, but mainly because most archaeologists still use their own research. It is considered only as a means of visualization, and not as a means of adding new information and gaining knowledge of the object or the context.

To date, there are many ways to create accurate 3D digital models, but the most common methods are based on data fields or images. These methods allow obtaining more precise and complete results than traditional research methods and, above all, do not destroy the identified areas. However, both methods have advantages and disadvantages. Recent research experience has clearly shown that there is no single 3D modeling method that meets all requirements at the same time. The method is then selected based on project size, required geometric and radiometric details, objectives, surface finish, object size, budget, and team experience. In most 3D modeling and imaging programs, the integration of different technologies provides better results in terms of detail, modification, and processing time or visual quality of the results, especially when registering large architectural objects or complex objects where technology alone does not. Effective and efficient, you can quickly build a complete and detailed model. Typically, the 3D data collected using these methods are combined with information relevant to the appropriate local context and scale.

3D modelling process

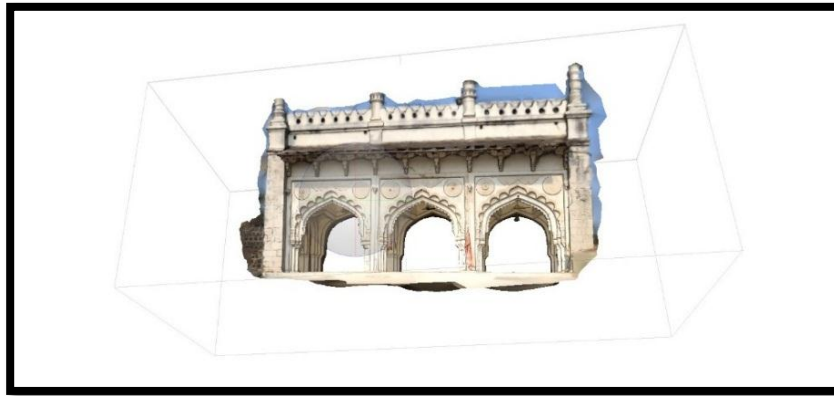
Photogrammetry was chosen as the technique for the relief and 3D modelling of the small medieval town. In fact, this technique, in particular terrestrial photogrammetry, is considered a good tool for digital documentation and a very promising alternative to the increasing use of distance sensors that are traditionally considered easy and efficient detection tools, but which are not always portable. And easily usable. For this project, a calibrated Canon 200D equipped with 18-55mm and 70-300mm lenses was used to obtain a set of useful images to reconstruct the main geometric characteristics of the different buildings. Photographic modelling software was used to process the photogrammetric images. The required connection points were calculated manually on adjacent images, then the main geometric structures were reconstructed in 3D using lines and surfaces. The reconstructed 3D geometric model of the building has also been textured for a photorealistic presentation. The whole photogrammetric process to derive metric and reliable information of an object from a set of images includes:-



Image orientation (Points)



3D scene reconstruction



Mesh



Texturing

Results, applications

The first results of 3D modeling of the Shahi Jama Masjid at Naldurg Fort are promising. It has been proven that it is possible to visualize reconstructed parts in 3D from different perspectives. Furthermore, digitizing, recording, and highlighting of specific architectural elements or stratigraphic patterns using some modeling software. Also distance, surface, volume, plan, section etc. To count some 3D redesign issues occurred in the most densely built areas, but the second part of the project, will solve this problem by getting new images.

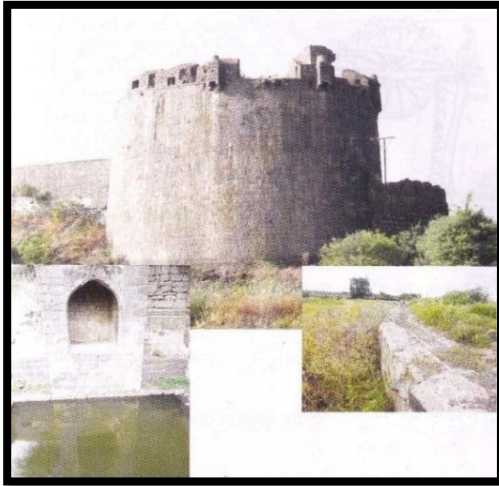
Water Management system Paranda Buruj

The water supply planning in Naldurg fort is worth visiting. To the north of the *Amberkhana* is the fortified *Paranda Buruj*. (fig.20). A large barrow can be seen behind it. One for the hydraulic system was being erected near the ramparts of the *Paranda* bastion and the other for the south of Barve in a large square hole. (fig.21). In this square tank, water was poured into the tank north of *Amberkhana*

by siphon method using Persian wheel method. (fig.22). From there, water was supplied to the Elephant Lake, *hamamkhana*, fort gardens and orchards by means of an underground canal. Remains of this water supply tank, water tank, can be seen even today. Considering the size of the fort. In this place, not every soldier could leave his place and go elsewhere. Therefore, water was supplied to the fort through this facility. Water was also poured from time to time into the tanks where there were guns. Because the tank has a lid, it may not evaporate quickly. Before taking water from Bori River to the fort, water was being supplied to the fort from this barve. But considering the above tension and upheaval, it seems that the then ruler solved the problem of water scarcity by diverting the river to the fort.

What exactly is a Persian wheel? Also known as Rahat (in Urdu), it is a simple water lifting device, in which small containers are attached to a long chain. Two toothed wheels make up the system and, during the rotation of the first, the vessels submerge and each one swallow the water from the well and immediately afterwards flow into a metal well which in turn flows into a complex network of drinking fountains that properly distributes the Water. Water through the cultivated area. The technology is believed to have originated in Egypt, and as the world shrank due to heavy trade, it spread to India and China. By Amitangshu Acharya. The earliest memories of Persian wheels come from missing pages in school geography textbooks. The passing mention of such systems was largely overlooked, as the larger and "important" chapters on dams were more crucial to national development and reviews. The notion of "primitive" and "modern" technology was raised very early. These blurred black and white images have taken on depth, color and meaning at Kolar, where some residual systems are still in use. Seeing the Persian wheels, up close and personal, has been integrated into a larger program to examine the challenges and threats facing these systems today. Its origin in India has a controversial history.

While some historians point to its introduction to the early days of the Delhi Sultanate, others attribute it to Babur's entry into India. One of the earliest mentions of the Persian wheel is in Babur's memoirs, Babur Nama (1526-30). As the Islamic government slowly began to consolidate its rule, there was a noticeable change in government. Ala Ud Din Khalji is an example of the early efforts of the state to increase and encourage the use of agricultural resources to increase land income. However, like many of his major projects (the best known being the Alai Minar), it fell apart. Later periods, especially under the Mughals, saw a growing interest in the unification of land-rent systems and land-related investments. Protection of agricultural property was needed, and as a result of that patronage, canals and irrigation systems such as Persian Wheels brought about phenomenal changes to the agricultural landscape of North India.



(fig.20)



(fig.21)



Persian Wheel in Kolar, Karnataka
(fig.22)

Baradari

A ramp can be seen on the right side of *Baradari*. (fig.23).The right side of *Baradari* is big enough to draw water from the river. (fig.24).In this place there are reservoirs for pumping water.(fig.25).The water was carried to *Vajukhana*, *Bagicha*, *Saraya*, *Imambada*, and *Rang Mahal*. The water was discharged through a *khapri* pipe into the *hammamkhana* built for the ladies and men of the royal family.



(fig.23)



(fig.24)



(fig.25).

Elephant Lake

This elephant lake is behind the nine bastions to the south of the fort. (fig.26). Since the slope of the main fort is on this side and a stone wall has been built at this place to prevent any damage to the ramparts due to this flowing water. For the other eight months after the rains, it was used to provide water to the soldiers in the area. At this time, the water brought from Baradari by thick and Persian wheel system was discharged into the lake through stone and *khapri pata*. Stairs are planned in the western side walls of this lake. There is also a well next to it. The wall of this lake is still strong. The proper use and storage of every single drop that falls on the ground is astonishing. On the east side is a slope for elephants to descend. This lake is known as Elephant Lake as elephants are bathed in this place.



(fig.26)

Male and female waterfall and water palace

The most beautiful and attractive structure of Naldurgh fort is *Pani Mahal* (fig.24). Rainfall in this part of Maharashtra is low and people do not get enough water from barracks and wells in the fort. In the summer, the situation became even direr. Therefore, the river Bori flowing through the elephant gate of Ranmandal fort has turned from Paranda Buruja and a dam has been built on it. In fact there is an inspection chamber to monitor the dam. This dam also has this chamber. But Imaduddin has made the hall in this dam look like a palace. The size of one of the halls is 23 * 20 * 10. (fig.28). The decoration of the palace is 26 * 3 * 36 in size. (fig.29). It has magnificent arches, fountains, separate rooms, bathrooms, toilet facilities, arched decoration, and mountains in front of it, river basin, Ranmandal and Naldurgh fort. (fig.29, 30, 31, 32, and 33). There are beautiful fountains in the palace. The room on the left has a toilet. (fig.35). From the decoration in front, it is possible to see the snow falling due to the water falling from both the waterfalls and the rainbow formed by it. There were grooves for making curtains for decoration. Are still today. In the main hall is an inscription in Persian script. (fig.34). Its meaning is as follows: - Dharma is the refuge in the king's court. In appointing the victorious Meer Mohammad Imadin..... The construction of this dam is a divine grace..... There are beautiful lines written in this inscription. They are as follows: - "आज दीदन ई चश्म मुहिब्बान रोशन, मिगदर्द व चश्म दुष्मनान गर्देद कूर"

Line No.	In Persian script	In English script
1)	امروز حضرت شاه دین پناه منصور	Aaj hajrat shah din panaah mansur
2)	سود می محمد آمدین مامور	Shud mi Mohammad amadin mamur
3)	دار باستن خدا خیرت بده	Dar basatn in sadubk fik Allah
4)	غمگین ای شدا چون غمگین ای ساکن شاهور	Sad I shuda chun sad i sakn shahur
5)	عینک های امروزی عاشق نور هستند	Aaj didn I chashm muhibban roshan
6)	میگرداد و دشمنان عینکی گاراد کور	Migdard wa chashm dushmnan garad kur
7)	آزاد نه کرد من سوال تاریخ تارکفت	Ajd n kird mi sawal tarikhi tarkuft
8)	کین سیدباطف شاه مند معمور	Kain sidbatuf shah mand mamur

In the rainy season when water comes in Bori river. Then water flows through the drains on both sides of the dam. So this scene looks so beautiful. These are known as male and female waterfalls. *Pani Mahal* is a masterpiece of engineering with its excellent construction. Hence the structure of this dam is called *Jalmahal* or *Panimahahal*. This water palace was built in the year 1022 AH, 1613 AD, during the reign of Ibrahim Adilshah II. The architect of this palace is Mir Mohammad Imadin. The main Naldurg fort and Ranmandal fort are connected by a dam on the river Bori. Pani Mahal has been built in these dams. The rock of the dam is basalt. The length of this dam is 144 meters which is 472 feet and the height is 19 meters and the width is two to 14 meters. The dam has three floors. Below the palace, there are guard gates and steps to get water out of the palace. The dam is straight on the outside and curved on the water side. It's amazing. This complete dam has been constructed by pouring metal. As the Bori River turns into a U-

shaped Ranmandal fort in English, its water velocity is higher than that of the female drain, so the drain is larger and deeper. So that the water falls down without the excess water pressure coming on the dam. The river Bori is dug in the shape of a Z along the ramparts of the fort and brought to the embankment. This slows down the flow of water. The water in the females also looks muddy. The male waterfall near *Ranmandal* fort is slightly higher than the female waterfall. Ramping down the drainage canopy, the water flushes out and looks white as it falls. So this sari is given this analogy.

The male squid is taller than the female squid. When the male cascades. Then this dam is full. There is such a sign. First the female drains. If it rains a lot, the male drains. It rained a lot. So sometimes all the exceptional water falls from the dam. But not a drop of water comes inside the palace. At this time, the locals say that the river was covered with a sheet. When these waterfalls start, the sound of its falling comes in the morning and evening in the village. Each dam has a single drain. But these two drains are removed. This is what people call male and female waterfalls. The water falling from it should not be carried away fast. Therefore, a ditch has been dug in the moat below the actual ramparts of Naldurgh fort and a drain has been left. Inside the dam, there are steps to descend from the side of Naldurgh fort. After landing there, the water mill takes its place.

A mill has been set up here to cater to a large number of soldiers in the fort. It runs on the water pressure in the dam. Here the fast energy machine seems to be converted into energy. The mill is below the water level. Therefore, the water wheel, which was placed under the mill, was turned by the pressure of the water when the water was released and the mill was turned and the flour was removed. There was also a facility to remove the flour as per convenience, i.e. to control the speed of the mill (Khochare, 2021).



(fig.24).



(fig.25)



(fig.26)



(fig.27)



(fig.27)



(fig.28)



(fig.29).



(fig.30)



(fig.31).



(fig.32)



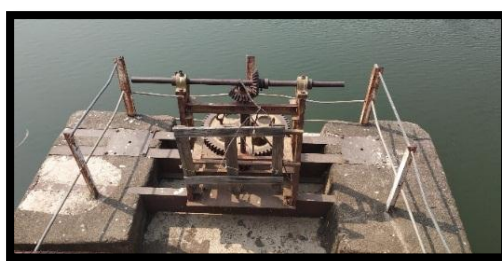
(fig.33).



(fig.34)



(fig.35).



(fig.36)

(fig.37)

Conclusion

Over the years, the archeological world has looked to modern technology to compile and visualize 3D data from the opposite side from initial skepticism and hostility to overzealousness and sometimes irrational thinking. Acknowledging the fact that the use of digital technology in archeology can be a tool to generate knowledge, not a goal, modern archaeologists must build a solid theoretical foundation and coordinate interdisciplinary groups capable of covering all different phases of archeological research. In order to communicate scientifically correctly and effectively, archaeologists need to know the pros and cons of the tools used to transmit and exchange different types of data. Among these new tools, immersive virtual environments play a fundamental role in archeology studies, as they allow you to visualize and analyze a wide variety of data in real-time and interact with them.

These systems can be configured to store and compare data in new data collection tools, giving archaeologists a better idea of the data set of recovered data. So far, 3D GIS has proven to be a very efficient modeling platform. However, special tools need to be developed for three-dimensional visualization and analysis. In particular, simpler and more efficient grid editing tools can greatly help archaeologists model and verify different interpretations. In addition, future implementation of these systems as a web platform will eventually provide a more complete and accurate picture of the past; Linking to a wide range of archaeological data from a variety of analyzes. Now this work emphasizes the importance and urgency of starting to theorize and experiment with new types of research methods that can identify new and more effective ways to collect, consolidate and analyze information according to more accurate and descriptive flow typologies. Data Collection Functions. . Undoubtedly, these systems have a profound effect on archeology studies, in particular, giving archaeologists the opportunity to be more thoughtful and apply more dynamic approaches to data management.

The breadth of its use makes it possible to create more accurate and detailed documentation of the archeological process; The sequence of excavations paid special attention to the theme of the landscape, studied in its multiple connections (real landscape, landscape map, reconstructed landscape, and imaginary landscape) and the possible properties of different meanings. The landscape is an excellent example of co-creation and joint creativity and every communication project should take care of this profound essence. Large amounts of data are a diverse, rigid, and highly interconnected database that can be better explored with its visual presentation to utilize your brain's capabilities, activating a third of the neurons in the information process. Visual information. Given the ever-increasing computing and graphics power of modern computers, scientists need to rediscover their research on what data to present and how to present it, with the ultimate goal of creating new ideas rather than highly informative, impressive and photorealistic information. Restructuring with low information capacity.

Overall, Ranmandal Fort should be the first fort. This is because according to its architectural style, it must have belonged to the Chalukya dynasty first, then to the fort after the invasion of the Bahamani Empire. In time, the fort passed to Adilshahi. The present Naldurgh fort, adjacent to Ranmandal fort, seems to have been built during the Adilshahi period. The reason for this seems to be that the stones built for the temples or their architecture on the Ranmandal fort appear to have been used from Ranmandal fort to Naldurgh fort. A vivid example of this is when one tries to reach Naldurgh fort from Ranmandal fort. The Pani Mahal, built during the reign of Ibrahim Adilshah I, seems to have been an early sign of that. Because some of the stones used in the construction of Panimahahal testify to this. One of them is Ganesh Patti. The entrance to Naldurgh fort is through Panimahahal or Jalmahal. Upon entering, you can see the carved stone carvings of the temple built in the Hindu architectural style on the *mandovara* in front of you. Also when we go further we enter Naldurgh fort.

At Shahi Jama Masjid on the front side while entering Naldurgh fort. The inscription you have received. That inscription appears on the pillars of the temple built according to Hindu architectural style. Over time, this column appears to have been influenced by Muslim architecture. That is to say, there are two pillars of the same type seen in this mosque. Another vivid example is when you enter the Naldurgh fort by road from the village, which is now the area where parking is available. There you can see the remnants of the pillar branch of the temple door. At the same time, water is provided in this fort. The water system appears to be influenced by Iranian architectural style, the Persian style. The evidence for this is as we have seen above. Significantly, the water used for the vajukhana used for the royal majjid or for the garden used in the fort or for the vajukhana as well as for the rangmahal was used to draw water through the ramps adjacent to the baradari. But now that the fort has come under the control of a few private entities, the water pipeline that used to be there seems to be extinct. So that was the style at the present time. Used for water it does not appear. But in the Paranda Buruja, you can see the Persian wheel, the way the water was pumped out. And that pumped water was used for water supply elsewhere through the Khapri pipeline. We have seen the remnants of this as well as in places where water was not provided through pipelines. For that which is part of the descent. I.e. the hill is part of the slope. At the site of the nine bastions, you can see an elephant pond. The Elephant Lake is a means of storing large amounts of water.

Panimahal is one of the finest examples of engineering in Naldurgh fort. Because of the method by which the water of Bori river was diverted to the fort. Evidence of this has been taken by you through GIS and GPS above and through the map. In it was the natural flow of the river Bori. How the stream is diverted to the male and female waterfalls. This is evident from the way the male and female waterfalls meet the needs of the people living in the fort and to meet their water needs. We can see this through the architectural pattern of this fort. The officer appointed by Ibrahim Adil Shah to build the water palace. He has presented to us the best example of whatever engineering is done through Iranian architecture. The stone which was used as foundation for Ranmandal fort and Naldurgh fort. The stone came out of the underground movement and landed on the ground. The lava

cooled over time. It was formed after cooling, which was basalt. The fort was built on that basalt.

Pani Mahal Hade is also built on the same ground. That is, the water palace on which the stone or the valley is built. It seems to have been put to good use by that officer. And it is used in such a way. That she has built a water palace in the same manner in which it was designed. That is when the male and female stand on the waterfall. So they have created separate rooms for males and females. It also has a very good method. For this, when we go under the female dam, the wood is used to pump water or to circulate the water, which is used to turn the mill. Evidence of this can be seen in the present moment. Then the male goes to this place when we go. Looks like a separate seating arrangement in your room. The seating arrangement in which we also see the inscription. From that room which is a natural beauty. The manner in which the windows are made in front of them. The windows are perfectly carved.

They are also found in the room under the male waterfall. The arrangement of seating in that room or the arrangement of the fountain in it as well as the person for whom it is now known as the Secret Room. You can see all the things that are needed for him, such as the arrangement of the bathroom for him or some other arrangement we see the Iranian style in the context of the Persian wheel, but the Persian wheel was used in the Naldurgh fort. You can find examples of this, but the Persian wheel is not visible. Because over time, the Persian wheel may have been broken or damaged. So his remains are no longer visible. But the manner in which the water was pumped out and pumped up with the help of that moat, how the water was conveyed through the pipeline to other places in the fort for this system or to the soldiers or even to the colony. You can see the answers here.

Through this research paper, the researcher wanted to prove that the architectural style developed in the Adilshahi Empire after the Bahamani Empire and how important Iranian architectural style was in that development and that the fort was built using the same architectural style. And their critical engineering through this research paper. Also in the history research paper the new technologies that are now being used. This research paper has been presented using the same method of documentation or presentation or different method of presentation

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