Learnings for the Modern Architecture From the Disaster Immune Kedarnath Temple Structure

Sathwika Padida [1]

Abstract

Situated amidst the altitudes of the Uttarakhand Himalayas and characterized by rugged terrain is the famous ancient Kedarnath temple. Due to its strategic location, the town of Kedarnath witnessed numerous natural disasters like earthquakes, floods, avalanches, and landslides. More than 1600 years since its inception, the temple stands so firm as well and stable without any hint of damage even after being struck by intense disasters. The temple's unique location, design elements, solid construction, and restoration efforts have played a significant role in its disaster resilience, enabling it to withstand and recover from adverse natural events. Predominantly built in stone, the temple is a remarkable example of ancient architecture and craftsmanship. This paper aims to give an overview of the temple structure in terms of its architectural style, construction technique, and structural stability as well as review its performance in the numerous major disasters that hit the region since time known. This temple structure is definitely an interesting aspect for study so that modern architecture and engineering can draw inspiration.

Keywords : **Ancient temple, construction and structure, disaster immune, Kedarnath temple, lessons, modern architecture, Uttarakhand**

I. INTRODUCTION

Kedarnath Temple is located in the town of Kedarnath, the Rudraprayag district of the Himalayan region of Uttarakhand, India. Surrounded by snow-capped mountains and the Mandakini River, the temple sits at an elevation of approximately 3,583 meters (11,755 feet) above sea level, making it one of the highest pilgrimage sites in the country. The temple is part of the Char Dham pilgrimage circuit, which includes the sacred sites of Yamunotri, Gangotri, and Badrinath, and is one of the 12 Jyotirlingas [1].

It is one of the finest pieces of Ashlar masonry, stones that are intricately carved and shaped to create a tight and seamless bonding, resulting in a solid and durable structure. Recently, metal clamps have been used in the restoration of the temple structure to make it more immune to disasters after the occurrence of the 2013 Uttarakhand flash floods. The stone slabs are interlocked with each other with the use of metal clams. The stones are held in place by their unique shapes and positions, creating a solid and resilient structure, withstanding the test of time, and enabling the temple to endure natural calamities like earthquakes and floods.

II. HISTORICAL BACKGROUND

According to ancient Hindu scriptures and beliefs, it is believed that the temple was established around 5000 years ago by the Pandavas themselves, the legendary heroes of the epic Mahabharata, after the great Kurukshetra war. Over the centuries, the Kedarnath Temple has been a significant pilgrimage site for devotees of Lord Shiva, especially for Shaivites. Throughout its history, the temple is believed to have undergone several renovations and reconstructions. The current structure of the temple dates back to the 8th century when it was rebuilt by Adi Shankaracharya, the renowned Hindu philosopher,

Paper Submission Date : April 20, 2023 ; Paper sent back for Revision : May 2, 2023 ; Paper Acceptance Date : May 5, 2023 ; Paper Published Online : June 5, 2023

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DOI : https://doi.org/10.17010/ijce/2023/v6i1/173003

and theologian who played a vital role in the revival of Hinduism.

Over the years, the temple has encountered several devastating disasters like landslides, avalanches, floods, and seismic activity due to its location in the fragile Himalayan terrain. The most notable of the disasters were the catastrophic floods and landslides in June 2013, which caused extensive damage to the temple complex and surrounding areas. However, it is noteworthy that there was no substantial damage caused to the main temple structure in any of the disasters, a perfect example of disaster immunity and resilience [2].

III. THE STRUCTURE AND THE CONSTRUCTION TECHNIQUES

The architecture of Kedarnath Temple is characterized by its distinct and ancient style, reflecting the cultural and religious traditions of the region, and showcasing the skilled craftsmanship of ancient artisans. There are no documented historical records or direct evidence that describe the artisans responsible for the construction of the temple or its ability to resist disasters given its strategic location. It withstood numerous devastating disasters. It is believed that skilled artisans and craftsmen from the local region would have been involved in the temple's construction, employing traditional techniques and architectural styles prevalent during that era. It can also be noted that the use of sturdy stone construction techniques including ashlar masonry and the conical shape of the temple may have contributed to its resilience and ability to withstand the environmental stress of disasters. A description of the construction and structural features of the Kedarnath temple which resist various disasters along with their devastating forces are as follows [3]:

1) *Location (Zoning)*: The temple builders chose the safest spot in the entire valley for constructing the temple. The temple site has an optimal slope gradient of around 5% and occupies a high ground to ensure safety from impending floodwater and the melting of snow.

2) *Foundation*: The temple rests on a solid and robust foundation that is built using large stone blocks or slabs or boulders along with stone fillers and is deep enough to reach the stable layers of the ground and prevent settling or shifting of the temple over time. The stones are carefully laid and interlocked to distribute the weight evenly and ensure stability. The interlocking of stones helps prevent localized stress concentrations, reducing the 'Inverted Pendulum Effect' due to the action of seismic and other shear forces during an earthquake and ensuring that the structure withstands external forces.

3) *Elevation or the plinth*: Along with its spatial location planning, the temple is constructed with a high plinth which helps mitigate the impact of floodwaters during heavy rainfall or cloudbursts.

4) *Ashlar stone masonry*: The use of ashlar masonry with interlocking locally sourced Gneiss stones held together by interlocking slabs and are up to 3 feet thick, strengthening the overall structure. The stones are carefully shaped and fitted together, creating a solid and cohesive assembly that can withstand lateral forces. The masonry wall is also additionally cemented using a composition made using over 15 ingredients of sourced limestone, jaggery, lentil paste, etc. which strengthens with the passage of time [4]. This interlocking pattern enhances the overall integrity of the masonry as well as evenly distributes the loads and stresses across the structure, making it less susceptible to collapse or failure during disasters such as seismic forces, ground movements, or heavy loads. This interlocking construction technique used in the temple is believed to have been passed down through generations of temple artisans. Stone masonry is less prone to decay or degradation which makes it more resilient against disasters caused by environmental factors in the region with heavy precipitation and snowfall. Recently, metal clamps have been used in the restoration of the temple structure to make it more immune to disasters after the occurrence of the 2013 Uttarakhand flash floods.

5) *Main shrine or the Shikhara*: The main shrine of Kedarnath temple features a relatively short Shikara which lowers the center of gravity of the superstructure and minimizes the tendency of the structure to topple in case of any seismic force. The Shikhara in conical shape helps to dissipate energy generated during an earthquake as the tapering allows the seismic forces to pass through and reduces the impact on the entire temple structure.

6) *Copper Roof*: The roof of Kedarnath temple is covered with copper sheets. Copper possesses good ductility and can deform or stretch under stress without fracturing. This

ductile behavior can absorb some of the energy generated by seismic forces, potentially reducing the impact on the structure. It also has good tensile strength which can help the roof withstand dynamic loads or tremors caused by seismic activity. Additionally, the sheets also add to the visual appeal of the temple as well as serve the purpose of protecting the temple interiors from rain and snowfall.

7) *Sloped mandapa roof*: The distinct architectural feature of the temple is the sloped roof which helps to shed off rainwater and snow, preventing water accumulation on the roof and minimizing the chances of structural damage or leakage. This element contributes to the temple's ability to withstand heavy precipitation.

IV. THE MAJOR NATURAL DISASTERS WHICH HIT KEDARNATH TOWN AND THEIR IMPACT ON THE TEMPLE STRUCTURE

The Kedarnath town has faced several major disasters throughout history. Some of the most significant disasters which struck the temple, town, or the surroundings in terms of the impact and damage caused to the temple structure are discussed next [5]:

(1) Mini-ice age from the middle of the 14th century till 1748 CE: Growth of lichens usually found growing in the moraines of the Mandakini Valley is also present on the outer and inner wall surfaces of the temple. With this, archeologists and scientists estimated that the temple could be submerged under a colossal mass of snow for around 400 years of the mentioned period [6].

↳ ***Impact on the temple structure :*** The temple could sustain the mini-ice age, thanks to the usage of stone, a sustainable material that is resistant to rot, decay, and vegetative growth.

(2) The 1803 Earthquake: An earthquake of an estimated 7.8 magnitude struck the Kedarnath region causing considerable damage to the temple and surrounding areas with the loss of between 200 and 300 lives. Severe damage to buildings and infrastructure was witnessed.

↳ ***Impact on the temple structure:*** With such severe damage to the surrounding properties, the Kedarnath temple also suffered damages where parts of the temple structure including the Shikhara collapsed. However, the magnitude of the damage caused to the temple was much lower as compared to the surroundings. Restoration activities were carried out to fix up the damages that occurred.

(3) The 1882 and 1893 Uttarakhand flash floods: Flash floods caused by torrential rains resulted in damage to the town and the surrounding areas.

↳ ***Impact on the temple structure:*** No records on the impact of the disaster on the temple structure indicate that no damage could have been caused.

(4) The 1998 Malpa Landslide: Malpa is a small village in the nearby Pithoragarh district. The village was wiped out, killing about 255 people. There was no direct impact of the Malpa landslide on the Kedarnath temple but extensive damage to the infrastructure connecting Kedarnath with the surroundings was witnessed which resulted in the isolation of the temple and hindered access to it.

↳ ***Impact on the temple structure:*** No records on the impact of the disaster on the temple structure indicate that no damage could have been caused.

(5) The 1999 Chamoli earthquake: The neighbouring Chamoli district was hit by an earthquake of 6.8 magnitude killing over 100 people. The earthquake resulted in several ground deformations and also changed the course of water flow.

↳ ***Impact on the temple structure***: No records on the impact of the disaster on the temple structure indicate that no damage could have been caused.

(6) Flash Floods and Landslides of 2013: One of the most devastating disasters to hit Kedarnath were the flash floods and landslides in June 2013. Heavy rainfall triggered massive floods and landslides in the region, resulting in the loss of thousands of lives, widespread destruction of infrastructure, and significant damage to the temple complex.

↳ ***Impact on the temple structure :*** Severe damages and debris build-up was witnessed in the temple complex but the main temple structure stood firm and stable.

(7) Heavy snowfall and avalanches: The Kedarnath

region is prone to heavy snowfall and avalanches during the winter months. These natural events can cause temporary closures of the temple and create challenges for access and maintenance of the site.

↳ ***Impact on the temple structure:*** The use of sustainable material (stone) is resistant to rot, decay, and vegetative growth, reducing the need for frequent repairs in the region with heavy precipitation and snowfall. Despite an encounter with frequent snowfall and avalanches, the temple structure withstands the time passed by [6].

V. SUMMARY AND CONCLUSION

To summarize, modern architecture can embrace the principles of sustainability and structural resilience from the Kedarnath temple. The Kedarnath temple highlights the significance of building structures that can withstand natural hazards specific to their geographic locations. The use of stone masonry, interlocking techniques, and robust foundation systems showcase the temple's resilience against various prevalent disasters and calamities. Modern architecture can incorporate similar principles, employing local materials and innovative construction methods to enhance the durability and safety of buildings in disaster prone regions. The use of locally available Gneiss stone as the primary construction material showcases a sustainable approach to modern buildings minimizing environmental impact and promoting resource efficiency. In an encounter with various disasters, the temple's strength could be gauged from the fact that while the shrine still stands, most of the other concrete structures in the temple town of Kedarnath were reduced to rubble or had become too unstable and unfit for use.

AUTHOR'S CONTRIBUTION

Sathwika Padida is the sole author and has conceptualized and designed the research idea and the study.

CONFLICT OF INTEREST

There is no conflict of interest regarding any involvement of any person or organization.

FUNDING ACKNOWLEDGEMENT

The author has not received any financial support for the research, authorship, and/or publication of the article.

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AMC INDIAN JOURNAL OF CIVIL ENGINEERING

Statement about ownership and other particulars about the newspaper "AMC Indian Journal of Civil Engineering" to be published in the 1st issue every year after the last day of February.

FORM 1V
(see Rule 18)

1.	**Place of Publication**	**:**	**NEW DELHI**
2.	**Periodicity of Publication**	**:**	**BI - ANNUAL**
3.	**4,5 Printer, Publisher and Editor's Name**	**:**	**S. GILANI**
4.	**Nationality**	**:**	**INDIAN**
5.	**Address**	**:**	**Y-21,HAUZ KHAS, NEW DELHI - 16**
6.	**Newspaper and Address of individual**	**:**	**ASSOCIATED MANAGEMENT**
	Who owns the newspaper and partner of	**:**	**CONSULTANTS PRIVATE LIMITED**
	Shareholder holding more than one percent.	**:**	**Y-21, HAUZ KHAS, NEW DELHI-16**

I, S. Gilani, hereby declare that the particulars given above are true to the best of my knowledge and belief.

DATED : March 1, 2023

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Signature of Publisher