Architecture and Structures of Kiradu Temple (Barmer Region, Rajasthan, India)

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Abstract Kiradu temple, known as the Khajuraho temple of Rajasthan, is an epitome of Maru-Gurjara style of architecture. Due to weathering, several sections of the temple complex has been decayed. Though several literatures have mentioned the architectural style of the Vishnu temple of Kiradu, very few work has mentioned the details of other temples existing within the temple complex. In this study we have attempted to understand the architecture and present structural condition of Kiradu. We have studied the strength analysis of one of the partially destructed temple to understand the vulnerability of the fractures. We have tried to look into different fractures and destructed artifacts to understand the real reason of their decay. This study will help us for the preservation and restoration of the temple and to understand the cultural and social lifestyle of the western India during medieval period.

Keywords Kiradu · Restoration

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1 Introduction

India is considered as the central peninsula in the south Asia. Due to diversity of climate, variety of races inhabited in the country. India has witnessed a wide-spread cultural diversity over ages. Temples and their architecture becomes integral part in Indian history.

The north Indian temples of medieval period (A.D. 900–1000) is classified into four major zones as the Upper, the Central, the Eastern and the Western. It is observed that the Western zone is the largest (Paranagar near Alwar in Upper Rajasthan to Parol near Mumbai, a north–south stretch of over a thousand km) and longest (west to east from Dewalthatha in Sind to Atru in eastern-most Rajasthan, a distance of nearly six hundred km) and most productive amongst these regions (Dhaky, 1967). Rajasthan is considered as one of the most important places in the western India for temple architecture and sculpture. Unfortunately only the ruins of many temples are left in this Indian state. Between seventh and tenth centuries, several temples were constructed and different regional architectural styles developed as temple designs. The temples of late medieval periods in Rajasthan are mostly constructed as per the Maru-Gurjara style.

The Kiradu temple in Barmer (Rajasthan) (Fig. 1a) is a fine example of an eleventh century Maru-Gurjara architectural style. As Kiradu is an arid area, the diurnal temperature variation is extreme especially during the summer and the winter time. This resulted in decay of the temple material. Most of the temples of Kiradu are made up of sandstones (Chanchani, 2014).

We present the architectural design and the present structural condition of the Kiradu temple. In most of the literatures, we obtain information only regarding the Vishnu temple. Though the Maru-Gurjara style of the architecture is elaborated in several literature, the detail design pattern of the outer walls and the Mandovara section of the Kiradu temple complex remained a due. This study provides us a detail information of the constructional design, which can be further utilised for the preservation and restoration of the temple maintaining its style of architecture.

2 Location of Kiradu

The Kiradu temple (Fig. 1) is located ~43 km NW from the town Barmer, Rajasthan at the Hathma village, which lies north of Khadon Railway station situated on Barmer–Munabao Railway line.

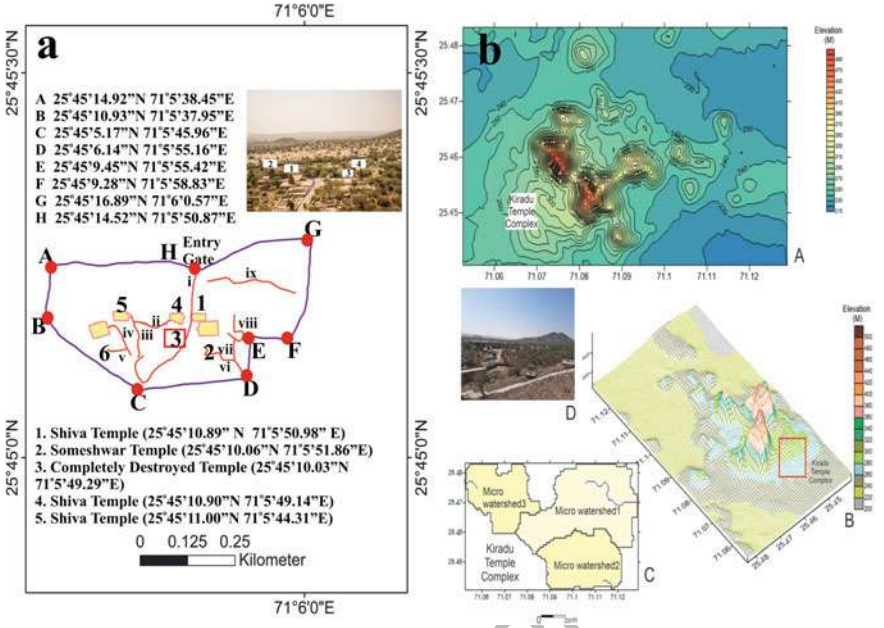


Fig. 1 Google Map of the Kiradu Temple **a** coordinates of longitude and latitude of Kiradu, **b** Kiradu temple and its adjacent area

3 General Description of the Kiradu Temple

The purple polygon in Fig. 1a demarcates ~ 0.16 km^2 of the Kiradu temple complex. Yellow rectangles denote the temples of the Kiradu. From the entry gate of the temple complex, the first temple (temple no. 1) is the Shiva temple. Temple no. 2 is the Someshwar temple. Rectangle 3 denotes the completely ruined temple area. Rectangle 4 and 5 denote temple no. 4 and 5, which are Shiva temples and rectangle 6 is a Vishnu temple. In Fig. 1b describes the Kiradu temple and its surrounding area. From Fig. 1b it is clear that micro watersheds surround the temple complex. These micro watersheds can indicate habitat surrounding the Kiradu temple in the past.

4 Weather of Kiradu

Kiradu is situated in an arid region. The temperature of Kiradu fluctuates much during summer and winter. In summer, the temperature rises upto 48–49 °C in the day time and drops to 27–29 °C at night. In winter, the temperature in day time is usually 26–27 °C and falls to 11–13 °C at night (Singh et al., 2010). The average rainfall in Barmer is 277 mm in a year but remains very dry in the monsoon (Poonia & Rao, 2018). Sometimes Barmer experienced abnormal rainfall due to weather depressions. Due

Fig. 2 Notices by Archeological survey of India (ASI), History of Kiradu-Group of temples

to being in arid region, Kiradu experiences high evaporation rate, wide temperature swing both daily and seasonally and very low precipitation (Saifuddin, 2000).

5 History of the Foundation

According to Ghurye (1968), and inscription dated 1153–1178 CE, the temples of Kiradu were built around twelfth century C.E (Ghurye, 1968). Art historian Percy Brown and Madhusudan Dhakay assigned the temples of Kiradu to the eleventh century C.E. (Dhaky, 1998). Inscriptions of 1161 A.D. period is found on the pillars of the Kiradu temple. The ancient name of 'Kiradu' is being mentioned as Kirat Koop. It appears from the dispersed rocks that Kiradu was a fully established town. Sindhu Raj was the founder of the Parmer rule of Kiradu town. The Parmer and Chauhan rules of Kiradu were under the regime of Solanki dynasty of Gujarat. The town got ruined due to foreign invasion. An 1178 C.E. Kiradu inscription, issued during the reign of the Chaulukya monarch Bhima II, records repairs to a temple damaged by the Turushkas (Turkic people). These Turushkas are identified with the Ghurids led by Muhammad of Ghor (Chaudhary, 2012). Figure 2 displays the temple history mentioned by the Archeological Survey of India. There is no specific information available regarding who built the temples of Kiradu. Though there are

Fig. 3 Kiradu temple complex

three inscription of twelfth century available, but they do not provide information related to the construction of the temple. The temples of the present Kiradu town are in a ruined state after the desolation of the magnificent Kirat Koop town, yet they are still known for their architectural splendor and testimony of ancient glory.

6 Architectural Style of the Kiradu Temple

The Kiradu temples are a group of ruined Hindu temples. Presently five temples are found in remnant state. They are mainly the Someshwar temple, three Shiva temples, and an almost ruined Vishnu temple. Besides these five temples, there are two completely ruined temples. Figure 3 shows the temple complex of Kiradu. In this figure, temple numbers 1 and 4 indicate the Shiva temple and temple number 2 is the Someshwar temple. Point 3 is a completely ruined temple (25°45′10.03″ N Latitude and 71°5′49.25″ E Longitude).

According to M. A. Dhaky the structure of the temple can be studied into two parts. The first one is along the vertical direction from the base foundation of the temple to the pinnacle of the temple top. This section is known as Udharvachhand (Chhand means roof, and Udharva means outer wall of the section where main

Fig. 4 Architecture of the Someshwar temple (Temple No. 2)

deity is installed) (Fig. 4).The second one is along the horizontal length from the one end (entry gate of the temple) to the other end of the structure. This portion is called Talchhand (Talchhand means under the roof in the front section of the temple) (Fig. 4).The Udharvachhand can be divided into four main sections viz., Jagati, Pitha or Adhisthan, Mandovara and Sikhara.

Jagati (Figs. 5, 6 and 7): Jagati is the pedestal or platform which is the moulded base of the structure. The Pitha of the Kiradu temple uniquely represents the early form of the Maru-Gurjara style of architecture. It is mainly constituted by seven or eight mouldings, starting with two successive Bhittas followed by Jadyakumbha, Kumuda, Grasapattika, Gajapitha, Ashvapitha and Narapitha. Rectangular Bhitta is the first moulding above the Jagati. Jadyakumbha is the moulding above the two Bhittas. It is inverted cyma-recta engraved with designs. Kumuda is the torus moulding above the Jadyakumbha. Grasapattika represents the band showing the gorgon heads. Gajapitha is the basal-band above the Grasapattika showing the frontal posture of the elephant figures. Ashvapitha is the band displaying the frontal posture of the horses. Narapitha displays the pitha-course showing human engaged in manifold activities.

Mandovara (Fig. 5): It is the temple's closed hall's portion above the Pitha and below the roof of the temple. The Mandovara consists of the Vedibandha, the

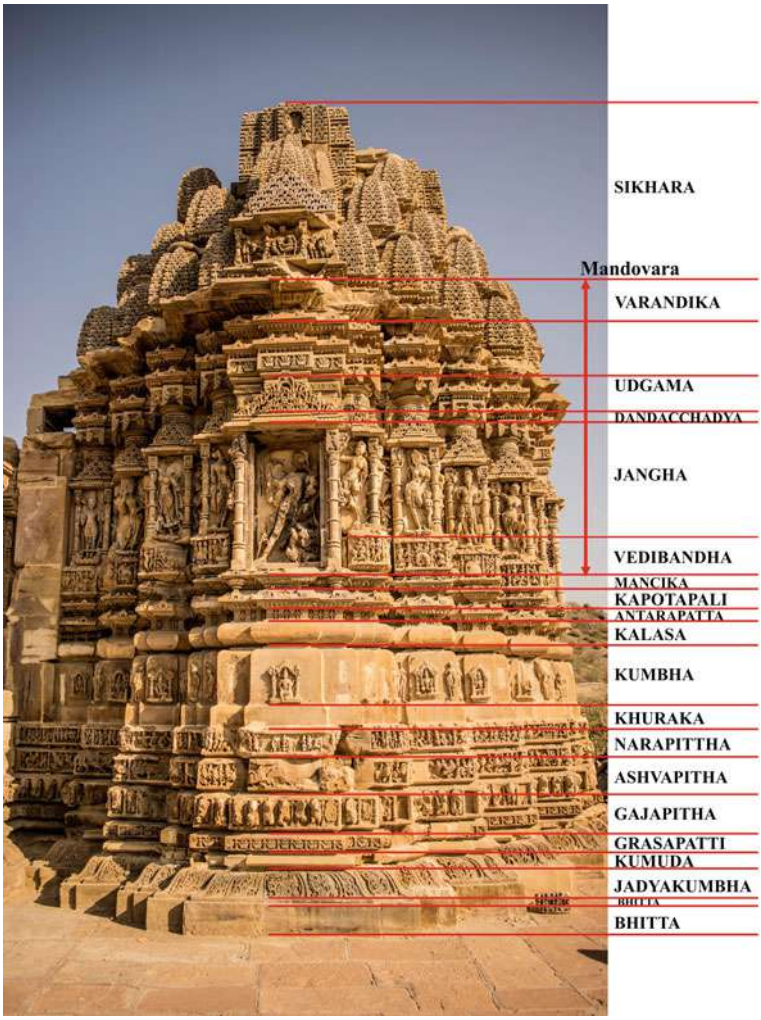


Fig. 5 Architectural details of Udharvachhand section of the Someshwar Temple (Temple No. 2) (Dhaky, 1998)

Jangha, and the Varandika. The Vedibandha is the aggregate of five basal wall-moulding consisting primarily of Khurda, Kumbha, Kalasa, Antarapatta and Kapota-palli. Khurda is the basal plain moulding of Vedibandha. Kumbha is the Vedibandha's 2nd moulding above the Khurda.

Sikhara (Fig. 5): It is the spire of the temple.

Figure 4 displays the Talchhand and Udharvachhand sections of the Someshwar temple (Temple No. 2). Architectural details of Udharvachhand section of the Someshwar Temple (Temple No 2) is exhibited in Fig. 5. A detail description of architecture of Talchhand of the temples of Kiradu was presented by Dhaky (1998)

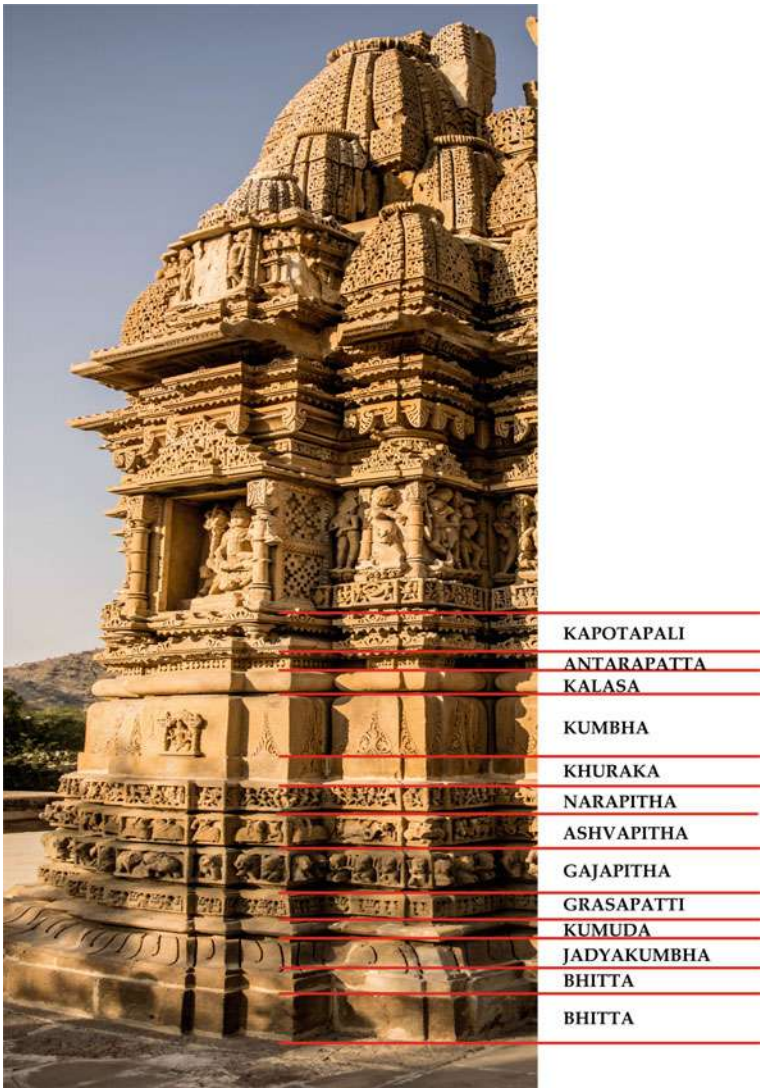


Fig. 6 Architectural details of Udharvachhand section of the Shiva Temple (Temple No. 1) (Dhaky, 1998)

and Chaudhary (2012) about the Vishnu temple (Temple no. 6; Fig. 7) (Chaudhary, 2012; Dhaky, 1998). It is clearly evident from their literature that the temples of Kiradu hold a significant turning point in the history of western architecture. The temples' architecture has characteristics that clearly features the Maru-Gurjara style. They further demonstrate that these temples are landmarks attesting to the beginning of the fusion of Maha-Gurjara style with Maha-Maru style to transmute into

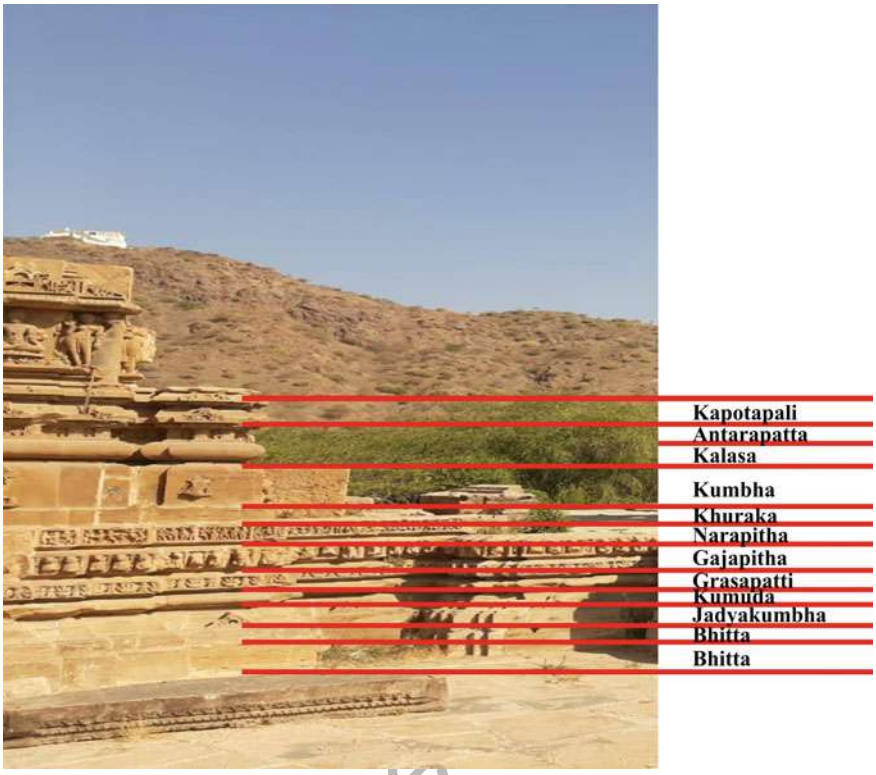


Fig. 7 Architectural details of Udharvachhand section of the Vishnu Temple (Temple No. 6) (Dhaky, 1998)

the Maru-Gurjara style (Agrawala, 1954, 2011; Banerjee, 2008; Bhandarkar, 1912; Dhaky, 1975).The Shiva temple (Temple no. 1; Fig. 6) and the Vishnu temple (Temple no. 6; Fig. 7) have also similar kind of pattern at the wall design. But the ashvapitha slab of pattern is missing from the Vishnu temple. This depicts that the Vishnu temple was built earlier than the Shiva temple and the Someshwar temple because the ashvapitha patten of design was introduced in Maru-Gurjara style later.

7 New Observations and Studies in This Work

The temples of Kiradu is majorly made of sandstone. Most of the temples of Kiradu are in ruined state. Some of them are due to weathering (Figs. 5 and 6) and some of the destructions are man-made (Figs. 26 and 27).

7.1 Temple No. 1 (The Shiva Temple)

The Talchhand section is completely destroyed in the Shiva temple. Only the Garbhagriha section is remaining. We have observed that the wall of the remaining section has been fabricated based on interlocking blocks. Interlocking blocks are suited for wall constructions with loads specially for two or more storeyed constructions. The temples of Kiradu are at a height more than two storeyed building with heavily sculptures inscribed wall. So this interlocking blocking helps to keep the strength of the wall. Figure 8 shows that lower panel section is attached to the upper panel with block to block locking. Some part of the temple is under restoration (Fig. 9). Figure 9a shows that the due to weathering, the Jadyakumbha portion of the wall is damaged and restoration is performed into that section as in Fig. 9b. Adhesive (calcareous cementing material) are usually used to attach one damaged section to the main construction (Fig. 10a, b). In Fig. 10b, we can observe that the Narapitha block is broken and it is attached with the Khuraka section using calcareous cement. Figure 11 presents a wind induced erosion in the temple rock.

Figure 11a presents damages in the gajaptha, ashvapitha and narapitha slabs. Figure 11b shows destruction of the frontal part of the sculpture. Figure 11c displays that the trunks of the elephants are damaged, and Fig. 11d is clearly shows that the

Fig. 8 Block to block locking system of rocks in the Shiva temple (Temple No. 1) (Pen of length 13 cm)

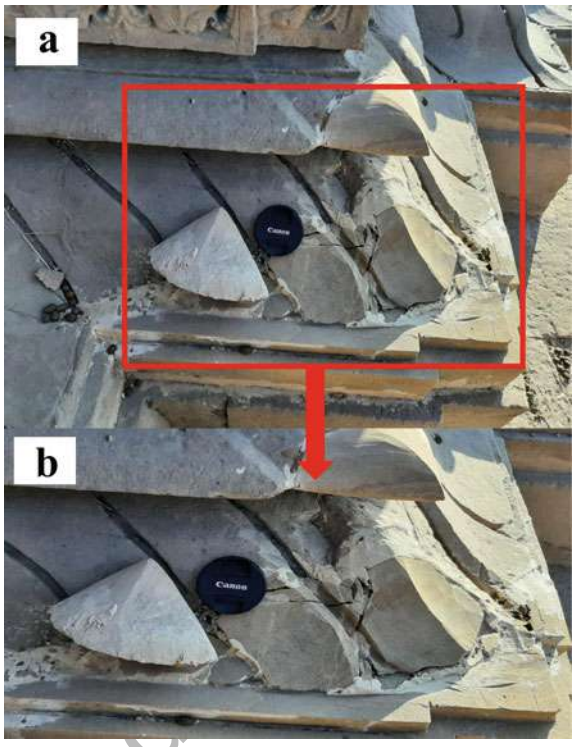


Fig. 9 Restoration of the Shiva Temple (Temple no. 1) (Camera cover marker, diameter 5.4 cm). **a** Restoration work is done in the damaged Jadyakumbha section; **b** restoration done using calcareous cement

middle sculpture is completely destroyed. These sections are the elevated portion of the sculptures. So due to weathering these elevated parts were affected most and got damaged. Due to weathering the top part of the Sikhara is also ruined. As Sikhara is the upper part of the temple, this section is completely exposed to the nature and we have observed damages at different sections of the Sikhara. Figure 12a–c show that the frontal part of the sculpture is ruined. Figure 12d displays the damaged part at the back end of the temple.

Restoration work done in this temple seems to be a continuous process. As restoration is performed at different time with different materials, color differences at different restoration sections are clearly evident (Fig. 13). In Fig. 13a, the dark yellow color at the bhitta section and pale yellow color at the restored section are observed. Similarly Fig. 13b shows that the color of the restored part is pale yellow, and the unrestored portion is dark yellow at the Jadyakumbha.

In the Shiva temple, several natural fractures were detected (e.g., Fig. 14). Arms, legs and breasts of the female idols show human-induced damages (Fig. 14b), and this is a persistent observation in the Kiradu temples.

Figure 15 shows restoration work within the sandstone using calcareous cementing material. We have seen a drain of width 8.1 cm and length 20 cm in north–south direction within the garbhagriha of the Shiva temple to drain the stored water. Figure 16 indicates the water outlet in north–south direction.

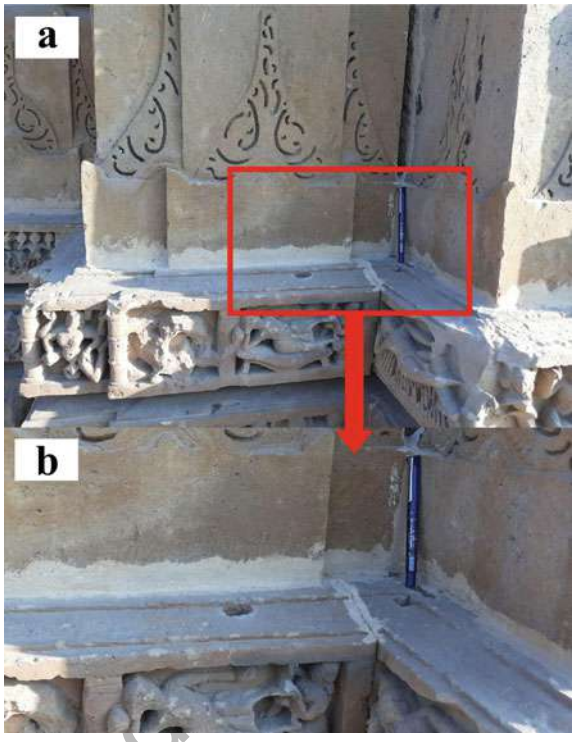


Fig. 10 Adhesive (calcareous cementing material) at the restoration site of the Shiva Temple (Temple no. 1) (Pen marker of length 13 cm) **a** Broken narapitha slab attached with the Khuraka portion with cementing, **b** A broken narapitha slab attached with another such slab with (calcareous cementing material)

Due to either weak metamorphism or some deformation, foliation planes developed within the sandstone, as observed in few places. The foliation is defined by the preferred concentration of micasalong some planar zones (Fig. 17). Such foliation planes act as planes of preferential breakage (Ghosh, 1993), and we note that such pieces of sandstones were not used in any vulnerable portion of the temple. Figure 17b shows a black coloured mineral weakly defining foliation in sandstone. Detail stress-strength analyses, and microstructural studies under an optical microscope would be important to understand the rheology and structures of the sandstone slabs that were used in constructing the Kiradu temples. This can give important constrain on the restoration process. Microorganisms and microchiropterans are very important for damaging any heritage monument. Six species of microchiropterans (Pipistrillus tenuis, Rhinopoma hardwickii, Taphozous perforates, Rhinopoma microphyllum kinneri, Taphozous melanopogon, and Taphozous nudiventris), most commonly known as bats are sited in the temples of Kiradu (Purohit, 2013). These bats induce moisture leading to leaching at the ceiling of the Shiva temple. Figure 18 shows leaching of water in sandstone that was produced by the increased moisture content of the wall created by bats.

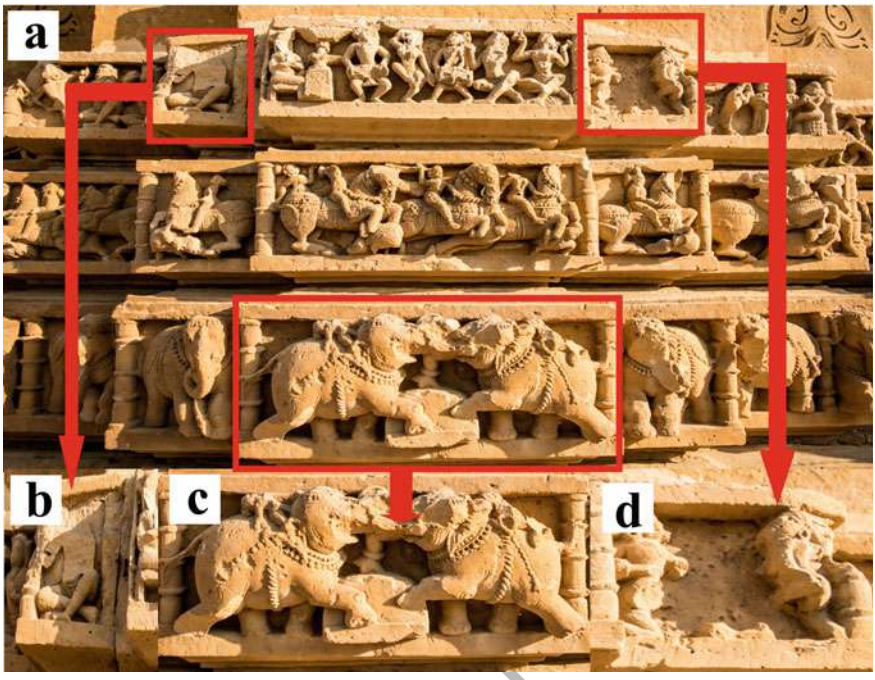


Fig. 11 Wind erosion affected in parts of the Shiva temple (Temple no. 1), **a** Ruined portions within three different slabs, **b** Frontal part is destroyed, **c** Trunks of the elephants are destroyed and **d** a sculpture is completely damaged

7.2 Temple No. 2 (The Someshwar Temple)

The Someshwar Temple (Temple no. 2) is the only temple where the Mahamandap and the Garbhagriha are not destroyed. In fact, this temple gives an idea about the architectural details of the temples of Kiradu. At the entry of the Udharvach-hand section of the temple, partially preserved inscriptions are observed at the wall (Fig. 19). A decorative door inscribed with several male and female sculptures are observed at the garbhagriha (Rep. Fig. 1). On this roof, there exists a design of lock and key within the beam to provide a rigid support to the roof (Fig. 20a, b). This type of architectural pattern shows how different stone slabs are stacked from floor to the ceiling of the temple.

We have observed different types of fractures on the connecting slabs of the pillars forming the Mahamandap (Fig. 21). These connecting slabs are directly exposed to the nature since the Mahamandap has no roof. Natural weathering has created fractures in them. The fractures are quit deep and the slabs are presently in a vulnerable condition. These connective slabs require immediate restoration. Figure 22 exhibits different types of fractures at the top part of the horizontal slabs connecting the

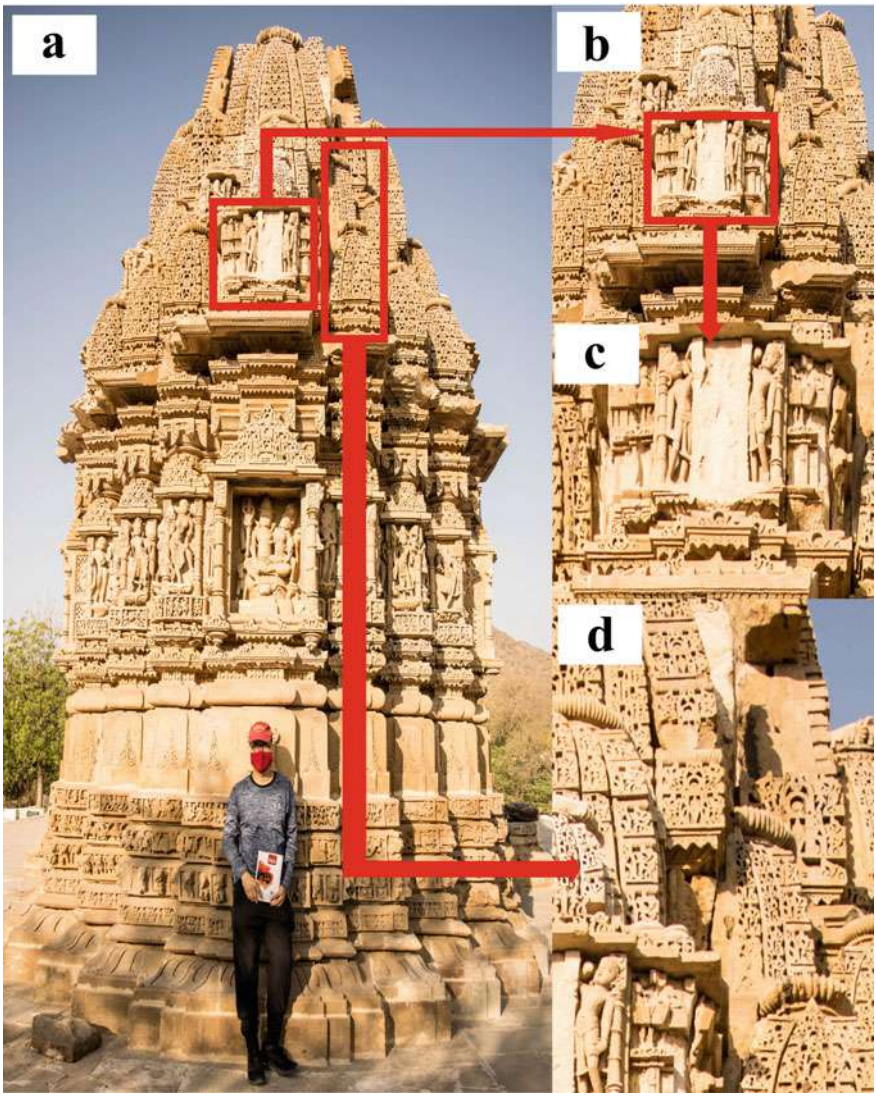


Fig. 12 Top part of the Sikhara of the Shiva temple (Temple no. 1) is completely ruined (Soumyajit Mukherjee as marker), **a** Several part of the Sikhara are damaged, **b, c** Frontal sculpture of the Sikhara is damaged, **d** Part of the back of the Sikhara is damaged

pillars. Natural fractures are also observed at the temple wall (Fig. 23a). Water-induced erosion has created ~2 cm deep cavities in sandstones, giving rise to finally honeycomb appearance (Fig. 23b). In Rep. Fig. 2, the Talchhand section (From the entry gate to the gate of Garbhagriha) is illustrated.

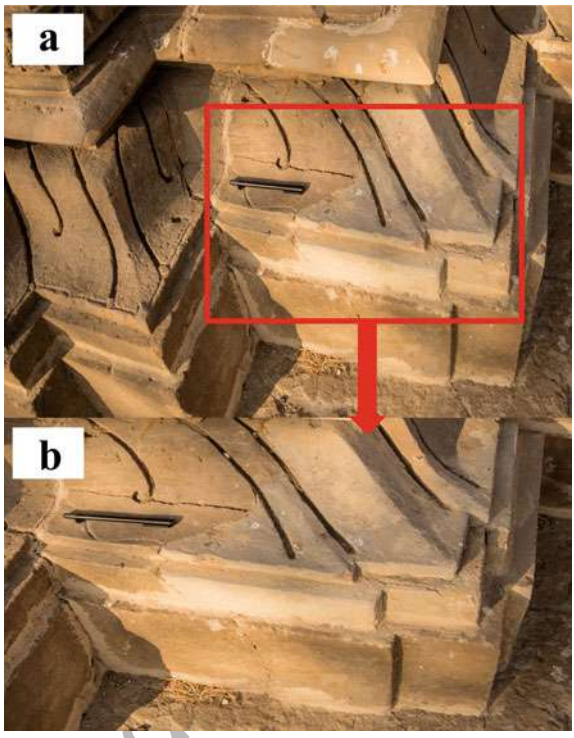


Fig. 13 Color difference in the restored section (black pen marker of length 15 cm) (Temple no. 1). **a** Dark yellow color at the Bhitta section and pale yellow color at the restored section, **b** The color of the restored part is pale yellow and not restored portion is dark yellow at the Jadyakumbha

Natural erosion has also observed at the wall of the Someshwar temple. Figure 24 presents the erosion of the wall. In this figure, the top portion of the left side of the slab is more damaged whereas the right side is more intact. This can occur due to direction of wind flow along a specific direction. In the lower section of this slab, we can observe that the sculptures are decayed due to water clogging. The natural decay at the wall of the Someshwar temple clearly indicates that we need a detail defect and stress distribution study of the temple rocks. The sandstones used to construct the Someshwar temple shows grain size variation in few places (Fig. 25a). In Fig. 25b, the fine grained softer particles are pink, whereas the harder coarse grains are yellow.

We have collected one sample foundation stone from the ruins of this temple and performed uniaxial compressive strength (UCS), transverse strength, porosity, density, abrasive strength calculation to understand the physical properties of the sample stone. Repository Figure 3 displays the sample. These physical properties are engineering properties of the building stone (Deere & Miller, 1966). Indian standard code, as per the present day norm, define the engineering criteria to select the building stone. Rock blocks used in building construction should have compressive strength between 60 and 200 N/mm^2 (IS9143, 1973). Similarly, specific gravity of the building stone can vary 2.4–2.8. Highly porous stone is not good for the moisture full environment condition, so, absorption should not be more than 5% and porosity should be <25% [IS 13030 (1991 reaffirmed 1996 and 2001)]. The porosity

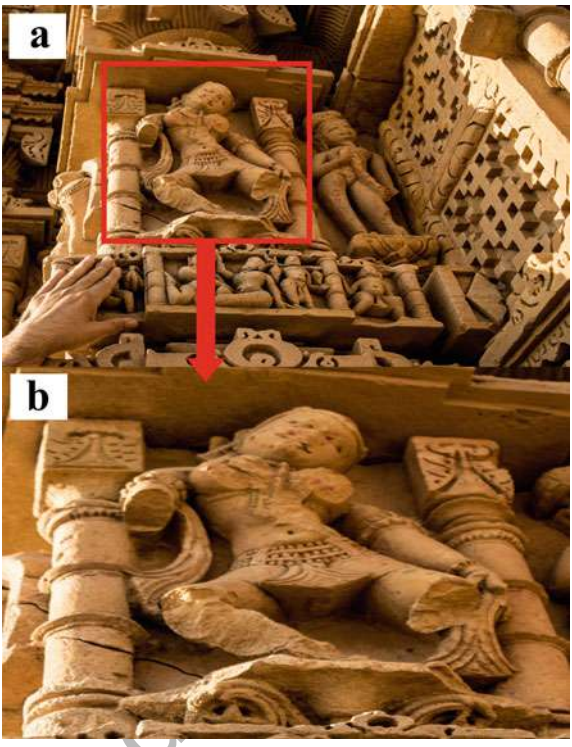


Fig. 14 Natural fracture at the Shiva temple (Temple no. 1) (**a**) and **b** arm, legs and breasts are damaged

of sandstone varies 10–40%. In this study, sandstone has porosity 35–37% in the dry and deserted Barmer area (as per our lab testing). UCS values lies between 12 and 17 N/mm^2. It shows week rock type (IS9143, 1973). But the samples of the Kiradu Temple are weathered; it might be possible, when this temple was constructed, rocks were fresh and had higher UCS values.

7.3 Temple No. 3 (A Completely Ruined Temple)

We have observed that there is no intense weathering related features but yet it is broken. (The fragmented sections of the temple clearly indicate that this temple is not destroyed by natural process. So this might be man-made (Fig. 26a). Figures 26b and 27 present a broken pillar of the Mahamandap. Repository Figure 4 represents a fallen idol (Temple no. 3). We have observed that the idol had worn beaded broad head-band, where the beads are designed as small pots fixed downward direction. The idol had worn a beaded choker and a kundan bead necklace. There are bangles at the arms and wrists of the statue.

Fig. 15 Restoration of sandstone block (black pen marker) (Temple no. 1) with calcareous cementing material

7.4 Temple No. 4 (The Shiva Temple)

In this temple, only the garbhagriha is remaining. The remainder is completely ruined. We have measured tensile strength variation at different sections of this temple using smith hammer. The first foundation stone from the base is of 25 cm thick. The following strengths are measured in four different basement stones (measured from bottom to top), 55 N mm^{-2}, 55 N mm^{-2}, 48 N mm^{-2} and 48 N mm^{-2}, respectively. Strength of the pillar foundation base is 46 N mm^{-2}. The height of the upper base of pillar is 90 cm. Figure 28 shows strength measurement with Smith Hammer at (a) 1st Foundation stone, (b) base of the pillar, (c) base of the Garbhagriha, from Bhitta to Grasapattika. An average of the following strengths measured in three different sides of the pillar are 44 N mm^{-2}, 62 N mm^{-2}, and 51 N mm^{-2} respectively. The strength of the pillar without restoration is evaluated as 56 N mm^{-2}.The strength of the pillar just above 200 cm height from the base is measured of 40 N mm^{-2} (Fig. 28d). The same measurements are performed on the second pillar both on vertical and horizontal plane and strengths are 56–57 N mm^{-2} and N mm^{-2}, respectively. Figure 29 presents the strength measurements at the pillars of the Shiva Temple in (a) vertical and (b) horizontal directions. The base of the Jagati is made up of basalt (Fig. 29d).

Fig. 16 Water outlet along north–south direction of width 8.1 cm and length 20 cm (Temple no. 1) (Canon cap marker of diameter 5.4 cm)

7.5 Temple No. 5 (The Shiva Temple)

Temple no. 5 is also a partially preserved Shiva temple (Rep. Fig. 5). In this figure it is clearly evident that the temple sanctum without Mahamandap where the Sikhara is damaged and some parts of the pillar sections have been restored.

7.6 Temple No. 6 (The Vishnu Temple)

Only the Mahamandap and the damaged wall of the garbhagriha are preserved (Figs. 30 and 31). Within this temple area, several broken slabs inscribed with male and female sculptures are scattered on the ground. Figure 32a, b exhibit the scattered broken slabs of the Vishnu temple. We have visualized male "(Ganesha?)" and female sculptures in those slabs. Decorations (A warrior in the jaw of Makara) at the partially damaged pillars of the Mahamandap are also observed (Rep. Fig. 6). Detail floral motif decorations at the partially damaged pillars of the Mahamandap of the Vishnu temple are still present (Rep. Fig. 7). At the inside wall of the damaged

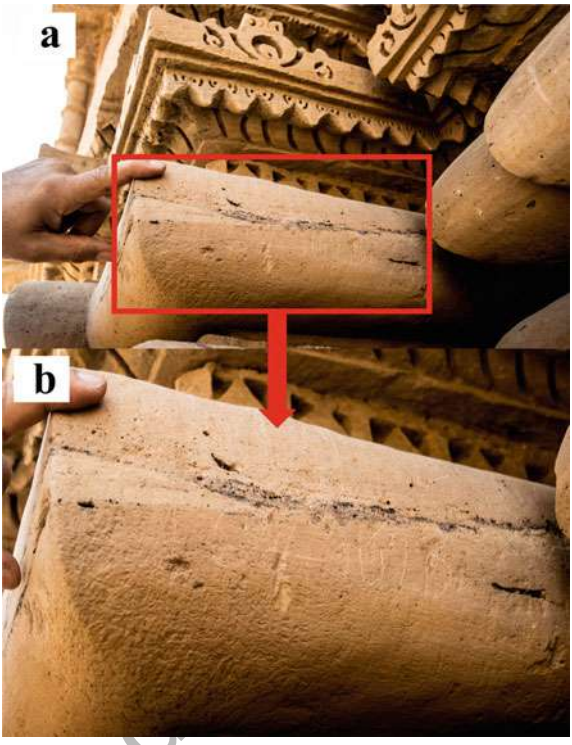


Fig. 17 **a** Black mineral grains marking weak foliation in sandstone (finger marker) (Temple no. 1), **b** A line of black material is observed at the surface of the sandstone

garbhagriha, brown patches are spotted within the sandstone (Fig. 33a, b) A chemical analysis is needed to fully understand the composition of the sandstone.

7.7 Selective Destruction of Female Statues

We have also detected that mostly the female statues of the Kiradu temple complex are destroyed. After a detail observation, it is clearly evident that most of the destruction is due to act of vandalism. An evidence of selectively female idols being vandalized is shown in Fig. 34 (Temple no. 5). In this figure we can clearly see from figure (b) and (d) that men sculptures are intact but figure (c) shows that hands, legs and breasts of the female idol is damaged. Similarly Fig. 35 also exhibits that only female statues are defaced at the Shiva temple (Temple No. 5).

Repository Figure 8 represents vandalized female statues in the Shiva temple (Temple no. 4). In figure Rep. Fig. 8a head and chest part of the female body are defaced. Repository Figure 8b shows that head and leg part of the female sculpture are ruined. Similarly Rep. Fig. 8c manifests that head, breast, hand and leg part of the female idol are completely broken.

Fig. 18 Leaching of water in sandstone at the ceiling of the Shiva temple (Temple no. 1)

Repository Figure 9 shows another female statue vandalized at the Shiva temple (Temple no. 4). Repository Figure 9b, c and d show the vandalized sections of the female body in details. The head, hands and leg part are defaced. Repository Figures 10 and 11 exhibit that only the female statues at the wall of the Shiva temple (Temple no. 4 and 5 respectively) are damaged. From Rep. Fig. 12, the same conclusion can be reached. (Temple no. 5).

7.8 Miscellaneous

In the Kiradu temple complex, we have found male and female idols involving in various activities which highlight a picture of the cultural and social life of Indian civilization during the period the temple was built. They look like isolated sculptures, but at times they are in a row indicating elephant ride and celebration.

Figure 36 displays miniatures in playing and dancing mode. From the left side of this panel, we can see idols playing musical instruments e.g., flute and, sarangi. Figure 37 shows female miniatures in various dancing pose. Man playing with elephants is also sculpted at the wall (Fig. 38). Statue in yoga posture (Padmasana) is observed (Fig. 39). We have found female idol holding some scriptures in hand

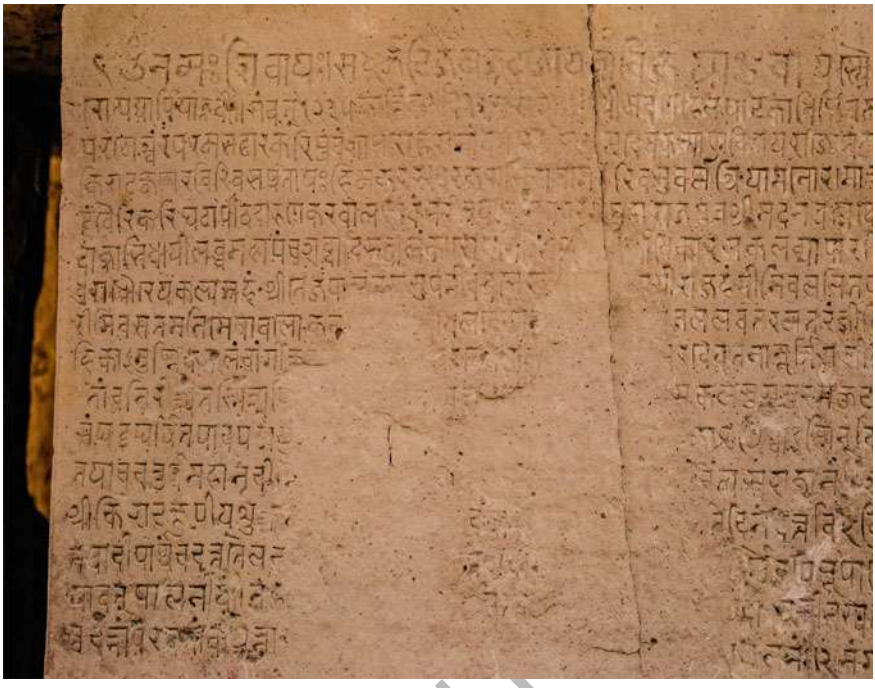


Fig. 19 Partly destroyed inscription at the wall of the Someshwar temple (Temple no. 2)

(Fig. 40). Warriors moving a chariot is also inscribed at the wall (Fig. 41). Panels of warriors fighting with swords are also observed (Fig. 42). From Fig. 43, we can see that sculpture ornamented with various jewellery like heavily designed kamar-bandh, baju-bandh, choker, necklace. We can also get an idea regarding the lifestyle and economic condition of the people of that time from these sculptures.

Besides, we have also observed different types of fractures at the panels of the temple wall. Figure 44 displays fracture cutting all the idols. Again we can observe almost sculptures eroded naturally (Fig. 45).

Indian temples sometimes tell a story like the story of the Ramayana or Mahabharata or life of Buddha. On our existing observations, no such stories are deciphered in the temples. In future, we need to check whether any coherent stories are told in any temple, or are they just designs.

8 Importance of Study and Future Scope

Despite few restoration works visible, some sections of the Kiradu temple are in a vulnerable state and restorations are urgently required. We need to investigate specific gravity, porosity, permeability, moisture content and chemical composition

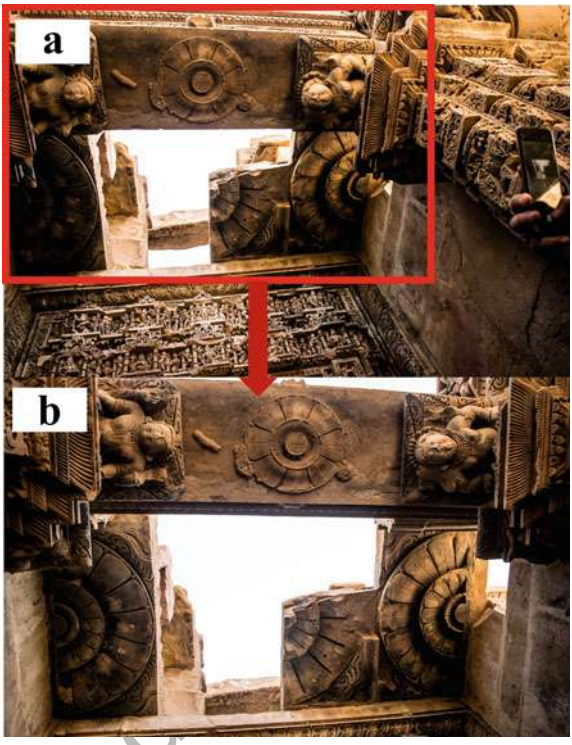
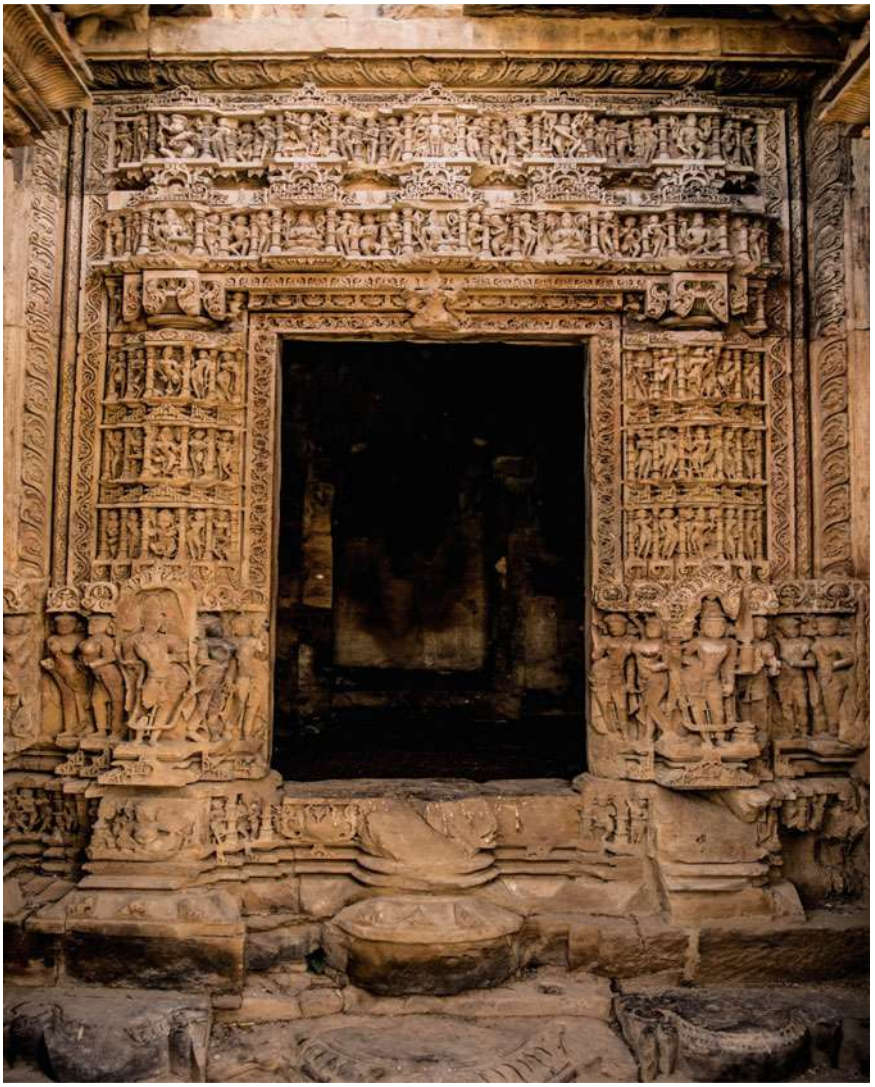


Fig. 20 Lock and key design atop the garbhagriha of the Someshwar temple (Temple no. 2). **a** Inside part of the roof over the door of the garbhagriha, **b** Lock and key design within the slab to hold the roof

of the constituent material of the temple, i.e., the sandstone. Analysis of physical properties, pore structures and a more detail strength test of the sandstones used to construct this temple would be the future task. We also should perform defect study at the surface to understand the diffusion, interface behavior and deformation of the constructional material.

9 Conclusions

In this study we have focused on the present status of the Kiradu temple. We have looked into different temples and tried to understand fractures and their origin and vulnerability. We have looked into the architectural design of the Shiva temple and the Someshwar temple and tried to make a connection between the architecture of the Vishnu temple as mentioned in the literature. We have measured the strength of various sections of one of the partially damaged Shiva temple. We have investigated several destructed male and female idols to understand their reason of their decay. We have observed the foliation and weathering at the outer wall of the temples. We have found that some of the fractures are actually in a very vulnerable situation and an immediate restoration is required. We have also documented several female idols



Rep. Fig. 1 Decorative door inscribed with several male and female sculptures are observed at the garbhagriha (Temple no. 2)

which are clear indication of man-made destruction. Though some analysis have been made so far, a detail compositional and strength study is required to understand the structural analysis of the temple.

Fig. 21 Fracture at the Mahamandap of the Someshwar temple (Temple no. 2). **a** Fracture at the top part of the connecting slab of the pillars. **b** The fracture is deep and vulnerable

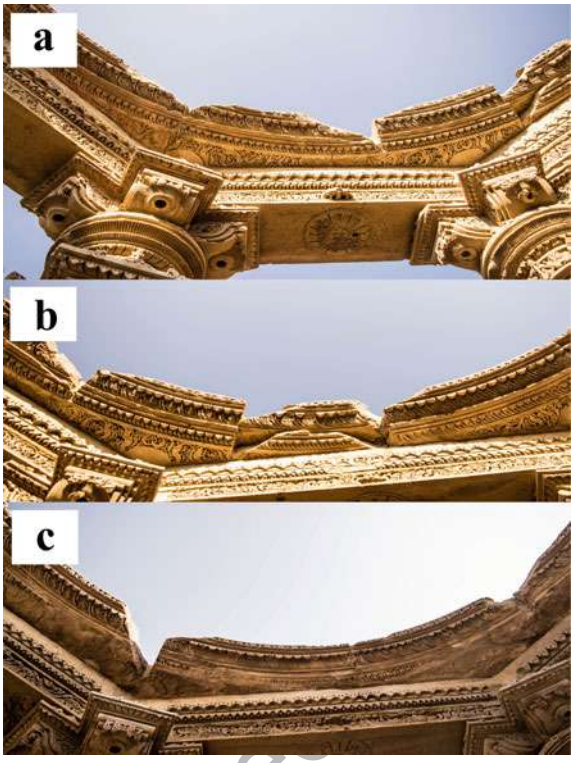


Fig. 22 Different types of fracture at Mahamandap of the Someshwar temple (Temple no. 2). **a–c** Fractures at the top part of the ligands connecting the pillar of Mahamandap

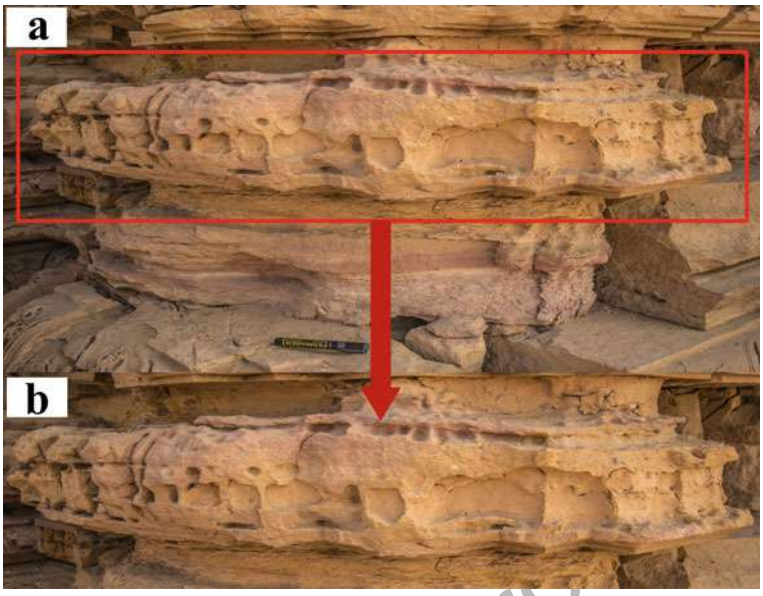


Fig. 23 **a** Natural fracture at the wall of the Someshwar temple (Temple no. 2) (black pen of length 14 cm), **b** Weathering of the wall producing a honeycomb geometry in sandstone

Rep. Fig. 2 Decorative pillars of Mahamandap and Talchhand (Temple no. 2). Soumyajit Mukherjee and Ritojit Mukherjee as markers

Fig. 24 Weathering of the Someshwar temple wall (Temple no. 2) (black pen of length 14 cm)

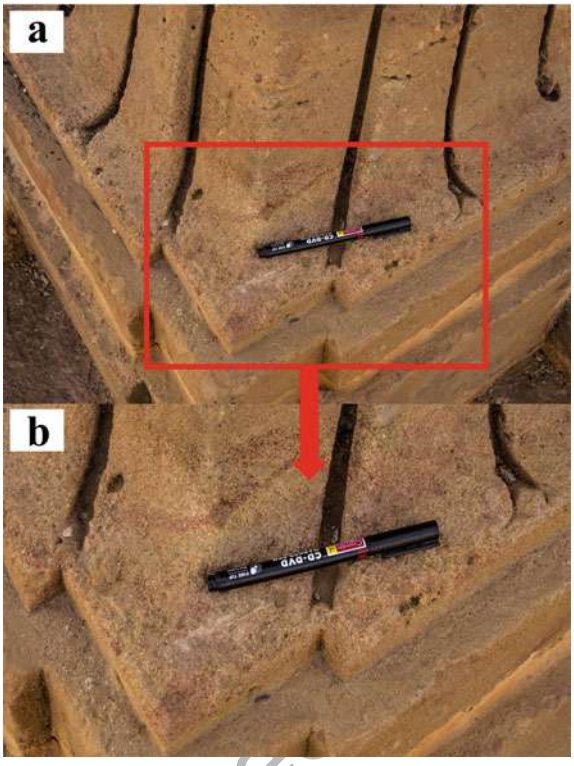


Fig. 25 **a** Grain size difference noted at the wall of the Someshwar temple (Temple no. 2) (black pen marker of length 14 cm); **b** coarse and fine grain within the sandstone are clearly distinguished

Rep. Fig. 3 Sample collected for testing from Temple no. 2

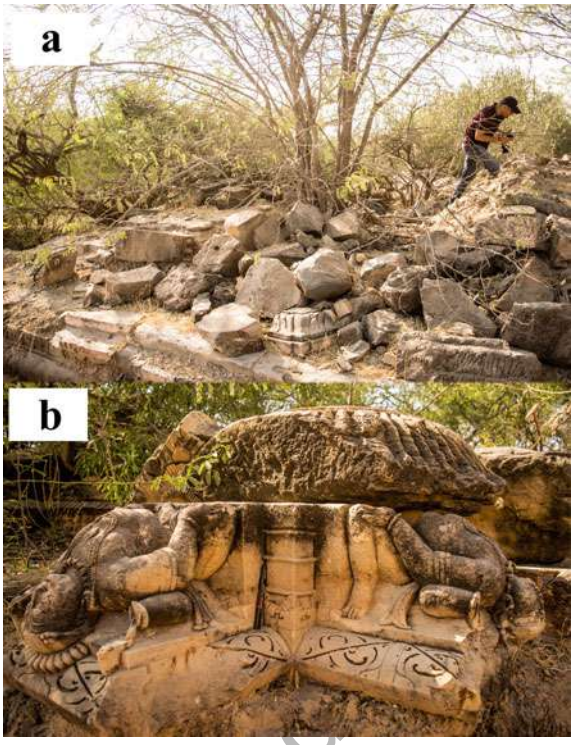


Fig. 26 **a** Completely destroyed temple (Temple no. 3). **b** Fragmented pillar of Mahamandap (black pen maker kept in between the two vandalised statues (Temple no. 3))

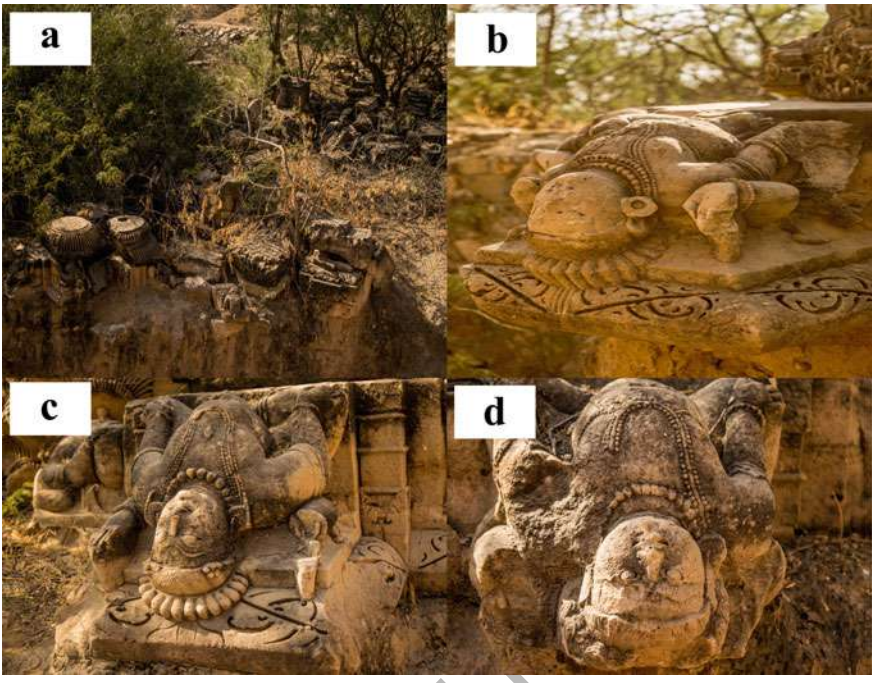
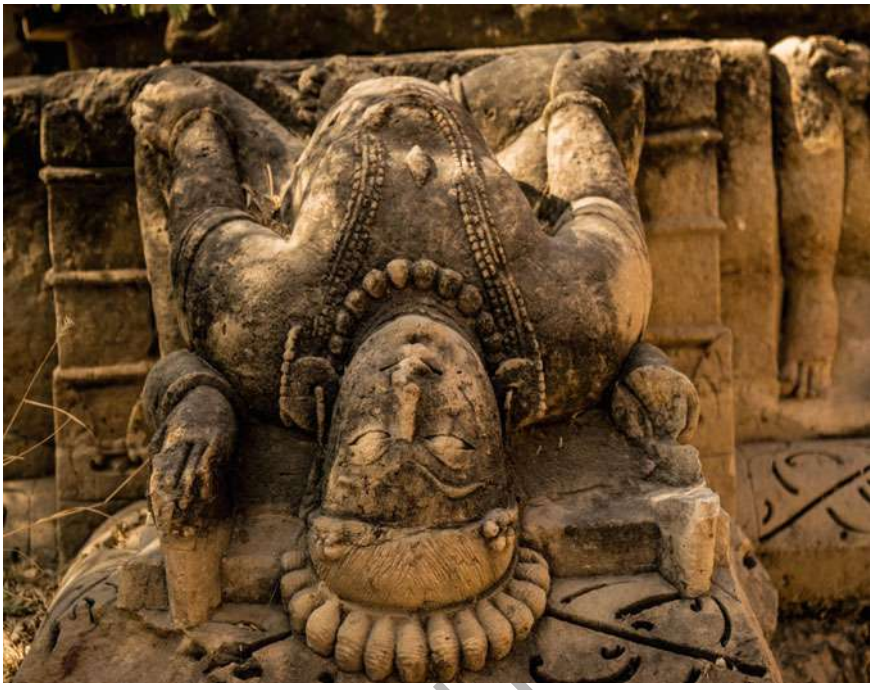


Fig. 27 **a** Scattered part of completely destroyed temple (Temple no. 3), **b–d** Demolished part of the pillars (Temple no. 3)



Rep. Fig. 4 A fallen idol ornamented with various jewellery (Temple no. 3)

Fig. 28 Strength measurement with Smith Hammer at the Shiva Temple (Temple no. 4) for **a** first foundation stone, **b** base of the pillar, **c** Height (from the base of the pillar to the section where the smith hammer is kept) and strength measurement at the base of the Garbhagriha (From Bhitta to Grasapattika), and **d** strength measurement at the pillar

Fig. 29 Strength measurement with Smith Hammer at the pillars of the Shiva Temple (Temple no. 4) in **a** vertical direction, **b** horizontal direction, **c** Basalt base of Jagati (Smith hammer marker of length 24 cm)

Rep. Fig. 5 Frontal image of the partially damaged Shiva temple (Temple no. 5)

Fig. 30 Vishnu Temple (Temple no. 6). Only Mahamandap is remaining and Garbhagriha is also in damaged condition

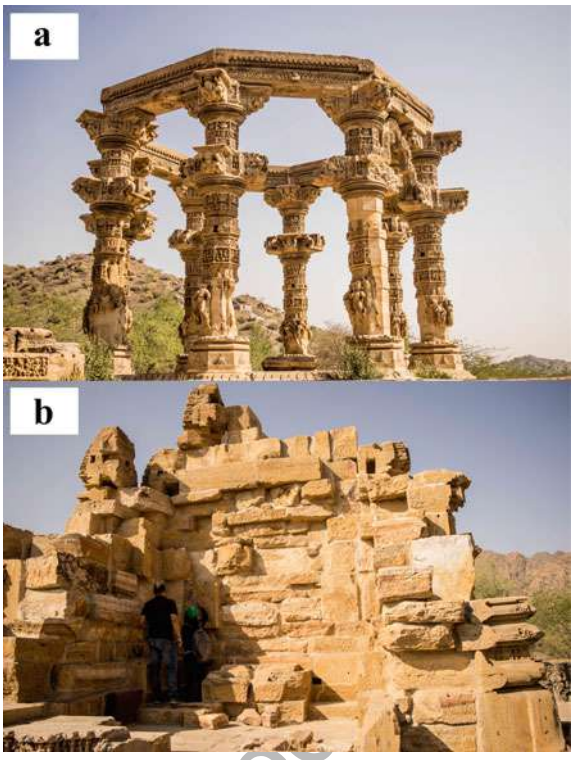


Fig. 31 Vishnu Temple (Temple no. 6). **a** Only Mahamandap is remaining, **b** Garbhagriha is completely ruined

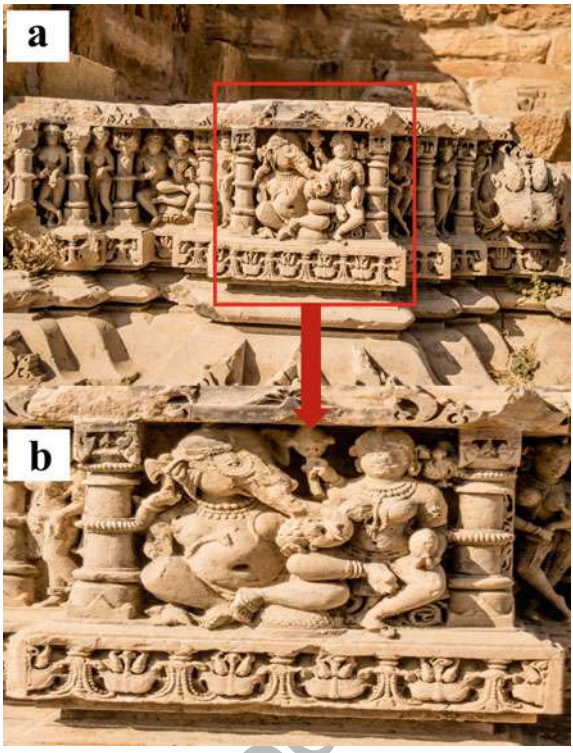


Fig. 32 **a, b** Display the broken slab of the Vishnu temple (Temple no. 6) inscribed with male "(Ganesha?)" and female sculptures

Rep. Fig. 6 Decorations (A warrior in the jaw of Makara) at the partially damaged pillars of the Mahamandap of the Vishnu temple (Temple no. 6)

Rep. Fig. 7 Detail Decorations (Floral motif) at the partially damaged pillars of the Mahamandap of the Vishnu temple (Temple no. 6)

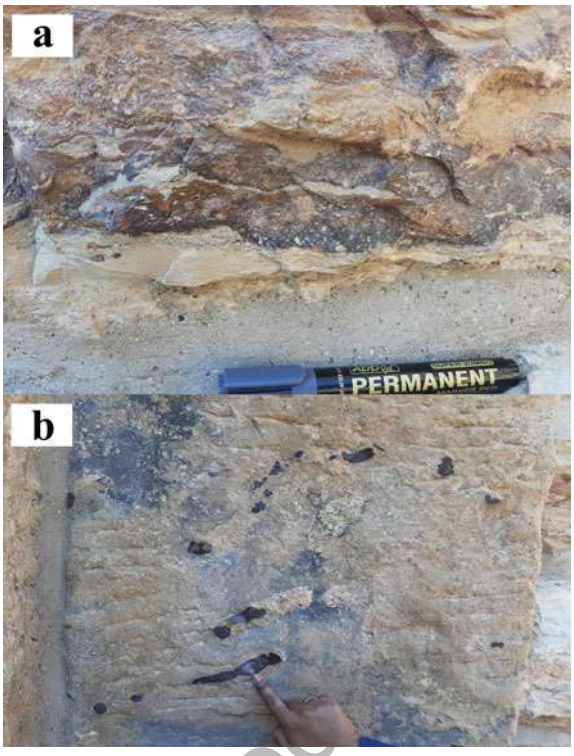


Fig. 33 **a** Presence of iron within the sandstone brown in color (black pen marker), **b** brown patches, possibly indicating iron (finger marker) at the wall of the Garbhagriha of Vishnu temple (temple no. 6)

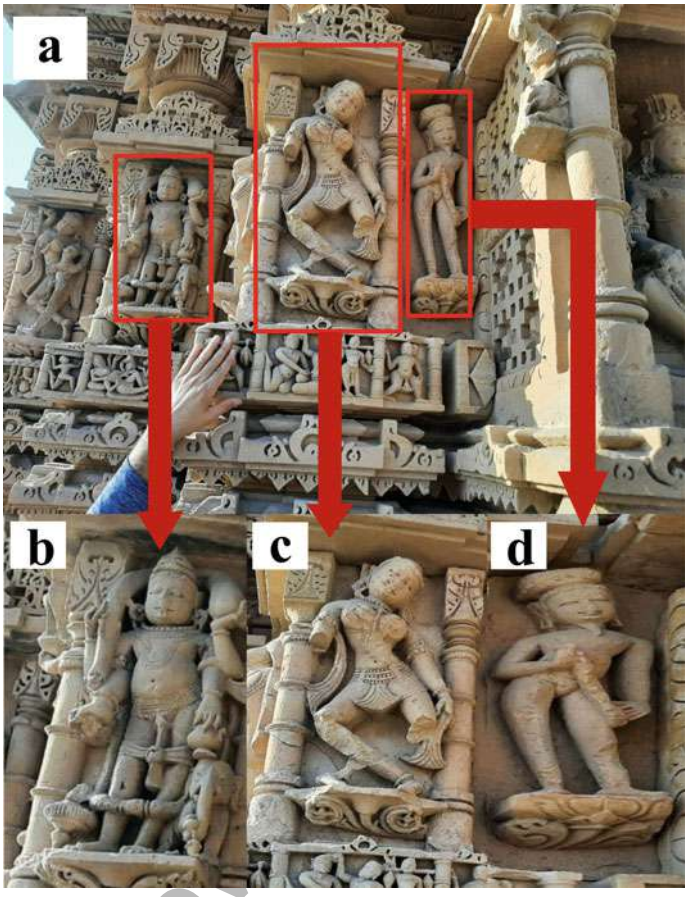


Fig. 34 **a** Only female statues are vandalized at the Shiva temple (Temple no. 5) (hand as marker), **b** sculpture of man idol is intact, **c** hand, legs of the female idol are damaged. **d** Sculpture of man idol is intact

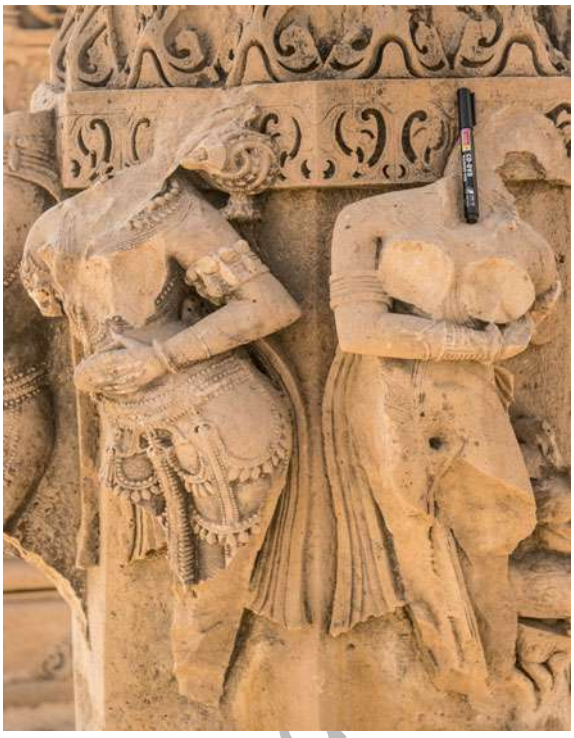
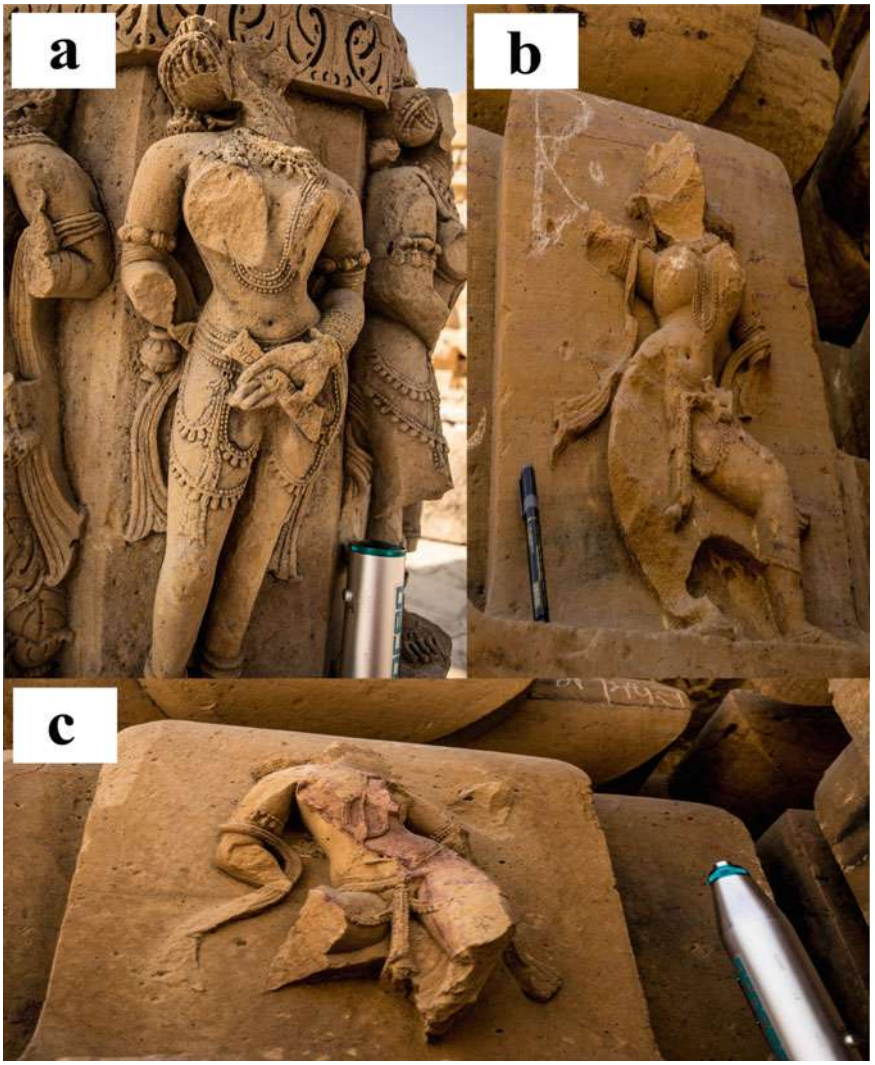
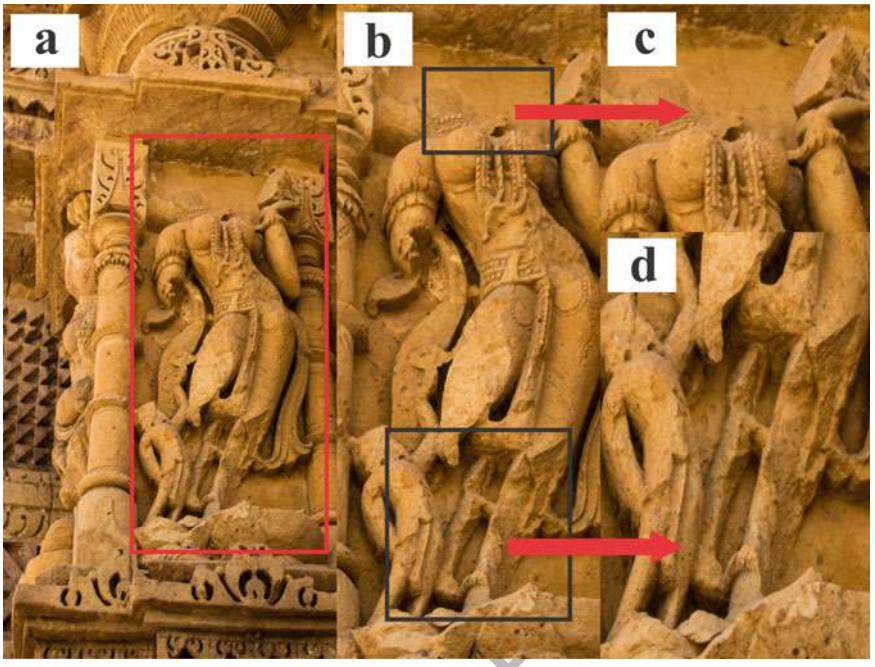


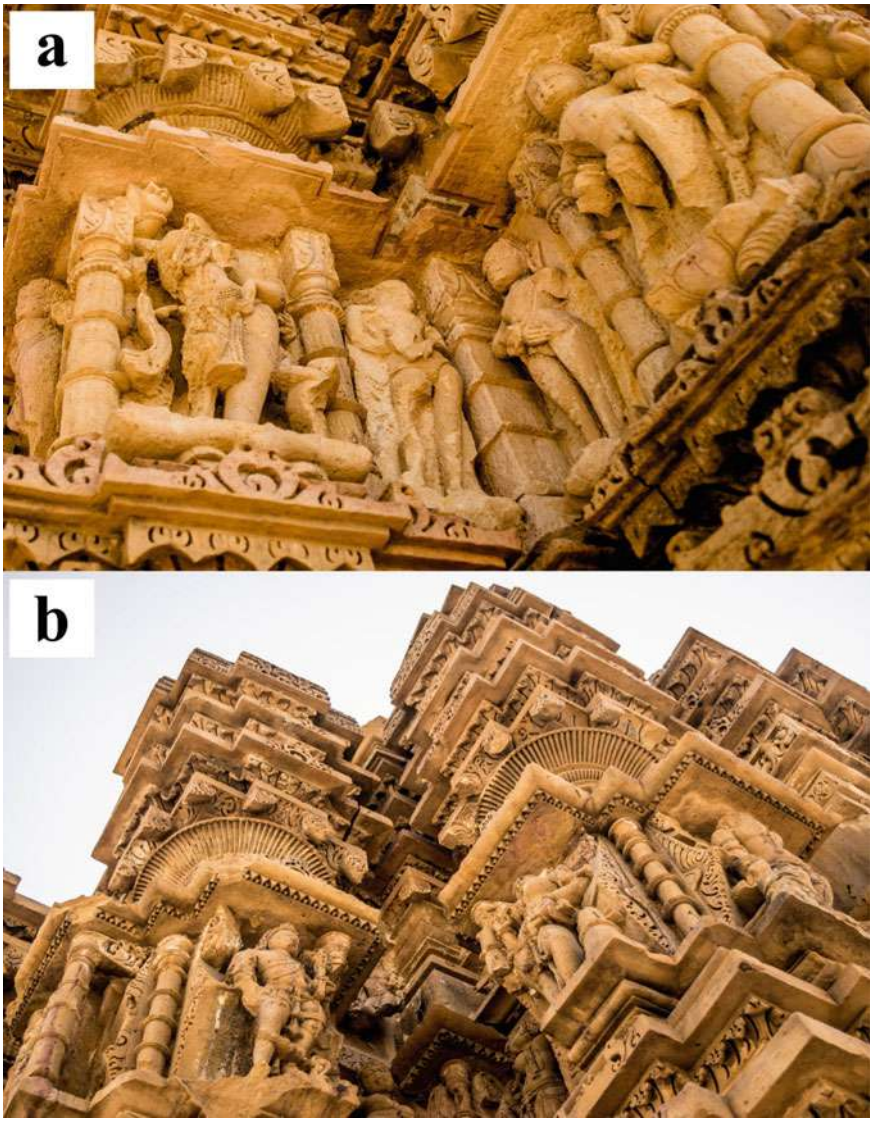
Fig. 35 Only female statues are vandalized at the Shiva temple (Temple no. 5) (black pen marker of length 14 cm)



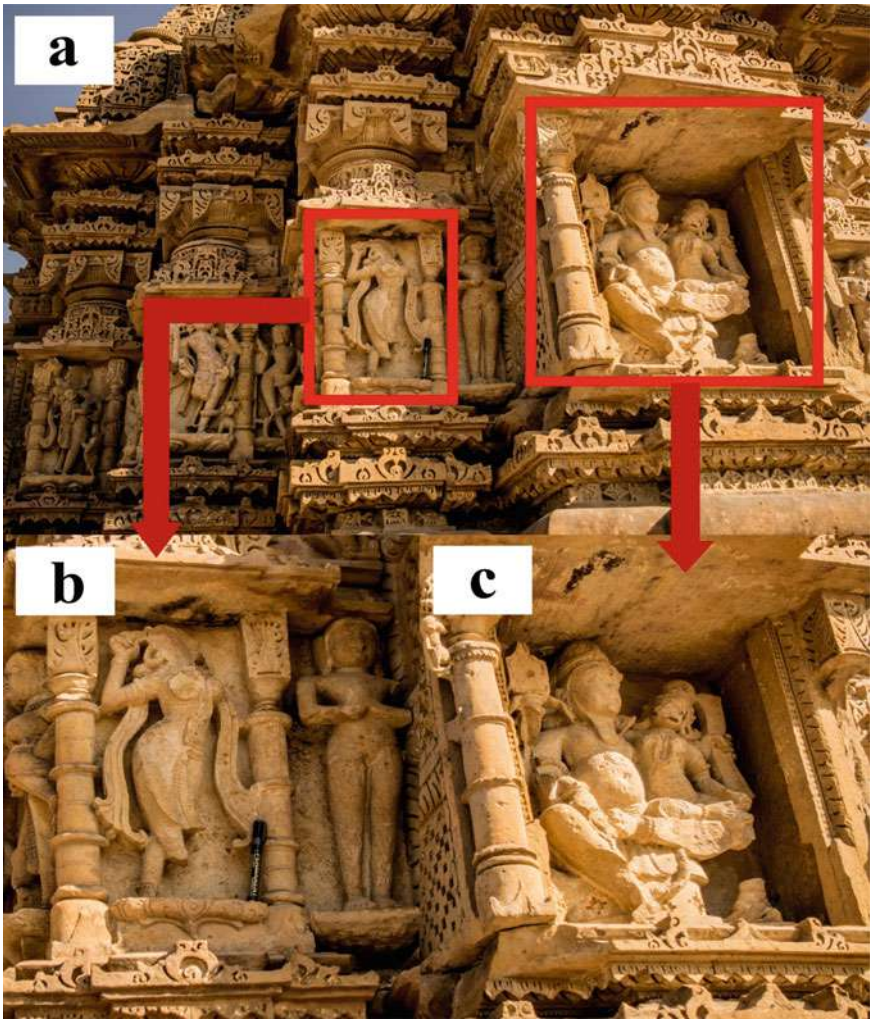
Rep. Fig. 8 Female statues are damaged due to act of vandalism at the Shiva temple (Temple no. 4) **a** Head and breasts destroyed (Smith hammer marker), **b** Head and leg of the female idol are ruined (black pen marker of length 14 cm), **c** Head, breasts, hands and legs of the female idol are broken (Smith hammer marker)



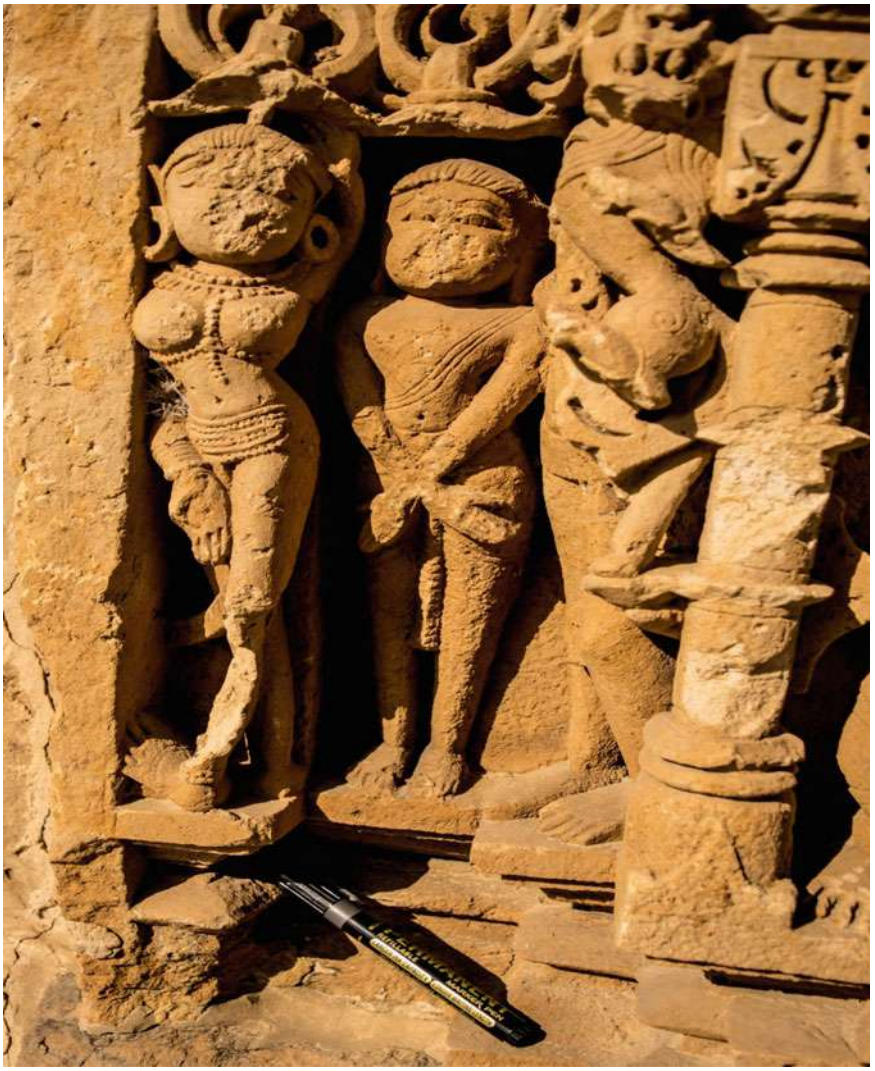
Rep. Fig. 9 **a** Female statue is damaged due to act of vandalism at the Shiva temple (Temple no. 4), **b** Head, hands and leg parts destroyed



Rep. Fig. 10 a, b Female statues are vandalized at the Shiva temple (Temple no. 4)



Rep. Fig. 11 **a** Only the female statues are vandalized at the Shiva temple (Temple no. 5), **b** Head, breasts, hand and leg are defaced of the female idol, **c** An idol of a man is not damaged



Rep. Fig. 12 At the Shiva temple (Temple no. 5) (black pen marker of length 14 cm)

Fig. 36 Statues playing music and dancing

Fig. 37 Female idols in dancing pose

Fig. 38 Wall decoration where man is playing with elephants

Fig. 39 Statue in a yoga posture (Padmasana)

Fig. 40 Female idol holding some scripture

Fig. 41 Moving a chariot

Fig. 42 Statues fighting with swords

Fig. 43 An idol ornamented with various jewellery

Fig. 44 Through going fracture cutting all the idols

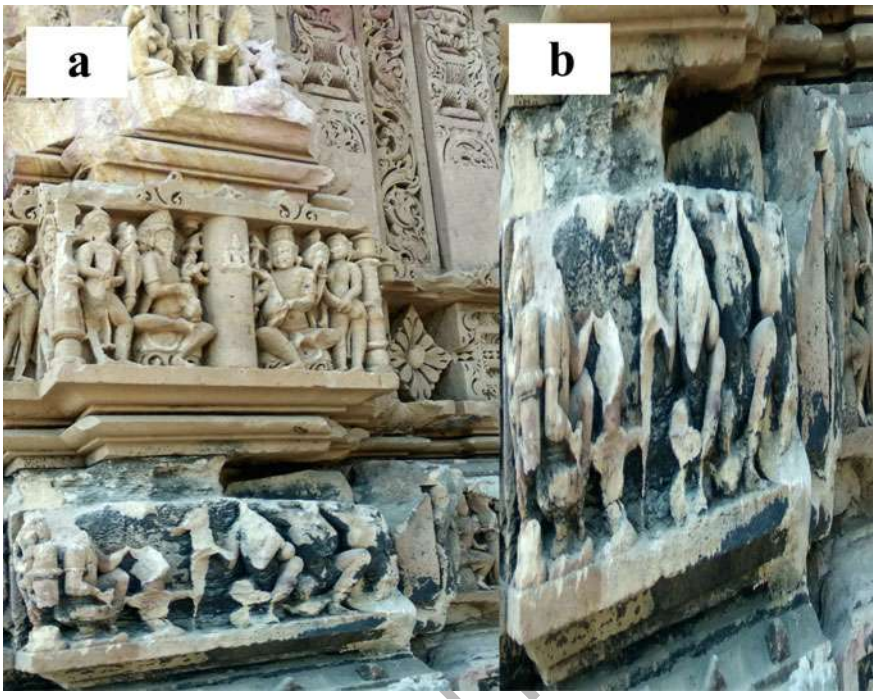


Fig. 45 Almost destructed sculpture by natural erosion

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