

The Grid and Modular Measures in The Town Planning of Mohenjodaro and Kathmandu Valley

A Study on Modular Measures in Block and Plot Divisions in the Planning of Mohenjodaro and Sirkap (Pakistan), and Thimi (Kathmandu Valley)

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Abstract

This paper studies the street and block plans of Mohenjodaro and Sirkap of Pakistan, and Thimi of Kathmandu Valley. Mohenjodaro was a renowned city of Indus civilization, while Sirkap of Taxila, was an important cultural center in later half of first millennium BC. While both of the cities are archaeological remains, Thimi is still a living town. The three cities, apparently separated by enormous time span and geographic space, exhibit certain features that is striking to draw the attention of archaeologists and urban historians. This study finds that all the three settlements employ exactly the same grid dimension in making the division of urban blocks. The standard modules conform to 'danda' and 'rajju', which are stated in *Arthashastra*, the work of Kautilya who lived during the later quarter of 4th century BC. This paper makes a morphological analysis of the revealed plans of Mohenjodaro, Sirkap and Thimi, and demonstrates a relationship in their town plan, the division of quarter blocks and the plot divisions as shown by the built clusters and street boundaries. This is the first direct evidence to link the urban civilization of Indus with the living settlements that continue to exist up to modern times.

Keywords: Mohenjodaro; Sirkap; Taxila; Kathmandu Valley; Thimi

1. Introduction

Mohenjodaro is a city in Indus Valley plain that flourished around 2500 BC (Figs. 1 and 2). The site was first discovered in 1922 by R. D. Banerjee,¹ and subsequently excavation works followed under John Marshall who published the results of the work in 1931. Marshall earlier had begun excavation works on Taxila, an early historic city located about 500 km northwest of Mohenjodaro. Taxila incorporates several settlements, among which Marshall excavated lower settlement known as Sirkap, and the other nearby site known as Bhir Mound. The excavated stratas of Sirkap revealed clearly that the town was a planned settlement. Marshall (1921) ascribed the planned settlement including the building of the city wall to Sakas who followed the Bactreans to rule the region of Gandhara. However, in his later work (1951), he ascribes the building of the planned city to Indo-Greeks (Bactreans).² Although similar assumptions made by Marshall with respect to other artefacts found in this city has been refuted by other researchers his suggestions on the building of Sirkap in Hellenistic principles is often uncritically accepted by subsequent writers (Ghosh, 1948).

Our attention to Taxila and to Mohenjodaro was drawn when the authors were seeking the possibility of existence of the planning features in the region that were discovered in an earlier study of Thimi, one of the ancient towns of Kathmandu Valley (Pant and Funo, 2003). It was an accidental finding that Taxila used similar measurements in the division of its urban blocks as that of Thimi. Further excursion on ancient settlements led to Mohenjodaro where, surprisingly, same modular dimensions were employed in the division of its settlement blocks.

A great many settlements and sites have been discovered in Sindhu and Punjab plains that belonged to Indus culture in the past seventy years. Settlements

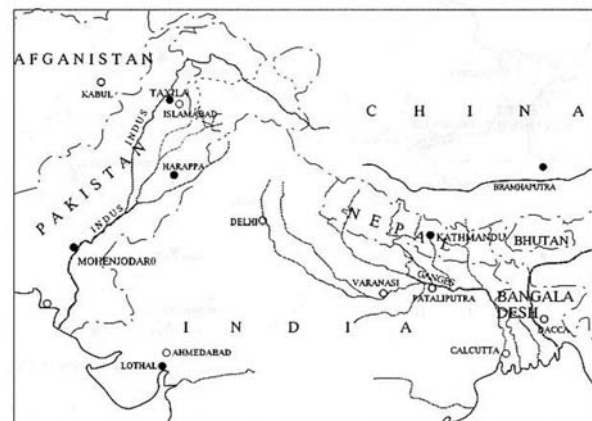


Fig.1. Indus and Kathmandu Valley

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such as Kalibangan and Lothal further demonstrated that Indus people did have planned town settlements (Rao, 1980).³ Metrological studies of Mainakar (1984) and Vij (1984) show the employment of standard system of weights throughout the Indus region.⁴ In spite of the extensiveness of Indus urban culture, the knowledge on the town settlement of Sirkap until now is completely independent of the culture of Indus people. The three volumes on Sirkap and other works by Marshall on Taxila don't mention Mohenjodaro or Harappa even once.⁵ However, later excavation works within the region of Taxila, and at localities close to Sirkap itself has begun to show that the region was settled from almost the beginning periods of Indus civilization to as late as the first centuries of the first millennium suggesting a probable continuity in the patterns of settlements in Taxila and Indus cities (Halim, 1972; Allchin, 1982). On the other hand, connections of certain communities of Kathmandu Valley with the Indus people have been considered a possibility by some researchers although in need of demonstrable evidences (Nepal, 1998: 7; Tiwari, 2003: 36). The present paper will, for the first time, make an analysis of the town plans of the three cities and demonstrate a cultural affinity between them.

2. Method of Analysis

The study will analyse the layout of streets, in particular, the dimensions of blocks defined by building clusters and quarter blocks revealed through the excavations in Mohenjodaro and Sirkap, and the existing street patterns of Thimi. In former two settlements, it is possible to discern such cluster blocks, which are formed by exterior walls or the boundary walls of a group of adjoined dwellings. These cluster blocks have well defined boundary lines, which either coincide with the street or lane, or are separated with the adjoining cluster block by a narrow gap. In many instances, the boundary lines show continuity through several cluster blocks, all the more emphasizing their nature as boundaries of plots. The next measurement is along settlement blocks defined by interval of lanes or the streets. Thus, the side of the lane or the boundaries of the blocks will define the terminal for the measurement and

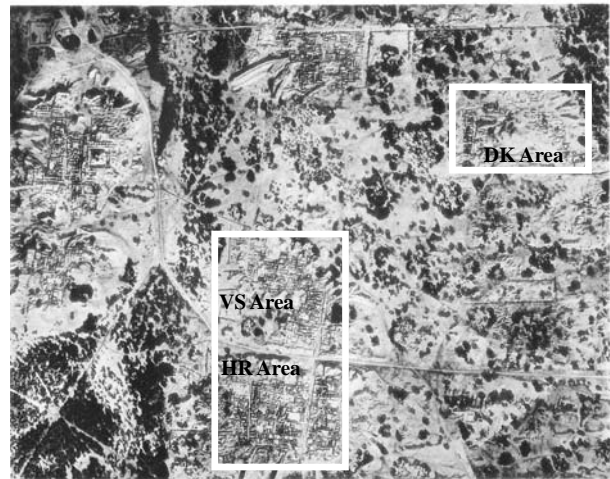
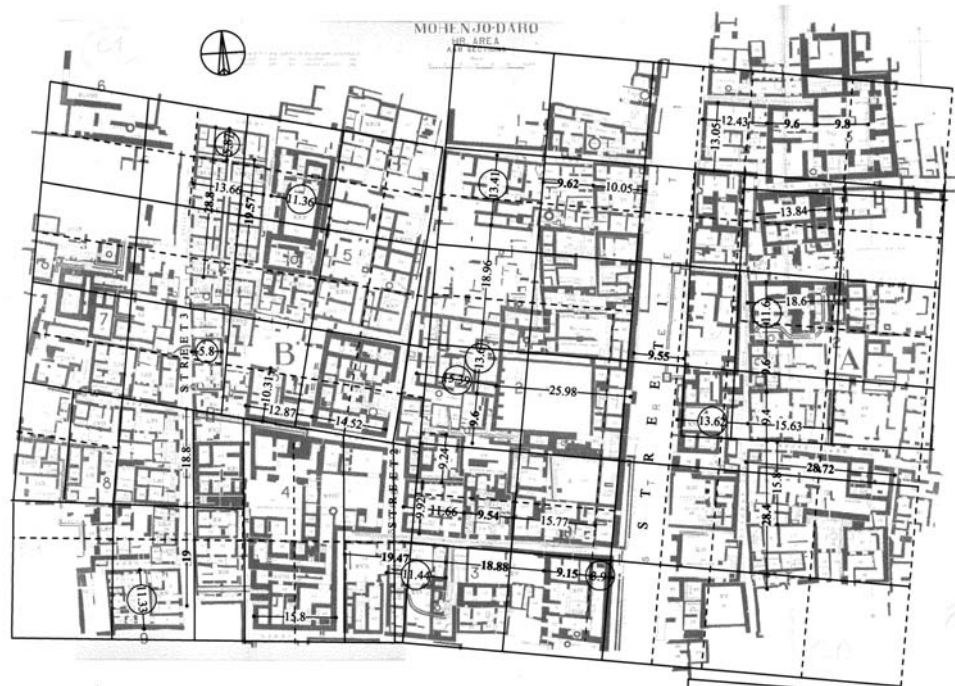


Fig.2. Mohenjodaro, Aerial Photograph (Ghosh, 1948)

dimensional analysis of the settlements.

The maps utilized for the purpose of this analysis are from Marshall (Mohenjodaro: 1931, scale: 1/250, 1/732; Sirkap: 1951, scale: 1/1000, 1/380), which provide workable accuracy for the present purpose of analysis. The dimensions of Thimi are from field measurements conducted by the authors in 1996 (Pant and Funo, 2003).

A preliminary study of the drawings showed that the layout of settlement blocks was related to a modular dimension of 19.2m, a length equivalent to one *rajju* (r) of ancient times, and initially discovered in the town of Thimi. Hence the grid of 19.2m (1r) is superimposed to all areas of Mohenjodaro and Sirkap to examine the



Note: The superimposed grid lines are at 19.20 m (1r) interval. The dimensions measured are of the cluster blocks not coinciding with the superimposed grid net. The measurements marked by circle are close to the multiples of danda. The measures close to 9.60 m (r/2) and its multiple are in bold. The values may be checked to the following scale:

danda	1d	2d	3d	4d	5d (r/2)	6d	7d	8d	9d	10d (r)	11d	12d	13d	14d	15d
meter	1.92	3.84	5.76	7.68	9.60	11.52	13.44	15.36	17.28	19.20	21.12	23.04	24.96	26.88	28.8

Fig.3a. Grid Pattern of HR Area, Mohenjodaro (Excavation Plan: Marshall, 1933, v. 3; Original Scale 1:250)

extent of planned regularity of the settlement. Thus, although the three cities are widely separated in space and time, the analytical approach will be the same to all the three cities. We will make their individual case study beginning from Mohenjodaro.

3. Mohenjodaro

The excavated areas of Mohenjodaro are distributed at different locations as can be seen in the aerial photograph. These areas have been named in the manner given in original drawings. The HR area is defined by two streets running north south. Within the region of excavated area, this part lies at the southern end. The wider street—Street 1, at the east is considered to be the Main Street of the city. This HR sector until now covers the widest area with high density of built clusters among the excavated areas. VS Area at north, is connected with HR Area by the Main Street. HR Area, VS Area and Dk Area on which the detail drawing plans are available, and constitute large clusters among the excavated areas, are selected for the purpose of present analysis.

3-1. The Main Street and The Axis of Alignment

The settlement blocks and dwelling clusters of Mohenjodaro, in general, follow the orthogonal pattern (Figs. 3a-3c) in their layout with slight deviations. For instance, HR section (Fig. 3a) shows three different alignments in the building clusters although alignment of the Main Street within the range of this area does not change. The lanes are occasionally found staggered. The building clusters at the interior that follow the alignment of lanes thus present an obvious difficulty to assume a single reference axis for the superimposition of the grid. However, in this instance, the Main Street, which is straight throughout from south to the north of the city, is taken as reference to proceed on the measurement work of the quarters. The dimensional measures obtained between the boundaries of the clusters, between the lanes, and between the boundaries of the blocks are shown in corresponding figures. It can be seen that all lanes including the Main Street closely coincide and align with the grid network. Further, minor cul-de-sacs and cluster boundaries are aligned with 9.6 m grids. The cluster blocks of 19.20 m width are most evident in Dk and VS areas.

It is important to note that despite four different cluster alignments in HR Area, boundaries in all cluster groups basically follow one reference grid that aligns with the Main street. The differing alignments are only a slight rotation from the reference grid, and show continuity in the grid lines. The conjunction of grid lines of various cluster alignments with the main reference axis therefore

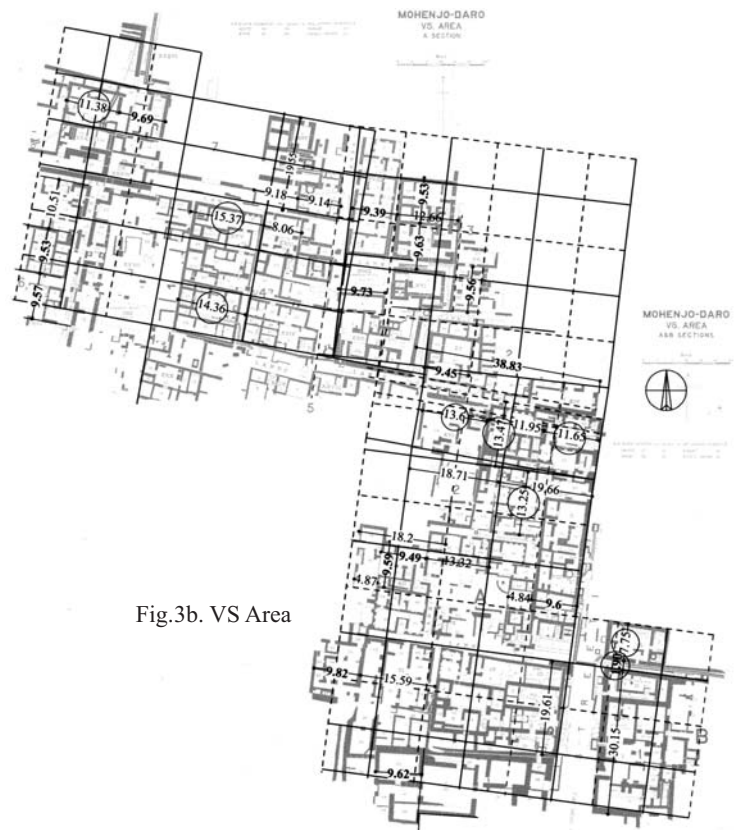


Fig.3b. VS Area

Notes: For dimensions in the figure, cf. Fig. 3a: note.



Fig.3c. DK Area (C Section)

Fig.3b, 3c. Grid Pattern of VS and DK Area, Mohenjodaro. (Excavation Plans: Marshall, 1933, v. 3; Original Scale: 1/732)

suggests their single reference origin. Minor bends from the reference alignment forming clusters of local grid are similarly found in other sectors. Aligning with the reference axis of the Main Street, the grids are continuous between HR Area and the VS Area that are separated by about a distance of 90 meter. It is also found from the measurement of the aerial photograph that the two areas follow one reference axis along the east-west direction as well.

3-2. The Pattern of Plots and Block Division

Among the east-west and the north-south boundaries of cluster blocks, the latter is comparatively more pronounced in its continuity. The longitudinal divisions, in general, define the depth of cluster blocks, which are most evident in HR and VS Area. The transverse divisions that give width of the blocks show a certain degree of variation. In the above figures the width of the blocks whose boundaries closely coincide with the superimposed grid are not noted. Measurement values are noted only for those blocks whose boundaries don't coincide with the grid. It can be seen that most of the cluster blocks have width from 9.6 m to 19.20 m, while quarter blocks with depth of 38.40 m are not uncommon in all the three areas. The coincidence of 9.6 m grid is considerable suggesting 9.6 m x 9.6 m as one of the standard plot sizes.

The reference grid, which is aligned with the western boundary of the Main Street, has revealed a vital feature on the manner of the layout of streets, lanes and the plots. The alignment of lane and plot boundaries with this reference grid shows that the survey measurement was not done by measuring from the centre of one street or the lane to the other. The continuity of boundaries in the longitudinal directions and the orientation of major streets suggest that these divisions were primary in the settlement layout. The conjunction of modular measures with the layout of streets and the close alignment of boundaries of the blocks suggest that the area was first regularly divided into longitudinal sectors of 19.20 m width. We are not certain whether this division preceded the beginning of the settlement or was necessitated as a first step for the foundation of the settlement. The layout of streets and lanes of the city might have complied with the existing field boundaries without obliterating them. This is particularly suggested from the instance that the blocks at the east of the Main Street in HR Area is not of usual depth formed by 19.2 m grid due to the width of the main street which is half a grid wide. Thus, it appears that the depth of plots

were defined by the existing net of field divisions and by lanes drawn within this grid, and not in a manner where blocks are laid in uniform size.

3-3. The Modular Dimension

It can be seen from the above three areas of Mohenjodaro that the dimension, which frequently occurs in major cluster blocks is 19.20 m. Likewise the most common dimension of minor individual blocks is 9.60 m, which is also found to be the width of the Main Streets. The coincidence of lanes with the grid of 19.20 m shows that this measure is determinant in the layout of settlement blocks and street planning. Interestingly, this grid measure is verified from street plans and survey measurements given by other researchers on Indus cities.

We have here available three sets of illustrations: from Piggot (1945) and Wanzke (1983-84) on Mohenjodaro (Fig. 4, Fig. 5) and one from Thapar (Cf. Jansen, 1984) on Kalibangan Fig.6). In his reconstructed street plan of Mohenjodaro, Piggot suggests the town formed by a grid net of 3 longitudinal streets and 2 traverse streets within the settlement area. Although the reconstructed street plan does not note the measurement dimensions, our measurements on the scaled drawing shows consistent employment of a basic module of 48 m (1s) with street grids at the intervals of 383, 288 and 240 m. These measurement values show modular correspondence with the measurement data given by Wanzke in his study of street axes of the town. His data shows that the axes of the town that includes the streets are at an interval that is the multiple of 1 *rajju* with a repetitive employment of a larger module of 192 m ($10r = 48 \times 4$).⁶

Similar modular multiples are found when measured in the street plan of Kalibangan. These data coming from independent studies are significant to demonstrate the employment of 1 *rajju* module in the planning of Indus cities.

In addition to these modular multiples defining the grid of the city, various other dimensions are noted in the width of the cluster blocks of Mohenjodaro. It is found that these values are multiples of a standard unit

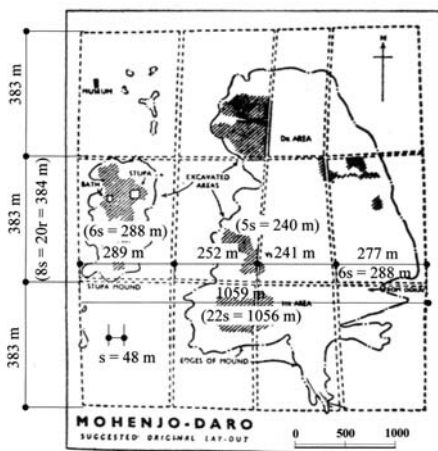


Fig.4. Grid Modules of Mohenjodaro. The Dimensions are Measured from the Drawing (Reconstructed Street Plan: Piggot, S, 1945)

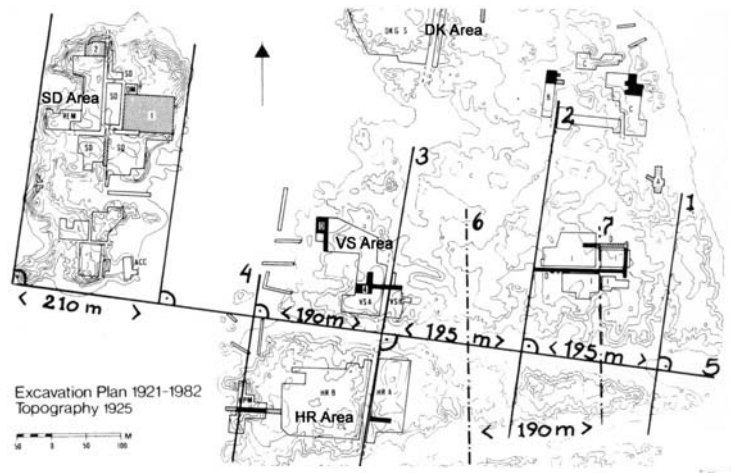


Fig.5. Axes of Mohenjodaro (Wanzke, 1983-84)

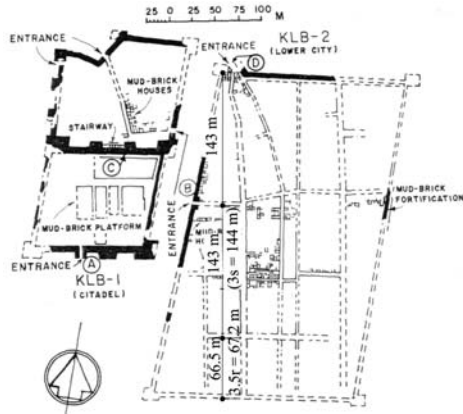


Fig.6. Kalibangan. Excavation plan: (Thapar, B., cf. Jansen, 1984). Note: The Dimensions are Measured from the Drawing

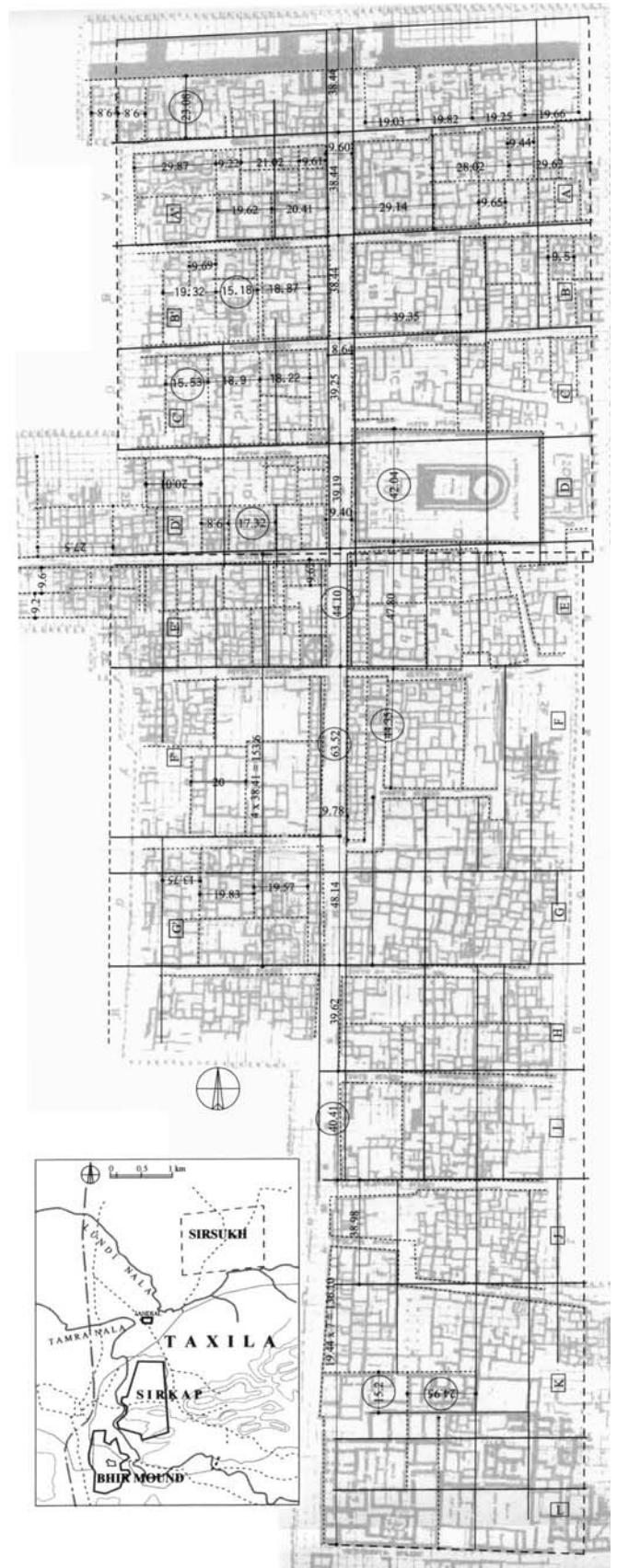
measure. This unit is close to *danda*, a measure that we begin to know only from Kautilya of 4th century BC (Kangle, 1972: 138-39). He gives the value of one *danda* of 108 digits (sanskrit: *angula*), a lower unit in the ancient tradition of cubit measure (sanskrit: *hasta*). Among the four *hasta* standards mentioned in classical architectural texts--*shishu-hasta*, *prajaptya-hasta*, *dhanurmusti-hasta* and *dhanurgraha-hasta*, which consist of 24, 25, 26 and 27 *angula*, 108 *angula* corresponds to 4 *dhanurgraha-hasta* or 4.5 *shishu-hasta*. Although there have been various estimation for the metric equivalent of one *hasta*, the study of Thimi has demonstrated a measure where the value approximates 48 cm with *dhanurgraha-hasta* as the standard (Pant and Funo, 2003). This gives 1.78 cm to one digit⁷, and with this measure, a *danda* will be 192 cm. Most of the dimensions of cluster blocks (marked by circle) of the settlement are close to the multiples of this value.⁸ In particular, what is to be emphasized is that 9.60 m and 19.20 m are 5 times and 10 times of one *danda* (5d and 10d). In Kautilya, ten times the length of a *danda*, is a unit called *rajju*, and 2 *rajju* one *paridesha*. To get lesser measurement units in Mohenjo-daro that make up a *danda* needs more detailed and accurate measurement studies, but what is certain from the available data is that the unit measures of *danda* and *rajju*, described by Kautilya, was already employed by the peoples of Mohenjodaro in their town planning.⁹

4. The case of Sirkap (Taxila) and Thimi (Kathmandu Valley)

4-1. Sirkap

Sirkap is one of the three separate settlement areas discovered within Taxila valley (Fig. 7). Bhir Mound, at southwest of Sirkap, is thought to be older to Sirkap, while Sirkukh, at northeast was a town built later in 2nd C. AD (Marshall, 1960). The excavated area of Sirkap reveals a settlement enclosed by ramparts within which there is a town at the lower plain, and an elevated hill terrace, which has few monastery complexes and a place thought to be the citadel.

The town has one main street almost at the centre of the settlement area that runs straight in the north south



Note: The horizontal grids are spaced in the intervals of the lanes. The longitudinal grids are superimposed at the spacing of 19.2 m or 9.6 m and are drawn where cluster boundaries coincide with the grid. The dotted lines are drawn at the boundaries of the cluster blocks. For dimensions in the figure, cf. Fig. 3a: notes.

Fig.7. Street Grids of Sirkap (Taxila)

direction. The town is then divided into blocks of equal width by lanes that run east west orthogonal to the Main Street. The size of quarter blocks differ at the central sector of the settlement and at southern part of the town. The width of blocks at northern section where there is a consistent pattern of division is close to 38.4 m (2r). These quarter blocks of regular pattern are analysed to study the division of blocks into plots and thereby examine the standard measures employed in the planning of Sirkap. The quarters, marked according to Marshall, are A to C at east, and A' to G' at west of the Main Street.

The continuity of boundaries of building clusters within these blocks shows a longitudinal division of the quarters into two halves with additional divisions within them. A series of division of 9.6 m width can be seen in A and B blocks. There are a number of instances where boundaries of the cluster blocks giving width of 9.6 m and 19.2 m cross even the quarter blocks suggesting a pattern of uniform plot division in the settlement. Blocks larger than 19.2 m are not common. The three measures of 9.6 m, 19.2 m and 38.4 m are thus hierarchical in making the divisions of plots and quarter blocks of the town. Interestingly the measure of 9.6 m, as in Mohenjodaro, is also the width of the Main Street of Sirkap. *Danda*, a lower multiple of this unit is also found to have been applied when checked in particular blocks with scale of 1/380 (Block H, Fig. 8). The dimensions of quarter blocks at south that differ from the standard width of 38.4 m, also give us a modular unit close to 1.92 m—the measure of a *danda*.

The study of aerial map (Ghosh, 1948) of the neighbourhood fields around the walled area of the city both inside and outside shows a division pattern of fields similar to the layout of lanes of the town settlement, i. e., the land is parcelled into plots of 19.2 m width where, in many instances, further subdivisions are to be found. What we are not certain is whether the land division long preceded the town layout or followed it along the same line. Given that Taxila was an inhabited area many centuries prior to the described period of building of Sirkap, and was the capital centre of the richest Satrapy of Achemedian Empire and a centre of learning during 6th-4th c. BC., it is certain that the Valley basin was intensely cultivated.¹⁰ As has been described earlier, the measuring system used in Sirkap was already known during the time of Maurya rule (324-



Fig.8. Dimensions of Cluster Blocks of Block H, Sirkap. (Excavation Plan: Marshall, 1951; Original Scale: 1/380)

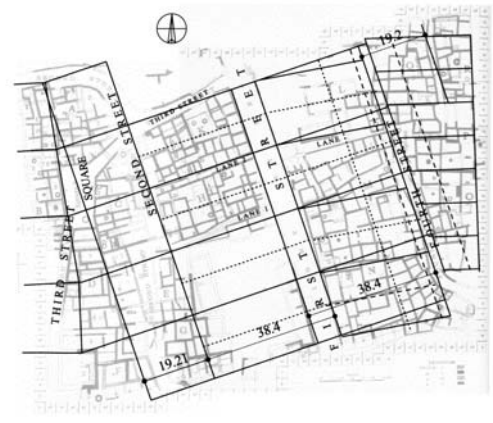


Fig.9. Grid Pattern of Bhir Mound, Taxila (Excavation Plan: Marshall, 1951; Original Scale: 1/435)

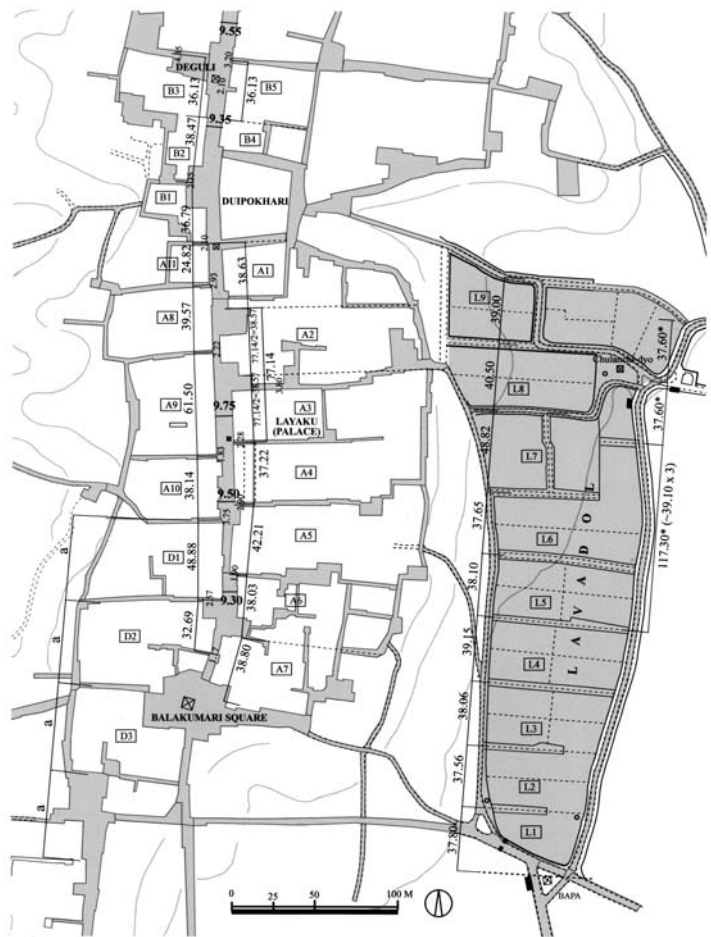


Fig.10. Thimi (Kathmandu Valley). Plan of Street and Blocks in the Town Plateau and the Field (at the Right) (Pant and Funo, 2003)

189 BC) long before the Bactreans arrived in Taxila.

Another even more important evidence to the earlier existence of this system of planning in Taxila comes from the settlement of Bhir Mound, which has been described as an existing settlement by 6th c. BC (Marshall, 1960). The settlement has been described as irregular and haphazard by Marshall. His opinion rests upon the limited area of excavation and the pattern of streets

revealed from the upper stratum. But fortunately, wall lines of the building clusters in the lower stratum are also shown in the drawings (Fig. 9). One can observe from this drawing that the earlier structures shown by dotted lines have more regularity in their layout. This is particularly apparent in the blocks between the First and Third Street. The superimposed grid shows a number of blocks in contiguity with a width of 19.2 m. The blocks that follow the grid cover greater part of the excavated area lying between Second and Fourth Street. Further, the width between First Street and Second Street is also 19.2 m. The division of 19.2 m wide blocks into half are apparent in blocks between Fourth Street and First Street. Such regular size of blocks within this small area is significant to establish a definite relationship between the settlement of Bhir Mound and the pattern of field divisions in Sirkap neighbourhoods as well as the planning of settlement there.

4-2. The Town of Thimi

The pattern of street planning similar to that of Sirkap is also found in one of the towns—Thimi, of Kathmandu Valley (Fig. 10). The Main Street of the town runs north south and the settlement is divided into quarter blocks by parallel lanes running east west that branch from the Main Street. The measurement survey of the early settlement core showed that the lanes were laid at an interval of 38.4 m (Pant and Funo, 2003). Licchavi period (2nd C. AD-9th C. AD) inscriptions found in the settlement and other features suggest the existence of the town by that period. The regularity in the planned form, through the long period of continued settlement, is considerably effaced but is still possible to see its early planned features. The finding of the module in the town settlement was aided by an earlier discovery of an area that lies at the lower basin right at the east of the town plateau. This area, now a vegetable garden, is regularly divided into 9 sectors whose average width is 38.48 m. The coincidence of the division pattern in the lower basin and the town shows the prevalent use of this module in the survey and planning of settlement in the region.

It has been found in Thimi that when the size of quarter blocks differ from the standard module, they do confirm to multiples of *danda*. On the other hand, the division pattern of the lower basin shows that there is first the longitudinal division of the sectors, which are then further divided into a number of plots. This pattern of division follows modular dimensions and shows similarity with the general division pattern of Sirkap. The employment of *danda* and *rajju* is also confirmed in the planning of Patan, one of the three major cities in Kathmandu Valley (Pant and Funo, 2004).

5. From Mohenjodaro to Sirkap and Thimi

The preceding analysis of the settlement of Thimi, Sirkap and Mohenjodaro demonstrates that the units of *rajju* and its half as standard modular measures are common to all the three towns. We know from other

standards of measure of Indus culture that they employed decimal as well as binary system. If the decimal system is adopted, *danda* is the one tenth of a *rajju*. The unit of *danda* is demonstrated in Thimi. The larger modules found in these settlements are close enough to prove that there is continuity in the survey and planning tradition from Mohenjodaro to Sirkap and Thimi. The plot division of Sirkap shows similarity with Thimi. It is therefore not a simple coincidence that the Main Street of all the three cities has the same width of 5 *danda* (9.6 m).

If we leave this fundamental convergence that exists among the three settlements, the differences in the manner of the division of the plot between the two settlements of Sirkap and Mohenjodaro are also apparent. In Mohenjodaro, the excavated areas have not revealed equal size of quarter blocks in between the lanes although it is to be noted that the more important lanes are invariably at a grid of 1 *rajju* (19.2 m). The lanes are often not through, but dog-legged. Short cul-de-sacs are often found leading to the interior from the Main Street. The lanes are more narrow, almost half the width of the lanes of Sirkap.

The town of Thimi has affinities both with Sirkap and Mohenjodaro. While the grid of 38.4 m is common to Sirkap, the lanes of Thimi including other towns of Kathmandu Valley, when not through, show a pattern similar to that of Mohenjodaro, which turn at right angles than going diagonal. In all the three towns, the access lanes to enter the plots of the quarter blocks are from the lane and not from the main street.

Marshall assumed that Sirkap was planned by Indo-Greeks when they ruled during 189-90 BC. Although Mohenjodaro clearly exhibited a grid system of planning he nevertheless thought that the planning principle of Sirkap owes to the Greek tradition. However, as there was no evidence to unequivocally support this argument, his reports written at different times contradict with each other.¹¹

6. Conclusion

The present study for the first time discovers the planning modules to guide the division of settlement quarters and dwelling plots of Mohenjodaro. It employed a measurement system, which shows conformity with that described by Kautilya of 4th century BC. It also demonstrates that the planning module employed in the Indus city of Mohenjodaro, Sirkap of Gandhara, and Thimi of Kathmandu Valley are the same. One of the links between these widely separated settlements is to be found in Kautilya himself who lived in Taxila and Pataliputra (Patna) the capital of Maurya empire, and who wrote exactly on this system of measurement in his economic treatise *Arthashastra*. Nepal was already in communication with Maurya Empire as is known from the same treatise.¹²

The next link of concern is between the early historic settlement of Sirkap and Mohenjodaro. It is to be born in mind that the archaeological reports on the remains

of Taxila including the Bhir Mound have not yet discovered the material that can definitely date the foundation of these settlements. Later archaeological works in the region of Taxila, for instance, that of Saraikhola and late findings in the Hathial Mound, a few hundred meters away from Sirkap, have now given the evidences of settlement in Taxila contemporary to Indus period. Allchin describes the finding of pottery sherds in the Hathial Mound area that belonged to early Indus period as well as those of later periods, thus suggesting continuity of settlement in Taxila from as far back as the beginning of Indus period. The present study of the structural remains of Sirkap shows its link with Bhir Mound and Mohenjodaro tradition of town planning. Thus, if continuity in the inheritance of the town planning idea from Indus to Sirkap and Thimi in Kathmandu Valley is evident as this paper shows, it also appears from other findings that there was also the continuity of the people themselves who built their settlement upon this tradition.

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Endnotes

- ¹ It was the finding of seals with legends inscribed in Indus script that led Banerjee, when he was digging the Buddhist remains in 1922, to conclude that the site belonged to Chalcolithic age. The discovery follows that of Harappa in 1921 by D. R. Sahn. Lal, B. B. and Gupta, 1984, p. x.
- ² The stratum of Sirkap city are classified into 6 levels—I to VI from top to bottom. Marshall assigns the lowest two levels to the Bactrian period, IV and III to Saka, and II and I to Saka Parthians and Kushana respectively.
- ³ Kalibangan is located at about 1600 km southeast of Harappa. The excavation has revealed the settlement made up of two fortified areas. The upper area is thought to be the ritual centre while the lower one the main settlement area. The town is divided into sectors and blocks by north-south streets that are parallel and laid at regular intervals, while the east-west streets are not always through as the north-south streets. For Lothal, see Lal, B. B., 1984.
- ⁴ Mainakar studies the relationship of the scale, carved in a strip of ivory, found in Mohenjodaro, and that of Lothal, which was carved in shell, with respect to the size of bricks, the plan of Great Bath of Mohenjodaro and the Dock of Lothal. While Vij makes a comparative analysis of weights and the dimensions of the Great Bath with respect to its implication of the knowledge of pi and astronomical instruments.
- ⁵ Marshall first published 'A guide to Taxila' in 1918 with subsequent editions, and revised in 1960. It probably owes to the conviction on the hypothesis of catastrophic theory of demise of Indus civilization, or the wholesale destruction of the Indus people by the 'invading Aryans' (Wheeler) or other nomads from the north (Marshall) that any search on the relationship of Sirkap to Indus culture was foreclosed. However, it is difficult to understand Marshall that when he with all the documents to speak on the planning features of Mohenjodaro, and Sirkap by 1960, still prefers to remain silent on

Indus tradition when writing on the town of Taxila.

- ⁶ Wanzke also gives in figure four axes in the east west direction but not the measurement. Wanzke's definition of 'access axes' is similar to ours. A note might be added on the terrain feature that in Fig. 5, a large number of contours are apparent. However other topographic maps with heights show that the three areas--HR, VS and DK areas, are relatively in a gentle terrain of 170 m (see Wheeler, 1960). Dumarcay considers that in terrains with level difference, horizontal projections might have been considered in the planning of settlement.
- ⁷ The measure of 1.78 cm to one digit is in close agreement with the bricks of the early settlement period of Mohenjodaro, which is given as 250 x 125 x 60 mm (Mainkar, 1984). Among the four brick sizes found in Mohenjodaro this particular size is common to Lothal. The measures correspond to the brick size 10 x 5 x 2.25 inches given by Marshall, 1933. The values are 14, 7 and 3.5 times 17.8 mm. The calibration in the available scale of Mohenjodaro has minimum unit of 6.7056 mm and of Lothal of 1.704 mm. The scale of Mohenjodaro does not give wholesome multiple to the brick sizes found in the remains. We are not yet certain on the minimum unit of division on the scale used in the town planning of Mohenjodaro. If the scale is to be related to the width of finger as in ancient India, the factor 17.8 mm is the closest. 27 of this digit give 480 mm.
- ⁸ The margin of error are within $\pm 5\%$ from the ideal value. The margin of error is calculated with respect to the modular unit, which in this case is one *danda* (1.92m). The error when calculated against the total length is much smaller.
- ⁹ Dumarcay (2005: p 15) suggests cubits of 51.56~52.83 cm and a measure of 33.02~33.52 cm, the feet equivalent, suggested by Wheeler (1960, p. 66) according to the fragment of a scale found from Mohenjodaro. It was desirable that the validity of these units be demonstrated through detail measurement analysis accompanied by relevant drawings. The multiples of suggested length of cubits don't coincide with *danda* and *rajju* proposed in this paper either by binary or decimal system known to have been employed in Indus culture. The feet equivalent measure of 33.02 cm may lead to a cubit of 49.53 cm relatively close to the *hasta* we proposed, but the accumulated difference becomes significant in larger multiples such as *rajju* when employed in town planning or field measurements. The evidence of the coincidence of the grid of *rajju*, as demonstrated in this paper, with the cluster blocks and the streets in the settlements of Mohenjodaro and other towns, in our opinion, precludes the possibility of these cubit measures to have been employed in the town planning scale of Mohenjodaro.
- ¹⁰ Taxila was the capital of Achemedian Empire from 6th century to the later quarter of 4th century BC before the invasion by the army of Alexander in 325 BC. His viceroys ruled only for 3 years in Taxila before they were driven away by the forces of Chandragupta in 323 BC. The Mauryan empire from Pataliputra ruled Taxila for around one and a quarter century whence it was the seat of viceroy prince Ashoka and later his son Kunala. In 189 BC the Bactrian came to rule in the Gandhara region with Taxila as their capital. Following them, Sakas (90 BC-78 AD) and Kushanas (78 AD-320 AD) ruled Gandhara until the advent of Gupta Empire. The archaeological remains and artefacts as well as the literary records all show that Taxila was one important centre of Buddhism. Panini (5th century BC), the celebrated grammarian of Sanskrit, and Kautilya the teacher of Chandragupta, lived and taught in Taxila.
- ¹¹ Since many authors following him continued to echo Marshall's view, we consider it relevant to quote some of the relevant parts at length:
 "...In accordance with the Hellenistic principles of defence, they included within their perimeter a considerable area of hilly ground as well as an isolated acropolis, and in other respects the city was laid out on the typically Greek chess-board pattern, with streets cutting on another at right-angles and regularly aligned blocks of buildings. Notwithstanding the city was several times destroyed and rebuilt and that many transformations were made in individual buildings, this Greek layout was on the whole well preserved down

to the latest days of the city's occupation." (Marshall, 1960). However, Mortimer Wheeler, following the new report of A. Ghosh on the excavation made in 1945 makes the following reference to Marshall's 1936 report, which according to him, needs modification:

At one or two points in the northern part of the walled city, Marshall dug down in small areas to the natural soil. He found 'remains belonging to six successive periods of habitation.....represented by clearly defined foundations of rubble masonry, with layers of debris above and below them. Of these successive strata of buildings, the fifth and sixth from the top belong to the period of Greek rule at Taxila (c. 190-85 BC).... The fourth city belongs to the time of the early Saka kings, probably of Azes I, many of whose coins were found buried in small hoards beneath the house floors. *It was this same Saka King who was responsible for contracting the city's perimeter and substituting well built walls and bastions of solid stone in place of the older fortifications of mud, and was responsible also for the symmetrical lay-out of streets and lanes which continued to distinguish it to the end of its history* [italics added]. The third city from the top, which is less clearly defined than the others, is also referable to the period of Sakas. The second city dates from Parthian times in the first half of the first century AD., and is characterised by the use of diaper masonry along with the ordinary local rubble. It is to this city that most of the structures exposed in Sirkap belong' (Ghosh, A., 1948).

- ¹² The mention of Nepal comes in the chapter 'The Activity of The Head of the Departments': The black *bhingisi*, made of a collection of eight woven strands (and) the *apasaraka* which keeps off rain, that is from Nepala. See Kangle, R. P., 1992, (2.11.100).

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