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RESEARCH ARTICLE
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Early Description of Numerical and Measuring System in Indus Valley Civilization

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ABSTRACT

The Indus valley civilization was the most ancient developed civilization as scientific measurements based on numerical values in most of developmental phases. The people of the Indus civilization were achieved great accuracy in measuring length, mass and time. They were among the first to develop a system of uniform weights and measures. Indian numerals were guided from 1 to 13 by the of Indus valley civilization. Ancient mathematics was used for practical purposes in measurement of weights and distances, scaling, fixed proportion adopted to urban structures, architectures, metallurgy etc. in many developmental planning of Indus civilization.

Key Words : Indus valley civilization, Measuring system, Numerical system

INTRODUCTION

The Indus Valley civilization was a Bronze Age civilization in the northwestern regions of South Asia, lasting from 3300 BC to 1300 BC, and matured between 2600 BC to 1900 BC. Along with ancient Egypt and Mesopotamia, it was one of three early civilizations of the region comprising North Africa, West Asia and South Asia. The most widespread along with its sites had spanned an area stretching from northeast Afghanistan, through much of Pakistan, and into western and northwestern India (Wright, 2009) and flourished in the basins of Indus River, which flows through the length of Pakistan and along a system of perennial, mostly monsoon-fed rivers that coursed in the vicinity of the seasonal Ghaggar-Hakra river in northwest India and eastern Pakistan. Bronze age civilization consisted mature period during 2600–1900 BC, primarily centered along the Indus and Punjab region. The civilization further extended into the Ghaggar-Hakra river valley of the region of the Ganges-Yamuna Doab, and encompassing mostly in many parts of Pakistan, western most states of India, south eastern Afghanistan, and eastern most part of Baluchistan. The mature phase of this civilization is known as the Harappan civilization as the first of its Civilization, as the first of its cities to be unearthed was the one at Harappa, and excavated in the 1920s at the time of Punjab province of British subcontinent. The excavation of Indus valley civilization sites have been done as ongoing since 1920, with important breakthroughs occurring as recently as Mohenjo-Daro, a UNESCO World heritage site.

Geography:

The Indus valley civilization encompassed most of Pakistan, extending from Baluchistan to Sindh, and extending into modern day up to Indian states of Gujarat, Rajasthan, Haryana, and Punjab, with an upward reach to Rupar on the upper on the upper Sutlej. There is evidence of dry river beds overlapping with the Hakra channel in Pakistan and the seasonal Ghaggar river in India. Many Indus valley or Harappan sites have been discovered along the Ghaggar-Hakra beds. According to some archaeologists, over 500 Harappan sites have been discovered along the dried up river beds of the Ghaggar –Hakra river basin and its tributaries. The

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Harappan sites about 100 along the Indus and its river basin tributaries presently as remains in kinds of major sites of the Indus valley civilization.

Numerical and Measurement system:

The people of the Indus river valley civilization achieved many notable advances in technology, including great accuracy in their numerical systems and tools for measuring length and mass. Fire baked bricks under urban architecture were found uniform in size and moisture-resistant and were used in building baths and sewage structures. Their scientific measurement evidenced that Harappans were among the first to develop a system of standardized weights and measures. The consistency of brick size across cities also suggests unity across the various urban areas, which is evidence of a broader civilization as earliest scientific based measurement system.

The oldest evidence of mathematical knowledge of Indians is found in the Indus valley civilization. The seals and pictographic inscriptions found in the excavations of Mohenjo Daro and Harappan, indicated that the people of this civilization had knowledge of numbers. The Harappan civilization was the womb of mathematics from where both the concept of numbers and numerical system originated. The numerical system which was first used by the Harappan later found its way into other ancient civilization. The first use of mathematics in the Indian subcontinent was in the Indus valley and dates as far back as 3000 BC (Wheeler, 1973).

The earliest known urban Indian scientific culture was at Harappa in the Punjab and at Mohenjo Daro near the Indus River. The Harappans adopted a uniform system of weights and measures (Connor and Robertson, 1986). Harappans used decimal numeral system without zero and place value system. Numerals were guided by the Indian numerals of Indus valley civilization of 3500 B.C. These are the numbers from 1 to 13 in Indus valley civilization (Datta and Singh, 1935).

Ancient mathematics was used for practical purposes in measurement of weights and distances, scaling, fixed proportion adopted to build bricks etc. in many developmental planning of Indus civilization. The detail analysis discovered that weights corresponding to ratios of 0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, and 500 were used. The existence of a graduated system of accurately marked weights showed that development of trade and commerce in Harappan society based on numerical system.

Some appliances for the measurement of length were also discovered. A remarkably accurate decimal rule known as the Mohenjo Daro sites is very interesting. Its numerical subdivision has a maximum error of just 0.005 inches at a length of 1.32 inches. The length has been named as Indus inch. Another measuring scale was discovered, when a bronze rod was found along with marked in lengths of 0.367 inches. The accuracy with these scales was marked in 100 units of this measure by 36.7 inches, which was the measure of a stride (Feurstein *et al.*, 2001). A number of scales for measuring the length were discovered during the excavations from the Indus sites. A decimal scale known as 'Indus Inch' based on a unit of measurement of 1.32 inches (3.35 cm) had been discovered. Another scale, a bronze rod was discovered that marked 0.367 inches. It is postulated that these measurements were used in the buildings and other urban structures by the Indus people with great accuracy.

The people of Mohenjo-Daro period had been used of decimal system as linear measurement revealed an uniform units of length were used in the planning of towns along with calibrated to about 1 D 16 inch (1.6 mm) made from ivory were used by the Indus valley civilization. Measurements of the ruins of buildings, which have been excavated from different sites of Indus valley civilization and showed that these units of length were accurately used by the Harappans in construction. The people of the Indus valley civilization achieved great accuracy in measuring length, mass, and time. They were among the first to develop a system of uniform weights and measures. A comparison of available objects indicates large scale variation across the Indus territories. They were among the first to develop a system of uniform weights and measures, although, as in other civilizations of the time, actual weights were not uniform from city to city. Their smallest division, which is marked on an ivory scale found in Lothal, was found approximately 1.704 mm and smallest division ever recorded on a scale of the Bronze age. The weights were in a perfect ratio of 5:2:1, on a scale very similar to the ncial imperial ounce or Greek uncial (Sergent, 1997).

Indus valley civilization achieved great accuracy in measuring length, mass, and time among the first to develop a system of uniform weights and measures to be extremely precise followed the decimal division of measurement for all practical purposes, including the measurement of mass as revealed by their hexahedron

hexahedron weights. These chert weights were used in a perfect ratio of 5:2:1 with weights of 0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, and 500 units, with each unit weighing approximately 28 approximately 28 grams. Harappan engineers have been followed the decimal division of measurement for all practical purposes, including the measurement of mass as revealed by their hexahedron weights in all development planning, architecture, metallurgy etc.

Indian geometry also had its origin in the Vedic period. The "Pythagoras" theorem was described in Sulbasutra authored by Baudhayana and others. Binary numbers were known at the time of Pingala's Chhandahshastra in around the fifth century. These chert weights were in a ratio of 5:2:1 with weights of 0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, and 500 units, with each unit weighing approximately 28 grams, similar to the ncial imperial ounce or Greek ncial, and smaller objects were weighed in similar ratios with the units of 0.871 . However, as in other cultures, actual weights were not uniform throughout the area. The weights and measures later used in Kautilya's *Arthashastra* as they are the same as those used in Lothal sites of Indus valley civilization.

E.J.H. Mackay, who excavated Mohenjo-Daro between 1927-1932 expressed surprise on finding that an instrument was actually used for this purpose as drawing circles in the Indus valley as early as 2500 BC (Mackay, 1938). In this context, it may be noted that later excavations at Lothal have unearthed thick, ring-like shell objects with four slits each in two margins that could have been used to measure angles on plane surfaces (Rao, 1985). The well-laid out street plans of the Indus cities and their accurate orientation along the cardinal directions have been long been taken as evidence that the Indus people had at least a working knowledge of geometry based on numerical angles (Sarasvati Amma, 1979; Parpola, 1994). Earlier mathematical studies have suggested that not only these people have done practical applications of measurement based on length and width, but that they also had an understanding of the basic principles of geometry (Kulkarni, 1978).

The discovery of scales and instruments for measuring length in different Indus sites indicated that the Indus culture knew that how to make accurate spatial measurements in city planning as per architectures rules (Vij, 1984; Balasubramaniam and Joshi, 2008). An ivory scale discovered at Lothal in the western coast of India and has 27 uniformly spaced lines over 46 mm, indicated an unit of length corresponding to 1.70 mm (Rao, 1985). The sophistication of the geometrical practiced by the Indus people were recorded by different sets of square circles. Geometric knowledge of the Indus civilization showed that about 443 of regularly shaped artifacts of various sizes have been identified as constituting a measurement system of standardized numbers and weights. Indeed, there is a surprising degree of uniformity in the measurement units used at the widely dispersed centers of the Indus civilization and indicated the scientific innovative phases were developed towards achieving an ancient standard system of units for measurement in the period of Indus valley civilization. While the Indus valley civilization is generally characterized as illiterate society on the evidence of these measurement inscriptions, and these description has been challenged by Farmer et al. (2004) argued that the Indus system did not encode language, but was instead similar to a variety of non-linguistic signs as measurement system used extensively in most of the developmental phases occurred during Indus valley civilization.

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