Journal of History, Archaeology and Architecture
ISSN: 2583-5106, Vol. 5, No. 1, 2026, pp. 25-39
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URL: http://www.pbjournals.com/jhaa
Publisher of Open Access Journals
Peer Reviewed Journal

Resources for Fort Making in a Hilly Religious Landscape: A Study of Vindhyachal Since Historical Times

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Abstract: The Vindhyānchal region of Uttar Pradesh lies in the Eastern Vindhya and Kamiur hills, with a unique interaction of the terrain; these regions are not only shaped geographically but also have embedded in them religious and cultural history. The geography of Vindhyānchal provides an elevated topography, rivers, hills, and escarpments that favored fortification in this region, endowed with Vindhyan sandstone, granite, quartzite, and the famous GI tag Chunar sandstone, which was used for both fortification and architecture across the northern plain along the Ganga from the Mauryan period to the colonial period. This region not only has geological but also has religious and cultural richness. The Vindhyānchal region is associated with Hindu mythology and sacred traditions, which makes the integration of forts into this sacred landscape unique. The forts in the region served not only defensive and luxurious purposes, but also as the center of political legitimacy and sacred authority, allowing themb to control the region. understanding Forts in the Vindhyāchal region requires moving beyond an isolated architectural perspective, focusing on a wider perspective of geography, religion, geology, and culture of the region to understand. Such an approach reveals how resources, sacred landscape, and culture collectively shaped fortification over centuries. This study is going to highlight the role of geography and religious landscapes in enhancing the dimension of fortification in the Vindhyanchal region.

Keywords: Vindhyāchal, Chunar sandstone, Fortification, Sacred landscape, Cultural Geography, Hindu mythology,

Received : 11 March 2026
Revised : 14 April 2026
Accepted : 19 April 2026
Published : 25 June 2026

TO CITE THIS ARTICLE:

Vijay Kumar (2026). Resources for Fort Making in a Hilly Religious Landscape: A Study of Vindhyachal Since Historical Times. *Journal of History, Archaeology and Architecture,* 5: 1, pp. 25-39.

INTRODUCTION

Landscape can be referred to as a cultural construct, a way of perception that evolves over time in response to societal needs and the shifting historical contexts within which it is situated. (Conzen,2001). It represents the dynamic interaction between humans and their surrounding environment, and their cultural and ecological relationship with nature. (Deng, *et al*, 2021) Religious landscapes embody the deliberate shaping of space and are filled with spiritual meaning, setting them apart from cultic sites and ritual spaces (De Polignac, F,2010). Architecture around religious landscapes constitute a unique role because it documents one of the most important components, material and Cultural Heritage of Religion (Mastalerczyk, 2016).

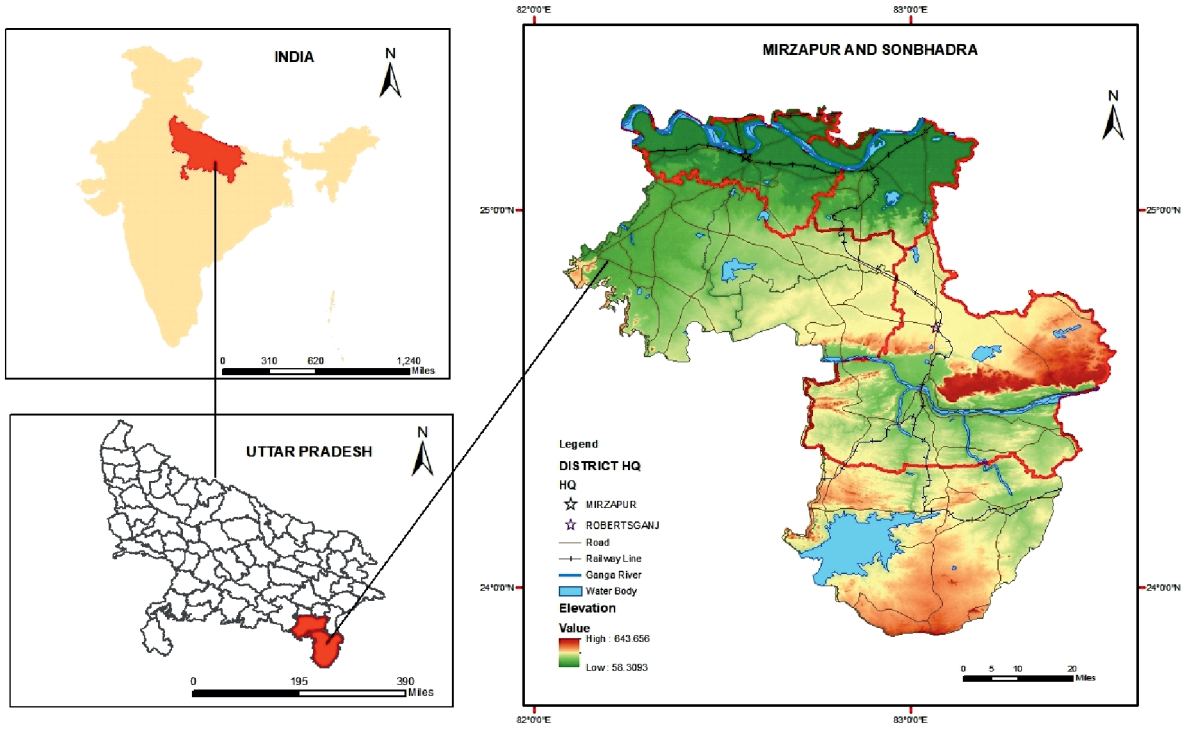

Fig. 1: Study Area Map

Throughout history, fortifications have played a vital role in the security and functioning of societies; they are representations of protective structures and have also served as symbols of cultural identity. (Remya,2023). Today forts stand as an extant and symbolic part of history; their origins trace back to the period before the rise of Kingdoms. The earliest form of forts is a deception of a defensive system often built in natural ecosystems, on the sides of rivers, Hills, and caves. The defence walls of the Citadel in the Harrapan civilization are a kind of fortification. Architectural transformations show the shifting socio-political climate of the region. These, seen in the medieval period, were deeply connected to the military and political interplay of the Indian subcontinent from the 13th to the 18th centuries.

The Vindhyānchal region is the amalgamation of Sacred sites, Pilgrimage, Riverine and Geological structures which provides a resources base for fortification. In the Vedic texts, India's two major epics, the Ramayana and the *Mahabharata*, contain numerous references to forts and their structures. Terms such as "Vapra" and "Chataja," meaning "earthen rampart," are used to describe these fortifications. The *Adiparva* of the *Mahabharata* depicts Indraprastha as a fortified city with multiple gates, towering walls, and a wide moat. On the other side, the Ramayana describes Ayodhya as an invincible city, completely surrounded by a dense, protective moat and secured with massive gateways and watchtowers. (Remay,2023)

India's history, the fort and the strength of the state have been interlinked, with forts functions as essential centers for the preservation and endurance of political authority (Deshpande, 2016). Vāstuvidyā and *Śilpaśāstra*, the ancient sciences of architecture, were among the earliest technical disciplines studied in India. Initially, the term vāstu referred to building construction, but over time it was also applied to the design and construction of fortifications.

Fortifications and forts reflect the geographical and topographical contexts in which they were built, and their forms evolved, differing across dynasties and historical periods. The Indian subcontinent has witnessed the construction of a vast number of forts throughout its history.

Hilly terrains have historically provided natural advantages for fort construction, a concept known in ancient Sanskrit texts as *giridurga* (hill fort) (Kangle, 1960). Elevated landforms, steep escarpments, and difficult access routes offered both defensive security and strategic command over surrounding plains. The Vindhya–Kaimur highlands of central India, rulers adapted topography into fortified landscapes that combined military, administrative, and religious functions (UNESCO, 2013; Wescoat, 2018). Within the Vindhyānchal hills, an important cultural and strategic zone, forts were often sited on sandstone plateaus and adaptation, built on a rock of Vindhyan sandstone overlooking the Ganga. Its strong ramparts, wells, and Afghan-era architectural additions reflect a long continuity from ancient to colonial control (Telesara *et al*., 2021).Vindhyānchal religious landscape and it rugged terrain, and Ganga and it is tributaries, not only shape the landscape but also associated with the divine narrative. The Picturesque hill rock, Terrace, river. offered natural defensive advantage which results religious landscape integrated with a fortification (Raghunathan & Shina, 2006) in the fortification in a religious landscape of Vindhyānchalis a fusion of different architectural style which reflected devotion and purpose. The purpose and function of space evolved over time, adapting to the changing political dynamics of successive dynasties and the cultural transformations they introduced, while being continually shaped by religious practices and socio-cultural traditions throughout history.

GEOLOGY AND GEOGRAPHY OF REGION

During the Paleo- to Mesoproterozoic era, the Earth witnessed the formation of numerous intra-cratonic basins within stable continental shields and platform regions worldwide. The Indian subcontinent

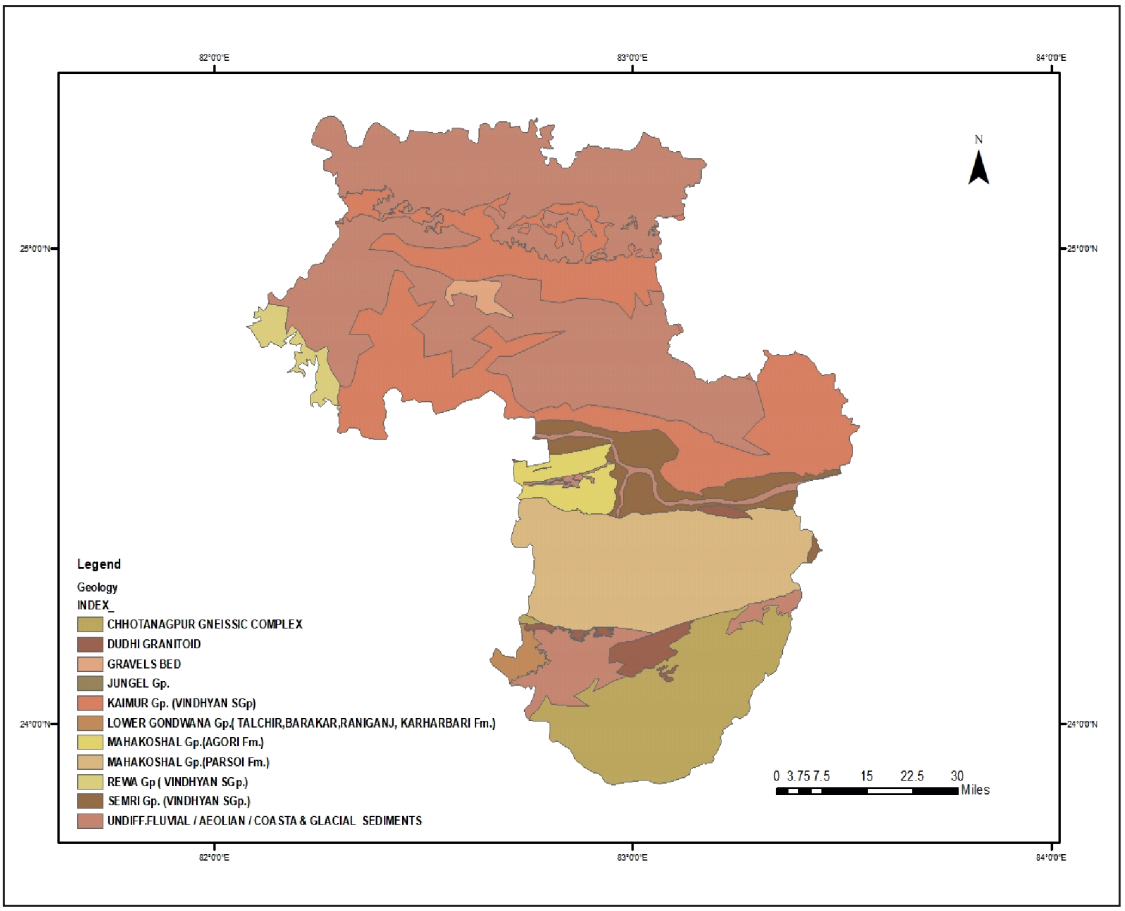

Fig. 2: Geological Map of Region

hosts four such basins, which developed as a result of prolonged rifting and subsidence in the central portion of the peninsular shield. Among these, the Vindhyan Basin, situated in central India, is notable for its extensive succession of rocks belonging to the Vindhyan Supergroup. (Kailasam, 1976; Bose *et al*., 2001; Basu & Chakrabarti, 2020)

The Vindhyan Supergroup is stratigraphically divided into two major units: the Lower Vindhyan, referred to as the Semri Group, and the Upper Vindhyan, which is further subdivided into the Kaimur, Rewa, and Bhander Groups. This classification is based on a prominent basin-wide unconformity and associated conformities. The Semri Group, in ascending order, consists of the Basal Conglomerate Formation, Kajarahat Limestone Formation, Porcellanite Formation, Kheinjua Formation, and Rohtas Limestone Formation. Within the Kheinjua Formation, three key lithounits are recognized: Olive Shale, Fawn Limestone, and Glauconitic Sandstone. A distinctive conglomerate bed, composed primarily of jasper pebbles, is present at the boundary between the Fawn Limestone and Glauconitic Sandstone. The age of the Vindhyan Supergroup remains debated; however, the Semri Group is generally considered to be around 1600 million years old, although reports of small shelly fossils of Cambrian affinity from the Semri Group have added to the controversy(Singh *et al*,(2014)

The Vindhyan Supergroup mostly includes gently tilted layers of sandstone, shale, and carbonate rocks, along with some conglomerates (rocks made of rounded pebbles) and volcanic-origin rocks. These are separated by a major regional break in deposition and several smaller local ones. In the southern uplands of Mirzapur, the Lower Vindhyan rocks are clearly visible. These include: Bijawar Shale, Dhandraul Quartzite, Sandstone, and limestone layers placed one over the other. These rock formations are very old, dating back to the Proterozoic Era, and are structurally stable, meaning they have not been changed much by pressure or heat over time. (Kumar & Yadav, 2015)

TABLELAND

The Vindhyan Plateau, or central plateau region, occupies the area between the Vindhyan escarpment and the Kaimur range. It stretches roughly 112 km east–west, with a north–south width of 30–40 km, covering over 1,600 square kilometres. The southern boundary is marked by the Kaimur range, which rises from about 365 m to nearly 800 m in its western part before breaking into smaller hills toward the centre and terminating in a steep escarpment overlooking the Son River valley. Southward, the plateau culminates in striking features such as the crag of Mangeswar, the fortified rock of Bijaygarh, and the Bagdhaura peak near Argarh. From this point, it trends east, gradually lowering in elevation until reaching the district boundary.

The eastern sector comprises the southern portion of the Kera-Mangraurpargana, characterized as a tableland enclosed by two roughly parallel hill ranges. Its surface is dissected by low, wooded ridges and narrow, fertile valleys drained by hill streams that eventually join the Belan and Son rivers.

South of the Chunar area, near the old Deccan road, the plateau slopes gradually southwestward toward the Belan River, where soil fertility improves but declines again beyond the river, giving way to long stretches of poorer soils reaching the Kaimur foothills. Further east, running almost to the Bihar border, lies a narrow yet exceptionally fertile strip passing through Halia, Ghorawal, Robertsganj, and Bijaygarh, roughly parallel to the Kaimur range.Toward the southern end, the landscape gives way to rocky terrain and forested tracts before dropping sharply into the Son River valley. (UttarPradesh District Gazetteers Mirzapur,1998)

VINDHYAN HILLS

The dominant landforms are the flat-topped, mesa-like hills, composed of horizontally bedded sandstone, shale, and limestone from the Kaimur, Rewa, and Bhander Groups. (Kaur *et al*, 2019) The Chunar Hills, located in southeastern Mirzapur district, are geologically part of the Vindhyan Supergroup, specifically the Kaimur Group of the Upper Vindhyan succession. These hills are predominantly composed of fine- to medium-grained, reddish quartzose sandstone, popularly known as Chunar Sandstone. The sandstone is massive, hard, and well-cemented with a ferruginous matrix, making it suitable for detailed carvings like those seen in the Chunar Fort and the Ashokan pillars (Singh, 2021)

The Kaimur hills, extending through the northern part of Sonbhadra district in southeastern Uttar Pradesh, form a prominent escarpment of the Vindhyan Supergroup, specifically belonging to the Upper Vindhyan succession. The rocks of the Kaimur Group are of fluvial origin. The Upper Kaimur Group is divided into three main layers: Bijaigarh Shale at the bottom, Scarp Sandstone in the middle, and Dhandraul Sandstone at the top. This group shows a abrading upward sequence, which means the rock layers change from fine-grained at the bottom to coarser material at the top. Bijaigarh Shale mainly consists of shales, which are made of sandy to clay-like material. It can be up to 50 meters thick. The estimated age of this layer varies; some studies suggest it is about 750 million years old. Common features in this layer include ripple marks and mud cracks, which are signs of ancient water movement and drying. Scarp Sandstone appears in colors like pinkish red, olive green, gray, and even black. It is a medium-grained sandstone and shows structures such as cross-bedding, current bedding, and lenticular bedding, which all suggest active water flow during its formation.(Mishra and Sen, 2010)

DRAINAGE

The Son River is the main river flowing through Sonbhadra district from east to west. It follows the natural alignment of the Vindhyan rocks and flows through softer rocks of the Lower Vindhyan Group. The Rihand and Bijul rivers, which are its main tributaries, flow from north to south and join the Son River at right angles. Geologically, the Son valley is a continuation of the Narmada valley. The Son River has a steep slope (about 35 to 55 cm per kilometer), which causes fast water flow and seasonal water levels. Most of its tributaries come from the south, except for the Ghaghara River, which comes from the north and joins the Son at Chopan. The Ghaghara flows mainly through areas with limestone rocks. The Kanhar River also flows from south to north and joins the Son near Kota. Similarly, the Panda River flows from the south and meets the Son near Kon, close to the Bihar border. (Mishra & Mishra, 2013)

Mirzapur district is primarily drained by the Ganga River and its southern tributaries, forming a dendritic to sub-dendritic drainage pattern influenced by the underlying Vindhyan geology. The Ganga River, flowing from west to east along the northern boundary of the district (Valdiya, 2010). In the southern part of the district, the drainage is governed by seasonal streams and rivers originating from the Vindhyan Plateau and hills. These streams generally flow northward, ultimately draining into the Ganga (Dubey & Singh, 2004).The Vindhyan escarpment and structural features, such as fractures and joints in the rock formations, guide the direction of flow. Due to hard, jointed sandstone bedrock and steep gradients in the south, many streams are seasonal with high runoff during the monsoon (CGWB, 2013).

CLIMATE

The climate of the region is tropical and influenced by the monsoon. The year is divided into three main seasons: winter (November to February), summer (April to mid-June), and the rainy season (late June to October). The average minimum temperature each month ranges from 13.4°C to 30.7°C, while the average maximum temperature ranges from 23.4°C to 40.2°C. The area stays dry for about nine months and remains moist for around three months, mainly due to the southwest monsoon, which brings around 87% of the total annual rainfall. The average yearly rainfall in the district is between 850 mm and 1300 mm, with most of it (about 85%) falling during the rainy season. (Mishra & Mishra,2013)

SOIL

The Vindhyānchalregion, stretching across parts of Mirzapur and Sonbhadra districts in southeastern Uttar Pradesh, features a diverse range of soils shaped by its complex geology, terrain, and climate. In Eastern Uttar Pradesh, the Sonbhadra and Mirzapur districts have similar weather, such as temperature and rainfall. However, Sonbhadra has more varied rock types, which lead to the formation of different kinds of fertile soils.

The soils in Sonbhadra have developed from very old rocks like sandstone, limestone, shale, slate, phyllite, and granite, which belong to the Archaean and Proterozoic periods. These soils were formed through long-term erosion, weathering, and leaching, and are mainly classified into three types: alfisols, ultisols, and vertisols. The northern and central parts of Sonbhadra mainly have alfisols and ultisols.

Mirzapur has a rocky landscape, and the soils are mostly residual and well-drained. The main soil types are entisols and alfisols, which are made from recent alluvial deposits and Kaimur sandstone (like the Dhandraul orthoquartzite). These soils are sandy to sandy loam, with a reddish to reddish-brown color. The entisols are found mainly in the northern part of the district along the Ganga River floodplain. Due to the rocky terrain, low soil fertility, and lack of government investment, Mirzapur still faces backwardness and has not developed much economically. The geology of the area has had a big impact on its soil and overall development. (Mishra and Mishra, 2013)

CULTURAL AND RELIGIOUS SPACE

The Vindhyachal region, situated on the rugged Vindhya Range in Mirzapur district, Uttar Pradesh, is a spiritually charged landscape where geography and devotion are seamlessly intertwined. At its heart lies the Vindhyavasini Devi Temple, a supreme Shakti Peeth located on the banks of the Ganges, drawing millions of pilgrims during the Navratri festivals of Chaitra and Ashwin. This temple is part of the sacred Trikona Parikrama, a triangular pilgrimage circuit that includes the Ashtabhuja Devi Temple atop a nearby hillock and the Kali Khoh Temple, a cave shrine dedicated to Goddess Kali. These sacred sites are spatially anchored in the Vindhyan terrain, linking hill, valley, and riverbank in a ritual landscape. (Tiwari, 2015) Beyond the Trikona, Vindhyachal hosts numerous shrines, kunds, and temples, including Sita Kund, Tarkeshwar Nath, Lal Bhairav, Budhe Nath, Kankali Devi, Shivashiv Samooh Awadhoot Ashram, and several sacred ponds like Gerua Talab and Sapta Sarovar. Together, these form a dense spiritual grid where natural landforms are consecrated and woven into local faith practices. Vindhyachal is part of a larger cosmic landscape of goddess worship connecting terrain, temple, and pilgrim routes. The region's mythic and physical topography serves as a sacred garment for the divine feminine, with pilgrimages transforming the Vindhya hills into a temple in themselves. Thus, Vindhyachal exemplifies how natural geography, hilltops, caves, rivers, and groves become sacralized through ritual practices, festivals such as the Kajali Mahotsav in Jyestha (June),

and community belief systems that see the landscape itself as divine (Tiwari & Sharma, 2008; Singh, Rana P.B., 2010; Tiwary, 2015)

FORT AND FORTIFICATION

Geography and architecture are interlinked. Their relationship is complex and multifaceted, encompassing the ways in which architectural forms interact with geographical factors and how the built environment reflects and responds to geographical settings, landscapes, and environmental conditions. (Dhawale & Nene,2024). The term "fortified settlements" primarily refers to strategically positioned stone-built structures that share common features. These sites are typically found in hard-to-reach areas, such as hilltops or cliffs (O'Connor *et al*,2020). Several ancient Indian texts provide detailed accounts of forts and fortifications. Prominent among these are the *Arthashastra*, *Nitisara* of Kamandaka, *Manusmriti*, and *Sukranitisara*. In addition, specialized treatises on fort architecture and design, such as the *Manasara, Mayamata, Viswakarma Vastu, and Silparatna*, discuss the principles of construction. References to fortifications are also found in various Puranic texts,including the *Agni Purana, Matsya Purana, Devi Purana, Brahmanda Purana, and Brahma Vaivarta Purana* (Subbarayudu & Naik, 2022).

HISTORICAL DEVELOPMENT OF FORTS

Vedic texts were among the earliest textual references to highlight the significance of forts. By the 6th century B.C., the sixteen *Mahajanapadas* had already established well-constructed forts. forts based on the materials such as earth, brick, stone, or masonry, and also differentiate by their geometric forms. (Namdeo & Chaturvedi,2022) The term *durga* that is fort mention in *Rig veda* with surffix Durgo (1.41.3,7.60.12,7.61.7) and *Durgeshu* (6.21.12) (Singh,2013). The Epic *Ramayana* and *Mahabharat* also mention about fort and fortification. There are 4 kinds of fort mention in *Ramanaya* that is *Nudeya, Parvata*, Fort in forest and last one is artificial fort. In *Mahabharat* there are 6 types of fort are mention *Dhanva durga, Mahi durga, Giri durga, Manushya Durga, Abd durga* and *Vand durga*. Even in Matsya Purana architecture pf fort have been describe that fort have moat and gopur with fort (Archareya,2017). Even Moats and ramparts are mentioned in *Upanishad* and wide description of fort also found in other books like *Kamandak Niti Sar, Artha Sastra, Shipla Sastra* and *Jatak* (Singh,2013). The *Agni Purana* also give 5 point that weaken the strength of forts these are i) the drying and silting of defensive ditches with sand and mun, ii) poor maintained ramparts and towers, iii) outdated and ineffective weapons,I v) neglect of the arsenal and v) and inadequately staffed garrison (Reddy,2011).

CLASSIFICATION OF FORTS BY YĀJÑAVALKYA AND CHAUSANAS

Type of Fort	Description
Dhanudurga (Desert Fort)	These forts were established in arid, desert areas, surrounded by nearly 20 *krośas* of waterless terrain, making enemy access and survival extremely challenging.
Mahidurga (Earth Fort)	Built using mud, stone, and bricks. Walls were made twice as high as their width, with broad tops to allow soldiers to patrol and defend the fort.
Jaladurga (Water Fort)	Situated within or surrounded by water, making it highly inaccessible. A sub-type, ***Sthala Durga***, is on elevated land and encircled by stagnant water or lakes.
Vṛkṣyadurga (Forest Fort)	Located deep within dense forests, with green cover extending nearly 4 *krośas* in all directions, offering natural concealment and defence.
Nṛdurga / Baladurga (Man Fort)	Protected by trained forces and animals such as elephants, horses, chariots, and infantry, forming the main defence line.
Gṛhadruga / Parvatdurga (Hill Fort)	Built on hilltops, taking advantage of natural elevation and secure water sources like ponds, wells, or *baolis* to sustain during long sieges.

KEY ARCHITECTURAL FEATURES OF FORTIFICATIONS (*ŚILPAŚĀSTRA*)

Architectural Element	*Description*
***Vapra* (Mound)**	An earthen mound was created on level ground, serving as a raised plinth for the fort. It prevented waterlogging and provided additional defence.
***Parikha* (Moat)**	Ditches dug around the fort, often filled with water and sometimes stocked with crocodiles or snakes, created an added layer of protection.
***Prākāra* (Fort Wall)**	Defensive walls built from mud mortar, bricks, stones, or rubble. The base was thicker than the top for strength, often bearing state emblems and including gates, watchtowers, battlements, and merlons.
***Attālakas* (Bastions)**	Projecting structures along the fort walls, providing vantage points for surveillance and counterattacks.
Entrance Gate	Heavy timber gates reinforced with iron nails; featured loopholes and openings to pour boiling liquids or fire arrows and stones on advancing enemies.

The Vindhyanchal region shows how forts were adapted to its rugged landscape. Chunar Fort on a sandstone hill above the Ganga River is the best example of a *Gṛhadruga*, using elevation and perennial water sources for defence. Bijaygarh Fort in Sonbhadra is another hill fort hidden within forested hills, similar to a *Vṛkṣyadurga* (forest fort), where thick vegetation provided natural cover. Some smaller forts like Agori were built on rocky uplands with limited water. These forts relied on strong garrisons (*Nṛdurga*), with infantry, cavalry, and elephants guarding key passes. Water defences were also integrated; Chunar used the Ganga's channel and inner reservoirs. These features highlight how forts in the Vindhyanchal region combined geography, resources, and strategy to create highly defensible constructions. Kautilya's description of fort-making is based on *Arthaśāstra*.

Aspect	*Details (as per Kautilya)*
Types of Forts	**Water Fort (Jala-durga)** – surrounded by water; **Mountain Fort (Giri-durga)** – built on hills; **Desert Fort (Maru-durga)** – located in arid zones; **Forest Fort (Vana-durga)** – hidden in dense forests.
Location of Capital	Fort should be centrally located in the kingdom, preferably near rivers, lakes, or water bodies, easily accessible by land and water.
Moats (Parikhā)	Three concentric moats; widths 14, 12, 10 dandas (~84, 72, 60 ft); depth ¼ or ½ width; filled with flowing water, lotus, crocodiles.
Ramparts (Vapra)	4 dandas (~24 ft) from inner moat; made of compacted earth, square base, thorny plants on top.
Parapets (Prākāra)	Brick walls on ramparts; spaced 12–24 hastas (~18–36 ft); height twice the breadth.
Towers & Gates	Square towers with movable ladders; gates bulge outward; width one-sixth of street; secret passages for emergency.
Obstacles	External traps: thorn pits, tridents, mounds, frying pans, sand pits, water pools.
Roads & Streets	Three royal roads east–west and north–south; 12 gates; street widths: royal roads ~24 ft, other roads 48 ft, chariot 7.5 ft, cattle 6 ft.
Internal Planning	Palace at center (1/9 area); ministers, priests, sacrificial spots nearby; granaries, markets, artisans, treasury, temples, residential quarters by caste.
Weapons & Storage	Stockpile of arms: stones, axes, spears, tridents, clubs, machines, explosives, war engines.
Public Utilities	Wells every 10 houses, temples for deities, community spaces, secret storage of food and weapons for sieges.

Source: Shamasastry, R. (1951). Kautilya's Arthasastra (Chap. 3 & 4). Mysore: Mysore Press. Retrieved from http://asi.nic.in/asi_books/900.pdf

RESOURCES AND MATERIALS IN FORT MAKING IN THE VINDHYACHAL REGION

The Vindhyānchal region stretches across Mirzapur and Sonbhadra, region and lies along the bank of River Ganga. The rugged topography of plateau, escarpments and River valley provided natural advantages for architecture. Local Resources essential for fortification it involves stone quarrying, lime process, water, and other relevant Resources, were local by geology.

Vindhyan sandstone

The Vindhyan Basin is composed of sequences of sandstone, shale, and limestone that is part of the Vindhyan Super group into The Chunar sandstone became the most important material for fort construction in the area. This fine-grained, buff-colored, quarzitic sandstone was widely quarried from Chunar and adjacent hill formations. (Sen *et al*,2002 & Kaur *et al*,2019)

The Vindhyan tableland, covering parts of Mirzapur and Sonbhadra, has rich geological resources that played a vital role in fort construction in the region. The Upper Vindhyan formations are dominated by sandstones, the upper and lower Kaimur sandstones, Rewah sandstones, and Bijagarh shale. The upper Kaimur sandstone has massive thickness, durability, and quality, making it a reliable material for architectural structures. It is the chief stone for building fort walls, gateways, and platforms in strongholds like Chunar Fort and Vijaygarh Fort, and ensures their long survival. In the western part of the district, the Rewah sandstones and shales appear in steep escarpments. These stones are thinner but locally quarried and used for fortifications. The southern plateau of the lower Kaimur sandstones and Bijagarh shales form outlying spurs of the Kaimur hills, also providing additional resources for foundations and defensive structures.

The Lower Vindhyan groups provide a diversity of building stone, including conglomerates, carbonaceous shales, and limestones. These materials were widely used in supplementary works like flooring, plaster, and the preparation of lime mortar. The thick, compact limestone beds (Approx 250 feet) were an important source of lime, a vital binding agent in built architecture. The Vindhyan and Kaimur geology provides a supply of sandstone, shale, and limestone helps in the construction of fort-building in the sacred hilly terrain of Vindhyachal. Their strength, accessibility, and adaptability explain how forts such as Chunar achieved monumental scale and durability, withstanding centuries of political and military upheaval.(District Gazetteer of Mirzapur,1892).

Chunar sandstone

The Vindhyan region, particularly the upper Kaimur sandstone quarried at Mirzapur and Chunar. This stone is famous for its durability, fine texture, and ability. It was “fine-grained and homogeneous, usually yellowish and greyish white in colour, occurring in beds several feet thick,” making it ideal for monumental construction (District Gazetteer of Mirzapur, 1892). The so-called Chunar Balua Patthar, Pattiya Patthar. In 2019, it got a Geographical Indication (GI) tag. Known for its durability and Natural appeal, this sandstone has been used since prehistoric and historic times, ranging from natural rock shelters to carved deity sculptures for temples, fortifications, heritage structures, and monuments. It’s been in use for centuries, extending from ancient and modern religious sites across eastern and central India, as well as in constructing riverfront embankments (ghats), forts, bridges and other structures (Sen *et al*, 2022).

The Chunar hills contain 452 recorded quarries of varying dimensions, exploiting thick sandstone layers. Quarrying typically reached depths of 2–4 meters, one or more consolidated layers of sandstone before moving to new locations, resulting in multiple quarry sites across the region. The quarrying process began with selecting suitable sandstone beds, usually in flat terrain. Workers used iron chisels and hammers to carve diamond-shaped grooves, extracting rectangular blocks by inserting long iron rods through cavities. Debris analysis reveals that the extracted stones matched the texture and colour of ancient carvings and sculptures. For example, pink sandstone with red hematite pellets resembles that used in Ashokan columns and Mauryan sculptures, while buff and pale-yellow sandstone was common in Gupta art. Pink, buff, and grey stones were also widely used in post-Gupta and medieval structures. Most of the stone blocks in the Chunar hills are their abundance, which clearly marks their in-situ locations from the original quarry site to the Ganga River.(Jayaswal,1998 & Olivieri, 2000)

Quartzite and Hard Sandstone Beds

The fine-grained sandstones, harder quartzite layers within the Vindhyan sequence were exploited for foundations, pavements, and heavily loaded structures. These provided greater compressive strength, particularly for bastions, towers, and retaining walls. Quartzite used for strengthening internal fill (Mishra *et al*,2011, Dinker *et al*,2019, Kaur *et al* ,2021& Odisha State Bureau of Textbook Preparation and Production, 2017)

Lime and limestone mortar

Lime and lime mortar have been used since ancient time as a binding material, also used as binding material in fort construction. Limestone beds of the Vindhyan Supergroup, when calcined, produced quicklime, which was slaked and mixed with sand or *surkhi* (powdered brick) to create durable mortars. Traditional used with organic material like as jaggery, *kadukkai* (*Terminalia chebula*), and black gram which help prevent crack resistance and give Compressive strength, which reduced porosity and increased mechanical strength. Lime mortars were used in bonding buildings, rubble-core infill, bastions, gateways, and arches (S.k *et al*,2013, Mani *et al*,2021 & Athira *et al*,2025).

Timber Resources

Stone and lime were essential materials, but timber was also an important material for fort-making. Hardwoods such as Sal (*Shorea robusta*), teak (*Tectona grandis*), and jamun (*Syzygium cumini*) were used for beams to support construction, floors, and roofing. In fortification, fort gates, windows, and others required large quantities of timber for construction. (District Gazetteer of Mirzapur,1892).

Iron use

The *Rig Veda* refers to ***ayas***, and also states that the Dasyus had *Ayas* (RV 2.20.8). In RV 4.2.17, "the gods are smelting like copper/metal ore the human generation"(Chakrabarti 1976). Iron-using and iron was prevalent in the Central Ganga Plain and the Eastern Vindhyas from the early second millennium BC. (Tiwar, 2003)

Iron ore was extensively used in fort construction for clamps, dowels, hinges, nails, and gate fittings. Massive gates of medieval Indian forts for defensive purposes. Archaeometallurgical evidence from the Mirzapur–Sonbhadra belt including sites like Malhar, Raja Nala-Ka-Tila, and Valley in Sonbhadra reveals a long tradition of local iron smelting, with furnaces, slag, and tuyeres dated to as early as 1800 BCE (Kaur *et al*,2022).

Table: Resources for Fort-making in the Vindhyānchal Region

Material	*Local Source / Quarry*	*Evidence (Archaeological/Modern)*	*Typical Use in Forts*
Sandstone (Chunar)	Vindhyan Basin quarries (Chunar)	Chunar Fort built directly on quarry outcrop; widely exported	Ramparts, bastions, gateways, carved pillars
Quartzite / Hard sandstone	Vindhyan escarpments	Geological surveys & rubble masonry remains	Foundations, pavements, core walls
Bricks	Local kilns near fort towns	Excavated brick layers at Chunar & Vijaygarh	Floors, chambers, modular masonry
Lime (quicklime)	Limestone beds of Vindhyan Supergroup	Lime kilns near forts; mortar remains	Mortar, plaster, waterproofing
Timber (sal, teak, jamun)	Forests of Mirzapur–Sonbhadra	Gate beams, palace roofs, scaffolding evidence	Gates, beams, roofing, scaffolds
Iron	Local smelting centers in Vindhyan region	Iron cramps, dowels, gates with iron spikes	Hinges, gates, clamps, artillery
Organic additives (jaggery, urad dal paste, gums)	Local agriculture	Identified in mortar samples	Strengthening mortar, preventing cracks

Hydrology

The Ganga and its tributaries played an important role in carving the landscape. Construction in the Vindhyānchalregion. Forts such as Chunar, built on a rocky hill along the side of the bank of the Ganga River, and Vijaygarh fort, at an elevation of 600 meters. The Ganga system not only give advantage and but also serves as a defensive but also fort trade. The fertile land and availability of water help in continuous supply of drinking water, irrigation and water for construction. The Ganga River used fort heavy transportation and for trade purpose which connect with other parts of nations. This water systems of the Ganga basin were not only physical part of landscape but also act as important source of livelihoods and provided water for construction in Vindhyānchalregion.

CONCLUSION

The Forts and fortifications in the Vindhyachal region analyse how geography, geology, religion, and culture shape architectural traditions. The Vindhyachal hills, part of the Eastern Vindhya and Kaimur ranges, provide natural defences and ample raw materials that made the region an important center for fortification from ancient to colonial times. The geology of the Vindhyan Super Group features thick deposits of sandstone, quartzite, limestone, and shale, which are utilized as raw materials for construction. The Chunar sandstone which, is known for its strength and fine grain, was extensively quarried throughout the time and used in monuments, temples, and forts across northern India. Awarded a GI tag in 2019, this stone symbolises the region's architectural legacy. The availability of other resources, such as quartzite for foundations, limestone for lime mortar, hardwood timber for gates and beams, and locally smelted iron for clamps and weaponry, gives a well-integrated system of resource exploitation that sustained centuries of fort-building.

The study emphasizes that geology alone cannot explain the fortification of Vidhyanchal. The region has a deep connection with Hindu mythology and pilgrimage traditions, the sacred Trikona Parikrama between Vindhyavasini Devi Temple, Ashtabhuja Temple, and Kali Khoh. These sites, embedded in hills and caves, created a holy geography in which forts acquired religious legitimacy with their political and defensive roles. The spiritual narratives in fortified landscapes, rulers not only had territorial control and protected it from their enemies, but also projected divine authority. The

Rigveda, Ramayana, Mahabharata, Arthashastra, and Puranic literature provide classifications of forts such as Giri-durga (hill forts), Jala-durga (water forts), and Vriksha-durga (forest forts), many of which are exemplified in Vindhyachal, like Chunar Fort strategically utilised the Ganga River as both a defensive barrier and trade route, while Vijaygarh Fort in Sonbhadra concealed itself within dense forests and high elevation represents the concept of *Vriksha-durga*.

The Ganga and Son river systems provide a fertile land for cultivation, irrigation for agriculture, it not only supports the settlement around the fort but also used for trading and defence purposes, with proofs of reservoirs, and moats focusing the integration of hydrology into fort design. Use of Organic additives like jaggery or herbal mixtures in lime mortar highlights how traditional knowledge combined with practical engineering. The forts of Vindhyachal studies the cultural landscapes rather than buildings and architects, which were shaped by time and not only by political and economic needs but also by traditions and culture that made land itself valuable. The convergence of geology, hydrology, sacred geography, and local craftsmanship transformed fortification into an interrelation between nature, spirituality, and authority. Thus, the Vindhyachal region reflects abiotic testimony to how terrain, tradition, and power intersected in the making of India's fortified heritage.

ACKNOWLEDGEMENTS

I gratefully acknowledge the financial support provided by the Indian Council of Social Science Research (ICSSR), New Delhi, for funding the research project titled "Revisiting Vindhyachal: A Study of Religious and Architectural Heritage." This study has been carried out as part of the objectives of the sanctioned project, and the support of ICSSR in facilitating fieldwork, data collection, spatial analysis, and scholarly interpretation.

We also express the sincere gratitude to the Department of Ancient Indian History, Culture and Archaeology, Banaras Hindu University, for providing academic guidance, research infrastructure, and institutional support throughout the course of the study.

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