LIGHTING SYSTEMS DESIGN FOR TEMPLES USING NEW TECHNOLOGIES

INDUSTRIAL DESIGN PROJECT II

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GUIDE:
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INDUSTRIAL DESIGN CENTRE
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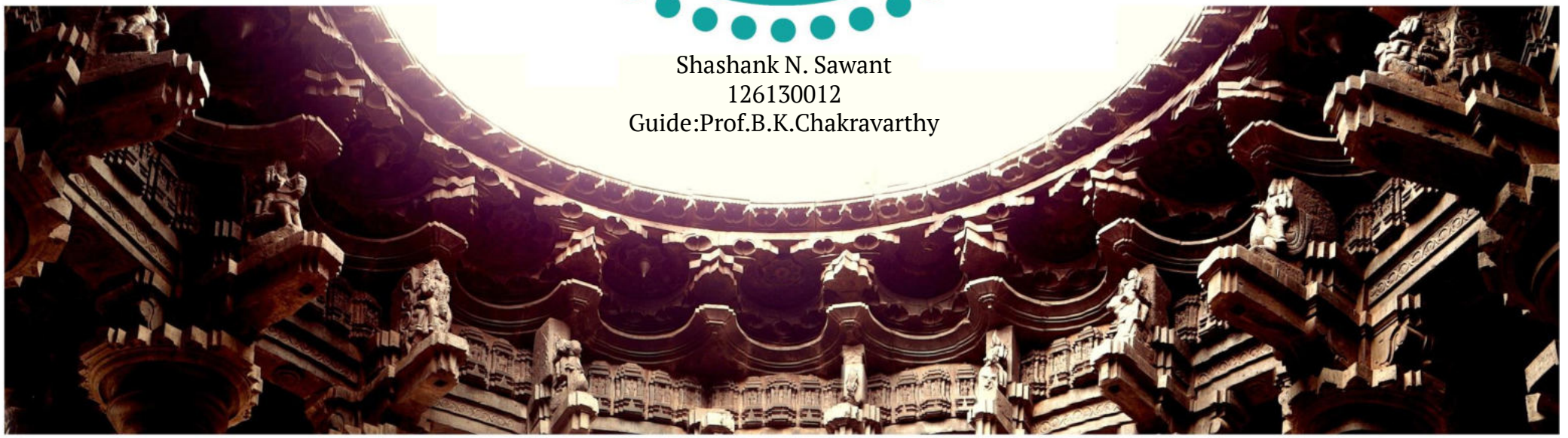

Approval

Industrial Design Project II

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by Shashank N. Sawant
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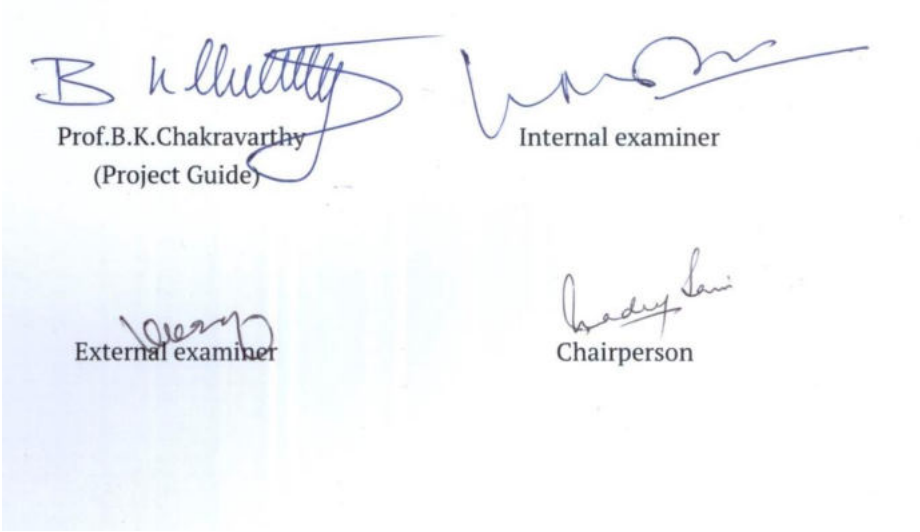

Declaration

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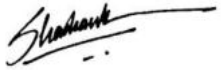
Signature: 

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Thanks to the team at VinLED for their collaborative efforts.

Also, a warm mention of Mr.Amey R. Ghatge, for inspiring me again and again!

And finally to my family, thanks for being ever so patient with me!

Contents

Abstract

History fascinates all of us. It speaks to us in various forms, through ruins, scrolls, stories and memories. In India, we are blessed to have temples and other monuments which weave the seamless tapestry of our existence since times immemorial. But as the footsteps of time approach louder, and modern technologies penetrate deeper and deeper into our lives, the insensitivity to these heritage structures is on the rise. Lighting which forms the crucial part of the temple-going experience is often neglected and thoughtlessly laid out. This is seen in terms of the entire system. Any damage to the structure results in permanent loss of our cultural heritage.

The project was conceived and executed keeping this 'pain' in mind. Within the scope of the project, it has been tried to address all issues related to lighting within the context of heritage temples. The issues that fall within this gamut include light sources, fixtures, wire management, switches and power supplies to some extent.

Accordingly, we worked within the context of Ambernath temple. The temple is a classical structure built circa 900 A.D., and is in need of urgent attention. Referring to books and in consultation with scholars, the temple was separated into zones and the lighting need for each zone was identified. The possible places where lights could be mounted were also identified. These included blank lintels and pillars. The crowd movement patterns through the temple were observed. The present power supply, switches and light sources were also listed.

Various luminaires and design directions were explored. Since the brief was to remain unobtrusive within the temple space, the luminaire was a simple channel designed to house the LED lights with temple motifs engraved on it. The module ensures protection, repeatability and variations in motifs across locations. The lights were then fabricated under collaboration with VinLED.

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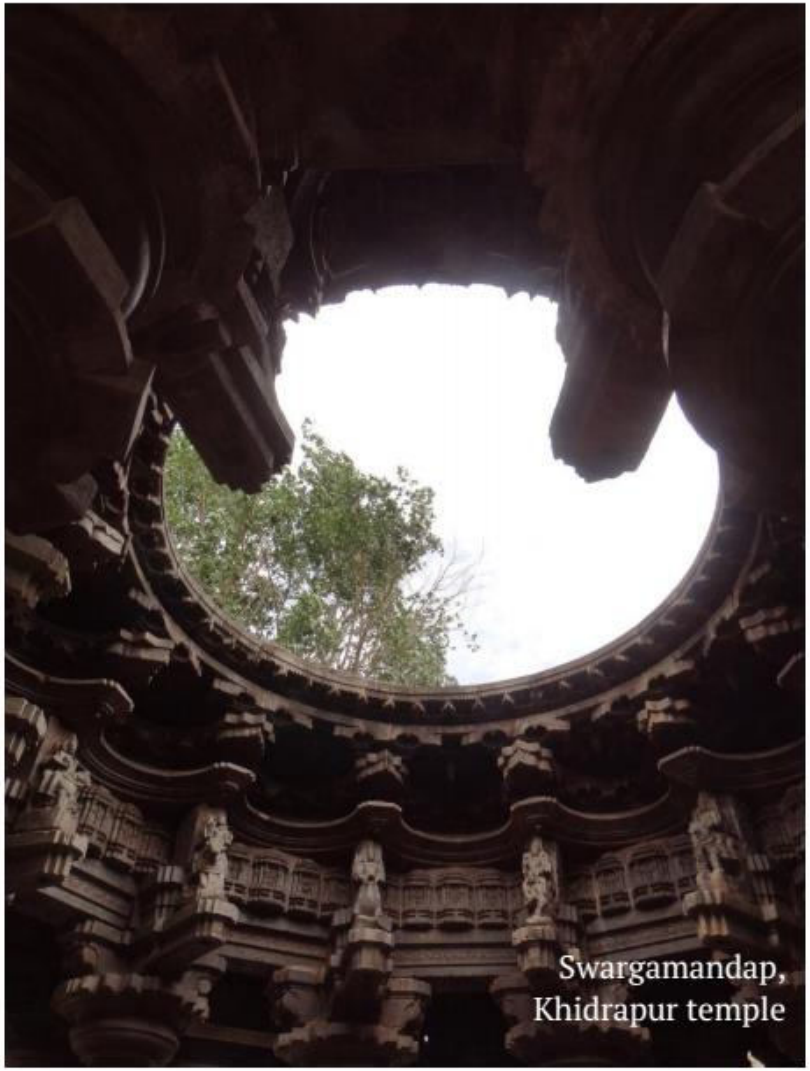
Throughout the project, enough attention has been paid to keep the proposed systems culturally sensitive and unobtrusive within the sacred space that is the Indian Temple.

1. Introduction

Even as semester two at IDC had hardly come to an end and we were to embark upon our internships, the staff asked to search for P-II projects in areas of design interventions in rural scenarios and sustainability. We would be interning across the length and breadth of India, some in Pondicherry, some at Santi Niketan (West Bengal), some at Ladakh and the staff was sure we would come up across some challenging design issues.

I found myself interning at Wings 44, an industrial design firm run by Mr.Amey R.Ghatge, an IDC alumnus, in Kolhapur. So by May, I was in a new city, alone and free to discover places at my ease. I started off by covering the popular places as the Mahalakshmi Temple complex, Panhala fort, New Palace, museums, and eventually the by-lanes of this old city. I was happy by whatever I was seeing. And then one evening, just as I was about to leave the office, Amey Sir asked me what all I had seen, where all I had been. As I rolled out the regular list, Amey Sir asked me to visit a temple at Khidrapur, some 50 odd kilometres from Kolhapur. I had never heard of it, neither did it feature on must-see list that adorned many hotels in Kolhapur.

My month in Kolhapur drew to a close sooner than I thought, and I visited a lot more odd places, but Khidrapur remained unseen. Finally on my last weekly off, I impulsively boarded a bus to Kurundwad, the nearest town to Khidrapur village. Then after a half an hour ride in an over-crowded old jeep, I found myself standing along the banks of Krishna river. I looked around and beyond the perimeter walls, I saw a temple that took my breath away at the first sight.



Swargamandap,
Khidrapur temple

Sabhamandap,
Khidrapur temple

Wikimapia had directed me here, but I was not prepared to see this thousand year old unique structure. The outer chamber was open to the circular pattern. As the sun moved across the sky, it illuminated the circular raised platform in the middle, even as the pillars were lit up, each awaiting its turn patiently across the day. In stark contrast was the inner chamber with equally beautiful pillars, but hidden in dark. I'll be truthful here and confess to not even having seen the God's image in the inner sanctum properly, so dark was it there.

I came out and continued photographing the outer sculptures, simply because they could be seen. but what still intrigued me was that I had seen a Jataka tale sculpted on one of the visible pillars inside and now I wondered what more was there hidden in the dark.

I returned to Kolhapur city and proceeded to spend the evening in Bhavani Mandap, located just near the Mahalakshmi temple. As the lights were gradually switched on my attention was drawn to the wires, the switchboards and the CFLs, tubelights that were sore to look at. They were fitted unimaginatively on teak ceilings and old wooden beams. Of the many topics that I would pitch to the staff for P-II, this was the moment when 'Lighting solutions for temples' came up in mind as a potential project. Over the coming months, I visited a number of temples along the ridge of Sahyadri built in the 'Hemadpanthi' style, collating this data with my previous experiences.

Jataka tale on a pillar, Khiddrapur

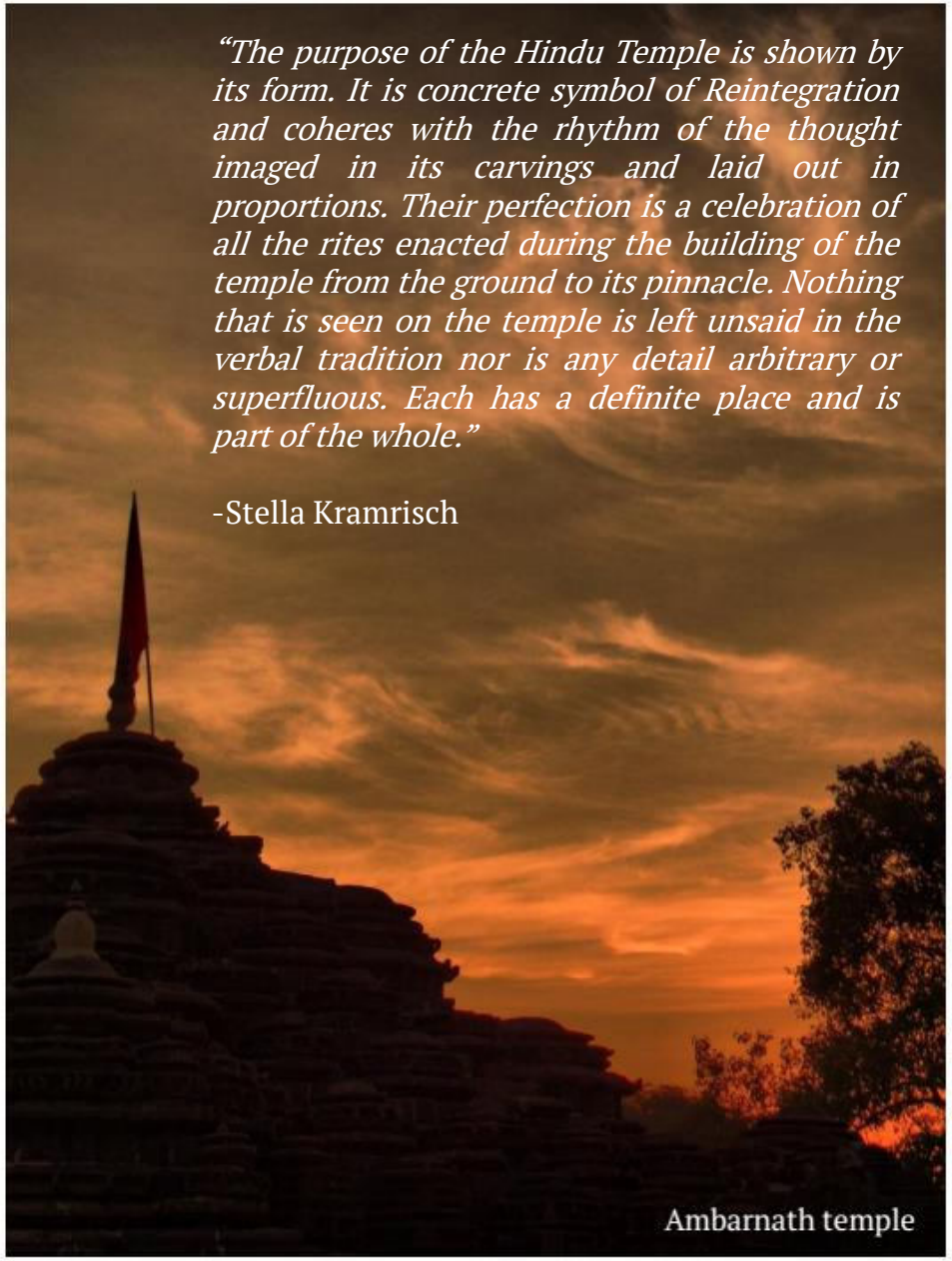
Lights at Bhavani Mandap, Kolhapur

Under the guidance of the Prof.B.K.Chakravarthy, the project took better form. He shared the same 'pain' and concern that I experienced seeing the state of these temples. He brought to my notice that the issue was an all-encompassing one and would include many stake-holders, all of whom we managed to pool in and convince slowly.

The Shiv Mandir at Ambernath forms the focal point of all the work done under the project owing not just to its proximity but also its classical architecture and urgent need for attention.

Lastly, as the villagers at Ambernath pointed out, it is His will that the project happen and I admire the faith that they have in Him. I shall be happy if the project has succeeded in enhancing their temple-going experience even a little bit and ensure that the coming generations see what our ancestors have built.

2. The Cause



The Hindu temple is an intriguing structure that has been venerated by millions for thousands of years and has fascinated an equal number. It is said when the Vedas were recited for the first time, there were no temples. The community performed sacred rites around a ritualistic fire. The tradition of idol worship came at the end of the Vedic period (1500-500 BC) which gave rise to the concept of temples as a place of worship. Temple architecture as a set of established rules developed gradually from the 4th century AD.

This growth phase of Hindu temples charts its rise and fall alongside the fate of the various dynasties that reigned India during the period majorly contributing and influencing the building of temples, especially in South India. The act of visiting a temple had great religious merit and hence the act of constructing one acquired even greater merit.

Under the patronage of various dynasties, temples were built at picturesque sites; along rivers, on hills, in meadows. At the forefront of this trend were southern dynasties like Cholas, Pallavas, Vijayanagar kings, Chalukyas and Rashtrakutas It crossed the seas and spilled over into Southeast Asia [1]. Even as dynasties collapsed, raids occurred, wars were fought, these temples held their ground and served as beacon of hope to the God-fearing masses. But this in turn made them a sensitive target to the invaders, the ransacking of a temple had repercussions on the greater psyche. Following the all-encompassing Mughal rule, temple architecture almost came to a standstill. As the Mughals weakened, Peshwas took the onus of reconstructing fallen temples and built new ones.
By 19th century, the modern world entered India. It brought telephone, telegram, cars, trains and electricity with it.


Siddhagad ruins

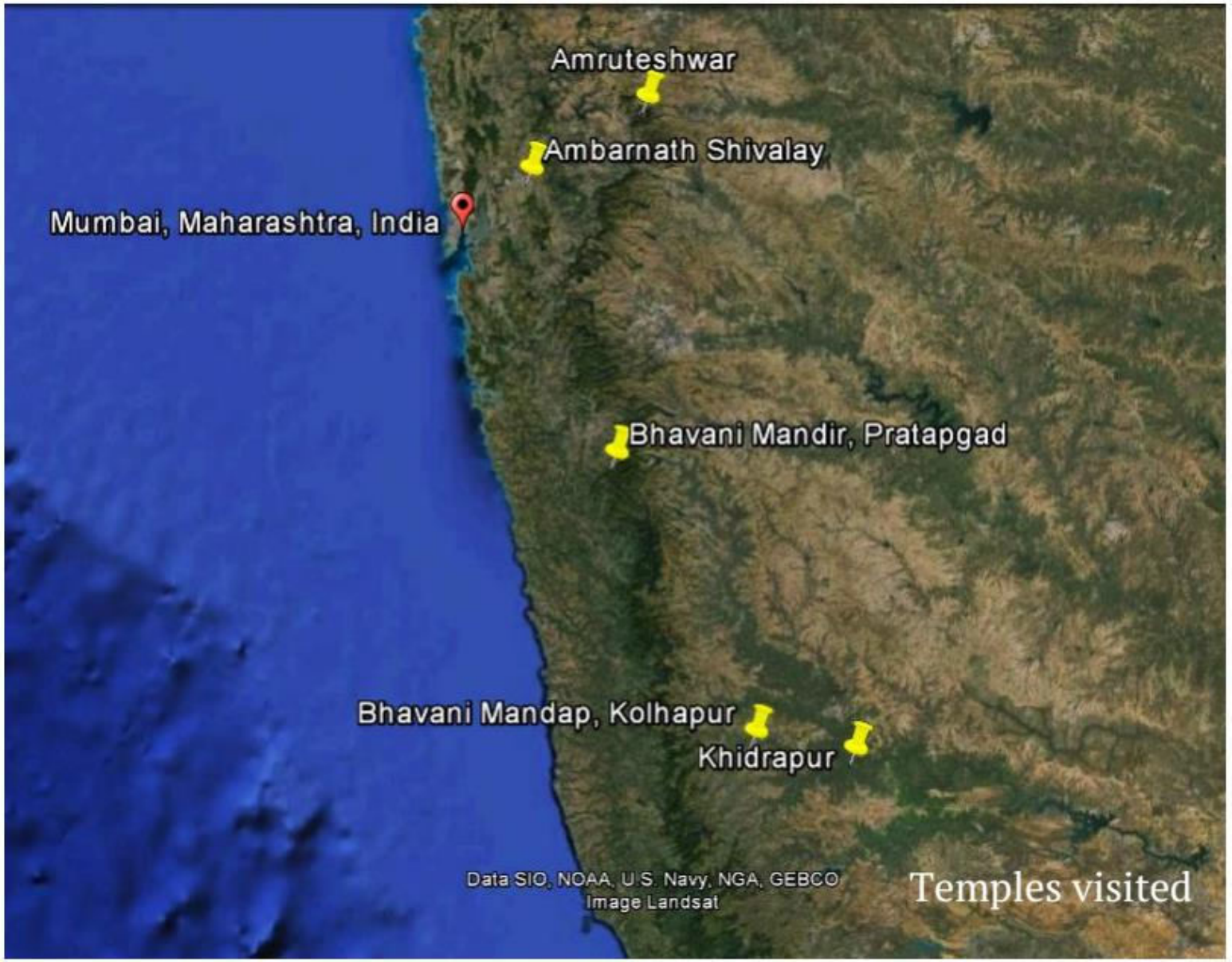

Kasba peth Ganpati, Pune

By 19th century, the modern world entered India. It brought telephone, telegram, cars, trains and electricity with it. This electricity was well suited to light up the interiors of temples. It was convenient, almost maintenance free and would eventually become cheaper.

The traditional lamps needed oil, ghee and a pious person to light them up. Electricity did away all of this. But it brought wires into the temple. Switchboards. Fixtures. They were fit on the delicately carved walls. Of stone. Of precious wood. Nails were driven. Holes were dug. All the sacred space was violated in favour of bringing light into the temples.

It is just of late that sensitivity towards this area has been rekindled. People are slowly realising that they cannot violate a structure that has been so meticulously built. Being an avid traveller, I have come across a number of temples across the country. Not just temples, but all types of holy places as Gurudwaras, Mosques, Churches, Agyaris, Stupas etc. They all face similar issues. It hurts to see them fall for convenient, temporary and shabby options instead of a dedicated approach to their places of worship.

People invest faith in these places, their hopes, their desires, their secret wishes. Why then do they not invest attention to lighting up these places? The project set out to search the same. The temples visited were not necessarily visited keeping the project context in mind, but there was some subconscious effort to document the damage done to these heritage structures by insensitive lighting.


Amruteshwar
Ambarnath Shivalay
Mumbai, Maharashtra, India
Bhavani Mandir, Pratapgad
Bhavani Mandap, Kolhapur
Khidrapur
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat
Temples visited


Pratapgad fort

1. Bhavani temple, Pratapgad (Satara, Maharashtra):

This temple was constructed along with the fort Pratapgad circa 1656 AD. The goddess is the patron deity of King Shivaji who commissioned the construction of this fort overlooking the mountain passes Par ghat and Radtondi ghat between the Sahyadri and the Konkan. The temple has been in continuous use for over 350 years now.

The lighting fixtures here have been put up on the Ganesh Patti which adorns the temple entrance. The wiring for the surrounding has been routed along the outer walls through a thick conduit. Owing to heavy rains, the fixtures are enclosed in a water proof casing giving it a very rigid, obtrusive look.

The Sabhamandap has been recently renovated and has old chandeliers installed in a better manner.


Sabhamandap
Bhavani Mandir


Bhavani Mandir


Lighting on the Ganesh patti


Khidrapur temple

1. 2. Kopeshwar temple, Khidrapur (Kolhapur, Maharashtra):

This temple was built in 960 AD along the banks of Krishna river on the Maharashtra-Karnataka border. It is dedicated to Lord Shiva who sits in a dark inner sanctum with no artificial lights.

The outer Swargamandap is circular with 48 pillars arranged in it. It is open to the skies with sunlight lighting up each of the pillars one by one.

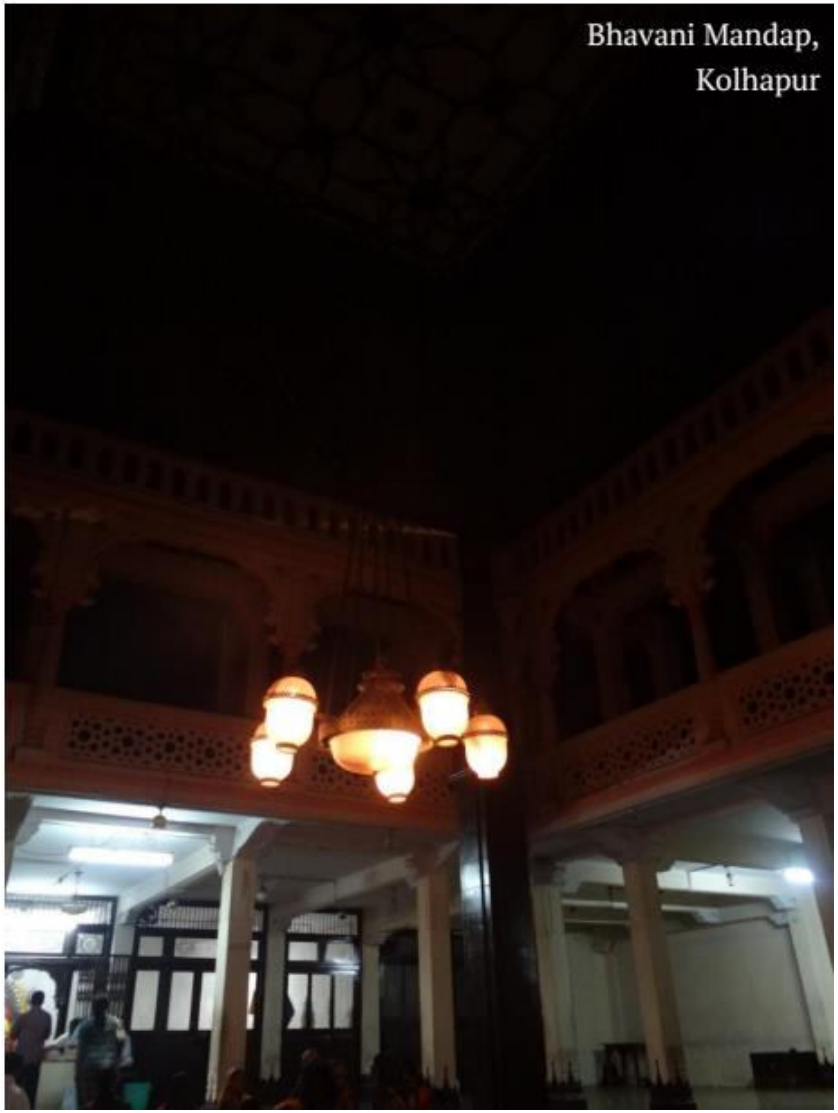
The only artificial lighting is done in the Sabhamandap, a huge inner chamber for congregation with tube-lights hung across the central dome.

Details on the swargamandap

Interiors of the swargamandap, Khidrapur

Khidrapur
Sabhamandap

Khidrapur
Sabhamandap



3. Bhavani Mandap, Kolhapur City (Kolhapur, Maharashtra) This is the temple devoted to the patron goddess of the Kolhapur royal family. It is a comparatively new structure, late 17th century and built in the 'wada' style with the royal quarters adjoining the temple. The temple has lighting and switchboards visibly dating back to early 1900s. The old incandescent bulbs have been replaced by CFLs inside the old fixtures. There are conduits running along teakwood ceilings and pillars.

Details of old switches

Tubelights,
Bhavani Mandap

Old fixtures,
Bhavani Mandap

Wiring,
Bhavani Mandap


Amruteshwar temple

4. Amruteshwar, Ratanwadi (Ahmednagar, Maharashtra) This beautiful stone temple is located deep within the hills of Bhandardara, a popular hill station. Just behind it is the Ratangad fort. Built in Hemadpanthi style circa 10thcentury AD, no space on this structure has been left unadorned by delicate sculptures. The spire rises 22m into the air, and to light it up a wire runs through the mesh of carvings. The interiors of the temple are not lit up. The Shivling itself sits in a sanctum that is filled with water [2].


Details on the ceiling


Temple spire


Ambarnath temple,
South face

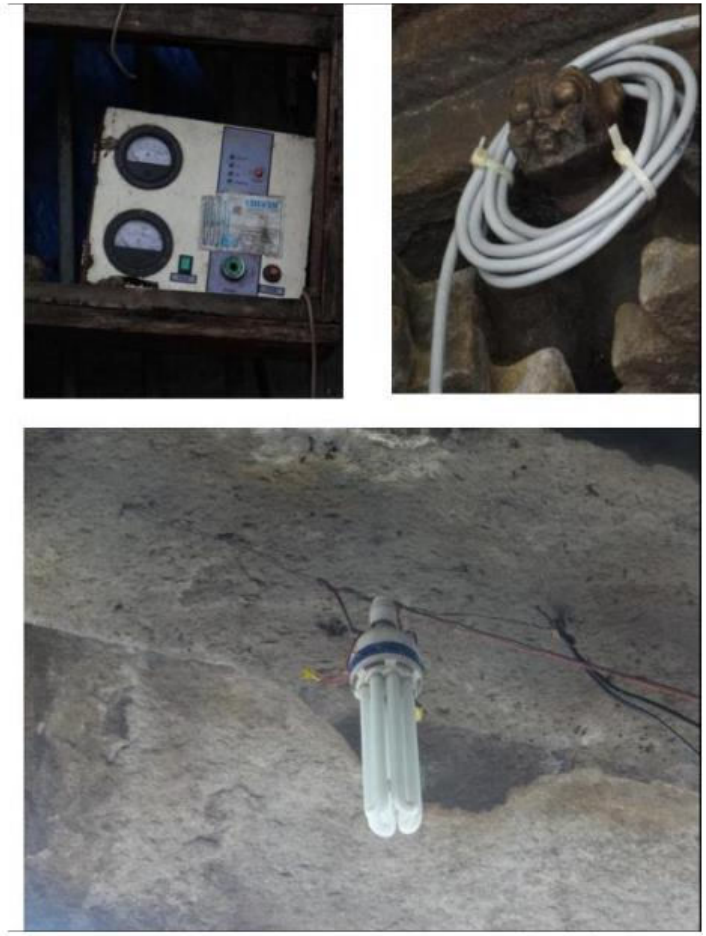
1. 5. Shiv Mandir, Ambernath (Thane, Maharashtra):

This stone temple built in Hemadpanthi style circa 1060 AD is just an hour away from Mumbai's concrete jungle. It is laid on a cruciform plan. The central spire has collapsed and yet the temple rises to a height of 22m.

The power supply for the temples needs is sourced from a roadside line that also powers the streetlamps. The wire has been routed messily along the temples north, west and south faces.

In the porches, lights are hung from wires nailed into the stone facades. Inside the temple, these wires are placed on the iron reinforcing columns and bulbs are hung from them. A damaged switchboard is placed on the wall near the north entrance. There are close to 3 tubelights and 2 lightbulbs inside the small subterranean sacred Garbhagruha.

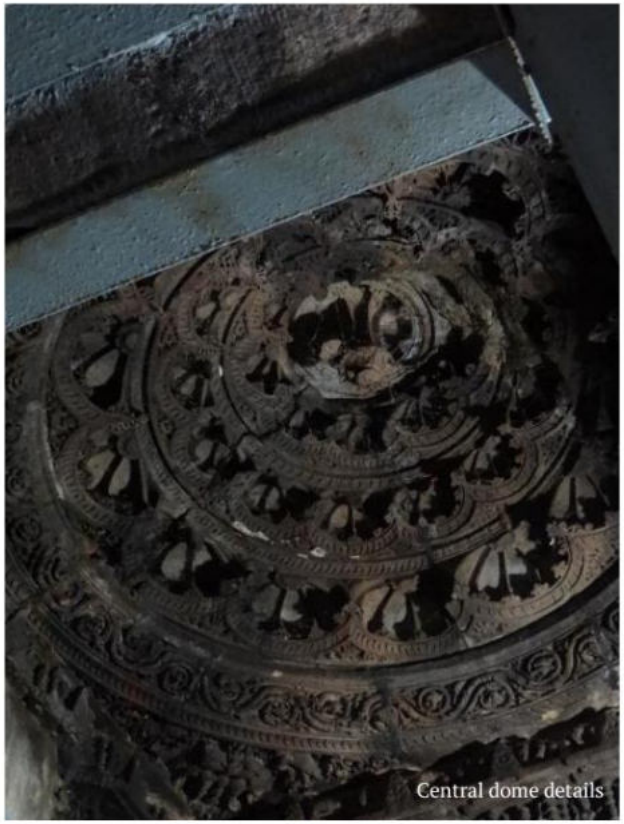

Ambarnath temple before sunrise



Wiring, fixtures and power supply units, Ambarnath temple

Iron beam reinforcements

Switchboard on northern side

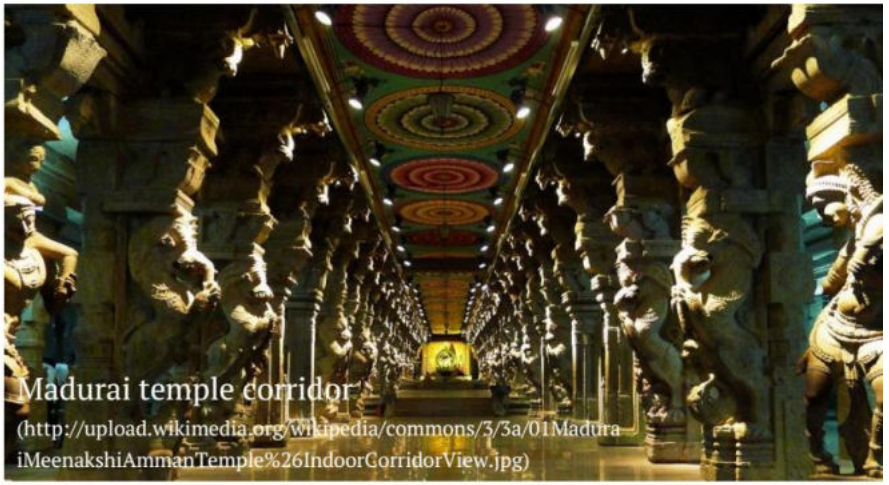


Central dome details

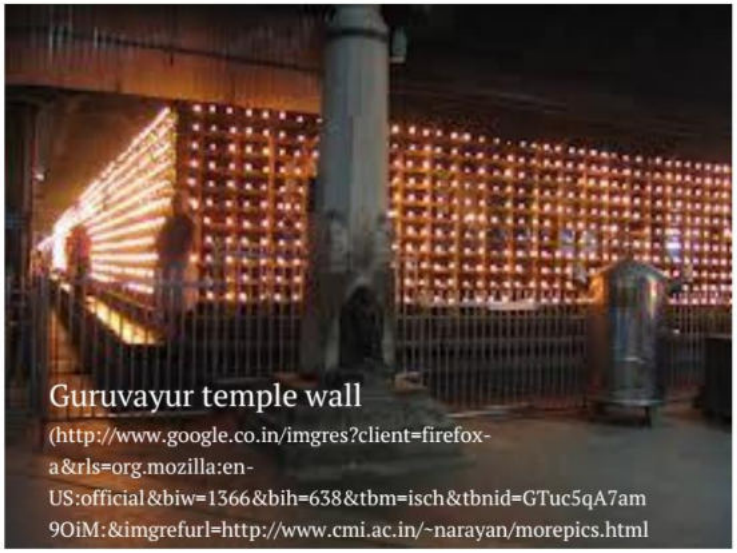
Traditionally temples have been lit up with diyas fuelled by ghee/oil. These lightings are very region specific.

For example in the southern parts of India, the inner sanctum is often kept free of any foreign materials to the extent that some are not even lit up. Tirupati Balaji temple, unarguably one of the most famous temples in the country, is poorly lit up and owing to the huge crowds of upto 65,000 devotees per day; the average darshan time varies from a mere 0.80 milliseconds to 1.5 seconds [ref:http://timesofindia.indiatimes.com/city/hyderabad/21-hour-wait-for-fleeting-darshan-of-the-Lord-at-Tirumala/articleshow/12410243.cms].

The Madurai temple affords a wonderfully lit up corridor. The Guruvayur temple in Kerala has a wall on the circumambulation path lit with diyas, but the same was vulnerable to a huge fire in 1970.



Madurai temple corridor
(http://upload.wikimedia.org/wikipedia/commons/3/3a/01Madura-iMeenakshiAmmanTemple%26IndoorCorridorView.jpg)

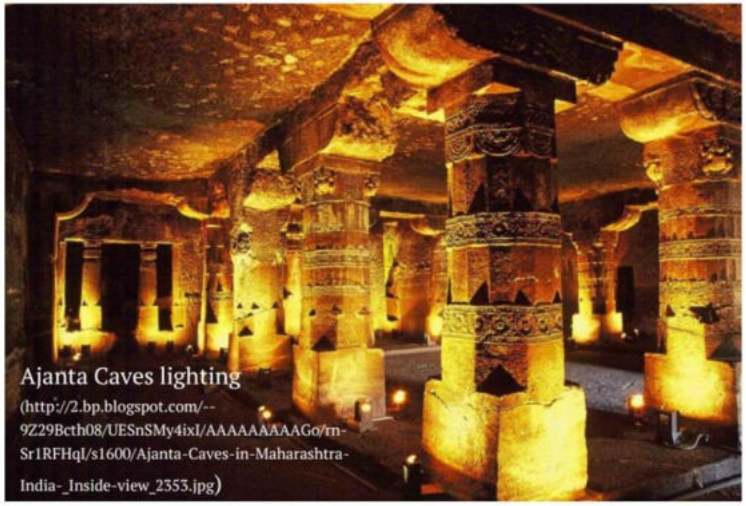


Guruvayur temple wall
(http://www.google.co.in/imgres?client=firefox-a&rls=org.mozilla:en-US:official&biw=1366&bih=638&tbm=isch&tbnid=GTuc5qA7am9OiM:&imgrefurl=http://www.cmi.ac.in/~narayan/morepics.html

In Maharashtra, there is a tradition of lighting up tall stone structures called 'Deepstambha's in front of the temples. Most of the popular temples like the Mahalakshmi temple in Kolhapur, Khandoba temple at Jejuri, the Jyotirlinga temples are fairly lit up with conventional lighting systems.

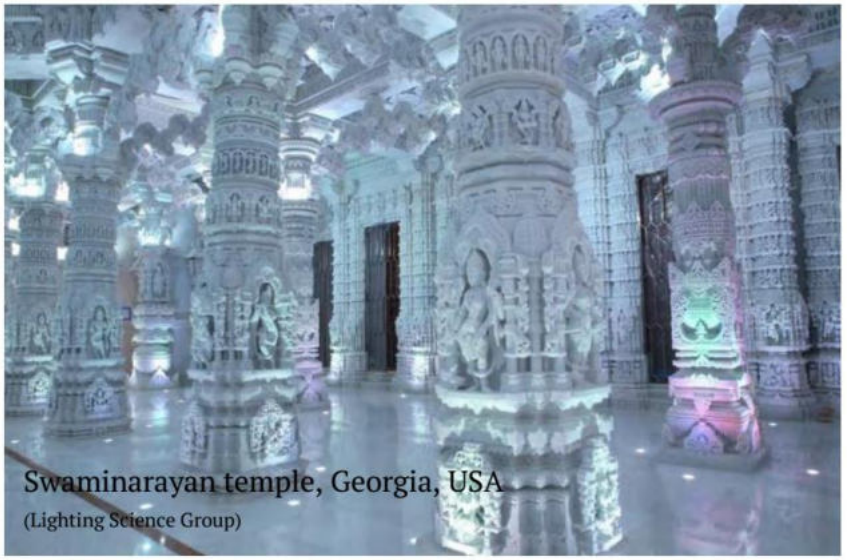
Jejuri temple Deepstambh

The world famous Ajanta and Ellora caves have been carefully lit up with a combination of optical fibres and conventional lighting systems. Optical fiber lighting reduces radiant heat and ultra-violet rays, which deteriorate the murals. It also enables a number of murals to be open to the public in a safe manner and is a highly effective measure for satisfying both heritage site protection and tourism promotion. This project has been carried out in collaboration with the Japanese government
[www.jica.go.jp/english/our_work/evaluation/oda.../project28.pdf].

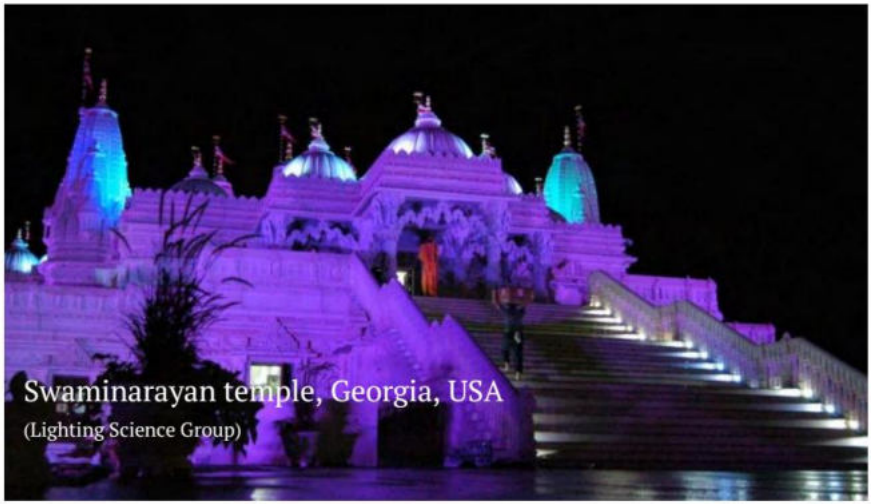


Ajanta Caves lighting
(http://2.bp.blogspot.com/--9Z29Bcth08/UESnSMy4ixI/AAAAAAAAAGo/rn-Sr1RFHqI/s1600/Ajanta-Caves-in-Maharashtra-India-_Inside-view_2353.jpg)

Modern temples have far better opportunities at lighting up their holy spaces as compared to heritage temples. The lectrical wiring systems are often incorporated into the plans of the structure itself and lights themselves are a part of the entire plan. Surprisingly, the most talked about example here would be the Swaminarayan Temples worldwide, outside India, especially the one at Lilburn in Georgia, USA. Various lighting design firms and manufacturers based the USA came forward and collaborated with skilled artisans from India and it is heartening to see such modern integrated temples that create a stunning visual spectacle which is modern and yet deeply rooted in tradition. [www.aeconline.ae/lighting-science-catalogue.../LSGC%20Catalogue.pdf]



Swaminarayan temple, Georgia, USA
(Lighting Science Group)



Swaminarayan temple, Georgia, USA
(Lighting Science Group)

3. Context & Comprehension


Ambarnath temple,
South face

To many, Ambernath is just a railway station on the way to Karjat, a satellite suburb on the outskirts of Mumbai's metropolitan area. But this suburb is also home to a jewel, far outdating Mumbai's timeline. The Shiv mandir at Ambernath is a classical temple built in the 'Hemadpanthi' style of temple architecture. Stylistically, the temple is 'Bhumija', a term that refers to the style of the spire. An inscription on the northern side mentions that it was built by the Shilahara king Chittaraja, later renovated by his son Mumunni in 1060 A.D. as mentioned in an inscription on the northern porch lintel [3].

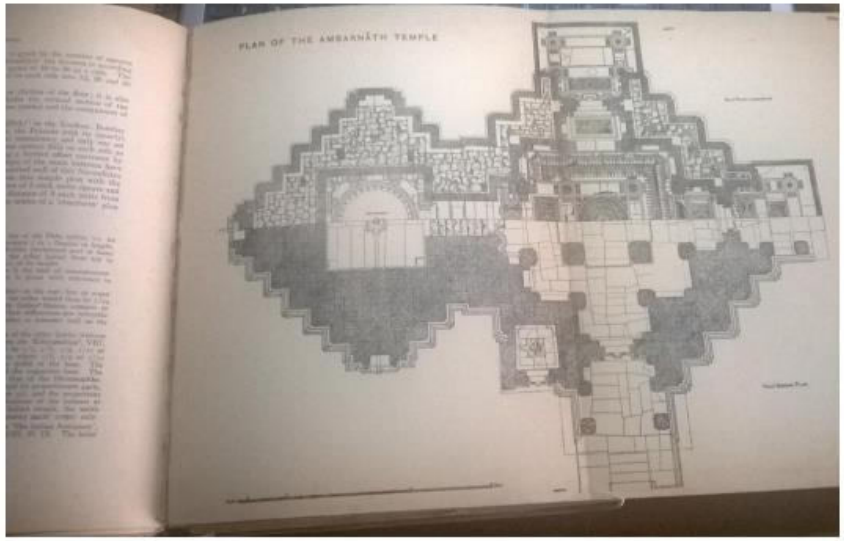
The temple has no central spire today, but remains of the spire have been excavated. The temple is laid out in a cruciform plan. The main entrance is from the western porch where two Nandis (bulls) stand guard. There are two more porches, one each on the north and east side. The outer wall is stepped and faceted, to accommodate as many sculptures as possible.


Ambarnath temple before sunrise

The temple measures approximately 29mx24m. even without the spire, the temple rises to upto 21m high. The Sabhamandap (outer chamber) is adorned by 18 pillars. Of these 4 remain intact, while others have been damaged/hidden in subsequent renovations. The temple dome is a trabeate dome, with exquisite carvings. To enter the Garbhagruha (inner sanctum),one has to descend a flight of steps, about 2 metres below the ground-level. The sanctum is a neat square with the ceiling rising high above it. Owing to the fallen spire, it is open to the skies and houses two 'Shiv Linga's. The outer wall is stepped and faceted to accommodate as many sculptures as possible in the niches created. The temple is held up by a layer of about 250 elephants called as 'Gajthar'. The layer above it houses about 70 Mithuna, Shrungara sculptures. Just outside the north porch is a smaller temple built adjoining the super-structure. The entire temple surroundings measure 50mx35m. Recent beautification and conservation efforts by Archaeological Survey of India have resulted in a well-kept environment.

Even as I scouted temples across Maharashtra, I knew that there existed this old temple at Ambernath. So keeping the project in mind, I visited this temple early on one fine Sunday morning. When I returned to IDC on Monday morning, I went through some books in the library. One of them was Stella Kramrisch's seminal work called 'The Hindu Temple'. To my surprise, it contained a two-page spread of the plans of the Ambernath temple. My excursion the day earlier made perfect sense now. In consultation with Prof.B.K.Chakravarthy, we narrowed down to this site and found context for the project.

Ambarnath temple in Diwali



Ambarnath temple plans published in 'The Hindu Temple' by Stella Kramrisch

"A casual look at what is left of the Ambernath temple shows one the effect of the march of time and points out how old the structure is. A second, introspective glance stops one in the tracks. The structure is old but the purpose for which it was built is ageless, as constant and relevant now as it was in ancient times. It is the never ending quest for the meaning of life, of creation. It brings forth the fact that the quest for the Universal truth is timeless. It is the wish to transcend the form to reach the formless, to go beyond the path and the medium to the message, to be able to understand the meaning of it all, a search for 'nirguna', 'nirakara' through the 'saguna', 'sakara'. The temple is not about the Shilahara dynasty but about this quest."

-Kumud Kanitkar

Ambarnath temple, south wall

Ambarnath, south porch

Ambarnath temple's fallen spire

To work within the premises of the temple we would need support from both the ASI and the local people. Accordingly, I set out to seek permissions from ASI. The Archaeological Survey of India (ASI), under the Ministry of Culture, is the premier organization for the archaeological researches and protection of the cultural heritage of the nation. Maintenance of ancient monuments and archaeological sites and remains of national importance is the prime concern of the ASI. Besides it regulates all archaeological activities in the country as per the provisions of the Ancient Monuments and Archaeological Sites and Remains Act, 1958. It also regulates Antiquities and Art Treasure Act, 1972.

For the maintenance of ancient monuments and archaeological sites and remains of national importance the entire country is divided into 24 Circles. The organization has a large work force of trained archaeologists, conservators, epigraphist, architects and scientists for conducting archaeological research projects through its Circles, Museums, Excavation Branches, Prehistory Branch, Epigraphy Branches, Science Branch, Horticulture Branch, Building Survey Project, Temple Survey Projects and Underwater Archaeology Wing.

ASI-Mumbai Circle started functioning with effect from the 1st December, 2004 and now, become the Mumbai Circle on 28th December, 2005 with its Head Quarter at Sion Fort, Sion (E), Mumbai. This Circle having a total 117 monuments has its jurisdiction over eleven Districts namely Kolhapur, Mumbai City, Mumbai-Suburban, Pune, Ratnagiri, Raigad, Sangli, Satara, Sindhudurg, Sholapur, and Thane, of Maharashtra. There are eleven Sub-Circles located at Alibag, Elephanta, Janjira, Junnar, Kolhapur Mumbai, Pune, Sholapur, Raigad, Vasai and Vijaydurg [4] [5].

(http://asi.nic.in/images/asi_new_logo.jpg)

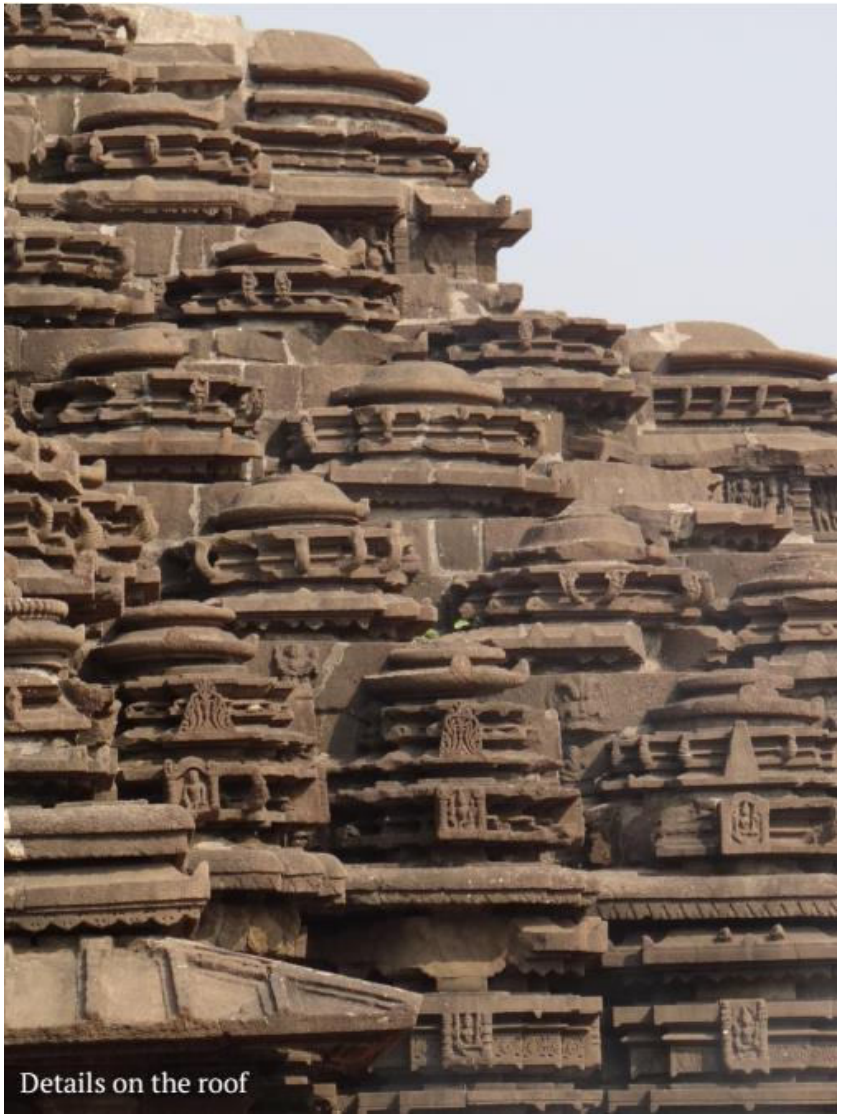
Superintending Archaeologist of ASI-Mumbai circle is Mr.Jitendra Nath. He was gracious enough to hear out the project patiently the first time I visited him. I explained that unless on-site trials/ lighting demos were conducted, it was impossible to gauge where and how the project were to proceed. ASI requested a letter from IDC to which it supplemented an authorising letter permitting me to work on-site at the Ambernath temple, albeit with a few restrictions.

ASI declaration board

The next step was to convince the locals of the need for better lighting. I was directed to Mr.Suresh Patil, who, I was told, handled all the affairs of the temple. When I met him at his shop, he was equally gracious to listen to me and ended up taking keen interest in the project. His family has been taking care of the temple for generations and he knows all the things related to the temple. It helps that he is a a warm-hearted person whim everybody looks up to. I showed him the books, some 3D models of the temple and some proposed lighting concepts and it just peaked his interest. He accompanied me to the temple and introduced me to the temple guards, priests and the ASI attendants asking them to co-operate with me on my project.

However owing to its 'Hemadpanthi' origins, the temple was built using male-female blocks of stone and no mortar was used. Over the years, the structure has weakened, almost tilted and slipping away in places. Owing to this, reinforcing iron beams are erected inside the Sabhagruha to strengthen the structure.

Lights came in the temple in 1980, and these were routed through the stones themselves. However as of now, the wire management is a mess. A worn-out switchboard sits near the northern side, from where the power actually enters the temple. From there power is routed to lights and other devices inside the temple. Other devices include CCTV cameras, a computer monitor and inverter batteries. CFLs are used extensively for lighting here. Incandescent bulbs are completely done away with. Halogen bulbs are installed on the west porch along with a tubelight here and there.



Details on the roof

Similar lighting is observed in the Garbhagruha which is undisputedly the holiest place of the temple. Wherever the fixtures are difficult to attach, nails have been driven into the walls.

The temple has no official trust as such and is managed by the local people on the offerings of the devotees, no donations are accepted. It is a centrally protected monument and lies within the care of ASI Mumbai circle. Any work to be done within this area has to be approved by ASI. Apart from ASI attendants, the temple is secured by private security.

It is within this context that I set out to work.

Wiring through sculptures

CFL bulbs hung on the porch and from the iron beam reinforcements

Wiring through stone

Switchboard

Lights in the Sabhagruha

(http://www.vinled.com/)

Simultaneously, we were also working with LED manufacturers to see how they could collaborate with us on the project. Accordingly, with help from Prof.Chakravarthy, we got permissions to visit VinLED's facility in Bhandup. They source LED strips from Osram and then placed on the designated place using a 'pick and place' machine. VinLED specialises in world class lighting solutions for LED lights, LED signages, LED video-walls and other types of lighting. At VinLED, Mr.Ghag made sure that I was toured around the facility properly. Mr.Srinivas Rao is in talks with us to see till what extent would they help us. Mr.Sameer Gudekar has been helping out in selecting proper fixtures and wattage for the proposed lighting. He has also been instrumental in giving design inputs from the company's side.

4. Check

The checks have been performed keeping in mind the following parts of the system:

1. Light sources
2. Fixtures
3. Switches
4. Power supply
5. Wire management

Each has been tackled in the following sections.

Light sources:
Currently, the lights installed in the temples are CFLs and normal tubelights with some halogens for powerful lighting. The temple has a cold, uninviting feeling owing to these bluish light sources.

For the project LEDs, Fiber optics and reflectors were considered Reflectors would refer to reflecting panels directing sunlight into the inner chambers. These would be visually very obtrusive and would require backup lights in the night and in monsoons/cloudy days.

Fiber optics refer to flexible, transparent fibers made of extruded high quality glass (silica) or plastic that serve as guides or pipes to transmit light between two ends. But this medium suffers from problems of attenuation and light output.

LEDs on the other hand are on their way to become the industry standard and are having widespread applications. LEDs have comparatively longer life. The light they produce is highly directional. They are generally more efficient at converting watts to lumens, which translates to higher efficiency.

The only issues are with heat dissipation, and considering that the light quality is a function of the temperature this becomes a major issue. Hence special fixtures and electronics have to be designed, increasing the initial installation costs but these are easily recovered owing to low power consumption.

Fixtures:
The fixtures had to keep three checks in mind. The form itself had to be non-obtrusive, minimalistic, neutral and yet cater to its primary functions. Since the fixtures would be going inside a sacred space, materials would have to be selected carefully. While die-cast aluminium is industry standard, materials like copper, bronze, brass are more preferred traditionally. Since the project deals with heritage structures, alternatives to nails and drills were looked upon these included adhesives, chemical anchors, clamp-on, suspended or floating.

Switches:
Not much attention was paid to this component in the earlier stages. But it was brought to notice in one of the stage presentations that the process of creation of light was also an important activity. It is a spiritual endeavour that is missed out in a simple switching action. Further most temples install switchboards meant for other purposes, say a small factory or so. Some temples just simply craft wooden boxes with wiring hidden in the box and fix the boxes on the temple walls. Accordingly, different types of switching options were considered. A visit was made to Line-Pro, a membrane-switch manufacturer in Bhiwandi.

Power Supplies:
This was the most crucial factor as it influenced the overall system. Wireless technologies were considered in the initial rounds of ideation. These included the following technologies:
1. Induction: This option is feasible only over small distances and for small range applications.
2. Radio wave: here the power transmitted has to be limited for safety. There are attenuation losses over the free space path. Also, smaller the size of the antenna smaller is the power transmitted/received and size is a critical factor in the temple space.
3. Power beaming: Light is generated in a LASER and transmitted to a photovoltaic cell where again power is generated to run the light source. However this system has inherent losses.
4. Conduction by ionisation of air: the breakdown voltage of air which is ~10000V is lowered by a high power UV beam to ionise the air and thus result in conduction. However this is a power intensive system. And there are practical issues in implementation
5. Evanescent wave coupling (Witricity): this method was developed at MIT labs. It is an improvement of simple induction method and operates on the principle of resonance providing over 10^6 times improvement in power transmission over the latter [6].

However, research into these technologies showed they are in a nascent stage.

"Wireless power system is in very early stage, I am not aware of its commercial deployment or availability. Also the cost may be high"
-Abhay Karandikar (E.E.Dept, IIT Bombay)

Though wireless power transmission are highly desirable for a project as this, it does not seem feasible at this point. Similarly if we were to look at implementation, we have to give up on this option as a possibility.

So again focus was shifted back to AC mains supplied by the electricity board. Backup in the form of solar-based photovoltaic cells were also taken into consideration. Attention needed to be paid to the efficient and optimum usage of power.

Wire management:
The current wires are routed along/ within/ on sculptures in the temple space. The gaps in the stones have also been utilised for the same. Flatter wires were considered and conduits were to be done away. Considering that the wire insulation would now be exposed to elements, the material selection would have to be wiser. If wires are to be taken around sensitively, the space itself needed careful dissection.

Based on these checks, the following design brief was proposed.

Switches:
the switching on/off itself was an important part of the lighting activity. It was found out that lighting up the entire temple by one single switch was not desirable. A gradual lighting up had to be attempted. For this, the earlier zoning could come in help. The following sections have been suggested:

1. The three outer porches
2. The Sabhamandap
3. The central altar and the dome above it.
4. The entrance to the Garbhagruha and the Garbhagruha itself

For the switch itself, membrane switches were initially explored. The position of the switches was to on a centralised board, preferably near the north side itself. But one more option explored was that of having them dispersed around the space near the light source itself. There it could be again a simple membrane switch itself or traditional string switches. Again to be taken into account here is the movement of the public itself around the temple space which may result in misuse/damage to the switches.

Wiring:
Wiring and wire management forms a crucial part of the project. It has been duly noted that main power reaches the Ambernath temple from the north side porch where a switchboard has been mounted and then routed all around the temple. The temple being built simply of male-female blocks has become susceptible to water leakages which presents a safety issue as far as electrical safety is concerned. The current cables are hung haphazardly along the temple space. For interventions we tried innovative techniques for wiring without significantly altering existing facades. Firstly we tried lighting demos at the temple itself, but the wire management part was overlooked. Next we tried gluing the wire to the surfaces using a hot-glue gun. Using this technique, the wire could be effectively routed around a room without much effort. Further 3M tapes were found to effective on stone surfaces also. The basalt rock used in construction of temple has inherent water affinity and hence accepts 3M tapes best after coating with a suitable primer, in this case 3M™ Silane Glass Treatment AP 115 or 3M™ Primer 94 similar silane coupling agent in IPA/water mixture [9].


LED lighting mounted with the help of 3M tapes on back


Hot glue gun

As far as the materials were concerned, it was found out that constant weather changes, as in the case of Ambarnath temple, can lead to environmental stress cracking in PVC coating. This is further accelerated by the presence of factories in the surrounding areas which leads to higher concentration of air pollutants. To overcome this, possible coatings were explored. Though PVC itself is a great coating material, something more inert would result in longer life. It is proposed to further coat the wires with DuPont™ Teflon® PTFE (polytetrafluoroethylene) as it is seen to be a resin offers highest thermal stability, stress crack resistance, flex life, and clarity of all grades [10].

Design Brief:

The main cause behind the project was to keep in check the insensitive approach in which temples across the country are lit up.

- The proposed lighting system should not compete with but complement the purpose and décor of the temple
- The wiring and fixtures should be unobtrusive and minimalistic
- The lighting systems should primarily accomplish basic task lighting and then secondarily show case the interiors of the temple
- Also, care should be taken that the traditional way of lighting is a spiritual endeavour in itself

All this has to be achieved within the Indian cultural context, keeping in mind international standards of heritage conservation.

"Temples are in themselves special structures. No detail that is seen on the temple is arbitrary or superfluous. Each has a definite place and is a part of the whole."
-Stella Kramrisch

5.Light

Lighting affects not only the space but also the psychological and behavioural patterns of users. The process for lighting designers follows the same basic phases used by all designers, going through programming and schematic design, through design development, etc. In the schematic design phase of the process, many lighting designers think in layers:
1. Visual task: providing enough light to recognize a flaw in black silk or to be able to walk safely through a corridor
2. General lighting or ambient lighting: to set a mood or impression and maybe the lighting that provides for safe circulation within the space
3. Visual interest: something that adds a touch of magic, or something to tickle the user's 'joy button'

For the sake of this project we settled upon providing basic task lighting. Dr. John Flynn developed criteria for evaluating the lighting of spaces. His work is considered seminal to this day. Flynn's conceptual framework used the following cues to determine the users' subjective response to the lighting of the space. Using a semantic deferential scale (using opposite terms to determine the subjects' attitudes or opinions along a continuum) and large numbers of subjects, he concluded that lighting could create a space that would make users say it was:
1. "pleasant" versus "unpleasant"
2. "public" versus "private"
3. "spacious" versus "confined"
4. "relaxed" versus "tense"
5. "visually clear" versus "hazy" [7]

However, research into these technologies showed they are in a nascent stage.

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Based on these checks, the following design brief was proposed.

Basic Task lighting

Enhancing the drama and ambience

Experience creation (light and sound shows)

Modern integrated temples

1. https://www.buildings.com/article-details/articleid/5609/title/temple-of-light.aspx
2. http://siliconindia.com:81/travelcity/images/special_images/Iu9O7E630egyAUC.jpeg
3. http://3.bp.blogspot.com/-EspJZKWdwNk/Tcb0xanx4tI/AAAAAAAACps/Diz9qA7Jao8/s1600/Night_Luxor_Entrance.JPG

LEDs: Since the lights selected for this project include LEDs, some discussion needs to be done in this direction.
A light-emitting diode (LED) is a semiconductor light source. When a light-emitting diode is switched on, electrons are able to recombine with holes within the device, releasing energy in the form of photons. This effect is called electroluminescence, and the colour of the light (corresponding to the energy of the photon) is determined by the energy band gap of the semiconductor.

An LED is often small in area (less than 1 mm), and integrated optical components may be used to shape its radiation pattern. LEDs have many advantages over incandescent light sources. These include:
1. Higher efficiency
2. Ability to produce almost any color
3. Small sizes
4. Quick on/off times
5. Easy dimming functions
6. Cool light (lesser IR radiations)
7. Longer lifetime
8. Shock resistance
9. Focussed lighting

However they come with their own set of limitations:
1. High initial price
2. Temperature dependence
3. Need for proper voltages and electrical polarity [8]

LED symbol
(http://4vector.com/i/free-vector-led-symbol-clip-art_116277_Led_Symbol_clip_art_hight.png)

LED on/off states
(http://en.wikipedia.org/wiki/File:On-state_off-state_white_LEDs.jpg)

6. Concepts and Demos

For the sake of lighting and lighting fixtures, three directions were considered.

1. The lamps or ‘diyas’:
Diyas have been lighting up temples since times immemorial. Over the period of time, they have evolved to have ornate features, abstraction of various forms and inspired by nature extensively. Sometimes as a flower, as a bird, as a throne and so on. Diyas are self sustained, having a concavity to hold oil with a vick that lights up. While, the diya illuminates the surroundings, it also highlights its on beauty. However in absence of a local, relevant artisan, Diyas are nowadays sourced from faraway locales and struggle to fit in a context that is itself crowded with its own language and design philosophy. The challenge during ideation was to incorporate diya as a modern light fixture with innovative use of LEDs, reflectors and newer abstractions.

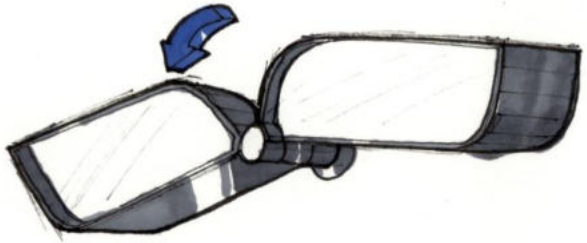
2. The deepstambh:
A deesptambh is a vertical structure in front of temples to hold lamps, specific mainly to Maharashtra. Its often faceted with numerous projections arranged to hold oil and wick to light up at nights. More than ambient lighting, the lighting upof a Deepstambh is considered auspicious and indicates festivities. Yet, its importance as a light source cannot be ignored. The vertical nature of a deepstambh in miniature form was emphasised to hold lights. Faceting was useful to include one face towards the walls for mounting. Further abstraction was considered to place lights along peripheries of a tapering vertical column, the column itself was also condensed to see possibilities.

3. Neutral Fixtures:
These included a host of geometrical explorations and free forms to incorporate LED lights and a reflectors. The other direction included exploring a central fixture for ambient lighting with a family of focused projector lights. Efforts were made to incorporate temple’s philosophy, for e.g. temple floor plans, temple motifs, etc. along with a conscious effort to remain neutral.

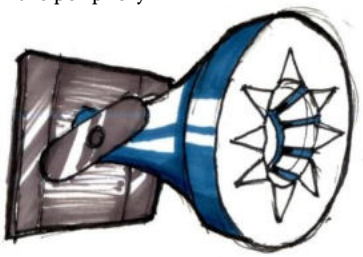
Ideation sketches for Traditional Diya:

Lotus inspired diya

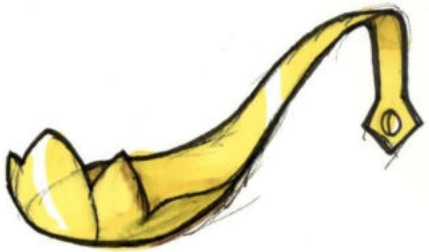
Ornate fixture inspired by a leaf, an oft repeated motif in temples

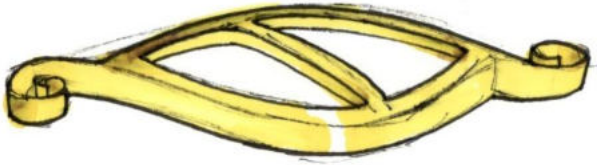


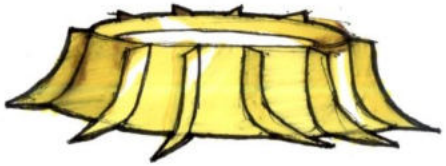
Diya inspired by a flower with LEDs embedded along the periphery



Some more ornate diya-like designs

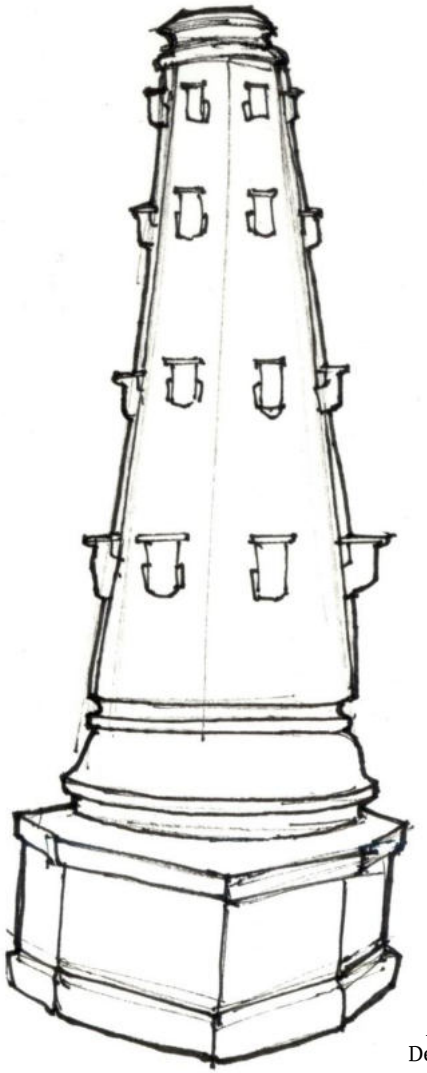




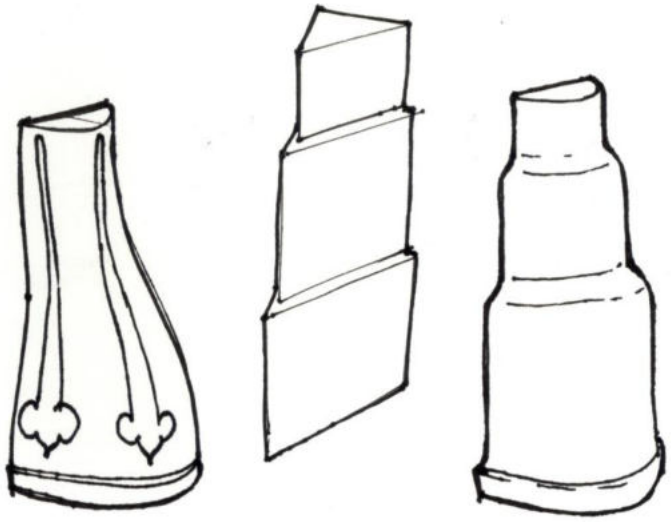


Diya inspired by a flower with cooling fins, a much sharper design

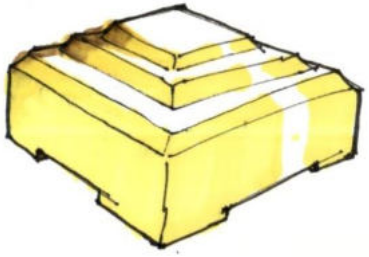
Ideation sketches for Deepstambh:



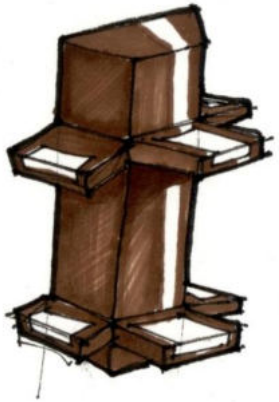
A typical Deepstambh



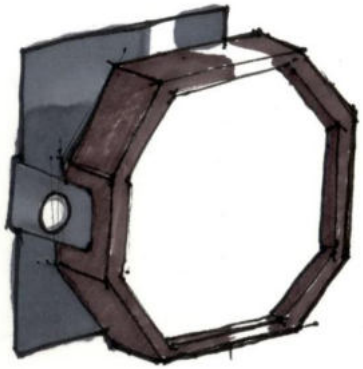
Deepstambh explorations



Condensed deepstambh form

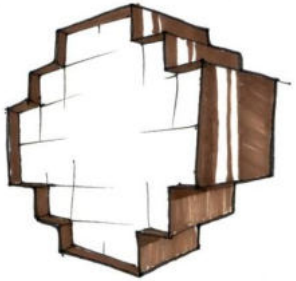


Multi-level lights
Inspired directly by
Deepstambh



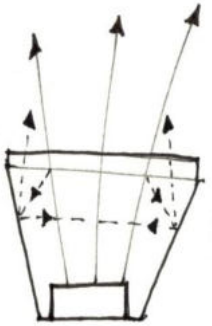
Octagonal fixture
inspired by
Deepstambh's base

Ideation sketches for Neutral Fixtures:

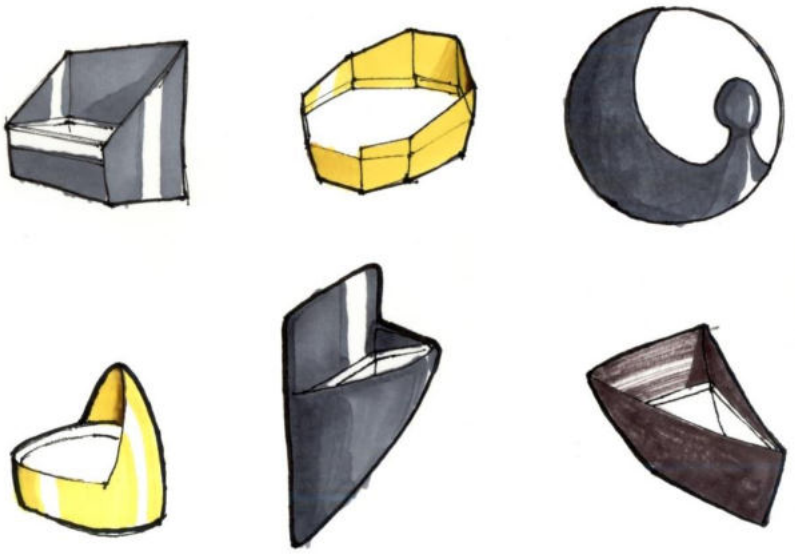


Fixture inspired by the floor plan of the temple

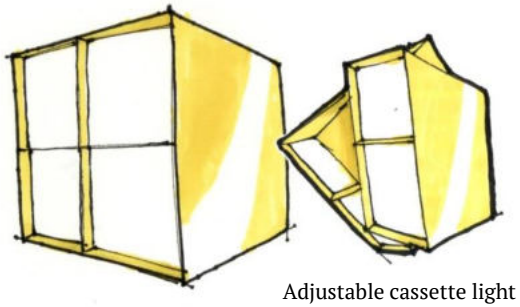
Light rail with adjustable angle for every individual light



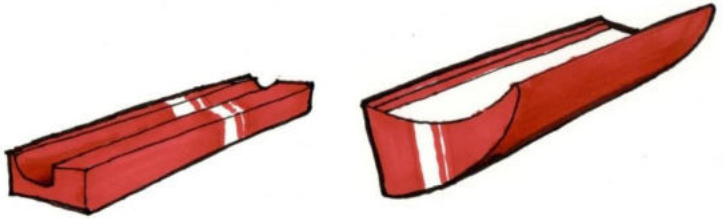
Special internal reflectors



Light fixtures with recessed a cavity and reflector hoods

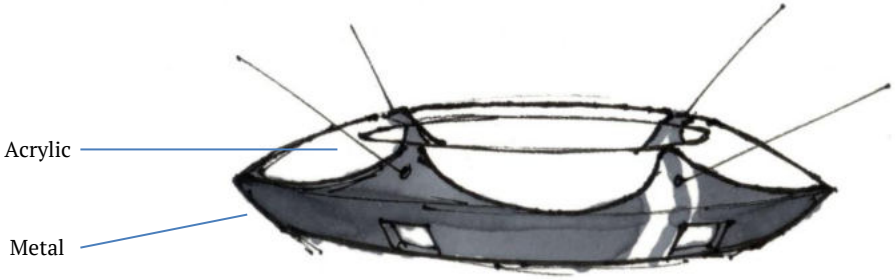


Adjustable cassette light

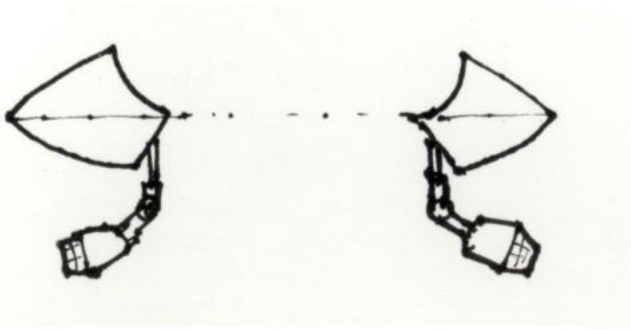


Strip Lights

Ideation sketches for Neutral Fixtures:



Ellipsoidal central fixture for ambient light with embedded focused lights at corners

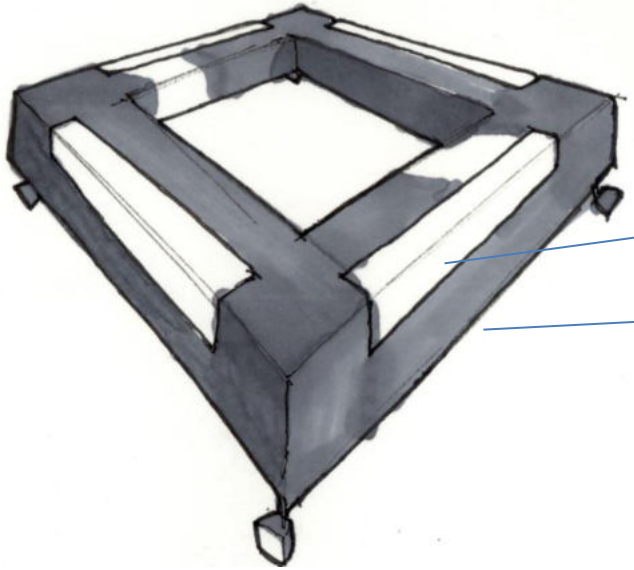


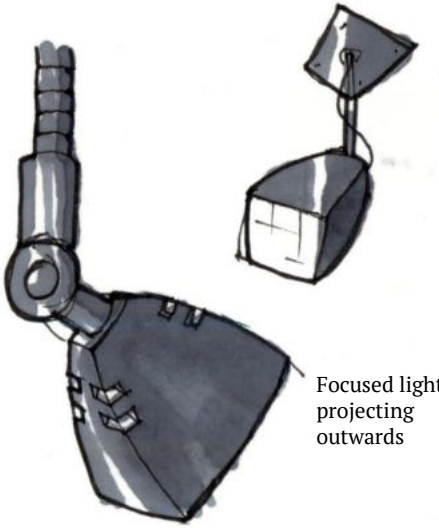
Focused lights projecting outwards

Focused lights recessed into the frame

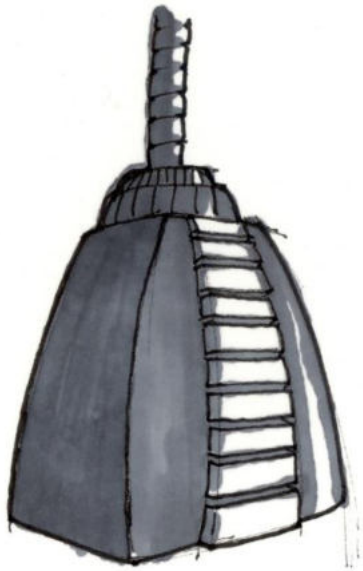
Ideation sketches for Neutral Fixtures:

Square central fixture for ambient light with focused lights at corners

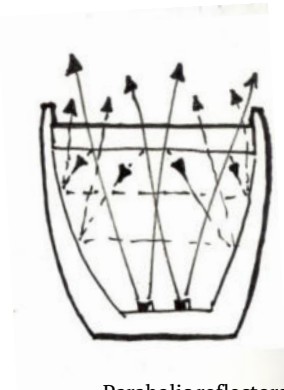




Focused lights projecting outwards

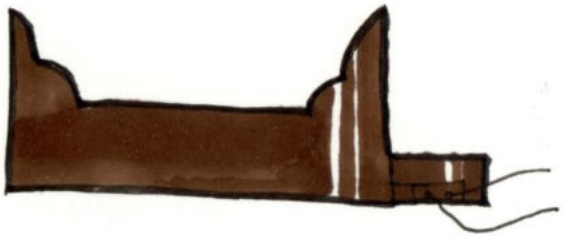


Fixture inspired by the Bhumija Shikhara of the temple



Parabolic reflectors for multiple internal reflections for better light output

Ideation sketches for Neutral Fixtures:



Track lights inspired by fort walls

Mounting on pillar

Trying to fit motifs within square grids

Details of motif

Concept evaluation:

Concept	Traditionalism (Weightage:30)	Minimalistic (Weightage:20)	Unobtrusive (Weightage:20)	Light Quality (Weightage:30)	Score
Diya	9 (27)	2 (4)	2 (4)	6 (18)	19 (53)
Deepstambh	7 (21)	3 (6)	3 (6)	6 (18)	18 (51)
Neutral Fixtures	2 (6)	7 (14)	7 (14)	7 (21)	23 (55)

Figures in Black indicate score out of 10
Figures in Red indicate weighted average scores

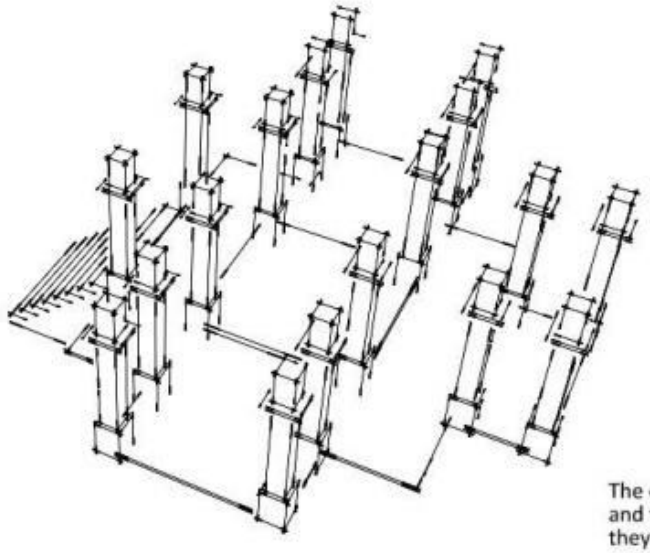
The designs for Diya are nowhere out of the place in the temple, but the design brief clearly states that impact has to be minimalistic. The product might become attention seeker in such case. Similarly with the Deepstambh, the concept is more suitable outside the temple. Hence neutral fixtures that score good on unobtrusiveness and minimalistic approach are suitable. They have to be improved upon in the sense of traditionalism. This can be done by addition of traditional elements, motifs, etc.

For the purpose of lighting the temple was split up into the following zones:

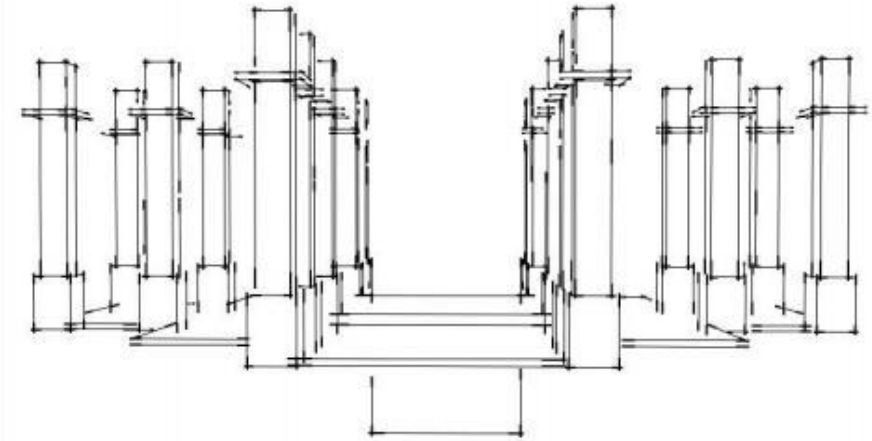
1. The entrance porches
2. The Sabhamandap
3. The Garbhagruha

Of these, the sabhamandap is in itself a special zone, with urgent need for attention. It is here that the bulk of the project would be implemented. This zone itself consists of two parts viz. the central raised altar and the rest of the space in the sabhagruha. The central altar is bound by four pillars (and the iron columns) and is topped by a richly carved trabeate dome. The rest of the space is occupied by 14 pillars, many of which are not in a good shape. But the ceiling above them and the lintels are in a fairly better condition. The height of the pillars ranges from 10ft to 12ft with ceiling rising upto 14ft high. Hence it was also decided to split the zone vertically into three levels viz. the lower part (base), the central part (which houses the bulk of the sculptural reliefs) and the upper part (which holds the Ghatam and the Dharvaahakas).

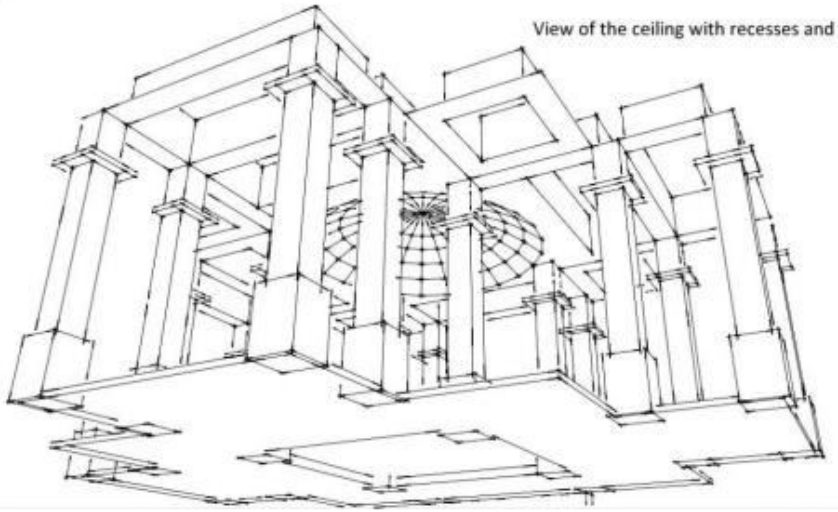
The Garbhagruha is a much more sacred place, as holy as a womb. It holds the manifestation of the God. Many temples usually avoid artificial light here, but Ambernath temple has a well-lit Garbhagruha. Any intervention here would require double the amount of forethought as put into the rest of the temple.



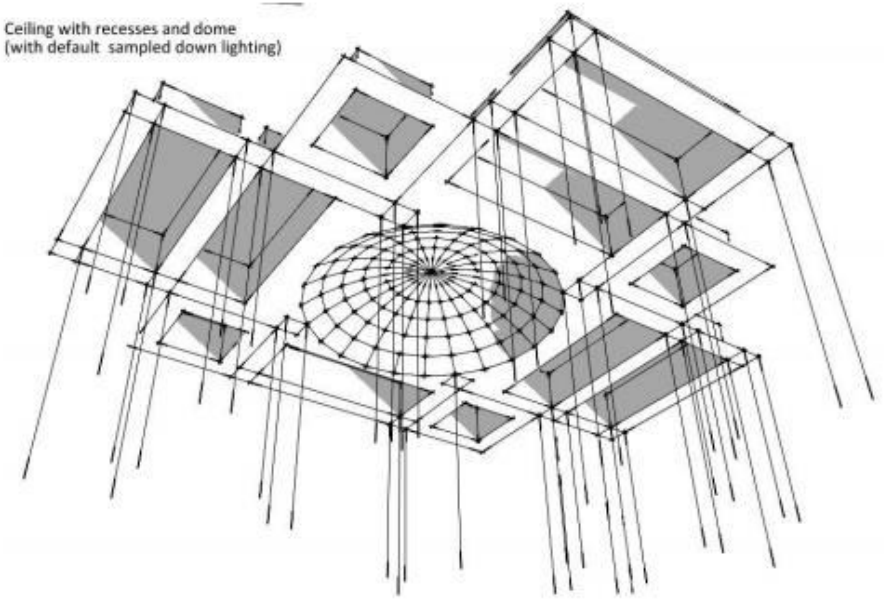
The cluster of 18 pillars and the scope of space they provide for lighting



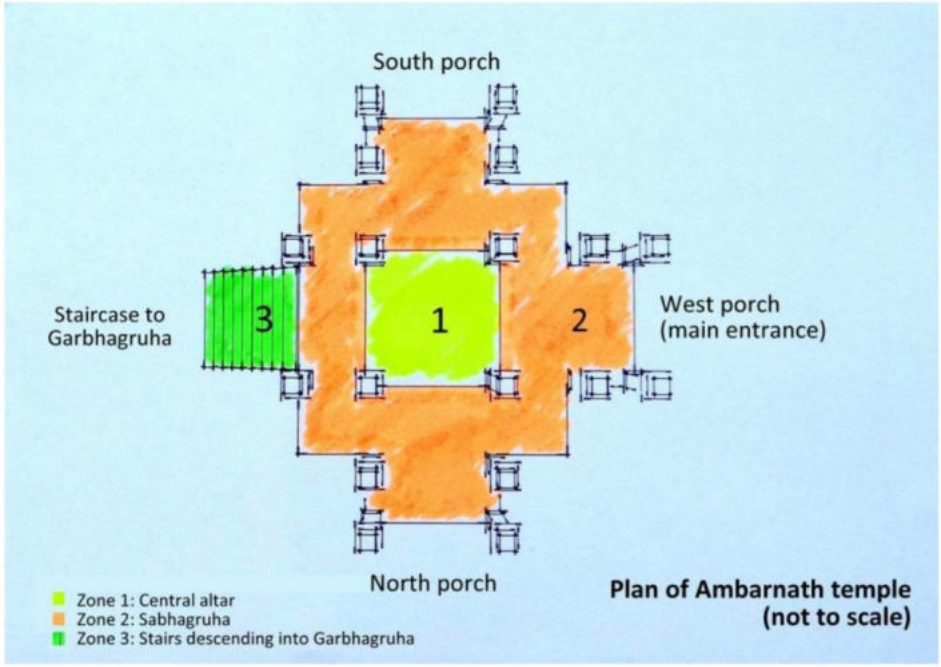
Typical view on entry from the west porch

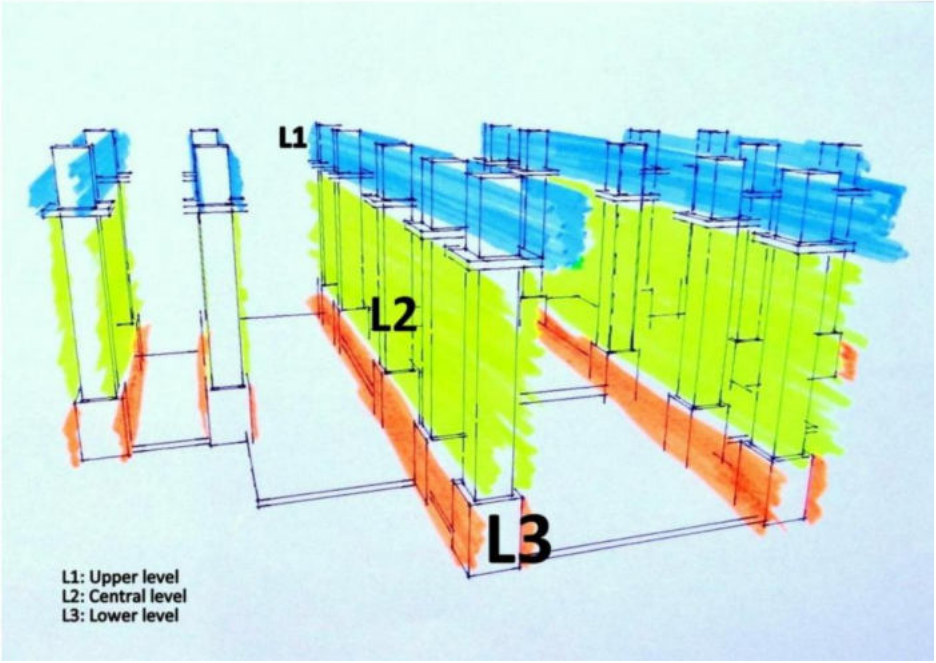


View of the ceiling with recesses and the dome

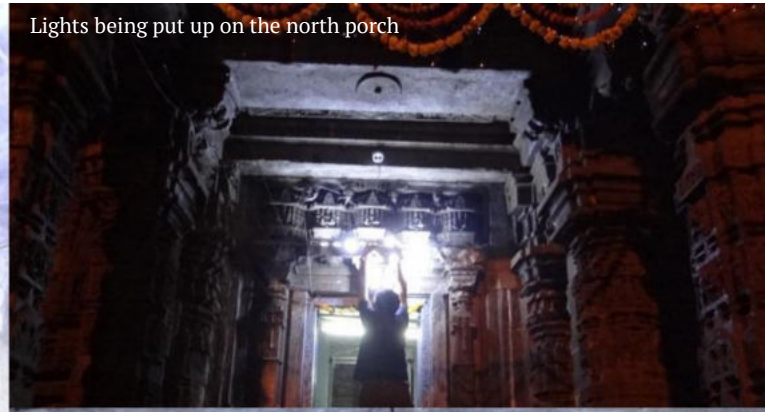


Ceiling with recesses and dome
(with default sampled down lighting)


South porch
Staircase to Garbhagruha
3
1
2
West porch (main entrance)
North porch
Zone 1: Central altar
Zone 2: Sabhagruha
Zone 3: Stairs descending into Garbhagruha
Plan of Ambarnath temple (not to scale)


L1
L2
L3
L1: Upper level
L2: Central level
L3: Lower level

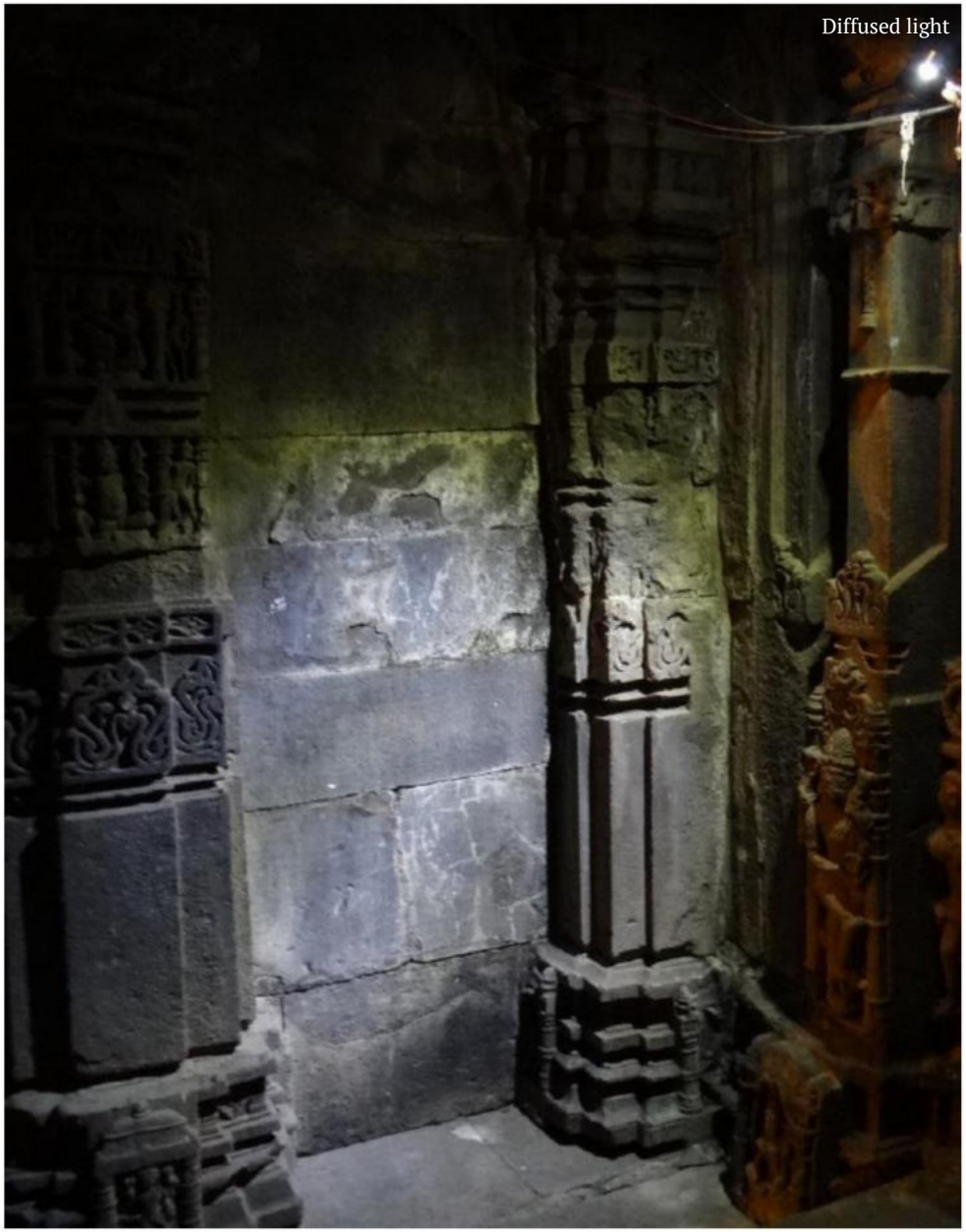
North porch lit up

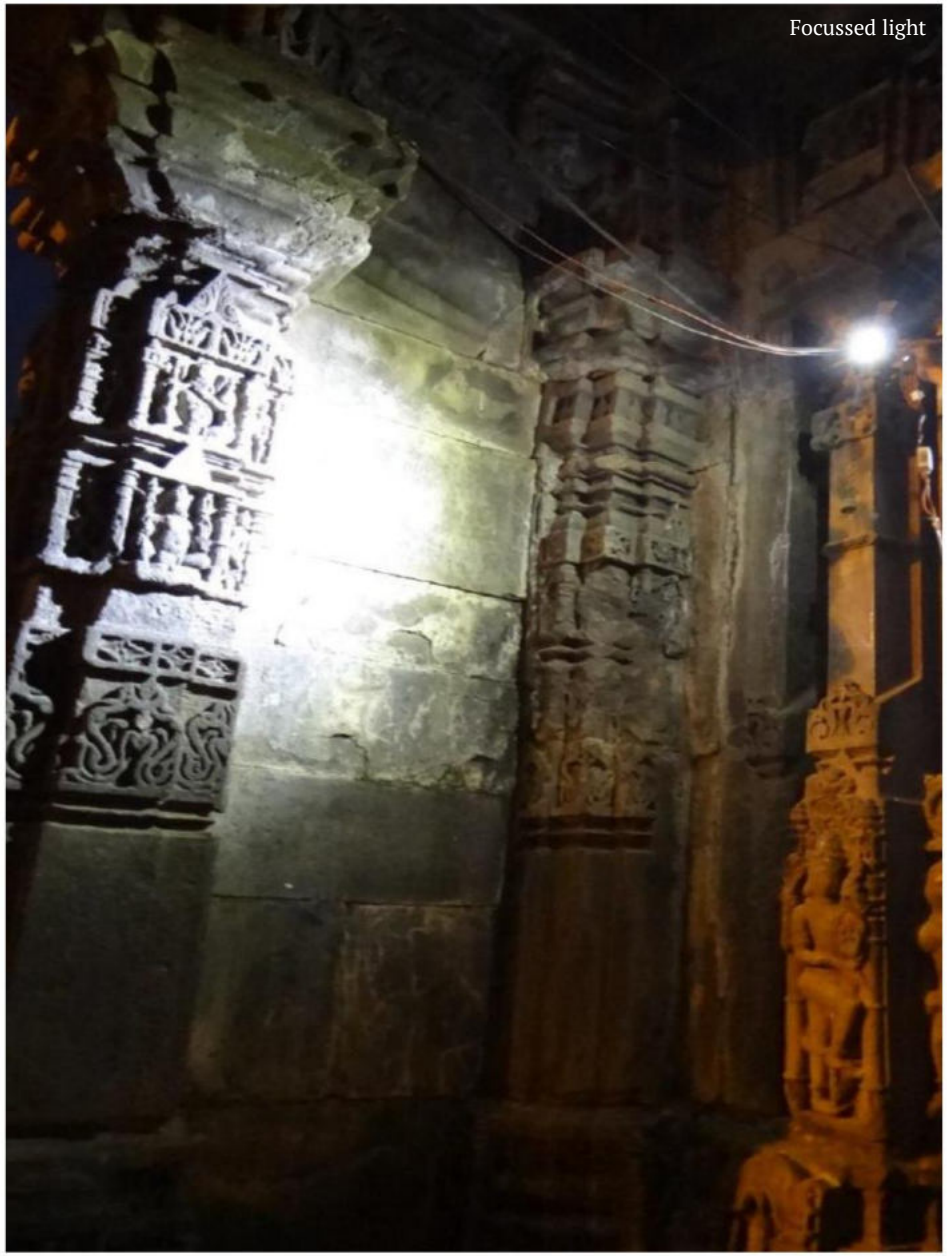


Lights being put up on the north porch

North porch entrance lintel lit up

Diffused lighting demos on-site:
To understand effects of lighting, sample lights were taken to the site and tested. The light was cold white light and focussed. The light was found to be colder and brighter than expected. Also, the shadows were found to obscure most figures in the far regions, while the illumination was ok in the middle region and excessively bright in the immediate region. But the need for lighting was completely justified by this demo.

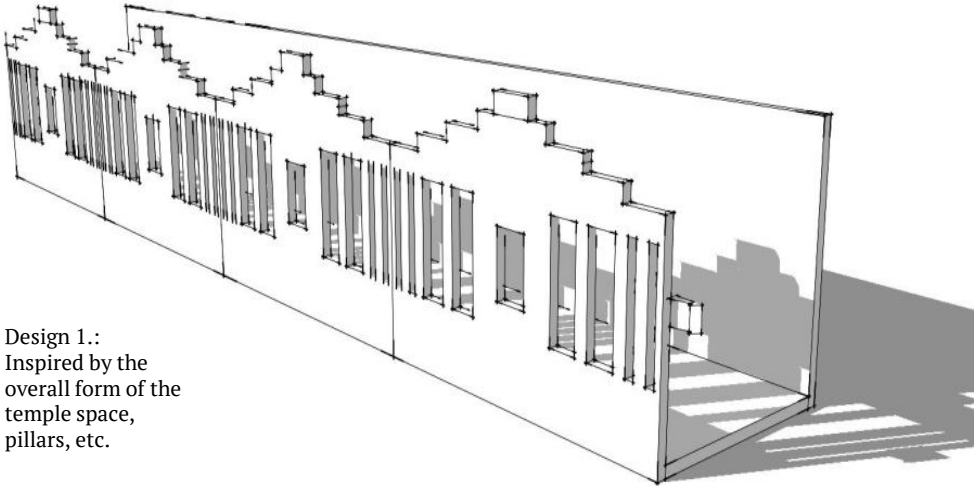

Diffused light


Focussed light

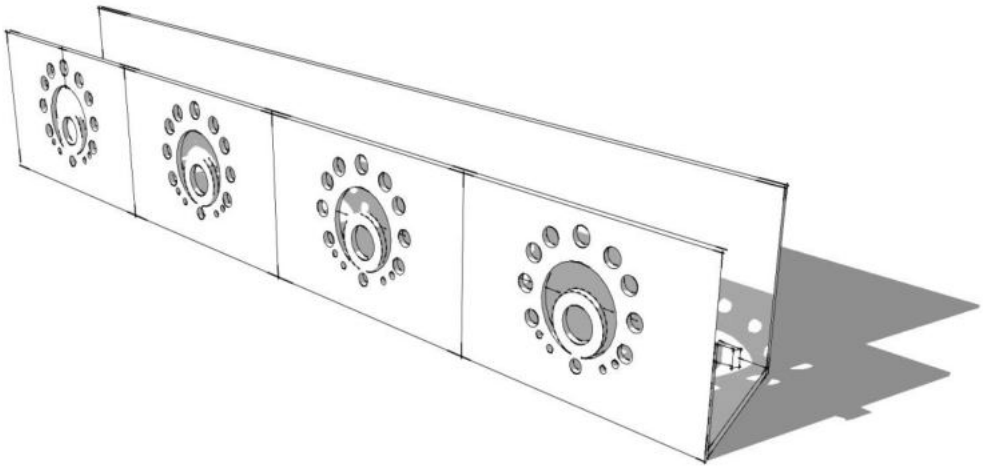
7. Final Concept, Crafting and Connection

The final concept drew inspiration from ‘merlons and crenels on ancient wall boundaries. The form is a track like light holder with LEDs embedded on the strip. The front face helps in preventing direct lighting and diffuses it beautifully with the help of cut-patterns and designs, inspired by the temple motifs. The modules are of certain length, thus ensuring repeatability and adaptability over any dimension of wall.

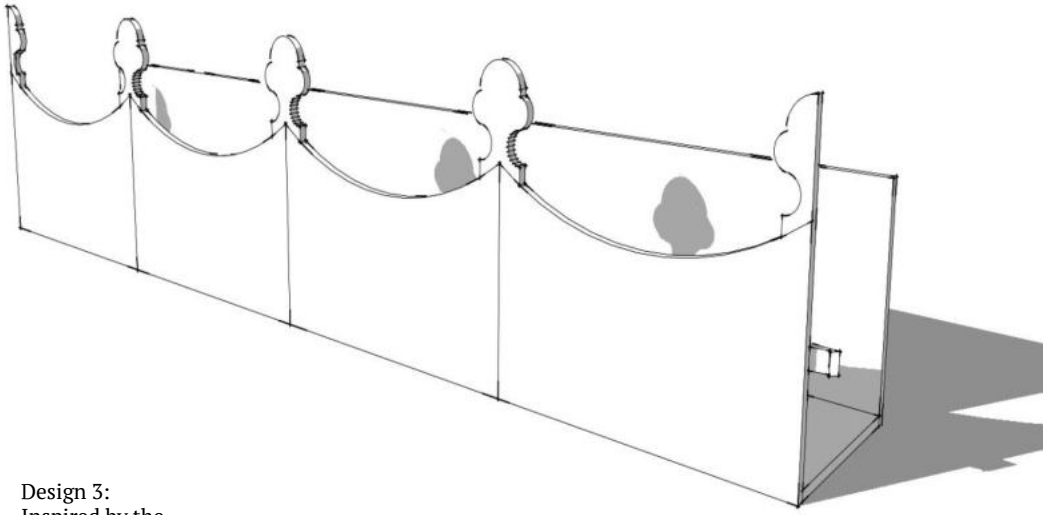
Fortifications on Malhargad



Design 1.:
Inspired by the overall form of the temple space, pillars, etc.

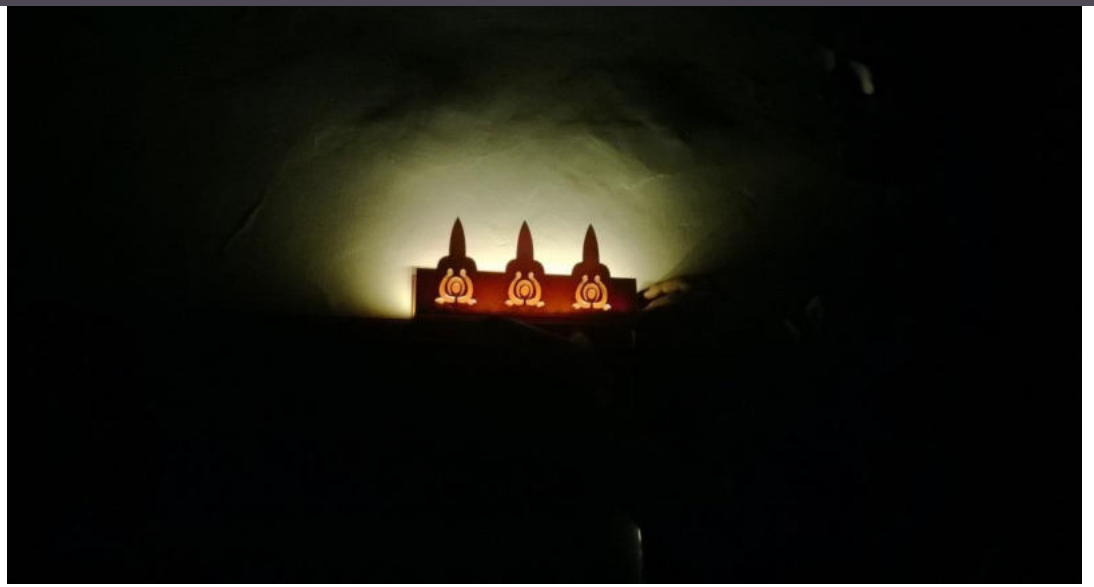


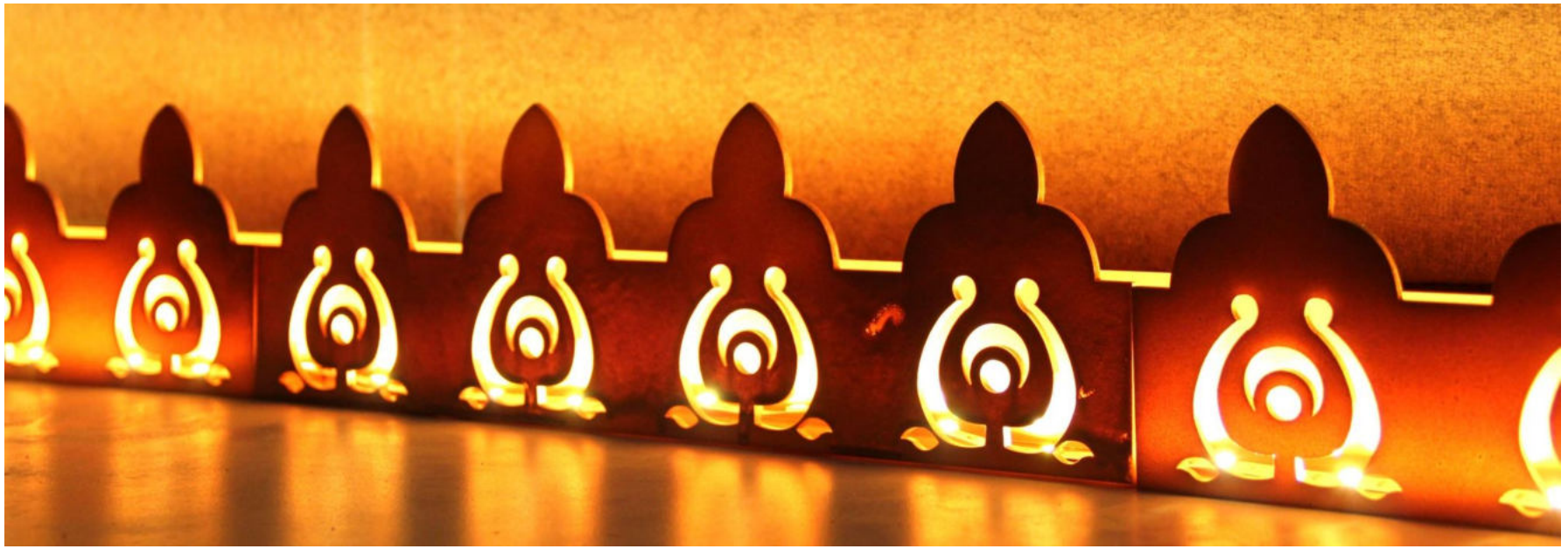
Design 2:
Inspired by the 'gavaksha' and the 'shuknishas'



Design 3:
Inspired by the projections on the dome interiors

Final concept:
Inspired by the Gavakshas on the temple, along with the motif of a mango leaf inscribed. The design serves as a coninuous lighting to be mounted along the periphery. A separate heat sink is not required. The open metal design itself serves the function of dissipating heat. Also, since it is in close contact with the stone walls of the temple, further cooling down is possible.



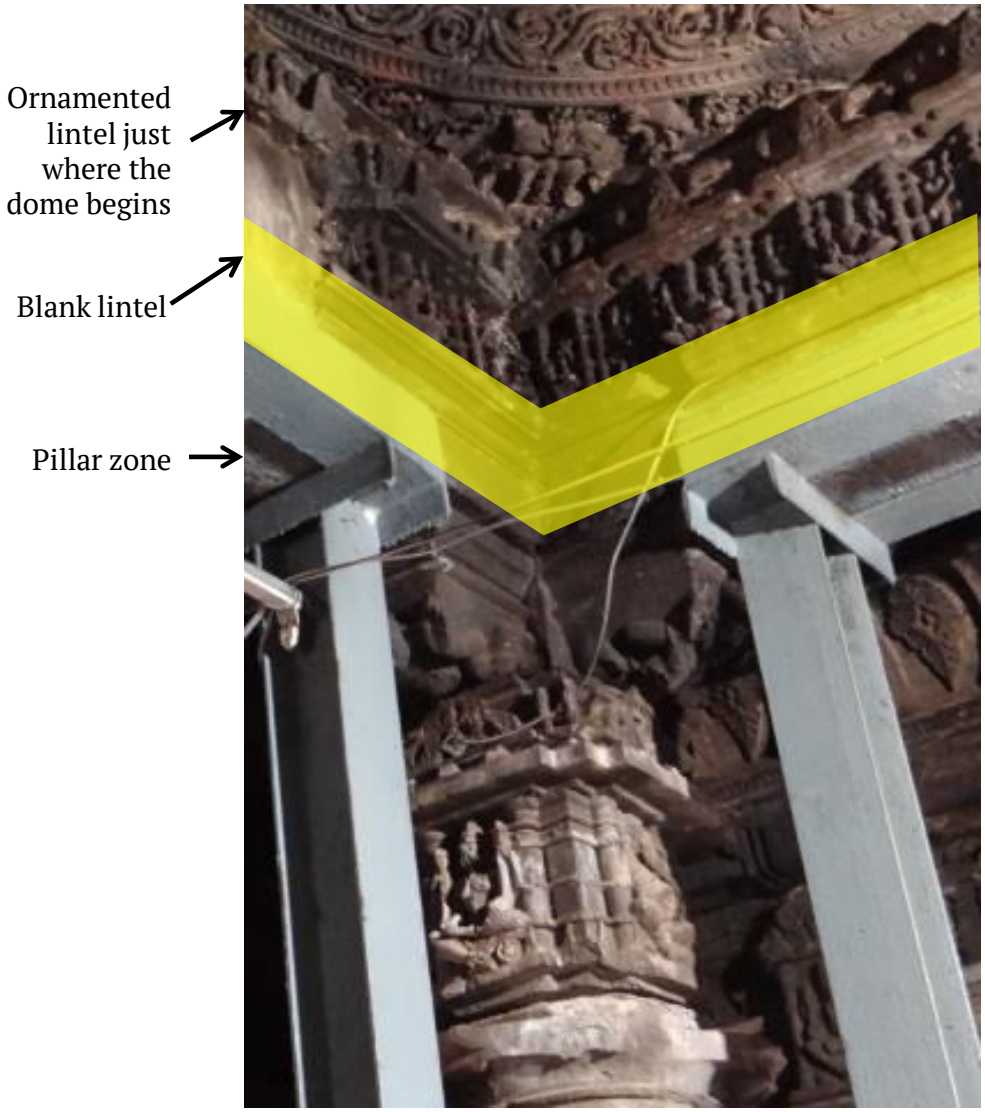


Details of lighting:
For the central altar, a blank lintel runs all along. The same blank lintel can also be found bordering the main interior wall. This level can used for mounting the lights.

Pillar height:
Zone 1- 3m
Zone 2-2.5m

Dome height: 5m

Height of installation: between 2.5-3m



Pilot study:
As a part of project, demo lights were manufactured by VinLED. The specifications were as follows:

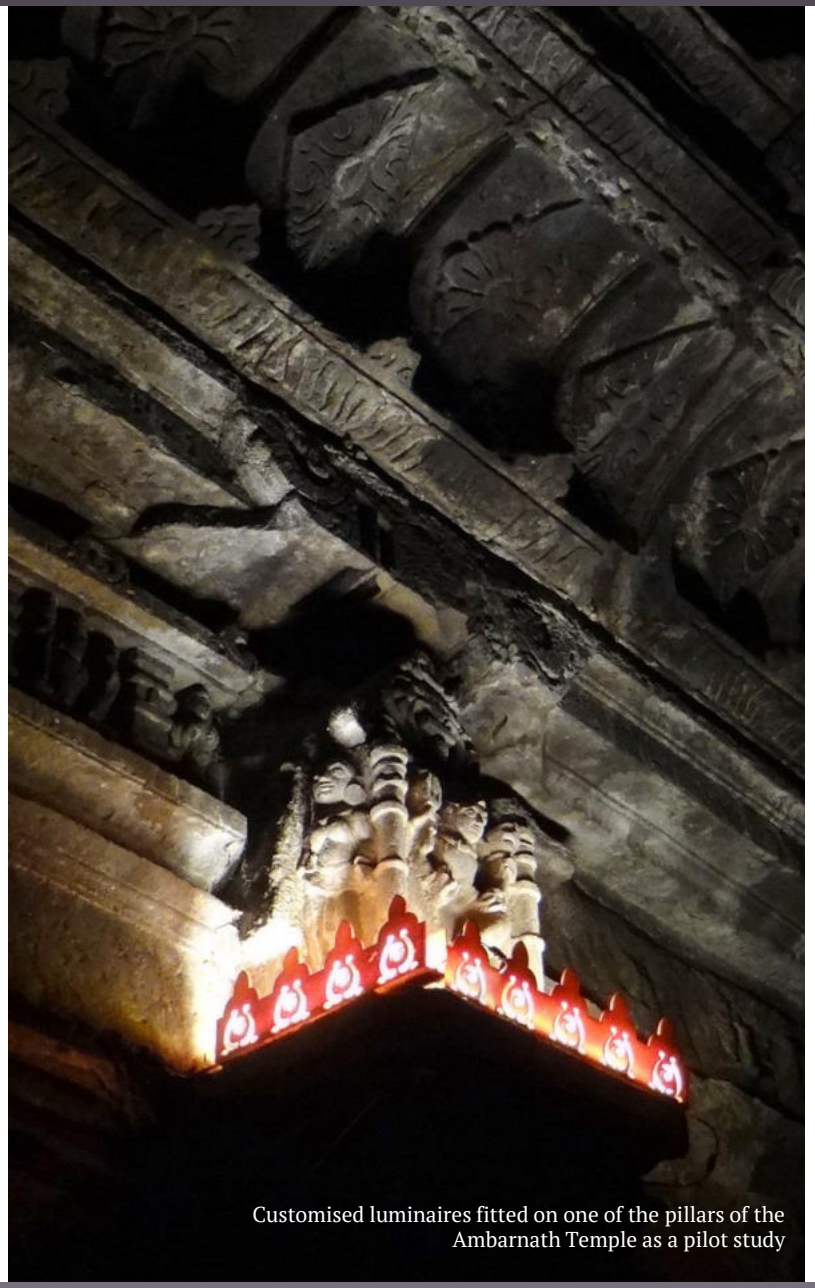
- 18 W total power consumption
- 7 lumens per LED
- 180 LEDs
- 25mA per LED

The lights were installed on-site in the Ambarnath temple on a cornice in the north-eastern corner of the temple.. Care was taken to provide enough warm light to light up the areas with just the right amount of lumens to ensure efficient illumination.

The amount of light was found to be enough to light up a single section. However, it was found to enhance the drama of the sculptures a tiny bit more than expected. This was bound to happen due to the up-lighting selected.

Also, it was gauged that the lighting along the periphery of interior wall would provide less than enough ambient lighting. It is better to come up with a family of luminaires for the temple, each for a different zone. Because each zone has special needs.

The sabhagruha can be lit along the periphery to highlight the décor along the edges. The central altar requires more of a bright ambient light that spills over into other zones as well. It is the hub of devotees' attention and can help give a sense of orientation.



Customised luminaires fitted on one of the pillars of the Ambarnath Temple as a pilot study

During, the demos, the LED housing was found to be visually more louder than expected. The product almost seemed to compete with the décor. Hence it was scaled down a bit for further iterations, in which it was crafted in copper.

Crafting details:

- Copper sheet details: 22mil (anything above 10 mil) gauge 16 ounce sheet
- Could utilise synergy of small scale copper workshops located across the country
- Tie-up with LED manufacturers
- Adjustable length of modules as per site

For the fabrication, the design was scaled down considerably, gauging the visual impact observed from the on-site installation.

Cutpieces (backside)

Cutpieces (front)

Design and Degree Show 2014:

In order to display the project effectively to the visitors, a scale model of the Ambernath Temple was made. The demo lights and the copper housings were also displayed.

The scale model attracted a number of questions from the visitors, regarding how to visit it and what to see. The cause of the project appealed to a lot of people.

Lights on display at Design and Degree Show 2014
along with scale model of Ambernath Temple

8. The Final product

The final product has the following components to be paid attention to:

Housing for lights:
For the demo purposes, the housing was made of laser cut acrylic pieces. These are helpful to gauge how designs and motifs look in final model, and are quite easy to test for a wide range if iterations. Further, these plastic cut pieces are easy to carry around and on-site demos.
The final housing is proposed to be made of copper. These were fabricated by water-jet cutting methods. Copper sheets are available in range of thicknesses. These can be sourced from anywhere in Kumbharwada.
For the first iteration, the housing was fairly large. When tested on-site, it was found to be have considerable visual impact. This was then scaled down for the next iteration.

LEDs:
For the sake of lighting we fabricated a custom made LED strip from VinLED, Bhandup. The LEDs in each module were laid out in two rows of 30 LEDs each of 7lumens. The color of light was warm white approx. 2500K.
This warm light was found to be suitable for illumination. The light was found to illuminate the décor adequately along the periphery i.e. in Zone 2. But for the purpose of ambient lighting, more lights would be needed. Proposed lighting for each zone include:

1. Bright ambient lighting for central altar
2. Lights along central pillars
3. Peripheral uplighting along interior walls

Wiring and switchboard:
A typical temple as the one at Ambernath, is fully equipped with modern power sources. Just they have ben brought inside the sacred premise without any thought. Wiring can be routed through crevices between the bricks and conveniently use corners, vertices to jump between zones. Flat wires encased in black outer sheath are preferred for hiding the wires layout.
Finally all these wires come together at a switchboard. In the Ambernath temple, the switchboard is near the northern porch, the closest entrance to external power lines. Since the temple is prone to leakages and constant presence of moisture, the switchboard has to be airtight. The layout of switches on it could clearly relate to the zones. Further, it would be preferable if a gradual illuminating effect could be achieved while switching the lights on.

Adhesives:
Another important point of the system is to achieve non-invasive mounting of the fixtures and wiring systems This can be achieved by using high end adhesive tapes from 3M and other suppliers. Stone accepts 3M tapes best after coating with a suitable primer, in this case 3M™ Silane Glass Treatment AP 115 or 3M™ Primer 94 similar silane coupling agent in isopropyl alcohol IPA/water mixture as suggested by 3M manuals.

9. Appendix 1

1. Heritage site lighting: from conservation to expression

Architects Didier Repellin and Simone Ricca

In 1903 Alois Riegl's* seminal work on monuments firmly established the concept of conservation. However, the debate about the exact nature of conservation still continues more than a century later. Should conservation stop at physical upkeep, or is it a form of expression that must be preserved in the cultural memory? Heritage site lighting design is, of course, at the center of this debate.

Between conservation and creation:
Each year, the French Ministry of Culture issues an average of 450 decrees protecting heritage sites. The country's list of protected historical monuments is more than 43,000 long. While old monuments dictate the conditions for their own conservation, the concept of heritage is not time-bound, and extends beyond the issue of conservation. "New York's 6th Avenue will be a heritage site someday, because it has something to teach us," said Didier Repellin, lead architect for France's Office of Historical Monuments. "In France, we tend to look at conservation and creation as two separate issues—but cities are constantly shifting. First, because some urban architecture is not designed to last; and second, because creation is not the result of following some recipe, it stems from talent and the ability to effect change." Therefore, cities must be considered in all of their dimensions, beyond what traditional heritage buildings spur us to turn into museums. As an example, the UNESCO World Heritage Site application procedure addresses creation and change, beyond traditional heritage buildings. Conservation can thus be understood to include a dynamic component.

Simone Ricca, an architect and consultant who often works with cities applying to be listed as UNESCO World Heritage Sites, noticed a shift in the philosophy underlying the selection process in the mid-1990s, when UNESCO began looking more closely at how World Heritage Sites are managed. "Today, a city can also get listed because it has a solid, sustainable management and conservation program. Cities need to have a medium-term plan, especially one that includes a thorough examination of the impact of tourism," said Ricca. Of course, while being listed as a World Heritage Site does not guarantee economic returns for a city—and may even bear negative consequences—it is clear that international recognition for a country's heritage is symbolically very important, and often brings financial benefits.

This somewhat more nuanced definition of heritage conservation determines how lighting is used, whether to beautify and operate a site, to preserve its contribution to human genius, or somewhere in between. For lighting designers, heritage sites pose the technical challenge of accounting for the site's scientific and cultural aspects. They also require that designers demonstrate a keen sensibility with regard to the site, and communicate that sensibility to observers. Heritage sites are more than just physical forms; they embody timeless ideas and concepts.

Taking the artifice out of heritage lighting design:
From a conservation standpoint, artificial lighting has little or no impact on heritage sites. Furthermore, lighting is reversible—it can simply be removed. The main issue surrounding heritage site lighting is what it adds to the site's symbolic value, and, more prosaically, how it furthers the site manager's marketing objectives. "From this standpoint, much progress remains to be made, both technically and theoretically," said Ricca. "The risk is that heritage site lighting will become standardized, pedestrian. Engineers come to these projects with strong technical skills, but their approach is not necessarily anchored in the heritage site's context and often does not go far enough in terms of leveraging academic research." Dramatic lighting that puts too much of the focus on the object itself is less effective than subtler lighting that mimics the moon, for example. Engineers must also take into account architectural issues like ensuring that any necessary cabling does not require altering either the structures or the surrounding site.

Lighting technology is continuously improving, especially with the advent of LED lamps and new power supply systems. Light fixtures are also getting smaller and less intrusive. Future innovations must focus on how lighting can add meaning to heritage sites. According to Repellin, "I am not a big fan of projecting images on heritage monuments. However, lighting can tell a monument's story. The 3D lighting effects at the Benedictine Abbey in Cluny, France, have been incredibly popular—and deservedly so. Not only is the result magical, but it is also educational. I am fully in favor of using lighting in this way." And Ricca agrees: "Heritage conservation has a cost, so you can't be too elitist about it. However, as today's technology allows you to do just about anything you can imagine, the main concern is not to go overboard. The challenge is to maintain a certain sensibility, and, of course, good taste."

One of the main problems is that lighting is often an afterthought. Depending on the available budget and skills, lighting designs are developed too late and not very intelligently. So there is a need to raise local politicians' awareness of the infinite lighting possibilities that exist, and to ensure strong communication and coordination between architects and lighting designers. All project stakeholders should be willing to make the leap together and rebuke conventional "sound-and-light" style lighting systems.

*Didier Repellin is the lead architect for France's Office of Historical Monuments. He coordinated the City of Lyon's bid to be listed as a UNESCO World Heritage Site. Simone Ricca is an architect and researcher. She is founder of consulting firm RC Heritage, which serves international organizations, foundations, and governments seeking to restore, conserve and develop their heritage sites.

*Alois Riegl was an Austrian art historian and author of *The Modern Cult of Monuments, its Character and Origin* (1903), a work considered by specialists to have founded modern thinking about heritage and the conservation of monuments.

10. Appendix 2

Case Studies
1. Rijksmuseum, Amsterdam, Netherlands

[http://www.lighting.philips.com/main/projects/rijksmuseum.wpd]

Challenge

The Rijksmuseum in Amsterdam, the Netherlands, is the national museum and home to master works of art from artists including Rembrandt, Vermeer and Van Gogh. It is one of the largest museums in the world, spanning 9,500 square meters and showcasing 7,500 works from the Middle Ages to the present. As part of a top-to-bottom renovation, the lighting was redesigned with an eye toward art preservation and achieving the quality of light that would best enhance the viewer experience. The goal was to mimic the color rendition of natural daylight throughout the museum, atrium, café and all other public spaces using LED lighting. It also became important, as Philips worked with the Rijksmuseum and other project partners, to optimize spotlights to bring out the unique features of each work of art – a task best accomplished using LED lighting.

Solution

Artwork in galleries has traditionally been lit using halogen lighting. However, halogens tend to be very good at rendering reds and yellows but less efficient at rendering blues and greens. Halogen light also tends to become redder upon dimming. LEDs do not suffer from these limitations.On the artwork, the LED solution from Philips Lumileds uses LUXEON S LEDs in warm white (3000K) with very high color rendering index (95) to bring out all colors of the spectrum – rendering the pinks, reds, ochres, yellows, greens and blues brilliantly. The LEDs emit uniform light that is safe for the artwork and meets international criteria for the conservation of art. Suspended light racks from the original museum were upgraded by interior designers Wilmotte & Associes in partnership with Philips, consultant Arup and engineering firm Bronnenberg. To achieve a minimalist design on the racks, the Philips StyllD fixture was customized using a magnetic mounting scheme with remotely-positioned driver. The light racks contain 3,800 StyllD fixtures with Fortimo LED Spotlight Module Tight Beam containing LUXEON S LEDs. Ceiling lighting was provided by approximately 1.8 kilometers of Philips Fortimo strip up-lighting, also positioned within the light racks. This approach allows seamless coherent lighting of the ceilings of varying heights in the galleries.

LED Advantages

One benefit to the combination of Philips Fortimo LED SLM Tight Beam and LUXEON S LEDs is the small light emitting surface (LES). Small LES allows a smaller optical reflector design, enabling very narrow beams, including 5˚ and 10˚ beams with high center-beam candlepower. In museum applications, a uniform and sharp beam pattern is possible with a crisp single-point-source shadow, which enhances the texture and sparkle of artifacts. To minimize glare from the light sources, an internal glare shield was developed for the StyllD fixture. When not directed at the artwork, the Rijksmuseum lighting mimics the color rendition of natural daylight (5000K). Additional benefits to the use of LED lighting over halogen include a typical lifetime that is 10X longer, significantly impacting maintenance costs, little heat generation and no ultraviolet radiation, which are known to damage artwork.

Control and Future-Proofing

The lighting control scheme was designed to enable museum staff to set lighting levels on individual works of art. The Philips' Dynalite DALI control system and webbased control interface were installed to provide flexibility in lighting including the dimming via a mobile application and iPad. Using DALI-controlled Xitanium drivers, practical dimming cut-off levels were set at 10%, which proved adequate for all but a few artifacts where neutral-density glass lenses were incorporated. The control system also addresses light output, which is constant, ensuring long-term lumen depreciation of the LEDs.Even given the long lifetime of LEDs, repair-ability and upgrade-ability must be considered. Philips designed for the future with Zhaga-compliant LED modules.

"At the heart of all the decisions we take are two aspects, the visitor's experience of the museum and the preservation of our art. We chose LED lighting for firstly, the high quality of the light emitted, and secondly the color rendering of LED lighting, which is very close to that of daylight. This allows the art to be viewed in the best light possible to bring out all the colors and details that the artist intended us to see."
–Tim Zeedijk
Head of Exhibitions, Rijksmuseum

PHILIPS
LUMILEDS

Case Studies
2. Santa Corona church, Vincenza, Italy

[http://www.lighting.philips.co.uk/subsites/oem/projects/case-study-santa-corona.wpd]

Background

Santa Corona is a medieval church located in Vicenza. It contains the Valmarana chapel (ca.1576), designed by the architect Andrea Palladio, who is, himself, buried in this church.

About the lighting system

The previous lighting system consisted mainly of halogen lamps and a few CDM lamps installed in the capitals. Many of these sources were perpetually out of order, creating gaps in the lighting. The costs of maintenance were extremely high and at the same time lighting maintenance was not easy. The accurate aiming of the spot lights, which is a key part of lighting designers' work everywhere in the world, was often not carried out when relamping took place. In Ninety percent of the time, staff would change the light source and then forget to repoint the fixture correctly.

The challenge

Mr Nereo Bianchi (President of Turn lights): "When it was completed in 2007, the project envisaged the installation of new lamps of the same type, as they were state of the art at that moment; however, the delays that are typical of the management of large public institutions allowed the introduction of a LED based solution. The main project objective of the Municipality of Vicenza was focused on reducing maintenance costs. With the fixtures installed up to 17 meters high, lighting maintenance was not easy. Relamping alone would become in all respects an extraordinary project. Also important was ensuring the absence of photobiological phenomena that could damage the artwork inside the church."

The solution

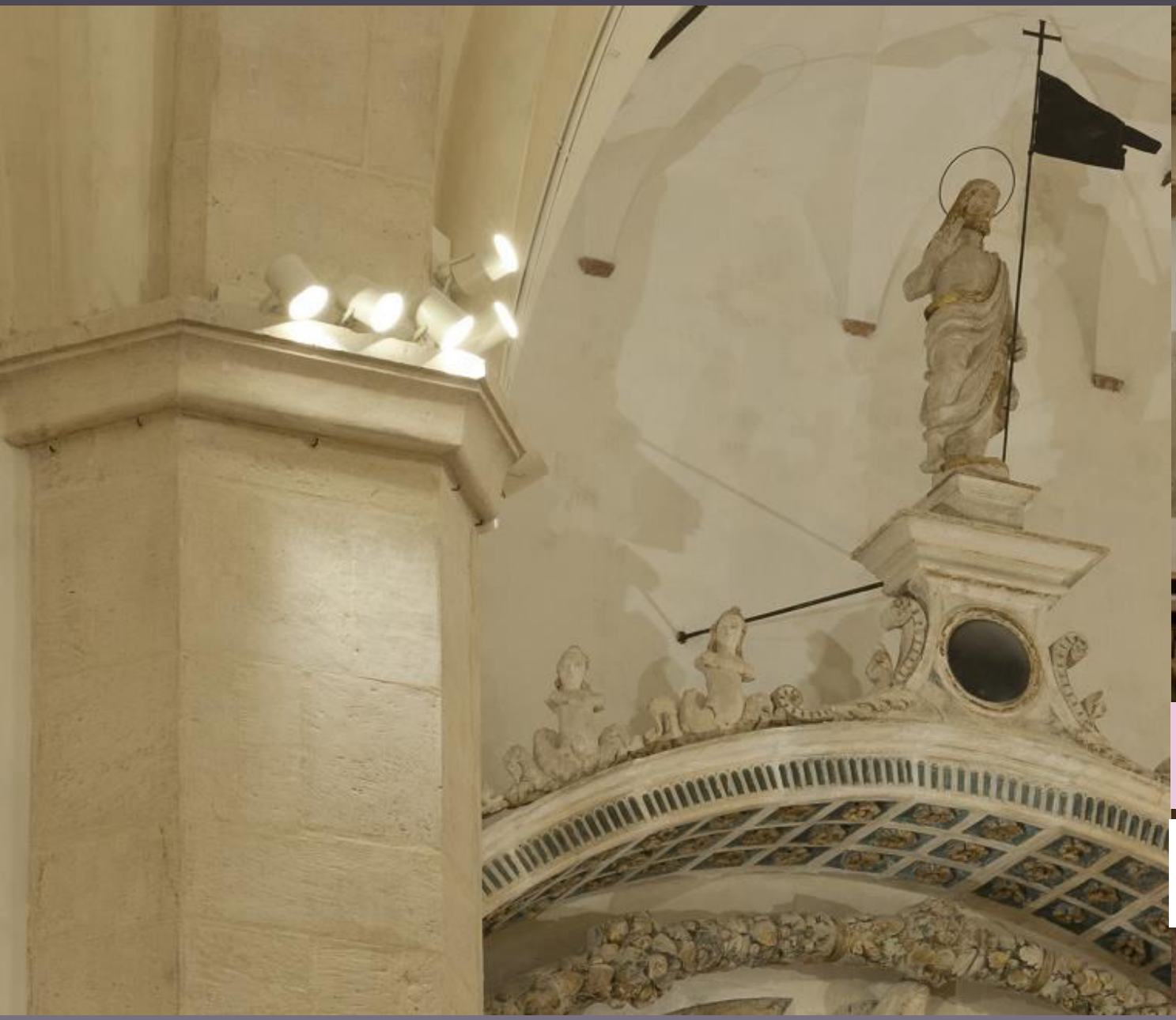
Mr. Bianchi: "Through the constant support of Philips we realised that we could achieve and guarantee a certain result with LED solutions. The Fortimo LED SLM was the best choice compared to optics with more controlled beams, which would have generated excessive shadow zones: though light colored, the church has a very low reflective index, and therefore the light is poorly diffused."

Mr. De Munari (Project supervisor): "The size and the amount of fixtures in a church is important. This solution with a limited number of compact fixtures ensures that there is no annoying, visual crowding of the space."

Benefits

Mr. Bianchi: "This solution provides us with a low energy consuming system (60% energy saving), since all light sources are very high performing and the optics are also highly efficient. We also have the outstanding benefit of many years without relamping. The lights are expected to have a service life of 50,000 hours. The lights are on for approximately 8 hours, 6-7 days a week, so we estimate a service life time of at least 14-15 years, which means zero maintenance costs for a very long time. We were also able to create three lighting design effects. The first,the so-called light for prayers, creates an atmosphere of concentration and deep respect. The second, almost the opposite of the first, draws out the artistic and architectural dimension of this space, which attracts a great number of people from all over the world. The third effect is a more general light setting for regular church services (e.g. the Sunday Mass). It evokes a brightly lit atmosphere for the community gatherings.

Mr Cesare de Munari (Project supervisor): "I was able to accept the proposal, because the characteristics it offered were essential: limited maintenance, no heat coming from the fixture and the possibility of installing smaller sized luminaires. The size and the amount of fixtures in a church is important. This solution with a limited number of compact fixtures makes sure that there is no annoying visual crowding of the space."



turnlights

PHILIPS
LUMILEDS

Case Studies
3. The World Heritage site of Quseir Amra, Jordan

[unesdoc.**unesco**.org/images/0015/001505/150594eo.pdf]

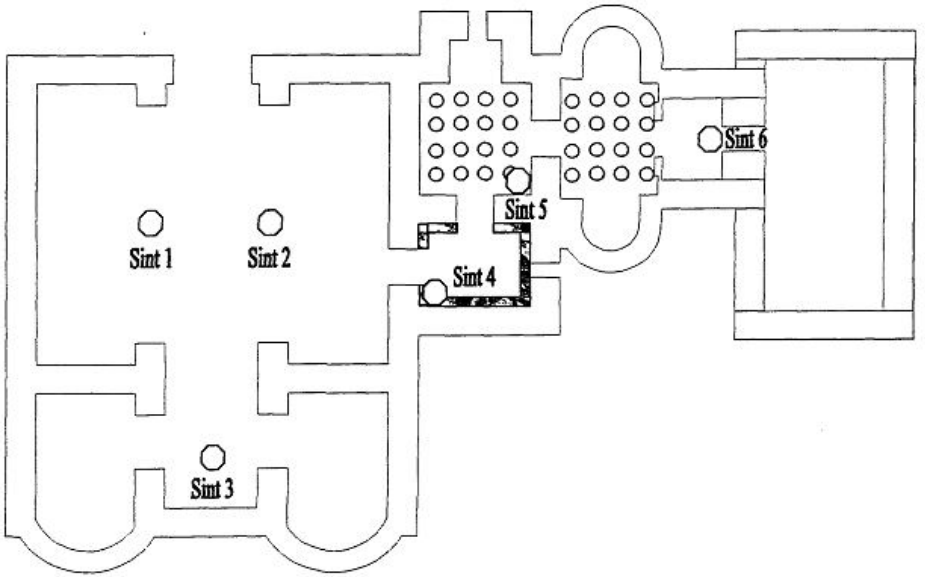
In April 2001, Mr.Jacques Montiuçon, expert consultant for UNESCO in the field of lighting of monuments and sites, carried out a preliminary mission to Jordan and visited two major sites of Jordan's cultural heritage, Quseir Amra and the castle of Ajlun. Further to this visit, the Ministry of Tourism and Antiquities requested UNESCO to undertake a feasibility study for the lighting of the World Heritage Site of Quseir Amra, through a self-benefiting Funds-in-Trust from the Government of the Hashemite Kingdom of Jordan (20,000US$) deposited within UNESCO .The objective of this project was to allow visitors high quality conditions for viewing the site and its paintings, both during the day and at night time.

Attached alongside are plans from the study that show the locations and types of lighting for the site.

Quseir Amra
[http://upload.wikimedia.org/wikipedia/commons/5/53/Qasr_Amra.jpg]

- **Inside the Monument:**

The recommended locations are represented on drawing 3



Drawing 3: Location of inside lighting sources

Inside lightening sources recommended characteristics:

- Lightening sources type: direct diffused light
- Lightening sources number: 6
- Position in the attached drawing 1: Sint1, Sint2, Sint6
- Diffusing surface profile: convex
- Diffusing surface area: less than 0.4m²
- Average lightening flux: 1200 lumens
- Luminance: 0.4 cd/cm²
- Colour temperature: 2950°K +/- 10%
- Spectrum: between 350nm and 750nm

Case Studies
4. The Chuson-ji Temple, Iwate, Japan

[http://www.toshiba.co.jp/about/press/2012_09/pr1201.htm]

Chuson-ji is the most famous of five sites making up the Hiraizumi World heritage Site, a complex of temples and gardens forming an earthly representation of the Buddhist Pure Land, or Nirvana. The temple, a Special Historic Site that dates back to the 12th century, is best known for the Konjikido, the Golden Hall, recognized as one of world's most beautiful and elaborately decorated buildings.
The philosophy of Chuson-ji is to live in peace and in harmony with nature, and the temple compound is renowned for its atmosphere of serenity and spirituality. Toshiba has respected this in its work at the temple and the lighting of the Golden Hall.

The photovoltaic system has a 5kW output capacity that feeds into the temple power supply, and more than compensates for power consumed by the LED lighting. The system is built on the roof of the souvenir shop near the Golden Hall, with no visible impact on the temple's scenic beauty, and respects the philosophy of Chuson-ji by delivering natural, renewable energy. Even more care has been taken with the lighting of the Golden Hall, in respect of its historic and cultural importance.

A wooden building entirely covered in maki-bashira gold leaf, supported by pillars intricately decorated with mother of pearl and maki-e lacquer in gold and silver, the Golden Hall houses three altars. Each is adorned with statues representing a seated Amida Buddha, surrounded by other standing bodhisattva: Kannon and Seishi, six Jizo and two Niten (though one Niten is missing). The Golden Hall is now protected from the elements by a concrete outer structure, the Shin-Oido.

Golden Hall, Chuson-ji Temple
[http://www.toshiba.co.jp/about/press/2012_09/pr1201.htm]

Lighting engineers from Toshiba Group companies carried out on-site investigation and extensive simulations to support the design and development of non-intrusive fixtures and lighting that not only provides interior and exterior illumination but a warmth and brilliance that renders lively, natural colors free of glare. The lighting is designed to complement the decoration and the artefacts, not to compete with them, and to make it seem as if the light originates within the objects, not outside them.

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