An exploratory study of the modern metric calculation of *Hasta* Measurement Unit

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Abstract

The traditional Indian architectural discipline is referred to as *Vāstuśāstra*, also known as *Sthapatya Veda*, which serves as a sub-discipline within the broader field. A fundamental principle of *Vāstuśāstra* is the precise calculation of relevant scales in the design of residential structures. The mathematical formulas utilized for determining various dimensions- such as length, width, height, circumference, diameter, and thickness of buildings - are rigorously articulated within this framework. Accurate scaling is indispensable not only for architectural design but also in the creation of sculptures; the meticulous application of scale is crucial for achieving design perfection. Proper proportions are vital for ensuring the overall harmony of the design elements. Within the scope of this research, descriptive research methodologies are employed, with primary architectural sources including *Mānasāra, Mayamata*, *Viśvakarmaprakāṣa*, and *Samarāṁgaṇa Sūtradhāra*. The standard unit of measurement utilized in primary architecture is the *hasta*, with the recommended scale set at 24 inches. *Hasta* varieties are categorized into three groups: 04, 05, and 08, based on scale variations. Among these varieties, the *Kiṣku hasta*, measuring 24 inches, is endorsed as the standard. This

measurement is derived from the scale of the barley seed, with a *mānāṁgula* representing eight barley seeds, thus establishing the standard hand measurement from 24 such units. The central inquiry of this research is to investigate the correlation between these traditional scales and contemporary metric values. The terms "*ratni*" and "*aratni*," referring to this unit of measurement, are documented in various primary sources. A complex contradiction has emerged concerning the determination of an appropriate scale for this unit. Multiple researchers have endeavored to equate the English measure of 18 inches with the unit of measurement known as the hasta, defining it as 24 inches. However, these efforts overlook fundamental criteria necessary for appropriately establishing the parameters of the hasta as a unit of measurement. Such attempts aim to render it numerically equivalent to the English measure without adequate justification. In traditional Sri Lankan architecture, the cubit (Riyana) is predominantly utilized as the principal measurement scale. The unit of measurement of the hasta referenced in architectural documentation is interpreted as equivalent to this Sri Lankan cubit scale. However, establishing measurements in this manner is neither scientifically rigorous nor academically sound. Consequently, the primary objective of this research is to develop a scientific methodology for determining the precise scale of the hand as a unit of measurement. This research involves conducting interviews with professionals directly engaged in house planning in Sri Lanka, including architectural consultants, designers, and masons. Additionally, data has been collected through questionnaires and subjected to scientific analysis. Utilizing a quantitative research methodology, measurements of barley seeds have been derived through laboratory calculations, and insights garnered from interviews with industry experts have been critically analyzed. This research strives to elucidate the definitive scale of the hand-measuring unit, which serves as a fundamental basis for architectural measurement. It aims to resolve existing contradictions related to the calculation of scale in residential design while promoting the proper application of

accurate measurement units. Ultimately, this research can be characterized as an academic initiative to foster new avenues of inquiry within the field of measurement, which is a core subject in architectural study.

Keywords: *Architecture, Cubit, Hasta, Measurement.*

Introduction

Vāstuśāstra, the traditional Indian architectural framework, is also referred to as *Sthapatyaveda*[1] and is recognized as an *Upaveda*.[2] All authoritative texts in the domain of architecture are composed in Sanskrit, wherein the principles associated with residential design are presented in a formal and scientific manner across fundamental architectural literature. A key recommendation of *Vāstuśāstra* is to accurately calculate all relevant scales in the planning of residential structures. Within the major branches of architecture, scale theory is prioritized over analytical approaches. The mathematical formulas for determining various dimensions, including length, width, height, circumference, diameter, and thickness of buildings, are thoroughly elucidated in *Vāstuśāstra*. The analysis of measurement and dimensional standards constitutes significant discipline within the field of architecture. Correct scales are essential not only in the design of buildings but also in the creation of sculptures; accurate proportions ensure the completeness of elements.[3] The existence of various scales is a fundamental requirement for all entities in the world.

The terms "*Hasta*" (*Sanskrit.*) and "*Hattha*" (*Pāli*) have been translated into Sinhala as "*Riyana*." In English, this unit of measurement is referred to as "cubit." According to English measurement standards, a cubit is defined as measuring 18 inches. The cubit is characterized

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1. Shukla, D. N. (1961). *Vastu Sastra Vol.-I Hindu Science of Architecture*, p.48. http://archive.org/details/in.ernet.dli.2015.408041
2. Ganapathisastri, T. (1966). *Samaramganasutradhara*. Oriental Institute, Baroda, p.1.
3 Shukla, D. N. (1961). *Vastu Sastra Vol.-I Hindu Science of Architecture*, p.180. http://archive.org/details/in.ernet.dli.2015.408041

by the distance from the tip of the elbow to the tip of the middle finger, which serves as the range for this unit of measurement. A complex contradiction has emerged concerning the determination of the appropriate scale for this unit of measurement, as the architectural Sanskrit source texts were translated into English and Sinhalese as cubits, rather than the original term *hasta*.

As a result, various researchers have sought to equate the English measurement of 18 inches with the *hasta* or hand unit, which is defined as 24 inches. However, not all scholars have taken into account the established parameters of the *hasta* measurement scale. Numerous attempts have been made to render it numerically equivalent to the English 18-inch measurement. Consequently, this research is to thoroughly investigate the precise scale of the hasta, which serves as the principal architectural unit of measurement.

Methodology

Within the framework of descriptive research methodology, foundational architectural texts were referenced. The analysis focused on pertinent sections of key texts from the Southern School, specifically the *Mānasāra, Mayamata*, and *Manuṣyālaya Candrikā*. Additionally, works such as the *Viśvakarmapakāṣa* and *Samarāṁganasūtradhāra,* which are representative of the Northern Tradition, were also examined. Furthermore, published scholarly research and academic publications pertaining to the Hindu architectural tradition were consulted to enhance the depth of the study.

The academic research papers published to date concerning the measurement of *yava* or barley corn have been meticulously analyzed. The measurements of the *yava* seed were derived through laboratory calculations, complemented by interviews with field experts. Among those interviewed were professionals with over five years of experience serving as architectural consultants. Additionally, the scales and the measuring formation practiced and utilized in the field of indigenous were investigated through field studies. This research employed various sources for data collection, including archaeological

references, online resources, and library materials, thereby ensuring a comprehensive approach to the subject matter.

Research Problem

A complex contradiction has emerged concerning the determination of the appropriate scale for this unit of measurement, as the architectural Sanskrit source texts were translated into English and Sinhalese as cubits, rather than the original term hasta. As a result, various researchers have sought to equate the English measurement of 18 inches with the hand unit, which is defined as 24 inches. However, not all scholars have taken into account the established parameters of the hasta measurement scale. Numerous attempts have been made to render it numerically equivalent to the English 18-inch measurement. Consequently, the research problem of this research is to thoroughly investigate the precise scale of the hand, which serves as the principal architectural unit of measurement.

Research objective

The precision of a house scale is an essential requirement in architectural practice. As such, it is imperative to examine the framework of measurement units, as well as the construction of scales that are both precise and accurate. Currently, the metric system predominates in residential planning; however, traditional architectural practitioners continue to utilize established mathematical formulas and patterns. Furthermore, contemporary architectural assessments are conducted on house plans prepared by chartered engineers. Consequently, the primary objective of this research is to investigate the precise scale of the basic standard hasta measurement units in relation to residential planning. Another objective of this research is to analyze the correlation between the existing metric scale and hasta measurement units.

Literature review

The principal units of measurement proposed in these mathematical frameworks have been established through two methodologies, the first of which involves deriving standard measurement units based on human physical characteristics. The height of an individual is referred to as *Puruṣamāṇa*, which serves as a measuring scale known as *Bamba* or fathom.[4] The length of the palm is designated as *Tāla*. Additionally, the scale on the middle ring of the middle finger of the right hand represents *"mātrāṁgula"*; a unit of measurement. The distance from the outstretched big toe to the tip of the ring finger also functions as a measuring scale *(Viyata)*. The *hasta*, consisting of 24 scales of finger breadth, is recognized as the primary standard unit of measurement. The process of gradual development from the atomic level to the determination of grain scale represents the methodology by which secondary units of measurement are established.[5] Based on these scale calculations, a *mānāṁgula* is devised utilizing eight *yava* grain scales. This measurement is equivalent to 24 inches, which is derived from the primary standard unit of measurement known as the *Hasta*.[6]

The primary architectural standard unit of measurement is defined by the *Hasta*, with additional terminologies such as *Ratni* and *Aratni* appearing in various foundational sources.[7] Architectural literature identifies eight principal varieties of *Hasta*. Notably, the firsthand or *hasta* unit of measurement is established as 24 inches, referred to as *Kiṣku*.[8]

4.   Vibhuti, C. (1998). *Indian Architectural Theory*. Curzon press, India, p.39.
5.   Acharya, P. K. (1933). *Architecture Of Manasara*, p.8. http://archive.org/details/in.ernet.dli.2015.31240
6.   Vibhuti, C. (1998). *Indian Architectural Theory*. Curzon press, India, p.38.
7.   Bruno, D. (1985). *Mayamata Vol. 1*. Motilal Banarsidas, India, p.9. http://archive.org/details/GwHQ_mayamata-by-bruno-dagens-vol.-1-motilal-banarasi-das
8.   T Ganpati Sastri. (1913). *The Vastuvidya*, p.2. http://archive.org/details/in.ernet.dli.2015.283841

24 aṁgulas	=	1 kiṣku
25 aṁgulas	=	1 prajāpatya
26 aṁgulas	=	1 dhanurmuṣṭi
27 aṁgulas	=	1 dhanusgraha
28 aṁgulas	=	1 prācya
29 aṁgulas	=	1 vaideha
30 aṁgulas	=	1 vaipulya
31 aṁgulas	=	1 prakīrṇa

Table 1- The eight kinds of Hasta units

Major Vāstu texts, including the *Mānasāra* and *Mayamata*, highlight only four variations pertaining to the *Hasta* unit of measurement. In all texts pertaining to *Vāstuśāstra*, the *Kiṣku hasta*, which consists of 24 mānāṁgulas, is established as the primary standard unit of measurement among various forms.[9]

24 aṁgulas	=	1 kiṣku
25 aṁgulas	=	1 prajāpatya
26 aṁgulas	=	1 dhanurmuṣṭi
27 aṁgulas	=	1 dhanusgraha

Table 2 - The specific four kinds of Hasta units

The second chapter of Mānasāra describes the formation of Mānāṁgula. Ślokas 40 through 50 detail the growth of various components of Mānāṁgula, including Rathadhūli, Vālāgra, Likṣā, Yuka, and Yava.[10] The text distinguishes between small, medium, and large variations of Mānāṁgula, with each size requiring a different number of components. The text also describes the measurement of

9. Bruno, D. (1985). *Mayamata Vol. 1*. Motilal Banarsidas, India, p.9. http://archive.org/details/GwHQ_mayamata-by-bruno-dagens-vol.-1-motilal-banarasi-das
10. Acharya, P. K. (1933). *Architecture Of Manasara*, p.8. http://archive.org/details/in.ernet.dli.2015.31240

various hand spans, with a vitasti requiring 12 inches and a Kiṣku hasta measuring 24 inches. Other hand spans, such as Dhanurmuṣṭi and Dhanugraha hasta, are constructed by increasing one aṁgula at a time. Notably, the text does not discuss the construction of the Prajāpatya Hasta, which measures 25 inches and is used to measure all mansions.[11]

The Viśvakarma Vāstuśāstram, translated into English by K. Vāsudeva Śāstrī and N.B. Gadre, stands as a masterpiece of the Indian traditional system of house planning. The 09th chapter of this text delineates the system of measurements and proportions, which are essential for both the aesthetic appeal and structural integrity of buildings. The methodology employed in this text for determining units of measurement is distinct. The smaller unit is derived from the paddy of Śālī Vrīhī, whereas other primary texts refer to the yava or barleycorn as the smallest unit. Three paddies constitute one aṁgula. This approach has also been employed in the Sri Lankan measurement system and Buddhist scriptures. In Vāstuśāstra, both yava or barleycorn and paddy or Śālī Vrīhī are utilized to standardize measurements.[12] (Sastri Sri K. Vasudeva., 1958, pp. 66–67).

The Samarāṁgaṇa Sūtradhāra, authored by Bhojarāja, is a seminal work that extensively analyses architectural theories. Chapter nine of the text specifically examines the characteristics of a hand, delving into aspects such as its three-fold arm and the process of forming the volume of a yava seed by progressively increasing from the atom.[13] (*2015.325544.Samarangana-Sutradhara.Pdf*, n.d., p. 35). The text replaces the term hasta with kara and states the volume of the hand to be 24 inches.[14] The chapter also elucidates the process of preparing the hand measuring unit and the division of the 24 aṁgulas

11. Acharya, P. K. (1933). *Architecture Of Manasara*, p.7-8. http://archive.org/details/in.ernet.dli.2015.31240
12. Sastri Sri K. Vasudeva. (1958). *Viswakarma Vastusastram (1958)*. T. M. S. S. M. Library, p.66-67. http://archive.org/details/dli.ernet.536734
13. Ganapathisastri, T. (1966). *Samaramganasutradhara*. Oriental Institute, Baroda, p.35.
14. Ganapathisastri, T. (1966). *Samaramganasutradhara*. Oriental Institute, Baroda, p.111.

of the hand into eight parva, with four parva accounting for half of the hand's size and the remaining volume marked in inches.

The handbook on architecture authored by Harmanis Appuhami has been a cornerstone for Sri Lankan society's construction practices for several decades. The text states that a hasta is equivalent to 24 aṁgula, although it does not provide a description of the different types of hands.[15] (Appuhami, 2017, p. 51). Additionally, the text explains four types of hasta based on their dosage, as described in a sloka in the Vaijayantatantra. The text also reveals that 60 vyaṁgulas are equivalent to one aṁgula, which is a crucial practice in the field's performance.[16]

Mañju Śri Bhāṣita Vāstuvidyāśāstra, a work believed to have been composed between the fifth and seventh centuries in Sri Lanka, provides an excellent source of authentic Ceylonese writings on Buddhist monasticism, including descriptions of Māna methods. The term hasta is also found in this book, but there is no description of the volume of a hasta. Walter Marasinghe, the editor and publisher of the book, stated in the preface that the ancient hasta was 24 inches and, in modern times, is equal to two feet and 8 inches.[17]

The Manuṣyālyacandrikā is an essential source for the study at hasta. Its third chapter, Mānabhedayonyādi Nirṇana, presents a similar analysis of the mānāṁgula, as other texts, made from yava seeds. It is stated that a vitasti measures 12 aṁgulas, and two vitastis make up a hand.[18]The terminologies Kiṣku, Kara, Aratni, Bhuja, Muṣṭi, etc., have been thoroughly investigated.

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15. Appuhami, H., Y. A. (2017). *Vāstuvidyā hevat Gṛhanirmāṇaśilpaya*. MD Gunasena Company, p.51.
16. Appuhami, H., Y. A. (2017). *Vāstuvidyā hevat Gṛhanirmāṇaśilpaya*. MD Gunasena Company, p.58.
17. Marasinghe, E. W. (1989). *The Vastuvidyasastra Ascribed to Manjusri*. Sri Satguru Publications, Delhi, India, p. xxi.
18. Gupta, Prof. S. K. (2017). Vastushastra System-Measurements and Proportions. *International Journal for Research in Applied Science and Engineering Technology*, *V*(XI), 615-622. https://doi.org/10.22214/ijraset.2017.11096

Results and Discussion

Architectural volumes have generally developed under two main methodologies. One of these methods is based on the human body, with the terminological signs related to the volumes, such as *Aṁgula, Hasta*, and *Parva*, being well established. The other method is the measurement tradition that developed around natural ingredients. In Vāstuśāstra, this type of measurement has been disseminated, centering on the *yava* (barley corn).

01.	Yavamāna	Measuring scales developed based on grains
02.	Yajamāna	Measuring scales developed based on human body

Table 3 - Two kinds of main measuring scales

Both the fundamental units of measure, namely the *mātrāṁgula* and the *mānāṁgula*, are advised for the calculation of residential architectural scales. The *mānāṁgula* is derived from a composition of eight barley corns. The methodology for determining the volume of a *yava* grain is delineated in Vāstuśāstra texts. According to these texts, the atom represents the smallest unit of measure. Eight atoms combine to create a dust particle, and eight dust particles further assemble to form the diameter of a human hair. Vāstuśāstra sources assert that the dimensions of a seed correspond to the progressive aggregation of eight sizes of a louse, achieved through successive development. This systematic approach reveals the origins of the information regarding the size of a *yava* grain, which emerges through structured advancement from the atomic level.

In ancient times, units of measurement were typically named and utilized based on the raw materials relevant to daily life. The methodology employed for calculating the volume of a *yava* grain within the framework of *Vāstuśāstra* is distinguished by its practical and scientific rigor. The unit of measurement known as mānāṁgula is derived from the aggregation of eight *yava* grains. Various scholars

have endeavored to correlate these historical units of measurement with the contemporary metric system.[19]

8 paramāṇu	=	1 Rathareṇṇu - car dust (000916mm)
8 rathareṇu	=	1 Līkṣā - nit (0.007328mm)
8 līkṣā	=	1 Yūkā - louse (0.058624mm)
8 Yūkā	=	1 Tila - Sesame seed (0.468992mm)
8 Tila	=	1 Yava - barley corn (3.751936mm, 3.75 unhusked paddy grain
8 Yava	=	1 Aṁgula (30mm, measurement of body dimension)

Table 4 - Metric Dimension of Primary units of scales

By estimating the average size of a *yava* grain at 3.75 mm, the corresponding size of a *mānāṁngula* is determined to be 30 mm. Furthermore, the combination of 24 mānāṁngulas establishes the volume of the *hasta*, which serves as the principal standard unit of measurement in architectural contexts.

24 aṁgulas	=	1 kiṣku	72cm
25 aṁgulas	=	1 prajāpatya	75cm
26 aṁgulas	=	1 dhanurmuṣṭi	78cm
27 aṁgulas	=	1 dhanusgraha	81cm
28 aṁgulas	=	1 prācya	84cm
29 aṁgulas	=	1 vaideha	87cm
30 aṁgulas	=	1 vaipulya	90cm
31 aṁgulas	=	1 prakīrṇa	93cm

Table 5 - Metric Dimension of Hasta units

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19. Vibhuti, C. (1998). *Indian Architectural Theory*. Curzon press, India, p.38.

The measurement unit for hand size is established at 720 millimeters, equivalent to 72 centimeters. The current accepted measurement is 28.3465 inches, which can be approximated to 28 inches. Calculating the size of a *yava* or barley corn grain as 3.75 millimeters reveals that this measurement does not align with the established scale of 28 inches.[20] Notably, comprehensive research has not substantiated the assessment of a barley corn grain at 3.75 millimeters. In contrast, laboratory studies and academic publications indicate that the average size of barley corn is 3.20 millimeters.[21] The cumulative measurement of eight grains amounts to 25.6 millimeters. Therefore, adjusting the hand measurement unit according to these findings results in a scale of 614.4 millimeters. Consequently, the revised fist measurement is determined to be 24.188 inches. Based on these research findings, it is concluded that the actual measurement unit for hand size should be recognized as 24 inches rather than 28 inches. In light of the current circumstances, it is necessary to revise the measurement scales for all hand measurement units ranging from twenty-four inches to thirty-one inches. The proposed modifications should be implemented as specified below.

24 aṁgulas	=	1 kiṣku	614.4 mm	24 inches
25 aṁgulas	=	1 prajāpatya	640 mm	24 inches
26 aṁgulas	=	1 dhanurmuṣṭi	665.6 mm	26 inches
27 aṁgulas	=	1 dhanusgraha	691.2 mm	27 inches
28 aṁgulas	=	1 prācya	716.8 mm	28 inches
29 aṁgulas	=	1 vaideha	742.4 mm	29 inches
30 aṁgulas	=	1 vaipulya	768 mm	30 inches
31 aṁgulas	=	1 prakīrṇa	793.6 mm	31 inches

Table 6 - New formation of the metric dimension of Hasta units

20. *Manusyālaya Candrikā* (T. Ganapathi Shastri). (1917). Super Intendent Government Press.
21. Shrivatsa, K. S. (2017). *International Journal of physical & social science*. P.7 (5).

The Sanskrit term "*hasta*" has been translated as "*Riyana*" in Sinhala texts and as "Cubit" in English literature, with a cubit conventionally measuring 18 inches. This translation has led to widespread misunderstanding, as many individuals tend to equate the *hasta* measurement unit to this 18-inch standard in Sinhala. Consequently, the conversion of the *hasta* measurement unit to cubit or *Riyana* in Sinhala is fundamentally flawed.

This confusion may be clarified by using the term that denotes the measurement of the *hasta* as "hasta or hand." It is noteworthy that the English cubit is defined as the distance from the tip of the elbow to the tip of the middle finger of the right hand. Vāstu practitioners have similarly used this definition when calculating measurements within the same range. The findings of this research indicate that measuring from the elbow to the tip of the finger is an inaccurate method for defining the scale of a *hasta*. It has been confirmed that while the lengths and spatial ranges for the cubit measurement are accurate, they should not be applied to the *hasta* or hand measurement. Furthermore, the practice of adjusting the *hasta* or hand scale in architectural contexts to align with the current English standard of 18 inches is deemed unscholarly.

Conclusion

The standards of measurement in architecture are rigorously and systematically analyzed in alignment with established mathematical principles. Scientific methodologies have been integrated into the architectural field to formulate precise units of measurement. The composition of fundamental measurement units is evaluated using raw materials sourced from the surrounding environment. The structure of a *mānāṁgula* is elucidated in practical architectural literature. Presently, its scale is recorded at 3.20 mm. The scale of the hand measurement unit, oriented along the longitude, measures 614.4 mm, indicating that the current scale of this hand measurement unit is equivalent to 24 inches. In academic discourse, the term "*Hasta*"

is utilized, without conversion to cubit or *Riyana*. It is imperative to elucidate the precise scale of this unit as employed in the Sinhalese tradition of house construction to foster advancement in the discipline. Moreover, addressing conflicting ideologies among Vastu consultants will promote uniformity and understanding within the field. By adhering to established architectural guidelines, clients can enhance their opportunities for progress and the realization of auspicious events.

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