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Tabo Monastery (996 CE) A Vernacular Architecture of Lahaul and Spiti Region of Himachal Pradesh, India: A Preliminary Investigation of Deterioration and Conservation of Murals of gSer-Khang Gumpha

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ABSTRACT

Tabo monastery of 996 CE, an example of vernacular architecture of the Lahaul and Spiti region of Himachal Pradesh, is one of the most significant examples of world cultural heritage, being not only a globally significant Buddhist site but also the oldest earthen building in India. Cultural heritage acts as a mirror of human civilization, culture, history, and development. This monastery has its own identity, which tells the story of its glorious past; the structures of the monastery are the most authentic example of the use of earthen raw materials and indigenous architectural features. The major creative forces for these structures are rooted in the local needs and traditions, which have evolved slowly over time. The mural paintings of the monastery, which are deteriorating due to natural and human induced activities, depict Buddhist Indian History. The main aim of this study is to determine the causes of this deterioration, and identify conservation measures that can be undertaken to protect the mural paintings. In fact, remarkable conservation works are already being conducted by Archaeological Survey of India, which is laudable. However, the investigation of the monastery's structural features, techniques used in mural execution, and the relevant climatic conditions of the region, with identification of causes of deterioration can be used to develop a more effective and sustainable conservation approach for preservation of these murals in the future.

Keywords: monastery, mural, tabo, deterioration, conservation

INTRODUCTION

The Tabo monastery, an example of vernacular architecture of the Lahaul and Spiti region of Himachal Pradesh, is the oldest existing mud building in India, and one of the most important monasteries in the entire Tibetan Buddhist world (Danal & Sharma, 2017). The major creative force behind this architecture was rooted in the local needs and construction materials, which reflect the long local tradition that is called Vernacular architecture. This architecture evolved slowly over time and reflects traditional knowledge as well as the environmental, historical, cultural, technological, and economic contexts in which the vernacular architecture exists, and it varies from region to region, depending upon the climatic factors and the availability of local materials (Lathiya, 2017). Thus, vernacular architecture comprises a tangible part of the heritage of a region. The concept of sustainability in architecture relates to understanding and analysis of a built structure along with related human activities and the surrounding environment. The architecture of Tabo monastery enacts the core of sustainability by naturally providing human comfort (as it was built in response to the local climate), the cultural beliefs of the people (not just at an individual level, but also at the settlement and regional levels), and tackling the natural geographic conditions and environmental resources by using local materials and indigenous practices (Dayaratne, 2018).

Tabo monastery is popularly known as Ajanta of the Himalayas and was founded more than a millennium back by 'Rin- Chen-b-Zang-po' in 996 CE (Gupta et al., 2020; Klimburg-Salter, 1996). The Tabo Monastery is located on desolate, flat ground with an area of approximately 6300 square meters, enclosed by a boundary wall built with sun-dried mud brick, and is one of the most authentic examples of the use of earthen raw materials and architectural features of the human past. This monastery complex has nine temples (gumpha), and possesses a priceless collection of manuscripts and thangkas (Buddhist scroll paintings), exquisite statues in stucco, and murals depicting tales from the Mahayana Buddhist Pantheon (Thakur, 2003; Wong, 2007). Every square inch of the gumpha walls is covered with mural paintings. Unfortunately, the mural paintings of these gumphas have deteriorated badly, not only due to the vagaries of time and the phenomenon of natural aging, but also due to natural and anthropogenic factors. At present, the situation has reached a critical stage.

A mural is a large painting, usually drawn or painted on a wall, that represents the cultural expression of human creativity (International Council on Monuments and Sites[ICOMOS], 1965). Mural paintings form an essential part of the world's cultural heritage, and, thus, their conservation is important. In the 'Venice Charter', wall paintings and decorations are highlighted as integral parts of monuments that must be safeguarded (ICOMOS, 1999). Mural paintings can be classified as 'fresco' or 'secco', according to the application process used in their creation. A painting executed on wet renderings in which pigments were fixed by the carbonization of lime from the rendering is called fresco, while paintings executed on dry surfaces in which pigments were fixed by binding media are called secco. Moreover, secco paintings can vary according to the binding medium used. If the binder medium is vegetable or animal glue, it is called 'tempera', while, if the binder is vegetable oil, it is called 'oil painting' (Mora et al., 1984).

In addition to any architectural defects of carrier walls and anthropogenic factors, mural paintings are extremely sensitive to the impact of environmental parameters (rain, snow, wind, and direct solar irradiation), as well as changes in the micro-climate (Becherini et al., 2010). There are many possible causes (natural and anthropogenic) of the deterioration of mural paintings, and several of these commonly promote the action of others. It is, therefore, necessary to give prominence to such causes, which may be regarded as fundamental, because in their absence, the secondary causes lose much of their significance (Mora, 1974). Changes in relative humidity and temperature play a key role in the activation of cracks, flaking, peeling, chipping of pigment layers, and salt action due to the porous nature of the carrier wall. Salts can crystallize on the artwork surface or subsurface, resulting in efflorescence or sub-efflorescence, which causes mechanical damage to the works of art (Ruiz-Agudo et al., 2007).

The gSer-khang Gumpha of Tabo monastery, known as the ‘golden temple’, is a national historic treasure of India and is protected by the Archaeological Survey of India. The Gumpha was exhaustively renovated in the 16th century by ‘Senge Namgyal’, the ruler of Ladakh. The walls and ceilings of this gumpha are embellished with outstanding murals of golden color. In this study, an attempt is made to discuss the natural and anthropogenic causes of deterioration, and conservation of this monastery’s murals. Specifically, the study aims to develop a sustainable conservation approach that takes into consideration the structural features, techniques of mural execution, construction materials, and climatic conditions of the region in reference to gSer-khang Gumpha of the monastery.

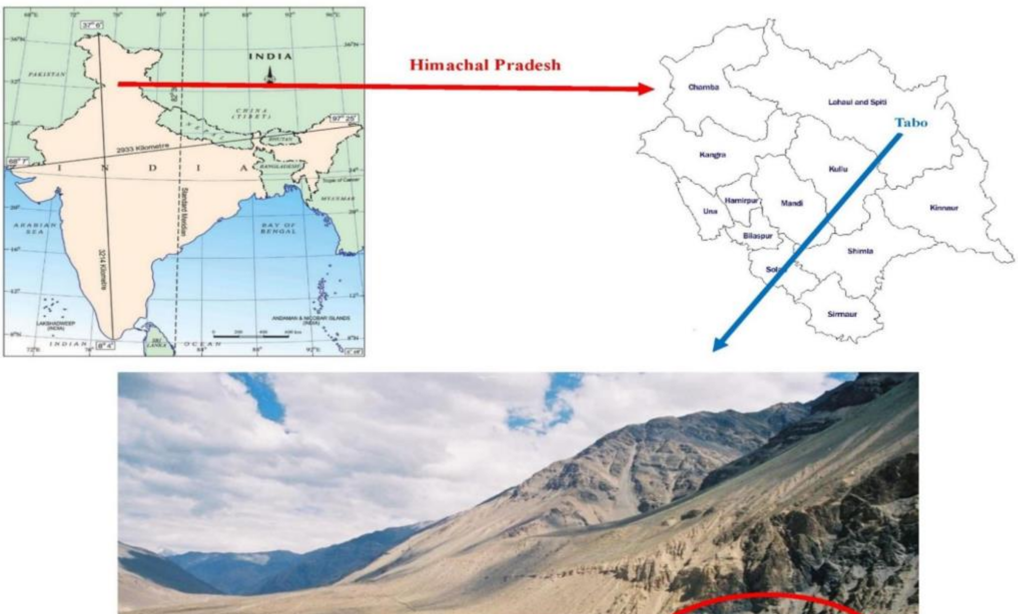
MATERIALS AND METHODS

Study area

The monastery is at the dizzying height of 3,050 meters, and is located in the small village of Tabo, on the left bank of the Spiti River (Figure 1). Geographically the monastery is situated on the barren, arid, snow covered, cold and rocky desert of the ‘Spiti’ valley of Lahaul and Spiti region, and lies between 32.0938°N and 78.3823°E. The word ‘Spiti’ refers to ‘the middle land’, i.e., the land between Tibet and India. The valley is delimited by Laddakh to the north, Lahaul and Kullu districts to the west and south-east respectively, and by Tibet and the Kinnaur district to the east. The adopted methodology for this study is given in Figure 2. With respect to the climatic conditions, the region has a short summer and a long, freezing winter. Snow begins to fall in December and remains on

Figure 1

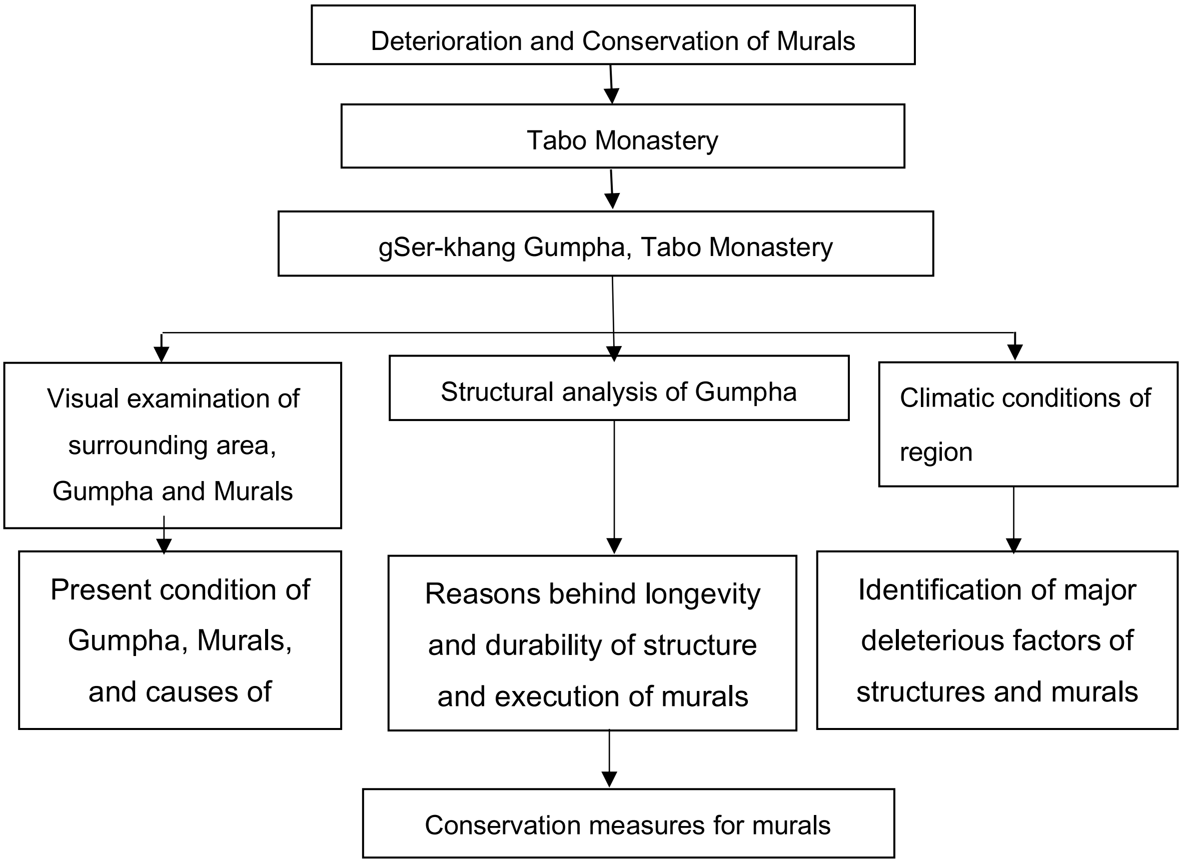
General View of Village-Tabo and Tabo Monastery, Tabo, District- Lahaul & Spiti (Himachal Pradesh), India



Note. From *Map and general view of Village-Tabo and Tabo Monastery*, by Google, 2023. Copyright 2023 by Google LLC.

Figure 2

Diagram of Methodology Adopted for Study



the ground until the end of April due to the moisture-laden westerlies. During heavy snowfall, temperatures have been recorded at -30 °C. The region accumulates ice and snow (Bajpai, 2002), and in the presence of weak Indian summer monsoon in the higher Himalaya, westerlies add to the glaciers that feed Himalayan rivers. Due to topographic barriers of the Pir Panjal range, summer monsoon rainfall does not reach this region, which receives only drizzling rain during the peak monsoon (Yadav, 2011). Average annual rainfall is about 1,200 mm, and snowfall varies from less than 1.0 meter to 3.0 meters annually, with an average of 2.0 meters. The minimum temperature varies from +12 °C to -22 °C, while maximum temperature ranges from 12 °C to -26 °C (Kumar et al., 2018).

Structural analysis of Gumphas

The gumphas of the monastery are constructed using locally available materials i.e., mud, soil, organic fiber, wood, etc. These materials were used at the time of monastery construction due to abundant availability, workability, ease of repair and simple technical skill requirements. Wood was employed mainly as a structural load bearing members, and for roofing and, occasionally, flooring. The number of wooden pillars depends on the span of the room. The roof of the temple is braced with wooden struts and supported by wooden pillars. The gumphas are designed with inherent systems to resist dynamic stresses resulting from seismic movement, wind flow etc., having regular geometric shape, symmetric plan and elevation, and using ductile construction materials such as wood from local trees. The wooden materials can withstand large deformations without failure. Also, depending on the span of the chamber, the wooden pillars subdivide the chamber and, thus, vertical loads are transferred to the ground, which arrests deformations and helps prevent progressive destruction of the walls. The investigation of broken portions of some wooden rafters of g Serkhang Gumpha revealed that the gumpha is a chamber of mud walls that is made of sun-dried mud bricks, which act as a support/carrier for mural paintings. On close examination of the deteriorated/ missing painted area, it was found that the substratum of the painting is made up of two different layers of mud plaster. The lower layers are coarser, while the uppermost layers are fine. The coarser layers comprise soil; that is, they are made of mud thoroughly mixed with some organic fibrous materials. Above these coarser layers a fine layer of mud with the same fibrous composition, but of a more compact nature (Figure 3). The execution of murals is in the tempera style, using earth/natural colors with a natural binding agent. It is most likely that the natural binding agent was extracted from wild Apricot (Chuli) or small shrubs (Somlata) that produce sticky substances (gum) and are abundant in this area. The prominent earth/natural colors are in different shades of red, yellow, blue, green, black, etc. In addition to these prominent colors, the use of golden color is also seen in the fine details of murals.

RESULTS AND DISCUSSION

Causes of deterioration and damage to structures

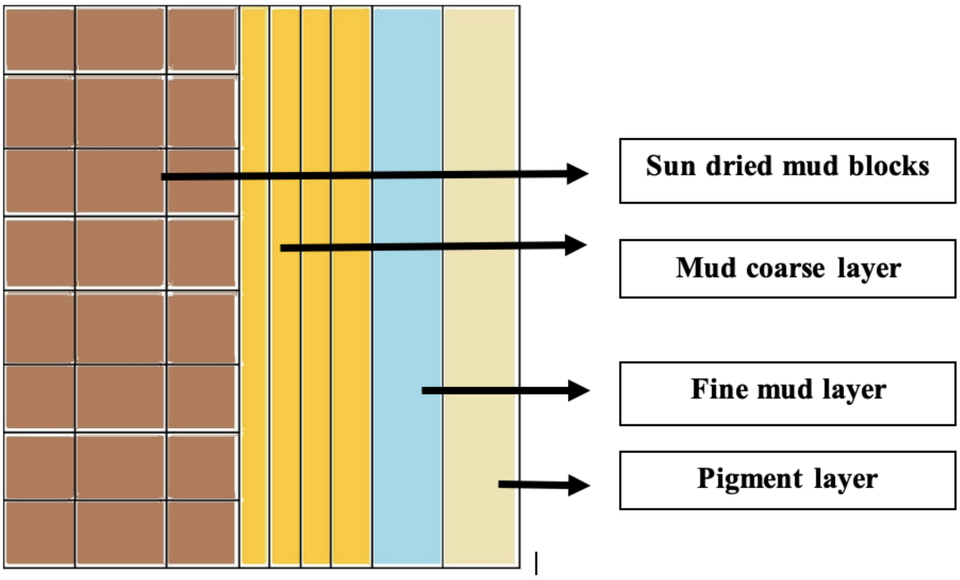
The vernacular designs of structures in the Tabo monastery result from its climatic conditions, landscape, and availability of raw materials and other natural sources, making them both indigenous and unique in this region (Figure 4A). Visual observation of murals and different gumphas in the monastery complex reveals different kinds/levels of deterioration and the accumulated effects of different factors. The monastery is situated in a cold and dry zone that has a huge variation in environmental parameters. In recent times, the annual minimum temperature of the region has been gradually increasing, while the annual maximum and mean temperatures, along with rainfall and snowfall, have fluctuated from year to year (Sharma et al., 2013). This fluctuation along with extreme diurnal temperatures, low to high snowfall during winter, and high temperatures and drought spells during summer are greatly influencing the overall environmental conditions of the region. Also, the percolation of water through the carrier wall of murals (Figure 4B, 4C), which is due to melting of snow and rainwater, causes fluctuations in humidity and changes in the micro-climate (Becherini et al., 2010). Moreover, the dampness trapped within the carrier wall has adverse effects; the painted plaster loses its hold on the wall due to resulting weakness of the binding agent, and pigments of murals showed a tendency towards fragmentation, powdery appearance, and loss of color (Coccato et al., 2017; Saunders & Kirby, 2004).

The abrupt changes in diurnal temperatures in summer and winter also contribute to remarkable damage to structures and murals. The average value of the annual and seasonal maximum and minimum temperatures for the period 1951-2021 (70 years) for both the state and the Lahaul and Spiti region shows temporal variability (Table 1) (Economic & Statistics Department, 2020; Gosain & Rao, 2018; India Meteorological Department, 2022; Kumar et al., 2018; Misra et al., 2021). The average annual maximum temperature of the state is 25.9 °C (range: 24.5 °C - 27.1 °C), while that of the district is 23.6 °C (range: 22.3 °C - 24.8 °C). Moreover, the average annual minimum temperature of state is 13.4 °C (range: 12.5 °C-14.5 °C), and that of the district is 11.5 °C (range: 10.6 °C-12.5 °C). Of concern, the mean maximum and minimum temperatures of the state and Lahaul and Spiti region are increasing (Table 2) (Gosain & Rao, 2018; India Meteorological Department [IMD], 2022). Due to this temperature variation and overall trend, the mud walls continuously undergo a process of alternate expansion and contraction, and these changes also set up different sheer stresses in the mud walls (He et al., 2014). This causes a breakdown of the mud bricks of the carrier wall and the ground layers close to the surface of the paintings, leading to cracking, bulging, detachment, flaking, and blistering of the pigment and its layers (Figure 4D). Over time these phenomena result in bulging and the widening of the cracks, which may increase in the future.

Another factor to be considered is that climatic changes of the region have led to cultivation of peas and apples along with other vegetation, which further affects the macro-climate of the

Figure 3

Cross Section View of Painting Wall



region and, ultimately, the micro-climate of mural paintings. The drizzling rain has become a common occurrence for the nearby area of Tabo, and yearly rain fall in the Spiti division increased by 334.20 mm to 440.37 mm between 2000 and 2011 (District Disaster Management Plan [DDMA], 2017). The mean value of the annual and seasonal rainfall for the period 1951-2021 (70 years) of overall state and Lahaul and Spiti region shows variation in trend (Table 3) (Bhatti & Bhooshan, 2021; Gosain & Rao, 2018; IMD, 2022); Jaswal et al., 2015. Moreover, the annual rainfall of both the state and of Lahaul and Spiti is projected to increase in the future (Table 4) (Gosain & Rao, 2018, IMD, 2022). Since the walls of the gumpha are made of mud with a wooden roof, during the rainy season due to wind velocity and its direction the walls became wet, and water gets trapped within the walls and the roof of gumphas. The downflow of rainwater through the leaky rooves carries allows water to seep into the mud, causing great damage to the paintings.

The state of Himachal Pradesh falls in a region of high to very high seismic hazard. The state falls in seismic zones IV & V where geologic hazards, namely, earthquakes and other seismic activities, are common (Bureau of India Standard [BIS], 2016). The average seismicity (number of earthquakes per day) is 1-2 events at stations Tabo, Lalaung, and Rangrik, while it is one event per two days at Mikkim (Geological Survey of India [GIS], 2013). As per the information reported by the National Disaster Reduction Control Portal, Himachal Pradesh, between 1800 and 2008, 553 earthquakes were recorded in the State. Out of these, about 99 were observed in the valley, which comprises 17.90 % of total reported in Himachal Pradesh in the same time period (National Disaster Risk Reduction Portal [NIDM], 2010). The disaster risk profile of the districts of Himachal Pradesh reveals that, of the total area of 13,841 km^2 of the Lahaul and Spiti region, 747 km^2 is classified as Earthquake Hazard Zone V, while 13,094 km^2 is classified as Earthquake Hazard Zone IV (National Disaster Management Authority [NDMA], 2019). The frequent seismic movement causes sudden stresses that spread in the system from load-bearing members to foundation (Dandona, 2006; Mydin et al., 2012). These sudden loads result in additional loads and some lateral forces for which the walls are not necessarily designed. For these structural systems, the result over time when progressively subjected to these types of forces, is loss of strength of structural members, which causes detachment of large chunks of painted plaster, vertical cracks from top to bottom of murals, tilting of walls, etc. (Figure 4E).

Figure 4

Structural Deterioration Problems in gSer-khang Gumpha, Tabo

Table 1

Comprehensive Temperature Statistics of Overall State and District for the Period From 1951-2021

		Himachal Pradesh		Lahaul & Spiti	
Season	Statistics	Maximum Temperature (⁰C)	Minimum Temperature (⁰C)	Maximum Temperature (⁰C)	Minimum Temperature (⁰C)
Annual	Average	25.9	13.4	23.6	11.5
	Range	24.5–27.1	12.5–14.5	22.3–24.8	10.6–12.5
	CV	0.020	0.034	0.022	0.038
Winter (Month: January and February)	Average	16.9	4.7	14.4	3.2
	Range	14.9–19.6	2.9–7.5	12.4–17.1	2.1–5.7
	CV	0.065	0.165	0.076	0.204
Pre-Monsoon (Month: March, April, and May)	Average	28.3	14.1	25.5	12.0
	Range	24.7–31.9	12.3–16.2	22.2–28.9	10.2–14.0
	CV	0.045	0.061	0.049	0.071
Monsoon (Month: June, July, August, and September)	Average	30.7	20.6	29.0	18.6
	Range	29.6–32.7	19.7–21.6	28.0–30.9	17.7–19.6
	CV	0.019	0.023	0.019	0.025

Table 1 (Continued)

		Himachal Pradesh		Lahaul & Spiti	
Season	Statistics	Maximum Temperature (^{0}C)	Minimum Temperature (^{0}C)	Maximum Temperature (^{0}C)	Minimum Temperature (^{0}C)
Post-Monsoon (Month: October, November, and December)	Average	23.0	8.8	20.7	7.0
	Range	19.7–24.2	7.6–10.1	17.7–21.9	5.9–8.2
	CV	0.035	0.077	0.039	0.086
CV: Coefficient of variation					

Table 2

Projected Increase (%) in Mean Temperature of Overall State and District

	Himachal Pradesh	Lahaul & Spiti
Period	Maximum temperature (^{0}C)	
Baseline (1981-2010) to Mid-Century (2021-2050)	1.4–1.6	1.7–2.0
Mid-Century (2021-2050) to End-Century (2071-2100)	2.5–5.0	3.3–5.9
	Minimum temperature (^{0}C)	
Baseline (1981-2010) to Mid-Century (2021-2050)	1.4–2.7	1.7–2.1
Mid-Century (2021-2050) to End-Century (2071-2100)	1.8–5.1	3.2–5.6

Table 3

Comprehensive Rainfall Statistics of Overall State and District for the Period From 1951-2021

Season	Statistics	Himachal Pradesh	Lahaul & Spiti
Annual	Average (mm)	1284.2	1036.0
	Range (mm)	704.7–2062.8	545.5–1776.0
	Inter- annual variation	0.24	0.27
Winter (Month: January and February)	Average (mm)	156.0	219.0
	Range (mm)	34.1–479.7	64.8–560.5
	Inter-annual variation	0.54	0.48
	Contribution to annual rainfall (%)	12.1	21.2
Pre-Monsoon (Month: March, April, and May)	Average (mm)	192.9	295.6
	Range (mm)	49.5–545.6	87.2–647.7
	Inter-annual variation	0.53	0.46

Table 3 (Continued)

Season	Statistics	Himachal Pradesh	Lahaul & Spiti
Pre-Monsoon (Month: March, April, and May)	Contribution to annual rainfall (%)	15.1	28.5
Monsoon (Month: June, July, August, and September)	Average (mm)	849.2	405.4
	Range (mm)	352.9–1504.1	146.1–1115.0
	Inter-annual variation	0.32	0.44
	Contribution to annual rainfall (%)	66.1	39.1
Post-Monsoon (Month: October, November, and December)	Average (mm)	86.1	116.0
	Range (mm)	3.7–444.7	5.9–399.4
	Inter-annual variation	0.95	0.77
	Contribution to annual rainfall (%)	6.7	11.2

Table 4

Projected Increase (%) in Mean Rainfall of Overall State and District

	Himachal Pradesh	Lahaul & Spiti
Period	Rainfall (mm)	
Baseline (1981-2010) to Mid-Century (2021-2050)	5.9–14.0	6.0–16.0
Mid-Century (2021-2050) to End-Century (2071-2100)	13.8–14.0	14.0–28.0

Deterioration of murals

The surface waves that arise due to these seismic activities are dangerous for mud wall contraction and play a significant role in damaging the paintings (Menon & Murty, 2013; Pradhan et al., 2012). Also, being a living structure, centuries of religious activities have led to the deposition of dirt and smoke, leaving the painted surfaces black and unrecognizable, while the constant rubbing of the lower portion of the painted wall by humans and by dust carried by wind has led to the deposition of thick coats of grime and dirt, and detachment of powdery and weakly adhered layers of the painted surface. Since the monastery is situated in a dry and cold region with oxygen deficiency, deterioration of murals due to biological agencies is not noticed; however, a clear quantification of the deleterious impact of different extrinsic environmental factors is difficult.

The painted surfaces are covered with a network of wide/fine, vertical/horizontal cracks traveling from the roof to the bottom and ends of walls (Figure 5A). Other issues include loss of pigment, fading of colors, bulging, flaking, peeling, and hanging of painted plaster (Figure 5B). At many places, the colors of the painting have been lost because of mud-streak, and only the line sketches are visible in the painted portions (Figure 5C). Human vandalism in the form of scratches and greasiness is also identifiable on the murals, especially on the lower portions. Old preservative coats (Figure 5D) also damage the natural look of paintings as they become hard, sticky, and yellowish due to changes in their physico-chemical properties as they age (Hari, 1987). These also result in the alteration of physico-chemical properties at the interface between the painting surface and its environment; the physico-chemical reaction of these materials alters the color and physical appearance of the painted surface, causing additional mechanical stress to the paint layers (Feller, 1994) that leads to the formation of network of fine cracks on the painted surfaces. Besides this, it is observed that, due to the polymeric degradation of preservative coats, reversibility of the coatings is reduced with time, and their removal by using organic solvents becomes much more difficult.

Conservation measures for murals

The main objectives of the conservation measures is to minimize the effect of deterioration factors on murals, the removal of superficial accretions, and reduction of the thickness of the old preservative coats to allow the underlying surfaces to breathe. Conservation ethics must be considered while performing the conservation measures; that is, intervention should be minimal, and should not disturb the originality of mural paintings. To achieve this, preventative conservation of gSer-khang gumpha is carried out with a clear understanding the underlying problems and the surrounding environment. Before starting the conservation work, thorough photo documentation was performed to record the condition and every fine detail of the murals.

Due to bulging, the surface of the paintings was uneven, and the entirety of the murals was covered with dust and dirt along with hard mud-streaks. The superficial accretions have been patiently removed using soft brushes to avoid any loss of the original pigment/painted layer. As discussed, the carrier wall of the painting is made up of mud; therefore, to perform filling/edging work, locally available materials akin to the originals such as soil/mud and husk were used (Yang et al., 2019). To prepare filling materials, the locally available soil/mud was thoroughly sieved into different grain sizes, and coarse grains were mixed with finely chopped husk in a 3:1 ratio (Figure 6A), while the top layer was prepared with fine particle-sized grains of soil/mud, with very little finely chopped husk mixed in (Figure 6B). After that, for color reintegration work, a very thin layer of lime was applied as a ground layer (Figure 6C).

Depending on accretion, scientific cleaning was performed using cotton swabs with different suitable organic solvents, individually or in combination, for the removal of superficial dust, dirt, mud streaks, thick coats of old preservatives, and other accretionary deposits. The biggest challenge during scientific cleaning is the removal of substances with different chemical compositions (accretionary deposits) from the original materials. The complete removal of these materials is often a delicate problem due to the heterogeneous and porous nature of the support. The use of organic solvents for cleaning, either individually or in combination (mixture), on porous surfaces can result in the partial redistribution of the unwanted substances through the porous ground, leading to chalkiness and stickiness on the cleaned painted areas (Morimotto & Suzuki, 1972). However, this problem can be controlled by minimizing the use of solvent mixtures (without giving the chemical mixture a chance to seep into the ground of painting), and by proper application (horizontal and vertical rubbing should be avoided). The organic solvents used (either individually or in combination) were Methyl alcohol, Ethyl alcohol, 2-Ethoxyethanol, Di-n-butyl phthalate, Triethanol amine, Ethyl acetate, Petroleum spirit, and others. The process is very delicate, and the result depends on the expertise and precision of the executing hand. During the scientific cleaning process, the goal has not been to reach the pigment surface because of great fear of losing any pigment or mural detail, so the cleaning process was carried out with the objective of removing ~ 75% - 80% of superficial accretions.

Over time, old preservative coats have become hard in several places, and due to the physio-chemical action, the underlying original color shows a fugitive tendency toward organic solvents (Wallert et al., 1995). So, when removing the preservative coat from these portions, extra care is taken to avoid any loss of the original color or fine details of murals (Figure 7A and 7B). After cleaning, minimum color reintegration works are performed on the newly cleaned area. Faded portions and areas of color loss are identified, followed by applications of a very thin coat of reversible preservative coating to preserve them from any further loss (Figure 8, Figure 9, and Figure 10).

Figure 6

Conservation Measures in Mural Painting, gSer-khang Gumpha, Tabo

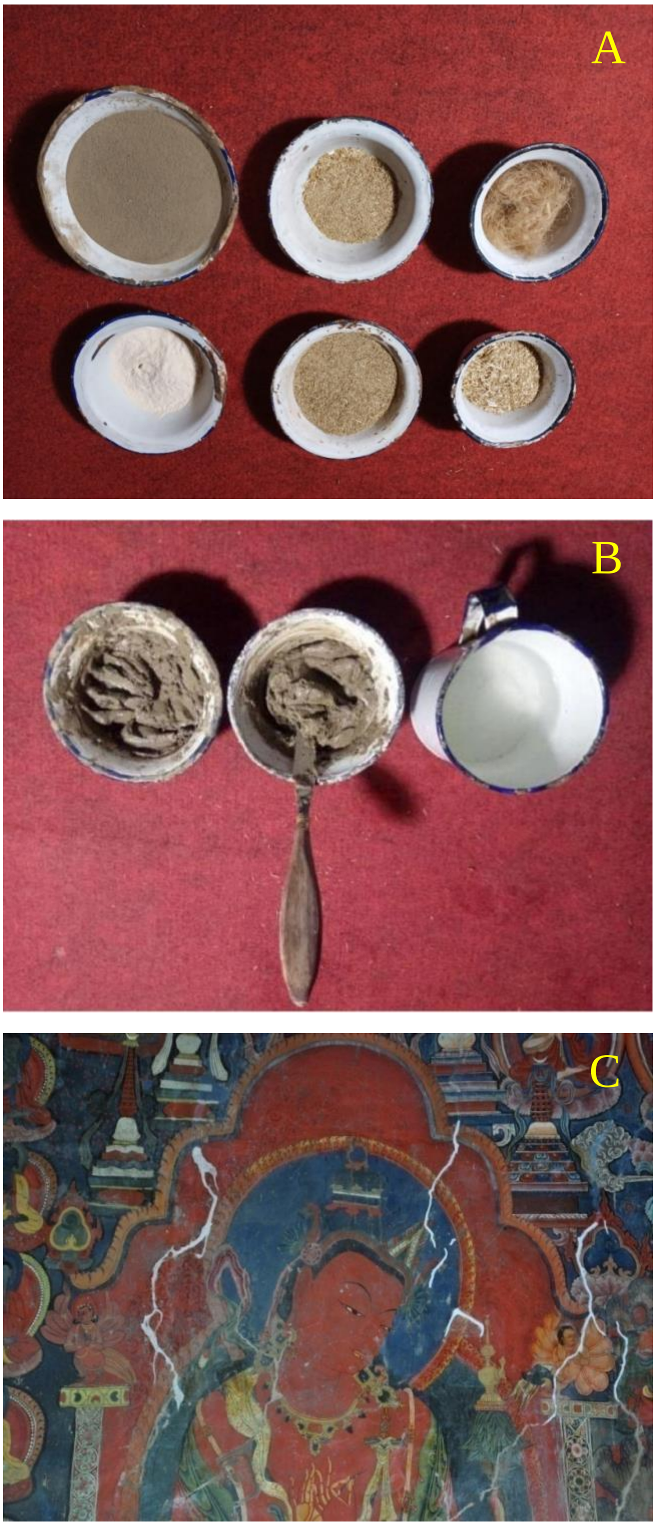


Figure 7

Cleaning of Mural Paintings, gSer-khang Gumpha, Tabo

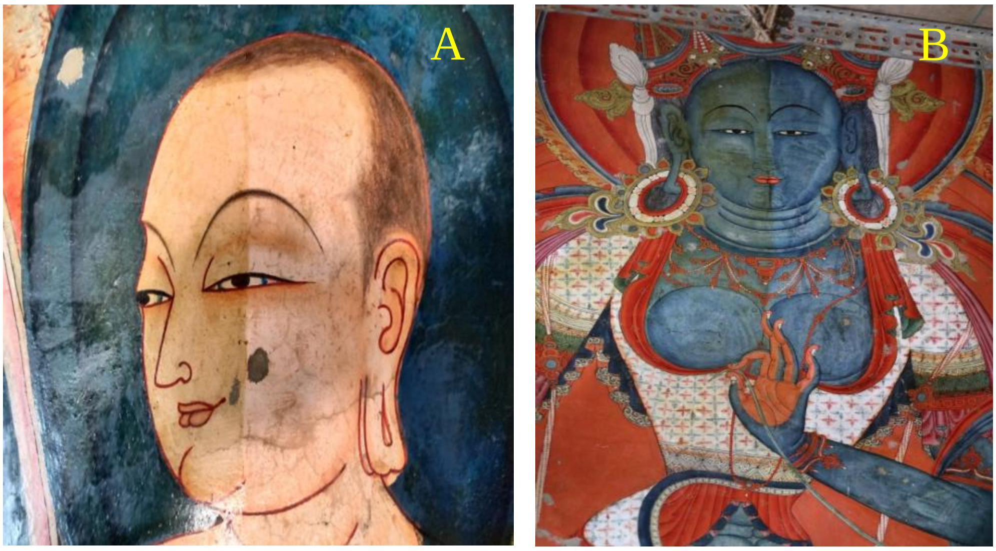


Figure 8

Conservation of Murals at gSer-khang Gumpha, Tabo

Figure 9

Conservation of Murals at gSer-khang Gumpha, Tabo

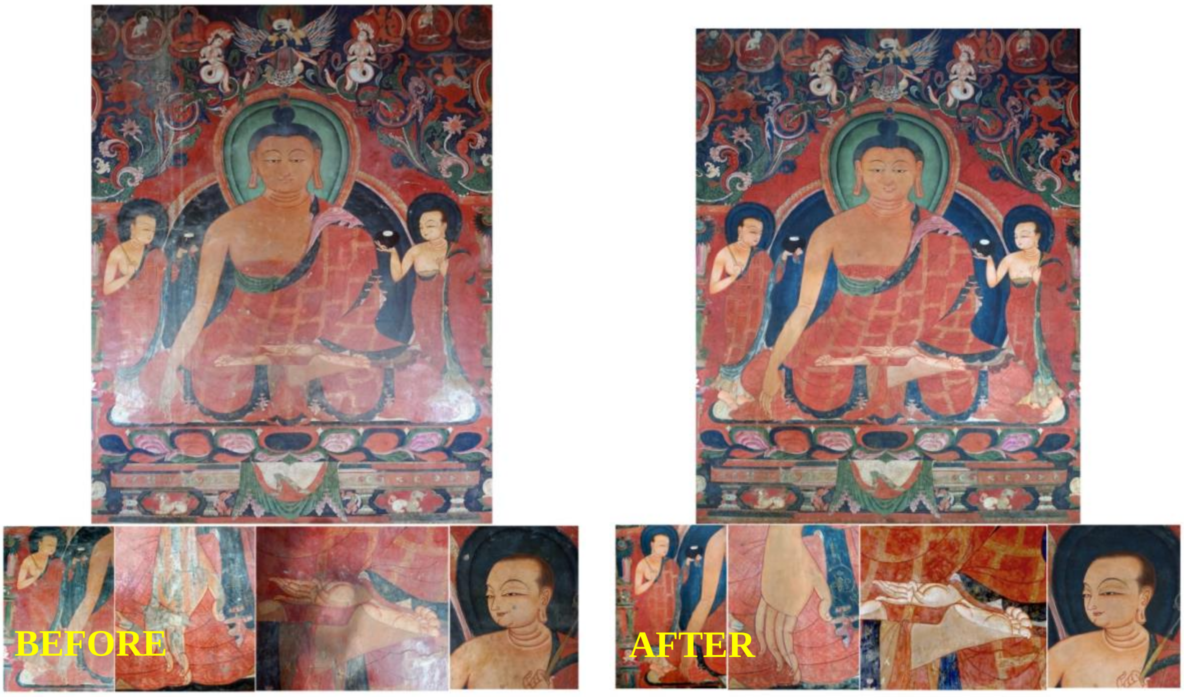


Figure 10

Conservation of Murals at gSer-khang Gumpha, Tabo

CONCLUSION

The conservation of cultural heritage is essential because it is the mirror of any culture, and it reflects the story of its past. It is also true that conserving heritage monumental structures possessing indigenous architectural features, local construction materials, and murals is not an easy task due to lack of knowledge regarding climatic conditions at the time of construction, architectural features, execution technique of murals, and non-availability of local construction materials. In today's changing climatic conditions, the use of incompatible materials and techniques may hasten the decay of original materials and inflict permanent harm to structures. Thus, knowing the problem is not sufficient for the conservation of these structures. For sustainable conservation, adequate knowledge of architecture, climatic scenario of the region, used construction materials, and execution techniques of murals is necessary. The local environment and locality in which the monument was initially built, the level of tourism, previously carried out conservation works, and causes of deterioration are all important factors to consider in creating a sustainable conservation approach. Besides this development of long-term comprehensive planning for "cultural resource management", development of integrated, interdisciplinary mitigation approaches to preservation is also essential. The detailed analytical investigation of executed murals, and the use of technically and scientifically established methods/materials are also important for the evaluation of long- term impact.

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