

Study of Raigad fort & its Construction and Planning Techniques of the Past and their adaptability to Today's Construction

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Abstract - Construction practices have evolved throughout the history of mankind from wattle and daub huts of ancient times, to the architectural marvels of the Middle Ages, to the towering structures like the Burj Khalifa, today. Modern practices though enabling us to erect structures of heretofore unseen dimensions, cannot always guarantee longevity and sturdiness without being capital intensive and leaving behind a large carbon footprint. In a haste to embrace modernity, we have let go of past lore within which were ensconced the ways to deal with problems that even rapidly evolving modern practices haven't been able to fix.

For this purpose, we have tried to explore any such avenues by carrying out study of a historical structure, namely, Raigad fort. We settled on this structure after going through a list of quite impressive structures such as the Taj Mahal, Konark Sun Temple, the Chausath Yogini Temple, etc. Of these the Chausath Yogini temple even served as a major impression on the design of the modern-day Indian Parliament building, thus showcasing how important analyzing these old structures can prove, when designing modern structures.

Our reasons for selecting Raigad

Raigad is nestled in an obscure place amongst the Sahyadri ranges, with a history of climatic extremes ranging from heavy rainfall to scorching heat and droughts. Yet, this fort exhibits some of the most impressive water supply schemes employed, within the framework of the classic ancient Indian Dhanush (Bow-shaped) type of town planning design.

Along with provision of toilets (something rare for medieval times) for the royal quarters and for ministerial mansions, sewerage systems, we also have impregnable fortifications, secret passageways, and immaculately designed grain storehouses and gunpowder storages. The highlight over this all is the Rajya Sabha, or the royal court which was designed in such a way so as to ensure that even a whisper at its entrance would be heard on the king's throne.

Keywords: - Ancient Construction, Ancient planning, Raigad, Construction techniques

1. INTRODUCTION

Our history creates a great impact on shaping our future. The ancient technologies adopted by our very own ancestors are extremely iconic. During the early times, there was an ecological balance maintained amongst the human and natural environment. They believed in amalgamating nature with the building to create a picturesque scenario so did not harm the natural beauty of the environment. India at present boasts about 3650 approximately renowned ancient heritage

structures and sites of national importance. Highlighted here is a regional study of the ancient construction techniques of Bengal and its undiscovered historical beauty. India has been recognized worldwide for its variant culture and its contribution to the same. If each and every heritage structure are taken in account, a common factor that seems to be distinctive is its construction technique and structural stability which ensures its existence even till date in spite of witnessing calamities, man-made disasters and negligence. This promotes and renders to the rich cultural heritage of our country. Divided into its various architectural types and styles, each and every structure has its own individuality and specialty. Not sure if it is the contribution of the English or our very own Aryan ancestors in the field of architecture, these places do come up with innumerable unique techniques which are still being discovered. While some structures are under the protection of the World Heritage Commission, Archaeological Survey of India or State Heritage Commission, there is also a shocking existence of more than 1 lakh structures, precincts and sites which are still unidentified and unprotected. Highlighting a particular region and its architectural style which was known for its simplicity and grandeur using locally available material. While technology and construction have progressed rapidly in recent years, allowing structures to be built taller and faster than ever, remnants of colossal ancient monuments remind us that construction techniques from as long as hundreds of years ago had enormous merit as well. In fact, many of the innovations of antiquity serve as foundations of modern construction, with the Roman invention of concrete serving as a cogent example. Other essential ancient construction techniques, such as the arch and the dome, are now often considered stylistic flourishes, with designs like the Met Opera House reinterpreting classical typologies in a modern context. Yet perhaps the most relevant reinterpretations of ancient construction today are those that do so in the interest of sustainability, renouncing high-energy modern construction methods in favor of older, more natural techniques. These reinterpretations have taken many different forms, ranging from the revived use of ancient materials to renewing ancient construction techniques. For example, a new type of rammed earth construction reimagines ancient sustainability from a material standpoint, transforming traditional rammed earth into the stronger cement-stabilized rammed earth (CSRE). Originally consisting of soil, water, and a natural stabilizer (animal urine, animal blood, plant fibers, or bitumen), rammed earth construction has existed for centuries, having been used in monumental ancient projects ranging from the Great Wall of

China to Alhambra. However, CSRE mixes soil, water, and cement instead, improving the material's strength by orders of magnitude. Yet the main ingredient still being local soil, CSRE thus crucially reduces the negative effects of transporting other materials. CSRE is also cheaper than many other more common building materials, making it a sustainable option for affordable housing as well. The Xi'an University of Architecture and Technology has explored using CSRE to help rural communities to build new houses, while the Western Australian Department of Housing has investigated using CSRE in remote Indigenous communities. With the field of construction necessarily experiencing a kind of reinvention in light of the ongoing climate crisis, some innovators have looked back to the past in their search for successful and sustainable alternatives to common contemporary construction methods. Although many of these techniques rely on the small-scale use of local materials, it is possible that ancient construction methods may be applicable to large-scale structures as well. As reinventions of old techniques, these changes don't necessarily constitute a step backward, but may indicate a more eco-conscious future instead.

1.1 Report on the present condition of Heritage Structures in India.

The world recognizes India as a place resplendent with a heritage dating back to 9,500 years ago. The architectural significance of these heritage buildings reflects the advanced understanding of design and engineering prowess during their respective eras. For many of us in India, our earliest school memories can be traced to picnics and gatherings at various National Heritage sites. In a cityscape which is continually evolving, these heritage buildings have remained as immovable and constant structures; the human settlement plans have been designed around them. These heritage buildings, then, become an integral part of the communities. The maintenance for these buildings needs to be spearheaded by the Government, backed by the support and cooperation of society in general. Heritage buildings and sites are remnants of our predecessors, a reflection of our past and an essential source of information to trace the evolution of our society as a civilization. Many of the heritage structures have stood the test of time. But, like human health, which requires precautions and check-ups from time to time, these buildings also require diligent preservation, conservation and restoration. For a country with such a rich and diverse history and culture, India does very little to preserve the remnants of its past. The ministry of culture receives well under 1% of the country's annual budget, and this lack of funds and initiative has resulted in most monuments and historical sites being neglected for years. Their surroundings are often poorly maintained and the whole experience of visiting them is a world away from what it's like to visit sites of more recent history in the developed world. What's worse is that some ancient monuments have even disappeared under the watch of the Archaeological Survey of India, the

government agency whose main purpose is protecting them. Yet, it is not a complete disaster story either. Because slowly, concerned citizens are taking it upon themselves to protect India's art and artifacts.

The good

Several Indians who have been collecting everything from paper money to historic maps for decades have begun to open up their collections to the public. Investing time and money to preserve rare and often fragile pieces of the past is no small feat, but that hasn't deterred Rizwan Razack, who owns the largest collection of Indian paper money, dating back to 1812, or Prashant Lahoti, who has collected some of the earliest maps ever made of the Indian subcontinent. Many private museums now, almost lovingly, focus on India's rich and diverse traditions and history: boats from Bengal, Goan architecture, or even the evolution of Indian transportation from palanquins to two-wheelers and buses. In fact, a new wave of curators is working to craft museums that are as engaging as those in the West. Technology has also played a big role: With digitization and social media, those looking for a shot of culture don't have to look for too long. On Instagram and elsewhere on the internet, you'll find locals meticulously documenting things like Kolkata's historic homes or the often-forgotten Art Deco buildings of Mumbai. And on Google Arts & Culture, interactive exhibitions reveal the history and architecture of everything from the Ajanta caves to the Red Fort, and part of the collections of museums such as the National Gallery of Modern Art and the Dr Bahu Daji Lad City Museum have been digitized. But of course, things are not so smooth on the ground.

The bad

Of late, local administrations in India seem to have embarked on a bulldozing spree, especially targeting historic buildings. In Bengaluru, the Murphy Town library, one of the city's oldest, was torn down last year. This was followed a few months later by the 100-year-old Krumbiegel Hall being pulled down. This month, the local chapter of the conservation NGO, Indian National Trust for Art and Cultural Heritage (INTACH), launched a petition to save yet another heritage building marked for destruction: the 83-year-old Janata Bazaar, which will likely be replaced by a shopping mall if the state government has its way, INTACH says. Even internationally recognized architectural icons haven't been spared: The Hall of Nations at New Delhi's Pragati Maidan was destroyed last year to make way for a convention center and parking lot, despite protests from activists and the then 82-year-old architect of the structure himself. All this happens because there's little protection given to heritage buildings in India. Even existing laws often aren't enforced. In fact, last year, the Narendra Modi government moved to amend the Ancient Monuments and Archaeological Sites and Remains Act that previously prohibited building activity within 100 meters from the limits of a monument. Saying that it was "adversely impacting various public works and developmental projects of the central government," the cabinet allowed for government-funded infrastructure projects to be constructed near historic monuments. "Let us

not mistake the consequences of the proposed new legislation," AG Krishna Menon, an architect and urban planner, wrote in the Hindustan Times newspaper last year." It will ring the death knell for many of the country's treasured monuments." But despite heavy criticism, the Lok Sabha passed the amendment bill in January this year. As if that wasn't enough, various aspects of India's history are themselves now being subjected to aggressive rival narratives, often threatening the material remnants.

1.2 Indian Architecture: What Kind of Buildings are Popular in India?

1. Taj Mahal
2. Rani ki Vav
3. Amber Fort, Rajasthan
4. Ajanta-Ellora Caves
5. Chand Baori
6. Sun Temple, Konark
7. Sanchi Stupa
8. Raigad fort
9. Humayun's Tomb
10. Chausath Yogini Temple

1.3 Raigad: Gadancha Raja... Rajanacha Gad

Standing up high on the mountains of Sahyadri, Raigad represents an architectural wonder built by men in the 1600's. India represents a country where forts have significant strategic importance and formed the place of Kings and Queens to reside safely; Forts of Maharashtra have a unique place in history. Not built or founded on plateaus like red fort of Delhi or castles Rajasthan but on tricky terrains of Sahyadri Ranges, the mighty Raigad is one such great fort built by 'Chatrapati Shivaji' during his reign of Swarajya. The architect of this great fort is 'Hiroji Indulkar.' The fort was expanded and renamed from Rairi to Raigad by Chatrapati Shivaji Maharaj. He made it into an impenetrable fortress, complete with an impressive granary, a massive kitchen, a meeting room, a marketplace, a queens' palace divided into six rooms, secret doorways for king's and queen's entry, more than ten water storage tanks, a place dedicated to giving capital punishment to criminals Located in the majestic Sahyadri range, a part of the Western Ghats, the Raigad fort is a glorious symbol of the early days of the Maratha empire. It is here that the Maratha warrior king Shivaji was crowned as the Chhatrapati. Carefully selected by him as the seat of the fledgling Maratha empire, the fort sits atop an impregnable mountain, which stands a little isolated from the main mountain range. Its steep sides make it impregnable. The main entrance of the fort is called Maha Darwaja, a massive 65-70 ft. tall door and watchtower. Other entrances were Nagarkhana Darwaja – that used to open up in the Darbar, Mena Darwaja – a private entrance for the royal ladies that led to Queen's quarters, and Palkhi Darwaja – for the King's convoy. One can see a replica of the throne in the Darbar from the main doorway. The Darbar had an

exceptional acoustic feature, where even a whisper by someone in the corner of the room was audible to the king sitting on the throne. Other remarkable spots in the fort are Hirkani Buruj, Jagdishwar temple, Bazaar Peth, Samadhi of Shivaji Maharaj, and Jijabai, Gangasagar Talao, etc. Raigad was a perfect example of fort architecture until 1818 when it was looted and destroyed by the British. From Magnificent doors to royal hallways to impregnable security this engineering marvel has got it all. Fort's simple yet advanced construction that has proven its worth centuries before and yet still amazes us till date and has therefore become the choice of our research.



Figure 1 Raigad Fort

1.4 Methodology

In the course of time the knowledge and expertise to do certain things a certain way become overshadowed or even neglected, when new methods and ways to do that come to the fore. When these new ways prove to be hiding some flaws within them, some other new way of dealing with that is developed or new techniques to mitigate those flaws are implemented, which may or may not prove to be the required solution which can rectify such a flaw with desired efficiency. Even if much more efficient answers to the problem faced may have been hiding amongst these old ways, yet now those are forgotten and that it could have provided us in easing our problems. Hence, we have undertaken the effort to find some of those methods and techniques used in last constructions which have been forgotten or ignored today, but yet still could provide economical and more efficient alternatives to address any defects and problems that occur, whether major or minor, in the prevalent construction practices of today.

Firstly, we will be following on the construction materials used in building the structures on the Raigad Fort, all of which serve varying purposes. This is to be done as the purpose served by these structures, is served by equivalent structures even today, though these equivalents are considered with steel and concrete which are prone to be damaged after a few years and require frequent maintenance, yet these older structures still stand the test of time (even if most of the Raigad Fort lies in ruins due to deliberate destruction at the hands of the British in 1818, yet some structure still stand intact). We seek such durability, if only adapted to modern construction methods.

Next to come under scrutiny are the structures themselves. The analysis of the structure is to understand the method of construction itself. The placing of beams, columns, arches, etc. or how certain joints are made. Play a vital role in the stability of the structure and the efficiency with which a structure serves its desired purpose. Any such techniques might prove cost-saving and/or result in much more efficient structure. Such techniques may consist of architectural innovations and ingenious use of basic engineering principles in aspects like planning of water supply, sewerage and even town planning, quite promising for use in modern construction.

Lastly any additional features that can be utilized to prevent any defects like leakage or improving essential aspects like ventilation and plumbing to outright prevent any defects and enhancing the functioning ability of these aspects, will prove extremely useful in increasing the safety and utility of modern structures. Improvements made in this sector of construction may also end up saving future maintenance and repair cost as compared to typical modern structures not having any such improvements.

2.0 Literature Review

SR. NO	Title	Author	Source	Year of Publication	Findings
1	Shreemad Raigirao (शिवकालिका रायगड नगररचना आणि वास्तुशास्त्र)	Gopal Chandorkar (ARCHITECT)	BOOK ISBN-978-93-80234-60-1	2017	The main aim of the book is to find out the features, construction methodology, materials, techniques used in the construction of each and every structure the Raigad Fort & also to study the structures in detail by finding out their exact dimensions. Purpose of each structure is mentioned in the book. The findings in the book are Rainwater Management, Ancient Underground water supply scheme, copper pipe used in the ballekilla for water supply, etc
2	Raigadchi Jeevankatha	Shantaram Awlaskar	BOOK ISBN-10 : 9380793022 ISBN-13 : 978-9380793023	1962	The book explains us the true story of Raigad Fort which was the capital of Shivaji Maharaj.
3	Architectural Marvel - Raigad	Ajinkya Waradpande	Blog: https://www.s mallstepsadventures.com/blog/architectural-marvel-raigad/	2016	This Blog defines how raigad stands out a fort and how its different, that led it to be the capital fort of The Maratha Empire ruled by Chatrapati Shivaji.
4	Incredible India Architectural Marvel	Incredible India	Blog: https://www.incredibleindia.org/content/incredibleindia/en/expert-views/heritage/architectural-marvels.html	2020	This Blog highlights about various architectural marvels present in India and reminds us about their glorious days and why they need to be preserved for the future
5	Ancient Construction Techniques of India: A Regional Study	Rupsa Chakraborty	Blog: https://worldarchitecture.org/article-links/eepfe/ancient-construction-techniques-of-india-a-regional-study.html	2019	This Article highlights about the field of architecture necessarily experiencing a kind of reinvention in light of the ongoing climate crisis, some innovators have looked back to the past in their search for successful and sustainable alternatives to common contemporary construction methods.

Fig 2 Literature Review

3. Adaptability of Construction techniques of Raigad Fort in Modern Construction

3.1 Thermal insulating Materials

Problem in today's construction

- Current thermal insulating techniques are not that effective as they require electrified cold storages for storing food and grains.
- This proves to be a major issue in the Remote areas of our country as they have major issues in use of electricity as the supply is not stable.
- Therefore, people in these regions have no other choice and have to invest in heavy electrical solutions which burn a hole in their pockets and also require frequent maintenance.
- This also comes as a challenge for mass storage of grains as the current technique the villagers use that involve cowdung is not that effective as well as doesn't impart good hygiene.

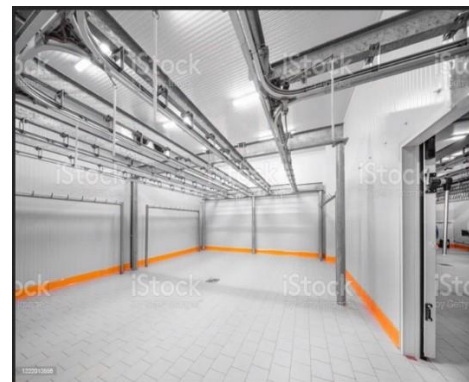


Fig 3 Cold Storage

Solutions from the past techniques

- Lime absorbs moisture and hence stabilize internal humidity.
- Lime has excellent cementing capabilities; this is obtained by their carbonation with carbon-dioxide. Lime is used as lime mortar for brick masonry construction.
- Lime can be used in the construction of monuments, retaining walls and also in load bearing walls.
- Lime has higher acid resistance due to its alkaline nature.



Fig 4 Food Storage in Ancient times

3.2 Water proofing

Problem in today's construction

- Current Water Proofing techniques used in today's construction are not that reliable as the material used here are pervious.
- This proves to be a major issue in the long-term reliability of the building as the water and moisture seeps through these gaps and damage the parapets, columns, slabs and walls.
- Current technique suggests that the use of expensive chemicals and water proofing materials which claim limited warranty.
- One has to choose between a weather shed or these kinds of waterproofing materials which are expensive and also doesn't provide any long-term solution.



Fig 5 Leakage from corner of slab

Solution from the past technique

- We can overcome this major issue by picking up one of the many innovations discovered in the construction of this fort.
- We can use Stone Pipe (Panhali)
- Where the roof of the structure meets a higher wall, stone pipe can be used to prevent the water from seeping down from the joints as we know stone is a perfectly impervious material.
- We can adopt this method of waterproofing in only Load Bearing structures as the Stone can be directly

integrated into the higher wall which is not possible in Reinforced Concrete Framed Structure.

- This solution will be cost effective as well as serve the need to major part of Modern Indian (Villages) as cost is a major factor in construction as well as this technique has proven its worth from centuries and is successfully integrated and requires no further Research and Development.

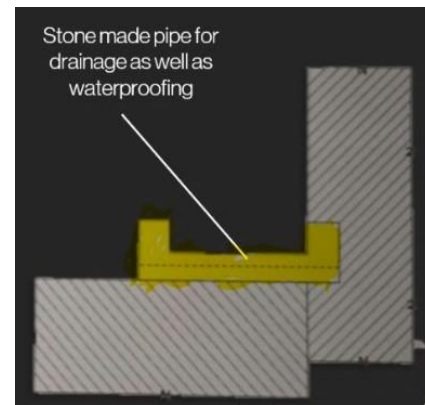


Fig 6 Stone Panhali (Stone Pipe)

4. Site visit report

Three to Four months ago the day came, 13th February 2021 when we got a chance to visit Raigad Fort. Along with our teachers (Prashant Mule sir, Barbude sir, Dode sir) and our project guide DR.Atulya Patil sir. We were very grateful to have these people with us for our project and thankful as they came with us and gave their precious time to our project work. Without their guidance and support it was not possible for us to complete the project work perfectly and systematically.

We left Mumbai at around 6am in the morning and have reached the destination at around 2pm. We were there for a stay of 1 day at one of the resorts in pachad village, as the fort was so large to cover and study that even a week's stay won't be enough. As we reached to our destination at resort, we rushed to visit the fort.

We were staying almost 10 km away from the fort, there were two ways to reach the fort, firstly we could walk all the way to the top from "CHIT DARWAJA" at the base of Pachad village. But we were running short on time and were late so we decided to go in Tramway/Ropeway. Even reaching to the top of the fort in ropeway was a great task, as it took around 1 ½ hour for our turn to go in ropeway. We all were so excited to see the "KING OF THE FORTS & FORT OF THE KING". The fort was located at a height of 2700 feet from the MSL. Before sitting in the vehicle which would take us to the top of the fort our weight was noted, and a maximum weight a vehicle can carry was 300 kg. The main engineering started here as while we were down at the main station, we could see the sag in the wires and the trolleys moving up. With the ropeway it took around 5-7 minutes to reach the top of the fort. It was really a

very great experience as we were gaining height our ears were getting clogged and could hear the whistle of the wind. As it was said that no one could climb the fort, only wind can come up and go down.

As soon as we reached the top of the fort, we were mesmerized to see the beauty of the magnificent fort.

From the ropeway we reached near Balekilla at around 5pm in the evening. As we were running short on time, we could only manage to explore the balekilla for the very first day and some of the nearby areas like the gangasagar, ashtapradhan wade etc. We opened our maps from the book which we were referring "Shreemad Raigirao" written by Gopal chandorkar, the architect. He has studied the fort very well in detail and have explained each and every structure and different areas along with their plans, sections, elevation, maps etc.

We started our journey from Balekilla. First it was difficult to read the maps and locate the structures, but the help of our teachers we managed to read the map correctly. Heading straight towards the north entering the balekilla on the west side we located a structure called the offices. There were myths or misunderstanding about the structure as Ranivasa Mahal, and people used to count these structures as seven in numbers, but in real there were six structures and these were the offices along which the four of them were connected to each other internally and the last two were connected from the outside and all the structures were at a rising elevation. These offices were having their W.C on the west side and a vent pipe was also there to get rid of the foul smell. Then if we walked straight ahead to the north down the staircase, we would exit the balekilla and could see the gangasagar straight ahead.

Moving forward to the next point at the east we located the food storage's they were covered with steel reinforcement, moving in the same direction to the south-east there are four offices placed opposite to each other. We headed towards the Rajmandir where the Samadhi of maharaj was located. On the east side of Rajmandir there was kitchen to cook food and all the wastes from the kitchen was so well managed that we were amazed. A drainage system was prepared as all the waste water through gravity was taken to the Khasbagh which was located to the extreme north. Also, the wastes of fruits, vegetables were put into this garden as it will decompose and make the soil fertile. Heading forward we had a look on khalbatkhana. We were not knowing as what was the purpose of khalbatkhana, a family on the fort informed us about it as the place where the secrets or the important messages were given to the King.

The Rajsabha was the most amazing place we visited because of its features. It was said that the Rajsabha was so engineered or built that even if someone whispers softly in

Rajsabha, the whispering could be heard at the throne very clearly. We were thinking about what could be the reason that the sound can be heard even from such a distance, was that the material used in the construction? Or else the medium was air through which the sound can travel? We just couldn't figure out the reason for this. We located a copper pipe in cylindrical shape, which would have been used for carrying fresh water from one place to the other. And lastly, we got a glimpse of the 22 offices in row and a wonderful sunset. Our first day ended here covering only the balekilla, we planned for our next day as what places should be visited and which are easily accessible.

On the very next day i.e on 14th February 2021 at 9:00 am in the morning we were at the top of the fort. We were planning to walk and reach the top of the fort but it would have taken around 2 hours to climb the fort, and we had to cover the entire fort in 7-8 hours so we choose the option of ropeway.

After reaching the top of the fort we headed straight towards the "holicha mal". After that we visited the place known as the "Holicha mal" where the festival of burning the holi was used to be played. We also located the rain water harvesting in many places for which different tanks were constructed like the Gangasagar, Hattitalav etc.

Visiting the next place, this place will have a controversy as some books, authors, and local people call it as a market place. And we think that these are the offices in lines (22 offices), and also mentioned in the book which we refer. We had taken the measurement of one office and prepared the rough line plan. The same dimension of one office was carried to the next offices in line and same for the opposite. And these offices were having a plinth level of 1.35m and the dimension of the riser and the tread were about 280mm and 400mm respectively. On the way from Balekilla to Jagdishwar Temple the road was about 40 feet wide. This place was given proper rain water management system at some specific intervals. Some markings of snake were permanently marked in the wall of the structure.

On the way to jagdishwar temple we had seen many places like the food storages, takmak point, and the houses of the people staying on the fort. The takmak point was used to punish the people who have committed any crime, they were used to be thrown from that point as a part of punishment. Then coming forward to the food storages they were placed in such a way that there should be proper ventilation of air in the storage chambers. As the wind flows from the east to the west and then clockwise in the north and then in the south. So accordingly, the windows were provided.

Then we move forward to the jagdishwar temple to the east side. Over here we found out that the inside temperature is much cooler than that outside. This was only because of the materials used in the construction i.e. (stones, lime mortar

for the joints, mud used as plaster). We referred a research paper for the "Use of mud in Construction Industry". As we found out that the thermal insulation keeps the indoor temperature constant during summer and winter seasons. The mud house aims to save energy by providing a more stable temperature and reduces heat losses. Mud is a thermal mass that absorbs sun light and warms the building over the course of the day.

Moving much more forward we at the end point of the fort where arms and ammunitions were used to be stored. This place was covered with a plant called as the 'Nivdunga' (Prickly Pear Cactus) as the enemy shouldn't identify this place. This place was at much lower altitude and the entire fort can be seen easily through this location. After exploring this point, we returned back and had a look on the Hirkani Buruj, from where a women named Hirkani descended the fort at night. From then onwards it was noticed that enemies can try to reach the fort from this point so wall was constructed named after the women's name "Hirkani Buruj".

Our project was complete as time was not left, some places were left unexplored as covering the entire fort in 2-3 days is highly impossible. Just as a tourist one can cover the entire fort in a day but studding the fort is another part it requires time. And it ended like this, thanks to all our teachers for the support, as without them it was not possible for us to study the fort.

Acknowledgement

This is not included only to complete the formalities as per tradition because everything is important in life, can be achieved only as a result of team work or collective efforts perseverance. Inspiration and motivation have always played a key role in the success of any venture. It is a great sense of accomplishment to express our sincere gratitude to our respected Project Guide Prof. A. P. Patil for their constant interest, encouragement and valuable guidance during completion of the project. We would like to extend our gratitude to Dr. A. S. Radke, HOD Civil Engg. Dept. and Dr. S. D. Sawarkar Principal who gave us valuable suggestions and all the required facilities to perform our project and to everyone who in their own special way helped us in our project. Finally, we express our sincere thanks to all those people who offered valuable time, suggestions and assistance directly or indirectly to us to achieve our aim.

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