

## AJANTA CAVES: PAST PRESENT AND FUTURE

Prathibha Prakash<sup>1</sup>, C Akhila<sup>2</sup>, Dr.Vijayakshmi Akella<sup>3</sup>, Sushma M<sup>4</sup>

<sup>1,2</sup>Student, Department of Civil Engineering, K. S. School of Engineering, Bengaluru, India

<sup>3</sup>Professor and HOD, Department of Civil Engineering, K. S. School of Engineering, Bengaluru, India

<sup>4</sup>Assistant Professor, Department of Civil Engineering, K. S. School of Engineering, Bengaluru, India

\*\*\*

**Abstract** – The Ajanta caves are 30 rock-cut Buddhist cave monuments which date from the 2<sup>nd</sup> century BCE to about 480CE. It is located in Aurangabad district, Maharashtra, India having latitude of 20.5519°N and longitude of 75.7033°E.

The caves include the paintings and rock-cut sculptures described as one among the finest surviving examples of ancient Indian art particularly expressive paintings that present emotions through gesture, pose and form. The caves are formed of Basaltic rock mass in the Deccan trap basaltic flow. Ajanta caves are declared as world heritage site by UNESCO, it is important to protect and nurture them for our country's pride and for future generations. In this paper an attempt is made to explore the causes of extensive deterioration of rocks in Ajanta caves and seepage of water from the surrounding water bodies and suggest suitable remedies.

**Keywords:-** Ajanta caves, Basaltic rock, deterioration of rocks, seepage.

### I. INTRODUCTION

Recognized by UNESCO as world heritage site due to its rich historical importance, Ajanta caves are one among the rare stone caves that belong to 2<sup>nd</sup> century BC<sup>[3]</sup>. Situated in Indian state of Maharashtra, near Jalgaon, Aurangabad outside the village of Ajinha shown in Fig1, having a latitude of 20°31'56"N and longitude of 75°44'44"E, are 29 Buddhist rock cut caves that have been excavated in horse-shoe shape forming semi-circular scrap of the Deccan trap basalts<sup>[4]</sup> shown in Fig2&3. The formation of Ajanta caves is the alternating sequence of basaltic lava flow with a blocky broken surfaces called "Aa" type flow and basaltic lava flow with a twisted billowy surface that resembles a coiled ropes called "Pahoehoe" flow.

The Ajanta ranges are surrounded by Purna river basin in the east and by Waghur, Girna, Vaya rivers of Tapi-Purna system in north. Further surrounding the caves are number of waterfalls including Sapthadhara (the most prominent waterfall), which, when the river is high, are audible from outside of the caves. This area is bounded by

3 major faults<sup>[1]</sup> namely, the ENE-WSW to E-W trending Tapi-Purna fault in the north, NW-SE trending Upper Godavari fault in the south and the Kaddam fault in the east.

In recent times the stability of the caves is decreasing due to the change in local topography, cropping pattern on the top hill, heavy rainfall causing water percolation and increasing number of visitors. The difficulties faced by the caves can be categorized into natural and man-made causes<sup>[1]</sup>. Natural causes include random and haphazard joint patterns on the top hill, weathering of rocks and soil erosion. Man-made causes include human intrusions that damage the inside and outside structure of the caves as well as its surroundings. Local environmental changes also adversely affect the site. There were reports<sup>[2]</sup> of major rock fall on site in 1998 and 2006 and minor ones take place from time to time that question the safety of the tourists and damage made to the caves. In this paper an attempt is made to understand the problems faced by Ajanta caves and correspondingly tried to suggest a few remedies.

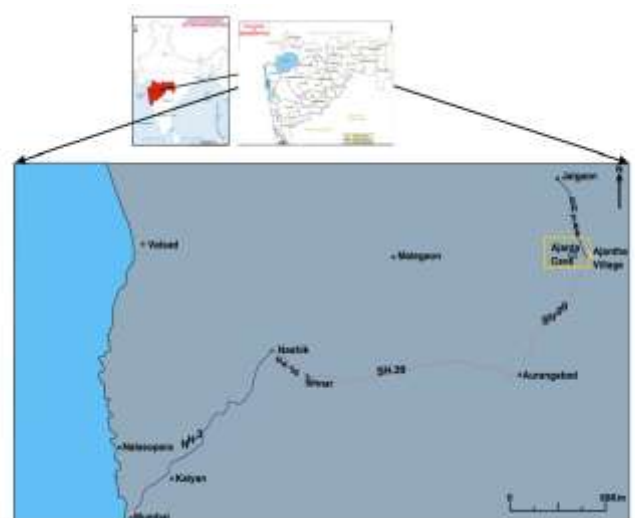


Figure 1: Location of Study Area



Figure 2: Ajanta Caves, the World Heritage Site



Figure 4: Side View of Ajanta Caves

## II. LITERATURE REVIEW

M.N Badge<sup>[1]</sup> et.al assessed and characterized the formation of boulders shown in Fig4 and suggested suitable stabilization measures. The boulder stabilization philosophy is based on the safety of tourists; keeping caves intact and considering stress distribution and deformation of the surrounding rocks. Techniques which could be planned for the stabilization of boulders suggested include: breaking down and removal of coarse boulders to reduce size of the unstable critical boulders; usage of epoxy resin based grouting to fill up the joints, discontinuities and cavities; application of rock bolting/ anchoring of unstable rocks in steep slopes; to reduce vulnerable bouldering, wire nets could be used and to maintain the esthetic value of the caves, camouflaging could be done. According to the study, the principles of engineering characterization of rock mass which was used along with proper human judgment was found to be useful in stabilizing the boulders. The priorities were given to the safety and stability of Ajanta caves by applying certain measures without altering the appearance of the caves. They have suggested the combination of various measures like epoxy resin/anchor bolting, wire net/mesh and catch net/draping.

M.K.Ansari<sup>[2]</sup> et.al conducted various tests on rock fall hazard to overcome the damage caused to the caves and for the safety of the tourists. Following tests were performed for studying the nature of rocks and their assessment: Barton-Bandis model in universal distinct element code from which test was done to obtain the information on detached rock mass; Rigorous Field study and laboratory experiment for rock simulation parameters; Rock fall 4.0 program for calculating maximum bounce heights total kinetic energies and translational velocities of the falling block of different weights shown in Fig 6. Their main focus of the survey was to study the description of slope geometry that was affected by rock falls and rock mass property. They have found that the reason for rock fall was due to downward forces acting on the rock mass changes which were due to pore pressure weathering of material, freezing/ thawing process and root growth with rock mass. As per the data obtained from the assessment they have concluded that the maximum of 917.66kJ kinetic energy for 2000kg mass and result showed that the kinetic energy was directly proportional to mass of falling rocks. The maximum translational velocity was found to be 40m/s and travelling up to a distance of 83m. Finally, they have concluded that the barrier capacity of 325kJ was calculated shown in Fig5 for 2000kg block of height of 50m to reduce the impact of rock fall.



Figure 3: Various Types of Boulders in the Study Area

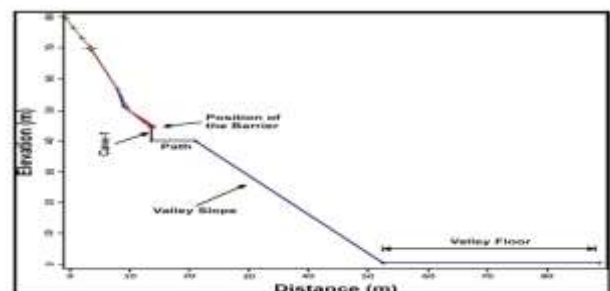


Figure 5: Critical Location of the Protection Barrier with Energy Capacity of the Order of 325kJ





**Figure 6: Various Sizes of Blocks Fallen down from Top are indicated by Dotted Area**

Paras R Pujari<sup>[3]</sup> et.al used Ground Penetration Radar (GPR) technique to detect seepage pathways in Ajanta caves. Reconnaissance survey was carried out to decide the survey parameters and select appropriate antenna frequency. GPR tool was used in finding the presence of fractures which may be the pathways for seepage into the caves. The data were collected by 40 and 200MHz antennas from geophysical survey systems, Inc. (GSSI). The data were edited and processed using the RADAN 6.5 software. The reflective zones indicated the fractures and strong absorbance zones showed homogeneous zone without any fracture. The positions (latitudes and longitude) of the profiles were acquired with the help of Garmin hand held GPS system. Based on the field condition GPR scans were obtained at 6 profiles in the study area. All profiles were subjected to fractures which vary with respect to their thickness, type and orientation. The massive compact basalt was found below 10m in profile P1 which resulted seepage at cave1. Presence of quartz veins shown in Fig7 at profile P2 contributed to fractures in cave 17 and 20. The profiles P3 shown in Fig8 and P4 indicated distinct patterns of fractures which were inclined in nature. The fractures in radar section were seen in profile P5 that caused dry condition in underlying caves 25 and 26. Profile P6 indicated fractures below 10.5m depth above which they it was seen to be homogeneous. From the data obtained from these profiles they have concluded that seepage can be avoided by providing proper drainage



**Figure 7: Quartz Veins in Basalt at Site Area**



**Figure 8: Schematic Position of Profile P3 with respect to the Drain**

### III.CONCLUSIONS

Various remedial measures were suggested in the above papers which includes grouting, anchoring and use of barriers for rock stabilization.

Understanding the geology of the place that are prone to erosion or denudation which resulted in valley widening and steep slope formation following remedial measures are suggested.

Gabion walls as shown in Fig9 which are wire baskets filled with rocks for steep slopes are majorly used in cave 3

**One Day National Conference on Recent Advancement in Civil Engineering (RACE 2K19)  
25<sup>th</sup> February 2019**

Organized by

**Department of Civil Engineering, T John Institute of Technology, Bangalore-83**

and cave5. They are used by considering its flexibility to conform to difficult site geometry, prevents building up of water pressure, it is economical and rate of construction is faster.

Crib walls shown in Fig10 which act as retaining walls, helps in slope stabilization, controls erosion and acts as rock fall protection for cave1 and the pathway for visitors.

To control seepage in mainly in profile P3 Bentonite shown in Fig11 clay minerals can be used near the drain path as indicated by red line in Fig8. Bentonite becomes hydrated with the moisture naturally present in soil and acts as impermeable barrier that absorbs and expels water. Hence an effort can be made to protect the world heritage site.



**Figure 11: Bentonite Clay**



**Figure 9: Gabion Wall**



**Figure 10: Crib Wall**

#### IV. REFERENCES

1. M.N.Badge," Characterization of failure modes and planned stabilization measures for the Ajanta caves in India" International Journal of Rock Mechanics and Mining Sciences, 12-18, 2016.
2. M.K.Ansari, M.Ahmad, Rajesh Singh, T.N Singh: "Rock fall hazard assessment at Ajanta cave, Aurangabad, Maharashtra, India", Saudi Society of Geosciences, 2013.
3. Paras R Pujari, Abhay Soni, C Padmakar, Piyush Mahore, Ramya Sanam, P Labhassetwar:" Ground penetration radar (GPR) study to detect seepage pathways in the Ajanta caves in India.", Springer-Verlag Berlin Heidelberg 2013.
4. DK Ghosh:" Geological evaluation of foundations of ancient monuments and stability of rock cut caves in central India "Springer Verlag New York Inc.,16, 15-22, 1990.