



## 3-D Mapping and Material Testing of Heritage sites of Bihar Kesariya Stupa

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**Abstract:** Our proposed study will focus on detailed study on Buddhist circuit of Bihar developed in Mauryan and Gupta age. The Mauryan age acquired almost all Indian except southern region. The XRF analysis of the artifacts of Kesariya Stupa of Mauryan age will be done to summarize the surface compositions of materials used at that time.

The objective of this project is to lengthen the life of the archaeological site. The process of maintenance and continued management will enhance the preservation of the

site. The process also helps to deepen understanding of the site. Also aids in the advancement of conservation and restoration techniques. To introduce a new field for research in an interdisciplinary manner. Presently relating history with science, particularly Physics, Chemistry, Computer Science. To make possible the construction of an environment that allows the archaeological site to be preserved as it is, without losing the information inherent in the site.

**Keywords:** 3D Mapping, XRF, XRD.

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### Introduction:

Heritage is our most precious inheritance through culture, nature, architecture and humanity itself. The terms includes tangible heritage like historic monuments, archeological settlements, artifacts etc. As a result this finite, non- renewable and irreversible resource of our country is fast disappearing without any record for the posterity. Therefore, there is an urgent need for a proper survey of such resources. The information gained in this discipline can be used in historical or archeological surveys and studies, or utilized for the preservation or restoration of archeological materials.

This is a pilot project for Lidar. We have tried doing 3-D Mapping of Kesariya by using drone and some apps. If lidar was available then it could have been much easier and fast.

3-D Mapping is a new vision technology in the field of cartography (science of practice of drawing map). It gives us a realistic view of a location that can be utilised by local authorities and planners. Lidar stands for Light Detection and Ranging, is a remote sensing method that uses light in the form of a pulsed laser to measures ranges to the Earth.

### Methodology :

#### XRF

XRF (X-ray Fluorescence) is the non- destructive analytical technique which is used to establish the elemental composition of materials.

The XRF processes are as follows:-

1. A solid sample is irradiated with high energy X-rays from controlled X-ray tube.
2. When an atom in the sample is struck with an X-ray of sufficient energy(greater than the atoms K or L shell binding energy),an electrons from one of the atom's inner orbital shells dislodged.
3. The atom regains stability, filling the vacancy left in the inner orbital shells is dislodged.
4. The electrons fall down to the lower energy state by releasing fluorescent X-ray. The energy of this fluorescent X-ray is equal to the specific difference in energy to quantum states of the electron. The basis of XRF analysis is the measurement of this energy.

#### XRF Results

Alloys	Alloys
<p>DATE: 2/2/2022</p> <p>ANALYST: 10/10/2022</p> <p>NO. OF REPS: 10</p> <p>ALLOY GRADE: NOT IDENTIFIED</p> <p>Fe: 70.6 ± 1.1%</p> <p>Ti: 12.7 ± 1.1%</p> <p>Tl: 5.6 ± 1.1%</p> <p>Al: 4 ± 4%</p> <p>Zr: 3.53 ± 0.23%</p> <p>Sn: 2.0 ± 2.1%</p> <p>Zn: 0.89 ± 0.23%</p> <p>Mn: 0.8 ± 0.3%</p> <p>Cu: 0.2 ± 0.3%</p> <p>Ga: 0.15 ± 0.14%</p>	<p>DATE: 2/2/2022</p> <p>ANALYST: 10/10/2022</p> <p>NO. OF REPS: 10</p> <p>ALLOY GRADE: NOT IDENTIFIED</p> <p>Fe: 80.5 ± 0.8%</p> <p>Si: 4.5 ± 0.6%</p> <p>Ti: 3.0 ± 0.7%</p> <p>Sb: 2.6 ± 2.2%</p> <p>Al: 2 ± 3%</p> <p>Mn: 2.13 ± 0.22%</p> <p>Sn: 1.4 ± 1.2%</p> <p>Zr: 1.30 ± 0.12%</p> <p>Zn: 0.78 ± 0.13%</p> <p>Pb: 0.29 ± 0.19%</p> <p>Cu: 0.18 ± 0.12%</p> <p>Ni: 0.17 ± 0.21%</p> <p>Ga: 0.10 ± 0.09%</p>
Alloys	Alloys
<p>DATE: 2/2/2022</p> <p>ANALYST: 10/10/2022</p> <p>NO. OF REPS: 10</p> <p>ALLOY GRADE: NOT IDENTIFIED</p> <p>Fe: 82.0 ± 0.9%</p> <p>Si: 5.6 ± 0.7%</p> <p>Ti: 3.4 ± 0.8%</p> <p>Sb: 2 ± 3%</p> <p>Al: 2 ± 3%</p> <p>Zr: 1.41 ± 0.15%</p> <p>Sn: 1.3 ± 1.5%</p> <p>Zn: 0.93 ± 0.16%</p> <p>Mn: 0.80 ± 0.25%</p> <p>Cu: 0.28 ± 0.14%</p>	<p>DATE: 2/2/2022</p> <p>ANALYST: 10/10/2022</p> <p>NO. OF REPS: 10</p> <p>ALLOY GRADE: NOT IDENTIFIED</p> <p>Fe: 78.1 ± 1.9%</p> <p>Mg: 6 ± 13%</p> <p>Si: 5.8 ± 0.7%</p> <p>Ti: 2.5 ± 0.6%</p> <p>Al: 2 ± 3%</p> <p>Zr: 1.46 ± 0.12%</p> <p>Sn: 1.2 ± 1.2%</p> <p>Mn: 1.15 ± 0.22%</p> <p>Zn: 0.91 ± 0.13%</p> <p>Pb: 0.44 ± 0.20%</p> <p>Ni: 0.22 ± 0.21%</p> <p>Cu: 0.20 ± 0.17%</p> <p>Ga: 0.16 ± 0.09%</p>

Elemental composition of Mauryan , Gupta and New bricks

### Average Percentage of Elements Present in Bricks

Elements	Mauryan brick	Gupta Brick	New Brick
Iron (Fe)	82.15 ± 0.9%	80.7 ± 0.9%	78.15 ± 1.1%
Silicon (Si)	5.275 ± 0.7%	5.0 ± 0.6%	5.35 ± 1.1%
Titanium (Ti)	3.1 ± 0.8%	2.7 ± 0.8%	3.40 ± 0.9%
Aluminium (Al)	1.5 ± 0.3%	2.0 ± 0.5%	4.00 ± 4.0%
Antimony (Sb)	2.15 ± 3%	4.0 ± 3%	-
Zinc (Zn)	1.54 ± 0.15%	1.87 ± 0.15%	3.05 ± 0.19%
tin (Sn)	1.35 ± 1.5%	-	2.5 ± 0.9%
Zinc (Zn)	1.052 ± 0.16%	1.21 ± 0.17%	1.00 ± 0.17%
Manganese (Mn)	0.86 ± 0.24%	0.53 ± 0.24%	0.85 ± 0.3%
Chromium (Cr)	-	-	0.2 ± 0.3%
Copper (Cu)	0.34 ± 0.14%	0.34 ± 0.14%	0.16 ± 0.17%
Gallium (Ga)	0.15 ± 0.10%	0.37 ± 0.17%	0.15 ± 0.17%
Lead (Pb)	0.445 ± 0.22%	-	0.5 ± 0.4%
Mercury (Hg)	6.00 ± 0.10%	-	-
Nickel (Ni)	0.275 ± 0.21%	0.30 ± 0.25%	-

#### Average percentage

#### XRD

XRD is a non-destructive technique used to identify crystalline phases and orientation and determine structural properties, like:

Lattice parameters, grain size, preferred orientation, phase composition, measures thickness of thin films and multilayers.

When X-rays incident on the sample , crystal atoms scatter incident X-rays , primarily through interaction with the atom's electrons. This phenomena is known as elastic scattering.

A regular array of scatterers produces a regular array of spherical waves. In the majority of directions, these waves cancel each other out through destructive interference, however they add constructively in a few specific directions determined by Bragg's law.

X-rays scattered by atoms enable us to understand about arrangements of atoms in solids. XRD helps us to find out the element present as well as structure of the sample in order to characterise the material.

#### Glimpses of Research Work





### Details of mapping technique

Lidar, which stands for Light Detection and Ranging, is a remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth. These light pulses combined with other data recorded by the airborne system generate precise, three-dimensional information about the shape of the Earth and its surface characteristics.

Using the time of travel (TOT) of this laser the distance between the transmitter and reflector is determined, since the Lidar was not available we used drone for the mapping.

### Structure of Kesariya Stupa

On analysing it was found that there are 16 trenches on North East slope of mound. The 1st terrace has a row of niches, the 2nd row has star pattern and 3rd has a serrated design.

The back of the cell of each terrace rise to meet the floor of upper terrace.

All the cell has images of Buddha in different posture.

One depicts Buddha seated in Dhyana mudra and in other 2 in Bhumisparsha mudra and the lumps of images have also been found in some of the cells.

### Conclusion:

On analysing we found that Iron is present in bricks of modern age, Mauryan age as well as Gupta age which gives durability and impermeability of the bricks.

However the different amount of iron is present in different ages. In modern age 73.3% of iron, in Mauryan age 82.15% and Gupta age 80.7%.

By adding more iron in bricks of modern age we may make it more durable.

Presence of more silica in Modern age makes it more brittle than Mauryan and Gupta Bricks.

Magnesium gives colour to the bricks but if in excess amount can reduce the shelf life. Magnesium in all the bricks is present in very little amount.

Aluminium provide plasticity to the brick which is good for bricks. presence of aluminium in modern age is 4%, in Mauryan age 1.5% is present and in Gupta age 2.0% is present.

By overall analysing we can conclude that bricks of Mauryan and Gupta age bricks is better than Modern age bricks. It can be made better by adding more iron to it.

- The investigation will provide the state of the art in the field of conservation of valuable materials.
- The data on chemical analysis of metal artifacts of ancient Indian origin are not as extensive and hardly systematized, and therefore, conclusions drawn will be of National importance.
- The non-invasive Equipments used will have no damage on the monuments.

A Major part of historical sites are still unexcavated and hence Lidar imaging shall be effective tool to analyze the portions beneath the surface which can be explored for historical and scientific relevance.

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